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# Preparatory study of ecodesign and energy labelling measures for domestic cooking appliances

*Final Report*

Rodríguez Quintero, R., Bernad Beltrán, D., Ranea Palma, A., Donatello, S., Villanueva, A., Paraskevas, D., Boyano, A., Stamminger, R.

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Joint Research Centre

EUR 31250 EN

**Contact information**
JRC-B5-COOKING@ec.europa.eu
Address: Edificio Expo. c/ Inca Garcilaso, 3. E-41092 Seville (Spain)

**EU Science Hub**
https://joint-research-centre.ec.europa.eu

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## Content

## Abstract

Ecodesign and Energy Labelling Regulation applicable to ovens, hobs and cooking fume extractors entered into force in 2015. Since then, the market has evolved and new technologies are available. Moreover, the implementing measures contain review clauses that are already due. Energy classes also need rescaling. Therefore, the Commission launched the revision of current Regulation for this product group. The study has been led by DG ENER and conducted by the Joint Research Centre (JRC).

The JRC team identified some areas where revised regulation could provide added value in this product group. Some oven manufacturers may be exploiting the characteristics of current measurement methods to declare energy consumption figures that are lower than real-life use. On top of that, the current approach for energy declaration allows the use of heating modes that are not consumer representative. Similarly, current energy efficiency measurement methods in cooking fume extractors may be pushing the market towards high airflow appliances, rather than to energy efficient ones. Other aspects that required further research were the ambition level of material efficiency requirements, the feasibility of energy sources such as hydrogen or the harmonization with other horizontal regulation such as low power modes, among others.

Based on these aspects, a set of policy options have been evaluated and presented as potential aspects to review in a hypothetical new version of the ecodesign and energy labelling regulation for cooking appliances.

## Executive summary

The energy used for the main cooking appliances (ovens, hobs and cooking fume extractors) represents around 6% of a household energy consumption. Aimed at increasing energy efficiency of these appliances, Ecodesign and Energy Labelling Regulation entered into force in 2015. Since then, the market has evolved and new technologies are available. The Commission launched the revision of current Regulation for this product group, and a preparatory study has been conducted by the JRC.

The analysis of this product group followed the Methodology for the Ecodesign of Energy-related products (MEErP), is based on available scientific information and data, used a life-cycle approach, and engaged stakeholder experts in order to discuss key issues and to develop a broad consensus. As a result, the JRC team has identified certain areas where revised regulation could contribute to increase energy and resource efficiency in this product group:

- A revision is due according to current ecodesign and energy labelling regulation
- The market has evolved and technological advancements may have occurred during this period
- Circumvention issues have been detected, particularly in the case of ovens
- Declared energy consumption is not always representative of real-life use, both for ovens and cooking fume extractors
- Due to improvements in energy efficiency, energy classes are less meaningful for the consumer and should be rescaled.
- Relevant performance parameters such as odour are not taken into account and should be considered in cooking fume extractors.
- Energy sources such as hydrogen are available and may be feasible in the near future in the domestic sector
- Current resource efficiency requirements may be more ambitious, considering current regulation of similar home appliances
- Clarity can be provided regarding other horizontal regulation such as low power modes.

Based on these aspects, a set of policy options have been evaluated and presented as potential aspects to review in a hypothetical new version of the ecodesign and energy labelling regulation for cooking appliances.

### Policy options for ovens

In terms of scope, JRC recommends to take the actions summarised in the table below.

| | Product description | Ecodesign – Material Efficiency | Ecodesign – Minimum Energy Performance | Energy Labelling |
|---|---|---|---|---|
| Solo microwave | Ovens that operate with microwave function only | Included | Not included | Not included |
| Combi microwave | Ovens that can operate with thermal heating function and combined microwave function | Included | Included, thermal function only | Not included |
| Small /Portable | Ovens with depth < 250mm or height < 120mm | Included | Not included | Not included |
| Solo steam | Ovens that operate with steam function only | Included | Not included | Not included |
| Combi steam | Ovens that can operate with thermal heating function and combined steam function | Included | Included, thermal function only | Included, thermal function |

| | | | | |
|---|---|---|---|---|
| | | | | only |

With a view on expanding the scope in future versions of regulation, a standardization request shall be initiated for

- Combi-microwave functions
- Solo steam functions
- Combi steam functions

With a view of expanding the number of ovens included in the scope, the definition of small and portable ovens shall be changed. Small and portable ovens shall be below 10 litres.

In terms of energy consumption declaration and energy label, the following actions shall be taken:

- Carry on with two different energy labels: one for electric ovens and one for gas ovens.
- Adopt the new version of EN 60350-1 that is under development by CENELEC (publication expected in June 2023) as the reference method to measure energy consumption of domestic electric ovens, as soon as it is published. For gas ovens, carry on measurements with current version of EN 15181 until a common and comparable method is defined for both energy sources
- In the energy label, declare two energy consumption values: standard mode and best performing mode. A standard mode can be either a "conventional" mode or a "fan-forced" mode. Both standard and best performing mode must be compliant with their corresponding requirements in the new version of EN 60350-1.
- For the declaration of energy consumption and energy classification, use an 80/20 weighted sum approach (80% for standard and 20% for best performing mode). For ovens with only one heating mode, that mode shall be the only one used for energy declaration and classification.
- For the different type of ovens and heating modes, the following shall be declared.

| | Standard | Best Performing Mode | Where should be declared |
|---|---|---|---|
| Electric oven with no additional functions | Declare thermal function | Declare thermal function, if available | Label & Manual |
| Gas oven with no additional functions | Declare thermal function | Declare thermal function, if available | Label & Manual |
| Solo MW | Declare microwave function | Not declare | Manual |
| Combi-MW | Declare thermal function | Declare thermal function | Manual |
| Combi steam | Declare thermal function | Declare thermal function | Label & Manual |

- In the calculation of Energy Efficiency Index (EEI), decouple the relationship between energy consumption and cavity volume: adopt the flat approach.

$$EEI = \frac{EC}{SEC}$$

Where:

EC = Energy Consumption, expressed as weighted sum between standard mode (80%) and best performing mode (20%)

SEC = Standard Energy Consumption, expressed as average of the market using the 80/20 weighted sum approach

- Measure cavity volume with the side racks, since the normal use of the oven is with them. Declare cavity volume in the energy label and in the manual.
- In information requirements, include recommendations about frequency of use of pyrolytic cleaning systems (in times per year, for instance) as an information requirement in product documentation
- In information requirements, include recommendations on the exceptional occasions in which pre-heating should be used.
- In information requirements for gas ovens, beyond energy consumption in MJ, declare energy consumption of the oven as well in a metric which allows a direct comparison to electric ovens.
- In terms of energy classes, adopt the following classification, both for electric and gas ovens

| Energy class | EEI |
|---|---|
| A | EEI < 66 |
| B | 66 ≤ EEI < 77 |
| C | 77 ≤ EEI < 88 |
| D | 88 ≤ EEI < 101 |
| E | 101 ≤ EEI < 116 |
| F | 116 ≤ EEI < 134 |
| G | EEI > 134 |

- In terms of ecodesign minimum performance, adopt the following thresholds, both for electric and gas ovens

| Tier 1: 2025 | Tier 2: 2027 | Tier 3: 2030 |
|---|---|---|
| EEI < 116 | EEI < 110 | EEI < 105 |

**Policy options for hobs**

In relation to the scope, it is recommended to:

- Include small (auxiliary) burners with a nominal heat input under 1.16 kW that are not covered by the current standard.
- Include hobs using 3rd family gases.

Regarding energy labelling, there is a small difference in the energy consumption of the three electric technologies (induction, radiant and solid plates), so it is difficult to set distinct energy classes. Energy labelling is not recommended for hobs.

Concerning to minimum requirements, the market analysis shows that induction technology is steadily replacing radiant technology in the EU households. Solid plate hobs sales are less than 5%, but this technology is still present, so making stricter the current common requirements would equal to banning solid plates hobs.

It is worth mentioning that common requirements for electric and gas hobs are not recommended, since the test methods available for electric and gas hobs are not comparable.

| **Option 1: common minimum requirement for electric hobs** | | |
|---|---|---|
| **Tiers** | **Electric hob (Energy consumption in Wh/kg)** | **Gas-fired hob (energy efficiency in %)** |
| February 2023 | < 195 | > 56 |
| February 2025 | < 190 | > 57 |
| February 2027 | < 185(*) | > 58 |

| **Option 2: different minimum requirements for solid plates, radiant and induction hobs** | | | |
|---|---|---|---|
| **Tiers** | **Solid plates hob** (Energy consumption in Wh/kg) | **Radiant/induction hob** (Energy consumption in Wh/kg) | **Gas-fired hob (energy efficiency in %)** |
| February 2023 | < 195 | < 195 | > 56 |
| February 2025 | < 195 | < 190 | > 57 |
| February 2027 | < 195 | < 185(*) | > 58 |

(*) According to some manufacturers flex and free induction could be banned

It is strongly recommended to work on a common test method for gas and electric hobs to be ready for the next revision. Furthermore, the energy consumption would need to be expressed as primary energy consumption, to allow for a fair comparison of the different energy sources. That would require consideration of the evolution of the electricity and gas mixes in EU and its shares of renewable energy sources and could provide a path for making data from electric and gas hobs more comparable.

**Policy options for cooking fume extractors (CFE)**

In terms of odour reduction, current standard EN 61591 contains a test method for the odour reduction with methyl ethyl ketone (MEK). There are several issues around this test method, mainly that it is just appropriate to measure the odour reduction efficiency of recirculation extractor. Apart from that, the odour reduction test should not only represent the removal of odorous substances, but the removal of all small pollutants in general that are emitted during cooking processes. However, this test method can be considered a good starting point to develop ecodesign measures for cooking fume extractors.

The functionality of a cooking fume extractor is defined by its capacity to reduce the odour, therefore, it is paramount to develop a test method that measures this performance parameter. To this purpose, a standardisation request needs to be submitted. However, in the meantime, the MEK test method can be used as transitional method, for both recirculation and extraction modes, to provide this information to consumers. A minimum requirement of 35% will discard the least efficient charcoal filters when sold together with the cooking fume extractor.

Some recirculation cooking fume extractors are sold without odour filter, which is purchased apart by the installation company or by the user. In this cases, it is recommended to test the recirculation cooking fume extractor with a standard odour filter, which will need to be defined. The manufacturer will inform the consumer that the odour reduction factor declared is only guaranteed if a similar filter is installed.

In terms of energy classes, different options have been described and analysed in this report:

| Parameter to determine EEI | Rule to choose energy classes |
|---|---|
| Fluid Dynamic Efficiency (FDE) as arithmetic mean | Energy classes have equal or similar EEI ranges |
| | Models are evenly distributed among energy classes |
| FDE as harmonic mean | Energy classes have equal or similar EEI ranges |
| | Models are evenly distributed among energy classes |
| Annual Energy Consumption including indirect energy consumption and Standard Annual Energy Consumption as function of airflow | Energy classes have equal or similar EEI ranges |
| | Models are evenly distributed among energy classes |

The recommended option is the one based on FDE as harmonic mean, since it may promote the market evolution towards the best available technologies. The energy classes with similar EEI ranges will support the technology change, as the conventional technologies will populate mostly the lower classes.

Regarding lighting and noise, it is recommended to include lighting in the annual energy consumption that is declared in the energy label, and setting a minimum energy efficiency, which is current class B for lighting. Lighting would not be part of the EEI since only the parameter FDE would be taken into account.

It is recommended that only one boost or intensive level is allowed in cooking fume extractors.

# Introduction

In 2018, households in the European Union (EU) accounted for a quarter of the total final energy consumption, and of this the energy used for the main cooking appliances represented 6.1%[1]. In 2014, the Commission adopted implementing measures under the Ecodesign Directive (European Commission, 2014a) and the Energy Labelling Directive in force at the time (European Commission, 2014b), applicable to domestic ovens, hobs (ecodesign only) and range hoods. The measures currently in force contain review clauses, and the regulation setting a framework for energy labelling also requires the rescaling of existing energy labels (European Commission, 2017). The European Commission has therefore launched the revision of the current ecodesign and energy labelling implementing measures for the product group "domestic ovens, hobs and range hoods". The review study is coordinated by the Commission's Directorate-General (DG) for Energy and is undertaken by the Commission's Joint Research Centre (JRC).

The methodology of the revision follows the Commission's Methodology for the Evaluation of Energy-related Products (MEErP) (COWI and VHK 2011), consisting of the following steps:

- Task 1: Scope definition, standard methods and legislation
- Task 2: Market analysis
- Task 3: Analysis of user behaviour and system aspects
- Task 4: Analysis of technologies
- Task 5: Environmental and economic assessment of base cases
- Task 6: Assessment of design options
- Task 7: Assessment of policy scenarios

The comprehensive analysis of the product group following the steps above will feed as research evidence into the revision of existing regulations. The research is based on available scientific information and data, uses a life-cycle approach, and engages stakeholder experts in order to discuss key issues and to develop a broad consensus.

A set of pieces of information of interest has been collected, starting from the initial preparatory studies ("ENER Lot 22" and "ENER Lot 23") prepared in 2011 and the resulting Regulations listed above on energy labelling and ecodesign for domestic ovens, hobs and range hoods. In this context, information is being revised, updated and integrated to reflect the current state of play, following the MEErP methodology.

As a final result, the JRC produces an updated review study including a comprehensive techno-economic and environmental assessment for this product group. This will provide policy makers with a basis for assessing whether and how to revise the existing regulations.

A Technical Working Group (TWG) has been created to support the JRC during the study. This TWG is composed of experts from Member States, industry, NGOs and academia who have voluntarily requested to be registered as stakeholders of the study. The TWG contributes to the study data, information and written feedback on questionnaires and working documents. Interaction with stakeholders has also taken place through meetings organised by the JRC. The contribution of stakeholders has been integrated in this report and is indicated as such.

[1] https://ec.europa.eu/eurostat/en/web/products-eurostat-news/-/ddn-20200626-1

# 1 Task 1: Scope, legislation and standardisation

## 1.1 Product scope and definitions

### 1.1.1 Technical description of domestic cooking appliances

The following section provides a technical description of domestic ovens, hobs and range hoods.

#### 1.1.1.1 Domestic ovens

An oven is defined as "*an appliance or part of an appliance which incorporates one or more cavities using electricity and/or gas in which food is prepared by use of a conventional or fan-forced mode*" (Regulation 65/2014 and Regulation 66/2014). Generally, the main components of domestic ovens are:

- cavity, where the food is located for cooking;
- chassis, the structure that supports the cavity and the rest of the oven assemblies;
- door, which enables access to the cavity;
- heating elements, which will differ depending on the heat source;
- thermostat, used to control the temperature in the cavity;
- fans, used to distribute heat evenly in convection ovens/mode;
- insulation, to restrict loss of heat;
- cables/pipes, which transfer energy from the heat source to the electrical resistance or heating element.

Depending on the characteristics of the main components, domestic ovens can be classified in multiple ways. In Table 1, a classification is provided considering four different criteria: heat source, cooking mode, number of cavities and mounting.

Table 1. Types of ovens

| **Heat source** | **Cooking mode** | **Number of cavities** | **Mounting** |
|---|---|---|---|
| Gas | Conventional | Single | Free-standing |
| Electricity | Fan-forced | Multiple | Built-in |
| | Steam | | Portable |
| | Microwave | | |

Regarding the heat source**,** domestic ovens can be powered either by gas or electricity. In principle, the main components of a gas or an electric oven (cavity, chassis, door, fans) are essentially the same, the only differences being in the way the heat is generated and the fuel transported through the appliance. Gas ovens generate heat via gas-fuelled burners, and therefore will need special pipes to transport it, an outlet for expulsion of fumes and gas-related control/safety systems. Electric ovens generate heat by using an electric resistance, so they will need cables to transport electricity (Landi, 2019).

With regards to cooking modes, domestic ovens can be classified, for instance, as conventional, fan-forced, steam, or microwave. Other examples of cooking modes offered in domestic ovens are grilling and roasting. Ovens can also offer a combination of these cooking modes.

In conventional cooking mode, a stationary heat source radiates heat in the oven and therefore uses only natural convection for the circulation of heated air inside the cavity. The heat source is generally (but not necessarily) at the bottom of the oven, although in some models additional burners or heating elements can be found at the top and at the back of the cavity. This heating mode is sometimes referred to as "static" or "top/bottom".

In fan-forced cooking mode, a built-in fan circulates heated air inside the cavity, distributing it evenly throughout. Ovens in this mode can run at slightly lower temperatures as they do not need to be as hot to heat up the contents of the oven (thanks to the increased heat transfer due to the forced convection). Ovens with fan-forced mode will need a motor to operate the fan, increasing slightly the complexity of the appliance.

A steam oven operates by leading steam, which is produced by injecting water into a steam generator, into the cavity, or directly generating steam inside the cooking cavity by evaporating water by means of one or more heating elements. The steam heats up the cavity of the oven, creating a very moist cooking environment within the device.

A microwave oven heats and cooks food by exposing it to electromagnetic radiation in the microwave frequency range, inducing polar molecules in the food to rotate and produce thermal energy in a process known as dielectric heating. The cavity of the ovens is the enclosed compartment in which the temperature can be controlled for preparation of food.

In terms of number of cavities, the most common configuration is the single-cavity oven, although multiple-cavity ovens (with two or more cavities) can also be found.

As far as the mounting configuration is concerned, ovens can be classified as built-in or free-standing (**Figure 1**). Free-standing ovens can either be installed separated from cabinets or by sliding them into an open space into the kitchen cabinetry. These appliances can also be known as cookers, since they include both an oven and a hob.

Free-standing (electric)

Free-standing (gas)

Built-in

Portable

Provided by APPLIA

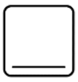
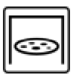
**Figure 1. Types of ovens based on mounting**

Built-in ovens are installed at a comfortable height in the wall, embedded between other kitchen cabinets or appliances.

Ovens can also be classified in terms of their size. According to Regulation 65/2014, a portable oven is one with "*a product mass of less than 18 kilograms, provided it is not designed for built-in installations*".

Ovens usually offer a wide variety of heating modes or settings in which they can be operated. Some of these settings are common to the majority of ovens in the market today, whereas others are more specialised and can only be found on a few models. The names of these settings are usually marketing-driven and may not necessarily be common in the industry. Although not universal, symbols used to represent each of those settings tend to be similar and recognisable. The most common oven settings, their symbols and a brief description can be seen in Table 2.

**Table 2. Typical oven heating modes**

| Symbol | Mode | Description |
|---|---|---|
|  | Conventional – bottom heating only | Heat will come solely from the heating element at the bottom of the oven. The fan will not be used to circulate the heat. |
|  | Conventional – top and bottom heating | Heat will be generated by elements in the top and bottom of the oven. Heat spreads through the oven by natural convection. |
|  | Fan-forced heating | Heat comes from a circular element surrounding the fan at the back of the oven and the fan then circulates this heat around. |
|  | Fan-forced with lower heating | Heat produced at the base and will be wafted around by the fan. On some occasions, heat can also be produced from the top (in that case, the symbol would include an additional horizontal line at the top) |
|  | Full grill | Heat is produced by the whole grill element. |
|  | Part grill | Only one section of the grill element gets hot. |
|  | Grill and fan | The grill and fan are alternating. The fan spreads the grill's heat |
|  | Defrost | The fan is on but no heat is produced, so no cooking takes place. The moving air defrosts food much more quickly than simply leaving it out of the freezer. |
|  | Plate warming | Plate-warming function. This gently warms plates or other dishes to prevent food from cooling too quickly when served. |
|  | Pyrolytic cleaning | This programme heats up the oven to around 500 °C, which has the effect of incinerating burnt-on cooking grime. |
|  | Eco | This is generally understood as the most energy-efficient mode of the oven. It is also commonly known as energy-saving mode and generally uses residual heat. On some occasions, it is a function for cooking small quantities of food, activating only a limited amount of the heating elements. |
|  | Pizza | This is a heating mode of the oven specifically designed to cook pizza. |
|  | Microwave | A heating mode where microwaves are used in the cooking cycle in order to speed up the process and save energy. |

| | | |
|---|---|---|
|  | Steam-assisted | A heating mode where steam is added to the cooking cycle in order to add specific characteristics to the food related to steam cooking. |
|  | Automatic functions | Some appliances have pre-programmed setting values that the consumer can use, in order to use the most appropriate temperature and time, according to the type of food being cooked. |

The definition of the most common oven heating modes at this point is relevant because they are directly related to certain aspects of current standards and legislation. For instance, the current standard for energy consumption of gas ovens (EN 15181) requires that the standard load is heated in "conventional" and "forced-air" heating functions. In a similar way, the current standard for energy consumption of electric ovens (EN 60350-1) requires that the standard load is heated in those two methods and in hot steam mode (if the appliance has it).

The current Ecodesign (REG 66/2014) and Energy Labelling Regulations (REG 65/2014) are also related to specific heating modes. In both, it is established that the energy consumption of an oven cavity shall be measured and declared in conventional and fan-forced mode. Then, "*energy consumption per cycle corresponding to the best performing mode shall be used in the calculations*" for determining the energy class. This freedom of choice for manufacturers has been highlighted by some stakeholders as an aspect to adress in future revisions of current regulation. This aspect will be covered in more detail in subsequent sections of this report.

#### 1.1.1.2 Domestic hobs

A hob is a domestic appliance used for heating food. It generally works as a primary heat or energy source which is used to warm a cooking vessel (a pan, pot, etc.), which then becomes the secondary heat source, transferring heat to the food within it. In the definitions section of Regulation 66/2014, the European Commission differentiates between electric hobs, gas hobs and mixed hobs:

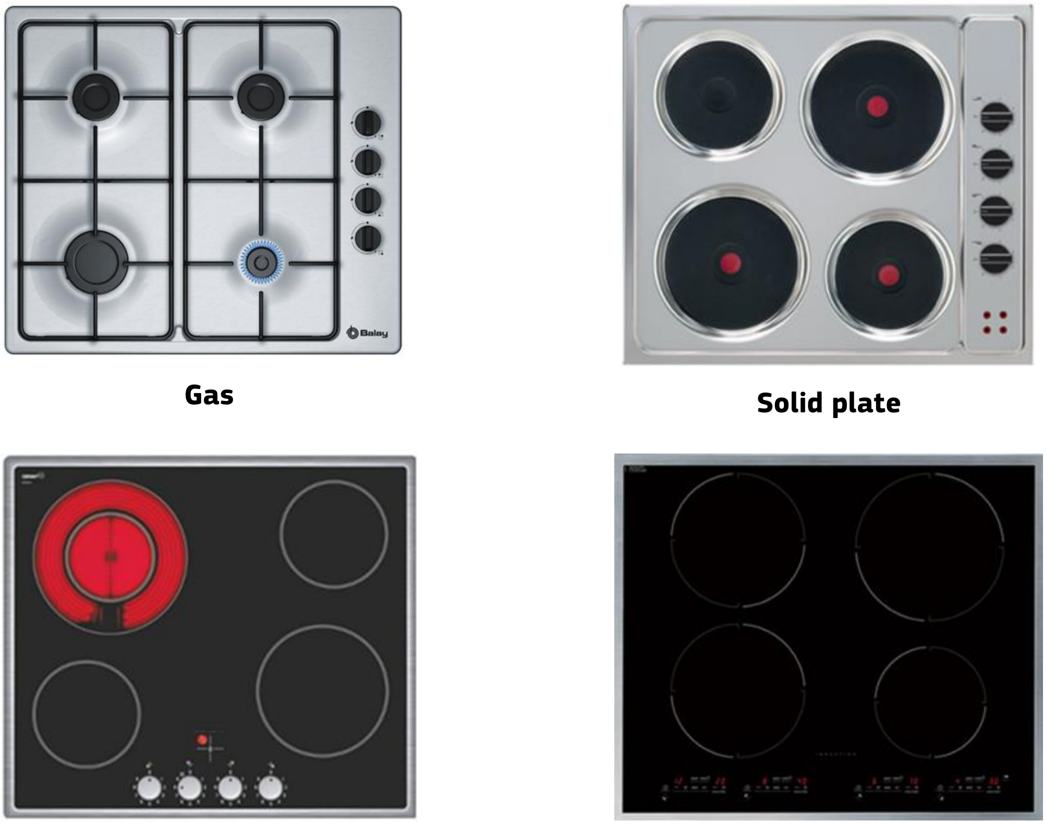
- Electric hob. Appliance which incorporates one or more cooking zones/areas, including a control unit, and which is heated by electricity.
- Gas hob. Appliance which incorporates one or more cooking zones/areas, including a control unit, which is heated by gas burners of a minimum power of 1.16 kW.
- Mixed hob. Appliance with one or more electrically heated cooking zones/areas and one or more cooking zones heated by gas burners.

Depending on the characteristics of the main components, domestic hobs can be classified in different ways. In Table 3, a classification is provided considering three criteria: heat source, heating element, and mounting.

**Table 3. Types of hobs**

| Heat source | Heating element | Mounting |
|---|---|---|
| Gas | Burners (gas) | Built-in |
| Electricity | Solid plate (electric) | Integrated in a cooker |
| | Radiant (electric) | Portable or table-top |
| | Induction (electric) | |

Regarding the heat source, domestic hobs can be powered either by gas or electricity. Gas hobs imply the use of burners that, after being ignited, maintain a flame that transfers heat to a cooking vessel. Although they can differ in size, configuration and ignition type, gas burners are relatively similar between them. On the other hand, there are more differences between electric powered hobs, depending on the heating element they use (**Figure 2**).



**Gas** **Solid plate**

**Radiant** **Induction**

Provided by APPLIA

**Figure 2**. **Different types of hobs according to their heating element**

In terms of the heating element, electric hobs can be classified in three different types:

- **Solid plate** hobs contain a sealed electric resistance, through which an electrical current circulates, transferring heat to the cooking vessel on top of it.

- **Radiant hobs** are a type of radiant cooking appliance. They use an electrical resistance wire or ribbon with a current that makes it glow red hot, so that most heat is transferred to the cooking vessel by infrared radiation via a glass-ceramic surface.

- **Induction hobs** are an electric cooking appliance where the hob itself is not specifically heated. Instead, below the surface of the hob there is a planar copper coil that is fed electrical power via a medium-frequency inverter. This alternating current induces eddy currents in nearby metallic objects (cooking vessel). These eddy currents heat up the cooking vessel, transferring the heat to the food.

#### 1.1.1.3 Domestic range hoods

A range hood can be defined as an appliance installed near the hob in the kitchen which uses a mechanical fan to collect steam, smoke and fumes and extract other airborne particles that may be generated while cooking. The extraction system consists of a centrifugal blower composed of an impeller coupled to an electric motor, both housed inside a scroll. The energy is provided to the exhaust air stream to then filter or expel the fumes. The system can work in multiple conditions of airflow rate, velocity and pressure (Bevilacqua, 2010). Generally, range hoods are manufactured with a combination of stainless steel, copper, bronze, nickel, zinc, tempered glass, aluminium, brass and heat-resistant plastics. The main components of a range hood are:

- capture panel and effluent plume, which are the elements that guide the thermal plume coming out of the cooking area towards the filter and ducting;
- filters, which are the elements of the range hood that capture the impurities when the cooking appliance is in operation;
- fans, which provide an active pressure gradient for ventilation;
- lighting, which provides illumination onto the cooking area.

Due to their predominantly visible location in kitchens, range hoods are increasingly seen not only as an appliance, but more as a piece of furniture. This is the main reason why a market for decorative hoods has been growing in recent years. Some hoods are also being offered with the ability to hold tools and objects, distributed on different levels. They may include hooks, shelves and even electrical outlets and Universal Serial Bus (USB) ports capable of charging electronic devices (Di Meo, 2018). Some models can be wirelessly connected to and controlled from hobs for more convenient and automatic activation/operation.

A typical classification of range hoods is in terms of the ventilation system used. According to this, range hoods can either be ducted or ductless. A ducted range hood is connected to a duct with pipes that carry the airborne particles away from the kitchen to the outdoors (Gannaway, 2015). On the other hand, in a ductless hood, air is pushed through filters that scrub the fumes, removing grease and odours (but not vapour/humidity), venting them back into the room (Dooley, 2019).

In terms of the installation method (Figure 3), range hoods can be defined as follows:

- Built-in: hoods are built into or concealed within a cupboard or fitted kitchen so they are less noticeable to the eye:
  - "Under cabinet", when it is mounted underneath the cabinets which are positioned above the stove. This is one of the most common and compact options: the design of the venting system is simple; it is versatile enough for almost any kitchen style and tends to save some wall space.
  - "Built-in" means an under cabinet hood fully integrated in the kitchen cabinet.
  - "Telescopic" means an under cabinet hood fully integrated in the kitchen cabinet and one of the grease filters slides out of the cabinet.
- Non-built-in: they are stand-alone units, which have not been integrated into a fitted kitchen:
  - "T-shape hood" and "chimney hood", when it is attached to the wall above the cooktop. In this case, the range hood is installed instead of a cabinet in the space over the stove. They often come with a chimney that helps with ventilation, typically venting out through an exterior wall behind them. This configuration can serve as a design element in the kitchen.
  - "Vertical hood", when the hood is installed vertically almost in parallel to the wall.
  - "Island-mounted" or "suspended", for kitchens where the cooktop is located on an island or not against a wall. This is the configuration generally used for larger, professional-style cooktops, in order to handle the extra output.
  - "Downdraft", when the range hood is kept inside the cooking space, integrated into the worktop and hidden away until it is used. According to manufacturers, their main

advantage is that they eliminate steam and odour right at the source. This is a less common configuration, a good solution for kitchens with limited space and when maintaining a clear sightline is a priority.

- "Downdraft integrated", an appliance that combines range hood and hob –usually induction- in just one. The working principles are similar to a downdraft hood.

- "Ceiling-mounted", when the hood is installed directly into the ceiling. The configuration is similar to that of an island-mounted hood, but in this case the result is a completely smooth surface rather than a hanging appliance in the centre of the kitchen.

**Under cabinet**

**Built-in**

**Telescopic**

**Chimney hood**

**Vertical hood**

**Ceiling hood**

**Suspended**

**Downdraft**

**Integrated**

*Pictures provided by APPLiA*

**Figure 3. Types of range hoods in terms of installation**

### 1.1.2 Existing definitions and categories for domestic cooking appliances

The following section provides an analysis of existing definitions of domestic ovens, hobs and range hoods using as a starting point the following categorisations:

- Ecodesign preparatory study Lot 22 and Lot 23;
- European statistics;
- legislation, such as the current EU Ecodesign and Energy Label Regulations, or third-country regulations;
- standards; and
- other voluntary initiatives such as ecolabels.

The product scope and definition are analysed within the frame of the Ecodesign and Energy Label framework legislation, in turn for each of the three subproducts that are a focus for the review study. Based on this information and further research and evidence, a preliminary revised scope and revised definitions are proposed. This proposal will take into account stakeholder feedback.

#### 1.1.2.1 Ecodesign preparatory study Lot 22 and Lot 23

The *Preparatory study for Ecodesign requirements of energy-using product Lot 22: Domestic and commercial ovens (electric, gas, microwave) including when incorporated in cookers, Task 1* (Section 1.1.1) defines:

> "*an <u>oven</u> as an enclosed compartment where the power/temperature can be adjusted for heating, baking and drying food and used for cooking*".

The study provides further detail on the end-use of the ovens if they are domestic, commercial or industrial and provides several definitions:

> "*<u>Domestic oven</u> includes ovens that are designed to be used in households. EN 30-1-1 defines domestic cooking appliances as "used by private individuals in domestic dwelling".*
>
> *"<u>Commercial oven</u> (e.g. impinge oven to cook pizza) include ovens that are designed to heat or bake product that are supplied directly to the end-consumers such as in restaurant, hotels, bakeries, canteens in factories, offices, hospitals, etc retailers such as supermarkets, etc".*
>
> *"<u>Industrial ovens</u> includes ovens whose primary use is to be used in an industrial setting, i.e. manufacture food that is sold to shops or other businesses and not directly to end-customers".*

The *Preparatory study for Ecodesign requirements of energy-using product Lot 23: Domestic and commercial hobs and grills, included when incorporated in cookers, Task 1* (Section 1.4) defines:

> *"A <u>hob</u> as an appliance or part of an appliance which incorporates one or more cooking zones, where a cooking zone is part of the hob or area marked on the surface of the hob which pans are placed for heating".*

Additionally, this study provides several definitions for a cooker or a range cooker:

> *"A <u>cooker</u> is defined as a large metal device for cooking food using gas and/or electricity. A cooker usually consists of an oven and a gas and/or electric hob"*.

#### 1.1.2.2 European statistics

The European statistical database for manufactured goods PRODCOM classifies the products included in this product group under the following NACE Rev2 codes:

- NACE 27.51 "Manufacture of electric domestic appliances";
- NACE 27.52 "Manufacture of non-electric domestic appliances".

In its subcategories, different types of ovens, hobs and range hoods are listed, as presented in Table 4.

**Table 4. PRODCOM classification for cooking appliances**

| Product | NACE code | Category |
|---|---|---|
| Domestic ovens | 27.51.28.10 | Domestic electric cookers with at least an oven and a hob (including combined gas-electric appliances) |
| | 27.51.24.50 | Domestic electric toasters (including toaster ovens for toasting bread, potatoes or other small items) |
| | 27.51.28.70 | Domestic electric ovens for building-in |
| | 27.51.28.90 | Domestic electric ovens (excluding those for building-in, microwave ovens) |
| | 27.52.11.13 | Iron or steel gas domestic cooking appliances and plate warmers, with an oven (including those with subsidiary boilers for central heating, separate ovens for both gas and other fuels) |
| Domestic hobs | 27.51.28.10 | Domestic electric cookers with at least an oven and a hob (including combined gas-electric appliances) |
| | 27.51.28.30 | Electric cooking plates, boiling rings and hobs for domestic use |
| | 27.51.28.33 | Domestic electric hobs for building-in |
| | 27.51.28.35 | Domestic electric cooking plates, boiling rings & hobs (excluding hobs for building-in) |
| | 27.52.11.13 | Iron or steel gas domestic cooking appliances and plate warmers, with an oven (including those with subsidiary boilers for central heating, separate ovens for both gas and other fuels) |
| | 27.52.11.15 | Iron or steel gas domestic cooking appliances and plate warmers (including those with subsidiary boilers for central heating, for both gas and other fuels; excluding those with ovens) |
| | 27.52.11.90 | Other domestic cooking appliances and plate warmers, of iron or steel or of copper, non-electric |
| Range hoods | 27.51.15.80 | Ventilating or recycling hoods incorporating a fan, with a maximum horizontal side ≤ 120 cm |

In the *Preparatory study for Ecodesign requirements of energy-using products, Lot 22: Domestic and commercial ovens (electric, gas, microwave), including when incorporated in cookers* (Mudgal et al., 2011), the classification of the domestic ovens corresponds with the classification presented in this section. Moreover, the preparatory study Lot 22 included the classification of commercial ovens as well as those with a microwave function.

In the *Preparatory study for Ecodesign requirements of energy-using products, Lot 23: Domestic and commercial hobs and grills, included when incorporated in cookers* (Mudgal et al., 2011), the classification separates those hobs that are built-in (NACE 27.51.28.33) from those which are free-standing, integrated in cookers or not (NACE 27.51.28.10 and NACE 27.51.28.35). Additionally, this preparatory study includes the classification of commercial hobs as well as grills and roasters, domestic and commercial.

#### 1.1.2.3 EU Regulation

**Regulation (EC) No 66/2014** with regard to ecodesign requirements for domestic ovens, hobs and range hoods (European Commission 2014) applies to:

> *"domestic ovens (including when incorporated in cookers), domestic hobs and domestic electric range hoods, including when sold for non-domestic purposes.*
>
> *This regulation shall not apply to*

- *appliances that use energy sources other than electricity or gas;*
- *appliances which offer 'microwave heating' function;*
- *small ovens;*
- *portable ovens;*
- *heat storage ovens;*
- *ovens which are heated with steam as primary heating function;*
- *covered gas burners in hobs;*
- *outdoor cooking appliances;*
- *appliances designed for use only with gases of the "third family" (propane and butane);*
- *grills".*

**Regulation (EC) No 65/2014** with regard to energy labelling of domestic ovens and range hoods (European Commission, 2014) applies to:

> *"domestic electric and gas ovens (including when incorporated into cookers) and for domestic electric range hoods, including when sold for non-domestic purposes.*
>
> *This Regulation shall not apply to:*

- *ovens that use energy sources other than electricity or gas;*
- *ovens which offer 'microwave heating' function;*
- *small ovens;*
- *portable ovens;*
- *heat storage ovens;*
- *ovens which are heated with steam as primary heating function;*
- *ovens designed for use only with gases of the "third family" (propane and butane)".*

For domestic ovens, hobs and range hoods, the following definitions are given:

> "*<u>oven</u> means an appliance or part of an appliance which incorporates one or more cavities using electricity and/or gas in which food is prepared by use of a conventional or fan-forced mode*";
>
> *"<u>range hood</u> means an appliance, operated by a motor which it controls, intended to collect contaminated air from above a hob, or which includes a downdraft system intended for installation adjacent to cooking ranges, hobs and similar cooling products, that draws vapour down into an internal exhaust duct*";
>
> *"<u>hob</u> means an electric hob, a gas hob or a mixed hob*";
>
> *"<u>electric hob</u> means an application or part of an appliance which incorporates one or more cooking zones and/or cooking areas including a control unit and which is heated by electricity*";
>
> *"<u>gas hob</u> means an appliance or part of an appliance which incorporates one or more cooking zones including a control unit and which is heated by gas burners of a minimum power of 1.16 kW*";
>
> *"<u>mixed hob</u> means an appliance with one or more electrically heated cooling zones or areas and one or more cooking zones heated by gas burners".*

The Regulation includes the definitions of some products that are not included in its scope, such as:

> *"<u>Small oven</u> means an oven where all cavities have a width and depth of less than 250mm or a height less than 120mm".*

*"Portable oven mean an oven with a product mass of less than 18 kilograms, provided it is not designed for built-in installations".*

*"Microwave heating means heating of food using electromagnetic energy".*

For range hoods, definitions within Regulation (EU) No 1253/2014 with regard to ecodesign requirements for ventilation are also relevant:

- *'Ventilation unit (VU)' means an electricity driven appliance equipped with at least one impeller, one motor and a casing and intended to replace utilised air by outdoor air in a building or a part of a building;*

  *'Residential ventilation unit' (RVU) means a ventilation unit where:*

  *(a) the maximum flow rate does not exceed 250 m3/h;*

  *(b) the maximum flow rate is between 250 and 1 000 m3/h, and the manufacturer declares its intended use as being exclusively for a residential ventilation application;*

  *'Non-residential ventilation unit' (NRVU) means a ventilation unit where the maximum flow rate of the ventilation unit exceeds 250 m3/h, and, where the maximum flow rate is between 250 and 1 000 m3/h, the manufacturer has not declared its intended use as being exclusively for a residential ventilation application.*

#### 1.1.2.4 Third-country regulations

In the United States, the Department of Energy (DOE) Regulations define kitchen ranges and ovens, or "cooking products", as:

> "*consumer products that are used as the major household cooking appliances. They are designed to cook or heat different types of food by one or more of the following sources of heat: gas, electricity or microwave energy. Each product may consist of a horizontal cooking top containing one or more surface units and/or more heating compartments*".

In addition, in an amendment carried out in 2016, the DOE proposed to define a combined cooking product as:

> "*a household cooking appliance that combines a conventional cooking top and/or conventional oven with other appliance functionality, which may or may not include another cooking product*".

The DOE's Regulation limits its scope to domestic cooking tops and domestic ovens (called *conventional cooking tops* or *conventional ovens*).

US regulation separated residential conventional cooking products into product classes. The classification followed refers to the following criteria: a) type of energy used, and b) capacity or other performance-related features such as those providing utility to the consumers.

For gas cooking tops, those are defined as those equipped with gas cooking tops with burner inputs rate equal to or lower than 14 000 Btu/h.

The product classes for electric cooking tops are:

- low- or high-wattage open (coil) elements; and

- smooth elements made of one large and continuous piece of glass and ceramic with the heating elements completely enclosed underneath the surface.

For electric ovens, the DOE determined that the type of oven cleaning is a utility feature that affects performance. The product classes are:

- standard oven with or without a catalytic line, and

- self-clean oven.

For gas ovens, the DOE determined that conventional gas ovens are those equipped with burner input rates equal to or lower than 22 500 Btu/h. For the classification, the same criteria as for electric ovens are followed. The product classes are:

- standard oven with or without a catalytic line, and
- self-clean oven.

#### 1.1.2.5 Standards

**International standards**

Three international standards have been identified as relevant for this product group:

- *IEC 60350-1:2016 on household electric cooking appliances – Part 1: ranges, ovens, steam ovens and grills – Methods for measuring performance.*
- *IEC 60705:2015 Household microwave ovens – methods for measuring performance.*
- *IEC 60350-2:2011 on household electric cooking appliances – Part 2: hobs – Methods for measuring performance.*
- *IEC 61591:2019 Cooking fume extractors – methods for measuring performance. Methods for measuring performance.*

The IEC 60350 standards specify methods for measuring the performance of electric cooking ranges, ovens, steam ovens, grills and electric hobs for household use. The hobs covered may be built-in or for placing on a work surface or the floor. The hob can also be a part of a cooking range.

The standard IEC 60705 describes methods for measuring the performance of microwave ovens. Its scope covers both solo microwave and combination ovens, though the methods are only meant to test the microwave function. The last amendment of the standard provides the following definitions:

- *Microwave oven: appliance using electromagnetic energy in one or several of the ISM frequency bands between 300 MHz and 30 GHz for heating food and beverages in a cavity.*
- *Combination microwave oven: microwave oven in which microwave energy is combined with energy transfer by forced air circulation, by conventional heating, by hot steam and by steam.*

The standard IEC 61591 includes definitions for cooking fume extractors:

- *Cooking fume extractor: appliance with a fan and filter intended to collect and treat cooking fumes, which can be operated in recirculation mode or extraction mode.*
- *Range hood: cooking fume extractor installed over a cooking appliance.*
- *Recirculating air mode: mode of a cooking fume extractor that discharges air back into the room, which includes an odour-reduction filter.*
- *Extraction mode: mode of a cooking fume extractor that discharges the air to the outside of the building by means of a ducting.*
- *Down-draft system: cooking fume extractor intended for installation adjacent to a cooking appliances or integrated in a cooking appliance that draws vapour down into a duct.*

**European standards**

The standard EN60350 "*Electric cooking ranges, hobs, ovens and grills for household use – Methods for measuring performance*" defines:

- an oven as *an appliance or compartment of a range cooker in which food is cooked by radiation, by natural convention, by forced-air convection or by a combination of these heating methods*;

– a hob as *an appliance or part of an appliance which incorporates one or more cooking zones, where a cooking zone is part of the hob or area marked on the surface of the hob which pans are placed for heating.*

#### 1.1.2.6 Labels and schemes

**European labels**

*Range hoods*

The scope of the German Ecolabel Blue Angel DE-UZ-147 for Household cooker hoods is given as follows:

> *"These Basic Award Criteria apply to household cooker hoods with an inbuilt fan for either recirculation operation[2] or exhaust operation[3] exhibiting a maximum air flow volume of 800 $m^3$/h at maximum continuous operation[4]".*

Specific requirements on the energy efficiency of the fan and the lighting, the power consumption of the off-mode and standby mode, automatic reset, grease and odour removal and noise emissions are not differentiated based on the size of the appliance.

**US Energy Star labels**

There is no Energy Star label for residential ovens, ranges, or microwave ovens at this time. However, there are Energy Starlabelled commercial ovens.

### 1.1.3 Feedback from stakeholders regarding definitions and scope

The project team distributed a questionnaire in October 2019. Stakeholders submitted their feedback on "Task 1: Scope" via this questionnaire.

**Existing definitions**

The stakeholders proposed a set of modifications to the existing definitions in order to clarify primary and secondary functions of the products, and also the different technologies.

In the case of ovens, stakeholders proposed to include secondary functions such as keeping the food warm. Proper definitions of the standardised cycle to be tested and of what an eco mode is were also requested.

Regarding hobs, some modifications were suggested to better reflect induction technology.

The definition of range hoods should be harmonised to take into account the filtration and recirculation of air, which are not properly covered by current definitions. The definitions should take into account the ones within EN 61591. Regarding functions, the main function is to remove airborne grease, odours, combustion products, fumes, smoke, heat, and steam from the air by evacuation of the air and/or filtration. However, recirculation would require the development of a test method that enables the rating of recirculation hoods. A secondary function mentioned by stakeholders is lighting, which should also be incorporated in the definitions.

**Commercial and professional products**

Some stakeholders proposed different options to define commercial and professional products and to make a clear distinction from domestic products. One suggestion was to include the different technologies that are common in the professional sector:

---

[2] Recirculating operation: The cooker hood removes impurities to filters and returns the air to the kitchen.

[3] Exhaust operation: The cooker hood guides the intake air to the outside via an exhaust system.

[4] The calculation is based on the air flow volume (free air delivery) determined in accordance with DIN EN 61591, as amended, at maximum rotational speed for normal use. If the hood offers a high-speed or intensive power mode this mode shall not be considered as a normal use mode.

*"Commercial ovens": static ovens, forced-conventional ovens, combi steamer ovens, deck oven (bakery ovens), rotatory rack ovens, in-store bakery convection ovens, impinge ovens, hot food holding cabinets, convection steamers and convection ovens.*

*"Commercial hobs": catering equipment manufacturers usually design series of modular elements with standard dimensions, so that appliances can be placed side by side to form a worktop or succession of pans. The main technologies are commercial gas open burners, gas solid tops, electric boiler tables, electric hobs, electric infrared hobs, electric induction hobs, griddles, tilt braising pans, pasta cookers, deep fryers, freestanding pressure cookers and Bain-Maries.*

Another proposal was based on the type of users and location where the appliance is to be used:

- Domestic. Appliances to be used in a household environment with an intended non-professional use.
- Commercial. Appliances to be used in an area accessible to the public (not a household) with an intended non-professional use.
- Professional. Appliances to be used in an area not accessible to the public with an intended professional use, with small-scale production.
- Industrial. Appliances to be used in an area not accessible to the public, with an intended professional use, for large-scale production.

Some stakeholders supported the development of Ecodesign/Energy Labelling measures of professional products based on their potential significant impact and their inclusion in Article 7 of the current Ecodesign Regulation. These stakeholders considered these measures an important driver of the sector towards more efficient products. On the other hand, other stakeholders had a completely different view and are against the development of Ecodesign/Energy Labelling measures. One of the main arguments for the exclusion is that professional appliances are completely different from household appliances:

- With regard to cooking behaviour, user needs and pattern of use.
- Cooking mode, in particular for ovens, is much more complex and with many cooking options.
- Professional and commercial cooking appliances are in many cases part of cooking system and not stand-alone-products.
- Household appliances have much less variability in models differentiation and they are produced in high quantities; commercial and professional cooking appliances have high variability in models' differentiation and they are produced in smaller quantities.

The Danish Technological Institute has tested a few professional appliances and the results support these arguments: usage and control options are very different from domestic appliances. Besides, it is easy to determine whether a product is a household appliance or a professional.

To the question of whether commercial and professional products should be separated from domestic, some stakeholders suggested that, since the function is the same, they should not be split up, which additionally would delay the development and adoption of measures. Other stakeholders pointed out the need for different standard tests to domestic ones and different requirements, since the professional use patterns diverge from domestic, and consequently the design of the product. In their opinion, professional cooking appliances cannot be covered under the same regulatory instrument as domestic ones. Professional cooking appliances cannot be analysed as a spin-off of the discussion on household cooking appliances; they must be studied separately under a specific research project.

This topic will be developed further in Sections 1.1.3 and 7.3.2.5.

**Exclusions of the current regulations**

Some stakeholders support appliances excluded from the current regulations being part of the review study, since their impact may be significant and they are similar appliances to the ones already within the scope. Other responses were more detailed and provided information about each particular product. These comments are summarised below:

- Products proposed to be excluded:
    - Steam ovens: Some stakeholders indicate that there is not enough data available to evaluate, and they are not market-relevant. Technical aspects of steam ovens will be covered in Section 4.1.2.6 and policy recommendations in Section 7.2.3.1.
    - Grills and grill ovens: Stakeholders indicate that they are not market-relevant and their use is limited. Moreover, there is no method to measure energy efficiency.
    - Only recirculation hood: it is a niche product with 1% of the market.
    - Hoods without an integrated fan for use with a central fan.
- Products proposed to be included or addressed more explicitly:
    - Combi-steam oven: they are market-relevant, though they are often only used in their conventional heating function. Technical aspects of combi steam ovens will be covered in Section 4.1.2.6 and policy recommendations in Section 7.2.6.6.
    - Gas cooking appliances designed for use only with Liquified Petroleum Gas (LPG). They are excluded from Regulation 66/2014 because at that time they were not covered by standard EN 15181, but this will change soon with an amendment.
    - Aspiration hob: it is a domestic hob (induction, radiant or gas) integrating a blower and grease filter to remove airborne grease, combustion products, fumes, smoke, heat and steam from the air by evacuation of the air and filtration. It is an all-in-one product merging the functionality of a cooktop and of a range hood. The product has to satisfy both the requirements for range hoods and for induction/radiant/gas cooktops. Products already in the market are sold with an energy label and product fiche for the range hood section and with product information for the domestic hob section according to Regulations 65/2014 and 66/2014.
    - Range hoods with mood lights.
- Products for which there is no clear agreement among stakeholders that expressed a view:
    - Table-top hobs or portable hobs.
    - Ovens with microwave function: some stakeholders argue that they should be excluded since their frequency of use is very low. Their classification (solo microwave oven, combi microwave ovens and microwave ovens with grill) may be very challenging, often designed in combination with other heating functions. A measurement method for the combi modes is not available. The greatest challenge is to measure the proportion of microwave power. On the other hand, other stakeholders argue that combined ovens including a microwave function should be covered by the Ecodesign and Energy Labelling Regulations for the conventional and/or fan-forced mode, in order to prevent loopholes. Technical aspects of ovens with MW-combi mode will be covered in Section 4.1.2.8 and policy recommendations in Sections 7.2.3.3 and 7.2.6.6.
    - Solo microwave ovens: according to results from the French monitoring campaign “Étude de mesure des consommations d’énergie pour l'usage cuisson domestique”-ADEME (2016), the electricity consumption of solo microwaves is larger than range hoods. However, manufacturers state that the improvement potential and the similar technology used do not seem to allow for Ecodesign or Energy Labelling measures. Technical aspects of solo MW ovens will be covered in Section 4.1.2.7 and policy recommendations in Section 7.2.3.2.

- Small and portable ovens. Some stakeholders argue that their overall energy consumption may not be negligible so their inclusion should be considered. Policy recommendations on small and portable ovens will be covered in Section 7.2.3.4.

- Level of inclusion in scope. Some of the products above, currently excluded from the Ecodesign and Energy Labelling Regulations, might be partially included in the next version of those Regulations. The level of inclusion of the appliances is also a matter to be considered.

For instance, some of the appliances mentioned above might be kept out of the scope of either the Ecodesign or Energy Label Regulation. Some others might be included in the scope of the Ecodesign Regulation, but just in terms of material efficiency aspects. Some others might be included in terms of material effiency and minimum energy performance requirements. Finally, some of the products mentioned above might be fully included in the scope of both Regulations. Policy options related to the scope will be discussed in more detail in Section 7.2.3 of this report.

## 1.2 Test standards

The following section aims to provide an overview regarding the most recent and relevant existing standards which are applicable to domestic and professional cooking appliances. This section has been completed with feedback from stakeholders.

Before going into the detail of each of the relevant standards, it is important to define aspects such as circumvention and jeopardy effects. In a report published in 2020 for the project named "Anti-Circumvention of Standards for better market Surveillance", also known as the ANTICSS project (Martin et al., 2020), the authors provide definitions for circumvention and jeopardy effects:

> *"Circumvention is the act of designing a product or prescribing test instructions, leading to an alteration of the behaviour or the properties of the product, specifically in the test situation, in order to reach more favourable results for any of the parameters specified in the relevant delegated or implemented act, or included in any of the documentations provided for the product. The act of circumvention is relevant only under test conditions and can be executed:*
>
> *a) by automatic detection of the test situation and alteration of the product performance*
>
> *b) by pre-set or manual alteration of the product affecting performance during test*
>
> *c) by pre-set alteration of the performance within a short period after putting the product into service*
>
> *Jeopardy effects encompass all aspects of products or test instructions, or interpretation of test results, which do not follow the goal of the EU ecodesign and/or energy labelling legislation of setting ecodesign requirements and providing reliable information about the resource consumption and/or performance of a product. These effects may not be classified as circumvention, but become possible due to loopholes or other weaknesses in standards or regulations."*

### 1.2.1 Standards applicable to domestic ovens

#### 1.2.1.1 EN 60350-1 Household electric cooking appliances – Part 1: Ranges, ovens, steam ovens and grills – Methods for measuring performance

This document consists of the text of IEC 60350-1:2011 and the corrigendum of February 2012 prepared by IEC/SC 59K "Ovens and microwave ovens, cooking ranges and similar appliances", of IEC/TC 59 "Performance of household and similar electrical appliances"

IEC 60350-1:2011 specifies methods for measuring the performance of electric cooking ranges, ovens, steam ovens and grills for household use. The ovens covered by this standard may be with or without a microwave function. Manufacturers should define the primary cooking function of the appliance – microwave function or thermal heat. The primary cooking function has to be matched with an existing method for measuring energy consumption. If the primary cooking function is declared as thermal heat, then IEC 60350-1 is applied for energy consumption measurement (if the primary cooking function is declared as a microwave function, then IEC 60705 applies for energy consumption measurement).

IEC-60350-1 defines the main performance characteristics of electric cooking ranges, ovens, steam ovens and grills, including energy consumption, heat distribution and ability to supply heat or ability to supply steam, and specifies methods for measuring these characteristics. It does not specify requirements for performance. In terms of energy consumption, the test consists of assessing the amount of energy required to heat a standard load (a water-saturated brick). This brick simulates both the thermal properties and the water content of food (Figure 4). This test method is commonly known within the industry as the Brickmethod 1.0 (BM1.0).

**Figure 4. Load used in EN 60350-1**

The brick is placed in the geometrical centre of the oven. The centre temperature of the brick is measured with a thermocouple.

The temperature of the oven settings is increased for three different levels and three different cooking modes: conventional, convection and hot steam (Figure 5).

| temperature rise | Heating functions | | |
|---|---|---|---|
| | Conventional ($ic$) | Forced air circulation ($if$) | Hot steam ($ih$) |
| $\Delta T_1^i$ | (140 ± 10) K | (135 ± 10) K | (135 ± 10) K |
| $\Delta T_2^i$ | (180 ± 10) K | (155 ± 10) K | (155 ± 10) K |
| $\Delta T_3^i$ | (220 ± 10) K[a] | (175 ± 10) K[a] | (175 ± 10) K[a] |
| [a] or the maximum temperature rise if this value cannot be reached. | | | |

**Figure 5. Heating functions and temperature rises in EN 60350-1**

For each of the temperature rises, the temperature of the brick is measured until it increases 55 K. The electricity consumption needed for that temperature increase in the brick is measured.

Then, the temperature of the oven needs to be checked (to ensure it corresponds with the temperature setting). To check that, the brick is removed from the oven and the oven is run for some extra time without changing the temperature setting or heating function (Figure 6). When steady state conditions are attained (five cycles of the thermostat or 1 hour, whichever is shorter) the temperature is measured. This is the end of the test.

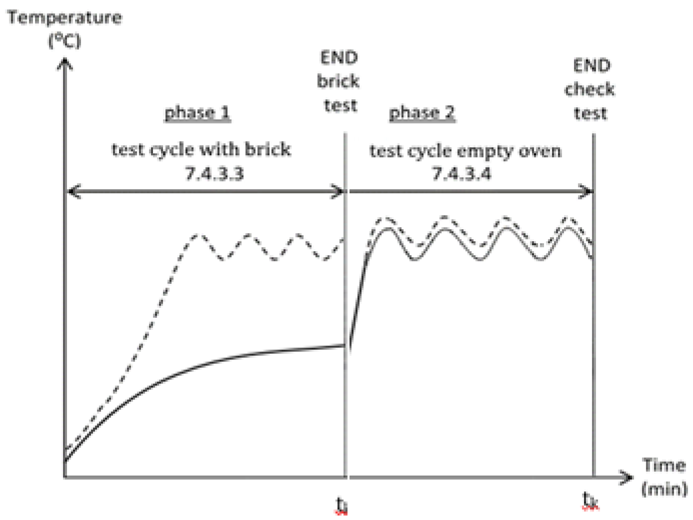
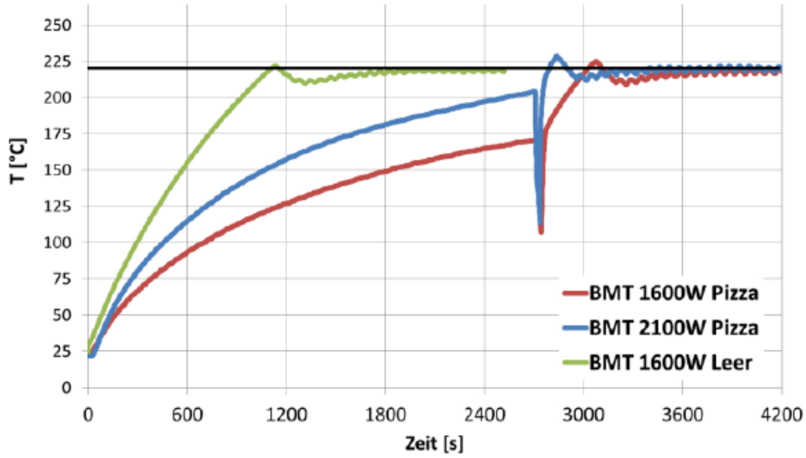



**Figure 6. Phases of energy consumption measurement in EN 60350-1**

As can be seen, the test consists of two phases. In phase 1, energy consumption is measured, with the brick inside the oven. In phase 2, temperature is measured with an empty cavity. The rationale for conducting the test in two separate phases is the following:

When the temperature setting is placed at 225 °C, it does not mean that the whole cavity will be at that specific temperature uniformly and under any conditions. It means that the oven cavity centre will be at that specific temperature, when the cavity is empty. In fact, the selected temperature and the actual oven temperature only match if the oven is empty.




Provided by APPLIA

**Figure 7. Oven temperature with empty cavity and with food**

In the example in Figure 7 it can be seen that only when the cavity is empty (green line) does the temperature of the oven actually match the temperature setting. When food is placed in the cavity, the temperature in the cabin is lower than the temperature setting.

As can be seen in Figure 8, there is a temperature gradient between the cavity centre and the cavity walls. The temperature gradient is very different depending on the presence or absence of a load in the cavity. The high temperature gradient caused by the load creates uncertainties in the measurement of temperatures in those conditions.

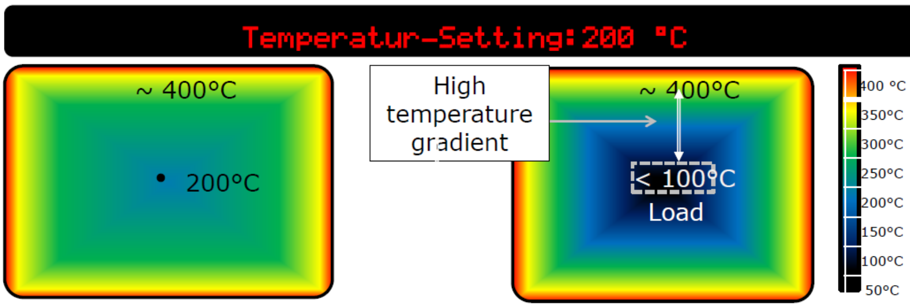



**Figure 8. Oven behaviour with and without load**

To avoid those measurement uncertainties, it was decided that, in phase 1 (with load) only the energy consumption is measured. In phase 2 (empty) the temperature is measured, to ensure that it matches the temperature setting.

Finally, the energy consumption used for ecodesign and energy label is calculated using a linear regression based on the temperature and the energy consumption for the three temperature rises.

#### 1.2.1.2 EN 15181 Measuring method of the energy consumption of gas fired ovens

Similary to EN 60350-1 described in Section 1.2.1.1 of this report, EN 15181 specifies the test method for determining the gas energy consumption in gas-fired domestic ovens. It applies to gas-fired domestic ovens which are capable of utilising gases from group H or group E, possibly after conversion according to instructions for use. It is applicable to gas-fired domestic ovens, whether they are separate appliances or component parts of domestic cooking appliances. It also applies to domestic appliances that can utilise gas and/or electrical energy to provide heat for cooking when the ovens are utilising gas energy to provide heat for cooking, but not when electric energy is used to provide any or all of the heat for cooking in the oven.

As in the test for electric ovens, the test for gas ovens consists of assessing the amount of energy required to heat a standard load, also a water-saturated brick. The brick is placed in the geometrical centre of the oven (Figure 4). The temperature of the oven settings is increased for three different levels and two different cooking modes (Table 5).

**Table 5. Heating functions and temperature rises in EN 15181**

| Oven temperature rise | Conventional | Forced air |
|---|---|---|
| ΔT1 | (140 -0/+10) K | (140 +/- 5) K |
| ΔT2 | (180 +/- 5) K | (165 +/- 5) K |
| ΔT3 | (220 +/- 5) K (1) | (180 +/- 5) K (1) |
| (1) or the maximum temperature rise if this value cannot be reached | | |

The temperature of the brick is measured until it increases 55 K, when the test finishes. The volume of gas required to reach this temperature increase is measured. The amount of energy contained in this volume of gas is calculated.

Then, the temperature of the oven needs to be checked (to ensure it corresponds with the temperature setting). To check that, the brick is removed from the oven and the oven is run for some extra time without changing the temperature setting or heating function (as done in EN 60350-1). When steady state conditions are attained the temperature is measured and the test ends.

#### 1.2.1.3 Jeopardy and circumvention issues associated with EN 60350-1

As explained above, the test cycle of EN 60350-1 consists of two phases: an energy consumption measurement with a wet brick (phase 1), followed by another cycle for temperature measurement with the oven empty (phase 2). Obviously, the oven needs to be opened between the two phases to remove the brick. This is an issue because the opening of the oven might allowing some oven manufacturers the option of circumvention.

The authors of ANTICSS pointed out that, in some ovens, the first opening of the oven was a control-relevant event and led to a changed regulatory behaviour: during phase 1 the temperature in the oven was considerably lower than the temperature setting. The opening and re-closing of the oven door caused a significant increase of the temperature in the interior of the oven and the set temperature was indeed reached.

An example of this behaviour can be seen in Figure 9. The length of phase 1 was 54 minutes. However, during that phase, the temperature set (190 °C) was only reached for a total of 20 minutes. It can also be seen that at a certain point in phase 1, the temperature decreases to around 90 °C. Then, the door is opened to remove the brick and start with phase 2. At this point, the temperature increases again until it reaches the temperature set (190 °C), which is maintained until the end.

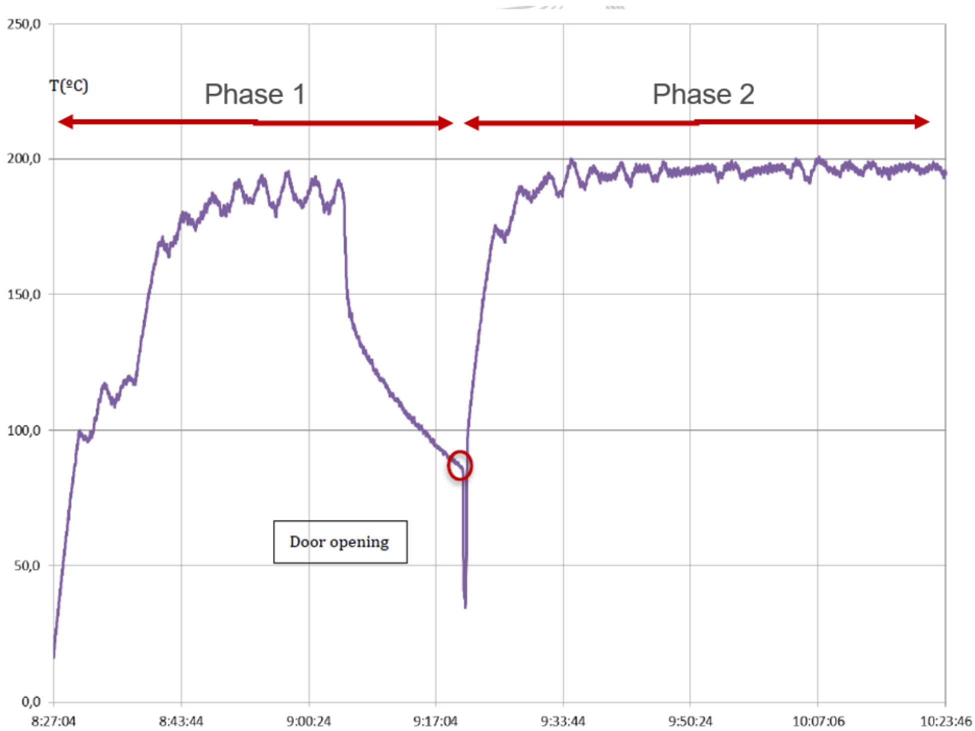



**Figure 9. Temperature of oven tested as part of the ANTICSS project**

In other words, some ovens may identify that they are under test conditions. In those cases, the ovens will decrease the temperature during certain periods of phase 1 to reduce energy consumption. Then, when phase 1 of the test finishes (door opening), they automatically increase their temperature, in order to fulfil the requirement of phase 2.

This issue was initially categorised in ANTICSS as a jeopardy effect, although different ovens tested showed slightly different behaviour. In some models, due to their irregular behaviour, they were considered borderline with regards to circumvention. This irregular behaviour was observed fundamentally in energy-saving modes, heating modes that make use of residual heat by lowering the temperature of the oven in some stages of the cycle (as seen in Figure 9). According to the authors of ANTICSS, one could theoretically think of the reduced temperature as an energy-saving function. However, an excessive use of this technique will not achieve the required baking performance. In their view, in some of the tested models, this energy-saving mode was only designed to achieve favourable results in the test situation and was only included in the appliance to be used during the test.

In order to address these circumvention issues, a new method to measure energy consumption has been under development by CENELEC WG17. A detailed description of this new method will be provided in the following section. Policy options will be presented as well in Section 7.2.6.2.

#### 1.2.1.4 A new method to measure the energy consumption of electric ovens

With the aim of addressing potential jeopardy and circumvention issues explained in the previous section, CENELEC WG 17 has been developing a new measurement method. This new method is commonly known within the industry as Brickmethod 2.0 (BM2.0). There are several differences between BM1.0 and BM2.0. This section aims to explain the main characteristics of BM2.0, the differences with the current method and its potential benefits.

**Unified temperature settings**

The temperature rises in BM2.0 are the same for every mode tested (Figure 10). This contrasts with BM1.0 (Figure 5), where each heating mode has a different temperature increase to achieve.

| Temperature rise | |
|---|---|
| $\Delta T_1$ | (135 ± 15) K |
| $\Delta T_2$ | (165 ± 15) K |
| $\Delta T_3$ | (195 ± 15) K[a] |
| [a] or the maximum temperature rise if this value cannot be reached. | |

**Figure 10. Temperature rises in EN 60350-1 (BM2.0)**

**New measurement procedure**

Circumvention issues have been detected in some ovens, related to the removal of the brick between phase 1 and phase 2. At that point, some appliances might be able to identify that they are under test conditions. To ensure that oven conditions in phase 1 (energy consumption measurement) and phase 2 (temperature measurement) are the same, a slightly different measurement procedure is defined in BM2.0 (Figure 11).

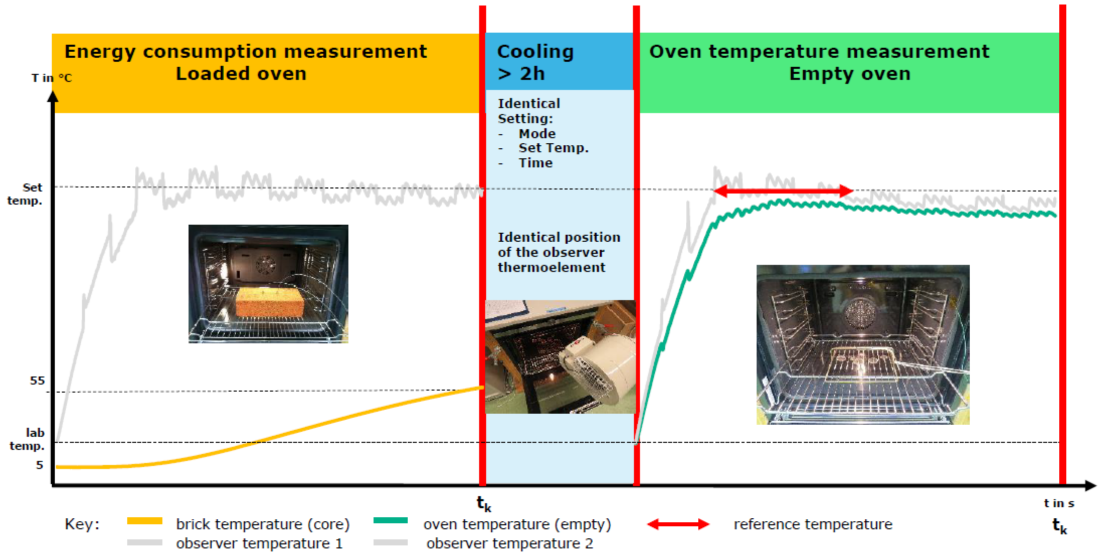



**Figure 11. Phases of energy consumption measurement in EN 60350-1 (BM2.0)**

Phase 1:

-Two thermocouples are placed in the cavity: one in the centre of the cavity attached to the grid ($T_c$) and another one next to the oven thermostat, defined as observer temperature ($T_o$).

-The brick is placed in the centre of the oven and its temperature is measured with another thermocouple ($T_{brick}$).

-Phase 1 starts at $t_0$. The temperature set ($T_k$) is risen according to the table shown in Figure 10.

-Phase 1 ends at $t_k$ (when $T_{brick}$ has risen 55 K).

-Energy consumption is measured between $t_0$ and $t_k$.

Cooling:

-Between phase 1 and phase 2, the oven needs to be switched off and cooled down. With this, the oven is unable to identify that it is under test conditions. Therefore, it cannot automatically readjust temperature in order to comply with the requirements of phase 2.

Phase 2:

-Except for the presence of the brick, an identical setting of the test must be followed in phase 2 (unchanged position of thermocouples, same temperature setting, same heating function).

-Phase 2 lasts for the same length of time as phase 1: $t_k$.

-The temperature in the cavity centre ($T_c$) and next to the thermostat ($T_0$) are measured.

## Definition of "heating function" and "eco function"

BM2.0 provides definitions for "heating function" and "eco function":

"Heating function" is heat transmission by natural air circulation and/or forced air circulation and/or radiation for baking and roasting (and some examples are provided).

"Eco function" is heat transmission by natural air circulation and/or forced air circulation and/or radiation for certain applications using efficient technical solutions, such as residual heat usage, low power heating or a combination.

**Determination of the reference temperature**

For a fair comparison of the energy efficiency of different ovens, the set temperature and the actual temperature in the oven cavity centre (the reference temperature) must be evaluated. As already mentioned above, the reference temperature is measured in phase 2 of the test (empty cavity). The reference temperature is calculated differently for heating functions and for eco functions.

-For heating functions (Figure 12), the reference temperature is calculated between $T_{ks-20}$ (temperature setting minus 20 degrees) and the end of phase 2 ($t_k$), using the observer thermocouple. The heating-up phase is therefore excluded. The duration of this measurement needs to be at least 60% of the phase (60% of $t_k$).

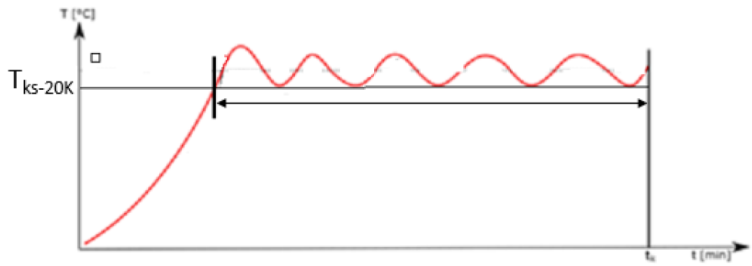



**Figure 12. Determination of the reference temperature in heating functions in EN 60350-1 (BM2.0)**

-For eco functions (Figure 13), the reference temperature is measured for 20 minutes (starting when the temperature setting is achieved in the observer thermocouple). This difference with heating functions is in order to allow the use of residual heat in eco functions.

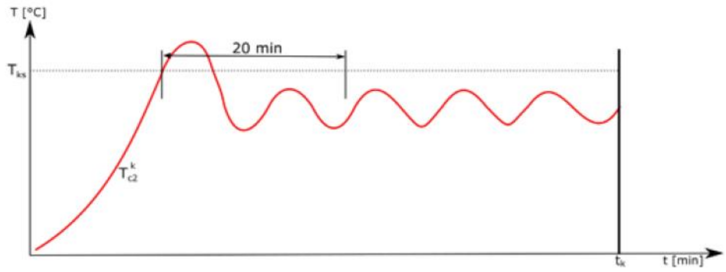



**Figure 13. Determination of the reference temperature in eco functions in EN 60350-1 (BM2.0)**

For the test to be valid, in both heating functions and eco functions:

-the average temperature rises must be within the temperature ranges defined in Figure 6;

-the difference between the average temperature rise and the temperature setting must be lower than 20 K.

**Quality criteria to verify thermal behaviour in phase 1 and phase 2**

As explained earlier, it is necessary to conduct the test in two phases: phase 1 to measure the energy consumption and phase 2 to measure the temperature in the oven. However, it needs to be ensured that the thermal behaviour of the two phases are the same (to prevent ovens decreasing the temperature in phase 1). This is achieved with the observer thermocouple, which was not included in BM1.0. The observer thermocouple is not placed in the cavity centre (where temperatures change with and without load), but next to the thermostat (where temperatures remain constant).

The observer thermocouple measures $T_o$ and verifies that the thermal behaviour in phase 1 and phase 2 are the same. For the comparison of the thermal behaviour of the two phases, two quality criteria are defined: the c-factor and the s-factor.

Applicable for heating functions and eco functions

$$\textit{c-factor} = \frac{T\ observer\ phase\ 1\ (whole\ cycle)}{T\ observer\ phase\ 2\ (whole\ cycle)}$$

The c-factor is measured for the whole cycle, for both heating functions and eco functions. It aims to ensure that the thermal behaviour of the oven in both phases is the same. For the test to be valid:

- in heating functions: c-factor ≥ 0.92;
- in eco functions: c-factor ≥ 0.82.

Applicable for heating functions only

$$\textit{s-factor} = \frac{T\ observer\ phase\ 1\ (last\ 20\min of\ cycle)}{T\ observer\ phase\ 2\ (last\ 20\min of\ cycle)}$$

The s-factor is only applicable for heating functions. The purpose of the s-factor is to ensure that no residual heat is used when a heating function is operated. This is the reason why it is only measured for the last 20 minutes of the cycle (when residual heat might be used). For the test to be valid:

- s-factor ≥ 0.92.

**Final electric energy consumption**

As in BM1.0, in BM2.0 the final energy consumption is calculated using a linear regression based on the temperature and the energy consumption for the three temperature rises.

**Potential benefits of BM2.0**

As a summary, the potential benefits of the adoption of BM2.0 are the following:

- The clear separation between phase 1 and phase 2 (with switching off and cooling down of the appliance) avoids circumvention issues related to the opening of the door in the test.
- Acceptance verification criteria on c-factor ensure that the thermal behaviour of the oven in phase 1 and phase 2 is sufficiently close, both for heating functions and eco functions.
- Acceptance verification criteria on s-factor ensure that no residual heat is used when a heating function is operated.

**Applicability of BM2.0 to gas ovens**

In its scope section, the last version available of BM2.0 indicates that "it specifies methods for measuring the performance of electric cooking ranges, ovens, steam ovens and grills for household use". It adds that "it is not applicable to microwave combination function, ovens with reciprocating trays or turntable, small cavity ovens, ovens without adjustable temperature control and appliances with only solo steam function".

Several stakeholders have requested clarification regarding the applicability of BM2.0 to gas ovens. On this matter, members from CENELEC WG17 have responded that the method used for gas ovens in today's regulation is described in EN 15181. In this method, the same load –a brick– is used for the measurement of energy consumption. However, the method is adapted to the functionality of gas ovens.

Members from WG17 add that complex temperature profiles in electric ovens need a sophisticated method to determine the reference temperature relevant for the energy consumption. However, in gas ovens, the temperature setting and control is generally less accurate. Moreover, eco functions are not relevant for gas ovens. The use of the observer thermocouple has not been used in gas ovens either, and it is deemed as challenging.

According to experts from WG17, a further development of the method in EN 15181 is currently not planned, and potentially not necessary. Gas ovens are generally very simple appliances. Depending on the set temperature, the flow of gas is controlled. In their view, the method to evaluate gas ovens is considered sufficient for determining the energy consumption of such appliances.

#### 1.2.1.5 Other issues related to EN 60350-1

In this section, other issues highlighted by stakeholders, related to EN 60350-1, are described.

**The removal of non-essential items during volume measurement**

In the harmonised standard (EN 60350-1), the paragraph relating to the measurement of the volume states the following: "*Removable items specified in the user instruction to be not essential for the operation of the appliance in the manner for which is intended shall be removed before measurement is carried out*". According to stakeholders, this sentence is ambiguous, as it is not clear whether oven elements (such as shelf guides, for instance) must be removed to measure the volume. This is relevant because higher volume implies a better Energy Efficiency Index. Various stakeholders highlight that this sentence should be revised as it may lead to higher declared volumes and thus a better EEI compared to the real-life usage of the ovens.

The authors of the ANTICSS report indicate that, in some ovens, in order to achieve better EEI results, the volume had been measured removing the shelf guides, because according to some recipes included in the user manual the cooking compartment must be empty. This issue was categorised as a jeopardy effect. The objective of the authors was to quantify if and how the difference in the measurement of the volume affects the EEI (and the corresponding energy class).

From the analysis of the tests conducted, the authors concluded that the use of an oven without the shelf guides seems to be an exceptional use and not the operation of the appliance in the manner for which it is usually intended. In their view, there is a loophole in the standard that should be solved. Their recommendation is that all relevant parameters should be measured in the same conditions. Therefore, if the shelf guides are needed for the measurement of the energy consumption, then the volume should be measured with the shelf guides.

On this topic, members of CENELEC Working Group 17 working on standard methods for ovens indicate that in the new version of the energy consumption test the rule will be to measure the cavity volume after removing the side racks. According to these members of WG17, conducting the energy consumption test with the side racks adds reproducibility issues, which could be eliminated by just conducting the test without them.

Policy recommendations on this topic will be made in Section 7.2.6.7 of this report.

**The maximum temperature of the oven during the energy consumption test**

In the current version of the standard, the energy consumption declaration is based on the energy consumption observed using different heating functions and temperature settings. However, if the highest of these temperatures cannot be reached by the oven, the standard requires the use of the maximum value achievable by the appliance. According to the authors of the ANTICSS project, this situation implies lower energy consumption results for those ovens that are not able to reach these temperatures – a situation of which manufacturers might take advantage. Allowing some ovens not to reach the highest temperature set in the standards might not be fair for those ovens that are capable of reaching it.

After conducting tests on ovens, the authors concluded that the initial jeopardy effect suspicion could not be confirmed. They explained that the energy consumption used for ecodesign and energy label is calculated using a linear regression based on the temperature and the energy consumption for the different temperature rises. This implies that there is a linear relation between the temperature rise and corresponding energy consumption, and that therefore the effect of a slightly lower temperature rise of the last of the three data points does not change the calculated energy consumption. The exception given for some ovens not to reach that maximum temperature has been allowed because it does not give any advantage to manufacturers.

**Heating mode used to declare energy consumption and to determine energy class of ovens**

A common topic mentioned by stakeholders for the revision of the current regulation is a clearer indication of which heating mode should be used to declare the energy consumption of ovens and to determine their energy class. An oven can provide different heating modes. In the current regulation on ecodesign, manufacturers can choose which mode shall be considered for energy labelling. REG 66/2014 states that "the energy consumption per cycle corresponding to the best performing mode shall be used for the calculations".

With current regulation, the best declared energy consumption is usually reached with energy-saving modes –also known as eco modes– that do not allow some dishes to be cooked and are not representative of a standard use. These modes use different strategies to reduce energy consumption (use of steam, oven totally airtight for a certain period of the cycle, lower the temperature within the oven for a certain part of the cycle, etc.) Different alternatives are suggested by stakeholders in terms of the heating mode used to declare energy consumption.

One option would be to test in one "standard" mode (compulsory) and in one "eco mode" (optional). These modes would need to be very precisely defined and differentiated. The test in standard usage conditions should be on a mode available on every oven and relevant to consumer practice. The test with the eco mode should be optional. The manufacturer could declare its consumption as a way of differentiating their product in terms of energy consumption. They should clearly indicate on the oven the cycle to be chosen in order to get the lowest energy consumption and the limit of this programme (regarding cooking performance). It could be seen as a bonus to stimulate innovation.

An alternative option would be to calculate the energy consumption of the oven as a weighted average of the consumption levels of different modes, including energy-saving modes. These modes provide energy savings for certain dishes and shall be taken into account for future regulation. These eco modes will be more challenged by the new Brickmethod 2.0 and consequently ensure a better performance than today. From their point of view, the new classification should be triggered by a mix of eco mode and hot air function.

Other stakeholders consider that energy-saving modes, should not be used for energy declaration. The mode used for energy declaration should be able to cook all relevant dishes. The energy consumption (or energy class) of the eco mode could instead be provided voluntarily and it should be stated that the mode is not suitable for all dishes.

The topic of energy-saving modes will be developed in more detail in Section 4.1.2.4 of this report. Policy recommendations regarding which heating mode to use for the energy declaration will be covered in Section 7.2.6.3.

**Cooking real food as a quality check for energy consumption measurements**

Another debate triggered by the use of "eco mode" is whether it is capable of reaching a sufficient cooking quality. Some stakeholders suggest that, on some occasions, eco modes lead to raw or burnt food, due to the way in which the oven delivers the heat to optimise the energy consumption. In this regard, CENELEC is working to develop a test for measuring the cooking quality (so-called Energy cake test). However, there are several issues to resolve to come up with a robust and reliable test, mainly related to the standardisation of ingredients and recipe and the reproducibility of the test. Policy recommendations on this topic will be presented in Section 7.2.6.5.

**The need for a different standard for steam ovens**

Regarding steam ovens, there is certain debate around the need for a different standard to test their energy consumption and efficiency. Currently, steam function is tested with the same standard as conventional and fan-forced convection.

On this issue, one stakeholder firstly indicates that pure steam ovens have less market relevance in Europe and should not be within the scope of the upcoming regulation. Combi steam ovens (ovens with conventional and/or forced circulation functions and a steam function) have a higher market share. Since these combi ovens are mainly used in their conventional and/or forced circulation function, these combi ovens should be covered only in these functions and not in their steam function. They also add that the energy measuring method for the hot steam function will be withdrawn from EN 60350-1. This measurement leads to an unfair comparison of different hot steam modes because the amount of steam is not measured.

A second stakeholder agrees with this reasoning: "taking into account that steam is not a primary function, both types of oven can have the same requirement".

A third stakeholder shows an intermediate position on the topic, indicating that it should be the same standard with slightly different boundary conditions, but mainly with the same equipment and strategy.

As indicated previously, technical aspects of steam ovens will be covered in Section 4.1.2.6 and policy recommendations on their heating functions in Section 7.2.6.6.

#### 1.2.1.6 EN 60705 Household microwave ovens – methods for measuring performance

This document consists of the text of IEC 60705 prepared by IEC/SC 59K "Ovens and microwave ovens, cooking ranges and similar appliances", of IEC/TC 59 "Performance of household and similar electrical appliances".

IEC 60705 defines methods for measuring the output power and efficiency of microwave ovens. The output power is measured with a water load in a glass container. The water is heated until it reaches the final temperature. The output power is calculated based on the temperature difference and the heating time. The efficiency is calculated as the ratio between the output energy (output power multiplied by time) and the input energy, including the energy consumed for heating up the magnetron filament.

The standard also includes tests to measure other performance parameters such as uniformity of heating, evenness of temperature when heating beverages, uniformity of heating using simulated food and cooking performance using foodstuff.

#### 1.2.1.7 EN 30-2-2:1999 Domestic cooking appliances burning gas – Part 2-2: Rational use of energy – Appliances having forced-convection ovens and/or grills

This European standard sets out the requirements and test method for the rational use of energy of gas cooking appliances having forced-convection ovens and/or grills using combustible gases. It covers type testing only, providing minimum requirements in terms of efficiencies of ovens, indicating the necessary formulas to calculate efficiency. It also provides guidance on how to conduct the test in terms of temperatures and environmental conditions.

This standard is equivalent to EN 30-2-1, in this case applicable to gas ovens with forced convection air. As in EN 30-2-1, maintenance consumption of the oven is the quantity of heat to be released per unit of time by the gas combustion to maintain the oven temperature constant. It shall not exceed the value obtained according to a formula dependent on useful oven volume. This energy consumption is calculated as follows: with the oven empty, the central burner device is adjusted so that under steady-state conditions the temperature at the geometrical centre of the oven is 155 K above ambient temperature. Maintenance consumption of the oven is measured in kW.

### 1.2.2 Standards applicable to domestic hobs

#### 1.2.2.1 EN 60350-2 Household electric cooking appliances – Part 2: Hobs – Methods for measuring performance

This document consists of the text of IEC 60350-2:2018, prepared by IEC/SC 59K "Ovens and microwave ovens, cooking ranges and similar appliances", of IEC/TC 59 "Performance of household and similar electrical appliances". EN60350-2:2018 is based on the IEC 60350-2:2017.

IEC 60350-2:2011 defines methods for measuring the performance of electric hobs for household use. This standard defines the main performance characteristics of these appliances which are of interest to the user and specifies methods for measuring these characteristics. This standard does not specify requirements for performance.

For energy consumption, the test consists of assessing the amount of energy required to heat a standard amount of water. Standardised, stainless-steel cookware with a lid is used. The hob undergoing testing is only preheated once after the appliance is installed in the lab. This is requested to ensure that there is no humidity in the system that could cause uncertainties. Before starting the energy consumption measurement the hob shall be at ambient temperature. The cookware is filled with water as specified in the standard at 15 °C. The energy consumption is measured, including the preheating phase starting from ambient temperature and water at 15 °C heating up to 90 °C plus 20 minutes simmering time. The power control is set to maximum power until water reaches 90 °C and simmering starts. The energy consumed after 20 minutes of simmering is measured. The amount of energy consumed is normalised per 1 000 grams of water.

The indicator used for standardisation is energy consumption, measured in Wh/kg water.

**Potential issues with water simmering test method**

A stakeholder highlights that the current method is difficult for unexperienced testers (market surveillance, external laboratories, etc.) to find the right setting (power) to get $T_{simmering}$. So it is proposed to give some indications in an informative annex.

Another stakeholder disagrees with the position above, indicating that for electric hobs the testing method is currently well applied. Different amounts and a selection of cookware sizes are already considered. Improvement potential so far is not known. Besides, there is an amendment in progress (CD status), which includes an informative annex describing in detail the pre-test to simplify the determination of the $T_{simmering}$ setting.

The same stakeholder adds that, regarding gas hobs, the test method for gas burners is given in EN 30-2-1. It is a robust method that has been used for a long time to measure the efficiency. It already considers different pot sizes and amounts of water depending on the power of the burner. The only concern they have is related to the lack of repeatability due to the new rounding to the first decimal place in EE *gas burner*, E *gas burner and E theoretic* included in the version of 2015, in line with Regulation 66/2014.

#### 1.2.2.2 EN 30-2-1 Domestic gas cooking appliances – Rational use of energy

This European standard sets out the requirements and the test method for the rational use of energy of gas-burning domestic cooking appliances. It covers type testing only, providing minimum requirements in terms of efficiencies of burners and ovens, indicating the necessary formulas to calculate efficiency in each case. It also provides guidance on how to conduct the test in terms of type of pans to be used, temperatures and environmental conditions.

For gas hobs, the test consists of assessing how efficient the hob is at heating a certain amount of water up to a specific temperature. For that, an aluminium test pan with a matte base, polished walls, no handles, with a lid, is used. Different amounts of water are used according to the range of power consumption of the burners. The burner is preheated for 10 minutes. Water is heated from 20 °C to 90 °C. The volume of gas required to achieve this temperature increase is measured. This amount of gas is compared to a theoretical amount of gas needed to bring about this temperature increase. The efficiency of the hob is calculated as the ratio between the theoretical amount of gas needed and the actual amount of gas consumed. The efficiency is measured in terms of percentage (%).

For gas ovens, the maintenance consumption of the oven is defined as the quantity of heat to be released per unit of time (power) by the gas combustion to maintain the oven temperature constant. The maintenance consumption of the oven is calculated as follows: with the oven empty, the central burner device is adjusted so that under steady-state conditions the temperature at the geometrical centre of the oven is 180 K above ambient temperature. The standard indicates that the maintenance combustion of the oven shall not exceed the value obtained according to a formula dependent on useful oven volume. The maintenance consumption of the oven is measured in kW.

### 1.2.3 Standards applicable to cooking fume extractors

#### 1.2.3.1 EN 61591 Cooking fume extractors – Methods for measuring performance

EN 61591:1997 is based on the text of IEC 61591:1997, prepared by IEC TC 59, Performance of household electrical appliances, without any modification.

IEC 61591:1997 applies to range hoods incorporating a fan for the recirculation or forced removal of air from above a hob situated in a household kitchen. This standard defines the main performance characteristics of range hoods and specifies methods for measuring these characteristics, for the information of users. This standard does not specify required values for performance characteristics.

Performance is measured in terms of input power, pressure, flow, grease absorption capacity, odour extraction capacity and effectiveness of hob light.

*New edition of the standard*

According to stakeholders, EN 61591 was updated in 2020 based on the already published IEC 615915:2019.

The main improvements of this new version are:

a) new subclause about instruments and measurements;

b) new procedure for measuring the fluid dynamic efficiency (FDE);

c) revised procedure for determining the odour reduction for cooking fume extractors in recirculation mode;

d) modification to the measurement of the effectiveness of the lighting system;

e) clearer procedure to measure the grease absorption.

**Grease absorption**

This test is used to measure the efficiency of the grease filter. The mass of the range hood is measured without a grease filter or odour extraction filter. A hob is placed 600 mm below the range hood, heating a pan of 200 mm at 250 °C. The range hood is operated at the highest setting control. Corn oil is dripped onto the heated pan at a constant rate together with water. The hob is working for 30 minutes and the range hood for an additional 10 minutes. The range hood is weighed again after removal of the grease filter. The mass of oil retained is determined adding the oil in the airways of the cooking fume extractor and in the ducting for connecting to the compensation chamber plus the oil that drips from the appliance after the measurement procedure plus the oil in the absolute and grease filters, after drying both, and the oil that drips from the filters during the drying process. The test is carried out twice. The absorption factor is calculated as the ratio between the mass of oil in the grease filter and the total mass of oil in the system. The grease absorption capacity is measured as a percentage (%).

Concerning the performance rating of range hoods (EN 61591:1997/A12:2015), a manufacturer has asked for clarification on how to measure the grease filtering efficiency for a range hood with a centrifugal filtering system. The applicable standard contains no defined method for this kind of product.

The formula used in the regulation implies that the mass of oil in the grease filter and all removable covers is compared to the total mass of oil in the range hood, the ducting and the absolute filter used during testing. A product that has no removable filter but uses a fixed part that is cleaned with a cloth to remove grease would be at a disadvantage in the rating even when the grease filtering works well.

According to NOVY, the test method is also at a disadvantage for hoods with 'hidden' grease filters, e.g. hoods with perimetral extraction. In such hoods the grease filters are behind the cover plate. In many cases, the cover plate is not removable. Moreover, a lot of grease deposits on the cover plate and parts of the hood upstream of the grease filters, which are easily accessible for cleaning. For hoods with perimetral extraction this means that the grease filter efficiency class may be F, even though downstream of the grease filters the oil concentration is less than 5% (and thus a class A is justifiable). One should take into account that the main goal of the grease filters is avoiding grease in fans and ducting. The grease filter efficiency would be better defined as all oil in the grease filters and on cleanable parts upstream of the grease filters divided by the total oil mass in the system.

**Odour reduction**

This test is used to assess the effectiveness of odour filters of recirculating-air range hoods and the capacity of air-extraction range hoods to remove odours. The test is carried out in a sealed room of 22 $m^3$. A range hood is installed along one of the longer walls of the room, centrally above a hob, 600 mm above it. A solution containing a certain mass of methyl-ethyl ketone (MEK) in distilled water is continually dripped onto the pan, and then evenly dispersed throughout the room by means of a fan. The concentration of MEK at that point will be C1. The room is then ventilated until the concentration is less than 1%. Then, the same amount of MEK and distilled water is dripped onto the pan, with the range hood in operation for 30 minutes. The air in the room is again evenly dispersed with a fan and the concentration C2 measured when the value has stabilised. The odour reduction factor is measured as the ratio between C1-C2 and C1. The odour reduction capacity is measured as a percentage (%).

An issue pointed out by stakeholders is that this test method was designed for activated carbon filters. Plasma filters can eliminate odours as well but not the test substance MEK. Therefore, the rating with MEK would create a technical barrier for plasma filters. However, plasma filters are not used in domestic appliances because they emit a high level of ozone.

BAM indicates that in general MEK is not a representative cooking smell. MEK is used as solvent and in cleaning agents, but is not a dominant smell while cooking. Typical smells while cooking include a fish smell (which is also experienced as very annoying). Fish smell (i.e. trimethylamine) would thus be a better substance for testing the odour reduction.

On the topic of range hoods, a stakeholder highlighted that a revised or new test for the evaluation of the capture efficiency of pollutants could improve the consumer relevance of the performance test. The same flow rates can lead to different capture rates depending on the shape of the airflow and where the range hood is positioned in relation to the hob. Therefore, the capture efficiency cannot be determined by the flow rate but requires a test method with a standardised kitchen and a source of pollution that is representative of cooking fumes. The test should determine the share of pollutants that was removed from the air. Such a test is similar to the odour reduction test in the standard EN 61591. However, the odour reduction test has a small standardised test room that is not representative of an average kitchen and uses the polluting substance MEK which is harmful to the test personnel and might not be representative enough of cooking fumes.

According to BAM Federal Institute for Materials Research and Testing, concerning the performance rating of range hoods (harmonised standard: EN 61591:1997/A12:2015):

- It uses the polluting substance MEK which might be harmful to the test personnel.
- The odour reduction test has a small standardised test room that is not representative of an average kitchen and helps air-extraction range hoods to remove MEK. Therefore, according to IEC 69159:2019, the test is only intended for recirculation range hoods.
- In recirculation mode, the reduction of MEK is not only dependent on the capturing ratio but also on the adsorption in the active charcoal filter or the decomposition in the plasma filter. Therefore,

it must be clarified if MEK is representative of the cooking emissions concerning its adsorption on an active charcoal filter and the decomposition in a plasma filter.

- The odour reduction test should not only represent the removal of odorous substances, but the removal of all small pollutants in general that are emitted during cooking processes. If a cooking fume extractor operates in extraction mode it should be acknowledged that the indoor air is replaced by outdoor air, which is polluted to some degree too. Thus, in reality the operation in extraction mode does not purify the air as well as it seems in the test with MEK where the replaced air contains none of the examined pollutant.

Other views suggest that a test on the recirculation filter itself may be more representative (and also easier/cheaper to perform) than a test on the whole hood system in recirculation mode. Such tests on filters are only, for example, breakthrough tests which are frequently used in the automotive industry. However, other views indicate that the performance of the odour filters is dependent on the air flow and on the tightness of the case from the range hood, so the filter and cooking fume extractor should be measured as a unit.

**Effectiveness of the lighting system**

The range hood is positioned 600 mm above a hob. Adjacent worktops are covered with a sheet of matteblack plywood or similar. The CFE light is switched on and a lux meter used to measure the luminance at four predetermined points (specied in the standards) on the board. The average lux values are measured. The effectiveness of the lighting system is measured in lux.

#### 1.2.3.2 EN 50564 Electrical and electronic household and office equipment - Measurement of low power consumption

The standby consumption of household electrical appliances is measured according to the European standard EN 50564:2011 including the common modification agreed at European level to the international standard IEC 62301:2011, prepared by CENELEC TC59X.

EN 50564 is intended to define requirements for the measurement of low power and:

- addresses issues associated with measuring electrical power, in particular low power (in the order of a few watts or less), consumed by mains-powered products;
- describes in detail the requirements for testing single-phase products with a rated input voltage in the range of 100 V a.c. to 250 V a.c. but it may, with some adaptations, also be used with three-phase products (relevant for professional appliances);
- may also be of assistance in determining the energy efficiency of products in conjunction with other, more specific, product standards.

The value of energy consumed depends on the operating mode of the product being tested, for instance whether the equipment is in an off mode, in a standby mode or in an active mode. This standard does not specify these modes; instead, it provides a method of measurement with a variety of modes which are defined elsewhere. The test method is applicable to other low power modes where the mode is steady state or providing a background or secondary function (e.g. monitoring or display).

Electric ovens and electric heat plates (electric hobs) are already covered by the standby and off mode electric power consumption by Commission Regulation (EC) No 1275/2008[5] amended by Commission Regulation (EU) No 801/2013[6]. This last Regulation Cooking fume extractors since they are electrical and electronic household equipment placed on the market. It is required to switch into a low power mode (such as standby) after a reasonable amount of time and they must not consume more than 0.5 watts in standby or in off mode. The power consumption in any condition providing only information or status

[5] Available at : https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32008R1275

[6] Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32013R0801

display, or providing only a combination of the reactivation function and information or status display shall not exceed 1.00 W.

#### 1.2.3.3 <u>EN 50643</u> Electrical and electronic household and office equipment - Measurement of networked standby power consumption of edge equipment

This European standard specifies methods of measurement of electrical power consumption in networked standby and the reporting of the results for edge equipment. Power consumption in standby (other than networked standby) is covered by EN 50564, including the input voltage range. This standard also provides a method to test power management and whether it is possible to deactivate wireless network connection(s).

### 1.2.4 Standards applicable to professional cooking appliances

In terms of functional performance standards applicable to professional cooking appliances, according to a relevant stakeholder, CENELECT TC59X WG18 is currently developing a standard on professional ovens. Three cooking modes are under evaluation: convection, steam and combi. Currently, no standards are available for professional gas hobs, gas ovens, electric hobs or range hoods.

Although currently there are no European harmonised standards on commercial cooking appliances, at a national level DIN 18873 standards do cover most of the equipment available in the market:

- **<u>DIN 18873</u>** Methods for measuring of the energy use from equipment for commercial kitchens

  - Part 1: Convection steamers
  - Part 2: Commercial coffee machines
  - Part 3: Deep fat fryers
  - Part 4: Convection ovens
  - Part 5: Tilting frying pans and stationary frying pans
  - Part 6: Tilting pressure braising pans and stationary pressure braising pans
  - Part 7: Multiple deck ovens
  - Part 8: Regenerating systems
  - Part 9: Cooking zones
  - Part 10: Ice machines
  - Part 11: Beverage cooler
  - Part 12: Ovens
  - Part 13: Microwave combination oven
  - Part 14: Point of use water dispenser for cooling and carbon dioxide enrichment
  - Part 15: Double jacketed boiling and quick boiling pans
  - Part 16: Kitchen machinery
  - Part 17: Noodle cookers
  - Part 18: Wafflebaker
  - Part 19: Frying and grilling appliances
  - Part 20: Crepe and Poffertjes-Bakers

However, DIN Standards series 18873 deal mainly with energy consumption and their content is not suitable to be used for the objective analysis and testing of cooking performance and energy efficiency parameters.

### 1.2.5 Product safety standards indirectly addressing durability

There are some standards which are related to the safety of products and components and seem to address the quality and/or durability of those components at least indirectly (**Table 6**). For example, EN 60335 addresses product safety as commented on in the previous section, whereas Part 2 of the standard is divided into specific subsections each containing appropriate appliance-specific safety requirements.

**Table 6. Safety standards and indirect requirements for quality and durability of components**

| Standard | Component | Requirement |
|---|---|---|
| Household and similar electrical appliances - Safety - Part 1: General requirements; EN 60335-1:2012/FprAD:2014, Annex C | Motors | Ageing-check for motors (in device-specific parts modifications are possible) |
| Household and similar electrical appliances - Safety - Part 1: General requirements; EN 60335-1:2012/FprAD:2014, Section 25 | Power supply and external cables | (In device-specific parts modifications are possible regarding the number of operating cycles) |
| Household and similar electrical appliances - Safety - Part 1: General requirements; EN 60335-1:2012/FprAD:2014; Section 23 | Inner cables | The flexible part is moved with 30 bends per minute backwards and forwards, so that the conductor is bent by the feasibly biggest angle, enabled with this construction. The number of bends are:<br>10 000 for conductors, which are bent during proper use<br>100 for conductors, which are bent during users-maintenance<br>(In device-specific parts modifications are possible, concerning the number of bends) |
| Household and similar electrical appliances - Safety - Part 1: General requirements; EN 60335-1:2012/FprAD:2014, section 24; standard for switches: IEC 61058-1 | Components: Switches | Number of operating cycles have to add up to at least 10 000 |
| Household and similar electrical appliances - Safety - Part 1: General requirements; EN 60335-1:2012/FprAD:2014, section 24; standard for Regulation- and control systems is IEC 60730-1 | Components: Regulation and control systems | Minimum number of required operating cycles for example:<br>for temperature controllers: 10 000;<br>for operating temperature limiter – 1 000<br>(In device-specific parts modifications are possible regarding the number of operating cycles) |
| Domestic cooking appliances burning gas fuel - Part 1-1: Safety – General, EN 30-1-1 | Gas taps, glass, etc. | Minimum number of operations requested to gas taps, requirements for glass, etc.) |

### 1.2.6 Horizontal durability, reparability and recyclability standards

**Mandate M/543**

On a horizontal level, Mandate M/543 (European Commission 2015a) had the objective to develop generic standards, for any product group covered by Ecodesign, in support of Ecodesign requirements related to material efficiency aspects.

Standardisation bodies CEN and CENELEC developed generic methodologies and terminology related to material efficiency, such as durability, reusability, recyclability and recoverability. Related aspects, such as upgradeability, reversible disassembly time, end of life dismantling time, part mass or value, calculation of recycled and reused content in products, or other relevant characteristics relevant for the product groups under consideration, were also investigated and included if appropriate. As a result of this work, the following standards have been published.

**EN 45552 General method for the assessment of the durability of energy-related products**

As energy-related products (ErPs) can often not be completely recycled, and the benefits associated with material recovery cannot fully compensate the energy (and material) demand of the whole production chain, each disposed ErP also means losses in energy and materials. Therefore, increasing the durability of ErPs can contribute to a reduction in the quantity of raw materials used and energy required for the production/disposal of ErPs and consequently reduces adverse environmental impacts.

When considering durability, the trade-off between longer lifetime (reducing impacts related to the manufacturing and disposal of the product) and reduced environmental impacts of new products (compared to worse/decreasing energy efficiency of older products) needs to be considered. In addition, consumer behaviour and advances in technology have to be taken into account.

This document covers a general method for the assessment of the reliability and the durability of ErPs. Reliability represents the assessment of a probability of duration from first use to first failure or in-between failures. Durability is the whole expected time for this same period and not a probability.

Durability can be expressed in units like calendar time, the number of operating cycles, distance, etc. Reliability can be expressed as a unit combined with a probability. An example is given in EN 45552 using a car for illustrative purposes:

> *"Durability could be 7 years for which a car is able to operate udner defined environmental conditions and operating conditions (20000 km/year). If the car is used under different operating conditions (28000 km/year), the expected durability could be 5 years. This assumes that all parts are able to withstand the defined conditions. A car operates with a a reliability R (t1, t2) > 0.9 (90%), where t1 and t2 could be respectively 0 km and 100000 km, under defined environmental and operating conditions."*

This document describes a general assessment method that is intended to be adapted for application at a product or product-group level, in order to assess the reliability/the durability of ErPs.

**EN 45553 General method for the assessment of the ability to remanufacture energy-related products**

This document provides a general method for assessing the ability of an energy-related product to be remanufactured. In this document, remanufacturing is identified as an industrial process where at least one change, which influences the safety, original performance, purpose or type of the product, is applied to the energy-related product. This document is intended to be used by technical committees when producing horizontal, generic, and product-specific, or product-group, publications.

**EN 45554 General methods for the assessment of the ability to repair, reuse and upgrade energy-related products**

In this document, common elements allowing an ErP to be repaired, reused or upgraded are addressed at component and product level. For instance, it includes an evaluation of the ability of certain parts to be disassembled.

**EN 45555 General methods for assessing the recyclability and recoverability of energy-related products**

To close the loop in a circular economy, the efficient handling of waste is paramount. Recovering materials and energy can reduce environmental impacts over the product life cycle, including reduced extraction of natural resources and associated emissions of primary material production.

While recycling of ErPs aims at closing the circular economy loop, trade-offs might arise between different material-efficiency-related topics. For instance, mass of an ErP, durability, reparability, reusability and energy efficiency need to be balanced in order to improve the environmental benefit.

Once an ErP has reached its end of life (EoL) and has become waste, the ErP can either be prepared for reuse or recycled/recovered. This document elaborates on the product characteristics which are relevant for recyclability and recoverability of an entire ErP. The focus is therefore on the recyclability/recoverability of the product itself rather than the recycling or recovery processes. The general method presented in this document takes into account the availability and efficiency of state-of-the-art recycling and recovery processes to determine the recyclability/recoverability rate of an ErP.

**EN 45556 General method for assessing the proportion of reused components in energy-related products**

This document provides general methods for assessing the proportion of reused components in an energy-related product. Four calculation methods based on mass of reused components and on the amount of reused components are presented.

**EN 45557 General method for assessing the proportion of recycled material in energy-related products**

This document facilitates the provision of substantiated claims of the recycled materials content of energy-related products (ErPs). Key for substantiated claims for new products is the recognition of the chain of custody (CoC), which allows the tracing of recycled materials from different sources. The recycled material content of a new product is a characteristic of the product and its parts, which contributes to material efficiency, in addition to the potential for reusability, recyclability and recoverability. With a focus on the efficient and effective use of natural resources, primary materials are often able to be substituted by recycled materials, reducing the demand for primary materials, with related potential environmental, social and economic implications. These could include reduced mining and consumption of natural resources, reduced landfill, reduced emissions and energy savings. The overall environmental impact will depend on the difference in the impacts of making materials from primary sources (oil, ore, etc.) vs. reprocessing waste into secondary materials which would directly substitute primary materials. The benefit of increasing recycled materials content in products is, in many cases, the incentivisation of recycling of end-of-life (EoL) waste material through the stimulation of demand for recycled materials. In other cases, where there is already high demand for recycled materials compared to the available supply, the link between specification of higher recycled materials content and the incentivisation of recycling is weaker. In that case, specification of recycled materials content may not be relevant to ecodesign. The rationale for specifying recycled materials content therefore needs to be considered for each material individually depending on the specific supply/demand situation.

**EN 45558 General method to declare the use of critical raw materials in energy-related products**

The European Commission has created a list of critical raw materials (CRMs). CRMs combine a high economic importance to the EU with a high risk associated with their supply, both of which are determined according to an objective methodology. The list of CRMs is regularly updated. The availability of information on the use of CRMs in energy-related products is intended to improve the exchange of information. CRMs are identified as a priority area of the European Commission's Circular Economy Action Plan.

As information on the use of CRMs in energy-related products by Member States and industry is still very scarce, efforts need to be made to acquire such knowledge. The objective of this document is to provide a general methodology for declaration of the use of CRMs in energy-related products in support of the implementation of the Ecodesign Directive (European Commission, 2009) in product-specific measures. Additionally, this document supports the implementation of the Raw Materials Initiative by the EU.

This document specifies a method for the declaration of CRMs, based on EN IEC 62474. Therefore, this document will be essential in supporting manufacturers of energy-related products to obtain information and report on the use of certain CRMs needed to comply with specific requirements in product-specific legislation in the future.

**EN 45559 Methods for providing information relating to material efficiency aspects of energy-related products**

This document describes a general method for the communication of material efficiency (ME) aspects of energy-related products (ErPs). It is intended to be used when developing a communication strategy in horizontal, generic, and product-specific, or product-group, publications. This document relates to the standards in the numerical range of EN 45552 – 45558.

**Mandate M/518 for standardisation in the field of Waste Electrical and Electronic Equipment (WEEE)**

In January 2013, the European Commission sent Mandate M/518 to the European standardisation organisations with the purpose of developing one or more European standard(s) for the treatment (including recovery, recycling and preparing for reuse) of waste electrical and electronic equipment, reflecting the state of the art. The European standard(s) requested by this mandate shall assist relevant treatment operators in fulfilling the requirements of the WEEE Directive (European Commission, 2012).

**EN 50625 standard series: Collection, logistics & treatment requirements for WEEE**

CENELEC, through its Technical Committee 'Environment' (CLC/TC 111X), is leading the development of standards (and other deliverables) that will support the implementation of the EU Directive on Waste Electrical and Electronic Equipment (European Commission, 2012). These standards cover various aspects of the treatment of electronic waste (including collection, treatment requirements, de-pollution and preparing for reuse). TC111X works on standards related to the environment and set up Working Group 6 for the EN 50625 series.

The standard on general treatment requirements includes on the one hand administrative and organisational requirements for the treatment operator and the treatment facility such as management, infrastructural pre-conditions, training and monitoring. On the other hand, technical requirements regarding the handling of WEEE, the storage of WEEE prior to treatment, the de-pollution process, the determination of recycling and recovery targets and documentation requirements. The technical specification further details different methodologies for monitoring of de-pollution.

If appliances are equipped with electronic displays greater than 100 $cm^2$, EN 50625-2-2 and TS 50625-3-3 would also apply. Precious metals, for which the technical specification TS 50625-5 is planned, can be found for example in PWBs, containing palladium, silver and gold.

While the standards and according technical specifications define requirements regarding the removal and further treatment of certain substances, mixtures and components such that they are contained as an identifiable stream or part of a stream by the end of the treatment process, they do not specify requirements for better identification or ease of dismantling of those components to facilitate the end-of-life treatment process itself.

**IEC/TR 62635 Guidelines for end-of-life information provided by manufacturers and recyclers and for recyclability rate calculation of electrical and electronic equipment**

The technical report IEC/TR 62635:2012 ed1.0 provides a methodology for information exchange involving EEE manufacturers and recyclers, and for calculating the recyclability and recoverability rates to:

- provide information to recyclers to enable appropriate and optimised end-of-life treatment operations;
- provide sufficient information to characterise activities at end-of-life treatment facilities in order to enable manufacturers to implement effective environmentally conscious design (ECD);

– evaluate the recyclability and recoverability rates based on product attributes and reflecting real end-of-life practices.

Furthermore, this technical report includes the following:

– Criteria to describe EoL treatment scenarios.
– Criteria to determine product parts that might require removal before material separation and related information to be provided by manufacturers (location and material composition).
– A format for information describing EoL scenarios and the results of EoL treatment activities.
– A method for calculating the recyclability and recoverability rate of EEE. The calculation is limited to EoL treatment and does not cover collection. The recyclability rate is expressed as a percentage of the mass of the product that can be recycled or reused, whereas the recoverability rate in addition includes a portion derived from energy recovery. This technical report can be applied to all electrical and electronic equipment.
– Some example data corresponding to identified scenarios.

**IEC/TC 111 PT 62824 Guidance on consideration and evaluation on material efficiency of electrical and electronic products in environmentally conscious design**

Furthermore, under the IEC Technical Committee 111, Project Team 62824 has been established to provide guidance on consideration and evaluation on material efficiency of electrical and electronic products in environmentally conscious design.

**ISO 11469 Plastics - Generic identification and marking of plastics products**

This International Standard, published in 2000, specifies a system of uniform marking of products that have been fabricated from plastics materials. The marking system is intended to help identify plastics products for subsequent decisions concerning handling, waste recovery or disposal. Generic identification of the plastics is provided by the symbols and abbreviated terms given in ISO 1043, Parts 1 to 4.

The standard includes requirements on the marking system and the method of marking. The marking system is subdivided into marking of products, of single-constituent products, of polymer blends or alloys, and of compositions with special additives (fillers or reinforcing agents, plasticisers, flame retardants and products with two or more components that are difficult to separate).

The standard is often referred to in ecolabels containing requirements on resource efficiency and end-of-life treatment of appliances.

**British standard BS 8887 Design for Manufacture, assembly, disassembly and end-of-life processing ("MADE")**

The British Standards Institution first developed a design for manufacture standards series BS 8887 (Design for Manufacture, Assembly, Disassembly and End-of-life processing (MADE)) in 2006. The series contains the following substandards:

– BS 8887-1: Design for manufacture, assembly, disassembly and end-of-life processing (MADE) – Part 1: General concepts, process and requirements (1 February 2012, superseding BS 8887-1:2006).
– BS 8887-2: Design for manufacture, assembly, disassembly and end-of-life processing (MADE) – Part 2: Terms and definitions (1 July 2014).
– BS 8887-220: Design for manufacture, assembly, disassembly and end-of-life processing (MADE) – Part 220: The process of remanufacture – specification. It outlines the steps required to change a used product into an 'as-new' product, with at least equivalent performance and warranty of a comparable new replacement product (BSI Group [n.d.]).
– BS 8887-240: Design for manufacture, assembly, disassembly and end-of-life processing (MADE) – Part 240: Reconditioning (March 2011).

According to BSI Group [n.d.], in 2012, BS 8887-1 was put forward to the ISO and it has been accepted onto the work programme of the ISO committee responsible for technical product documentation. A new working group is being set up, which will be led by the UK, and will work to convert BS 8887-1 into an international standard.

The international standard BS ISO 8887-1 Design for manufacture, assembly, disassembly and end-of-life processing (MADE) Part 1: General concepts, process and requirements is currently under development by the BSI committee TDW/4 'Technical Product Realization'.

**Austrian standard ONR 192102:2014 on durable, repair-friendly designed electrical and electronic appliances**

This standard describes a label for repair-friendly designed appliances. Manufacturers of electrical and electronic equipment who intend to label their products have to test their products according to the requirements of ONR 192102 verifying compliance with a test report. According to Ricardo-AEA (2015), this standard suggests a labelling system with three levels of achievement (good, very good, excellent) based mostly upon reparability criteria. The standard includes around 40 criteria for white goods (such as hobs or ovens), and 53 criteria for small electronics (brown goods). The aim is to consider reparability to ensure products are not discarded sooner than is necessary as the result of a fault or inability to repair a fault.

The 40 criteria for white goods are split into mandatory criteria and other criteria for which a certain score can be achieved. To comply, products have to fulfil all mandatory requirements and achieve a minimum score for common criteria and for service documentation.

The types of requirements include criteria such as accessibility of components, ease of disassembly, use of standard components, achievable service life (at least 10 years for white goods), availability of spare parts (at least 10 years after the last production batch), facilitation of regular maintenance, and further service information (*inter alia* free access for all repair facilities (not only authorised repairers) to repair-specific information). Each requirement is underpinned with some examples of realisation; however, no specific testing procedures and techniques are detailed.

**British PAS 141 re-use standard**

The PAS 141 specification has been developed by British Standards Institution (BSI) to increase the reuse of electrical and electronic equipment and to ensure that they are tested and repaired to a minimum level. The British non-for-profit company WRAP has developed a set of protocols based on industry experience highlighting tests and procedures to be carried out. The product protocols form a baseline for electrical product assessment and repair for reuse and can be used as a guideline for product assessment and testing.

### 1.2.7 Emissions Standards

- **EN 62233** Measurement methods for electromagnetic fields of household appliances and similar apparatus with regard to human exposure
- **EN 62311** Assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields (0 Hz - 300 GHz)

### 1.2.8 Safety standards

**Household cooking appliances**

- **EN 60335-1** Household and similar electrical appliances - Safety - Part 1: General requirements

- **EN 60335-2-6** Household and similar electrical appliances - Safety - Part 2-6: Particular requirements for stationary cooking ranges, hobs, ovens and similar appliances (IEC 60335-2-6:2014, modified)

- **EN 60335-2-9** Household and similar electrical appliances - Safety - Part 2-9: Particular requirements for grills, toasters and similar portable cooking appliances

- **EN 60335-2-13** Household and similar electrical appliances - Safety - Part 2-13: Particular requirements for deep fat fryers, frying pans and similar appliances

- **EN 60335-2-25** Household and similar electrical appliances - Safety - Part 2-25: Particular requirements for microwave ovens, including combination microwave ovens

- **EN 60335-2-31** Household and similar electrical appliances - Safety - Part 2-31: Particular requirements for range hoods and other cooking fume extractors

- **EN 60335-2-102** Household and similar electrical appliances - Safety - Part 2-102: Particular requirements for gas, oil and solid-fuel burning appliances having electrical connections

- **EN 30-1-1** Domestic cooking appliances burning gas - Part 1-1: Safety – General

- **EN 30-1-2** Domestic cooking appliances burning gas - Safety - Part 1-2: Appliances having forced-convection ovens and/or grills

- **EN 30-1-3** Domestic cooking appliances burning gas - Part 1-3: Safety - Appliances having a glass ceramic hotplate

- **EN 30-1-4** Domestic cooking appliances burning gas - Safety - Part 1-4: Appliances having one or more burners with an automatic burner control system

**Professional cooking appliances**

In terms of safety standards applicable to professional cooking appliances, a relevant stakeholder indicated that safety of gas and electric products is fully covered by the following standards, which are endorsed by the Machinery Directive and Gas Appliances Regulation:

- **Machinery Directive**
- **EN 60335-1** Safety of household and similar electrical appliances - Part 1: General requirements
- **EN 60335-2-36** Particular requirements for commercial electric cooking ranges, ovens, hobs and hob elements
- **EN 60335-2-42** Particular requirements for commercial electric forced convection ovens, steam cookers and steam-convection ovens
- **EN 60335 -2-90** Household and similar electrical appliances - Safety - Part 2-90: Particular requirements for commercial microwave ovens
- **EN 60335-2-99** Particular requirements for commercial electric hoods
- **EN 60335-2-102** Household and similar electrical appliances - Safety Part 2: Particular requirements for gas, oil and solid-fuel burning appliances having electrical connections

**Gas Appliances Regulation**

- **EN 203-1** Gas heated catering equipment - Part 1: General safety rules
- **EN 203-2-1** Gas heated catering equipment - Part 2-1: Open burners and wok burners

- **EN 203-2-2** Gas heated catering equipment - Part 2-2: Ovens

### 1.2.9 Noise and vibrations standards

- **EN 60704-2-13** Household and similar electrical appliances – Test code for the determination of airborne acoustical noise – Part 2-13: Particular requirements for range hoods and other cooking fume extractors
- **EN 60704-2-10** Household and similar electrical appliances – Test code for the determination of airborne acoustical noise – Part 2-10: Particular requirements for electric cooking ranges, ovens, grills, microwave ovens and any combination of these

### 1.2.10 Other applicable standards

- **EN 50581** Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances
- **EN 55011** Industrial, scientific and medical equipment - Radio-frequency disturbance characteristics - Limits and methods of measurement
- **EN 55014-1** Electromagnetic compatibility - Requirements for household appliances, electric tools and similar apparatus - Part 1: Emission
- **EN 55014-2** Electromagnetic compatibility - Requirements for household appliances, electric tools and similar apparatus - Part 2: Immunity
- **EN 55015** Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment
- **EN 61000-3-2** Electromagnetic compatibility (EMC) - Part 3-2: Limits - Limits for harmonic current emissions (equipment input current <= 16 A per phase)
- **EN 61000-3-3** Electromagnetic compatibility (EMC) - Part 3-3: Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current <= 16 A per phase and not subject to conditional connection
- **EN 61000-3-11** Electromagnetic compatibility (EMC) - Part 3-11: Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems - Equipment with rated current <= 75 A and subject to conditional connection
- **EN 61000-3-12** Electromagnetic compatibility (EMC) - Part 3-12: Limits - Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current > 16 A and <= 75 A per phase
- **EN 301 489-1** ElectroMagnetic Compatibility (EMC) standard for radio equipment and services - Part 1: Common technical requirements
- **EN 301 489-17** ElectroMagnetic Compatibility (EMC) standard for radio equipment and services - Part 17: Specific conditions for Broadband Data Transmission Systems
- **EN 50614** Requirements for the preparing for re-use of waste electrical and electronic equipment

### 1.2.11 Third-country test standards

#### 1.2.11.1 USA

**Household appliances**

The standard for conventional cooking products establishes provisions for determining estimated annual operating costs, cooking efficiency (defined as the ratio of cooking energy output to cooking energy input), and the energy factor (EF) (defined as the ratio of annual useful cooking energy output to total annual energy input)[7]. Its scope covers cooking tops both electrical and gas, and microwave ovens.

The standards were amended to include the standby and off modes, according the consideration of IEC 62301 and IEC 62087. The DOE additionally introduced a methodology to measure certain active modes such as fan-only mode for conventional household cooking products. The inclusion of methods to measure these additional modes allows for the calculation of integrated annual energy consumption.

In 2013, the DOE published an amendment proposing the measurement for testing the active mode energy consumption of induction cooking products. The DOE proposed to incorporate induction cooking tops by amending the definition of conventional cooking tops to include induction heating technology. Furthermore, the DOE proposed to require for all cooking tops the use of test equipment compatible with induction technology. Specifically, the DOE proposed to replace aluminium test blocks for cooking tops with hybrid test blocks comprising two separate pieces: an aluminium body and a stainless steel base.

In 2014, the DOE introduced another modification in which it proposed to specify different test equipment that would allow for measuring the energy efficiency of induction cooking tops, and would include an additional test block size for electric surface units with large diameters. It also proposed methods to test non-circular electric surface units, electric surface units with flexible concentric cooking zones, and full-surface induction cooking tops.

In 2016, the DOE proposed to amend its standard to incorporate the relevant sections of EN 60350-2:2013 which provides a water-heating test method to measure the energy consumption of electric cooking tops. The test method specifies the quantity of water to be heated in a standardised test vessel whose size is selected based on the diameter of the surface unit being tested. The test vessels specified in EN 60350-2:2013 are compatible with all cooking top technologies and surface unit diameters available on the US market.

Finally, the DOE proposed to extend the test methods provided in EN 60530-2:2013 to gas cooking tops by correlating the burner input rate and test vessel diameters specified in EN 30-2-1:1998 to the test vessel diameter and water loads already included in EN 60350-2:2013. The range of gas burner input rates covered by EN 30-2-1 includes surface units with burners exceeding 14 000 Btu/h, and thus EN 30-2-1 provides a method to test gas surface units with high input rate burners, which previously had not been addressed in US standards.

**Professional appliances**

Energy Star for Commercial Food Service Equipment is based on the following American Society for Testing and Materials (ASTM) standards:

- *ASTM F2140 - 11(2019) Standard Test Method for Performance of hot food holding cabinets*

  This test method evaluates the preheat energy consumption and idle energy consumption of hot food holding cabinets. A hot food holding cabinet is described as a commercial kitchen appliance that is used to hold hot food that has been cooked in a separate appliance at a specified temperature.

  The hot food holding cabinet can be evaluated with respect to the following (where applicable):

    - energy input rate;
    - temperature calibration;
    - preheat energy consumption and time;
    - energy consumption (idle energy rate);
    - energy consumption with water (humidity pan) device and relative humidity (if applicable);
    - temperature uniformity.

- *ASTM F1275 - 14 Standard Test Method for Performance of Griddles*

[7] https://www.law.cornell.edu/cfr/text/10/appendix-I_to_subpart_B_of_part_430

This test method evaluates the energy consumption and cooking performance of griddles. It is applicable to thermostatically controlled, single-source (bottom) gas and electric griddles.

The griddle can be evaluated with respect to the following parameters:

- energy input rate;
- temperature uniformity across the cooking surface and accuracy of the thermostats;
- preheat energy and time;
- idle energy rate;
- pilot energy rate;
- cooking energy rate and efficiency;
- production capacity and cooking surface temperature recovery time.

- *ASTM F1605 - 14(2019) Standard Test Method for Performance of Double-Sided Griddles*

This test method covers the energy consumption and cooking performance of double-sided griddles. It is applicable to thermostatically controlled, double-sided gas and electric (or combination gas and electric) contact griddles with separately heated top surfaces.

The double-sided griddle can be evaluated with respect to the following (where applicable):

- energy input rate;
- temperature uniformity across the cooking surface(s) and thermostat accuracy;
- preheat energy and time;
- idle energy rate;
- pilot energy rate, if applicable;
- cooking energy rate and efficiency;
- production capacity and cooking surface temperature recovery time.

- *ASTM F1496 - 13(2019) Standard Test Method for Performance of Convection Ovens*

This test method covers the energy consumption and cooking performance evaluation of convection ovens. The test method is also applicable to convection ovens with limited moisture injection. It applies to general purpose, full-size, and half-size convection ovens and bakery ovens used primarily for baking food products. It is not applicable to ovens used primarily for slow cooking and holding food products, to large roll-in rack-type ovens, or to ovens that can operate in a steam-only mode (combination ovens).

This test method is intended to be applied to convection ovens that operate close to their rated input in the dry heating mode, with the circulating fan operating at its maximum speed.

The oven's energy consumption and cooking performance are evaluated in this test method specifically with respect to the following:

- thermostat;
- rnergy input rate and preheat energy consumption and time;
- pilot energy rate (if applicable);
- idle energy rate;
- cooking energy efficiency and production capacity;
- cooking uniformity;
- white sheet cake browning;
- bakery steam mode, if applicable.

- *ASTM F2861 - 17 Standard Test Method for Enhanced Performance of Combination Oven in Various Modes*

This test method covers the evaluation of the energy and water consumption and the cooking performance of combination ovens that can be operated in hot air convection, steam, and the combination of both hot air convection and steam modes. The test method is also applicable to convection ovens with moisture injection. It is applicable to gas and electric combination ovens that can be operated in convection, steam and combination modes.

The combination oven can be evaluated with respect to the following (where applicable):

- energy input rate and thermostat calibration;
- preheat energy consumption and time;
- idle energy rate in convection, steam and combination modes;
- pilot energy rate;
- cooking-energy efficiency, cooking energy rate, production capacity, water consumption and condensate temperature in steam;
- cooking-energy efficiency, cooking energy rate, and production capacity in convection mode;
- cooking uniformity in combination mode.

- *ASTM F1484 - 18 Standard Test Methods for Performance of Steam Cookers*

These test methods are applicable to the following steam cookers: high-pressure, low-pressure, pressureless and vacuum steam cookers; convection and non-convection steam cookers; steam cookers with self-contained gas-fired, electric, or steam coil steam generators, and those connected directly to an external potable steam source.

The steam cookers will be tested for the following (where applicable):

- maximum energy input rate;
- preheat energy consumption and duration;
- idle energy rate;
- pilot energy rate;
- frozen green pea cooking energy efficiency;
- frozen green pea production capacity;
- whole potato cooking energy efficiency;
- whole potato production capacity;
- water consumption;
- condensate temperature;
- cooking uniformity.

#### 1.2.11.2 Canada

CAN/CSA-C358 (Energy Consumption Test Methods for Household Electric Ranges) applies to household electric ranges that are intended to be used on a 60 Hz AC supply with a nominal system voltage of 120/240 V. This standard specifies the methods to be used in measuring the capacity, the energy consumption, and the energy efficiency of electrically operated ranges. It does not apply to:

(a) microwave cooking appliances;
(b) portable units designed for an electrical supply of 120 V;
(c) induction heating elements; or
(d) warming compartments or zones that are not intended for cooking.

#### 1.2.11.3 Switzerland

In the professional sector, the Swiss organism ENAK provides a certification system based on test definitions and procedures set by itself, available for turbo-ovens, cooking hobs, cooking and frying pans, deep fryers and pasta cookers, combi steamers, convection ovens, bain-maries and heated display cabinets.

#### 1.2.11.4 Comparative analysis for overlapping test standards on performance

In the previous sections, overlapping test standards on performance have been identified and described. Table 7 gathers the differences between these standards.

**Table 7. Differences between overlapping test standards on performance**

| EN standard | Overlaps with | Differences |
|---|---|---|
| EN 60350-1 Household electric cooking appliances – Part 1: Ranges, ovens, steam ovens and grills – Methods for measuring performance | DOE 10 CFR part 430, subpart B, appendix I (USA) | The US standard measures the annual energy consumption of the oven taking into account the different modes of the oven. |
| | CAN/CSA-C358 Energy Consumption Test Methods for Household Electric Ranges | The CAN/CSA standard sets a normal bake mode to reach 130 °C and then the oven is allowed to operate a full thermostat cycle until reaching 205 °C. The EN Standard sets a temperature rise of 55 K. |
| EN 60350-2 Household electric cooking appliances – Part 2: Hobs – Methods for measuring performance | DOE 10 CFR part 430, subpart B, appendix I (USA) | The US standard measures the annual energy consumption of the hob taking into account the standby and off-modes. |
| | CAN/CSA-C358 Energy Consumption Test Methods for Household Electric Ranges | Stardarised test vessels used are made of aluminium and the test is not meant to test induction hobs. |
| EN 30-2-1 Domestic gas cooking appliances – Rational use of energy | DOE 10 CFR part 430, subpart B, appendix I (USA) | No significant differences have been found. The US standard incorporates relevant sections of the EN standard for gas cooking appliances. |

## 1.3 Legislation on Ecodesign, energy efficiency, performance and resource efficiency

In the following sections of this chapter, the European legislation with regard to Ecodesign, energy efficiency, performance and resource efficiency are described, followed by a compilation of international and third-country legislation.

### 1.3.1 EU legislation

Table 8 provides an overview of the European legislation discussed in this section.

**Table 8. Overview of European legislation on Ecodesign, energy efficiency and performance**

| European legislation | |
|---|---|
| Ecodesign Regulation | Ecodesign Regulation (EC) No 66/2014 on Ecodesign requirements for domestic ovens, hobs and range hoods. |
| | Ecodesign Regulation (EC) No 1275/2008 for standby and off mode |
| | Ecodesign Regulation (EC) No 801/2013 on networked standby |
| | Ecodesign Regulation (EC) No 327/2011 on fans driven by motors with an electric input power between 125 W and 500 kW |
| | Ecodesign Regulation (EC) No 640/2009 for electric motors |
| | Ecodesign preparatory study on smart appliances (ENER Lot 33, ongoing) |
| Energy efficiency and performance | Energy Label Regulation (EC) No 65/2014 on energy label requirements for domestic ovens and range hoods. |
| | Low Voltage Directive (LVD) 2014/35/EU |
| | Electromagnetic Compatibility Directive (ECD) 2014/30/EU |

#### 1.3.1.1 Ecodesign regulations relevant for domestic cooking appliances

- **Ecodesign Regulation (EU) No 66/2014**

Based on Directive 2009/125/EU with regard to Ecodesign requirements for energy-related products, Regulation (EC) No 66/2014 with regard to Ecodesign requirements for domestic ovens, hobs and range hoods establishes general and specific requirements that all appliances need to fulfil to be distributed on the European market. General requirements include:

- for domestic ovens:

  - energy efficiency requirements for the appliance performance under one standardised cycle in a conventional mode and in a fan-force mode, if available;

  - the provision of obligatory information in the booklet;

- for domestic hobs:

  - maximum energy consumption for domestic electric hobs;

  - energy efficiency of gas burners for domestic gas hobs;

  - the provision of obligatory information in the booklet;

- for domestic range hoods:

  - minimum energy efficiency and minimum fluid dynamic efficiency requirements for the appliance performance under a standardised cycle;

  - maximum air flow that shall revert to an air flow lower than or equal to 650m$^3$/h in a specified time at the best efficiency point;

  - maximum energy consumption of the low power modes off mode and standby modes;

  - minimum average illumination of the lighting system;

  - the provision of obligatory information in the booklet.

The specific requirements prescribe the minimum limits for energy efficiency or the maximum energy consumption according to the Energy Efficiency Index (EEI), as seen in Table 9.

**Table 9. Ecodesign requirements in REG 66/2014**

| Appliance | Due date | Specific requirements |
|---|---|---|
| Domestic ovens | February 2015 | $EEI_{cavity}$ <146 |
| | February 2016 | $EEI_{cavity}$ <121 |
| | February 2019 | $EEI_{cavity}$ <96 |
| Electric domestic hobs | February 2015 | $EC_{elect\ hob}$ <210 Wh/kg |
| | February 2017 | $EC_{electhob}$ <200 Wh/kg |
| | February 2019 | $EC_{elect\ hob}$ <195 Wh/kg |
| Gas-fired domestic hobs | February 2015 | $EE_{gas\ hob}$ >53% |
| | February 2017 | $EE_{gas\ hob}$ >54% |
| | February 2019 | $EE_{gas\ hob}$ >55% |
| Domestic range hoods | February 2015 | $EEI_{hood}$ <120 $FDE_{hood}$ >3 |
| | February 2017 | $EEI_{hood}$ <110 $FDE_{hood}$ >5 |
| | February 2019 | $EEI_{hood}$ <100 $FDE_{hood}$ >8 |
| | February 2015 | Air flow ≤650m$^3$/h |
| | February 2015 | $E_{middle}$ >40 lux |

The above requirements are subject to revision in this preparatory study: in Annex II to Directive 2009/2015 on ecodesign requirements for energy-related products, it is stated that:

*"Concrete measures must be taken with a view to minimising the product's environmental impact. Concerning energy consumption in use, the level of energy efficiency must be set aiming at the life cycle cost minimum to end-users".*

Regulation (EC) No 66/2014 prescribes formulas for the calculation of EEI, EC, EE or FDE and the respective energy consumption, theoretic minimum required energy or annual energy consumption. These equations are taken up in the Energy Label Regulation (EC) No 65/2014, when appropriate.

In addition, the Ecodesign Regulation sets minimum requirements for the low power modes of range hoods. From September 2017 the following requirements applied:

- the power consumption of any off mode condition shall not exceed 0.50 W;
- the power consumption in any condition providing only a reactivation function, or providing only a reactivation function and information or status display shall not exceed 1.00 W;
- when domestic range hoods are not providing the main functions or when other energy-using product(s) are not dependent on its functions, equipment shall, unless inappropriate for the intended use, offer a power management function, or a similar function, that switches equipment after the shortest possible period of time appropriate for the intended use of the equipment, automatically into standby mode or off mode or another condition which does not exceed the applicable power consumption requirements for off more and/or standby mode when the equipment is connected to the mains power source.

The power management function shall be activated before delivery.

For range hoods with an automatically functioning mode during the cooking period and fully automatic range hoods, the delay time after which the product switches automatically into the modes and conditions as referred to in the previous point shall be one minute after the motor and lighting have both been switched off either automatically or manually.

Additionally for the verification process tolerances for all measures values are given, as well as reference values of the most efficient appliances (electric and gas-fed) available on the market at that time.

- **Ecodesign Regulation (EC) No 1275/2008 for standby and off mode**

Regulation (EC) No 1275/2008 implements Directive 2005/32/EC with regard to Ecodesign requirements for standby and off mode electric power consumption of electrical and electronic household and office equipment (European Commission, 2008). According to Annex I to the Regulation, electric ovens, electric hot plates and other appliances for cooking are covered by this Regulation. Range hoods are not included in the list of products within Annex I to this Regulation, and, in this case, standby and off mode requirements are set by the Ecodesign Regulation, as explained above.

Currently, stage 2 is applicable for products placed on the market from 7 January 2013, with the following requirements regarding power consumption of standby and off mode, as well as power management or similar functions.

- power consumption in standby modes:

    - the power consumption of equipment in any condition providing only a reactivation function, or providing only a reactivation function and a mere indication of enabled reactivation function, shall not exceed 0.50 W;

    - the power consumption of equipment in any condition providing only information or status display, or providing only a combination of reaction function and information status display shall not exceed 1.00 W;

- power consumption in off-mode: power consumption of equipment in any off-mode conditions shall not exceed 0.5 W:

- availability of off mode and/or standby mode: equipment shall, except where this is inappropriate for the intended use, provide off mode and/or standby mode, and/or another condition which does not exceed the applicable power consumption requirements for off mode and/or standby mode when the equipment is connected to the mains power source;

- power management: when equipment is not providing the main function, or when other energy-using product(s) are not dependent on its functions, equipment shall, unless inappropriate for the intended use, offer a power management function, or a similar function, that switches equipment after the shortest possible period of time appropriate for the intended use of the equipment, automatically into:

  - standby mode, or off mode, or another condition which does not exceed the applicable power consumption requirements for off mode and/or standby mode when the equipment is connected to the mains power source; the power management function shall be activated before delivery.

- **Ecodesign Regulation (EU) No 801/2013 on networked standby**

Regulation (EU) No 801/2013 (European Commission 2013b) is an amendment to Regulation (EC) No 1275/2008 for standby and off mode, expanding this with Ecodesign requirements related to networked standby electric power consumption for the placing on the market of electrical and electronic household and office equipment.

In this context, “networked standby” means a condition in which the equipment is able to resume function throughout a remotely initiated trigger from a network connection, i.e. a signal that comes from outside the equipment via a network. Thus, the Regulation applies to all domestic ovens, hobs and range hoods that can be connected to a network. In the networked standby, the equipment is inactive (not performing a main function but in a condition allowing it to be reactivated via an external network signal).

While Ecodesign Regulation (EC) No 1275/2008 for standby and off mode requires power management for all equipment other than networked equipment put on the market since 2013, as of 1 January 2015 the following requirements apply to networked equipment:

- The possibility of deactivating wireless network connection(s): any networked equipment that can be connected to a wireless network shall offer the user the possibility to deactivate the wireless network connection(s). This requirement does not apply to products which rely on a single wireless network connection for intended use and have no wired network connection.

- Power management for networked equipment: equipment shall, unless unappropriated of the intended use, offer a power management function or a similar function. When the equipment is not providing a main function, and other energy-using product(s) are not dependent on its functions, the power management function shall switch equipment after the shortest possible period of time appropriate for the intended use of the equipment, automatically into a condition having networked standby. In a condition providing networked standby, the power management function may switch equipment automatically into standby mode or off mode or another condition which does not exceed the applicable power consumption requirements for standby and/or off mode as specified in Regulation (EC) No 1275/2088. The power management function, or a similar function, shall be available for all network ports of the networked equipment. The power management function, or a similar function, shall be activated, unless all network ports are deactivated. In the latter case the power management function, or a similar function, shall be activated if any of the network ports are activated. The default period of time after which the power management function, or a similar function, switches the equipment automatically into a condition providing networked standby shall not exceed 20 minutes.

- Networked equipment that has one or more standby modes shall comply with the requirements for these standby mode(s):

  – when all network ports are deactivated (since 1 January 2015);
  – when all wired network ports are disconnected and when all wireless network ports are deactivated (1 January 2017).

- Networked equipment other than HiNA equipment (high network availability equipment) shall comply with the provisions of “power management for all equipment other than networked equipment”:

– when all network ports are deactivated (since 1 January 2015);
– when all wired network ports are disconnected and when all wireless network ports are deactivated (1 January 2017).

- The power consumption of “other” network equipment (i.e. not HiNA equipment or equipment with HiNA functionality) in a condition providing networked standby into which the equipment is switched by the power management function, or a similar function:

– shall not exceed 6.00 W (since 1 January 2015);
– shall not exceed 3.00 W (since 1 January 2017);
– shall not exceed 2.00 W (since 1 January 2019).

In January 2022, a draft act was published by the European Commission to gather feedback on the revised version of this Regulation. This feedback will be taken into account for the finalisation of this initiative.

- **Ecodesign Regulation (EU) No 327/2011 on fans driven by motors with an electric input power between 125 W and 500 kW**

Regulation (EC) No 327/2011 covers fans that are integrated in other products without being separately placed on the market or put into service as long as they are between 125 W and 500 kW.

This Regulation however does not apply to the fan integrated into kitchen hoods with < 280 W total maximum electrical input attributable to the fan(s). A specific case can be found where the total maximum electrical power attributable to the fan is above 280 W but the input power in the optimum efficiency point is below. In this case, as the exclusion is made based on the total maximum electrical input power, the fan must comply with the Regulation.

Most domestic range hoods will then be excluded from this Ecodesign Regulation as most of them have a maximum electrical input lower than 280 W.

If any of them are above this limit, as commented in the example before, then the definition applied in this Regulation is that a *fan is defined as a rotatory bladed machine that is used to maintain a continuous flow of gas, typically air, passing through it and whose work per unit mass does not exceed 25kJ/kg and which:*

1 is designed for use with or equipped with an electrical motor with an electric input power between 125 W and 500 kW (≥125 W and ≤500 kW) to drive the impeller at tis optimum energy efficiency point;
2 is an axial fan, cross flow or mixed flowed fan;
3 may or may not be equipped with a motor when placed on the market or put into service.

The requirements of this Regulation refer to minimum energy efficiency requirements and information requirements. In addition, the Regulation requires the provision of information related to the technical characteristics of the fan in the free access websites of the manufacturers of fans, related to the year of manufacture and details of the manufacturers. In addition, the Regulation requires information relevant for facilitating disassembly, recycling or disposal at the end-of-life, to minimise impact on the environment and ensure optimal life expectancy as regards installation, use and maintenance of the fan and a description of additional items used when determining the fan energy efficiency, such as ducts, that are not described in the measurement category and not supplied with the fan. Finally, manufacturers should provide information in the instruction manual on specific precautions to be taken when fans are assembled, installed or maintained as well as the details of the characteristics of the variable speed drive (VSD) that must be installed with the fan, if needed, to ensure optimal use after assembly.

- **Ecodesign Regulation (EU) No 2019/1781 for electric motors**

Electric motors are subject to EU Ecodesign requirements that establish minimum requirements for the products within its scope. The Regulation covers electric single-speed, three-phase 50 Hz or 50/60 Hz, squirrel cage induction motors that:

- have 2 to 6 poles;
- have a rated voltage up to 1 000 V;
- have a rated power output between 0.75 kW and 375 kW;
- are rated on the basis of continuous duty operation;
- smaller motors between 120 W and 750 W;
- larger motors between 375 kW and 1 000 kW;
- 60 Hz motors, 8 poles motors and single-phase motors (the latter only as of July 2023).

The Regulation does not cover motors completely integrated into a product (for example into a gear, pump, fan or compressor) and whose energy performance cannot be tested independently from the product. Therefore, motors used in ovens or range hoods are not included in the scope of this Regulation.

- **Ecodesign Regulation (EU) 1253/2014 on ecodesign requirements for ventilation**

Regulation (EC) No 1253/2014 sets ecodesign requirements for ventilation units for their placing on the market or entry into service.

This Regulation establishes requirements in terms of Specific Energy Consumption (SEC), noise, multi-speed/variable speed drives, thermal bypass facilities and filters (among other parameters).

#### 1.3.1.2 Energy efficiency regulations relevant for domestic cooking appliances

- **Energy Label Regulation (EU) No 65/2014 on energy label requirements for domestic ovens and range hoods**

Regulation (EC) No 65/2014 with regard to energy labelling of domestic ovens and range hoods came into force in January 2015 (European Commission, 2014b). It describes the uniform design and content of the new energy label that shall be used for the declaration of performance characteristics.

The current energy label in both cases has a multilingual design and displays energy efficiency from classes A+++ to D. In the case of domestic ovens, further information displayed on the label refers to the capacity (in terms of cavity volume) and the energy consumption for the conventional heating function and, if available, the forced air convection. In the case of range hoods, supplementary information refers to annual energy consumption, fluid dynamic efficiency classes, lighting efficiency classes, grease filtering efficiency classes and noise.

Sizes and colours for all elements and declarations are prescribed in detail, as well as formulas to calculate annual consumption levels, efficiency indices and tables that indicate minimum and maximum values for energy efficiency classes.

*Domestic ovens*

The energy efficiency classes of domestic ovens shall be determined separately for each cavity in accordance with values as set out in Table 10. Each cavity in multi-cavity ovens should have its own label.

**Table 10. Energy efficiency classes and energy efficiency index in ovens**

| **Energy efficiency class** | **Energy efficiency index ($EEI_{cavity}$)** |
|---|---|
| A+++ (most efficient) | $EEI_{cavity} < 45$ |
| A++ | $45 \leq EEI_{cavity} < 62$ |
| A+ | $62 \leq EEI_{cavity} < 82$ |
| A | $82 \leq EEI_{cavity} < 107$ |
| B | $107 \leq EEI_{cavity} < 132$ |
| C | $132 \leq EEI_{cavity} < 159$ |
| D (least efficient) | $EEI_{cavity} < 159$ |

EEI is calculated according to the following equations:

- for domestic electric ovens:

$$EEI_{cavity} = \frac{EC_{electric\ cavity}}{SEC_{electric\ cavity}}\ x\ 100$$

$$SEC_{electric\ cavity} = 0.0042\ x\ V + 0.55\ (in\ kWh)$$

- for domestic gas ovens:

$$EEI_{cavity} = \frac{EC_{gas\ cavity}}{SEC_{gas\ cavity}}\ x\ 100$$

$$SEC_{gas\ cavity} = 0.044\ x\ V + 3.53\ (in\ MJ)$$

where:

$EEI_{cavity}$ is the energy efficiency index for each cavity of a domestic oven, in % rounded to the first decimal place;

$SEC_{electric\ cavity}$ is the standard energy consumption (electricity) required to heat a standardised load in a cavity of an electrically heated domestic oven during a cycle, expressed in kWh, rounded to the second decimal place;

$SEC_{gas\ cavity}$ is the standard energy consumption (electricity) required to heat a standardised load in a cavity of a gas-heated domestic oven during a cycle, expressed in kWh, rounded to the second decimal place;

$EC_{electric\ cavity}$ is the energy consumption required to heat a standardised load in a cavity of an electrically heated domestic oven during a cycle, expressed in kWh, rounded to the second decimal place;

$EC_{gas\ cavity}$ is the energy consumption required to heat a standardised load in a cavity of a gas-heated domestic oven during a cycle, expressed in kWh, rounded to the second decimal place.

In the current Regulation, SEC was defined as a linear regression relating energy consumption and cavity volume, based on the market situation at that time. The definition of SEC is subject to revision in this preparatory study. The relation between energy consumption and cavity volume will be considered in Section 4.1.2.3. Policy recommendations on this topic will be made in Sections 7.3.4.1 and 7.3.4.4.

*Domestic range hoods*

The energy efficiency classes for domestic range hoods shall be determined in accordance with values as set out in Table 11.

**Table 11. Energy efficiency classes and energy efficiency index in range hoods**

| **Energy efficiency class** | **Energy efficiency index ($EEI_{hood}$)** | | | |
|---|---|---|---|---|
| | **Label 1** | **Label 2** | **Label 3** | **Label 4** |
| $A^{+++}$ (most efficient) | | | | $EEI_{hood} < 30$ |
| $A^{++}$ | | | $EEI_{hood} < 37$ | $30 \leq EEI_{hood} < 37$ |
| $A^{+}$ | | $EEI_{hood} < 45$ | $37 \leq EEI_{hood} < 45$ | $37 \leq EEI_{hood} < 45$ |
| A | $EEI_{hood} < 55$ | $45 \leq EEI_{hood} < 55$ | $45 \leq EEI_{hood} < 55$ | $45 \leq EEI_{hood} < 55$ |
| B | $55 \leq EEI_{hood} < 70$ | $55 \leq EEI_{hood} < 70$ | $55 \leq EEI_{hood} < 70$ | $55 \leq EEI_{hood} < 70$ |
| C | $70 \leq EEI_{hood} < 85$ | $70 \leq EEI_{hood} < 85$ | $70 \leq EEI_{hood} < 85$ | $70 \leq EEI_{hood} < 85$ |

| | | | | |
|---|---|---|---|---|
| D | 85 ≤ $EEI_{hood}$ < 100 | 85 ≤ $EEI_{hood}$ < 100 | 85 ≤ $EEI_{hood}$ < 100 | $EEI_{hood}$ ≥ 85 |
| E | 100 ≤ $EEI_{hood}$ < 110 | 100 ≤ $EEI_{hood}$ < 110 | $EEI_{hood}$ ≥ 100 | |
| F | 110 ≤ $EEI_{hood}$ < 120 | $EEI_{hood}$ ≥ 110 | | |
| G (Least efficient) | $EEI_{hood}$ ≥ 120 | | | |

EEI is calculated according to the following equations:

$$EEI_{hood} = \frac{AEC_{hood}}{SAEC_{hood}} \ x \ 100$$

$$SAEC_{hood} = 0.55 \ x \ (W_{BEP} + \ W_L) + 15.3$$

where:

$EEI_{hood}$ is the energy efficiency index for a hood, rounded to the first decimal place;

$SAEC_{hood}$ is the standard annual energy consumption of the domestic range hood in kWh/y rounded to the first decimal place;

$AEC_{hood}$ is the annual energy consumption of the domestic range hood in kWh/y, rounded to the second decimal place;

$W_{BEP}$ is the electric power input of the domestic range hood at the best efficiency point in watts, rounded to the first decimal place;

$W_L$ is the nominal electric power input of the lighting system of the domestic range hood on the cooking surface in watts, rounded to the first decimal place.

The $AEC_{hood}$ of a domestic range hood is calculated as:

i) for fully automatic domestic range hoods:

$$AEC_{hood} = \left[\frac{(W_{BEP} \ x \ t_H \ x \ f) + (W_L \ x \ t_L)}{60 + 1000} + \frac{P_0 \ x \ (1440 - \ t_H \ x \ f)}{2 \ x \ 60 \ x \ 1000} + \frac{P_s \ x \ (1440 - \ t_H \ x \ f)}{2 \ x \ 60 \ x \ 1000}\right] x \ 365$$

ii) for all other domestic range hoods:

$$AEC_{hood} = \left[\frac{(W_{BEP} \ x \ t_H \ x \ f) + (W_L \ x \ t_L)}{60 + 1000}\right] x \ 365$$

where:

$t_L$ is the average lighting time per day, in minutes (tL = 120);

$t_H$ is the average running time per day for domestic range hoods, in minutes (tH = 60);

$P_0$ is the electric power input in off mode of the domestic range hood, in watts and rounded to the second decimal place;

$P_s$ is the electric power input in standby mode of the domestic range hood, in watts and rounded to the seond decimal place;

f is the time increase factor, calculated and rounded to the first decimal place as:

$$f = 2 - \frac{(FDE_{hood} \ x \ 3.6)}{100}$$

The $FED_{hood}$ is the fluid dynamic efficiency and it is calculated at the best efficiency point by the following formula, and is rounded to the first decimal place:

$$FDE_{hood} = \frac{Q_{BEP}\ x\ P_{BEP}}{3600\ x\ W_{BEP}}\ x\ 100$$

where:

$Q_{BEP}$ is the flow rate of the domestic range hood at best efficiency point, expressed in $m^3/h$ and rounded to the first decimal point;

$P_{BEP}$ is the static pressure difference of the domestic range hood at best efficiency point, expressed in Pa and rounded to the nearest integer;

$W_{BEP}$ is the electric power input of the domestic range hood at the best efficiency point, expressed in watts and rounded to the first decimal place.

Further annexes prescribe obligatory information for the product fiche, technical documentation, distribution and marketing.

All the values presented in Table 10 and Table 11 are subject to revision (rescaling) in this preparatory study. According to the Energy Label Regulation, "rescaling" means an exercise making the requirements for achieving the energy class on a label for a particular product group more stringent. REG 2017/1369 states that:

*The Commission shall review the label with a view to energy classes rescaling if it estimates that:*

*(a) 30 % of the units of models belonging to a product group sold within the Union market fall into the top energy efficiency class A and further technological development can be expected; or*

*(b) 50 % of the units of models belonging to a product group sold within the Union market fall into the top two energy efficiency classes A and B and further technological development can be expected.*

Also on the matter of rescaling, REG 2017/1369 states that:

*For several labels established by delegated acts adopted pursuant to Directive 2010/30/EU, products are available only or mostly in the top classes (European Commission, 2010). This reduces the effectiveness of the labels. The classes on existing labels, depending on the product group have varying scales, where the top class can be anything between classes A to A+++. As a result, when customers compare labels across different product groups, they could be led to believe that better energy classes exist for a particular label than those that are displayed. To avoid such potential confusion, it is appropriate to carry out, as a first step, an initial rescaling of existing labels, in order to ensure a homogeneous A to G scale.*

*A newly rescaled label should leave the top class empty to encourage technological progress, provide for regulatory stability, limit the frequency of rescaling and enable ever more efficient products to be developed and recognised. In exceptional cases, where technology is expected to develop more rapidly, no products should fall within the top two classes at the moment of introduction of the newly rescaled label.*

#### 1.3.1.3 Potential issues of the current Ecodesign and Energy Labelling Regulations on domestic cooking appliances

**Ovens: Including energy consumption of preheating phase in product information requirements**

According to stakeholders, the inclusion of the preheating phase in the declared energy consumption per cycle should be explored, as it is the way consumers use their oven (in France 29% of people always preheat their oven and 40% most of the time are). Policy recommendations on this topic will be made in Section 7.3.4.9.

**Ovens: Including the energy consumption of self-cleaning systems in product information requirements**

The inclusion of information on the energy consumption of the cleaning function should be explored, according to some stakeholders. The frequency of use of this function will be evaluated in Task 3. Policy recommendations on this topic will be made in Section 7.3.4.8.

**Hobs: Intermediate rounding in energy efficiency of gas hobs**

Regarding gas hobs, the intermediate rounding to the first decimal, requested in Regulation 66/2014 (Annex II, clause 2.2) and in EN 30-2-1:2015 (clause 5.2.1) for $E_{theoric}$ and $E_{gas}$ of the burner should be re-evaluated or removed. Otherwise, a small difference in the input data results in a considerable difference in the final result. Previous versions of EN 30-2-1 did not include that rounding.

**Range hoods: Real-life representativeness**

According to stakeholders, current indexes may not reflect real-life usage in the case of range hoods, since the energy efficiency rating is based on a measurement at the best efficiency point (BEP). The BEP is defined by the highest value of flow rate times pressure divided by power input. The BEP is usually at pressures that are much higher than pressures in real applications. The change in efficiency from high to low pressures can differ between models. Therefore, the energy efficiency rating should be based on measurements at lower pressures which resemble an average scenario in households. This is supported by several stakeholders, who also indicated that the actual Energy Label and Ecodesign Regulation pushed manufacturers to increase more and more the energy efficiency of the product with the focus on maximum available speed (even in boosted mode) because the measurement of Annual Energy Consumption (AEC) and EEI take into consideration just this setting; the result is that the energy efficiency of the other available speeds is relatively low. Market analysis, on the contrary, shows that the product is used at all available speeds and in particular at minimum and maximum not boosted speeds, and that the boost setting is rarely activated, just in situations with a high level of fumes and vapour, because of the noise generated by the hood itself which increases with the speed. For this reason, they suggest reviewing the method for the calculation of AEC and EEI with a view to being more consistent with user behaviour and so taking into consideration all the speeds declared in the actual product fiche and not just the maximum even in boosted (if any).

Stakeholders recommend changing the measurement of efficiency from best efficiency point to typical uses, with a typical pressure drop over the exhaust piping. In the current standard the fluid dynamic efficiency (FDE) is determined in the best efficiency point, defined as the point where the FDE is the highest. However, in practice, the range hood seldom operates in the best efficiency point, thus the FDE results in an efficiency which is different from a normal working point of the appliance. Therefore, to allow the evaluation of the efficiency of range hoods in typical working conditions, it is proposed to develop a pressure – airflow curve and the corresponding electric power curve for the minimum and maximum continuous modes and for the boost mode, and to include these in the test reports together with the efficiencies calculated based on the measurements. Then, it will be possible to base the Ecodesign Regulation and energy labelling on energy efficiency requirements at a typical working point for the fume extractors.

With the aim of solving some of these issues, CENELEC WG 8 is currently working on an update of the FDE measuring method, to take into account a profile of use which is more representative of the real-life usage of consumers. This new method is commonly known in the industry as the 9-point method. This method is described in more detail in Section 4.3.3.2 of this report.

**Range hoods: Capture efficiency**

In a study from the Swedish Energy Agency (Blomqvist et al, 2019) the authors provide recommendations for a modification in the Ecodesign and Energy Labelling Regulations for range hoods. The rationale behind the proposed modification is based on the argument that the current Regulation is based only on energy efficiency in relation to airflow and pressure, but not on the primary function of a range hood, which they argue is capture efficiency.

In their view, a range hood with a higher airflow could have the same labelling as a hood with a significantly lower airflow, whereas the ideal case would be to promote low airflow hoods (low energy consumption hoods) with high odour removal efficiencies. Therefore, the current Ecodesign and Energy Labelling Regulations for range hoods do not reward high efficiency and do not drive manufacturers towards more energy-efficient products, guiding the end-users to purchase suboptimal products.

The authors recommend that the Regulations should be based on a calculation which considers the aspects below:

- efficiency of capture of cooking odour;
- energy consumption of heating or cooling of replaced air;
- energy consumption of the range hood.

The study that supports this proposal shows the results of the methodology applied to several hoods including those without a motor installed in central ventilation systems. The results prove that the central ventilation configuration would result in an annual energy consumption one order of magnitude lower than range hoods equipped with an electric motor. The effect of the energy consumption of heating or cooling of replaced air does not exceed the effect of the pressure losses due to the charcoal filter in recirculating hoods, which result in an annual energy consumption one order of magnitude higher.

In the study, the authors provide a method in which the Energy Efficiency Index (EEI) could be improved in order to capture all those aspects.

Other stakeholders expressed their disagreement with this proposal, arguing that the energy efficiency of a product should not depend on external factors, such as heating or cooling systems or ventilation systems, since it would discourage any technological progress within the reach of manufacturers and product designers. Besides, moisture, grease and pollutants from cooking need to be eliminated and, in many cases, the most efficient way is expelling the fumes out of the building.

**Range hoods: EEI and lighting efficiency**

With regards to lighting efficiency in range hoods, a stakeholder argues that the technology-driven efficiency of the lighting system has reached a maximum, so that the light itself is no longer a quantitative aspect of the overall efficiency/main label aspect. In parallel, the fluid dynamic efficiency is measured only at one point of the highest level at the best efficiency point. This FDE runs into a factor “f” which is considered within the EEI. The EEI can be “optimised” by reducing the light’s brightness to simply reduce the power consumption. This has no negative effect on the light sub-label since there, only Lux per watt is relevant. As mentioned before, on the main part of the label - the scale - a bright appliance with a good lighting system will be punished in future. The light sub-label (icon below the energy efficiency scale on the label), based on Lux per watt, will be not affected and could be preserved. Due to the limit of LED technology, Lux per watt becomes a constant value. If you want to have a brighter light you need to linearly increase your power consumption. This is a tolerated mechanism in other devices, but not in the main label and sub-label. For appliances which are integrated into furniture, there is room for different interpretations regarding light and noise labelling. A recommendation from APPLiA is to eliminate the light efficiency calculation from the EEI formula, considering that there are only Light-Emitting Diodes (LEDs) now in new-generation range hoods and LEDs are separately regulated by Lighting ED regulation. However, other stakeholders, such BAM, do not agree with this proposal, and only recommend eliminating the icon from the label.

Also related to the time increase factor "f", another stakeholder points out that this factor is rounded to the first decimal place in current standards’ calculations. However, this may have a strong influence on the FDE and EEI. For instance, with $W_{BEP}$ = 100 W and WL = 10 W:

f = 0.752 is rounded to 0.8; EEI = 43.4 = A+

f = 0.748 is rounded to 0.7; EEI = 48.2 = A

Their suggestion is to round f to the second decimal place.

**Range hoods: Verification tolerances**

In terms of verification tolerances in range hoods, several comments have been made by stakeholders. One of them indicates that $Q_{BEP}$, $P_{BEP}$ and $W_{BEP}$ have a verification tolerance of 5%. However, the best efficiency point is the maximum of a curve that can have a small slope (long horizontal line) around the maximum. For such a curve, the values of the determined $Q_{BEP}$, $P_{BEP}$ and $W_{BEP}$ vary greatly with just small disturbing factors in the measurement. Furthermore, the test standard does not restrict the air density in the test room. A change in air density causes a change in two or sometimes all three parameters. Laboratories at different altitudes will test in different air densities. A round robin test in five laboratories on two range hoods conducted by the Federal Institute for Materials Research and Testing in Germany gave relative standard deviations of: 8.2% for $Q_{BEP}$, 6.0% for $P_{BEP}$ and 6.1% for $W_{BEP}$. Deviations between parameters were partially compensated when calculating the fluid dynamic efficiency (FDE) which had a relative standard deviation of 5.0%. For example, when a laboratory had the same $Q_{BEP}$ but a higher $P_{BEP}$ then it also measured a higher $W_{BEP}$. Therefore, it is suggested that the verification tolerance is set for the FDE instead of $Q_{BEP}$, $P_{BEP}$ and $W_{BEP}$.

The same stakeholder adds that in the round robin test the grease filtering efficiency had a relative standard deviation of 5.2%. Thus, a verification tolerance of 5% is too restrictive. Small improvements are possible by a more thorough description in the standardisation. However, no major leaps in an improved reproducibility are expected. A verification tolerance of 8% might be justified.

Finally, they argue that lighting with LEDs demands low power inputs. A tested range hood on the market had a declared value of WL = 3.3 W. For this case, the verification tolerance of 5% relates to an absolute tolerance of 0.165 W. This accuracy is difficult to achieve for inter-laboratory comparisons. A minimum absolute tolerance of 0.3 W could be added to the relative tolerance of 5%.

Another stakeholder recommends not defining verification tolerances on $Q_{BEP}$, $P_{BEP}$ and $W_{BEP}$, but to define a verification tolerance on the FDE (e.g. 8%), which is the consumer-relevant parameter. The FDE is also less sensitive to measurement uncertainties.

They add that currently the verification tolerance on sound power level (LwA) is 0%. As a consequence, reported sound levels are higher than actual sound levels. They recommend using an absolute verification tolerance of 2dB (A). Differences below 3dB (A) can hardly be heard by non-professionals.

### 1.3.2 EU safety legislation

- **<u>Low Voltage Directive (LVD) (Directive 2014/35/EU)</u>**

The purpose of the LVD (European Commission, 2014c) is to ensure that electrical equipment on the market fulfils the requirements to provide a high level of protection of health and safety of persons and of domestic animals and property, while guaranteeing the functioning of the internal market. The Directive applies to electrical equipment designed for use with a voltage rating of between 50 V and 1 000 V for alternating current and between 75 V and 1 500 V for direct current, which is new to the EU market when it is placed on the market (for example, a new piece of electrical equipment made by a manufacturer established in the EU or new or second-hand equipment imported from a third country).

Manufacturers of electrical equipment covered by the Directive are obliged to carry out the conformity assessment procedure. The Conformité Européene (CE) marking, indicating the conformity of electrical equipment, is the visible consequence of a whole process comprising the conformity assessment.

- **<u>Electromagnetic Compatibility Directive (ECD) (Directive 2014/30/EU)</u>**

Directive 2014/30/EU (European Commission, 2014d) aims to ensure the functioning of the internal market by requiring equipment to comply with an adequate level of electromagnetic compatibility, i.e. the ability of equipment to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to other equipment in that environment.

Equipment shall be designed and manufactured, having regard to the state of art, so as to ensure that:

- the electromagnetic disturbance generated does not exceed the level above which radio and telecommunications equipment or other equipment cannot operate as intended;

- it has a level of immunity to the electromagnetic disturbance to be expected in this intended use which allows it to operate without unacceptable degradation of its intended use.

Manufacturers of equipment covered by this Directive are obliged to carry out the conformity assessment procedure. The CE marking, indicating the conformity of apparatus, is the visible consequence of a whole process comprising conformity assessment. Equipment shall be accompanied by information on any specific precautions that must be taken when the apparatus is assembled, installed, maintained or used, in order to ensure that, when put into service, the apparatus is in conformity with the essential requirements set out in the Directive.

### 1.3.3 EU legislation on substances, material and resource efficiency and end-of-life

In Annex I, part 1.3, the Ecodesign Directive 2009/125/EC defines parameters which must be used, as appropriate, and supplemented by others, where necessary, for evaluating the potential for improving the environmental aspects of products. According to Directive 2009/125/EC (European Parliament 2009a), this includes the following:

- *Ease for reuse and recycling as expressed through: number of materials and components used, use of standard components, time necessary for disassembly, complexity of tools necessary for disassembly, use of component and material coding standards for the identification of components and materials suitable for reuse and recycling (including making of plastic parts in accordance with ISO standards), use of easily recyclable materials, easy access to valuable and other recyclable components and materials; easy access to components and materials containing hazardous substances*
- *Incorporating of used components;*
- *Avoidance of technical solutions detrimental to reuse and recycling of components and whole appliances.*

This section identifies and provides an overview of legislation in the EU for the products within the scope with a focus on resource use and material efficiency.

- **RoHS Directive (Directive 2011/65/EU)**

Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment (commonly referred to as RoHS 2) restricts the use of certain hazardous substances in electrical and electronic equipment to be sold in the EU and repeals Directive 2002/95/EC from 3 January 2013 (European Commission, 2011a)

The RoHS Directive restricts the presence of the substances listed in Annex II to the Directive, currently including the following substances: lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB) and polybrominated diphenyl ether (PDBE).

The RoHS Directive limits the presence of these substances in electrical and electronic equipment to be placed on the EU market, to concentrations not exceeding 0.1% by weight of homogeneous material. For cadmium the threshold level is 0.01%.

Exemptions from these provisions are only possible provided that the availability of an exemption does not weaken the environmental and health protection afforded by Regulation (EC) No 1907/2006, and that at least one of the following conditions is fulfilled:

- substitution is not possible from a scientific and technical point of view;
- the reliability of substitutes is not ensured;
- the negative environmental, health and consumer safety impacts caused by substitution are likely to outweigh the benefits;

Decisions on exemptions and on their duration may also take into consideration the following aspects, though it is understood that these do not suffice on their own to justify an exemption:

- the availability of substitutes;
- socio-economic impacts of substitution;
- impacts on innovation; and
- life-cycle thinking on the overall impact of an exemption.

Applications for granting, renewing or revoking exemptions have to be submitted to the European Commission in accordance with Annex V to the Directive, and are required to include among others a justification including comprehensive information on the substance application and possible substitutes. All applications undergo a technical analysis as well as a stakeholder consultation.

In general, applications exempted from the restriction are listed in Annex III to the RoHS Directive. As most of the exemptions are very specific, it is not possible to generalise certain topics for household appliances. Possible exemptions might be for example lead in various alloys (steel, copper, aluminium) probably relevant for housings, though depending on the applied housing materials, as well as other components for which such alloys are in use. Theoretically, another example of exemptions might be Compact Fluorescent Light (CFL) backlight systems if still being used in displays, although it is assumed that most displays are now LED backlight systems.

- **WEEE Directive (Directive 2012/19/EU)**

Directive 2012/19/EU (European Commission, 2012) on waste electrical and electronic equipment (commonly referred to as the WEEE-Directive) regulates the separate collection, treatment and recycling of end-of-life electrical and electronic equipment. Directive 2012/19/EU requires Member States to achieve quantitative collection targets (e.g. 65% of the average weight of EEE placed on the market in the 3 preceding years). It also requires Member States to ensure that producers provide for the financing of the collection, treatment, recovery and environmentally sound disposal of WEEE (Article 12).

The WEEE Directive classifies EEE in various categories. From 15 August 2018 the domestic ovens, hobs and range hoods are not classified in one single category as before ("large household appliances"), but instead fall under the following new categories:

- Category 1: Temperature exchange equipment; in the case of domestic ovens;
- Category 2: Screens, monitors, and equipment containing screens having a surface greater than 100 $cm^2$; this category might apply to domestic ovens in case of having a large control panel;
- Category 4: Large equipment (any external dimension more than 50 cm); this category will mainly apply to household ovens

- **REACH Regulation (Regulation 1907/2006/EC)**

The Registration, Evaluation, Authorisation and Restriction of Chemicals Regulation (also known as REACH Regulation (European Parliament 2006b)) entered into force on 1 June 2007. Under the REACH Regulation, certain substances that may have serious and often irreversible effects on human health and the environment can be identified as Substances of Very High Concern (SVHCs). If identified, the substance is added to the Candidate List, which includes candidate substances for possible inclusion on the Authorisation List (Annex XIV). Those SVHCs which are included in Annex XIV become subject to authorisation. By this procedure, REACH aims at ensuring that the risks resulting from the use of SVHCs are controlled and that the substances are replaced where possible.

In this regard, REACH also introduced new obligations concerning general information requirements on substances in articles. Producers and importers of articles that contain SVHCs included on the candidate list will be required to notify these to the European Chemicals Agency (ECHA) if both of the following conditions are met:

- the substance is present in those articles in quantities totalling over 1 t/y per producer or importer;
- the substance is present in those articles above a concentration of 0.1% weight by weight (w/w).

Notification will not be required in the event that the SVHC has already been registered for this use by any other registrant (Article 7(6)), or exposure to humans or environment can be excluded (Article 7(3)).

In addition, Article 33(1) requires producers and importers of articles containing more than 0.1% w/w of an SVHC included on the candidate list to provide sufficient information to allow safe handling and use of the article to its recipients. As a minimum, the name of the substance is to be communicated.

The provisions of Article 33(1) apply regardless of the total amount of the SVHC used by that actor (no tonnage threshold) and regardless of a registration of that use. Furthermore, this information has to be communicated to consumers, on request, free of charge and within 45 days (Article 33(2)).

The above-mentioned Candidate List is updated regularly (two to three times a year). In July 2019, 201 substances were on the list. Several of these substances can be present in ovens, hobs or range hoods, e.g. plasticisers in seals.

- **EU CLP Regulation (Regulation 1272/2008/EC)**

The Classification, Labelling and Packaging Regulation is also known as the CLP Regulation (European Commission, 2008). The purpose of the CLP Regulation is to identify hazardous chemicals and to inform their users about particular threats with the help of standard symbols and phrases on the packaging labels and through safety data sheets. The purpose of the globally harmonised system (UN-GHS) is to make the level of protection of human health and the environment more uniform, transparent and comparable as well as to simplify free movement of chemical substances, mixtures and certain specific articles within the EU.

Substances had to be classified until 1 December 2010 pursuant to Directive 67/548/EEC and mixtures until 1 June 2015 pursuant to Directive 1999/45/EC. Differing from this provision, the classification, labelling and packaging of substances and preparation could already be used before 1 December 2010 and 1 June 2015 in accordance with the provisions of the CLP Regulation. After these dates the provisions of the CLP Regulation became mandatory. The REACH Regulation is complemented by the CLP Regulation.

### 1.3.4 Third-country regulation

**USA**

The National Appliance Energy Conservation Act of 1978 amended the Energy Policy and Conservation Act (EPCA) to establish prescriptive standards for gas cooking products requiring gas ranges and ovens with an electrical supply cord that are manufactured on or after January 1990 not to be equipped with a constant burning pilot light.

The DOE undertook a study and concluded in 1998 that no standards were justified for conventional electric cooking products at that time. In addition, partly due to the difficulty of conclusively demonstrating that elimination of standing pilots for conventional gas cooking products without an electrical supply cord was economically justified, the DOE did not include amended standards for conventional gas cooking products in the final rule.

In 2009 the DOE published a rule amending the energy conservation standard for conventional cooking products to prohibit constant burning pilots for all gas cooking products (i.e. gas cooking products either with or without an electrical supply cord) manufactured on or after April 2012. The DOE decided not to adopt energy conservation standards pertaining to the cooking efficiency of conventional electric cooking products because it determined that such standards would not be technologically feasible and economically justified at that time. This rule was requested to be revised no later than 6 years after its issuance.

ENERGY STAR, the voluntary labelling programme managed by the U.S. Environmental Protection Agency (EPA), sets compliance thresholds for energy efficiency for the certification of professional kitchen appliances. It is based on the ASTM standards and their parameters, which are described in Section 1.2.4.

**Canada**

All residential cooking appliances are subject to Canada's *Energy Efficiency Regulations*, which set a performance standard for their energy consumption. This helps keep the least efficient products off the Canadian market. In addition, they must have an EnerGuide label that informs how much energy a model uses (except for gas ranges).

The Canadian regulation does not include an energy label or an Energy Star specification to qualify cooking appliances because the energy consumption difference between different models is small. The minimum energy performance standards are applied to household ranges that are:

- free-standing appliances equipped with one or more surface elements and one or more ovens;
- built-in appliances equipped with one or more surface elements and one or more ovens;
- built-in appliances equipped with one or more ovens and no surface elements;
- wall-mounted appliances equipped with one or more ovens and no surface elements;
- counter-mounted appliances equipped with one or more surface elements and no ovens.

The Canadian MEPS do not cover the following:

- appliances designed for an electrical supply of 120 volts;
- household appliances with one or more tungsten-halogen heating elements.

The EnerGuide (Figure 14) informs about the energy consumption of an appliance and allows comparison between the model and the rest of the models on the market. The EnerGuide label is mandatory for all cooking appliances except gas ranges. It must be easy to see on the outside or inside of the product. The label shows the product type, the model number and average energy consumption in kWh/year. A scale shows how the model performs in comparison with other models: the lower the number, the more energy-efficient the product.

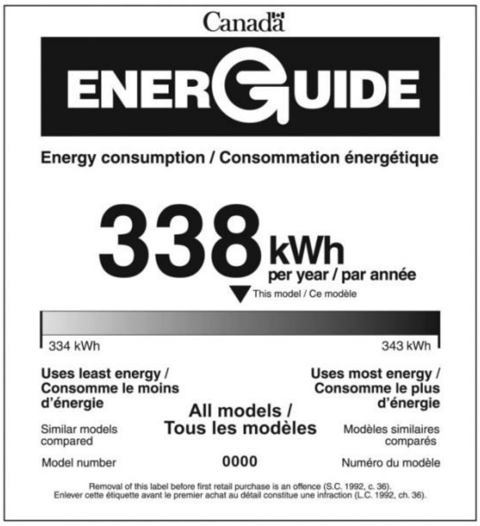



**Figure 14. EnerGuide label for cooking appliances in Canada**

Regarding the energy efficiency regulations in Canada, there are two regulations that apply to gas ranges and electric ranges respectively.

<u>*A) Gas ranges*</u>

A gas range, according to the regulation, is a household propane or natural gas range that has an electrical power source, and is used for food preparation and provides one of the following functions:

surface cooking, oven cooking, or broiling. This applies to appliance manufacturers as of February 1995. There is no testing standard associated with this regulation.

The energy efficiency requirement requires that the range must not have a continuously burning pilot light.

In addition to the minimum energy efficiency requirements, the regulation indicates that the following energy efficiency report requirements should be delivered;

- name of the product;
- brand name;
- model number;
- manufacturer;
- volume of usable oven space in litres;
- whether the range is built-in or free-standing;
- whether the broilers are open or closed;
- whether a mathematical model as defined in the regulations was used to generate any of the information provided.

*B) Electric ranges*

An electric range is defined in this regulation as *a household electric range. It does not include a portable range that is designed for an electrical supply of 120 V or a microwave oven.* The regulation has been in force since 2013 and refers to the testing standard CAN/CSA-C358-03.

The minimum energy efficiency performance (in kWh/year) depends on the type of product (range, cooktop or oven) and is related to cavity volume in the case of ranges and ovens.

**China**

China set minimum allowable energy efficiency values and energy efficiency grades for household induction hobs. This mandatory programme specifies the minimum allowable values for energy efficiency, evaluating values for energy conservation, energy efficiency grades, test methods and inspection rules for household induction hobs. It applies to household induction hobs with one or multiple heating units and of which the rating power of one heating unit is from 700 W to 2 800 W. Commercial induction hobs, power frequency induction hobs and concave induction hobs are not included in the scope of this standard.

**Japan**

“Top Runner” is a Japanese programme in which the energy consumption of domestic gas cooking appliances is tracked. Top Runner is mandatory but is not a MEPS. Manufacturers and importers are obliged to comply with the standards by energy conservation law. Enforcement within the Top Runner programme relies on ‘name and shame’ which works well in Japan. The following information shall appear on the label:

- fiscal year of the label;
- manufacturer and model;
- expected annual electricity bill of the device concerned;
- rating system.

In case of non-compliance, the name of the company and the fine are made publicly available.

**Russia**

The Gosudarstvennyy Standart (GOST) R 51388-99 lays down the rules for delivering the information about the energy performance of domestic electric appliances to consumers. The standard determines the general requirements, the rules and the amount of information to be given to consumers as well as energy performance classes, indices of saved energy costs, and other parameters of the appliances.

Electric cooking ranges and ovens are on the list of domestic electric appliances which require labelling scheme. Information about efficiency performance is delivered by providing an energy performance label, which contains indicators of energy efficiency and data on the compliance of these indicators with the requirements of the respective standards. Energy labels are assigned to the appliances for a period of 3 years at most. The energy performance indicators of appliances are described in GOST R 51541-99. GOST 14919-83 sets energy performance requirements for domestic electric cooking ranges, cooking plates and cooking ovens. The average consumed power can be calculated according to a formula that includes the size, the number of cycles and the time.

**Costa Rica**

Costa Rica has a programme of labels that must be placed on products prior to leaving the factory or customs. Non-compliance results in a fine of 25% of the product sale price. The label displays the product's energy consumption and the required MEPS level for that compliance.

## 1.4 Recommendations

### 1.4.1 Preliminary product scope

In Section 1.1 of Task 1, a review has been completed on domestic cooking appliances regarding definitions and scope. Preliminary recommendations on these two aspects are summarised below.

**Definitions**

The definitions of domestic cooking appliances making use of data from Eurostat (NACE Rev2 database) is not straightforward. First, there are several product codes which could be interpreted as falling within the scope of this study, as presented in Table 4. Although there is a high level of granularity in the data available in the NACE Rev2 database for domestic cooking appliances, the definitions of ovens and hobs are not clear-cut, since there are overlaps between these two product types. As can be seen in Section 1.1.2.2 of this report, certain product categories refer to only one of those types of appliances (such as 27.51.28.70: *"Domestic electric ovens for building-in"*), whereas other categories refer to appliances which include both (27.51.28.10: *"Domestic electric cookers with at least an oven and a hob"*).

In the case of commercial and professional appliances, Eurostat does not provide a high level of granularity, as only three categories are available: bakery/biscuit ovens, infra-red radiation ovens and equipment for cooking/heating food. Using this product classification, there is no clear differentiation between ovens, hobs and range hoods. No detailed data is provided regarding the energy source of commercial and professional cooking appliances either.

Product definitions are clearer in Regulation (EU) No 65/2014 on Energy labelling and Regulation (EU) No 66/2014 on Ecodesign. Ovens, hobs and range hoods are clearly distinguished and further product category definitions are provided for each of them (for instance, definitions are provided for *small*, *portable* and *microwave* ovens). In addition, the Ecodesign Regulation defines its scope as "*domestic ovens (including when incorporated in cookers), domestic hobs and domestic electric range hoods, including when sold for non-domestic purposes*". Therefore, current legislation seems to acknowledge the possibility of using these appliances outside the household sphere.

Modifications were suggested by stakeholders and taken into account in this preliminary scope proposal. Based on the information available, the following changes to the definitions of domestic cooking appliances covered by current legislation are recommended:

- In order to align with the terms of the standard, use the term "cooking fume extractors" instead of range hoods.
- In order to include the filtration function and recirculation systems: in the definition of range hoods and to align the definitions with the IEC 61591, add the following or similar:
  - *Cooking fume extractor: appliance with a fan and filter intended to collect and treat cooking fumes, which can be operated in recirculation mode or extraction mode.*
  - *Range hood: cooking fume extractor installed over a cooking appliance.*
  - *Recirculation mode: mode of a cooking fume extractor that discharges the air back into the room, which includes an odour-reduction filter.*

- *Extraction mode: mode of a cooking fume extractor that discahges the air to the outside of the building by means of ducting.*

- In order to better reflect induction technologies in the definition of electric hobs, add the following:

  *Electric hob means an appliance or part of an appliance which incorporates one or more cooking zones and/or cooking areas including a control unit and which is ~~heated~~ supplied with electricity*"

In the current regulation, the definition of microwave heating is the following: "Microwave heating means heating of food using electromagnetic energy." It is proposed to be replaced with "…heating of food by exposing it to electromagnetic radiation in the microwave frequency range."

**Scope**

Domestic appliances such as ovens or hobs using energy sources besides electricity or gas, microwaves, portable ovens, small ovens, outdoor cooking appliances, among others, are not included within the scope of the current regulations. There are divergent views among stakeholders about their possible future inclusion in the scope of this review.

There is broad agreement regarding some specific products, which should be covered by the scope according to stakeholders:

- Combi steam oven. They are and must remain within the scope of the current Ecodesign and Energy Labelling Regulations, due to their market relevance. In current version of EN-60350 they are only tested in their conventional or convection modes. There is some debate around the need to develop tests for each function (including steam function).
- Gas cooking appliances designed for use only with LPG.
- Range hoods without lights.

There is no similar agreement regarding the exclusion of the following products proposed by some stakeholders:

- Solo microwave ovens. Considering the size and market growth of microwave ovens, it might be necessary to reconsider their inclusion in the Ecodesign/Energy Labelling Regulations. For products with lower savings potential such as these, the starting point could be an energy label, as well as information requirements to foster innovation and differentiation.
- Ovens including a combined-microwave functionality, which represent a trend in the market, should be covered by the Ecodesign and Energy Labelling Regulations, at least for their conventional and/or fan-forced modes. This could close a potential loophole for products with a microwave function. Another possibility would be to develop a test method to quantify the effect of the microwave function in a heating cycle, to show consumers the advantages of a combined microwave oven mode.
- Steam ovens. Solo steam ovens are outside the scope of the current Ecodesign and Energy Labelling Regulations, due to their low market share (5% of EU stock in 2020). Most stakeholders support this exclusion.
- Grills and grill ovens.
- Only recirculation cooking fume extractors.
- Cooking fume extractors without an integrated fan for use with a central fan.

The latter appliances are proposed to be incorporated in this preliminary scope in order to evaluate during the review process whether their current exclusion is still valid. For example, the exclusion of *ovens which offer a 'microwave heating' function* needs to be reviewed since this microwave heating function may be becoming a standard feature. In any case, the reasons provided by stakeholders for their exclusion (i.e. low frequency of use, small market share, lack of performance test method) will be part of this review process.

**Inclusion of professional cooking appliances within the project scope**

A relevant topic at this point is the potential inclusion of professional cooking appliances in the project scope. In Article 7, the Ecodesign Regulation (66/2014) indicates that:

*The review of the regulation shall assess, amongst others, the inclusion of professional and commercial appliances.*

First of the aspects to consider is whether commercial and/or professional cooking appliances should be covered by the Ecodesign and Energy Labelling Regulations. Consulted on this aspect, stakeholders have mixed opinions.

Against the development of regulation, three main arguments are provided:

- Users of commercial and professional cooking appliances have very different needs to the users of domestic appliances. This leads to significantly different intensity of use, cooking options, temperature settings as well as performance and durability requirements.
- Commercial and professional products have a much wider variability than domestic products, making it more difficult to standardise requirements.
- Commercial and professional products are often conceived as part of a system, with modular aspects designed in combination with other appliances in the kitchen

In favour of developing regulation, two main arguments are provided:

- The commercial and professional sector is potentially a high-impact sector from the energy consumption point of view (initial exploratory calculations indicate it might account for around half of the energy consumption of the domestic market, with a significantly lower market share).
- Having an ecodesign regulation could be a relevant driver to energy efficiency in the commercial/professional sector.

If regulation is developed for commercial and professional cooking appliances, stakeholders also have mixed opinions on whether they should be covered under the same regulation as domestic appliances, or whether they should have their own specific regulation.

In favour of having the same regulation for domestic and commercial/professional cooking appliances, two main arguments are provided:

- The function of domestic and commercial/professional cooking appliances is essentially the same (cooking food), therefore they should be covered under the same ecodesign/energy labelling regulation.
- Separating the review of domestic cooking appliances regulation from the development of a new regulation for commercial/professional appliances would delay the adoption of measures in this sector.

In favour of having two different regulations (one for domestic and a new one for commercial/professional), two main arguments are provided:

- Different user needs and significant product variability would make it particularly difficult to establish requirements which are satisfactory for all product types. Incompatibilities of definitions, formulas and energy categories are expected if domestic and commercial/professional appliacnes are included under the same regulation.
- The lack of harmonised European standards for commercial/professional products complicates the fair comparison of products and the definition of minimum requirements and energy categories (availability of standards will be covered in detail in Section 1.2 of this report).

Considering the reasoning above provided by relevant stakeholders, it would appear that regulation for commercial/professional cooking appliances might be worthwhile, since it is potentially a high-impact energy-consuming sector with possibilities for improvement. Regulation in the commercial/professional sector could boost innovation and be a driver for efficiency.

However, in order to provide appropriate ecodesign requirements, potential regulation for commercial/professional cooking appliances should be specific and separated from the domestic cooking appliances regulation. This will ensure that every requirement and energy labelling category defined is suitable and meaningful, considering sector-specific user needs, and that the review and rescaling of the current labels is not delayed due to additional complexity being added by such a  wide extention.

### 1.4.2 Standard methods and regulation

**Ovens**

- In the current version of the Regulation, manufacturers declare energy consumption based on their best-performing heating mode. Manufacturers may use so-called energy-saving modes (eco modes) for energy consumption declaration, modes which might differ greatly between similar products in terms of temperature profiles and that might not be able to cook some recipes appropriately. Several stakeholders indicate that it is important to clarify which heating mode should be used to declare energy consumption and to determine energy class.
- Another debate triggered by the use of the energy-saving modes is whether it is capable of achieving a sufficient cooking quality. Some stakeholders suggest that, on some occasions, these modes lead to under- or over-cooking. In this regard, CENELEC is working to develop a test to measure the cooking quality (so-called Energy cake test). However, there are several issues to resolve to come up with a robust and reliable test, mainly related to the standardisation of ingredients and recipe and the reproducibility of the test.
- In the current version of the Regulation, the energy consumption declaration is based on the energy consumption observed using different heating functions and temperature settings. However, if the highest of these temperatures cannot be reached by the oven, the standard requires using the maximum value that can be achieved by the appliance. Although this has been highlighted as a potential issue by some stakeholders, the current testing method already takes care of this, as the final result in terms of energy consumption is based on an interpolation of the different temperatures considered. The interpolation temperature is the same for every oven.
- The volume of the oven cavity is used to calculate the Energy Efficiency Index. Due to the way that EN-60350 is written, manufacturers have an incentive to declare the biggest possible cavity volume when testing an oven. The text in the standard could be revised as it may lead to higher declared volumes and thus a better EEI compared to real life usage.
- Preheating the oven is a widespread practice among consumers with a potentially significant energy impact. However, while this practice may only be required for a limited amount of recipes and is not considered an energy-efficient user behaviour,  declaring the energy consumption of the preheating phase could send a misleading message regarding the appropriateness of this activity. If results from the user behaviour study in Task 3 indicate that the overall energy consumption of preheating is significant, different options to address this issue may be evaluated in this preparatory study.
- Self-cleaning systems such as pyrolysis are a widespread feature in current domestic ovens and involve significant energy consumption due to the high temperatures required. Declaring the energy consumption of self-cleaning systems is difficult however since currently there is no standard method to evaluate the level of cleanliness of ovens, making the comparison of the performance of this feature unfeasible.

**Gas hobs**

- Small (auxiliary) burners with a nominal heat input under 1.16 kW are not covered by the current standard, since the test procedure is not optimal for them (they are not normally used for boiling large amounts of water). If small burners are to be included in the scope of the Ecodesign Regulation, a test should be developed
- The intermediate rounding of the energy efficiency of gas hobs should be removed to enable the repeatability of results.

**Range hoods**

- Real-life representativeness

  The best efficiency point (BEP) is defined by the highest value of flow rate times pressure divided by power input. The BEP is not the usual mode in which range hoods operate in real life. Therefore, the energy efficiency rating should be based on measurements at lower pressures which resemble an average scenario in households.

  It is recommended to follow the suggestions from stakeholders and shift the measurement of efficiency from best efficiency point to typical uses, with a typical pressure drop over the exhaust piping. To allow for this, stakeholders proposed to develop a pressure – airflow curve and the corresponding electric power curve for the minimum and maximum continuous modes and for the boost mode, and to include these in the test reports together with the efficiencies calculated based on the measurements. Then, it will be possible to base the Ecodesign Regulation and Energy Labelling Regulations on energy efficiency requirements at a typical working conditions for the fume extractors.

- Odour reduction efficiency

  There is debate about whether the regulation should be based on the primary function of a range hood, instead of energy efficiency in relation to airflow and pressure. Those in favour of including the primary function performance in terms of capture efficiency argue that current Ecodesign and Energy Labelling Regulations push manufacturers towards high-airflow products, instead of optimal products.

  Following this reasoning, some stakeholders recommend that regulations should be based on a calculation which considers the aspects below:

  - odour reduction efficiency;
  - energy consumption of heating or cooling of replaced air;
  - energy consumption of range hood.

  According to this proposal, the central ventilation configuration would be the most efficient, resulting in annual energy consumption levels one order of magnitude lower than range hoods equipped with an electric motor.

  Stakeholders against this proposal argue that the energy efficiency of a product should not depend on external factors, such as heating or cooling systems or ventilation systems, since it would discourage any technological progress within the reach of manufacturers and product designers. Besides, moisture, grease and pollutants from cooking need to be eliminated and, in many cases, the most efficient way is ducting the fumes out of the building.

  In this regard, EN 61591 contains a test method for the odour reduction with the substance MEK. There are several issues around this test method, mainly that it is only appropriate to measure the odour reduction efficiency of recirculation hoods. The odour reduction efficiency of ducted range hoods always results >90%, as it just depends on the capture efficiency, i.e. the airflow. Apart from that, the odour reduction test should not only represent the removal of odorous substances, but the removal of all small pollutants in general that are emitted during cooking processes. However, this test method can be considered a good starting point with sufficient margin for improvement.

# 2 Task 2: Markets

The purpose of this task is to present the economic and market analysis related to domestic and commercial ovens, hobs and cooking fume extractors within the scope of the revision of the Regulations on Ecodesign and Energy Label. The aim of this section is, firstly, to place these product groups within the context of EU industry and trade policy.

Secondly, this section provides market and cost inputs for the assessment of the EU-wide environmental impacts of the product group.

Thirdly, it aims at providing insights into the latest market trends in order to identify market structures and ongoing trends in product design. This market data will serve as input for subsequent tasks such as the base-case analysis and improvement potential (task 5 and task 7 respectively).

Finally, the data on consumer prices and rates is to be used later in the study of the life-cycle costs (LCC) calculations.

## 2.1 Generic economic data: analysis of Eurostat data

This section presents an economic analysis based on official European statistics provided by Eurostat[8] concerning production and trade data. For this section, the PRODCOM Annual Data on manufactured goods were extracted for the years 2008–2018. The PRODCOM statistics have the advantage of being the official EU source that is also used and referenced in other EU policy documents regarding trade and economic policy, thus guaranteeing consistency.

PRODCOM data is based on products whose definitions are standardised across the European Member States and thus allow comparability between the Member State data. However, as mentioned in Task 1 under product definition, the PRODCOM classification is not detailed enough to cover all the products identified in Task 1 as there is no specific category for cooking appliances specifically in the PRODCOM database. However, there are several product categories that can be considered (Table 12).

**Table 12. PRODCOM product categories related to cooking appliances**

| Product category | Description |
|---|---|
| 27511580 | Ventilating or recycling hoods incorporating a fan, with a maximum horizontal side = 120 cm |
| 27521115 | Iron or steel gas domestic cooking appliances and plate warmers |
| 27521190 | Other domestic cooking appliances and plate warmers, of iron or steel or of copper, non-electric |
| 27512833 | Domestic electric hobs for building-in |
| 27512835 | Domestic electric cooking plates, boiling rings & hobs (excluding hobs for building-in) |
| 27512870 | Domestic electric ovens for building-in |
| 27512890 | Domestic electric ovens (excluding those for building-in, microwave ovens) |
| 27521113 | Iron or steel gas domestic cooking appliances and plate warmers, with an oven |
| 27512810 | Domestic electric cookers with at least an oven and a hob (including combined gas-electric appliances) |
| 28211330 | Electric bakery and biscuit ovens |
| 28211357 | Electric infra-red radiation ovens |
| 28931580 | Non-domestic equipment for cooking or heating food |

[8] https://ec.europa.eu/eurostat/web/prodcom/data/database

The above product categories have been divided in the first place between Domestic Appliances and Commercial Appliances. This document covers the analysis only for Domestic Appliances. Data will be presented graphically to establish the differences between specific appliances, as explained below.

Cooking fume extractors are a relatively independent category from the rest and need no aggregation with other categories:

- Appliances under PRODCOM category 27511580 *"Ventilating or recycling hoods incorporating a fan, with a maximum horizontal side = 120 cm$^2$"* will be considered a "**cooking fume extractor**".

In the case of hobs (hobs which are sold isolated, without an oven), the below PRODCOM categories have been aggregated:

- Appliances under PRODCOM category 27521115 *"Iron or steel gas domestic cooking appliances and plate warmers"* will be considered a "**gas hob**".
- Appliances under PRODCOM category 27512833 *"Domestic electric hobs for building-in''* and every appliance under PRODCOM category '27512835 *"Domestic electric cooking plates, boiling rings & hobs (excluding hobs for building-in)"*, will be both considered as "**electric hobs**".
- Appliances under PRODCOM category 27521190 *"Other domestic cooking appliances and plate warmers, of iron or steel or of copper, non-electric"* will be considered a "**non-electric hob**".

Under domestic ovens, a distinction has been made between ovens and cookers (ovens with hobs together). In the case of **ovens**, the PRODCOM database only contains electric ovens:

- Appliances under PRODCOM category 27512870 *"Domestic electric ovens for building-in*" and 27512890 *"Domestic electric ovens (excluding those for building-in, microwave ovens)*" will be considered "**electric ovens**". The first of those categories refers to what is also known in the industry as a 'wall oven', or an oven which is installed directly on a wall. The second of these categories refers to what is also known in the industry as a 'slide-in' oven or 'drop-in' oven. As it is not explicitly stated in the dataset title, it is assumed that ovens under category 27512890 do not include a hob above them. Unfortunately, the definition of these categories does not specify whether portable ovens are included.

In the case of **cookers**, the PRODCOM database contains gas and electric ovens:

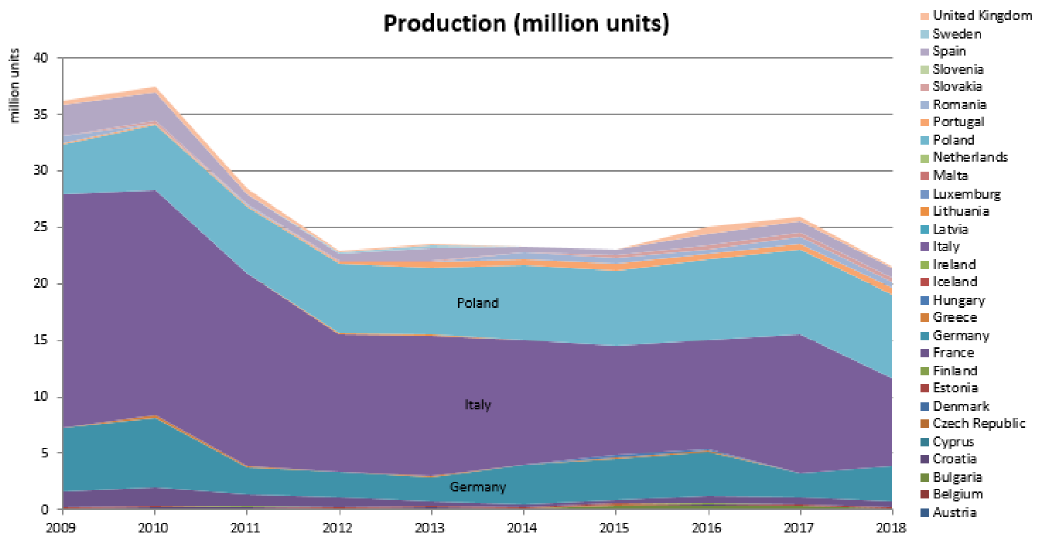
- Appliances under PRODCOM category 27521113 *"Iron or steel gas domestic cooking appliances and plate warmers, with an oven"* will be considered a "**gas cooker**".
- Appliances under PRODCOM category 27512810 *"Domestic electric cookers with at least an oven and a hob (including combined gas-electric appliances)*" will be considered an "**electric cooker**".

### 2.1.1 Domestic cooking appliances – EU-28 production

Based on data from Eurostat, more than 21.5 million units of cooking appliances were produced in the EU in 2018. The countries with the largest production volume in that year were Italy, Poland (both with more than 7 million units each) and Germany (3 million units). Other significant producers were Spain, France, Portugal and Romania, all of them with over half a million units produced in 2018.

Figure 15 shows the evolution of production volume between 2009 and 2018, by country. It can be seen that the total volume in the EU-28 decreased from over 35 million units in 2010 to 21.5 million in 2018. The largest decrease is observed in Italy, where 20 million units were produced in 2009, going down to 7.8 million in 2018. Production also decreased significantly in Spain (from 2.6 million in 2009 down to 0.9 million in 2018) and in Germany (from 5.6 million to 3.1 million). In contrast, production grew in Poland over the period 2009-2018: from 4.3 million to 7.4 million. It is difficult to determine whether this overall decrease is real or is more related to issues of data quality, since there are significant data gaps in the PRODCOM database. For instance, there is no data available on electric hobs (PRODCOM categories

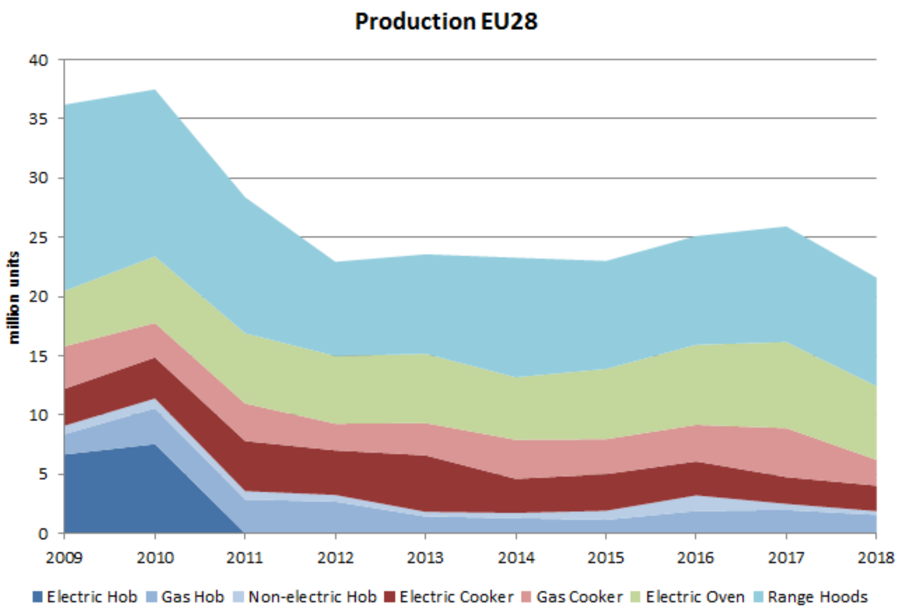
27512833 and 27512835) after 2011 for any of the EU-28 countries. It seems likely that the decrease in production observed from 2012 onwards is related to this lack of data on electric hobs.




Source: Eurostat

**Figure 15. Production volume in units in 2009-2018, per country**

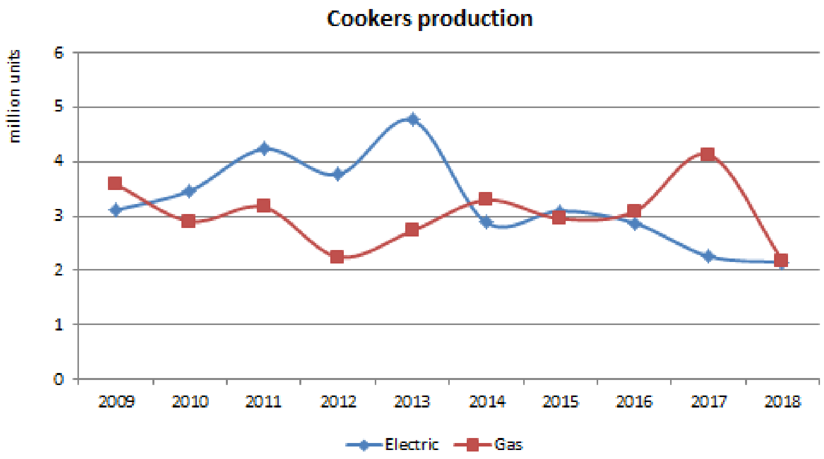
Figure 16 provides a breakdown of production per type of appliance. As can be seen, more than 40% of units produced in 2018 were cooking fume extractors, followed by electric ovens (29%). This proportion has remained stable in the EU-28 for the past 6-7 years, being significantly different at the beginning of the period studied, when 25% of units produced were hobs and 13% ovens (cooking fume extractors and cookers remained similar as of today). As can be observed, production of electric hobs seems to fall considerably in 2011, although this drop might be related to the lack of data on production of electric hobs after that year.




Source: Eurostat

**Figure 16. Production volume in units in 2009-2018, per type of appliance**

In order to evaluate which is the most common energy source of the appliances produced in the EU-28, an in-depth analysis has been carried out in Figure 17 (cookers data for 2009-2018). Over the past 10 years, production numbers have been oscillating without significant differences between them. In 2018, the share of electric and gas was equal. From these data, it appears that for cookers consumers seem to prefer electricity and gas in equal measures. Consistent data from Eurostat was not available for hobs.




Source: Eurostat

**Figure 17. Cookers – Production**

Based on data from Eurostat, in terms of value, domestic cooking appliances market represented a total of EUR 3 659 million in the EU-28. This is a 24% decrease compared to 2009, where the value of this sector was EUR 4 837 million.

### 2.1.2 Domestic cooking appliances – EU-28 import-export

Table 13 contains data regarding imports and exports in the EU-28 for the year 2018, in units and in million euro. In terms of units, the EU28 is a net importer of cooking appliances: 38 million difference, which is more than double imports than exports. In terms of value, the EU28 appears as a net importer, although the difference is much smaller in this case (4% bigger).

**Table 13. Domestic cooking appliances – EU28 import-export**

| | 2018 (Units) | | 2018 (Million EUR) | |
|---|---|---|---|---|
| | Imports | Exports | Imports | Exports |
| EU-28 | 72 954 454 | 34 512 531 | 5 092 | 4 880 |
| Austria | 1 017 633 | 520 411 | 140 | 67 |
| Belgium | 2 362 485 | 1 538 027 | 196 | 90 |
| Bulgaria | 641 978 | 47 342 | 40 | 6 |
| Croatia | 353 644 | 61 612 | 32 | 11 |
| Cyprus | 88 004 | 203 | 9 | 0 |
| Czech Republic | 16 256 575 | 1 106 738 | 103 | 96 |
| Denmark | 915 319 | 285 677 | 154 | 66 |
| Estonia | 114 375 | 18 212 | 15 | 4 |
| Finland | 409 155 | 68 974 | 62 | 6 |
| France | 8 058 286 | 1 356 312 | 653 | 142 |
| Germany | 7 953 664 | 4 584 380 | 912 | 1 280 |

| | | | | |
|---|---|---|---|---|
| Greece | 837 321 | 299 173 | 70 | 34 |
| Hungary | 793 864 | 97 217 | 59 | 7 |
| Ireland | 743 552 | 51 769 | 67 | 9 |
| Italy | 3 874 440 | 7 323 330 | 254 | 1 122 |
| Latvia | 111 027 | 23 865 | 11 | 4 |
| Lithuania | 306 287 | 113 014 | 28 | 13 |
| Luxembourg | 62 585 | 9 120 | 17 | 4 |
| Malta | 50 853 | 699 | 6 | 1 |
| Netherlands | 4 393 885 | 2 628 905 | 422 | 247 |
| Poland | 2 867 573 | 7 858 365 | 232 | 851 |
| Portugal | 747 100 | 637 973 | 70 | 48 |
| Romania | 1 666 554 | 655 017 | 112 | 65 |
| Slovakia | 1 007 804 | 409 258 | 65 | 34 |
| Slovenia | 532 521 | 922 516 | 42 | 142 |
| Spain | 4 974 821 | 2 201 287 | 274 | 257 |
| Sweden | 1 424 249 | 596 303 | 232 | 142 |
| United Kingdom | 10 388 900 | 1 096 832 | 814 | 131 |

Source: Eurostat

The largest number of imports in 2018 appear to be in the Czech Republic. However, this number needs to be taken with caution, since it seems too big considering its population (16 million imports for less than 11 million people in that year) and the number of imports in previous years in that country (just over 1 million in 2016 and 2017). Countries with a large number of imports are the United Kingdom, France, Germany, Spain and Italy. Considering the import-export balance, most of the EU-28 countries are net importers of cooking appliances, with the exception of Poland, Italy and Slovenia.

### 2.1.3 Domestic cooking appliances – Average value

Table 14 provides information regarding the average value per unit of cooking appliances in the EU-28. The numbers have been obtained dividing the value of total production in euro by the number of total units produced, for each year.

**Table 14. Domestic cooking appliances – Average value**

| | **Average production (EUR/unit)** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Product** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** |
| Cooking fume extractors | 55 | 60 | 75 | 95 | 99 | 88 | 96 | 93 | 104 | 113 |
| Hobs - Electric | 153 | 150 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Hob - Gas | 72 | 69 | 74 | 75 | 99 | 74 | 98 | 94 | 91 | 81 |
| Oven - Electric - built-in | 281 | 253 | 249 | 235 | 235 | 227 | 229 | 253 | 253 | 240 |
| Oven - Electric - non-built-in | 132 | 206 | 193 | 249 | 218 | 285 | n/a | 107 | 118 | n/a |
| Cooker - Electric | 237 | 252 | 215 | 183 | 152 | 258 | 272 | 256 | 257 | 269 |
| Cooker - Gas | 180 | 217 | 223 | 201 | 155 | 155 | 141 | 113 | 144 | 175 |

n/a: not available

Source: Eurostat

### 2.1.4 Extra-EU-28 trade

Table 15 gathers the figures of extra-EU-28 trade with selected countries which represent more than 75% of extra-EU-28 exports and more than 95% of extra-EU-28 imports.

The product groups correspond to the following codes:

- 851660: Electric ovens, cookers, cooking plates and boiling rings, electric grillers and roasters, for domestic use (excl. Space-heating stoves and microwave ovens);
- 732111: Appliances for baking, frying, grilling and cooking and plate warmers, for domestic use, of iron or steel, for gas fuel or for both gas and other fuels (excluding Large cooking appliances).

In the case of electric appliances, China and Turkey are by far the largest exporters to the EU-28 (49% and 40% of extra-EU-28 imports respectively). On the other hand, the main destinations of European exports are Russia, Australia, China and the United States.

**Table 15. Value of extra-EU-28 trade of electric appliances with some countries in 2018**

| Country | Imports | Exports |
|---|---|---|
| China | 634 245 921 | 100 612 573 |
| Turkey | 528 046 707 | 27 319 133 |
| Malaysia | 86 811 178 | 3 732 298 |
| United States | 12 234 335 | 94 270 879 |
| Hong Kong | 5 709 010 | 15 202 327 |
| Serbia | 2 011 992 | 14 867 477 |
| Taiwan | 1 988 155 | 6 373 825 |
| South Korea | 1 820 304 | 27 570 792 |
| Singapore | 1 704 045 | 8 361 531 |
| Ukraine | 1 404 234 | 34 610 528 |
| Thailand | 1 270 861 | 9 206 151 |
| Norway | 1 083 978 | 121 453 708 |
| Indonesia | 625 169 | 1 547 069 |
| Japan | 624 994 | 3 929 680 |
| Canada | 240 717 | 19 073 013 |
| Australia | 193 683 | 125 150 724 |
| Vietnam | 74 864 | 21 355 794 |
| Russian Federation (Russia) | 69 092 | 230 004 617 |
| United Arab Emirates | 47 331 | 12 310 116 |
| Israel | 33 537 | 43 618 547 |
| New Zealand | 20 339 | 20 508 739 |
| South Africa | 15 841 | 19 478 573 |
| Saudi Arabia | 1 127 | 17 168 763 |

Note: The countries are ordered by value of imports to the EU, from the largest to the smallest.

*Source:* Eurostat

### 2.1.5 Conclusions from analysis of Eurostat data

EUROSTAT data represents the official EU source and provides valuable qualitative information about the roles played by each country in this sector. However, as has already been pointed out in this section, the data need to be interpreted with caution as there are significant gaps for some countries, which prevent a robust analysis.

Moreover, the level of detail provided by EUROSTAT data is not sufficient to conduct a relevant environmental and economic impact analysis. For instance, it does not provide information regarding sales of appliances with different energy efficiency categories, which is essential to properly understand the benefits provided by ecodesign regulation. Also, the product classification does not differentiate clearly between relevant technologies in each product type (gas, radiant and induction hobs, for instance).

In order to estimate the total energy consumption of the product groups under review, it is necessary to calculate the total stocks of each of them in the EU. An essential piece of information to calculate the stocks are the annual sales, data which is also not available in the EUROSTAT database.

For these reasons, the subsequent modelling tasks of the preparatory study will not be based on EUROSTAT data. In order to overcome this, relevant data will be obtained from trusted sources with significant expertise in the market of the different product groups. This data will be presented in Section 2.2.

## 2.2 Market, stocks and trends of domestic cooking appliances

### 2.2.1 Data sources for environmental and economic impact modelling

Alternative data sources to EUROSTAT will be used in subsequent sections of this preparatory study. These data sources are:

- previous preparatory study for Ecodesign requirements for domestic cooking appliances (Mudgal et al., 2011);
- EUROMONITOR data for high-level market analysis;
- GfK data for in-detail market analysis: disaggregated data for five EU countries that represent 58% of EU population and are representative in terms of socioeconomic and cultural characteristics.

### 2.2.2 Ecodesign Impact Accounting

The European Commission has identified a need to systematically monitor and report on the impact of Ecodesign, energy label and tyre labelling measures, including potentially new forthcoming actions, with a view to improving its understanding of the impacts over time as well as forecasting and reporting capacity. The Ecodesign Impact Accounting Annual Report 2020 (VHK, 2021) provides the most recent figures:

- In the 2020–2030 period, sales of electric hobs are expected to increase by 21% from 11.5 million to 12.8 million, while those of gas hobs are decreasing by 10%, from 5 million to 4.5 million. The result is an increase in the hobs stock to 250 million in 2030 (+8%), and an increase in the electric share (71% of installed hobs in 2030).
- For ovens the picture is similar, with 230 million installed in 2020 (84% electric and 16% gas). Sales of electric ovens are slightly increasing from 11.6 million in 2020 to 11.9 million in 2030 (+2.5%), while those of gas ovens decrease from 1.77 million to 1.72 million (-3%). The result is an increase in the stock of ovens to 250 million in 2030 (+8%), and an increase in the electric share (87% of installed ovens in 2030).

In 2020, there were 95 million electric range hoods installed. Also, here sales are increasing from 7.2 million in 2015 to 8 million in 2030 (+10%), raising the stock to 105 million units in 2030. The Ecodesign Regulation sets gradually stricter energy efficiency requirements in three tiers, in 2015, 2016 and 2019. The total primary energy consumption by cooking appliances was 205 TWh/y in 2020.

Without measures, the energy consumption in 2030 is expected to be 199 TWh/y. With measures, this is expected to drop to 175 TWh/y (-12%). The majority of these savings are due to low-power modes of electric hobs and ovens (53%), range hoods (27%) and on-mode of electric ovens (13%).

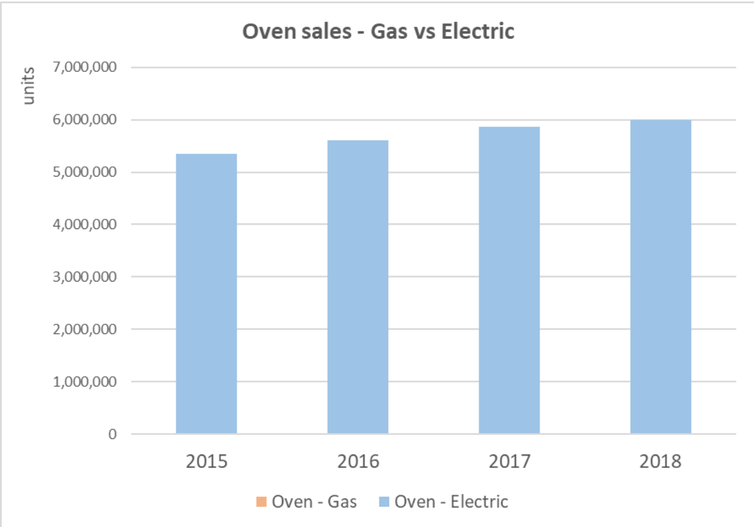
Due to the lower primary energy use, the 2030 GHG emissions related to the use of cooking appliances decrease from 33 Mt $CO_2$eq/y (without measures) to 29 Mt $CO_2$eq/y.

### 2.2.3 Sales of domestic cooking appliances

In this section, data regarding sales of the different product groups is presented. Sources of information are Euromonitor (2019) and GfK (2019).

#### 2.2.3.1 Ovens

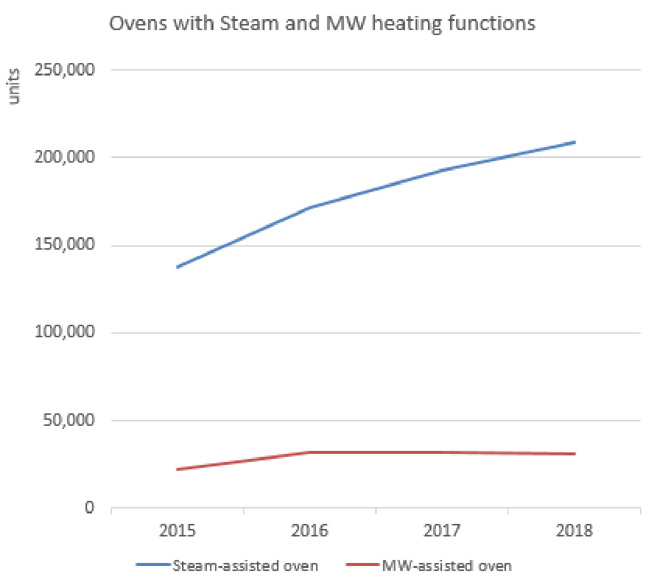
Over the period 2015-2018, oven sales grew steadily, from nearly 5.5 million units sold in 2015 to slightly over 6 million units in 2018 (Figure 18). The vast majority of ovens sold over that period were electrically heated (sales of gas ovens are so small that they are not visible in the graph).




Euromonitor (2019)

**Figure 18. Oven sales in 2015-2018 in the EU**

Ovens in the market are currently being offered with a wide variety of modes, including steam-assisted and microwave-assisted heating functions. In Figure 19 data is shown for five representative EU countries. As can be seen, steam-assisted ovens tend to be growing over recent years, reaching 200 000 units in these five countries in 2018, with microwave-assisted ovens relatively stable at around 30 000 units. If these numbers are compared with the total market of ovens in those countries, it can be observed that these functions still represent a very low percentage of the market.



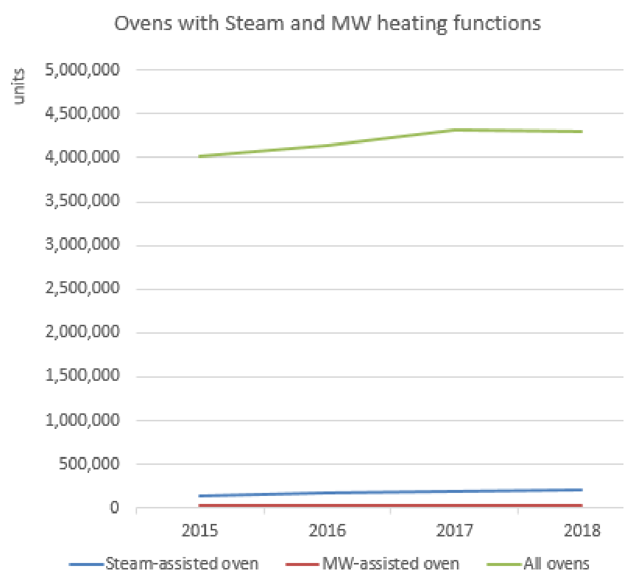
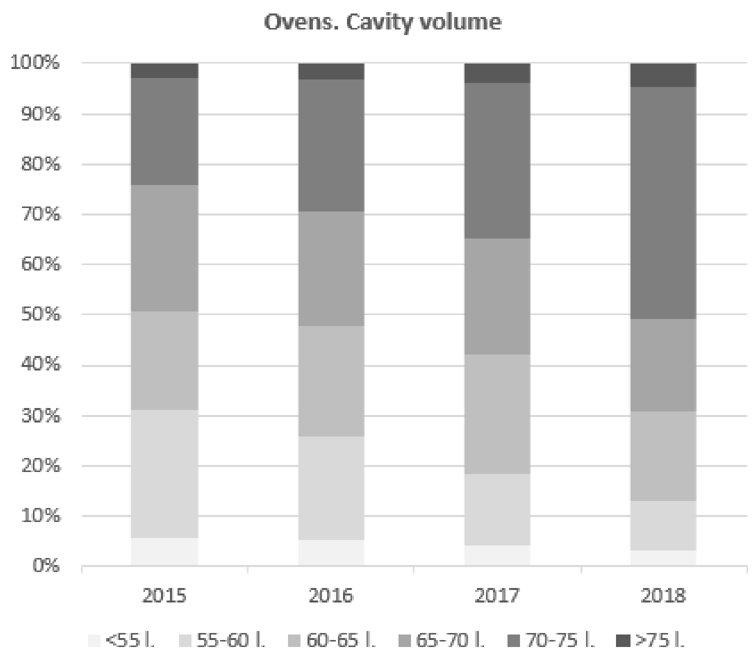




**Figure 19. Ovens with steam and MW heating functions for 5 representative EU countries**

In terms of cavity volume, there is a growing trend for larger-cavity ovens (Figure 20). In 2015 the most popular choice were 55-60 l. ovens, whereas in 2018 the cavity volume with the highest sales was 70-75 l.

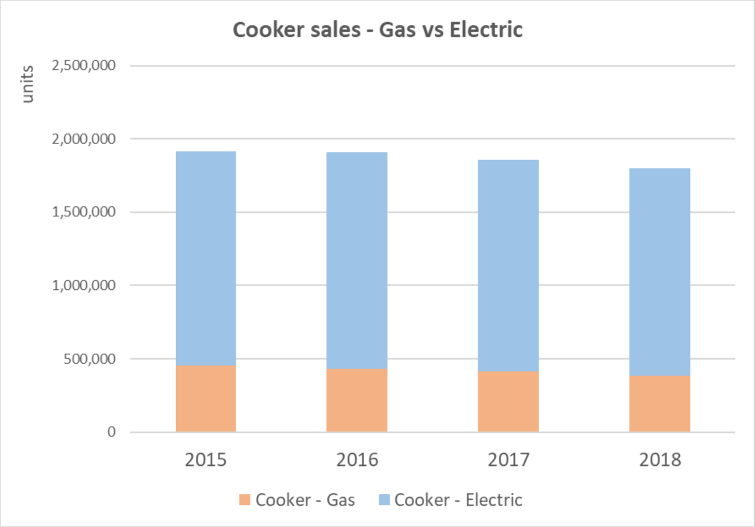



GfK (2019)

**Figure 20. Oven sales by cavity volume**

#### 2.2.3.2 Cookers

In terms of cookers, sales decreased slightly over the period 2015-2018, with approximately 1.8 million units sold in 2018 (Figure 21). In contrast with ovens, the proportion of gas-heated cookers is 21%, with electricity still being the most popular choice.

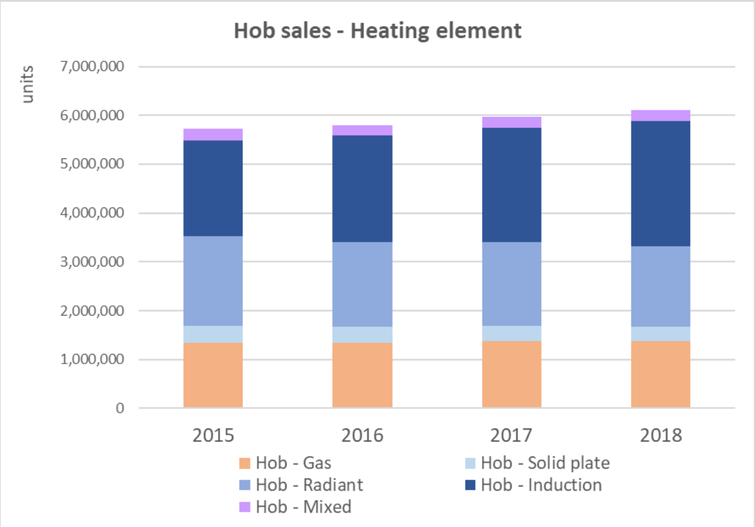



GfK (2019)

**Figure 21. Cooker sales in EU2015-2018 in the EU**

#### 2.2.3.3 Hobs

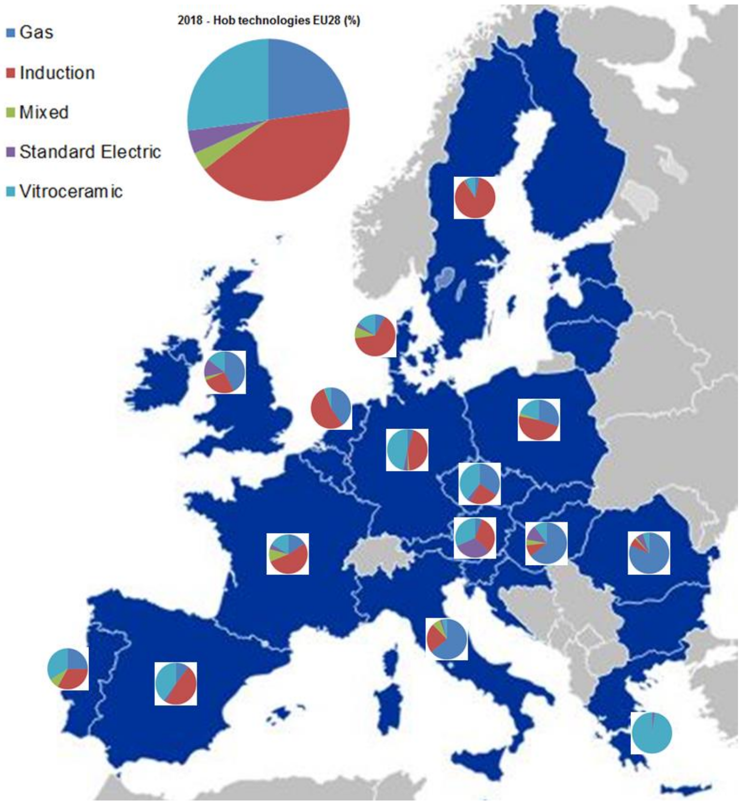
In terms of hobs, sales grew slowly over the period 2015-2018, from 5.8 million to 6.1 million in 2018. The technology that grew the most was induction: 41% of units sold in 2018 were induction.




GfK (2019)

**Figure 22. Hob sales in EU2015-2018 in the EU**

However, significant differences can be observed between different countries and regions (Figure 23).



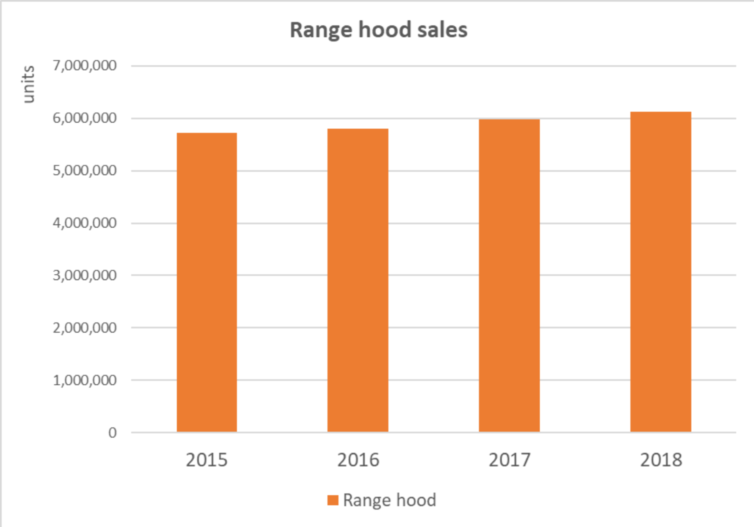

Euromonitor (2019)

**Figure 23. Share of hob technologies in 2018 in 15 EU countries**

In Sweden and Denmark, a remarkable dominance in sales was observed in the case of induction hobs (87% and 65%, respectively). This technology was the choice for most of the consumers as well in Poland, the Netherlands, France and Spain. On the opposite side, most of the consumers in Hungary, Italy and Romania preferred a gas hob in 2018. Finally, the only countries where the most sold hob technology was radiant were Austria, Germany and the Czech Republic.

#### 2.2.3.4 Cooking fume extractors

Finally, in terms of cooking fume extractors, sales grew from 5.8 million in 2015 to nearly 6.1 million units in 2018 (Figure 24), following a similar pattern to hobs.




Euromonitor (2019)

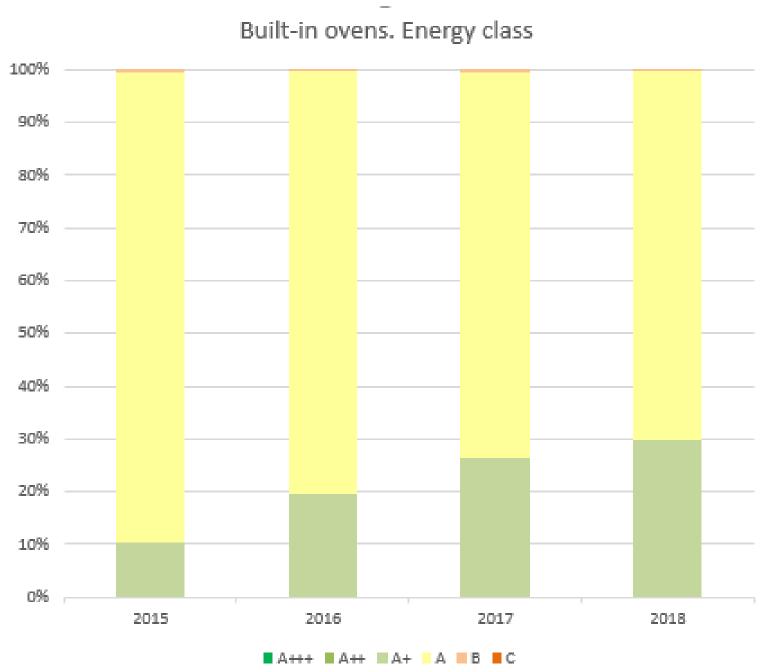
**Figure 24. Cooking fume extractor sales in EU2015-2018 in the EU**

### 2.2.4 Energy efficiency classes of domestic cooking appliances

In this section, an analysis is conducted on the distribution of energy classes for the different product groups applicable (ovens, cookers and cooking fume extractors). The source is GFK market data for five representative European countries, which account for 58% of the EU population. Every graph in this section represents percentages of units sold.

#### 2.2.4.1 Ovens

Figure 25 shows the distribution of energy classes for domestic ovens sold over the period 2015-2018.




GfK (2019)

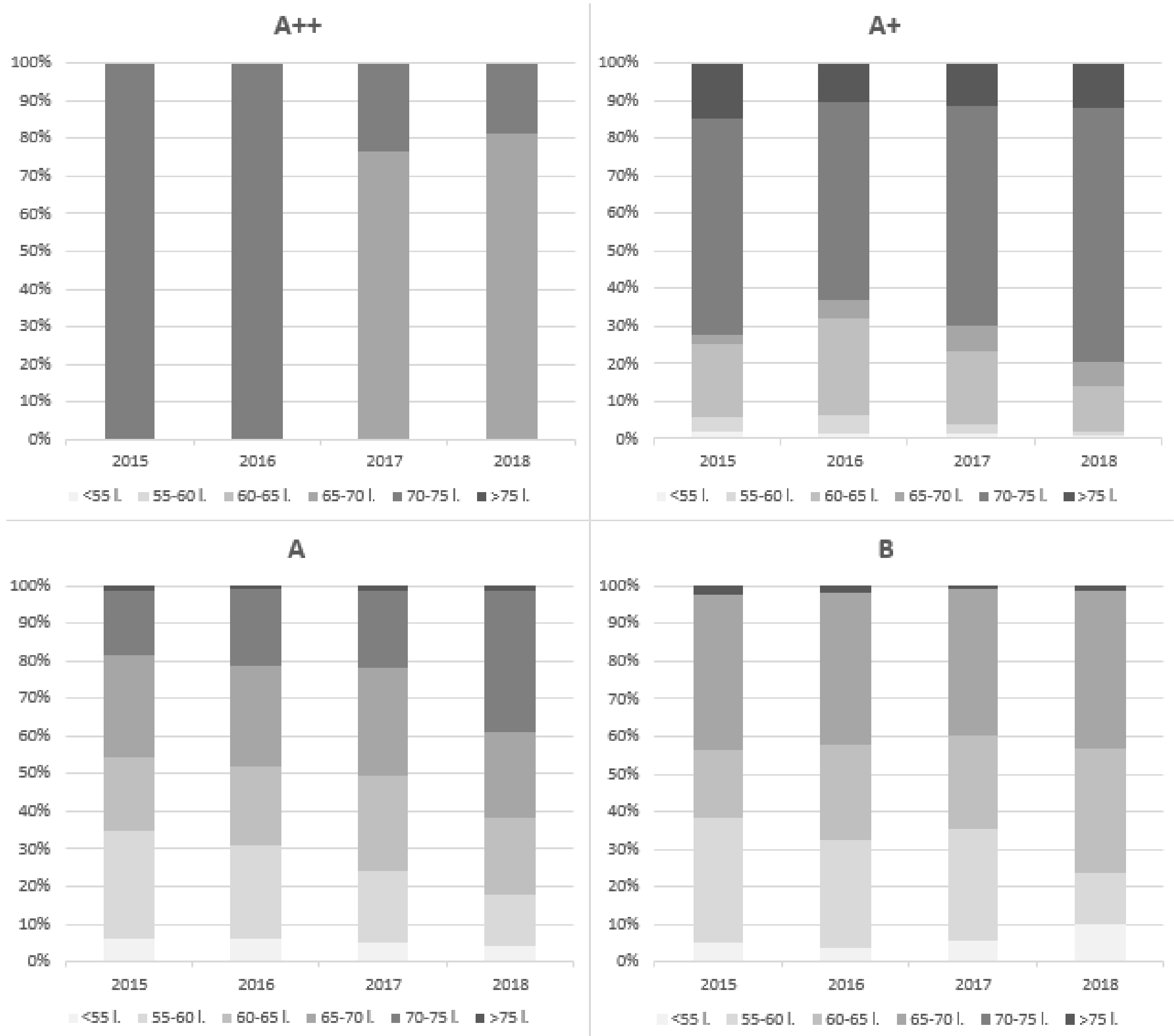
**Figure 25. Built-in ovens – Energy class**

The most significant points that can be extracted are summarised below:

- There were no A+++ ovens and only 0.06% were A++ (top energy classes).
- The A+ category grew to 29% in 2018.
- The vast majority of ovens are either A or A+.
- Nearly 70% of ovens in 2018 were A (minimum possible class after 2020).
- 0.24% of ovens in 2018 were either B or C (banned after 2020 except as part of multi-cavity units where B is still allowed for the second and any additional cavities).
- There were no ovens in the lowest energy class (D).

From that information, it can be interpreted that industry has found it difficult to reach the top energy classes (A++ or A+++). Less than a third of the ovens in the sample are A+.

An oven characteristic that might have an effect on the energy efficiency class is cavity volume. As already seen in Figure 20, consumers are moving from smaller to higher cavity volumes: in 2015 the most popular choice was 55-65 litres, whereas in 2018 the most common was 70-75 litres. To understand whether this shift in cavity volume is having an effect on overall energy consumption, an analysis is conducted on Figure 26, to see whether there is a relationship between cavity volumes and energy efficiency class.

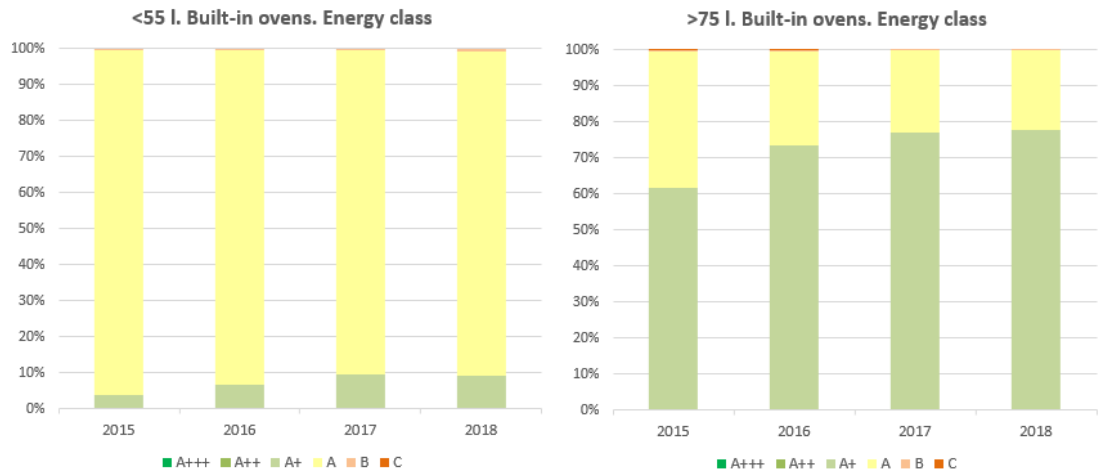



GfK (2019)

**Figure 26. Built-in ovens – The effect of cavity volume on energy class**

A slight trend can be observed from the interpretation of Figure 26. It appears that there is a greater proportion of larger cavity volumes in the top energy classes (A++ and A+) than in the low energy classes (A and B). There is no clear explanation for this trend at this point. Either it is technically more difficult to achieve higher energy classes with small cavity volumes or bigger cavity volumes are considered "high-end" and therefore are equipped with better insulation and energy conservation features which allow them to achieve A+ and A++ classes.

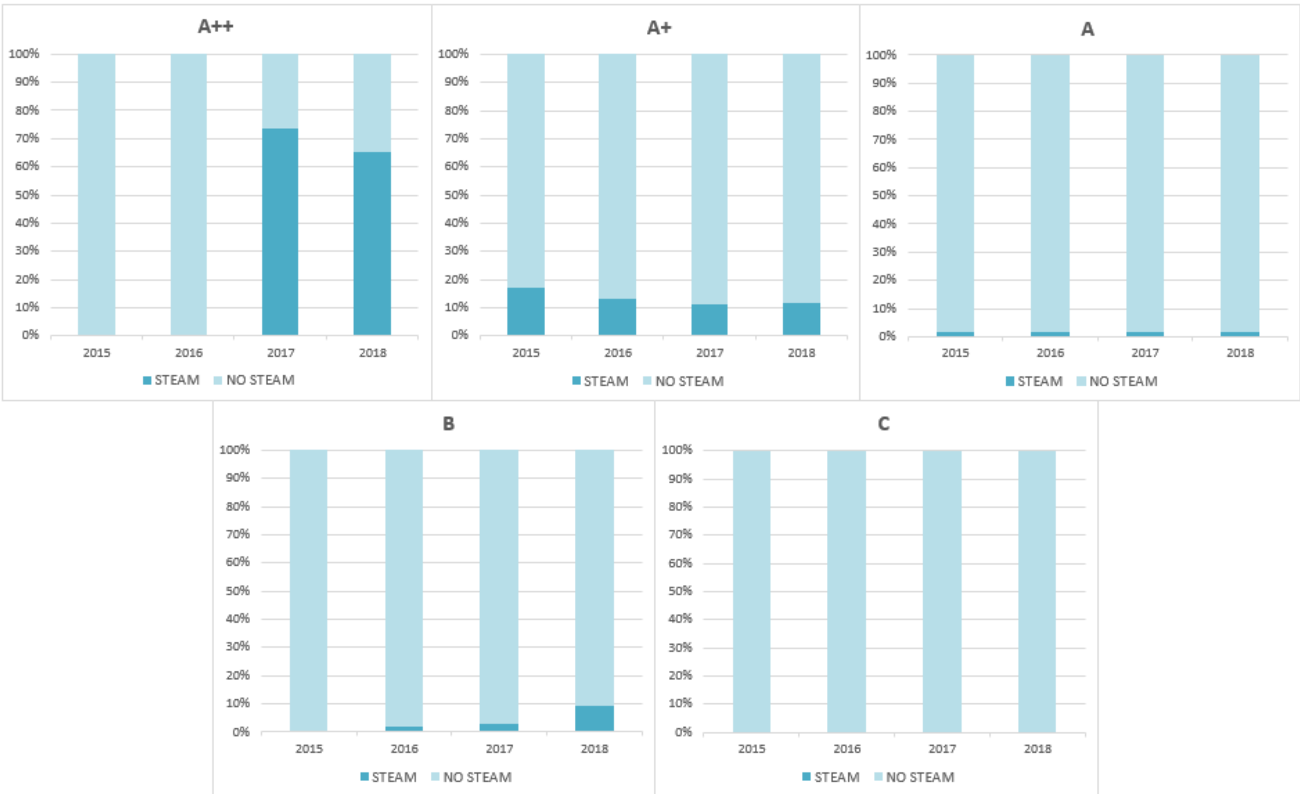
This trend is confirmed when comparing the largest and smallest cavity volumes available in the data sample (Figure 27). Most of the ovens with a cavity volume smaller than 55 litres are A, whereas most of the ovens with a cavity volume larger than 75 litres are A+.




GfK (2019)

**Figure 27. Built-in ovens – Small and big cavity volumes and energy class**

Another oven characteristic that might have an effect on the energy efficiency class is the presence of a steam heating function supporting the convective heating process. An analysis is conducted in Figure 28.



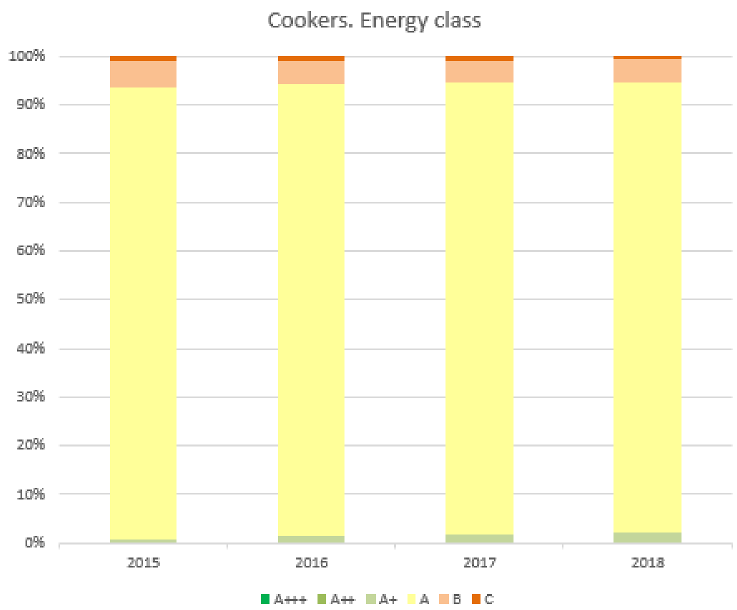

GfK (2019)

**Figure 28. Built-in ovens – The effect of a steam heating function**

From the interpretation of Figure 28, it can be seen that nearly 70% of A++ ovens in 2018 had a steam heating function. Meanwhile, none of the ovens in C class had this feature. However, the proportion of B ovens with a steam heating function is approximately as high as that of class A+ ovens and much higher than that of class A ovens. From this graph, it could be inferred that it seems easier to reach the highest energy class (A++) when the oven has a steam heating function. However, feedback from industry points out that the support of steam does not necessarily lead to lower energy consumption. This topic will be developed in Task 4.

#### 2.2.4.2 Cookers

A similar analysis to the one conducted for ovens is presented for cookers in this section. Figure 29 shows the distribution of energy classes for domestic cookers sold over the period 2015-2018.




GfK (2019)

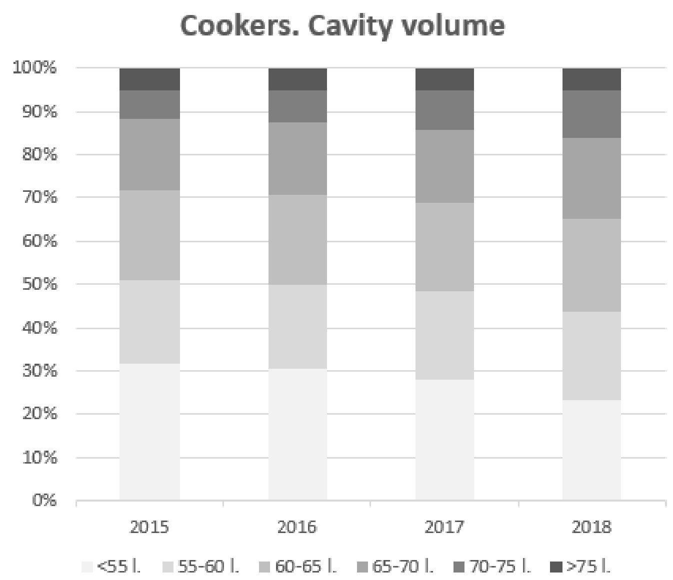
**Figure 29. Cookers – Energy class**

The most significant points that can be extracted are summarised below:

- There were no A+++ or A++ cookers (top energy classes).
- The A+ category grew very slowly up to 2% in 2018.
- The vast majority (79%) of cookers were A (minimum energy class after 2020).
- 4.5% of cookers in 2018 were either B or C (banned after 2020).
- There were no cookers in the lowest energy class (D).

From that information, it can be interpreted that industry has found it difficult to achieve the top energy classes in cookers. Only a residual percentage of these appliances (2%) reached the A+ class. It could be interpreted that cookers are 2-in-1 appliances (oven + hob) with lower energy efficiency than their individual counterparts. As a stakeholder highlights, cookers are more low-end products with the primary focus on price.

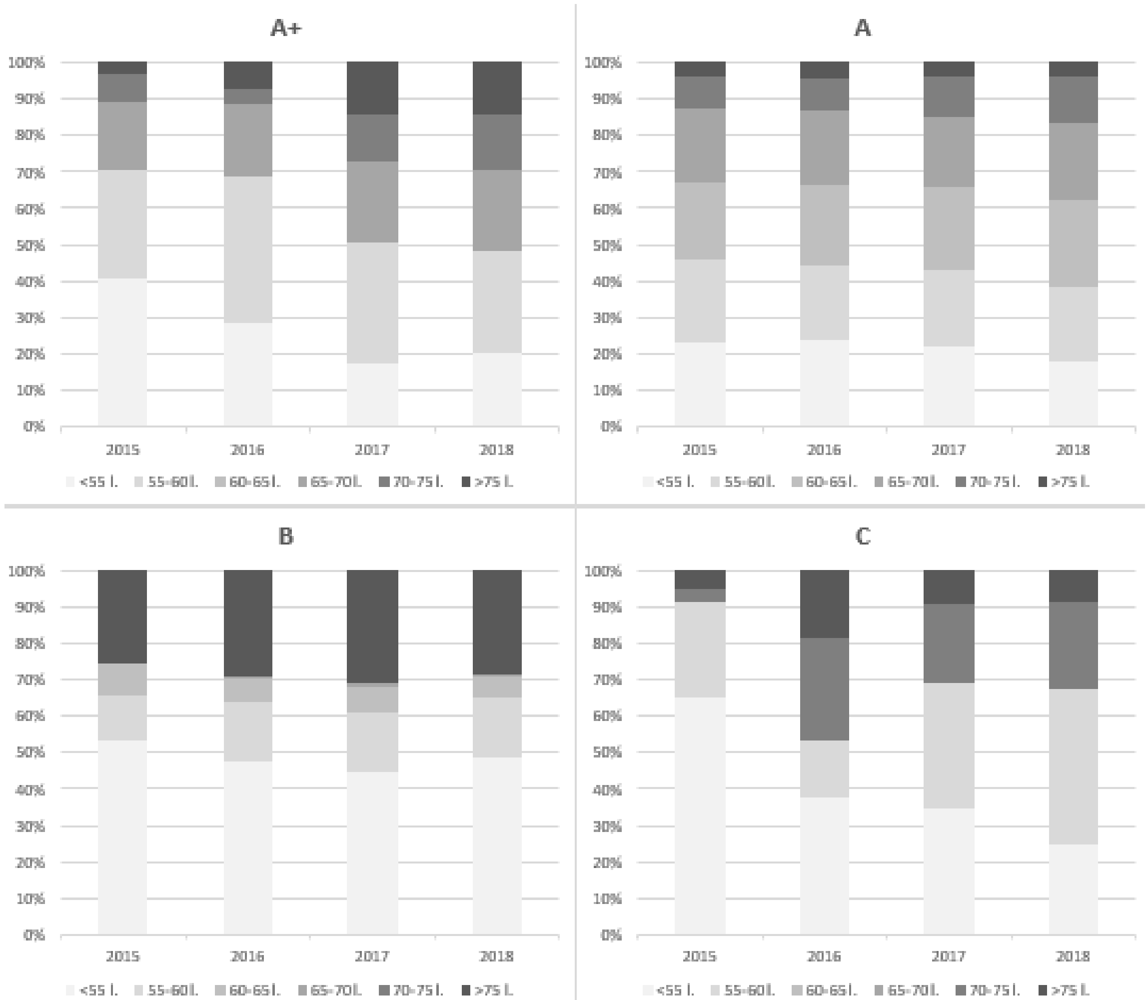
As in the case of ovens, in Figure 30, the distribution of cavity volumes sold in the five representative European countries are presented. For easier interpretation, darker colours represent larger cavity volumes.




GfK (2019)

**Figure 30. Cookers – Cavity volumes**

In contrast to ovens, cavity volumes of cookers appear to be more stable over the period 2015-2018. In fact, in 2018, sales were almost equally distributed between <55 litres, 55-60 litres and 60-65 litres. The most popular choice for ovens (70-75 litres) is less common in cookers. To understand if cooker cavity volume has an influence on the energy class of the appliance, an analysis is conducted in Figure 31.

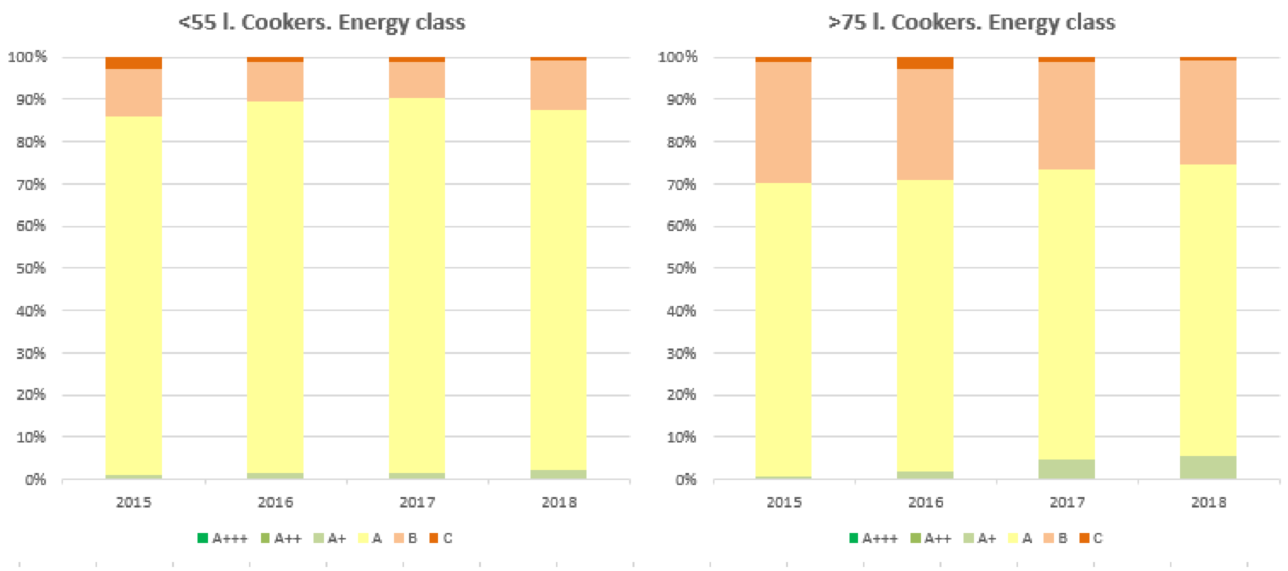



GfK (2019)

**Figure 31. Cookers – The effect of cavity volumes on energy class**

The trend observed in the case of ovens is less apparent in cookers. However, looking at 2018, it can be seen that nearly 70% of cookers in the lowest class C had small cavities (less than 60 litres), whereas only 40% of the cookers in the highest class A+ had them. Again, it appears to be more difficult to reach the top energy classes with a small cavity.

This trend can be confirmed with the analysis of Figure 32, when comparing the smallest and biggest cavities available in the data sample. It can be seen that only 2% of the small cookers reached A+ class, whereas up to 5% of the largest ovens reached it.

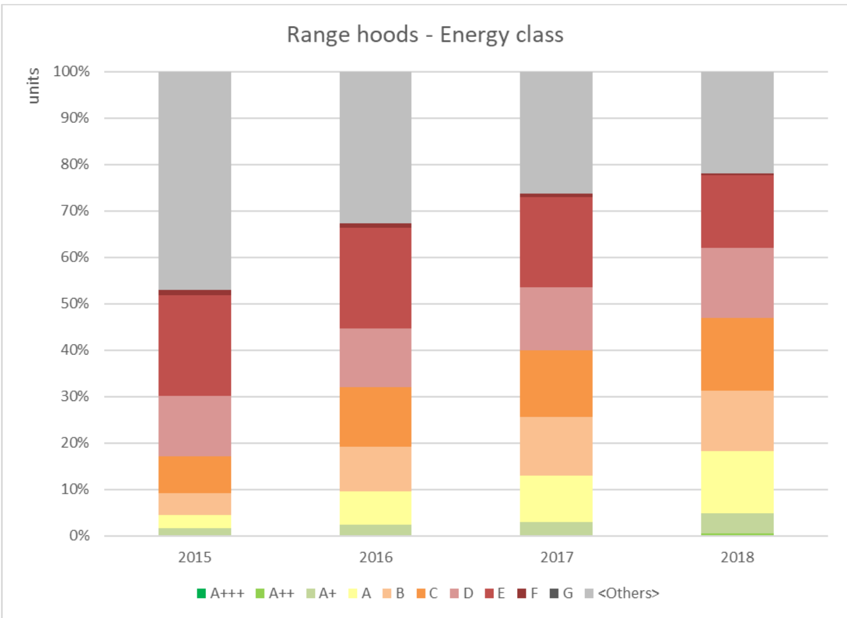



GfK (2019)

**Figure 32. Cookers – Small and big cavity volumes and energy class**

### 2.2.4.3 Cooking fume extractors

Figure 33 shows the distribution of energy classes for domestic cooking fume extractors sold over the period 2015-2018.




GfK (2019)

**Figure 33. Evolution of cooking fume extractors sales per energy class**

As can be observed, the energy classes of cooking fume extractors have improved over the period, leading to a relatively even composition among energy classes A to E. The penetration of A+ increased significantly from 2015 to 2018, mainly due to the sales of ceiling hoods and worktop vent hoods (consisting of downdraft and integrated downdraft) as is shown in Figure 34.

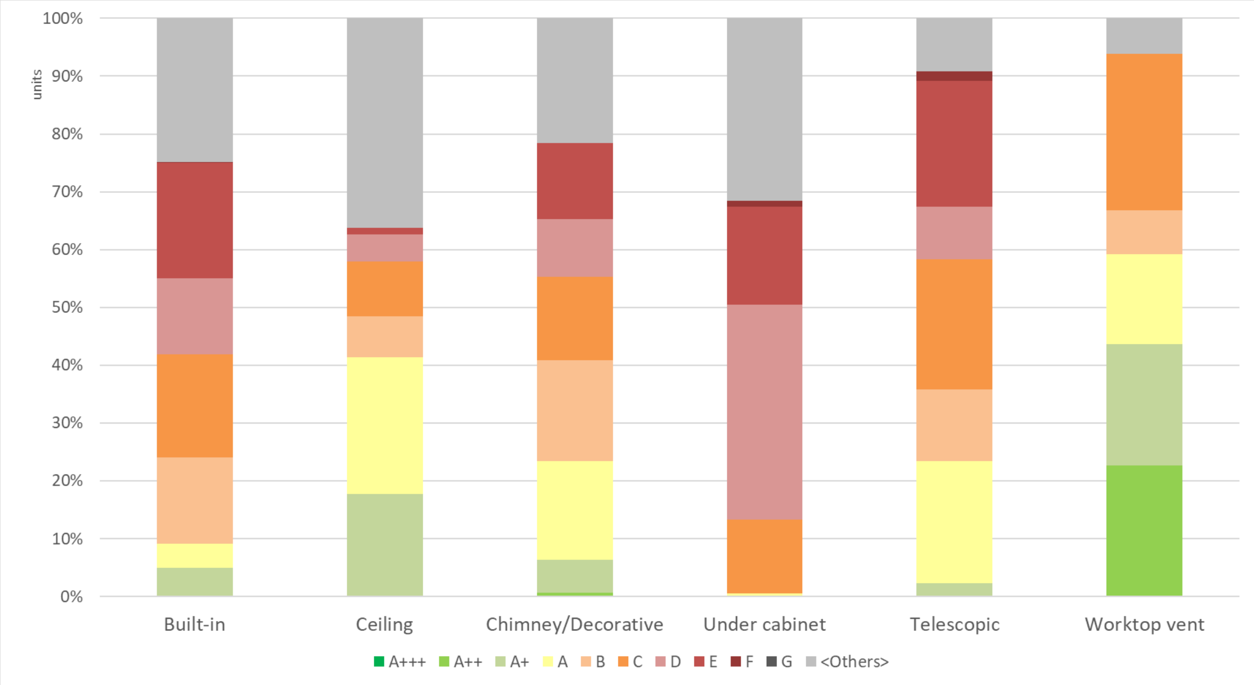
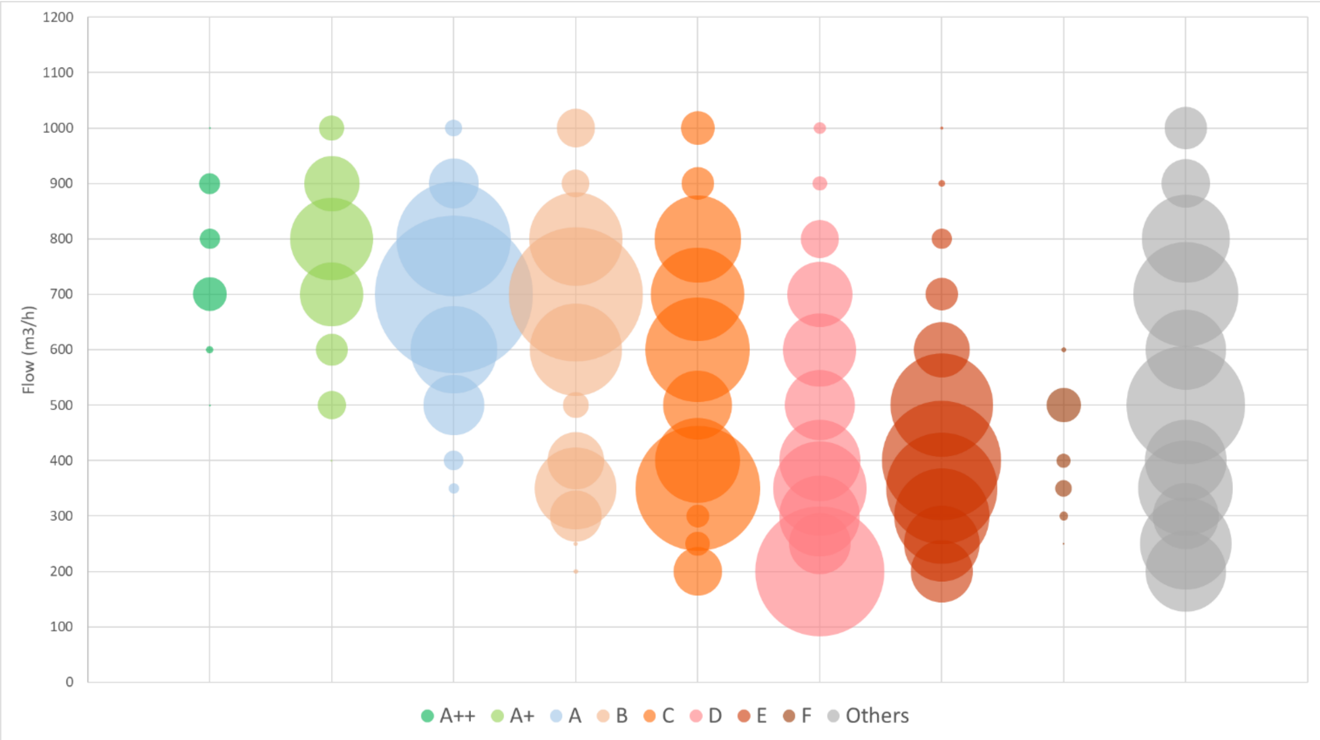



**Figure 34. Types of cooking fume extractor in terms of energy classes in 2018**

In particular, worktop vent cooking fume extractors reached the A++ energy class, though their market share is still very low. However, it must be taken into account that these cooking fume extractors have high airflows and relatively low capture rates. This can be seen as an example of the appropriateness of defining an energy efficiency calculation method which is not to closely linked to high airflow rates. This has already been mentioned in Task 1 of this report and will be addressed again in more detail in Task 4.

More common types of cooking fume extractors, such as under cabinet, have stagnated in C class and lower classes, which may be related to their typical sizes and flows. Figure 35 offers a better insight into this matter, showing the distribution of sales by energy class and airflow. The area of the bubble represents the sales in units, differentiated by energy class (colour) and airflow in m$^3$ per hour (vertical axis, i.e. the higher the bubble is located the bigger its flow).

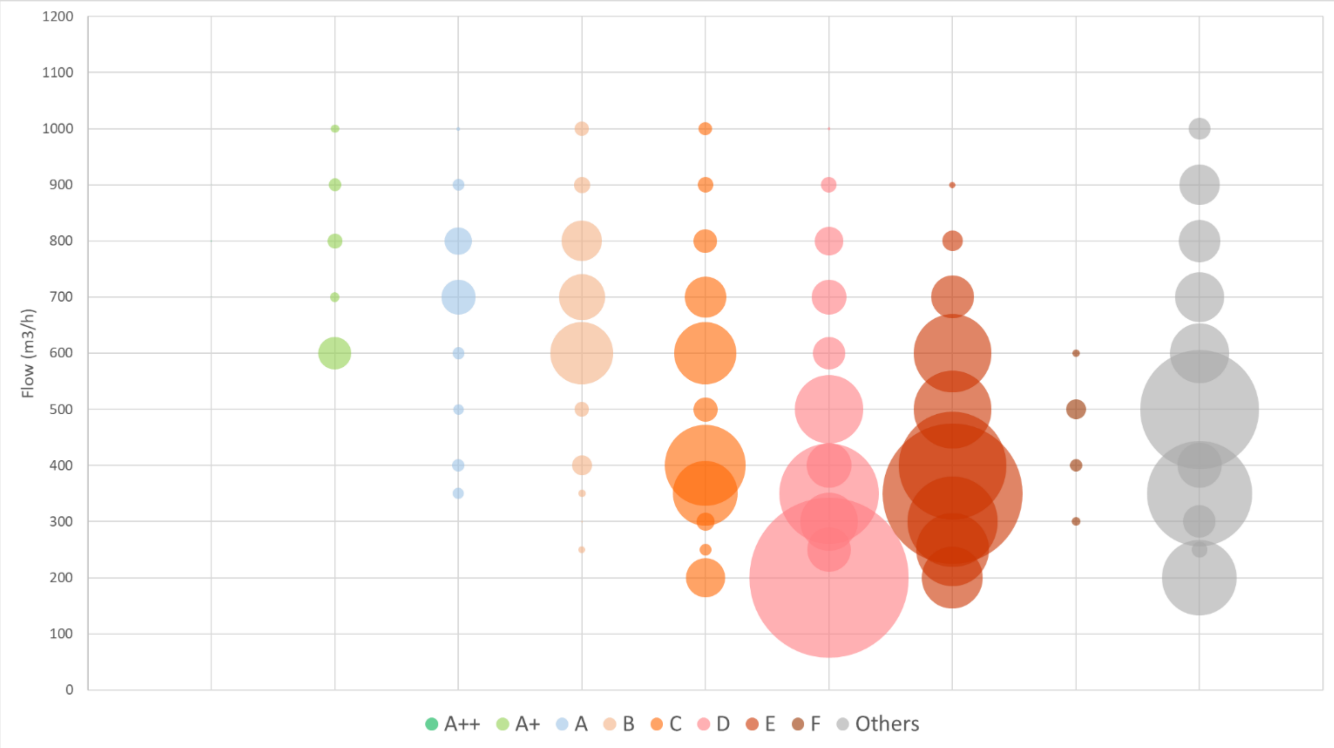



GfK (2019)

**Figure 35. Unit sales per energy class and airflow in five EU countries (2018)**

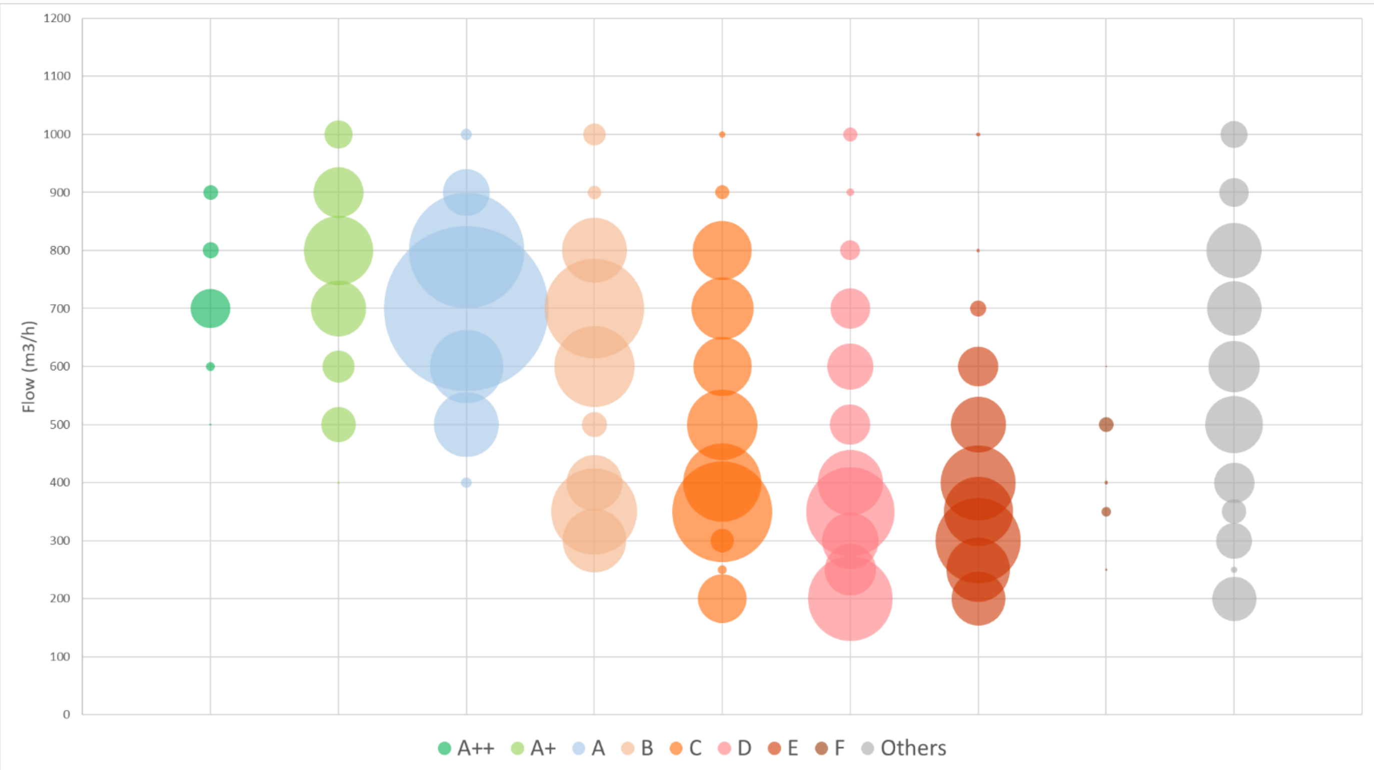
As can be observed, the largest sales of energy class A or better are more apparent in cooking fume extractors with an airflow above 600 $m^3/h$. On the other side, the sales of energy class C or worse are larger in cooking fume extractors with an airflow below 400 $m^3/h$.

The volume of the cooking fume extractors sold varies significantly among countries, since it is limited by the kitchen furniture and the space available in the kitchen. This variation can be observed in Figure 36 and Figure 37.




GfK (2019)

**Figure 36. Unit sales (bubble area) per energy class and airflow in Poland (2018)**



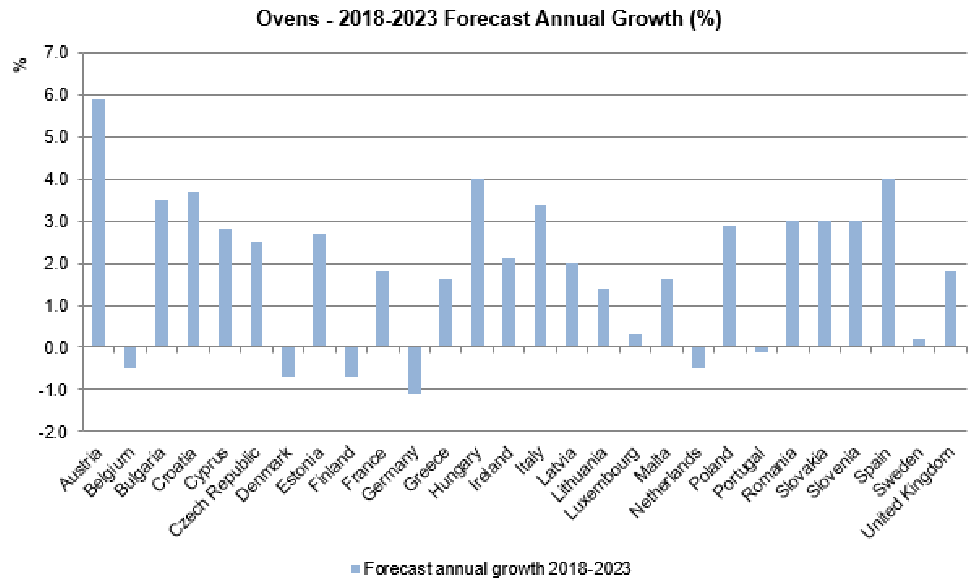

GfK (2019)

**Figure 37. Unit sales (bubble area) per energy class and airflow in Germany (2018)**

Poland and Germany clearly differ on the airflow of cooking fume extractors typically sold in their national markets. In Poland, lower-airflow cooking fume extractors are more common, and, as can be observed, the energy classes are concentrated in D and E. The contrary occurs in Germany, where the cooking fume extractors sold typically have a larger airflow and also achieve better energy classes. As indicated before, there seems to be a relation between airflow and energy class.

### 2.2.5 Trends of domestic cooking appliances

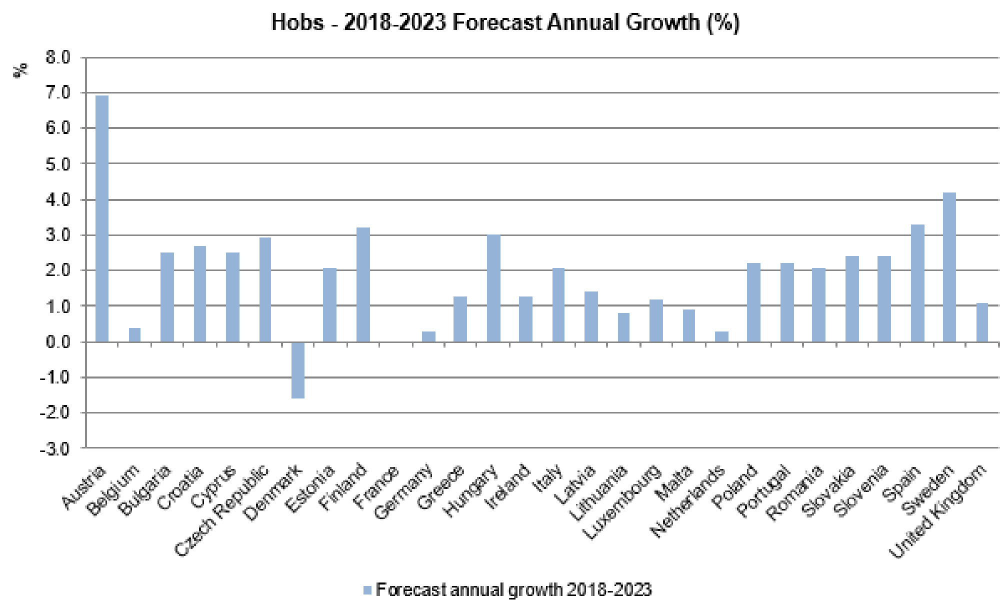
In this section, trends in domestic cooking appliances in terms of growth are presented. Figure 38 shows the annual growth forecast for ovens over the period 2018-2023. Most of the countries in the EU will see a growth in oven sales over that period, with maximum growth expected in Austria at nearly 6%. On the other hand, Belgium, Denmark, Finland, Germany, the Netherlands and Portugal will observe slow decreases in sales over that period.




Euromonitor (2019)

**Figure 38. Ovens sales – Annual growth forecast**

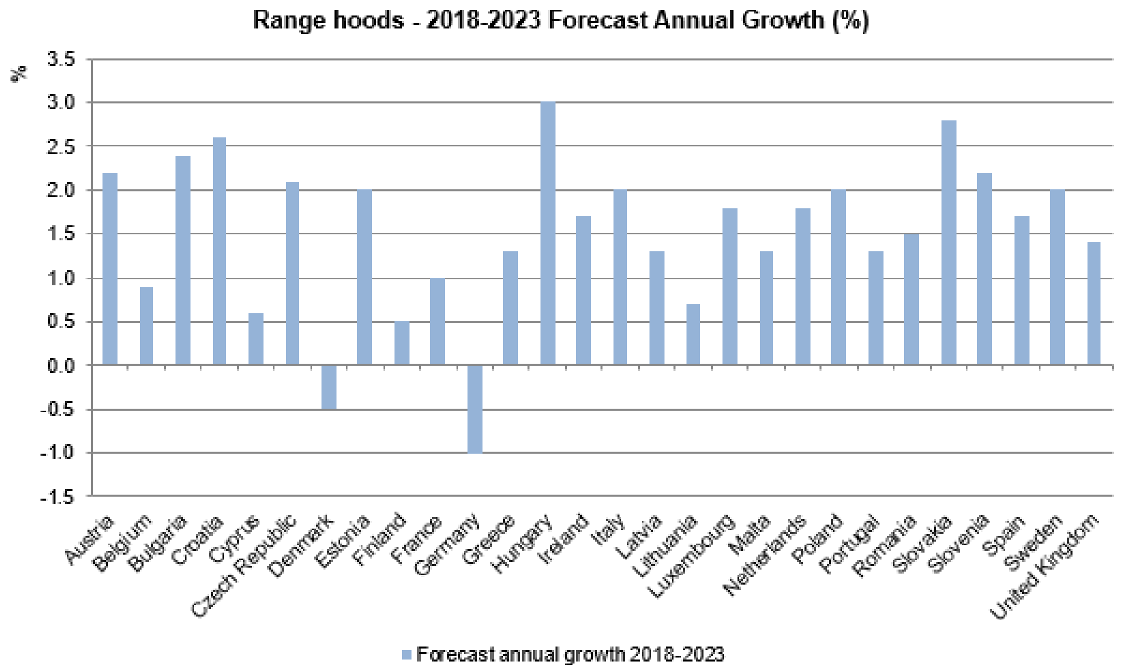
Figure 39 shows the annual growth forecast for hobs over the period 2018-2023. Again, most of the countries in the EU will see a growth in hob sales over that period, with maximum growth expected in Austria at nearly 7%. Meanwhile, only Denmark will observe a decrease in sales over that period.



Euromonitor (2019)

**Figure 39. Hobs sales – Annual growth forecast**

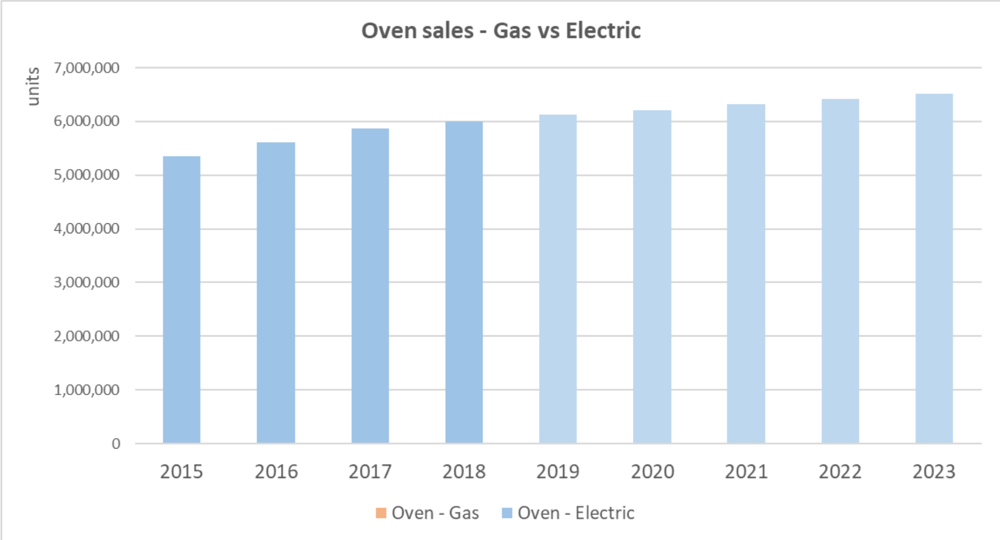
Figure 40 shows the annual growth forecast for cooking fume extractors over the period 2018-2023. Again, most of the countries in the EU will see a growth in cooking fume extractor sales over that period, with maximum growth expected in Hungary at 3%. In contrast, only Denmark and Germany will observe a decrease in sales over that period.




Euromonitor (2019)

**Figure 40. Cooking fume extractors sales – Annual growth forecast**

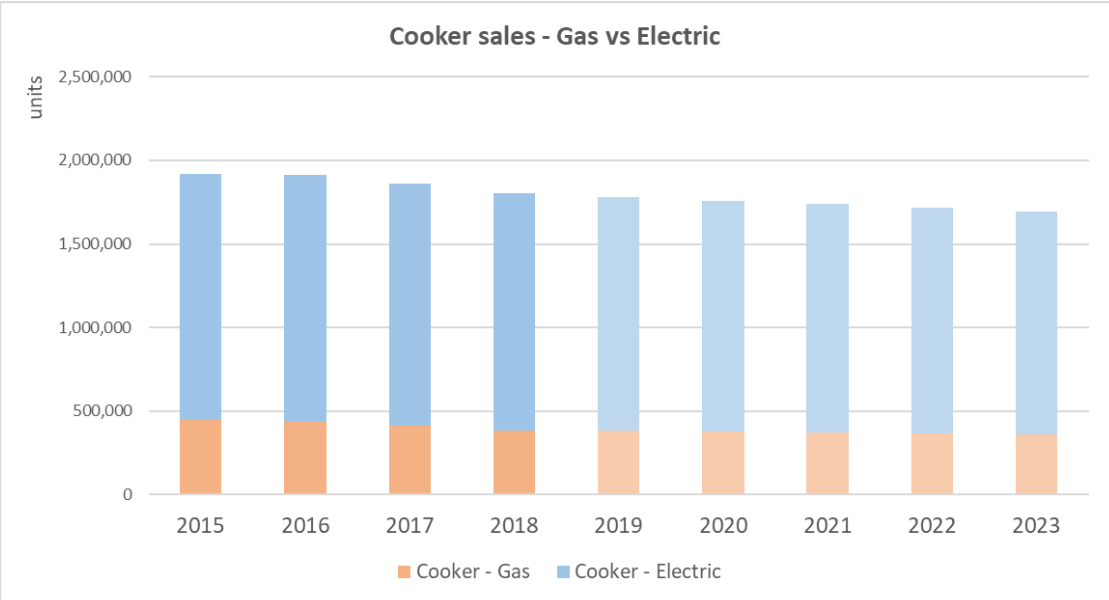
Based on the above annual growth forecast, it is possible to estimate sales for the period 2018-2023 for the different product groups. As can be seen in Figure 41, oven sales may grow up to 6.5 million units in 2023, with the vast majority of products being electrically heated.




Euromonitor (2019)

**Figure 41. Oven sales trends**

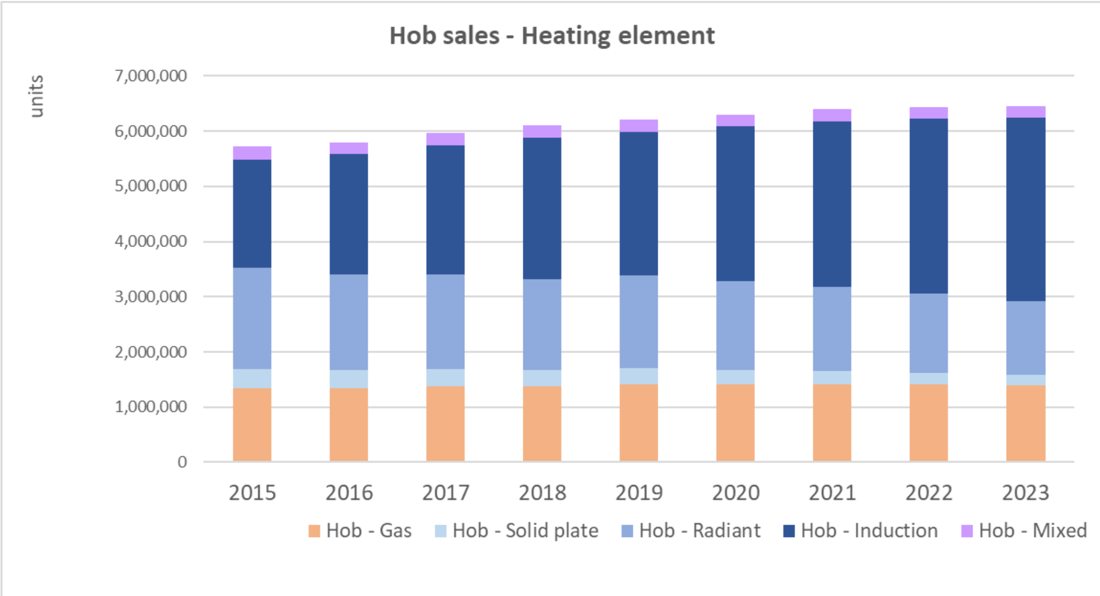
Cooker sales may see a slow decrease over the period 2018-2023, reaching slightly above 1.7 million units in 2023 (Figure 42). In this product group, less than half a million correspond to gas-heated appliances.




Euromonitor (2019)

**Figure 42. Cooker sales trends**

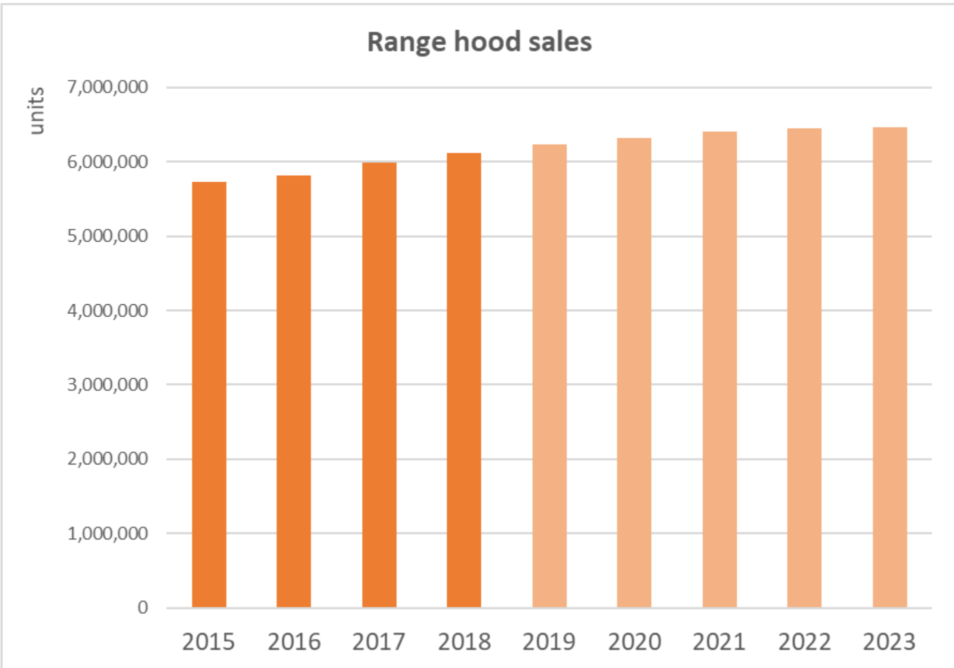
In terms of hobs, sales are expected to grow to nearly 6.4 million units in 2023, with most of the sales in that year being induction appliances (Figure 43).




Euromonitor (2019)

**Figure 43. Hob sales trends**

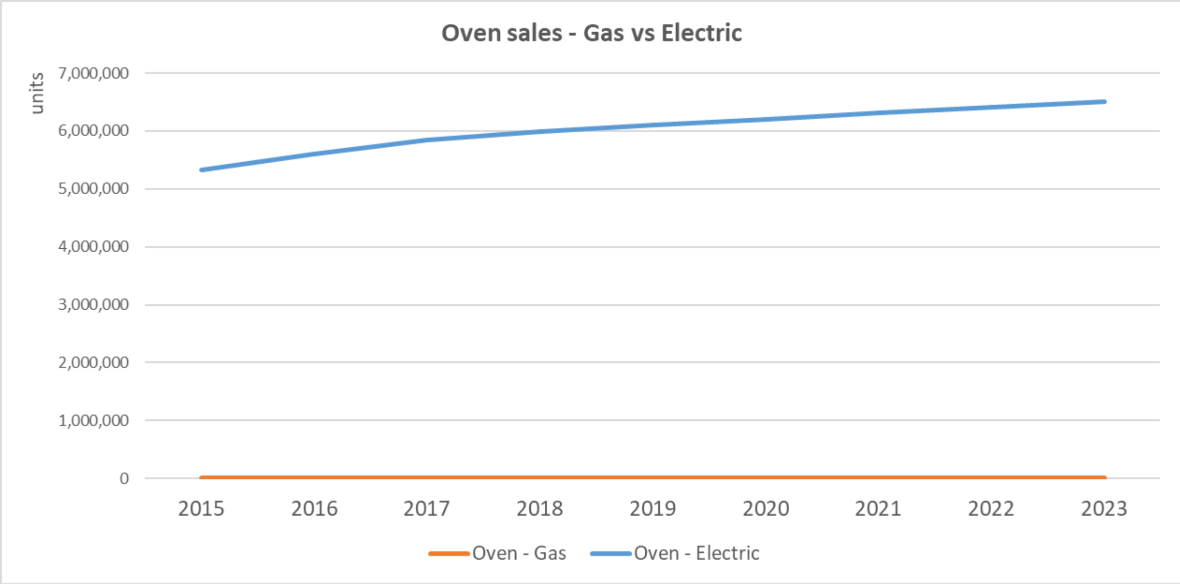
Finally, cooking fume extractors are expected to grow over the same period, reaching slightly over 6.5 million units in 2023 (Figure 44).




Euromonitor (2019)

**Figure 44. Cooking fume extractors sales trends**

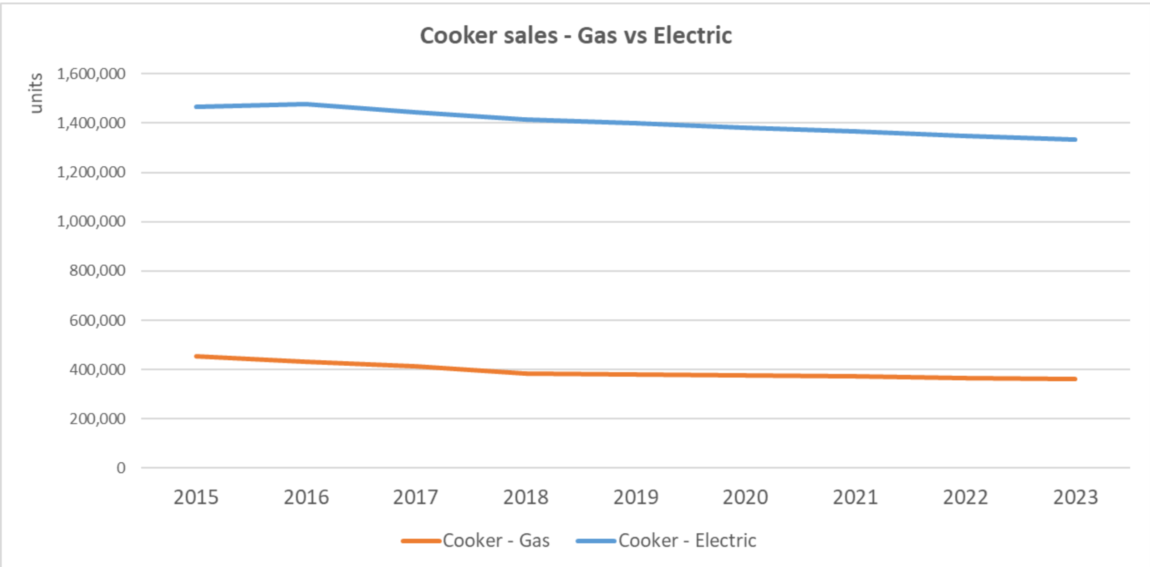
Looking specifically at technology trends for the different product groups (Figure 45), it can be seen in the first instance that electric ovens are expected to continue to dominate the market over the coming years (sales of gas ovens are so small that the red line appears almost flat on the graph).




Euromonitor (2019)

**Figure 45. Oven heat source trends**

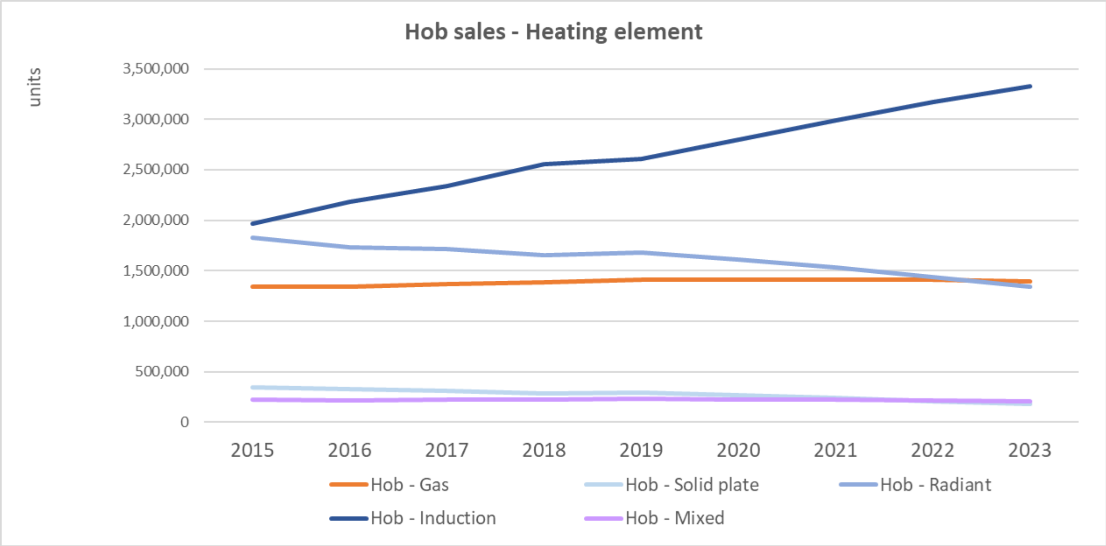
In terms of cookers (Figure 46), energy sources are distributed differently, with approximately 25% of the sales being gas and 75% electric. In both cases, sales are expected to slowly decrease over the period 2018-2023.




Euromonitor (2019)

**Figure 46. Cooker heat source trends**

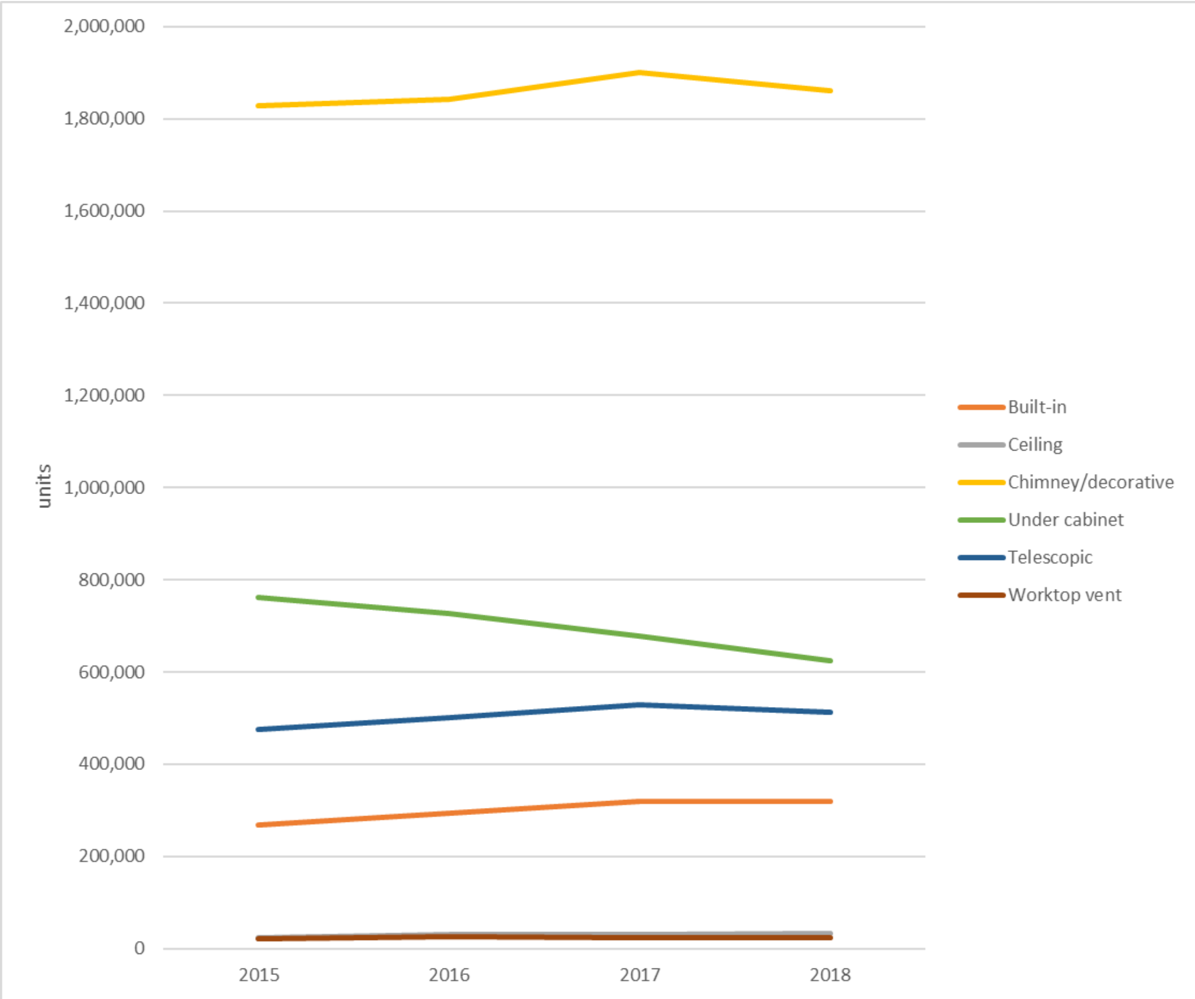
For hobs (Figure 47), induction technologies are expected to see a significant growth over the coming years. Gas hob sales are expected to grow at a very slow rate, with radiant and solid plate technologies decreasing gradually.




Euromonitor (2019)

**Figure 47. Hob heat source trends**

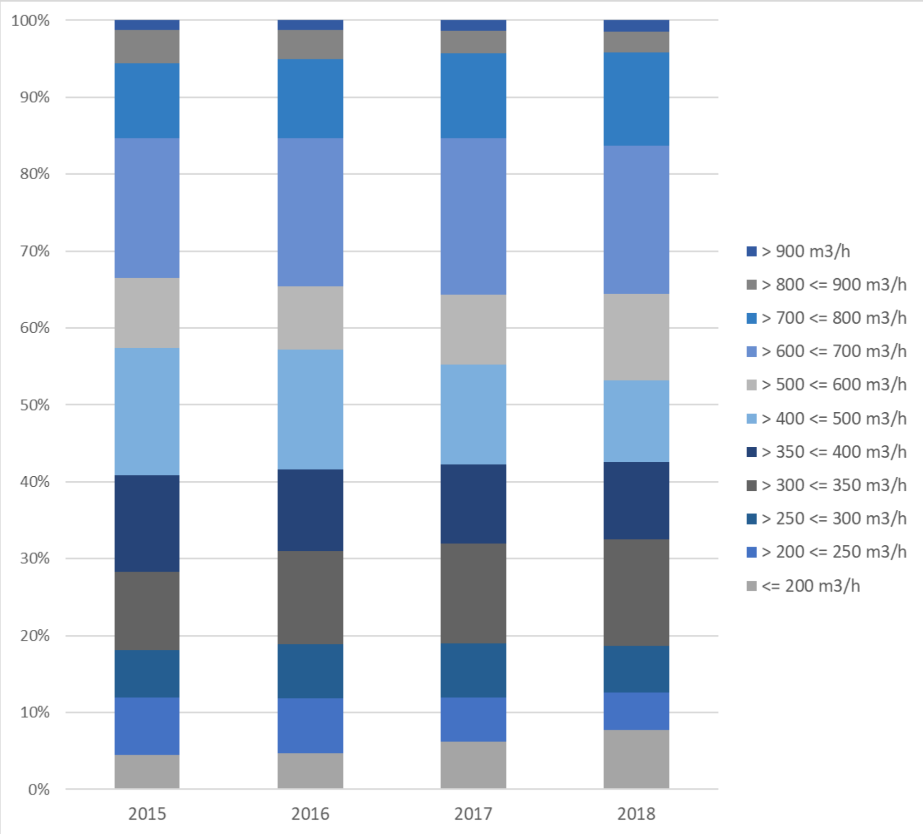
According to the market data of five EU countries, the sales of cooking fume extractors slightly decreased between 2017 and 2018. As can be observed in Figure 48, under cabinet cooking fume extractors declined at a constant pace seemingly to the advantage of built-in hoods. Chimney hoods are by far the most dominant type of cooking fume extractor among sales.




Euromonitor (2019)

**Figure 48. Evolution of sales of different types of cooking fume extractors**

In the case of the market distribution in terms of flow, no significant trend is apparent, as Figure 49 shows. The different flow ranges are relatively evenly distributed, since it is related to the different types and sizes of kitchen furniture and the space available.




Euromonitor (2019)

**Figure 49. Evolution of sales of different cooking fume extractors in terms of flow**

### 2.2.6 Stock of domestic cooking appliances

In this section, the stock of appliances will be estimated for:

a) ovens;
b) cookers;
c) hobs;
d) cooking fume extractors.

In this report, the estimation of stocks has been made based on the penetration rates published in Mugdal et al. (2011) and the results of the user behaviour study (Task 3). These sources show that the ovens and hobs market is saturated (penetration >90%) while the penetration of cooking fume extractors is lower, 45% in 2012 and 70% in 2020, and, according to the annual sales, not expected to go beyond 75%.

The changes in the stock each year are determined by the sales of appliances (entry of appliances in the stock) and the probabilities of obsolescence, which represent the number of appliances that have reached the end of their lifetime and are hence leaving the system as waste flow. The relation of these elements is presented in the following formula:

*Stock in year (X) = Stock in year (X-1) + Sales over year (X) – Obsolete products over year (X)*

In order to conduct stock estimations, data regarding annual sales of ovens, cookers, hobs and cooking fume extractors is needed for a considerable number of years in order to produce reliable forecasts. However, annual sales data for appliances is very valuable and therefore scarce. In this study, sales data is available for 2015-2018, with growth estimations for 2019-2023. Therefore, certain assumptions and estimations need to be made. The data sources and the assumptions made are detailed below:

- Annual sales data for the period 2015–2018 comes from GfK and Euromonitor.

- Annual sales data trends for the period 2019–2023 comes from Euromonitor.
- For data not available from GfK or Euromonitor, annual growth trends from Mugdal et al. (2011) have been used.
- Annual sales data for the periods 2000-2014 and 2024-2040 has been estimated based on best-fit trends for each product group.

As can be seen in Figure 50, the total stock of ovens is estimated to increase in 2019-2040 from 122 million to 154 million approximately.

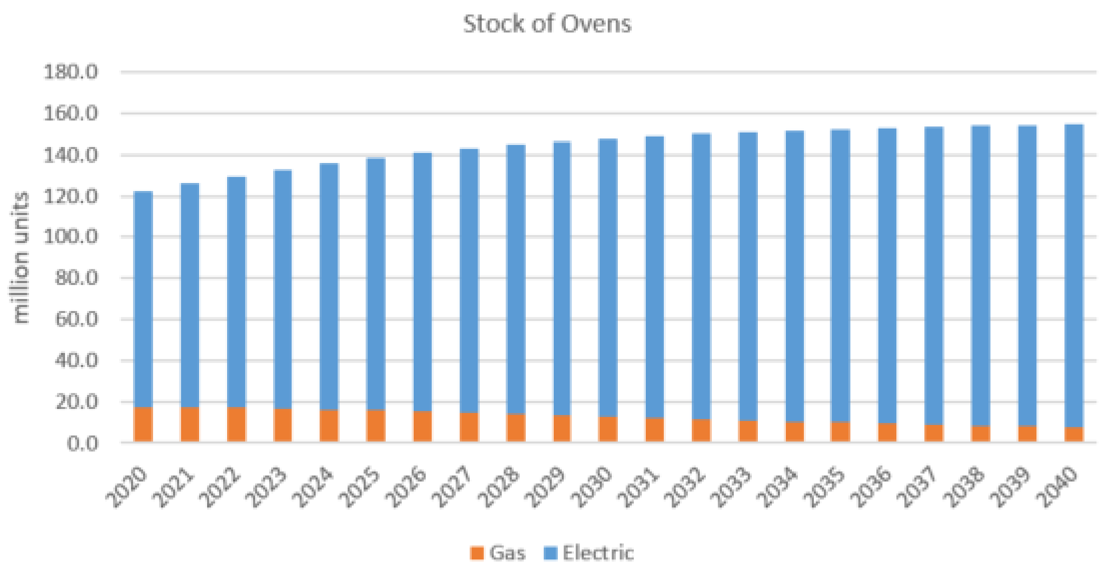



**Figure 50. Estimated oven stock in 2020-2040**

In Figure 51, the total stock of hobs is presented.

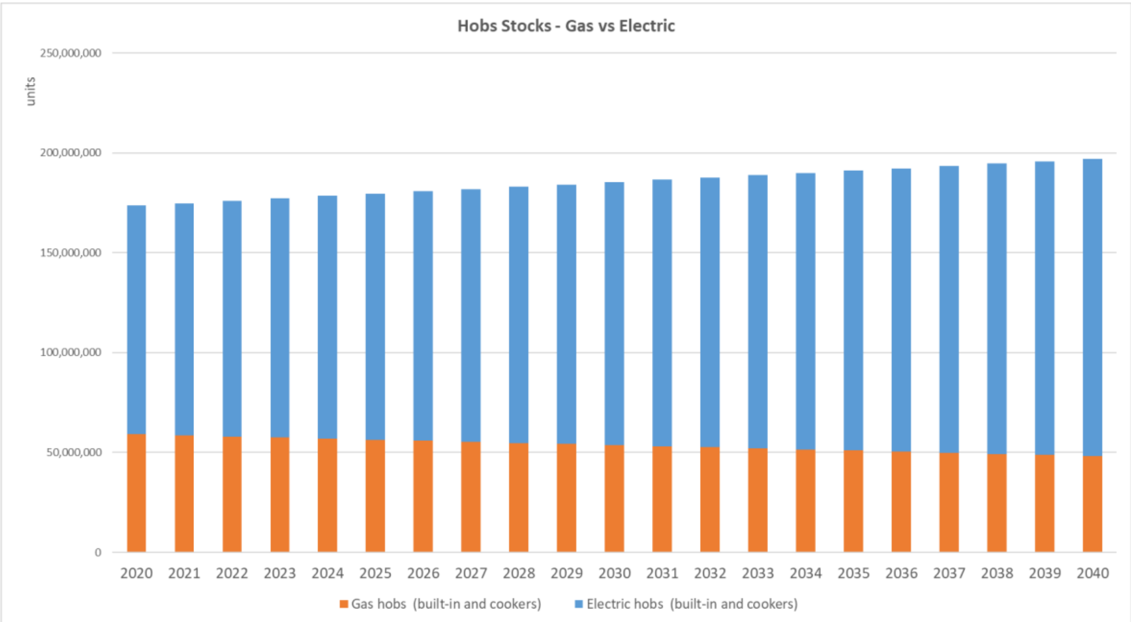



**Figure 51. Estimated hob stock in 2020-2040**

According to the sales data, induction will grow significantly, becoming the most common technology in the coming years. (Figure 52).

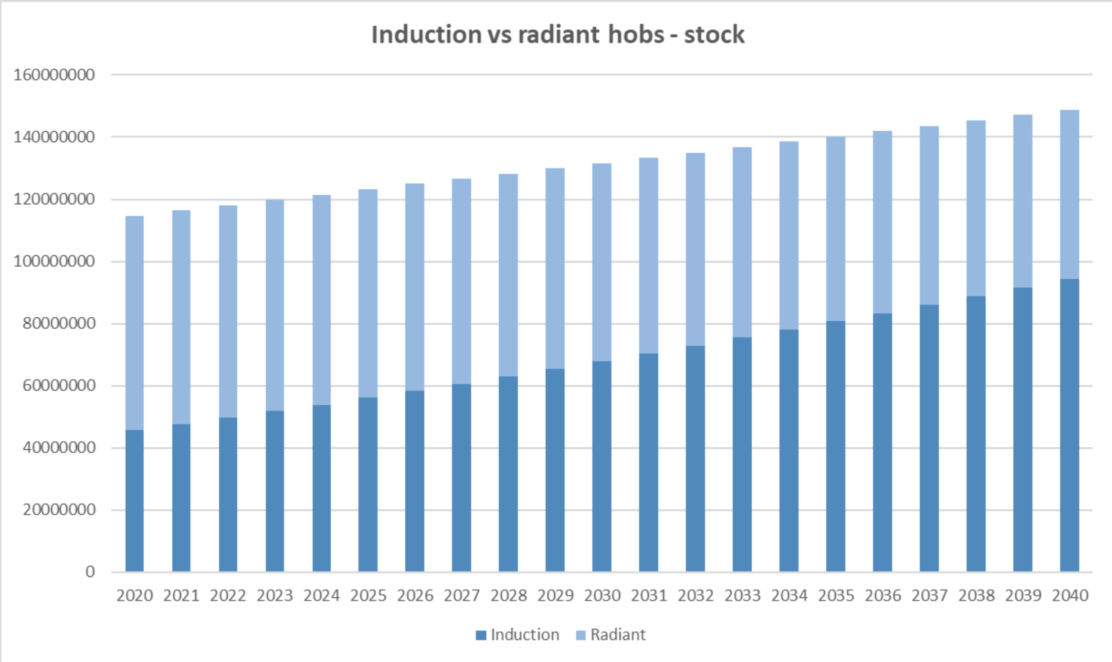



**Figure 52 Estimated induction / radiant hob stock in 2020-2040**

As can be seen in Figure 53, the total stock of cooking fume extractors is estimated to grow in 2019-2040 up to 160 million units in 2040. This growth is consistent with the expected growth in sales for the period 2015-2018 seen in Section 2.2.3.

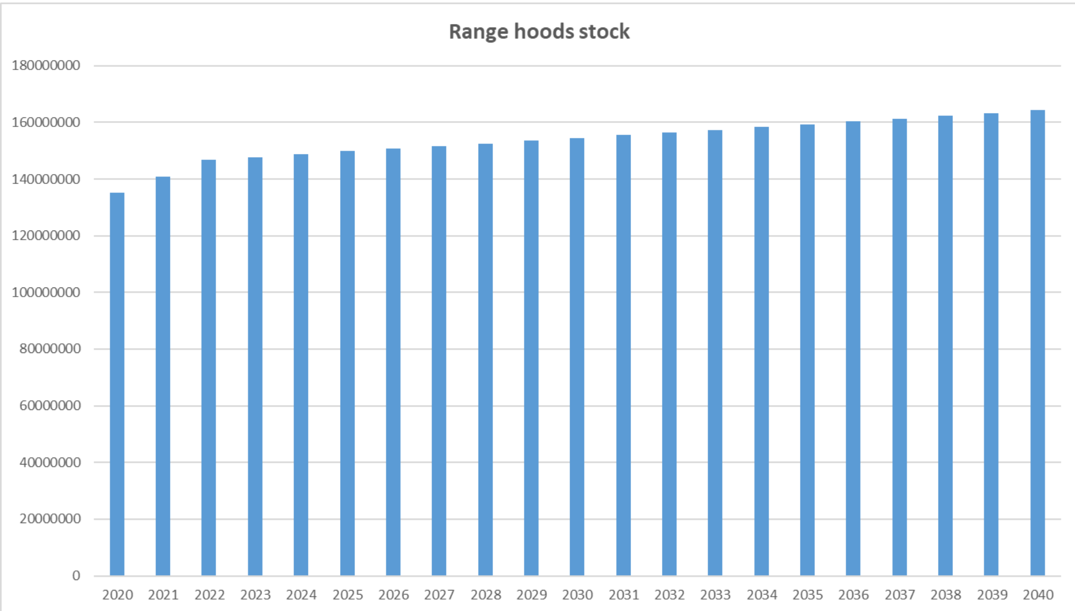



**Figure 53. Estimated cooking fume extractors stock in 2020-2040**

### 2.2.7 Stock of microwave ovens

At the time of development of this report, data on sales of microwave ovens was not available; therefore, the estimation of stocks could not be made following the same method as for the rest of product groups. However, for the development of Task 3, a survey was launched to understand the user behaviour of European consumers with regards to cooking appliances. In that study, it was estimated that the penetration rate of microwave ovens was 75.3% in 2020, or a total of 145 million appliances.

### 2.2.8 Market structure of the European domestic cooking appliances industry

According to Mudgal et al. (2011), the domestic oven market appears to be highly concentrated. In 1999, the three leading manufacturers covered between 40% and 80% of the market (e.g. General domestic appliances and Electrolux in the UK and BSH in Germany). The situation was considered to be similar in 2008, even though the number of brands rose due to increased competition, especially from Asian manufacturers.

The relevance of original equipment manufacturers (OEMs) in the domestic cooking appliance sector is significant. OEMs are producers of appliances for other brands, which generally operate as small and medium enterprises (SMEs). According to Mudgal et al. (2011), they manufactured approximately 25% of appliances in 1999. In that year, most of the factories were located in Italy, Germany and the UK. Some manufacturers also own factories outside the EU (in eastern Europe or Turkey). The size of the factories is variable, from 50 to more than 3 000 employees. The production of these factories is also very variable, potentially ranging from 30 000 to 300 000 units. APPLIA provides an indication of the location of large home appliances manufacturing sites in Europe in 2018 (Figure 54).


APPLIA (2019)

**Figure 54. Large home appliances manufacturing sites in Europe in 2018**

As can be seen in Figure 54, the countries with the highest number of manufacturers are Germany and Italy, followed by France, Poland and Turkey. Spain, the UK and Romania also have a significant number of manufacturing sites.

Since the publication of Mudgal et al. (2011), not much data has been made publicly available regarding cooking appliances specifically. Most of the data in this section will therefore refer to household appliances in general: it will include cooking appliances in particular but also fridges, washing machines, dishwashers, etc.

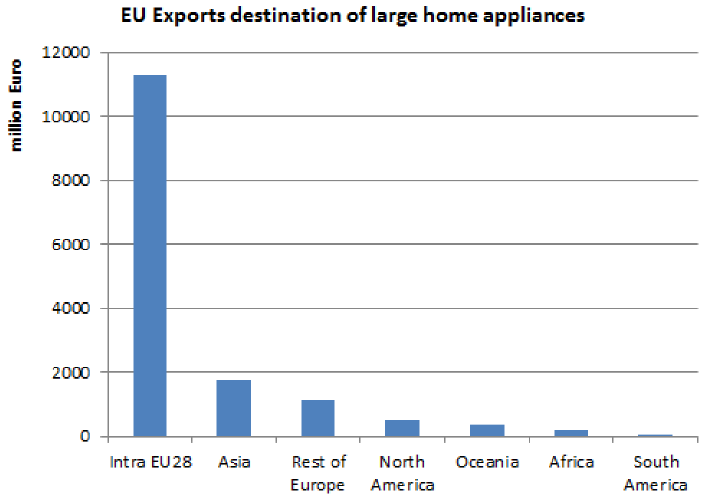
In terms of value, the global household appliances market was valued at USD 501 532 million in 2017 and is projected to reach USD 763 451 million by 2025, growing at a CAGR of 5.4% from 2018 to 2025 (AMR, 2019). Some of the key factors affecting this growth are:

- technological advancements;
- shift towards more energy-efficient appliances;
- rapid urbanisation;
- growth in housing sector;
- rise in per capita income;

- improved living standards;
- surge in need for comfort in household chores;
- change in consumer lifestyle;
- escalating number of smaller households.

Considering distribution channels, AMR indicates that most household appliances are purchased through specialist stores, followed by supermarkets/hypermarkets, online commerce and others. This trend is expected to continue towards 2025. The biggest growth is expected to happen in the e-commerce segment, due to the high penetration of internet connection and smartphones.

A brief analysis by region shows that the European market has been experiencing growth owing to low interest rates and a good economic situation. The market has been witnessing an increase in demand for premium built-in or integrated appliances such as ovens, with an integrated steam function, flexible induction hobs and integrated hob extractors. Destinations of EU exports can be seen in Figure 55.




APPLIA (2019)

**Figure 55. EU export destinations of large home appliances in 2017**

Still focusing on the EU market, the top five exports destinations outside the EU were Russia, the USA, Norway, Switzerland and Australia. Meanwhile, the top five countries of origin of large home appliances from outside the EU were China, Turkey, South Korea, Malaysia and Russia.

North America is a mature and homogeneous market for household appliances with high product penetration. The demand for household appliances is dominated by product replacement. The Asia-Pacific household appliances market is anticipated to witness strong growth owing to an increase in household income, rapid urbanisation, an increase in the middle-class population, easy access to goods through development of retail channels, easy access to consumer finance, and a change in lifestyles of the population.

## 2.3 Consumer expenditure base data

This section presents purchase prices, installation, repair and maintenance costs as well as applicable rates for running costs (e.g. electricity, natural gas) and other financial parameters (e.g. taxes, rates of interest, inflation rates). This data will be input for later tasks where Life Cycle Costing (LCC) for new products will be calculated.

The average consumer prices and costs experienced by the end user throughout the product lifetime are determined by unit prices in the following categories:

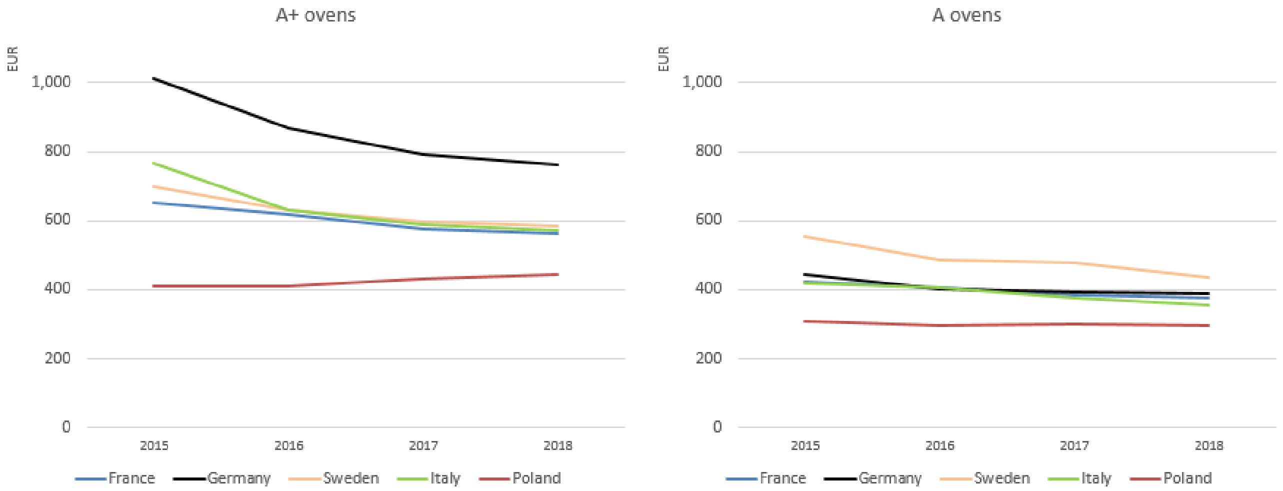
- average price per unit for each category;

- consumer prices of electricity and fuel;
- inflation and discount rate;
- installation costs;
- repair and maintenance costs;
- disposal tariffs and end-of-life cost.

### 2.3.1 Average unit values of domestic cooking appliances

#### 2.3.1.1 Average unit value of ovens

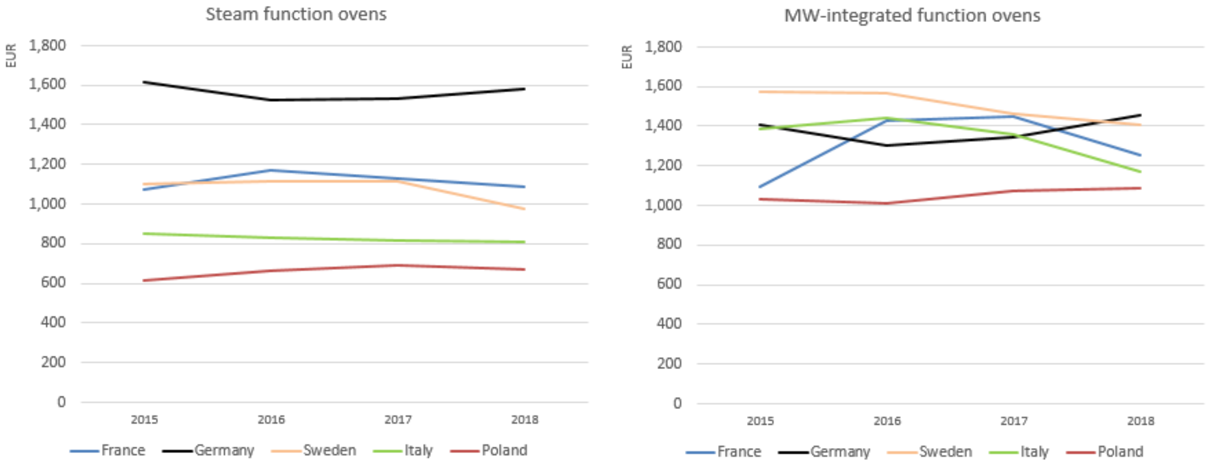
In Figure 56, a comparison is made between the two most common energy classes for ovens (A+ and A) for five different countries in terms of price. As can be seen, there is a significant difference between the price of A+ and A ovens. Both energy classes saw a decrease in price between 2015 and 2018.




GfK (2019)

**Figure 56. Price of ovens by energy class**

In Figure 57, a comparison is conducted between two different functions offered by ovens (steam and microwave functions) for five different countries in terms of price. As can be inferred from the graph, both functions tend to be found in high-end products. A wider range of prices can be seen in steam-assisted ovens, whereas prices of microwave-assisted ovens tend to be consistently higher. Prices of ovens with both types of functions are stable over the period 2015-2018.

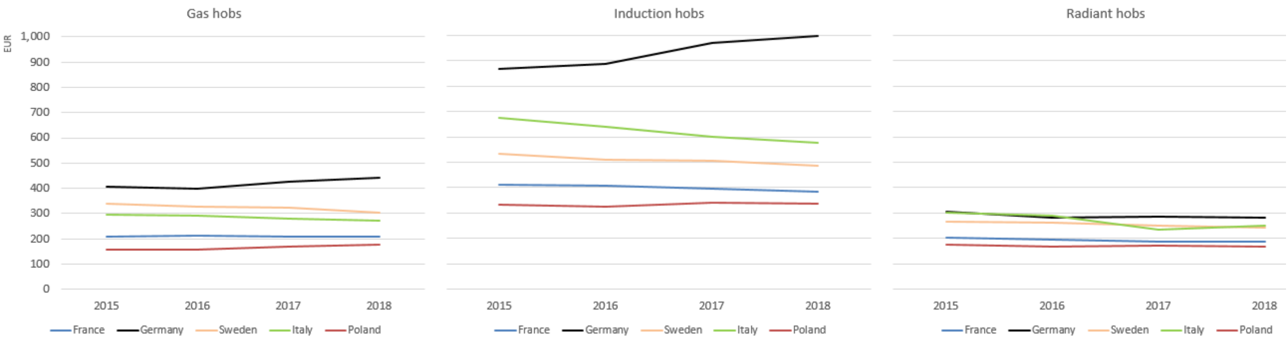



GfK (2019)

**Figure 57. Price of ovens by function**

#### 2.3.1.2 Average unit value of hobs

In Figure 58, a comparison is made between three different heating elements for hobs (gas, induction and radiant) for five different countries in terms of price. As can be seen, the most expensive technology is currently induction. Gas and radiant hobs tend to have similar prices, with a wider range for gas appliances. Prices of the three types of technologies are stable over the period 2015-2018.

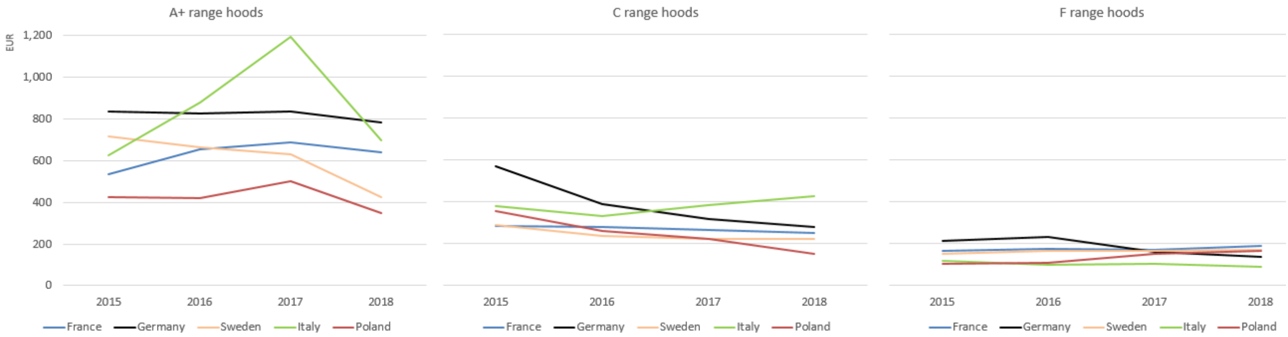



GfK (2019)

**Figure 58. Price of hobs by heating element**

#### 2.3.1.3 Average unit value of cooking fume extractors

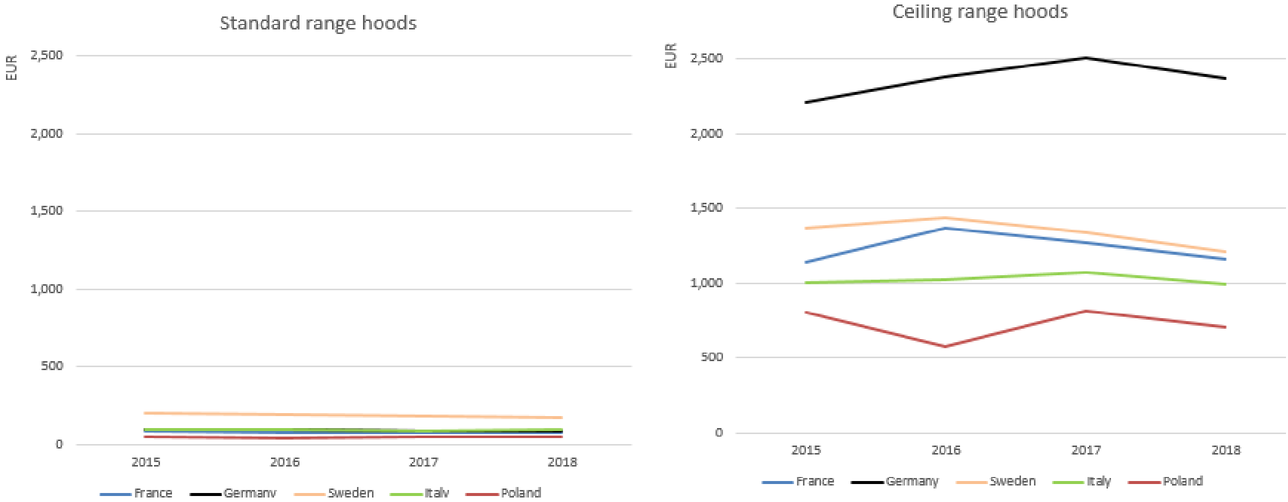
In Figure 59, a comparison is made between three different energy classes for cooking fume extractors (A+, C and F) for five different countries in terms of price. As can be seen, there is a clear correlation between energy class and price in the case of cooking fume extractors. The top categories (A+) have significantly higher prices than middle and low categories (C and F).




GfK (2019)

**Figure 59. Price of cooking fume extractors by energy class**

In Figure 60, a comparison is made between two different mounting configurations in cooking fume extractors (standard and ceiling) for five different countries in terms of price. Standard cooking fume extractors tend to be in the lowest energy classes and ceiling cooking fume extractors tend to be in the top energy classes, as seen in Figure 34. Price is consistent with what was already observed previously: standard cooking fume extractors are in the lower spectrum of prices (the most expensive is less than EUR 250), whereas ceiling cooking fume extractors are in the highest spectrum (with cooking fume extractors up to EUR 2 500).

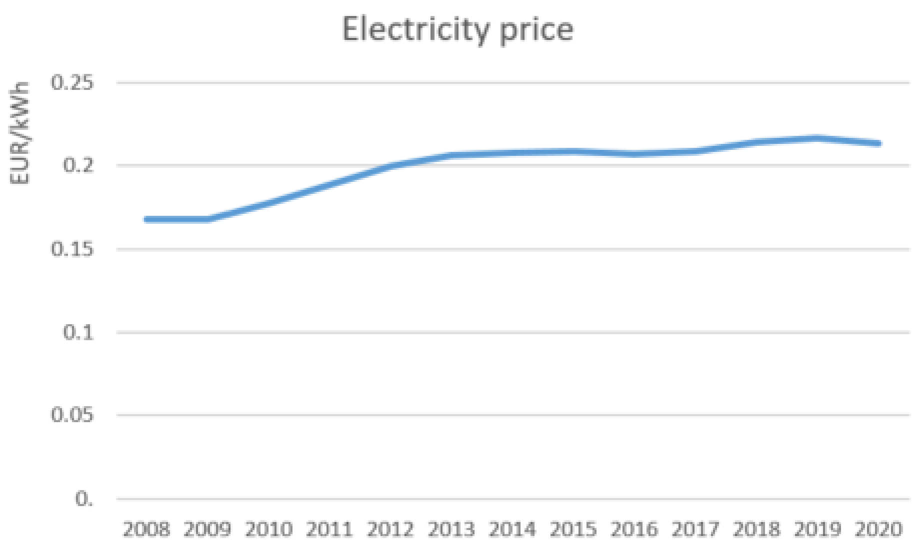



GfK (2019)

**Figure 60. Price of cooking fume extractors by configuration**

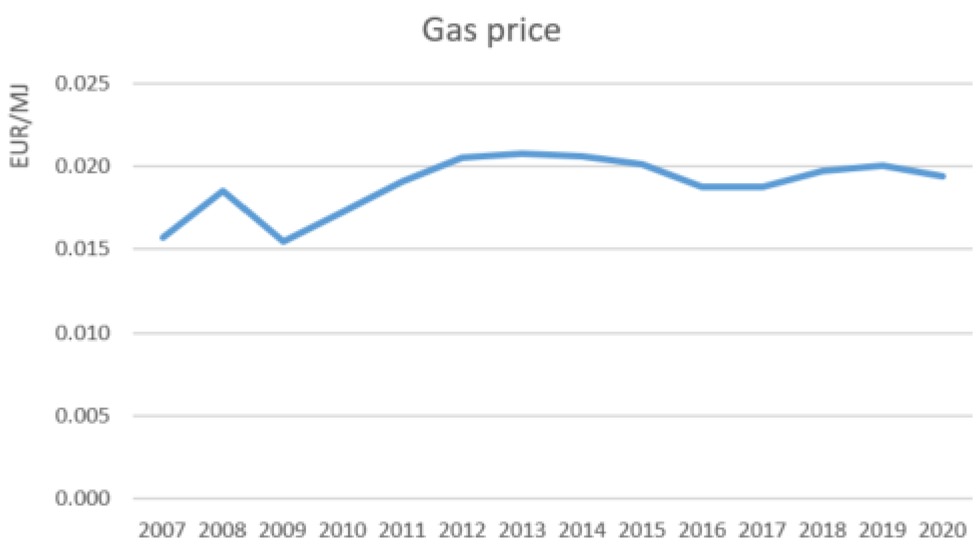
### 2.3.2 Consumer prices of electricity and gas

Annual energy prices for the period 2008-2020 are taken from Eurostat:




Eurostat (2022)

**Figure 61. Electricity price**




Eurostat (2022)

**Figure 62. Gas price**

It must be noted that energy prices used in this report were taken from Eurostat in February 2022. Those prices contain data up to 2021. The European situation in terms of energy cost and availability has changed significantly at the time of publication of this report (end of 2022), with electricity and gas prices much higher than the ones showed in Figure 61 and Figure 62. The extraordinary situation in terms of energy prices of 2022 has not been taken into account in this report, and this must be taken with caution when interpreting consumer expenditure results.

### 2.3.3 Installation, repair and maintenance costs

If the installation, repair or maintenance requires a professional service, the average EU labour cost in the category "Industry, construction and services (except public administration, defence, compulsory social security)" is to be used, as shown in Table 16[9].

**Table 16. Average total labour costs for repair services**

| Year | 2000 | 2004 | 2008 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|
| EU-28 countries, (EUR/h) | 16.7 | 19.8 | 21.5 | 23.9 | 24.2 | 24.5 | 25.0 | 26.0 | 26.7 | 27.4 |

### 2.3.4 Disposal tariffs/ taxes

Since domestic cooking appliances are covered by the WEEE Directive and producers are responsible for paying a WEEE tax or in some other way financing the EoL treatment, it is assumed that end users will not experience any further EoL costs. The WEEE tax paid by manufacturers is assumed to be reflected in the sales prices of cooking appliances to end users. In the end user life cycle cost calculations, the EoL cost is therefore set to zero.

## 2.4 Conclusions

**Ovens and cookers conclusions**

In terms of sales and technology, the following trends can be observed:

- Total oven sales are growing steadily. The vast majority of consumers today purchase electric ovens.
- Steam-assisted oven sales are growing rapidly, although they are still a very small part of the market.
- MW-combi oven sales are stable and are a very small part of the market.
- Larger-cavity-volume oven sales are growing and currently are the preferred option of consumers.
- Connected oven sales are growing rapidly, although they are still a very small part of the market.
- Total cooker sales are decreasing. The majority of consumers prefer electric cookers.

In terms of energy classes (ovens), the following trends can be observed:

- There are no A+++ ovens and only 0.06% are A++ (top energy classes).
- The A+ category grew to 29% in 2018.
- The vast majority of ovens are either A or A+ (originally middle energy classes, and now the lowest two).
- Nearly 70% of ovens in 2018 are A (minimum possible class after 2020).
- 0.24% of ovens in 2018 are either B or C (banned after 2020).
- There are no ovens in the lowest energy class (D).
- It appears that there is a bigger proportion of larger cavity volumes in the top energy classes (A++ and A+) than in the low energy classes (A and B).

[9] http://ec.europa.eu/eurostat/cache/metadata/en/lc_lci_lev_esms.htm#unit_measure1475137997963

- It seems easier to reach the top energy classes when the oven has a steam heating function supporting the convective function. However, these appliances have improved sealing with reduced vapour outlet, which leads to better results in the standard test, although the vapour function may not be active.

In terms of energy classes (cookers), the following trends can be observed:

- There are no A+++ or A++ cookers (top energy classes).
- The A+ category grew very slowly to 2% in 2018.
- The vast majority (79%) of cookers are A (minimum energy class after 2020).
- 4.5% of cookers in 2018 were either B or C (banned after 2020, except as part of multi-cavity units where B is still allowed for the second and any additional cavities).
- There are no cookers in the lowest energy class (D).

**Hobs conclusions**

- Induction technologies are expected to see a significant growth over the coming years. Gas hob sales are expected to grow at a very slow rate, with radiant and solid plate technologies decreasing gradually.

**Cooking fume extractors conclusions**

- The energy classes of the sales have improved over recent years, and worktop vent hoods have reached A++. However, the market share of this type of hood is very low (<1%). Under cabinet hoods are in the worst energy classes (C to E), and their sales show a downward trend.
- There seems to be a relation between energy class and flow, since the data available shows a concentration of the best energy classes in the larger flow ranges and of the worst energy classes in the smaller flow ranges. However, there is not a significant trend towards a specific flow range, probably because the flow and the size of the hood are dependent on the kitchen furniture and space available, which significantly vary across EU households.

# 3 Task 3. Analysis of user behaviour and system aspects

User behaviour has a significant effect on the environmental impacts of domestic cooking appliances during all phases of their life cycle: firstly through the selection of the appliance type, secondly through the actual use of the appliance over its lifetime and finally on the end-of-life. To some extent, product design can also influence consumer behaviour and consequently the environmental impacts and the energy efficiency associated with the product's use.

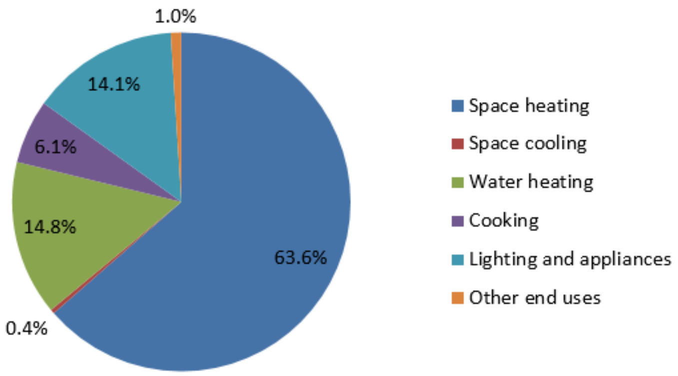
The aim of this section is to investigate the influence of consumer behaviour on the energy and environmental performance of cooking appliances, as well as best practices in sustainable product use.

- In Section 3.1, the relevance of the energy consumption of domestic cooking activities will be put in perspective within the European context.
- In Section 3.2, system aspects affecting energy consumption such as frequency of use and duration of cycles will be presented. This section will include currently available published data and will be used for reference.
- In Section 3.3, other aspects affecting total energy consumption such as purchasing decisions and cooking habits will be presented.
- Section 3.4 will provide aspects related to user behaviour cooking habits.
- Section 3.5 will cover aspects related to the information offered to consumers.
- In Section 3.6, aspects related to user behaviour and end of life –such as reusability, reparability and disposal channels- will be presented.
- In Section 3.7, aspects related to local infrastructure will be addressed. For domestic cooking appliances, these will be mainly related to the effects of product installation and maintenance on performance and durability.
- Section 3.8 will include the results of a complete user behaviour study, with information on frequency of use, duration of cycles and preferred programmes and modes.

## 3.1 The relevance of domestic cooking activities in the EU context

In 2017, households' energy consumption represented 27% of the total final energy consumption in the European Union (Eurostat, 2017), being the second highest consuming sector after transport (33%). The peak energy consumption in the residential sector was observed in 2010 with 3 721 MWh, with a slight decrease of 9% since then (European Commission, 2018). Total energy consumption in EU households may be reduced with the help of energy efficiency initiatives. It has been estimated that European households could save roughly 27-30% of their energy usage by correcting inefficiencies (PENNY, 2019).

Energy is used for various purposes within households: space and water heating, space cooling, cooking, lighting and other electrical appliances and other end uses. Most of that energy is spent in space heating (64%). Cooking activities represent 6.1% of household electricity consumption (Figure 63).




Eurostat (2019)

**Figure 63. Final energy consumption in the residential sector of the EU-28**

The average annual energy consumption for cooking has been estimated at 460 kWh per year and person (Zimmermann et al., 2012). Energy consumption also differs significantly depending on the type of household and on the level of occupancy. The highest energy consumption has been reported in households with single non-pensioner inhabitants, with 505 kWh/year and person, whereas the lowest average is in households with multiple people and with children: 422 kWh/year and person (Zimmermann et al., 2012).

The share of final energy consumption dedicated to cooking activities within the household varies considerably when analysing Member States individually, ranging from 1% up to 39%. Several factors can affect that wide variability. First, in certain countries, most of the energy may be used in other areas, such as space heating (as happens in Finland with 66%), reducing proportionally the share dedicated to cooking. In fact, it is observed that most of the countries with the highest proportion of energy dedicated to cooking are in the South/Mediterranean area (Portugal, 39%; Malta, 12%; Spain, 8%), whereas those with the lowest proportion tend to be in the North (Finland, 1%; Sweden, 2%; Denmark, 2%; UK, 3%). Differences in terms of food culture and diet may have an influence on the energy spent on cooking.

## 3.2 Reference values of frequency of use and energy consumption

In the current version of the energy label, the energy consumption of domestic cooking appliances is measured as in Table 17.

**Table 17. Energy consumption for domestic cooking appliances**

| Appliance | Energy efficiency in product declaration | Unit |
|---|---|---|
| Ovens | Energy per cycle | Electric (kWh/cycle)<br>Gas (MJ/cycle) |
| Hobs | Energy per amount of standard load | Electric (kWh/kg water)<br>EE[1] (%) |
| Cooking fume extractors | Energy per year | kWh/year |

1. EE is expressed in % in gas hobs but is also related to the energy required to heat a standard amount of water (see Task 1 for details).

A key parameter in the analysis of user behaviour for cooking appliances is the frequency of use (generally expressed in cycles/year). A secondary but also relevant parameter will be the duration of each cycle (generally expressed in minutes/cycle). Data published so far on those two parameters is presented in Section 3.2.1. Based on frequency of use, typical energy consumption values are presented in Section 3.2.2.

### 3.2.1 Frequency of use of domestic cooking appliances

European citizens invest a considerable amount of time in cooking at home, both on weekdays and at weekends. As was analysed in Foteinaki et al. (2019) for the case of Denmark, at certain times of the day, nearly 30% of the population may be performing cooking/eating-related activities.

Similar patterns, with slight differences, are observed in other European countries. As indicated in Santiago et al. (2014), food preparation shows a small peak in the morning, another much larger peak at midday (with 20% of households involved in this activity on weekdays and more than 30% at weekends), and another peak corresponding to the evening. In that study, it is shown that there are differences in the schedules and habits among the different European countries, reflecting different lifestyles and routines, closely linked to the customs, practices and climate of each zone. Another relevant comment pointed out by the authors is that energy consumption related to cooking activities coincides with household active occupancy peaks and with the greatest electricity demand in the residential sector. This is a time interval which is difficult to modify, as it is closely linked to habits and working schedules and therefore occupants must necessarily be in the home.

In general, cooking activities last between 36 and 43 min/day, with slightly longer durations at weekends and in colder seasons (Barthelmes et al., 2018). Lower energy consumption for cooking activities in summer is also observed, mainly because of the type of meals prepared and the time spent on cooking (Zimmermann et al., 2012). In Wood et al. (2003), it is also observed that the energy consumption for cooking on an average Sunday is twice the energy consumption on the average weekday. Santiago et al. (2014) also indicate that the size of the municipality has a certain influence on the amount of energy spent on cooking activities. In small municipalities, there are more homes dedicated to cooking than in cities during the day. At the midday peak, for instance, there are 8% more households engaged in this activity than in big cities.

The consequences of the COVID19 pandemic, with a significant increase in the number of people who are teleworking more often, might have had an impact on cooking behaviours, such as an increase in the frequency of use of the appliances. However, the user behaviour section of this study was developed before 2020, so these effects are not considered in the analysis.

**Ovens**

In the Preparatory Study for Domestic cooking appliances it is stated that on average a household uses the oven 110 times per year (Table 18). The average duration of uses was estimated at 55 minutes for both electric and gas ovens.

**Table 18. Frequency of use and cycle duration for ovens**

| | **Electric oven** | **Gas oven** |
|---|---|---|
| Frequency of use (uses/year) | 110 | 110 |
| Average duration of cycle (min) | 55 | 55 |
| Standby mode (hours/year) | 8595 | 8595 |

*Source:* Mudgal et al. (2011)

**Hobs**

In the Preparatory Study for Domestic cooking appliances the frequency of use for domestic hobs is given as 424 cycles per year (Table 19).

**Table 19. Frequency of use and cycle duration for hobs**

| | Gas | Solid plate | Glass-ceramic | Induction |
|---|---|---|---|---|
| Frequency of use (cycles/year) | 424 | 424 | 424 | 424 |
| Average duration of cycle (min) | n/a | 26 | 45 | 58 |

*Source:* Mudgal et al. (2011)

According to Mudgal et al. (2011), induction hobs are used for an average time of 58 minutes per cycle, whereas for ceramic and solid plates it is 45 minutes and 26 minutes respectively (Table 19). The differences in times are not explained in the report, even though induction hobs heat food more quickly with lower heat losses and therefore shorten the cooking time and consume less electricity annually than other types of hobs. An explanation could be related to different usage patterns.

**Cooking fume extractors**

In the Preparatory Study for Domestic cooking appliances no data is provided on cooking fume extractors in terms of frequency of use or duration of cycles. According to a stakeholder, a cooking fume extractor operates for approximately **300 hours/year**. Other stakeholders indicate that, according to internal company studies, all speeds of cooking fume extractors (minimum, medium, maximum) are used equally, whereas boost mode is rarely activated and is used only during specific types of cooking. The frequency of use is **1-3h/day**.

### 3.2.2 Typical energy consumption of domestic cooking appliances

In this section, typical energy consumption values (primary energy) are presented, based on the available bibliography.

**Ovens**

In terms of ovens, Mudgal et al. (2011a) gathered data on user behaviour; specifically, information on typical dishes, the number of times they were prepared and the temperature used was collected for several countries. The study concluded that it was not possible to identify major differences in oven use practices. Information was collected for six different types of cooking uses: meat, home-made meals, cakes/bread, snacks, ready meals, and reheating.

A decrease in the consumption per use of 25% from 1980 to 2008 was also reported, possibly due to the fact the market share of more energy-efficienct ovens and cookers increased, although the energy consumption in additional functions (such as standby power) also increased, and to shrinking households and the shift to other appliances (e.g. microwave ovens). Values for energy consumption, frequency and duration used in the Preparatory Study for Ecodesign Requirements for Cooking Appliances are presented in Table 20.

**Table 20. Electricity consumption of electric and gas ovens**

| | Electric oven | Gas oven |
|---|---|---|
| Energy consumption | 1.1 kWh/cycle | 1.67 kWh/cycle |
| Annual electricity consumption (kWh/year) | 164 | 184 |

*Source:* Mudgal et al. (2011)

**Hobs**

Energy consumption values used for scenario modelling and analysis in the Preparatory Study for Ecodesign Requirements for Cooking Appliances are reported in Table 21. The figures below do not include standby consumption.

**Table 21. Energy consumption of hobs**

| | Gas | Solid plate | Glass-ceramic | Induction |
|---|---|---|---|---|
| Energy consumption (kWh/cycle) | 0.78 | 0.58 | 0.57 | 0.45 |
| Annual energy consumption (kWh/year) | 334 | 250 | 240 | 190 |

*Source:* Mudgal et al. (2011)

Regarding gas hobs, Mudgal et al. (2011) suggested that the evolution of gas hobs' energy consumption was roughly constant for 20 years (1980-2008), as the main parameters remained constant: the consumption per use and the number of uses per year. The reason for the slight increase in the evolution is the standby power demand, which has increased in recent years.

According to a stakeholder, the energy consumption of current hobs is around **0.55 kWh/cycle for radiant vitroceramic** and around **0.75 kWh/cycle for gas**. These figures are in the same order of magnitude as in the preparatory study.

**Cooking fume extractors**

In the Preparatory Study for Domestic cooking appliances no data is provided on cooking fume extractors in terms of energy consumption.

According to a stakeholder, the energy consumption of domestic cooking fume extractors is **between 36.5 kWh/year and 72.1 kWh/year**, depending on different performance factors such as airflow, lighting power and grease filtering efficiency.

## 3.3 Purchase of domestic cooking appliances

Most of the households in the EU-28 have some type of oven, hob and hood. In a study focused on Denmark (Foteinaki et al., 2019), it is stated that these appliances can be found in 90% of households. Separate hobs or ovens are present in 14% and 12% of households respectively (EIA, 2019).

On a similar topic, some authors (Baldini et al., 2018) have focused their analysis on the socioeconomic characteristics that can best predict the decision to purchase energy-efficient appliances in general (not focused on cooking appliances). The variables used in this study were the number of inhabitants in the household, the type, age and size of house, the age of respondents, their job, their income and their environmental awareness. Some of the findings from this study are summarised below:

- The higher the income, the higher the probability of choosing more energy-efficient appliances.
- It is more likely that more energy-efficient appliances are chosen in farmhouses and single houses than in townhouses and apartments.
- The higher the number of people living in the dwelling, the greater the propensity to choose an energy-efficient appliance.
- The higher the environmental awareness and behaviour, the higher the chance of selecting a more energy-efficient appliance.
- Older respondents have a higher propensity to choose energy-efficient appliances.

Since there is no specific research on purchase behaviour for cooking appliances, it is only possible to extrapolate conclusions from previous studies on different products. Some of the potential aspects influencing purchase behaviour for ovens, hobs and hoods are commented on in this section.

**Price** and **cost of use** are obvious factors that may affect purchase decisions relating to cooking appliances. At an equal level of performance in terms of features/functionalities or energy consumption, consumers will likely prefer appliances that allow them to save money across their lifetime if that information is readily available to them. Aspects which may influence consumers when acquiring a more expensive product –with a similar performance- are brand reputation or aesthetics. It has been demonstrated that consumer age is a factor that correlates with the amount of money spent on home appliances (Hennies et al., 2016). In general, younger people buy significantly more low-cost appliances such as washing machines and TVs. It has also been observed that the price paid for these appliances correlates significantly with the lifespan of the appliance.

Related to price and cost of use, **durability** is a relevant factor as well that may affect purchase decisions. In the case of cooking appliances, consumers tend to prefer ovens, hobs and hoods that guarantee longer periods without maintenance needs or critical failures. Durable products avoid –or significantly delay - the need to acquire new appliances to substitute old ones. Consumers have shown a clear preference for durable products: in Perez-Belis et al. (2017), it was concluded that 79% of consumers find it very important to include durability requirements in the product design.

In terms of the **second-hand market**, there is not much data publicly available for ovens, hobs and cooking fume extractors. With regards to other home appliances such as small devices, it has been estimated that only 12% of the population actually purchase second-hand products (Bovea et al., 2018), and that when they do it is mainly due to economic reasons (environmental aspects are generally ignored). This figure is even lower in Perez-Belis et al. (2017), where only 0.75% of respondents to a survey admitted having bought second-hand small home appliances. When they actually did, they did not invest more than EUR 20 in them.

In terms of the barriers creating this low preference for second-hand products from the consumers' side, the most common are the association with potential premature failure of second-hand products, health, safety and hygiene concerns, perception of inferior quality, perception of little difference in price between new and second-hand products, lack of repair guarantees and a general desire to acquire new products. In addition to those, second-hand product sellers also argue that barriers for this market to grow are the unpredictability of supply and demand, the lack of legal incentives to promote repair and the perception that, on occasions, consumers may feel ashamed of purchasing second-hand products (Bovea et al., 2017).

Other authors suggest that the **reputation** of the seller of the second-hand product is important. Reputation mechanisms such as the ones in online second-hand selling sites can provide signals about product or service quality and help mitigate uncertainties faced by potential buyers of remanufactured products. It has also been observed that consumers pay relatively higher prices (8%) for products remanufactured by OEMs or their authorised factories than those remanufactured by third parties (Subramanian et al., 2012).

Another important purchase decision regarding cooking appliances may be the **energy source**. Considering that, it is relevant to point out that most ovens and hobs in the EU are electrically heated. The market share of electrical appliances is growing even bigger, with gas appliances still at a significant 16% for ovens and 36% of for hobs (European Commission, 2012).

Another factor that can influence the selection of gas or electric appliances is the **local infrastructure**. For example, many rural locations throughout the EU are not connected to natural gas distribution networks and so, if gas cooking is preferred, users need to use bottled gases which are far more expensive than natural gas. This cost difference encourages the selection of electric cooking appliances instead of gas. On the other hand, there are also kitchens which are equipped with a gas connection and not with a three-phase electrical outlet. In this case, the consumer will very likely purchase a gas appliance instead of an electric appliance.

An important aspect influencing the purchase decision is the amount and type of **information provided** to the consumer. According to the results presented in PENNY (2019), providing tailored information about the potential for monetary savings by adopting new energy-efficient durables induces households to purchase home appliances that consume on average 18% less electricity compared to those purchased by households that did not receive such information. In the same study, it is also highlighted that what matters is not only the content of the information provided, but also the way in which this information is presented. For instance, if information on energy usage cost for a specific product is presented –instead of monetary savings-, consumers tend to shift towards less efficient products. The format of the information presented is therefore a strong moderator of the effectiveness of information policies on investments.

Another important factor is **literacy** regarding energy consumption and the related environmental impact of appliances. It has been observed that households with a low degree of energy literacy tend to underestimate the benefits of purchasing efficient appliances. Therefore, educational campaigns could increase the level of energy literacy and promote investments in energy-efficient appliances. Still on the matter of information provided, in Baldini et al. (2018), it is concluded that information campaigns such as labelling have not had significant effects in promoting energy efficiency improvements. The authors recommend that the focus for future policies is to consider not only what metric is shown on the label, but also what this metric actually means to the customer at the moment of purchase. In this sense, it is advised to convert energy savings into benefits easily understood by the consumer, such as the light needed to illuminate a room for a number of hours, or to keep the battery of a mobile phone running for a number of hours or to charge an electric scooter so that it can travel a number of kilometres.

In terms of appliance choice, it is also worth mentioning that, in certain contexts, consumers cannot affect the energy efficiency of cooking activities through the purchase of appliances, such as tenants in already furnished houses or students in residences, where energy-efficient devices are often not the option. On other occasions, people may be economically constrained when trying to incorporate energy-efficient behaviour, not being able to replace old inefficient appliances even if they are willing to do so. In these situations, the only way consumers can affect energy consumption will be through the actual use they make of those appliances.

**Oven capacity** (cavity volume) is a factor for consumers when purchasing a new oven. Even when the dishes cooked more often might not be large in size, they might opt for ovens with more capacity to cover the rare occasions when they cook large meals. On this topic, one stakeholder indicated that for built-in ovens the maximum capacity is limited due to the typical furniture in European kitchens. Also, the used capacity varies strongly during the year. For a given consumer, even if only once per year a large meal (such as a goose) is prepared, this consumer will never decide on a smaller capacity. Usually, the oven provides more levels for inserting the food to optimise the application for the different modes and dishes. In order to ensure the very high range of applications (grilling, cooking pizza, roasting a turkey, baking cookies on several levels, baking bread), the concept of more levels in a certain volume is needed. Another stakeholder adds that the optimal capacity of the oven also depends on the family composition and status. In this sense, one stakeholder indicates that it is worth exploring a different way to calculate energy efficiency and make a less linear correlation with cavity volume. It could be a flat volume above a certain value. In their view, the current formula is driving manufacturers to design larger ovens to achieve a better energy class.

The purchase decision relating to a cooking fume extractor is usually made together with the **kitchen design and installation**, and it is usually limited by the space available and numerous other choices having to be made if part of a bigger kitchen project. The size of the cooking fume extractor has a significant impact on its components and its energy efficiency. This is further explained in Task 4.

## 3.4 User cooking habits

It has been estimated that 26-36% of the total in-home energy use is directly related to residents' behaviour (Wood et al., 2003). Specifically related to cooking, energy use has decreased 50% since the 1970s, but these gains have not come from changes in cooking methods but from the use of more energy-efficient cooking devices (such as microwaves), through the expansion of ready-made meals and takeaways and from eating out habits. In fact, the connections between cookery practices and environmental impacts are often ignored by consumers, industry and government policy, when these practices may account for up to 50% of the energy use when analysing a food product's life cycle (Reynolds, 2017).

There are numerous energy-saving behaviours that can be performed during cooking. Even when cooking simple meals, energy-efficient techniques can help to reduce the energy consumed by a third (Oliveira et al., 2012). Changing energy-using behaviour during cooking therefore has significant potential for energy conservation.

An appropriate **cooking temperature** is a very relevant factor concerning the energy consumption of appliances, especially in the case of ovens. Using higher temperatures than needed will mean a significant waste of heat, and the possibility of spoiling the meal. However, it is also worth taking into account that, according to Reynolds (2017), cooking at lower temperatures in the oven than indicated in the recipe actually increases energy use since it also increases the amount of time the meal needs to be in the appliance. The right balance in terms of temperature settings is essential.

Switching to **smart** or more **energy-efficient appliances** has the potential to significantly reduce energy use while cooking. In the case of cooking fume extractors, it has been demonstrated that is beneficial the use of smart devices, which are able to automatically adapt its performance and optimise its operation, depending on the type of system used (Castorani et al., 2018).

Clear **indications** and **energy consumption feedback** in cooking appliances have significant improvement potential. Indications of cooking appliances being on/off are important for reduced energy consumption. In Oliveira et al. (2012), it is demonstrated how a confusing display on a hob can lead to a significant amount of energy being wasted when cooking a simple meal. Generally, with controls on the same format as the burners, subjects tend to make less mistakes in identifying which one is working. It is also worth mentioning the cost reduction potential of information feedback to the consumer. It has been demonstrated that a significant proportion of households are able to reduce electricity expenditures while cooking if they are given feedback on their energy-related behaviours, especially if it is immediate and in electronic format (Wood et al., 2003).

Accurate **cooking times** can be a relevant factor that influences energy consumption. Turning hobs off when water is already boiling or switching ovens off for the last minutes of cooking has been highlighted as a technique that has a big energy-saving potential (Oliveira et al., 2012).

Reading **cooking instructions** carefully can have significant energy-saving potential, as it can lead to reducing errors in temperature settings, cooking times and quantities, as can the use of other simple tips such as the use of lids or not opening the oven door to check is food is already cooked.

The **choice of cookware** has an important effect on the final consumption per use. Although there is no information on different types of cookware tested in various appliances (e.g. electrical, induction or gas hobs) to enable comparison between them, a test conducted on an electric hob of two different types of pans demonstrated the significance of this factor. Other relevant aspects related to cookware are the intelligent use of the residual heat, selecting the right size pan, using lids, etc.

As already mentioned in Section 3.3, product **durability** can affect purchase decisions. At the same time, consumer behaviour is also decisive on product durability. They way in which the product is used and maintained can compromise the limit of their lifetime.

In O'Leary et al. (2019), it is estimated that the existing domestic kitchen ventilation strategies and airflow rates are inadequate in over 88% of houses when the cooking fume extractor is used only during the cooking operation. However, if the **cooking fume extractor is used for a period of time after cooking**, it can reduce the daily mean PM2.5 concentration significantly. This concentration can be reduced by 58% if the cooking fume extractor operates for 10 extra minutes after cooking. Dobbin et al (2018) also found benefits in operating the hood for longer after cooking, although in their experiment it had a relatively small effect compared to the effects of fan flow rate and the specific fan used during cooking. For PM2.5, the effect of running an exhaust fan for 15 minutes after cooking was similar in magnitude to the impact of a 168 $m^3$/h increase in the flow rate used during cooking. This suggests that one can partially compensate for a low-flow-rate exhaust fan by continuing to run the fan after cooking. It must also be taken into account that running the hood for some time after cooking would be detrimental for the total energy consumption of the appliance, so a clear trade-off arises here between the capture and energy efficiency of cooking fume extractors.

## 3.5 Information to consumers

Information provided to consumers (both in terms of energy efficiency and on end of life) is a very relevant topic.

One stakeholder argues that consumer studies have shown (https://www.verbraucherzentrale-rlp.de/sites/default/files/migration_files/media231718A.pdf) that the energy efficiency classes are better understood than the information on the total consumption. Thus, there is certainly room to explain this aspect better to consumers.

Some stakeholders provided feedback on potential additional information requirements which could be included in future regulation for domestic cooking appliances:

- Overall, they recommend to follow the example set by the recently adopted Ecodesign and Energy Labelling Regulations in which improved information requirements (also on resource efficiency aspects) have been set.
- Include information on how to carry out maintenance and repair, as well as information on end-of-life treatment.
- Explore the icons on the Energy Label that could help consumers buy more durable, reparable products, such as the free warranty period offered by the manufacturer or spare parts availability. DG Justice's behavioural study on consumer engagement in the circular economy describes how effective this could be in shifting purchasing decisions towards products with greater durability and reparability.
- Ovens: indicate on the energy label both the energy consumption in standard mode and optionally in the eco mode (assuming the latter were well defined and framed).
- Cooking fume extractors: Table 6 Annex I "information on domestic cooking fume extractors" contains a list of information, symbols, values and units but not on the type of cooking fume extractors which is important.
- Provide consumers with information on the performance of the appliances by introducing an energy label for hobs, and for the commercial appliances.

Anther stakeholder adds that information about the used energy by a heating process, not in terms of absolute values, but in terms of steps or ranges (low-mid-high energy consumption) could guide users to save energy. Absolute values should be avoided, because the product is not mentioned as a measurement system and the tolerances of the power installation would require an advanced measurement system, which would make costs higher without a significant user advantage. Currently, the users have no possibility to evaluate and improve their usage behaviour.

## 3.6 User behaviour aspects related to material efficiency and end of life

Domestic ovens, hobs and cooking fume extractors are appliances that are present in the majority of households of the EU. Domestic cooking appliances are heavy, bulky items with abundant different materials, including ferrous and non-ferrous metals, plastics and several types of electronics. This abundancy of materials –very valuable, but also energy-intensive and rich in rare resources- makes their proper management at end of life a very relevant aspect of their life cycle. Ovens, hobs and cooking fume extractors –among other large household appliances- are under the scope of Directive 2012/19/EU on waste electrical and electronic equipment (WEEE Directive).

The habits of consumers in relation to end-of-life strategies concerning electrical and electronic equipment have not been widely analysed so far. However, it is necessary to know whether consumer behaviour is aligned with the objectives promoted by policies such as the WEEE Directive and also with the principles of the Circular Economy. This is fundamental to determine whether more awareness-raising actions are required to guide consumers towards priority strategies in the waste hierarchy, such as reuse and repair.

To date there is not much literature available on reuse and repair practices for domestic cooking devices specifically. In this section, information is provided on consumer behaviour at end of life regarding small electrical and electronic equipment and large home appliances in general. Although crucial aspects such as lifetime expectancies, usability patterns and technology evolution may be significantly different between those and domestic cooking appliances, some interesting conclusions can still be made based on the data available.

### 3.6.1 Maintenance of domestic cooking appliances

Maintenance is a very relevant factor concerning the end of life of domestic cooking appliances. According to a stakeholder, for the proper performance and durability of appliances, they should be appropriately cleaned and maintained. The following examples are given:

- The cavity of the oven and the door sealing need to be regularly cleaned, in order to avoid excessive grease and soil deposition, which can burn irreversibly into the enamel and which can disturb the good functioning of the heating elements.
- In gas hobs, burners should be periodially cleaned.
- Grease filters of hoods have to be regularly replaced or cleaned. Active charcoal filters of recirculation hoods also have to be cleaned or replaced according the manufacturers' instructions.

With proper maintenance, the performance is ensured and the risk of repairs can be significantly reduced.

### 3.6.2 Reusing and repairing domestic cooking appliances

In recent years, it has been observed that electrical and electronic appliances are replaced earlier than they actually need to be. In Bovea et al. (2018), the authors conducted an analysis of the habits of consumers regarding the substitution, repair or second-hand purchase of the most frequent information and communication technology (ICT) devices in Spain (mobile phones, e-book readers and tablets). Some of their findings were that only 13% of the population stopped using the devices because they were broken. In terms of functionality or safety, there was not a real need to dispose of or substitute the device, but the consumer still decided to change it. This is in line with the findings of Dindarian et al. (2012) regarding microwave ovens: half of the units studied required only minor repairs, some of them only minor cosmetic or cleaning operations. This short substitution cycle leads to an accelerated growth of the amount of waste, and is mainly caused by rapid technology evolution, particularly in the ICT sector.

Domestic cooking appliances are significantly different to ICT devices. They have different usage patterns, they are not so related to trends, and they generally do not generate an emotional attachment in consumers and, perhaps most importantly, they may be more cumbersome to replace due to the need for installation/integration in the kitchen. Their lifetime, which will be discussed in further detail in subsequent sections of this report, is generally expected to be longer than ICT devices. However, this trend of substituting appliances even if they are still functioning –or if they can be easily repaired- may also be happening at a slower pace in the large appliances sector. More research should be carried in this field to confirm this aspect.

In terms of the potential **reusability** of appliances, in Bovea et al. (2016) a methodology was defined to classify small WEEE according to its potential reuse. The methodology was then applied to a sample of small devices. From the analysis it was concluded that 30% of the sample had to be diverted to recycling due to functional or safety requirements not met; 2% of the sample could be directly reused after minor cleaning operations; and 68% of the sample required posterior evaluation of its potential repair. Adding up the last two, it may be concluded that the total proportion of the sample with the potential for reuse is 70%. As said earlier, this cannot be directly extrapolated to the domestic cooking appliances sector due to the obvious differences between product types. However, it does provide an indication of the potential reusability and reparability of appliances in general.

In terms of the **reparability** of domestic cooking appliances, from a consumer perspective, the barriers to repairing used appliances are related to the fact that most of them (79%) do not consider it worthwhile given the price of purchasing new equipment (including in relation to the difficulty or cost that may be associated with repairing or aquriing spare parts). Moreover, Dindarian et al. (2012) also point out that refurbishing and remanufacturing costs are for some products only a fraction of the manufacturing costs of a new product. Other barriers are not knowing where to take the appliance in order to be repaired and the inconvenience of bringing the equipment to the repair centre. From the repairers' perspective, the unpredictability of supply and demand and the difficulty of obtaining cheap spare parts are highlighted as the main barriers for this end-of-life alternative.

### 3.6.3 Disposal channels for domestic cooking appliances

Although reuse and repair are the preferable end-of-life alternatives, the average consumer is generally not aware of the options beyond recycling or landfilling. According to Dindarian et al. (2012), 67% of consumers bringing microwave ovens to collection points are not aware of other end-of-life options for this appliance. Reuse and repair do not seem like options that consumers are considering widely. When home appliances are not reused or repaired, consumers still need to dispose of them in an appropriate manner. Different disposal alternatives for consumers regarding waste of electric and electronic equipment (WEEE) are:

– municipal collection points;
– retailers;
– door-to-door collection;
– charity initiatives.

Related to the disposal channels above, in Magalani et al. (2012) an analysis was conducted of the main disposal channels for large household appliances. The two main disposal paths in Italy are through municipal collection points and retailers. Regarding retailers, large household appliances are mostly picked up at consumers' homes, 75-95% of the time, often in conjunction with the delivery of new equipment (Table 22).

**Table 22. Disposal channels for large household appliances in Italy**

| Disposal channel | Average* |
|---|---|
| Municipal collection points | 39.1% |
| Retailers | 37.1% |
| Reuse (sold or given away) | 8.0% |
| Bad habits (e.g. waste bin, plastic waste, other wrong streams) | 5.8% |
| Life extension (old house….) | 5.3% |
| Do not know, do not remember | 4.1% |
| Warranty replacement | 0.6% |

*Values correspond to large home appliances: dishwashers, washing machines, washer dryers and centrifuges, furnaces and ovens and microwave ovens.

*Source:* Magalini et al. (2012)

Most of the materials recovered from the collection of large home appliances are ferrous metals, followed by plastics and non-ferrous metals in smaller proportions. Nowadays, the majority of these products are recycled at the end of life (Magalini et al., 2017).

### 3.6.4 Stakeholder feedback on material efficiency and end-of-life behaviour

Regarding end of life, one stakeholder considers that appliances that are placed on the market today do not pose any recycling problems, as they have to respect applicable substance regulation. For older appliances, there is a potential risk. Information about that potential risk can be found on the Information for Recyclers online platform: https://i4r-platform.eu/.

In terms of **reusing and remanufacturing** products, relevant stakeholders state they cannot provide any information on the market for reused products as no conclusive data about that market –which is mostly informal– is available. They add that the market for remanufactured cooking appliances is rather limited, most likely due to accumulated dirt and grease residues in the products after several years of use. Preparation for reuse organisations mostly focus on washing machines, tumble dryers, dishwashers and cooling and freezing appliances. The same is true for components.

According to another stakeholder, the market for reused and remanufactured cooking products is very limited (for instance, charity organisations). The remanufacturing of an appliance could seriously affect the safety, EMC, performance and energy consumption of the product itself. For this reason, this operation should be done just by the original manufacturer who is the only player with the proper knowledge and capability for retesting and reverification of repaired products. Remanufacturing by other operators that are not the original manufacturers should be made clear to the users and it must not, for any reason, affect the original manufacturer or the status of the original placement of the product in the market.

Another stakeholder recalls that Circular Economy, resource savings and savings on embedded energy and $CO_2$ are clear priorities for the EU. They have been assessed as necessary to reach our climate goals as set in the EU Long-term Decarbonisation Strategy for 2050. They believe that ambitious action should be taken in this regard through the ecodesign policy. Several studies show that the lifetime for large household appliances has declined and such a decline in a product's service time needs to be reversed. A way to improve the lifetime of household appliances is to design products that are easier and less costly to repair so that it is more affordable for consumers to repair appliances than to replace them. Furthermore, they recommend exploring guidance for easy maintenance and proper cleaning of the cooking appliances.

## 3.7 Local infrastructure

### 3.7.1 Installation of domestic cooking appliances

One of the aspects that should be taken into account when installing a domestic cooking appliance is its most appropriate location within the kitchen. For instance, studies suggest that the location of the cooking appliances can have a significant effect on the total energy consumed in the household. For instance, it is recommended that an oven is not placed adjacent to a fridge (Wood et al., 2003). A stakeholder indicates that this is more relevant for free-standing appliances than for built-in. For the latter, there is enough distance between them, and due to the low usage of the cooking appliance compared to the fridge, the impact will be relatively low.

Product installation may have a significant influence on product durability and maintenance. On this topic, a stakeholder indicates that ovens and hobs are appliances which need ventilation for cooling of the electronics, furniture, etc. Proper circulation of air should be assured by following the installation instruction manuals. However, experience shows that this is often not the case. The following examples are given:

- Wrong electrical connection on 400 V instead of 230 V can cause defects to the appliance.
- Constraints of power quality can cause defects and may influence the lifetime of products.
- Wrong installation leads to complaints from users. The cooking fume extractor is identified as the cause, where in fact it is the installation.

In the case of cooking fume extractors, the type of installation has a significant impact on the configuration and performance of the hood. Hood performance is related to its design, both in terms of inherent **aerodynamic properties** and in terms of **mounting configuration**, since they all have different capture areas and are mounted at different heights relative to the cooking equipment. Island-mounted hoods, for instance, require greater exhaust airflow rate than wall-mounted hoods. They are also more sensitive to make-up air supply and cross drafts than wall-mounted (Fisher et al., 2015).

The exhaust **duct arrangement** of the hood also has an influence on the hood capture efficiency. For optimal performance, duct runs must be short with a minimal amount of bends and corners.

The type of ventilation and the availability of the exhaust duct also affects the installation and operation. Three different configurations can be distinguished:

1) **Recirculation Hoods:** a grease filter and a charcoal filter clean the air collected, then it is recirculated into the ambient air.
2) **Extraction Hoods:** the air collected is filtered by a grease filter and then evacuated outside.
3) **Extraction Hoods connected to a Central Ventilation System:** the air collected is filtered by a grease filter and is then evacuated outside. There is no motor and the hood does not control the motor speed but it can open or close a damper.

According to the industry, cooking fume extractors working only in a recirculation configuration represent a niche market, and almost 100% of products can work in both conditions, recirculation and extraction mode.

In terms of **size and position**, minimising the vertical distance from the appliance to the lower edge of the hood can reduce the required exhaust airflow rate and therefore improve performance. The higher the distance between hood and cooktop, the higher the opportunities for leakage, as cooking oil mists' thermal plume expands with vertical distance from the generation source. It has been demonstrated that increasing the installation height of the hood by 30 cm requires a 14% increase in airflow (Swierczyna et al., 2006). However, low installations may affect cooking operations and are more likely to cause fires. Also, the concentration of particles in the breathing zone of the cooker is higher when the distance between the hood and cooktop is lower (Sjaastad et al, 2010). Other authors indicate that, for optimal performance, it should be 50-60 cm above an electric cooktop and 60-70 cm above a gas cooktop (Lowes, 2019).

Relevant parameters in cooking fume extractor performance are also the **front overhang** and the **rear gap**, as explained in Han (2019). For same sized-hoods, increasing the front overhang significantly improves the hood's ability to capture and contain cooking pollutants. A similar thing happens with the rear gap. In Swierczyna et al., 2006, it was demonstrated that, for the same front overhang, a deeper hood required less airflow to operate, since the rear gap becomes smaller. This is also the reason why inserting a rear seal behind the appliance to fill in the rear gap can improve hood performance, as some of the replacement air, which would have otherwise been drawn up from behind the appliance, is instead drawn in along the perimeter of the hood, helping guide the plume into the hood. Other authors point out that, for optimal performance, the hood must be preferably around 8 cm longer than the cooktop on each side (Lowes, 2019). Related to the overhang and rear gap is the **position of the burners**, which may also have an effect on the hood capture efficiency. In Rim et al. (2012), it is suggested that at the same hood flow rate, using the back burners is more effective in reducing particles than using the front burners.

**Disturbing airflows** from cooking behaviour, movement of people, open windows or doors, etc., are unavoidable. These airflows have a detrimental effect on hood performance. The presence of a person in front of the cooktop, for instance, creates a wake which can potentially transport the pollutants out of the hood. In general, an island cooking fume extractor is more affected by disturbing airflows than a wall-mounted hood. A potential solution to mitigate the negative effects of these airflows is the use of side panels next to the cooktop, which permit the use of a reduced exhaust rate in the cooking fume extractor (CEC, 2012). However, they are not very popular in domestic kitchens for aesthetic reasons.

Another relevant aspect in capture efficiency is the effect of **make-up air**. A cooking fume extractor extracts air from the kitchen area. This air removed from the kitchen must be replaced with an equal volume of air through a different pathway. This equal volume of air is known as the make-up air. The strategy used to introduce make-up air can significantly impact hood performance. Make-up air introduced close to the hood's capture zone may create local air velocities and turbulence that result in failures in thermal plume capture and containment. A series of design recommendations regarding make-up air installation is provided in CEC, 2012.

### 3.7.2 Energy: Reliability, availability and nature

In this section, relevant aspects of energy, such as reliability, availability and nature, are covered. The consequences of the energy crisis of 2022, which caused a significant increase in cost of energy for European consumers, might have had an impact on cooking behaviours and on the purchase patterns of cooking appliances. However, this section of the study was developed around 2020, and at the date of publication of this study, the potential effects of this energy crisis on the cooking appliances sector is still unkown and difficult to predict. Thefore, the effects of this crisis –potentially relevant in terms of consumer expenditure- are considered out of scope of the analysis.

**Electricity**

The power sector is in a state of transition, moving from fossil fuels to renewable energy. The origin of the electricity is a very important factor to consider regarding both the environmental impact of using electrical cooking appliances and how it may affect consumer behaviour. A binding renewable energy target of at least 32% of final energy consumption for the EU was agreed in 2018 for 2030. The final energy consumption is the total energy consumed directly by end users, such as households, industry and agriculture. It is the energy which reaches the final consumer's door and excludes that which is used by the energy sector itself.

The reliability of the electricity grid could, to some degree, be affected by the transition to a renewable energy system. With more renewable energy in the system new challenges occur, e.g. with excess production of wind energy and the two-directional transfer of energy (e.g. electric cars that can supply electricity to the grid when they are not in use). Renewable energy production can vary greatly from hour to hour and day to day.

Due to technological developments, the reliability of the electricity supply in many EU countries is ensured via the expansion of the electricity grid to distribute renewable energy. The quality of the electricity grid in Europe is considered to be high and among the best in the world.

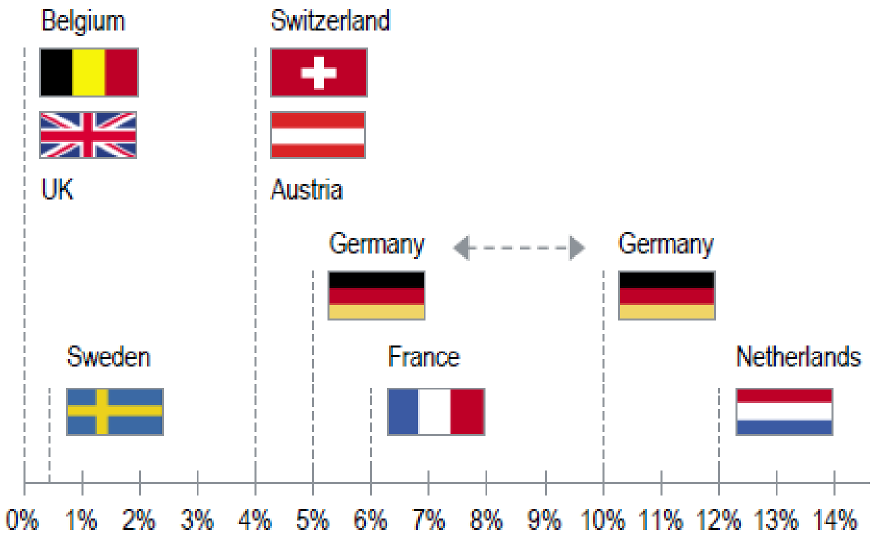
**Natural gas**

According to the EU Reference Scenario 2016 (European Commission, 2016), natural gas consumption in the residential sector is projected to remain constant. The main consumers of natural gas are water and space heating appliances, while the share of cooking appliances in natural gas consumption is much lower.

The composition of the natural gas affects the safety, performance and the environmental impact of gas cooking appliances. Therefore, each manufacturer must test the oven or hob using the natural gas that is typical of the country where the appliance is to be sold.

The GHG emissions from the combustion of natural gas can be drastically reduced by the injection of biomethane (upgraded biogas) in the natural gas grids. The terms "upgraded biogas" or "biomethane" are used to refer to the biogas that has undergone the upgrading process to remove impurities and achieve the standard requirements for grid injection purposes. Biogas is mainly produced from agriculture: energy crops, agricultural residues and manure. Other sources are sewage sludge and landfill, though more than 70% come from agriculture (European Biogas Association, 2014). Biomethane production increased from 752 GWh in 2011 to 17 264 GWh in 2016 (European Biogas Association, 2017). This represents less than 2% of the total natural gas consumption in the residential sector. The increment between 2015 and 2016 was 40%, with Germany, France and Sweden the top countries in terms of production increase (European Biogas Association, 2017). However, the injection of biomethane into the grids is far from common practice in the EU. According to Scarlat et al. (2018), in 2015 most of the biomethane injected into the gas grid was in the Netherlands and marginal volumes in other countries.

Natural gas can also be blended with hydrogen, which would reduce the GHG emissions from its combustion too. The permitted concentration of hydrogen in the gas grid varies across EU countries ranging from 0.1 Vol.% to 14 Vol.%, and it can also vary within each country (e.g. Germany) (**Figure 64**).




*Source:* FCF and Roland Berger, 2017

**Figure 64. Injection percentage in EU countries**

Injections above 15% would require investments to adapt the infrastructure, including monitoring and maintenance measures, and upgrading due to the lower durability of the materials when exposed to hydrogen. Hydrogen injection is not allowed in a large number of EU countries (Hydrogen Europe 2019, FCH and Roland Berger, 2017).

There are no standards setting a common admissible concentration of hydrogen in the natural gas network. The European Committee for Standardisation (CEN) standard EN 16726: 2015 recommends a case-by-case analysis since the variety within the EU gas infrastructure prevents a general valid solution (Hydrogen Europe, 2019)

Concerning hydrogen production, the most common method in industry to produce hydrogen is Steam Methane Reforming (SMR), a chemical synthesis process which generates syngas (hydrogen and carbon monoxide) from hydrocarbons and natural gas. This process is conducted in a reformer which reacts steam at high temperature and pressure with methane in the presence of a nickel catalyst. SMR has been deemed by some authors (Schmidt-Rivera et al., 2018) as unsustainable for two reasons: as it requires natural gas it means a depletion of fossil fuel resources; moreover, the actual process of conversion generates significant greenhouse gas emissions. To avoid these emissions, $CO_2$ could be captured and then sequestered underground, as suggested in Frazer-Nash (2018). The resulting hydrogen would then be transferred into the national grid pipeline to provide zero-carbon heat at the point of end use.

Alternatively to SMR, excess energy from renewable sources such as photovoltaic (PV) panels could be used to produce hydrogen from the electrolysis of water. Hydrogen would then be blended with natural gas in the pipeline infrastructure, by compressed gas canisters or in low-pressure metal hydride tanks. This is a solution proposed by certain authors (Tropiska, 2016) for developing countries, where fuels such as charcoal, firewood or animal dung are primarily used for cooking. The use of these fuels causes significant air pollution and safety issues, so generating hydrogen from a renewable energy source may have the potential to solve several issues at a time.

An environmental analysis of that kind was completed in Schmidt-Rivera et al. (2018). The authors evaluated different scenarios of substitution of solid fuels and liquefied petroleum gas (LPG) by hydrogen generated from renewable sources (solar PV). Results from the analysis indicated that, when compared to charcoal and firewood, hydrogen is the best option in terms of fossil fuel depletion, climate change (2.5 to 14.1 times lower), ozone depletion and summer smog. However, hydrogen was worse when considering depletion of minerals, fresh water eutrophication and fresh water/marine ecotoxicity. They also pointed out that for most of impacts analysed, LPG is still a better option than hydrogen.

## 3.8 Study on consumer behaviour and domestic cooking appliances

### 3.8.1 Methodology

A semi-representative online survey was conducted in April 2020. The aim of the survey was to assess the behaviour of 5 100 households in 11 countries (Czech Republic, Finland, France, Germany, Hungary, Italy, Poland, Romania, Spain, Sweden and Ireland) representing 70% of all households in the EU. A questionnaire was developed by the authors based on their professional (home economics) product know-how and with support from the JRC and other stakeholders. Registered consumers were included in the survey considering the required quotas (age between 20 and 80 years, corresponding to statistical data regarding household size and age; more than 50% female) for each country. The panellists included had to answer positively to the question of whether they are 'mostly/all the time involved in preparing the meals for your household'. Thus, the survey delivers a representative sample of the relevant population of most EU countries. Although participants were asked to report about their 'normal' behaviour in using their oven, hob and cooking fume extractor, the influence of the COVID-19 lockdown and other measures cannot be excluded.

The participants were asked about the type of cooking devices they have at home and details of their usage. Demographic data was recorded additionally. Before starting the analyses, the validity of each dataset was checked with the aid of two predefined consistency check criteria (number of meals prepared and number of ovens used per week). Datasets were excluded from the following evaluation in the case of inconsistent answers. The survey consisted of a total of 4 922 valid answers. Thus, the statistical uncertainty level of the overall sample (given as $\sqrt{n}/n$) was 1.4%.

Results from the online questionnaire were analysed using SPSS (by IBM) and presented in a descriptive and analytic format. Furthermore, a weighting according to the number of households of each country compared to the sum of all countries investigated is implemented for calculating the result given as "all hh weighted" (Table 23).

**Table 23. Overview of the panels and databases for analysis**

| Country | | Panel target | Panel after consistency check | Private households | Contribution to total |
|---|---|---|---|---|---|
| | Abbreviation | | | (millions) | (%) |
| Czech Rep. | CZ | 350 | 340 | 4,759,800 | 3 |
| Finland | FI | 350 | 340 | 2,677,100 | 2 |
| France | FR | 600 | 592 | 29,802,900 | 19 |
| Germany | DE | 600 | 584 | 40,806,600 | 26 |
| Hungary | HU | 350 | 339 | 4,124,800 | 3 |
| Italy | IT | 600 | 577 | 25,925,800 | 17 |
| Poland | PL | 600 | 566 | 14,608,900 | 9 |
| Romania | RO | 350 | 332 | 7,494,300 | 5 |
| Spain | ES | 600 | 577 | 18,580,600 | 12 |
| Sweden | SE | 350 | 340 | 5,239,500 | 3 |
| Ireland | IE | 350 | 335 | 1,842,000 | 1 |
| All households in the EU sample | 'all hh weighted' | 5,100 | 4,922 | 155,862,300 | 100 |
| Total number of households in the EU | | | | 222,839,600 | 70 |

### 3.8.2 Demographics

Following the predefined quotas, the age and household size distribution of the participants represents the national distribution per country (Figure 65 and Figure 66). Nevertheless, it is worth keeping in mind when analysing the results of the survey and comparing the answers for different countries that there are significant differences in the composition of the age and household sizes between countries.

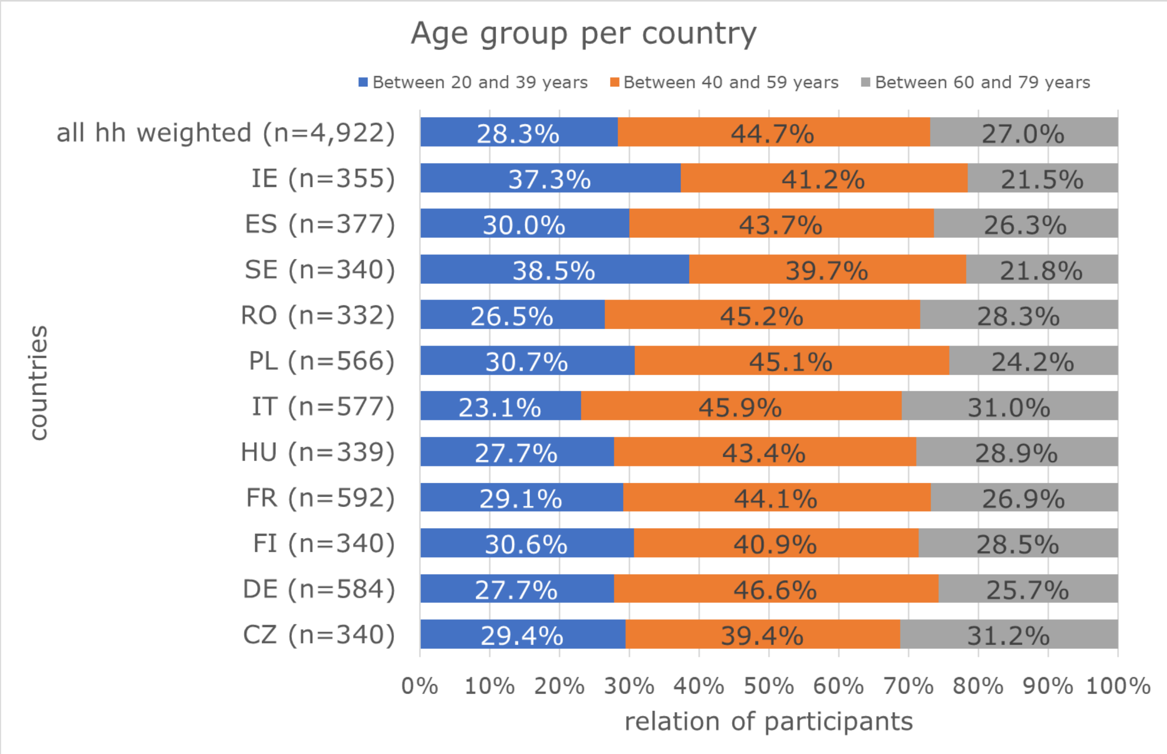



**Figure 65. Age group distribution of the panel**

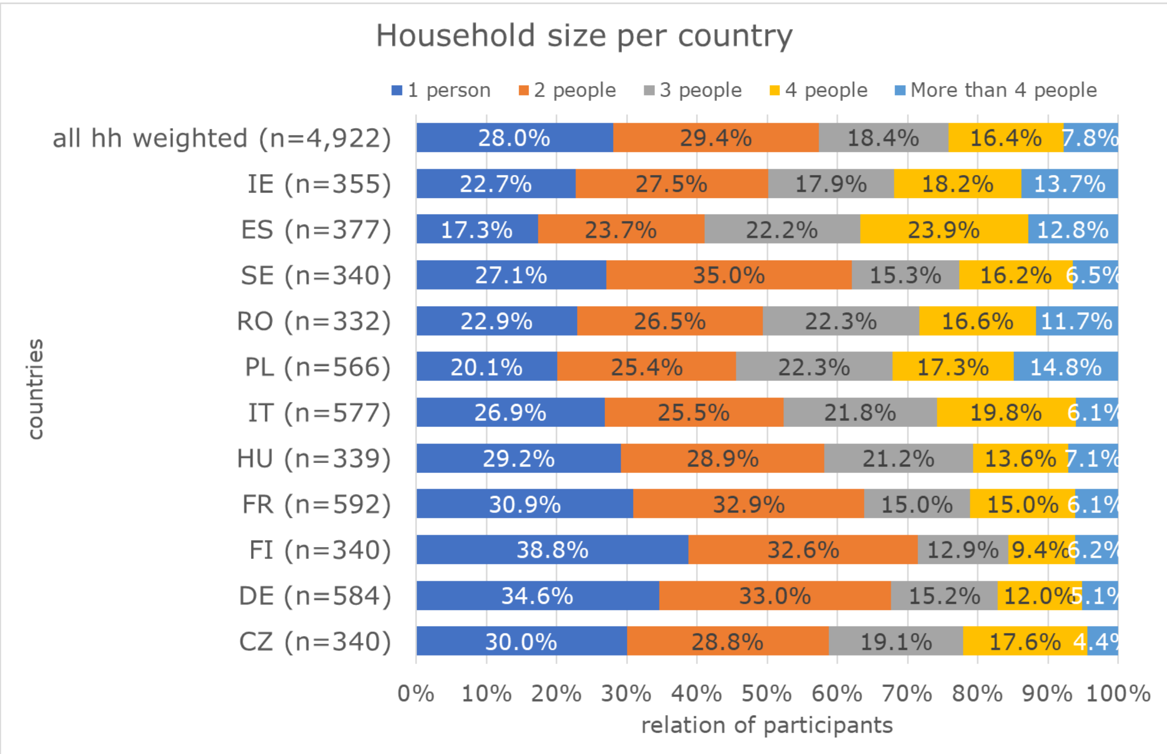



**Figure 66. Household size distribution of the panel**

Differences between the 'official' demographic household size distribution and the distribution of the panel (Figure 67) are explained by the exclusion of very young and very old households in the panel. Thus, the sample is representative of consumers who are mostly or always involved in preparing the meals for their household regarding gender, age and household size distribution in the individual 11 countries which cover about 70% of the population of the EU.

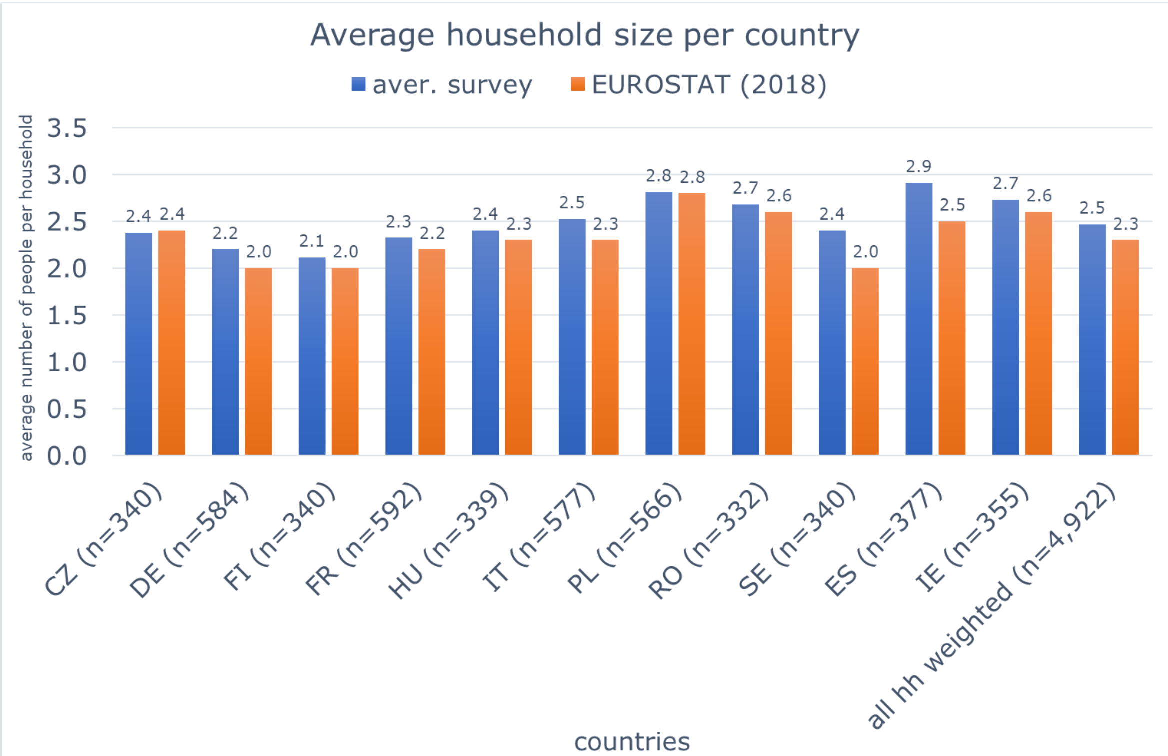



**Figure 67. Comparison of the average household size of the panel with the household size given by Eurostat**

The distribution of gender in the panel was approximately 50:50.

As the panellists had to be 'mostly/all the time involved in preparing the meals for your household', the answers to the question "How many cooked meals do you prepare at home for yourself and any other members of the household?" somehow reflect the minimum of the cooking activities of the household.

A cooked meal is prepared seven times per week in most households (Figure 68), followed by 14 meals per week. Averaging all the answers shows that cooked meals are prepared between 5.2 and 11.6 times per week (Figure 69) per country per household. An average of 8.9 cooked meals are prepared in the households of the respondents per week (4.8 per person).

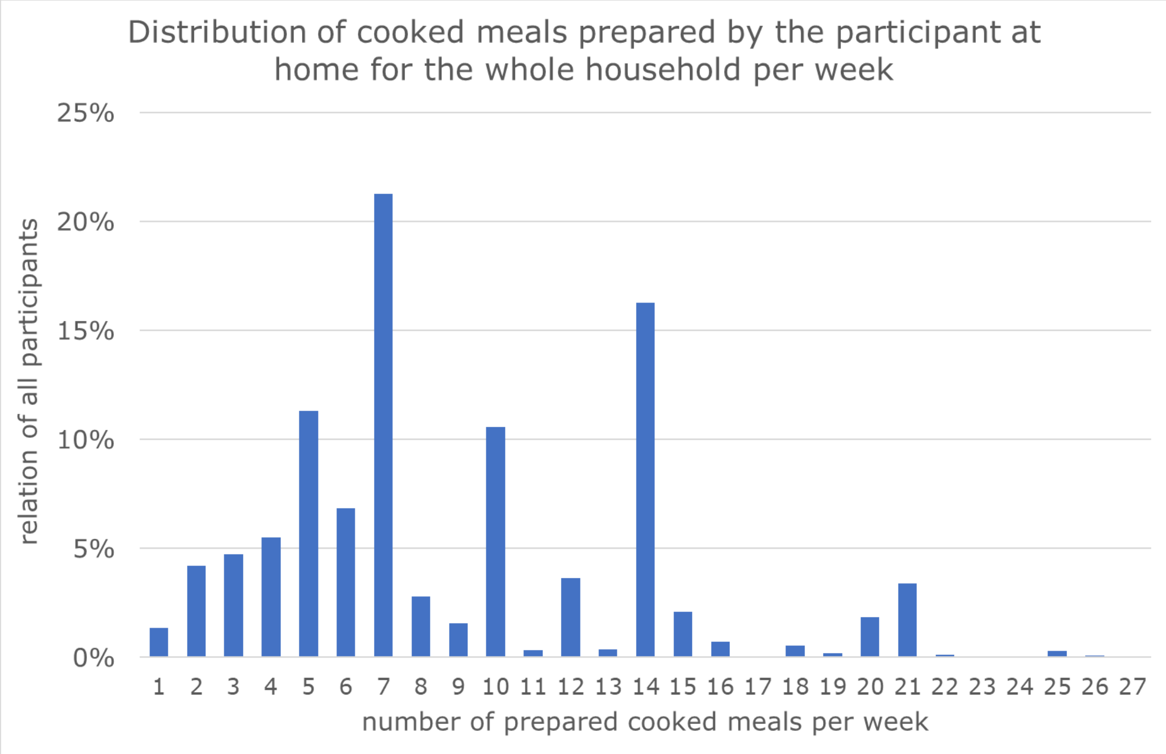



**Figure 68. Number of meals prepared at home per week**

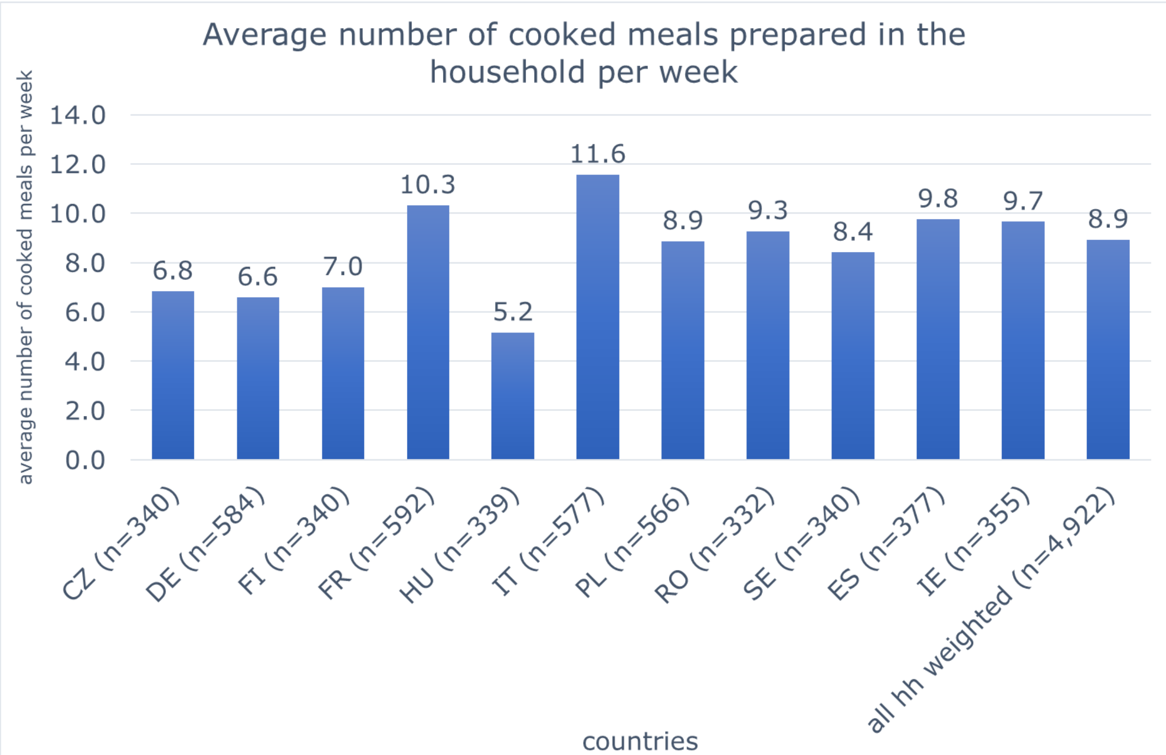



**Figure 69. Average number of cooked meals per household per week**

As household sizes are different between countries, it may be interesting to normalise those answers by the number of people living in each household: this distribution shows that most households prepare a cooked meal between 1.0 and 7.0 times per person per week (Figure 70) with extreme averages for Hungary (2.8 cooked meals per person and household per week) and Italy (6.2) (Figure 71).

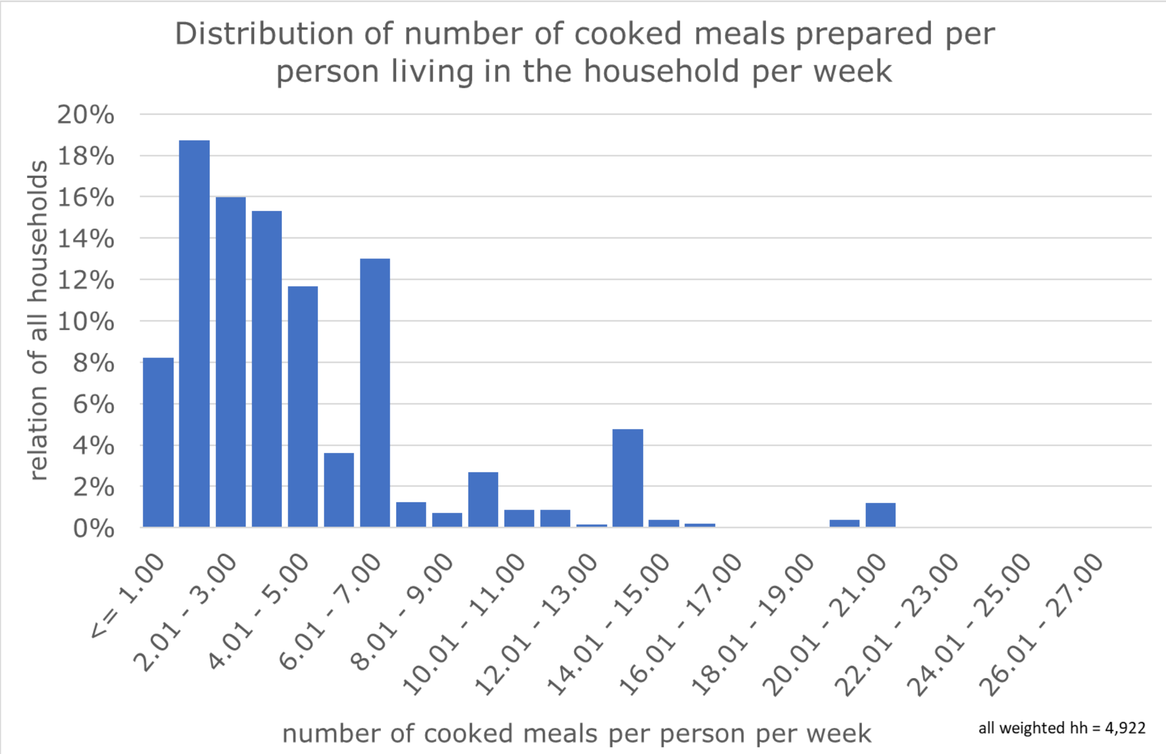



**Figure 70. Number of cooked meals at home per person in the household per week**

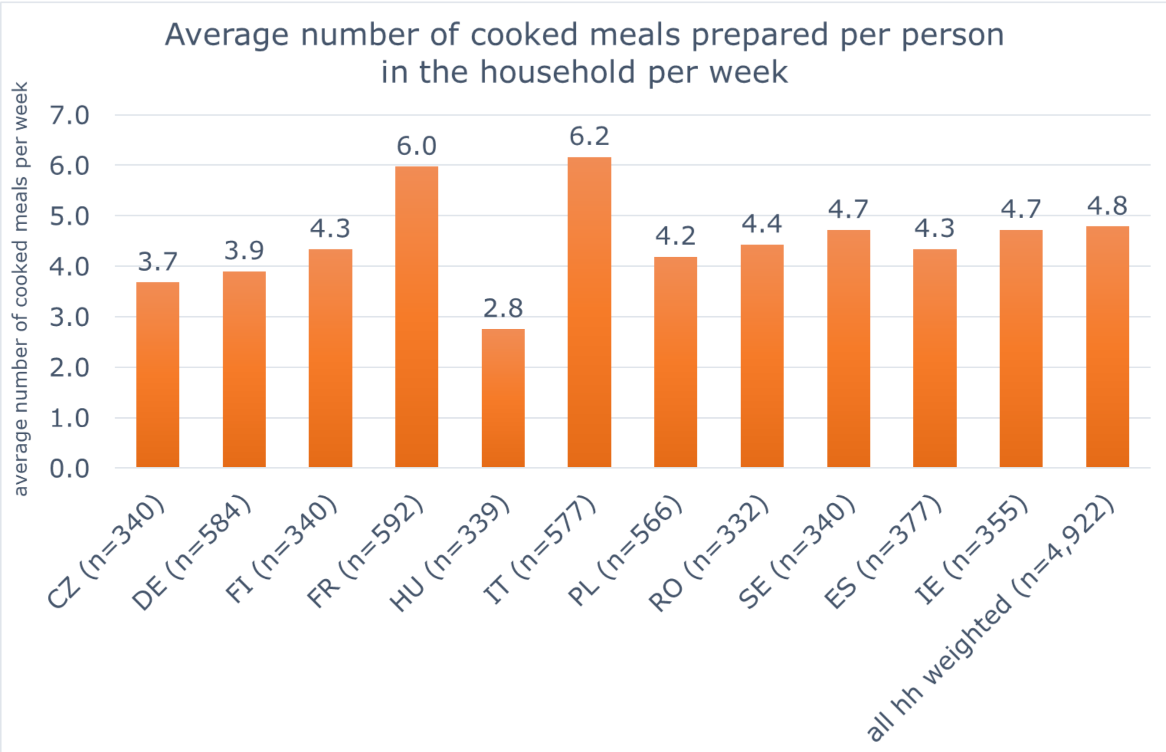



**Figure 71. Average number of cooked meals per person per week**

### 3.8.3 Cooking appliances in homes

Going more deeply into the stock of appliances, a predefined list of kitchen appliances was given to the participants with the request to indicate all those that they have in their household. Overall, almost 9 out of 10 households indicated that they have a conventional oven (Figure 72) and about 3 out of 4 indicate that they have a solo microwave, a cooking fume extractor and a fixed hob. Portable appliances for cooking are available only to a minority of households and a pure steam oven is a rarity, as it is available in only about 5% of households.

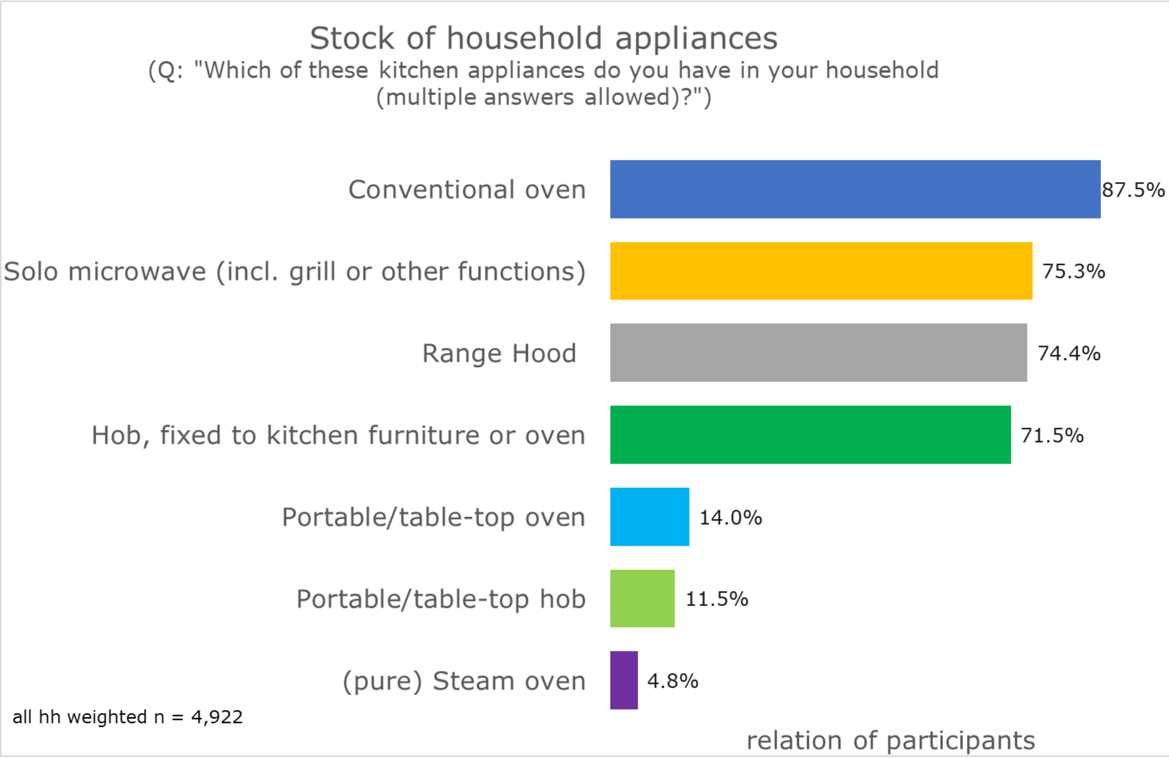



**Figure 72. Stock of cooking appliances**

However, there are significant differences between the stock of cooking appliances in various countries (Figure 73). For example, less than 50% of the households own a conventional oven in the Czech Republic and cooking fume extractors are owned by a few more than just one out of four households in Ireland. However, there are generally between 3 and 3.5 cooking appliances in the stock of households in all countries. Surprisingly, this is also the range of the stock of cooking appliances for one to multiple person households (Figure 74).

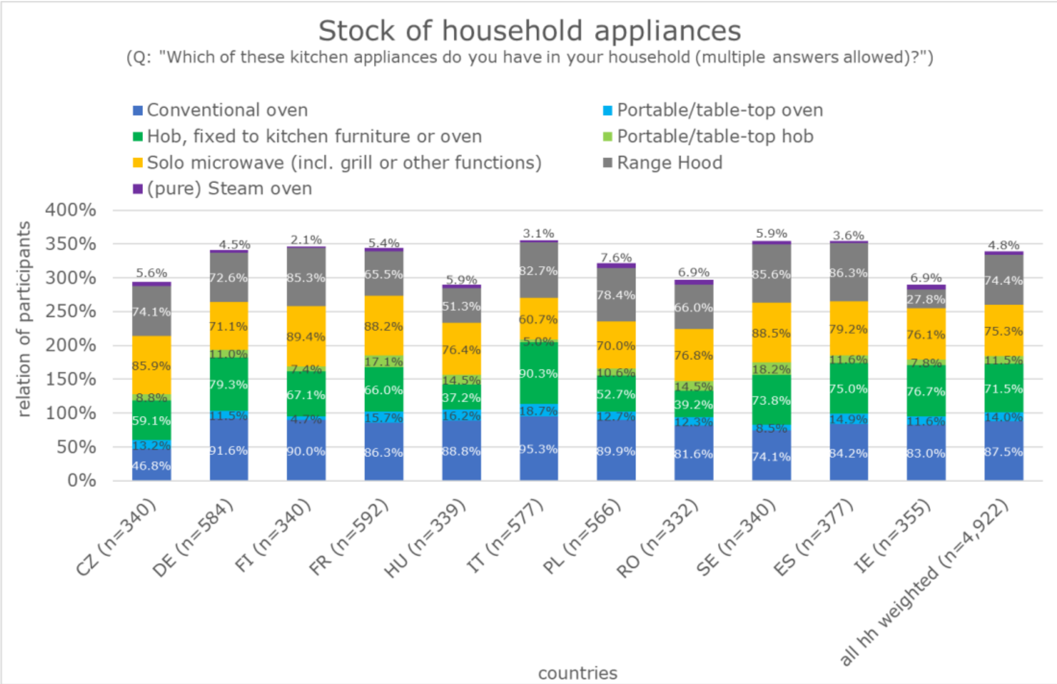



**Figure 73. Stock of cooking appliances per country**

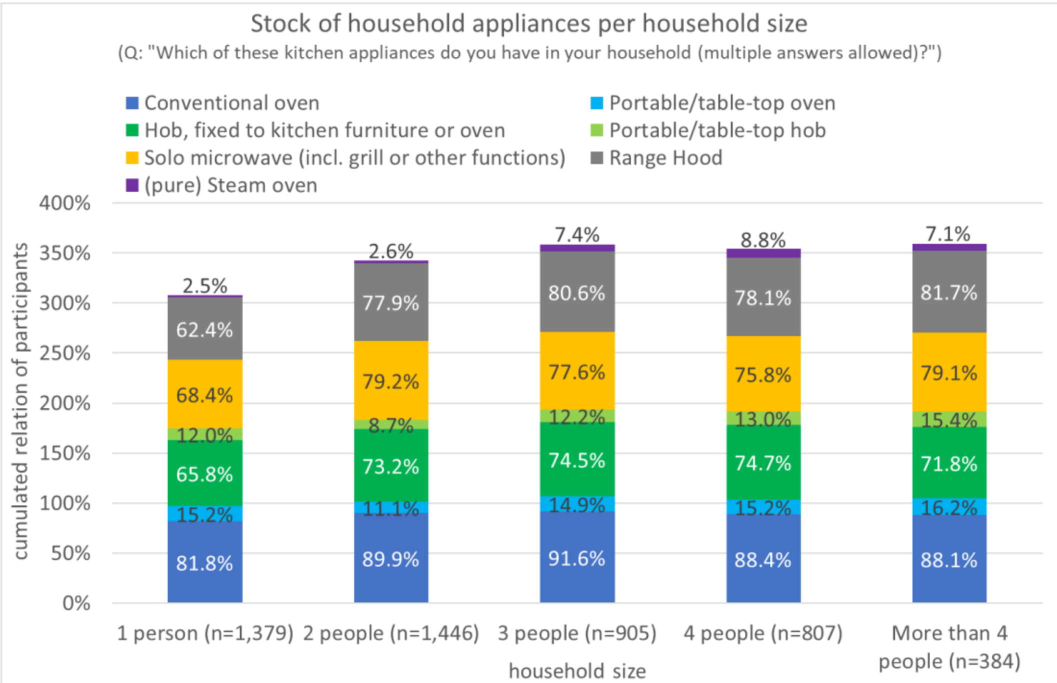



**Figure 74. Stock of cooking appliances per household size**

### 3.8.4 Ovens

#### 3.8.4.1 Types of oven available

Asked in detail what kind of oven they have (conventional or portable/table-top), the participants revealed that 85% own a conventional oven. Only about 4% own a portable/table-top oven and about 11% own both types of ovens (Figure 75). However, there are relatively large differences between countries: almost

23% of households in the Czech Republic, for example, own a portable/table-top oven and for most of them this is the only oven they have (Figure 76).

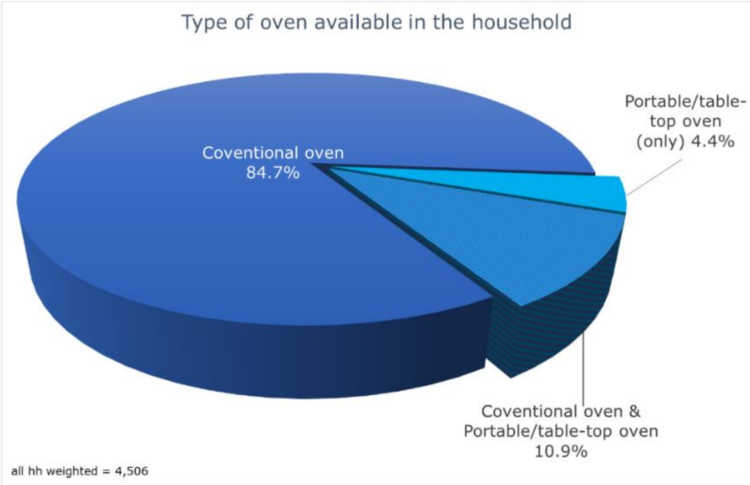



**Figure 75. Type of oven available**

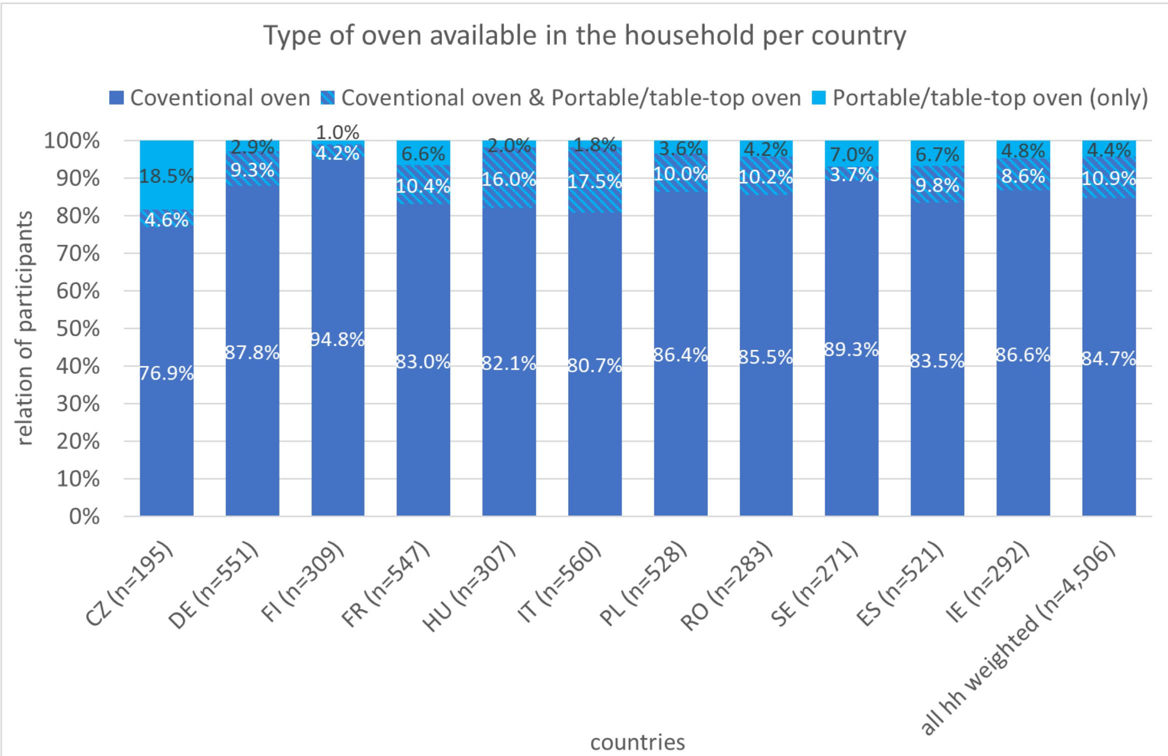



**Figure 76. Type of oven by country**

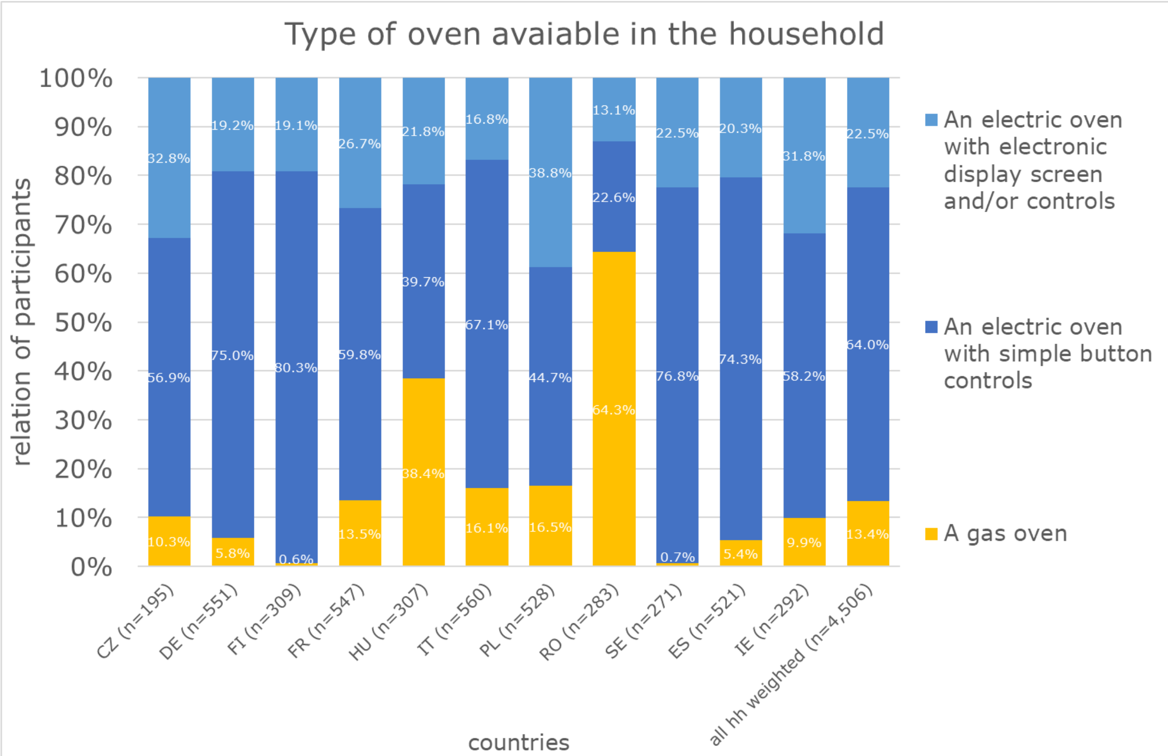



**Figure 77. Oven energy source available by country**

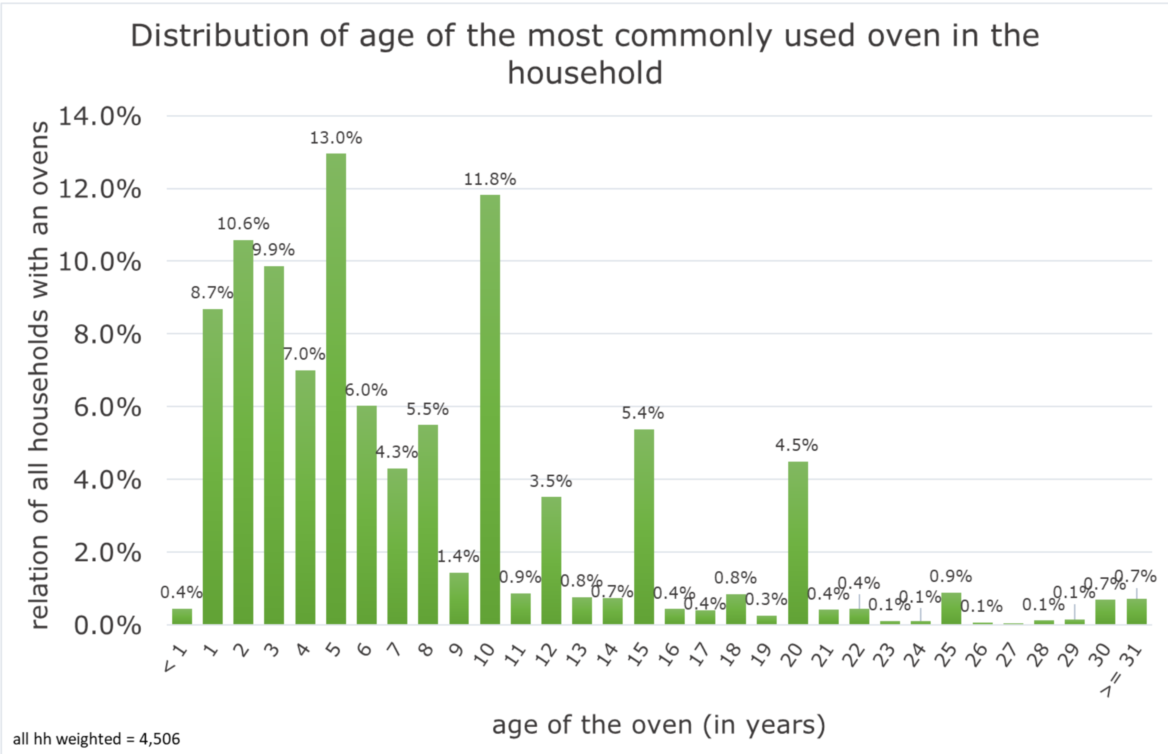



**Figure 78. Age distribution of the oven**

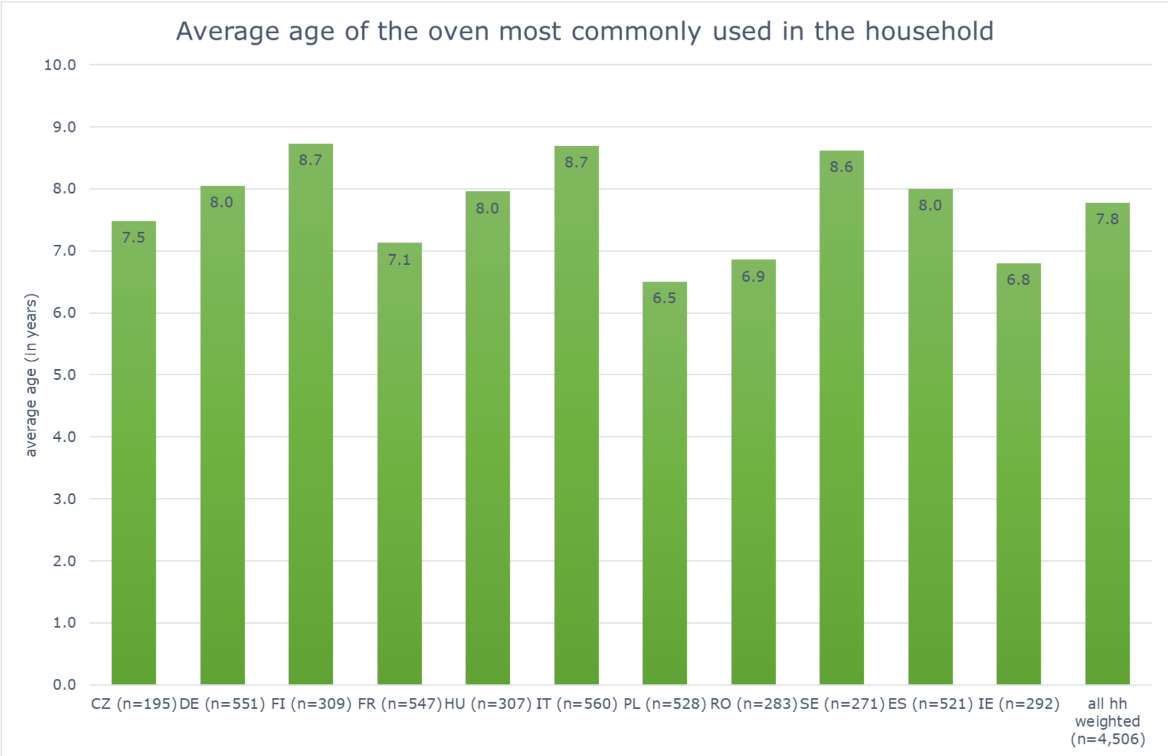



**Figure 79. Average age of the oven by country**

Participants were also asked about the age of the oven most commonly used in their household. The answers given show a large distribution of ages (Figure 78), with some spikes at 5, 10, 15 and 20 years old. The average age was found to be 7.8 years, with some differences between countries (Figure 79).

#### 3.8.4.2 Frequency of use of the oven

In this section, the respondents were asked about how frequently they use their ovens each week. The usage frequency of the oven was investigated twice in different parts of the questionnaire. This was done to check the consistency of the participants' answers. The answers were given as nominal indications (Figure 80) and show some country-specific differences.

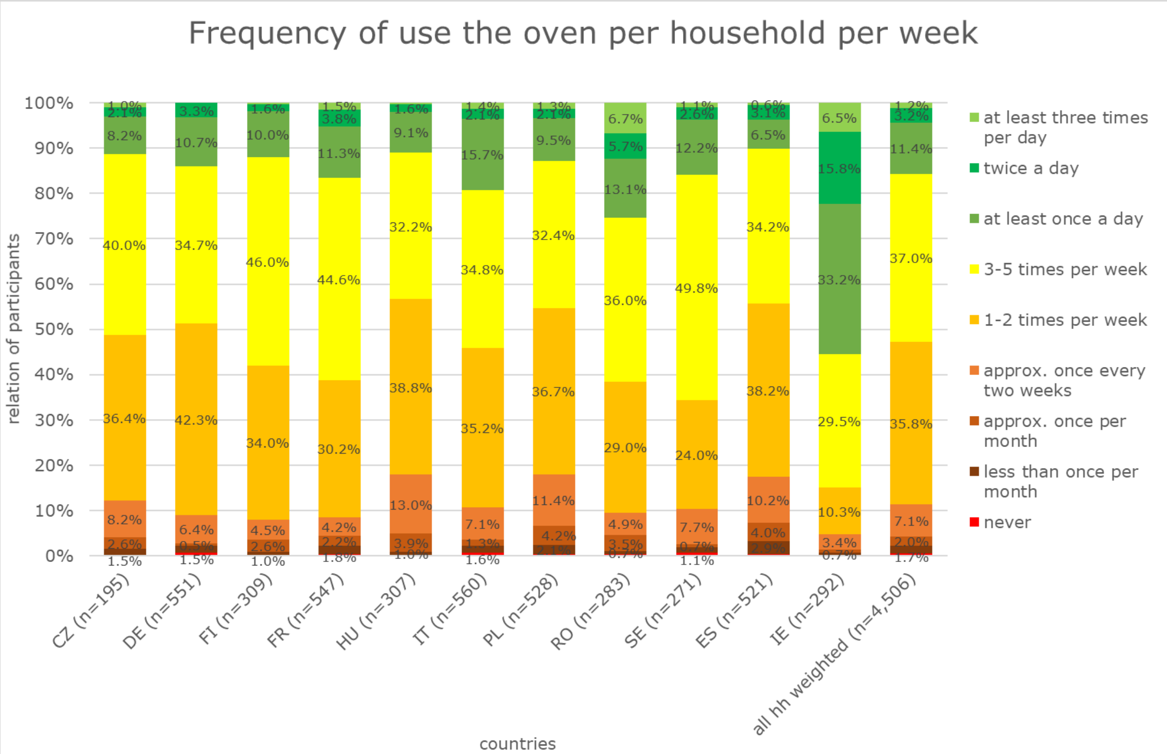



**Figure 80. Average usage of the oven per week by country**

Household size is one of the most important variables defining the number of oven usages (Figure 81).

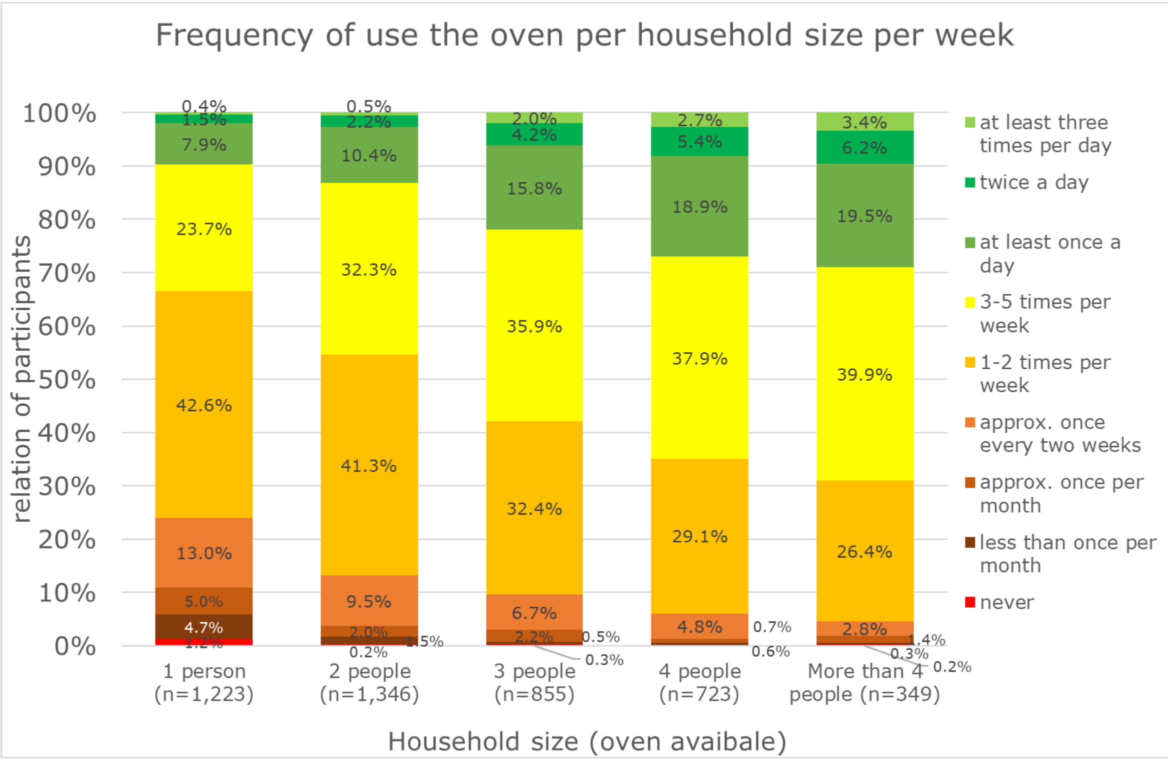



**Figure 81. Average usage of the oven per week by household size**

It is easier to compare different behaviours if the nominal answers are decoded into numerical values. The results of this decoding now show the differences between countries very clearly (Figure 82), with a high peak of 7.3 usages of the oven per week in Ireland for the first time the question was asked.

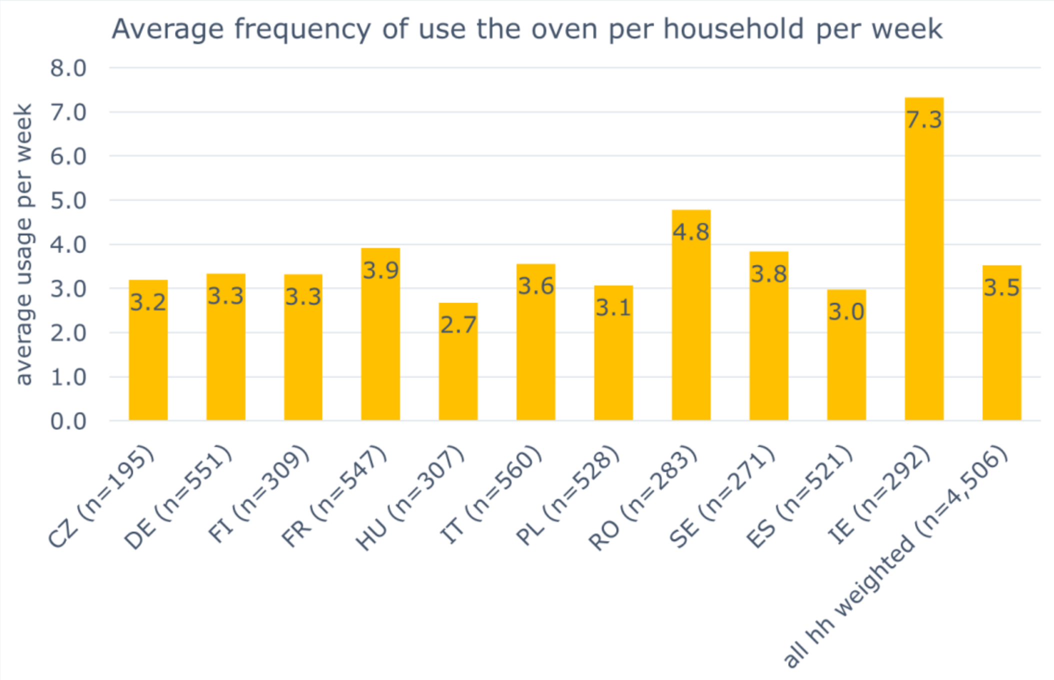



**Figure 82. Average usage of the oven per week**

This also allows us to quantify the dependency of the oven use on household size as a clear trend in all countries (Figure 83). The overall average frequency of use is 3.5 times per household per week.

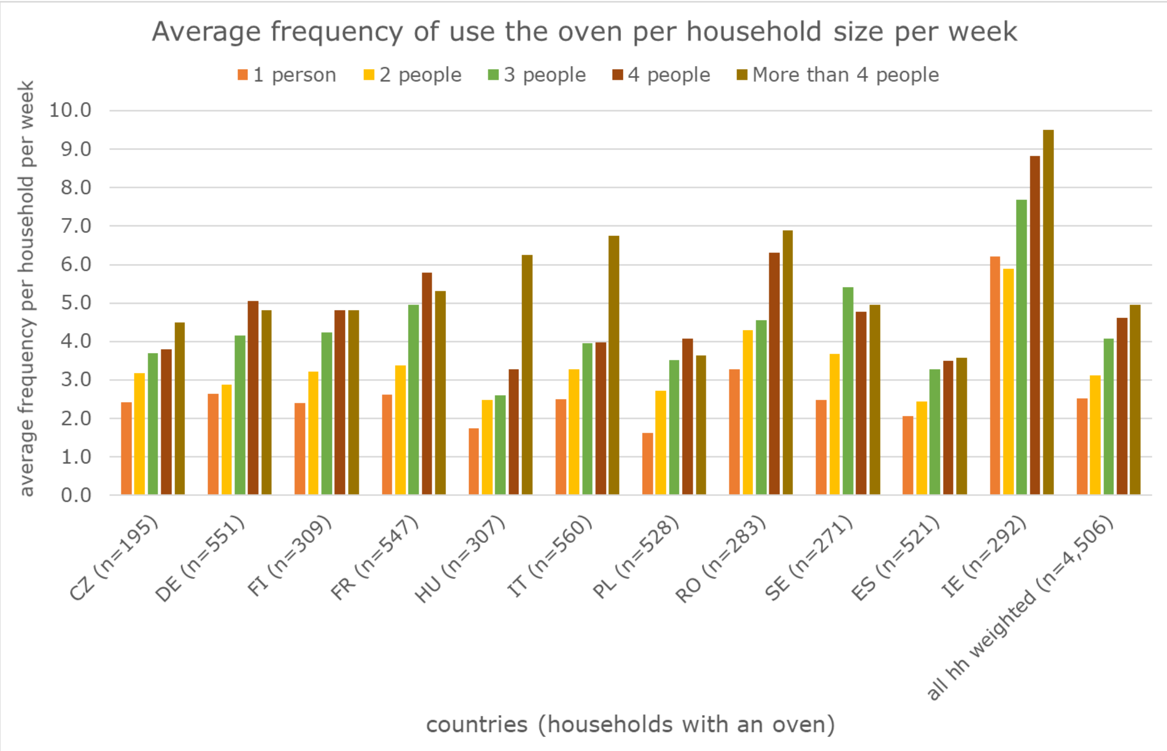



**Figure 83. Average use of the oven by household size and by country**

### 3.8.4.3 Frequency and duration of use of oven heating modes

A more detailed list of questions was requested to be answered by the participants regarding their currently available oven. At first, the heating modes available were investigated. As the relevant European regulation was only introduced in 2014, the analysis was split regarding the age of the oven (50% of the ovens are 5 years old or less) and between gas and electric ovens. The heating modes 'top and bottom heat', 'grill' and 'convection/hot air' and combinations thereof are available in almost all ovens which fall under this regulation as they were 5 years old or less (Figure 84, Figure 86). A separate 'Energy-saving mode/Eco mode' is available (and can be identified by the respondent) in about two thirds of the ovens. This is in clear contrast to the older ovens, where this mode is only identified by about one third of the respondents (Figure 85, Figure 87). Besides the 'Energy-saving mode/Eco mode', it is interesting to note that younger ovens do have a lot of additional features available compared to the older ovens and combine the oven function with additional heating and cooking functions (like combi-microwave and combi steam functions) for gas and electric ovens.

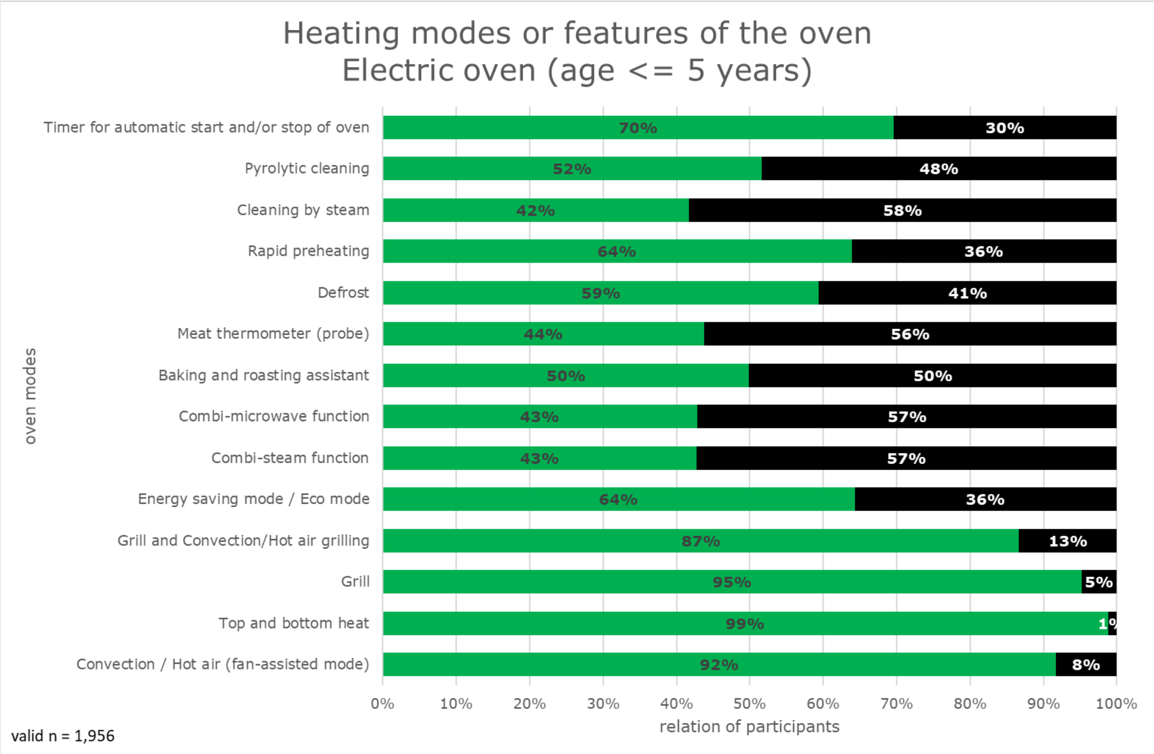



**Figure 84. Heating modes available in electric ovens < 5 years**

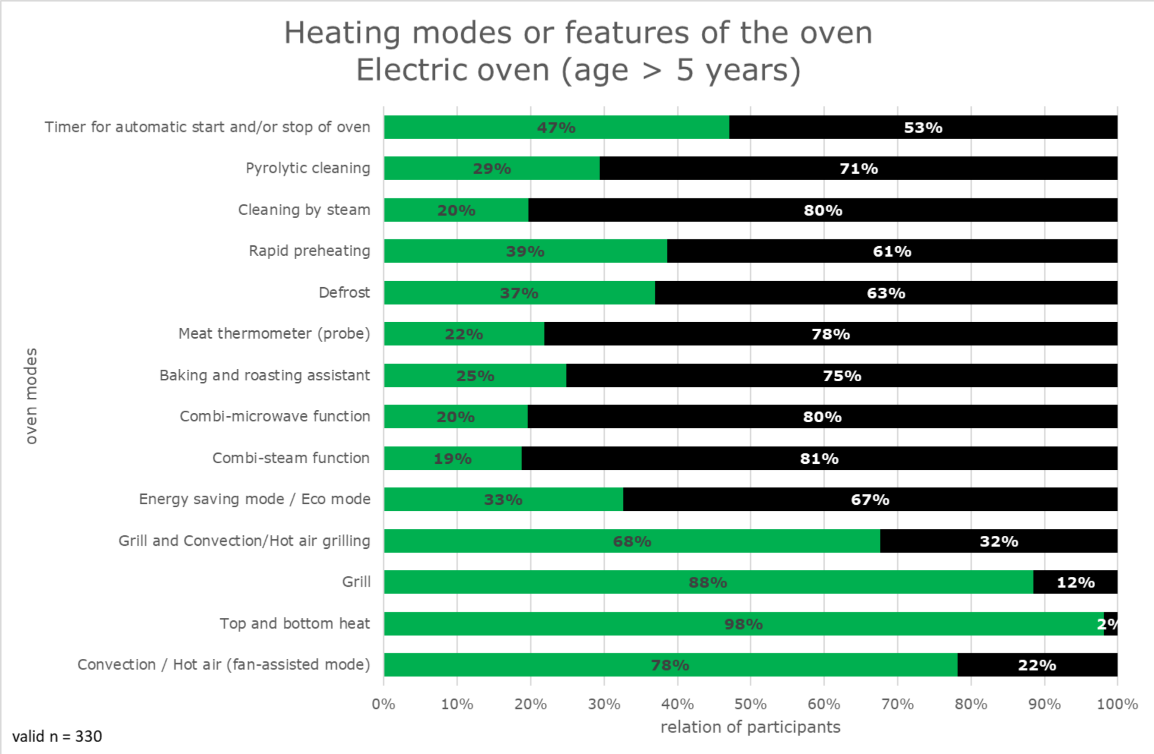



**Figure 85. Heating modes available in electric ovens > 5 years**

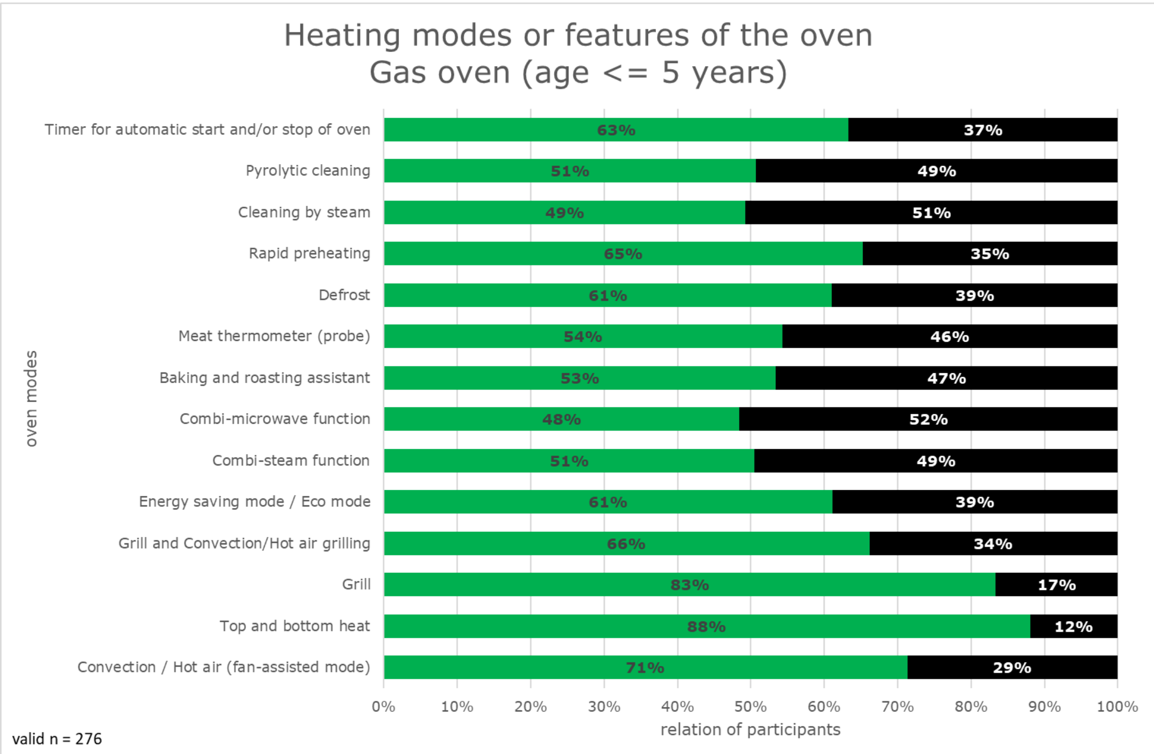



**Figure 86. Heating modes available in gas ovens < 5 years**

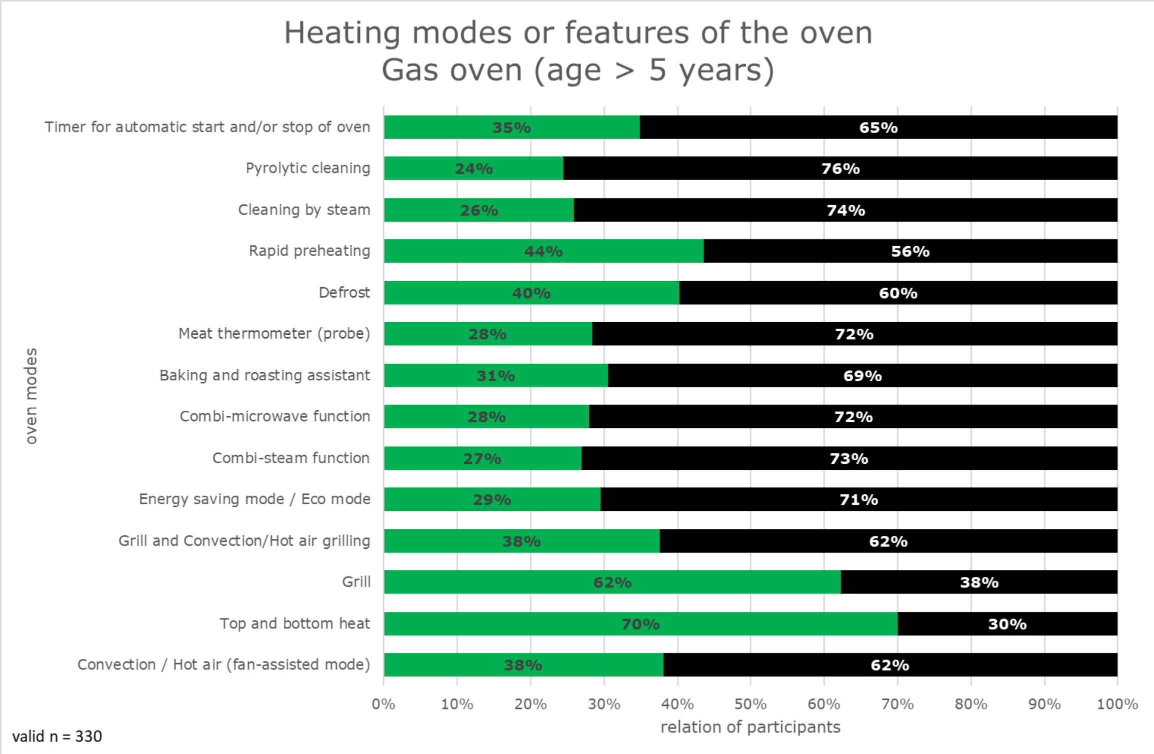



**Figure 87. Heating modes available in gas ovens > 5 years**

However, this difference in available operation modes of the oven depending on their age does not show up in a corresponding difference in the usage of these modes. Comparing the results of the second question regarding the usage frequency of those modes which are available in the oven (gas and electric combined) of the respondent for all respondents (Figure 88) and for these with a younger (Figure 89) and older oven (Figure 90) reveals only minor differences. Generally, the 'traditional' modes of 'top and bottom heat' and 'convection/hot air' are more used in older appliances.

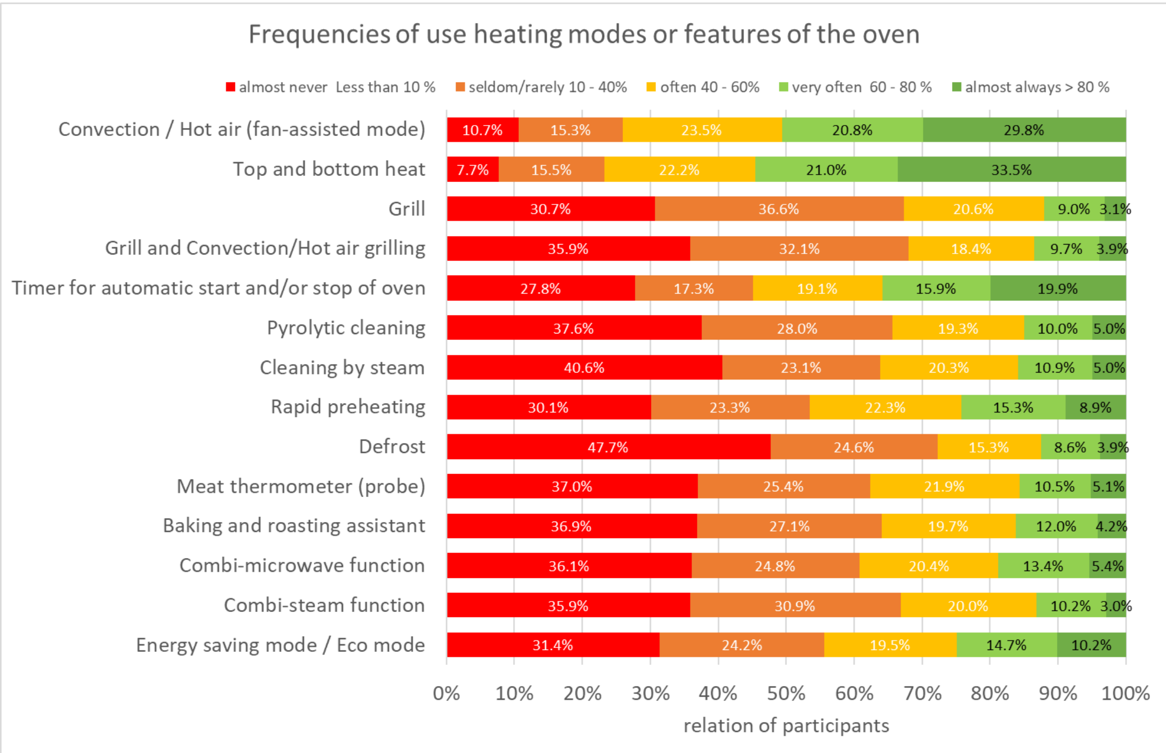



**Figure 88. Frequency of use of heating modes of all ovens**

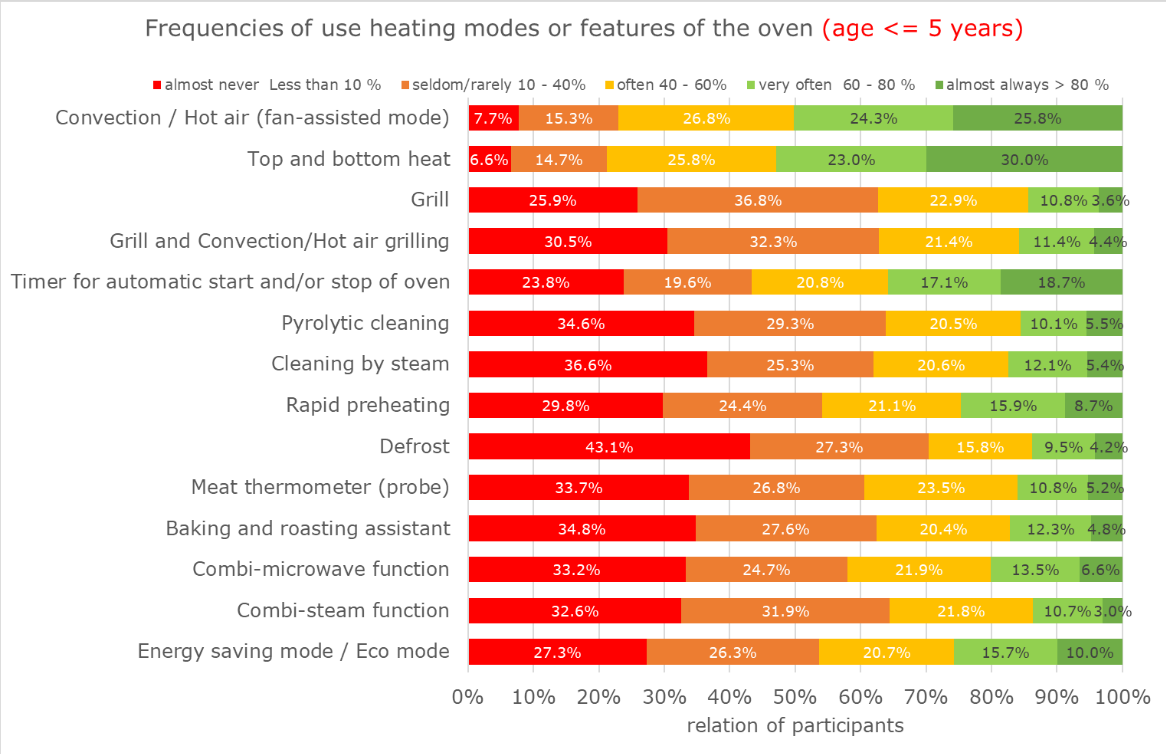



**Figure 89. Frequency of use of heating modes of all ovens < 5 years**

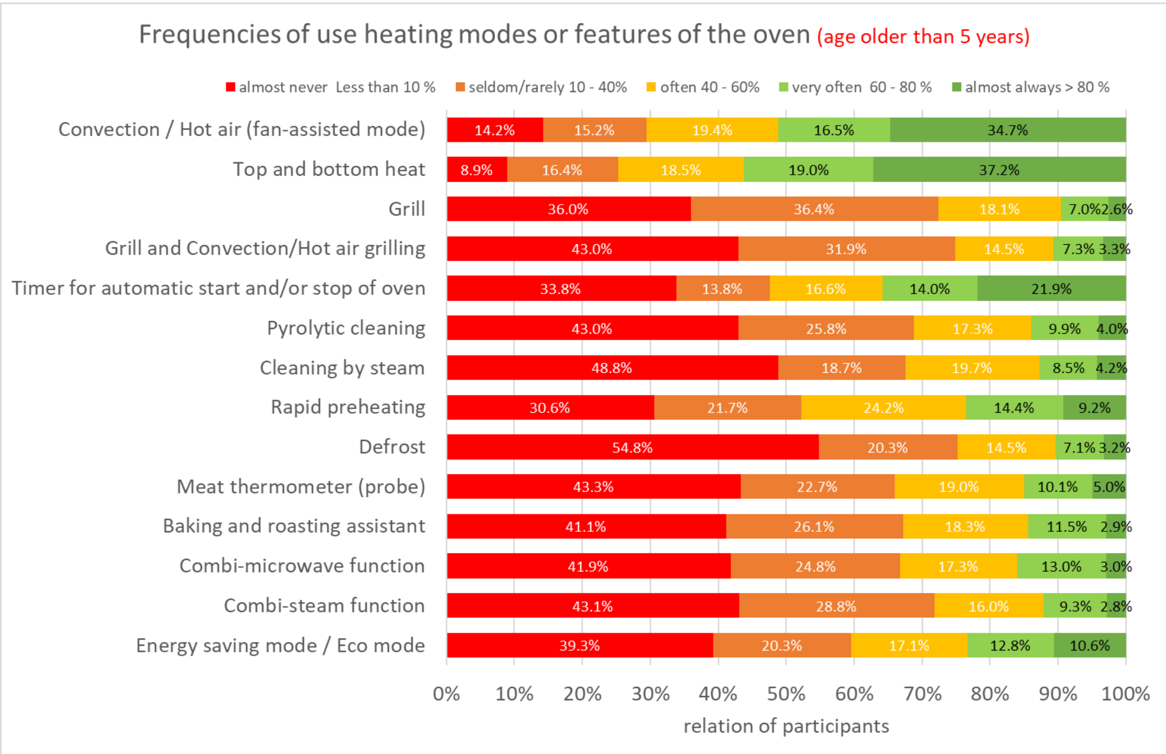



**Figure 90. Frequency of use of heating modes of all ovens > 5 years**

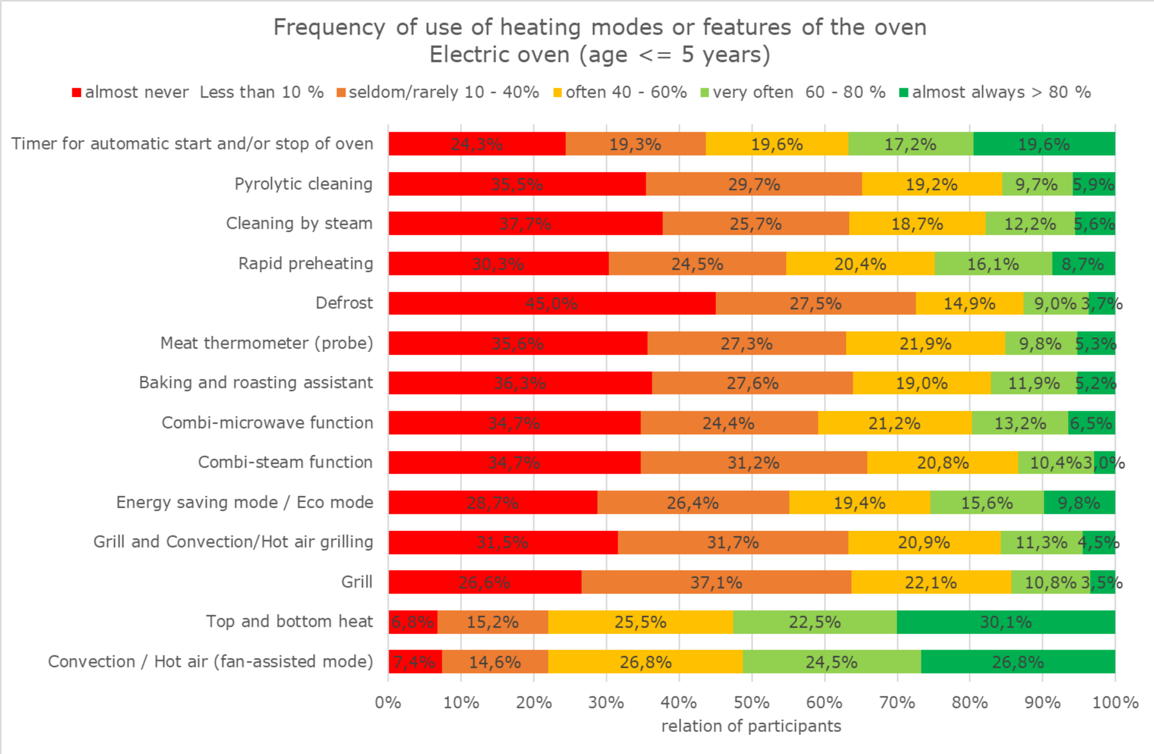



**Figure 91. Frequency of use of heating modes of electric ovens < 5 years**

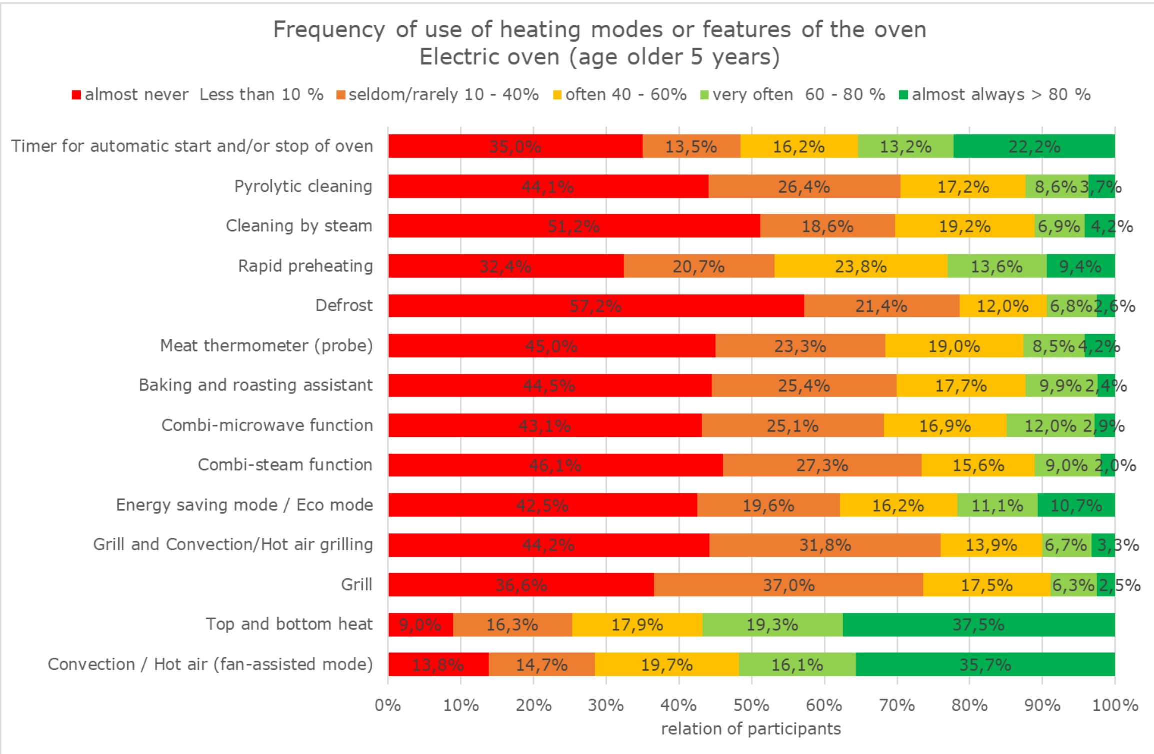



**Figure 92. Frequency of use of heating modes of electric ovens > 5 years**

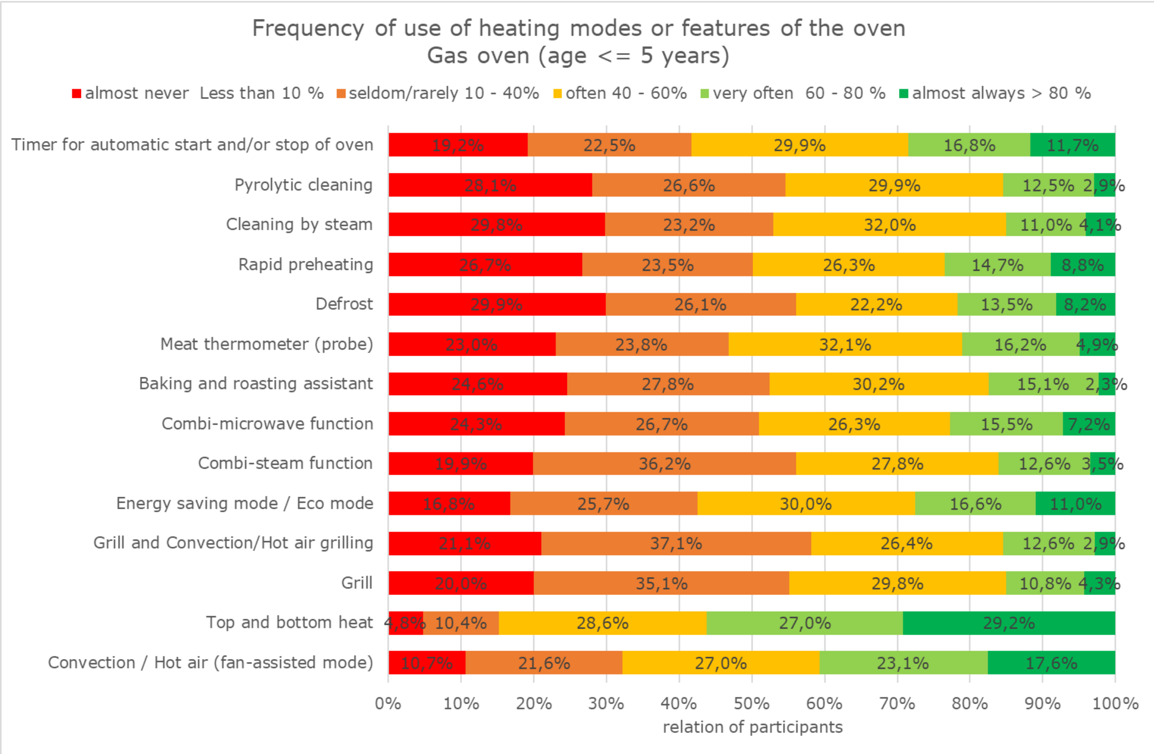



**Figure 93. Frequency of use of heating modes of gas ovens < 5 years**

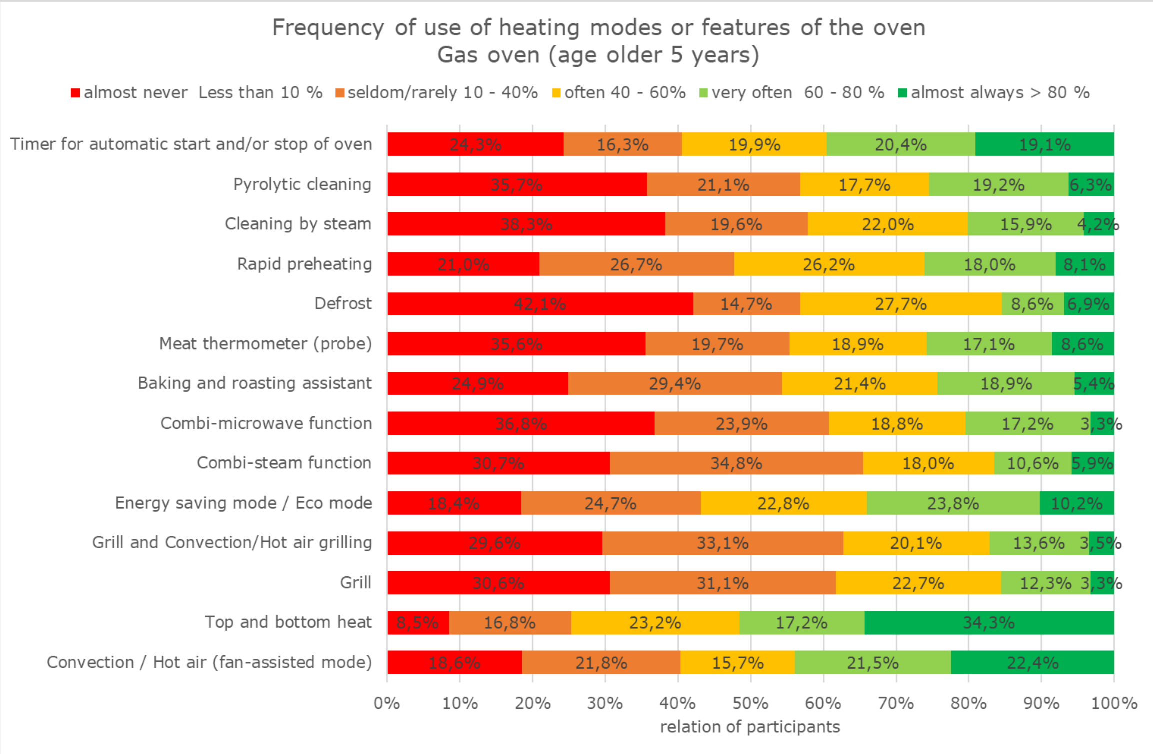



**Figure 94. Frequency of use of heating modes of gas ovens > 5 years**

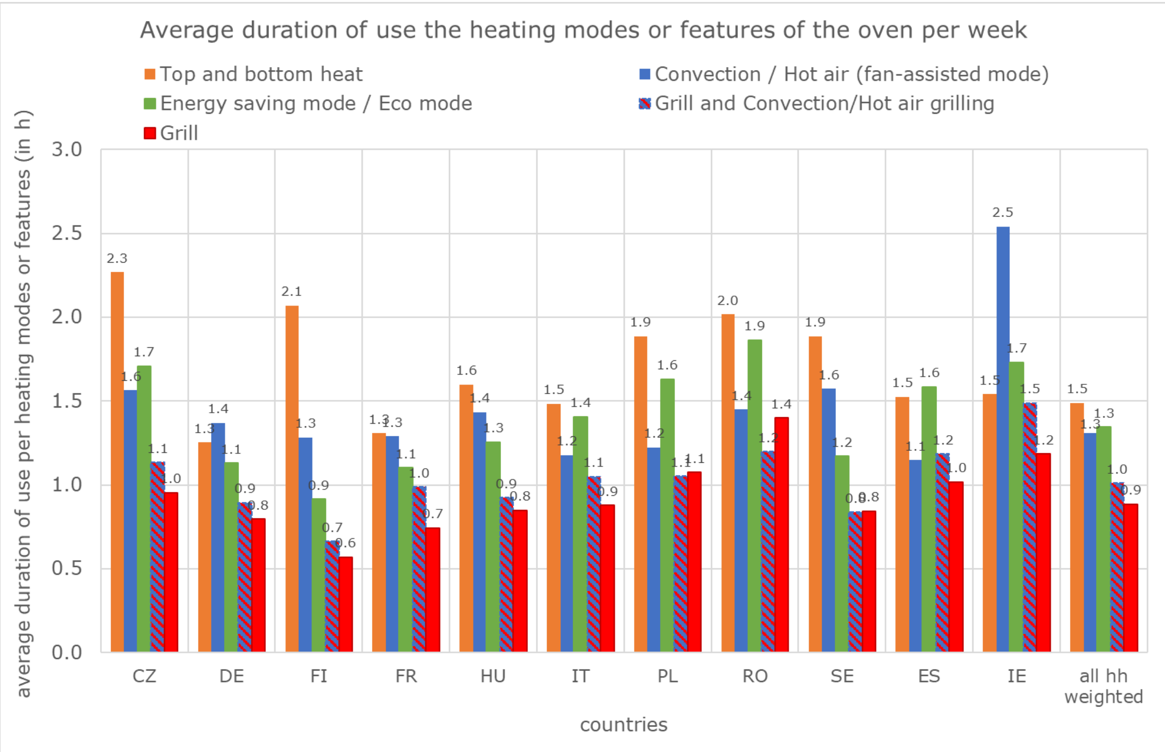



**Figure 95. Duration of use of heating modes of all the ovens**

### 3.8.4.4 Oven cooking habits

The Preparatory Study for Ecodesign Requirements for Ovens (Mugdal et al, 2011) has already shown that there are significant differences in oven electricity consumption, which can be explained by differences in cooking preferences and oven usage among the EU Member States. Participants were asked about their cooking habits when using the oven to shed some light on those differences. Five recommendations for an energy-efficient use of the oven (gas and electric combined) were presented to the participant and they were asked how much they practise this habit. Letting frozen or chilled food approach ambient temperature before placing it in the oven is very often or almost always done by more than 50% of the respondents (Figure 96). Reducing the heat several minutes before the cooking time is completed is followed by less than 40% very often or almost always (Figure 96). An average of more than 70% of the consumers responded (Figure 96) that they very often or almost always remove unused trays from the oven before use. In contrast to this, no preheating of the oven before inserting food is followed by less than 25% of the participants very often or almost always (Figure 96). An average of almost 60% follow the advice to check the dish during cooking via the window only, instead of opening the door very often or almost always (Figure 96).

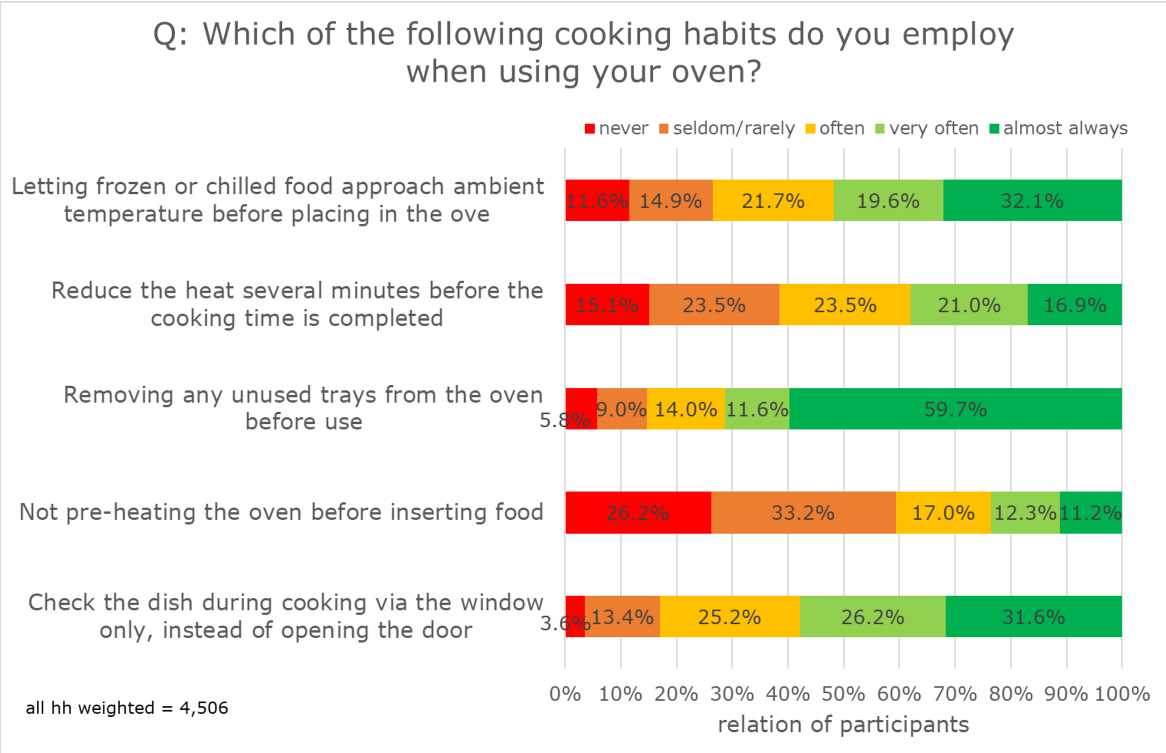



**Figure 96. Cooking habits when using the oven**

#### 3.8.4.5 Frequency of preparation of dishes with the oven

The usage behaviour differences regarding the oven may be influenced by the types of dishes prepared. A list of selected dishes was presented in an arbitrary order to the participants and they were asked how often those dishes were prepared in the oven. When looking at the answers overall, they do not show many differences between the different dishes (Figure 97).

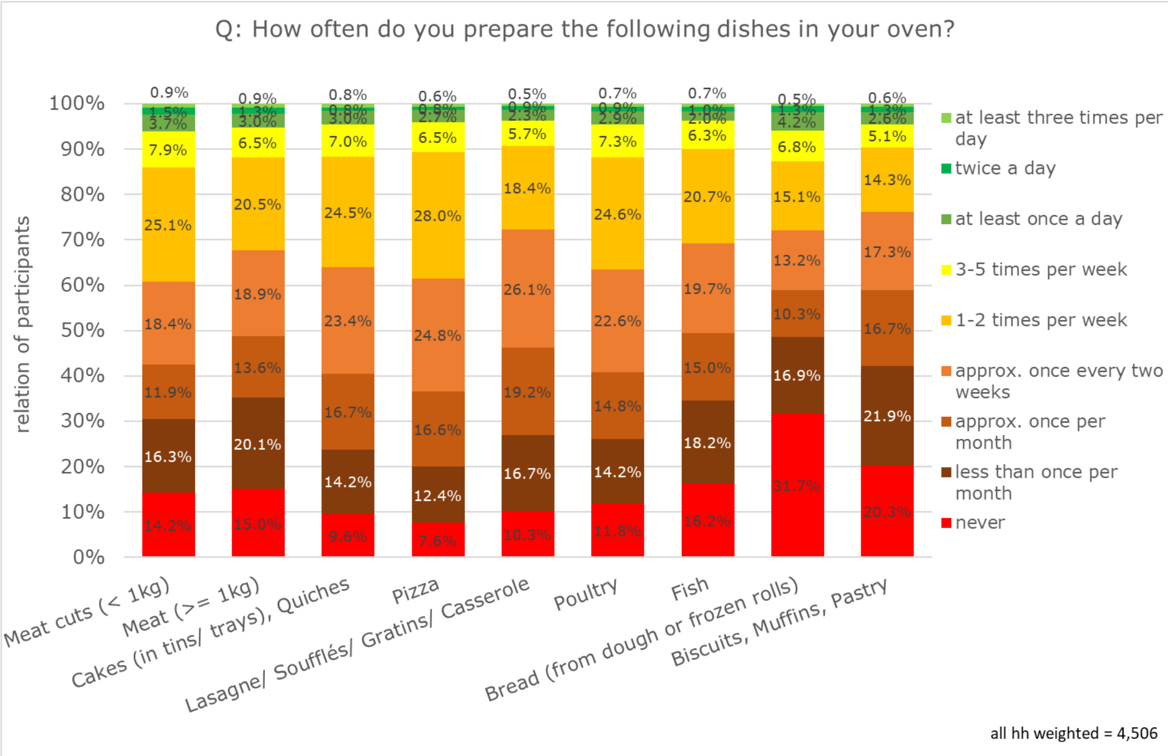



**Figure 97. Frequency of preparing dishes**

However, more differences can be observed regarding the use of the oven looking at the individual dishes by country. Decoding the nominal answers into numerical values depicts the differences between the countries in a simpler way (Table 24). The frequency of preparation of all those dishes over all households only varies between 1.1 and 1.5 times per week. It is not justified to sum up the usage frequencies as some of the dishes can be prepared in parallel in the oven.

**Table 24. Average frequency of preparing dishes per week**

| | countries | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CZ (n=195) | DE (n=551) | FI (n=309) | FR (n=547) | HU (n=307) | IT (n=560) | PL (n=528) | RO (n=283) | SE (n=271) | ES (n=521) | IE (n=292) | all hh weighted (n=4,506) |
| | aver. freq. per week | | | | | | | | | | | |
| Meat cuts (< 1kg) | 1.8 | 1.3 | 1.3 | 1.6 | 1.5 | 1.3 | 1.9 | 2.6 | 1.1 | 1.3 | 2.9 | 1.5 |
| Meat (>= 1kg) | 1.5 | 1.2 | 0.5 | 1.3 | 1.4 | 1.1 | 1.8 | 2.1 | 1.1 | 1.2 | 2.4 | 1.3 |
| Cakes (in tins/ trays), Quiches | 0.8 | 1.1 | 0.5 | 1.6 | 0.9 | 1.5 | 1.5 | 1.6 | 0.7 | 1.2 | 1.2 | 1.3 |
| Pizza | 1.0 | 1.2 | 0.9 | 1.3 | 0.9 | 1.5 | 1.3 | 1.5 | 0.7 | 1.6 | 1.6 | 1.3 |
| Lasagne/ Soufflés/ Gratins/ Casserole | 0.7 | 1.0 | 0.8 | 1.2 | 0.8 | 1.1 | 1.1 | 1.3 | 0.8 | 1.2 | 1.2 | 1.1 |
| Poultry | 1.6 | 1.1 | 0.9 | 1.2 | 1.5 | 1.3 | 1.8 | 2.4 | 1.2 | 1.3 | 2.1 | 1.3 |
| Fish | 0.8 | 0.9 | 0.7 | 1.2 | 0.7 | 1.3 | 1.4 | 1.7 | 1.0 | 1.5 | 1.5 | 1.2 |
| Bread (from dough or frozen rolls) | 0.9 | 1.4 | 0.7 | 1.1 | 0.6 | 1.2 | 1.1 | 1.6 | 0.9 | 1.2 | 1.2 | 1.2 |
| Biscuits, Muffins, Pastry | 1.0 | 0.9 | 0.5 | 1.2 | 0.6 | 1.2 | 1.4 | 1.3 | 0.7 | 1.0 | 0.9 | 1.1 |

### 3.8.5 Hobs

#### 3.8.5.1 Types of hob available

Asked in detail what kind of hob (fixed to kitchen/oven or portable/table-top), the participants revealed that 85% own a hob fixed to the kitchen or oven. About 7% own only a portable/table-top hob and about 8% own both types of hobs (Figure 98). However, there are relatively large differences between countries:

in Hungary and Romania, for example, more than 30% own a portable/table-top hob and for 18% this is the only hob they have (Figure 99).

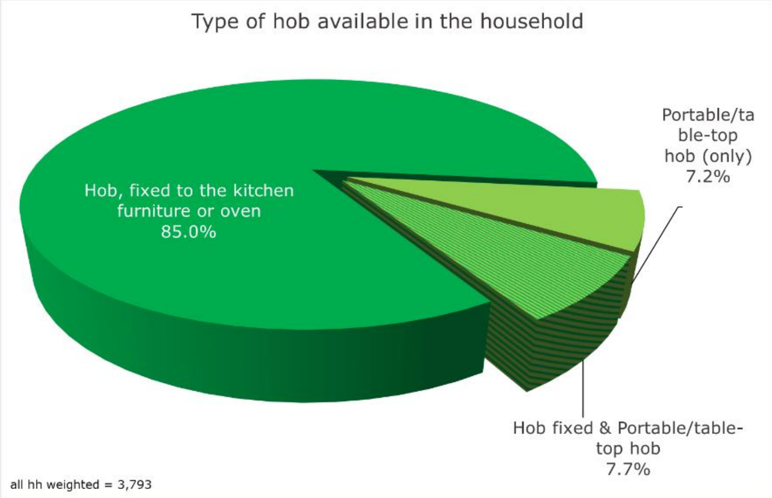



**Figure 98. Type of hob available**

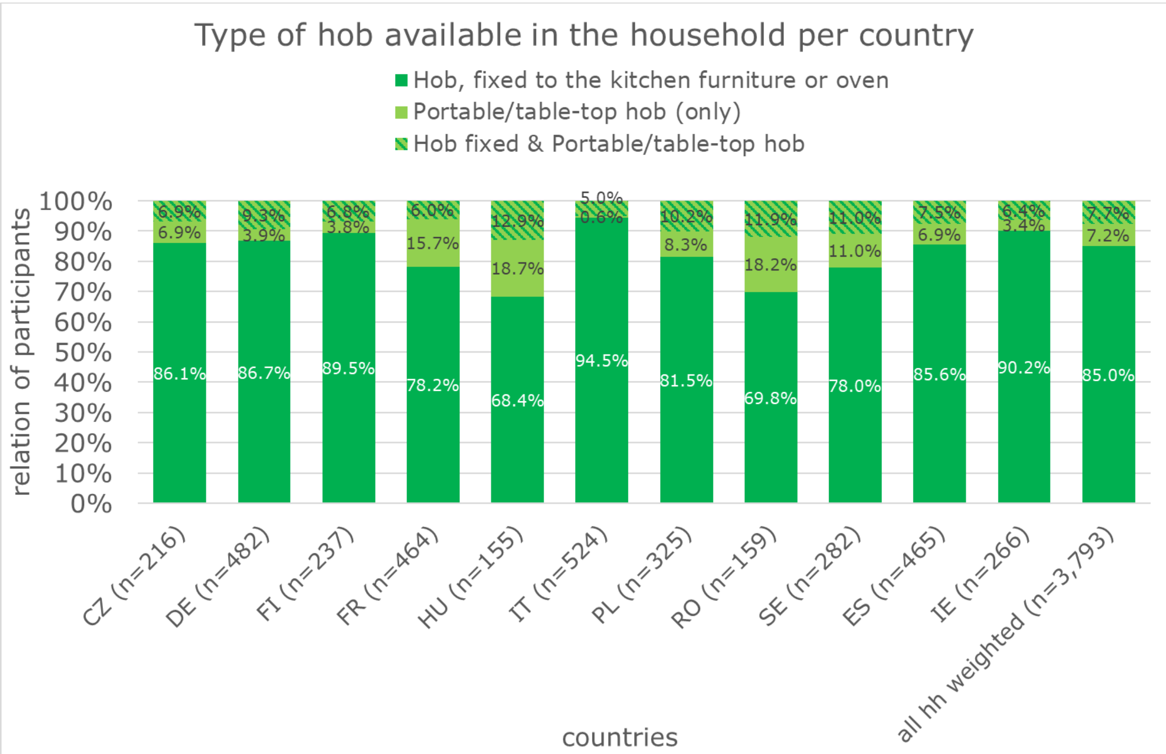



**Figure 99. Type of hob available by country**

#### 3.8.5.2 Types of hob and energy source

As part of the survey, the participating consumers were asked about the energy source of the hob they have and the number of cooking zones or burners their hob has. The answers reveal (Table 25) that 63% of consumers use electricity to run their hob and 31% use gas. Only 6% use both kinds of energy source. This split is almost independent of the kind of hob used in the households.

**Table 25. Type/kind of hob and energy source**

| | | Which of these appliances do you have in your household? | | | |
|---|---|---|---|---|---|
| | | Hob, fixed to the kitchen furniture or oven | Portable/table-top hob | Hob fixed & Portable/table-top hob | all hh weighted (valid n) 3,700) |
| Which type/kind of hob do you have and how many cooking zones or burners are available? | Gas & Electric hob | 4% | 1% | 1% | 6% |
| | Gas hob | 28% | 2% | 2% | 31% |
| | Electric hob | 54% | 5% | 5% | 63% |
| | all hh weighted (valid n = 3,700) | 86% | 7% | 7% | 100% |

Going into more detail about the number of cooking zones and burners their hob has, most electric hobs have four cooking zones (Table 26, Figure 100). Gas hobs also mostly have four single-flame burners – but only one double-flame burner (Figure 101). The situation is very fragmented for hobs using a combination of gas and electricity (Figure 102).

**Table 26. Average number of cooking zones/burners**

| | **Which type/kind of hob do you have and how many cooking zones or burners are available?** | | |
|---|---|---|---|
| | Gas & Electric hob | Gas hob | Electric hob |
| | Aver. | Aver. | Aver. |
| Metallic surface with single-flame burners | 3.0 | 3.7 | |
| and double-flame burners | 2.2 | 1.9 | |
| Glass surface with single-flame burners | 2.4 | 3.4 | |
| and double-flame burners | 2.1 | 2.1 | |
| Solid iron plate with cooking zone(s) | 1.9 | | 3.0 |
| Radiant glass-ceramic with cooking zone(s) | 2.0 | | 3.6 |
| Induction with cooking zone(s) | 2.1 | | 3.3 |

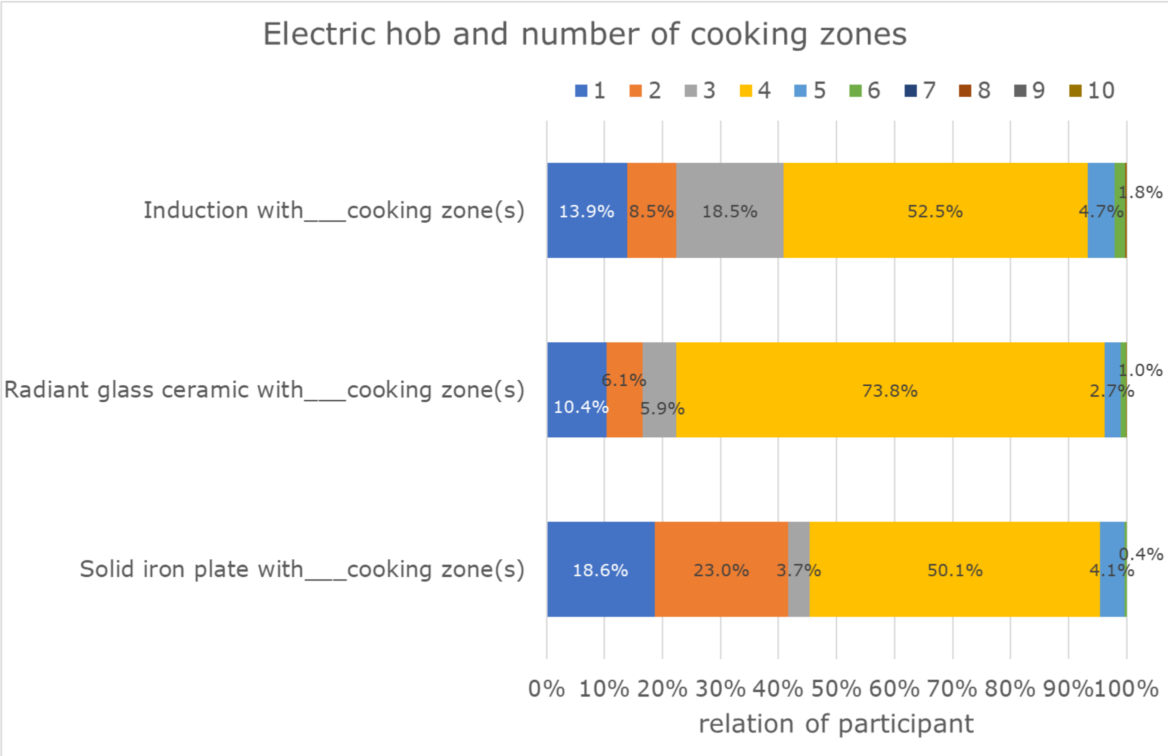



**Figure 100. Electric hob and number of cooking zones**

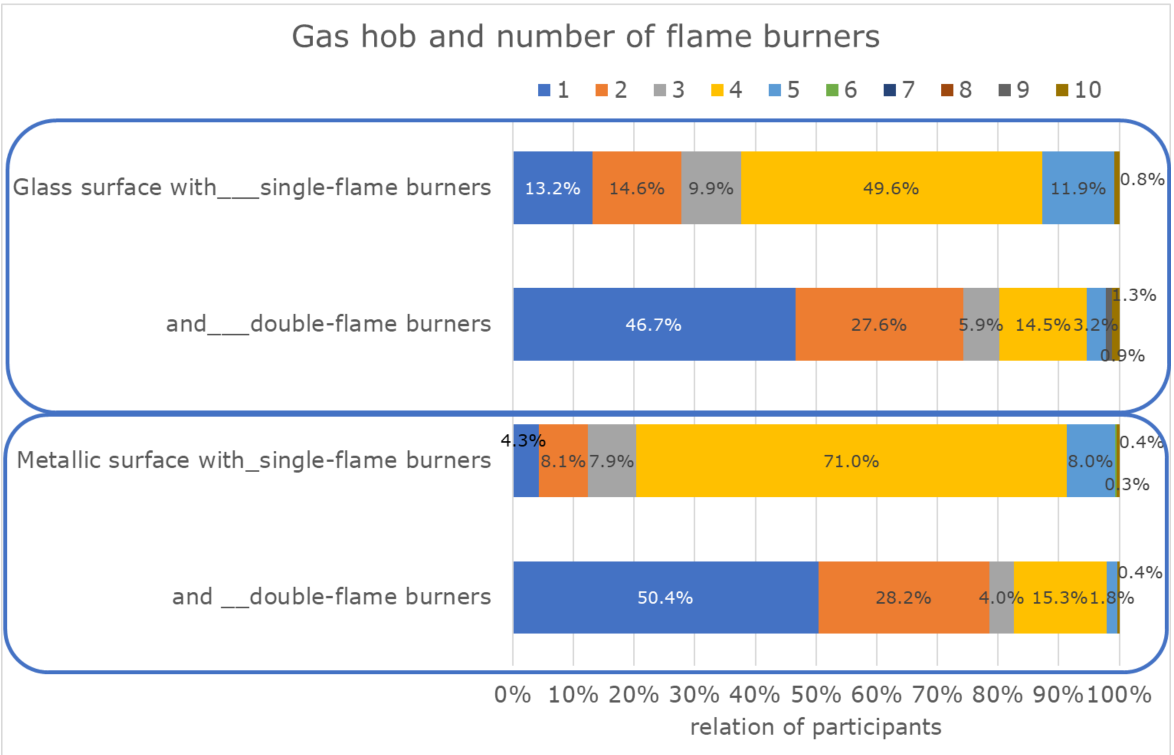



**Figure 101. Gas hob and number of flame burners**

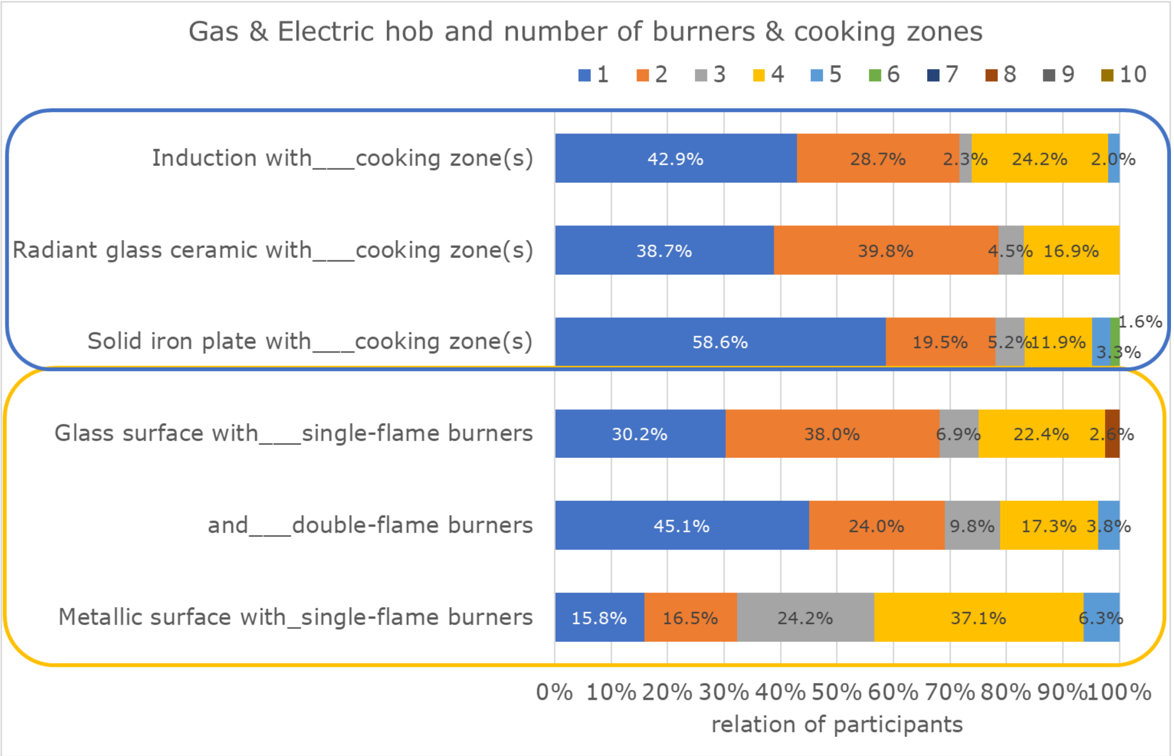



**Figure 102. Electric hob and gas hob and number of cooking zones/flame burners**

Answers to this question also allow one to deduce what kind of cooking surfaces are in use in the households. Gas hobs have a metallic surface for almost 90% of the consumers (Figure 103), while glass-ceramic surfaces are most common for electric hobs in 84% of the households (assuming all which do not have an iron solid plate surface = 16.2%). A combination of surfaces also exists for combined gas and electric hobs as multiple answers were given (Figure 104).

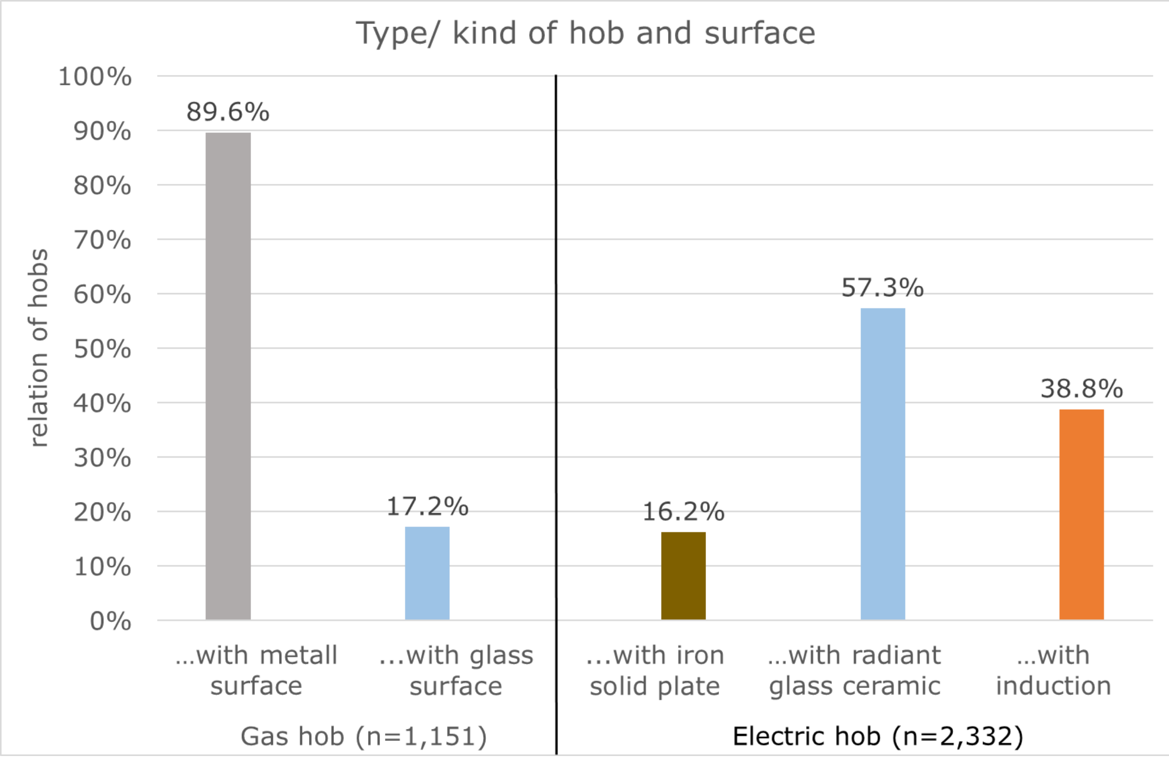



**Figure 103. Gas and electric hob surfaces**

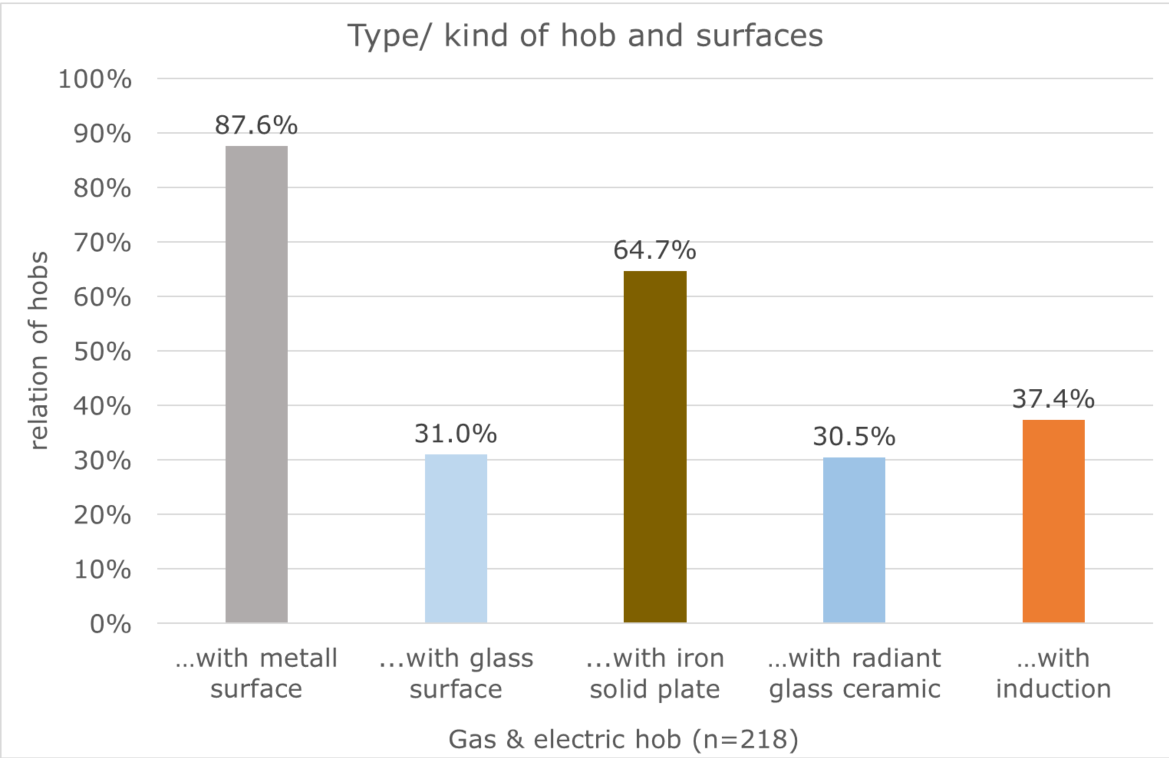



**Figure 104. Combination gas and electric hob surfaces**

Investigating the age of the hob (Figure 105) shows that the average age is highest for combined gas and electric hobs (9.4 years), followed by gas hobs (8.6 years) and electric hobs (7.1 years).

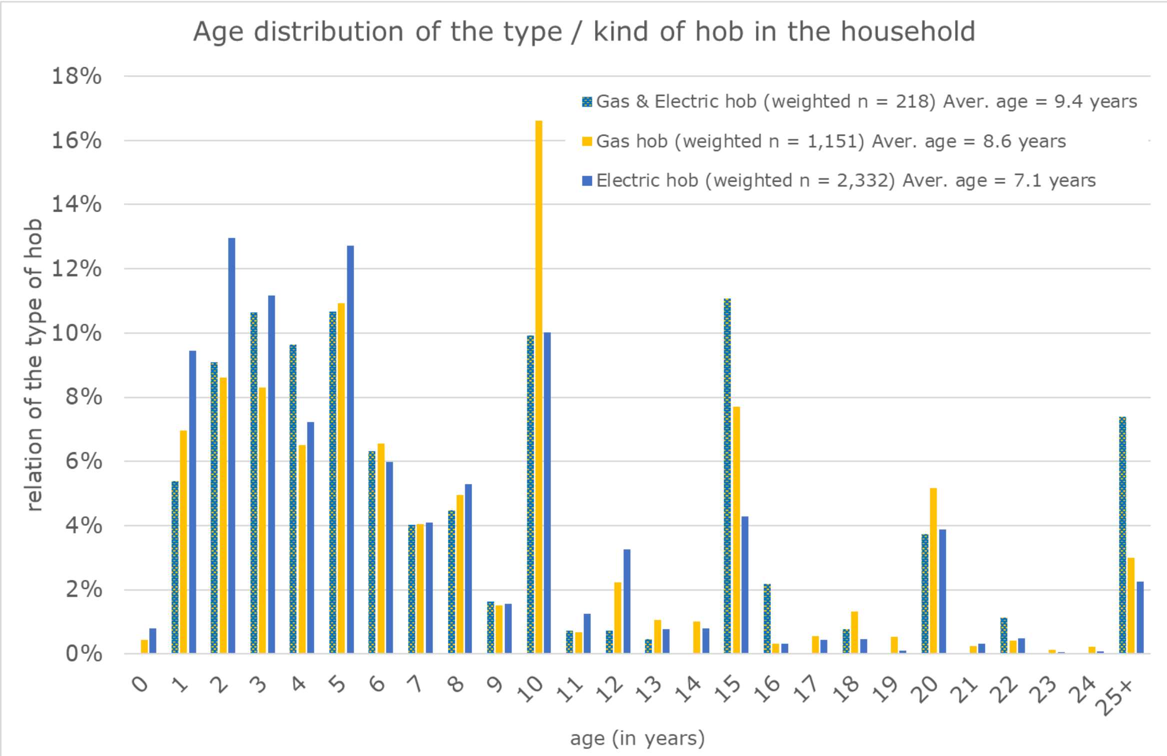



**Figure 105. Age distribution of different types of hobs**

Country-specific averages (Figure 106) show some differences between the average age of hobs, for example in Romania (4.6 years) and Italy (9.4 years).

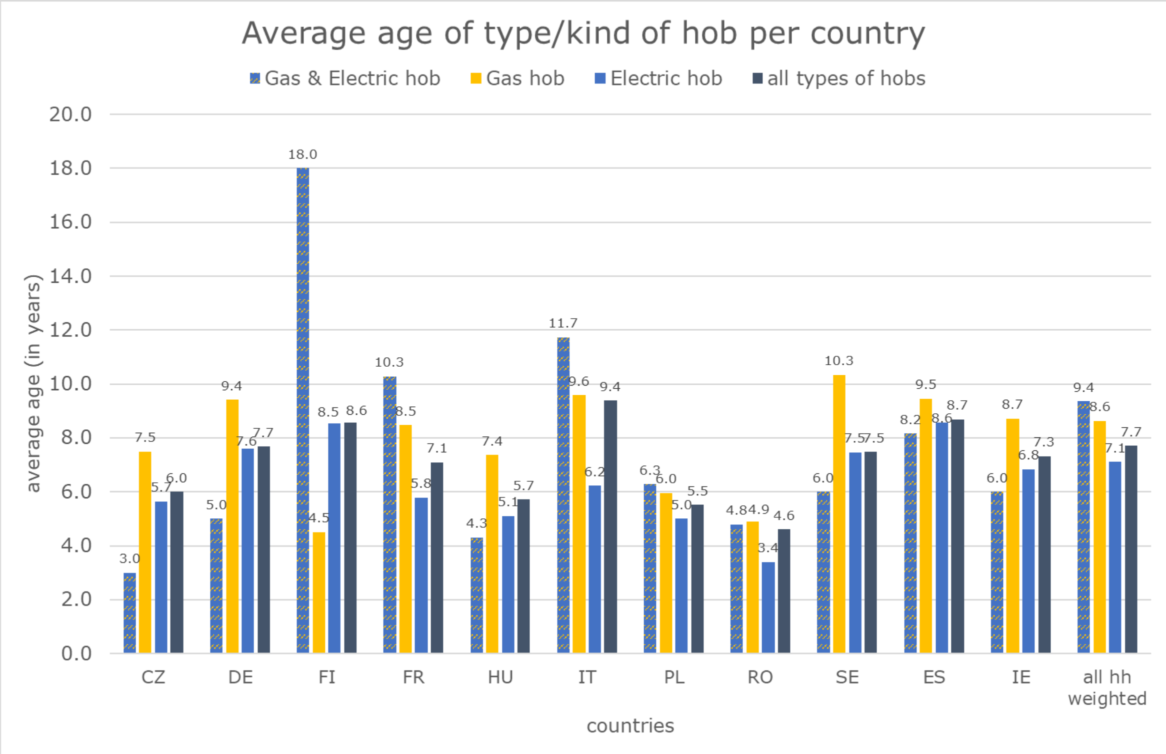
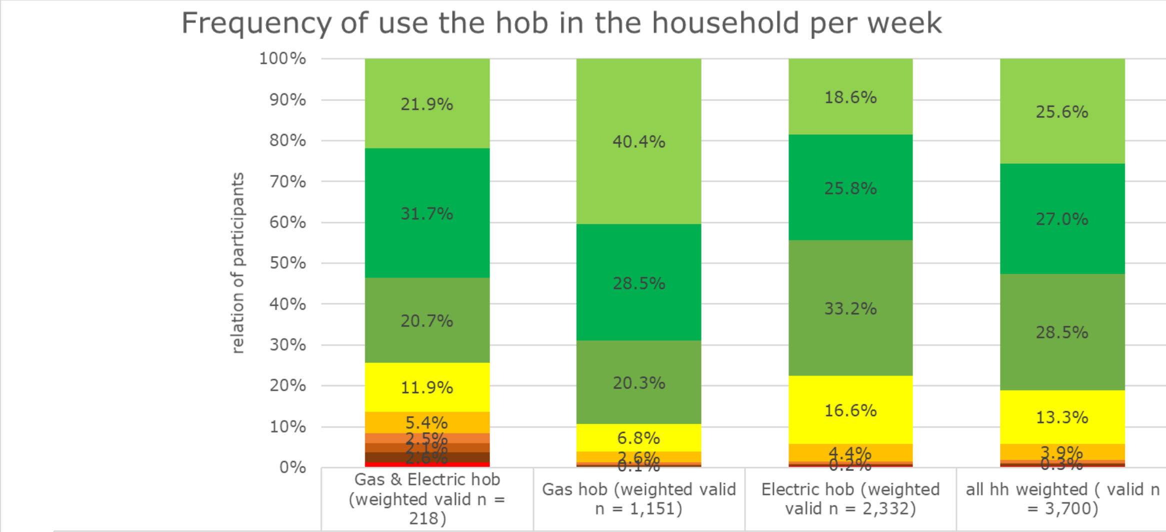



**Figure 106. Average age of different types of hobs**

### 3.8.5.3 Frequency and duration of the use of the hob

The frequency of use of the hob was gathered again by some semi-nominal variables the participants could select. The answers (Figure 107) show that hobs are generally used by about 80% of the consumers at least once per day. Gas-operated hobs are used even more frequently. Decoding the answers into numerical values (Figure 108) shows even more clearly that gas-operated hobs are used more frequently (14.2 times per week), especially compared to electric hobs (10.6 times per week). The hob is used an average of 11.7 times per week. However, the usage averages are very different from country to country (Figure 108). Household size is just one variable to explain those differences, as there is a clear tendency for a more frequent use with an increasing number of members of the household (Figure 109).




| | Gas & Electric hob (weighted valid n = 218) | Gas hob (weighted valid n = 1,151) | Electric hob (weighted valid n = 2,332) | all hh weighted ( valid n = 3,700) |
|---|---|---|---|---|
| at least three times per day | 21.9% | 40.4% | 18.6% | 25.6% |
| twice a day | 31.7% | 28.5% | 25.8% | 27.0% |
| at least once a day | 20.7% | 20.3% | 33.2% | 28.5% |
| 3-5 times per week | 11.9% | 6.8% | 16.6% | 13.3% |
| 1-2 times per week | 5.4% | 2.6% | 4.4% | 3.9% |
| approx. once every two weeks | 2.5% | 0.6% | 0.5% | 0.7% |
| approx. once per month | 2.1% | 0.1% | 0.2% | 0.3% |
| less than once per month | 2.6% | 0.4% | 0.3% | 0.5% |
| never | 1.2% | 0.2% | 0.3% | 0.3% |

**Figure 107. Frequency of use of the hob per week and household**

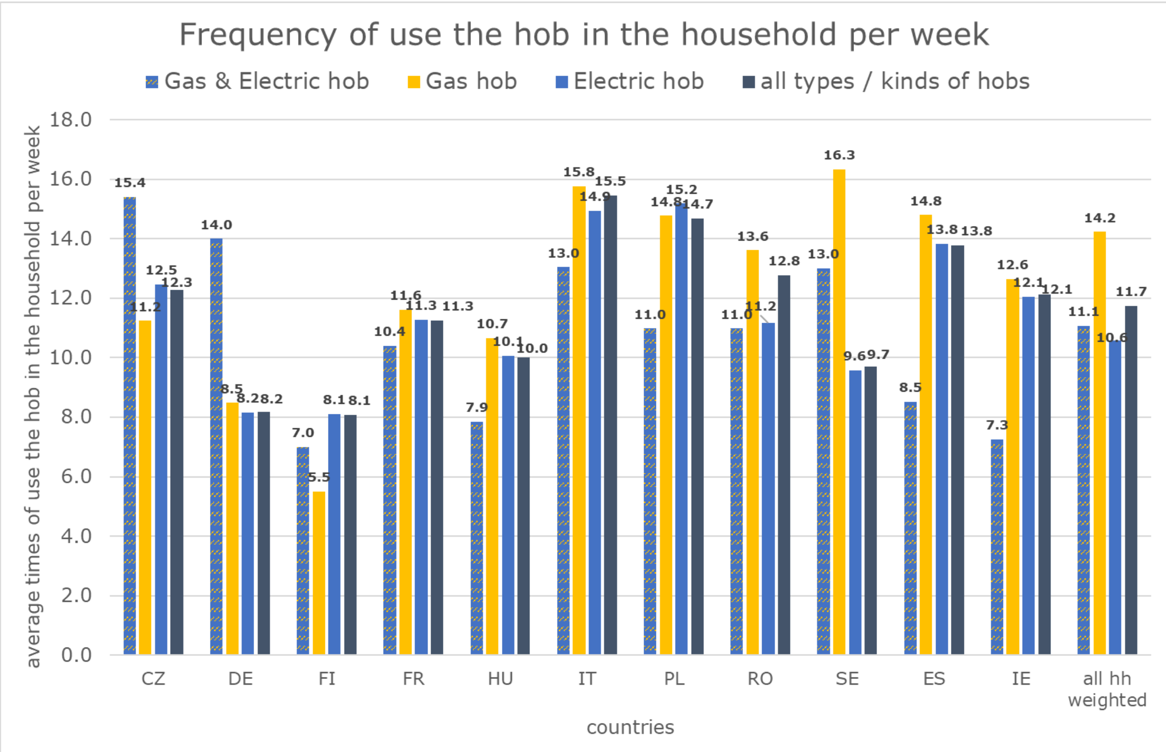



**Figure 108. Average frequency of use by different types of hobs**

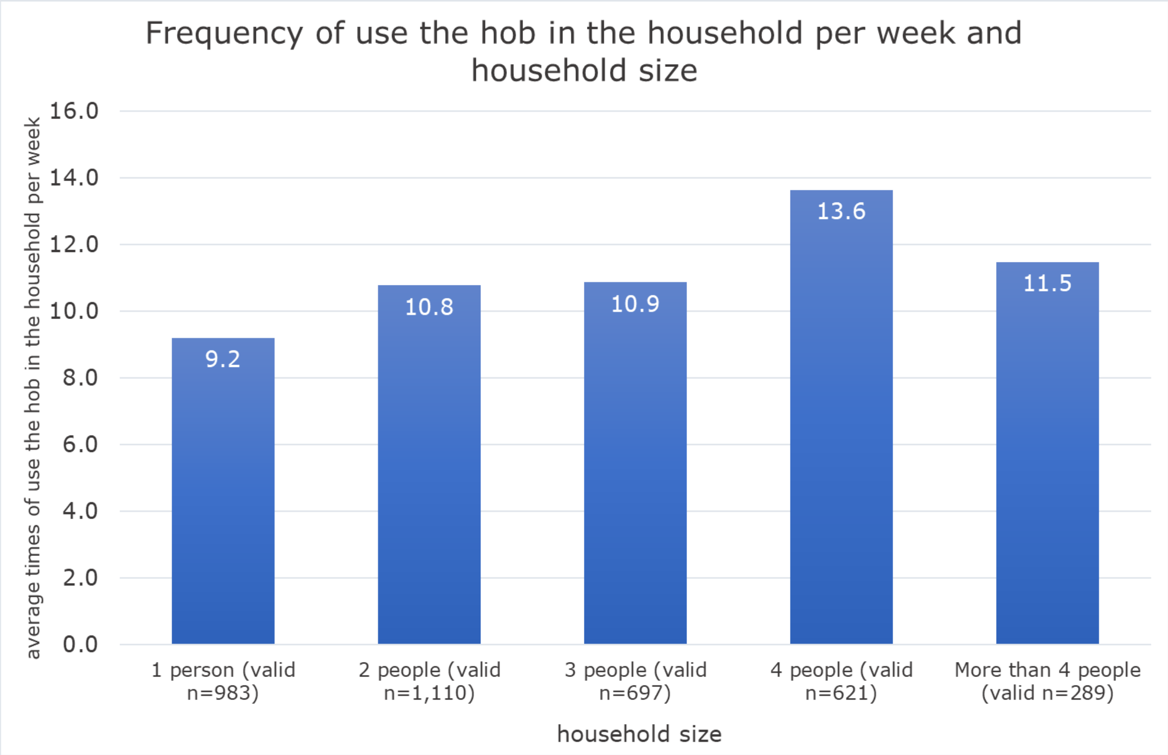



**Figure 109. Average frequency of use of the hob per week and household size**

Regarding the energy consumption, it is more important to know for how long the hob is used. This was addressed in another question where the participants were asked to select the average use of the hob per week. The results show (Figure 110) an almost equal distribution of the answers given between longer than 30 minutes and more than 8 hours. However, looking at the data on a country level reveals significant differences between countries (Figure 111).

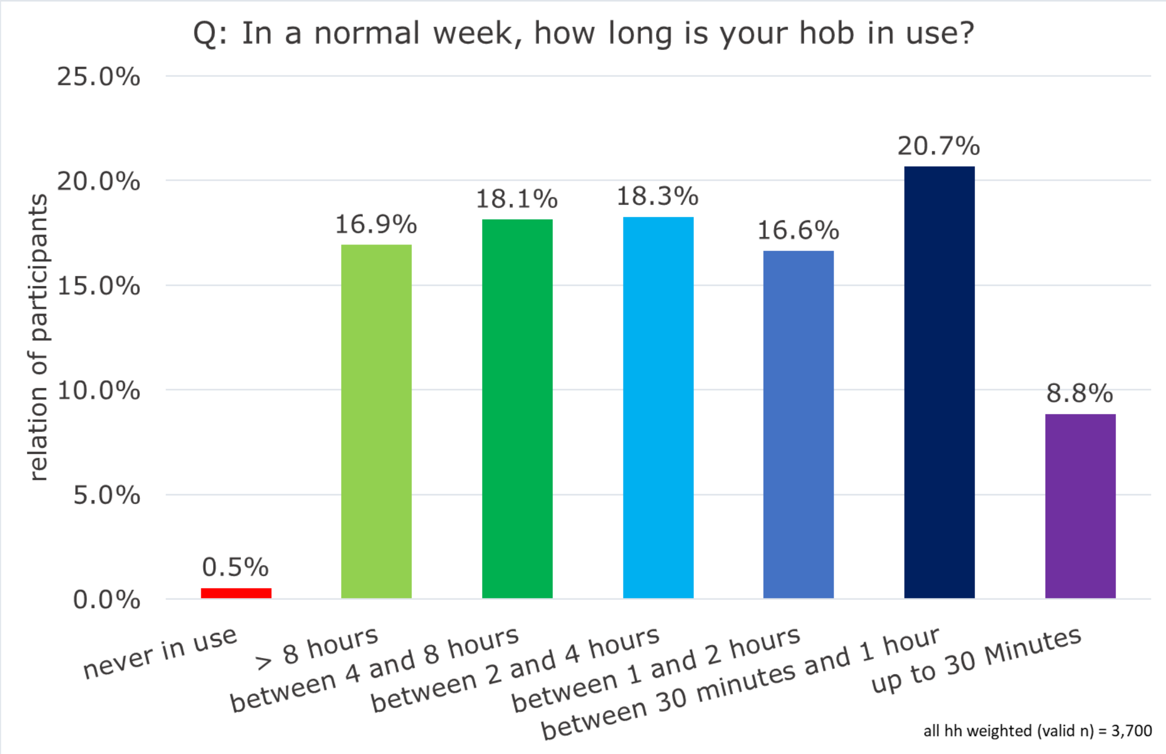



**Figure 110. Distribution of duration of use**

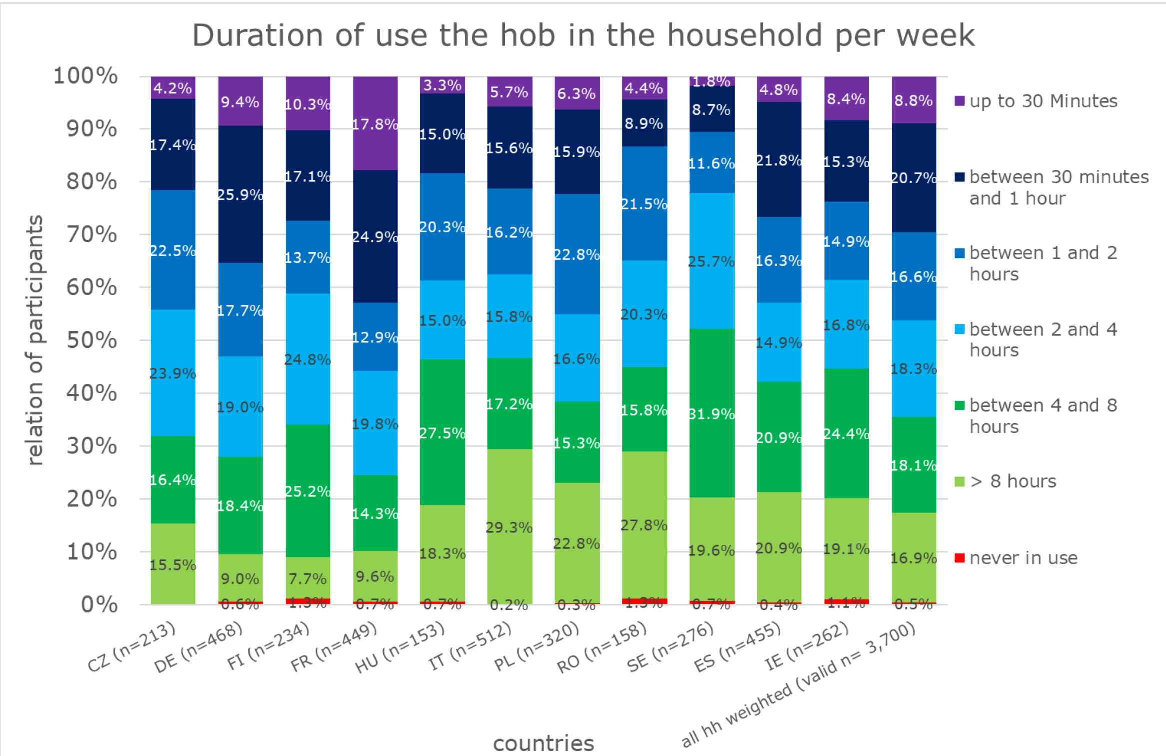



**Figure 111. Distribution of duration of use per country**

Again, decoding the nominal selection of the respondents into numerical values shows that the hob is in use between 2.9 hours (France) and 4.9 hours (Sweden) per week (Figure 112). The overall average use is for 3.8 hours per week.

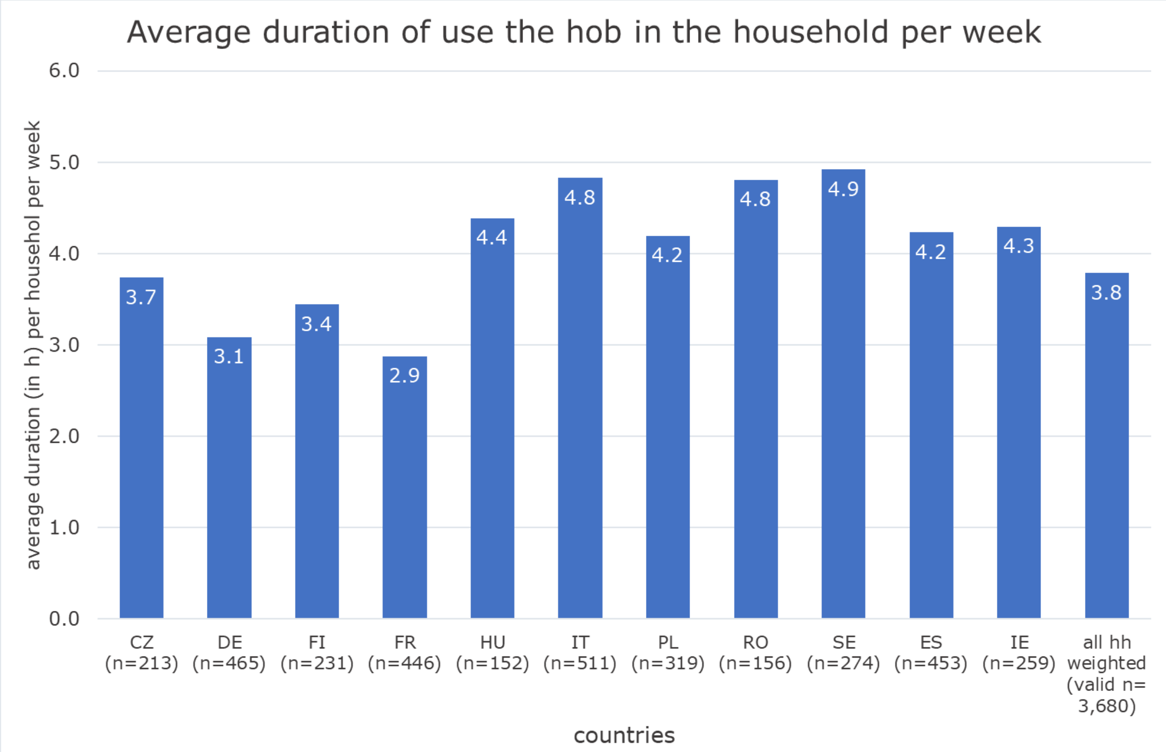



**Figure 112. Average duration of use per week**

The answers about the features the hob has shows that those features are not common, as about one third of the participants do not have any features at all (Figure 113). The most common feature is to keep dishes warm, but the feature most used is the power boost or rapid cooking.

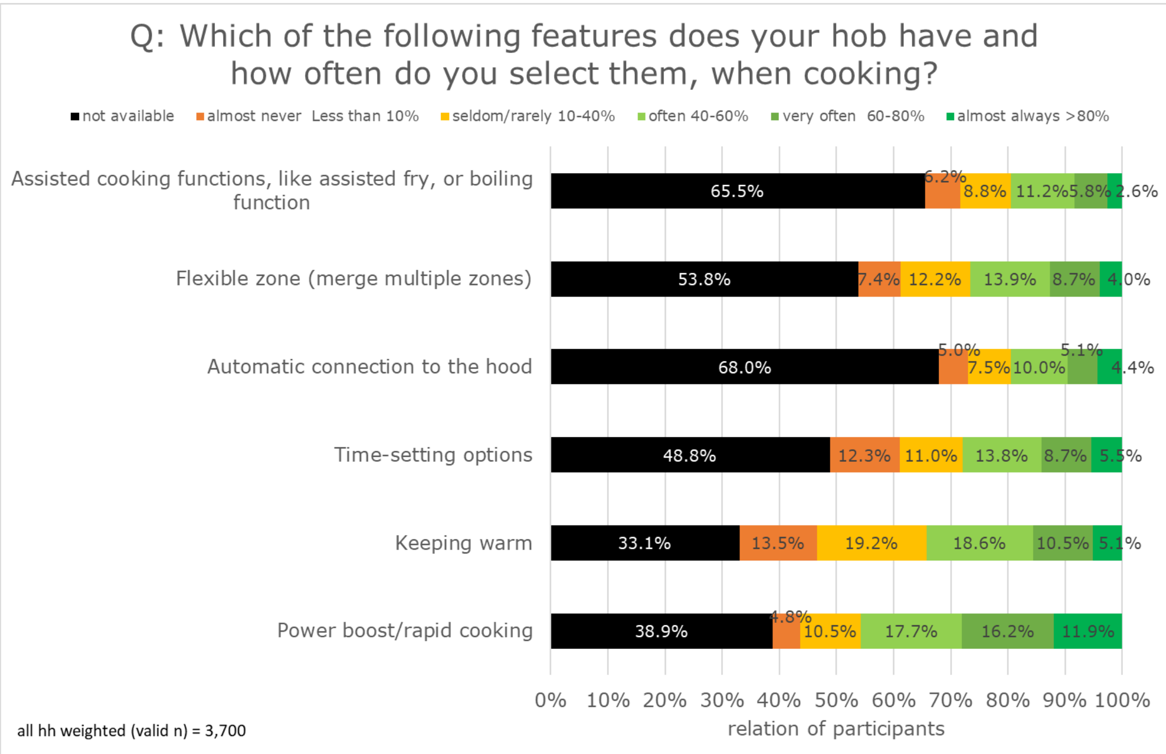



**Figure 113. Availability and frequency of use of features of the hob**

The purpose of using the hob was raised in another question and a range of options were given to the participants as possible answers. The purpose of use most answered was generally cooking pasta, followed by cooking rice or boiling or steaming vegetables (Figure 114).

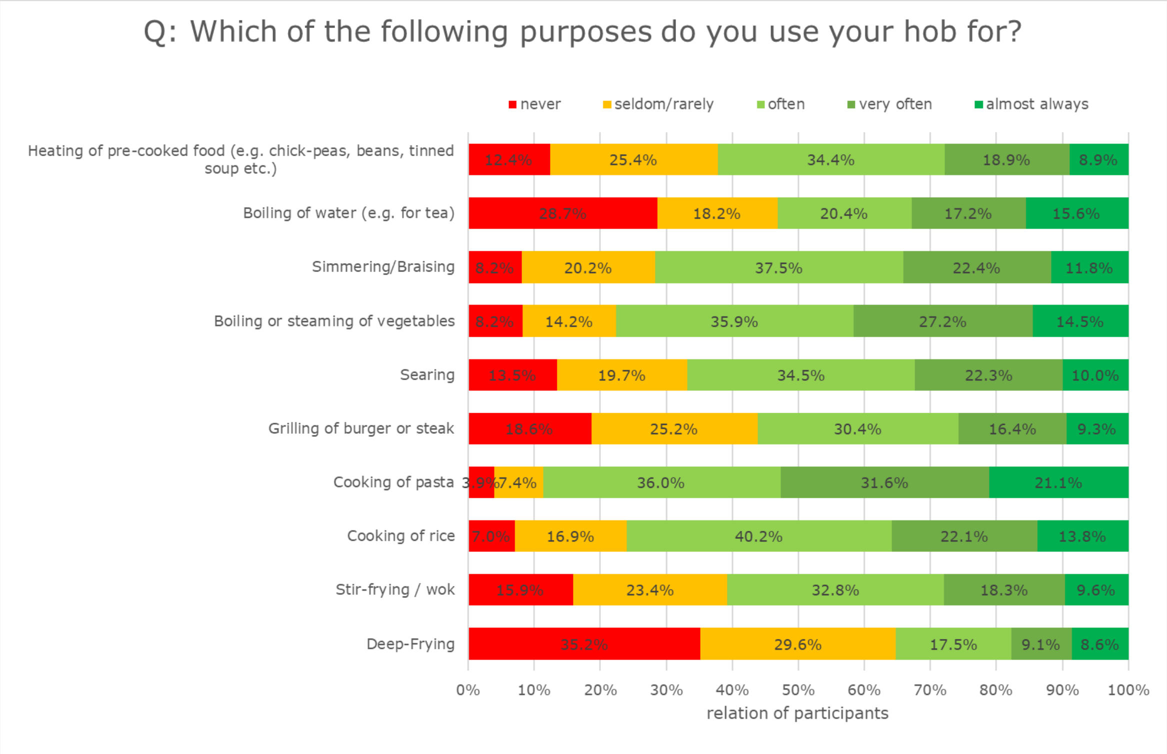



**Figure 114. Purposes of using the hob**

#### 3.8.5.4 Hob cooking habits

Best practice and energy-saving cooking habits when using the hob are followed often, very often or always by an average of at least 80% of the participants, according to their responses (Figure 115).

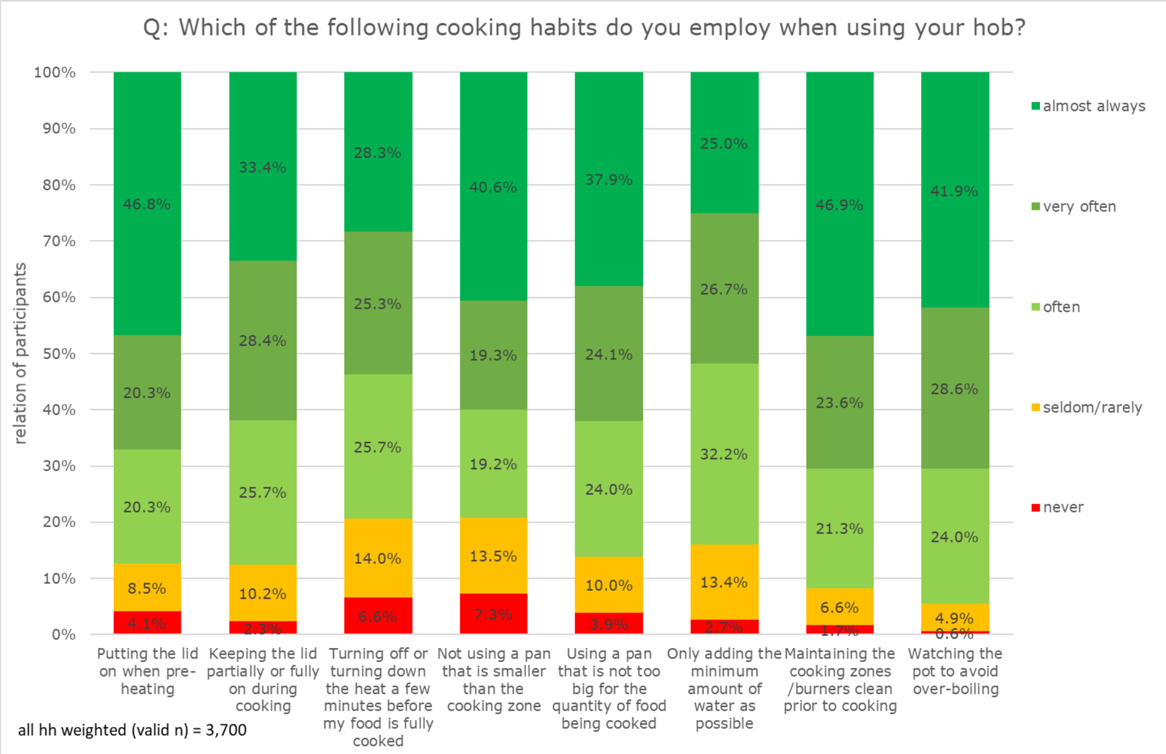



**Figure 115. Cooking habits when using the hob**

## 3.8.6 Cooking fume extractors

### 3.8.6.1 Types of cooking fume extractors in European households

There are various kinds of cooking fume extractors installed in kitchens in Europe (Figure 116). Overall, close to 40% of respondents own a cooking fume extractor built into kitchen furniture and about one third have a stand-alone, wall-mounted cooking fume extractor. One can find a ceiling-mounted cooking fume extractor less frequently. The latest innovation of a downdraft cooking fume extractor mounted at the height of the hob is found in about 8% of the kitchens. However, there are high variations between the countries in our survey.

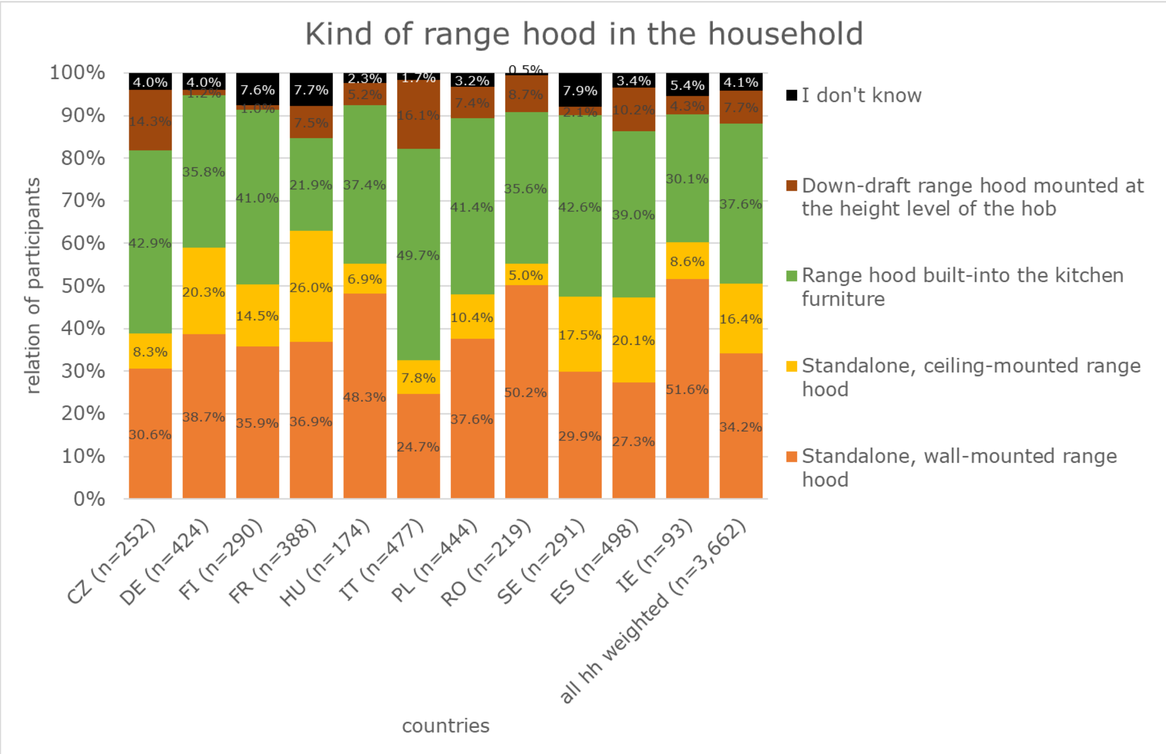



**Figure 116. Type of cooking fume extractor used in the household by country**

### 3.8.6.2 Use of the cooking fume extractor

About 80% of the respondents use the fan of the cooking fume extractor often or almost always when the hob is in use and about 60% use the light of the cooking fume extractor (Figure 117). The differences in usage between countries are not high, but the usage in Sweden and Finland, for example, is highest for both functions (Figure 118, Figure 119). About 14% of the respondents claim also to use the cooking fume extractor when not cooking (Figure 120). Using the cooking fume extractor light as a substitute for the kitchen light is the most important use of the cooking fume extractor when not cooking (Figure 121). Other purposes, such as getting rid of residual food odours and humidity after cooking, when someone is or has been smoking in the kitchen or when cleaning with chemicals in the kitchen, are less often named.

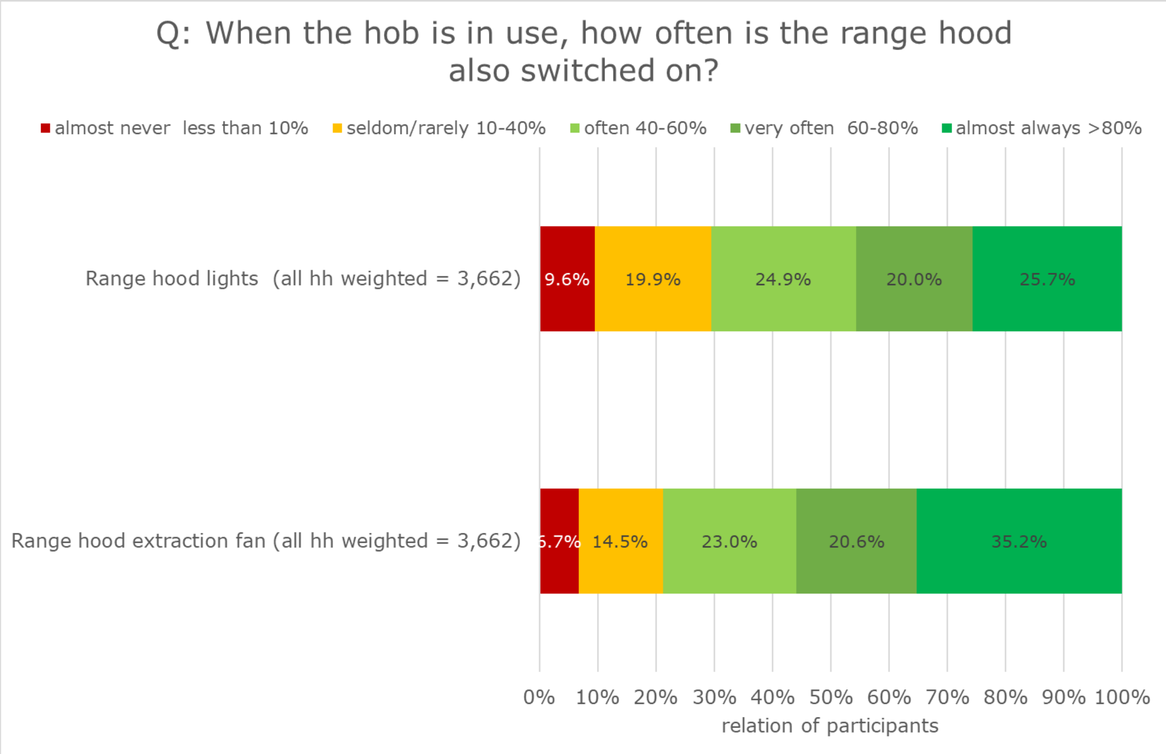



**Figure 117. Frequency of switching on the cooking fume extractor when the hob is used**

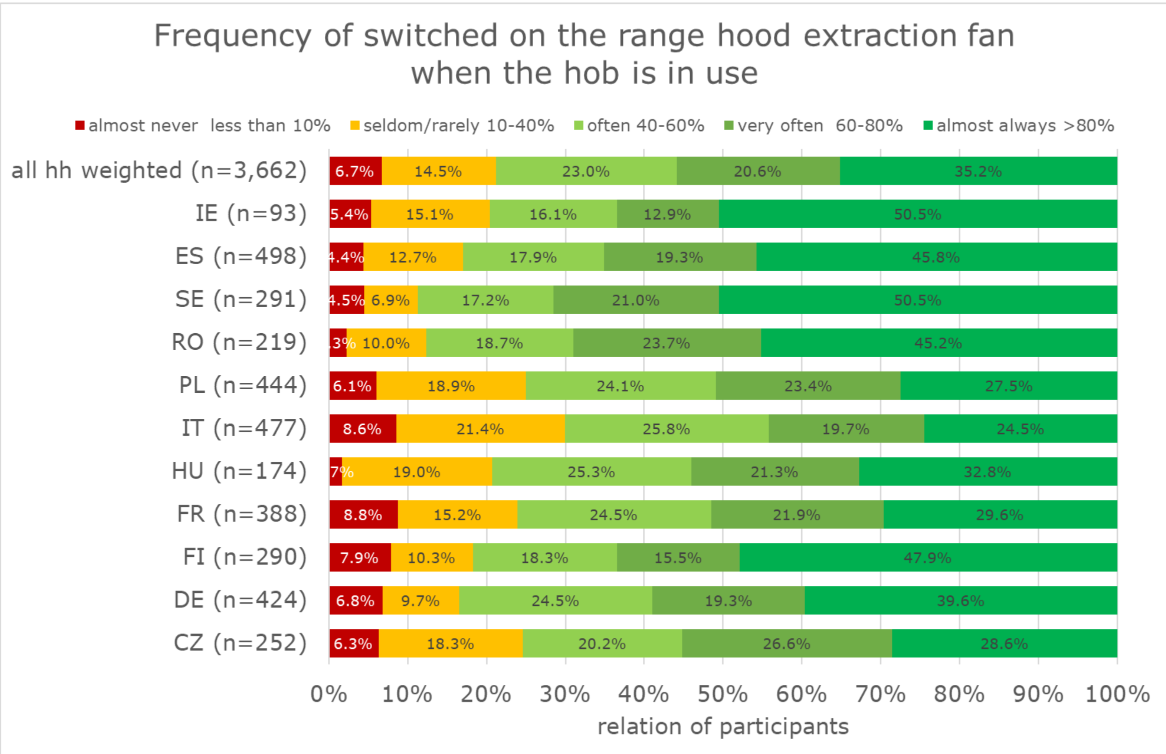



**Figure 118. Frequency of switching on the cooking fume extractor extraction fan when the hob is used**

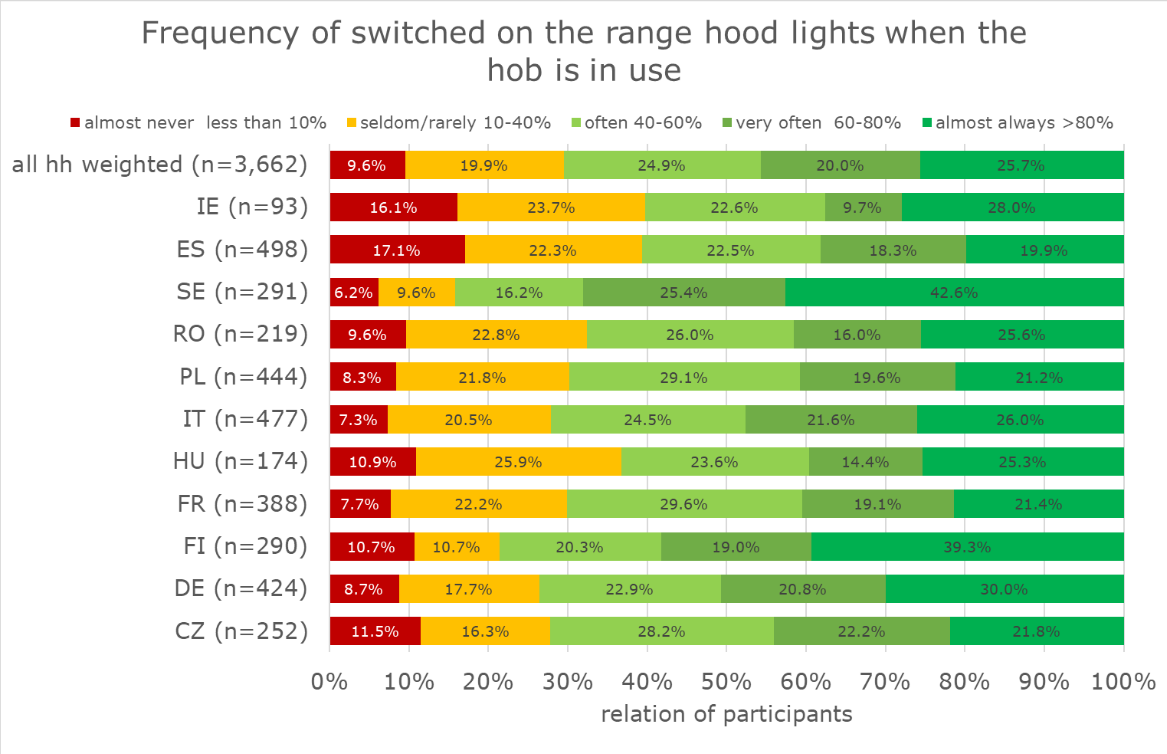



**Figure 119. Frequency of switching on the cooking fume extractor light when the hob is used**

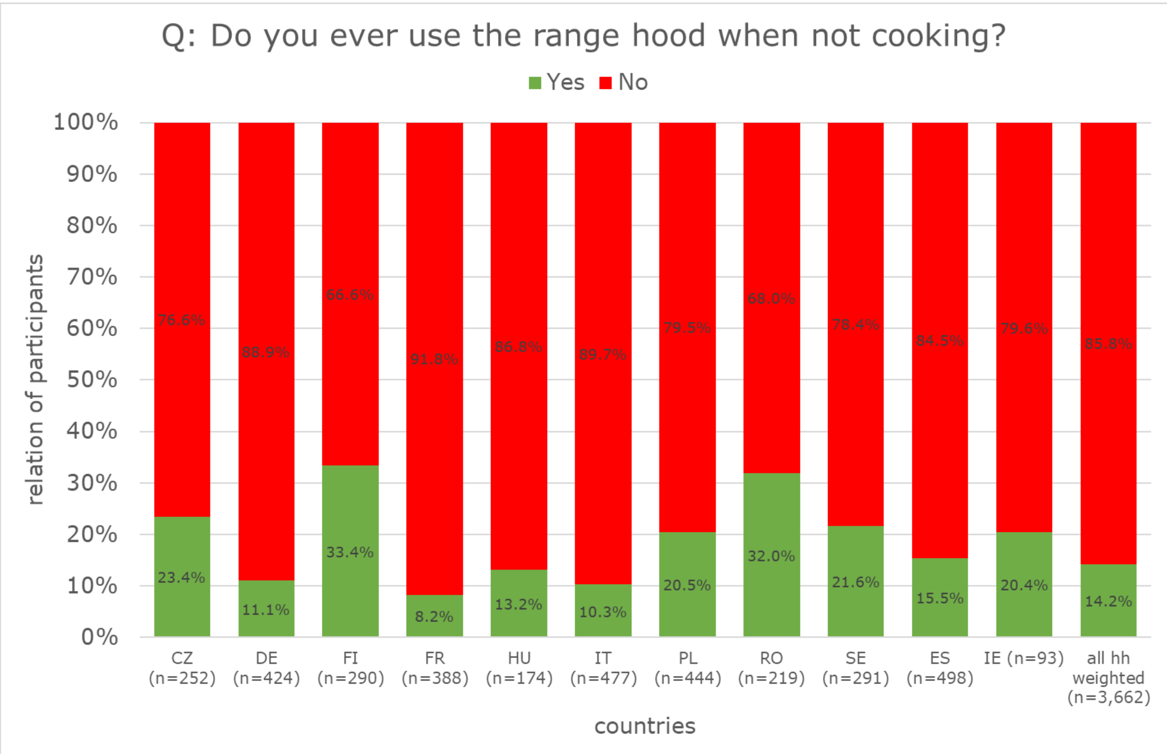



**Figure 120. Usage of the cooking fume extractor when not cooking**

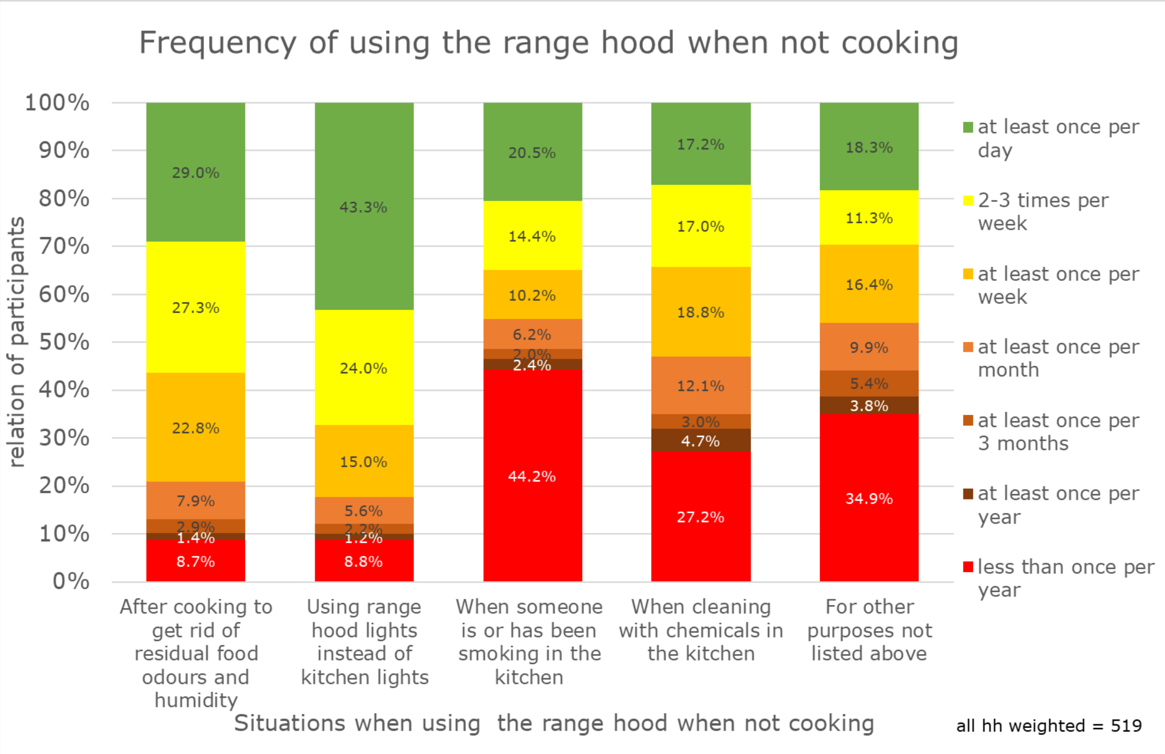



**Figure 121. Frequency of use of the cooking fume extractor when not cooking**

Decoding the nominal answers into numerical values determines the frequency of use of the cooking fume extractor for other purposes on average by country (Table 27).

**Table 27. Average frequency of use of the cooking fume extractor for other purposes per week**

| | After cooking to get rid of residual food odours and humidity | Using cooking fume extractor light instead of kitchen light | When someone is or has been smoking in the kitchen | When cleaning with chemicals in the kitchen | For other purposes not listed above |
|---|---|---|---|---|---|
| | avg. freq. per week | | | | |
| CZ (n = 59) | 2.5 | 3.4 | 1.3 | 1.3 | 0.7 |
| DE (n = 47) | 1.8 | 4.5 | 1.5 | 0.8 | 0.9 |
| FI (n = 97) | 2.5 | 3.2 | 0.8 | 1.3 | 2.0 |
| FR (n = 32) | 2.3 | 3.2 | 1.9 | 1.8 | 1.5 |
| HU (n = 23) | 3.0 | 3.7 | 1.1 | 1.1 | 0.9 |
| IT (n = 49) | 2.8 | 3.4 | 1.9 | 2.6 | 2.0 |
| PL (n = 91) | 4.2 | 4.3 | 2.3 | 2.5 | 2.8 |
| RO (n = 70) | 3.9 | 3.2 | 3.3 | 2.5 | 1.8 |
| SE (n = 63) | 3.4 | 4.0 | 1.2 | 1.0 | 1.7 |
| ES (n = 77) | 3.4 | 3.8 | 2.3 | 2.3 | 2.2 |
| IE (n = 19) | 2.6 | 2.4 | 1.1 | 1.5 | 0.9 |
| all hh weighted (n = 519) | 3.0 | 3.8 | 1.9 | 1.9 | 1.8 |

Variable fan speeds are available in at least 80% of all cooking fume extractors (Figure 122). A boost speed function is available for about 40% of the participants. An intermediate speed function is used the most in all countries (Figure 123).

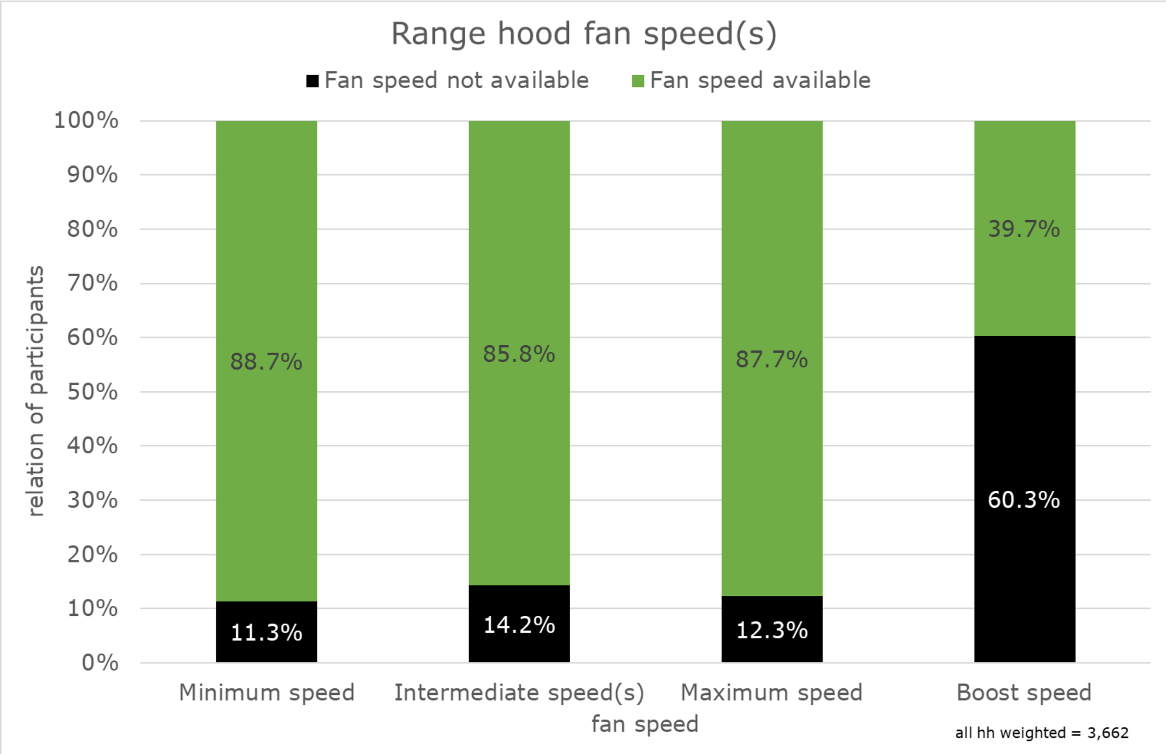



**Figure 122. Availability of fan speeds of the cooking fume extractor**

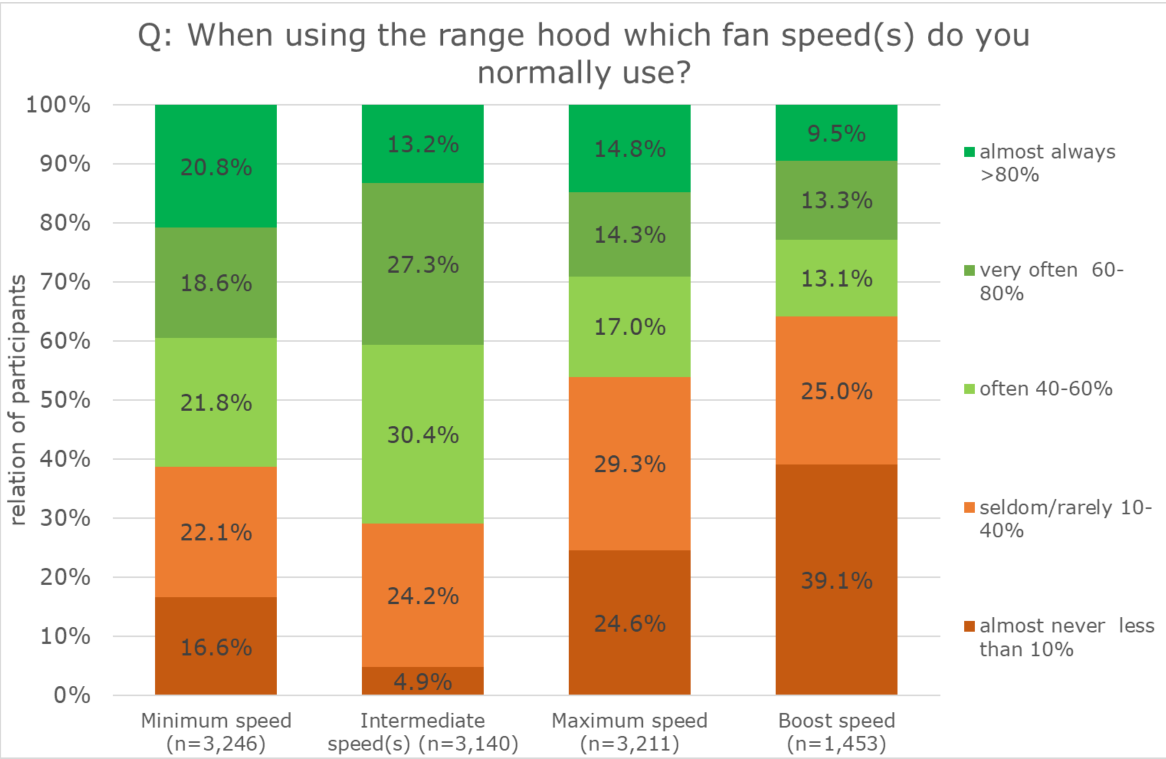



**Figure 123. Usage of fan speeds of the cooking fume extractor**

About 45% of the participants claim that their cooking fume extractor is equipped with a metal mesh filter and roughly 20% each claim to have a paper or fabric-based filter and a charcoal cartridge filter (Figure 124). However, 15% do not know which filter their cooking fume extractor has. The latter are probably those who claim not to know or never to clean the filter of the cooking fume extractor (Figure 125). About 50% of the respondents claim to clean the filter at least once every 3 months.

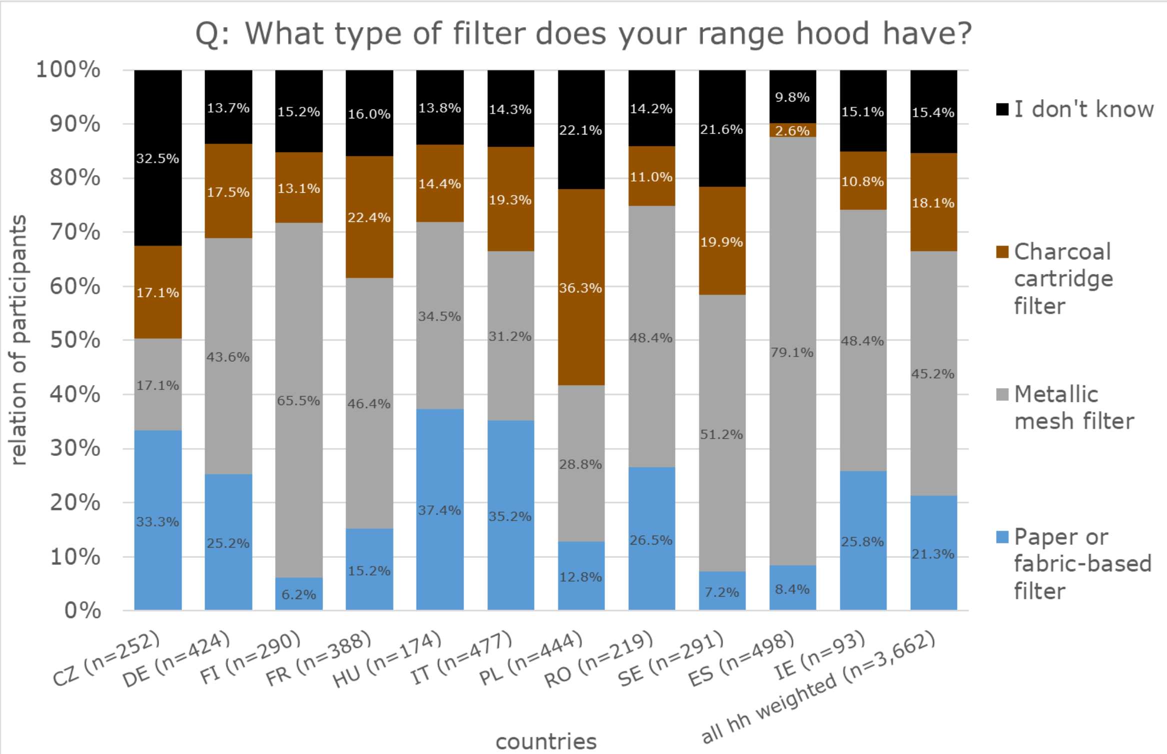



**Figure 124. Type of filter of the cooking fume extractor**

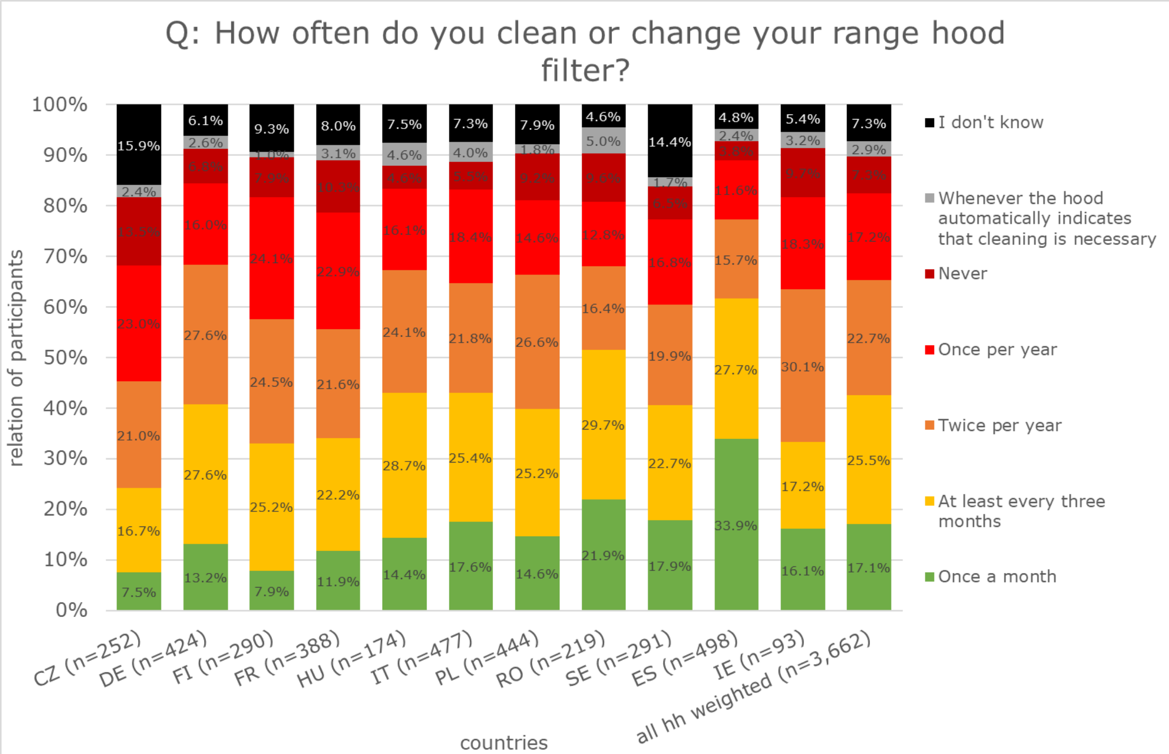



**Figure 125. Frequency of changing the filter of a cooking fume extractor**

### 3.8.7 Solo microwave ovens

Regarding microwave ovens, a predefined list of six applications was provided and the participants were asked about the frequency of use. Almost all participants use this appliance to warm up precooked food (Figure 126). Many participants use it to defrost and to warm up beverages. Only 7 out of 10 use it to cook fresh food and even fewer have and use the grill and hot air function.

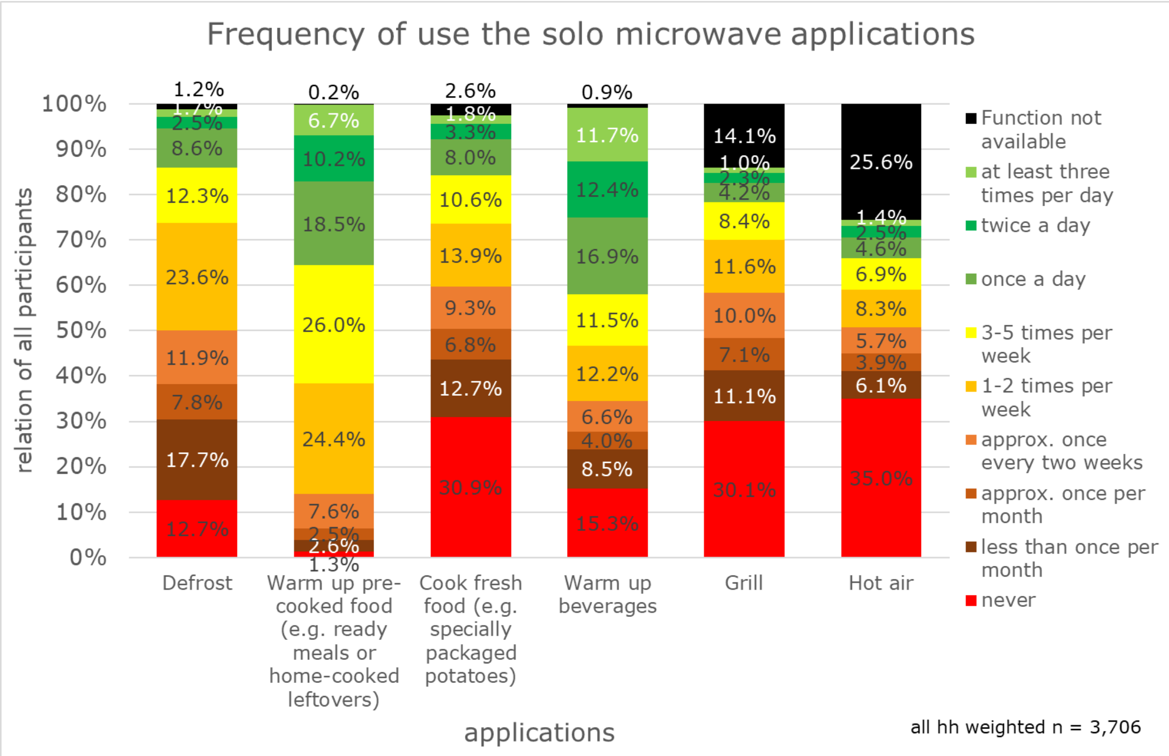



**Figure 126. Frequency of use of microwave applications for all participants**

The nominal answers given by the participants were decoded into a numerical figure of how often the application was used per week to ease the interpretation. Owners of a solo microwave generally use the 'warm up beverages' function 6.1 times per week and 'warm up precooked food' function 5.6 times per week when this function is available in their microwave oven. The other applications are used, when available, much less often. High variations can be observed when the European countries are compared regarding their use of a microwave oven, for example the high use of the 'warm up precooked food' function in the Czech Republic and Finland and the contrasting dominant use of the 'heat up beverages' function in Spain (Figure 128). The solo microwave – when available in the household – is generally used 18.9 times per week as a European average, with high variations between countries (Figure 129).

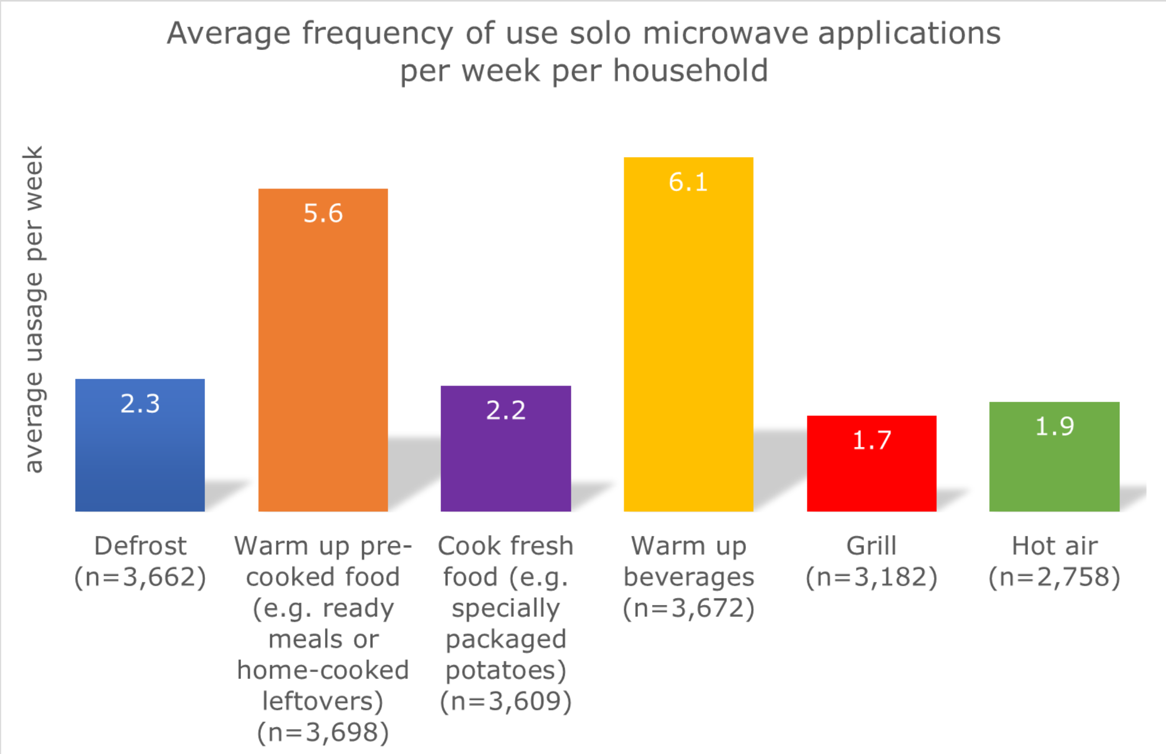



**Figure 127. Average frequency of use of various microwave applications**

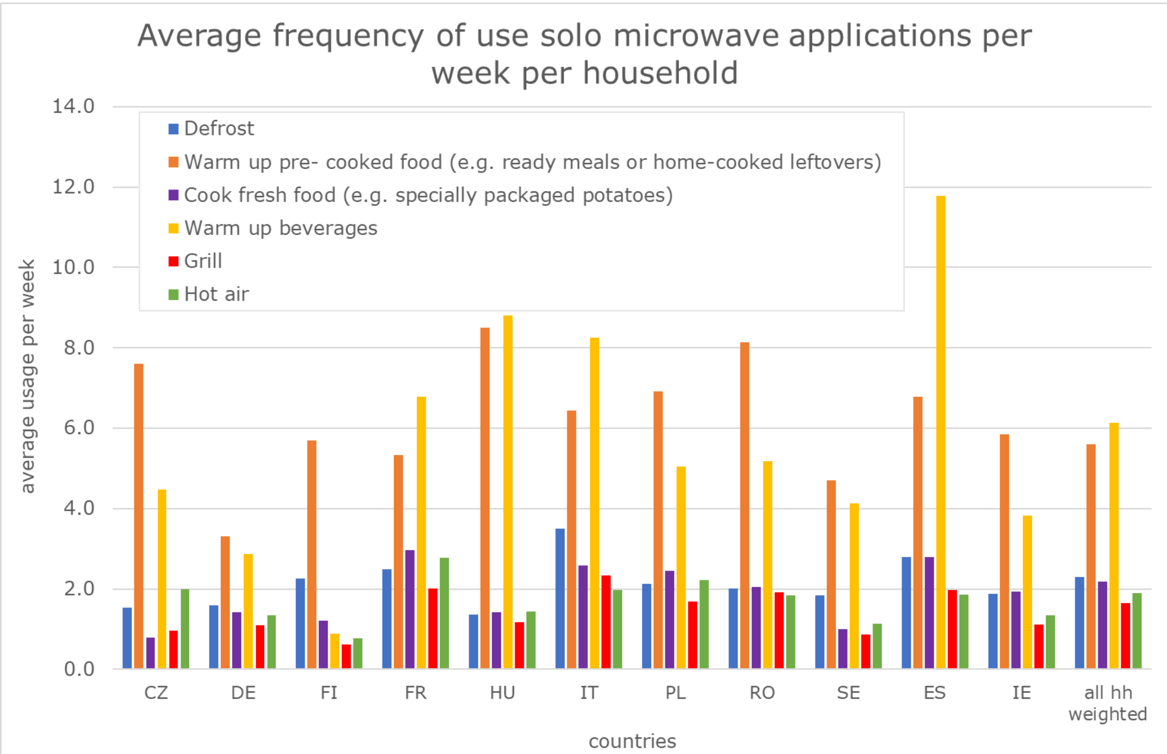



**Figure 128. Average frequency of use of various microwave applications**

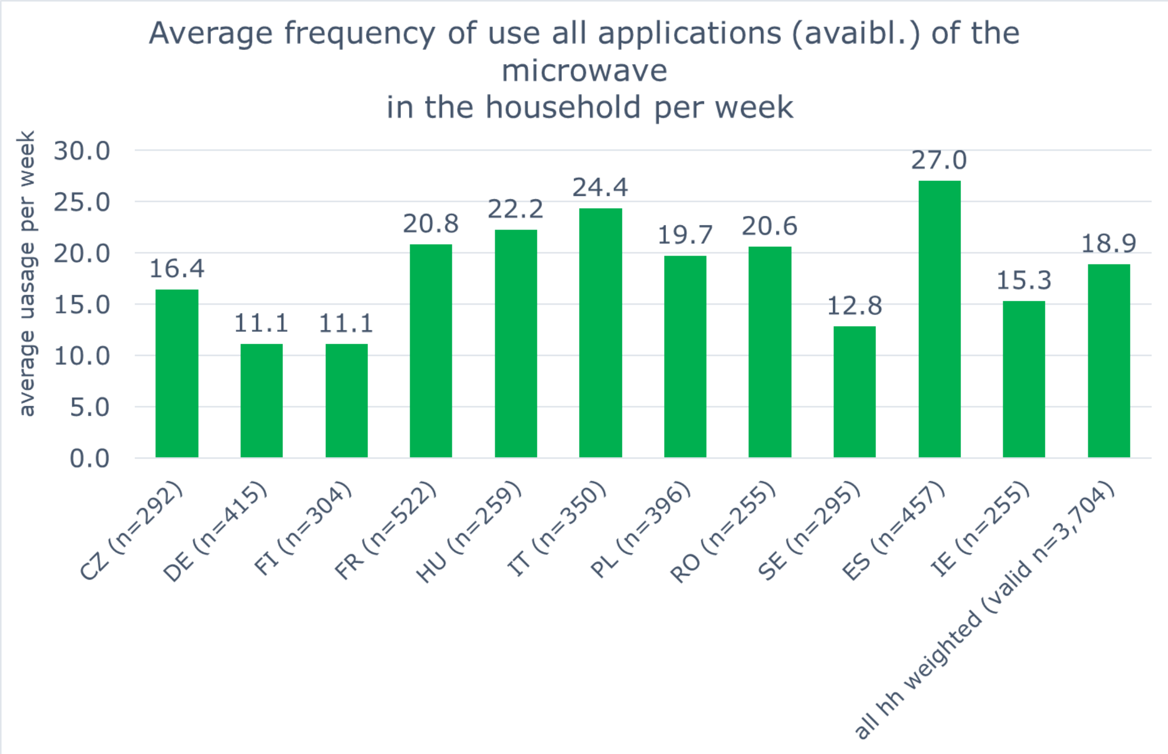



**Figure 129. Average frequency of use of microwave ovens independent of the application**

### 3.8.8 Pure steam oven

A pure steam oven is only available to 4.8% of European households (Figure 72). However, when available, it is used by about one third of the participants at least once per day and another 40% use it at least once per week as a European average, with some variation between countries (Figure 130).

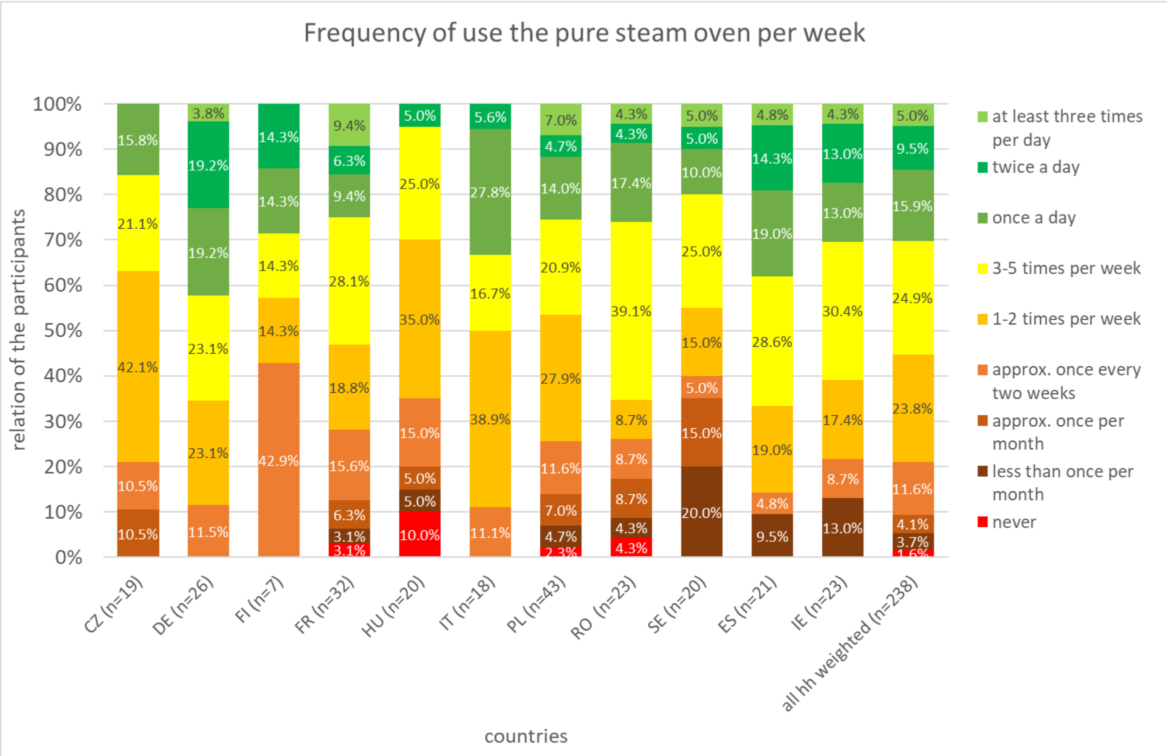



**Figure 130. Frequency of use of the pure steam oven**

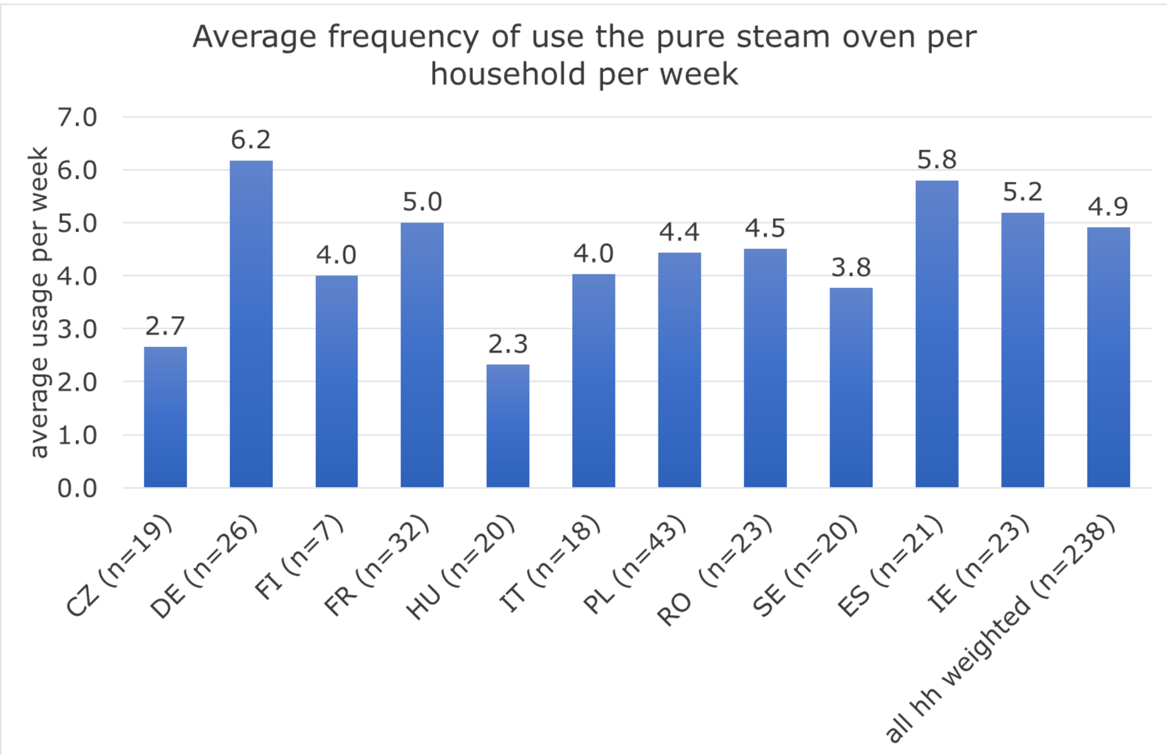



**Figure 131. Average frequency of use of the pure steam oven**

Again, decoding the nominal answers to numerical frequencies of usage per week gives a European average of almost 5 (4.9) usages of the pure steam oven per week.

### 3.8.9 Energy Label Relevance

Respondents were asked for the six most important aspects when buying a new oven, hob and/or cooking fume extractor from a list of 16 randomly presented factors. They were asked to rank them based on priority from 1 (top priority) to 6 (last priority) (Figure 132). The analysis of the priority position results in a median of 2 (Table 28) for the feature ‘Energy efficiency and label class’. Features such as the ‘Purchase price’, ‘Capacity’, ‘Energy source’, ‘Convenience of use’ and ‘Durability’ have a median of 3. The other features reached a median of 4.

A ranking of importance can be shown by a calculation of points. The priority levels 1 to 6 were scored with points and these were subsequently summed up (Figure 133). After this allocation of points, the analysis shows that the most important feature seems to be ‘Purchase price’, closely followed by ‘Energy efficiency and label class’. Five other criteria are listed with some gaps in priorities: ‘Convenience of use’, ‘Durability’, ‘Energy source’, ‘Ease of cleaning and maintenance’ and ‘Capacity’. Features such as ‘Smart functionality/networked control’ are among the least important features.

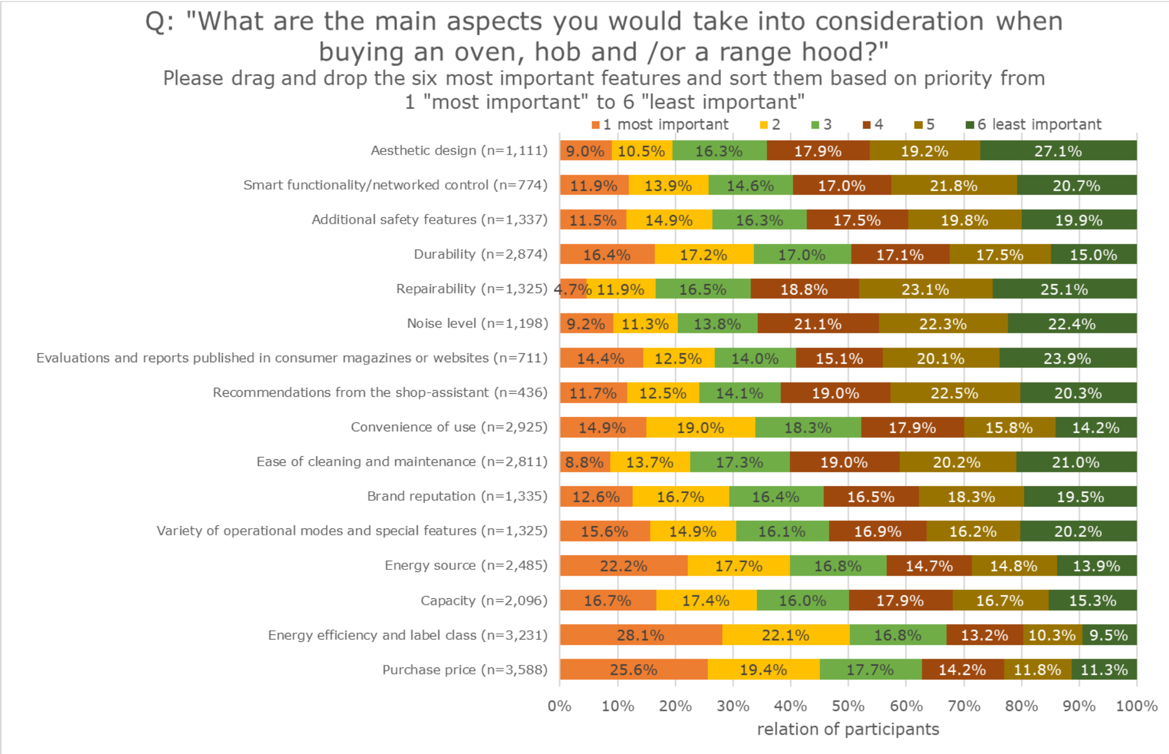



**Figure 132. Main aspects considered when buying a new oven, hob and/or cooking fume extractor**

**Table 28. Ranking of most important aspects when buying a new oven, hob and/or cooking fume extractor**

| Q: “What are the main aspects you would take into consideration when buying an oven, hob and /or a cooking fume extractor?” | avg. | median | mode |
|---|---|---|---|
| Purchase price (n = 3,588) | 3.0 | 3 | 1 |
| Energy efficiency and label class (n = 3,231) | 2.8 | 2 | 1 |
| Capacity (n = 2,096) | 3.5 | 3 | 4 |
| Energy source (n = 2,485) | 3.2 | 3 | 1 |
| Variety of operational modes and special features (n = 1,325) | 3.6 | 4 | 6 |
| Brand reputation (n = 1,335) | 3.7 | 4 | 6 |
| Ease of cleaning and maintenance (n = 2,811) | 3.9 | 4 | 6 |
| Convenience of use (n = 2,925) | 3.4 | 3 | 2 |

| | | | |
|---|---|---|---|
| Recommendations from the shop-assistant (n = 436) | 3.9 | 4 | 5 |
| Evaluations and reports published in consumer magazines or websites (n = 711) | 3.9 | 4 | 6 |
| Noise level (n = 1,198) | 4.0 | 4 | 6 |
| Reparability (n = 1,325) | 4.2 | 4 | 6 |
| Durability (n = 2,874) | 3.5 | 3 | 5 |
| Additional safety features (n = 1,337) | 3.8 | 4 | 6 |
| Smart functionality/networked control (n = 774) | 3.9 | 4 | 5 |
| Aesthetic design (n = 1,111) | 4.1 | 4 | 6 |

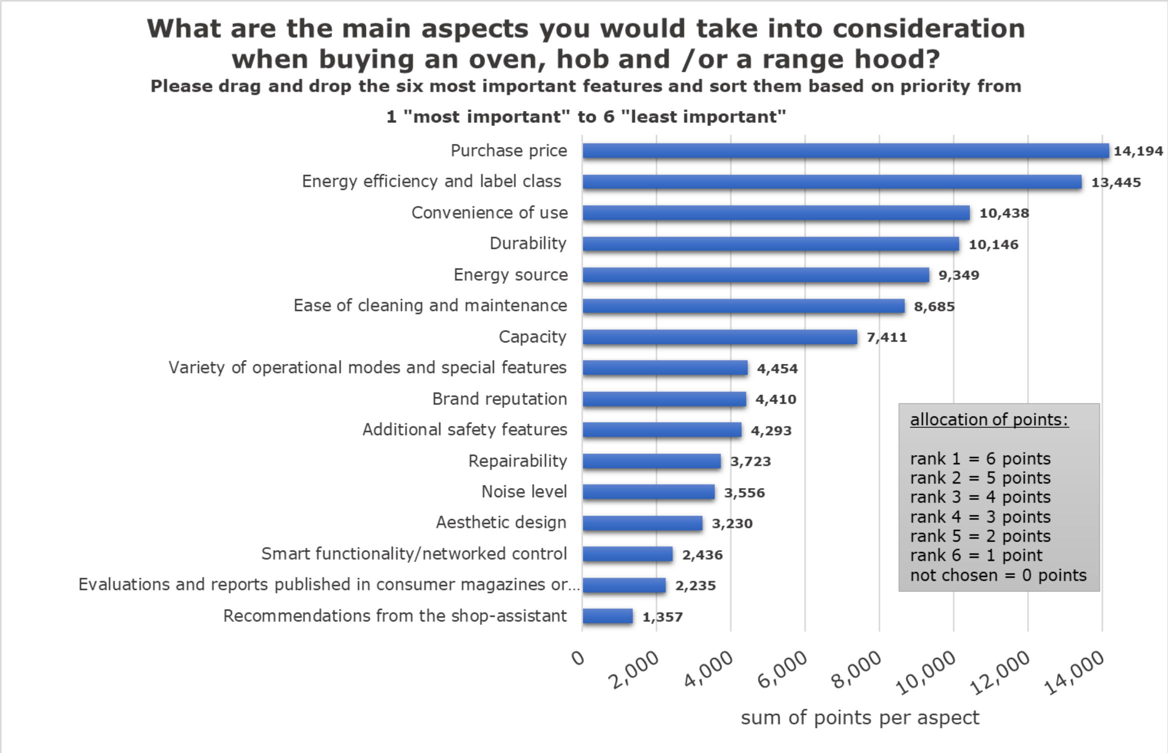



**Figure 133. Main aspects considered when buying a new oven, hob and/or cooking fume extractor**

Participants were asked about the importance of a hypothetical energy label for those appliances independent of whether an energy label for one of the cooking appliances in the focus of this investigation exists today. Overall, 80% of the participants rate it as very or extremely important for ovens and about 75% for hobs. A few less (almost 70%) consider it very or extremely important for microwave ovens, more than 60% for cooking fume extractors and about 55% for pure steam ovens (Figure 134).

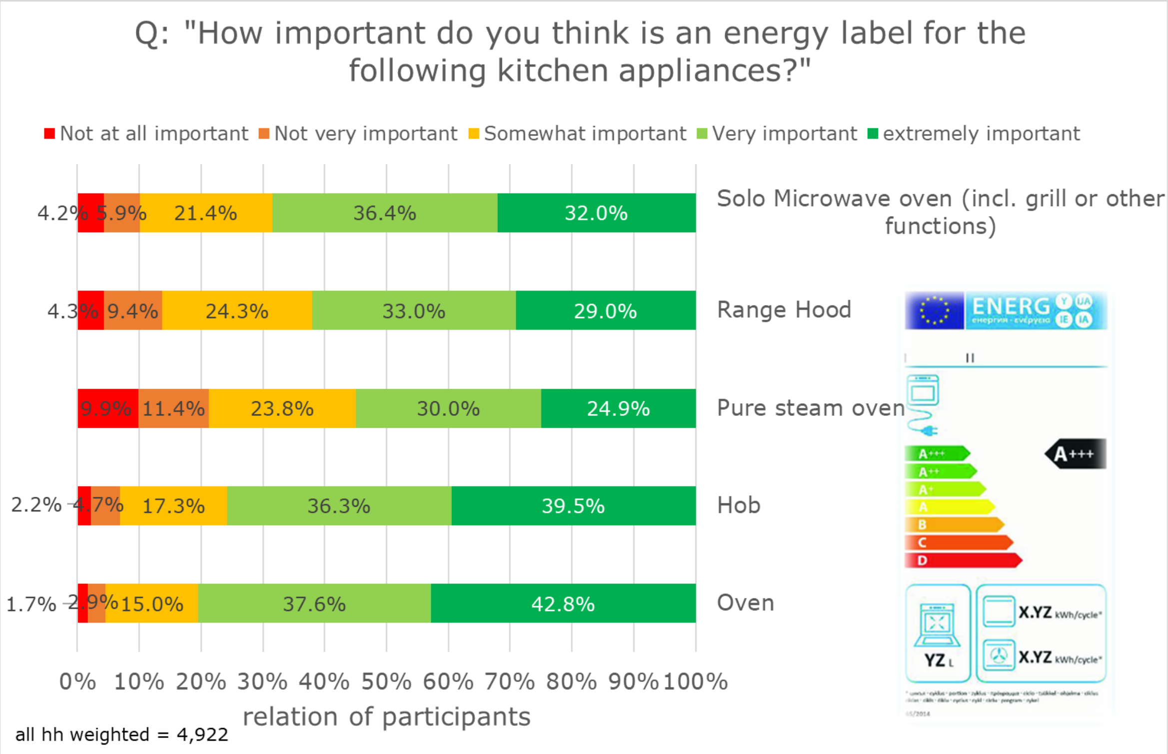



**Figure 134. Importance of a hypothetical energy label for cooking appliances**

Participants were asked in detail which pieces of information given for a potential future energy label for ovens, hobs and cooking fume extractors are important and to sort those pieces of information from most to least important. Their responses reveal that the top priority for ovens is the energy efficiency class followed by the kind of energy source (Figure 136). Additional energy information (i.e. for a standard programme, annual energy consumption, cycle energy consumption given) follows, only broken up by the expected lifetime of the product. Reparability (ease of access to repair parts) and smart functionality/networked control are rated the least important. The picture for hobs looks fairly similar, except that the number of cooking zones/burners is rated as the third priority (Figure 138). The picture for cooking fume extractors is different, as here, just after the energy efficiency class, performance values such as noise emission, odour removal performance, grease filtering efficiency and fan power are rated as the next most important (Figure 139, Figure 140).

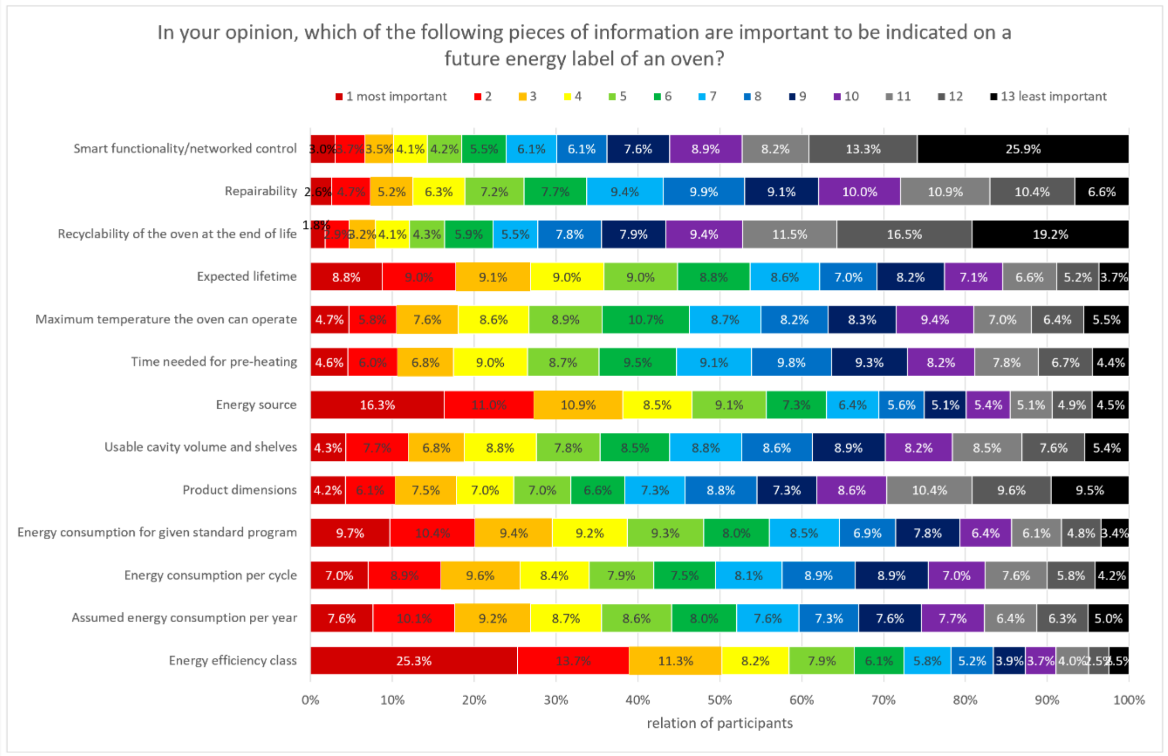



**Figure 135. Importance of information indicated on a future energy label of an oven**

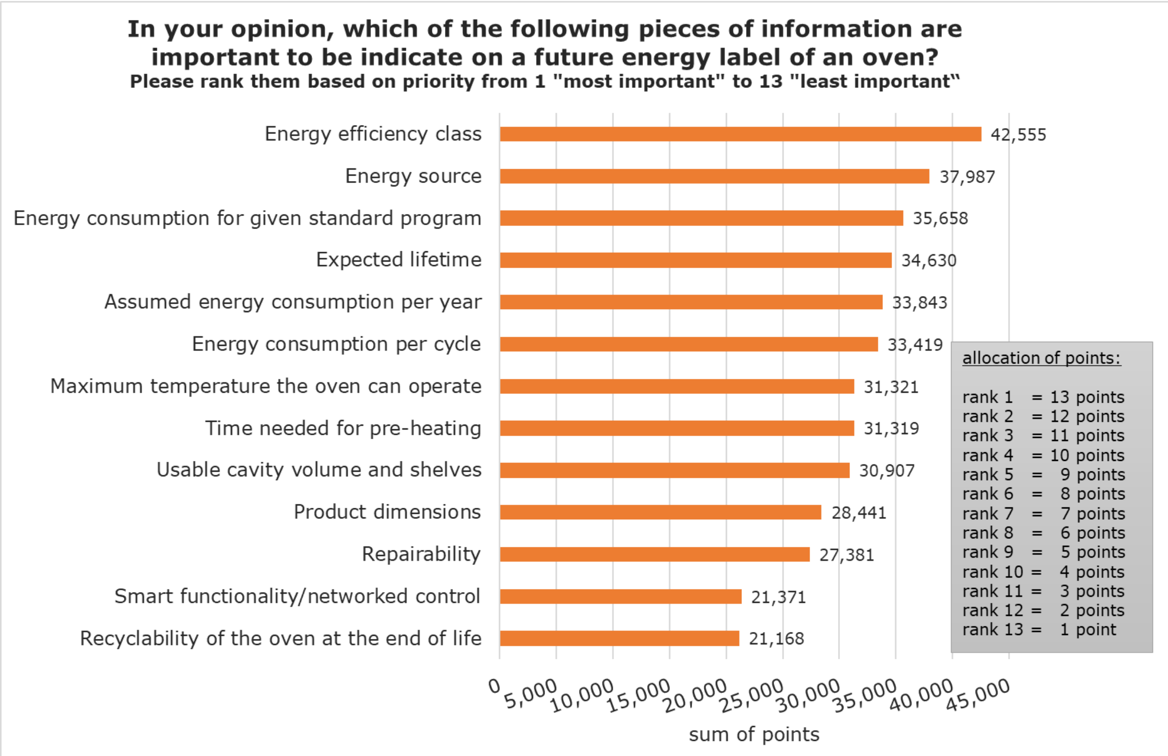



**Figure 136. Importance of information indicated on a future energy label of an oven**

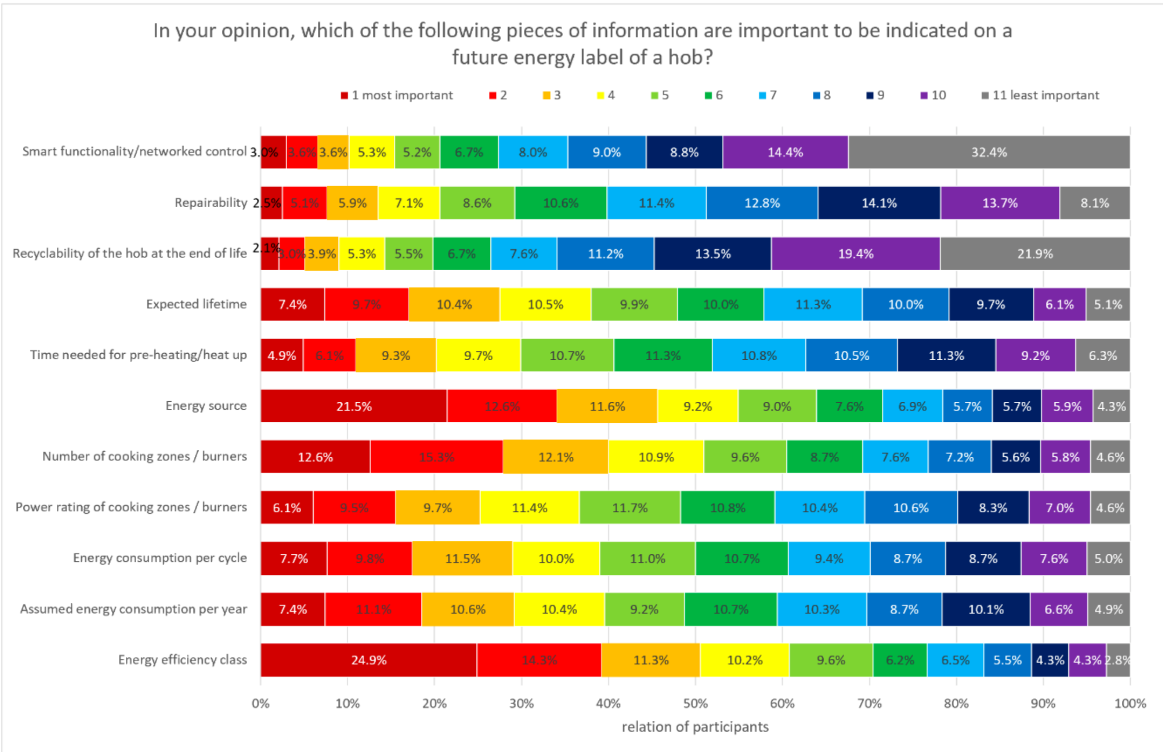



**Figure 137. Importance of information indicated on a future energy label of a hob**

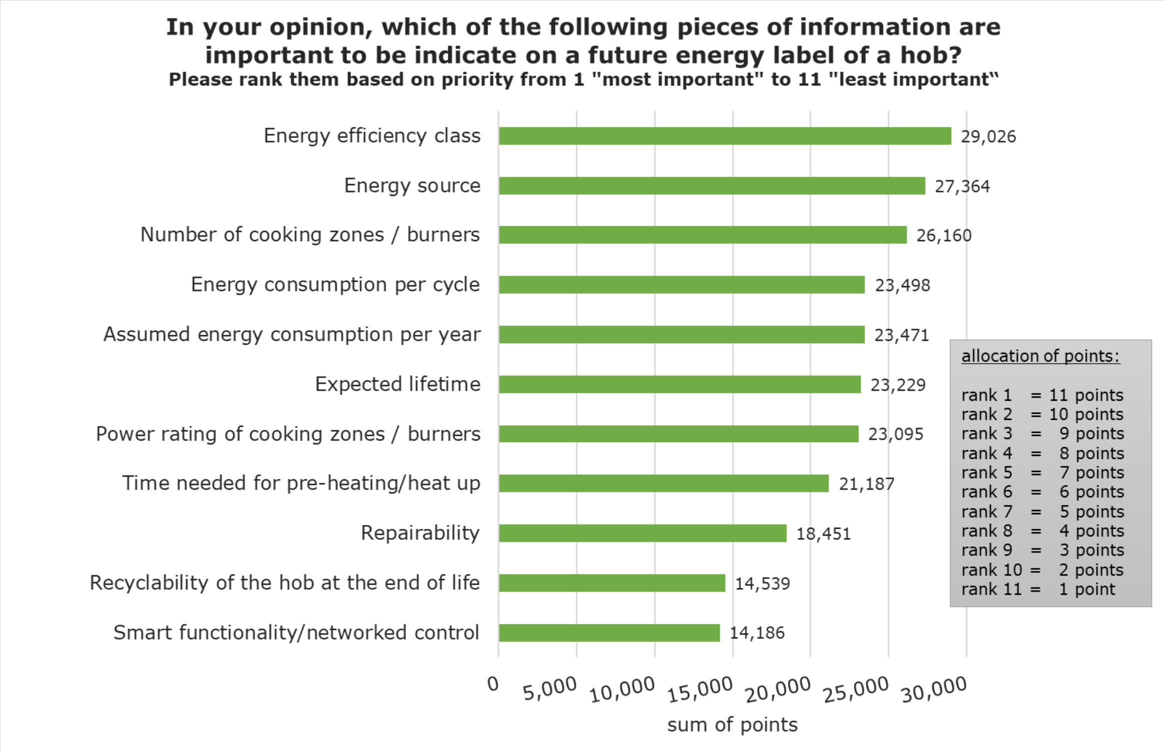



**Figure 138. Importance of information indicated on a future energy label of a hob**

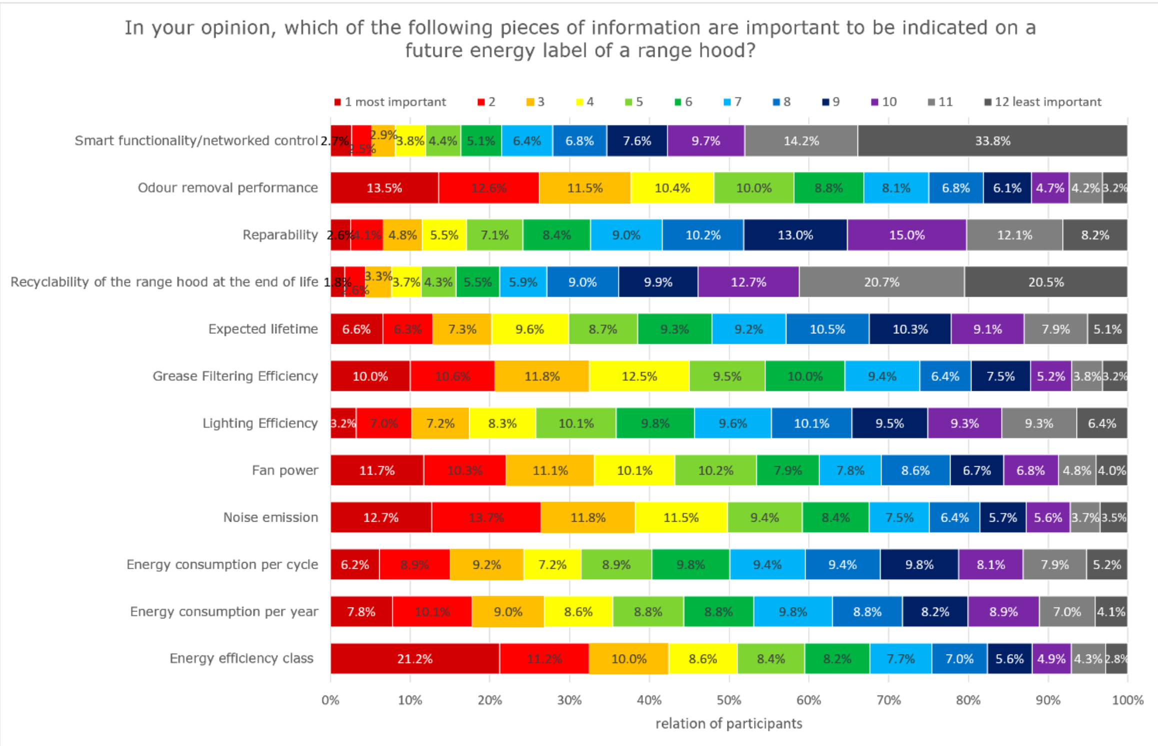



**Figure 139. Importance of information indicated on a future energy label of a cooking fume extractor**

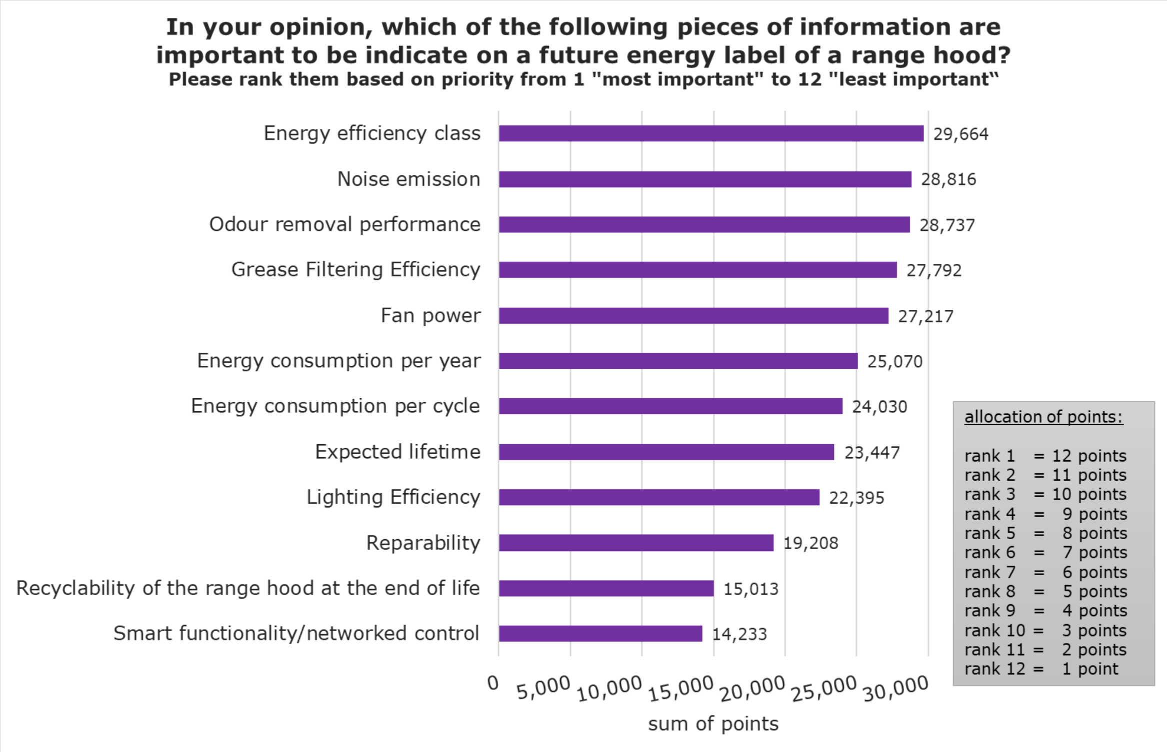



**Figure 140. Importance of information indicated on a future energy label of a cooking fume extractor**

### 3.8.10 Conclusions

- According to the results of the user behaviour study conducted, 87.5% of European households have a conventional oven, 75.3% have a microwave oven, 74.9% have a cooking fume extractor, 71.5% have a hob and 4.8% have a steam oven.

- The average frequency of use of domestic ovens is 3.5 times per week.

- According to the results of the user behaviour study conducted, considering all ovens combined, the most frequently used heating modes and features are, in decreasing order: top/bottom (conventional), fan-forced, timer for automatic start, rapid preheating, eco mode and grill. Meanwhile, the heating modes used for a longer time are, in decreasing order: top/bottom, eco mode, fan-forced, grill, and convection and grill.

- The most frequently used cooking habits when using the oven are, in decreasing order: removing unused trays before cooking; not opening the door; letting frozen food approach ambient temperature before cooking; and making use of residual heat.

- Regarding hobs, 63% of consumers use electricity to run their hob and 31% use gas. Only 6% use both kinds of energy source. Most electric and gas hobs have four cooking zones.

- The hob is used an average of 11.7 times per week. The overall average use is for 3.8 hours per week.

- The most frequently used cooking habits when using the hob are, in decreasing order: watching the pot to avoid it boiling over; maintaining cooking zones clean; using the lid when preheating; and using the right size pan for the amount of food.

- About 80% of the respondents use the fan of the cooking fume extractor often or almost always when the hob is in use and about 60% use the light of the cooking fume extractor. About 14% of the respondents claim to also use the cooking fume extractor when not cooking. Using the cooking fume extractor light as a substitute for the kitchen light is the most important use of the cooking fume extractor when not cooking.

- The most frequently used cooking fume extractor fan speeds are, in decreasing order: intermediate, minimum, maximum and boost speed.

- Solo microwave ovens are used 18.9 times per week as a European average, with high variations between countries.

- A pure steam oven is only available to 4.8% of European households (Figure 72). However, when available, it is used by about one third of the participants at least once per day and another 40% use it at least once per week as a European average, with some variation between countries. The frequencies of usage per week give a European average of almost 5 (4.9) usages of the pure steam oven per week.

- According to the responses from consumers, the most important pieces of information to include on a future energy label of an oven are, in decreasing order: energy efficiency class; energy source; energy consumption for given standard program; expected lifetime; and assumed energy consumption per year.

- According to the responses, the most important pieces of information to include on an hypothetical energy label of a hob are, in decreasing order: energy efficiency class; energy source; number of cooking zones; energy consumption per cycle; and assumed energy consumption per year.

- According to participants, the most important pieces of information to include on a future energy label of a cooking fume extractor are, in decreasing order: energy efficiency class; energy source; noise emissions; odour removal performance; grease filtering efficiency; and fan power.

# 4 Task 4: Analysis of technologies

Cooking is the transfer of heat into food items to make them more palatable and easier to digest. In order to cook food, heat must be transferred from a heat source to and through the food. When a substance gets hot, it means that the molecules have absorbed energy, which causes the molecules to vibrate rapidly. The molecules start to expand and bounce off one another. As the molecules move, they collide with nearby molecules, causing a transfer of heat energy. Heat can be transferred to food in different ways:

- **Conduction**. This is one of the most basic principles of cooking. It consists of the transfer of heat through direct contact. This is the type of heat transfer that happens when using a hob and a frying pan: the flame or the electrically heated surface of cooking zone from the hob touches the bottom of the pan, heat is conducted to the pan and finally transferred to the food.
- **Convection**. This is the transfer of heat through a fluid, which may be in a liquid or gas state. There are two types of convection: natural and mechanical.
    - **Natural convection** causes a natural circulation of heat because warm fluids (liquid or gas) have a tendency to rise while cooler fluids fall. This is the type of heat transfer that happens in a conventional oven.
    - **Mechanical convection** makes heat circulate more evenly and quickly through mechanical elements such as fans. This is the type of heat transfer that happens in a convection oven.
- **Radiation**. This is the transfer of heat by waves of heat or light striking the food. There are two types of radiation in the cooking context:
    - **Infrared radiation**, where an electric or ceramic element is heated to such a high temperature that gives off waves of radiant heat. This is the type of heat transfer that happens in toasters and broilers.
    - **Microwave radiation**, where food is cooked by exposing it to electromagnetic radiation in the microwave frequency range. This induces polar molecules in the food to rotate and produce thermal energy in a process known as dielectric heating.
- **Induction**, where food is cooked by means of a magnetic field generated by electric current flowing through a coil, heating the bottom of a ferromagnetic pot placed above a hob.

The act of cooking is conducted with the help of cooking appliances, mostly ovens and hobs for the actual heating of food, often using cooking fume extractors to collect and remove odours and volatile substances as well. Cooking appliance designs have evolved quickly over recent years. Starting from a traditional, purely functional design and size, there is a current trend to offer ovens, hobs and cooking fume extractors that are a mixture between a cooking appliance and a piece of furniture.

In this section of the report, the main technologies related to domestic ovens, hobs and cooking fume extractors are described in more detail. The intention is not to cover every single technological aspect related to these appliances, but only the ones that have the potential to in some way influence the environmental impact over their life cycles. Each of the three appliance groups will be covered in an individual subsection. Within each of them, technical descriptions and basic product types will be provided. Moreover, a brief description of relevant technological aspects and potential best available technologies will be discussed.

## 4.1 Domestic ovens

### 4.1.1 Technical product description: domestic ovens

An oven is an appliance which incorporates one or more cavities using electricity and/or gas in which food is prepared (Regulation 65/2014). The main components of domestic ovens are outlined below. An exploded view of a typical electric oven can be seen in Figure 141.

- Cavity, where the food is located for cooking.
- Chassis, the structure that supports the cavity and the rest of the oven assemblies.
- Door, which enables access to the cavity.
- Heating elements, which will differ depending on the heat source.
- Fans, used to distribute heat evenly in the convection oven.
- Cables/pipes, which transfer energy from the heat source to the electrical resistance or burner.
- Thermostat, to keep control of the temperature.
- Insulation, to restrict the loss of heat.

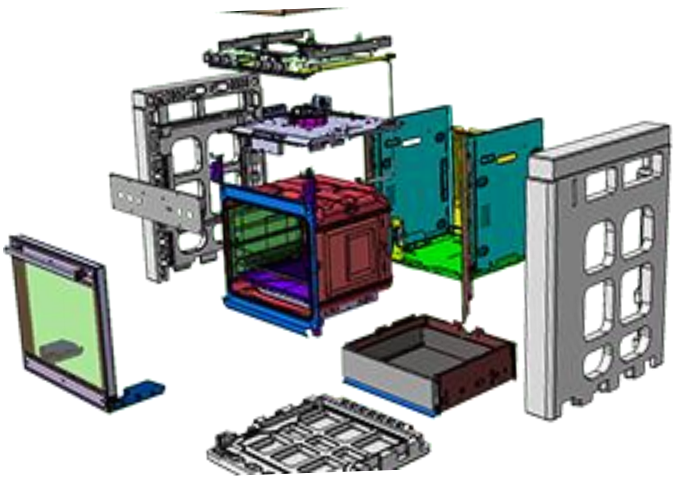


**Figure 141. Exploded view of a domestic oven**

### 4.1.2 Technology areas: domestic ovens

According to Green Kitchen Project (2014), ovens are one of the least energy-efficient appliances in a household, since only about 10-12% of the input power is used to heat the food being prepared. Therefore, they offer one of the best areas for improvement with regards to energy efficiency. In opposition to that, feedback received from manufacturers suggests that the potential for energy efficiency improvement in some of these areas has already been depleted or is close to the maximum. In their view, there is not much room for further energy efficiency improvements, since there are no simple solutions that can be implemented. According to them, the oven system has already reached the top efficiency and, with the current physical system, it is already close to optimal condition.

In the development of the previous preparatory study (Mudgal et al et al, 2011), similar considerations were made. In fact, the design options presented then already showed olny small or marginal improvement potential (enhanced glazing system: 1.5%; reflective layers: 2%; enhanced insulation: 4%). Some others have already been implemented in current ovens (low standby, electronic control). From that information, one might conclude that there is potential for improvement in the energy efficiency of ovens, but it is likely small.

The aim of the following sections is to summarise the information available at this point regarding the different technology areas of domestic ovens, and to identify which of these areas provide opportunities for energy efficiency improvements or resource savings.

#### 4.1.2.1 Technology area 1: Electricity versus gas as heat sources for ovens

Domestic ovens can be powered either by electricity or by gas. The main elements of electric and gas ovens will be similar or equal, the only differences being in the heating system. Different energy consumption levels and environmental impacts are observed as well when comparing similarly performing electric and gas ovens. A brief summary of these aspects is presented in this section.

In an electric oven, electric current is passed through a wire within the heating element and encounters electrical resistance that heats the wire and surrounds bulk of the element (Figure 142).

Provided by APPLIA

**Figure 142. Heating elements in an electric oven**

Heating elements for electric domestic ovens typically use Nichrome wire (80% nickel, 20% chromium), ribbon or strip, a material with relatively high resistance which forms an adherent layer of chromium oxide when it is heated for the first time. The wire is generally wound into a coil that is surrounded by densely packed magnesium oxide powder and then encased in a protective sheath. This material provides excellent thermal conductivity and dielectric strength. Ceramic or mica insulators ensure the electrical insulation of the terminal stud from the sheath. Due to the nature of the energy source and the possibilities it allows in terms of modulating temperature, a wide variety of heating modes are usually available in an electric oven.

In contrast, the heating element in a gas oven is a gas burner located at the rear of the oven base, which burns a stream of gas in air, generating stable and controllable arrays of small flames, modulating the desired cavity temperatures (Figure 143). Additionally in some cases, a grill burner is located at the top of the cavity (Figure 144).

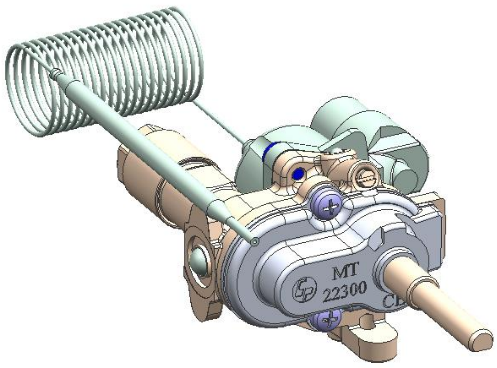
Provided by APPLIA

**Figure 143. Gas burner** **Figure 144. Grill burner**

Gas ovens can work with different kinds of gases:

- Manufactured gases (also known as town gas) of variable composition (hydrogen, nitrogen, methane), with nominal pressure of 8 mbars.
- Natural gas (mainly methane) with nominal pressures of 20-25 mbars.
- Liquefied petroleum gas (mainly propane or butane), with nominal pressures of 28-30 mbars and 37-50 mbars, respectively.

In gas ovens, the gas burner is located outside the food compartment and hot air is allowed to enter via ports to produce a more even spread of heat temperature throughout the oven, often with additional fans for improved efficiency. Due to the relatively slow circulatory motion, temperature zones develop within gas oven cavities, the hottest regions being at the top. The volume of gas entering the burner is managed through a thermostatic gas valve (Figure 145). Hot gases are eventually discharged from the rear of the oven by means of a flue. Ventilation of gas ovens is more important than electric ones, since toxic gases such as carbon monoxide (CO) may be produced.




Provided by APPLIA

**Figure 145. Thermostatic gas valve**

In a gas oven, only a few cooking modes are normally available, since typically they have a burner at the bottom and a grill burner at the top. The burner at the bottom is mostly used for baking or preparing pizza, while the grill can be used for roasting or grilling meat and fish. Their settings are therefore much simpler than those of an electric oven, consisting mainly of a temperature setting and a grill setting (if available). Gas ovens do not offer automatic cleaning functions like pyrolytic systems.

Although in current regulation energy consumption of electric and gas ovens is measured differently (in kWh and MJ, respectively), recent research has been conducted to make a direct comparison of electric and gas ovens in kWh over the lifetime of the appliance (Landi, 2019). This research indicates that lifetime energy consumption tends to be higher in gas ovens, both in intensive and non-intensive uses (considering final energy). However, it must be taken into account that electricity and gas are energy sources of a different nature. Gas is a raw material, whereas electricity is an energy carrier obtained from other sources.

As already seen in Task 1, in the current Ecodesign and Energy Labelling Regulations, direct comparison between electric and gas appliances is not possible, since each energy source has its own energy label and EEI calculation formulas. Some stakeholders support comprehensive and comparable labelling for all appliances based on primary energy, therefore not differentiating between gas and electricity. In their view, since the objective of these regulations is to reduce the overall energy consumption, all technology options and decisions need to be assessed using a comparable parameter: primary energy. According to them, when gas and electricity are compared, a 2.1 conversion factor should be used to convert electricity to primary energy, allowing the comparison between electric and gas appliances. In Section 7.2.5, a scenario analysis is conducted to evaluate the potential benefits of a combined energy label.

#### 4.1.2.2 Technology area 2: Cavity materials

In domestic ovens, the cavity and casing are generally made of pressed mild steel, a material that fulfils the requirements of functional strength and ease of manufacture, being suitable for bending and piercing, and offering a durable surface with scratch and corrosion resistance. The selection and use of this material has a significant influence on the energy consumption of the oven. In fact, the energy fraction actually absorbed by the food during cooking is low because a considerable amount of the energy goes into the structure (walls, door, insulation), and is lost in the surrounding environment. High-emissivity linings absorb the thermal radiation energy from the cavity which then is lost through conductive bridges and convective leaks. In addition to that, a lot of energy is lost through the venting of the evaporated moisture form the cavity (Burlon, 2015).

The mass of materials inside the oven cavity –casing, racks, internal parts– is proportional to the energy consumed when bringing the oven up to its operating temperature. Therefore, in order to reduce the energy consumption, manufacturers are continuously working on reducing the mass of metal used in the cavity and casing. In Burlon (2015), it is reported that reducing the mass of the oven structure has an energy savings potential of between 10% and 18%. Modern ovens use steel sheet about 1 mm thick.

Enamel-coated steels are commonly utilised in the oven cavity. Conventional porcelain enamels for low-carbon steel substrates are generally based on alkali borosilicate glasses which are fired at 750-850 °C on a continuous fast belt furnace. The most abundant materials in a standard enamel are $Al_2O_3$ (37%), S (16%) and $Fe_2O_3$ (13%). A complete breakdown of enamel materials is presented in Palmisano et al. (2011).

Regarding oven interior walls, there has been debate over the years around emissivity and energy consumption. Certain studies point out that low-emissivity ovens use around 35% less energy than standard ovens (Shaughnessy, 2000), whereas others indicate that wall emissivity should be high, as dark surfaces adsorb energy but are also efficient energy radiators. The project named Highly Efficient Oven (Santacatterina et al., 2016) is a demonstration project involving four European partners, co-financed by the LIFE Environmental Programme. Its main objective is to showcase a mix of environmentally friendly technologies for manufacturing domestic electric ovens when compared with current state-of-the-art ovens, in order to:

- use less energy in the production process;
- avoid the use of toxic substances;
- improve efficiency during use.

To achieve that, specific aspects of the electric oven that were investigated are:

- substitution of the steel enamel cavity with a stainless steel cavity with increased reflectivity;
- use of a new sol-gel coating applied to avoid deterioration of oven's metal cavities;

- upgrade of the oven heating system to increase the amount of energy transferred directly to food.

The rationale of this project is based on the fact that traditional ovens use convection as the main vector of heat transfer to food. Radiation does not provide a significant contribution to this transfer, since the cavity is usually made of a dark enamelled material. In this project, it was identified that using a reflective cavity wall was a good solution to increase radiation heat transfer, allowing the reduction of energy consumption during use.

As part of the experiment, different ferritic stainless steels were compared to identify the best substrate for the oven cavity based on the worst-case working conditions (highest temperature). Several transparent coatings (instead of dark enamel) were evaluated: a sol-gel coating was selected, since it was the only transparent coating which was able to withstand temperatures without degrading and due to its extremely high chemical resistance. The selection of this material for the cavity allowed the energy use during cavity manufacture to be reduced by 50% (compared to a typical dark enamel oven). Moreover, a set of tests on prototypes were carried out to evaluate performance. When following the 'brick test method', there was an energy efficiency improvement of 30% in comparison to a conventional oven (black enamelled cavity).

Related to this project is also the work from Isik (2017), where a novel combination of surface properties was developed, based on "hybrid emissivity" materials (essentially, the top and bottom walls of the cavity were dyed with a black paint). They obtained energy savings of 4%.

However, it must be noted that the use of stainless steel in oven cavities comes with certain disadvantages, mainly related to the cleaning process. Feedback from industry points out that they generally do not admit pyrolytic processes, since high temperatures degrade stainless steel surfaces. Also, the emissivity of heat from the bottom part of the cavity is worse when using stainless steel. For these reasons, most modern ovens use dark high-emissivity surfaces. Highly reflective surfaces are normally used for solo and combi microwave ovens and for steam ovens, to avoid corrosion issues.

Also regarding materials used in the cavity, one stakeholder highlights the potential issues with the use of refractory ceramic fibres in domestic cooking appliances. According to them, ideally the use of these fibres should be prohibited. If not completely prohibited, at least they should be clearly marked (marking 5 cm big minimum, in clear colour).

#### 4.1.2.3 Technology area 3: Cavity volume

In terms of cavity volume (generally measured in litres), a wide variety is available in the market today (Figure 146).


Provided by APPLIA

**Figure 146. Different cavity volumes in the market**

Cavity volume has a relevant role in the energy consumption declaration of ovens. In principle, the bigger the cavity volume, the larger the mass of the oven and therefore the higher the energy consumption of the oven. Cavity volume is taken into account when calculating the EEI in current regulation:

$$EEI_{cavity} = \frac{EC_{electric\ cavity}}{SEC_{electric\ cavity}} \times 100$$

$$SEC_{electric\ cavity} = 0{,}0042 \times V + 0{,}55 \text{ (in kWh)}$$

Figure 147 shows the energy consumption thresholds for ovens in the current energy label. Within an energy class (A, for instance) a 100-litre oven may have higher energy consumption than a 40-litre oven (and still remain A).

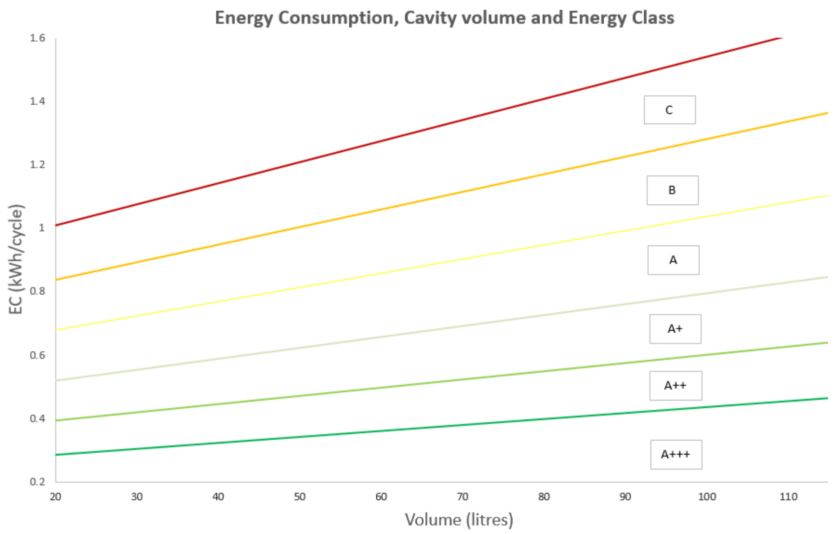



**Figure 147. Energy consumption, cavity volume and energy class**

However, as already seen in Task 2, a market trend towards larger cavity ovens has been observed in the past few years. If a consumer compares a 45-litre "A" oven with a 71-litre "A+" oven, they might perceive that the latter has a lower energy consumption (as it holds a better energy class). Based on this, it appears reasonable to question whether current formulas to calculate the EEI are somehow driving consumers to buy larger ovens than they actually need. It might be worth exploring a slightly different way to calculate the EEI, in order to make a less linear correlation between energy efficiency and cavity volume. Several consumer organisations support this approach since there could be a potential reduction in total energy consumption by promoting the purchase of "the right size" of ovens. This will be covered in Section 7.2.6.4 of this report.

Another aspect related to cavity volume concerns the fact that, due to the way that EN 60350 is written, manufacturers have an incentive to declare the biggest possible volume cavity when testing an oven ("*Removable items specified in the user instruction to be not essential for the operation of the appliance in the manner for which is intended shall be removed before measurement is carried out*"). According to different stakeholders, this sentence should be revised as it may lead to higher declared volumes and thus a better EEI compared to real-life usage. Other organisations disagree with this position indicating that there are very few removable items inside the oven cavity, therefore this is not an important issue.

Domestic oven cavities are rectangular to facilitate usability. Regarding cavity shape, it is worth mentioning the patent by Nuñez (2009), an oven with a cylindrical cavity. According to the authors of this patent, a cylindrical cavity facilitates the movement of hot air. This allows it to reach all the points inside the oven, helping the heat accumulated on the walls to be reflected by radiation in a uniform manner. In the experimental tests they observed that energy consumption is 29% lower compared to ovens with a square cavity. The main disadvantage regarding a cylindrical cavity is related to usability. The authors of the patent indicate that a circular oven's useful volume is 10% less than the standard shape. However, due to the cylindrical shape, only one tray could be used at a time.

#### 4.1.2.4 Technology area 4: Conventional, fan-forced and energy-saving modes

As stated earlier, in a domestic oven, the food is cooked by transferring heat by means of radiation, convection or conduction. A typical measure of performance for a domestic oven is the heat transfer coefficient, which gives an indication of the heat flux between the appliance and the product being cooked. An oven has heat transfer coefficients referred to radiation (Hr) and to convection (Hc). Some authors also use the combined heat transfer coefficient, which takes into account both radiation and convection (Sakin, 2009).

In conventional cooking mode, food is only cooked by radiation and natural convection: the convection is not forced by any external element. In these ovens, heat transfer between the appliance and the food typically happens 70% by radiation and 30% by convection.

In fan-forced cooking mode, heat transfer is artificially forced by the use of a fan. The use of this fan helps to distribute the hot air evenly throughout the oven, reaching food which is located anywhere inside the cavity, achieving even temperatures and evaporation rates. Operating under a forced-air convection mode, values of Hc roughly double. This allows the reduction of cooking times and operation at slightly lower temperatures since the heating element does not need to be as hot to heat up the cavity. In contrast to conventional ovens, in convection ovens, the ratio of heat transfer due to convection can be up to 60% (Cernela, 2014). However, it must be kept in mind that increasing the level of convective heat transfer leads to an increase in the product drying rate (the evaporation rate is higher in the convective process), resulting in product surface desiccation and overheating. An appropriate balance between convection and radiation heat transfer needs to be achieved, depending on the dish being cooked.

In Ramirez-Laboreo et al. (2016), an analysis is conducted on how much energy is transferred to a standard load and lost in different cooking modes in a domestic oven, comparing heat transfer in convective and radiative processes. According to the authors, more energy is transferred to the load (the food) in a convective process than in a purely radiative process (13% versus 11%). Energy losses in the radiative process tend to be higher, mainly because fan operation during convective cooking causes the heat generated in the ring heating element to flow into the cavity, losing less energy through the rear side. However, although energy losses are higher in a purely radiative process, this does not mean convection should be the only cooking function to use, as this will depend on the type of food to be cooked. In bread baking, for instance, an even heat distribution and considerable water evaporation are needed, therefore a convective process is more appropriate. However, for meat or fish roasting, water evaporation has to be minimal to keep food juicy and succulent, therefore a radiative process is the most appropriate option (Ramirez-Laboreo et al., 2016).

In a typical oven with a fan-forced cooking mode, a centrifugal fan is mounted on the back wall. The fan shrouding tends to be minimal and it can expel air at all points around its circumference. An appropriate design of the fan and its surrounding elements has a significant effect on the temperature distribution and energy consumption of the oven. The fan is generally separated from the oven cavity by a baffling plate, which allows circulation of air through holes, which may have a variety of geometries.

**Energy-saving modes**

A particular variant of fan-forced modes are energy-saving modes. Although there is no specific definition in current legislation or in the standards, they are generally known within the industry as “eco modes” and are an energy-saving alternative to convection modes. These energy savings can be achieved in different ways, generally by using residual heat.

This lack of definition for energy-saving modes is an aspect to improve from current regulation and standards. It is not possible to evaluate the appropriateness of using these heating modes for the energy consumption declaration as there are no agreed definitions for such modes. To tackle this issue, recent publications from WG17 in CENELEC have attempted to provide a definition for energy-saving modes. The proposal is to define “eco functions” as follows:

*Heat transmission by natural air circulation and/or forced air circulation and/or radiation for certain applications using efficient technical solutions. Examples of these technical solutions are residual heat usage, low power heating or a combination of both.*

According to feedback from manufacturers, current ovens are close to optimal condition in terms of energy efficiency. There is not much room for improvement. In fact, the biggest opportunity for improvement in terms of energy efficiency is related to the development of energy-saving modes. They are currently seen as an incentive for innovation. Manufacturers are nowadays free to choose the heating mode to use for the energy declaration and to determine the energy class. Most manufacturers are already using these modes for the energy declaration.

Energy-saving modes allow the reduction of the energy consumption of ovens, but they have two fundamental issues, as highlighted by some stakeholders. First, energy-saving modes can produce unsatisfactory cooking results in the form of food being underdone or burnt. Second, they are not the most frequently used heating modes, as confirmed by the user behaviour results.

The fundamental question related to energy-saving modes is whether to allow their use for the energy declaration and to determine the energy class of ovens. Some stakeholders are in favour of allowing their use; some others are against their use; and some stakeholders recommend some sort of commitment between energy-saving modes and conventional modes for the energy declaration. There are benefits and drawbacks related to each option. The topic of allowing or banning energy-saving modes for the energy declaration and to determine the energy class will be addressed in more detail in Section 7.2.6.3 of this preparatory study.

#### 4.1.2.5 Technology area 5: Thermal insulation and door glazing

Domestic ovens have a layer of insulation to restrict loss of heat. The performance of the thermal insulation depends on the thickness, density and thermal conductivity. Generally, the mass of insulation material is proportional to the heat energy used by the oven. Air trapped between fibres or particles acts as a good insulator, although this air must not be allowed to move, since the flow of hot air from interior to exterior surfaces may cause heat losses. Ideal insulating materials have microporous characteristics, with trapped porosity which prevents airflow and low density. However, these materials tend to be less flexible, a preferable condition in ovens because of the considerable expansion and contraction that occurs during heat-up and cool-down (as much as 1 cm in pyrolytic ovens during cleaning cycles). If insulation is damaged, heat losses will occur through gaps in the material.

In domestic ovens, insulation is based on flexible rolls or rigid slabs made of glass-fibre. For non-pyrolytic ovens, 25 mm thickness is typically used. Pyrolytic ovens require superior insulation systems to maintain external surface temperatures below safe limits and to comply with applicable standards, therefore slightly thicker and denser layers are used, with additional layers of aluminium foil acting as a reflector of heat radiation. According to feedback from industry, increasing the insulation level from 25 mm to 40 mm can reduce the energy consumption by 12% with the brick method test.

Regarding insulation, a patent has been identified that might be of interest. The patent by Bareyt (2016) is related to a new insulation material for ovens. This material is formed of at least two layers. A first layer, placed towards the heating element to be isolated, formed of wool and/or mineral fibre, and a second layer, further away, formed of airgel or of amorphous silica or insulators under vacuum. The use of the insulating, composite and multilayer product according to the patent makes it possible to improve the performance in terms of the energy consumption of ovens (10-20% according to experimental results). These results might suggest that there is still some room for improvement in terms of insulation.

In terms of glazing, historically ovens did not have glazed doors. This element of the door is actually a significant source of heat loss. Certain studies indicate that an oven with an unglazed door has a very significant opportunity to reduce the energy consumption (Burlon, 2015). However, if an oven door does not allow the visualisation of the interior of the cavity, it will be opened more frequently by the user, causing even more significant heat losses. Since the widespread introduction of this feature, unglazed doors have become an unacceptable product feature in domestic ovens. The combination of a glass door and oven cavity light reduces the number of times that the oven door must be opened to check the progress of the cooking, limiting the amount of heat lost each time the door is opened.

Oven doors are opened during cooking processes mainly to examine and to turn and manipulate food. On some occasions, ovens doors may also be opened to allow humidity to escape. When they are opened, most of the hot air from inside the cavity escapes. The relation between opening frequency, window size and heat loss is complex and no data is available. However, it is assumed that window size potentially has an influence on the opening frequency: a bigger window may reduce the number of opening times as it allows a proper examination of the food. Nevertheless, certain conflicting effects need to be considered:

- More heat is lost by conduction through windows than through insulated metal panels, so ovens with no window –or a small window- lose less heat. This is counterbalanced by the heat lost every time the door is opened.
- The outer layer of the glass needs to be air cooled to limit the outer surface temperature to safe limits (this is not necessary for insulated metal panels).
- Heat consumption is proportional to the mass of materials: the higher the mass, the larger the energy consumed by the oven. More layers of glass provide a higher level of insulation but also induce higher energy consumption. Depending on cooking times, more layers of glass will be beneficial or detrimental. As a general rule, for shorter cooking times, less layers of glass are better, whereas for longer cooking times, the insulating effect of additional layers compensates the increase of energy consumption.

Two types of glass window configurations are used. In one, the glass window is inserted into an opening in the metal door using heat-resistant adhesives. In the other, the door itself is made of a sandwich of two or more sheets of glass so that there is no need to seal the glass to a metal door. The outer sheet is usually made of clear float glass, tinted glass, coated –mirror effect- or white glass. For the middle and inner glass, heat transfer is limited by the use of low-emissivity glass. The inner panel of most new domestic ovens includes an infrared reflective coating as well.

#### 4.1.2.6 Technology area 6: Ovens with steam functions

Depending on the way in which the steam is used in the oven cavity, different options are available in the market (Table 29) in terms of steam ovens.

**Table 29. Types of steam ovens**

| Type of steam oven | Ecodesign / Energy Label Regulation | Heating functions |
|---|---|---|
| a) Solo steam oven | Out of scope | - Steam cooking |
| b) Combi steam oven | Within scope | - Steam cooking<br>- Steam cooking with fan-forced convection<br>- Fan-forced convection/Top-bottom |
| c) Steam-assisted oven | Within scope | - Steam cooking with fan-forced convection<br>- Fan-forced convection/Top-bottom |

**a) <u>Solo steam ovens</u>**

A steam oven (also known as a solo steam oven) uses hot steam rather than hot air to cook food. They work by siphoning water from a small tank into a built-in boiler, heating it to 100 °C, and releasing the steam into the cavity. Steam ovens are generally considered to be healthier than standard ovens, since steam helps lock moisture into the food being cooked, eliminating the need for extra oils and fats to keep food moist. The main downside of solo steam ovens is that they do not allow the cooking of foods that require temperatures above 100 °C, since this is the boiling temperature for water. They are only able to conduct “wet” cooking. Also, they are not able to roast or brown food, limiting their cooking possibilities. Unlike in conventional ovens, steam prohibits the formation of a crust on the surface of the food.

As already discussed in Task 1, solo steam ovens are outside the scope of the current Ecodesign and Energy Labelling Regulations. The reasons argued for this exclusion are related to the fact that solo steam ovens have a low market share and are therefore less relevant than other cooking appliances in terms of total energy consumption. Most of the stakeholders support this exclusion today and data presented in Task 2 points in the same direction (they were in 5% of European households in 2020).

**b) Combi steam ovens**

Convection steam ovens -or combi steam ovens- can cook using three different functions: with steam only, with steam and fan-forced convection, and with fan-forced convection only. Convection steam ovens combine both wet and dry cooking, with the advantages of evenly distributed heat. In a convection-steam oven, while the movement of hot air ensures consistent heating and browning, steam adds moisture at the right times in the right amounts (Papageorge, 2013). In Burlon (2015), an analysis is conducted on how much energy is transferred to a standard load and lost in different mechanisms within a convection steam oven. Around 79% of the energy goes to the load in the centre of the oven, whereas the rest is lost in walls (6%), vapours (11%), door (3%) and liquids (1%). These figures contrast with the ones presented in Ramirez-Laboreo et al. (2016) and already cited in Section 4.1.2.4 of this report (where the amount of energy transferred to the load with a convection oven was much lower). To understand the significant differences would require a detailed analysis of the experiments conducted in those studies, but they are likely related to methodological differences in the experiments conducted and the load used for the analysis. Also, the experiment conducted in Burlon (2015) is with a commercial steam oven.

As already discussed in Task 1, combi steam ovens are within the scope of the current Ecodesign and Energy Labelling Regulations. The main reason for their inclusion is their market relevance. There is a general consensus among stakeholders that they should be included. However, there is some debate over which heating functions should be tested for the energy declaration in combi steam ovens. In current and future versions of EN-60350 (Brickmethod 1.0 and 2.0, respectively), they are only tested in their conventional or convection modes (heating function with steam only is not tested), since they are the modes more commonly used. According to a stakeholder, tests should be developed for each function (including the steam function). In their view, it is necessary to be sure that the use of the steam mode is common among consumers, to decide if it should be allowed during the test for the energy declaration.

**c) Steam-assisted ovens**

A steam-assisted oven is a similar appliance to a convection steam oven. In this case, however, the oven can work in two modes only: either fan-forced convection or fan-forced convection with addition of steam. This appliances does not offer the option of working with a solo steam function. The steam function in these types of ovens is essentially used to add moisture to the food. These appliances are within the scope of the current Ecodesign and Energy Labelling Regulations. In the current version of EN-60350, they are tested for the three modes (top-bottom, fan-forced and steam), but in the new version of that test (Brickmethod 2.0), the intention is to leave the steam heating function out.

An interesting aspect of steam-assisted ovens is that they perform well in terms of the EEI, often achieving high energy classes (as already seen in Task 2). In the TopTen database (which provides data on a different range of products) ovens are classified in three categories: ovens, steamers and stoves. There is no explicit definition of these categories on their website, although from the analysis of the models, it appears that they can be understood as:

- ovens: built-in ovens, without additional steam function and without a hob.;
- steamers: built-in ovens, with additional steam function and without a hob;
- stoves: without additional steam function, with a hob (cookers).

All ovens currently listed within this database are either in energy classes A+ or A++. The energy efficiency classes and EEI of the 46 models listed in TopTen are displayed in Figure 148. An indicative benchmark as in Ecodesign Regulation 66/2014 is also shown in the graph by the orange dotted line.

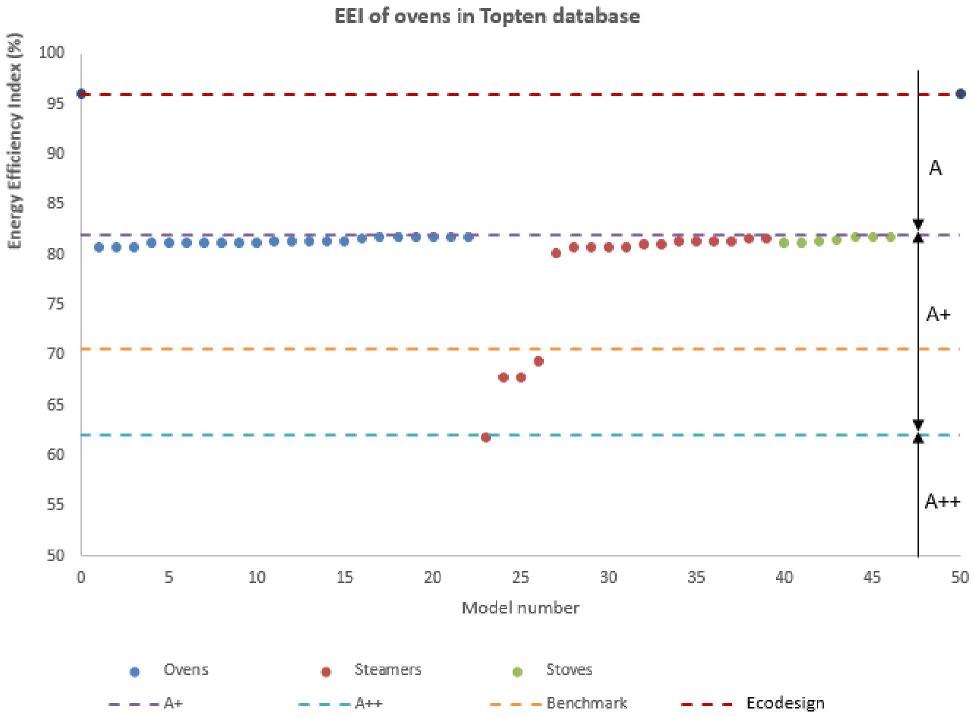



**Figure 148. EEI and Energy classes of ovens in the Topten database**

As can be observed, most of the products in the database have a very similar EEI, with very little variation between them (80.2-81.7%), with no significant difference between ovens, steamers or stoves. The most relevant conclusion from this analysis is that there are four products with significantly better EEIs than the rest and all of them are steamers (ovens with an additional steam function).

- All four of those steamers are below the indicative benchmark for electric ovens (70.7%).
- Only one of those steamers is within the A++ energy class.

From this analysis, one might conclude that the steam-assisted function is the best to obtain better EEI results and therefore relevant to achieve better energy classes. However, certain aspects must be taken into account:

- The Ecodesign and Energy Labelling Regulations say that EEI calculations shall be made with the energy consumption of the best-performing mode of the oven. However, this does not mean that the mode used for the calculations is the steam-assisted mode (the best performing may have been another mode).
- Feedback from industry points out that ovens with a steam-assisted function have better sealing and isolation characteristics with a reduced vapour outlet, compared to conventional ovens. This better sealing leads to better results in the energy consumption test (although the steam function may not have been active during the test). Manufacturers highlight that the support of steam does not necessarily lead to lower energy consumption.

Considering the points above, there is some debate around the possibility of improving the energy efficiency of ovens by enhancing their sealing conditions. Some stakeholders suggest that a promising way of improving the energy efficiency of ovens in general is in the development of ovens with the sealing characteristics of steam-assisted ovens, modifying "airtightness" during the cooking cycle in order to reduce heat loss (as suggested in Pensek et al., 2005). However, manufacturers do not agree with this suggestion either, since there are some recipes which do not work with such highly sealed conditions and require some air leakage.

#### 4.1.2.7 Technology area 7: Microwave ovens

Microwave ovens are appliances where food is exposed to microwave radiation at a frequency of 2.45 GHz, with a power usually ranging from 500 W to 1 100 W. Microwaves are produced by an electronic tube called a magnetron. Once the oven is switched on, the microwaves are dispersed in the oven cavity and reflected by a stirrer fan so the microwaves are propagated in all directions. They are reflected by the metal sides of the oven cavity and absorbed by the food. Uniformity of heating in the food is usually assisted by having the food on a rotating turntable in the oven. Water molecules vibrate when they absorb microwave energy, and the friction between the molecules results in heating which cooks the food. Unlike conventional ovens, microwaves are absorbed only in the food and not in the surrounding oven cavity. In comparison to heating in conventional ovens, the main differences of microwave heating are as follows (Datta et al., 2013):

- It is a quicker process. The rates of heating are much higher than in conventional heating.
- It is a less uniform process.
- It is a selective process. Moist areas heat more than dry areas of food.
- It has significant internal evaporation, enhancing moisture loss during heating.
- It can be turned on or off instantly.

One stakeholder adds another difference related to cooking time. It is more dependent on the size of the load (of the food to be prepared). If the weight is double, the time to heat it will also be doubled. Cooking with microwave ovens is more efficient for smaller portions.

The main components of a microwave oven are as follows:

- Enclosure, usually made of steel.
- Door, usually made of glass with a metallic mesh which provides a barrier to radiation with enough visibility of the interior.
- Magnetron, which generates the microwave radiation. This is a device made mainly from copper with an electrode inside a specially shaped cavity.
- Circuitry, in charge of converting mains input into microwave frequency for operating the magnetron.
- Fans, which cool the magnetron and circuitry.
- Turntables, which allow food to rotate while cooking, ensuring an even distribution of microwave radiation.

To prevent microwave radiation from escaping, the interior of the oven comprises a metallic mesh structure that prevents microwave radiation from passing through. This is used on the glass door and has gaps that are large enough for light to pass.

In terms of energy consumption, microwave cooking can offer substantial energy savings over alternative cooking methods. Industry estimates that typically up to 40% of the input energy is transferred to the food when using microwave ovens, although this figure depends on many variables, particularly the size of the load and whether it is being heated to raise its temperature or extended cooking is being carried out. Estimates of energy savings obtained with microwave ovens in comparison to alternative methods were published in Market Transformation Programme (2007).

**Table 30. Energy savings when cooking with a microwave oven**

| Food | Energy saving (%) | Alternative method |
|---|---|---|
| Potatoes | 70-75 | Pan on hob |
| Fresh salmon fillet | 63-78 | Pan on hob |
| Frozen ready meal | 55-73 | Electric oven |

| | | |
|---|---|---|
| Lasagne | 40-81 | Electric oven |
| Milk | 25-50 | Saucepan on hob |
| Frozen vegetables | 65 | Pan on hob |

Adapted from MTP (2007)

In global terms, the numbers above suggest that an increased use of microwave ovens in substitution of other ovens or hobs -when the recipe allows it- would reduce total energy consumption. However, since there is no method to measure energy consumption in microwave ovens comparable to the method used in conventional ovens –the brick method-, direct energy efficiency comparisons between conventional and microwave ovens are currently not possible.

As already indicated in Task 1, microwave ovens are out of the scope of the current Ecodesign and Energy Labelling Regulations. Some of the reasons given for not being included in the current Regulations are listed below:

- There is a wide variety of different products with a microwave function, which makes comparisons challenging. Consumers can find ovens with a microwave function only, but also appliances that combine conventional heating and microwave heating (see Section 4.1.2.8).
- Microwave ovens tend to be used for short cooking periods (1-2 minutes) with maximum powers of 1 000 W, making their total energy consumption significantly lower than other cooking appliances.
- The use of turntables makes the testing method used for conventional ovens (the brick method test) unfeasible for microwave ovens.
- The use of thermocouples to check the temperature of a standard load inside the oven is also not possible in microwave ovens.
- The potential for improvement in terms of energy efficiency has been considered low.

The last bullet point (potential improvement of microwave ovens) appears a topic under debate. On one hand, in a report published in 2005 by the Energy Conservation Center of Japan (ECCJ, 2005), it was stated that in the previous years, engineering developments had been carried out mainly with the objective of improving the taste of food cooked with microwave technology. In addition, although engineering developments had also been taking place for improving energy consumption efficiency –such as reduction of standby power consumption- it was concluded that there was still some room for improvement in terms of the efficiency of microwave ovens, possibly by improving the radiation method and thermal insulation performance. The efficiency of the magnetron, which comprises a large percentage of the power consumption, appeared to be close to its maximum. On the other hand, in the previous Preparatory study for Ecodesign requirements for domestic and commercial ovens (Mudgal et al, 2011), it was stated that, in the view of members of the European Committee of Domestic Equipment Manufacturers (CECED), modern microwave oven designs are close to the maximum energy efficiency. Cavity size has no effect on it whereas internal coatings could only improve it by 1-2%.

The second bullet point has also created debate among stakeholders. Some of them argue that, considering the size and market growth of microwave ovens, it is necessary to reconsider their inclusion in the Ecodesign/Energy Labelling Regulations. For products with lower savings potential like these, the starting point could be an energy label, as well as information requirements to foster innovation and differentiation. The same stakeholders supported this reasoning with the results from monitoring campaigns conducted in France (ADEME, 2016), where it was estimated that the energy consumption of microwave ovens is around 45 kWh/year (higher than the energy consumption of cooking fume extractors).

#### 4.1.2.8 Technology area 8: Microwave combination heating

Some manufacturers offer ovens with the combined function of forced-air convection and microwave heating. These appliances integrate the advantages of microwave energy to overcome the shortcomings of other food processing technologies. Adding microwaves to convective heating, for instance, generates heat inside food in a short time due to heightened penetration depth and rapid heating.

In general, the main reasons to introduce microwave energy within conventional domestic ovens is to reduce cooking times, improve quality in certain recipes and to obtain a higher degree of automation (Datta et al., 2013). A clear advantage of these appliances is that they allow the faster heating of the microwave ovens with the surface browning ability of hot air or grills.

Microwave energy can be introduced in many different ways when cooking a specific dish in an oven, in terms of power level, duration, sequence, etc. Therefore, there is enormous variation between manufacturers of similar ovens in terms of how to combine these modes. Due to this high variation in terms of options, microwave combined heating is generally used in an automated mode, for specific processes or recipes. In a typical microwave combination oven, the user can select the power levels used for each individual heating mode (hot air and microwave) as well as the sequence of the combination (for instance, microwave first followed by forced-air convection). According to Datta et al. (2013), microwave combination heating appliances can be grouped into the following:

- Microwave with infra-red. A source of infrared heat is provided inside the oven, using halogen lamps or heated rods (grill).
- Microwave with hot air. Typically forced hot air is provided to emulate simultaneous hot air heating. This is the most common microwave combination mode in the domestic market.
- Microwave with steam. This is a relatively recent feature. Steam is generated and fed to the oven cavity. Generally steam does not appear to be used simultaneously with microwaves, although it should be possible to design combinations that use both together.
- Microwave with induction. A shielding plate is mounted on the bottom surface and an induction coil is provided below it to selectively choose between microwave and/or induction cooking. Currently there is no known commercially available unit with this technology.

Benefits and drawbacks of the above microwave-assisted food processing technologies and others (such as ultrasound, ohmic heating, vacuum) are listed in Chizoba et al. (2017).

The main differences between a conventional oven and a microwave combination oven are the presence of all the required components for the generation of the actual microwaves (essentially the magnetron and rest of componentry listed in Section 4.1.2.7). With microwave combination ovens there are a number of compromises that need to be made in design. For example, enamelled surfaces are better for conventional oven modes but stainless surfaces are better for microwave modes. Enamelled surfaces are required if pyrolytic cleaning is an option. A microwave combination oven also requires a different level of insulation to avoid potential leakage of microwaves.

As indicated in the previous section, an appliance that offers a microwave heating function is currently out of the scope of the Ecodesign and Energy Labelling Regulations. One of the main reasons for this exclusion is that any oven with a microwave functionality and a turntable cannot be tested by the brick method, according to feedback from industry. Ovens with a microwave function but no turntable can be tested by the conventional brick method, but the microwave function would need to be decoupled first because some manufacturers may "hide" microwave operation within conventional operating modes. Moreover, door seals for ovens with a microwave function are tighter and make it more complicated to run a thermocouple wire through the door. Any hidden microwave activity would be potentially dangerous for the convection test set-up. Additionally to those reasons, there are so many different combinations of convection heating and microwave heating possible that it would make comparisons between products unfeasible (unless a standard combined cycle was defined).

Feedback from industry highlights the energy- and time-saving potential of these microwave combi modes, observed in tests with real food. Depending on the type of dish being prepared, when compared to convective heating, the following savings arise:

- time savings: 40-55%;
- energy savings: 5-20%.

However, despite this energy-saving potential of microwave combination ovens, since there is no standard test to evaluate these savings in comparison to conventional ovens, this potential is currently not perceived by consumers.

Some stakeholders suggest that ovens including a microwave functionality should be covered by the Ecodesign and Energy Labelling Regulations, but only for their conventional and/or fan-forced modes. This could close a potential loophole for products with a microwave function.

Other stakeholders also raise concerns about the risks of not including ovens with a microwave function, which seem to represent a trend in the market. Their recommendation is to include them within the scope and to develop a test method to quantify the effect of the microwave function in a heating cycle. Another stakeholder agrees with this position, adding that a measurement method showing the advantages of a combined microwave oven mode would lead to a better understanding of the consumer of how to save energy.

#### 4.1.2.9 Technology area 9: Self-cleaning systems

Ovens are appliances which need periodical cleaning. Most of the modern appliances already incorporate some sort of self-cleaning system, but before that the only way to clean a domestic oven was manually, often using toxic products. Three different cleaning methods are available in the market (Schmidt, 2019):

- Pyrolytic cleaning. This is currently the main commercial solution in the market, a self-cleaning process where the oven is heated in a special heating cycle up to 500 °C for long periods of time (1-3 hours). This causes fat deposits to pyrolyse, mainly to gaseous by-products. Organic residues are incinerated, then easily removed as dust. In comparison to a standard oven, the composition of the enamel is significantly different, in order to withstand the higher temperatures. The most abundant materials in the enamel in this case are SiO2 (29%), $ZrO_2$ (19%) and $CeO_2$ (11%). A complete breakdown of materials for a pyrolytic enamel is presented in Palmisano et al. (2011). The pyrolytic cleaning cycle has high energy consumption, which could be larger than the energy saved by the improved insulation needed for these types of oven. The total annual energy consumption will depend on how frequently this system is used.

- Catalytic cleaning. This is a modern version of the self-cleaning oven, where the cleaning cycle is conducted at a lower temperature than the pyrolytic one (around 350 °C). These are ovens which can be recognised by their porous interior walls which are rough to touch. This type of wall absorbs the cooking grease. The catalysis destroys splashes of fat by oxidation when cooking dishes at more than 200 °C. It has been reported that catalytic cleaning is less effective than pyrolytic cleaning, since the catalytic liners cannot be cleaned, and there are certain gaps within the cavity which may need to be cleaned manually using chemicals. Catalytic liners require additional parts to be installed, adding about 1 kg of mass. This additional mass will absorb heat, increasing the oven's energy consumption. However, published research points out that there is still room for improvement, mainly around the properties of the oven wall coating.

- Hydrolytic cleaning. This is a cleaning process which involves the use of steam, combining evaporation and condensation. The dirt in the oven turns soft and detaches easily, making it easier to clean the oven. The system is simple and economical, as it just needs a small amount of water and washing up liquid. This is also the least energy-consuming self-cleaning process.

Considering the results from Task 3 regarding the use of the pyrolytic function and the high temperatures required during that cycle, the total energy consumption of this function could be significant. Stakeholders suggest that the pyrolytic function represents around 25% of the lifetime energy consumption of the oven. Other stakeholders indicate that it is important that consumers have access to information about the huge energy consumption of pyrolytic cleaning and that it should be declared. Their proposal is to include information on the energy consumption of self-cleaning systems in the user manual. However, they acknowledge the difficulty in including such information. In fact, this is the position of the manufacturers, who point out that self-cleaning systems should not be included in the Ecodesign/Energy Labelling Regulations, as it would be very challenging to evaluate different levels of cleanliness and to compare self-cleaning programmes with manual cleaning.

In terms of innovative solutions for self-cleaning ovens, in Palmisano et al. (2011), a series of tests were conducted to analyse the ability of cerium oxide ($CeO_2$) as the main component in the enamel of catalytic self-cleaning ovens. Four different synthesis techniques were studied for $CeO_2$ deposition over an enamelled oven tray. In terms of temperatures required, it was observed that for four different solid residues, when using the $CeO_2$-based enamel, the temperatures needed to remove 90% of that residue were between 8% and 49% lower than with a standard enamel. Moreover, when comparing the $CeO_2$ catalytic enamel with an equivalent pyrolytic enamel, it was observed that similar results in terms of residue elimination can be obtained at temperatures around 150 °C lower. These results indicate that there may be room for improvement in the energy consumption of self-cleaning systems.

#### 4.1.2.10 Technology area 10: Smart and connected ovens

Modern cooking appliances are increasingly equipped with automatic and connectivity features. A smart cooking appliance is essentially a Wi-Fi-enabled appliance which allows its connection to the Internet as well as the use of automatic cooking programmes that reduce the influence of the user during the cooking process.

As was mentioned in Task 2 of this report, the influence of the user is one of the aspects that affects the energy consumption of the oven, with inefficient cooking habits such as preheating with the oven empty or opening the door to check the state of the food. Ovens that incorporate automatic cooking functions can help to mitigate these inefficiencies. With the help of sensors, the oven can detect the status of the dish being prepared and adjust temperature and heating functions accordingly, without the intervention of the user. If the oven is connected to the Internet, it may have access to a database of recipes. The user selects a recipe from the database and loads it onto the device, which automatically sets the right temperature and timing for the selected dish. As highlighted in Favi et al. (2020), smart software can help to modulate the power depending on the recipe being cooked, without affecting product manufacturing or materials.

According to feedback from manufacturers, the use of automatic programmes can reduce the energy consumption of the oven by approximately 15% per cycle. However, the savings of the automatic functions cannot be easily shown with the current measurement methods (Brickmethod 1.0 or Brickmethod 2.0).

Being connected to the Internet provides a series of benefits to its users (although not particularly related to energy consumption savings). A connected oven, for instance, may become the hub or the centre of connection and dialogue for the management of all kitchen appliances: induction hob, cooking fume extractor, refrigerator, dishwasher and washer dryer. A connected oven can also be manipulated remotely by the user via smartphone or tablet. A connected oven can also provide information regarding the remaining cooking time or send a notification to the user when a programme has ended.

### 4.1.3 Best Available Technologies (BAT) in ovens

In this section, the Best Available Technologies (BAT) in terms of energy efficiency for domestic ovens are investigated. Data for this investigation will be taken again from the TopTen database (as in Section 4.1.2.6). All ovens currently listed within this database are either in energy classes A+ or A++. The energy efficiency classes and EEI of the 46 models listed in TopTen are displayed in Figure 148. An indicative benchmark as in Ecodesign Regulation 66/2014 is also shown in the graph by the orange dotted line. As can be observed, most of the products in the database have a very similar EEI, with very little variation between them (80.2-81.7%), with no significant difference between ovens, steamers or stoves.

- All the products in the database are below the EEI ecodesign limit for 2019 (96%).
- There are four products with a significantly better EEI than the rest and all of them are steamers (ovens with an additional steam function):
    - Those four steamers are below the indicative benchmark for electric ovens (70.7%).
    - Only one of those steamers is within the A++ energy class.
- Ovens and stoves show similar EEI values:
    - All of the ovens and stoves are below the value to be within the A+ energy class (82%).

An additional analysis is conducted to investigate whether there is a relationship between EEI and cavity volume (Figure 149).

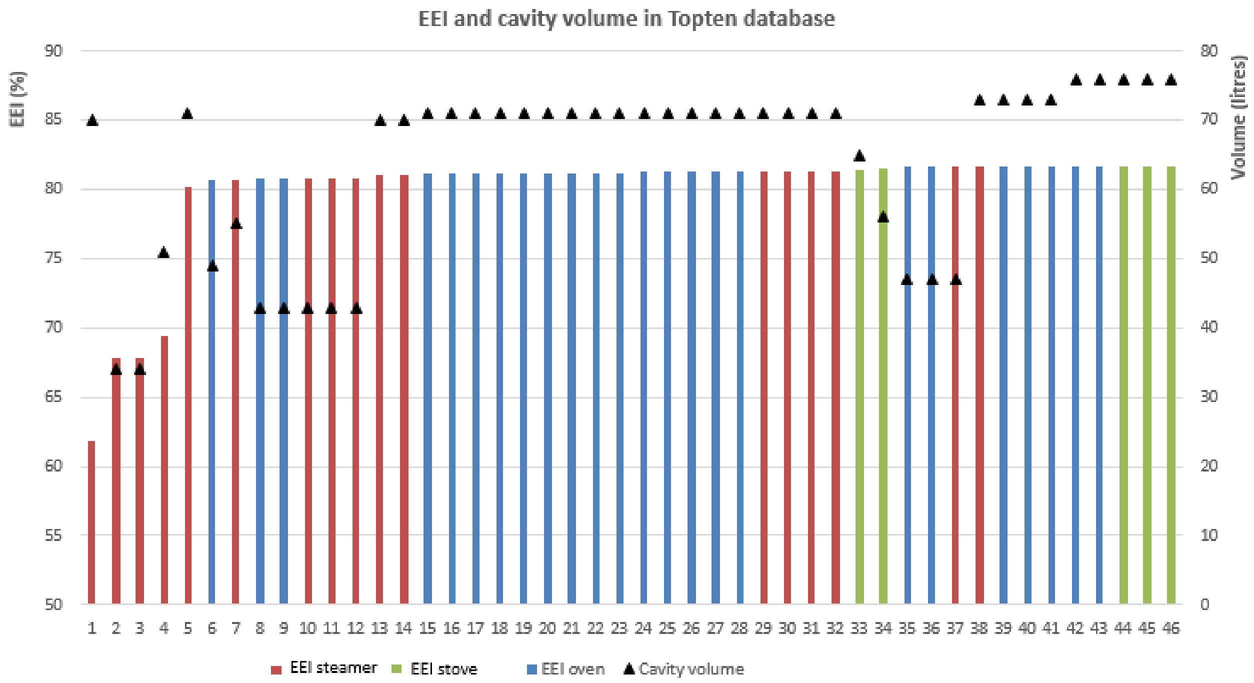



**Figure 149. EEI and cavity volume of ovens and stoves in the Topten database**

As can be seen in Figure 149, subtle trends can be observed regarding EEI and cavity volume:

- The best-performing product is model number 1 in this figure (EEI = 61.9%) and has a big cavity (70 litres).
- In contrast, the next two models in terms of EEI (67.8%) have smaller cavities (34 litres).
- The nine products (models 36-45) with the highest EEI values (81.7%) also have the highest cavity volumes (73-76 litres).

A very slight trend can be observed regarding EEI and cavity volume: bigger cavities lead to slightly higher EEI values. However, this needs to be taken with caution, since the sample is small (46 models) and the differences in EEI among most of the models are marginal (most of them between 80.2% and 81.7%).

**<u>BAT 1: Oven with heating mode that uses residual heat</u>**

Based on feedback from manufacturers, the biggest opportunity for improving energy efficiency in current ovens is through the development of heating modes that use residual heat to reduce energy consumption, also known as energy-saving modes, or eco modes. The use of these heating modes for the energy declaration and to determine the energy class is now being questioned by some stakeholders, as already explained in Section 4.1.2.4.

**BAT 2: Oven with steam-assisted function**

From the analysis of Figure 149, it could be concluded that the Best Available Technology (BAT) regarding energy efficiency is an oven with an additional steam function, since the five most energy-efficient products in the database are within this category. However, as mentioned earlier in this report, feedback from industry points out that the support of steam does not necessarily lead to lower energy consumption. Ovens with an additional steam function have improved sealing with a reduced vapour outlet, which is essential for steam functions. This leads to better results in the test, but the steam function may not be active during the test. An alternative to BAT could be to consider that the best-performing oven in terms of energy efficiency is an oven that works in convection mode, but with the improved sealing characteristics of a steam-assisted oven, which would reduce heat loss. However, manufacturers do not agree with this suggestion either, since there are some recipes which do not work with such highly sealed conditions and require some air leakage.

**BAT 3: Oven with microwave combination function**

Another alternative to BAT 1 and BAT 2 would be to take into account the promising results in terms of energy savings observed by industry (seen in Section 4.1.2.8) and consider that the best-performing oven in terms of energy efficiency is an oven with a microwave combination function. However, the lack of a method to measure the energy consumption of such a mode makes it currently impossible to determine how much better these ovens are in terms of energy efficiency.

**BAT 4: Oven with automatic functionality**

According to feedback from manufacturers, an oven with automatic functionality may provide energy savings. There is currently no data to support this potential improvement, but the feedback indicates that they could reduce the energy consumption per cycle by 15%.

### 4.1.4 Best Not Available Technologies (BNAT) in ovens

In this section, the Best Not Available Technologies (BNAT) in terms of energy efficiency for domestic ovens are investigated. Data for this investigation will be obtained from scientific literature and feedback from industry and stakeholders.

From the analysis of scientific literature, there is no obvious technology for domestic ovens currently available in the market which could drastically improve energy efficiency in the near future. Feedback from manufacturers also points to the fact that there are no significant technology developments expected in terms of energy efficiency in the coming years. In their view, the biggest potential for energy efficiency improvement is more related to user behaviour than to the actual appliances. Best practices for energy savings when cooking with an oven have been mentioned in Task 3 of this report.

A new technology mentioned in specialist magazines is solid-state semiconductor materials. As explained in Section 4.1.2.7, microwave ovens are based on the use of magnetrons, devices capable of creating microwaves, a form of electromagnetic radiation with waves shorter than radio waves but longer than anything human eye can see. When electricity runs through a metal filament, negatively charged electrons rush to the positive end. Magnetrons keep these electrons going in a loop created by a magnet, creating electromagnetic waves that radiate outward. These waves affect the water molecules in the food, which start wiggling around rapidly. Metal mesh lining in microwave ovens reflects these waves, bouncing them around the cavity about 2.5 billion times per second. The friction created by this movement of water molecules heats food from within (Foley, 2017). One of the main disadvantages of microwave ovens is related to the uncontrolled bouncing of the electromagnetic waves within the cavity, affecting the food from different angles. The turntable is in charge of balancing this but the cooking results are often not repeatable even using the same amount of power.

In Werner (2015), a potential solution is presented to overcome this issue, based on the use of a solid-state semiconductor, paired with signal amplifiers and receivers. Semiconductors are made out of ceramics like silicon, which typically block the flow of electrons,but have chemical impurities that help electrons move only in one direction. Semiconductors slow down electricity coursing through a system. The amplifier and receiver create a power feedback loop that allows the semiconductor to adjust and produce the right amount of microwaves, at the right power level, and for the correct length of time, to heat food evenly. Unlike conventional microwave technology, this one may allow for much higher precision cooking because the signals generated provide a feedback loop to help the oven understand and target specific zones within the cooking cavity. A few examples of companies working on ovens with this technology is compiled in Wolf (2017). Another potential advantage of semiconductor-based microwave ovens is their portability. Substituting magnetrons (which are bulky, heavy components) with lighter and more compact semiconductor materials could open up the possibility of the manufacture of portable microwave cookers (Hambling, 2016).

Currently, there is no scientific evidence published regarding any potential improvements in terms of energy efficiency regarding this technology. Feedback from industry indicates that whereas the efficiency of generating microwaves with a magnetron is around 70%, that of generating them by semiconductors is only 35%. Semiconductors offer the theoretical advantage of variable wavelength. However, this also brings disadvantages as the ovens need to be dimensioned for a specific frequency to assure efficient use and especially to avoid microwave leakage. On top of that, the costs of this technology are still far from being applicable for the domestic sector.

A different technology was presented as part of the Green Kitchen Project (2014). In this project, the main goal was to develop and share knowledge for future home appliances for improving energy efficiency. This project led to the development of a prototype for gathering and storing thermal energy making use of Phase Change Materials (substances which absorb or release large amounts of ‘latent’ heat when they go through a change in their physical state). This resulted in an oven design that, according to the authors, can reduce electric power consumption by up to 20%.

On top of those, the MAESDOSO project (2017) aims to develop electrochromic devices for use in domestic ovens, mainly in glass doors. Electrochromic devices generate reversible colour changes responding to electricity. They are promising candidates in display, smart window, and military camouflage applications. In the MAESDOSO project, the reduction of heat losses in the glass will be achieved by reflection of infrared radiation using low-emissivity coatings on transparent conducting oxide. Unfortunately, no savings are mentioned in the report.

## 4.2 Domestic hobs

### 4.2.1 Technical product description: hobs

A hob is a domestic appliance used for heating food. It generally works as a primary heat source which is used to warm a cooking vessel (a pan, pot, etc.), which then becomes the secondary heating source, transferring heat to the food within it. In the definitions section of Regulation 65/2014, the European Commission differentiates between electric hobs, gas hobs and mixed hobs:

- **Electric hob**. Appliance which incorporates one or more cooking zones/areas, including a control unit, and which is heated by electricity.

- **Gas hob**. Appliance which incorporates one or more cooking zones/areas, including a control unit, which is heated by gas burners with a minimum power of 1.16 kW.
- **Mixed hob**. Appliance with one or more electrically heated cooking zones/areas and one or more cooking zones heated by gas burners.

### 4.2.2 Basic product types

Depending on the characteristics of the main components, domestic hobs can be classified in different ways. In Table 31, a classification is provided considering three criteria: heat source, heating element, and mounting.

**Table 31. Types of hobs**

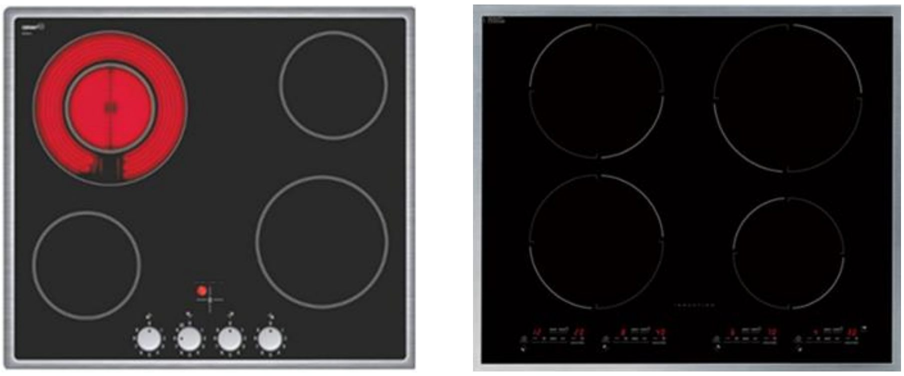
| Heat source | Heating element | Mounting |
|---|---|---|
| Gas | Burners (gas) | Built-in |
| Electricity | Solid plate (electric) | Integrated in a cooker |
| | Radiant (electric) | Portable or table-top |
| | Induction (electric) | |

With regards to the heat source, domestic hobs can be powered either by gas or electricity. Gas hobs imply the use of burners that, after being ignited, maintain a flame that transfers heat to a cooking vessel. Although they can differ in size, configuration and ignition type, gas burners are relatively similar. However, there are more differences between electric hobs, depending on the heating element they use. In terms of the heating element, electric hobs can be classified in different types (Figure 150):

- **Solid plate** hobs contain a sealed electrical resistance, through which circulates electrical current, transferring heat to the cooking vessel on top of it.
- **Radiant hobs** are a type of radiant cooking appliance. They use an electrical resistance wire or ribbon with a current that makes it glow red hot, so that most heat is transferred to the cooking vessel by infrared radiation via a glass-ceramic surface
- **Induction hobs** are an electric cooking appliance where the hob itself is not specifically heated. Instead, below the surface of the hob there is a planar copper coil that is fed electrical power via a medium-frequency inverter. This alternating current induces eddy currents in nearby metallic objects (cooking vessel). These eddy currents heat up the cooking vessel, transferring the heat to the food.

**Gas**

**Solid plate**



**Radiant** **Induction**

Provided by APPLIA

**Figure 150. Different types of hobs according their heating element**

An important usability factor when comparing domestic hobs is the ability to **control temperature**, as this is a key aspect of the cooking process. In general, it is considered that gas hobs offer a basic level of control, whereas radiant ones allow the user to be slightly more accurate thanks to the different levels offered in this kind of cooktop.

**Time response** is another factor valued by consumers. Induction hobs have the quickest response to temperature changes. As an average, the time needed to boil 2 litres of water with an induction hob is 5 minutes. This is mainly due to the fact that the electromagnetic fields created in these hobs do not heat the cooking surface, but rather the cooking vessel directly. Moreover, the flat surface prevents heat being lost (highest energy efficiency among hobs).

In terms of **durability**, gas hobs have been widely used over time and their durability has long been proven. A widespread figure given for gas hobs' lifetime is 19 years (ETSAP, 2012). In contrast, glass-ceramic is more prone to scratching and breaking. If a pot is accidentally dropped on the cooktop it may damage the surface, affecting its performance. Induction and radiant hobs may have a slightly lower average lifetime for that reason (a range between 15 and 19 years is provided in ETSAP, 2012). Moreover, the significant amount of electronic components present in induction hobs may reduce the lifetime of these appliances. As reported in Favi et al. (2018), a lifetime bottleneck is usually represented by electronic components, which tend to have the shortest lifetime among all components of a product. It is suggested that the lifetime may be lower than gas or radiant cooktops, and more similar to other electrical products (10-15 years).

### 4.2.3 Safety in domestic hobs

In terms of safety, it is worth noting that generally every product placed on the market has put in place every measure required to make it safe enough for the consumer. However, this does not mean that the user will never make any mistake when using the appliance, such as forgetting to turn it off after cooking or touching the cooking surface accidentally.

Considering accidental touches, there is an obvious risk in touching a gas hob when it is working, as the flame can cause instant burns to the user. Nevertheless, it seems unlikely that this sort of accident may happen. In contrast, this is a situation that seems slightly more likely in the case of electric radiant hobs. The flat surface is often used to cook and chop food, particularly in small kitchens where cooking space is limited. Radiant hobs have a glowing red colour when turned on, but almost instantly go black after use. Although there is generally a small pilot light indicating that the surface is still hot, the user may rush to use it for preparing food, increasing the risk of accidental burns. Some manufacturers offer electric hobs with LED lights which simulate the appearance of the flame and light up or down according to the temperature. Finally, induction hobs are the safest from this point of view. While cooking, the surface will only get slightly warm, due to the heat transmitted from the pan to the actual surface.

Forgetting to turn off the hob after cooking is a common mistake made by users. Generally, gas hobs do not come with any automatic turn-off device, so if the user forgets to turn it off after cooking, it will keep on burning gas indefinitely, posing an obvious fire risk. According to certain studies, 62% of home fires start because of the hob (Rance, 2019). Just a limited number of gas hobs are equipped with independent timers for programming the cooking times and switching off each burner after a certain time. Others also include an alarm that sounds if the hob remains active beyond a certain threshold (Preda, 2018). There is some risk as well in forgetting to turn off an electric radiant hob. In this case, the highest risk is also related to burns by accidental touch. Induction hobs will again be the safest ones: if the user forgets to turn off the device after cooking, the pan will get hot, but it is unlikely that a fire will start because of a hot pan, or that any other user would touch the interior of the pan. If the user forgets to turn off an induction hob, but removes the pan from the surface, nothing will happen, as induction needs a ferromagnetic material to be located on top of the surface to start working.

### 4.2.4 Technology areas: hobs

#### 4.2.4.1 Technology area 1: Gas hobs

Gas hobs are usually made of a metal plate that functions as a frame, upon which several cooking spots or burners are mounted (a typical configuration is four burners). Generally, hobs are made with burners of two or more different sizes and maximum energy output, in order to accommodate different size cooking vessels. Each cooking zone includes a metallic grid, or pan support, where the vessel is placed for cooking. The main components of gas hobs are:

- burners;
- igniters;
- gas flow controllers.

Most burners are round with an array of small gas flames around the periphery. Typical domestic hob burners have a maximum power output of approximately 3.7 kW, although some burners with up to 6 kW can also be found. In traditional gas hobs, each burner is centrally located below a pan support and surrounded by a dish shaped depression to avoid spillages from the cooking vessels extinguishing the flame. Control of the power to the burner is typically only by the control of the gas supply, although some manufacturers market dual burners consisting of inner and outer circular burners, intended to provide more even heat distribution.

The size and power of burners is a relevant aspect in ecodesign regulation. Small burners (below 1.16 kW) are currently out of the scope. Some of the reasons given for leaving small burners out of the scope was that they are mostly used for simmering and not cooking; and that due to their low power and the nature of the standard test (the temperature rise is not adequate to measure their performance), they may cause reproducibility issues during testing. However, some stakeholders consider that, unless substantiated by data, smaller hobs should also be included in the scope. To overcome reproducibility issues, stakeholders recommend developing a simmering test for small burners, to collect data on a significant number of them and set efficiency minimum requirements. Manufacturers highlight that, although a test could be developed for small burners, a minimum power threshold to be within the scope of ecodesign regulation should still be in place.

In gas hobs, gas is premixed with some air before it reaches the burner, so that a smoke-free blue flame is produced. Combustion also requires secondary air from around the flame to burn all the hydrocarbon gases. To avoid CO formation, it is essential that some excess air is mixed in the flame. The amount needs to be limited, as too much cold air cools the flame and reduces the heat transfer efficiency.

High-voltage spark igniters are the most common type of domestic hobs, since they provide near-instantaneous ignition of the gas. The spark electrode surfaces are affected by contamination and moisture, causing gradual loss of energy efficiency. However, their useful life is long and they usually do not need to be replaced over the hob lifetime. Hot surface igniters use electrically heated ceramic surfaces that are sufficiently hot to ignite the gas. Originally, these took as long as 30 seconds before ignition, but some recent designs operate much more quickly. One potential problem is that, being made of ceramic, the igniters could be physically damaged by thermal shock. This technology is rare in the EU and more common in the US. Hot wire igniters use a proprietary alloy resistance wire that heats up to over 1000 °C in order to ignite the gas. Ignition takes less than 3 seconds. The wire is not affected by contamination and there are no electromagnetic compatibility issues. This type of igniter is also rare in the EU.

In terms of the type of gases covered by the Ecodesign Regulation for cooking appliances, it is worth recalling at this point that the current Regulation leaves out of the scope (among others) those appliances designed for use only with gases of the 3rd family (butane and propane). However, according to manufacturers, this exception does not make sense nowadays, so appliances which work with gases of the 3rd family should be included in the scope.

Gas flow control elements (valves) are made from either brass or aluminium. Valves restrict the flow of gas in order to control the heat output. Electronic gas control valves have recently been introduced, providing a variety of functions, including:

- automatic burner ignition (reignites the gas if the flame goes out);
- electronic gas flow control (more accurate control of the gas flow);
- safety switch that turns the gas off after a certain time;
- timers to turn the gas off after a pre-set time;
- touch control systems;
- flame supervision device: safety device designed to stop flammable gas going to the burner of a gas appliance if the flame is extinguished.

The main materials used to manufacture gas hobs are aluminium alloy, carbon steel, copper, brass and synthetic rubber. A detailed Bill of Materials of a gas hob system is presented in Favi et al. (2018).

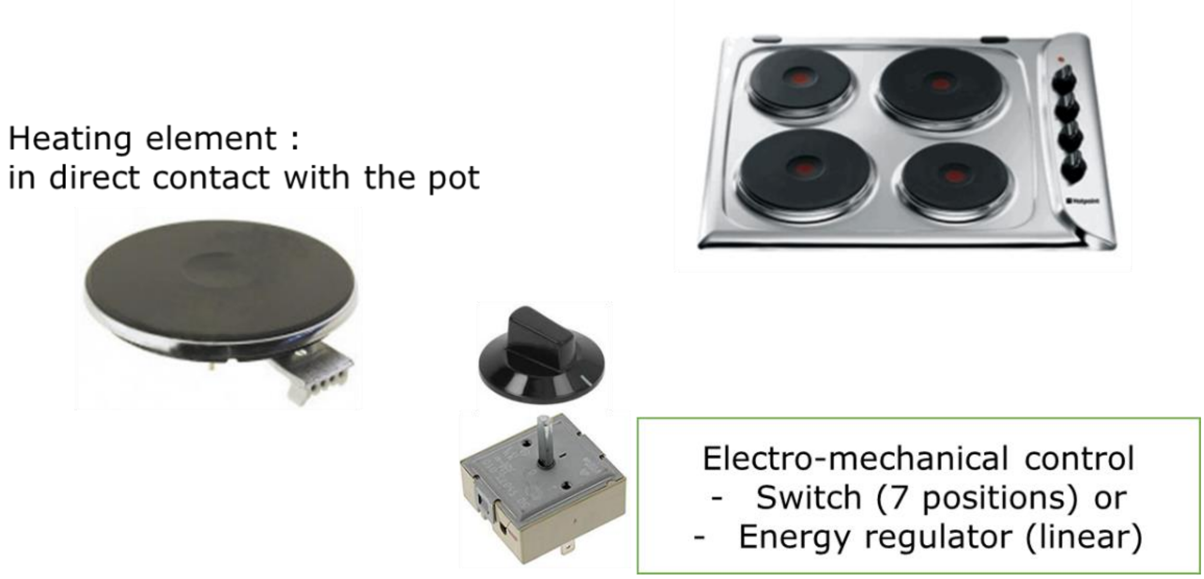
In terms of energy efficiency, it is generally considered that gas technology is largely accepted and well known in the global market. Therefore, less research and development actions are currently being undertaken to improve its efficiency (in comparison to other types of hob technology such as induction). Current innovations in gas hobs are related to the aspects listed below:

- The design of gas hobs with a smaller distance between the pot and the flame, which may increase the speed of cooking and lower energy consumption (Corti, 2019b). However, this may jeopardise the safety of the hob, thus any improvement in this area is limited by safety requirements that must be fulfilled above any other requirement. Also, although efficiency can be improved by bringing the flame closer to the pot, it can also increase the pollutant emissions of the burner as the chemical reaction occurring during combustion could be stopped when the flame touches the pot. Therefore, reducing the distance between pot and burner is an area which it is not recommended to explore as a way to improve energy efficiency.

- A more precise flame control that makes the gas hob more efficient and perform better. Manufacturers are offering gas hobs where the flame increases or decreases according to several power levels, with a similar precision to that of induction (Preda, 2018).

#### 4.2.4.2 Technology area 2: solid plates

**Solid plates** consist of a resistance wire of Nichrome, either as a spiral ring or within a solid plate. Heat transfer is primarily by conduction, so it only occurs efficiently where the cooking vessel and the ring are actually in contact. Hobs are usually sold with a range of ring sizes to accommodate cookware of different dimensions. The main elements of solid plates are shown in Figure 151.




Provided by APPLIA

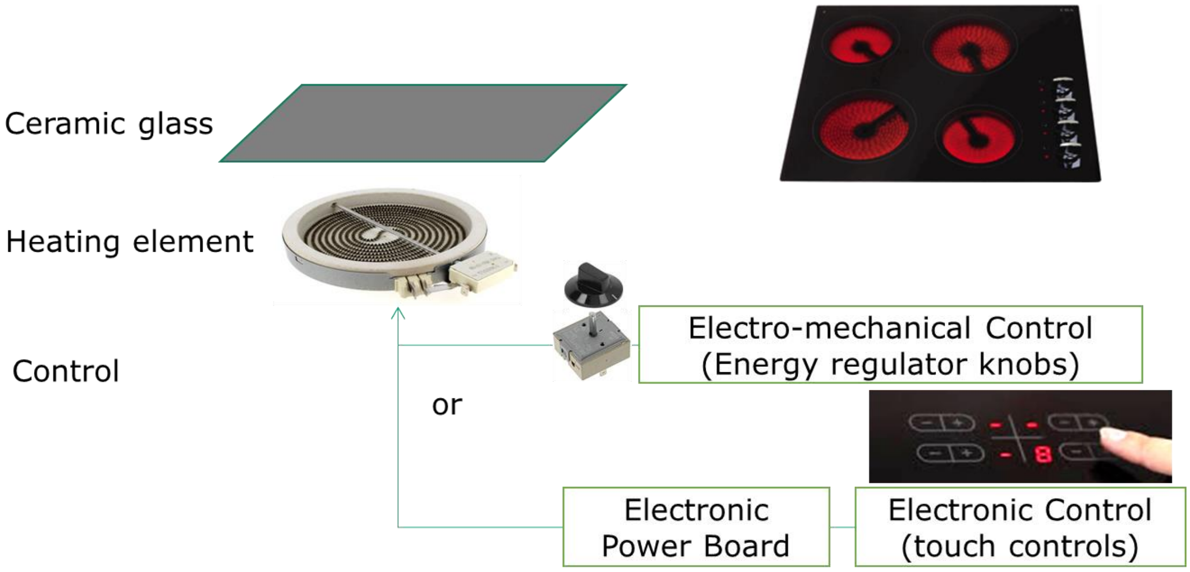
**Figure 151. Components of solid plates**

The main advantages of these hobs are the low price and robustness. However, cooking temperature control is difficult as they are relatively slow to respond to changes in the controls due to their high thermal mass (inertia of the plate).

According to feedback from manufacturers, the potential for improving energy efficiency in solid plate hobs is almost exhausted at this point, since today's solid plates are already generally equipped with energy regulators (no longer seven-step switches), due to the current requirements of ecodesign regulation.

#### 4.2.4.3 Technology area 3: Radiant hobs

Electric radiant hobs consist of a glass-ceramic surface, beneath which electrical current flows through a unique metal coil. Electrical resistance heats to generate a hot glowing metal coil that transfers its heat through the glass-ceramic via radiant energy and to the glass-ceramic via convective heat (Joachim, 2019). The main components of radiant hobs are shown in Figure 152.




Provided by APPLIA

**Figure 152. Components of radiant hobs**

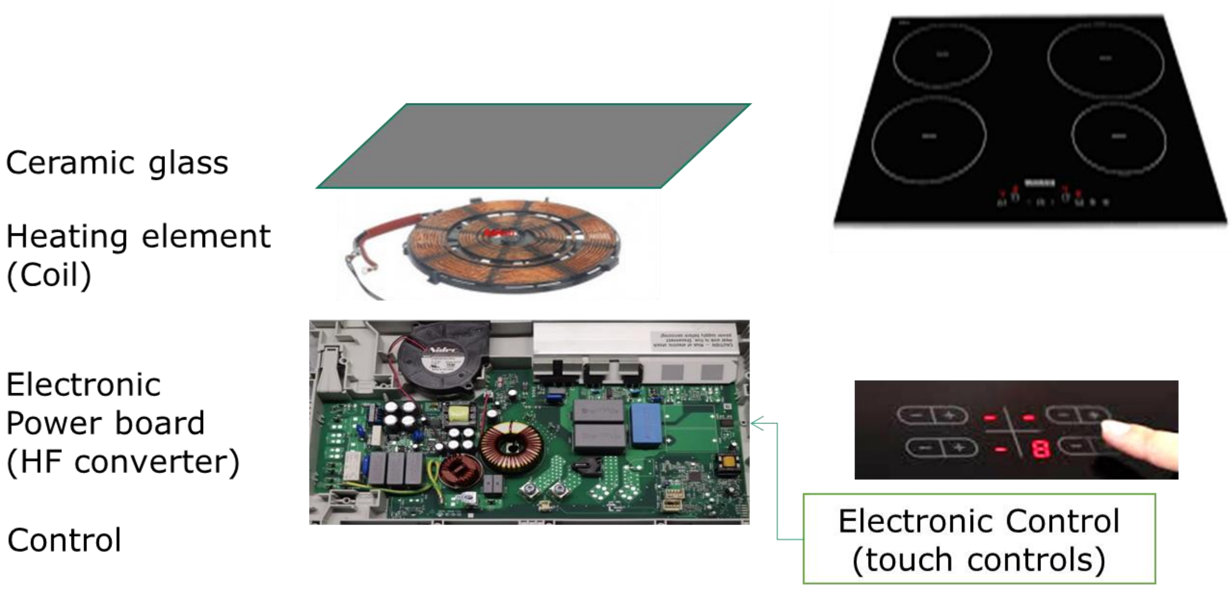
Food is cooked by the transfer of heat from the electric coil to the ceramic-glass surface and finally to the cookware. At the same time, the surrounding surface of the glass-ceramic remains relatively cool. The glass-ceramic continues to emit heat after electricity stops flowing, so this residual heat can be used to continue cooking or to keep food warm (Wegert, 2015). As the thermal mass of the heating elements is relatively low, they cool rapidly when the current is reduced, giving much better temperature control than solid plate hobs. The response time is not as fast as in induction hobs, as some heat is retained by the glass-ceramic.

Because of the glass-ceramic's low thermal expansion and infrared transmission and emission characteristics, the pot or pan on the cooking zone is warmed evenly by the energy transmitted through the glass-ceramic to the cookware. They also have less thermal inertia and a faster response than solid plates.

#### 4.2.4.4 Technology area 4: Electric induction hobs

In induction hobs, below a glass-ceramic cooktop, there is an electronically controlled coil of copper. When the power is on, constantly changing electric current flows through that coil, generating a magnetic field that terminates at the bottom of the ferromagnetic pot placed above the hob. This fluctuant magnetic field indirectly produces heat by inducing an electrical current flow in the pot: an eddy current (Favi et al., 2018). A diagram explaining the basic functioning of an induction hob can be seen in Hager et al. (2013).

The electromagnetic induction generates eddy currents within the metal and its resistance leads to Joule heating and also generates losses due to the hysteresis of the magnetic material in the pan. An induction cooker consists of a copper coil (generally), through which a high-frequency alternating current (AC) is passed. The frequency of the AC used is based on the maximum switching frequency of the switch of the power converter. The main components of an induction hob are shown in Figure 153.




Provided by APPLIA

**Figure 153. Components of induction hobs**

The most common topologies for induction heating are the Half-Bridge series Resonant converter and the Single-switch Quasi-Resonant converter. The Resonant Half-Bridge is the most employed topology in induction cookers for multiple-burner high-power systems due to its simplicity, its cost-effectiveness, and the electrical requirements of its components. Quasi-Resonant converters require only one switch, and only one resonant capacitor. Quasi-resonant converters might be considered as a good compromise between cost and energy conversion efficiency (Semiconductor Components Industries, LLC, 2014)

In terms of required cookware, any ferromagnetic steel flat-bottomed pot is suitable. However, specially designed cookware is also used. These have ferromagnetic metallic bases that couple efficiency with the AC signal. Cooking area size is much less important in these hobs, as induction only heats the actual size of the pan being used. Heat losses are therefore reduced significantly with these appliances. The medium-frequency coil needs to be located at a certain distance from the pan base for optimum coupling efficiency. The heat energy generated in the pan is inversely proportional to the square of the coupling distance. Therefore, the hob needs to be designed with the correct distance between the coil and the pan.

The main materials used in an induction hob are glass-ceramic, stainless steel, carbon steel, aluminium alloy, polypropylene and a considerable amount of copper –for induction coils and power cables- and electronics. A detailed Bill of Materials of an induction hob system is shown in Favi et al. (2018). Focusing on electronics, there are fundamentally resistors, inductors, capacitors, transistors and microcontrollers, attached on top of printed circuit boards (PCBs). A detailed inventory of the materials used in such PCBs can be seen in Elduque et al. (2014).

In terms of energy efficiency, induction hobs tend to have a very fast response and better performance than the other hob technologies, particularly during heating up, as the pan is heated directly and energy is not wasted heating the cooker itself. During subsequent cooking, the difference in energy consumption is slightly lower, as the hob does warm up a little due to heat losses from the induction electronics and conduction of heat away from the pot to the hob surface. Certain energy losses happen as well from the induction electrical control circuitry that generates the medium-frequency current applied to the coil. These occur during heating up at full power and during simmering. Furthermore, as technological development advances, the overall efficiency of induction hobs keeps improving.

However, it needs to be taken into consideration that induction hobs are more complex, in terms of number of parts and technology, than conventional electrical or gas hobs. This may lead to shorter lifetimes than other hob technologies (more similar to other consumer electrical products). Another drawback is that the performance is affected by the material of the pot, which needs to be compatible with the induction technology.

#### 4.2.4.5 Technology area 5: Smart and connected hobs

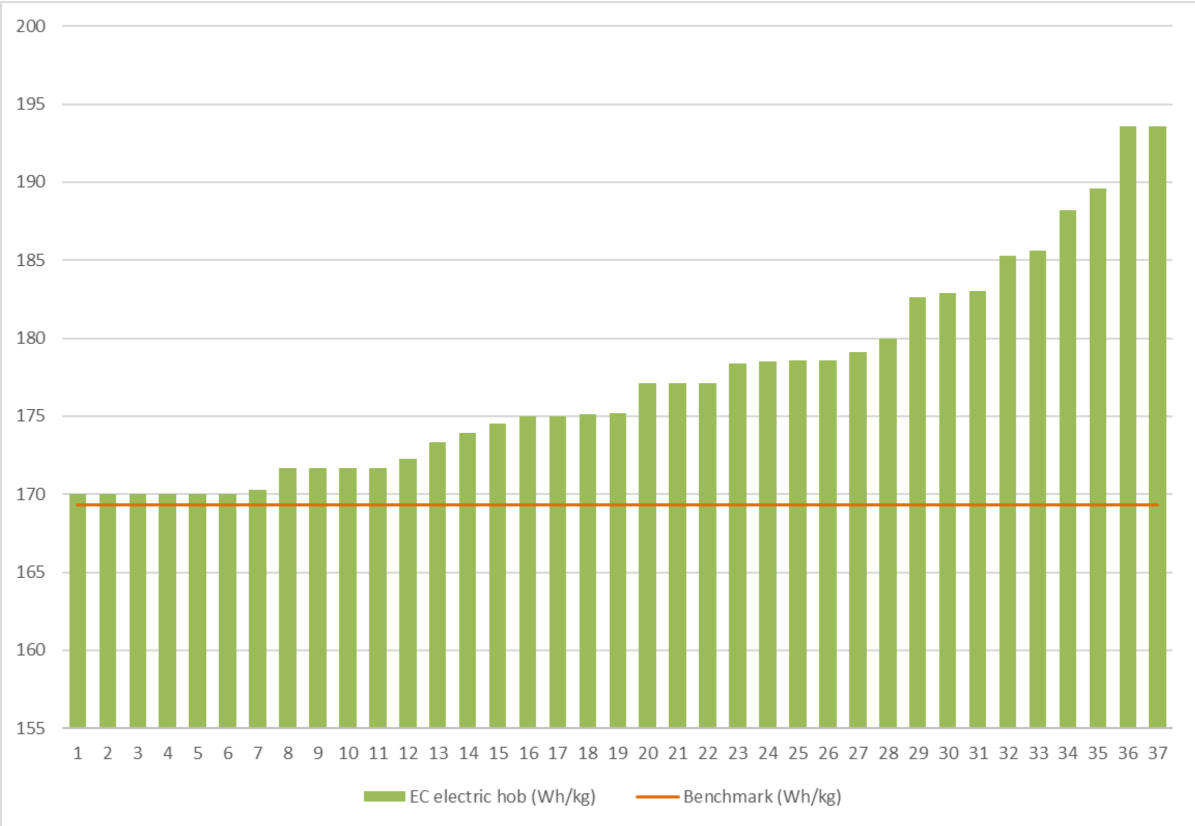
A smart hob is broadly understood as a cooktop with a built-in Wi-Fi module that can be synchronised with an application managed from a portable device such as a smartphone or tablet. The benefits of a smart hob are very similar to those of a smart oven and can be summarised as follows:

- A connected hob may have access to an extensive database of recipes. The user may select a recipe from the database and load it onto the device, which automatically sets the right temperature and timing for the selected dish.
- A connected hob can be manipulated from an application on a smartphone or tablet, making it easier for the user to access the functions and basic settings. It is worth noting that, unlike ovens, cooktops are not designed to be left unattended and the cooking process must be monitored at all times. The goal of a connected hob is not to be managed remotely.
- A connected hob may be also operated via voice control devices. While the user is preparing other food in the kitchen, the hob may be turned off via voice command, without the need to approach the cooktop or touch the controls. This may help reduce cooking time and also avoid leaving fingerprints on the surface.
- A connected hob with a failure may send a notification to the user when it detects something is not working properly, and can also be diagnosed remotely. With remote diagnosis, customer service can obtain online access to the device, identifying the cause of any problems and giving advice on what needs to be done.

### 4.2.5 Best Available Technologies (BAT) in domestic hobs

In this section, the Best Available Technologies (BAT) in terms of energy efficiency for domestic hobs are investigated. Data for this investigation will be taken from the TopTen database.

In terms of domestic hobs, Topten provides data only regarding induction hobs, so no comparison can be made with other electric or gas hobs. The list of most efficient induction hobs is provided in terms of energy consumption per kg of water, according to a criteria set that is regularly updated. The energy consumption figures of the 37 models listed in the TopTen database are displayed in Figure 154.

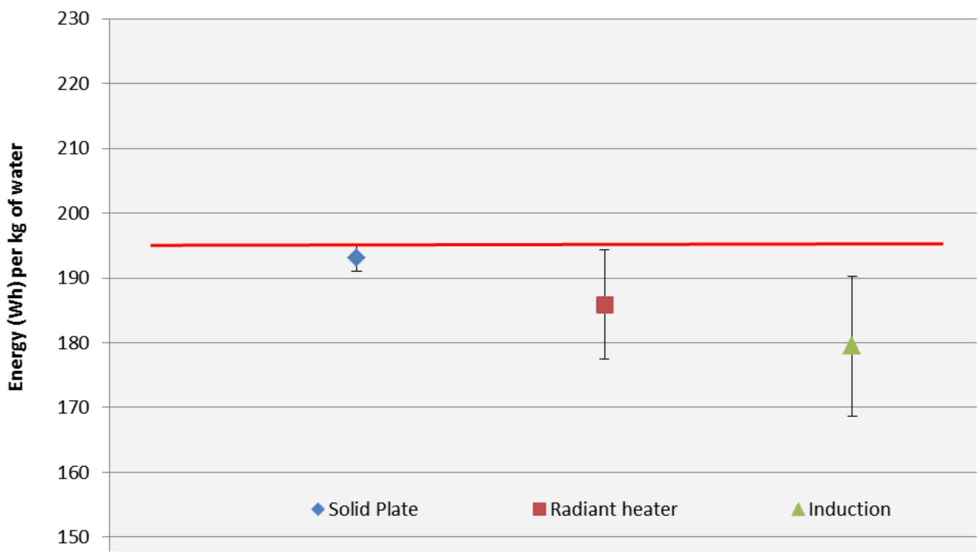



Available models in TopTen in January 2020

**Figure 154. Energy consumption of induction hob models**

As can be observed, only six models are close to the benchmark set by Regulation 66/2014 (169.3 Wh/kg). There is only a 14% difference in terms of energy consumption between the worst- and the best-performing models of the database (193.6 Wh/kg versus 170 Wh/kg).

Apart from the data provided by TopTen, manufacturers shared the range of energy consumption that the three types of electric hobs (solid plate, radiant heater and induction) typically perform (Figure 155). The ecodesign limit for energy consumption after 2019 is displayed by the red line (195 Wh/kg).




Provided by APPLIA

**Figure 155. Energy consumption ranges of electric hobs**

From the analysis of Figure 155, it can be concluded that the Best Available Technology (BAT) for domestic hobs is induction. It can also be seen that the range of energy consumption values that solid plates can provide are very close to the minimum requirements of the Ecodesign Regulation.

As can be seen in Figure 155, there is a small difference between the energy consumption of the three technologies under comparison. This is one of the main reasons for not having an energy label for domestic hobs.

### 4.2.6 Best Not Available Technologies (BNAT) in domestic hobs

In this section, the Best Not Available Technologies (BNAT) in terms of energy efficiency for domestic hobs are investigated. Data for this investigation will be obtained from scientific literature and feedback from industry and stakeholders.

Some manufacturers pointed out the fact that there are no significant technology developments expected in terms of energy efficiency in the coming years. In their view, as is the case for ovens, the biggest potential for energy efficiency improvement is more related to user behaviour than to the actual appliances. Best practices for energy savings when cooking with hobs have been mentioned in Task 3 of this report. However, a manufacturer highlighted that conduction cookware could significantly improve the energy consumption of domestic hobs and shared a report with the results of different tests on a prototype. From the results, it can be estimated that the conduction prototype could achieve 109 Wh/kg according to the simmering test method.

Also according to stakeholders, the cookware used has a very significant influence on the energy efficiency of the appliance. An extremely energy-efficient appliance can deliver a very poor performance in terms of energy consumption if inappropriate or low-quality cookware is used.

The most significant technology development in the near future regarding hobs may be related to changes in terms of uses of gas. This is explained in more detail below.

#### 4.2.6.1 Hydrogen as an energy source for domestic cooking appliances

This section is applicable to both gas hobs and gas ovens.

Natural gas is today one of the most important primary energy sources in Europe, with utilisation ranging from power generation, industry and mobility to appliances in the residential and commercial sector (such as cooking appliances). As natural gas is a fossil fuel, gas utilisation is thus responsible for significant emissions of $CO_2$. The residential and commercial sector is the biggest end-user sector for natural gas in the EU. The most promising alternative fuels for decarbonising the gas sector are biomethane and hydrogen (Schaffert et al., 2020). Therefore, currently there is a growing interest in understanding how hydrogen-based technologies could contribute to the decarbonisation of the heat supply sector for households (either for cooking or warming).

Taking into account the EU Hydrogen Strategy (COM(2020) 301), it is likely that the use of gases such as hydrogen will increase in the midterm. Consequently, appliances such as gas hobs and ovens will have to adapt to these new gas mixtures, keeping a high level of safety, reliability and performance. On top of that, the THyGA European project (Testing Hydrogen admixture for Gas Appliances) aims to close knowledge gaps regarding hydrogen and natural gas blends, to identify and recommend appropriate codes, standards that should be modified or adapted to answer the needs for new and existing appliances (THyGA, 2022).

At this point, the domestic cooking appliances industry seems to be in an immature state in terms of adaptation to the use of hydrogen as an energy source. In H21 (2019), some examples are provided of hydrogen-fired cooking equipment, mostly from US suppliers. According to the authors of the study, their presence in the market confirms that hydrogen can be readily used for cooking.

According to other authors (Frazer-Nash, 2018), there are three options for the adoption of hydrogen as an energy source:

a) Developing new appliances from scratch, which would use only hydrogen as a fuel. This offers the freedom of designing and optimising a new solution, with the associated challenges of rolling out a completely new product.

b) Adapting existing appliances, currently running on natural gas, to run on hydrogen. This option could soften the challenges of a completely new roll-out, but would also come with technical and operational issues.

c) Developing dual fuel appliances, capable of operating on natural gas and hydrogen. In one case, it would mean appliances being able to use both fuels for their whole life cycle. In a second case, it would mean appliances designed to be used first with natural gas, and then with hydrogen when the surrounding infrastructure is ready. In this second case, it would require certain components to be changed at the point of the switchover from natural gas to hydrogen.

Manufacturers disagree with some of the statements presented in Frazer-Nash (2018). For instance, they highlight that one gas appliance will never be able to switch from natural gas to pure hydrogen without any adaptation. Gas controls or burners designed to work with natural gas cannot work directly with hydrogen. Switching from natural gas to hydrogen would mean challenges in several areas of the cooking appliances sector, mainly around combustion, heat transfer, controls, piping, seals and casings.

According to Hydrogen Europe, hydrogen can be blended with natural gas, offering an easy entry point into the hydrogen economy. Although the physico-chemical properties of natural gas and hydrogen differ, as well as their energy content per $m^3$, blending a small percentage of hydrogen with natural gas is possible without major investments, or compromising gas specifications and downstream user equipment (Chatzimarkakis, 2021).

According to another stakeholder in the energy sector, the characteristics of biomethane are similar to natural gas, so burners would not require major adaptations for that energy source. However, the situation is more complex in the case of hydrogen-natural gas blends, since they would have significant effects on the characteristics of the combustion (such as flame velocity or Wobbe index). Gas appliances may then require design adaptations and other control strategy operations, depending on the percentage of hydrogen in the blend. This position agrees with recent scientific publications on this topic (de Vries et al., 2017; Leicher et al., 2022).

Preliminary work on the impact of hydrogen on appliances is unfinished and works on the integration of $H_2$ in gas standards has recently begun. A recommendation from the stakeholder in the energy sector is to work on a progressive and voluntary approach (instead of a compulsory requirement) concerning the ability of gas burners to operate with gas blends. The favoured option would be the use of a specific pictogram on the equipment (and its energy label) illustrating its possible operation with a minimum rate of X% of hydrogen in natural gas. Their recommendation is an objective of 20% $H_2$ in 2030. Furthermore, the same principle could be implemented for pure hydrogen, with a voluntary specific pictogram such as '100% $H_2$ ready'. Similar proposals -in relation to space heaters- for ecodesign requirements to allow up to 20% blending (but no pictogram), and information requirements and definitions in relation to 100% $H_2$ readiness, were already put forward to the Consultation Forum in 2021 by the Commission services.

This recommendation regarding hydrogen readiness is compatible with feedback provided by manufacturers. In their view, the use of 20% hydrogen combined with natural gas in domestic cooking appliances could be possible around 2030. However, they highlight the need to adapt or convert these gas appliances in order to operate safely with that amount of hydrogen.

Although this adaptation is technically feasible, manufacturers highlight that the cost of this conversion might be considerable in the domestic cooking appliances sector. Gas ovens and hobs are generally simpler and cheaper appliances. Therefore, the cost of adapting the appliance to be able to operate with hydrogen might be comparable to the initial cost of the appliance. The need for this conversion might discourage consumers from purchasing these kinds of appliances.

Other stakeholders highlight the relevance of hydrogen production in the context of decarbonisation. They point out that, without renewable and low-carbon hydrogen on a large scale, the EU will not achieve its decarbonisation targets (Hydrogen Europe, 2022).

NGOs contributing to this project add that hydrogen quickly rose on the political agenda as an easy way to decarbonise energy systems. However, in their view it is rather far from being a clean solution. Hydrogen has potential only if it is produced from the excess renewable electricity that would otherwise be wasted, and if it is then used in sectors where direct renewable electrification is not possible. In their view, hydrogen should not be considered as an energy source in sectors other than heavy industry and transport.

As a summary from this section, it can be concluded that hydrogen is a promising technology for domestic gas cooking appliances, which might be able to contribute to decarbonisation (if hydrogen is produced from renewable sources). Technologies in this sector are currently not sufficiently mature for operation with hydrogen blends, but their conversion or adaptation is technically feasible. In addition, standards need to be updated and developed.

With this in mind, the new Ecodesign Regulation on cooking appliances might require that gas ovens and hobs shall be able to operate safely and efficiently with a blend of a fossil gas and up to at least certain percentage of hydrogen. A tiered approach to allow for adaptation of appliances might also be needed.

## 4.3 Domestic cooking fume extractors

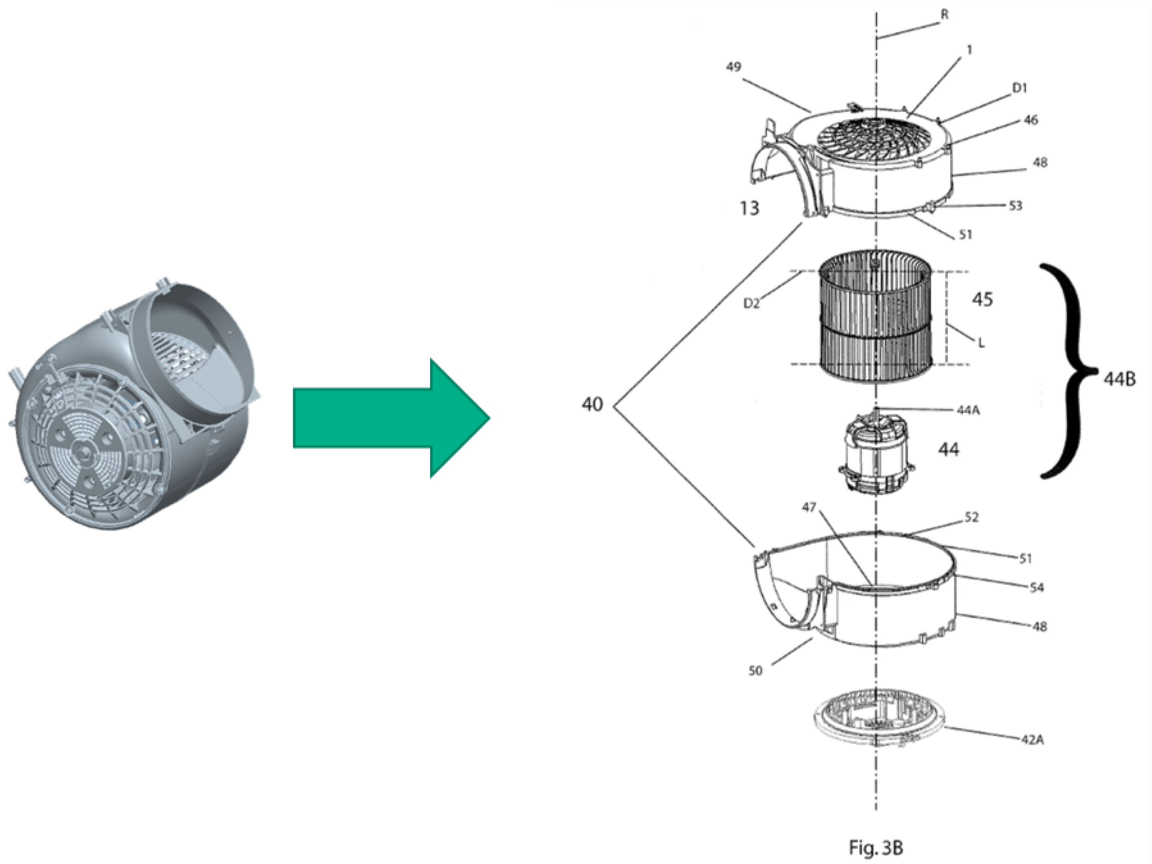
### 4.3.1 Technical product description: cooking fume extractors

Cooking is a significant source of indoor pollutants. Fumes generated during cooking processes usually comprise sub-micrometre-sized particles, such as oil droplets, combustion products, steam and condensed organic pollutants (Abdullahi et al., 2013). Additional pollutants (including $NO_2$, CO and unburned methane) may arise where hobs with gas burners are used. Exposure to cooking fumes has been recognised to cause adverse health effects. As an example, the World Health Organization (WHO) recommends that mean PM2.5 concentrations in ambient air (including indoor environment) are less than 10 μg/m$^3$ per year and 25 µg/m$^3$ per day. Minimising the presence of pollutants in kitchens is the fundamental reason to use cooking fume extractors.

A cooking fume extractor can be defined as an appliance hanging above the cooktop in the kitchen which uses a blower to collect steam, smoke, fumes and other airborne particles that may be generated while cooking. Its main purpose is therefore to control smoke and odours that are associated with cooking at the stove.

Using a cooking fume extractor is not the only strategy that can be used to remove pollutants from cooking. Natural ventilation –also known as infiltration– can help to reduce those pollutants in households. However, it has been estimated that 98% of houses (in England) are too airtight to provide sufficient infiltration to dilute PM2.5 emissions from cooking to be below the WHO guidelines. It is not desirable to increase infiltration because it is positively correlated with heating energy demand, and current policies seek to improve the energy performance of housing stocks. Therefore, controlled ventilation is required in kitchens to mitigate against negative impacts on occupant health from cooking (O'Leary et al., 2019).

The extraction system of a cooking fume extractor typically consists of a centrifugal blower composed of a conveyor, a fan and an electric motor, all housed inside a scroll (Figure 156). The energy is provided to the exhausts to expel the fumes.




Provided by APPLIA

**Figure 156. Illustration of a blower and its three components**

The system can work in multiple conditions of airflow rate, velocity and pressure (Bevilacqua, 2010). Generally, cooking fume extractors are manufactured with a combination of stainless steel, copper, bronze, nickel, zinc, tempered glass, aluminium, brass and heat-resistant plastics. The main functional components of a cooking fume extractor are:

- filters, which are the elements of the cooking fume extractor that capture the impurities when the cooking appliance is in operation;
- fans, which provide an active pressure gradient for ventilation;
- lighting, which provides illumination onto the cooking area.

Due to their predominantly visible location in kitchens, cooking fume extractors are increasingly seen not only as an appliance, but more as a piece of furniture. This is the main reason why a market for decorative hoods has been growing in recent years. Some hoods are also being offered with the ability to hold tools and objects, distributed on different levels. They may include hooks, shelves and even electrical outlets and USB ports capable of charging electronic devices (Di Meo, 2018).

### 4.3.2 Basic product types

Depending on the characteristics of the main components, domestic cooking fume extractors can be classified in different ways. Considering their ventilation system, cooking fume extractors can be either ducted or ductless. In ducted systems (also known as air-extraction cooking fume extractors), the output collar of the extractor hood's blower motor is attached to a ducting system which terminates outside the building. The cooking fumes are pushed through the ductwork to the exterior of the building and vented outside (Dooley, 2019). This is the most common configuration in European kitchens, as they tend to be more efficient in the removal of airborne contamination and they eliminate the need for regular replacement of filters. However, ducted systems require a more complex installation as they need more ducting and venting elements. This limits the areas where such a configuration can be installed, which could be impractical if lack of space in the kitchen is an issue (Gannaway, 2015).

On the other hand, ductless cooking fume extractors (also known as recirculating cooking fume extractors) make use of a strong air filtration system and then pump out the air back into the room. The fumes are therefore pushed through filters that remove odour and smoke particles from the air before venting it back into the kitchen. In this configuration, the use and periodical replacement of filters is essential and implies an additional ongoing material consumption. Recirculating heat and moisture into the kitchen might increase the levels of humidity in the kitchen fairly quickly. It is worth taking into account that filtering might not be 100% effective, so odours might not be completely removed in ductless hoods. Moreover, ductless hoods tend to be noisier, as they often require more fan power, due to the fact the air stream is reintroduced in the internal ambient air. However, ductless systems have the advantage of versatility and “design freedom”: since they need less ducting and venting elements, they require a simpler installation and can be placed in more locations within the kitchen.

As already mentioned in Task 1 of this report, “recirculating-only” cooking fume extractors are currently out of the scope of the Ecodesign and Energy Labelling Regulations, mostly due to their low market share and the lack of a standardised test method allowing comparison of their performance with that of air-extraction cooking fume extractors. However, some stakeholders disagree with this reasoning and support the inclusion of recirculating cooking fume extractors in the scope of new regulation. To overcome the lack of standard, they also recommend the development of a test that enables them to be rated and compared with models that operate in extraction mode, and even with models that are part of a central ventilation system. The comparison should include the evaluation of energy consumption for additional air tempering when cooking fume extractors operate in extraction mode (this topic will be developed further in Section 4.3.3.3).

In terms of installation method (**Figure 157**), cooking fume extractors can be defined as follows:

- Built-in: hoods are built into or concealed within a cupboard or fitted kitchen so they are less noticeable to the eye.
    - o Under cabinet, when it is mounted underneath the cabinets which are positioned above the stove. This is one of the most common and compact options: the design of

the venting system is simple; it is versatile enough for almost any kitchen style and tends to save some wall space.

- Built-in means an under cabinet hood fully integrated in the kitchen cabinet.

- Telescopic means an under cabinet hood fully integrated in the kitchen cabinet and one of the grease filters slides out of the cabinet.

- T-shape hood and chimney hood, when it is attached to the wall above the cooktop. In this case, the cooking fume extractor is installed instead of a cabinet in the space over the stove. They often come with a chimney that helps with ventilation, typically venting out through an exterior wall behind them. This configuration can serve as a design element in the kitchen.

- Vertical hood, when the hood is installed vertically almost in parallel to the wall.

- Island-mounted or suspended, for kitchens where the cooktop is located on an island or not against a wall. This is the configuration generally used for larger, professional style cooktops, in order to handle the extra output.

- Downdraft, when the cooking fume extractor is kept inside the cooking space, integrated into the worktop and hidden away until it is used. According to manufacturers, their main advantage is that they eliminate steam and odour right at the source. This is a less common configuration, a good solution for kitchens with limited space and when maintaining a clear sightline is a priority.

- Downdraft integrated, as already described in the previous section regarding air venting hobs. This is an appliance that combines a cooking fume extractor and hob – usually induction– in just one. The working principles are similar to a downdraft hood.

- Ceiling-mounted, when the hood is installed directly into the ceiling. The configuration is similar to that of an island-mounted hood, but in this case the result is a completely smooth surface rather than a hanging appliance in the centre of the kitchen.

**Under cabinet**

**Built-in**

**Telescopic**

**Chimney hood**

**Vertical hood**

**Ceiling hood**

**Suspended**

**Downdraft**

**Integrated venting**

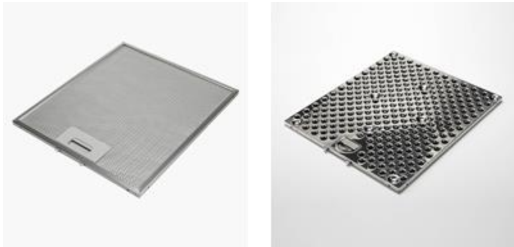
Provided by APPLIA

**Figure 157. Types of cooking fume extractors in terms of installation**

Cooking fume extractors are equipped with two types of filters, depending on the installation:

- The grease filter protects the hood by retaining grease particles. It is present in all cooking fume extractors regardless of their installation.
- The activated charcoal filter, which is needed only in recirculating hoods, captures and retains odorous particles.

There are different grease filters, such as aluminium filters (the most common ones), stainless steel filters, steel filters and paper filters. Paper filters need to be replaced once a month while metal filters must be cleaned once a month using mild detergents, either hand-washed or in the dishwasher at low temperatures and on a short cycle. This cleaning may fade the metal grease filter though the filtering performance is not affected.



Provided by APPLIA

**Figure 158. Grease filters**

Charcoal filters contain a fine powdered activated charcoal material, mounted in a honeycomb structure. Activated charcoal is a carbon-based compound that has been treated with oxygen to make it very porous. Impurities that are attracted to carbon become absorbed through the pores of the mineral and are kept trapped inside. These filters are needed/intended for use in ductless/recirculating configurations for filtration of odours before air is returned to the room. They cannot be cleaned, so need to be replaced approximately every 3 or 4 months. If the charcoal filter is not regularly changed, a significant decrease of indoor air quality can be expected.

Provided by APPLIA

**Figure 159. Charcoal filters**

According to stakeholders' feedback, the most common cooking fume extractors that could be considered base cases have the features shown in Table 32.

**Table 32. Typical features of the most common cooking fume extractors**

| | |
|---|---|
| **Ventilation**<br>(ducted/ductless) | ducted |
| **Airflow rate MAX**<br>($m^3$/min) | 700 - 800 |
| **Airflow rate MIN**<br>($m^3$/min) | 260 - 300 |
| **Noise at Airflow rate MAX**<br>(dB(A)) | 66 - 73 |
| **Noise at Airflow rate MIN**<br>(dB(A)) | 40 - 60 |
| **Installation**<br>(under cabinet/wall/island/downdraft/ceiling/integrated with hob) | cabinet / wall |
| **Type of filter**<br>(mesh/baffle/charcoal/none) | mesh |
| **Lighting**<br>(LED/other/none) | halogen / LED |
| **Lighting power**<br>(W) | 3 - 40 |
| **Grease Filtering Efficiency**<br>(%) | 70 - 90 |
| **Smart features**<br>(remote control & diagnosis/voice activation) | remote control and diagnosis |
| **Packaging materials**<br>(list of materials) | Cardboard, wood, EPS, foil |
| **Mass**<br>(kg) | 8.3 -21 |
| **Annual energy consumption**<br>(kWh/year) | 36 - 68 |

### 4.3.3 Energy efficiency in cooking fume extractors

#### 4.3.3.1 Current approach

The current approach for measuring the Energy Efficiency Index and Fluid Dynamic Efficiency of cooking fume extractors is based on the Best Efficiency Point (BEP) of the appliance. The BEP of cooking fume extractors is generally found at maximum operating speeds, therefore the standard requires testing at the highest speed available in the appliance.

The FDE curve is obtained by changing the pressure drop in the installation, providing different airflow (Q) and power (W) values (minimum 20 points to represent the curve). At each of those points, the FDE is calculated as:

$$FDE = \frac{Q \ x \ P}{3600 \ x \ W} x100 \ (\%)$$

Then, the maximum value (point G) is identified in the curve ($FDE_{BEP}$), and similarly the values for $Q_{BEP}$, $P_{BEP}$ and $W_{BEP}$ are obtained. With this method, $FDE_{BEP}$ is calculated with the same formula, at just one operating point of the appliance (point H).

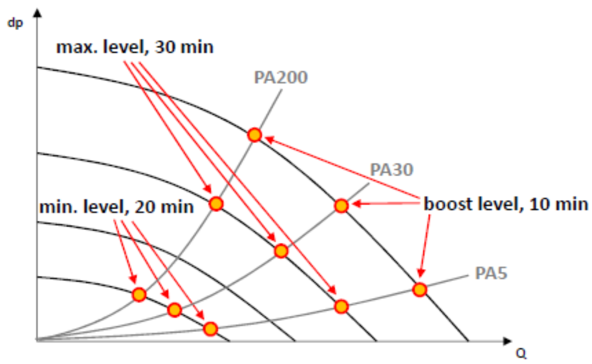
As already detailed in Task 1 of this report, there is a real-life representativeness issue with the current method of calculating the EEI and FDE. According to several stakeholders, current indexes do not reflect real-life usage, since they are based on measurements at the best efficiency point (BEP). The current method pushes manufacturers to increase the energy efficiency of products, focusing on the highest speeds of operation only. The result is that the energy efficiency of the lower speeds is relatively low and that cooking fume extractors with higher airflow rates tend to obtain better energy classes (also observed in Task 2 of this report).

Moreover, market analysis shows that cooking fume extractors are used at all available speeds and not only at maximum speeds. In fact, most common uses are intermediate and slow speeds. Therefore, with the current approach, cooking fume extractors are being awarded their energy class based on an airflow rate (or working speed) that does not correspond to their most common use. Stakeholders suggest reviewing the method for the calculation of the EEI to be more consistent with typical user behaviours and so taking into consideration all the speeds declared in the product fiche.

In response to this real-life representativeness issue, a new method to calculate the FDE is currently under development by CENELEC (commonly known as the 9-point method), described in more detail in the next section.

#### 4.3.3.2 The 9-point method

A new method to calculate the FDE has been proposed, based on an average of 9 points: 3 different pressures at 3 different settings, rather than using the best efficiency point (Figure 160). The test settings are identical, but in this case more measurements are taken into account.




Provided by APPLIA

**Figure 160. Graphic description of the 9-point method**

The main differences of the new method are that:

- instead of setting the cooking fume extractor only at its maximum speed, it is now set at 3 different speeds;
- instead of setting the cooking fume extractor only at 1 pressure value, it is now set at 3 different pressures;
- therefore, a total of 9 working points of the appliance are considered;
- instead of calculating only 1 value of the FDE ($FDE_{BEP}$), 3 different FDEs are calculated (one for each speed);
- the FDE of the appliance ($FDE_{cooking\ fume\ extractor}$) is calculated by weighting the 3 different speeds according to how often those speeds are used.

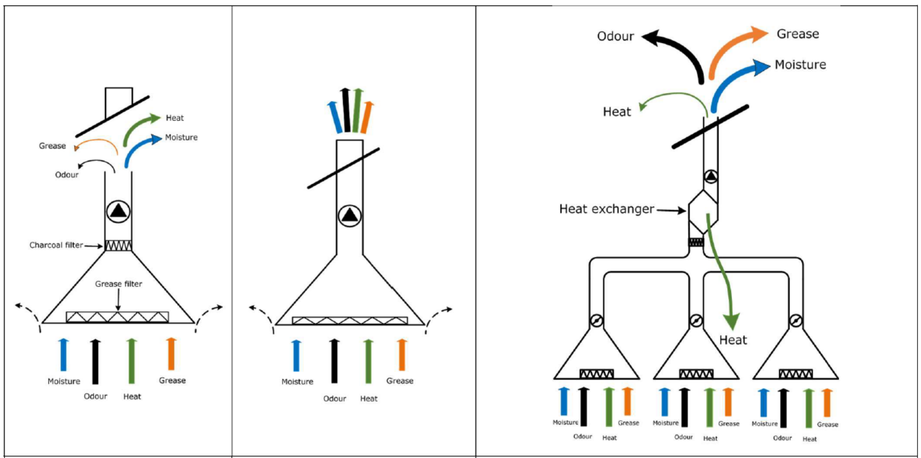
The main benefits of this method is that the FDE is calculated at different blower levels and at user-relevant operating points, therefore it prevents the optimisation at a non-relevant point. Moreover, the differences between the blower technologies (see Section 4.3.5.2) become more visible.

Based on feedback received from different stakeholders, there is a general consensus that moving from the current method to the 9-point method would be a positive development.

#### 4.3.3.3 Inclusion of energy consumption of heating/cooling replacement air

Another issue brought up by some stakeholders regarding current methods for measuring the EEI is the fact that it only takes the direct energy consumption of the cooking fume extractor into account. When a hood is operated, it removes air from the kitchen that needs to be replaced with air from the exterior (replacement air). This air will need to be either cooled or heated by the heating system of the household. The energy consumption of the heating system is a direct consequence of the cooking fume extractor usage, therefore some stakeholders consider it should be reflected on the energy label.

Their recommendation is that, beyond Annual Energy Consumption, the EEI should also take into consideration the indirect Annual Heating/Cooling Consumption. The weighting between those two elements should be determined carefully, as well as the way of taking into account the different climate zones. This proposal has been explained in detail in the document “Standards for testing cooking fume extractors based on odour reduction” (DTI, 2019). According to that document, the inclusion of energy required for tempering replacement air would make cooking fume extractors more comparable in terms of their installation characteristics: extraction, recirculating and connected to central ventilation systems (Figure 161).




| | | |
|---|---|---|
| *Recirculating range hood with integrated motor and charcoal filter* ***(1)*** | *Air-Extraction range hoods connected to outlet with integrated motor* ***(2)*** | *Air-Extraction range hoods connected to central ventilation systems* ***(3)*** |

*Source:* Blomqvist (2019)

**Figure 161. Types of cooking fume extractor installations**

Manufacturers generally disagree with this proposal, arguing that the energy efficiency of a product should not depend on external factors, such as heating/cooling systems or ventilation systems, since it would discourage any technological progress within the reach of manufacturers and product designers.

### 4.3.4 Capture efficiency in cooking fume extractors

Several stakeholders indicate that the current approach for measuring the energy efficiency of cooking fume extractors (based on annual energy consumption and fluid dynamic efficiency) is not sufficient and that the capture efficiency should be taken into account in some manner. Capture efficiency can be defined as the ability of a cooking fume extractor to collect contaminants produced during cooking activities (CEC, 2012). It quantifies the fraction of generated pollutants removed either directly or over the duration of exhaust fan operation. As a general rule, it can be calculated as:

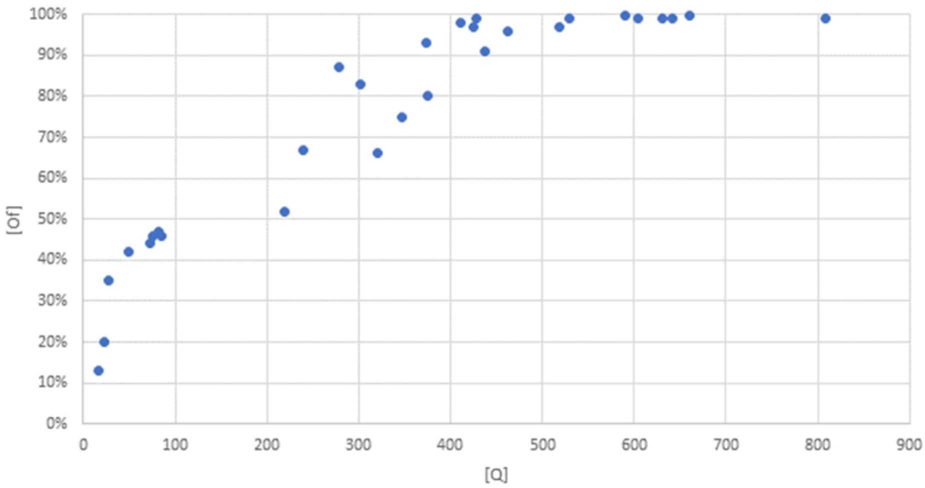
$$Capture\ efficiency = \frac{Contaminant\ produced\ at\ source - Contaminant\ escaping\ from\ hood}{Contaminant\ produced\ at\ source}$$

Capture efficiency is a function of different parameters such as airflow rate, installation height, hood capture volume and fraction of cooktop covered by the hood, among others (O'Leary et al., 2019). As it depends on a wide variety of factors and there is no harmonised standard to calculate it, the current capture efficiency of cooking fume extractors is unknown. According to Dobbin et al. (2018), it can vary between 12% and 98%.

There are different ways in which the capture efficiency could be evaluated for cooking fume extractors. One of the most commonly supported by different stakeholders is related to the capacity for removing odour.

#### 4.3.4.1 Odour reduction factor

The odour reduction factor is considered a first approximation of cooking fume extractor capture efficiency by some stakeholders. According to them, current regulation focuses exclusively on the hydraulic power of the hood but not on the primary function: the odour reduction. Therefore, the cooking fume extractor is only described as a fan and not as a tool for capturing cooking odour from the kitchen, as the requirements only focus on how much electrical energy is used to move the air. In data provided by the Danish Energy Agency (Figure 162) it can be seen that increases in airflow rates often lead to marginal increases in the function of the cooking fume extractor: odour reduction. As can be seen, odour reduction increases minimally for airflow rates above 500 $m^3/h$, which could present an issue of excessive energy consumption without improvement in functionality.




Provided by DEA

**Figure 162. Odour reduction factor versus airflow rate**

DTI (2019) has developed a proposal to incorporate the odour reduction factor (Of) into the Annual Energy Consumption formula, so that both energy consumption and odour removal are considered when measuring the EEI. EN-61591 indicates how the odour reduction factor of a cooking fume extractor can be measured. As already explained in Task 1 of this report, it is based on the usage of the substance MEK. In its study, DTI suggests a modification to the way it is calculated in the standard.

However, manufacturers highlight that the odour reduction factor is not suitable for the evaluation of the capture efficiency because the volume of the test room is too small, so it is not appropriate for a high-flow CFE. The volume of the test chamber at the EN 61591 is 21,875 $m^3$, so a CFE with an airflow of

500 m³/h would renew the air in the chamber 174 times in an hour. A specific test for ducted CFE should be developed.

#### 4.3.4.2 Particle removal

Related to capture efficiency, other stakeholders propose a different approach. EN-61591 defines an odour reduction efficiency, but since the test is performed at a short distance between the hob and the hood, the capture efficiency is almost 100%, and thus the capture efficiency effect is not taken into account. That is the reason why they are in favour of performing a real capture efficiency test and a separate odour filter test. In the capture efficiency test, the distance between the hob and the hood would be dependent on the type of hood and the air would be extracted to the outside of the test room, also for recirculation hoods.

### 4.3.5 Technology areas: cooking fume extractors

#### 4.3.5.1 Technology area 1: Fans

Blowers are typically equipped with one of these two types of fans (Figure 163), depending on the dimension and installation of the hood:

- Tangential fan with **two air inlets**. This type of fan can have different dimensions, and thus the hood can reach higher efficiencies, since the efficiency increases with its overall dimension.
- Radial fan with **one air inlet**. Due to space limitations, under cabinet cooking fume extractors or cooking fume extractors with small dimensions are usually equipped with this type of fan. For this reason, efficiencies are usually lower.

- Tangential fan
- Radial fan

Provided by APPLIA

**Figure 163. Illustration of types of fans**

#### 4.3.5.2 Technology area 2: Electric motors

The key component that influences the energy efficiency and the price of the hood is the electric motor. Cooking fume extractors are equipped with one of these three types of electric motors: brushless, asynchronous capacitors and asynchronous shaded poles. The main features of these motors are described below:

- **Brushless motors**: they are components of high-end models that can reach energy classes between A+ and A+++. They achieve high motor efficiencies, within the range of 70% to 85%. They are smaller and lighter than capacitor or shaded poles motors.

- **Asynchronous capacitor motors**: they are components of middle and high-end models that can reach energy classes between D and A+. They have lower motor efficiencies than brushless motors, within the range of 55% to 70%.
- **Asynchronous shaded poles motors:** they are components of low-end models whose energy classes are between D and C. They achieve the lowest efficiencies, within the range of 20% to 30%, and they are the most economical ones.

#### 4.3.5.3 Technology area 3: Filters

**Odour filters**

Charcoal filters are usually disposable devices; however, there are long-life filters with a duration of 3 years. The charcoal filter is able to be regenerated by a cleaning and drying cycle every 2 or 3 months. The cleaning is done in the dishwasher at 65 °C or by hand with hot water and a neutral detergent. Then it is dried in the oven at 100 °C for 10 minutes.

A specific type of long-life filter is the ceramic filter. In this case, the charcoal filter is mounted in a ceramic frame and can be thermally regenerated every 2 or 3 months in the oven at 200 °C for 45 minutes, reaching a maximum lifetime of 5 years.

Plasma filters are an alternative to charcoal filters in recirculating cooking fume extractors. As explained earlier, active carbon filters retain cooking fume particles and need to be replaced when they become saturated. According to manufacturers, plasma filters aim to remove all foreign particles from air by eliminating and not storing them in a filter (which would eventually need to be replaced). This technology, also known as non-thermal plasma (NTP), is a flexible electrical technique for exhaust air treatment. Typical features of an NTP are the acceleration of free electrons in an external electrical field, the formation of activated chemical species by collisions between electrons and gas molecules and chemical reactions of these species with other gas constituents, such as the cooking pollutants.

In a laboratory study, Holzer et al. (2018) showed that the model substances as representatives for odorous organic compounds being produced in cooking processes like roasting, baking and cooking can be completely eliminated by a homogeneous gas phase plasma. However, the relatively large contents of CO and $O_3$ are not acceptable and require further treatment steps. Also, the energy efficiency in the laboratory experiments is still too low for practical use, especially when running the system in a continuous mode. These limitations require further investigations.

According to some stakeholders, plasma filters might be at a disadvantage when compared to other filtering technologies if the standard odour removal test EN 61591 is followed. As indicated in Task 1 of this report, this test is to determine how efficiently the carbon filter stores MEK molecules. This test is not intended for recirculation filters based on plasma and ionisation. Also according to stakeholders, plasma filters have been used in certain applications of commercial products, where the extraction is always towards the exterior of the building. These filters are not appropriate for a domestic environment as issues with ozone generation may arise.

**Grease filters**

The basic principle of **centrifugal filters** is the use of centrifugal force for air cleaning. In these cooking fume extractors, cooking vapours are sucked through a narrow gap into the extractor hood. Once inside, the vapour flow rate is accelerated and the flow is diverted in two bends which create centrifugal force. This force hurls fats and oils out of the air. A subsequent integrated residue separator removes the finest particles of fat and traps them, allowing the air to escape clean at the end. Some of these filters can be cleaned in the dishwasher and can have long lifetimes. According to stakeholder feedback, this technology is not common in Europe and is mostly used in markets with significantly different cooking styles.

#### 4.3.5.4 Technology area 4: Downdraft cooking fume extractors

A downdraft cooking fume extractor is a ceramic or induction hob with an integrated extractor fan in the centre of the hob. They are designed to remove cooking vapours and lingering odours as soon as they appear, by drawing the air directly from the cooking vessel. Instead of sucking air up, downdraft cooking fume extractors have a cross flow which is greater than the rising speed of the cooking vapour, therefore they capture them before they escape around the kitchen area, creating a transversal flow (Corti, 2019). Downdraft cooking fume extractors are relatively new in the cooking appliances market, offering an alternative option to the traditional extraction methods. They are generally commercialised with high-end products such as induction cooktops.

There are downdraft cooking fume extractors with manual settings and others that tend to correct fan settings automatically without user input, regulating it continuously during the cooking process. There are models with the aspirator positioned in the centre of the cooktop (with a circular or rectangular grid) or versions in which the extraction takes place through lateral slits.

Downdraft cooking fume extractors are complex appliances as they combine cooktops and extraction systems in one. This generally has an impact on price. Also, having the extraction system in the centre of the cooktop reduces the surface available for cooking.

The most direct advantage of a downdraft cooking fume extractor is that it combines two appliances in one: cooktop and cooking fume extractor. It makes good use of space in the kitchen and has aesthetical benefits, particularly when the cooktop is placed on an 'island' in the middle of the kitchen, where placing a traditional cooking fume extractor would be difficult. However, this type of cooking fume extractor needs more suction power for the same ventilation results, as the fumes naturally tend to go up, and this could require more energy for the same results. They could be also noisier than typical hoods due to this increase in power demand.

#### 4.3.5.5 Technology area 5: Smart and connected cooking fume extractors

A smart cooking fume extractor is broadly understood as a hood with a built-in Wi-Fi module that can be synchronised with an application managed from a portable device such as a smartphone or tablet. The benefits of a smart cooking fume extractor are similar to those of a smart oven or hob, and can be summarised as follows:

- A connected cooking fume extractor may be connected to other cooking appliances such as the hob. When the system detects that food is being cooked, it automatically connects at the required airflow, depending on temperature and other factors. When the cooking activity ends, the cooking fume extractor automatically switches off or remains in an idle state.
- A connected cooking fume extractor can be manipulated from an application on a smartphone or tablet, making it easier for the user to access the functions and basic settings.
- A connected cooking fume extractor may let the user know when the grease or activated charcoal filter needs cleaning, changing or regenerating, providing tips and instructions on how to change it.
- A connected cooking fume extractor may send a notification to the user when it detects something is not working properly, and it can also diagnose the problem remotely.

### 4.3.6 Best Available Technologies (BAT) in cooking fume extractors

In this section, the Best Available Technologies (BAT) in terms of energy efficiency for domestic cooking fume extractors are investigated. Data for this investigation will be taken from the TopTen database. Topten shows the availability of efficient cooking fume extractors, according to a criteria set that is regularly updated.

In terms of the different parameters shown in the energy label for cooking fume extractors, the appliances currently listed in the database are as follows:

- Energy Efficiency: A, A+ and A++;
- Fluid Dynamic Efficiency: A;
- Lighting Efficiency: A;
- Grease Filtering Efficiency: A, B and C.

The energy efficiency classes (coloured dots, left axis) and grease filtering efficiency classes (grey bars, right axis) of the 137 models listed in TopTen are shown in Figure 164.

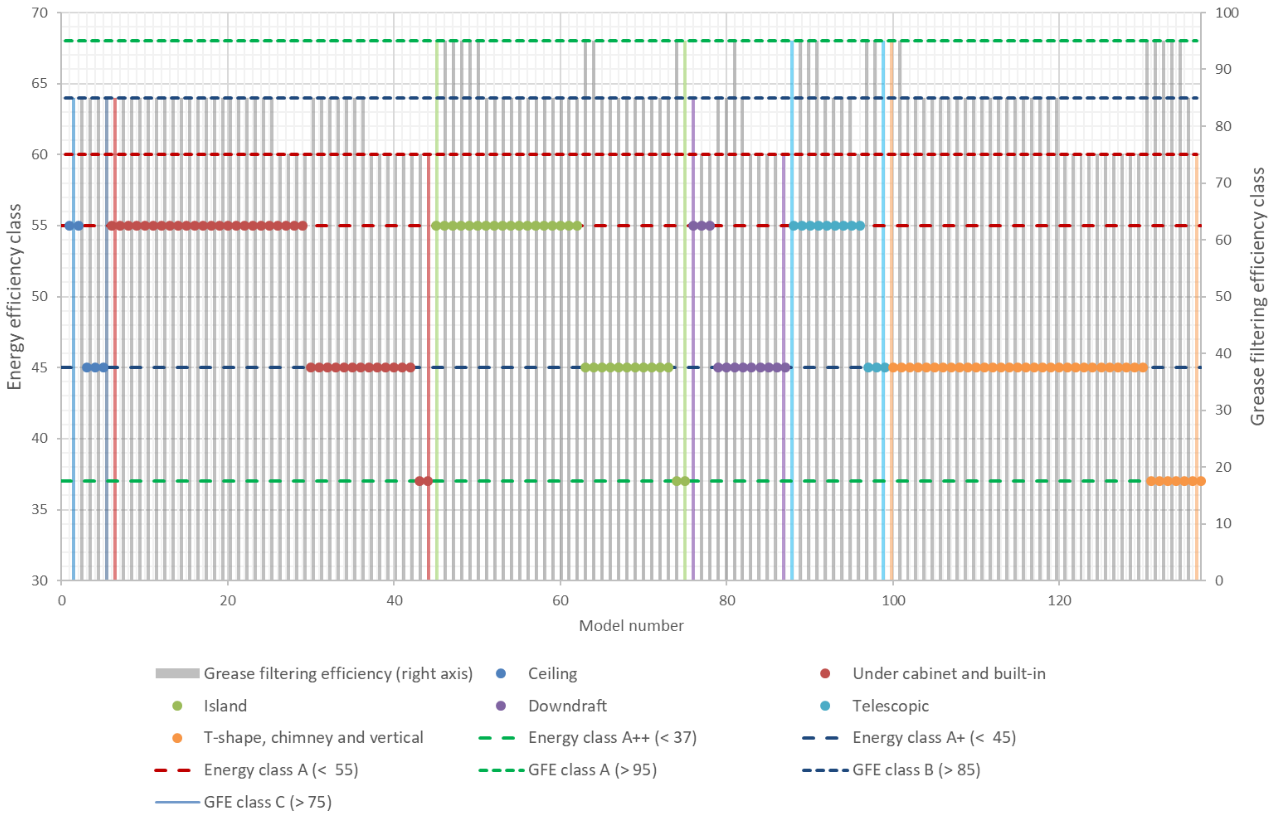



**Figure 164. EEI and GFE of cooking fume extractors in Topten**

The main findings from this analysis are as follows:

- 11 models reach the Energy Efficiency Class A++:
  - 2 are under cabinet;
  - 2 are island-mounted;
  - 7 are chimney (wall-mounted);
  - 0 are downdraft*.

  *This contradicts the findings from Task 2, where the best-performing hoods were worktop vent (downdraft), while under cabinet ones did not reach good energy classes.

- From the 7 chimney A++ models:
  - 5 reach Grease Filtering Efficiency Class A.

- From the 2 island-mounted A++ models:
  - Both of them reach Grease Filtering Efficiency Class A.

- From the 2 under cabinet A++ models:
  - Both of them reach Grease Filtering Efficiency Class C.

In terms of mounting and energy efficiency, it could be concluded that it is easier for wall-mounted hoods to reach the top energy classes. This could be related to the typically bigger size of wall-mounted hoods compared to the other ones. A bigger cooking fume extractor can have a bigger and therefore more powerful electric motor, capable of reaching higher airflow rates, which is the significant factor to achieve higher energy classes.

As already explained in Section 4.3.5.2 of this report, the key component that influences energy efficiency and the price of a cooking fume extractor is the electric motor:

- brushless motors: able to reach Energy Efficiency classes between A+ and A+++;
- asynchronous capacitor motors: able to reach Energy Efficiency classes between D and A+;
- asynchronous shaded poles motors: able to reach Energy Efficiency classes between D and C.

From the analysis conducted in this section, it could be concluded that the Best Available Technology in terms of energy efficiency is a wall-mounted cooking fume extractor equipped with a brushless motor.

## 4.4 Production, distribution and end of life of domestic appliances

Domestic cooking appliances under the scope of this study are relatively long-lived products with high energy consumption in comparison to many other home appliances. For that reason, from a life cycle assessment perspective, in the previous sections more focus has been put on the analysis of the use stage, which is where energy consumption contributes the most. The significant contribution of the use stage in the life cycle impact is confirmed in scientific literature in the case of ovens (Landi et al., 2018), gas hobs (Favi et al., 2018), induction hobs (Elduque et al., 2014) and cooking fume extractors (Bevilacqua et al., 2010).

Despite this preponderance of the use stage, other life cycle stages such as production, distribution and end of life also have their relevance, such as metal depletion potential or marine eutrophication potential (Landi et al., 2018). The relevance of the end–of-life stage is even higher if Circular Economy principles are to be incorporated into future product design.

In this section, aspects affecting production, distribution and end of life are presented. Some of these aspects are product weight and materials, primary scrap production, packaging materials and volumes, means of transport and shipment, product lifetimes and waste material flows.

### 4.4.1 Aspects affecting production of domestic cooking appliances

#### 4.4.1.1 Product weight and materials

When considering the impact of production and manufacturing, a product Bill of Materials (BoM) is a key piece of information required to conduct a robust environmental and economic assessment. However, without access to data from manufacturers, it is usually difficult to find data available regarding the mass and material breakdown of specific products. Even in LCA or LCC scientific literature, BoMs are usually published partially, providing only a breakdown of materials in percentage, number of components, etc. For instance, in Magalini et al. (2017), an average material composition of kitchen appliances is published, but it is not clearly specified whether it refers to a cooktop, an oven or an average of those and more kitchen appliances.

A detailed BoM for domestic gas and electric ovens is published in Landi et al. (2019). In Favi et al. (2018), a BoM is provided for gas and induction hobs. A list of assemblies, components, quantities and materials is provided for both types of hobs. No mass data is presented. In Elduque et al. (2014), a detailed BoM of the electronic components of an induction hob is provided.

To date, no Bill of Materials has been found in scientific literature regarding cooking fume extractors. The closest data to a BoM is published in Bevilacqua et al. (2010), where a list of materials present in a domestic cooking fume extractor is shown. No mass data is provided.

### 4.4.2 Aspects affecting transport of domestic cooking appliances

As already seen in previous sections, the main environmental impact of cooking products is during the use phase. By comparison, transport and packaging tend to have a low environmental impact in these products. For information on transport activities, manufacturers tend to provide information in their annual sustainability reports.

#### 4.4.2.1 Packaging materials

Typical packaging materials in the domestic cooking appliances industry are cardboard, wood, expanded polystyrene EPS, foil and paper. According to a stakeholder, for three different ovens, the volumes of packaged products are as in Table 33.

**Table 33. Volume of packaged oven**

| | **Oven 1** | **Oven 2** | **Oven 3** |
|---|---|---|---|
| Capacity of oven (litres) | 70 | 50 | 70 |
| Volume of oven ($m^3$) | 0.22 | 0.16 | 0.31 |
| Volume of oven with packaging ($m^3$) | 0.34 | 0.27 | 0.47 |

In terms of built-in hobs, the volumes of packaged products are as in Table 34.

**Table 34. Volume of packaged built-in hob**

| | **Hob 1** |
|---|---|
| Number of cooking areas | 4 |
| Volume of hob ($m^3$) | 0.02 |
| Volume of hob with packaging ($m^3$) | 0.05 |

In terms of wall cooking fume extractors, the volumes of packaged products are as in Table 35.

**Table 35. Volume of packaged cooking fume extractor**

| | **Cooking fume extractor 1** | **Cooking fume extractor 2** |
|---|---|---|
| Volume of cooking fume extractor ($m^3$) | 0.21 | 0.31 |
| Volume of cooking fume extractor with packaging ($m^3$) | 0.32 | 0.49 |

### 4.4.3 Aspects affecting end of life of domestic cooking appliances

#### 4.4.3.1 Critical parts and failures in domestic cooking appliances

The study conducted by Evans et al. (2015) for the European Commission was intended to identify priority products and develop a method to measure their durability; and to estimate the benefits and costs of more durable products. A detailed list of definitions related to the concept of durability is provided in this study.

In European product policy, durability is usually addressed by the provision of spare parts for around 10 years after the end of production of an appliance to enable appropriate repair. When addressing the durability –or lifetime- of products in product policy, it is essential to have data on which are the key critical components in terms of failures.

Domestic ovens are appliances which make use of critical components to deliver their main function, which will be subject to abrupt temperature variations. It has proven difficult to find reliable figures regarding the reasons for domestic ovens failing or needing repair. In Evans et al. (2015), an analysis of the critical components failing in an oven is conducted for domestic ovens. Data provided by Which and UK Whitegoods -consumer organisations in the United Kingdom- and UK retailer repair records, there is little difference between built-in and free-standing cookers/ovens. These appliances are generally reliable and not prone to breaking down or developing faults. The most common problems in domestic ovens are as follows:

- Failure of fan. These components are prone to failure since they are subject to the stress of quick heating and cooling.
- Failure of thermostat, the most probable cause being oven overheating.
- Light not working.
- Dials or controls not working, potentially due to faulty thermostat or thermal fuse.
- Door not closing properly, potentially due to failure in sealing, rollers or hinge runners. This may cause uneven cooking, higher energy use and damage to adjacent units.
- Oven cutting out after being on for a while
- Noise, potentially due to moving parts being misaligned or due to bearing failures.
- Glass door breaking, potentially due to overheating or the presence of temperature differentials.
- Handles breaking.

In the report mentioned, some data is provided regarding the frequency of failure and main components requiring attention. However, this data needs to be taken with caution as the figures do not seem consistent.

**Table 36. Percentage of appliances recorded with each type of fault**

| Fault | Built-in oven | Free-standing oven |
|---|---|---|
| Light not working | 32% | 9% |
| Door not closing properly | 8% | 9% |
| Dials/controls broken | 7% | 12% |

(Which, published in Evans et al (2015)

**Table 37. Percentage of appliances recorded with each type of fault**

| Component | Percentage of appliances with fault in component |
|---|---|
| Thermocouples | 8% |
| Knobs and controls | 6% |
| Thermostats | 3% |
| Door gaskets or seals | 4% |
| Hotplates | 4% |
| Heating elements | 2-3% |
| Selection switches | 2-3% |

| | |
|---|---|
| Glass lid assembly | 2-3% |
| Hinges | 2-3% |

(UK Whitegoods, published in Evans et al (2015)

According to a manufacturer, they have no reliable data available about the most frequently occurring failures and defects, as they do not receive repair information over the entire usage lifetime of the appliances. Repair of appliances is performed by the manufacturer within the legal guarantee period. After that, repairs are mostly conducted by independent professional repairers. The same manufacturer highlights that it is part of their core business to extend the lifetime of a product as much as possible, also through repair. They develop appliances with the aim of longevity and durability. Cooking appliances are appliances which are typically used for a long time. These appliances are not fashion- or trend-related. In principle, every failure/defect can be repaired. The decision for repair lies with the end user. In terms of the most common failures in components for ovens, hobs and cooking fume extractors, their feedback is as follows:

- Ovens: a very wide variety of technologies is used. From very basic models up to highly complex appliances with an integrated microwave and/or steam function with TFT displays and Wi-Fi connection for example. Therefore, any general recommendation about the most frequently failing components cannot be made.
- Hobs: as there are many hob technologies available (radiant, gas, induction) and different solutions are offered within one technology, a general response to occurring failures/defects cannot be given.
- Cooking fume extractors: the main recurrent complaints are “the appliance is too loud” and “does not evacuate well”. In most cases this is due to incorrect installation.

Related to hobs, the main usual failures are:

- switch may not work;
- leaking gas or erratic flame coming through the burners;
- ceramic hobtop gets scratched quickly;
- ignition not working;
- cooking plate not heating up;
- inability to adjust heat.

So, analysing the different parts of the hobs, we can state that the most commonly needed spare parts would be those shown below, while indicating that among them only the switches could be repaired by a consumer:

- grill pans;
- pan support;
- burner caps;
- burners;
- hotplates;
- ignitors;
- knobs;
- lamps;
- PCB;
- switches;
- thermocouples;
- hob top;
- valves.

#### 4.4.3.2 Product lifetime of domestic cooking appliances

The lifetime of a product ends when it is replaced by another product that takes over the original application. A concept directly related to this is durability, understood as the ability of a product to endure for its full lifetime. Regarding the lifetime of domestic cooking appliances, there is a significant lack of data available in the form of scientific research or national/regional statistics. There is consensus on the fact that the life expectancy of a typical appliance depends to a great extent on the use that is made of it. There is also consensus on the fact that nowadays appliances are often replaced long before they are worn out, since changes in styling, features (including in relation to safety and convenience), technology and consumer preferences make newer products more desirable. According to a study conducted by Bank of America (2007), the average life expectancy for cooking appliances is:

- electric oven with hob: 13 years;
- gas oven with hob: 15 years;
- cooking fume extractor: 14 years.

More recent research conducted for the development of the previous Ecodesign Regulation on cooking appliances (Mudgal et al., 2011) provides data on the expected lifespan of domestic cooking appliances as well (Table 38).

**Table 38. Product lifetime for cooking appliances**

| Appliance | Average lifetime (years) |
|---|---|
| Domestic electric hobs – solid plates | 19 |
| Domestic electric hobs – radiant | 19 |
| Domestic electric hobs – induction | 15 |
| Domestic gas hobs | 19 |
| Electric ovens | 19 |
| Gas ovens | 19 |

*Source:* Mugdal et al. (2011)

In its Annual Energy Outlook, the EIA (2019) provides slightly different lifetime ranges (minimum and maximum) for different household appliances, including domestic ones (Table 39).

**Table 39. Product lifetime for cooking appliances**

| Appliance | Lifetime range (years) |
|---|---|
| Natural gas and propane cooking ranges, cooktops and ovens | 9 - 15 |
| Electric cooking ranges, cooktops and ovens | 10 - 20 |

*Source:* EIA (2019)

According to a manufacturer, there is no reliable data available on the product lifetime of domestic cooking appliances. Their internal testing shall ensure a minimum lifetime of 10 years, but there are appliances in households which are much older. The lifetime depends on the usage and maintenance of the appliances. It is their experience that maintenance is a bigger concern for cooking appliances than for dishwashers, for instance. Maintenance is a bigger concern for cooking fume extractors, especially related to filter cleaning and changing. A commonly accepted average lifetime they highlight is 19 years for ovens and hobs.

#### 4.4.3.3 Trade-off between durability and efficiency in the use phase

There is a clear relationship between the durability of a product, the resources consumed and the emissions generated during its lifetime. In the specific case of electrical and electronic appliances, extending product life is considered an effective means to contribute to resource conservation: fundamentally materials and energy. In principle, with extended lifetimes of products, fewer appliances will have to be produced to cover consumer demand. However, there is a trade-off that needs to be taken into account, which is the potential savings achieved in the production/manufacturing stage versus energy consumed during the use phase (Truttman et al., 2006). According to several authors, extending the lifetime, also referred to as 'reuse' end-of-life strategy in literature review, should not be an a priori goal-oriented strategy, but analysed case by case. In this line, there are certain factors related to the practical limits on lifetimes that need to be taken into account:

- A very durable product may have cost implications in terms of changes to materials, components and manufacturing processes.
- Innovation rates in certain markets may cause extended lifetime products to quickly become obsolete.
- Consumer buying habits and expectations may divert them from very durable products.
- Durable products may have a negative effect on the product's potential second life.

The environmental performance of end-of-life strategies which consider the extended lifetime of products has not been widely covered in scientific research. Studies addressing the potential benefits of reuse and remanufacturing of products has been limited to a small number of papers published over the past three decades, according to Zanghelini et al. (2014). Some of this research is summarised in this section.

In Truttman et al. (2006), the authors investigated the potential benefits of reusing –extending the lifetime- of several home appliances (refrigerator, washing machine, dishwasher, microwave, PC, video, monitor and TV), taking into account use of materials and energy consumption. In terms of materials, it was observed that increasing the product lifetime by a factor of 1.5 decreased all material flows in the system by the same factor. However, these factors were based on assumptions, and different values should be considered for different types of products and substances. Also regarding materials, the authors analysed the potential benefits of extending the lifetime versus the benefits of improving the recycling efficiency. They observed that material use is more sensitive due to changes in recycling efficiency. Even doubling product lifetimes could be offset by comparably small losses of 10% in the recycling efficiency. In terms of energy consumption, the authors observed that around 10% less energy is consumed in extended-life scenarios. However, the benefits in energy use were very different between appliances: greater benefits were obtained in PCs and washing machines and lower ones in videos and monitors.

Along similar lines, in Tasaki et al. (2013) the authors refer to parameters which may have an influence on the potential benefit of extending the lifetime of a product or replacing it with a more efficient one, such as the size of the two products (the old one and the new one), their function, the patterns of use and the time of replacement. According to their findings, whether product replacement is preferable from the viewpoint of reducing energy consumption depends substantially on how often a consumer uses the product and the characteristics of the particular replacement product. As specific examples, they indicate that replacement of refrigerators after 8-10 years of use is preferable, even if the replacement product is larger. In contrast, the replacement of TVs tends not to be preferable if it is not used often or if the consumer replaces it with a larger one (which tends to be the case).

Specifically on cooking appliances, in Iraldo et al. (2017) an analysis was carried out to understand the potential benefits of durable ovens. Two scenarios were defined for that purpose: a scenario where a Product A was substituted by a more energy-efficient Product B after a certain period of time; and a scenario where Product A was not substituted and was being used for an extended period of time. Results from this study –using data from available scientific literature– showed that the durable option had a lower environmental impact in four impact categories. In the rest of the impact categories analysed, if a certain energy efficiency improvement (energy efficiency threshold) is achieved in Product B, replacing Product A with Product B is preferable to maintaining Product A for a longer period of time. Essentially, for the impact categories whose significant contribution comes from production and end of life, the durable option is always preferred, even with improvements in energy efficiency. However, for most of the impact categories, a small improvement in the energy efficiency of the replacement product is sufficient to deliver environmental benefits by substituting the product. For instance, in the case of climate change, if the new oven (Product B) is 20% more energy-efficient than Product A, it is preferable to substitute it than to extend its lifetime.

#### 4.4.3.4 Material efficiency aspects

In recent years, material efficiency aspects have been addressed by several authors from different perspectives. The most relevant studies on this matter are summarised in this section.

**Ecodesign Directive version 2.0 – from energy efficiency to resource efficiency by Bundgaard et al.**

Bundgaard et al. (2015) in their study "Ecodesign Directive version 2.0 – from energy efficiency to resource efficiency" reviewed a total of 23 currently adopted implementing measures and voluntary agreements under the Ecodesign Directive, criteria for resource efficiency in voluntary instruments such as ecolabels and Green Public Procurement as well as recent Commission projects with regard to implementation of resource efficiency aspects in the Ecodesign Directive.

In the study, Bundgaard et al. generally subsume the following measures under "resource efficiency":

- Reducing materials and energy use in the entire life cycle of products (mining of materials, production / use / final disposal of the product).
- Improving possibilities for maintenance and repair (e.g. guidelines).
- Ensuring reuse or redistribution, i.e. multiple use cycles.
- Increasing the potential for remanufacturing or refurbishment of the product, i.e. multiple use cycles (e.g. improving reparability, access to spare parts)Improving recyclability of materials used in the product

The review of existing instruments revealed that resource efficiency is already widely applied in voluntary instruments covering energy-related products. The instruments include the following criteria which were also assessed by the study team with regard to their transferability to the Ecodesign Directive (Bundgaard et al., 2015):

*Declaration and threshold of RRR (reusability, recyclability and recoverability) ratio*

According to Bundgaard et al. (2015), transferring declaration and threshold requirements with regard to the RRR ratio to the implementing measures and voluntary agreements of the Ecodesign Directive first needs a common methodology to be developed on how to calculate the RRR ratio for products and materials to verify the requirements based on technical information provided by the producers.

However, setting requirements for the RRR ratio of the material or the product only reflects the theoretical potential and will not ensure that the materials or products are in fact reused, recycled or recovered, which depends on the infrastructure for collection and treatment and the technologies available.

In the event of future requirements regarding the RRR ratio, it is recommended to align them according to the waste hierarchy, by prioritising reuse before recycling, and recycling before recovery.

*Declaration and/or threshold of recycled content*

According to Bundgaard et al. (2015), setting criteria for the threshold of recycled materials can help create a market for these materials. The environmental benefits of using recycled materials would depend on the type of material. However, before transferring these requirements to the Ecodesign Directive, it is important to assess if the manufacturers of recycled materials can handle the increase in demand that a requirement would create. A possibility could be to begin by setting declaration requirements and then tightening them continuously by setting threshold requirements.

Setting criteria for recycled materials, however, first needs reliable technologies for an analytical assessment of the recycled content in the products, to enable verification and market surveillance.

*Bill of materials (BOM)*

BOMs are an important source of information to conduct LCAs, assess the product's recyclability, recoverability and recycled content and identify priority resources in the product to ensure their reuse and recycling; all of these activities are the basis for other requirements to improve resource efficiency.

However, Bundgaard et al. (2015) conclude that, due to the complexity of the supply chain of electronic and electrical equipment, a mandatory requirement on providing BOMs would be especially challenging to comply with for small producers, as they might not have the ability to pass these requirements on to their larger suppliers. Furthermore, the implementation of such a requirement might first need the setup of a system that can ensure the companies' property rights, e.g. with regard to the use of rare metals.

*Identification of plastic components*

Marking of plastic components according to ISO 11469 shall help recyclers identifying different plastic types and parts to ensure correct handling during waste recovery or disposal, when the plastic parts are manually sorted. Also, the visual marking of plastic parts according to certain ISO standards might be easy to verify visually by market surveillance authorities when dismantling the product.

On the other hand, there are certain drawbacks shown by the literature research of Bundgaard et al. (2015): A certain percentage of the labels were found to be incorrect and, mainly, for automatic sorting (currently the large majority of treatment) systems the ISO labels had no effect as these systems sort according to the plastic's mechanical, optical and electrostatic properties.

Thus, Bundgaard et al. (2015) recommend that, before setting criteria for visual marking of plastics in the Ecodesign Directive, the extent to which the waste is manually sorted for the product group in question should be further examined, and what the future waste treatment of the product might look like should be considered. Furthermore, alternative marking methods should be examined (e.g. Radio Frequency ID), which could be applied for example in automatic sorting systems.

*Contamination of materials/plastics*

Requirements regarding contamination of materials are relevant for the recyclability, as the potential for recycling is reduced if incompatible materials are combined, e.g. painting, coating or metallising large plastic parts making them incompatible with recycling. Depending on the specific requirement, it could be verified visually.

*Mono-materials*

Using compatible or a reduced number of plastics can improve the recyclability of, for example, thermoplastics, as a mixture of different polymers or a contamination of the plastic fractions can significantly decrease the plastics' properties and thereby the use of the recycled materials.

Bundgaard et al. (2015) recommend that setting these types of requirements should be supplemented with a dialogue with the stakeholders from the recycling industry to ensure the effectiveness of these types of requirements which depends on the recycling system that the products enter.

*Durability requirements (including extended warranty, upgradability and repair, spare parts, modularity)*

All criteria strive to extend the lifetime of the product, thereby preventing electronic waste. Durability is also related to the previous category, disassembly, where criteria targeting easy disassembly for repair and upgradability are included.

The length of the warranty should be product-specific and it is also strongly related to the availability of spare parts, which is also an issue for reparability. When determining how long spare parts should be available taking into account both economic and resource efficiency aspects, on one hand components should be available to enable repair, but on the other hand the risk is that too large an inventory of components will become outdated and never utilised. Modular design and easy disassembly enable upgrading and repair and are thus prerequisites for lifetime extension. Upgradability can potentially reduce the frequency of replacement against the background of rapid technological product developments.

Bundgaard et al. (2015) conclude that durability should be included as possible resource efficiency requirements in the Ecodesign Directive, also due to the requirements being possibly verifiable by market surveillance authorities. However, it is important to ensure that prolonging the lifetime of the product is the environmentally best solution in a life cycle perspective, e.g. that possible environmental benefits are not evened out by increased the energy consumption of the older product compared to a new more energy-efficient product.

*Easy disassembly*

Easy or manual disassembly can help improve the reparability and upgradability of the product, improving the durability of the product. Criteria might be detailed with regard to the components to be separated, the type of connections or the tools to be used.

Regarding end-of-life treatment, Bundgaard et al. (2015) conclude that it is not possible based on the findings of their study to assess whether or not requirements for manual disassembly will improve the recyclability and recoverability of electrical and electronic equipment in the future. This is because manual disassembly in the waste treatment process of electrical and electronic equipment (EEE) is increasingly being replaced by automatic or destructive disassembly in many developed countries, which raises the question of whether requirements for easy or manual disassembly will improve the recyclability and recoverability of EEE if they are fed into an automatic or destructive disassembly system. However, manual disassembly is still performed when economically feasible, e.g. components or materials containing valuable resources, or when regulations such as the WEEE Directive require it, e.g. by removal for separate treatment of components containing hazardous substances. Bundgaard et al. (2015) propose requirements in addition to manual disassembly which might target automatic or destructive disassembly, although without further specifying details of this proposal.

*Waste from manufacturing*

By including requirements regarding the manufacturing, the scope would be expanded from a product focus towards a production focus which is applicable to the Ecodesign Directive, which mainly sets requirements for the design of the product, while still targeting the environmental performance of the entire product life cycle. Therefore, design requirements for the product that might improve the manufacturing process would be highly relevant. However, as many electronic products are produced outside Europe, it might be difficult to enforce these criteria (Bundgaard et al., 2015).

*Further requirements*

Further requirements on hazardous substances, take-back schemes and packaging identified in voluntary instruments such as ecolabels are not recommended to be transferred to the Ecodesign Directive as there are large overlaps with existing legislation such as the REACH, RoHS and WEEE Directives and the European Directive on packaging and packaging waste.

*Information requirements related to resource efficiency*

With regard to information and specific requirements targeting resource efficiency in Ecodesign, Bundgaard et al. (2015) recommend the following in their study:

- Information and specific requirements on durability (e.g. on the lifetime of the product, such as for lamps, or for components, such as minimum loading cycles for batteries in computers):
  - Relevant for consumers to enable them to select the most durable product.
- Information requirements with regard to resource consumption in the use phase:
  - Relevant for consumers: e.g. to encourage consumers to choose the most efficient programmes in terms of energy and water consumption and the best suitable detergents.
- Information requirements on hazardous substances, precious metals or rare earths:
  - Relevant for recyclers to a) avoid contamination of the materials when they are recycled or b) ensure a more optimal recovery of precious materials.
- Information relevant for disassembly, recycling or disposal at end of life:
  - Relevant for end users to know how to correctly dispose of the product at its end of life.
  - Relevant for recyclers to know how to disassemble and recycle the products in the best possible way, for example to ensure that hazardous substances are removed and treated correctly. As in the case of the information on hazardous substances, precious metals and rare earths, it is suggested that such information could be made more easily available, by embedding it in the product, e.g. in a Radio Frequency Identification (RFID). This would result in a greater benefit for the recyclers compared to information provided on webpages or in user instructions. Furthermore, it could be specified in the Directive which type of information the recyclers may need. This could be done in close collaboration with the recyclers to ensure that the information is indeed relevant for their processes.
- Information and specific requirements on easy disassembly:
  - Relevant for consumers / repair facilities to help improve maintenance and repairs. Generic information requirements for non-destructive disassembly for maintenance could be supplemented by requirements for the producers to make repair and service manuals public. It may also be relevant to set specific requirements for easy disassembly of the product for maintenance purposes.
  - Relevant for recyclers to help improve end-of-life treatment, for example the removal of certain components which have to be treated separately in accordance with the WEEE Directive (batteries, heat pumps, etc.)

**Material Efficiency Ecodesign Report and Module to the Methodology for the Ecodesign of Energy-related Products (MEErP)**

BIO Intelligence Service (2013) conducted a study to clarify the implications of material efficiency from the pragmatic perspective of its practical application for Ecodesign purposes, and for the elaboration of recommendations for the MEErP methodology (Part 1). It also undertook an update of the MEErP methodology and its component EcoReport tool, to include the necessary means for better analysing material efficiency in MEErP (Part 2). Part 2 also contains a guidance document for analysing material efficiency in ErPs, as well as an updated version of the EcoReport Tool and a report of the test of the updated methodology on two case studies.

The project identified from available evidence the most significant parameters regarding material efficiency that may be used in MEErP, in order to analyse the environmental impacts of ErPs, and assessed their suitability and robustness for Ecodesign purposes, together with associated information parameters.

The parameters selected as most suitable were as follows:

- Recyclability benefit ratio, describing the "potential output" for future recycling, based on a formula considering the recyclable mass per material and its recycling rate and a down-cycling index. It implies that it is possible to assess the potential benefits of recyclable plastic parts in a product. However, due to data constraints, only data on the recyclability benefit rate for bulk and technical plastic is included.
- Recycled content, describing the "input" of materials with their origins in waste, based on new datasets for materials. The dataset makes it possible to model products with recycled material as input material. However, again due to data constraints, only data on paper, polyvinyl chloride (PVC), polyethylene terephthalate (PET) and high-density polyethylene (HDPE) has been included in the EcoReport Tool.
- Lifetime, a mechanism to display impacts not only as a total over the whole lifespan, but also per year of use, allowing an easier comparison of products with different lifetimes or analysing the effect of a lifetime extension. The product lifetime can refer to the following:
    - The technical lifetime is the time that a product is designed to last to fulfil its primary function (technical lifetime).
    - The actual time in service is the time the product is used by the consumer (service lifetime). The actual time in service is not a typical parameter in industry and depends more on the user than on the manufacturers of the product design.
- Critical raw materials, a tool to analyse products including critical raw materials to display differences between different product designs and improvement options.

A key end result of this project was that the new features within the MEErP, enabling further analyses of material efficiency aspects in products, are fully functional and ready to be used in future Ecodesign preparatory studies. However, Bundgaard et al. (2015) conclude in their study:

> *The MEErP methodology has not been changed significantly. The alterations made to the EcoReport Tool are minor and to some extent updates of existing elements. Hence, despite the good intentions to include material efficiency into MEErP, the current update and expansion of MEErP will properly not be enough to ensure a focus on material efficiency in future implementing measures and voluntary agreements.*

**Durability of products**

Ricardo-AEA, in collaboration with Sustainability Management at Scuola Superiore Sant'Anna di Pisa (SuM) and Intertek, was commissioned by the European Commission – DG Environment to conduct a study on the durability of products. The purpose of the study was to identify two priority products and develop a methodology for measuring their durability. The study also aimed to estimate the benefits and costs of more durable products. The outputs from this work can then be used in relevant product policies (Ricardo-AEA 2015).

Within the durability study, the authors undertook a literature analysis to develop an appropriate definition of durability. For example, Ecodesign Directive 2009/125/EC in Annex I, Part 1.3 defines parameters which must be used, as appropriate, and supplemented by others, where necessary, for evaluating the potential for improving the environmental aspects of products. According to European Parliament (2009a), this includes *inter alia*:

> *"Extension of lifetime as expressed through: minimum guaranteed lifetime, minimum time for availability of spare parts, modularity, upgradeability, reparability."*

The following definition has been developed by Ricardo-AEA (2015) and is proposed to be potentially also applied to other policy interventions in Europe aimed at improved durability of products:

*"Durability is the ability of a product to perform its function at the anticipated performance level over a given period (number of cycles – uses – hours in use), under the expected conditions of use and under foreseeable actions.*

*Performing the recommended regular servicing, maintenance, and replacement activities as specified by the manufacturer will help to ensure that a product achieves its intended lifetime."*

The authors further discussed the possibility of creating an extended definition of durability that encompasses repair, design for repair and remanufacturing, and that such an extended definition of durability could be developed for inclusion within for example the EU Ecolabel and Green Public Procurement (GPP) criteria requirements.

*"A product to maintain its functions over time and the degree to which it is repairable before it becomes obsolete."…. "In other words, a product should not cease to function after relatively little usage and its reparability should not be hindered by its design."*

It is thus worth considering that, within this context, extended durability is the aim to extend the life of a product past its first life by ensuring a product can be easily repaired, upgraded, remanufactured and, at end of life, dismantled and recycled.

Beyond the above definitions on durability, Ardente et al. (2012) concluded their literature review, cited in Ricardo-AEA (2015), with the following definitions for a number of relevant terms:

– Design for durability: considering the product's longevity, reparability and maintainability; considering environmental improvements emerging from new technologies (ISO/TR 14062 2002).
– Operating time: average time frame during which the product is supposed to be used. Operating time can be derived from product statistics or from estimating models.
– Extension of operating time: estimated time frame extension of the operating time that can be achieved due to specific design and maintenance actions.

Within the study of Ricardo-AEA (2015), domestic refrigerators and freezers, and ovens were selected for further analysis. The selection is based on the assumption that they might also be applicable to other products with similar components. The study results are expected to be transferable to a large extent as the following components are similar: outer casing, pumps, filters, heating elements, mechanical elements such as hinges and catches and electronics, including controls and displays.

**Addressing resource efficiency through the Ecodesign Directive - Case study on electric motors**

Dalhammar et al. (2014) conducted a case study in 2012 on the potential inclusion of permanent magnet (PM) motors in the Ecodesign requirements for electric motors. The objective was to see how the Ecodesign Directive could promote eco-innovation for resource use in PM motors, and to:

– investigate what kind of requirements related to resource use of rare earth elements (REE) are of relevance for permanent magnet electric motors; and
– obtain input from experts on the feasibility of outlined potential requirements, and the most important drivers for eco-innovations.

Against the background of increased demand for REE, combined with global supply imbalances and unavailable post-consumer recycling options for REE, their substitution in magnets is currently being investigated in several pilot projects. Replacing REEs with other materials however can come with a performance loss in the PM motor (i.e. reduced energy efficiency due to a reduced energy density in the magnet and more material use). Therefore, increasing the recyclability of permanent magnets is of interest, if technically and economically feasible at the point in time of interest, as it could provide a stable supply of REEs and thus encourage their continued use to achieve more energy-efficient motors.

Based on interviews with material experts, Dalhammar et al. (2014) outline potential implementing measures facilitating recycling of REE:

- Generic requirements that producers should show how they take design for recycling into account in the design process.
- Design for dismantling, e.g. modularisation; or preventing permanent magnets being covered by plastic for instance, which would ease recycling practices.
- BOMs providing information about key materials and their positions to promote future recycling (when new technologies may allow for profitable recycling if the motors are easy to disassemble).
- Additional information to recyclers that is relevant for allowing cost-effective recycling.
- Take-back obligation; it might provide incentives to design a motor from which materials can more easily be recycled.

Dalhammar et al. (2014) conclude that it appears that a more developed set of requirements cannot be set under the Ecodesign Directive until pilot projects and ongoing research have provided more insights into the technical and economic viability of REE recycling. The long timescales involved (i.e. time before the motors are at the EoL stage) however mean that future recycling options and associated costs and benefits are uncertain compared to products with shorter lifespans, e.g. laptops or cell phones.

**Resource efficiency requirements in Ecodesign: Review of practical and legal implications (VHK, 2014)**

This study for the Dutch Ministry of Infraestructure and Environment explores the potential role of material resource efficiency, except energy efficiency during use, in the Ecodesign Directive for ErPs. This study strengthens the role of material efficiency in Ecodesign, beyond energy efficiency, and concludes that Ecodesign measures regarding savings on non-energy resources consumption in the use phase have proven to be enforceable, at least for directly consumed resources, legally and in practice. The methodology and measures regarding weight-saving measures in Ecodesign would need to be developed. The measures on product durability (lifetime extension) have proven to be enforceable when formulated in terms of the minimum technical lifetime of the product or components according to harmonised testing and calculation procedures. Also, minimum warranty times and the time period during which spare parts are available can be enforced.

Should Ecodesign preparatory studies be able to provide robust evidence that justifies introduction of specific RRR measures in legislation, then (a set of) specific or tailor-made requirements should be introduced in Ecodesign legislation that could meet legal and practical criteria enforceability. Amongst others, this means that the requirements should be technically and economically feasible and preferably relate to parameters that can be assessed with an accurate, reliable and reproducible test and calculation methods at product level. If they were to depend on input from upstream actors (suppliers) or downstream (end-of-life) processes, the administrative burden would be considerable and still the accuracy and reproducibility of measurements would require robust test standards to be in place to guarantee a level playing field.

International trade agreements emphasise the relation between the proposed measure and its means of verification. Measures that can be verified on the product itself are considered to constitute less of a (potential) barrier to trade than measures that can only be verified indirectly as they relate to non-product-related production and process methods. There are however measures that may relate solely to the product, such as parameters dealing with durability, light-weighting, presence of substances (hazardous or critical raw materials, etc.)

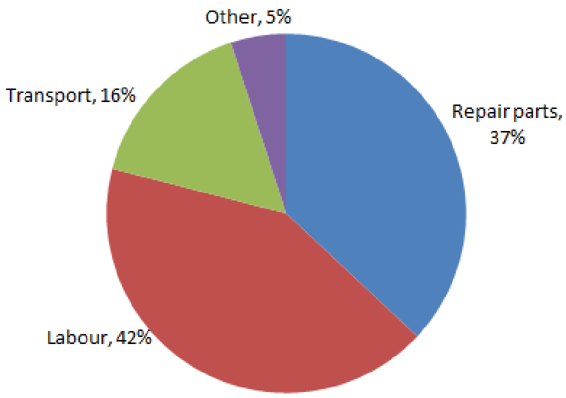
#### 4.4.3.5 Product design in relation to durability and reparability

In terms of the reparability of domestic cooking appliances specifically, there is little data regarding the habits of consumers or on the number and success of repairs performed in this sector. There is also limited information regarding the disassembly and reassembly properties (key aspects in reparability) of home appliances in general. Related to this topic, Dindarian et al. (2012) investigate the quality and costs of remanufacturing microwaves and propose design changes based on that. Some of their recommendations, which may be applicable to domestic cooking appliances such as ovens, hobs and cooking fume extractors, are:

- reduce the complexity of how printed circuit boards are assembled;
- facilitate the access to internal parts;
- redesign how key components are fitted to make them more accessible;
- change paint characteristics to make it more durable;
- change the design of mains cables and plugs to make them removable or interchangeable;
- reduce the number of different designs of mechanical parts to make them more interchangeable.

Along the same lines, using a sample of 749 units of small household WEEE, an analysis of the current situation in terms of their disassembly properties and material characterisation was conducted in Bovea et al., 2016b. It was observed that the most problematic aspects regarding disassembly in small WEEE were ease of material identification and ease of separation of individual components. Some of the joints used needed to be broken in order to disassemble them, whereas others required two people to avoid having to break them. In order to improve the reparability of these appliances, the authors recommended reducing the number and variety of types of joints, along with the utilisation of more intuitive snap-fits, clips or sliding connections. These recommendations are also applicable in the case of large domestic appliances such as ovens, hobs and cooking fume extractors.

When a consumer needs to repair their faulty appliance, one of the options is to get in touch with the manufacturer. According to data collected from members of APPLIA, 81% of the requests to manufacturers for a repair of a product resulted in an actual repair in 2016. The breakdown of costs of repair activities in large home appliances can be seen in Figure 165.




*Source:* APPLIA (2019)

**Figure 165. Cost breakdown for repair activites in large home appliances**

As can be observed, the most significant contribution to the cost of repair is related to labour. However, it needs to be taken into account that, depending on the country, there are different considerations from the consumers due to differences in the labour cost. The labour cost needs to be factored in, in particular in countries where it is very high. For that, data from Eurostat regarding hourly labour costs will be used in the modelling section.

A product design with a view to reparability and disassembly has the potential to significantly reduce the time and energy spent on repairing the appliance, as well as to improve the capacity for recovering valuable materials at end of life. Barriers to the reusability and reparability of home appliances have already been addressed in Task 3 of this report.

In terms of the technical benefits of repairing domestic cooking appliances, no specific data has been found on the topic. In their analysis on home appliances, Hennies et al. (2016) indicate that when a washing machine repair has taken place, its lifespan is significantly higher (by 2 years). The authors also observed that the more expensive the washing machines, the more times they are repaired over their lifetimes, potentially because they last longer or because the cost of the repair relative to the cost of acquisition is lower. Repairs due to early failures in appliances under warranty period are very rare (5%). They also recommend that increasing the awareness of environmental factors could change the attitudes of consumers and push the market economy in a direction towards a more sustainable approach.

On reparability, a manufacturer indicated that they can support the approach with respect to spare part availability for professional repairers and end users, as for washing machines, washer dryers, dishwashers and refrigerating appliances in their revised ecodesign regulations. This can be implemented for domestic ovens, hobs and cooking fume extractors. The specific content of the requirements for these appliances should be discussed with industry.

#### 4.4.3.6 Material flows and collection effort at end of life

From 2011 to 2018, the amount of electrical and electronic equipment (EEE) put on the market in the EU evolved from 7.6 million tonnes in 2011 to 8.7 million tonnes in 2018. In the same period, at EU level, the total WEEE collected improved from 3.0 to 4.0 million tonnes (+30.9%), the total WEEE treated grew from 3.3 million tonnes to 3.9 million tonnes (+19.5%), total WEEE recovered developed from 2.7 million tonnes to 3.6 million tonnes (+30.3%) and total WEEE recycled and prepared for reuse evolved from 2.6 million tonnes to 3.2 million tonnes (+26.2%) (Eurostat, 2021).

Focusing on home appliances waste, Magalini et a.l (2017) report that home appliances waste is mostly made up of:

- electrical and electronic waste (WEEE);
- packaging waste, mainly in the distribution phase;
- batteries, particularly for small home appliances.

Considering all sizes of home appliances, it can be observed that WEEE flows are steadily increasing (Figure 166), with a total of 5 million tonnes in 2016 (30% increase in 9 years). It is estimated that nearly 50% of that mass corresponds to large home appliances (which include ovens, hobs and cooking fume extractors).

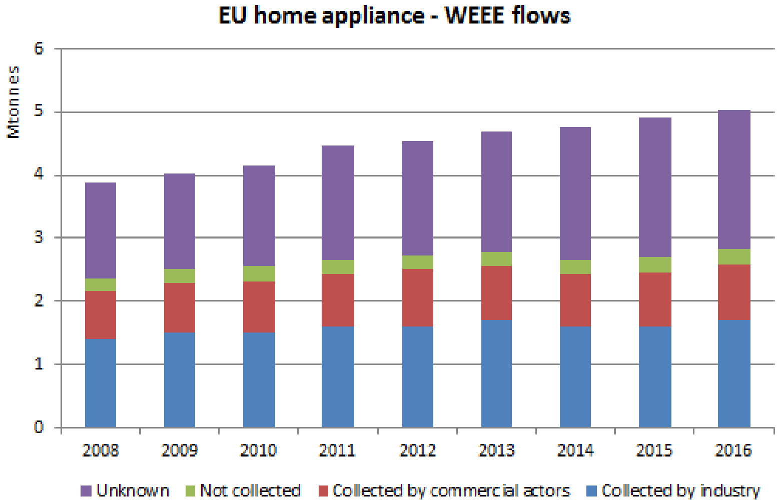



**Figure 166. Home appliance WEEE flows**

Four main streams are identified for home appliances waste:

- collected by industry;
- collected by commercial actors;
- not collected;
- unknown.

In 2016, only 34% of the total was actually collected by the home appliance industry. The reason for this low amount is related to the high metal content of this waste stream and the presence of a mature recycling industry even before the WEEE Directive was implemented. Commodity prices play a fundamental role in how home appliances are collected and treated. This means that a large share of this waste is handled by commercial actors, outside the industry-driven recycling schemes. Appropriate tracking mechanisms are still not in place, and the destination of a significant 44% of home appliances waste is currently unknown. The remaining 5% is not collected separately in any form and therefore can be considered as sent to landfill.

In terms of materials, steel is the material which is recovered the most for large, small and cooling/freezing appliances (Figure 167). Approximately 0.15 million tonnes of concrete are recovered from large home appliances, presumably from built-in devices. Plastics, copper, aluminium and glass are other materials with a significant presence in this waste stream.

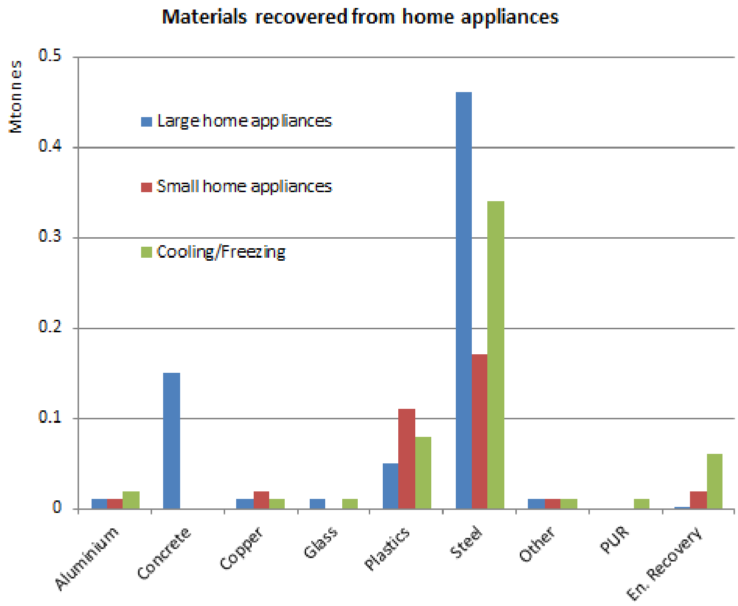



**Figure 167. Materials recovered from home appliances waste**

## 4.5 Conclusions

### 4.5.1 Ovens

- Some stakeholders support comprehensive and comparable labelling for all appliances based on primary energy, therefore not differentiating between gas and electricity. For that, a conversion factor should be used to convert electricity to primary energy, allowing the comparison between electric and gas appliances. However, others argue that the sales of gas ovens is low and decreasing and the comparision between gas and electric is not possible because of differences in the measurement methods.

- The use of stainless steel in oven cavities comes with certain disadvantages, mainly related to the cleaning process: the high temperatures of the pyrolytic process degrade stainless steel surfaces. Also, the emissivity of heat from the bottom part of the cavity is poorer when using stainless steel.

- It might be worth exploring a way to calculate the EEI, in order to make a less linear correlation between energy efficiency and cavity volume.

- Energy-saving modes are one of the main opportunities for improvement in terms of the energy efficiency of ovens and they are seen as an incentive for innovation. However, on some occasions they can produce unsatisfactory results in the form of food being underdone or burnt. Moreover, they are not the most frequently used heating modes. For these reasons, some stakeholders are against their use. Further analysis is needed to determine the benefits and drawbacks of allowing/banning their use for the energy declaration.

- There is limited potential for improvement in conventional ovens with fan-forced functions. Steam-assisted ovens appear to obtain better EEI results and therefore achieve higher energy classes. However, the mode used for the energy declaration may not have been the steam-assisted mode (the best-performing may have been conventional or fan-forced), and better performance is rather presumed to be related to certain features (typically associated with ovens with a steam-assisted function: better sealing and isolation characteristics with a reduced vapour outlet, compared to conventional ovens. In conclusion, the support of steam does not in itself necessarily lead to lower energy consumption.

- There is certain debate around the possibility of improving the energy efficiency of ovens by enhancing their sealing conditions. A way of improving the energy efficiency of ovens in general is in the development of ovens with the sealing characteristics of steam-assisted ovens, modifying "airtightness" during the cooking cycle in order to reduce heat loss. A potential issue with this reasoning is that there are some recipes which do not work with such highly sealed conditions and require some air leakage.

- There is energy- and time-saving potential in microwave combi modes, observed in tests with real food. Depending on the type of dish being prepared, when compared to convective heating, energy savings can vary between 5% and 20%. However, despite this energy-saving potential, since there is no standard test to evaluate these savings, it is currently not perceived by consumers.

- According to feedback from manufacturers, the use of automatic programmes can reduce the energy consumption of the oven by approximately 15% per cycle. However, the savings of the automatic functions cannot be easily shown or compared with the current measurement methods.

- The total energy consumption of the pyrolytic function could be significant. It is important that consumers have access to information about the energy consumption of systems. There are proposals to include information on the energy consumption of self-cleaning systems in the user manual. However, it would be very challenging to evaluate different levels of cleanliness and to compare self-cleaning programmes with manual cleaning.

### 4.5.2 Hobs

- There is still a limited differentiation in terms of energy efficiency which prevents the introduction of energy labelling measures.

- The Best Available Technology in terms of energy efficiency is an induction hob.

- Small burners (below 1.16 kW, which will be reduced in the next revision of EN 30-2-1, probably to 800 W) are currently out of the scope because they are mostly used for simmering and not cooking; and because the temperature rise in the test standard is not adequate to measure their performance. However, there are proposals to include them in the scope, after the development of a simmering test for small burners. A minimum power threshold to be within the scope of the Ecodesign Regulation should still be in place.

- Current regulation leaves out of the scope appliances designed for use only with gases of the 3$^{rd}$ family (butane and propane). However, this exception does not make sense nowadays.

- The design of gas hobs which reduce the distance between the pot and the flame, which may speed up the cooking and lower the energy consumption. However, this may jeopardise the safety of the hob, thus any improvement in this area is limited by safety requirements. Moreover, it can also increase the pollutant emissions of the burner. Therefore, this strategy is not recommended to improve energy efficiency.

- The potential for improving energy efficiency in solid plate hobs is almost exhausted at this point, since today's solid plates are already equipped mainly with energy regulators (no longer seven-step switches), due to the current requirements of the Ecodesign Regulation.

- In terms of using hydrogen as an energy source for cooking appliances, there are several areas where technology is currently not ready for its adoption. A current gas appliance could never switch from natural gas to pure hydrogen without any adaptation. Moreover, hydrogen appears to be far from being a clean solution based on today's production methods: it has potential if, for example, it is produced from the excess renewable electricity that would otherwise be wasted, and if it is then used in sectors where direct renewable electrification is not posible. That said, in most pathways there is a primary energy loss involved in production. There are recommendations from some stakeholders to work on a progressive approach concerning the ability of gas burners to operate with gas blends (for instance, concerning its possible operation with a minimum rate of X% of hydrogen in natural gas).

### 4.5.3 Cooking fume extractors

- There is a significant improvement potential related to the type of electric motors of the blower. Brushless motors are more efficient and are able to reach the highest efficiencies; however, they are the most expensive and therefore they are currently only present in high-end models.

- The type of fan used in the blower plays a role in the energy efficiency of the cooking fume extractor; however, it is often limited by the space available to install the cooking fume extractor.

- The Best Available Technology in terms of energy efficiency is a wall-mounted cooking fume extractor equipped with a brushless motor.

- Recirculating-only cooking fume extractors are out of the scope of the Ecodesign and Energy Labelling Regulations. There are recommendations to include them in the scope of the new Regulations to enable them to be rated and compared with models that operate in extraction mode, and even with models that are part of a central ventilation system.

- Current EEIs in cooking fume extractors are not reflecting real-life usage, since they are based on measurements at the best efficiency point (BEP), usually found at pressures much higher than the ones in real applications. Manufacturers have an incentive to focus on high speeds of operation. The result is that the energy efficiency of the lower speeds is relatively low and that cooking fume extractors with higher airflow rates tend to obtain better energy classes. There is a general consensus that moving from the current method to the 9-point method will be a positive aspect for the energy efficiency rating of cooking fume extractors.

- The current method to measure EEI only takes the direct energy consumption of the cooking fume extractor into account. However, when a hood is operated, it removes air from the kitchen that needs to be replaced with air from the exterior (replacement air). This air will need to be either cooled or heated by the heating system of the household. There are recommendations to also take into consideration the indirect Annual Heating/Cooling Consumption when calculating the EEI. However, doing that would mean that the energy efficiency of a product would depend on external factors, such as heating/cooling systems or ventilation systems.

- Some stakeholders consider that the current approach for measuring the energy efficiency of cooking fume extractors is not sufficient and that the capture efficiency should be taken into account in some manner. The odour reduction factor is considered by some stakeholders as a first approximation for that. There are proposals to incorporate the odour reduction factor (Of) into the Annual Energy Consumption formula, so that both energy consumption and odour removal are considered when measuring the EEI. However, manufacturers indicated that the MEK test method is not appropriate for ducted cooking fume extractors.

# 5 Task 5: Environment and economics

The aim of this section is to assess the environmental and economic impacts associated with different base cases of ovens, hobs and cooking fume extractors. The assessment is based on the updated version of the EcoReport Tool (version 3.06), as provided with the MEErP 2011 methodology (COWI and VHK 2011b).

According to the MEErP methodology, base cases (BC) should reflect average EU products. Different products of similar functionalities, Bill of Materials (BoM), technologies and efficiency can be compiled into a single base case. Therefore, it may not represent a real product on the shelves, but it is the most representative one. The base cases are used as a reference for modelling the stock of products together with their environmental and economic impacts and the available improvement design options.

For the identification of the base cases for cooking appliances, the analyses presented in the previous Tasks 1 (Scope and definition), 2 (Markets), 3 (Users) and 4 (Technologies) have been considered.

## 5.1 Technical description of base cases

### 5.1.1 Ovens base cases

The aim in this section is to define three base cases: one for electric ovens, one for gas cookers and one for microwave ovens. Each of those base cases should represent, to the extent possible, the “typical” or “average” appliance. The following base cases have been identified and chosen to further assess the environmental and economic impacts over the life cycle of ovens:

- Base Case 1 (BC1): Electric built-in oven, 65-75 litres, “A” energy class.
- Base Case 2 (BC2): Gas cooker, 55-65 litres, “A” energy class.
- Base Case 3 (BC3): Free-standing microwave oven, 20 litres.

The main characteristics of BC1, BC2 and BC3 are summarised in Table 40.

**Table 40. Ovens – summary of base cases**

| | BC1<br>Electric oven | BC2<br>Gas cooker | BC3<br>Microwave oven (3) |
|---|---|---|---|
| **Energy class** | A | A | n/a |
| **Energy source** | Electric | Gas | Electric |
| **Self-cleaning cycle** | Pyrolytic | None | None |
| **Capacity** (litres) | 70 | 65 | n/a (4) |
| **Number of cavities** | 1 | 1 | 1 |
| **Mounting configuration** | Built-in | Free-standing | Free-standing |
| **Opening system** | Drop-down | Drop-down | Side |
| **Interior lighting** | halogen/inca | halogen/inca | n/a |
| **Smart features** | n/a | n/a | n/a |
| **Volume of product** ($m^3$) | 0.6x0.6x0.55m = 0.198 $m^3$ | 0.85x0.6x0.6m = 0.306 $m^3$ | n/a |
| **Volume of packaged product** ($m^3$) | 0.265 $m^3$ | 0.396 $m^3$ | 0.092 $m^3$ |
| **Packaging materials** | EPS, cardboard and foil and in some cases also wood | EPS, cardboard rd and foil and in some cases also wood | EPS, cardboard and foil |
| **Mass** (kg) | 40 | 45 | 13.5 |
| **Energy consumption (1) (Natural convection / Top bottom)** | 0.89 kWh/cycle | 5.6 MJ/cycle<br>1.56 kWh/cycle | n/a |
| **Energy consumption (1) (Convection / Fan-forced)** | 0.79 kWh/cycle | n/a | n/a |
| **Power output (2) (Microwave)** | n/a | n/a | 700 W |

(1) Energy consumption measured with standard test EN 60350-1 (Brickmethod 1.0).

(2) Efficiency of appliance assumed as 55% based on feedback from manufacturers.

(3) Data for BC3 taken from product brochure.

(4) Capacity of microwave ovens is not indicated since the measurement method is different to electric and gas ovens.

#### 5.1.1.1 Ovens – Bill of Materials (BoM)

The manufacturing phase includes the extraction and production of the required materials including the following steps necessary to produce and assemble one product. The MEErP 2011 EcoReport tool contains a detailed list of materials and processes for which defined environmental indicators are provided as default values.

The Bills of Materials (BoM) of BC1, BC2 and BC3 have been selected based on input provided by stakeholders (Table 41). BC1, BC2 and BC3 have the same BoM as in in the previous preparatory study (Lot 22).

**Table 41. Bill of materials of BC1, BC2 and BC3 for ovens**

| Material category | BC1 (electric oven) | BC2 (gas oven) | BC3 (MW oven) |
|---|---|---|---|
| | Mass (g) | | |
| 1-BulkPlastics | 250.8 | 65.0 | 1077.4 |
| 2-TecPlastics | 583.3 | 2172.2 | 41 |
| 3-Ferro | 30105.6 | 34730.5 | 6977.8 |
| 4-Non-ferro | 1859.6 | 2974.3 | 2339.6 |
| 5-Coating | 0.0 | 0.0 | 216 |
| 6-Electronics | 162.0 | 0.0 | 510 |
| 7-Misc. | 7038.6 | 5058.1 | 2361.2 |

To compile the BoM considered for the oven base cases, it is worth noting that in the data base available in the ErP EcoReport many materials are missing. The materials not mentioned in the data base have been reallocated to the existing material categories. For certain other materials no correspondence is possible. In this case, the missing materials' weight is reallocated in other material categories.

#### 5.1.1.2 Ovens – manufacturing process

The manufacturing process is mainly fixed in the EcoReport tool. The only variable which can be edited is the percentage of sheet metal scrap. The default value is 25%.

#### 5.1.1.3 Ovens – distribution phase

This phase comprises the distribution of the packaged product. According to the MEErP methodology report (COWI and VHK 2011b), the section on Final Assembly and Distribution covers all activities from OEM components to the final customer. The only design variable, however, is the volume of the final (packaged) product:

- 0.266 $m^3$ for Base Case 1;
- 0.396 $m^3$ for Base Case 2;
- 0.092 $m^3$ for Base Case 3.

#### 5.1.1.4 Ovens – use phase

There are two relevant parameters in the use phase of an oven: pattern of use by consumers and energy consumption per cycle. In the previous preparatory study (Lot 23), a common pattern of use of 110 cycles/year and 55 minutes/cycle was considered for both electric and gas ovens. For microwave ovens, the figures used were 1 200 cycles/year and 2.6 minutes/cycle (with an average power of 500 W).

In this report, a user behaviour study has been conducted and presented in Task 3. In this study, respondents provided information regarding their frequency of use (in total and by heating mode) and duration of use per heating mode. Considering the frequency of times that the appliance is used (ignoring the duration of time that each cycle is used), results indicate that ovens are used 182 cycles/year, a significant increase when compared to the previous preparatory study. For the calculation of the annual energy consumption, the energy consumption of top and bottom and fan-forced heating modes will be used, with a weighted average of 50% each, resulting in an energy consumption per cycle of 0.84 kWh/cycle.

Regarding microwave ovens, results from the user behaviour study indicate that microwave ovens are used 842 cycles/year, a decrease from the previous preparatory study.

As a result of using the data presented in this section, the annual energy consumption (including standby) is estimated for the different cases and presented in Table 42.

**Table 42. Annual energy consumption of oven base cases**

| BC1: Electric oven | BC2: Gas oven | BC3: Microwave oven |
|---|---|---|
| 156.6 kWh/year | 1051 MJ/year | 33.2 kWh/year |

#### 5.1.1.5 Ovens – end-of-life (EoL) phase

Recycling of materials can avoid the extraction of raw materials and the production of virgin materials. This is modelled in the EcoReport tool as credits (avoided impacts), i.e. negative impacts.

For the product (stock) life, i.e. the period between when the oven is purchased and discarded, 15 years have been assumed, the same as for the product service life, i.e. the period that the product is in use and operational.

As "unit sales L years ago", it would correspond to the units sold in the year 2020 minus the product life, and the resulting unit sales figures would be:

BC1 = 5.4 million units;

BC2 = 0.8 million units;

BC3 = 7.3 million units.

The current fraction of materials contained in appliances on the market is calculated by the EcoReport tool based on the material shares of the BoM and the calculated spare parts for maintenance and repair. This tool requires input on the destination at the EoL of the different fractions in terms of reuse, recycling, recovery, incineration and landfill/missing/fugitive. Due to a lack of more specific data on the destination of the material fractions of ovens, the default values of the EcoReport tool have been used. For the calculation of base cases, an average recyclability of the fractions has been chosen.

### 5.1.2 Hobs base cases

Task 2 shows that radiant hobs represent 35% of the current stock and induction hobs are 28%. According the historic sales series, this situation is expected to shift in the future, with induction hobs becoming the dominant technology. There is still a small share of solid plates which is expected to be reduced over time, from the current 14% to 3% in 2040. Gas hobs are expected to retain their share in the future, ranging from 20% to 30% of the stock.

The following base cases have thus been identified and chosen to further assess the environmental and economic impacts over the life cycle of hobs:

- Radiant technology, 4 cooking zones.
- Induction technology, 4 cooking zones.
- Gas technology, 4 cooking zones.

Three base cases have been chosen to represent the types of hobs on the market, while solid plates are discarded as unrepresentative. However, solid plates will still be within the scope of regulations.

Table 43 summarises the detailed performance characteristics chosen for the hobs base cases including the respective underlying sources and assumptions.

**Table 43: Characteristics of the chosen base cases for hobs**

| | BC1 (radiant) | BC2 (induction) | BC3 (gas) | Sources |
|---|---|---|---|---|
| Cooking zones | 4 | 4 | 4 | From Task 3 and task 4 |
| Power on mode (kW) | 7.4 | 7.4 | 9 | BC1 and BC3 Lot 23, BC2 |
| Power off mode (W) | 0.49 | 0.49 | - | Technical specifications |
| Weight (kg) | 8.3 | 11.2 | 7.8 | From manufacturers |
| Energy efficiency as ED | 190 Wh/kg water | 185 Wh/kg water | 56% | From manufacturers |

Compared to the base cases used in the ecodesign preparatory study of 2011 ("Lot 23") by BIO (2011), the current base cases explicitly include induction technology, based on its current and future share in the market.

#### 5.1.2.1 Hobs – Bill of Materials (BoM)

The manufacturing phase includes the extraction and production of the required materials including the following steps necessary to produce and assemble one product. The MEErP 2011 EcoReport tool contains a detailed list of materials and processes for which defined environmental indicators are provided as default values.

The Bills of Materials (BoM) of the base case products have been selected based on input provided by stakeholders (mainly personal communication with manufacturers). In order to define the average model for each base case, the data collected was analysed and aggregated or averaged regarding the type of material.

To compile the BoM considered for the hob base cases, it is worth noting that in the data base available in the ErP EcoReport many materials are missing. The materials not mentioned in the data base have been reallocated to the existing material categories. For certain other materials no correspondence is possible. In this case, the missing materials' weight is reallocated in other material categories. The amount of materials that does not exactly correspond to the categories included in the ErP EcoReport data base is around 7% of the total mass.

**Table 44: Aggregated BoM considered for hobs base cases**

| Component / Material | BC1 (radiant) | BC2 (induction) | BC 3 (gas) |
|---|---|---|---|
| | Weight (in g) | Weight (in g) | Weight (in g) |
| *Product* | | | |
| Bulk Plastics | 253 | 253 | 107 |
| TecPlastics | 283 | 71 | 151 |
| Ferro | 1 769 | 1 738 | 5 467 |
| Non-ferro | 182 | 2 262 | 2031 |
| Electronics | 266 | 3 203 | 0 |
| Miscellaneous (glass) | 5 002 | 3 060 | 0 |
| Miscellaneous (others) | 510 | 634 | 39 |

#### 5.1.2.2 Hobs – manufacturing process

The manufacturing process is mainly fixed in the EcoReport tool. The only variable which can be edited is the percentage of sheet metal scrap. The default value is 25%.

#### 5.1.2.3 Hobs – distribution phase

This phase comprises the distribution of the packaged product. According to the MEErP methodology report (COWI and VHK 2011b), the section on Final Assembly and Distribution covers all activities from OEM components to the final customer. The only design variable, however, is the volume of the final (packaged) product.

Regarding the average volume of the final packaged product, the same values as in Lot 23 (BIOS 2011) are assumed:

- 0.061 $m^3$ for Base Cases 1 and 2;
- 0.057 $m^3$ for Base Case 3.

#### 5.1.2.4 Hobs – use phase

The only input at the use phase is the energy consumption. The estimation of the energy consumption requires the following parameters:

- Energy consumption per kg, for electric hobs, and energy efficiency, for gas hobs, is provided in the technical description of base cases.
- Frequency of use per week: according to Task 3 User behaviour: 12 times per week, 624 times per year.
- For electric hobs: it is assumed that the simmering test method represents a cooking cycle and that 1 kg of water represents a normalised amount of food to be cooked.
- For gas hobs: it is assumed that the cooking cycle is represented by heating up an amount of water from 20 °C to 90 °C in an aluminium pan, according to EN 30-2-1. The normalised amount of water is 1.5 kg, which would account for the different cooking cycles of electric and gas hobs, e.g. the simmering phase in a gas hob would correspond to the shifting of the pan to a smaller hob.

Assuming that the test conditions are not the same for electric and gas hobs, the results are shown in Table 45.

**Table 45: Summary of cycles and energy consumption of hobs at the use phase**

| | **Efficiency according Ecodesign Regulation** | **Energy consumed per cycle** | **Energy consumed per year** | **Energy consumed per year in Lot 23 (for comparison)** |
|---|---|---|---|---|
| Radiant | 190 Wh/kg water | 190.0 Wh | 118.6 kWh | 240 kWh |
| Induction | 185 Wh/kg water | 185 Wh | 115.4 kWh | - |
| Gas | 56% (heat output/heat input) | 825.4 kJ | 515.0 MJ (143.1 kWh) | 328.5 kWh |

*Source:* Panel Usages Electrodomestiques. ADEME 2021.

#### 5.1.2.5 Hobs – end-of-life (EoL) phase

Recycling of materials can avoid the extraction of raw materials and the production of virgin materials. This is modelled in the EcoReport tool as credits (avoided impacts), i.e. negative impacts.

For the product (stock) life, i.e. the period between when the hob is purchased and discarded, 15 and 19 years have been assumed for electric and gas hobs, respectively. They are the same as for the product service life, i.e. the period that the product is in use and operational. This assumption is made because consumers do not keep the old hobs stocked after buying a new one.

As "unit sales L years ago" would correspond to the units sold in the year 2020 minus the product life, the resulting unit sales figures would be:

- 6.93 million units, for radiant hobs, Base Case 1 in 2005;
- 1.22 million units, for induction hobs, Base Case 2 in 2005;
- 1.90 million units, for gas hobs, Base Case 2 in 2001.

The EcoReport tool requires input on the destination at the EoL of five fractions in mass: reuse, recycling (material), recovery (heat), incineration and landfill/missing/fugitive. Due to a lack of more specific data on the destination of the material fractions of hobs, the default values of the EcoReport tool have not been changed.

The EcoReport tool needs to define the 'EoL recyclability' qualitatively. This relates to the potential of the new products to change the course of the material flows, e.g. due to faster pre-disassembly or other ways to bring about less contamination of the mass to be recycled. In that case, it is likely that the recycled mass at the EoL will displace more virgin material in other applications. The recyclability does not influence the mass balance but it does give a reduction or increase of up to 10% on all impacts of the recycled mass. For the calculation of base cases, an average recyclability of the fractions is chosen.

Table 46 gives a summary of the assumptions.

**Table 46: End-of-life destination of material fractions**

| Per fraction (post-consumer) | Bulk Plastics | TecPlastics | Ferro | Non-ferro | Coating | Electronics | Misc. , excl. refrigerant | Refrigerant | Extra | Auxiliaries |
|---|---|---|---|---|---|---|---|---|---|---|
| EoL mass fraction to r-use, in % | *1* | | | *1* | | *1* | *1* | *1* | *1* | *0* |
| EoL mass fraction to (materials) recycling, in % | *29* | | | *94* | | *50* | *64* | *30* | *60* | *0* |
| EoL mass fraction to (heat) recovery, in % | *15* | | | *0* | | *0* | *1* | *0* | *0* | *0* |
| EoL mass fraction to non-recov. incineration, in % | *22* | | | *0* | | *30* | *5* | *5* | *10* | *0* |
| EoL mass fraction to landfill/ missing/fugitive, in % | *33* | | | *5* | | *19* | *29* | *64* | *29* | *100* |
| TOTAL, in % | *100* | *100* | *100* | *100* | *100* | *100* | *100* | *100* | *100* | *100* |
| EoL recyclability | avg | avg | avg | avg | avg | avg | avg | avg | avg | avg |

### 5.1.3 Cooking fume extractors base cases

Section 2.2.3.4 reveals that chimney cooking fume extractors represented 55% of sales in 2016, 2017 and 2018, followed by under cabinet, telescopic and built-in (43%). These three types could be named under the descriptor cabinet cooking fume extractors. Ceiling and worktop vent cooking fume extractors represent 2% of sales.

The energy class profile of the different types of cooking fume extractors is shown in Figure 168.

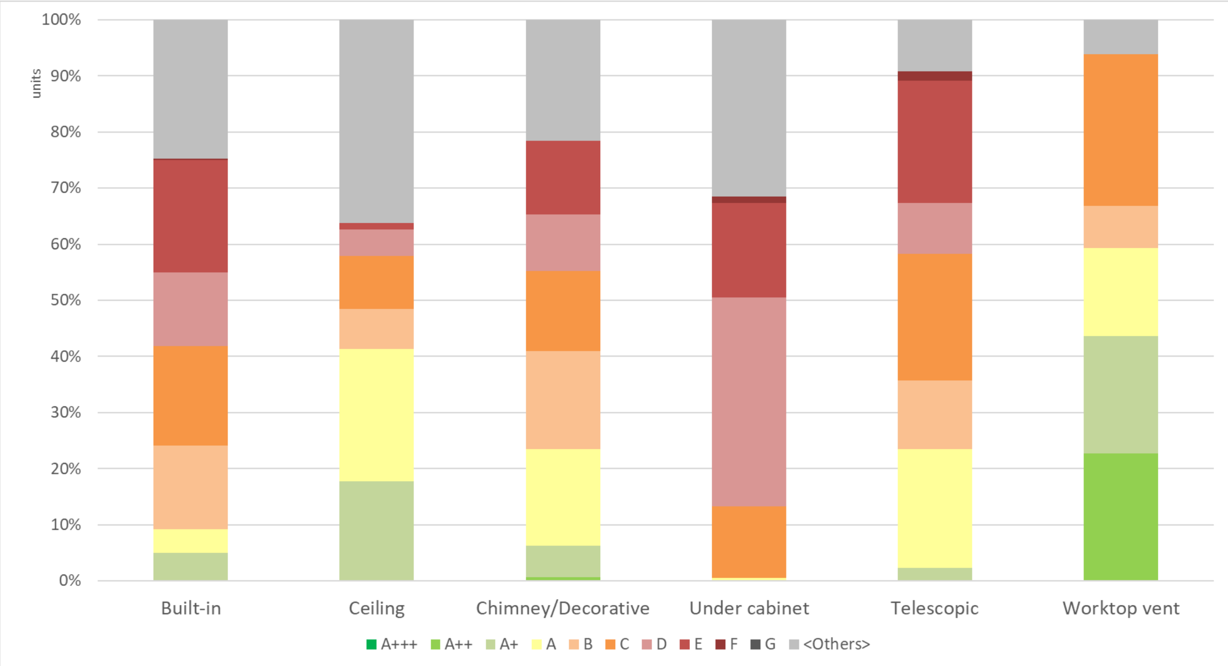



**Figure 168: Distribution of energy classes of the different types of cooking fume extractors**

Under cabinet hoods are typically less efficient, due to the space limitation, though there seems to be a jump from C class to A, perhaps due to a change in the motor technology. The other two cabinet cooking fume extractors can achieve energy classes of B and better. For the purpose of base case definition, the typical energy class of a cabinet cooking fume extractor is set as C. Chimney cooking fume extractors show a wide range of energy classes, reaching A+. The energy class of the base case is set as B, as a middle point within this range of energy classes.

Therefore, the following base cases have thus been identified and chosen to further assess the environmental and economic impacts over the life cycle of cooking fume extractors:

- Chimney cooking fume extractor, energy class B.
- Cabinet cooking fume extractor, energy class C.

While the market of cooking fume extractors is highly segmented, there is robust evidence pointing to these two types of products as representative of the stock and of the overall energy performance of these products. They also represent the typical kitchens in the EU, where there may be space limitations that only allow for the installation of small, integrated cooking fume extractors.

Table 47 summarises the detailed performance characteristics chosen for the cooking fume extractors base cases including the respective underlying sources and assumptions. The data has been provided by manufacturers.

**Table 47. Characteristics of the chosen Base Cases 1 and 2 for cooking fume extractors**

| | Base case 1 | Base case 2 |
|---|---|---|
| **Ventilation** | ducted | ducted |
| **Airflow rate MAX ($m^3/h$)** | 387. | 707.2 |
| **Airflow rate MIN** | 255.8 | 278.3 |
| **Noise at Airflow rate MAX (dB)** | 67 | 73 |
| **Noise at Airflow rate MIN (dB)** | 60 | 52 |
| **Installation** | cabinet | chimney or wall |
| **.Type of filter** | mesh | mesh |
| **Lighting** | halogen | LED |
| **Lighting power (W)** | 43.5 | 3.5 |
| **Grease filtering efficiency (%)** | 86,6 | 91.1 |
| **Smart features** | - | - |
| **Volume of product ($m^3$)** | 0.0378 | 0.04 |
| **Volume of packaged product ($m^3$)** | 0.0704 | 0.233 |
| **Packaging materials** | Cardboard, wood, EPS, foil | Cardboard, wood, EPS, foil |
| **Mass (kg)** | 8.36 | 9.93 |
| **Electricity consumption (kWh/year)** | 68.30 | 63.00 |
| **Energy class** | C | B |
| **Retail price (EUR)** | 82.5 | 363.2 – 236.2 |

### 5.1.3.1 Cooking fume extractors – Bill of Materials (BoM)

The manufacturing phase includes the extraction and production of the required materials including the following steps necessary to produce and assemble one product. The MEErP 2011 EcoReport tool contains a detailed list of materials and processes for which defined environmental indicators are provided as default values.

The Bills of Materials (BoM) of the base case products have been selected based on input provided by stakeholders (mainly personal communication with manufacturers). In order to define the average model for each base case, the data collected was analysed and aggregated or averaged regarding the type of material.

To compile the BoM considered for the CFE base cases, it is worth noting that in the data base available in the ErP EcoReport many materials are missing. The materials not mentioned in the data base have been reallocated to the existing material categories. For certain other materials no correspondence is possible. In this case, the missing materials' weight is reallocated in other material categories.

The aggregated BoM for cooking fume extractors is shown in Table 48.

**Table 48. Aggregated BoM of cooking fume extractor base cases and the base case used in Lot 10**

| Component / Material | BC 1 (under cabinet) | BC 2 (chimney) | Lot 10 |
|---|---|---|---|
| | | | |
| | | | |
| Bulk Plastics | 5% | 2% | 10% |
| TecPlastics | 5% | 2% | 9% |
| Ferro | 86% | 94% | 80% |
| Non-ferro (Copper) | 3% | 1% | 2% |
| Electronics | 2% | 1% | 2% |
| Miscellaneous (glass) | 0% | 0% | 0% |

#### 5.1.3.2 Cooking fume extractors – manufacturing process

The manufacturing process is mainly fixed in the EcoReport tool. The only variable which can be edited is the percentage of sheet metal scrap. The default value is 25%.

#### 5.1.3.3 Cooking fume extractors – distribution phase

This phase comprises the distribution of the packaged product. According to the MEErP methodology report (COWI and VHK 2011b), the section on Final Assembly and Distribution covers all activities from OEM components to the final customer. The only design variable, however, is the volume of the final (packaged) product.

The values were reported by manufacturers by means of the questionnaire:

- 0.0704 $m^3$ for Base Case 1;
- 0.233 $m^3$ for Base Case 2.

#### 5.1.3.4 Cooking fume extractors – use phase

The energy consumed by the cooking fume extractor depends on the load, FDE and the time of use. According to the current methodology, the AEC is calculated assuming an average running time per day of 60 minutes and an average lighting time per day of 120 minutes.

The outcomes of the user behaviour study show that about 80% of the respondents use the fan of the cooking fume extractor often or almost always when the hob is in use and about 60% use the light of the cooking fume extractor. This means that the average time of use of the cooking fume extractor is similar to the use of the hob. Assuming that 80% of the time the hob is in use the cooking fume extractor is also switched on, it would mean 3 hours per week (25 minutes per day). Most respondents also indicated that the use of the cooking fume extractor is linked to the use of the hob (only 15% reported the use of the cooking fume extractor when not cooking). Using the cooking fume extractor light as a substitute for the kitchen light is the most important use of the cooking fume extractor when not cooking, with an average of 3.8 times per week. Assuming an average time of use of 30 minutes, the average times of use per day of the cooking fume extractor would be:

- average running time per day: 25 minutes;
- average lighting time: 41 minutes.

The results of the survey confirm that the average times of use in the current methodology may overestimate the annual energy consumption of the cooking fume extractor. However, manufacturers have consistently used this methodology for consumer information; therefore, the modelling will be based on the current methodology, unless better information is provided.

The annual energy consumption of a domestic cooking fume extractor ($AEC_{hood}$) is calculated as a function of the electric power input of the domestic cooking fume extractor at the best efficiency point. As explained in Task 1 and Task 3, the best efficiency point is usually the boost speed, and it is not representative of real use. According to Task 3, the typical load profile of a cooking fume extractor use cycle is the following:

- time at minimum speed equal to 20 minutes;
- time at maximum speed equal to 30 minutes;
- time at boost equal to 10 minutes.

Manufacturers have developed a new method to take into account the different speeds in the AEC calculation. The so-called 9-point method is based on measurements at three different blower speeds and three different operating points representing common hydraulic loads in a real kitchen. The average of the three blower speeds is based on the same time profile shown by the user behaviour study.

Manufacturers provided the data of different models, measured using the current method and the 9-point method. The data allowed the conversion of the declared AEC of the base cases into a 9-point AEC method. The conversion factors used are shown in Table 49.

**Table 49: AEC of base cases based on current methodology and 9-point method**

| Base case | Conversion factor | AEC current (kWh) | AEC 9-point (kWh) |
|---|---|---|---|
| BC1 (cabinet) | 0.69 | 68.3 | 47.1 |
| BC2 (chimney) | 0.68 | 63.0 | 42.8 |

#### 5.1.3.5 Cooking fume extractors – end-of-life phase

Recycling of materials can avoid the extraction of raw materials and the production of virgin materials. This is modelled in the EcoReport tool as credits (avoided impacts), i.e. negative impacts.

For the product (stock) life, i.e. the period between when the cooking fume extractor is purchased and discarded, a lifetime of 15 years is assumed. It is the same as for the product service life, i.e. the period that the product is in use and operational. This assumption is made because consumers do not keep the old cooking fume extractor stocked after buying a new one.

As “unit sales L years ago” would correspond to the units sold in the year 2020 minus the product life, the resulting unit sales figures would be:

- 4.2 million units, for cooking fume extractors in 2005, of which 45% would be cabinet cooking fume extractors and 55% chimney cooking fume extractors.

The EcoReport tool requires input on the destination at the EoL of five fractions in mass: reuse, recycling (material), recovery (heat), incineration and landfill/missing/fugitive. Due to a lack of more specific data on the destination of the material fractions of cooking fume extractors, the default values of the EcoReport tool have not been changed.

## 5.2 Life cycle cost input data

### 5.2.1 Common input data

In the EcoReport tool, the Life Cycle Costs (LCC) are calculated according to the following formula:

$$LCC = PP + PWF * OE + EoL$$

Where:

- LCC is the Life Cycle Costs to end-users in EUR;
- PP is the purchase price (including installation costs) in EUR;
- OE is the annual operating expense in EUR;
- EoL is the end-of-life costs for end users (i.e. costs for disposal);
- PWF is the (Present Worth Factor).

$$\mathbf{PWF} = 1 - \left(\frac{1+e}{1+d}\right) \cdot \left[1 - \left(\frac{1+e}{1+d}\right)^N\right] \qquad (d \neq e)$$

Where:

- e is the aggregated annual growth rate of the operating expense ('escalation rate');
- d is the discount rate in %;
- N is the product life in years.

#### 5.2.1.1 Discount and escalation rate

To calculate the PWF, the discount rate (d) and the escalation rate (e) of the operating expenses have to be defined. For the discount rate (d = interest - inflation), COWI and VHK (2011b) recommend applying 4% (which is also the required discount rate of the impact assessment guidelines of the Commission).

The escalation rate (e = inflation corrected running cost price increase) shall be the weighted average of the different annual growth rates of the different elements of the operating expenses. COWI and VHK (2011b) suggest a default value of 4%.

Additionally, end users in Europe do not have separate costs for the disposal of household cooking appliances, so the EoL cost is zero.

### 5.2.2 Ovens – life cycle cost inputs

#### 5.2.2.1 Ovens – stock and sales data

For the calculation of the EU totals, data on the annual sales and the stock from Task 2 are taken into account.

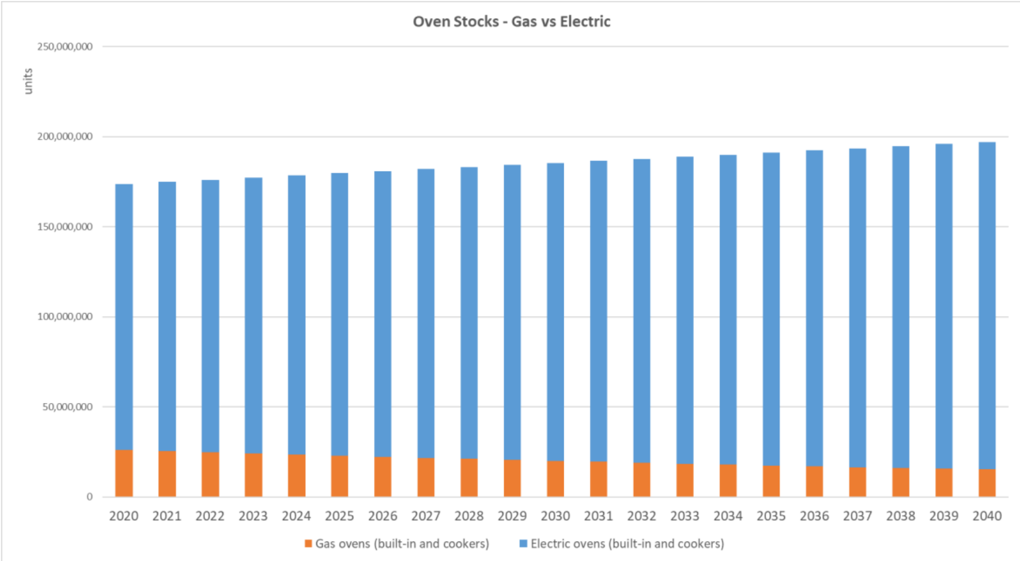



**Figure 169. Stock of ovens**

As seen in Figure 169, the stock of electric ovens (BC1) in 2020 is 147.6 million units, whereas the stock of gas cookers (BC2) is 26.0 million units. Considering a penetration rate of 75.3%, the stock of microwave ovens (BC3) was estimated as 145.0 million units.

#### 5.2.2.2 Ovens – product prices

As shown in Task 2 of this report, the average unit prices of electric ovens and gas cookers over the years 2015-2018 can be seen in Figure 170.

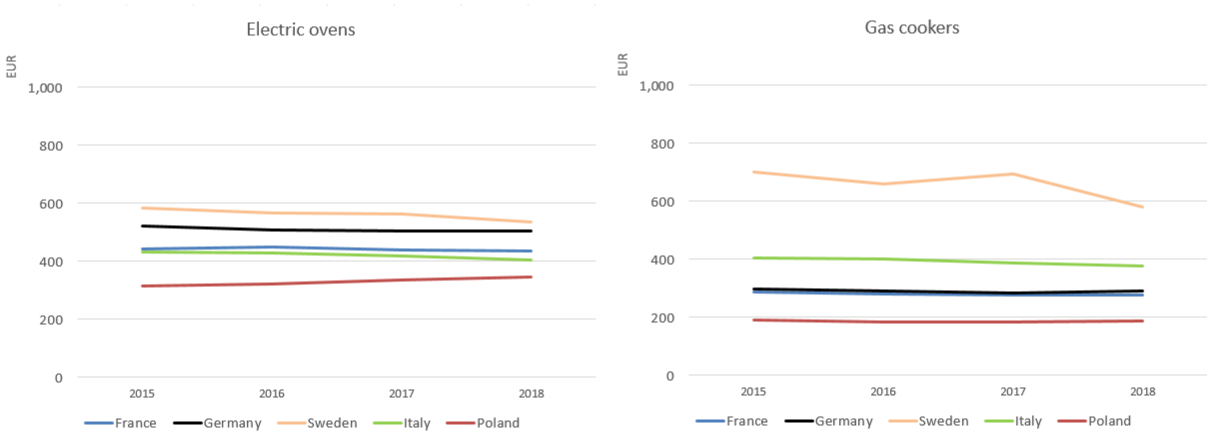



**Figure 170. Ovens – product prices**

The average price for the EU of BC1 is EUR 446, whereas for BC2 it is EUR 342. The average price of BC3 has been estimated as EUR 60.

#### 5.2.2.3 Ovens – maintenance and repair costs

Maintenance and repair costs are estimated for the three base cases according to their technical features and lifetime. The costs are based on the following parameters:

- The percentage that require repair once in their lifetime.
- The cost of the spare parts used in the repair, assumed as 1/10 of the price of the product.

- The labour costs, taking into account the dedicated time and the cost per hour, according to Task 2.

Installation costs are calculated based on the labour costs.

The results are shown in Table 50.

**Table 50. Maintenance and repair costs of ovens**

| | % requiring repair | Cost of spare parts (EUR) | Labour costs(1) (EUR) | Maintenance and repair cost (EUR) | Installation cost (EUR) |
|---|---|---|---|---|---|
| BC1 | 15 | 44.6 | 82.2 | 19.02 | 82 |
| BC2 | 15 | 34.2 | 82.2 | 17.46 | 82 |
| BC3(2) | 0 | 0 | 0 | 0 | 0 |

(1) Assuming 3 hours average.

(2) Assuming that MW ovens are not repaired due to the low cost of the product and the potentially high cost of spare parts.

#### 5.2.2.4 Ovens – ratio average new appliance vs stock

Finally, the ratio between the energy consumption of the average new product and the energy consumption of the average product installed ('stock') has to be derived. For the average product installed, data provided by APPLIA on 2012 models has been used, with an average energy consumption of 0.82 kWh/cycle in their best-performing mode. For the average new product, data from the TopTen database in 2019 has been used, with an average energy consumption of 0.65 kWh/cycle in their best-performing mode. With these numbers, the resulting ratio is 79%.

### 5.2.3 Hobs – life cycle cost inputs

#### 5.2.3.1 Hobs – stock and sales

For the calculation of the EU totals, data on the annual sales and the stock from Task 2 are taken into account.

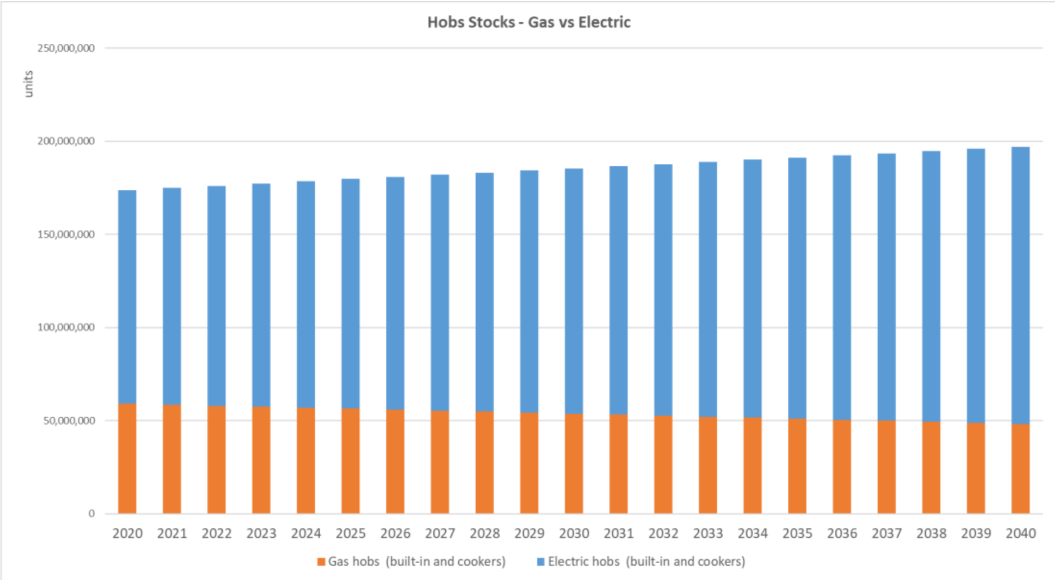



**Figure 171. Stock of hobs**

As seen in Figure 171, the stock of electric hobs (BC1) in 2020 is 114.6 million units, whereas the stock of gas hobs (BC2) is 59.0 million units. The sales in 2020 of radiant and induction hobs are estimated as 6.25 million units respectively. Gas hobs sales are estimated to be 1.81 million units.

#### 5.2.3.2 Hobs – product price

The retail prices of hobs are described under Task 2, and, as can be observed, there is a significant variation across EU countries, particularly for induction hobs (Figure 172).

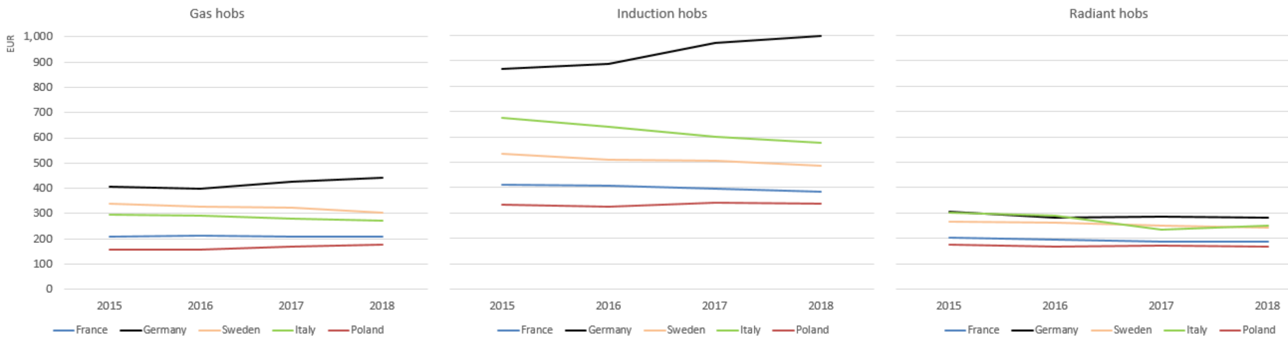



**Figure 172. Price of hobs by heating element**

An average value can be calculated, taking into account the units sold in each country, resulting in the following values for the year 2018:

- BC1 radiant hob: EUR 252.0;
- BC2 induction hob: EUR 535;
- BC3 gas hob (without glass surface): EUR 210.0.

#### 5.2.3.3 Hobs – installation, maintenance and repair costs

Maintenance and repair costs are estimated for the three base cases according to their technical features and lifetime. The costs are based on the following parameters:

- The percentage that require repair once in their lifetime.
- The cost of the spare parts used in the repair, assumed as 1/10 of the price of the product.

- The labour costs, taking into account the dedicated time and the cost per hour, according to Task 2.

Installation costs are calculated based on the labour costs. The results are shown in Table 51.

**Table 51: Maintenance and repair costs and installation costs for the base cases**

| | % requiring repair | Cost of spare parts (EUR) | Labour costs (average 3 hours) (EUR) | Maintenance and repair cost (EUR) | Installation cost (EUR) |
|---|---|---|---|---|---|
| Hobs BC1 | 15 | 23 | 82 | 15.8 | 82 |
| Hobs BC2 | 20 | 56 | 82 | 27.6 | 82 |
| Hobs BC3 | 10 | 28 | 82 | 11.0 | 82 |

These estimations rely heavily on assumptions that bring a wide range of uncertainty to the results. The impact of repairs has been analysed by means of a sensitivity analysis. In this study a higher and a lower repair rate is proposed as the effect would be similar to a higher or lower cost per repair respectively.

#### 5.2.3.4 Hobs – ratio average new appliance vs stock

Finally, the ratio between the energy consumption of the average new product and the energy consumption of the average product installed ('stock') has to be derived. The average product installed approximately equals the average new product a number of years ago.

For electric hobs, the ratio is assumed to be 0.92, based on the typical range of energy consumption per kg of water provided by manufacturers. For gas hobs, a ratio of 90% can be derived from the mandatory thresholds of energy efficiency set by Ecodesign measures.

### 5.2.4 Cooking fume extractors – life cycle cost inputs

#### 5.2.4.1 Cooking fume extractors – stock and sales data

For the calculation of the EU totals, data on the annual sales and the stock from Task 2 are taken into account.

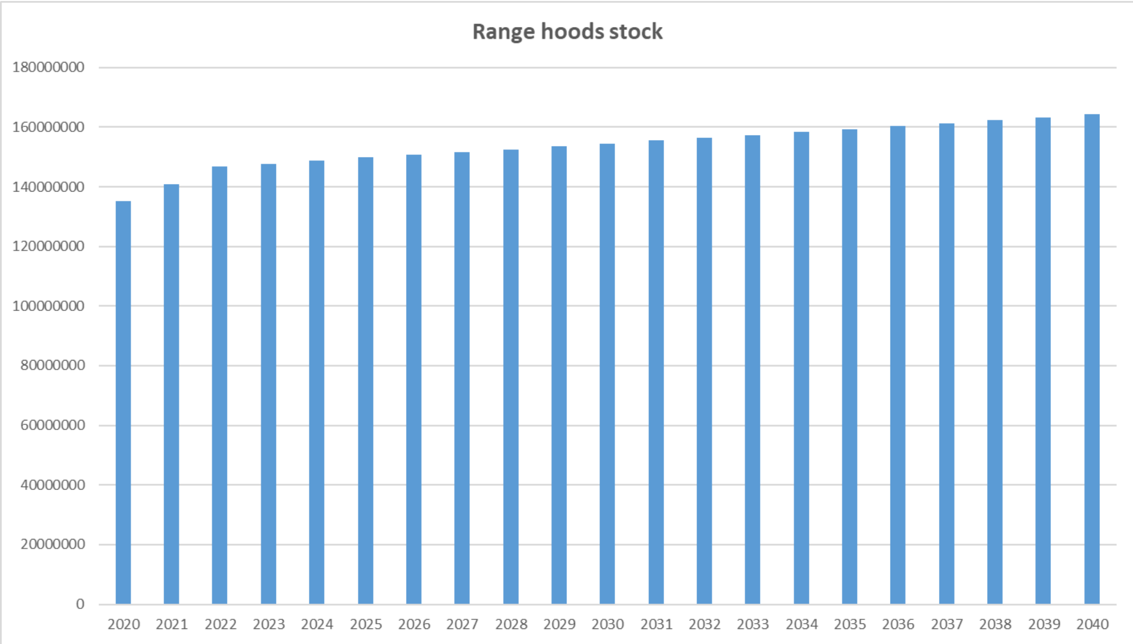



**Figure 173. Stock of cooking fume extractors**

As seen in Figure 173, the stock of cooking fume extractors in 2020 is 164.3 million units. According to the results of the user behaviour study, close to 40% of EU stock can be considered cooking fume extractors built into kitchen furniture and about one third have a stand-alone, wall-mounted cooking fume extractor. Ceiling-mounted cooking fume extractors are less frequent (16.4%). The latest innovation of a downdraft cooking fume extractor mounted at the height of the hob is found in about 8% of the kitchens. Since the two base cases chosen represent the EU stock, it is assumed that ceiling cooking fume extractors are within the same group as chimney cooking fume extractors (stand-alone cooking fume extractors) while downdraft extractors are meant to replace standard cabinet cooking fume extractors.

**Table 52. Assumptions on stock of cooking fume extractors**

| | Assumption | Share of the stock | Stock (2020) (in million units) |
|---|---|---|---|
| BC1 Cabinet | Cabinet and down-draft | 47.2% | 77.6 |
| BC2 Chimney | Wall-mounted and ceiling-mounted | 52.8% | 86.7 |

For sales, projections have been developed based on GfK and Euromonitor data, which result in a figure of estimated sales of 6.32 million units of cooking fume extractors. As explained in previous sections, the sales of chimney cooking fume extractors represent 55% of the market and the sales of cabinet cooking fume extractors 43%. It is assumed that 55% of sales are chimney cooking fume extractors and 45% cabinet cooking fume extractors.

#### 5.2.4.2 Cooking fume extractors – product prices

The retail prices of cooking fume extractors are described under Task 2. An average value can be calculated, taking into account the units sold in each country, resulting in the following values for the year 2018:

- BC1 cabinet: EUR 189.4;
- BC2 chimney: EUR 334.4.

#### 5.2.4.3 Cooking fume extractors – installation, maintenance and repair costs

Maintenance and repair costs are estimated for the three base cases according to their technical features and lifetime. The costs are based on the following parameters:

- The percentage that require repair once in their lifetime.
- The cost of the spare parts used in the repair, assumed as 1/10 of the price of the product.
- The labour costs, taking into account the dedicated time and the cost per hour, according to Task 2.

Installation costs are calculated based on the labour costs.

The results are shown in Table 53.

**Table 53: Maintenance and repair costs and installation costs for the base cases**

| | % requiring repair | Cost of spare parts | Labour costs (average 3 hours) (EUR) | Maintenance and repair cost (EUR) | Installation cost (EUR) |
|---|---|---|---|---|---|
| Cooking fume extractor BC1 | 15 | 18.9 | 82 | 15.1 | 82 |
| Cooking fume extractor BC2 | 15 | 33.4 | 82 | 17.3 | 82 |

These estimations rely heavily on assumptions that bring a wide range of uncertainty to the results. The impact of repairs has been analysed by means of a sensitivity analysis. In this study a higher and a lower repair rate is proposed as the effect would be similar to a higher or lower cost per repair respectively.

#### 5.2.4.4 Cooking fume extractors – ratio average new appliance vs stock

Finally, the ratio between the energy consumption of the average new product and the energy consumption of the average product installed ('stock') has to be derived. The average product installed approximately equals the average new product a number of years ago.

For cooking fume extractors, it is assumed that this new product would be an energy class lower than the base case currently considered. The ratio would be 0.85 for BC1 and 0.82 for BC2.

## 5.3 Environmental Impact Assessment of base cases

The environmental impacts have been calculated with the MEErP EcoReport tool and the data inputs presented in the previous section. This section shows the results of these calculations in the MEErP format for:

- raw materials use and manufacturing;
- distribution;
- use phase, taking User behaviour approach 2, described above;
- end-of-life phase.

### 5.3.1 Environmental Impact Assessment of ovens

#### 5.3.1.1 Base Case 1: Electric ovens

Table 54 shows the material consumption of an electric oven over the whole life cycle of 15 years. The material consumption during the production equals the input values of the bill of materials. The materials consumed during the use phase correspond to the materials consumed for maintenance and repair of the bill of materials. The material consumption during the end-of-life phase is split into disposal, recycling and the stock. The latter value results from the effect that the mass discarded seldom equals the mass of new products sold.

**Table 54. Material consumption of BC1 ovens**

| Resources Use | | Production | Distribution | Use | End of Life-Disposal | End of Life-Recycling | End of Life-Stock |
|---|---|---|---|---|---|---|---|
| Bulk Plastics | [g] | 250.8 | 0.0 | 2.5 | 98.8 | 80.8 | 73.7 |
| TecPlastics | [g] | 583.3 | 0.0 | 5.8 | 229.7 | 188.0 | 171.5 |
| Ferro | [g] | 30105.6 | 0.0 | 301.1 | 1077.9 | 20479.6 | 8849.2 |
| Non-ferro | [g] | 1859.6 | 0.0 | 18.6 | 66.6 | 1265.0 | 546.6 |
| Coating | [g] | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Electronics | [g] | 162.0 | 0.0 | 1.6 | 56.9 | 59.2 | 47.6 |
| Misc. | [g] | 7038.6 | 0.0 | 70.4 | 1713.6 | 3326.5 | 2068.9 |
| Extra | [g] | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Auxiliaries | [g] | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Refrigerant | [g] | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Total weight | [g] | 40000.0 | 0.0 | 400.0 | 3243.4 | 25399.0 | 11757.6 |

Table 55 shows the environmental impacts of an electric oven over the whole life cycle of 15 years. The results are also shown in Figure 174 in terms of the relative contributions (%) of each life cycle phase (i.e. manufacturing, distribution, use and end of life) to the overall results. The results are presented for each impact category as the sum of the contributions (%) of all the phases in absolute values summing up to 100%. Negative values in the end-of-life phase represent credits, i.e. avoided impacts.

**Table 55. Environmental impact of BC1 ovens**

| Life Cycle Phase | | Production | | | Distribution | Use | End-of-Life | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Material | Manuf. | Total | | | Disposal | Recycling | Stock | |
| Resources & Waste | | | | | | | | | | |
| Total Energy (GER) | [MJ] | 2467.2 | 537.6 | 3004.8 | 429.6 | 18279.8 | 13.0 | -627.3 | | 21099.9 |
| of which, electricity (in primary MJ) | [MJ] | 491.7 | 307.7 | 799.4 | 0.8 | 21737.2 | 0.0 | -108.5 | | 22428.8 |
| Water (process) | [l] | 2186.1 | 4.1 | 2190.2 | 0.0 | 21.9 | 0.0 | -580.8 | | 1631.3 |
| Water (cooling) | [l] | 530.6 | 129.0 | 659.7 | 0.0 | 971.2 | 0.0 | -97.9 | | 1533.0 |
| Waste, non-haz./ landfill | [g] | 30495.6 | 2674.8 | 33170.4 | 265.6 | 11504.3 | 269.1 | -8205.0 | | 37004.5 |
| Waste, hazardous/ incinerated | [g] | 16.3 | 0.4 | 16.8 | 5.3 | 343.1 | 0.0 | -2.2 | | 362.9 |
| Emissions (Air) | | | | | | | | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Greenhouse Gases in GWP100 | [kg $CO_2$ eq.] | 211.2 | 30.8 | 242.0 | 28.8 | 425.7 | 0.1 | -55.2 | | 641.3 |
| Acidification, emissions | [g $SO_2$ eq.] | 2107.7 | 133.6 | 2241.4 | 87.1 | 4126.1 | 1.1 | -558.6 | | 5896.9 |
| Volatile Organic Compounds (VOCs) | [g] | 5.2 | 0.6 | 5.8 | 5.6 | 485.4 | 0.0 | -1.3 | | 495.6 |
| Persistent Organic Pollutants (POP) | [ng i-Teq] | 260.9 | 74.8 | 335.6 | 1.5 | 53.3 | 0.1 | -70.8 | | 319.7 |
| Heavy Metals | [mg Ni eq.] | 4161.6 | 173.6 | 4335.2 | 13.5 | 261.4 | 3.0 | -1130.2 | | 3482.9 |
| PAHs | [mg Ni eq.] | 111.5 | 0.2 | 111.7 | 14.5 | 51.8 | 0.0 | -29.1 | | 148.9 |
| Particulate Matter (PM, dust) | [g] | 253.0 | 20.3 | 273.3 | 909.9 | 89.5 | 1.2 | -66.8 | | 1207.1 |
| Emissions (Water) | | | | | | | | | | |
| Heavy Metals | [mg Hg/20] | 2605.8 | 5.6 | 2611.5 | 0.4 | 119.6 | 0.7 | -694.5 | | 2037.7 |
| Eutrophication | [g PO4] | 68.5 | 0.2 | 68.7 | 0.0 | 4.8 | 1.3 | -18.0 | | 56.8 |

From the analysis of emissions to air (Figure 174), it can be seen that the use of the oven is the most significant stage in three impact categories: Greenhouse gases (GHG), Acidification and Volatile Organic Compounds (VOCs). This is related to product characteristics in terms of materials: predominance of ferromagnetic materials (75%) and glass (14%), and a low amount of plastics (1.5%) and electronics (0.4%).

On the other hand, for other impact categories such as Persistent Organic Pollutants (POP), Heavy metals (HM) and Polycyclic Aromatic Hydrocarbons (PAHs), the most significant life cycle stage is production (including both the materials used and the manufacturing of the product). In contrast with all of the above, product distribution is the most significant stage for the impact category Particulate matter (PM).

Credits (negative impact) are obtained thanks to the recovery of materials at end of life. The impact categories most benefited from these credits are HM, POP and PAHs.

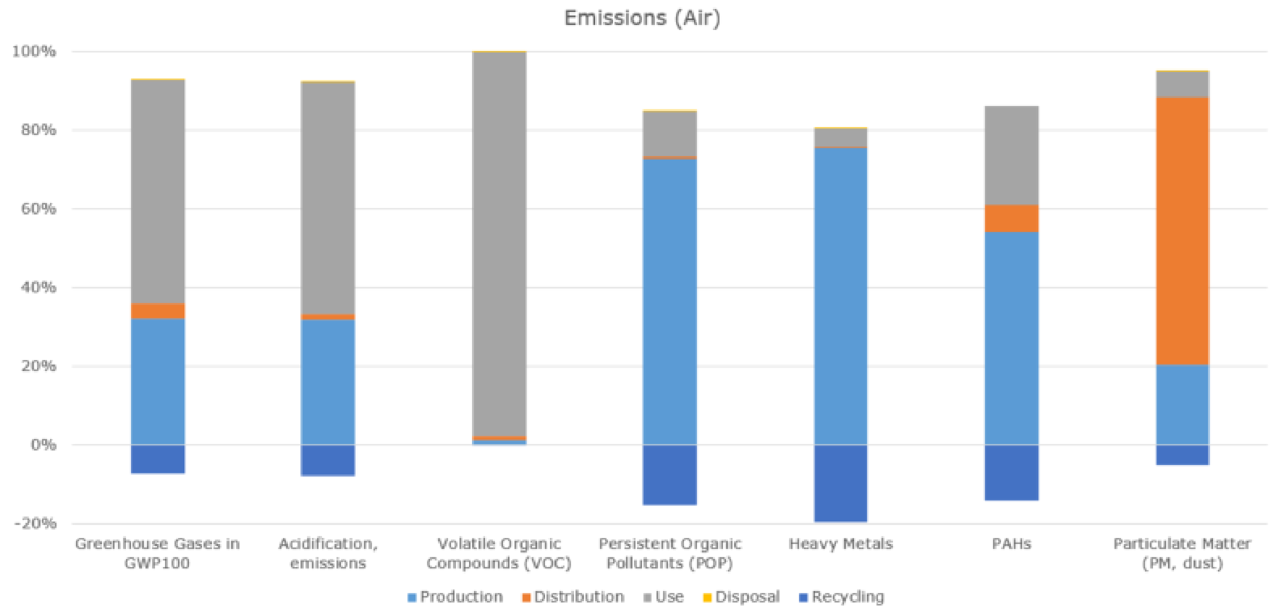



**Figure 174. Impact of air emissions of BC1 ovens**

From the analysis of other resources and waste (Figure 175), it can be seen that the use stage is again the most significant phase for energy, water (cooling) and hazardous waste sent to incineration. It appears reasonable that the use stage is the most significant for the energy category, since an electric oven is a product with a relatively simple manufacturing process but a significant energy consumption. Meanwhile, for water related to the production process and non-hazardous waste, the most significant life cycle stage is production (including materials and manufacturing).

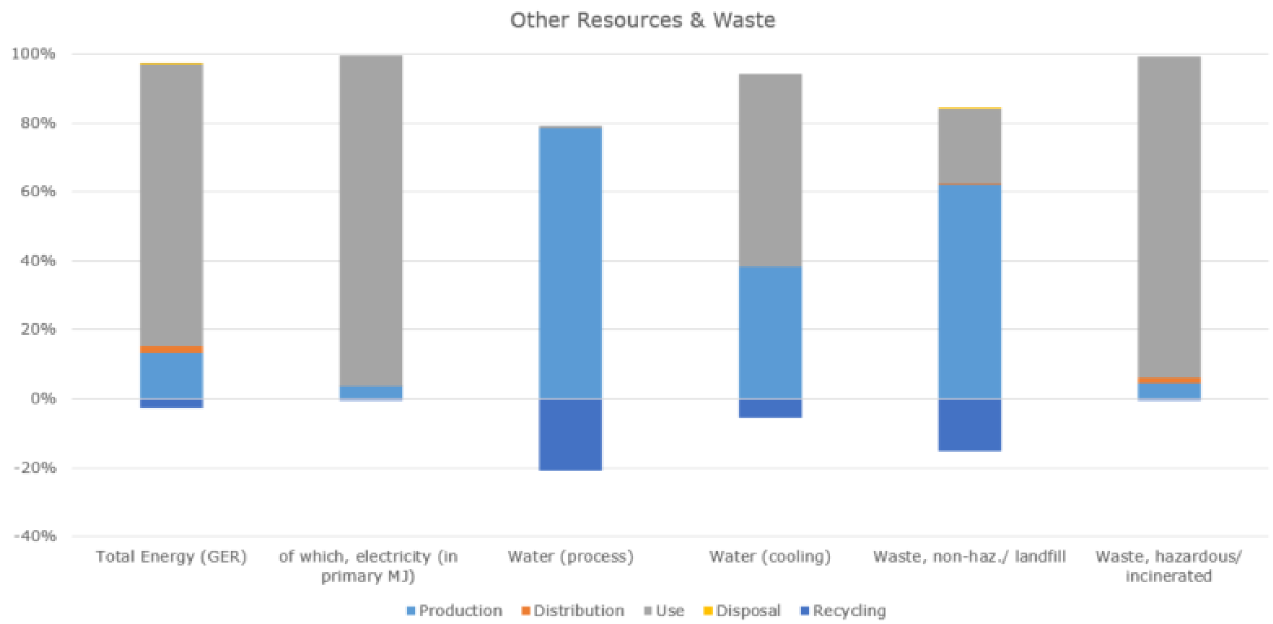



**Figure 175. Impact of other resources & waste of BC1 ovens**

From the analysis of emissions to water (Figure 176), it can be seen that the most significant life cycle stage for both impact categories (Heavy Metals and Eutrophication) is production. Again, this is coherent with the product characteristics (an oven does not consume water during its use).

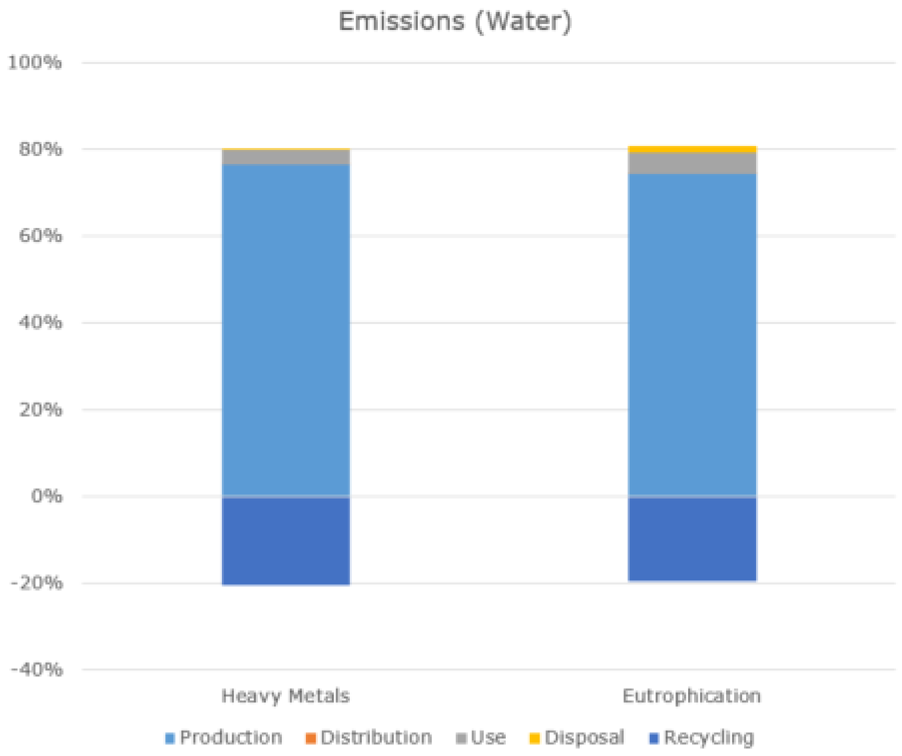



**Figure 176. Impact of emissions to water of BC1 ovens**

#### 5.3.1.2 Base Case 2: Free-standing gas cookers

Table 56 shows the material consumption of a free-standing gas cooker over the whole life cycle of 15 years.

**Table 56. Material consumption of BC2 ovens**

| Resources Use | | Production | Distribution | Use | End of Life-Disposal | End of Life-Recycling | End of Life-Stock |
|---|---|---|---|---|---|---|---|
| Bulk Plastics | [g] | 65.0 | | 0.6 | 71.2 | 58.2 | -63.8 |
| TecPlastics | [g] | 2172.2 | | 21.7 | 2379.0 | 1946.5 | -2131.6 |
| Ferro | [g] | 34730.5 | | 347.3 | 3457.9 | 65700.6 | -34080.7 |
| Non-ferro | [g] | 2974.3 | | 29.7 | 296.1 | 5626.5 | -2918.6 |
| Coating | [g] | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 |
| Electronics | [g] | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 |
| Misc. | [g] | 5058.1 | | 50.6 | 3424.5 | 6647.6 | -4963.4 |
| Extra | [g] | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 |
| Auxiliaries | [g] | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 |
| Refrigerant | [g] | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 |
| Total weight | [g] | 45000.0 | | 450.0 | 9628.8 | 79979.4 | -44158.1 |

Table 57 shows the environmental impacts of a free-standing gas cooker over the whole life cycle of 15 years. The results are also shown in Figure 177 in terms of the relative contributions (%) of each life cycle phase (i.e. manufacturing, distribution, use and end of life) to the overall results. The results are presented for each impact category as the sum of the contributions (%) of all the phases in absolute values summing up to 100%. Negative values in the end-of-life phase represent credits, i.e. avoided impacts.

**Table 57. Environmental impact of BC2 ovens**

| | | Production | | | Distribution | Use | End-of-Life | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Material | Manuf. | Production | | Use | End of Life - Disposal | End of Life - Recycling | Stock | |
| Other Resources & Waste | | | | | | | | | | |
| Total Energy (GER) | [MJ] | 2481.2 | 415.9 | 2897.1 | 429.6 | 20136.1 | 40.4 | -1728.3 | | 21775.0 |
| of which, electricity (in primary MJ) | [MJ] | 308.0 | 240.4 | 548.5 | 0.8 | 594.4 | 0.0 | -199.7 | | 943.8 |
| Water (process) | [l] | 1836.2 | 3.3 | 1839.5 | 0.0 | 18.4 | 0.0 | -1311.7 | | 546.2 |
| Water (cooling) | [l] | 1006.3 | 103.4 | 1109.7 | 0.0 | 36.3 | 0.0 | -398.0 | | 748.0 |
| Waste, non-haz./ landfill | [g] | 54263.3 | 1920.9 | 56184.2 | 265.6 | 847.3 | 1332.6 | -40609.1 | | 18020.7 |
| Waste, hazardous/ incinerated | [g] | 29.9 | 0.3 | 30.2 | 5.3 | 9.6 | 0.0 | -10.2 | | 34.9 |
| Emissions (Air) | | | | | | | | | | |
| Greenhouse Gases in GWP100 | [kg $CO_2$ eq.] | 198.8 | 23.7 | 222.5 | 28.8 | 1098.0 | 0.2 | -144.1 | | 1205.3 |
| Acidification, emissions | [g $SO_2$ eq.] | 1436.0 | 102.6 | 1538.7 | 87.1 | 441.9 | 2.4 | -1039.9 | | 1030.1 |
| Volatile Organic Compounds (VOCs) | [g] | 33.0 | 0.4 | 33.4 | 5.6 | 27.8 | 0.0 | -18.6 | | 48.2 |
| Persistent Organic Pollutants (POP) | [ng i-Teq] | 734.7 | 46.6 | 781.3 | 1.5 | 8.7 | 0.6 | -555.5 | | 236.7 |
| Heavy Metals | [mg Ni eq.] | 3053.6 | 108.3 | 3161.9 | 13.5 | 36.5 | 6.4 | -2301.8 | | 916.4 |
| PAHs | [mg Ni eq.] | 85.1 | 0.1 | 85.3 | 14.5 | 2.8 | 0.0 | -63.6 | | 39.0 |
| Particulate Matter (PM, dust) | [g] | 1135.2 | 15.7 | 1150.9 | 909.9 | 19.2 | 57.4 | -640.8 | | 1496.6 |
| Emissions (Water) | | | | | | | | | | |
| Heavy Metals | [mg Hg/20] | 1802.9 | 3.5 | 1806.4 | 0.4 | 20.6 | 1.9 | -1297.6 | | 531.6 |
| Eutrophication | [g PO4] | 53.9 | 0.2 | 54.1 | 0.0 | 0.7 | 5.0 | -36.4 | | 23.4 |

From the analysis of emissions to air (Figure 177), it can be seen that the use of the gas cooker is the most significant stage in one impact category: Greenhouse gases (GHG). As in the case of electric ovens, this is coherent with the product characteristics in terms of material: predominance of ferromagnetic materials (77%) and glass (11%), and a low amount of plastics (5%) and absence of electronics.

On the other hand, for the rest of impact categories (Acidification, Volatile Organic Compounds (VOCs), Persistent Organic Pollutants (POP), Heavy metals (HM), PAHs and Particulate Matter), the most significant life cycle stage is production (including both the materials used and the manufacturing of the product). In contrast with all of the above, and as was the case for electric ovens, product distribution has a significant impact for the category Particulate matter (PM) in the case of gas cookers. Credits (negative impact) are obtained thanks to the recovery of materials at end of life. The impact categories most benefited from these credits are ACD, HM, POP and PAHs.

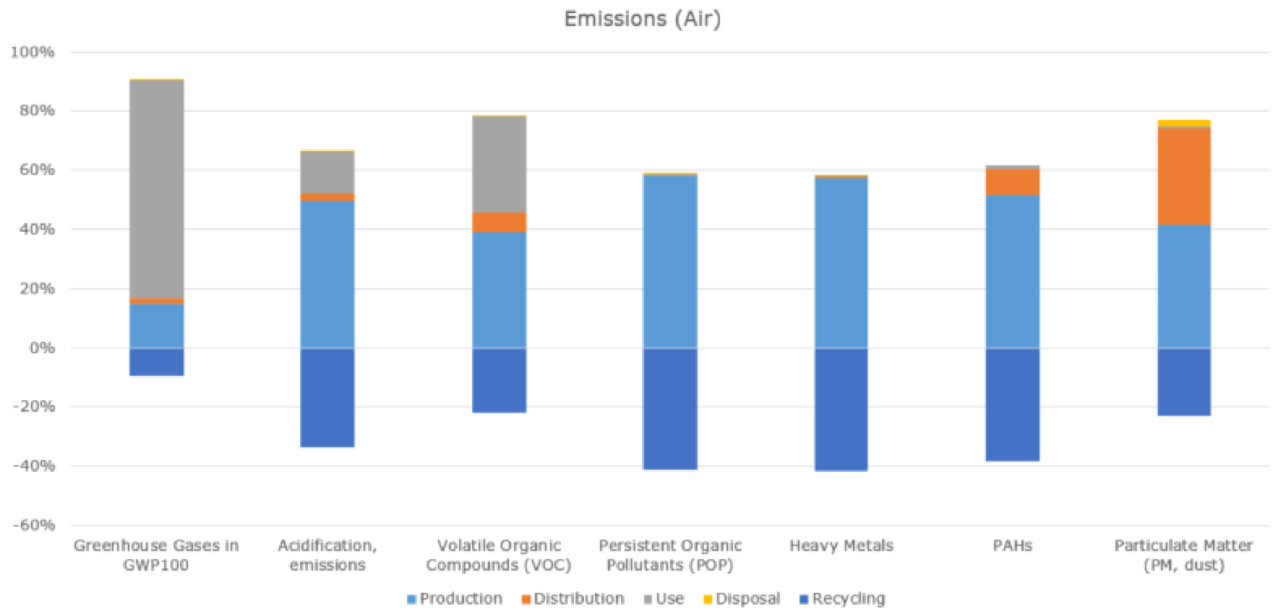



**Figure 177. Impact of emissions to air of BC2 ovens**

From the analysis of other resources and waste (Figure 178), it can be seen that the use stage is again the most significant phase for energy, again coherent with product characteristics, since a gas cooker is a product with a relatively simple manufacturing process but a significant energy consumption. Meanwhile, for water (both related to the production process and for cooling, and for waste (hazardous and non-hazardous), the most significant life cycle stage is production (including materials and manufacturing).

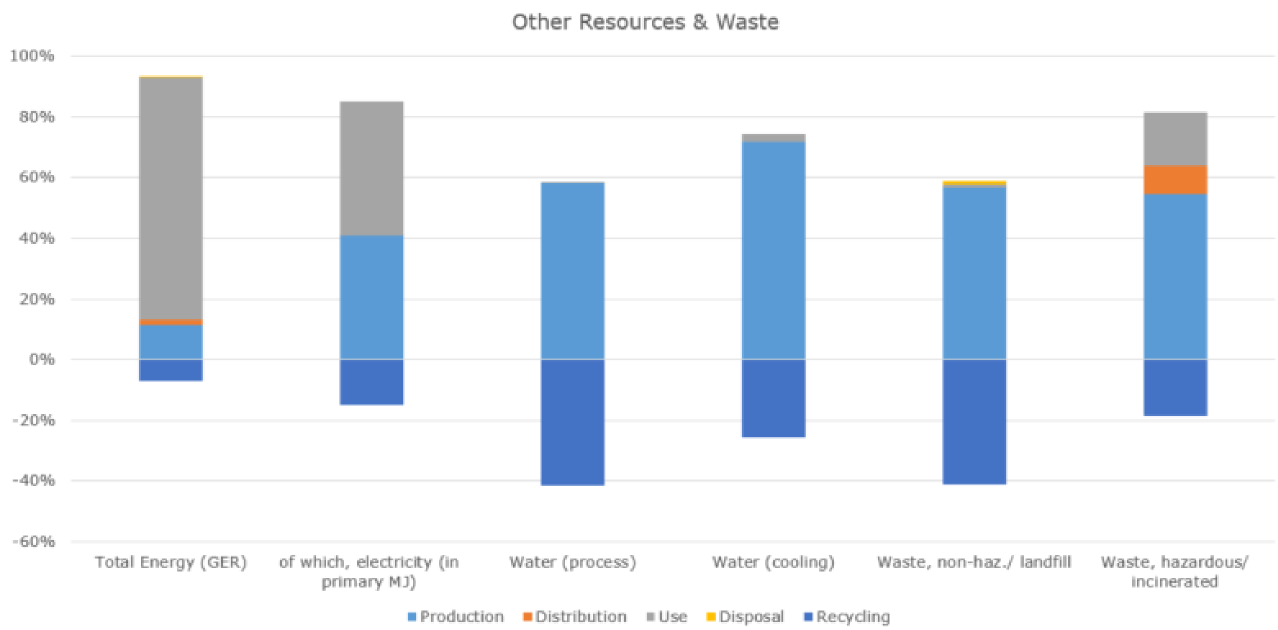



**Figure 178. Impact of other resources & waste of BC2 ovens**

From the analysis of emissions to water (Figure 179), it can be seen that the most significant life cycle stage for both impact categories (Heavy Metals and Eutrophication) is production. Again, this is coherent with the product characteristics (a gas cooker does not consume water during its use).

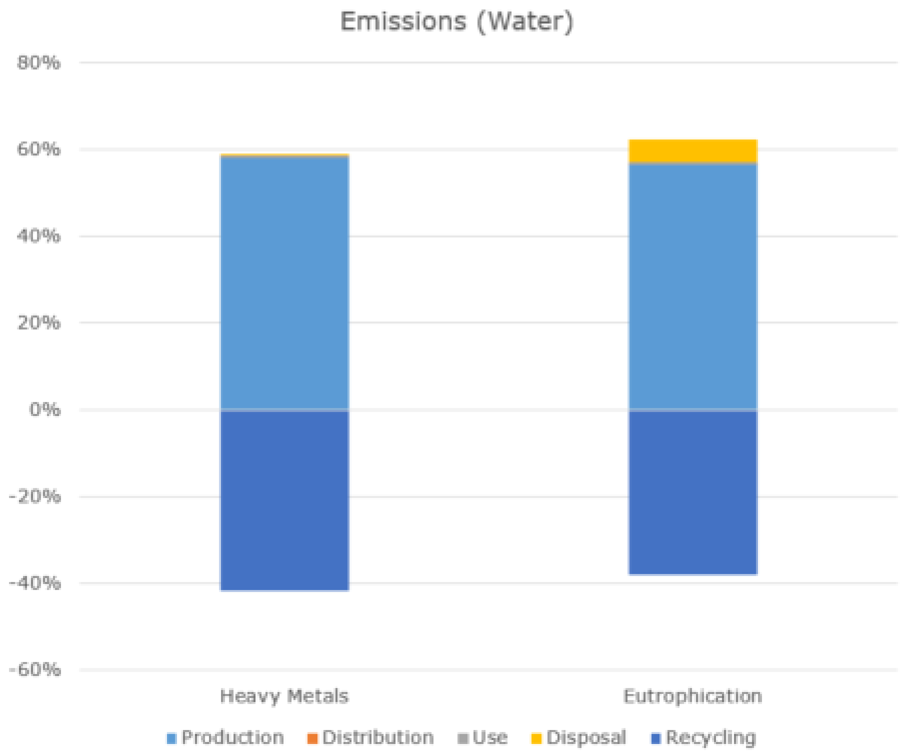



**Figure 179. Impact of emissions to water of BC2 ovens**

#### 5.3.1.3 Base Case 3: Microwave ovens

Table 58 shows the material consumption of a microwave oven over the whole life cycle of 15 years.

**Table 58. Material consumption of BC3 ovens**

| Resources Use | | Production | Distribution | Use | End of Life-Disposal | End of Life-Recycling | End of Life-Stock |
|---|---|---|---|---|---|---|---|
| Bulk Plastics | [g] | 1077.4 | | 10.8 | 487.5 | 398.9 | 201.8 |
| TecPlastics | [g] | 41.0 | | 0.4 | 18.6 | 15.2 | 7.7 |
| Ferro | [g] | 6977.8 | | 69.8 | 287.0 | 5453.6 | 1307.0 |
| Non-ferro | [g] | 2339.6 | | 23.4 | 96.2 | 1828.5 | 438.2 |
| Coating | [g] | 216.0 | | 2.2 | 8.9 | 168.8 | 40.5 |
| Electronics | [g] | 510.0 | | 5.1 | 205.6 | 214.0 | 95.5 |
| Misc. | [g] | 2361.2 | | 23.6 | 660.5 | 1282.1 | 442.3 |
| Extra | [g] | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 |
| Auxiliaries | [g] | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 |
| Refrigerant | [g] | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 |
| Total weight | [g] | 13523.0 | | 135.2 | 1764.3 | 9361.0 | 2533.0 |

Table 59 shows the environmental impacts of a microwave oven over the whole life cycle of 15 years. The results are also shown in Figure 180 in terms of the relative contributions (%) of each life cycle phase (i.e. manufacturing, distribution, use and end of life) to the overall results. The results are presented for each impact category as the sum of the contributions (%) of all the phases in absolute values summing up to 100%. Negative values in the end-of-life phase represent credits, i.e. avoided impacts.

**Table 59. Environmental impact of BC3 ovens**

| | | Production | | | Distribution | Use | End-of-Life | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Material | Manuf. | Production | | Use | End of Life - Disposal | End of Life - Recycling | Stock | |
| Other Resources & Waste | | | | | | | | | | |
| Total Energy (GER) | [MJ] | 1234.7 | 192.9 | 1427.6 | 220.8 | 2578.6 | 16.7 | -299.3 | | 3944.5 |
| of which, electricity (in primary MJ) | [MJ] | 340.5 | 99.8 | 440.3 | 0.3 | 3058.5 | 0.0 | -62.2 | | 3436.8 |
| Water (process) | [l] | 151.7 | 3.4 | 155.1 | 0.0 | 1.5 | 0.0 | -39.7 | | 116.8 |
| Water (cooling) | [l] | 268.0 | 48.8 | 316.8 | 0.0 | 138.5 | 0.0 | -42.4 | | 412.8 |
| Waste, non-haz./ landfill | [g] | 14939.6 | 802.4 | 15742.0 | 161.3 | 1723.8 | 157.3 | -4571.4 | | 13212.9 |
| Waste, hazardous/ incinerated | [g] | 29.8 | 0.8 | 30.6 | 3.2 | 48.5 | 0.0 | -5.3 | | 77.0 |
| Emissions (Air) | | | | | | | | | | |
| Greenhouse Gases in GWP100 | [kg $CO_2$ eq.] | 73.8 | 11.3 | 85.0 | 15.5 | 60.3 | 0.1 | -18.5 | | 142.4 |
| Acidification, emissions | [g $SO_2$ eq.] | 957.6 | 50.5 | 1008.1 | 46.4 | 586.6 | 1.0 | -270.6 | | 1371.6 |
| Volatile Organic Compounds (VOCs) | [g] | 3.6 | 0.5 | 4.1 | 2.0 | 68.3 | 0.0 | -0.8 | | 73.6 |
| Persistent Organic Pollutants (POP) | [ng i-Teq] | 226.3 | 18.6 | 244.9 | 0.9 | 9.4 | 0.1 | -70.3 | | 185.0 |
| Heavy Metals | [mg Ni eq.] | 260.2 | 43.5 | 303.7 | 8.2 | 33.5 | 0.4 | -77.6 | | 268.2 |
| PAHs | [mg Ni eq.] | 89.3 | 0.6 | 89.9 | 6.8 | 8.0 | 0.0 | -14.8 | | 89.9 |
| Particulate Matter (PM, dust) | [g] | 50.4 | 9.0 | 59.4 | 315.1 | 12.7 | 0.7 | -13.0 | | 375.0 |
| Emissions (Water) | | | | | | | | | | |
| Heavy Metals | [mg Hg/20] | 168.7 | 1.4 | 170.1 | 0.3 | 14.8 | 0.3 | -34.3 | | 151.2 |
| Eutrophication | [g PO4] | 5.3 | 0.2 | 5.4 | 0.0 | 0.6 | 0.3 | -1.3 | | 5.1 |

From the analysis of emissions to air (Figure 180), it can be seen that the use of the microwave is the most significant stage in one impact category: Volatile Organic Compounds (VOCs). As in the case of electric ovens, this is coherent with the product characteristics in terms of materials: a relatively light product, with predominance of ferromagnetic materials (51%), copper (16%), glass and plastics (8% each), and a certain amount of electronics (4%).

On the other hand, for other impact categories such as Greenhouse Gases, Acidification, Persistent Organic Pollutants (POP), Heavy metals (HM) and PAHs, the most significant life cycle stage is production (including both the materials used and the manufacturing of the product). Product distribution is a very significant stage for the impact category Particulate matter (PM) in the case of microwave ovens, with a similar contribution to the production stage.

Credits (negative impact) are obtained thanks to the recovery of materials at end of life. The impact categories most benefited from these credits are POP, HMs, Acidification and PAHs.

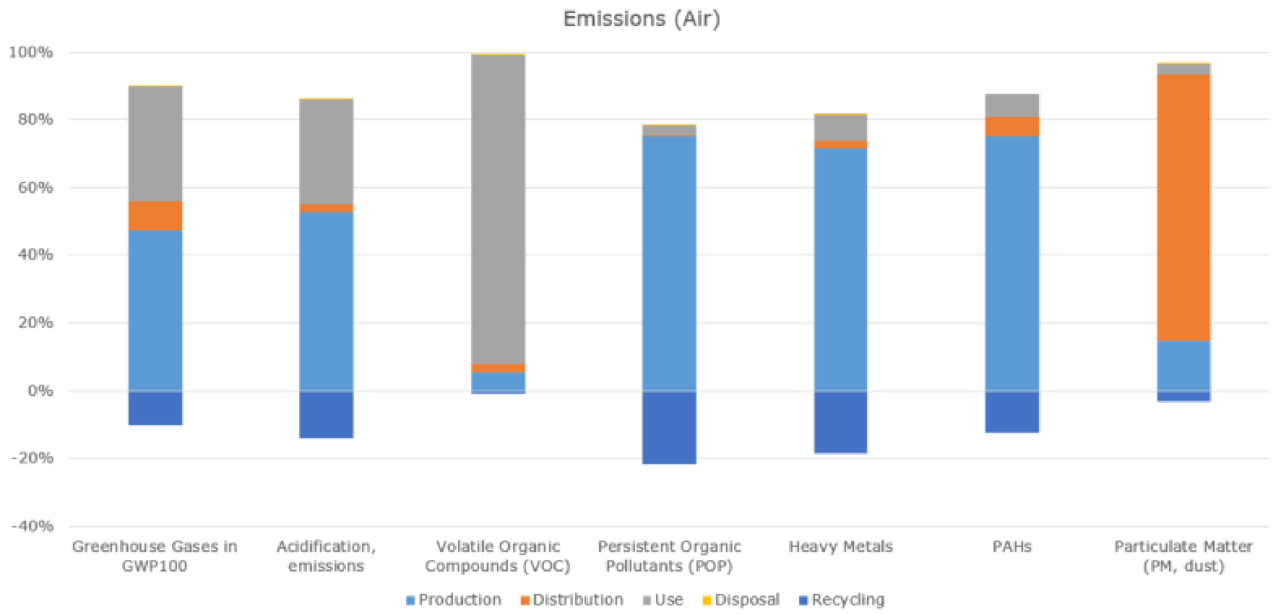



**Figure 180. Impact of emissions to air of BC3 ovens**

From the analysis of other resources and waste (Figure 181), it can be seen that the use stage is again the most significant phase for energy, again coherent with product characteristics, since a microwave oven is a product with a relatively simple manufacturing process but a significant energy consumption. Meanwhile, for water (both related to the production process and for cooling, and for waste (hazardous and non-hazardous), the most significant life cycle stage is production (including materials and manufacturing).

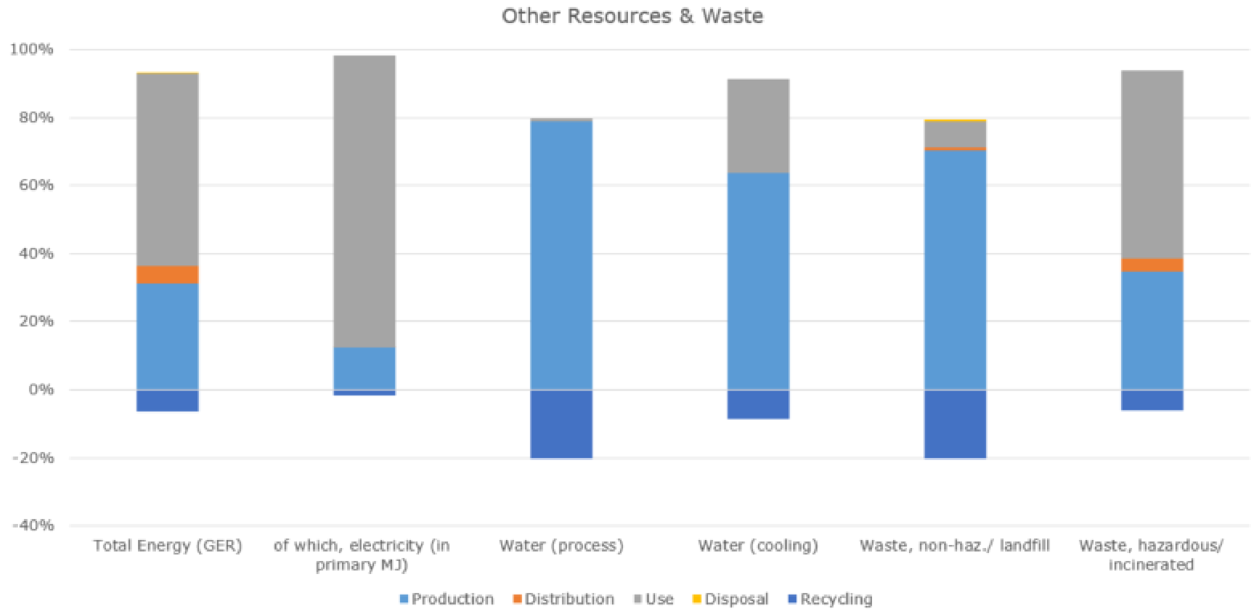



**Figure 181. Impact of other resources & waste of BC3 ovens**

From the analysis of emissions to water (Figure 182), it can be seen that the most significant life cycle stage for both impact categories (Heavy Metals and Eutrophication) is production. Again, this is coherent with the product characteristics (a microwave oven does not consume water during its use).

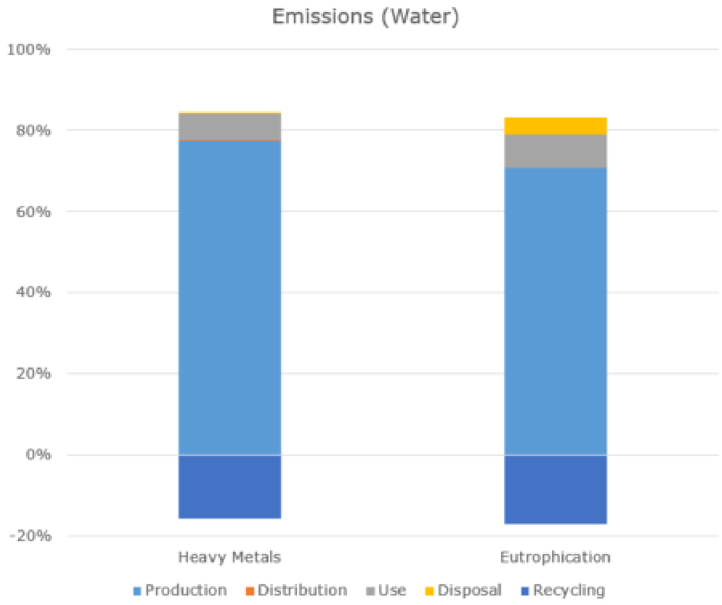



**Figure 182. Impact of emissions to water of BC3 ovens**

#### 5.3.1.4 Analysis of pyrolytic function

In this section, a brief analysis of the effect of the pyrolytic cleaning function will be conducted, to understand how significant its contribution to impact categories such as Global Warming Potential (GWP) or Total Energy is. It has been assumed that this function is only available in an electric oven.

According to the ECUEL Project (1999), pyrolytic cleaning has an average consumption of 3.49 kWh/cycle. The analysis of the responses of the user behaviour presented in Task 3 suggests that this function is operated an average of 0.12 times/week, or around 6 times/year. Based on this, it can be assumed that the total energy consumption of pyrolytic cleaning is 20.94 kWh/year.

Figure 183 shows the life cycle impact on GWP and Total Energy of an electric oven with and without use of the pyrolytic function.

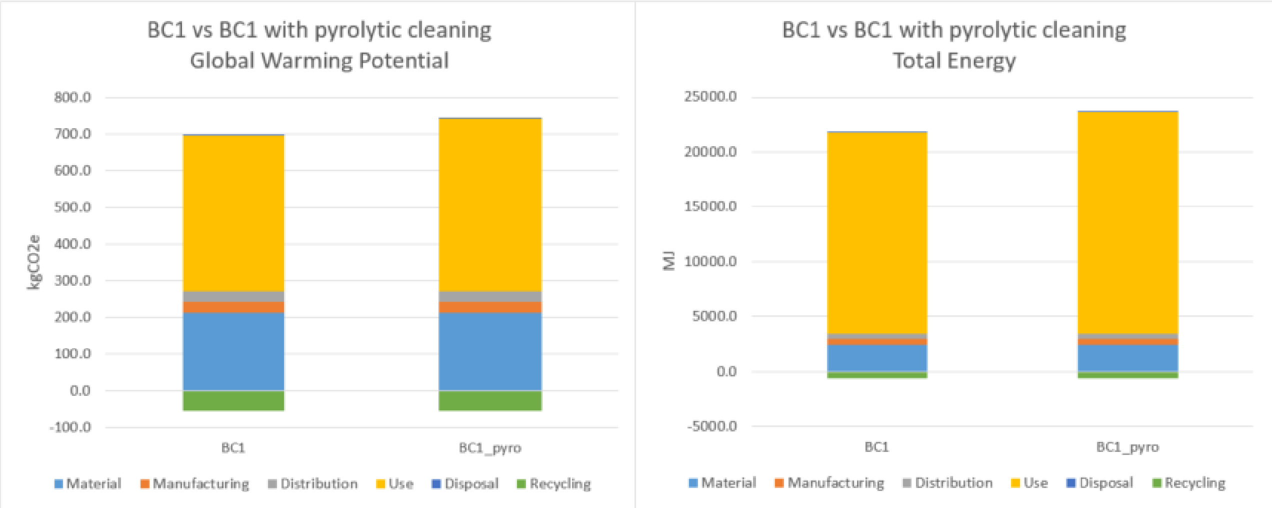



**Figure 183. Analysis of the impact of the pyrolytic function**

In both impact categories evaluated, the use stage is the one affected by the additional energy consumption of the pyrolytic function, with a growth of 11%. This represents a total growth of the life cycle impact attributable to the pyrolytic function of 9%.

#### 5.3.1.5 Environmental impact assessment of EU totals for ovens

Table 60 shows the environmental impacts of all new electric ovens and gas cookers (sales) produced in 2020 over their lifetime, and the impact of the stock on that year.

**Table 60. Environmental impact of ovens – EU totals**

| | Sales 2020 | | | Stock 2020 | | |
|---|---|---|---|---|---|---|
| | BC1 | BC2 | BC3 | BC1 | BC2 | BC3 |
| Greenhouse Gases in GWP100 [Mt CO2 eq.] | 4.9 | 0.5 | 1.1 | 94.7 | 31.4 | 21.0 |
| Acidification, emissions [kt $SO_2$ eq.] | 44.7 | 0.4 | 10.4 | 870.5 | 26.8 | 202.5 |
| Volatile Organic Compounds (VOCs) [kt] | 3.8 | 0.0 | 0.6 | 73.2 | 1.3 | 10.9 |
| Persistent Organic Pollutants (POP) [kg i-Teq] | 2.4 | 0.1 | 1.4 | 47.2 | 6.2 | 27.3 |
| Heavy Metals [t Ni eq.] | 26.4 | 0.4 | 2.0 | 514.1 | 23.9 | 39.6 |
| PAHs [t Ni eq.] | 1.1 | 0.0 | 0.7 | 22.0 | 1.0 | 13.3 |
| Particulate Matter (PM, dust) [kt] | 9.1 | 0.6 | 2.8 | 178.2 | 39.0 | 55.4 |
| Total Energy (GER) [PJ] | 159.9 | 8.4 | 29.9 | 3114.7 | 567.0 | 582.3 |

### 5.3.2 Environmental impact assessment of hobs

The environmental impacts have been calculated with the MEErP EcoReport tool and the data inputs presented in the previous section. This section shows the results of these calculations in the MEErP format for

- raw materials use and manufacturing;

- distribution;
- use phase;
- end-of-life phase.

#### 5.3.2.1 Base Case 1: Radiant hobs

Table 61 shows the material consumption of a radiant hob over the whole life cycle of 15 years. The material consumption during the production equals the input values of the bill of materials. The materials consumed during the use phase correspond to the materials consumed for maintenance and repair which account for 1% of the bill of materials. The material consumption during the end-of-life phase is split into disposal, recycling and the stock. The latter value results from the effect that the mass discarded seldom equals the mass of new products sold.

**Table 61: Life cycle material consumption of a radiant hob**

| Life Cycle phases --> | | Production | Distribution | Use phase | End-of-Life | | |
|---|---|---|---|---|---|---|---|
| **Material** | Unit | | | | **Disposal** | **Recycling** | **Stock** |
| Bulk Plastics | g | **253** | | **3** | 361 | 295 | -400 |
| TecPlastics | g | **283** | | **3** | 403 | 330 | -448 |
| Ferro | g | **1,769** | | **18** | 229 | 4,357 | -2,799 |
| Non-ferro | g | **182** | | **2** | 24 | 448 | -288 |
| Coating | g | **0** | | **0** | 0 | 0 | 0 |
| Electronics | g | **266** | | **3** | 338 | 352 | -421 |
| Misc. | g | **5,512** | | **55** | 11,145 | 3,144 | -8,722 |
| Extra | g | **0** | | **0** | 0 | 0 | 0 |
| Auxiliaries | g | **0** | | **0** | 0 | 0 | 0 |
| Refrigerant | g | **0** | | **0** | 0 | 0 | 0 |
| **Total weight** | g | **8,265** | | **83** | 12,500 | 8,925 | -13,078 |

Table 62 shows the environmental impacts of a radiant hob over the whole life cycle of 15 years under the conditions explained in Section 5.1.1.4.

The results are also shown in Figure 184, Figure 185 and Figure 186 in terms of the relative contributions (%) of each life cycle phase (i.e. manufacturing, distribution, use and end of life) to the overall results. The results are presented for each impact category as the sum of the contributions (%) of all the phases in absolute values summing up to 100%. Negative values in the end-of-life phase represent credits, i.e. avoided impacts.

**Table 62. Life cycle environmental impacts of a radiant hob**

| | Unit | Material | Manufacturing | Distribution | Use phase | Disposal | Recycling | Total |
|---|---|---|---|---|---|---|---|---|
| Resources & Waste | | | | | | | | |
| Total Energy (GER) | MJ | 484 | 54 | 184 | 13,454 | 41 | -255 | 13,961 |
| of which, electricity (in primary MJ) | MJ | 276 | 31 | 0 | 13,452 | 0 | -129 | 13,632 |
| Water (process) | l | 62 | 0 | 0 | 1 | 0 | -20 | 43 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Water (cooling) | l | 130 | 14 | 0 | 713 | 0 | -48 | 808 |
| Waste, non-haz./ landfill | g | 3,492 | 232 | 143 | 8,286 | 172 | -3,200 | 9,125 |
| Waste, hazardous/ incinerated | g | 16 | 0 | 3 | 253 | 0 | -8 | 264 |
| Emissions (Air) | | | | | | | | |
| Greenhouse Gases in GWP100 | kg CO2 eq. | 46 | 3 | 13 | 312 | 0 | -25 | 350 |
| Acidification, emissions | g SO2 eq. | 310 | 13 | 39 | 3 027 | 4 | -164 | 3 230 |
| Volatile Organic Compounds (VOCs) | g | 2 | 0 | 1 | 358 | 0 | -1 | 360 |
| Persistent Organic Pollutants (POP) | ng i-Teq | 51 | 5 | 1 | 38 | 0 | -49 | 46 |
| Heavy Metals | mg Ni eq. | 121 | 11 | 7 | 163 | 3 | -67 | 238 |
| PAHs | mg Ni eq. | 29 | 0 | 5 | 38 | 0 | -11 | 62 |
| Particulate Matter (PM dust) | g | 226 | 2 | 209 | 66 | 24 | -122 | 405 |
| Emissions (Water) | | | | | | | | |
| Heavy Metals | mg Hg/20 | 49 | 0 | 0 | 69 | 0 | -28 | 92 |
| Eutrophication | g PO4 | 2 | 0 | 0 | 3 | 1 | -1 | 5 |

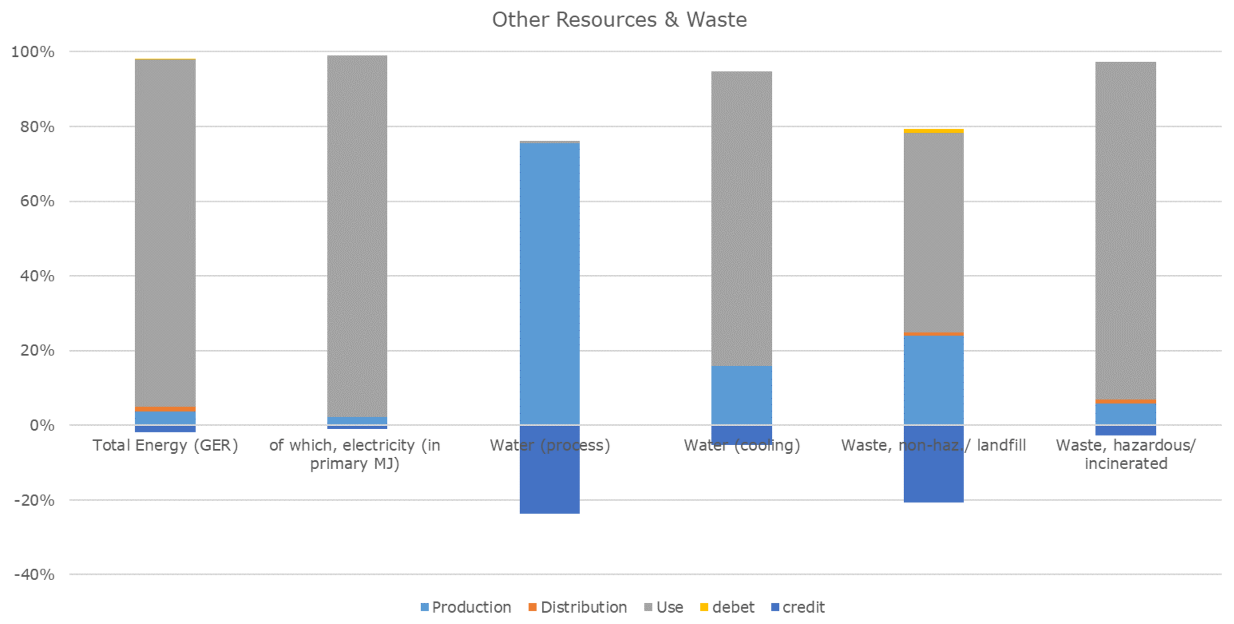



**Figure 184: Contribution of each life cycle stage of a radiant hob to resources and waste**

Figure 184 shows that the use phase clearly dominates the consumption of energy and water and the generation of hazardous/incinerated waste over the life cycle. Consumption of electricity is the main contribution to all the other indicators of these three macro categories.

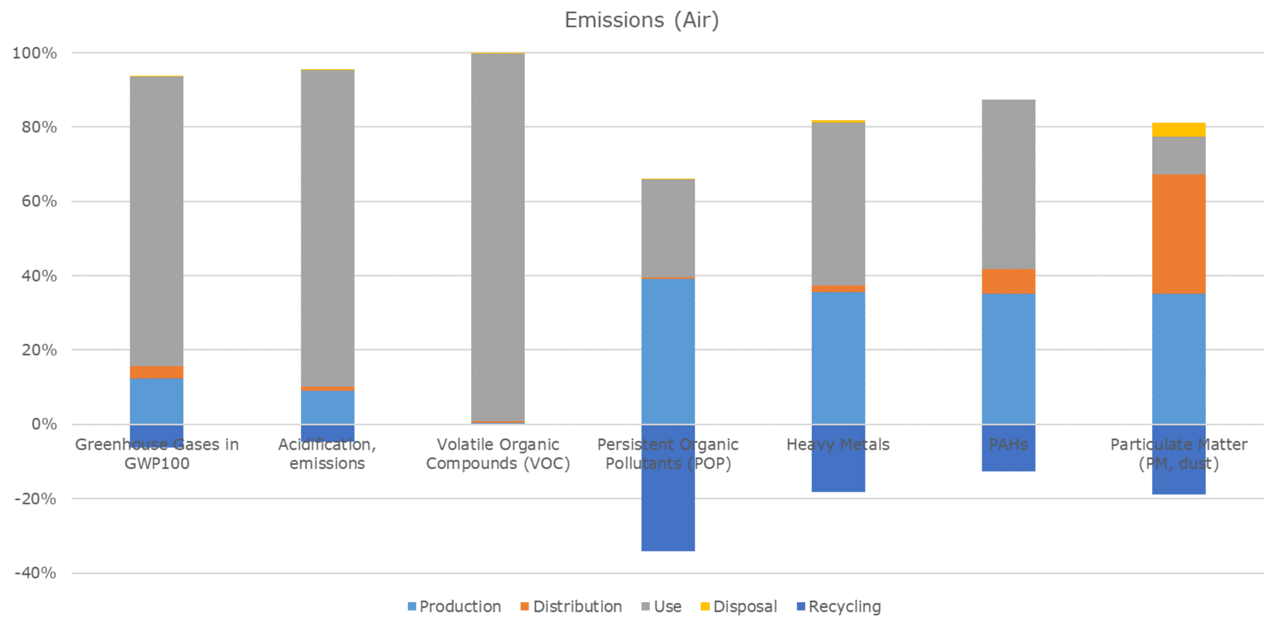



**Figure 185: Contribution of each life cycle stage of a radiant hob to emissions to air**

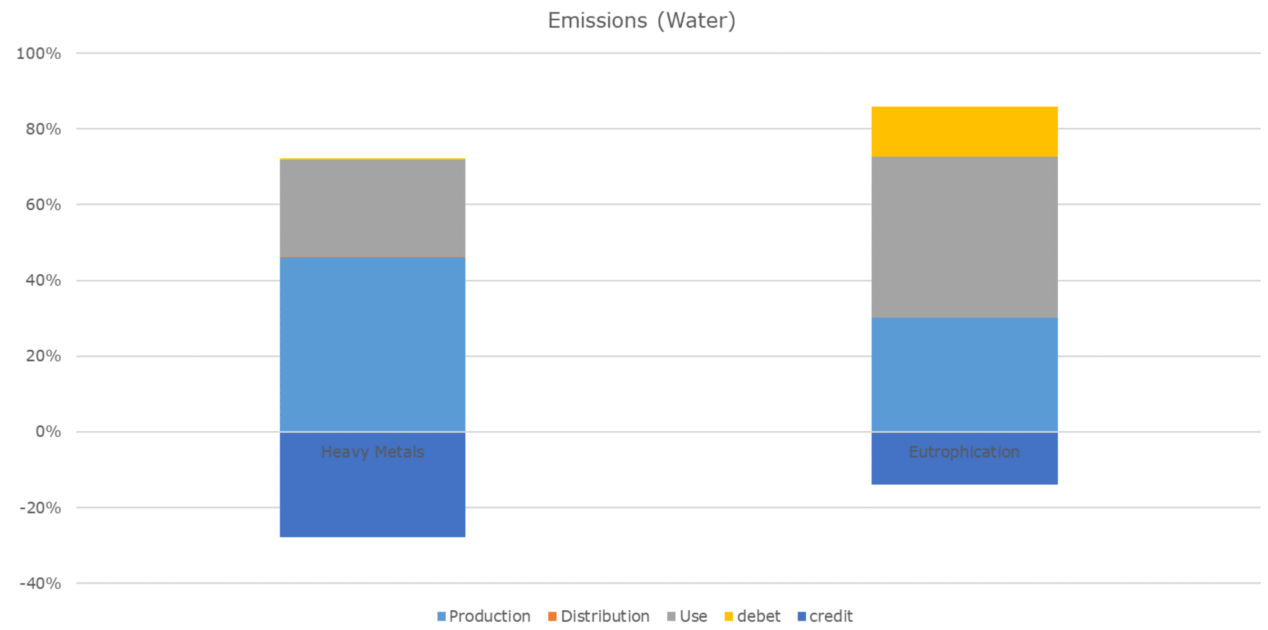



**Figure 186: Contribution of each life cycle stage of a radiant hob to emissions to water**

Regarding the emissions to air and water (Figure 185 and Figure 186), the use phase also dominates global warming potential (GWP100), acidification potential (AP), volatile organic compounds (VOC) and eutrophication. For heavy metals to air (HM air), persistent organic pollutants (POP), polyaromatic hydrocarbons (PAHs), particulate matter (PM dust), the use phase has a contribution ranging from 15% to close to over 30% of the total of each category. This is mainly caused by the consumption of electricity.

The contribution of the production phase significantly contributes in the following impact categories: POP (≈ 50%), HM air (≈ 40%), PAHs ( 40%) and PM (40%). This is mainly due to the extraction of raw materials such as minerals and the further manufacturing to steel or processing of raw materials to get the different types of plastics.

The distribution phase is relevant only for the generation of PM (≈30%) due to the transport of the packaged products.

The EoL presents significant negative impacts in some categories. This is due to the credits (avoided impacts) that the EcoReport tool assigns to the recycling of materials. For instance, the contribution of the EoL POP is -35%. This high percentage is also influenced by the replacement of radiant hobs by induction hobs, which the EcoReport tool interprets as an increase in the recycling share at the EoL.

#### 5.3.2.2 Base Case 2: Induction hobs

Table 63 shows the material consumption of an induction hob over the whole life cycle of 15 years. The material consumption during the production equals the input values of the bill of materials. The materials consumed during the use phase correspond to the materials consumed for maintenance and repair which account for 1% of the bill of materials. The material consumption during the end-of-life phase is split into disposal, recycling and the stock. The latter value results from the effect that the mass discarded seldom equals the mass of new products sold.

**Table 63: Life cycle material consumption of an induction hob**

| **Life Cycle phases -->** | | Production | Distribution | Use phase | End-of-Life | | |
|---|---|---|---|---|---|---|---|
| **Material** | Unit | | | | **Disposal** | **Recycling** | **Stock** |
| Bulk Plastics | g | 253 | | 3 | 49 | 40 | 167 |

| Life Cycle phases --> | | Production | Distribution | Use phase | End-of-Life | | |
|---|---|---|---|---|---|---|---|
| **Material** | Unit | | | | **Disposal** | **Recycling** | **Stock** |
| TecPlastics | g | 71 | | 1 | 14 | 11 | 47 |
| Ferro | g | 1738 | | 17 | 30 | 576 | 1149 |
| Non-ferro | g | 2262 | | 23 | 39 | 750 | 1495 |
| Coating | g | 0 | | 0 | 0 | 0 | 0 |
| Electronics | g | 3203 | | 32 | 548 | 570 | 2117 |
| Misc. | g | 3694 | | 37 | 1006 | 284 | 2441 |
| Extra | g | 0 | | 0 | 0 | 0 | 0 |
| Auxiliaries | g | 0 | | 0 | 0 | 0 | 0 |
| Refrigerant | g | 0 | | 0 | 0 | 0 | 0 |
| **Total weight** | g | 11221 | | 112 | 1686 | 2231 | 7416 |

Table 64 shows the environmental impacts of an induction hob over the whole life cycle of 15 years under the conditions explained in Section 5.1.1.4.

The results are also shown in Figure 187 in terms of the relative contributions (%) of each life cycle phase (i.e. manufacturing, distribution, use and end of life) to the overall results. The results are presented for each impact category as the sum of the contributions (%) of all the phases in absolute values summing up to 100%. Negative values in the end-of-life phase represent credits, i.e. avoided impacts.

**Table 64. Life cycle environmental impacts of an induction hob**

| | Unit | Material | Manufacturing | Distribution | Use phase | Disposal | Recycling | Total |
|---|---|---|---|---|---|---|---|---|
| Resources & Waste | | | | | | | | |
| Total Energy (GER) | MJ | 3619 | 85 | 184 | 13123 | 37 | -286 | 16761 |
| of which, electricity (in primary MJ) | MJ | 2470 | 49 | 0 | 13111 | 0 | -176 | 15455 |
| Water (process) | l | 202 | 1 | 0 | 2 | 0 | -13 | 191 |
| Water (cooling) | l | 346 | 21 | 0 | 696 | 0 | -23 | 1040 |
| Waste, non-haz./ landfill | g | 7,364 | 406 | 143 | 8102 | 71 | -755 | 15331 |
| Waste, hazardous/ incinerated | g | 113 | 0 | 3 | 247 | 0 | -8 | 355 |
| Emissions (Air) | | | | | | | | |
| Greenhouse Gases in GWP100 | kg CO2 eq. | 219 | 5 | 13 | 306 | 0 | -17 | 526 |
| Acidification, | g SO2 | 1411 | 21 | 39 | 2957 | 2 | -111 | 4318 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| emissions | eq. | | | | | | | |
| Volatile Organic Compounds (VOCs) | g | 22 | 0 | 1 | 348 | 0 | -2 | 370 |
| Persistent Organic Pollutants (POP) | ng i-Teq | 74 | 11 | 1 | 37 | 0 | -9 | 114 |
| Heavy Metals | mg Ni eq. | 214 | 25 | 7 | 160 | 1 | -16 | 390 |
| PAHs | mg Ni eq. | 422 | 0 | 5 | 41 | 0 | -43 | 425 |
| Particulate Matter (PM dust) | g | 126 | 3 | 209 | 64 | 1 | -12 | 392 |
| Emissions (Water) | | | | | | | | |
| Heavy Metals | mg Hg/20 | 1143 | 1 | 0 | 78 | 1 | -87 | 1136 |
| Eutrophication | g PO4 | 12 | 0 | 0 | 3 | 1 | -1 | 15 |

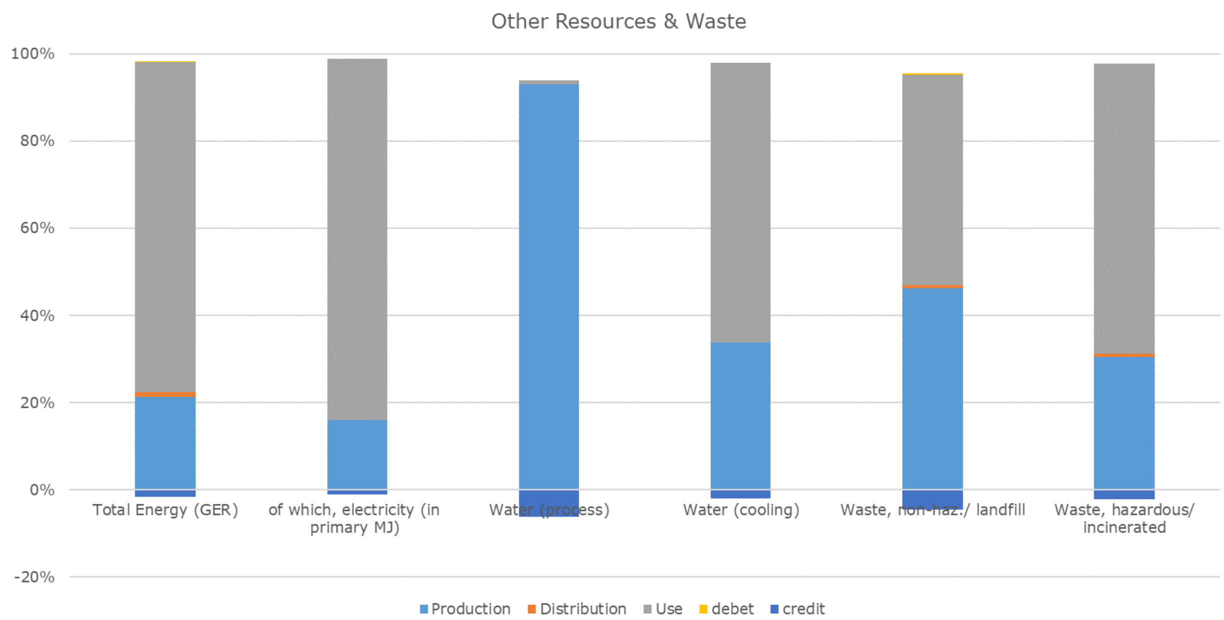



**Figure 187: Contribution of each life cycle stage of an induction hob to resources and waste**

Figure 187 shows that the use phase dominates the consumption of energy and water. Consumption of electricity is the main contribution to all the other indicators of these macro categories.

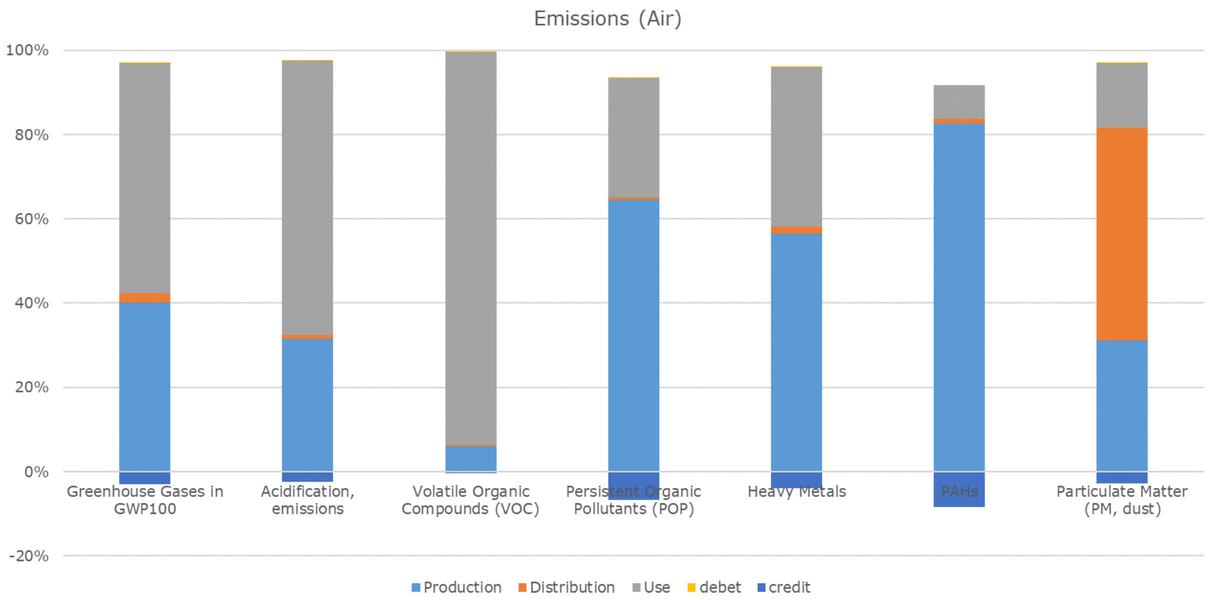



**Figure 188: Contribution of each life cycle stage of an induction hob to emissions to air**

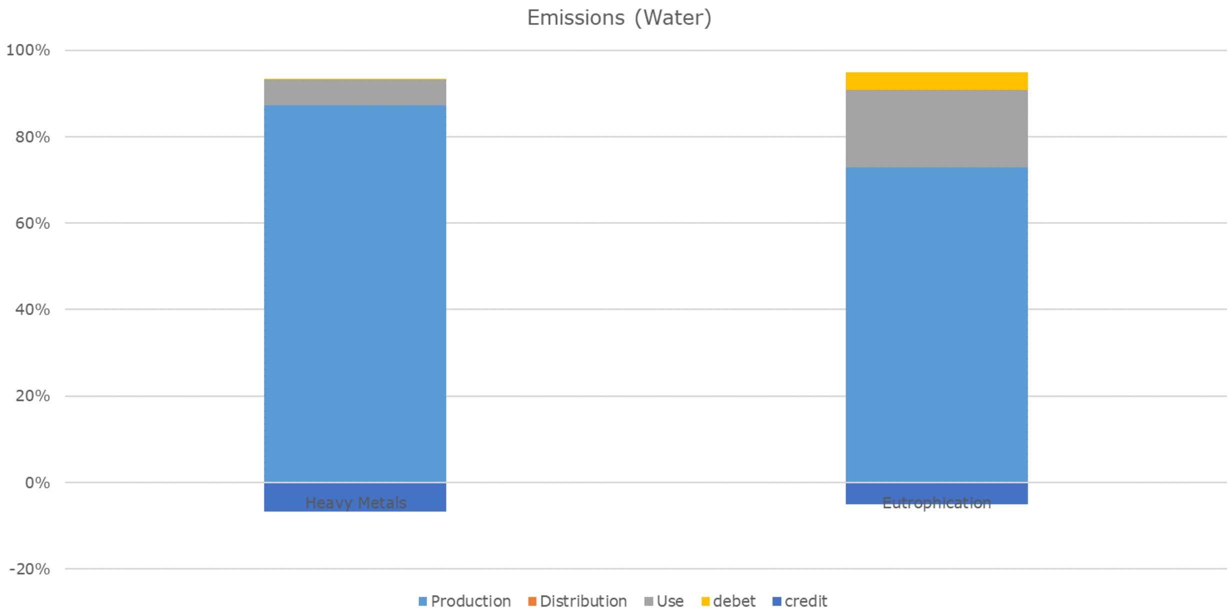



**Figure 189: Contribution of each life cycle stage of an induction hob to emissions to water**

Regarding the emissions to air and water (Figure 188 and Figure 189), the use phase also dominates global warming potential (GWP100), and volatile organic compounds (VOCs). For acidification potential (AP), persistent organic pollutants (POP), heavy metals to air (HM air), polyaromatic hydrocarbons (PAHs), particulate matter (PM dust), the use phase has a contribution ranging from 5% to close to over 20% of the total of each category. This is mainly caused by the consumption of electricity.

The contribution of the production phase significantly contributes in the following impact categories: AP, POP, HM to air, and PAHs, PM, heavy metals to water. This is mainly due to the extraction of raw materials such as minerals for the electronic components, and the further manufacturing to steel or processing of raw materials to get the different types of plastics and electronic components.

The distribution phase is relevant only for the generation of PM due to the transport of the packaged products.

The EoL presents significant negative impacts in some categories. This is due to the credits (avoided impacts) that the EcoReport tool assigns to the recycling of materials. For instance, the contribution of the EoL PAHs is -10%.

#### 5.3.2.3 Base Case 3: Gas hobs

Table 65 shows the material consumption of a gas hob over the whole life cycle of 19 years.

**Table 65: Life cycle material consumption of a gas hob**

| Life Cycle phases -> | | Production | Distribution | Use phase | End-of-Life | | |
|---|---|---|---|---|---|---|---|
| **Material** | **Unit** | | | | **Disposal** | **Recycling** | **Stock** |
| Bulk Plastics | g | 107 | | 1 | 62 | 51 | -5 |
| TecPlastics | g | 151 | | 2 | 88 | 72 | -8 |
| Ferro | g | 5 467 | | 55 | 290 | 5 506 | -275 |
| Non-ferro | g | 2 031 | | 20 | 108 | 2 045 | -102 |
| Coating | g | 0 | | 0 | 0 | 0 | 0 |
| Electronics | g | 0 | | 0 | 0 | 0 | 0 |
| Misc. | g | 39 | | 0 | 14 | 27 | -2 |
| Extra | g | 0 | | 0 | 0 | 0 | 0 |
| Auxiliaries | g | 0 | | 0 | 0 | 0 | 0 |
| Refrigerant | g | 0 | | 0 | 0 | 0 | 0 |
| **Total weight** | g | 7 794 | | 78 | 562 | 7 702 | -391 |

**Table 66. Life cycle environmental impacts of a gas hob**

| | Unit | Material | Manufacturing | Distribution | Use | Disposal | Recycling | Total |
|---|---|---|---|---|---|---|---|---|
| Resources & Waste | | | | | | | | |
| Total Energy (GER) | MJ | 604 | 146 | 184 | 14373 | 3 | -236 | 15074 |
| of which electricity (in primary MJ) | MJ | 16 | 84 | 0 | 0 | 0 | -6 | 94 |
| Water (process) | l | 3 | 1 | 0 | 0 | 0 | -1 | 4 |
| Water (cooling) | l | 35 | 35 | 0 | 0 | 0 | -4 | 66 |
| Waste non-haz./ landfill | g | 10,179 | 726 | 143 | 102 | 123 | -4089 | 7185 |
| Waste hazardous/ incinerated | g | 3 | 0 | 3 | 0 | 0 | 0 | 5 |
| Emissions (Air) | | | | | | | | |
| Greenhouse Gases in | kg CO2 eq. | 38 | 8 | 13 | 795 | 0 | -15 | 839 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| GWP100 | | | | | | | | |
| Acidification emissions | g SO2 eq. | 183 | 36 | 39 | 233 | 0 | -72 | 420 |
| Volatile Organic Compounds (VOCs) | g | 1 | 0 | 1 | 10 | 0 | 0 | 13 |
| Persistent Organic Pollutants (POP) | ng i-Teq | 152 | 20 | 1 | 2 | 0 | -61 | 114 |
| Heavy Metals | mg Ni eq. | 27 | 47 | 7 | 0 | 0 | -11 | 70 |
| PAHs | mg Ni eq. | 197 | 0 | 5 | 2 | 0 | -79 | 125 |
| Particulate Matter (PM dust) | g | 50 | 6 | 209 | 5 | 0 | -20 | 250 |
| Emissions (Water) | | | | | | | | |
| Heavy Metals | mg Hg/20 | 91 | 2 | 0 | 1 | 0 | -36 | 57 |
| Eutrophication | g PO4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |

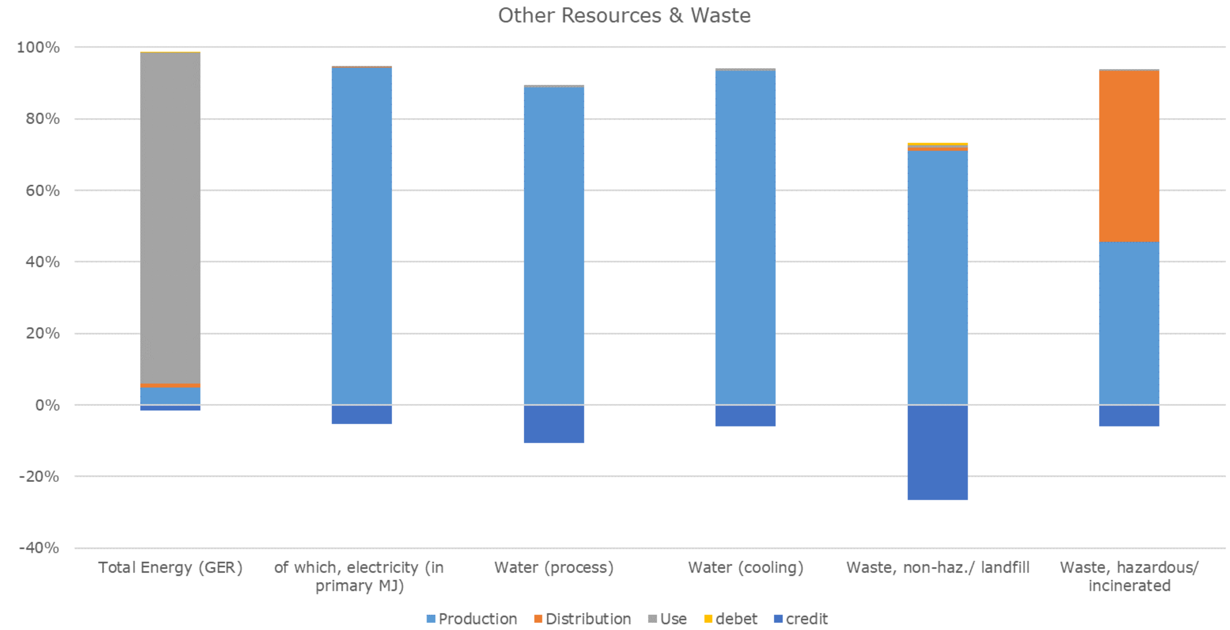



**Figure 190: Contribution of each life cycle stage of a gas hob to resources and waste**

Figure 190 shows that the use phase clearly dominates the consumption of energy while the production phase is predominant in the rest of the indicators.

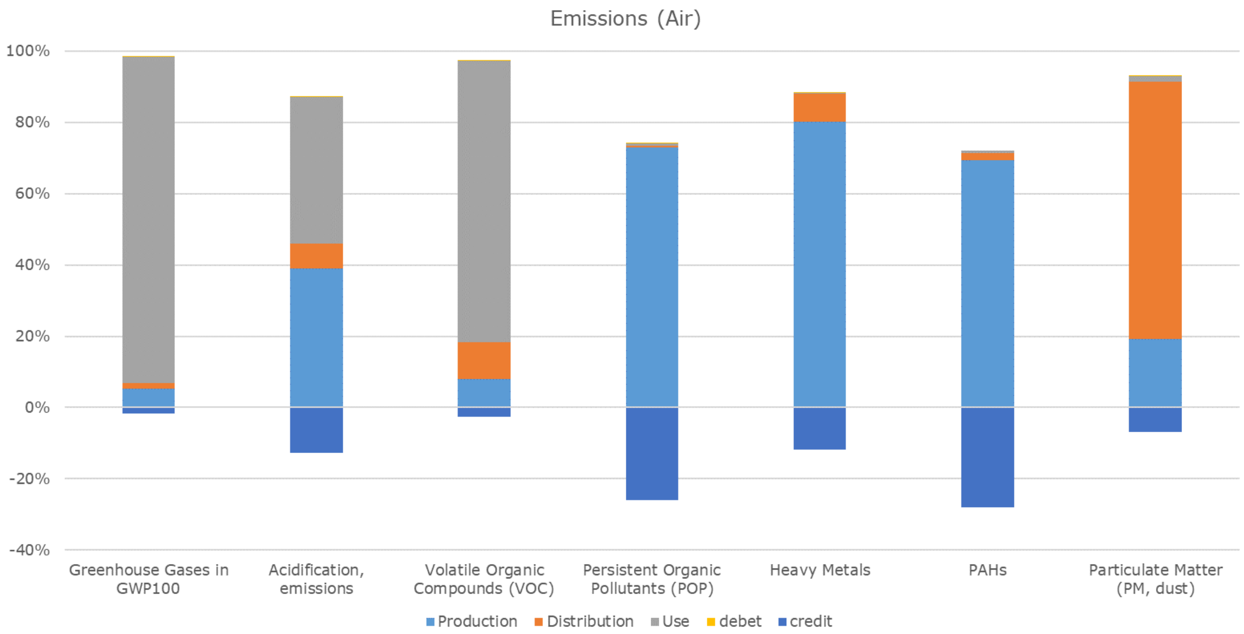



**Figure 191: Contribution of each life cycle stage of a gas hob to emissions to air**

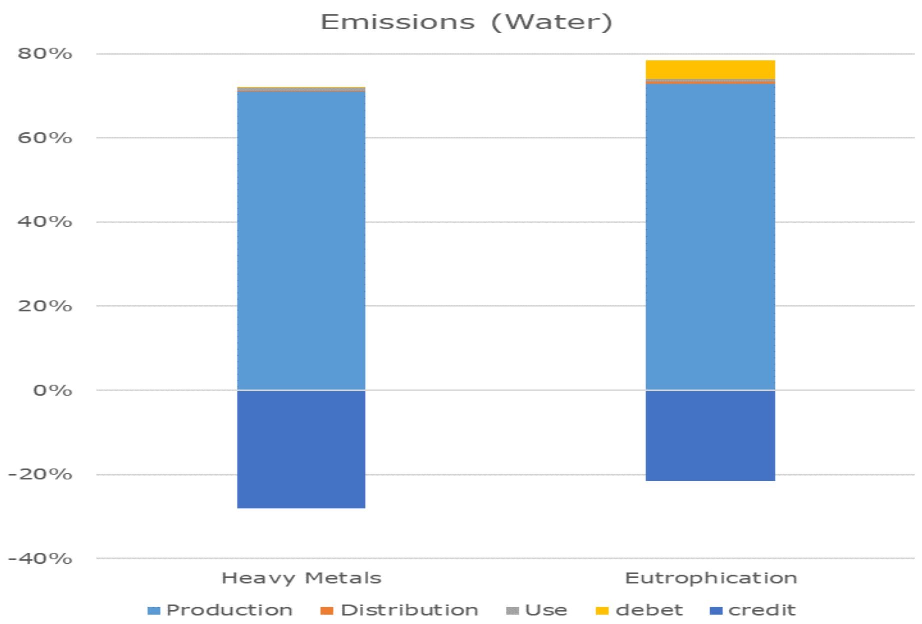



**Figure 192: Contribution of each life cycle stage of a gas hob to emissions to water**

Regarding the emissions to air and water (Figure 191 and Figure 192), the use phase also dominates global warming potential (GWP100) and volatile organic compounds (VOCs). For acidification potential (AP), the use phase contributes around 40%.

The contribution of the production phase significantly contributes in the following impact categories: acidification potential (AP), persistent organic pollutants (POP), heavy metals (HM) to air, and HM water. This is mainly due to the extraction of raw materials such as minerals and the further manufacturing to steel or processing of raw materials to get the different types of plastics.

The distribution phase is relevant only for the generation PM due to the transport of the packaged products.

The EoL presents significant negative impacts in some categories. This is due to the credits (avoided impacts) that the EcoReport tool assigns to the recycling of materials. For instance, the contribution of the EoL to POP, PAHs and HM to air and water is around -25%.

#### 5.3.2.4 Environmental impact assessment of EU totals for hobs

The environmental impacts and the LCC under real-life conditions are aggregated using stock and market data indicating:

- the life cycle environmental impact of all new products designed in 2020 (reference year);
- the annual environmental impacts of the stock of hobs in 2020 (including production, use and end of life);
- the annual monetary costs for consumers (also for 2020) (including acquisition, use and maintenance and repair).

Table 67 shows the environmental impacts of all hobs produced in 2020 over their lifetime.

**Table 67: Life cycle environmental impacts of all hobs reflected for base cases produced in 2020 (over their lifetime)**

| | Unit | Base Case 1 (radiant) | Base Case 2 (induction) | Base Case 3 (gas) |
|---|---|---|---|---|
| | | | | |
| Total Energy (GER) | PJ | 37.70 | 59.17 | 27.28 |
| of which electricity (in primary PJ) | PJ | 36.81 | 54.56 | 0.17 |
| Water (process) | mln. $m^3$ | 0.12 | 0.68 | 0.01 |
| Water (cooling) | mln. $m^3$ | 2.18 | 3.67 | 0.12 |
| Waste non-haz./ landfill | Kt | 24.64 | 54.12 | 13.00 |
| Waste hazardous/ incinerated | Kt | 0.71 | 1.25 | 0.01 |
| | | | | |
| Greenhouse Gases in GWP100 | mt $CO_2$ eq. | 0.92 | 1.86 | 1.52 |
| Acidification emissions | kt $SO_2$ eq. | 8.51 | 15.24 | 0.76 |
| Volatile Organic Compounds (VOCs) | Kt | 0.97 | 1.31 | 0.02 |
| Persistent Organic Pollutants (POP) | g i-Teq | 0.12 | 0.40 | 0.21 |
| Heavy Metals | ton Ni eq. | 0.51 | 1.38 | 0.13 |
| PAHs | ton Ni eq. | 0.17 | 1.50 | 0.23 |
| Particulate Matter (PM dust) | Kt | 0.76 | 1.38 | 0.45 |
| | | | | |
| Heavy Metals | ton Hg/20 | 0.33 | 4.01 | 0.10 |
| Eutrophication | kt $PO_4$ | 0.01 | 0.05 | 0.00 |

*GER stands for Gross Energy Requirement.

Table 68 shows the annual environmental impact of the stock of hobs in the reference year (2020). The stock refers to:

- the environmental impact through the production of the annual sales of hobs in the reference year;
- the environmental impact of 1 year of use of the whole stock;

- the end-of-life treatment of the amount of hobs discarded in that year (according to the EcoReport tool: "simplified model assuming produced = EoL").

**Table 68: EU total impact of the stock of hobs in the reference year 2020 (produced / in use / discarded) (real-life conditions)**

| | Unit | Base Case 1 (radiant) | Base Case 2 (induction) | Base Case 3 (gas) |
|---|---|---|---|---|
| **Resources & Waste** | | | | |
| Total Energy (GER*) | PJ | 69.2 | 57.5 | 50.2 |
| of which electricity (in primary PJ) | PJ | 68.1 | 52.6 | 0.2 |
| Water (process) | million $m^3$ | 0.2 | 0.7 | 0.0 |
| Water (cooling) | million $m^3$ | 4.0 | 3.6 | 0.1 |
| Waste non-haz./ landfill | Kt | 51.9 | 54.9 | 20.3 |
| Waste hazardous/ incinerated | Kt | 1.3 | 1.2 | 0.0 |
| **Emissions (Air)** | | | | |
| Greenhouse Gases in GWP100 | mt $CO_2$ eq. | 1.7 | 1.9 | 2.8 |
| Acidification emissions | kt $SO_2$ eq. | 15.8 | 15.0 | 1.3 |
| Volatile Organic Compounds (VOCs) | Kt | 1.8 | 1.2 | 0.0 |
| Persistent Organic Pollutants (POP) | g i-Teq | 0.3 | 0.4 | 0.3 |
| Heavy Metals | t Ni eq. | 1.0 | 1.4 | 0.1 |
| PAHs | t Ni eq. | 0.3 | 1.6 | 0.4 |
| Particulate Matter (PM dust) | Kt | 0.9 | 1.4 | 0.5 |
| **Emissions (Water)** | | | | |
| Heavy Metals | ton Hg/20 | 0.7 | 4.3 | 0.2 |
| Eutrophication | kt $PO_4$ | 0.0 | 0.1 | 0.0 |

### 5.3.3 Environmental impact assessment of cooking fume extractors

The environmental impacts have been calculated with the MEErP EcoReport tool and the data inputs presented in the previous section. This section shows the results of these calculations in the MEErP format for:

- raw materials use and manufacturing;
- distribution;
- use phase;
- end-of-life phase.

#### 5.3.3.1 Base Case 1: Cabinet cooking fume extractors

Table 69 shows the material consumption of a cabinet cooking fume extractor over the whole life cycle of 15 years. The material consumption during the production equals the input values of the bill of materials. The materials consumed during the use phase correspond to the materials consumed for maintenance and repair which account for 1% of the bill of materials. The material consumption during the end-of-life phase is split into disposal, recycling and the stock. The latter value results from the effect that the mass discarded seldom equals the mass of new products sold.

**Table 69. Material consumption of a cabinet cooking fume extractor**

| Life Cycle phases --> | | Production | Distribution | Use phase | End-of-Life | | |
|---|---|---|---|---|---|---|---|
| **Material** | Unit | | | | **Disposal** | **Recycling** | **Stock** |
| Bulk Plastics | g | 418 | - | 4 | 152 | 124 | 146 |
| TecPlastics | g | 334 | - | 3 | 121 | 99 | 117 |
| Ferro | g | 7 190 | - | 72 | 237 | 4 506 | 2 519 |
| Non-ferro | g | 251 | - | 3 | 8 | 157 | 88 |
| Coating | g | 0 | - | 0 | 0 | 0 | 0 |
| Electronics | g | 167 | - | 2 | 54 | 56 | 59 |
| Misc. | g | 0 | - | 0 | 0 | 0 | 0 |
| Extra | g | 0 | - | 0 | 0 | 0 | 0 |
| Auxiliaries | g | 0 | - | 0 | 0 | 0 | 0 |
| Refrigerant | g | 0 | - | 0 | 0 | 0 | 0 |
| **Total weight** | g | 8 360 | - | 84 | 572 | 4 942 | 2 929 |

Table 70 shows the environmental impacts of a cabinet cooking fume extractor over the whole life cycle of 15 years under the conditions set by the 9-point method, i.e. an average of minimum, maximum and boost speeds.

The results are also shown in terms of the relative contributions (%) of each life cycle phase (i.e. manufacturing, distribution, use and end of life) to the overall results. The results are presented for each impact category as the sum of the contributions (%) of all the phases in absolute values summing up to 100%. Negative values in the end-of-life phase represent credits, i.e. avoided impacts.

**Table 70. Life cycle environmental impacts of a cabinet cooking fume extractor**

| | Unit | Material | Manufacturing | Distribution | Use phase | Disposal | Recycling | Total |
|---|---|---|---|---|---|---|---|---|
| Resources & Waste | | | | | | | | |
| Total Energy (GER) | MJ | 949 | 161 | 195 | 5,351 | 17 | -176 | 6,497 |
| of which electricity (in primary MJ) | MJ | 404 | 93 | 0 | 5,345 | 0 | -64 | 5,779 |
| Water (process) | l | 22 | 1 | 0 | 0 | 0 | -4 | 20 |
| Water (cooling) | l | 220 | 40 | 0 | 285 | 0 | -26 | 518 |
| Waste non-haz./ landfill | g | 12,426 | 761 | 148 | 3,401 | 108 | -3,502 | 13,343 |
| Waste hazardous/ incinerated | g | 8 | 0 | 3 | 100 | 0 | -1 | 111 |
| Emissions (Air) | | | | | | | | |
| Greenhouse Gases in | kg CO2 eq. | 56 | 9 | 14 | 124 | 0 | -11 | 192 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| GWP100 | | | | | | | | |
| Acidification emissions | g SO2 eq. | 157 | 40 | 41 | 1,203 | 0 | -40 | 1,401 |
| Volatile Organic Compounds (VOCs) | g | 1 | 0 | 2 | 142 | 0 | 0 | 145 |
| Persistent Organic Pollutants (POP) | ng i-Teq | 186 | 19 | 1 | 17 | 0 | -53 | 171 |
| Heavy Metals | mg Ni eq. | 52 | 45 | 8 | 65 | 0 | -15 | 154 |
| PAHs | mg Ni eq. | 3 | 0 | 6 | 15 | 0 | -1 | 23 |
| Particulate Matter (PM dust) | g | 24 | 6 | 241 | 26 | 0 | -6 | 291 |
| Emissions (Water) | | | | | | | | |
| Heavy Metals | mg Hg/20 | 57 | 1 | 0 | 28 | 0 | -16 | 71 |
| Eutrophication | g PO4 | 1 | 0 | 0 | 1 | 0 | 0 | 2 |

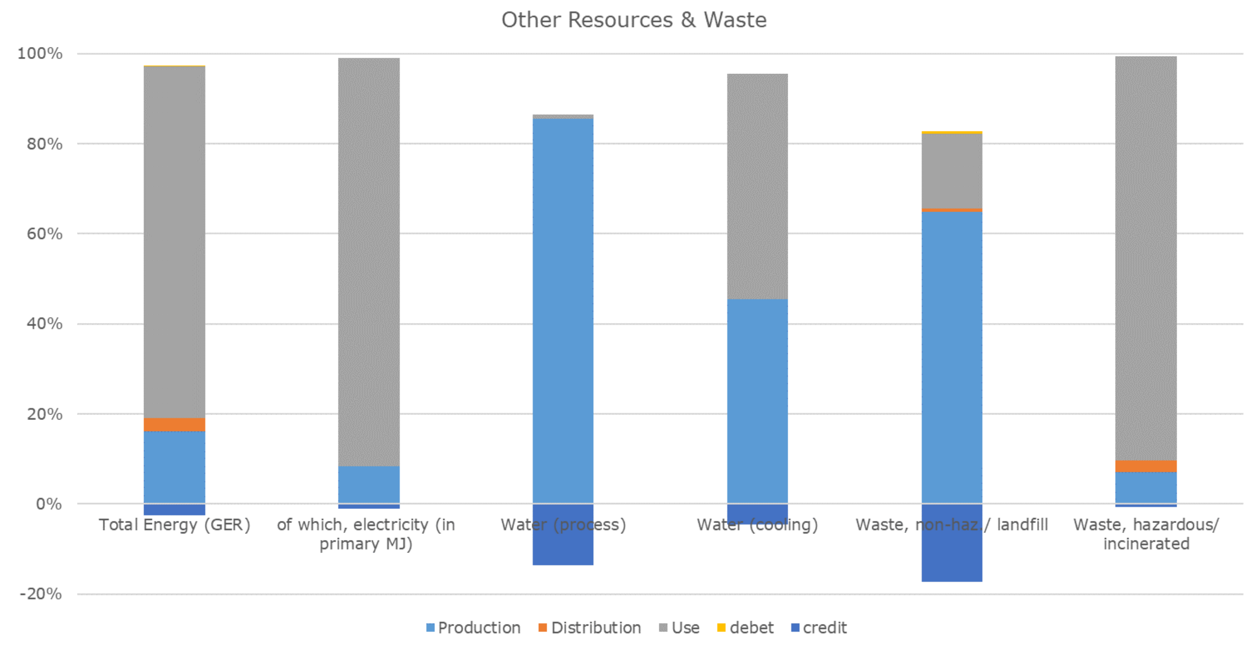



**Figure 193. Impact of resources and waste of a cabinet cooking fume extractor**

Figure 193 shows that the use phase clearly dominates the consumption of energy (80%) and the generation of hazardous/incinerated waste over the life cycle (90%). Consumption of electricity is the main contribution to all the other indicators of these three macro categories.

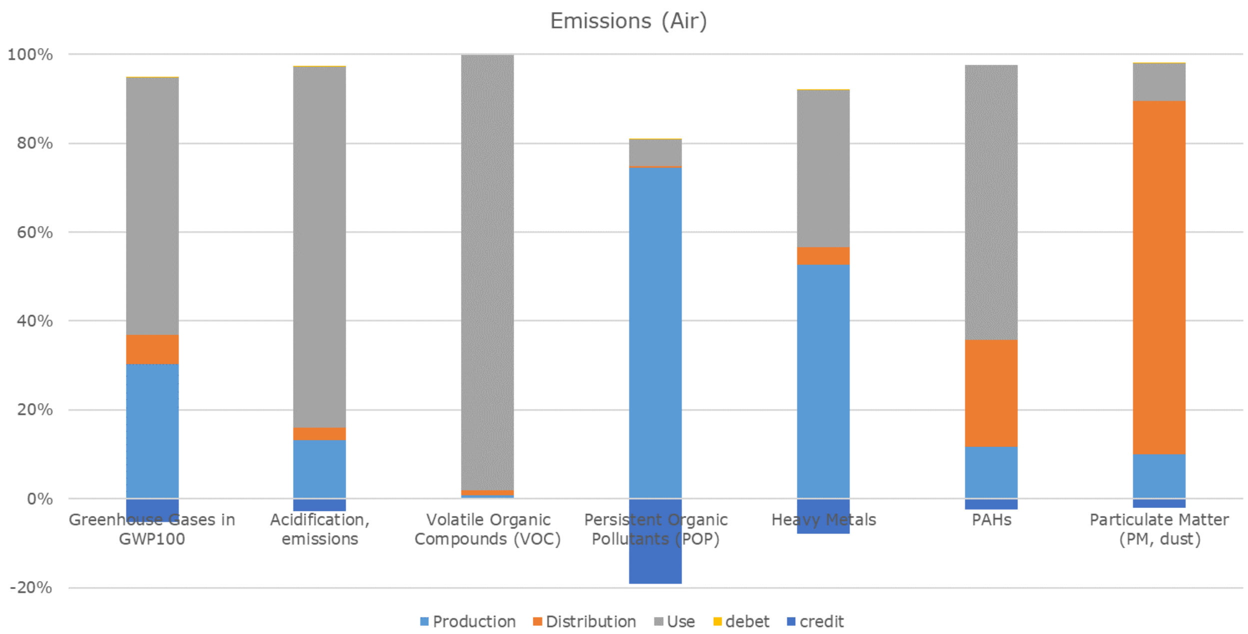



**Figure 194: Impact of emissions to air of a cabinet cooking fume extractor**

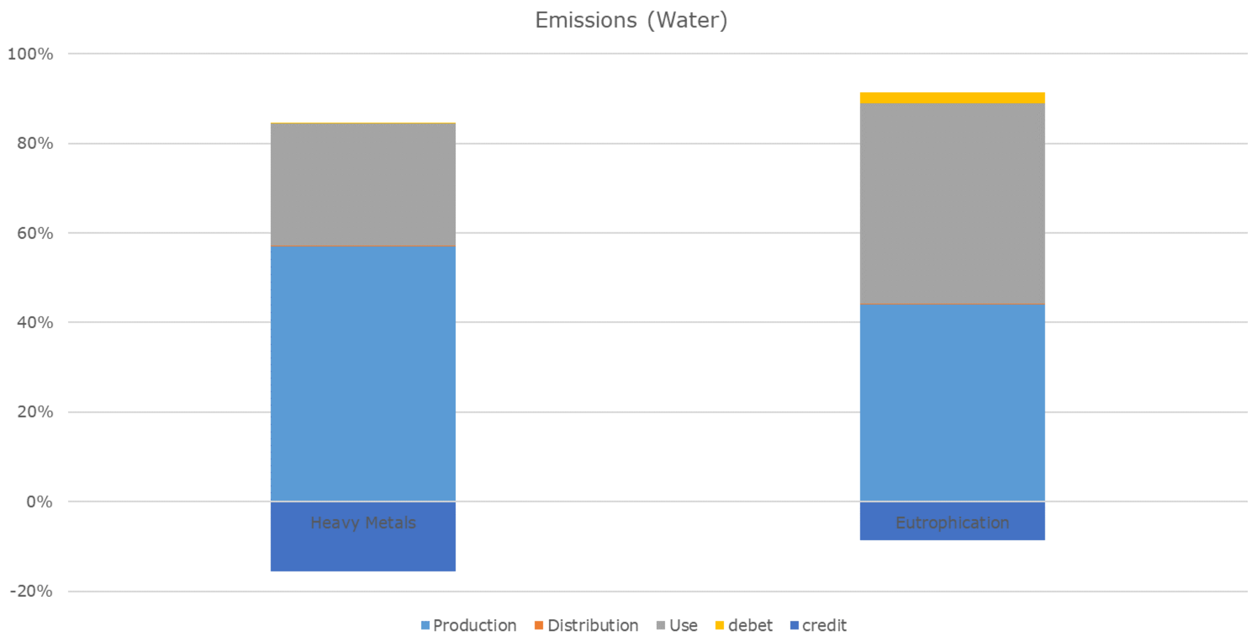



**Figure 195. Impact of emissions to water of a cabinet cooking fume extractor**

Regarding the emissions to air and water (Figure 194 and Figure 195), the use phase also dominates global warming potential (GWP100) (≈ 60%), acidification potential (AP) (≈ 80%), volatile organic compounds (VOCs) (≈ 95%) and polycyclic aromatic hydrocarbons (PAHs) (≈60%). For persistent organic pollutants (POP), heavy metals to air (HM air), particulate matter (PM dust) and heavy metals to water (HM water), the use phase has a contribution ranging from 5% to close to over 30% from the total of each category. This is mainly caused by the consumption of electricity.

The contribution of the production phase significantly contributes in the following impact categories: non-hazardous waste (≈ 70%), POP (≈ 75%), HM air (≈ 55%) and HM water (getting approximately 60% of the total of this category). This is mainly due to the extraction of raw materials such as minerals and the further manufacturing to steel or processing of raw materials to get the different types of plastics.

The distribution phase is relevant only for the generation of PM (80%) due to the transport of the packaged products.

The EoL presents significant negative impacts in some categories. This is due to the credits (avoided impacts) that the EcoReport tool assigns to the recycling of materials. For instance, the contribution of the EoL POP is close to -20%.

#### 5.3.3.2 Base Case 2: Chimney cooking fume extractors

Table 71 shows the material consumption of a chimney cooking fume extractor over the whole life cycle of 15 years.

**Table 71. Material consumption of a chimney cooking fume extractor**

| **Life Cycle phases ->** | | **Production** | **Distribution** | **Use phase** | **End-of-Life** | | |
|---|---|---|---|---|---|---|---|
| **Material** | **Unit** | | | | **Disposal** | **Recycling** | **Stock** |
| Bulk Plastics | g | 199 | - | 2 | 73 | 60 | 68 |
| TecPlastics | g | 199 | - | 2 | 73 | 60 | 68 |
| Ferro | g | 9 334 | - | 93 | 312 | 5 924 | 3 192 |
| Non-ferro | g | 99 | - | 1 | 3 | 63 | 34 |
| Coating | g | 0 | - | 0 | 0 | 0 | 0 |
| Electronics | g | 99 | - | 1 | 33 | 34 | 34 |
| Misc. | g | 0 | - | 0 | 0 | 0 | 0 |
| Extra | g | 0 | - | 0 | 0 | 0 | 0 |
| Auxiliaries | g | 0 | - | 0 | 0 | 0 | 0 |
| Refrigerant | g | 0 | - | 0 | 0 | 0 | 0 |
| **Total weight** | g | 9 930 | - | 99 | 494 | 6 140 | 3 396 |

**Table 72. Life cycle environmental impacts of a chimney cooking fume extractor**

| | Unit | Material | Manufacturing | Distribution | Use | Disposal | Recycling | Total |
|---|---|---|---|---|---|---|---|---|
| Resources & Waste | | | | | | | | |
| Total Energy (GER) | MJ | 835 | 185 | 390 | 4,862 | 10 | -163 | 6,118 |
| of which electricity (in primary MJ) | MJ | 280 | 106 | 1 | 4,856 | 0 | -44 | 5,199 |
| Water (process) | l | 310 | 1 | 0 | 3 | 0 | -77 | 237 |
| Water (cooling) | l | 155 | 45 | 0 | 258 | 0 | -22 | 437 |
| Waste non-haz./ landfill | g | 13,263 | 914 | 246 | 3,110 | 101 | -3,355 | 14,279 |
| Waste hazardous/ incinerated | g | 4 | 0 | 5 | 91 | 0 | 0 | 100 |
| Emissions (Air) | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Greenhouse Gases in GWP100 | kg CO2 eq. | 60 | 11 | 26 | 113 | 0 | -13 | 198 |
| Acidification emissions | g SO2 eq. | 306 | 46 | 79 | 1,094 | 0 | -75 | 1,450 |
| Volatile Organic Compounds (VOCs) | g | 1 | 0 | 5 | 129 | 0 | 0 | 135 |
| Persistent Organic Pollutants (POP) | ng i-Teq | 170 | 25 | 1 | 15 | 0 | -43 | 169 |
| Heavy Metals | mg Ni eq. | 614 | 58 | 13 | 65 | 0 | -156 | 594 |
| PAHs | mg Ni eq. | 1 | 0 | 13 | 13 | 0 | 0 | 28 |
| Particulate Matter (PM dust) | g | 48 | 7 | 797 | 24 | 0 | -12 | 864 |
| Emissions (Water) | | | | | | | | |
| Heavy Metals | mg Hg/20 | 372 | 2 | 0 | 29 | 0 | -94 | 309 |
| Eutrophication | g PO4 | 10 | 0 | 0 | 1 | 0 | -2 | 9 |

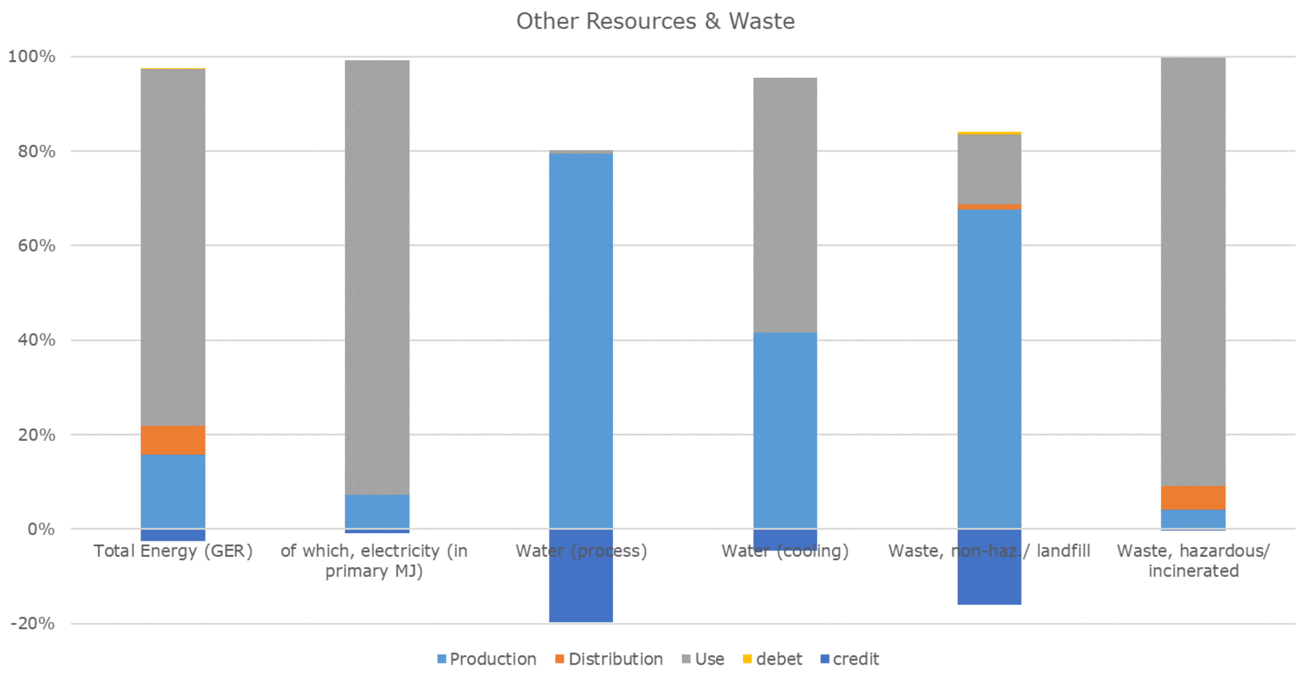



**Figure 196. Impact of resources and waste of a chimney cooking fume extractor**

Figure 196 (BC2) shows very similar results to Figure 193 (BC1). The use phase clearly dominates the consumption of energy (80%) and the generation of hazardous/incinerated waste over the life cycle. Consumption of electricity is the main contribution to all the other indicators of these three macro categories.

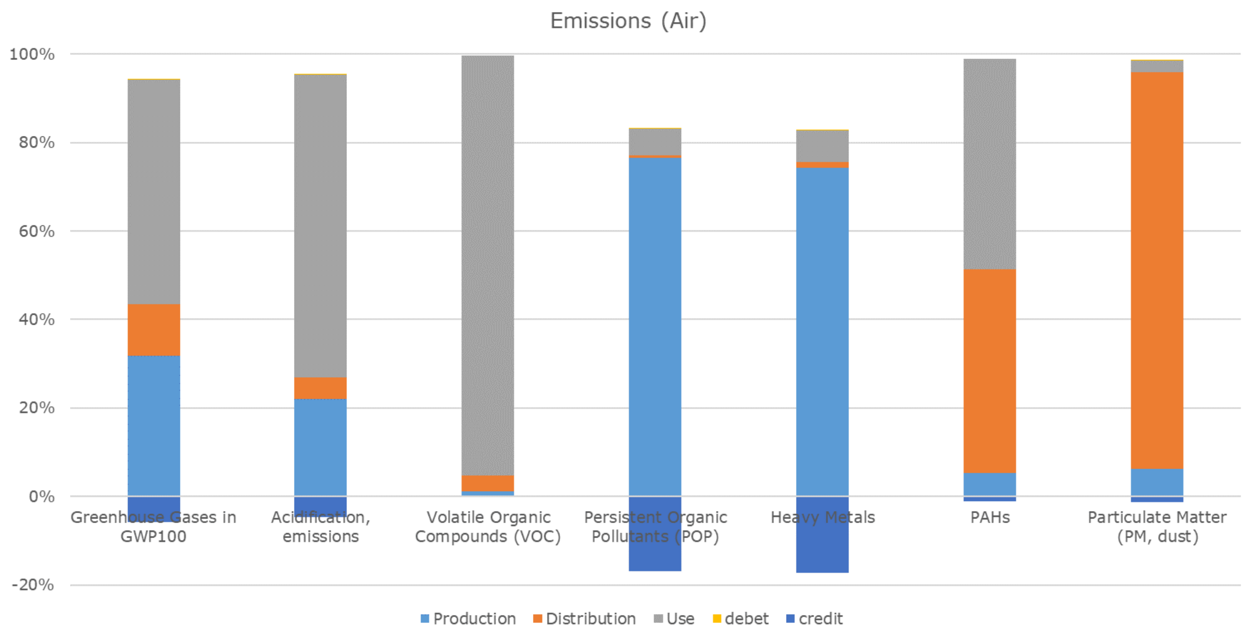



**Figure 197. Impact of emissions to air of a chimney cooking fume extractor**

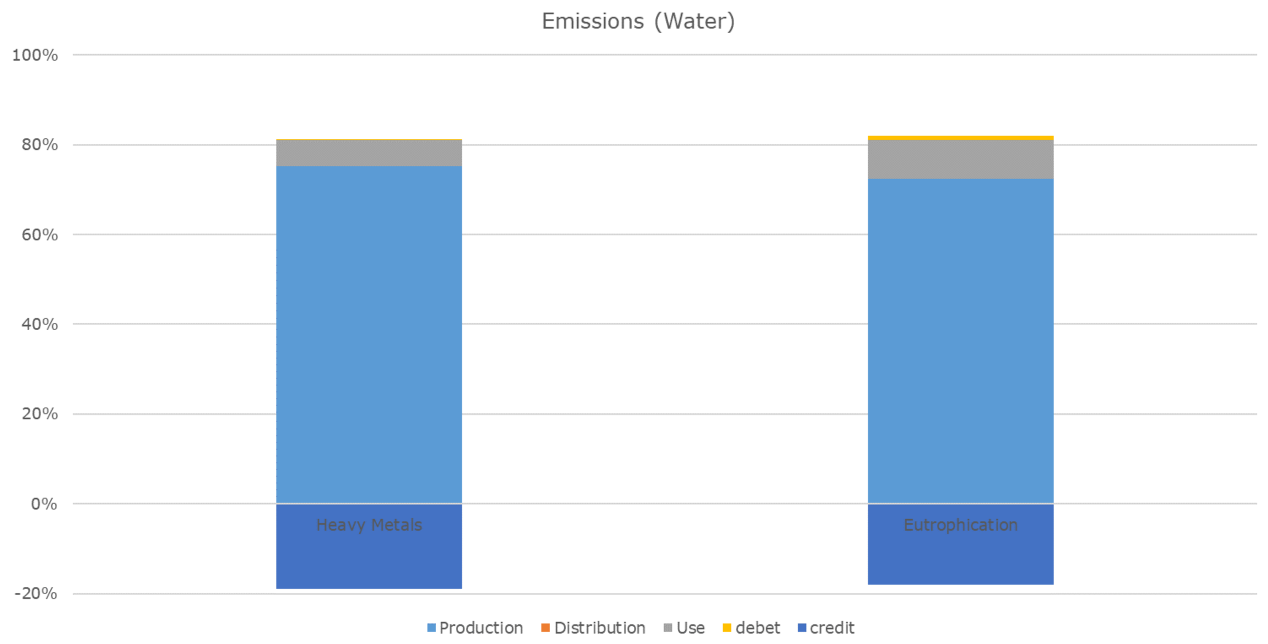



**Figure 198: Impact of emissions to water of a chimney cooking fume extractor**

Regarding the emissions to air and water (Figure 197 and Figure 198), the use phase also dominates global warming potential (GWP100) (≈ 60%), acidification potential (AP) (≈ 70%), volatile organic compounds (VOCs) (≈ 95%) and polycyclic aromatic hydrocarbons (PAHs) (≈50%). For persistent organic pollutants (POP), heavy metals to air (HM air), particulate matter (PM dust) and heavy metals to water (HM water), the use phase has a contribution ranging from 5% to close to over 10% of the total of each category. This is mainly caused by the consumption of electricity.

The contribution of the production phase significantly contributes in the following impact categories: non-hazardous waste (≈ 70%), POP (≈ 75%), HM air (≈ 75%) and HM water (getting approximately 80% of the total of this category). This is mainly due to the extraction of raw materials such as minerals and the further manufacturing to steel or processing of raw materials to get the different types of plastics.

The distribution phase is relevant only for the generation of PM (90%) and polycyclic aromatic hydrocarbons (PAHs) (≈45%), due to the transport of the packaged products.

The EoL presents significant negative impacts in some categories. This is due to the credits (avoided impacts) that the EcoReport tool assigns to the recycling of materials. For instance the contribution of the EoL to POP and HM to air and water is close to -20%.

#### 5.3.3.3 Environmental impact assessment of EU totals for cooking fume extractors

The environmental impacts and the LCC under real-life conditions are aggregated using stock and market data indicating:

- the life cycle environmental impact of all new products designed in 2020 (reference year);
- the annual environmental impacts of the stock of cooking fume extractors in 2020 (including production, use and end of life);
- the annual monetary costs for consumers (also for 2020) (including acquisition, use and maintenance and repair).

Table 73 shows the environmental impacts of all cooking fume extractors produced in 2020 over their lifetime.

**Table 73. Life cycle environmental impacts of all new cooking fume extractors reflected for both base cases produced in 2020 (over their lifetime)**

| | Unit | Base Case 1 (cabinet) | Base Case 2 (cabinet) | Total |
|---|---|---|---|---|
| **Resources & Waste** | | | | |
| Total Energy (GER) | PJ | 18.48 | 21.27 | 39.75 |
| of which electricity (in primary PJ) | PJ | 16.43 | 18.07 | 34.5 |
| Water (process) | mln. $m^3$ | 0.06 | 0.82 | 0.88 |
| Water (cooling) | mln. $m^3$ | 1.47 | 1.52 | 2.99 |
| Waste non-haz./ landfill | Kt | 37.95 | 49.64 | 87.59 |
| Waste hazardous/ incinerated | Kt | 0.31 | 0.35 | 0.66 |
| **Emissions (Air)** | | | | |
| Greenhouse Gases in GWP100 | mt $CO_2$ eq. | 0.55 | 0.69 | 1.24 |
| Acidification emissions | kt $SO_2$ eq. | 3.98 | 5.04 | 9.02 |
| Volatile Organic Compounds (VOC) | Kt | 0.41 | 0.47 | 0.88 |
| Persistent Organic Pollutants (POP) | g i-Teq | 0.48 | 0.59 | 1.07 |
| Heavy Metals | ton Ni eq. | 0.44 | 2.06 | 2.5 |
| PAHs | ton Ni eq. | 0.07 | 0.10 | 0.17 |
| Particulate Matter (PM dust) | Kt | 0.83 | 3.00 | 3.83 |
| **Emissions (Water)** | | | | |
| Heavy Metals | ton Hg/20 | 0.20 | 1.07 | 1.27 |
| Eutrophication | kt $PO_4$ | 0.01 | 0.03 | 0.04 |

*GER stands for Gross Energy Requirement.

Table 74 shows the annual environmental impact of the stock of cooking fume extractors in the reference year (2020). The stock refers to:

- the environmental impact through the production of the annual sales of cooking fume extractors in the reference year;
- the environmental impact of 1 year of use of the whole stock;
- the end-of-life treatment of the amount of cooking fume extractors discarded in that year (according to the EcoReport tool: “simplified model assuming produced = EoL”).

**Table 74. EU total impact of the stock of cooking fume extractors in the reference year 2020 (produced / in use / discarded) (real-life conditions)**

| | Unit | Base Case 1 (cabinet) | Base Case 2 (cabinet) | Total |
|---|---|---|---|---|
| **Resources & Waste** | | | | |
| Total Energy (GER*) | PJ | 36.3 | 39.2 | 75.5 |
| of which electricity (in primary PJ) | PJ | 33.9 | 35.6 | 69.5 |
| Water (process) | mln. $m^3$ | 0.1 | 1.1 | 1.2 |
| Water (cooling) | mln. $m^3$ | 2.5 | 2.5 | 5 |
| Waste non-haz./ landfill | Kt | 58.6 | 72.1 | 130.7 |
| Waste hazardous/ incinerated | Kt | 0.6 | 0.7 | 1.3 |
| **Emissions (Air)** | | | | |
| Greenhouse Gases in GWP100 | mt $CO_2$ eq. | 1.0 | 1.1 | 2.1 |
| Acidification emissions | kt $SO_2$ eq. | 8.0 | 9.2 | 17.2 |
| Volatile Organic Compounds (VOCs) | Kt | 0.9 | 0.9 | 1.8 |
| Persistent Organic Pollutants (POP) | g i-Teq | 0.7 | 0.8 | 1.5 |
| Heavy Metals | ton Ni eq. | 0.7 | 2.8 | 3.5 |
| PAHs | ton Ni eq. | 0.1 | 0.1 | 0.2 |
| Particulate Matter (PM dust) | Kt | 0.9 | 3.1 | 4 |
| **Emissions (Water)** | | | | |
| Heavy Metals | ton Hg/20 | 0.3 | 1.5 | 1.8 |
| Eutrophication | kt $PO_4$ | 0.0 | 0.0 | 0 |

## 5.4 Life cycle costs of the base cases

The life cycle costs have been calculated with the EcoReport tool. The methodology and the assumptions (regarding product price, energy and water costs, repair and maintenance costs) are described in Section 2.3.2.

### 5.4.1 Life cycle costs of ovens

The life cycle costs per appliance over a lifetime of 15 years are summarised for the three base cases in Table 75 and Figure 199.

**Table 75. Life cycle costs of ovens**

| | BC1 (EUR) | BC2 (EUR) | BC3 (EUR) |
|---|---|---|---|
| Product price | 446 | 342 | 60 |
| Installation | 82 | 82 | 0 |
| Fuel (gas) | 0 | 407 | 0 |
| Electricity | 561 | 14 | 72 |
| Water | 0 | 0 | 0 |
| Repair & maintenance costs | 63 | 52 | 0 |
| Total | 1152 | 897 | 132 |

The total life cycle cost of an electric oven (EUR 1 152) is higher than the cost of a gas cooker (EUR 897) and a microwave oven (EUR 132), across 15 years. These differences are mainly related to the higher product price of the electric oven, and the higher relative cost of electricity versus gas. It is interesting to note that, in the case of microwave ovens, the cost of electricity over its lifetime (EUR 72) is higher than the cost of acquisition of the product (EUR 60).

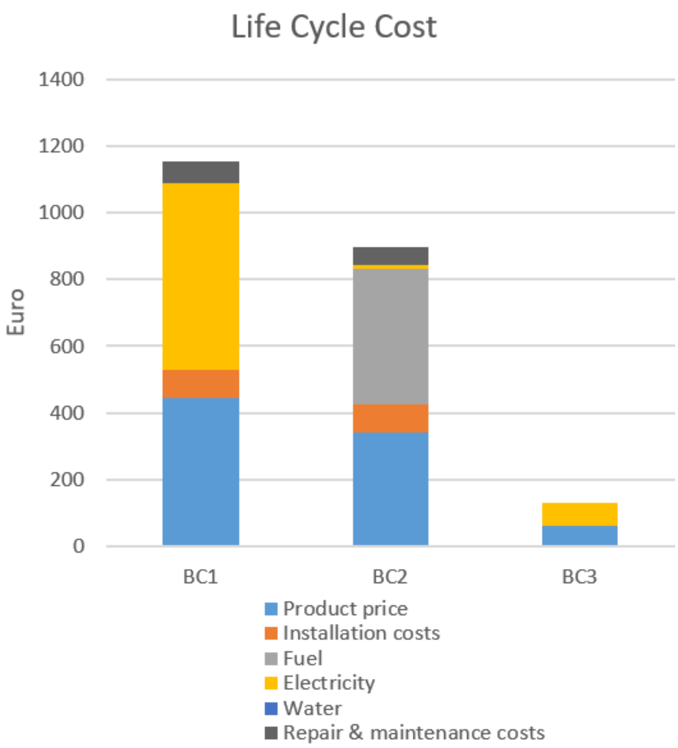



**Figure 199. Life cycle cost of ovens**

Table 76Table 78 shows the total consumer expenditure of all EU consumers in 2020.

**Table 76. Annual expenditure of all EU consumers in 2020**

| | Unit | **Base Case 1 (electric)** | **Base Case 2 (gas)** |
|---|---|---|---|
| Product price | Million EUR | 3381 | 132 |
| Installation | Million EUR | 622 | 32 |
| Energy | Million EUR | 5014 | 635 |
| Repair & maintenance costs | Million EUR | 187 | 30 |
| Total | Million EUR | 9203 | 853 |

### 5.4.2 Life cycle costs of hobs

The life cycle costs have been calculated with the EcoReport tool. The methodology and the assumptions are described in Section 5.2.

The life cycle costs per appliance over a lifetime of 15 years are summarised for the three base cases in Table 77.

**Table 77: Life cycle costs for the base cases over the whole product life cycle**

| | Unit | Base Case 1 (radiant) | Base Case 2 (induction) | Base Case 3 (gas hob) |
|---|---|---|---|---|
| Product price | EUR | 252 | 557 | 210 |
| Installation | EUR | 82 | 82 | 82 |
| Energy | EUR | 375 | 365 | 281 |
| Repair & maintenance costs | EUR | 16 | 27 | 11 |
| Total | EUR | 725 | 1031 | 584 |

Table 78 shows the total annual expenditure of all EU consumers in 2020.

**Table 78: Annual expenditure of all EU consumers in 2020**

| | Unit | Base Case 1 (radiant) | Base Case 2 (induction) | Base Case 3 (gas) |
|---|---|---|---|---|
| Product price | Million EUR | 680 | 1 966 | 380 |
| Installation | Million EUR | 221 | 289 | 148 |
| Energy | Million EUR | 1 727 | 1 120 | 871 |
| Repair & maintenance costs | Million EUR | 73 | 83 | 34 |
| Total | Million EUR | 2 701 | 3 458 | 1433 |

### 5.4.3 Life cycle costs of cooking fume extractors

The life cycle costs per appliance over a lifetime of 15 years are summarised for both base cases in Table 79.

**Table 79. Life cycle costs for the base cases over the whole product life cycle**

| | Unit | Base Case 1 (cabinet) | Base Case 2 (chimney) |
|---|---|---|---|
| Product price | EUR | 189 | 334 |
| Installation | EUR | 82 | 82 |
| Electricity | EUR | 149 | 135 |
| Repair & maintenance costs | EUR | 30 | 35 |
| Total | EUR | 451 | 586 |

The contribution of the different cost elements are shown in Figure 200 for both base cases. The largest contributions to the overall costs come from the purchase price and the expenditures in electricity. Installation costs also represent a significant share (20% in BC1 and 10% in BC2).

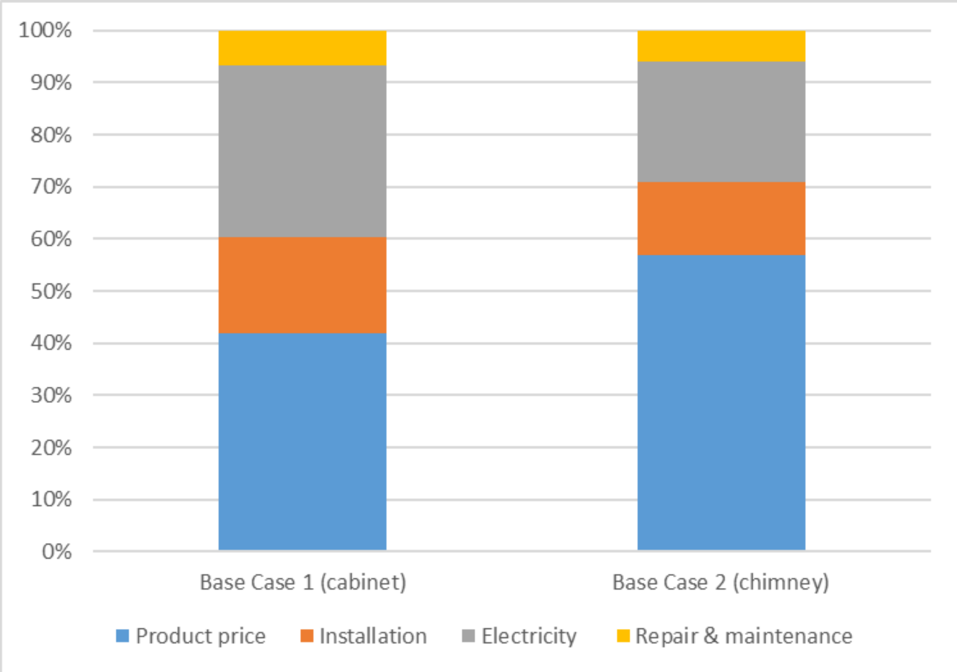


**Figure 200. Life cycle cost of cooking fume extractors**

Table 80 shows the total annual expenditure of all EU consumers in 2020.

**Table 80. Annual expenditure of all EU consumers in 2020**

| | Unit | **Base Case 1 (cabinet)** | **Base Case 2 (chimney)** |
|---|---|---|---|
| Product price | Million EUR | 539 | 1 162 |
| Installation | Million EUR | 233 | 285 |
| Electricity | Million EUR | 771 | 783 |
| Repair & maintenance costs | Million EUR | 157 | 200 |
| Total | Million EUR | 1 700 | 2 430 |

### 5.4.4 Sensitivity analysis: discount rate = 0%

In this section, a sensitivity analysis is conducted for the three product groups, assuming that the discount rate is 0% (instead of the 4% value assumed for the life cycle cost analysis of the base cases).

#### 5.4.4.1 Ovens

Table 81 shows the results of the sensitivity analysis for Base Case 1 of ovens. The life cycle costs when applying a discount rate of 0% are higher compared to the base case. This results from the fact that in the base case both the discount and the escalation rate have the same value (4%), thus both effects compensate each other. By setting the discount rate to 0% only the escalation rate is effective, i.e. the operating expenses increase over time.

Two main effects can be seen:

- the overall LCC is higher compared to the base case; and
- the relative contribution of the purchase price at the overall LCC is lower (reduced from 39% to 34%) while the relative contribution from the electricity consumption is increased.

As a result of the latter effect, the additional costs of design options would pay off more quickly if a discount rate of 0% was applied.

**Table 81. Life cycle costs – sensitivity analysis ovens**

| | Base Case 1 (electric oven) discount rate = 4% | | Sensitivity analysis: discount rate = 0% | |
|---|---|---|---|---|
| | Absolute LCC (**EUR)** | Relative contribution | Absolute LCC (**EUR)** | Relative contribution |
| Product price | 446 | 39% | 446 | 34% |
| Electricity | 561 | 49% | 707 | 54% |
| Installation | 82 | 7% | 82 | 6% |
| Repair & maintenance costs | 63 | 5% | 70 | 5% |
| Total | 1152 | 100% | 1305 | 100% |

#### 5.4.4.2 Hobs

Table 82 shows the results of the sensitivity analysis for Base Case 1 of hobs. The life cycle costs when applying a discount rate of 0% are higher compared to the base case. This results from the fact that in the base case both the discount and the escalation rate have the same value (4%), thus both effects compensate each other. By setting the discount rate to 0% only the escalation rate is effective, i.e. the operating expenses increase over time.

As in the case of ovens, two main effects can be seen:

- the overall LCC is higher compared to the base case; and
- the relative contribution of the purchase price at the overall LCC is lower (reduced from 32% to 26%) while the relative contribution from the electricity consumption is increased.

As a result of the latter effect, the additional costs of design options would pay off more quickly if a discount rate of 0% was applied.

**Table 82. Life cycle costs – sensitivity analysis hobs**

| | Base Case 1 (electric) discount rate = 4% | | Sensitivity: discount rate = 0% | |
|---|---|---|---|---|
| | Absolute LCC (**EUR)** | Relative contribution | Absolute LCC (**EUR)** | Relative contribution |
| Product price | 252 | 32% | 252 | 26% |
| Electricity | 365 | 51% | 507 | 58% |
| Installation | 82 | 12% | 82 | 9% |
| Repair & maintenance costs | 16 | 5% | 52 | 6% |
| Total | 725 | 100% | 881 | 100% |

#### 5.4.4.3 Cooking fume extractors

Table 83 shows the results of the sensitivity analysis for Base Case 1 of cooking fume extractors. The life cycle costs when applying a discount rate of 0% are higher compared to the base case. This results from the fact that in the base case both the discount and the escalation rate have the same value (4%), thus both effects compensate each other. By setting the discount rate to 0% only the escalation rate is effective, i.e. the operating expenses increase over time (the resulting present worth factor (PWF) is 16.45 years).

Similarly to ovens and hobs, two main effects can be seen:

- the overall LCC is higher compared to the base case; and
- the relative contribution of the purchase price at the overall LCC is lower (reduced from 42% to 36%) while the relative contribution from the electricity consumption is increased.

As a result of the latter effect, the additional costs of design options would pay off more quickly if a discount rate of 0% was applied.

**Table 83. Life cycle costs – sensitivity analysis cooking fume extractors**

| | Base Case 1 (cabinet) discount rate = 4% | | Sensitivity: discount rate = 0% | |
|---|---|---|---|---|
| | Absolute LCC (**EUR)** | Relative contribution | Absolute LCC (**EUR)** | Relative contribution |
| Product price | 189 | 42% | 189 | 36% |
| Electricity | 149 | 33% | 207 | 40% |
| Installation | 82 | 18% | 82 | 16% |
| Repair & maintenance costs | 30 | 7% | 42 | 8% |
| Total | 451 | 100% | 520 | 100% |

# 6 Task 6: Design options

## 6.1 Definition of oven design options

In Task 6, different design options to improve the energy efficiency and their relative impacts are discussed. In Task 4, several technologies related to domestic ovens have been described in detail. Some of them can be considered design options with the capacity for improving energy efficiency and consumption.

On various occasions during the development of this preparatory project, the authors have been in touch with associations of manufacturers, asking specifically for information regarding the base cases and best available technologies for current domestic ovens. Based on this consultation, Table 84 summarises the design options considered for ovens.

**Table 84. Summary of oven design options**

| Design options | Reference Base Case | Description |
|---|---|---|
| Option 1 (DO1): Electric oven with enhanced sealing reaching A+ energy class | BC1 | - The most common electric oven today is in the A energy class<br>- A potential best available technology today is an electric oven that has an enhanced sealing system, which makes use of residual heat, allowing it to reach A+ or A++ classes.<br>- Based on this feedback from manufacturers, two design options have been defined in this project: DO1 and DO2. |
| Option 2 (DO2): Electronic oven with enhanced sealing reaching A++ energy class | BC1 | |
| Option 3 (DO3): Gas oven reaching A+ energy class | BC2 | - The most common gas cooker today is in the A energy class<br>- A potential best available technology today is a gas cooker that has an enhanced sealing system, which makes use of residual heat, allowing it to reach A+ or A++ classes.<br>- Based on this feedback from manufacturers, two design options have been defined in this project: DO3 and DO4. |
| Option 4 (DO4): Gas oven reaching A++ energy class | BC2 | |
| Option 5 (DO5): Electric oven with microwave-assisted combined function | BC1 | As described in Section 4.1.4.8 of this preparatory study, some manufacturers offer ovens with combined function of forced-air convection and microwave. Feedback from industry highlights that there are energy and time saving potentials in these microwave combined modes. DO5 has been defined based on this feedback. |
| Option 6 (DO6): Electric oven with automatic functions | BC1 | According to some manufacturers, automatic features in ovens can guide the consumer in a more efficient use of their oven, by helping them choose the most appropriate heating mode and cooking time, depending on recipe. DO6 has been defined based on this feedback. |

These options are compared to the base cases (BC1 and BC2). Changes induced by the design options will be compared to the base cases with regard to:

- energy consumption;
- material composition (compared to the BoM of the base cases);
- manufacturing costs, maintenance and repair costs;
- product price.

## Design Options 1 and 2 (DO1 & DO2)

Design Options 1 (DO1) and 2 (DO2) have been defined in reference to Base Case 1 (BC1), so they will represent technologies with the potential to improve the energy consumption of current domestic electric ovens.

- DO1 will be an electric oven with an enhanced sealing system and appropriate use of residual heat that can reach A+ energy class (with Brickmethod 1.0).
- In the same way, DO2 will be an electric oven with an enhanced sealing system and appropriate use of residual heat that can reach A++ energy class (with Brickmethod 1.0).

Current energy labelling regulation identifies A+ and A++ ovens with EEI values as in Table 85.

**Table 85. EEI of energy classes A+ and A++**

| Energy class | EEI range | EEI (mid value) |
|---|---|---|
| A+ | 62 – 82 | 72 |
| A++ | 45 - 62 | 53.5 |

For DO1 and DO2, it will be considered that the ovens are at the middle of the A+ and A++ bands, respectively, as indicated in the table. The estimated energy consumption of DO1 and DO2 are presented in Table 86.

**Table 86. Energy consumption of DO1 and DO2**

| | Energy consumption Conventional (kWh/cycle) | Energy consumption Fan-forced (kWh/cycle) |
|---|---|---|
| DO1 | 0.89 | 0.61 |
| DO2 | 0.89 | 0.45 |

In terms of materials, they are fundamentally the same as the base case (the benefit is obtained through the use of residual heat in the energy-saving mode):

- <u>DO1</u>: no change in material composition;
- <u>DO2</u>: no change in material composition.

Based on manufacturers' feedback, there is no change in the manufacturing process in DO1 and DO2 when compared to the Base Case:

- <u>DO1</u>: manufacturing costs as in BC1;
- <u>DO2</u>: manufacturing costs as in BC1.

It will also be considered that the installation, maintenance and repair costs will be not significant when compared to BC1.

Regarding product price, in Task 2 an analysis has been conducted on the market of domestic ovens. Comparing the average prices of ovens in the A class with ovens in the A+ class, there are price increases between 26% and 49%, depending on the country. For the analysis in this section, an indicative 35% price increase between A and A+ will be assumed. In a similar way, the price increase between A+ and A++ will be assumed as 35%:

- <u>DO1</u>: product price 35% higher than BC1;
- <u>DO2</u>: product price 35% higher than DO1.

It is worth noting here that two stakeholders do not consider DO1 and DO2 as relevant design options, because of their theoretically lower performance compared to the most frequently used standard modes. In their view, the performance of these ovens for a "normal" common use is probably not better than an A oven.

For clarification, the JRC has selected DO1 and DO2 based on feedback from manufacturers, considering ovens available today in the market, under the assumption that they can provide satisfactory results with the modes used to achieve their energy class.

## Design Options 3 and 4 (DO3 & DO4)

Following a similar approach as described in the section above, Design Options 3 (DO3) and 4 (DO4) have been defined in reference to Base Case 2 (BC2), so they will represent technologies with the potential to improve the energy consumption of current domestic gas ovens (cookers):

- DO3 will be a gas cooker with an enhanced sealing system that allows 5% improvement in energy consumption from the Base Case;
- DO4 will be a gas cooker with an enhanced sealing system that allows 10% improvement in energy consumption from the Base Case.

The estimated energy consumption of DO3 and DO4 are:

- DO3: 5.4 MJ/cycle;
- DO4: 5.1 MJ/cycle.

In terms of materials, they are fundamentally the same as the base case:

- DO3: no change in material composition;
- DO4: no change in material composition.

Based on manufacturers' feedback, there is no change in the manufacturing process in DO3 and DO4 when compared to the Base Case:

- DO3: manufacturing costs as in BC2;
- DO4: manufacturing costs as in BC2.

It will also be considered that the installation, maintenance and repair costs will be not significant when compared to BC2.

Regarding product price, the assumptions will be analogous to the ones taken in DO1 and DO2:

- DO3: product price 35% higher than BC2;
- DO4: product price 35% higher than DO2.

## Design Option 5 (DO5)

As described in Section 4.1.4.8 of this preparatory study, feedback from industry highlights that there is energy- and time-saving potential in microwave combined modes. This savings potential was observed in tests with real food (not standardised). Depending on the type of dish being prepared, when compared to forced-air convection without a microwave function, the energy savings range between 5% and 20%. For the purpose of this design option, it will be considered that an electric oven with a microwave-assisted combined function is a design option with the capacity to reduce the energy consumption by an average of 10%. In this case, the improvement has been considered for both conventional and fan-forced heating modes (Table 87).

**Table 87. Energy consumption of DO5**

| | Energy consumption Conventional (kWh/cycle) | Energy consumption Fan-forced (kWh/cycle) |
|---|---|---|
| DO5 | 0.80 | 0.71 |

In terms of materials, the additional materials considered in DO5 will be the ones used in the components required for the microwave function:

- magnetron: 668 g of copper; 74 g of ceramics;
- electronic components: 333 g of controller boards, 161 g of ABS, 15 g of PC.

Taking into account that an oven with a microwave combined function is a product with a higher level of complexity than the one defined in BC1, it will be assumed that in DO5 manufacturing costs are 15% higher:

- DO5: manufacturing costs 15% higher than BC1.

Following a similar reasoning, it will be assumed that installation, maintenance and repair costs are 10% higher than in BC1:

- DO5: installation, maintenance and repair costs 10% higher than BC1.

Regarding product price, the average price of electric ovens with a microwave function is between EUR 1 089 and EUR 1 454, depending on the country. For the analysis in this section, an indicative product price of EUR 1 200 will be assumed.

## Design Option 6 (DO6)

According to some manufacturers, automatic features in ovens can guide the consumer in a more efficient use of their oven, by helping them choose the most appropriate heating mode and cooking time, depending on the recipe.

For the purpose of this design option, it will be considered that an electric oven with automatic features is a design option with the capacity to reduce the energy consumption by an average of 15%. In this case, the improvement has been considered for both conventional and fan-forced heating modes (Table 88).

**Table 88. Energy consumption of DO6**

| | Energy consumption Conventional (kWh/cycle) | Energy consumption Fan-forced (kWh/cycle) |
|---|---|---|
| DO6 | 0.76 | 0.67 |

In terms of materials, the additional materials considered will be the ones used in the required sensors and timers:

- electronic components: 300 g of controller boards, 150 g of ABS, 15 g of PC.

Taking into account that an oven with automatic functions is a product with a higher level of complexity than the one defined in BC1, it will be assumed that in DO6 manufacturing costs are 30% higher:

- DO6: manufacturing costs 30% higher than BC1.

Following a similar reasoning, it will be assumed that installation, maintenance and repair costs are 10% higher than in BC1:

- <u>DO6</u>: installation, maintenance and repair costs 10% higher than BC1.

Regarding product price, an indicative 50% increase in the product price will be assumed.

## Design Options involving Microwave ovens

In terms of design options with the capacity to reduce the energy consumption of microwave ovens, in Section 4.1.4.7 of this report, the authors mentioned a publication from 2005 by the Energy Conservation Center of Japan (ECCJ, 2005), where one of the conclusions was that there was still room for improvement in the efficiency of microwaves, possibly by improving the radiation method and thermal insulation performance. However, in the previous preparatory study for domestic and commercial cooking appliances (Mudgal et al., 2011), manufacturers assured that modern microwave ovens are close to maximum efficiency. Cavity size had no effect on it, while internal coatings could only improve it by 1-2%. Over the development of this project, no other specific technology with the capacity for reducing the energy consumption of microwave ovens has been mentioned by stakeholders.

In Section 4.1.6 of this report, the authors mentioned solid-state semiconductors as a potential best not available technology, which could help in the future to make more efficient use of these appliances, by adjusting and producing just the right amount of microwaves, at the right level of power and for the correct length of time, to heat food evenly. However, currently there is no scientific evidence regarding potential improvements in terms of the energy efficiency of this technology. Moreover, feedback from manufacturers indicates that the efficiency of generating microwaves by a semiconductor is much lower than with a magnetron; and the oven needs to be dimensioned for a specific frequency to assure an efficient use and avoid microwave leakage. The costs of this technology are currently significantly high.

As a summary of this section, it could be stated that:

- the room for reducing the energy consumption of current microwave ovens is very small or non-existent;
- potential technologies that are still not available to reduce the energy consumption of microwave ovens are too expensive or have not shown evidence of their reduction capacity.

For the reasons pointed out above, the authors of this report took the decision of not including a design option to model the energy reduction of microwave ovens.

## Summary of oven design options

As a conclusion of this section, a summary of the characteristics of the different Design Options that will be evaluated further are presented in Table 89.

**Table 89. Summary of oven design options**

| Design option | Ref. Base Case | Description | Energy consumption Conventional | Energy consumption Fan-forced | Changes in material composition | Manufacturing costs | Maintenance and repair costs | Product price |
|---|---|---|---|---|---|---|---|---|
| DO1 | BC1 | An electronic oven with appropriate sealing/insulation reaching A+, with current measurement method. This oven | 0.89 kWh/cycle | 0.61 kWh/cycle | No change | No change | No change | 35% higher than BC1 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | also reuses residual heat/eco mode | | | | | | |
| DO2 | BC1 | An electronic oven with appropriate sealing/insulation reaching A++, with current measurement method. This oven also reuses residual heat/eco mode | 0.89 kWh/cycle | 0.45 kWh/cycle | No change | No change | No change | 35% higher than DO1 |
| DO3 | BC2 | A gas oven reaching A+ | 5.4 MJ/cycle | n/a | No change | No change | No change | 35% higher than BC2 |
| DO4 | BC2 | A gas oven reaching A++ | 5.1 MJ/cycle | n/a | No change | No change | No change | 35% higher than DO3 |
| DO5 | BC1 | An electric oven with MW-assisted heating function | 0.80 kWh/cycle | 0.71 kWh/cycle | Additional materials related to MW oven: magnetron, electronics | 15% higher than BC | 10% higher than BC | 1200 Euro |
| DO6 | BC1 | An electric oven with smart features to select optimum heating modes and cooking times, which allows the reduction of the average energy consumption | 0.76 kWh/cycle | 0.67 kWh/cycle | Additional materials related to electronics | 30% higher than BC | 10% higher than BC | 50% higher than BC1 |

One stakeholder argued that no design option considers mechanical design improvements, such as material changes (lighter, reflexive, triple glass for door, type of insulation, sealing, etc.), which could provide energy savings regardless of the type of use.

For clarification, the JRC has assessed the potential improvements related to those areas in Task 4 of this report. Although potential improvements have been claimed in different areas related to materials (Burlon, 2015), these improvements are either very small or without enough background to be considered as a design option. This is the case of the findings presented in Isik (2017), Bareyt (2016) and MAESDOSO (2017). Other alternatives, such as high-emissivity walls, have been discarded since these ovens have low market potential due to issues related to degradation of the walls (see Section 4.1.2.2). Other options such as a cylindrical cavity (Nuñez, 2009) were not considered as design options due to the low potential market share of this type of oven.

## 6.2 Definition of hob design options

In Task 4, several technologies related to hobs were described, including the typical energy consumption range of electric hobs. This information can be translated into design options that represent the improvement potential of this product. Table 90 summarises the initial design options.

**Table 90. Hob design options**

| Design options | Reference Base Case | Description |
|---|---|---|
| Option 1 (DO1): (Best induction technology) | BC2 | Most efficient induction technology. The energy consumption is 175 Wh/kg. |
| Option 2 (DO2): A gas hob with better energy efficiency | BC3 | According to the information provided by manufacturers, gas hobs can reach a maximum of 58%. |

Manufacturers were asked to provide specific technical and cost data for the above listed design options. These options are compared to the base cases (BC2 and BC3). Changes induced by the design options will be compared to the base cases with regard to:

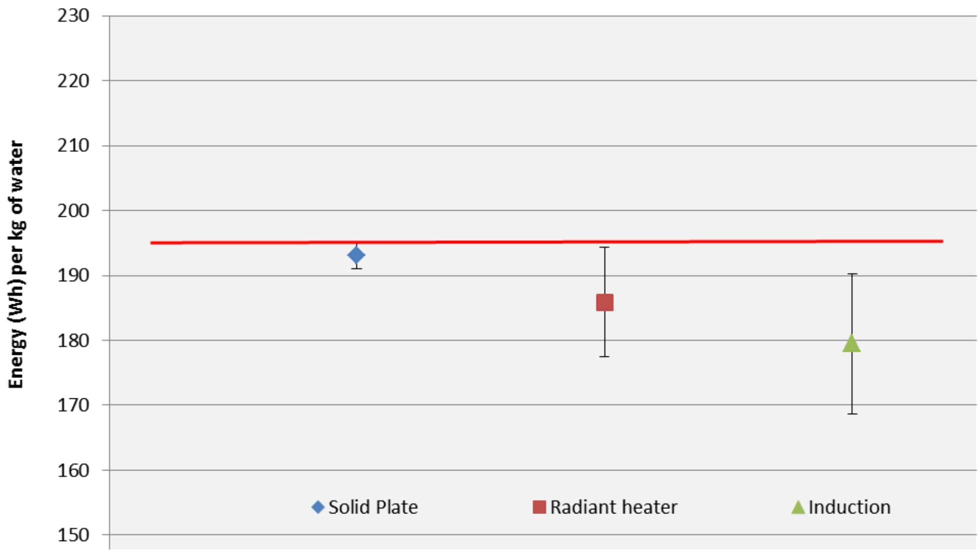
- energy consumption;
- material composition (compared to the BoM of the base cases);
- manufacturing costs, maintenance and repair costs;
- product price.

Based on this input and additional expert knowledge, the project team has assumed the input for further calculations as described in the following sections.

## Design Option 1

Design Option 1 (DO1) has been defined in reference to Base Case 2 (BC2), so it will represent technologies with the potential to improve the energy consumption of current domestic induction hobs.

Manufacturers shared the range of energy consumption that the three types of electric hobs (solid plate, radiant heater and induction) typically achieve (Figure 201). The red line shows the ecodesign limit for energy consumption after 2019 (195 Wh/kg).




Source: APPLIA

**Figure 201. Energy consumption ranges of electric hobs**

The ranges observed in the graph correspond to the variety of sizes and number of heating zones within radiant and induction hobs. They do not represent different performances for a given base case.

Manufacturers have provided specific information about base cases and best available technologies. Regarding domestic electric hobs, manufacturers responded the following:

a) No further energy savings can be achieved for radiant hobs. The margin allowed by improving controls have been fully developed.

b) A potential best available technology today is induction technology.

Based on this feedback from manufacturers, DO1 has been defined as the best available induction hob with four defined cooking areas.

In terms of materials, DO1 would not entail any change in the weight or the Bill of Materials, compared to BC2.

## Design Option 2

Following a similar approach as described in the section above, Design Option 2 has been defined in reference to Base Case 2 (BC2), so it will represent the potential to improve the energy consumption of current domestic gas hobs.

The authors have been in touch with association of manufacturers, asking specifically for information regarding base cases and best available technologies. Regarding domestic gas hobs, manufacturers responded that gas hobs can reach a maximum energy efficiency of 58%. Higher efficiencies would jeopardise safety requirements, therefore no further design options have been considered. Apart from that, this efficiency would not be feasible for the special case of hobs having one burner only, which are normally very powerful dual burners, and usually achieve lower efficiencies.

In terms of materials, DO2 obtains the energy consumption benefits by improving the heat transference. No additional materials would be needed

In order to achieve the assumed energy consumption reductions, DO2 will require slightly different manufacturing processes, potentially with higher levels of quality control. Therefore, it will be assumed that manufacturing costs will be 10% higher than in BC3.

Regarding product price, in Task 2 an analysis has been conducted on the market of domestic hobs. For the analysis in this section, an indicative 20% price increase between BC3 and DO2 will be assumed.

## Summary of hob design options

As a conclusion of this section, a summary of the characteristics of the different Design Options that will be evaluated further are presented in Table 91.

**Table 91. Summary of hob design options**

| Design option | Ref. Base Case | Description | Energy consumption vs BC | Changes in material composition | Manufacturing costs | Maintenance and repair costs | Product price |
|---|---|---|---|---|---|---|---|
| DO1 | BC2 | Best available induction | 170 vs 185 Wh/Kg | No change | +10% | No change | +20% |
| DO2 | BC3 | A gas hob with better energy efficiency | 60% vs 55% | Negligible | +10% | No change | +20% |

## 6.3 Definition of cooking fume extractors design options

In Task 4, several technologies related to cooking fume extractors were described, including the different technical options to improve the energy efficiency of this product. This information can be translated into design options that represent the improvement potential of this product. Table 92 summarises the initial design options.

**Table 92. Cooking fume extractor design options**

| Design options | Reference Base Case | Description |
|---|---|---|
| Option 1 (DO1):<br>More efficient capacitor motor | BC1 | According to the information provided by manufacturers, the capacitor motor achieves energy efficiencies that range from 60% to 70%. This option will reduce the annual energy consumption of the base case by 23% in cabinet cooking fume extractors. |
| Option 2 (DO2, DO3):<br>Brushless motor | BC1, BC2 | According to the information provided by manufacturers, brushless motors achieve energy efficiencies that range from 70% to 80%. This option will reduce the annual energy consumption of the base case by 55% in T-shape cooking fume extractors and 60% in cabinet cooking fume extractors. |
| Option 3 (DO4, DO5):<br>Optimisation of working conditions | BC1, BC2 | The application of the 9-point method and introduction of capture efficiency will mean that the cooking fume extractors will be set up at optimal efficiencies. This may increase the real efficiency around 10%. |

Manufacturers were asked to provide specific technical and cost data for the above listed design options. These options are compared to the base cases (BC1 and BC2). Changes induced by the design options will be compared to the base cases with regard to:

- energy consumption;
- material composition (compared to the BoM of the base cases);
- manufacturing costs, maintenance and repair costs;
- product price.

Based on this input and additional expert knowledge, the project team has assumed the input for further calculations as described in the following sections.

## Design Options 1, 2 and 3

Design Options 1 (DO1) and 2 (DO2) have been defined in reference to Base Case 1 (BC1), and Design Option 3 (DO3) in reference to Base Case 2 (BC2). They will represent technologies with the potential to improve the energy consumption of current domestic cooking fume extractors.

Manufacturers shared the range of energy efficiencies of the motors that cooking fume extractors are equipped with, as follows:

- **Brushless motors**: they are components of high-end models that can reach energy classes between A++ and A+++. They achieve high motor efficiencies, within the range of 70% and 85%. They are smaller and lighter than capacitor or shaded poles motors.
- **Asynchronous capacitor motors**: they are components of middle and high-end models that can reach energy classes between D and A+. They achieve lower motor efficiencies than brushless motors, within the range of 55% and 70%.
- **Asynchronous shaded poles motors:** they are components of low-end models whose energy classes are between D and C. They achieve the lowest efficiencies, within the range of 20% and 30%, and they are the most economical ones.

Design Option 1 consists of a cabinet cooking fume extractor equipped with an improved motor of the same technology, i.e. capacitor. This can be considered a standard improvement option as it can be achieved without change of technology. The reduction in the annual energy consumption has been estimated by comparing the performance of the base case cabinet cooking fume extractor and a similar (in terms of maximum airflow) cabinet cooking fume extractor, also equipped with a capacitor motor. The data come from the APPLiA database.

In contrast, Design Options 2 and 3 will entail a shift in technology to a brushless motor. Besides, this option represents the best energy classes currently in the market, and therefore it can be considered best available technology. Like Design Option 1, the base cases have been compared to a similar cooking fume extractor equipped with a brushless motor.

In terms of materials, DO1 obtains energy consumption benefits by improving the base case technology. The additional materials needed are considered negligible, according to manufacturers.

In the case of DO2 and DO3, the change of technology would entail a change of materials. Since brushless motors are usually smaller, the weight of the cooking fume extractor could be reduced. This reduction is assumed to be 5%.

In order to achieve the assumed energy consumption reductions, DO1 will require an improved motor that will entail an additional manufacturing cost of EUR 5. The change to brushless motors will involve higher costs, based on manufacturers' information, i.e. an additional cost of EUR 18.

Regarding product price, the price increase calculated according to standard manufacturers' and retailers' profit rates:

- DO1: product price 7% higher than BC1;
- DO2: product price 25% higher than BC1;
- DO3: product price 14% higher than BC2.

## Design Options 4 and 5

Design Options 4 (referred to BC1) and 5 (referred to BC2) will be derived from the application of the 9-point method to calculate the annual energy consumption and EEI of cooking fume extractors. The current methodology measures these parameters at best efficiency point, which is usually the maximum or boost speed. This means that at lower speeds the motor delivers the power at lower efficiencies. The 9-point method will drive the design of the cooking fume extractors towards optimal efficiencies in real-life conditions, which will lead to a reduction of the annual energy consumption. In the case of recirculation CFE, the design option to optimise the odour reduction factor will also lead to optimised working conditions and higher energy efficiency.

This improvement option will not require additional materials or additional costs, since it will only need a best match between the motor design and the actual conditions of usage.

## Summary of cooking fume extractors design options

As a conclusion of this section, a summary of the characteristics of the different Design Options that will be evaluated further are presented in Table 93.

**Table 93. Summary of cooking fume extractor design options**

| Design option | Ref. Base Case | Description | Energy consumption vs BC | Changes in material composition | Manufacturing costs | Maintenance and repair costs | Product price |
|---|---|---|---|---|---|---|---|
| DO1 | BC1 | More efficient capacitor motor | 23% reduction of the AEC | No | + EUR 5 | No change | +7% |
| DO2 | BC1 | Brushless motor | 60% reduction of the AEC | Smaller motor, 5% reduction of cooking fume extractor weight | + EUR 18 | No change | +25% |
| DO3 | BC2 | Brushless motor | 55% reduction of the AEC | Smaller motor, 5% reduction of cooking fume extractor wight | + EUR 18 | No change | +14% |
| DO4, DO5 | BC1, BC2 | Optimisation of working conditions | The application of the 9-point method will entail setting up cooking fume extractors at optimal efficiencies at the three speeds.<br>This may increase the real efficiency of motors around 10%. | | | | |

## 6.4 Environmental analysis of design options

### 6.4.1 Environmental analysis of ovens

**Design Options related to BC1 ovens**

Base Case 1 is a 70-litre electric oven with an A energy class. Potential improvements regarding this BC are equivalent ovens in superior energy classes: A+ (DO1) and A++ (DO2). A direct and obvious consequence of these design options is the reduction of electricity consumption, both in terms of Total Energy and Electricity, as can be observed in Figure 202 and Table 94. In DO1, Total Energy is reduced by

9% and in DO2 17%. Also related to this improvement in energy consumption is the reduction in Greenhouse Gases: 7% in DO1 and 13% in DO2.

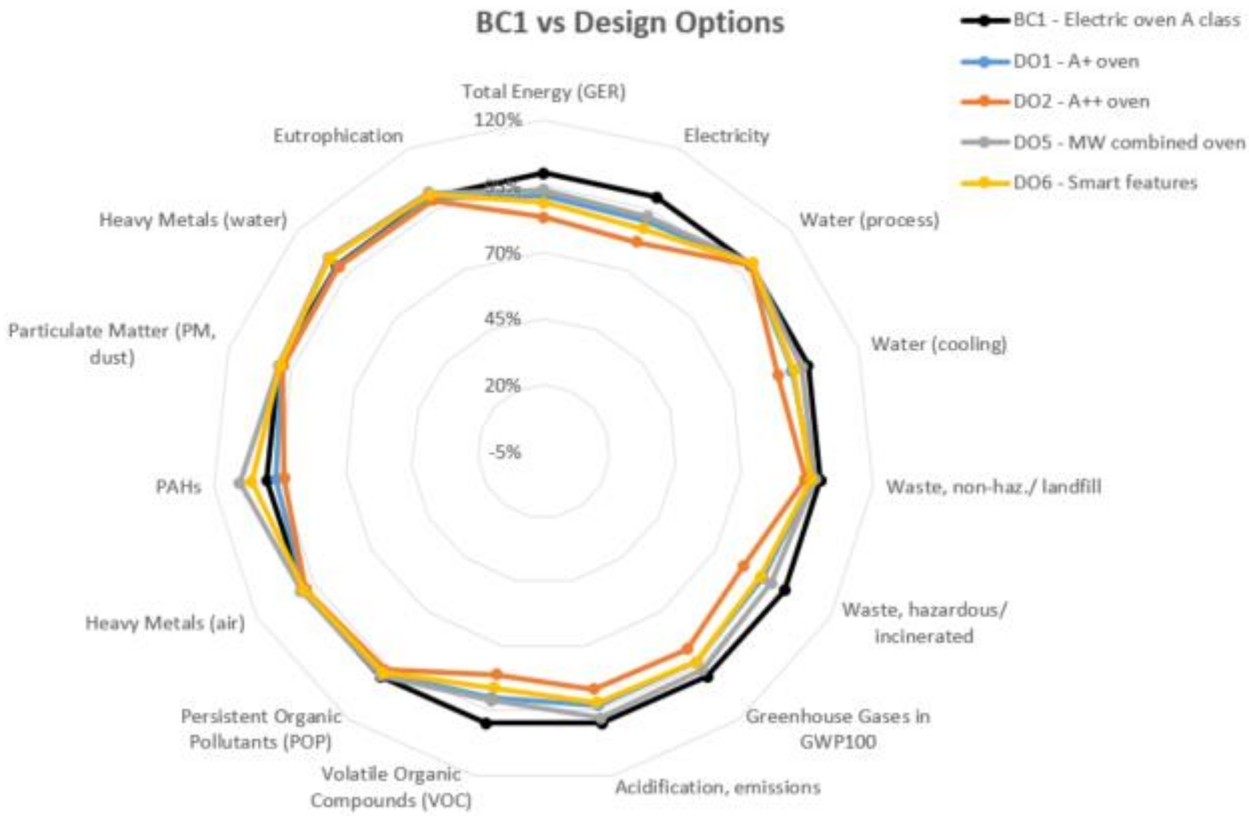



**Figure 202. Environmental analysis of BC1 oven design options**

Significant improvements are also observed in Hazardous waste/incinerated (10% in DO1 and 18% in DO2): if less electricity is required, less waste related to electricity generation will be produced. A similar situation is observed in Acidification and Volatile Organic Compounds. These are emissions that are directly related to electricity generation. When less electricity is needed, the emissions are reduced drastically.

The improvements above related to DO1 and DO2 come with no trade-offs in other categories: by definition, DO1 and DO2 only differ from BC1 in the fact that they consume less energy (they are the same oven in terms of material composition). Therefore, reducing the energy consumption of the base case can only have beneficial consequences.

DO5 is an electric oven with a microwave-combined function, assumed to reduce the energy consumption per cycle by 10% compared to BC1. This reduction in energy consumption translates into improvements in categories such as Total Energy (6%), Electricity (8%) or VOCs (9%), all of them emissions directly related to the generation of electricity. The main changes of DO5 compared to BC1 are the addition of materials related to microwave oven components: the magnetron and the electronics. The addition of those materials has a direct effect on the increased impact of categories such as Water/process (1%), PAHs (10%) and Heavy Metals (1%).

Finally, DO6 is an electric oven with automatic features, assumed to reduce the energy consumption per cycle by 15% compared to BC1. Similarly to the design option above, this reduction in energy consumption translates into improvements in categories such as Total Energy (11%), Electricity (13%), Greenhouse Gas Emissions (7%), Acidification (8%) or VOCs (14%). The addition of electric components related to an oven with automatic features has a negative effect on categories such as Water/process (1%), PAHs (10%) and Heavy Metals (1%).

All the results discussed in this section can be seen in Table 94.

**Table 94. Results of BC1 oven design options**

| | | | | | |
|---|---|---|---|---|---|
| **Other Resources & Waste** | | | | | |
| | **BC1** | **DO1** | **DO2** | **DO5** | **DO6** |
| Total Energy (GER) [MJ] | 21099.9 | 19251.5 | 17595.9 | 19750.3 | 18765.9 |
| % vs BC1 | | -9% | -17% | -6% | -11% |
| Electricity [MJ] | 22428.8 | 20228.3 | 18257.3 | 20599.8 | 19524.9 |
| % vs BC1 | | -10% | -19% | -8% | -13% |
| Water (process) [ltr] | 1631.3 | 1631.3 | 1631.3 | 1648.6 | 1647.0 |
| % vs BC1 | | 0% | 0% | 1% | 1% |
| Water (cooling) [ltr] | 1533.0 | 1435.2 | 1347.6 | 1496.3 | 1445.1 |
| % vs BC1 | | -6% | -12% | -2% | -6% |
| Waste, non-haz./ landfill [g] | 37004.5 | 35870.5 | 34854.7 | 36330.6 | 35733.4 |
| % vs BC1 | | -3% | -6% | -2% | -3% |
| Waste, hazardous/ incinerated [g] | 362.9 | 328.1 | 297.0 | 342.4 | 324.3 |
| % vs BC1 | | -10% | -18% | -6% | -11% |
| **Emissions (Air)** | | | | | |
| | **BC1** | **DO1** | **DO2** | **DO5** | **DO6** |
| Greenhouse Gases in GWP100 [kg $CO_2$ eq.] | 641.3 | 598.4 | 560.0 | 622.8 | 596.9 |
| % vs BC1 | | -7% | -13% | -3% | -7% |
| Acidification, emissions [g $SO_2$ eq.] | 5896.9 | 5481.3 | 5109.0 | 5773.6 | 5413.6 |
| % vs BC1 | | -7% | -13% | -2% | -8% |
| Volatile Organic Compounds (VOCs) [g] | 495.6 | 446.4 | 402.4 | 451.7 | 428.0 |
| % vs BC1 | | -10% | -19% | -9% | -14% |
| Persistent Organic Pollutants (POP) [ng i-Teq] | 319.7 | 314.6 | 310.0 | 318.5 | 313.9 |
| % vs BC1 | | -2% | -3% | 0% | -2% |
| Heavy Metals [mg Ni eq.] | 3482.9 | 3460.6 | 3440.7 | 3507.8 | 3467.4 |
| % vs BC1 | | -1% | -1% | 1% | 0% |
| PAHs [mg Ni eq.] | 148.9 | 143.8 | 139.2 | 164.4 | 157.5 |
| % vs BC1 | | -3% | -7% | 10% | 6% |
| Particulate Matter (PM, dust) [g] | 1207.1 | 1198.3 | 1190.4 | 1208.9 | 1202.4 |
| % vs BC1 | | -1% | -1% | 0% | 0% |
| **Emissions (Water)** | | | | | |
| | **BC1** | **DO1** | **DO2** | **DO5** | **DO6** |
| Heavy Metals [mg Hg/20] | 2037.7 | 2028.2 | 2019.7 | 2126.6 | 2109.8 |
| % vs BC1 | | 0% | -1% | 4% | 4% |
| Eutrophication [g PO4] | 56.8 | 56.4 | 56.0 | 57.8 | 57.4 |

| | | | | | |
|---|---|---|---|---|---|
| % vs BC1 | | -1% | -1% | 2% | 1% |

**Design Options related to BC2 ovens**

Base Case 2 is a 65-litre gas cooker with an A energy class. Potential improvements regarding this BC are equivalent ovens with energy consumption reductions of 5% (BC3) and 10% (BC4). As described in the previous section, the direct and obvious consequence of these design options is the reduction of the gas consumption, mainly in terms of Total Energy (6% in DO3 and 10% in DO4), as can be observed in Figure 203 and Table 95. Also related to this improvement in Total Energy consumption is the reduction in Greenhouse Gases: 6% in DO3 and 10% in DO4.

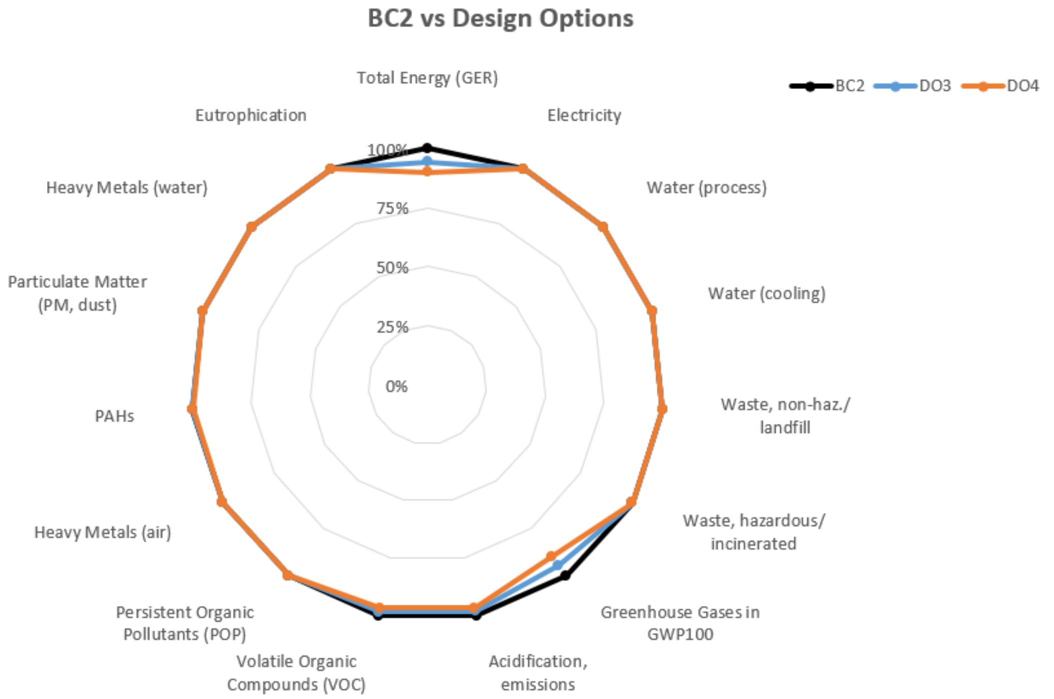



**Figure 203. Environmental analysis of BC2 oven design options**

**Table 95. Results of BC2 oven design options**

| **Other Resources & Waste** | | | |
|---|---|---|---|
| | **BC1** | **DO3** | **DO4** |
| Total Energy (GER) [MJ] | 21775.0 | 20543.2 | 19572.8 |
| % vs BC1 | | -6% | -10% |
| Electricity (Primary Energy) [MJ] | 943.8 | 943.8 | 943.8 |
| % vs BC1 | | 0% | 0% |
| Water (process) [l] | 546.2 | 546.2 | 546.2 |
| % vs BC1 | | 0% | 0% |
| Water (cooling) [l] | 748.0 | 748.0 | 748.0 |
| % vs BC1 | | 0% | 0% |
| Waste, non-haz./ landfill [g] | 18020.7 | 18020.7 | 18020.7 |
| % vs BC1 | | 0% | 0% |
| Waste, hazardous/ incinerated [g] | 34.9 | 34.9 | 34.9 |

| | | | |
|---|---|---|---|
| % vs BC1 | | 0% | 0% |
| **Emissions (air)** | | | |
| | **BC2** | **DO3** | **DO4** |
| Greenhouse Gases in GWP100 [kg $CO_2$ eq.] | 1205.3 | 1137.2 | 1083.5 |
| % vs BC1 | | -6% | -10% |
| Acidification, emissions [g $SO_2$ eq.] | 1030.1 | 1010.2 | 994.6 |
| % vs BC1 | | -2% | -3% |
| Volatile Organic Compounds (VOCs) [g] | 48.2 | 47.3 | 46.6 |
| % vs BC1 | | -2% | -3% |
| Persistent Organic Pollutants (POP) [ng i-Teq] | 236.7 | 236.7 | 236.7 |
| % vs BC1 | | 0% | 0% |
| Heavy Metals [mg Ni eq.] | 916.4 | 916.4 | 916.4 |
| % vs BC1 | | 0% | 0% |
| PAHs [mg Ni eq.] | 39.0 | 38.9 | 38.9 |
| % vs BC1 | | 0% | 0% |
| Particulate Matter (PM, dust) [g] | 1496.6 | 1496.2 | 1496.0 |
| % vs BC1 | | 0% | 0% |
| **Emissions (water)** | | | |
| | **BC2** | **DO3** | **DO4** |
| Heavy Metals [mg Hg/20] | 531.6 | 531.6 | 531.6 |
| % vs BC1 | | 0% | 0% |
| Eutrophication [g PO4] | 23.4 | 23.4 | 23.4 |
| % vs BC1 | | 0% | 0% |

### 6.4.2 Environmental analysis of hobs

**Design Options related to BC2 hobs**

Base Case 2 is a four-heating-zone induction hob that consumes 185 Wh/kg water. There is a margin for improvement in these products, and the only design option identified is the most efficienct induction hob currently in the market, which can reach a consumption of 170 Wh/kg water. This improvement does not entail any addition of materials. A direct consequence is a reduction of the electricity consumption, in terms of Total Energy (12%), as can be observed in Figure 204 and Table 96. Also related to this improvement in Total Energy consumption is a similar reduction in Greenhouse Gases, Acidification and VOC emissions.

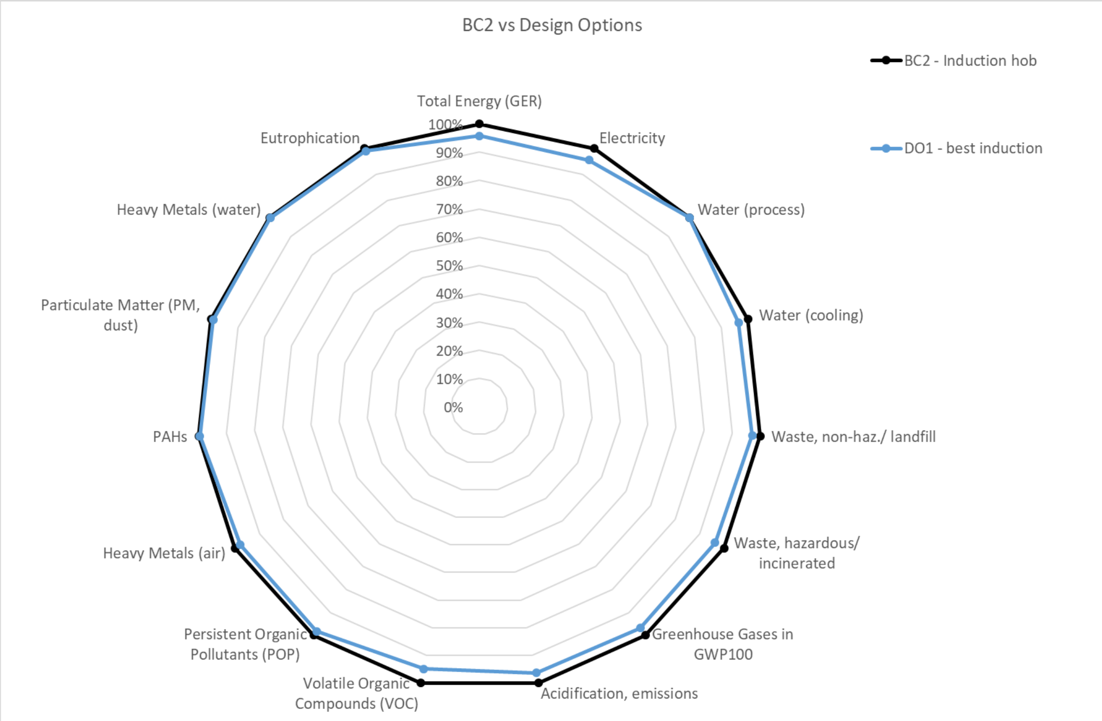



**Figure 204. Environmental analaysis of BC2 hob design options**

All the results discussed in this section can be seen in Table 96.

**Table 96. Results of BC2 hob design options**

| **Other Resources & Waste** | | |
|---|---|---|
| | **BC2** | **DO1** |
| Total Energy (GER) [MJ] | 16760.7 | 16053.3 |
| % vs BC2 | | -4% |
| Primary Energy [MJ] | 15454.7 | 14747.3 |
| % vs BC2 | | -5% |
| Water (process) [l] | 191.5 | 191.5 |
| % vs BC2 | | 0% |
| Water (cooling) [l] | 1039.6 | 1002.2 |
| % vs BC2 | | -4% |
| Waste, non-haz./ landfill [g] | 15331.2 | 14897.2 |
| % vs BC2 | | -3% |
| Waste, hazardous/ incinerated [g] | 354.7 | 341.4 |
| % vs BC2 | | -4% |
| **Emissions (Air)** | | |
| | **BC2** | **DO1** |
| Greenhouse Gases in GWP100 [kg CO2 eq.] | 526.2 | 509.8 |
| % vs BC2 | | -3% |
| Acidification, emissions [g SO2 eq.] | 4318.4 | 4159.4 |

| | | |
|---|---|---|
| % vs BC2 | | -4% |
| Volatile Organic Compounds (VOCs) [g] | 369.9 | 351.1 |
| % vs BC2 | | -5% |
| Persistent Organic Pollutants (POP) [ng i-Teq] | 113.8 | 111.8 |
| % vs BC2 | | -2% |
| Heavy Metals [mg Ni eq.] | 389.5 | 381.0 |
| % vs BC2 | | -2% |
| PAHs [mg Ni eq.] | 425.1 | 423.1 |
| % vs BC2 | | 0% |
| Particulate Matter (PM, dust) [g] | 391.8 | 388.5 |
| % vs BC2 | | -1% |
| **Emissions (Water)** | | |
| | **BC2** | **DO1** |
| Heavy Metals [mg Hg/20] | 1136.5 | 1132.8 |
| % vs BC2 | | 0% |
| Eutrophication [g PO4] | 15.4 | 15.2 |
| % vs BC2 | | -1% |

**Design Options related to BC3 hobs**

Base Case 3 is a four-burner gas hob with an efficiency of 56%. There is little margin for improvement in these products, though the only design option identified is the most efficienct gas hob currently in the market, which can reach 58% energy efficiency. This improvement does not entail any addition of materials. A direct consequence is a modest reduction of the gas consumption, in terms of Total Energy (3%), as can be observed in Figure 205 and Table 97. Also related to this improvement in Total Energy consumption is the same reduction in Greenhouse Gases, Acidification and VOC emissions.

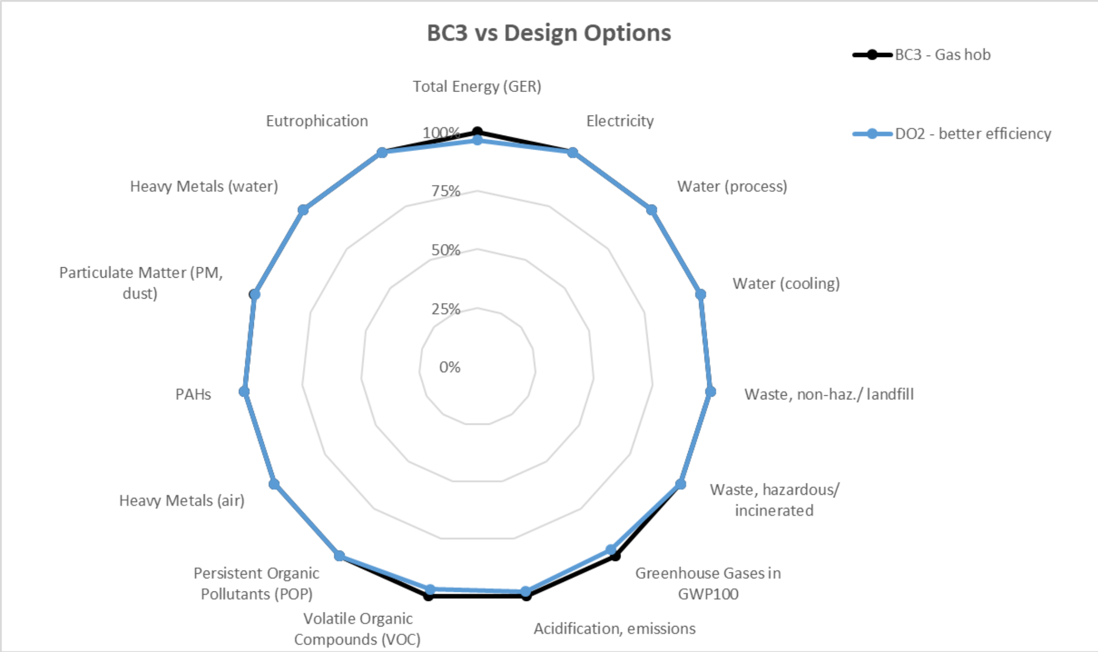



**Figure 205. Environmental analysis of BC3 hob design options**

All the results discussed in this section can be seen in Table 97.

**Table 97. Results of BC3 hob design options**

| **Other Resources & Waste** | | |
|---|---|---|
| | **BC3** | **DO2** |
| Total Energy (GER) [MJ] | 15073.9 | 14561.9 |
| % vs BC3 | | -3% |
| Primary Energy [MJ] | 94.5 | 94.5 |
| % vs BC3 | | 0% |
| Water (process) [l] | 4.0 | 4.0 |
| % vs BC3 | | 0% |
| Water (cooling) [l] | 65.9 | 65.9 |
| % vs BC3 | | 0% |
| Waste, non-haz./ landfill [g] | 7184.5 | 7184.5 |
| % vs BC3 | | 0% |
| Waste, hazardous/ incinerated [g] | 5.2 | 5.2 |
| % vs BC3 | | 0% |
| | **BC3** | **DO2** |
| Greenhouse Gases in GWP100 [kg $CO_2$ eq.] | 839.1 | 810.7 |
| % vs BC3 | | -3% |
| Acidification, emissions [g $SO_2$ eq.] | 419.8 | 411.6 |
| % vs BC3 | | -2% |
| Volatile Organic Compounds (VOCs) [g] | 12.5 | 12.2 |

| | | |
|---|---|---|
| % vs BC3 | | -3% |
| Persistent Organic Pollutants (POP) [ng i-Teq] | 113.6 | 113.6 |
| % vs BC3 | | 0% |
| Heavy Metals [mg Ni eq.] | 70.4 | 70.4 |
| % vs BC3 | | 0% |
| PAHs [mg Ni eq.] | 125.4 | 125.4 |
| % vs BC3 | | 0% |
| Particulate Matter (PM, dust) [g] | 249.9 | 249.8 |
| % vs BC3 | | 0% |
| **Emissions (water)** | | |
| | **BC3** | **DO2** |
| Heavy Metals [mg Hg/20] | 57.0 | 57.0 |
| % vs BC3 | | 0% |
| Eutrophication [g PO4] | 0.4 | 0.4 |
| % vs BC3 | | 0% |

### 6.4.3 Environmental analysis of cooking fume extractors

**Design Options related to BC1 cooking fume extractors**

Base Case 1 is a cabinet cooking fume extractor equipped with a capacitor motor and with an annual energy consumption of 47.1 kWh (9-point method). Potential improvements regarding this base case are a more efficient capacitor motor (DO1), a brushless motor (DO2) and optimised working conditions (DO4). These design options lead to the reduction of the electricity consumption, both in terms of Total Energy and Electricity, as can be observed in Figure 206 and Table 98. In DO1, Total Energy is reduced by 19%, 50% and 8% in DO1, DO2 and DO4 respectively. The significant reduction of DO2 is due to the lower weight of the brushless motor. Also related to this improvement in energy consumption is the reduction in Greenhouse Gases: 15%, 40% and 6% respectively.

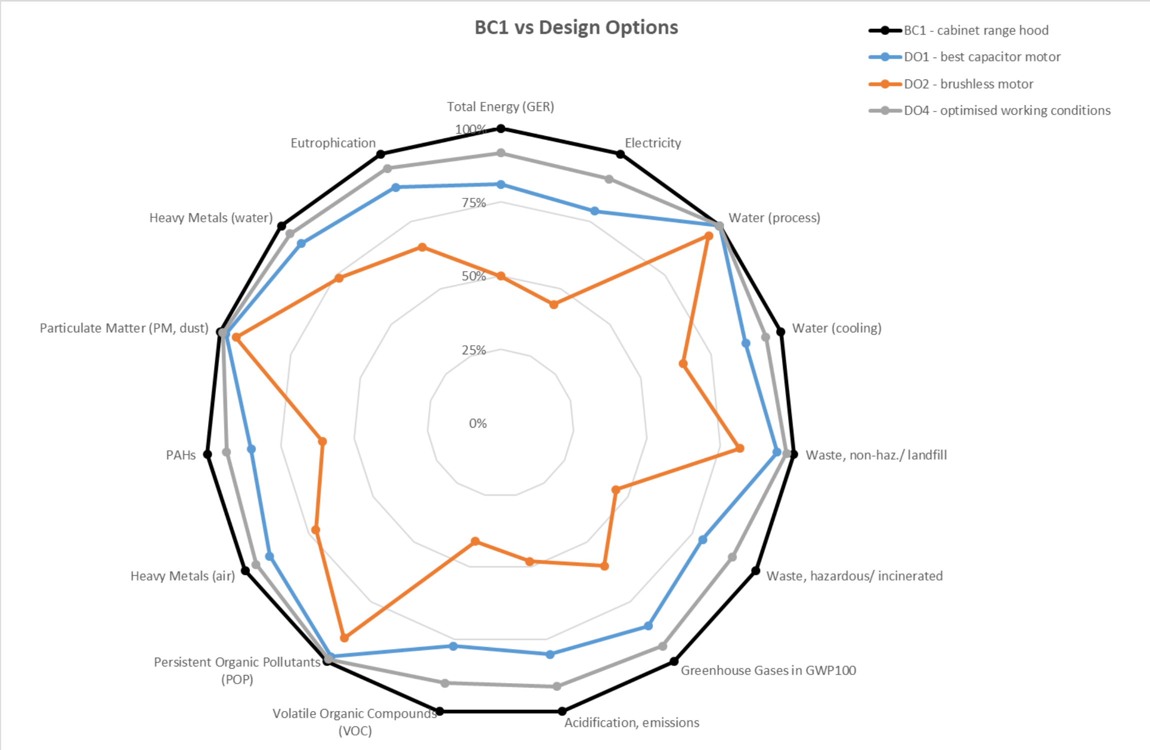



**Figure 206. Environmental analysis of BC1 cooking fume extractor design options**

Significant improvements are also observed in Hazardous waste/incinerated (21% in DO1, 55% in DO2 and 9% in DO4): if less electricity is required, less waste related to electricity generation will be produced. A similar situation is observed in Acidification and Volatile Organic Compounds.

All the results discussed in this section can be seen in Table 98.

**Table 98. Results of BC1 cooking fume extractor design options**

| **Other Resources & Waste** | | | | |
|---|---|---|---|---|
| | **BC1** | **DO1** | **DO2** | **DO4** |
| Total Energy (GER) [MJ] | 6496.6 | 5268.1 | 3243.9 | 5962.5 |
| % vs BC1 | | -19% | -50% | -8% |
| Primary Energy [MJ] | 5778.8 | 4550.4 | 2552.3 | 5244.7 |
| % vs BC1 | | -21% | -56% | -9% |
| Water (process) [l] | 20.1 | 20.1 | 19.1 | 20.1 |
| % vs BC1 | | 0% | -5% | 0% |
| Water (cooling) [l] | 518.1 | 453.1 | 336.8 | 489.9 |
| % vs BC1 | | -13% | -35% | -5% |
| Waste, non-haz./ landfill [g] | 13342.7 | 12589.1 | 10880.8 | 13015.1 |
| % vs BC1 | | -6% | -18% | -2% |
| Waste, hazardous/ incinerated [g] | 110.5 | 87.4 | 50.0 | 100.5 |
| % vs BC1 | | -21% | -55% | -9% |
| **Emissions (Air)** | | | | |
| | **BC1** | **DO1** | **DO2** | **DO5** |

| | | | | |
|---|---|---|---|---|
| Greenhouse Gases in GWP100 [kg $CO_2$ eq.] | 192.5 | 164.0 | 115.4 | 180.1 |
| % vs BC1 | | -15% | -40% | -6% |
| Acidification, emissions [g $SO_2$ eq.] | 1400.5 | 1124.3 | 672.0 | 1280.4 |
| % vs BC1 | | -20% | -52% | -9% |
| Volatile Organic Compounds (VOCs) [g] | 144.5 | 111.8 | 59.3 | 130.3 |
| % vs BC1 | | -23% | -59% | -10% |
| Persistent Organic Pollutants (POP) [ng i-Teq] | 170.5 | 167.1 | 153.9 | 169.0 |
| % vs BC1 | | -2% | -10% | -1% |
| Heavy Metals [mg Ni eq.] | 154.3 | 139.5 | 111.6 | 147.8 |
| % vs BC1 | | -10% | -28% | -4% |
| PAHs [mg Ni eq.] | 22.9 | 19.5 | 13.9 | 21.4 |
| % vs BC1 | | -15% | -39% | -6% |
| Particulate Matter (PM, dust) [g] | 291.1 | 285.2 | 274.6 | 288.5 |
| % vs BC1 | | -2% | -6% | -1% |
| **Emissions (Water)** | | | | |
| | **BC1** | **DO1** | **DO2** | **DO5** |
| Heavy Metals [mg Hg/20] | 70.7 | 64.4 | 52.1 | 67.9 |
| % vs BC1 | | -9% | -26% | -4% |
| Eutrophication [g PO4] | 2.2 | 2.0 | 1.5 | 2.1 |
| % vs BC1 | | -12% | -35% | -5% |

**Design Options related to BC2 cooking fume extractors**

Base Case 1 is a chimney cooking fume extractor equipped with a capacitor motor and with an annual energy consumption of 42.8 kWh (9-point method). Potential improvements regarding this BC are a brushless motor (DO3) and optimised working conditions (DO5). A direct and obvious consequence of these design options is the reduction of electricity consumption, both in terms of Total Energy and Electricity, as can be observed in Figure 207 and Table 118. In DO1, Total Energy is reduced by 44% and 8% in DO3 and DO5 respectively. Also related to this improvement in energy consumption is the reduction in Greenhouse Gases: 33% and 6% respectively.

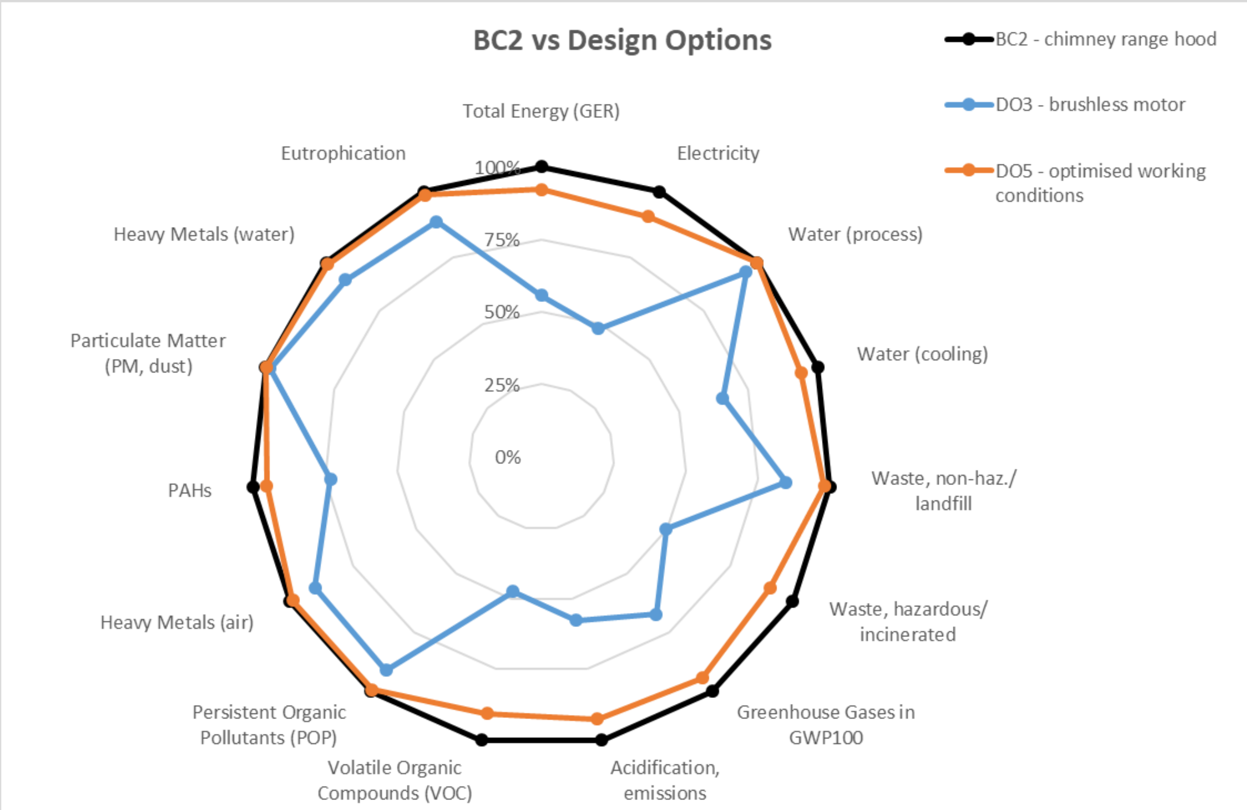



**Figure 207. Environmental analysis of BC2 cooking fume extractor design options**

Similarly to BC1, significant improvements are also observed in Hazardous waste/incinerated (50% in DO3 and 9% in DO5): if less electricity is required, less waste related to electricity generation will be produced. The same is observed in Acidification and Volatile Organic Compounds.

It is important to highlight the significant improvement of the indicators mentioned in DO3. This technology leads to a significant reduction of the electricity consumption in the use phase, which is the major contributor to this improvement. It also has an impact in the production phase because of the lower weight of the brushless motor; however, it only represents 1% of the total energy reduction.

All the results discussed in this section can be seen in Table 99.

**Table 99. Results of BC2 cooking fume extractor design options**

| **Other Resources & Waste** | | | |
|---|---|---|---|
| | **BC2** | **DO3** | **DO4** |
| Total Energy (GER) [MJ] | 6118.4 | 3405.2 | 5633.1 |
| % vs BC1 | | -44% | -8% |
| Primary Energy [MJ] | 5199.5 | 2512.8 | 4714.1 |
| % vs BC1 | | -52% | -9% |
| Water (process) [l] | 237.1 | 225.3 | 237.1 |
| % vs BC1 | | -5% | 0% |
| Water (cooling) [l] | 436.7 | 286.4 | 411.0 |
| % vs BC1 | | -34% | -6% |
| Waste, non-haz./ landfill [g] | 14279.3 | 12088.9 | 13981.6 |

| | | | |
|---|---|---|---|
| % vs BC1 | | -15% | -2% |
| Waste, hazardous/ incinerated [g] | 100.0 | 49.6 | 90.9 |
| % vs BC1 | | -50% | -9% |
| **Emissions (air)** | | | |
| | **BC2** | **DO3** | **DO4** |
| Greenhouse Gases in GWP100 [kg $CO_2$ eq.] | 197.6 | 132.8 | 186.4 |
| % vs BC1 | | -33% | -6% |
| Acidification, emissions [g $SO_2$ eq.] | 1450.4 | 836.2 | 1341.3 |
| % vs BC1 | | -42% | -8% |
| Volatile Organic Compounds (VOCs) [g] | 135.2 | 64.2 | 122.3 |
| % vs BC1 | | -53% | -10% |
| Persistent Organic Pollutants (POP) [ng i-Teq] | 168.9 | 153.8 | 167.6 |
| % vs BC1 | | -9% | -1% |
| Heavy Metals [mg Ni eq.] | 593.8 | 535.5 | 587.9 |
| % vs BC1 | | -10% | -1% |
| PAHs [mg Ni eq.] | 27.8 | 20.3 | 26.4 |
| % vs BC1 | | -27% | -5% |
| Particulate Matter (PM, dust) [g] | 864.2 | 849.3 | 861.9 |
| % vs BC1 | | -2% | 0% |
| **Emissions (water)** | | | |
| | **BC2** | **DO3** | **DO4** |
| Heavy Metals [mg Hg/20] | 308.6 | 280.7 | 306.1 |
| % vs BC1 | | -9% | -1% |
| Eutrophication [g PO4] | 8.8 | 7.8 | 8.7 |
| % vs BC1 | | -11% | -1% |

## 6.5 Life cycle cost of design options

### 6.5.1 Life cycle cost of oven design options

In terms of life cycle costs for BC1, as can be seen in Figure 208, only one design option is cheaper for the consumer than BC1: the life cycle cost of DO1 (A+ electric oven) is EUR 40 cheaper over its lifetime. In this particular case, the savings obtained in electricity consumption compensate the product price increase.

The rest of the design options presented in this section are more costly for the consumer than the base case. It is interesting to note that DO5 (oven with MW-combined function) is penalised by its currently high product price (on average EUR 1 200).

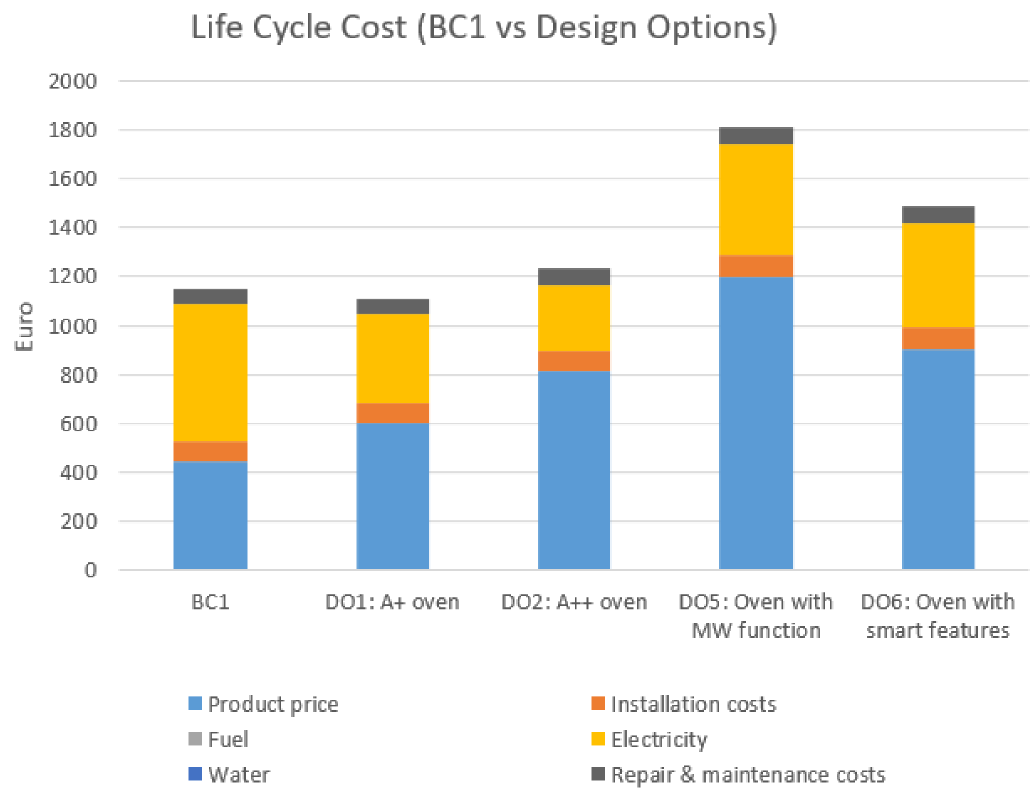



**Figure 208. Life cycle cost of BC1 oven design options**

A similar situation can be observed in BC2 and its design options (Figure 209). DO3 shows exactly the same price as BC1 over its lifetime. The higher product price is compensated by the lower gas consumed after 15 years. DO4 is more costly to the consumer than BC2. In this case, the assumed increase in product price cannot be compensated by the reduction in energy consumption.

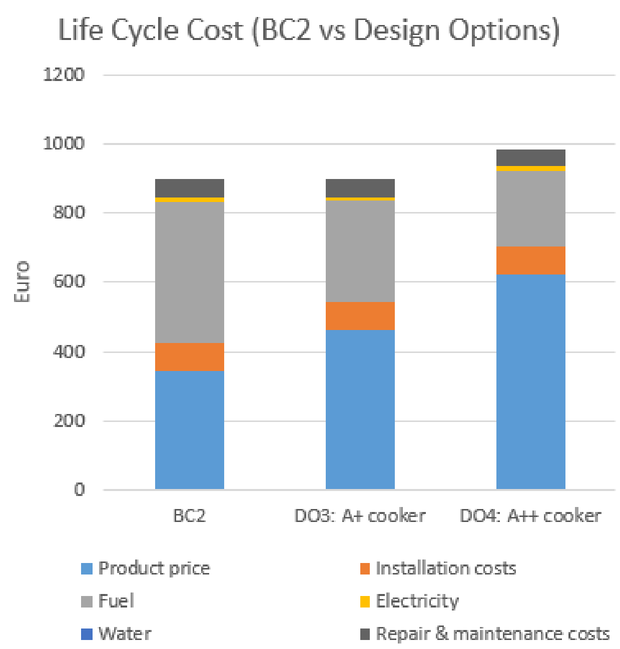



**Figure 209. Life cycle cost of BC2 oven design options**

The life cycle costs and the environmental impacts of the base cases and design options are plotted together in Figure 210 and Figure 211 for BC1 and BC2, respectively. As an environmental impact indicator, the Total Energy consumption (MJ) over the life cycle is chosen, although similar trends would be seen in categories such as Greenhouse Gases, Acidification or VOCs.

From the analysis of Figure 210, it can be seen that DO1 and DO2 appear to be good alternatives for BC1, since they provide energy savings, with some additional savings (DO1) or only a small increase in life cycle cost for the consumer (DO2). DO5 and DO6 provide a similar energy saving to DO1, with a significant drawback in terms of cost.

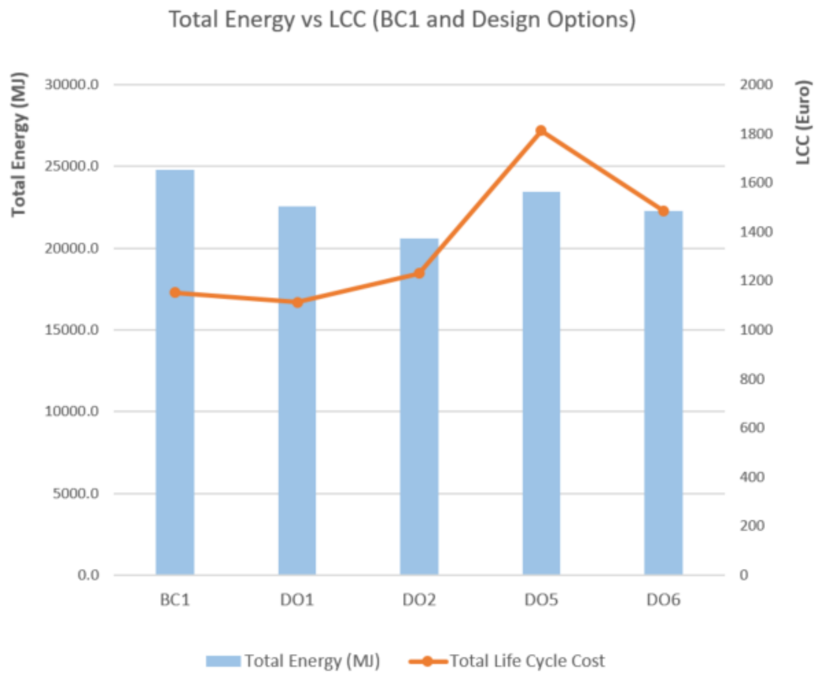



**Figure 210. Life cycle cost and energy consumption of BC1 oven design options**

In the case of BC2, both design options are beneficial in terms of energy consumption. As mentioned above, DO3 costs approximately the same as BC2 for the consumer after 15 years and is beneficial in terms of total energy consumption. DO4 is even more beneficial from the energy point of view but the savings in gas consumption cannot compensate the price increase.

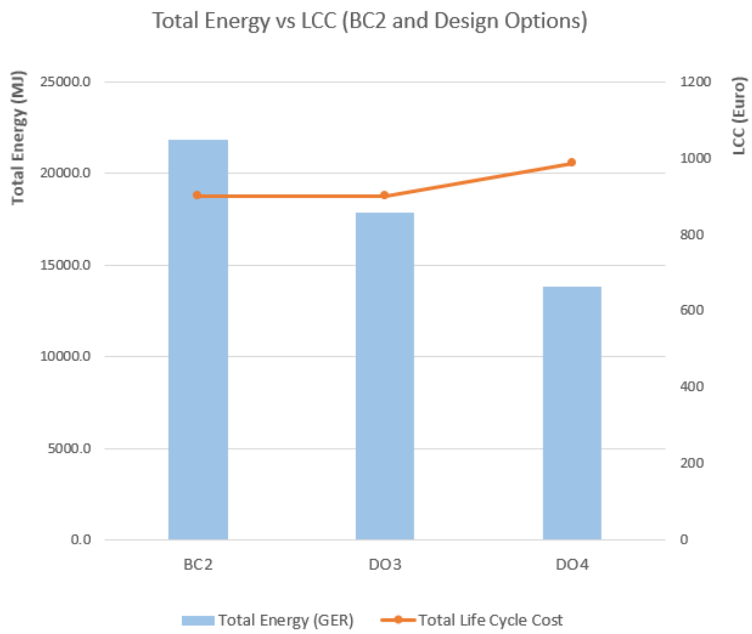



**Figure 211. Life cycle cost and environmental consumption of BC2 oven design options**

### 6.5.2 Life cycle cost of hob design options

In terms of life cycle costs for BC2, as can be seen in Figure 212, every design option presented in this section is more costly for the consumer than the base case. The reduction in the electricity consumption in the use phase does not compensate the increase of the purchase price.

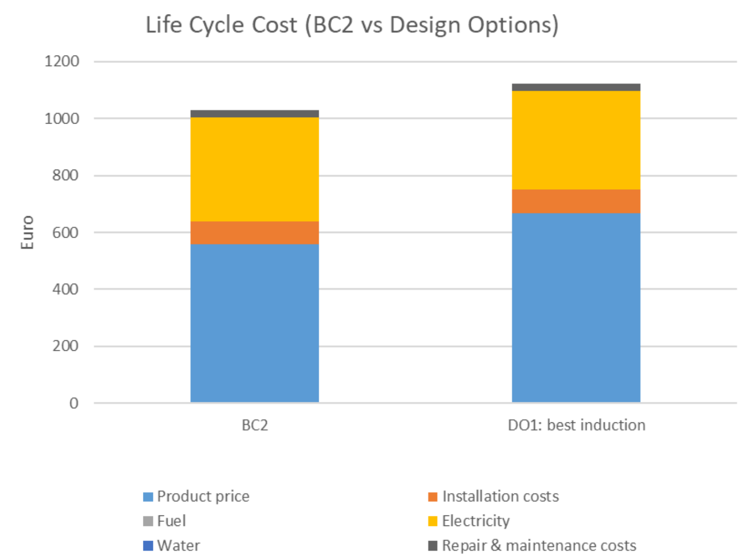



**Figure 212. Life cycle cost of BC2 hob design options**

In BC3, the increase of the life cycle cost of DO1 is not so significant. The additional purchase price also outweighs the reduction of fuel costs due to the better efficiency.

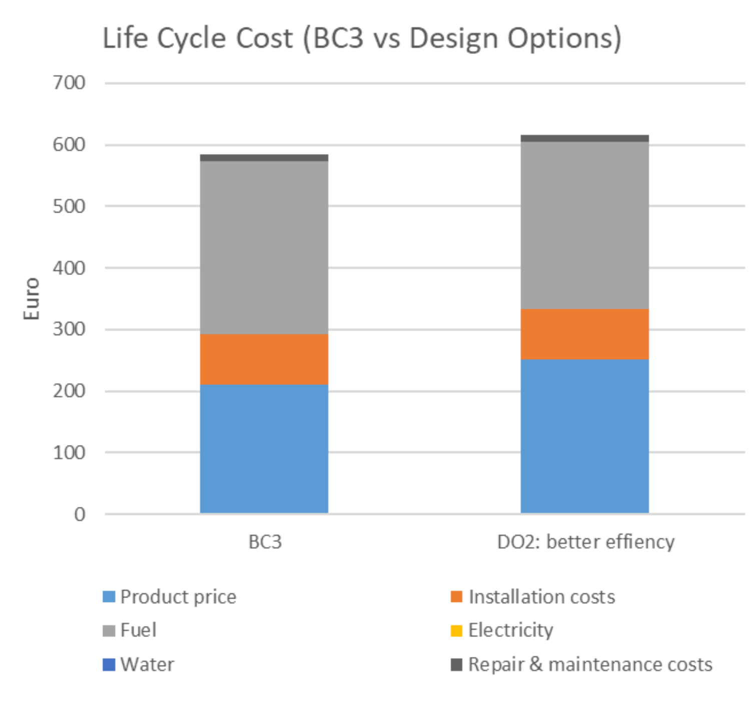



**Figure 213. Life cycle cost of BC3 hob design options**

The life cycle costs and the environmental impacts of the base cases and design options are plotted together in Figure 214 and Figure 215 for BC2 and BC3, respectively. As an environmental impact indicator, the Total Energy consumption (MJ) over the life cycle is chosen, although similar trends would be seen in categories such as Greenhouse Gases, Acidification or VOCs.

From the analysis of Figure 214, it can be seen that DO1 provides a significant decrease in the total energy consumption for BC1, with a life cycle cost increase of around 5%.

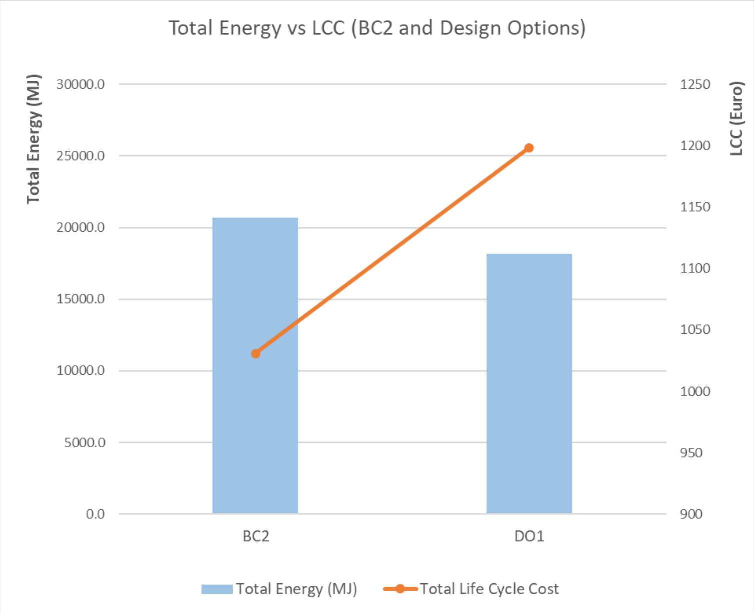



**Figure 214. Life cycle cost and energy consumption of BC2 hob design options**

In BC3, the design option is slightly beneficial for energy consumption with an increase in the life cycle cost of 5%.

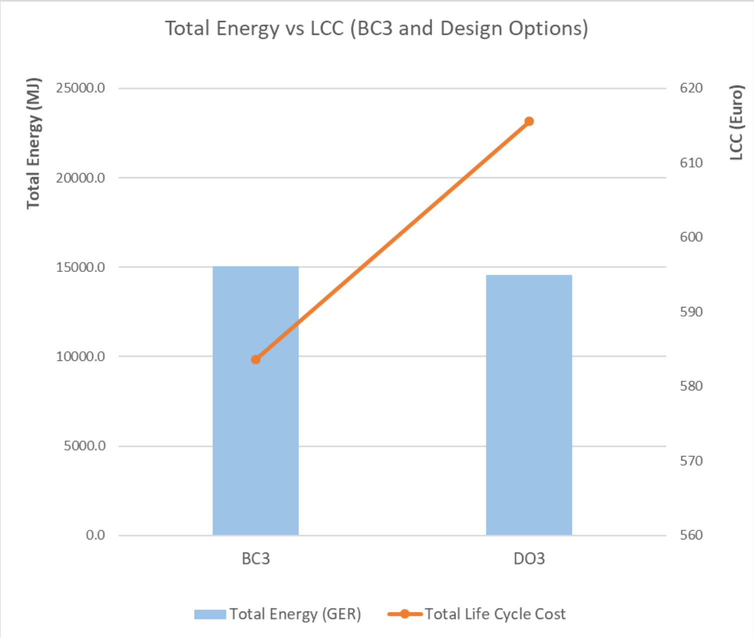



**Figure 215. Life cycle cost and energy consumption of BC3 hob design options**

### 6.5.3 Life cycle cost of cooking fume extractor design options

In terms of life cycle costs for BC1, as can be seen in Figure 216, every design option presented in this section is less costly for the consumer than the base case. DO1 entails a modest additional cost, and the savings obtained in electricity consumption compensate the product price increase. DO2 (cooking fume extractor equipped with a brushless motor) entails a higher product price, which is also offset by the decrease in energy cost.

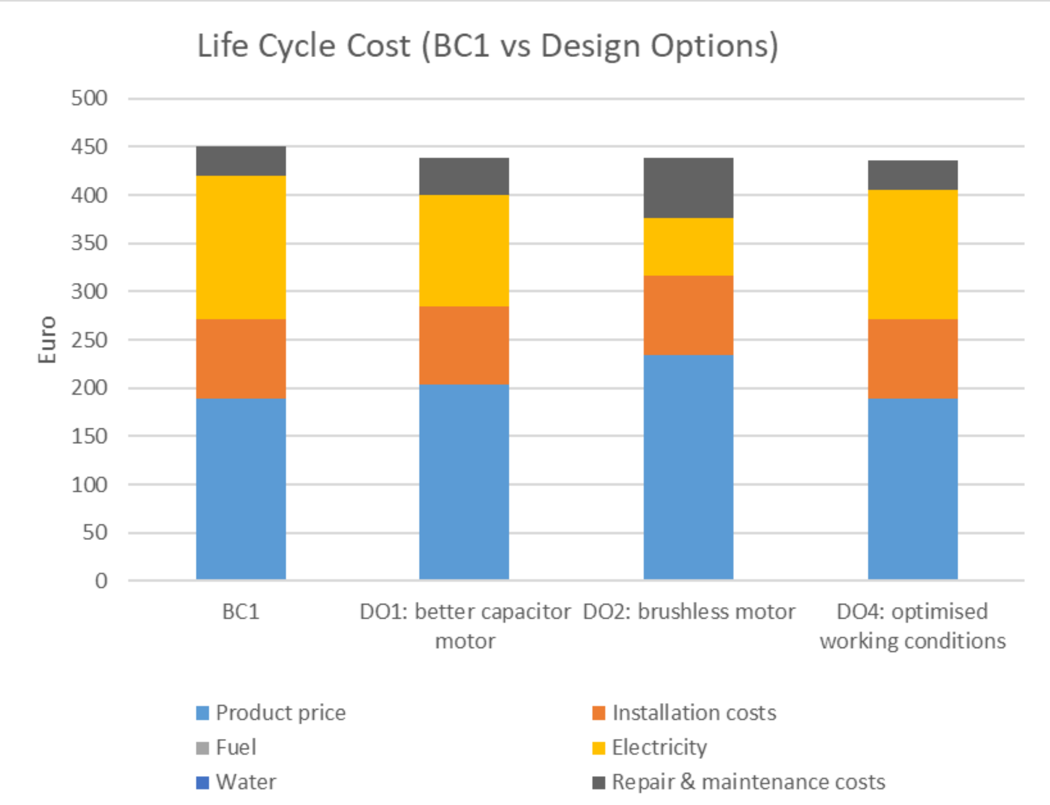



**Figure 216. Life cycle cost of BC1 cooking fume extractor design options**

In BC2 and its design options (Figure 217), DO3 is much more costly to the consumer than BC2, due to the additional purchase price, which is not compensated by the energy savings.

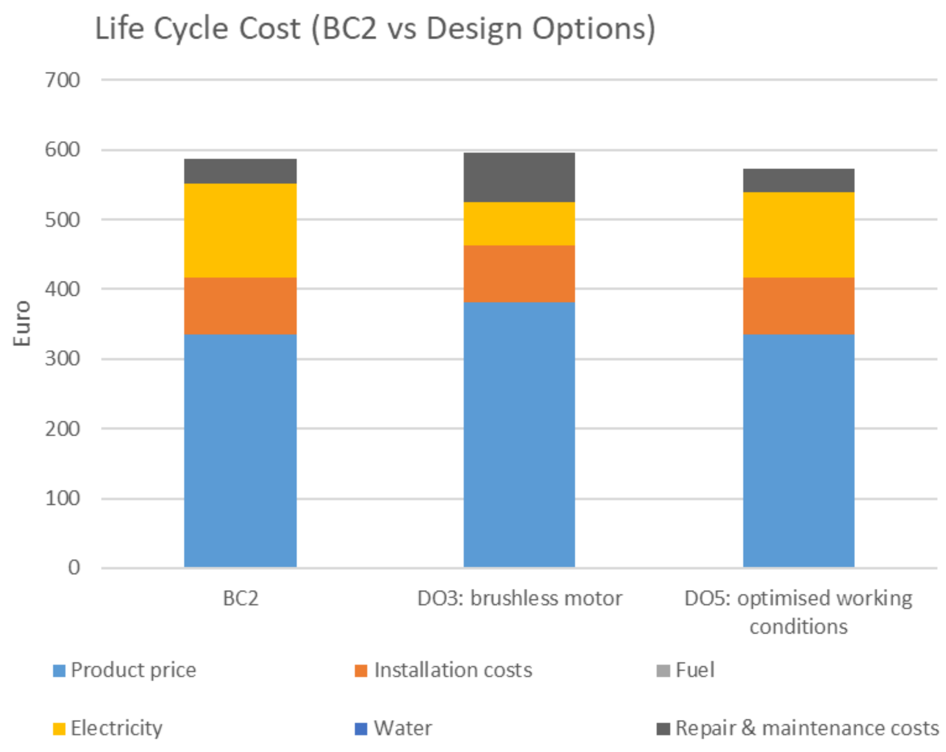



**Figure 217. Life cycle cost of BC2 cooking fume extractor design options**

The life cycle costs and the environmental impacts of the base cases and design options are plotted together in Figure 218 and Figure 219 for BC1 and BC2, respectively. As an environmental impact indicator, the Total Energy consumption (MJ) over the life cycle is chosen, although similar trends would be seen in categories such as Greenhouse Gases, Acidification or VOCs.

From the analysis of Figure 218, it can be seen that DO1 provides a significant energy saving (-19%) and a decrease in life cycle cost for the consumer (-3%). DO4 provides both energy and life cycle cost reductions, as you would expect from a more energy-efficient. DO2 would entail a significant reduction in energy consumption (-50%) and LCC (-3%).

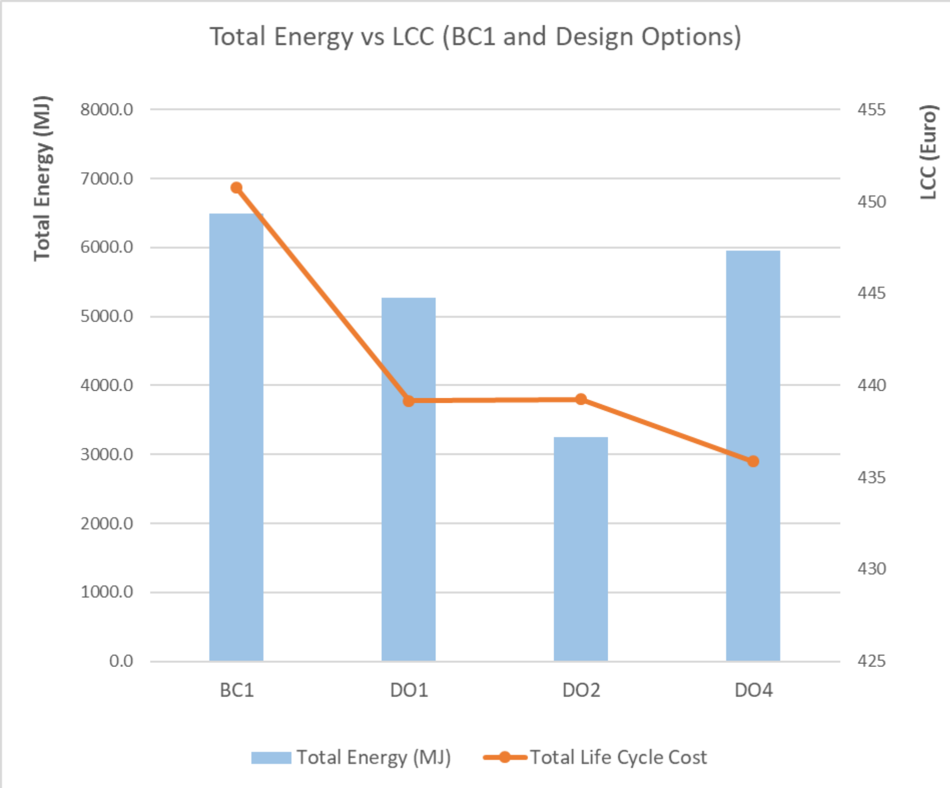



**Figure 218. Life cycle cost and energy consumption of BC1 cooking fume extractor design options**

The situation is different for BC2, where the brushless cooking fume extractor would increase the life cycle cost (+2%) and provide significant energy savings (-44%).

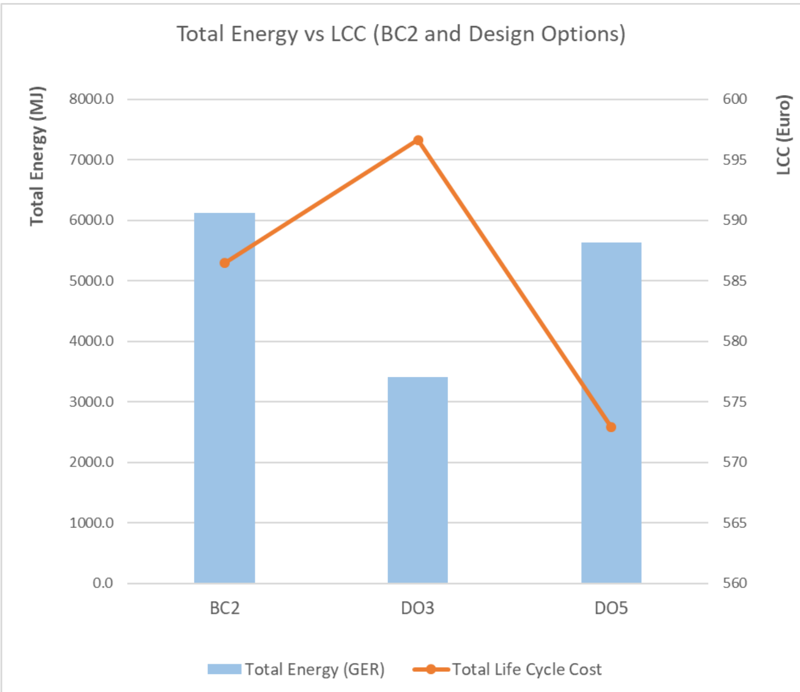



**Figure 219. Life cycle cost and energy consumption of BC2 cooking fume extractor design options**

# 7 Task 7: Policy analysis and scenarios

## 7.1 The added value of revised Ecodesign and Energy Labelling Regulations for domestic cooking appliances

Based on the research conducted so far, some areas where new regulation could provide added value in the cooking appliances sector have been identified:

**A revision is due according to the current Regulations**. The current Ecodesign and Energy Labelling Regulations entered into force in 2015. Article 7 of the Ecodesign Regulation states that a review of this Regulation should be brought to the Consultation Forum no later than 2022. Article 7 of the Energy Labelling Regulation states that a review shall be conducted no later than January 2021.

**The market has evolved**. The last preparatory study was published in 2011. Technological advancements may have occurred during this period, as well as market trend changes in terms of energy source or consumer behaviour. For instance, ovens today have an even wider variety of heating functions, some of them with the potential for reducing the overall energy consumption, such as microwave combi modes, or automatic functions. Induction will be soon the dominant technology in the hob market, with flexible cooking zones a clear growing trend. Brushless motors in cooking fume extractors can contribute significantly to increase energy efficiency. New regulation can help to keep removing from the market the worst-performing models through updated minimum ecodesign requirements; and to make the differences in energy consumption associated with the best available technologies more visible to consumers.

**Circumvention issues have been detected**. The current energy consumption test method for electric ovens has been used since 2012. Recent publications have shown that some manufacturers may be exploiting some of the characteristics of this test to declare energy consumption figures that are considerably lower than real-life use. In response to this issue, the industry and standardisation experts have been developing a new method that addresses these circumvention issues. New regulation can ensure that the most recent and representative of real-life measurement methods are adopted.

**The declared energy consumption is not always representative of real-life use**. The current Ecodesign and Energy Labelling Regulations state that the energy consumption of ovens is declared with the best-performing mode of the appliance. This has created an incentive for manufacturers to design heating modes with the lowest energy consumption possible (commonly known as eco modes), in order to obtain the highest energy classes. Some of these eco modes cannot cook properly and are rarely used by consumers. Similarly, energy efficiency in cooking fume extractors is measured at the best efficiency point, usually achieved with a function –boost mode- that consumers do not use very often. This may have pushed the market towards high-airflow appliances, rather than to more energy-efficient ones. In response to this issue, the industry has been developing a new measurement method that better represents the real use of cooking fume extractors. With new regulation, it can be ensured that the energy consumption values declared by manufacturers are more representative of consumers than today.

**Energy classes are less meaningful**. Most ovens today are shared between two energy classes only, so it is difficult for consumers to establish differences in terms of the energy efficiency of ovens. Current energy labelling dates from 2015. Over this period, the industry has adapted to regulation by removing from the market the worst-performing appliances and by consolidating most of their models among the A and A+ energy classes. A trend has also been observed towards larger cavity ovens (even though the full capacity is rarely used). New regulation can help to establish clearer differentiation of ovens in terms of their energy efficiency, by rescaling energy class thresholds taking into consideration the characteristics of the market today. A new approach can also be taken when measuring energy efficiency, in order to compare the real energy consumption of devices (rather than relying on cavity volume as a factor) and promote the right sizing of ovens.

**Relevant performance parameters are not taken into account**. The current Ecodesign Regulation for cooking fume extractors does not take into account one of the main performance parameters of these devices: the capacity to absorb odour. Available measurement methods are suitable for a very small market segment (recirculation) but not for the most part (extraction). New regulation can help with the development of new energy consumption measurement methods that take into account relevant performance parameters such as odour reduction efficiency.

**New energy sources are available**. It is likely that the use of gases such as hydrogen will increase in the midterm. Consequently, appliances such as gas hobs and ovens will have to adapt to these new gas mixtures, keeping a high level of safety, reliability and performance. With new regulation, compatibility, adaptability and information requirements can be included to ensure that new products are able to operate with these new energy sources.

**Material efficiency requirements can be more ambitious**. Current regulation includes some material efficiency requirements in the product information section. However, these requirements are not in line with the level of ambition of the Circular Economy Action Plan 2020. New regulation can ensure that material efficiency requirements in the cooking appliances sector are at least as ambitious as in recently published regulations on other domestic appliances such as dishwashers, washing machines or dry cleaners.

**Clarity can be provided regarding low power modes**. Current regulation has different approaches in terms of low power modes for the cooking appliances within the scope of this project. Whereas ovens and hobs are covered horizontally under REG 1275/2008, range hoods are addressed vertically with specific requirements in REG 66/2014. This situation has created confusion for manufacturers. New regulation can establish new specific low power mode requirements that provides clarity on this situation and that raises the level of ambition of cooking appliances, to be in line with other domestic appliances.

Based on the areas above –and some others not listed in this section– a variety of policy options for ovens, hobs and cooking fume extractors have been proposed:

- Policy options for electric ovens (Section 7.2).
- Policy options for gas ovens (Section 7.3).
- Policy options for hobs (Section 7.4).
- Policy options for cooking fume extractors (Section 7.5).
- Horizontal policy options for domestic cooking appliances (Section 7.6).

## 7.2 Policy options for electric ovens

In this section, a set of policy options will be presented for domestic electric ovens. In Section 7.2.3, a set of policy options related to the scope of new regulation will be presented. As already described in Task 1 of this report, decisions will need to be made regarding the inclusion of steam, microwave, portable and professional ovens.

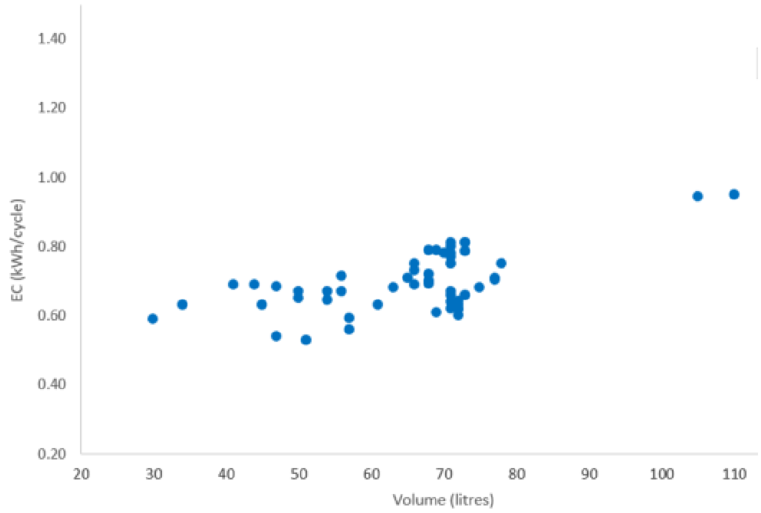
In Section 7.2.4, the need for an energy label for ovens will be discussed. The possibility of using a combined label for electric and gas ovens will be discussed in Section 7.2.5. Certain aspects of the declaration of energy consumption will be discussed in Section 7.2.6. The aspects under discussion will be the definition of the Standard Energy Consumption (SEC), the measurement method (BM1.0 or BM2.0), the heating mode used for energy declaration and other aspects (such as the use of real food in testing). Based on the outcome of Section 7.2.6, different ecodesign requirements and energy class definitions will be evaluated in Sections 7.2.8 and 7.2.7, respectively.

### 7.2.1 A new database of electric ovens: APPLIA2020

To contribute to the definition of policy options for ovens, a database was provided by APPLIA to the JRC between November 2020 and January 2021. This database contains data on 54 models, regarding their energy consumption, cavity volume and other relevant aspects. This database of ovens will be used to evaluate the consequences of the different policy options in subsequent sections. In this document, the authors will refer to this database as "APPLIA2020".

It is important to highlight the limitations of this database before conducting any analysis. At the moment of publication of this report, it contained data on 54 models only. It is also not a neutral database, since it was provided by manufacturers. However, in the next sections it will be assumed that APPLIA2020 is a fair representation of the stock of ovens today, and its data will be used to present different policy options and their potential consequences in terms of ecodesign limits and energy class. However, due to the reduced number of ovens, the consequences related to each policy option must be taken with caution and should be used as an indication only. Ideally, an analogous analysis should be conducted when data is available for a more significant amount of ovens.

In Figure 220, the energy consumption shown corresponds to the best performing mode (BPM), measured with BM1.0. This BPM is generally a fan-forced mode. The cavity volumes of ovens in APPLIA2020 range from 30 litres to 110 litres. The energy consumption levels of the BPM measured with BM1.0 range from 0.53 kWh/cycle to 0.95 kWh/cycle.




Source: APPLIA

**Figure 220. APPLIA database of ovens 2020**

More data is available in APPLIA2020 in terms of heating modes, measurement methods and oven characteristics. In Figure 221, an analysis has been conducted to check the influence of the availability of steam functions on the energy consumption of the oven (BPM). It can be observed that ovens with a steam function tend to be in the lower side of the graph, confirming what was already seen in previous sections of this report: ovens with a steam function have higher efficiency when the energy consumption is measured with the current standard method.


**Figure 221. Steam function availability**

In Figure 222, an analysis has been conducted to check the influence on the energy consumption of the oven (BPM) of eletromechanic or electronic ovens. It can be clearly seen that electromechanic ovens perfom worse than electronic ovens in terms of energy consumption. However, one stakeholder wonders if these results are linked to the current testing method (BM1.0), where energy-saving modes are often used (electromechanic ovens generally do not have these modes). According to them, if the test was done with standard modes (not energy-saving), the results might be different.

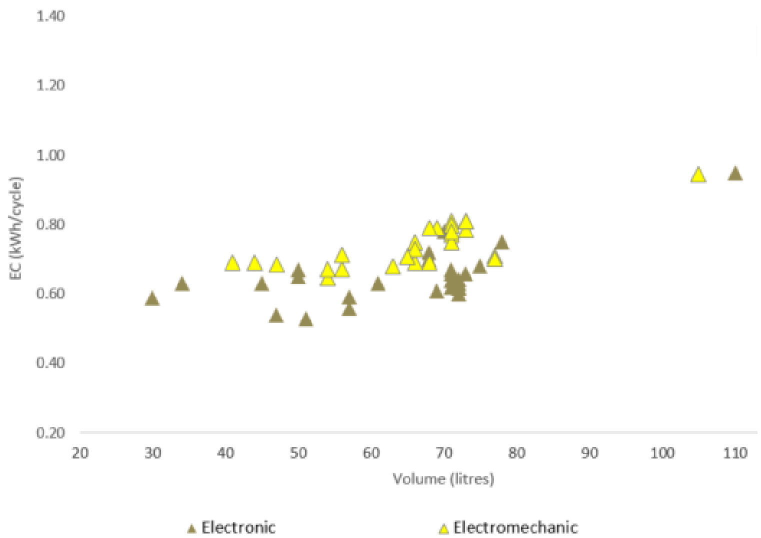
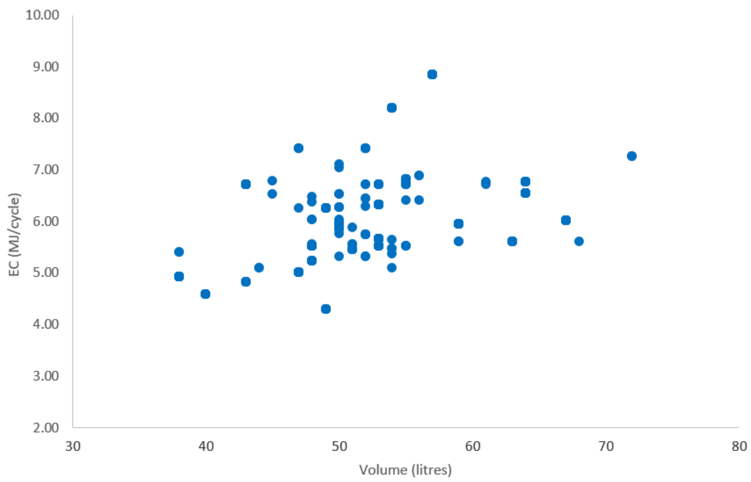



**Figure 222. Electromechanic and electronic ovens**

### 7.2.2 Available databases of gas ovens

In 2012, CECED generated a database of ovens in support of the previous preparatory study (Mugdal et al., 2011). This database contained information on 1 456 gas ovens. In Figure 223, the database is represented using the best performing mode and measuring with BM1.0.




Source: CECED

**Figure 223. CECED database of gas ovens 2012**

In the absence of more recent data, policy options for gas ovens will be proposed using this database. In this report, this database will be known as CECED2012.

### 7.2.3 Policy options related to the scope

In this section, different policy options related to the scope are described, considering the expected benefits, drawbacks, risks and work needed for new regulation and future regulation. Table 100 is a summary of the different policy options considered regarding the scope for ovens.

**Table 100. Summary of policy options considered related to scope for ovens**

| **Topic** | **Policy options** |
|---|---|
| 1. Inclusion of solo steam ovens in scope | 1.a Out of scope of Ecodesign and Energy Labelling |
| | 1.b In scope of Ecodesign for Material Efficiency only |
| | 1.c In scope of Ecodesign for Material Efficiency and Minimum Energy Performance |
| | 1.d In scope of E Ecodesign D and Energy Labelling |
| 2. Inclusion of solo MW ovens in scope | 2.a Out of scope of Ecodesign and Energy Labelling |
| | 2.b In scope of Ecodesign for Material Efficiency only |
| | 2.c In scope of Ecodesign for Material Efficiency and Minimum Energy Performance |
| | 2.d In scope of Ecodesign and Energy Labelling |
| 3. Inclusion of combi-MW ovens in scope | 3.a Out of scope of Ecodesign and Energy Labelling |
| | 3.b In scope of Ecodesign for Material Efficiency only |
| | 3.c In scope of Ecodesign for Material Efficiency and Minimum Energy Performance |
| | 3.d In scope of Ecodesign and Energy Labelling |
| 4. Inclusion of small and portable ovens in scope | 4.a Out of scope of Ecodesign and Energy Labelling |
| | 4.b In scope of Ecodesign for Material Efficiency only |
| | 4.c In scope of Ecodesign for Material Efficiency and Minimum Energy Performance |
| | 4.d In scope of Ecodesign and Energy Labelling |

| | |
|---|---|
| 5. Inclusion of combi steam ovens in scope | 5.a Out of scope of Ecodesign and Energy Labelling |
| | 5.b In scope of Ecodesign for Material Efficiency only |
| | 5.c In scope of Ecodesign for Material Efficiency and Minimum Energy Performance |
| | 5.d In scope of Ecodesign and Energy Labelling |

At this point, it is relevant to clarify the distinction between “new regulation” and “future regulation”. For some product types, stakeholders and the JRC would like to recommend their inclusion in the scope of the Regulations. However, it is not possible to do so at the moment, for instance due to lack of measurement method. In this case, the recommendation will be to include them in the scope in future revisions of the Regulations. Therefore, for clarification in the following sections, “new regulation” refers to regulation resulting from this preparatory study. “Future regulation” refers to regulation resulting from future revisions of new regulation (whenever that takes place).

#### 7.2.3.1 Inclusion of solo steam ovens in the scope

In the previous preparatory study (Mudgal et al., 2011), solo steam ovens were considered a niche market so they were left out of the scope of the Ecodesign and Energy Labelling Regulations.

*Policy option 1a* would be to maintain the current situation, not including these appliances in the scope.

Regarding ecodesign, considering the new Circular Economy Action Plan, it is relevant to include these appliances in the scope to introduce material efficiency requirements (*Policy option 1b*). These aspects will be developed in more detail in Section 7.6.

It is worth checking at this point if solo steam ovens are still a niche product, in order to consider their inclusion in ecodesign for minimum energy performance or energy labelling. Some stakeholders provided data indicating that, in some markets (such as in Germany), their sales doubled from 2006 to 2010. The user behaviour study presented in Task 3 of this report indicates that solo steam ovens are available in 4.8% of European households. In the households where a solo steam oven is present, 40% use it at least once a week. The penetration rate of other cooking appliances analysed in this study (ovens: 87.5%, hobs: 71.5%, range hoods: 74.4%) is considerably higher than the one of solo steam ovens.

Based on these figures, it can be assumed that the total energy consumption of solo steam ovens is still negligible when compared to the appliances mentioned above, so their inclusion in the scope of the Energy Labelling Regulation (*Policy option 1d*) does not seem urgent. In terms of ecodesign, this lack of urgency also applies to including them in terms of minimum energy performance (*Policy option 1c*). This aligns with what was suggested by a stakeholder, who recommended including solo steam ovens in the scope of ecodesign and energy labelling only if a significant saving potential exists.

Moreover, there is currently no standard measurement method that allows the estimation of the energy consumption of solo steam modes. With a view to applying *Policy options 1c* and *1d* in future regulation, it is recommended to start the development of a method to measure the energy consumption of solo steam ovens. According to one stakeholder, CLC TC59X WG18 is currently working on a test method for measuring the performance of professional steam ovens. The methodology of this test could be adapted for domestic solo steam ovens.

<u>Recommendation for new regulation</u>: to include solo steam ovens in the scope of ecodesign for material efficiency only (*Policy option 1b*). Start the development of a standard method for the energy consumption of the solo steam function.

<u>Recommendation for future regulation</u>: when a standard method is available, consider inclusion in ecodesign for minimum energy performance and energy labelling, depending on product penetration at that time.

#### 7.2.3.2 Inclusion of solo MW ovens in the scope

Solo MW ovens are excluded from the scope of the current Regulations. *Policy option 2a* would be to maintain the current situation.

During the development of this preparatory study, the potential inclusion of solo microwave ovens within the scope of the Ecodesign and Energy Labelling Regulations has been discussed.

Regarding ecodesign, considering the new Circular Economy Action Plan, it is relevant to include these appliances in the scope to introduce material efficiency requirements (*Policy option 2b*). These aspects will be developed in more detail in Section 7.6.

Some stakeholders consider that the size of the market of these appliances –which would include solo MW ovens that have a grill function– is big enough to include them either in terms of minimum energy performance requirements or in the energy label scope, since their overall energy consumption at EU level might not be negligible.

Results from the user behaviour study presented in Task 3 indicate that solo MW ovens are present in 75.3% of EU households and they are used an average of 842 times/year. According to studies provided by the stakeholders, the annual energy consumption of MW ovens is 45 kWh/year. Scientific literature estimates are around 72 kWh/year (Gallego-Schmidt et al., 2018). In the previous preparatory study, it was estimated as 86 kWh/year. In the current study, it has been estimated as around 33 kWh/year. This suggests that the energy consumption of solo MW ovens is not negligible and that therefore these appliances should somehow be included within the scope of the ED/EL Regulations (*Policies 2c or 2d*). However, in current regulation, solo microwave ovens were left out of the scope for a variety of reasons that are still valid today (Mugdal et al., 2011):

- small difference between most and least efficient appliance;
- small improvement potential in terms of energy consumption (in the previous preparatory study, the combined improvement potential of these appliances was estimated as 4%).

Those reasons make the inclusion of microwave ovens in the scope of the Energy Labelling Regulation (*Policy option 2d*) not particularly useful. From the consumer perspective, it will be difficult to establish meaningful differences between appliances. In Detz et al. (2020), it is concluded that although enormous microwave oven capacity is available worldwide, the overall energy consumption of domestic microwave ovens is fairly limited, since the average usage time amounts to typically only a few minutes per day. In the study of Gallego-Schmidt et al. (2018), it is concluded that microwaves are mature products from the energy efficiency perspective and, therefore, efforts to reduce energy consumption should focus on improving consumer behaviour to use them more efficiently, for example by adjusting the time of heating to each type of food. The provision of best practices and guidelines by microwave manufacturers could help consumers to integrate these into daily practices.

Regarding ecodesign, it might be of interest to include them in terms of minimum energy performance requirements (*Policy option 2c*), in order to remove the least energy-efficient appliances from the market. This is supported by several stakeholders, who consider that even if the difference in performance is too small to justify energy labelling, the ecodesign requirements will ensure that the worst performers are not allowed in the market.

At the point of development of this preparatory study, there is not enough data to evaluate minimum energy performance thresholds. Therefore, with a view to implementing *Policy option 2c* in future regulation, it is recommended to start the development of a database of energy consumption of solo MW ovens.

<u>Recommendation for new regulation</u>: to include solo MW ovens in the scope of ecodesign for material efficiency only (*Policy option 2b*).

Recommendation for future regulation: when enough data is available to evaluate appropriate thresholds, include solo MW ovens in ecodesign for minimum energy performance.

#### 7.2.3.3 Inclusion of MW-combi ovens in the scope

Ovens that include any form of microwave heating function are currently excluded from the Ecodesign and Energy Labelling Regulations. Reasons for them currently being out of the scope are:

- these appliances were a niche market product in 2014, when the current Regulations entered into force, so their overall energy consumption was not significant at EU level;
- there is no standard measurement method to estimate the energy consumption of a microwave combined heating mode.

*Policy option 3a* would be to maintain the current situation.

Regarding ecodesign, considering the new Circular Economy Action Plan, it is relevant to include these appliances in the scope to introduce material efficiency requirements (*Policy option 3b*). These aspects will be developed in more detail in Section 7.6.

Results from the user behaviour study presented in Task 3 indicate that 43% of ovens (less than 5 years) have a combi-MW function (this figure is debated by manufactures, who claim that this penetration is significantly lower). In terms of frequency of use, consumers responded that 19% use it very often/almost always.

Leaving these appliances out of the scope of ecodesign for energy performance (*Policy option 3c*) or energy labelling (*Policy option 3d*) may bring two fundamental issues:

- It could be a loophole for conventional ovens not complying with some elements of the current Regulations (for instance, minimum energy performance of heating modes).
- Consumers are not aware of the potential for reduction of energy consumption of these appliances. As already indicated in Task 6 of this report, ovens with a microwave combined function can help to reduce the energy consumption per cycle by an average of 10%.

*Policy option 3c* would overcome the first of the issues above, mainly by the introduction of minimum energy performance requirements for conventional or fan-forced modes. This approach is supported by various stakeholders. However, if this approach is taken, only ovens without a turntable could be tested and therefore included in the Regulation (BM1.0 or BM2.0 cannot be applied to ovens with a turntable). There is a risk that this –having a turntable– could be used as a loophole to avoid regulation.

Ovens with MW-combi modes could also be included in the scope of the Energy Labelling Regulation (*Policy option 3d).* Some stakeholders suggest that they should be included in the Regulation, but again only in their conventional or fan-forced modes (the issue with turntables is also applicable here). However, the energy savings of MW-combi modes would still not be visible for consumers.

To make these energy savings visible for consumers and incentivise the development of more efficient MW-combined modes, these appliances should be included in the scope of the Energy Labelling Regulation. However, at this point there is no available measurement method to measure the energy consumption of those heating modes.

On the development of this standard method, CENELEC WG17 highlights that to develop a method to measure the energy consumption of combi-microwave functions is likely to be highly complex and not possible in the time frame of the revision. The current version of BM2.0 does not support the testing of MW-combi modes. In their view, to measure the energy consumption of the oven part of all combi-microwave ovens, BM2.0 should be transformed, especially regarding combi-microwave ovens with a turntable. A standardisation request to TC 59X could be helpful to push forward this project.

Recommendation for new regulation: include combi-MW ovens in the scope of ecodesign for material efficiency and minimum energy performance (*Policy option 3c*). Applicable only to thermal functions (fan-forced, conventional, etc.) and to ovens without a turntable. Start the development of a standard method to measure the energy consumption of MW-combi modes (including ovens with a turntable).

Recommendation for future regulation: include every combi-MW oven (with or without turntable) in the scope of energy labelling, for their thermal and MW modes.

#### 7.2.3.4 Inclusion of small and portable ovens in the scope

Small ovens (width < 250mm, length < 250 mm, height < 120 mm) and portable ovens (mass < 18 kg) are currently out of the scope of the Ecodesign and Energy Labelling Regulations. They were excluded because they were a niche market when the current Regulations were developed. This still seems valid in the 2020 context.

*Policy option 4a* would be to maintain the current situation.

Regarding ecodesign, considering the new Circular Economy Action Plan, it appears relevant to include these appliances in the scope to introduce material efficiency requirements (*Policy option 4b*). These aspects will be developed in more detail in Section 7.6. Some stakeholders support including small and portable ovens only in terms of material efficiency, due to their low penetration, and also because they believe that such ovens are typically only used for heating of small portions and are not used very often.

Results from the user behaviour study presented in Task 3 point out that portable ovens are present in 14% of European households (far from the 87% of conventional ovens). Their small size suggests that they require less power to heat a similar load. Considering a hypothetical oven of 250x250x120 mm (7.5 litres) and the EC vs Volume regression line of the market average (BM1.0 and BPM), its energy consumption could be around 0.47 kWh/cycle.

In terms of measurement methods, BM1.0 or BM2.0 can be applied to almost every oven in the market (only ovens smaller than 10 litres cannot be tested due to their reduced size).

If the 14% presence in European households is deemed significant, regarding ecodesign it might be of interest to include them in terms of minimum energy performance requirements (*Policy option 4c*), in order to remove the least energy-efficient appliances from the market. This approach is supported by some stakeholders. However, there is currently no available information on their average energy consumption.

Depending on product differentiation, it might be of interest to consider their inclusion in the Energy Labelling Regulation in the future (*Policy option 4d*).

Recommendation for new regulation: include in the scope of ecodesign for material efficiency (*Policy option 4b*). Set stricter requirements in terms of size so that every oven that can be tested with BM2.0 is included in ecodesign for minimum energy performance: change the definition of small and portable ovens. In the new definition, a small and portable oven shall be below 10 litres. Start the development of a standard method for testing the energy consumption of ovens with a capacity lower than 10 litres.

Recommendations for future regulation: include in the Energy Labelling Regulation, if there is enough product differentiation.

#### 7.2.3.5 Inclusion of ovens with combi steam function in the scope

Ovens with a combi steam function are already included in the Ecodesign and Energy Labelling Regulations, if their declared primary function is thermal heating. The recommendation for these appliances is to maintain the current situation in terms of the scope, adding their inclusion in terms of material efficiency (*Policy option 5d*).

In terms of the energy consumption declaration, combi steam functions are currently not declared. Only the thermal functions of combi steam ovens are declared. The topic of the energy declaration for combi steam functions will be covered in Section 7.2.6.6.

#### 7.2.3.6 Summary of recommendations regarding scope of ovens

Table 101 is a summary of the recommendations presented in the previous sections regarding the scope of ovens in the new Ecodesign and Energy Labelling Regulations.

**Table 101. Summary of recommendations regarding the scope of ovens**

| | New regulation | | | Work needed → | Future regulation | | |
|---|---|---|---|---|---|---|---|
| | Ecodesign – Material Efficiency | Ecodesign – Minimum Energy Performance | Energy Labelling | | Ecodesign – Material Efficiency | Ecodesign – Minimum Energy Performance | Energy Labelling |
| Solo MW | Y | N | N | | Y | Y | N |
| Combi-MW | Y | Y (thermal function) (only ovens without turntable) | N | Standard method for **combi-MW** function | Y | Y | Y |
| Small/Portable | Y | N | N | Standard method for **ovens <10 litres** | Y | Y* | Y* |
| Solo steam | Y | N | N | Standard method for **solo steam** function | Y | Y* | Y* |
| Combi steam | Y | Y (thermal function) | Y (thermal function) | Standard method for **combi steam** function | Y | Y | Y |

NB. Y: Yes, include. N: Not include.

In Table 101, recommendations are given for new regulation and for future regulation. As already highlighted by one stakeholder, it is too early to decide whether for instance solo steam should be included in future ecodesign regulation, since that will depend on the results of the next review study and the following decision process. However, it is relevant in the current study to recommend inclusion in the regulations under review now. The right-hand side of of Table 101 (recommendations for future regulation) should be interpreted in this manner.

### 7.2.4 The need for an energy label for ovens

The EU Energy Label is an established instrument to provide information and draw attention to the energy consumption characteristics of household appliances, helping consumers to make better purchase choices.

It plays an important role in the increase of energy efficiency and protection of the environment. As highlighted in Russo et al. (2018), the introduction of an energy label boosts economic growth, alongside consumer demand and competitive position, creating high-quality jobs in several sectors related to energy efficiency. Different studies have also shown that the Energy Label Regulation has provided significant benefits to consumers in terms of monetary savings, to industry in terms of design innovation and competitiveness and to the environment in terms of reduced impacts. Therefore, having an energy label on a product category must be considereds a fundamentally positive aspect.

An energy label classification is meaningful if there is enough differentiation between the products in the market in terms of energy efficiency. As already indicated in previous sections, there are no big improvements to the energy efficiency of electric ovens foreseen, beyond the already mentioned improvements related to energy-saving modes, microwave combined and automatic functions. Considering that, some stakeholders wonder whether an energy label is still of interest for electric ovens in the current landscape.

On this topic, one stakeholder argues that removing the energy label would go against innovations and improvements in energy efficiency. It would be a step backwards. In their view, a probable contributing factor to the small differentiation is that the ovens are currently tested in unrealistic cooking modes (energy-saving modes), and that it is reasonable to believe that there will be more difference between ovens if they are tested in standard mode. They add that the energy label should not be questioned as it is a crucial tool for informing consumers and pushing improvements.

The distribution of energy classes in APPLIA2020 can be seen in Figure 224: A (65%) and A+ (35%). With the current energy classification (best performing mode and BM1.0), it can be seen that there is not much differentiation in terms of energy class in these appliances. However, looking specifically at the ovens around 70 litres, there is a significant difference between the best and the worst (0.54 kWh vs 0.81 kWh). This suggests that there is enough difference between different appliances, but that the current energy classification does not show it with clarity.

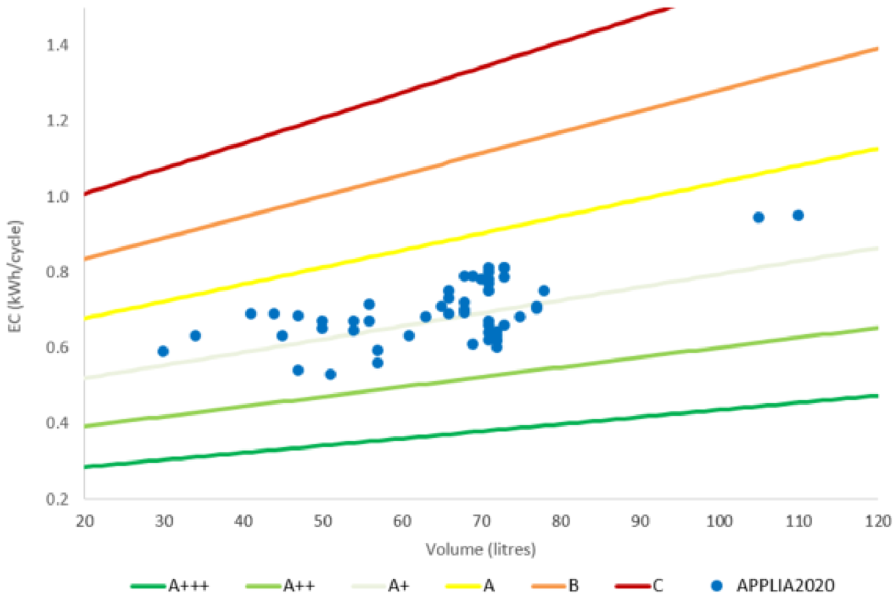



**Figure 224. Energy classes of ovens in APPLIA2020**

In Article 11, REG 2017/1369 states that it shall ensure at a least a homogeneous A to G scale. Therefore, any energy label with classes different to that (with A+, A++, etc.) must be first set to the new scale (A-G).

On top of that, the Commission shall review the label with a view to rescaling if it estimates that:

(a) 30% of the units of models belonging to a product group sold within the Union market fall into the top energy efficiency class A and further technological development can be expected; or

(b) 50% of the units of models belonging to a product group sold within the Union market fall into the top two energy efficiency classes A and B and further technological development can be expected.

In Task 2 of this report, market data was presented regarding the energy classes of ovens sold between 2015 and 2018 in five reference countries in the EU. According to that data, energy classes of sold ovens are mostly distributed between A (70%) and A+ (30%). Therefore, a rescaling of the energy classes would be necessary.

When defining energy classes, it is also necessary to consider that between the different energy class steps, there must be enough difference to avoid repeatability and reproducibility issues. In the current version of the standard method (BM1.0), the criteria for accepting the test results is 0.05 kWh standard deviation. Feedback from WG17 in CENELEC is that the steps between the energy classes should not be smaller than 0.10 kWh. According to them, the defined standard deviation of the regression line can result in mistakes of up to 0.33 kWh. The reproducibility of BM1.0 was found to be up to 3-5% (0.30 kWh). Additional variations of the brick can decrease reprodubility and the EEI is additionally affected by uncertainties of the volume measurement, hence the 0.10 kWh recommendation for class width.

In APPLIA2020, looking at the best performing modes measured with BM1.0, the oven with the highest energy consumption uses 0.81 kWh/cycle and the lowest 0.54 kWh/cycle. Considering this spread of values and the 0.10 kWh range for difference between energy class steps, the ovens in APPLIA2020 could be distributed in three energy classes only. On this topic, one stakeholder recalls that if the spread of the products is too low, it might be worth considering using a label with fewer energy classes.

Table 102 shows the step difference between the different energy classes with current regulation, using as an example three cavity volumes (35 litres, 70 litres and 100 litres). Every step difference is higher than 0.10 kWh.

**Table 102. Step difference between energy classes**

| | Step difference (kWh) | | | Step difference (%) | | |
|---|---|---|---|---|---|---|
| | **35 l** | **70 l** | **100 l** | **35 l** | **70 l** | **100 l** |
| **A+++ - A++** | 0.12 | 0.14 | 0.16 | 27% | 27% | 27% |
| **A++ - A+** | 0.14 | 0.17 | 0.19 | 24% | 24% | 24% |
| **A+ - A** | 0.17 | 0.21 | 0.24 | 23% | 23% | 23% |
| **A - B** | 0.17 | 0.21 | 0.24 | 19% | 19% | 19% |
| **B - C** | 0.19 | 0.23 | 0.26 | 17% | 17% | 17% |

In the following sections, several policy options will be presented in relation to energy classes. In every case, it will be analysed whether there is enough differentiation between products in terms of energy class, and it will be checked that the step difference does not risk causing repeatability or reproducibility issues.

### 7.2.5 A combined label for electric and gas ovens

The current Energy Label Regulation has two different labels for ovens: one for electric and one for gas appliances. From a customer perspective, it might appear that there is just one label, since the appearance of the two is almost identical, only differentiated by the symbol identifying the energy source in the top left corner. It might also appear that electric and gas ovens are under the same energy classification, since the thresholds of the classes are the same. However, they are different. The EEI for energy and gas appliances is calculated taking as a reference the market average for each of those energy sources, separately.

In other words, an electric oven is compared with the market of electric ovens; and a gas oven is compared with the market of gas ovens. Therefore, the energy classes of electric and gas ovens cannot be compared directly with the current energy classification. This approach assumes that, although they are used for the same purpose, electric and gas ovens are slightly different types of appliances, not only in terms of energy source, but also in terms of functionalities. With the current approach (separate labels), it is assumed that intra-technology granularity can bring energy savings by promoting the most efficient technologies (among each energy source).

Some stakeholders support a different approach: comprehensive and comparable labelling that does not differentiate between gas and electricity. In their view, the main objective of the Ecodesign and Energy Labelling Regulations is to reduce the overall energy consumption (primary energy), so every decision should be taken assessing how much primary energy is consumed or saved. When gas and electricity are compared, what needs to be compared is the primary energy consumed, so a factor to convert electric energy to primary energy should be applied. Today this Primary Energy Factor (PEF) is assumed as 2.1. If PEF = 2.1 is used for the electricity consumed by ovens, the comparison between electric and gas appliances can be made (Figure 225).

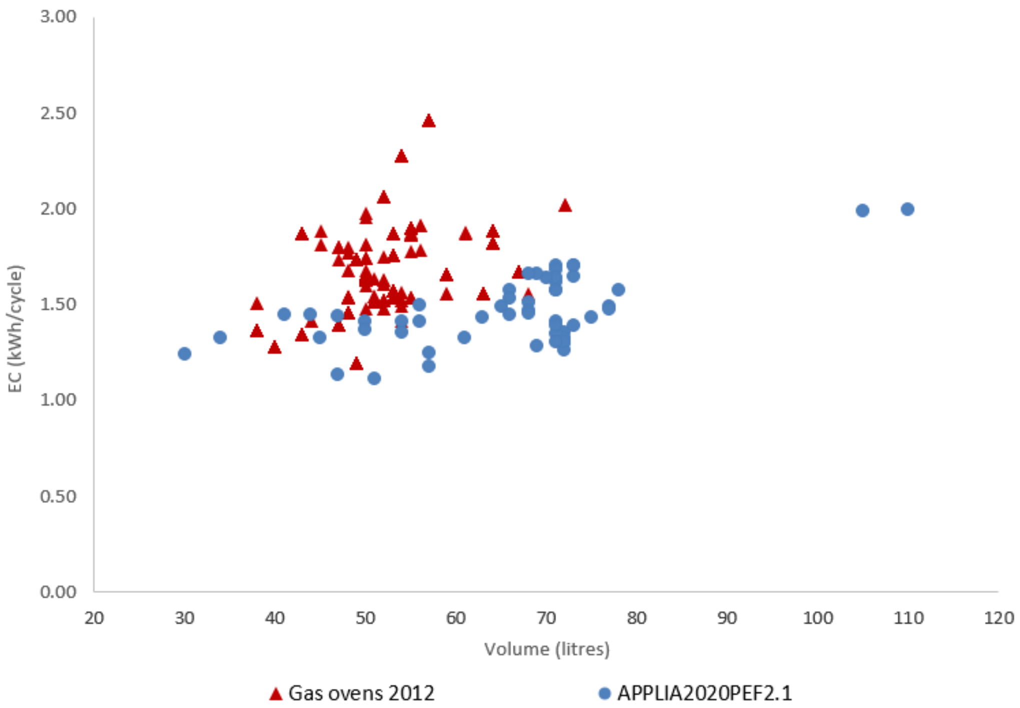



**Figure 225. Electric ovens (APPLIA2020) vs gas ovens (CECED2012)**

According to stakeholders in favour of the combined label for electric and gas ovens, this approach would bring the following benefits:

- If, on average, gas ovens perform worse than electric ovens, a combined label might give higher energy classes to electric ovens and lower energy classes to gas ovens. This would help consumers identify the most efficient appliances from the primary energy point of view.
- In the mid to long term, a substitution effect might take place, from gas to electric appliances. This substitution effect might bring more energy savings than the savings of intra-tecnology granularity (separate labels).

In order to identify the most suitable approach (separate versus common label), a simple scenario analysis has been conducted (Table 103). The aim is to estimate the energy savings that might be achieved by these two options: separate labels that promote intra-technology comparisons, or combined labels that promote energy source comparisons.

**Table 103. Substitution scenario electric / gas ovens**

| **Scenario** | **Description** |
|---|---|
| BAU | No change from current sales trend Electric / Gas |
| Sc1 – Substitution Low<br>(combined label) | 5% yearly reduction of gas ovens, replaced by electric ovens |
| Sc2 – Substitution High<br>(combined label) | 10% yearly reduction of gas ovens, replaced by electric ovens |
| Sc3 – No substitution – Efficiency improvements<br>(separate label) | No change from current sales trend Electric / Gas<br>0.25% yearly improvement in Energy Consumption |

In BAU, it is assumed that the sales trends of both electric and gas ovens do not change from today's estimations. In Sc1 and Sc2, two different substitution scenarios are modelled (Low and High). In Sc3, no electric/gas substitution is assumed, but a 0.25% yearly energy consumption, both for electric and gas ovens. Some assumptions have been made for the evaluation of these scenarios (Table 104).

**Table 104. Substitution scenario assumptions**

| | **Final energy consumption** (1) (2) | **Primary energy consumption** (3) **(MJ/cycle)** | **Annual primary energy consumption (MJ/year)** (4) |
|---|---|---|---|
| **Electric oven** | 0.69 kWh/cycle | 5.21 | 948.2 |
| **Gas oven** | 5.89 MJ/cycle | 5.89 | 1072.0 |

(1) Average of APPLIA databases.
(2) BM1.0, best performing mode.
(3) PEF = 2.1.
(4) 182 cycles/year.

The results of the substitution scenario analysis can be seen in Figure 226.

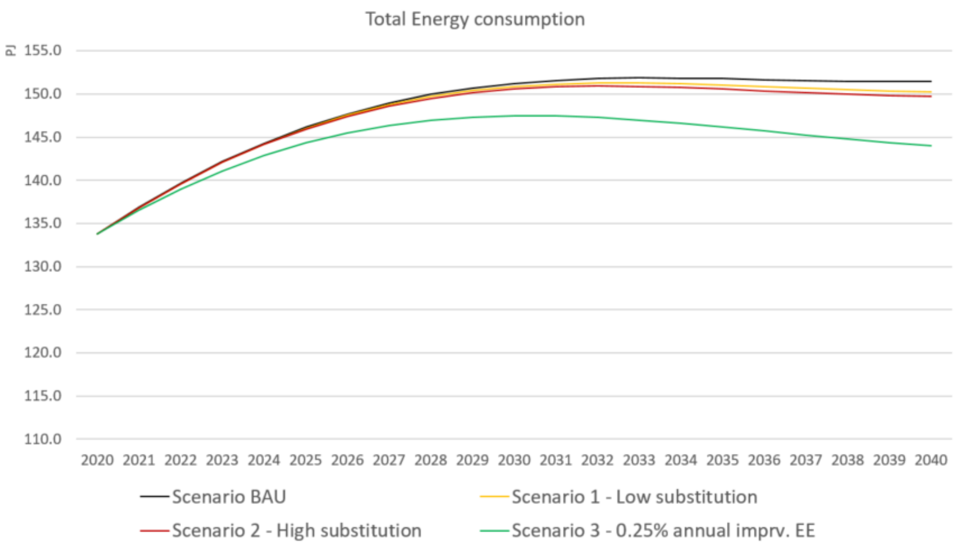



**Figure 226. Substitution scenario results**

The results show that there is little reward in terms of energy savings related to the substitution scenarios defined (both Low and High). Even with a 10% yearly reduction of gas ovens (substituted by electric ovens), the savings that may be achieved are lower than the savings related to 0.25% yearly improvements in energy efficiency. This is due to the low sales of gas ovens, with a decreasing tendency. Even though gas ovens are on average less efficient than electric ovens, their sales are so low compared to electric ovens (see Figure 45) that the benefit achieved by the substitution scenarios is not significant. It might be concluded that, for ovens, more savings may be achieved with separate labels that help consumers identify the best products among each energy source.

Other stakeholders support the approach of separate energy labels for electric and gas ovens. According to them, there are some drawbacks related to a combined label for electric and gas ovens:

- The behaviour of gas ovens differs from that of electric ovens, both with regards to fine granular tuning of temperatures and feature availability.
- If there is no common test method, it does not make sense to compare the products on a common label.
- For electric ovens, the task to distribute appliances across the scale is already difficult. The inclusion of other technologies might make this task even harder, and distort the picture and lead to a differentiation between but not within technologies.
- Preconditions for consumers' buying decisions are completely different (e.g. availability of gas).
- The impact of a combined label is unclear and largely depends on the conversion factor of primary energy and on calculations that might be used in the effort to make appliances comparable.

### 7.2.6 Policy options related to the energy consumption declaration

In this section, different policy options related to the energy consumption declaration of ovens are described, considering the expected benefits, drawbacks, risks and work neded. Table 105 is a summary of the different policy options considered on the declaration of energy consumption of ovens.

**Table 105. Summary of policy options considered on the energy consumption declaration**

| Topic | Policy options |
|---|---|
| 6. Definition of Standard Energy Consumption (SEC) | 6.a Same linear regression as in current regulation |
| | 6.b New linear regression based on market of ovens today |
| 7. Adoption of BM2.0 as reference measurement method | 7.a Use BM1.0 as reference measurement method for electric ovens |
| | 7.b Use BM2.0 as reference measurement method for electric ovens |
| 8. Heating mode to declare energy consumption | 8.a Best performing mode / BM1.0 |
| | 8.b Best performing mode / BM2.0 |
| | 8.c Weighted sum Best perfoming mode & Standard mode / BM2.0 |
| | 8.d Conventional mode without use of residual heat / BM2.0 |
| 9. Non-linear relation between SEC and cavity volume | 9.a Linear regression SEC and Cavity volume |
| | 9.b Flat approach |
| | 9.c Logarithmic or power approach |
| 10. Cooking real food to declare energy consumption | 10.a Not using food to declare energy consumption |
| | 10.b Cook real food to declare energy consumption of energy-saving modes |
| | 10c. Cook real food to declare energy consumption of every heating mode |
| 11. Energy declaration of combi steam functions | 11.a Not declare energy consumption of combi steam mode |
| | 11.b Declare energy consumption of combi steam mode in energy label |
| | 11.c Declare energy consumption of combi steam mode in user manual |
| 12. Energy declaration of combi-MW | 12.a Not declare energy consumption of combi-MW mode |
| | 12.b Declare energy consumption of combi-MW mode in energy label |
| | 12.c Give a 10% bonus in energy consumption to ovens with combi-MW mode |
| 13. Energy declaration of automatic functions | 13.a Not declare energy consumption of automatic functions |
| | 13.b Declare energy consumption of automatic functions on energy label |
| | 12.c Give a 15% bonus in energy consumption to ovens with automatic functions |
| 14. Measurement of cavity volume | 14a. Measure cavity volume with side racks |
| | 14b. Measure cavity volume without side racks |
| 15. Declare energy consumption of pyrolysis cleaning | 15a. Not declare energy consumption of pyrolysis cleaning |
| | 15b. Declare energy consumption of pyrolysis cleaning |
| | 15c. Include recommendations about frequency of use of pyrolysis cleaning |
| 16. Declare energy consumption of preheating phase | 16a. Not declare energy consumption of preheating phase |
| | 16.b. Declare energy consumption of preheating phase |
| | 16.c. Include recommendations about when to preheat the oven |

Before going into the detail of each policy option, it is worth returning to the definition of the Energy Efficiency Index (EEI) of ovens. In the current regulation, the EEI for electric ovens is defined as:

$$EEI_{cavity} = \frac{EC_{electric\ cavity}}{SEC_{electric\ cavity}}\ x\ 100 \qquad EEI_{cavity} = \frac{EC_{gas\ cavity}}{SEC_{gas\ cavity}} \times 100$$

EC is the energy required to heat a standardised load, considering the best performing mode. SEC is the standard energy consumption required to heat a standardised load, represented as a linear regression that relates energy consumption and cavity volume, based on the market at a specific time. In current regulation, SEC is defined as:

$$SEC_{electric\ cavity} = 0.0042\ x\ V + 0.55\ (in\ kWh) \qquad SEC_{gas\ cavity} = 0{,}044 \times V + 3{,}53\ (\text{in MJ})$$

Based on the EEI value, ovens are awarded their energy class according to Table 106.

**Table 106. Energy efficiency classes and EEI**

| Energy efficiency class | Energy Efficiency Index |
|---|---|
| A+++ | EEI < 45 |
| A++ | 45 ≤ EEI < 62 |
| A+ | 62 ≤ EEI < 82 |
| A | 82 ≤ EEI < 107 |
| B | 107 ≤ EEI < 132 |
| C | 132 ≤ EEI < 159 |
| D | EEI ≥ 159 |

The EEI is therefore a ratio between the energy consumed by the oven (EC) and the energy consumed by a standard reference based on the market (SEC). There are certain aspects of the EEI that are under debate. For simplification, all those aspects will be evaluated individually in the following sections:

- Update of SEC: Section 7.2.6.1.
- Adoption of BM2.0: Section 7.2.6.2.
- Heating mode to declare energy consumption and determine energy class: Section 7.2.6.3.
- A non-linear relation between energy consumption and cavity volume: Section 7.2.6.4.
- Cooking real food as a quality check: Section 7.2.6.5.
- Energy declaration of steam-assisted, MW-combi and automatic functions: Section 7.2.6.6.
- Cavity volume measurement: Section 7.2.6.7.
- Energy declaration of self-cleaning functions: Section 7.2.6.8.
- Energy declaration of preheating phase: Section 7.2.6.9.

#### 7.2.6.1 Definition of Standard Energy Consumption (SEC)

In the current Regulation, SEC was defined as a linear regression relating energy consumption and cavity volume. It was considered that cavity volume was a valid parameter for comparison between ovens, consumer-relevant and directly related to the energy consumption and therefore to the energy class of the appliance. It also allowed larger cavity ovens access to the top energy classes.

Based on the feedback received by stakeholders, it might be of interest to evaluate a change in the definition of SEC, using either other functions (power, logarithmic, etc.) or even to decouple the relationship between SEC and cavity volume. These analyses will be presented in Section 7.2.6.4.

In this section, analysis will be conducted assuming that SEC is still a linear regression of cavity volume. The parameters of this linear function were selected during the development of the current Regulation to represent an average of the market at that time:

Current Regulation:	SEC = 0.0042*V + 0.55 (in kWh)

*Policy option 6a* would be to maintain the current situation and use the same linear regression in new regulation.

*Policy option 6b* considers that the energy consumption of electric ovens has evolved over the years; therefore, it is reasonable to evaluate whether the SEC regression needs to be updated for the new version of the Regulation. Taking into account the models in APPLIA2020, an updated version of SEC can be calculated. In Figure 227, SEC is calculated using the energy consumption of the best performing mode, measuring with BM1.0.

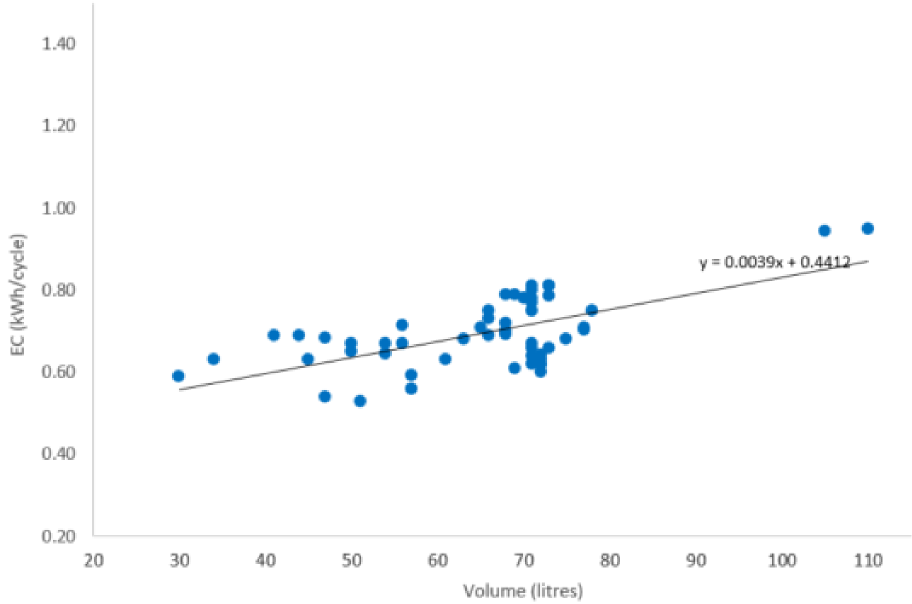



**Figure 227. Updated SEC, BPM, BM1.0**

Updated version, Best Performing Mode, BM1.0:	SEC = 0.0039*V + 0.4412

As can be seen in Figure 228, just by updating the SEC linear regression, ovens in the APPLIA2020 database would have a different energy class. With the updated SEC, 67% would be A and 33% B. The energy classification is the same as in the current Regulation (Table 106).

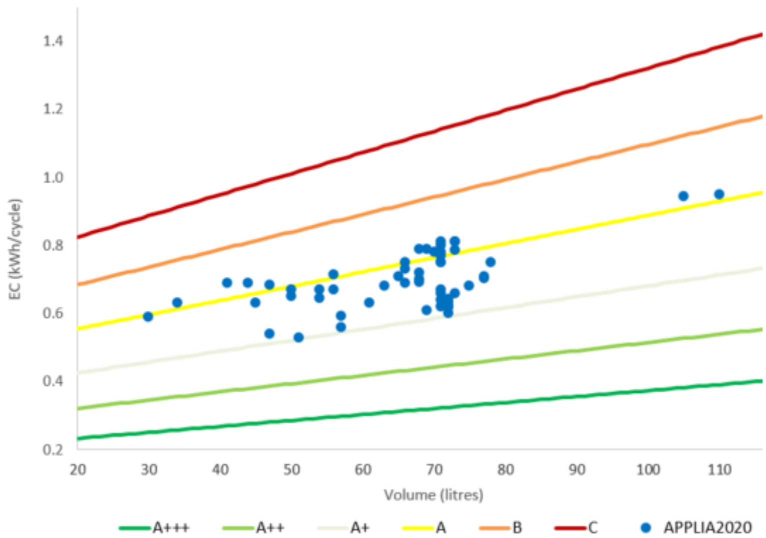



**Figure 228. APPLIA2020, Updated SEC, Best Performing Mode, BM1.0**

In principle, it seems reasonable to update the SEC curve for the new version of the Regulation (*policy 6b*). Moreover, the update on the SEC would work as a strengthening of the requirements to reach the top energy classes (without rescaling). The specific parameters of SEC will depend on the approach taken to declare the energy consumption, in terms of heating mode (best performing mode, conventional, weighted sum) and measurement method (BM1.0 or BM2.0).

<u>Recommendation for new regulation</u>: update SEC accordingly, based on recent market data, depending on the heating method used for the energy declaration and measurement method used (*Policy option 6b*).

#### 7.2.6.2 The adoption of Brickmethod 2.0 as the measurement method for energy consumption

In this report, the potential adoption of a new measurement method for energy consumption has been discussed. *Policy option 7a* would be to maintain the current method (BM1.0). *Policy option 7b* would be to adopt BM2.0 as the reference method for measuring the energy consumption.

The main aim of the development of BM2.0 is to address some jeopardy effects or circumvention issues observed in some domestic ovens. The main differences between the current method and BM2.0, as well as the potential benefits of its adoption, have been described in Section 1.2.1.4.

In terms of energy classes, the consequences of the adoption of BM2.0 can be observed comparing Figure 229 and Figure 230. Energy classification is the same as in the current Regulation (Table 106).

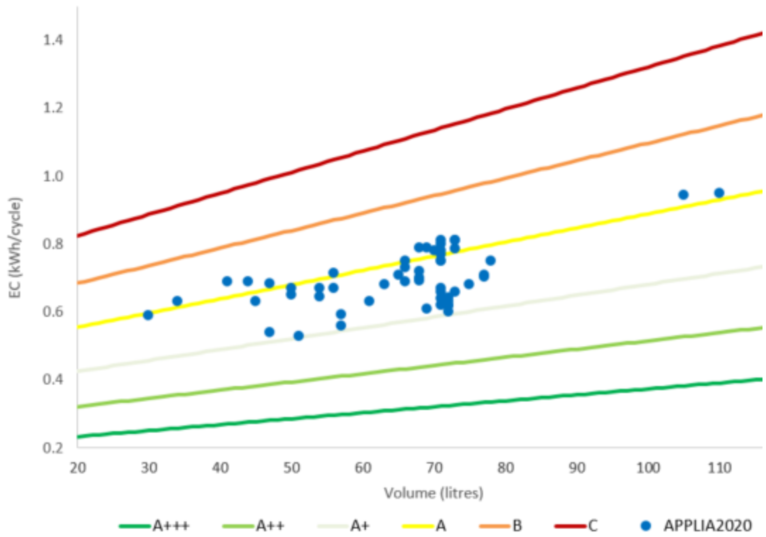



**Figure 229. APPLIA2020, Updated SEC, Best Performing Mode, BM1.0**

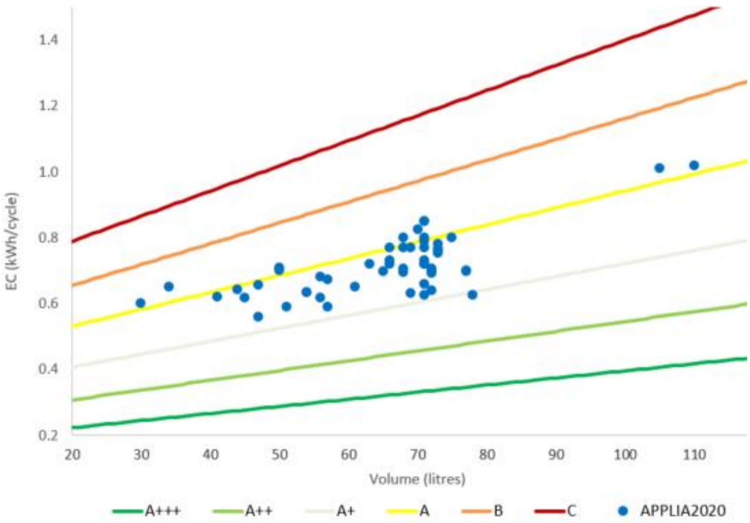



**Figure 230. APPLIA2020, Best Performing Mode, BM2.0**

With the adoption of BM2.0, 76% of the ovens in APPLIA2020 would be A energy class, 22% would be B and 2% would get the A+ class. Some appliances appear to get a worse EEI with BM2.0. It appears that manufacturers in general do not obtain a benefit in terms of energy declaration with the adoption of BM2.0.

BM2.0 is a new method under development and is therefore not a perfect or consolidated method. In general, it is considered an improvement with significant benefits, particularly the separation of phases, which prevents circumvention. In its current version it still has some drawbacks and points to improvement. For instance, one stakeholder pointed out that BM2.0 disqualifies a few ovens that make bad use of residual heat but not all of them. According to them, in order to identify all, it is necessary to define additional specific clauses to discriminate between standard and eco functions.

Recommendation for new regulation: adopt BM2.0 as the reference method to measure the energy consumption of domestic electric ovens.

#### 7.2.6.3 Heating mode used to declare the energy consumption

The current Energy Labelling Regulation establishes that "energy consumption shall be measured for one standardised cycle, in a conventional and in a fan-forced mode". These two modes (conventional and fan-forced) are defined in the Regulation. *Policy option 8a* would be to maintain the current situation.

Energy-saving modes are a feature in electric ovens that allow the reduction of energy consumption. Generally, they work using residual heat to reduce the consumption of energy. The topic of energy-saving modes has been debated extensively during the development of this preparatory study. The main issue in this discussion, raised by a variety of stakeholders, is whether to allow the use of energy-saving modes for the energy declaration and energy label classification.

Currently, there is no definition of what constitutes an energy-saving mode, be that in regulation or in the standards. An energy-saving mode can easily fall within the definitions of conventional or fan-forced modes (particularly the latter). So nowadays, manufacturers are allowed to use an energy-saving mode to declare their energy consumption. In fact, manufacturers are already using different variations of these modes to declare their energy consumption.

Some stakeholders are in favour of allowing their use; some others are against their use; and some stakeholders recommend some sort of compromise between energy-saving modes and conventional modes for energy declaration. Some of the views expressed are summarised below:

*"Energy-saving modes are proposed for several years now and as the user behaviour study indicates they are not extensively used. We believe the energy declaration should be based on the standard mode as this is the best reflection of how the oven is used. If it is however decided to consider energy-saving modes for energy declaration, a clear and detailed communication plan to advertise these modes should be implemented in parallel. We do not think that the sole promotion in user manuals is enough"*

"*We do not support use of energy-saving modes for declaration of energy consumption or to determine the energy class. The best performing standard mode without use of residual heat should be used. And no weighted sum as it will be more costly to perform market surveillance and the transparency will be lower*"

Within the industry, conventional modes are also referred to as "standard" modes. There are benefits and drawbacks related to each option (allowing or banning the use of energy-saving modes). In essence, the main issues of using energy-saving modes for the energy consumption declaration are as follows:

- Energy-saving modes reduce temperature during different phases of the cooking cycle. This can produce unsatisfactory results when cooking some recipes, in the form of food being underdone or burnt, depending on the temperature profile used to reduce the energy consumption.
- Energy-saving modes are not the most frequently used modes, according to the results of the user behaviour study presented in Task 3. Therefore, in real-life use, consumers might be observing energy consumption values that are higher than the ones marked on the energy label of the appliance.

To overcome these issues, BM2.0 is being developed. In the previous section, it has been concluded that, even though there are still some specifics of the method under debate, with the information available at this point, it is reasonable to conduct measurements with BM2.0 as soon as the method is ready.

The key question in this section is: *Should energy-saving modes be allowed for the declaration of energy consumption and to determine the energy class of ovens?*

Allowing the use of energy-saving modes for the energy declaration can be seen as an incentive for innovation. This does not mean that energy-saving modes are the only path for innovation, but one of them. If manufacturers are allowed to use a certain amount of residual heat, this is potential for improvement. If most of the ovens in the market have energy-saving modes and their use is promoted appropriately among consumers, there is potential for overall energy savings. On top of that, another stakeholder suggested that, in the Ecodesign Regulation, there could be an information requirement where manufacturers need to explain what the mode referred to as "energy-saving mode" actually does.

Allowing the use of energy-saving modes for the energy declaration can obviously have some risks. For instance, if these modes are not controlled in some manner, there is a risk of having ovens in the market that cannot cook appropriately due to incorrect use of residual heat. Moreover, if energy-saving modes do not work properly or are not promoted among consumers (for instance, encouraging its use in the instructions manual), the energy consumption values on the label will differ greatly from the energy actually consumed by the user.

At this point, it can be stated that, to take advantage of the benefits and reduce the associated risks, energy-saving modes should be allowed for the energy declaration, provided that they can cook appropriately. One way of ensuring this is with the adoption of BM2.0, completed by the definition of the type of function "standard/energy-saving" validated by the test method. An additional way of ensuring it is with the use of real food in the energy consumption test (this aspect will be discussed further in Section 7.2.6.5).

Based on this background, some policy options are identified (Table 107).

**Table 107. Summary of policy options related to heating modes**

| Policy option | Heating mode to determine energy class | Method to measure energy consumption | Applicable to Electric/Gas |
|---|---|---|---|
| **8.a current situation** | Best performing mode (BPM) | BM 1.0 | Electric & Gas |
| **8.b** | Best performing mode (BPM) | BM 2.0 | Electric |
| **8.c** | Weighted sum of BPM and Standard mode (1) | BM 2.0 | Electric |
| **8.d** | Any Standard heating mode (1) that does not use residual heat | BM 2.0 | Electric |

(1) A Standard mode can be either a conventional or a fan-forced mode.

Each of the policy options will have different energy consumption (EC) values and slightly different SEC regression lines. Therefore, each of the policy options defined in Table 107 will have different consequences in terms of energy classes. In this section, the consequences of each of those policy options is presented, using as a basis APPLIA2020.

**Policy option 8a**

*Policy option 8a* consists of maintaining the current situation: declaring the energy consumption with the best performing mode (BPM), and measuring with BM1.0, implementing only the change of an updated SEC (based on the oven market today), as discussed in Section 7.2.6.1. This policy option would be applicable to both electric and gas ovens. With *policy option 8a*, 67% would be A energy class and 33% would be B (Figure 231). Energy classification is the same as in the current Regulation (Table 106).

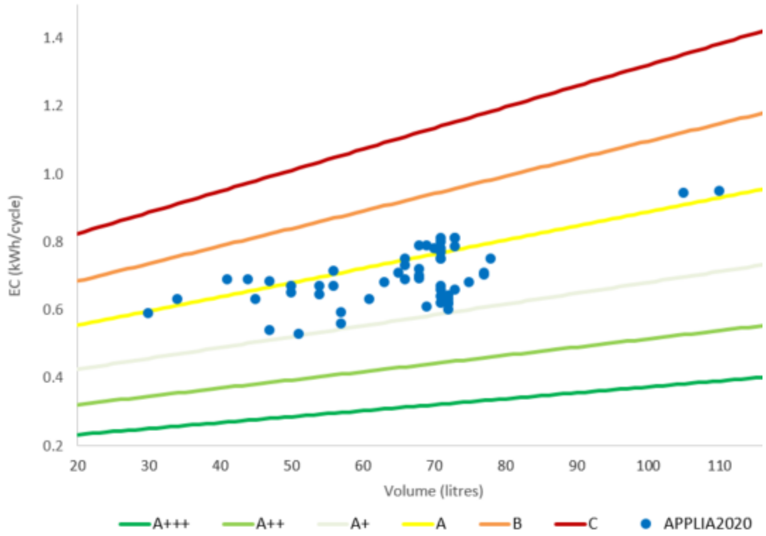



**Figure 231. APPLIA2020, Policy option 8a**

A benefit of this policy option is that it only requires the update of the SEC regression line. Another benefit is that it is a stricter version of the current Regulation in terms of energy class. On top of that, it is applicable to both electric and gas ovens. However, it comes with some drawbacks, since it does not have the benefits related to the adoption of BM2.0.

**Policy option 8b**

*Policy option 8b* consists of declaring the energy consumption with the best performing mode (BPM), and measuring with BM2.0, with an updated SEC regression. This policy option would be applicable to electric ovens only. The consequences of the adoption of BM2.0 have already been presented in the previous section but they are included again here for clarification (Figure 232). Energy classification is the same as in the current Regulation (Table 106).

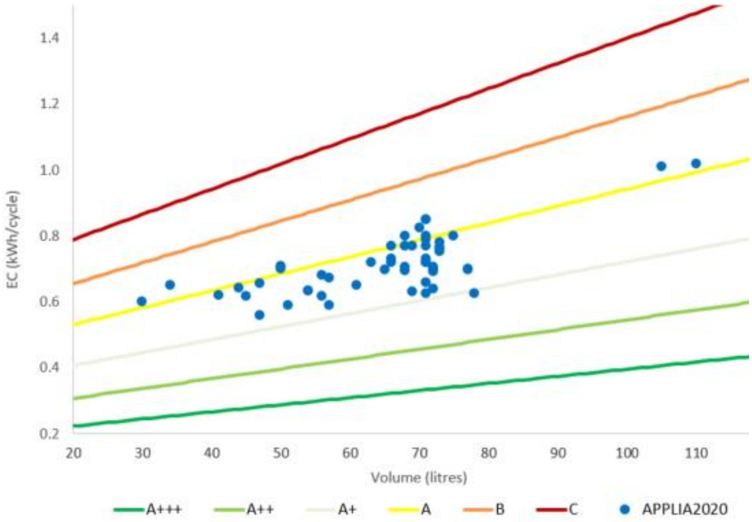



**Figure 232. APPLIA2020, Policy option 8b**

With *policy option 8b*, 76% would be A energy class, 22% would be B and 2% would remain in the A+ class.

A benefit of this policy option is that it is a stricter version of the current Regulation in terms of energy class. Moreover, it has the benefits related to the adoption of BM2.0. A drawback of this option is that it would only be applicable to electric ovens.

**Policy option 8c**

*Policy option 8c* consists of declaring the energy consumption as a weighted sum between the best performing mode (BPM) and a conventional mode, measuring with BM2.0, with an updated SEC regression. This conventional mode can be either a static heating mode or a fan-forced mode (a “standard” mode). This policy option would be applicable to electric ovens only and allows for certain use of energy-saving modes, depending on the terms of the weighted sum.

There are multiple options in terms of the weighted sum. Two options will be evaluated: a 50/50 approach and an 80/20 approach (80% conventional and 20% BPM). The 80/20 approach would be the closest to the current use profile of consumers today (see Figure 107 in Task 3 for time spent using each heating mode). The 50/50 approach would be an approach giving more weight to energy-saving modes.

With *policy option 8c 50/50*, 91% would be A, and 9% would be B (Figure 233).

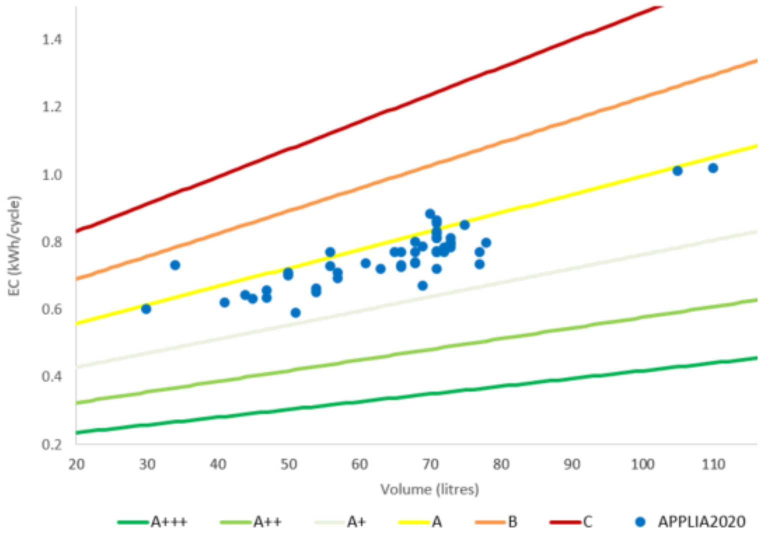



**Figure 233. APPLIA2020, Policy option 8c, 50/50**

With *policy option 8c 80/20*, 93% would be A and 7% would be B (Figure 234).

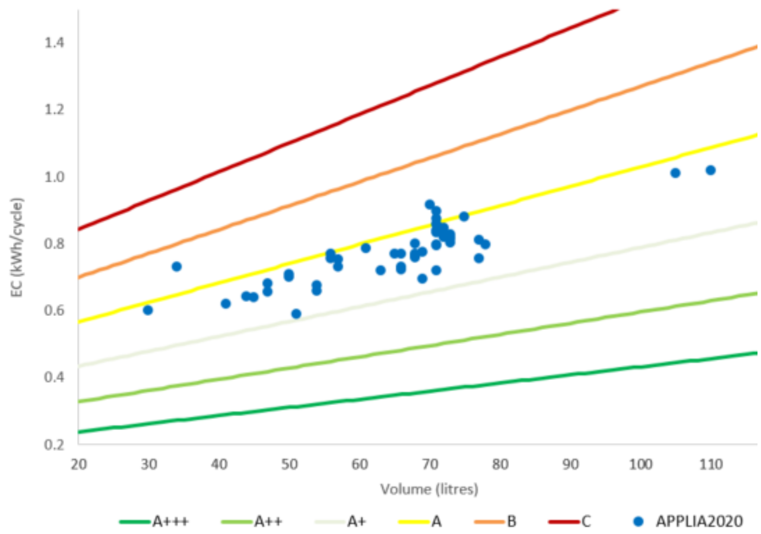



**Figure 234. APPLIA2020, Policy option 8c, 80/20**

A benefit of either of these two options (50/50 or 80/20) is that they are stricter versions of the current Regulation in terms of energy class (without an actual rescaling). Moreover, they have the benefits related to the adoption of BM2.0. A drawback of this option is that it would only be applicable to electric ovens. It can be observed that there is not much difference between a 50/50 approach and an 80/20 approach in terms of the energy class obtained by the ovens.

For *policy option 8c* to work appropriately, there should be enough differentiation between the conventional mode and the best performing mode. Otherwise, there is a risk that some manufacturers can declare the energy consumption using an energy-saving mode (as BPM) and something very similar to an energy-saving mode (but considered a fan-forced mode).

Most stakeholders support the weighted sum approach. If this approach is taken, the preferred option among most stakeholders is the 80/20 one, according to comments received in writing and during the 2nd TWG Stakeholder meeting. According to one of them, since energy-saving modes are not the most used they recommend to go for 80/20. It will be an incentive for manufacturers to innovate not only on energy-saving modes but also on the general features of the ovens (producing savings for all kinds of modes). If energy-saving modes are used more frequently in the future, the formula can be changed in the next version of the Regulation.

Finally, if an oven has no energy-saving mode, the weighted sum approach would not apply. The only mode to consider for the energy declaration would be the standard one.

**Policy option 8d**

*Policy option 8d* consists of declaring the energy consumption with a conventional mode only, and measuring with BM2.0, with an updated SEC regression. This conventional mode can be either a conventional heating mode or a fan-forced mode (a "standard" mode). This policy option would be applicable to electric ovens only. With *policy option 8d*, 92% would be A energy class and 8% would be B (Figure 235).

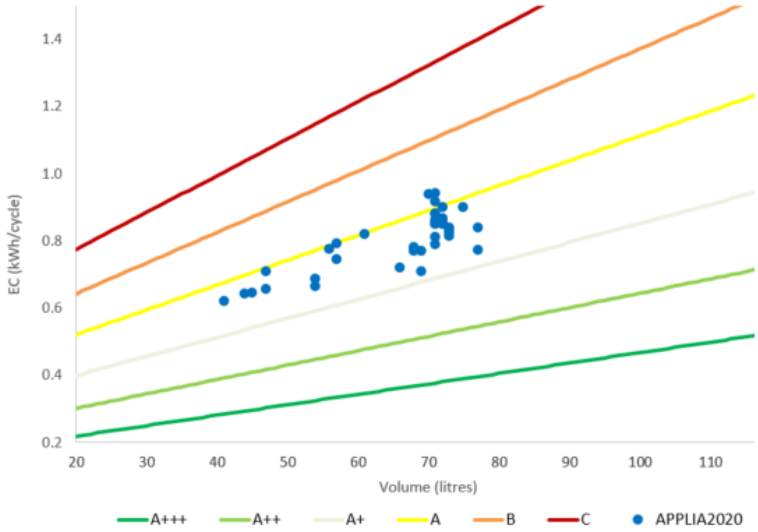



**Figure 235. APPLIA2020, Policy option 8d**

A benefit of this policy option is that it is a stricter version of the current Regulation in terms of energy class. However, this option does not allow the use of energy-saving modes for the energy declaration, which could be a disincentive for manufacturers for the development of these modes.

This option is supported by one stakeholder. According to them, they do not find the use of energy-saving modes appropriate because of the lower performance compared to standard modes.

**Conclusions**

Based on the analysis of the different policy options presented in this section, and considering feedback gathered in bilateral meetings with different stakeholders, some preliminary conclusions can be made at this point:

- Energy-saving modes are a feature that can help reduce the overall energy consumption and are an incentive for innovation, providing they ensure satisfactory cooking results. Only one stakeholder completely discourages the use of energy-saving modes for the energy declaration, recommending the use of conventional modes only.

- In *policy option 8c*, a weighted sum approach is conducted between the BPM and a conventional mode. Most stakeholders support the weighted sum approach. According to the analysis conducted in this section, there is not a significant difference between the use of a 50/50 approach and an 80/20 approach, in terms of the energy class obtained by ovens. However, most stakeholders support the 80/20 approach. Therefore, for simplification from now on, only *policy option 8c 80/20* will be considered. This policy option would require a precise definition of what the "standard" modes are (which can be ensured with the application of BM2.0).

- *Policy option 8c 80/20* would work as a strengthening of the requirements to reach the top energy classes in comparison to the current label.

Recommendation for new regulation: declare the energy consumption using an 80/20 weighted sum approach, 80% for standard and 20% for energy-saving (*Policy option 8c*).

#### 7.2.6.4 Non-linear relationship between Standard Energy Consumption and volume

As indicated in previous sections, some stakeholders have questioned whether current formulas to calculate the EEI are driving consumers to buy larger ovens than they actually need. Coming back to the analysis conducted in Task 2 of this report, it appears that there is a bigger proportion of larger cavity volumes in the top energy classes (A++ and A+) than in the low energy classes (A and B).

*Policy option 9a* would be to carry on with the current linear regression between SEC and cavity volume.

Some stakeholders have suggested decoupling the Energy Efficiency Index from cavity volume. In their view, this approach has high consumer relevance, since the label value (and energy class) would show the actual energy consumption and there would be no distortions associated with size of the oven. As explained in Waechter et al. (2015), consumers focus on the energy efficiency class and disregard information on an appliance's expected electricity consumption in kWh. The authors argue that this could cause a misleading effect of the energy label if product size is a considerable driver of electricity use (as in the case of domestic ovens). Consumers tend to judge an appliance only based on the energy efficiency class despite size-related differences in electricity consumption. Some authors call this effect the "energy efficiency fallacy", which is particularly driven by the visual representation of the energy class.

With this approach (*Policy option 9b*), the EEI would be calculated as:

EEI = EC / SEC

Where SEC would be a fix value, based on the market database (for instance, the average energy consumption).

For simplification, this approach will be known as the "flat approach" in this report. Regarding the results of adoption the flat approach and a weighted sum 80/20 approach, the energy classes would be as in Figure 236: 24% B, 70% A and 6% A+.

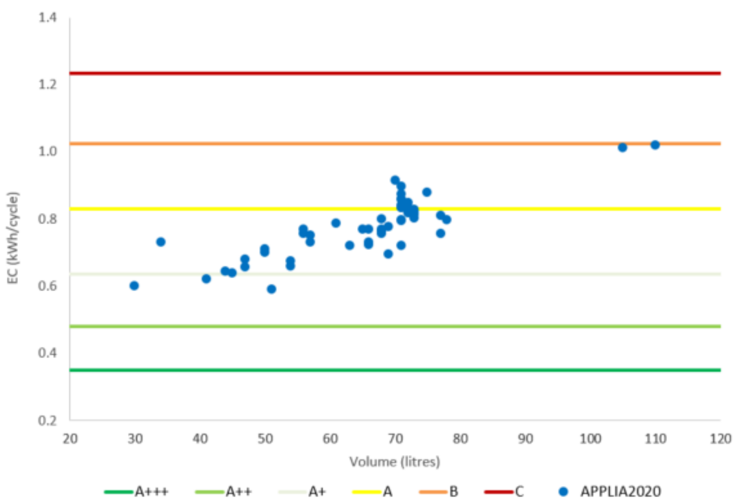



**Figure 236. Flat approach and policy option 8c 80/20**

With the adoption of the flat approach, a potential trend towards larger cavities could be slowed down, helping to reduce the overall energy consumption. It would also limit the incentive for manufacturers to produce ovens with high rated volume. On top of that, the best energy classes would almost always be related to smaller ovens.

It must also be noted that the flat approach could reduce the demand for large cavity ovens, which could affect some manufacturers offering a wide range of these appliances. Also, in terms of ecodesign minimum requirements, it would be difficult for larger ovens to comply. To reduce this impact, some stakeholders suggest establishing a threshold between "regular" and "large" ovens, for instance at 85 litres. Therefore, ovens below 85 litres would have a minimum ecodesign requirement which is stricter than the minimum ecodesign requirement for ovens larger than 85 litres. An example of this approach is shown in Figure 237. The specific ecodesign limits for each group of ovens would still need to be decided, based on the market average of "regular" and "large" ovens.

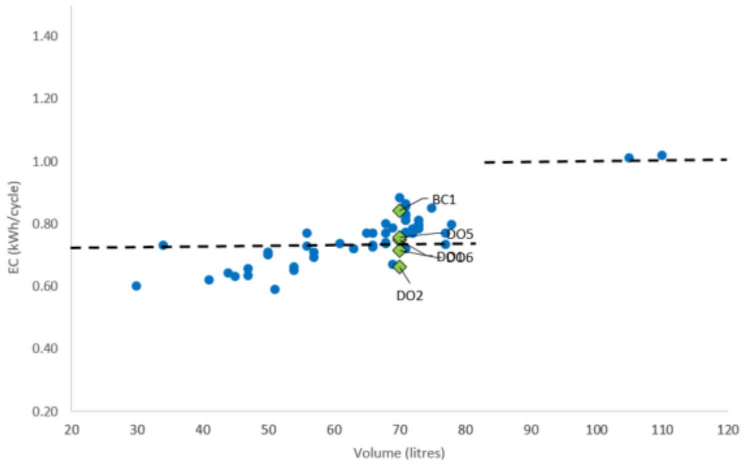



**Figure 237. Flat approach and different ecodesign thresholds**

An intermediate approach to the current Regulation and to the flat approach could be to use a non-linear relationship between energy consumption and cavity volume (essentially, a curve that is flatter on the side of the larger volumes). According to some stakeholders, such an approach could bring about a potential reduction in the total energy consumption by promoting the purchase of "the right size" of ovens.

In Figure 238 to Figure 241, in addition to the linear regression, three different functions are tested, using APPLIA2020: logarithmic, power and exponential. The best-fit equation is presented in each case. For simplification in this section, only *weighted sum 80/20* between BPM and conventional is tested.

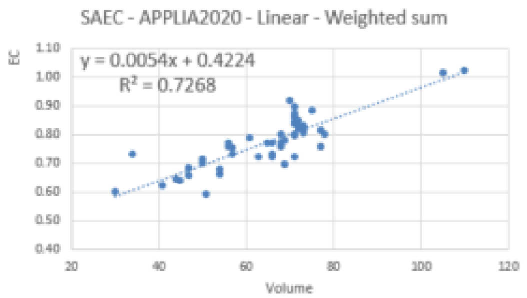



**Figure 238. Linear regression**

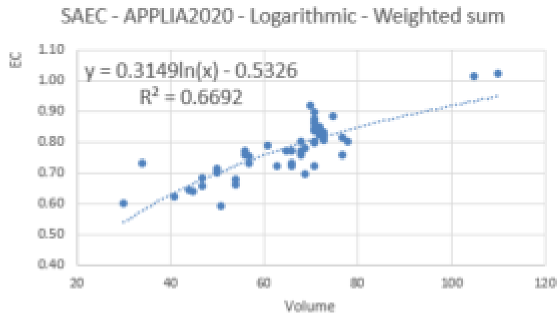



**Figure 239. Logarithmic regression**

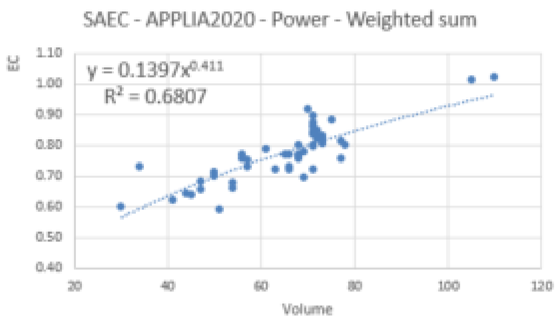



**Figure 240. Power regression**

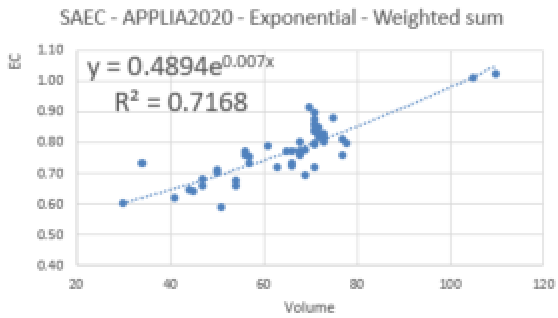



**Figure 241. Exponential regression**

Using a non-linear approach would have consequences in terms of the energy classes obtained by ovens. If the aim is to make it more difficult for larger cavity ovens to reach the top energy classes, the ideal curve is either a logarithmic or a power regression (*Policy option 9c*). The consequences of using alternative regression lines to define SEC can be seen in Figure 242 and Figure 243.

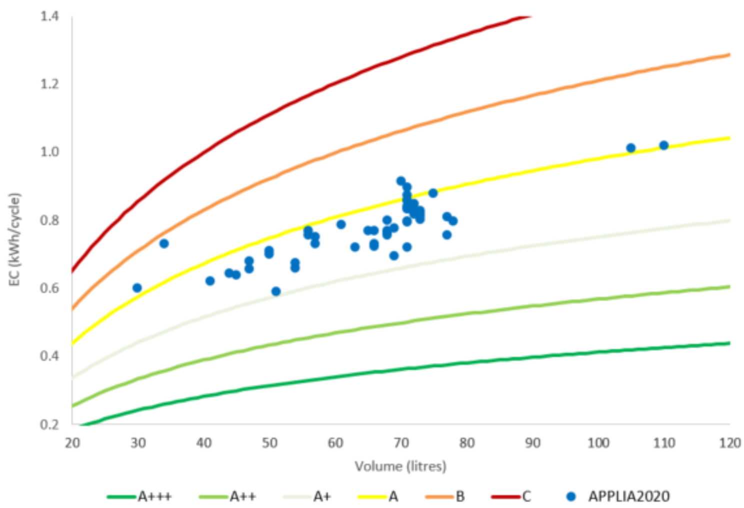



**Figure 242. Logarithmic regression and policy option 8c 80/20**

**SEC = 0.315*ln(V) – 0.53**

The flatter right side of the curve makes it more difficult for larger cavity ovens to access the top energy classes.

In a similar way to the logarithmic regression, the consequences of using a power regression to define SEC can be seen in Figure 243. As happened with the logarithmic regression, the flatter right side of the curve makes it more difficult for larger cavity ovens to access the top energy classes.

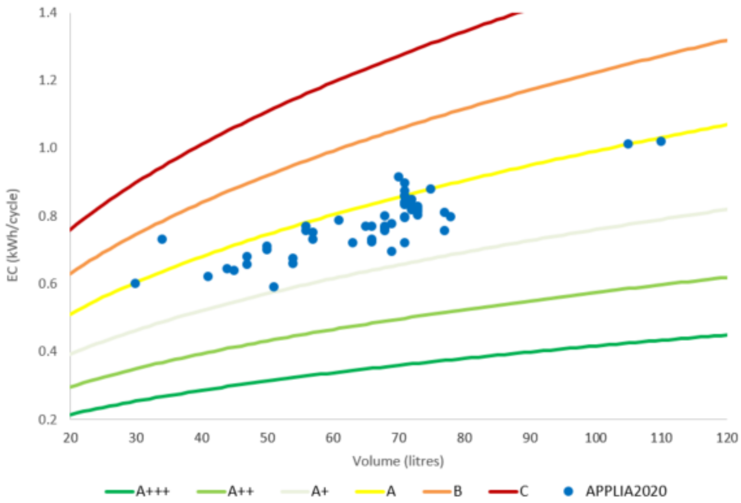



**Figure 243. Power regression and policy option 8c 80/20**

**SEC = 0.1397*$V^{0.41}$**

Several stakeholders support the decoupling of energy consumption and cavity volume for the calculation of the EEI. According to one, the flat approach for the SEC calculation (or the logarithmic approach as a second choice) would give an advantage to small/medium ovens over larger ones. Small ovens cost less and consume less. If manufacturers want to propose a very large oven, they will have to innovate in order to improve their efficiency. The flat approach goes towards sufficiency. Another stakeholder in favour of a non-linear approach adds that it seems to provide larger differentiation on energy classes.

Recommendation for new regulation: consider the flat approach in the analysis of scenarios in comparison to the linear approach to evaluate potential benefits (evaluate *Policy options 9a* and *9b*).

#### 7.2.6.5 Cooking real food to declare the energy consumption

The current version of the standard (EN 60350-1) is based on heating up a brick, useful to represent a relevant load and the energy needed to cook it, but unable to test aspects such as browning or doneness. This standard includes methods to evaluate the capacity of heat distribution and heat supply of ovens. However, these methods are not linked to the test for the energy consumption declaration. The current Regulation does not specify the need to use real food to ensure the good performance of the heating modes used for the energy declaration.

In the view of some stakeholders, performance -understood as the ability to produce quality food- should be included in the next version of the energy label, to allow consumers a better comparison of ovens. A potential way of solving this could be to introduce the testing of real food in some part of the energy declaration test.

*Policy option 10a* would be to maintain the current situation in terms of the use of real food.

An alternative to the current situation (*Policy option 10b*) would be to use real food as a quality check, to ensure energy-saving modes are able to cook appropriately. The use of residual heat in energy-saving modes may cause a decrease in the cooking quality results. Therefore, it might be interesting to introduce this quality check if energy-saving modes are still allowed for the energy declaration. With this policy, it would be easier to ensure an appropriate cooking performance of energy-saving modes. However, this requires a robust procedure.

An even more ambitious option (*Policy option 10c*) would be to use real food as a quality check, to ensure that every heating mode can cook appropriately (and not only energy-saving modes). With this policy, it would be easier to ensure an appropriate cooking performance of every heating mode tested.

Using real food as a quality check is seen as a good idea and is of capital importance for consumer and standardisation agencies, particularly in the current landscape, where energy-saving modes are widespread. In their view, linking energy consumption and cooking performance seems necessary for ovens, since it has been foreseen since the beginning of the regulation process. They add that not including cooking performance in the first version of the label is acceptable, but in the long run it should be included so as to enable the consumer to better compare different ovens.

In opposition to that, other stakeholders do not support cooking real food for quality. They argue that this will make market surveillance more complicated and increase the cost. Instead, they recommend that energy-saving modes are not used for the energy declaration.

Currently, there is a standard method under development to be used as verification of the energy declaration test, to check if that energy is sufficient in terms of core temperature, volume and browning intensity. This method is commonly known within the industry as the “Energy cake test”. This method provides the materials and procedure to cook a standard cake, as well as acceptance criteria for temperature, volume and browning. The main difficulty of developing such a method is related to reproducibility, since food can only be standardised to a very limited extent, which leads to high uncertainties. At this point in time, there are still open topics in the development of this new test, mainly related to the following:

- Ingredients of the cake. Some stakeholders question the use of palm fat, which could have harmful effects if it is not processed appropriately. Also, there is debate around how representative of the real consumers the use of ingredients such as milk powder or egg powder (which are used because they have advantages related to logistics) is.
- Issues with the test procedure related to the thermocouple, which on some occasions does not allow a proper rising of the cake, leading to reproducibility issues.
- Issues with evaluation of the standard deviation.
- Measurement of the core temperature. Issues related with insufficient specification. To tackle those, an alternative measuring rack construction is under development.
- Issues related to the positioning and distances of the thermocouples, the evaluation of the browning intensity of the cake, the determination of the set temperature, etc.

It might also be of interest in this section to mention the investigation carried out by Favi et al. (2020), where the authors characterise the cooking performance of different EU diets in terms of the environmental impact for the development of ecodesign actions related to cooking appliances. In this experiment, four different diets are defined and standardised in terms of type and quantity of food, procedure, sequence, containers, temperature and cooking functions. The cooking procedures are defined with accuracy in order to guarantee repetitiveness. Due to their complexity, the recipes used in this experiment might not be completely adequate for a standardised method, but the work conducted to define the procedures might inspire a way forward in this field.

<u>Recommendation for new regulation</u>: testing the cooking performance of ovens should be mandatory for energy-saving modes only (*policy option 10b*) in the new Regulation, *as soon as* there is a robust test with no reproducibility issues.

At this point, a common dilemma is presented. On one hand, testing performance with real food cannot be made mandatory if there is no robust test to measure it. On the other hand, if testing with real food is not made mandatory by regulation, there is no urge to develop such a test. Regulation cannot be based on testing methods that still do not exist formally, but could work as an incentive to finalise the testing methods that are under development. How this incentive could work is still unclear and open to debate.

In order to incentivise the completion of this test, some of the thresholds formulated in the new Regulations (for ecodesign or for energy labelling) could be linked to the development of the test. Examples of incentives could work like this:

- With the current version of the Regulation, in order to get an A energy class, an oven needs to obatin an EEI of 66. In the new Regulation, this threshold could be conditional to the availability of a standard method with the use of real food. When the test is available, that same threshold might be changed to a 10% higher value (EEI = 72), making it less strict when the testing of real food is in place.

- If *policy 8c* is adopted, the weighted sum could be conditional to the availability of the test with real food. For instance, an 80/20 approach is taken if there is no test to ensure that energy-saving modes can cook appropriately; and the 50/50 approach will be taken as soon as there is a test.

Some stakeholders agree with the approach to incentivise the completion of the test. However, they do not support conditioning the availability of the test with energy class thresholds. Instead, one of these stakeholders supports conditioning the ecodesign minimum EEI for Tier 1 to the availability of a test based on real food. In this case, the ecodesign minimum EEI for Tier 1 could be higher if the food performance test is ready. This would have an incentivising effect, but have no influence on the formula or on the energy class threshold. According to them, the same approach should be taken for gas ovens.

Another alternative proposed by one stakeholder is to consider MW-combi and automatic functions as energy-saving modes, as soon as the cooking performance test is ready. This would work as an incentive to quickly develop this new test method.

Some stakeholders do not agree with this approach. In their view, it is strange to see a regulation that changes the requirements when a new test method is available. Instead, they recommend shifting the use of real food for future regulation.

#### 7.2.6.6 Energy declaration of steam-assisted, MW-combi and automatic functions

**Combi steam ovens**

Solo steam ovens are out of the scope of the current Regulation. Other ovens with steam functions (such as the ones presented in Table 108) are included in the scope.

**Table 108. Steam ovens and their heating functions**

| Type oven | Heating functions available |
|---|---|
| Combi steam oven | - Steam cooking<br>- Steam cooking with fan-forced convection<br>- Fan-forced convection |
| Steam-assisted oven | - Steam cooking with fan-forced convection<br>- Fan-forced convection |

However, the above appliances are covered in the Regulation just by their conventional or fan-forced heating functions (their primary functions), and not the ones using steam. In principle, it is rare to find in the market gas ovens with these types of functions, so the policy options presented in this section would only be applicable to electric ovens.

*Policy option 11a* would be to maintain the current situation: not declaring the energy consumption of any steam-related mode.

As already seen in Task 2, sales of ovens with steam-assisted heating functions have been growing over recent years. The availability of steam-assisted functions is confirmed in the results of the user behaviour study presented in Task 3: they are present in 19% of ovens older than 5 years and in 51% of ovens younger than 5 years. Moreover, 33% of consumers use it either often/very or often/almost always.

Data from the TopTen database presented in Task 4 of this report suggested that ovens that include steam-assisted functions tend to perform well in terms of energy class. An analysis with APPLIA2020 reveals that with *Policy option 8c 80/20* (Figure 244) ovens with a steam-assisted function simply get an A energy class.

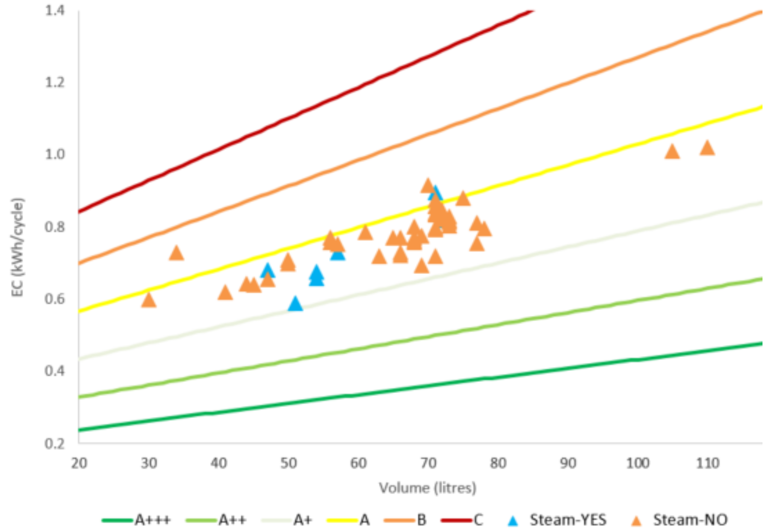



**Figure 244. APPLIA2020, Policy option 8c, 80/20**

Feedback from industry points out that ovens with a steam-assisted function have better sealing and isolation characteristics with a reduced vapour outlet, compared to conventional ovens. This better sealing leads to better results in the energy consumption test. Manufacturers highlight that the support of steam does not necessarily lead to lower energy consumption (it is commonly the opposite).

In summary, steam-assisted heating functions are:

- gradually growing in terms of their availability in electric ovens and their use by consumers;
- generally more energy-consuming than conventional or fan-forced modes;
- indirectly helping to achieve good energy-efficient classification with the current Regulation;
- not declared or regulated if the primary function of the oven is declared as “thermal heat”.

The situation described above invites the consideration of the inclusion of steam-assisted heating functions in the scope of the new Regulation. Two policy options can be identified at this point:

*Policy option 11b* would be to declare the energy consumption of steam-assisted heating modes (even if the oven is declared with “thermal heat” as primary function), not affecting the energy class. In this case, these modes could be declared on the energy label.

*Policy option 11c* would be to declare the energy consumption of steam-assisted heating modes, including this information in the user manual.

Declaring the energy consumption of steam-assisted functions comes with additional difficulties. Currently there is no standard method to measure the energy consumption of these functions. Therefore, for both *Policy option 11b* and *11c*, a new test standard should be available to allow their energy declaration.

<u>Recommendation for new regulation</u>: carry on with the current approach for ovens declared with “thermal heat” as their primary function. Declare the energy consumption of conventional and best performing modes only (*Policy option 11a*).

**<u>MW-combi and automatic functions</u>**

A similar issue to the above is related to MW-combi or automatic functions. *Policy options 12a* and *13a* would be to maintain the current situation (not declare their energy consumption or associated savings).

As explained in previous sections, some ovens have functions that have the potential to reduce energy consumed during cooking, such as MW-combi modes or automatic functions. According to feedback received from stakeholders, MW-combi modes can reduce the energy consumption by 10% and automatic functions by 15% (see the corresponding sections in Task 4 for more details). However, the benefits of these settings are not directly perceived by consumers.

Ideally, in order to declare the energy consumption in the user manual and to take into account the benefits of those settings in achieving a better energy class, a standard method should be developed for both of them: the use of a MW-combi mode (*Policy option 12b*) and the use of automatic functions (*Policy option 13b*).

Until standard measurement methods are developed, a possible way to show consumers the potential energy consumption savings of these functions is to apply a percentage reduction during the calculation of the Energy Efficiency Index. For instance, a 10% reduction in the declared energy consumption (EC) value could be used in the case of appliances with MW-combi modes (*Policy option 12c*) and a 15% reduction in the case of appliances with an automatic setting (*Policy option 13c*). Some stakeholders do not agree with the bonus approach, particularly if there is no background supporting a specific figure. Instead, they consider that an information requirement regarding potential energy savings for combi functions would work better.

As already mentioned, an alternative proposed by one stakeholder is to consider MW-combi and automatic functions as energy-saving modes, as soon as the cooking performance test is ready. This would work as an incentive to quickly develop this new test method.

<u>Recommendation for new regulation</u>: declare the energy consumption of the standard and best performing modes of MW-combi and ovens with automatic functions (*Policy options 12a* and *13a*), for their thermal functions only.

#### 7.2.6.7 Measurement of cavity volume to declare the energy consumption

The Energy Efficiency Index (EEI) of an oven (and therefore its energy class) is directly related to its energy consumption and cavity volume. Regarding cavity volume measurement, the current version of the standard EN 60350-1 states that:

> *"Removable items specified in the user instruction to be not essential for the operation of the appliance in the manner for which is intended shall be removed before measurement is carried out".*

According to some stakeholders, this sentence should be revised as it may lead (and in many cases does lead) to higher declared volumes and thus a better EEI compared to real-life usage of the ovens. In order to declare higher cavity volumes, side racks are often removed during the test. It might be argued if side racks are essential or not for the operation of the appliance.

As already indicated in Section 1.2.1.2 of this report, the authors of the ANTICSS project concluded that the use of an oven without the side racks seems to be an exceptional use and not the operation of the appliance in the manner for which it is usually intended. In their view, there is a loophole in the standard that should be solved. Their recommendation is that all relevant parameters should be measured in the same conditions. Therefore, if the side racks are needed for the measurement of the energy consumption, then the volume should be measured with the side racks (*Policy option 14a*).

This approach is supported by most of the stakeholders. According to one, removing side racks from the oven is an exceptional, non-consumer-relevant use. Measuring the volume this way gives a misleading EEI (if volume is a factor in the EEI). Another reason to measure the volume with shelf racks is that these are needed to perform the measurement of the energy consumption, and it is reasonable to keep parameters constant between measuring volume and measuring energy consumption.

However, members of CENELEC Working Group 17 working on standard methods for ovens disagree with the above point of view. They indicate that in the new version of the energy consumption test, the rule will be to measure the cavity volume after removing the side racks. According to these members of WG17, conducting the energy consumption test with the side racks adds reproducibility issues, which could be eliminated by just conducting the test without them (*Policy option 14b*). This would also be consistent with the past and compatible with the current and previous databases. In their view, if the volume has to be determined with side racks, all calculations (SEC, etc.), class limits and ecodesign limits would have to be adapted.

Recommendation for new regulation: to measure the cavity volume with the side racks (*Policy option 14a*), since the normal use of the oven is with them. Although it may require adapting current databases and calculations, the current review stage of the cooking appliances Ecodesign Regulation seems a good opportunity for change.

#### 7.2.6.8 The inclusion of the energy consumption of self-cleaning systems in the product information requirements

The most common self-cleaning system in ovens today is pyrolytic cleaning. With this system, the oven is heated in a special heating cycle up to 500 °C for long periods of time (1-3 hours). This causes fat deposits to pyrolyse, mainly to gaseous by-products. Organic residues are incinerated, then easily removed as dust. The pyrolytic cleaning cycle has high energy consumption. The total annual energy consumption will depend on how frequently this system is used.

Results from Task 3 regarding the use of the pyrolytic function indicate that 15% of consumers use the pyrolytic function almost always or very often. Some stakeholders suggest that the pyrolytic function represents around 25% of the lifetime energy consumption of the oven. Results shown in Task 5 of this report indicate that a moderate use of pyrolytic cleaning (6 times/year) can increase the total energy consumption of the oven by 10%.

Currently, it is not mandatory to declare the energy consumption of pyrolytic cleaning. *Policy option 15a* would be to maintain the current situation. However, its impact on the total energy consumption seems significant. Some stakeholders suggest that it is important that consumers have access to information about the energy consumption of pyrolytic cleaning and that it should be declared. Their proposal is to include information on the energy consumption of self-cleaning systems in the user manual. Providing the consumer with information on the energy consumption of self-cleaning systems might foster a reasonable use of this feature (*Policy option 15b*). This is supported by some stakeholders, who consider that consumers should have access to information on the energy use of pyrolytic cleaning, seeing as it can represent a very significant share of the total energy use.

The main difficulty of declaring the energy consumption of the pyrolytic function is the fact that it would be very challenging to evaluate different levels of cleanliness and to compare self-cleaning programmes with manual cleaning. There is currently no standard method to evaluate the performance of cleaning systems in ovens.

A potential solution for this situation could be to include recommendations about the frequency of use of this system (in times per year, for instance) as an information requirement in the product documentation (*Policy option 15c*). Providing consumers with these recommendations on frequency of use of self-cleaning systems might promote a reasonable use of this feature, without the need to develop a new standard method.

Recommendation for new regulation: to include recommendations about the frequency of use of this system (in times per year, for instance) as an information requirement in the product documentation (*Policy option 15c*).

#### 7.2.6.9 The inclusion of the preheating phase energy consumption in the product information requirements

According to the results of the user behaviour study presented in Task 3, around 28% of consumers preheat their oven before use. Preheating the oven is considered within the industry as an inefficient activity. Most recipes do not require a preheated oven; however, many consumers still perceive this is a necessary step in cooking with the oven. Based on this, it appears that a significant amount of energy is wasted on this inefficient cooking habit. Policy options presented in this section would be applicable to both electric and gas ovens.

The current Regulation does not require the declaration of the energy consumption of the preheating phase. *Policy option 16a* would be to maintain the current situation.

In the current and new version (BM2.0) of the EN 60350-1 test method, the oven is tested at ambient temperature, so preheating is not considered. Some stakeholders indicate that the inclusion of the preheating phase in the energy consumption declaration should be explored, as it is the way consumers use their oven. In this case (*Policy option 16b*), the energy consumption of preheating should be declared using a cycle with an empty cavity (no standard load).

It must be taken into account that including the declaration of the energy consumption of preheating in product documentation might convey the idea that this is a necessary step in the cooking process. An alternative to avoid this issue would be to include, as an information requirement, recommendations on when to preheat and when not to preheat the oven (*Policy option 16c*). One stakeholder agrees with this approach. However, they add that as long as preheating is suggested in most recipes they doubt it will have any significant impact. User manuals do not seem to be the best means to inform consumers.

<u>Recommendation for new regulation</u>: to include, as an information requirement, recommendations on when to preheat and when not to preheat the oven (*Policy option 16c*).

#### 7.2.6.10 A comparable metric of the energy consumption of electric and gas ovens

In Section 7.2.5, the possibility of using a combined label for electric and gas ovens has been discussed. It has been concluded that more savings may be achieved with separate labels that help consumers identify the best products among each energy source.

In any case, if the Commission aims at helping consumers compare the energy consumption of ovens in terms of primary energy, an alternative –and less drastic– approach to the combined label might be the introduction of an information requirement for gas ovens. This could be, for instance, a mandatory requirement to declare their energy consumption in a metric which is comparable with electric ovens. To facilitate the development of this metric, a tiered approach could be followed for this information requirement (for instance, applicable for gas ovens placed on the market after 2025).

#### 7.2.6.11 Summary of policy options regarding the declaration of energy consumption

Table 109 shows a summary of the different policy options presented in the previous sections.

**Table 109. Summary of policy options regarding the declaration of energy consumption**

| | New regulation ≈ 2022 | Work needed → | Future regulation ≈ 2030 |
|---|---|---|---|

| | Standard | Best Performing Mode | Other functions | | Standard | Best Performing Mode | Other functions |
|---|---|---|---|---|---|---|---|
| Conventional | Y (thermal function) | Y (thermal function) | N | | Y (thermal function) | Y (thermal function) | N |
| Conventional with auto function | Y (thermal function) | Y (thermal function) | N | Standard method for **auto-** function | Y (thermal function) | Y (thermal function) | Y (auto function) |
| Solo MW | Y (MW function) | N | N | Standard method for **solo MW** function | Y (MW function) | N | N |
| Combi-MW | Y (thermal function) | Y (thermal function) | N | Standard method for **combi-MW** function | Y (thermal function) | Y (thermal function) | Y (combi MW function) |
| Small/Portable (< 10 litres) | N | N | N | Standard method for **ovens <10litre** | Y | Y | Y |
| Solo steam | N | N | N | Standard method for **solo steam** function | N | N | Y (steam function) |
| Combi steam | Y (thermal function) | Y (thermal function) | N | Standard method for **combi steam** function | Y (thermal function) | Y (thermal function) | Y (combi steam function) |

NB. Y: Yes, include. N: Not include.

### 7.2.7 Definition of energy label and energy classes

In this section, different options in terms of energy label and energy classes will be evaluated. Based on the content presented in previous sections, it will be assumed that:

- BM2.0 is the preferred measurement method for electric ovens;
- as the heating mode to declare the energy consumption, *Policy option 8c 80/20* will be considered;
- SEC linear regression and the flat approach will be compared.

The current version of the energy label of ovens can be seen in Figure 245.

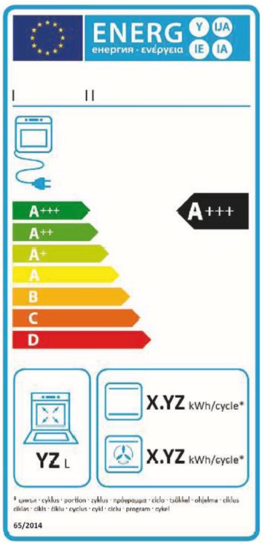



**Figure 245. Current energy label**

The **energy consumption** of the oven is an essential parameter for the energy label and should be visible in some manner. The current version of the label provides the energy consumption as energy per cycle. In the case of ovens, energy per cycle appears to be more relevant than other metrics such as annual energy consumption, as it is easier to define what a cycle is. According to the user behaviour study, energy consumption for a given standard programme ranks 3rd in terms of importance, whereas assumed energy consumption per year ranks 5th.

Some studies have analysed whether providing information in monetary terms (instead of in physical terms, such as electricity consumption) has an effect (Stadelman, 2018). Contrary to their initial expectations, the authors indicate that a label with monetary and lifetime-oriented information does not lead to a larger reduction in mean expected electricity consumption than the current version of the EU energy label.

The current version of the label includes information on the **energy consumption of different heating modes**: conventional and fan-forced. It has been suggested by some stakeholders to declare the energy consumption of more heating modes in the oven. These additional heating modes could be declared either in the energy label –adding their respective symbols– or in a simpler way in the user manual. To add any of those heating modes to the energy label or to the user manual, standard methods to measure their energy consumption would need to be available.

The current version of the label includes information on the **cavity volume**, in litres. As discussed in this section, cavity volume is still a relevant factor that defines and differentiates ovens. However, cavity volume ranks relatively low in terms of importance for the energy label, according to results from the user behaviour study: it is 9th parameter in terms of importance for consumers asked.

Some **material efficiency** aspects have been highlighted as important by consumers. For instance, expected lifetime ranks 4th in importance. The presence on the energy label of other aspects such as reparability (11th) and recyclability (13th) appear less relevant for consumers. However, material efficiency aspects are currently not considered for the label.

**Smart and automatic functionality** of ovens has not been highlighted as important by consumers, as it ranks 12th among all the parameters available. However, it has been mentioned in this report that this functionality can provide up to 15% energy savings compared to conventional/fan-forced modes. These energy savings are not apparent to the consumer, since methods to measure energy consumption are not able to show them. The current version of the label does not show consumers the energy-saving benefits of ovens with these smart features. A potential modification of future energy labels might include information on this aspect. Currently, it is difficult to determine the specific energy savings of cooking with these automatic features. Therefore, it does not seem feasible to include any figure in terms of percentage informing about the potential savings. An alternative could be to introduce a symbol on the label that indicates the availability of an automatic functionality.

Other functions of the oven are in a similar situation to the automatic functionality. This is the case of **microwave combined heating modes**. As has been described in various sections of this report, this function might offer an average of 10% energy savings compared to conventional/fan-forced modes. These energy savings are not apparent to the consumer, since there are no standard methods to measure the energy consumption of these modes. The current version of the label does not show consumers the energy-saving benefits of ovens with microwave combined modes. A potential modification of future energy labels might include information on this aspect. Currently, it is difficult to determine the specific energy savings of cooking with these combi MW features. Therefore, it does not seem feasible to include any figure in terms of percentage informing about the potential savings. An alternative could be to introduce a symbol on the label that indicates the availability of microwave combined modes.

Other parameters with different levels of importance mentioned by consumers that could be evaluated for inclusion in the next version of the energy label are: **maximum temperature** at which the oven can operate (7$^{th}$), time needed for **preheating** (8$^{th}$) and product **dimensions** (9$^{th}$).

In terms of label layout, Russo et al. (2018) highlighted some of the potential limitations of current labels. For instance, the authors indicate that the style and format sometimes do not allow easy comparison with other similar product models in the market, limiting the label's effectiveness. Grankvist et al. (2004) also found differences in consumers' responses, depending on their views about environmental issues and on the fact that the label is "positive" or "negative". According to their results, people with less environmental concerns were more sensitive to "negative" labels, for instance warnings informing that a product is disadvantageous from an environmental point of view with respect to another one.

In terms of content to be present on the label, recommendations for the new regulation are:

- keep the symbol to differentiate the energy source if the label stays separated for electric and gas ovens;
- keep information on the cavity volume, in litres;
- declare the energy consumption of two heating modes: standard and best performing mode (standard mode could be either conventional or fan-forced mode);
- best performing mode may be an energy-saving mode (according to definitions provided in BM2.0);
- the way to discriminate between standard and energy-saving mode is also based on BM2.0;
- ff an oven does not have a heating function which could be classified as energy-saving, only one mode (standard mode) is declared on the label.

Another aspect to consider is the **rescaling of the energy classes**. According to the Energy Label Regulation, "rescaling" means an exercise making the requirements for achieving the energy class on a label for a particular product group more stringent. As already indicated at the beginning of this section, REG 2017/1369 states the following:

> *The Commission shall review the label with a view to energy classes rescaling if it estimates that:*
>
> *(a) 30 % of the units of models belonging to a product group sold within the Union market fall into the top energy efficiency class A and further technological development can be expected; or*
>
> *(b) 50 % of the units of models belonging to a product group sold within the Union market fall into the top two energy efficiency classes A and B and further technological development can be expected.*

Market data available at this point shows that these conditions are met, so, in principle, a rescaling of the energy classes would be necessary. Also on the matter of rescaling, REG 2017/1369 states the following:

*For several labels established by delegated acts adopted pursuant to Directive 2010/30/EU, products are available only or mostly in the top classes. This reduces the effectiveness of the labels. The classes on existing labels, depending on the product group have varying scales, where the top class can be anything between classes A to A+++. As a result, when customers compare labels across different product groups, they could be led to believe that better energy classes exist for a particular label than those that are displayed. To avoid such potential confusion, it is appropriate to carry out, as a first step, an initial rescaling of existing labels, in order to ensure a homogeneous A to G scale.*

*A newly rescaled label should leave the top class empty to encourage technological progress, provide for regulatory stability, limit the frequency of rescaling and enable ever more efficient products to be developed and recognised. In exceptional cases, where technology is expected to develop more rapidly, no products should fall within the top two classes at the moment of introduction of the newly rescaled label.*

With the aim of showing the potential consequences of rescaling, in the next sections different options will be presented.

#### 7.2.7.1 Rescaling energy classes

As already mentioned above, a newly rescaled label should leave the top class empty to encourage technological progress, provide for regulatory stability, limit the frequency of rescaling and enable ever more efficient products to be developed and recognised.

One way of rescaling could be with the adoption of *policy option 8c 80/20* and renaming the energy classes from A to G (Table 110).

**Table 110. Rescaling of energy classes**

| Energy efficiency class | Energy Efficiency Index |
|---|---|
| A | EEI < 45 |
| B | 45 ≤ EEI < 62 |
| C | 62 ≤ EEI < 82 |
| D | 82 ≤ EEI < 107 |
| E | 107 ≤ EEI < 132 |
| F | 132 ≤ EEI < 159 |
| G | EEI < 159 |

With *policy option 8c 80/20 linear* (Figure 246) and a renaming of the energy classes, 93% of ovens in APPLIA2020 would be D and 7% would be E.

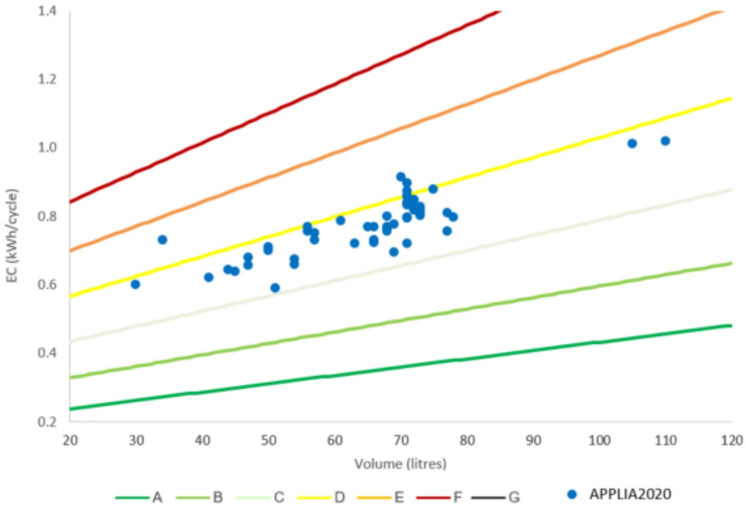



**Figure 246. Policy option 8c 80/20 linear energy classes**

With *policy option 8c 80/20 flat approach* (Figure 247) and a renaming of the energy classes, 6% of ovens in APPLIA2020 would be C, 70% would be D and 24% would be E.

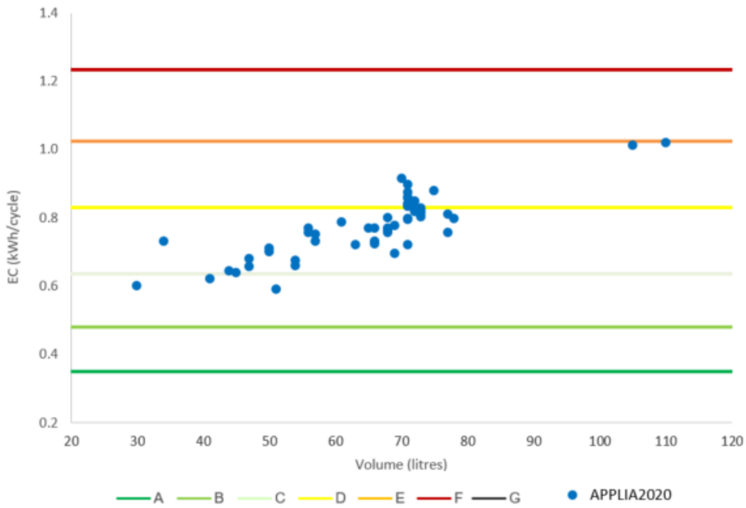



**Figure 247. Policy option 8c 80/20 flat energy classes**

The mere adoption of *policy options 8c 80/20 (linear or flat)* would be a drastic change for electric ovens in terms of energy class.

**Table 111. Step difference with policy option 8c 80/20 linear**

| | Step difference (kWh) | | | Step difference (%) | | |
|---|---|---|---|---|---|---|
| | 35 l | 70 l | 100 l | 35 l | 70 l | 100 l |
| A – B | 0.10 | 0.14 | 0.16 | 27% | 27% | 27% |
| B – C | 0.12 | 0.16 | 0.19 | 24% | 24% | 24% |
| C – D | 0.15 | 0.20 | 0.24 | 23% | 23% | 23% |
| D – E | 0.15 | 0.20 | 0.24 | 19% | 19% | 19% |
| E – F | 0.17 | 0.22 | 0.26 | 17% | 17% | 17% |

**Table 112. Step difference with policy option 8c 80/20 flat**

| | Step difference (kWh) | | | Step difference (%) | | |
|---|---|---|---|---|---|---|
| | **35 l** | **70 l** | **100 l** | **35 l** | **70 l** | **100 l** |
| **A – B** | 0.13 | 0.13 | 0.13 | 27% | 27% | 27% |
| **B – C** | 0.16 | 0.16 | 0.16 | 24% | 24% | 24% |
| **C – D** | 0.19 | 0.19 | 0.19 | 23% | 23% | 23% |
| **D – E** | 0.19 | 0.19 | 0.19 | 19% | 19% | 19% |
| **E – F** | 0.21 | 0.21 | 0.21 | 17% | 17% | 17% |

A simple rescaling of the energy classes has certain disadvantages. First, most of the ovens are spread among few energy classes. Also, the gap between the top energy classes is still considerably wide, reducing the incentive for manufacturers to invest in technologies that allow them to close that gap. In the next sections, alternative energy classifications are presented to tackle those disadvantages**.**

#### 7.2.7.2 Rescaling energy classes to promote differentiation

One of the key aspects of an energy label is product differentiation in terms of energy classes. The analysis of APPLIA2020 in previous sections has shown that most of the ovens in the market are located in few energy classes. In this section, an alternative energy classification is presented, in order to promote a higher differentiation between appliances. In this classification, the threshold of the top energy class has been established at EEI = 66 in order to make it more achievable than with current thresholds. Then, an equal 13% differential has been established between each energy class. The resulting classification can be seen in Table 113.

**Table 113. Rescaling energy classes to promote differentiation**

| Energy efficiency class | Current Energy Efficiency Index | Energy Efficiency Index (proposal) |
|---|---|---|
| A | EEI < 45 | EEI < 66 |
| B | 45 ≤ EEI < 62 | 66 ≤ EEI < 77 |
| C | 62 ≤ EEI < 82 | 77 ≤ EEI < 88 |
| D | 82 ≤ EEI < 107 | 88 ≤ EEI < 101 |
| E | 107 ≤ EEI < 132 | 101 ≤ EEI < 116 |
| F | 132 ≤ EEI < 159 | 116 ≤ EEI < 134 |
| G | EEI > 159 | EEI > 134 |

With this alternative classification, ovens in APPLIA2020 would be in the energy classes shown in Figure 248. A total of 4% of ovens would be C, 54% D, 41% E and 2% F.

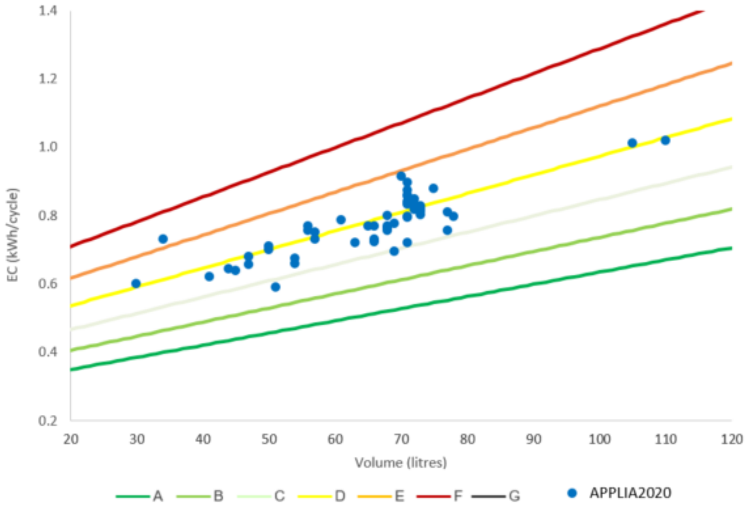



**Figure 248. Rescaling energy classes to promote differentiation (linear)**

However, there is a drawback with this approach. Since ovens in APPLIA2020 are clustered in a small area of the EC-Volume graph, if the energy class thresholds are narrowed to promote product differentiation, the steps between the energy classes are smaller (Table 114).

**Table 114. Step difference between energy classes to promote differentiation (linear)**

| | Step difference (kWh) | | | Step difference (%) | | |
|---|---|---|---|---|---|---|
| | **35 l** | **70 l** | **100 l** | **35 l** | **70 l** | **100 l** |
| **A – B** | 0.06 | 0.08 | 0.10 | 14% | 14% | 14% |
| **B – C** | 0.07 | 0.09 | 0.11 | 13% | 13% | 13% |
| **C – D** | 0.08 | 0.11 | 0.13 | 13% | 13% | 13% |
| **D – E** | 0.09 | 0.12 | 0.15 | 13% | 13% | 13% |
| **E – F** | 0.11 | 0.14 | 0.17 | 13% | 13% | 13% |

In Figure 249, the same classification is tested with the flat approach. In this case, 2% of the ovens would be B, 15% C, 35% D, 43% E and 6% F.

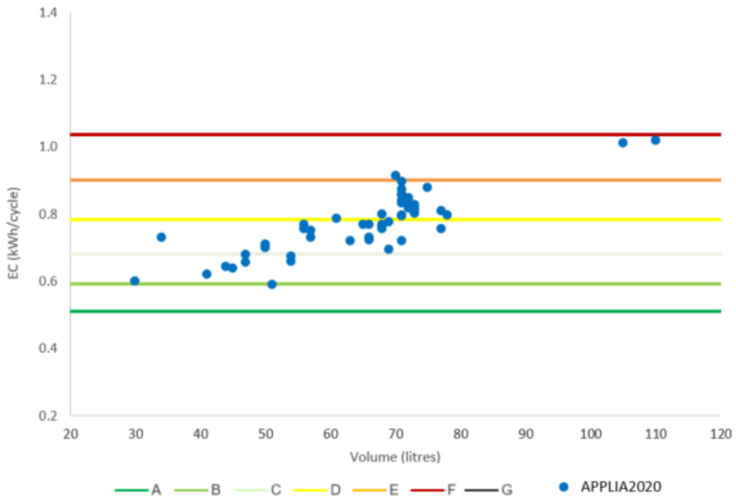



**Figure 249. Rescaling energy classes to promote differentiation (flat)**

With the flat approach, the steps between energy classes (Table 115) are wider than with the linear approach.

**Table 115. Step difference between energy classes to promote differentiation (flat)**

| | Step difference (kWh) | | | Step difference (%) | | |
|---|---|---|---|---|---|---|
| | **35 l** | **70 l** | **100 l** | **35 l** | **70 l** | **100 l** |
| **A – B** | 0.08 | 0.08 | 0.08 | 14% | 14% | 14% |
| **B – C** | 0.09 | 0.09 | 0.09 | 13% | 13% | 13% |
| **C – D** | 0.10 | 0.10 | 0.10 | 13% | 13% | 13% |
| **D – E** | 0.12 | 0.12 | 0.12 | 13% | 13% | 13% |
| **E - F** | 0.14 | 0.14 | 0.14 | 13% | 13% | 13% |

#### 7.2.7.3 Rescaling energy classes to promote innovation in the top energy classes

A potential way to promote innovation in the top energy classes could be to have energy classes where the steps are shorter in the top ones and larger in the bottom ones. This way, it would reward manufacturers investing in the most innovative and potentially most expensive technologies. An example of this approach is shown in this section. In this classification, the threshold of the top energy class has been established at EEI = 66 in order to make it more achievable than with current thresholds. Then, a gap of 13% has been established between the top three energy classes and a 17% gap between the rest. The thresholds of this classification can be seen in Table 116.

**Table 116. Rescaling energy classes to promote innovation in the top energy classes**

| **Energy efficiency class** | **Current Energy Efficiency Index** | **Energy Efficiency Index (proposal)** |
|---|---|---|
| A | EEI < 45 | EEI < 66 |
| B | 45 ≤ EEI < 62 | 66 ≤ EEI < 76 |
| C | 62 ≤ EEI < 82 | 76 ≤ EEI < 87 |
| D | 82 ≤ EEI < 107 | 87 ≤ EEI < 100 |
| E | 107 ≤ EEI < 132 | 100 ≤ EEI < 120 |
| F | 132 ≤ EEI < 159 | 120 ≤ EEI < 145 |
| G | EEI > 159 | EEI > 145 |

With this alternative classification and a linear approach, the ovens in APPLIA2020 would be in the energy classes shown in Figure 250. As can be seen, the top energy classes would still remain empty with this approach. A total of 2% of ovens would be C, 48% of the ovens would be D, 48% would be E and 2% F.

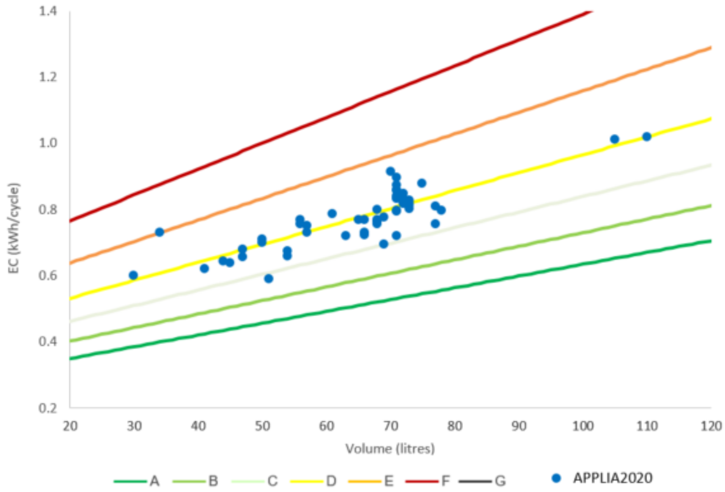



**Figure 250. Rescaling energy classes to promote innovation in the top energy classes (linear)**

With this approach, an oven in the E energy class is very close to the D energy class and relatively close as well to the top A, B and C energy classes. This could work as an incentive to invest in those technologies that allow the reduction of this gap, which are generally more costly that the technologies needed to progress between E and D classes, for instance.

One of the potential disadvantages of this approach is that it requires very short steps between the top energy classes (Table 117).

**Table 117. Step difference between energy classes to promote innovation in the top energy classes (linear)**

| | Step difference (kWh) | | | Step difference (%) | | |
|---|---|---|---|---|---|---|
| | **35 l** | **70 l** | **100 l** | **35 l** | **70 l** | **100 l** |
| **A – B** | 0.06 | 0.08 | 0.10 | 13% | 13% | 13% |
| **B – C** | 0.07 | 0.09 | 0.11 | 13% | 13% | 13% |
| **C – D** | 0.08 | 0.10 | 0.13 | 13% | 13% | 13% |
| **D – E** | 0.12 | 0.16 | 0.19 | 17% | 17% | 17% |
| **E - F** | 0.15 | 0.19 | 0.23 | 17% | 17% | 17% |

In Figure 251, the same classification is tested with the flat approach. In this case, 15% of the ovens would be C, 37% D, 44% E and 4% F.

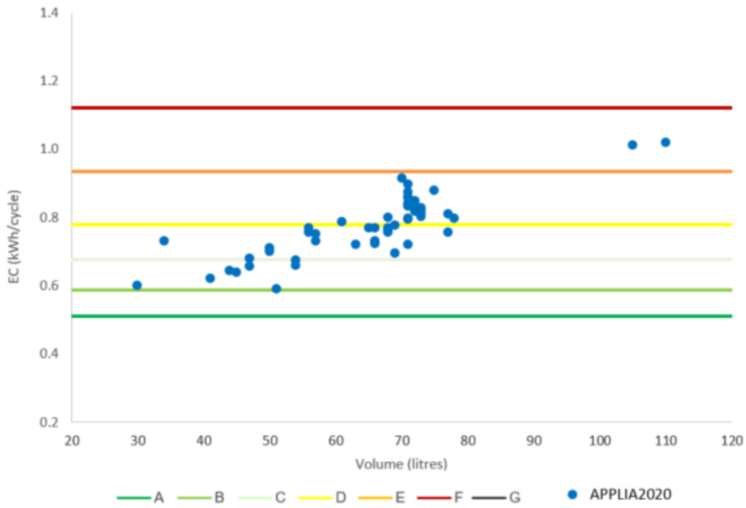



**Figure 251. Rescaling energy classes to promote innovation in the top energy classes (flat)**

With the flat approach, the energy class steps are slightly wider (Table 118).

**Table 118. Step difference between energy classes to promote innovation in the top energy classes (linear)**

| | Step difference (kWh) | | | Step difference (%) | | |
|---|---|---|---|---|---|---|
| | **35 l** | **70 l** | **100 l** | **35 l** | **70 l** | **100 l** |
| **A – B** | 0.08 | 0.08 | 0.08 | 13% | 13% | 13% |
| **B – C** | 0.09 | 0.09 | 0.09 | 13% | 13% | 13% |
| **C – D** | 0.10 | 0.10 | 0.10 | 13% | 13% | 13% |
| **D – E** | 0.16 | 0.16 | 0.16 | 17% | 17% | 17% |
| **E - F** | 0.19 | 0.19 | 0.19 | 17% | 17% | 17% |

#### 7.2.7.4 Summary of energy classifications proposed for electric ovens

In this section, a comparison of the three alternative energy classifications shown in previous sections is presented (Figure 252).

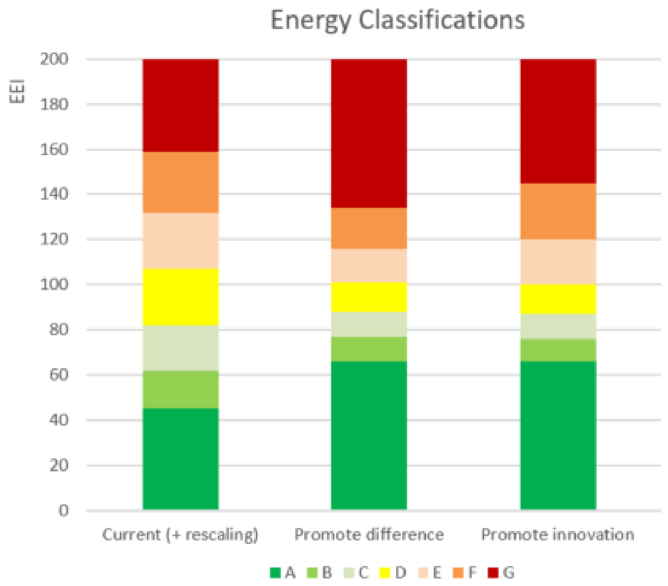



**Figure 252. Comparison of energy classifications**

With the current thresholds and rescaling, the top energy class A is stricter than the other two alternatives. Then, thresholds for the lower energy classes are less strict with this option (see F energy class, for instance).

With the second alternative (promote difference), it becomes easier to get an A energy class, but the limits for the lower energy classes are stricter. Something similar happens with the third alternative (promote innovation). In this case, the gap between the top energy classes is narrower to promote investment in technologies with significant potential for improvement.

For subsequent sections, the energy classification to promote differentiation will be taken, since it is slightly stricter for the low energy classes.

In terms of the comparison between the linear approach and flat approach, the flat approach seems to provide clear benefits (additional to the benefit of promoting ovens with smaller cavities): it allows for more product differentiation and it results in wider energy class steps.

#### 7.2.8 Ecodesign minimum energy performance requirements

In this section, different options in terms of ecodesign minimum requirements will be evaluated. Based on the content presented in previous sections, it will be assumed that:

- BM2.0 is the preferred measurement method for electric ovens;
- as the heating mode to declare the energy consumption, *Policy option 8c 80/20* will be considered;
- SEC linear regression and the flat approach will be compared.

The current Ecodesign Regulation establishes minimum requirements in terms of EEI for domestic ovens as seen in Table 119.

**Table 119. Ecodesign minimum requirements in the current Regulation**

| | **EEI minimum requirements** |
|---|---|
| February 2015 | EEI <146 |
| February 2016 | EEI <121 |
| February 2019 | EEI <96 |

In Annex II to Directive 2009/2015 on ecodesign requirements for energy-related products, it is stated that:

> *"Concrete measures must be taken with a view to minimising the product's environmental impact. Concerning energy consumption in use, the level of energy efficiency must be set aiming at the life cycle cost minimum to end-users"*

Results presented in Task 6 of this report indicate that the Least Life Cycle Cost (LLCC) design option is DO1. According to the Ecodesign Regulation, the level of energy efficiency should be set to promote these types of products. In order to achieve that, lower thresholds of ecodesign compliance could be used as tiers for different years in the future.

With *policy option 8c 80/20* (linear approach) and an ecodesign limit at the Least Life Cycle Cost (EEI = 101), 63% of ovens in the database would comply with the minimum ecodesign requirements (Figure 253).

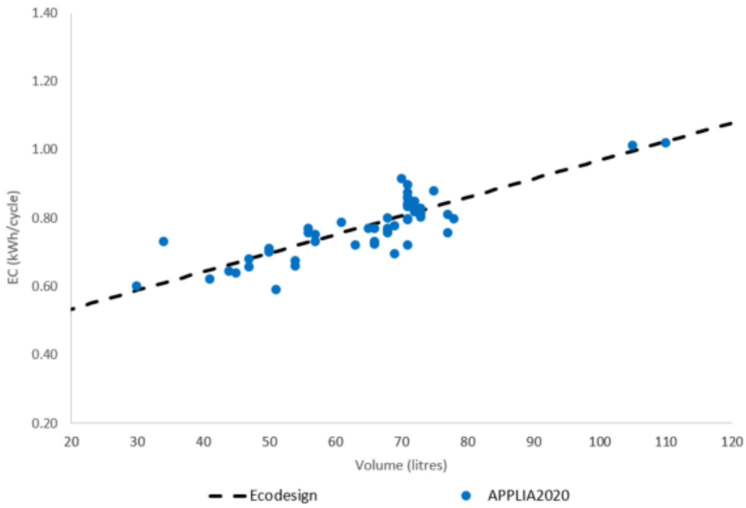



**Figure 253. Policy option 8c 80/20 linear – Ecodesign threshold at LLCC EEI = 101**

With *policy option 8c 80/20* (flat approach) and an ecodesign limit at the Least Life Cycle Cost (EEI = 101), 52% of ovens in the database would comply with the minimum ecodesign requirements

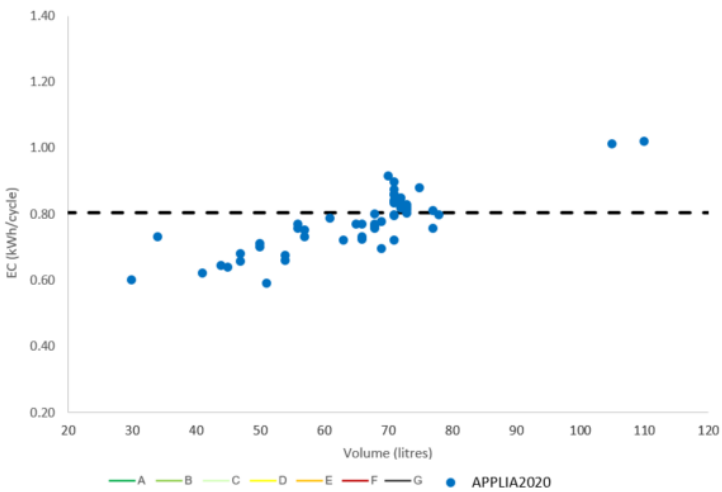



**Figure 254. Policy option 8c 80/20 flat – Ecodesign threshold at LLCC EEI = 101**

An alternative to setting ecodesign thresholds is to link those threshold with the energy classification. For instance, for the first tier, remove the two worst energy classes from the market. If this approach is taken, the limit would be EEI = 116. With the linear approach (Figure 255), 98% of ovens in APPLIA2020 would comply.

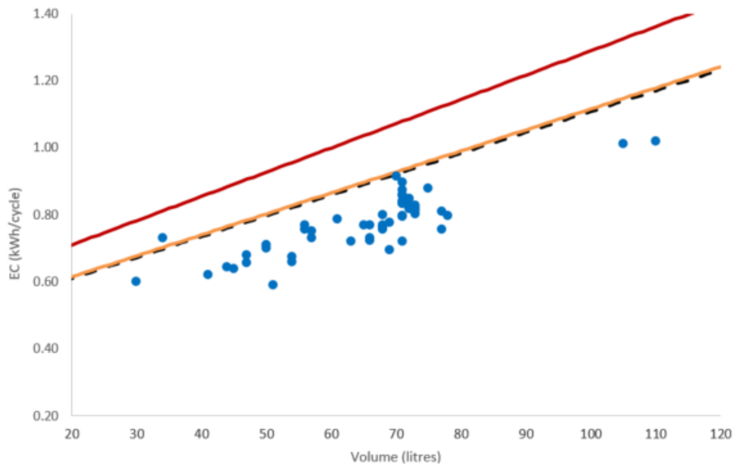



**Figure 255. Policy option 8c 80/20 linear – Ecodesign threshold at LLCC EEI = 116**

With the flat approach (Figure 256), 93% of ovens in APPLIA2020 would comply.

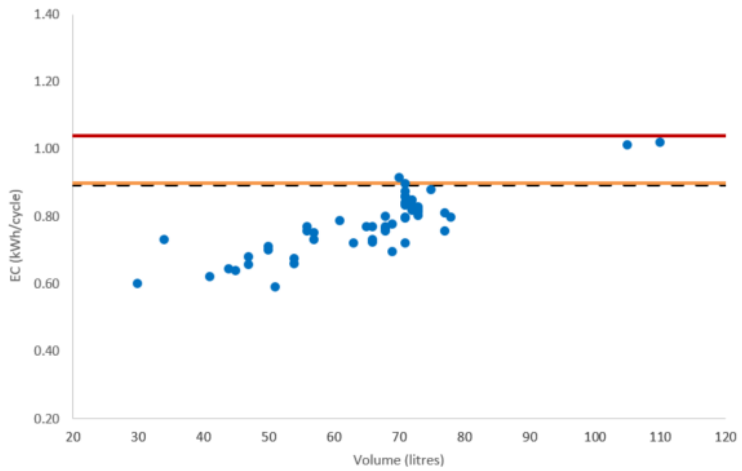



**Figure 256. Policy option 8c 80/20 flat – Ecodesign threshold at LLCC EEI = 116**

Therefore, based on the analysis conducted in this section, different tiers could be used for the introduction of these minimum requirements (Table 120), in combination with the linear or flat options for the SEC. The EEI is still calculated as the ratio between the energy consumption per cycle (EC) and SEC. In this case, the EC will be taken as the weighted sum between standard and BPM at 80/20.

**Table 120. Ecodesign minimum energy performance requirements for electric ovens**

| Ecodesign threshold option | Reasoning for EEI threshold | SEC | Tier 1: 2025 | Tier 2: 2027 | Tier 3: 2030 |
|---|---|---|---|---|---|
| 1 | Remove F/G | SEC = 0.0042V+0.55 | EEI = 116 | EEI = 110 | EEI = 105 |
| 2 | Remove F/G | SEC = 0.775 | EEI = 116 | EEI = 110 | EEI = 105 |
| 3 | LLCC | SEC = 0.0042V+0.55 | EEI = 101 | EEI = 96 | EEI = 91 |
| 4 | LLCC | Flat = 0.775 | EEI = 101 | EEI = 96 | EEI = 91 |

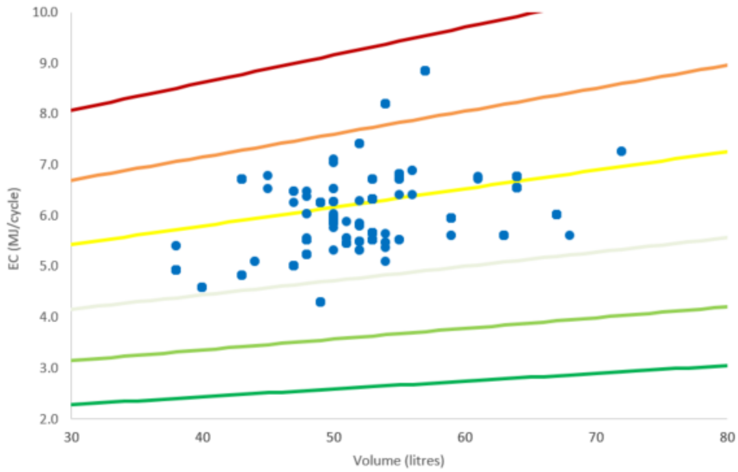
## 7.3 Policy options for gas ovens

Based on the policy options recommended for electric ovens, some specific policy options for gas ovens are presented in this section.

The current SEC for gas ovens in the Regulation is:

SEC = 0.044*V + 3.53 (in MJ).

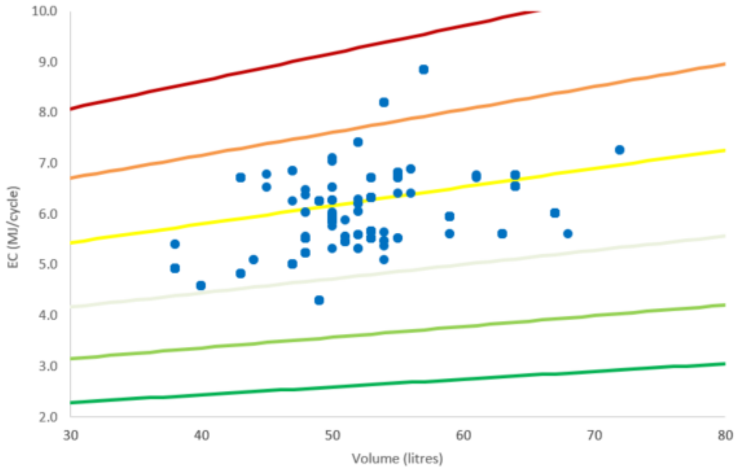
In Section 7.2.6.1, an analysis was conducted regarding the update of the SEC for electric ovens. Ideally, when data is available, a similar analysis should be carried out for gas ovens, to evaluate if the market of these appliances has evolved towards more efficient products. Considering data from CECED2012, measuring the energy consumption with BM1.0, taking into account the best performing mode, ovens in CECED2012 would get the energy classes as in Figure 257: 1% of ovens would be A+, 82% would be A, 14% would be B and 3% would be C.




SEC = 0.034*V + 4.05 (in MJ)

**Figure 257. Best Performing Mode**

In Section 7.2.6.3, an analysis was conducted regarding which heating mode should be used for the energy declaration and obtaining the energy class. When new data is available for gas ovens, a similar analysis should be carried out for gas ovens. For now, a preliminary analysis has been conducted with CECED2012. For instance, taking an equivalent option to *policy option 8c 80/20* for gas ovens, the consequences in terms of energy classes can be observed in Figure 155. The percentages between energy classes are equivalent to the previous policy option. This is because very few ovens in the database have an energy-saving mode different from conventional (almost every oven in the database has only one heating mode).




SEC = 0.034*V + 4.06

**Figure 258. Weighted sum 80/20 between Conventional and BPM**

In Figure 259, an equivalent energy class rescaling to that of electric ovens is applied to gas ovens (rescaling to promote differentiation).

**Table 121. Rescaling energy classes to promote differentiation**

| Energy efficiency class | Current Energy Efficiency Index | Energy Efficiency Index (proposal) |
|---|---|---|
| A | EEI < 45 | EEI < 66 |
| B | 45 ≤ EEI < 62 | 66 ≤ EEI < 77 |
| C | 62 ≤ EEI < 82 | 77 ≤ EEI < 88 |
| D | 82 ≤ EEI < 107 | 88 ≤ EEI < 101 |
| E | 107 ≤ EEI < 132 | 101 ≤ EEI < 116 |
| F | 132 ≤ EEI < 159 | 116 ≤ EEI < 134 |
| G | EEI > 159 | EEI > 134 |

With this approach, 1% would be B, 2% would be C, 64% would be D, 30% would be E and 3% would be F.

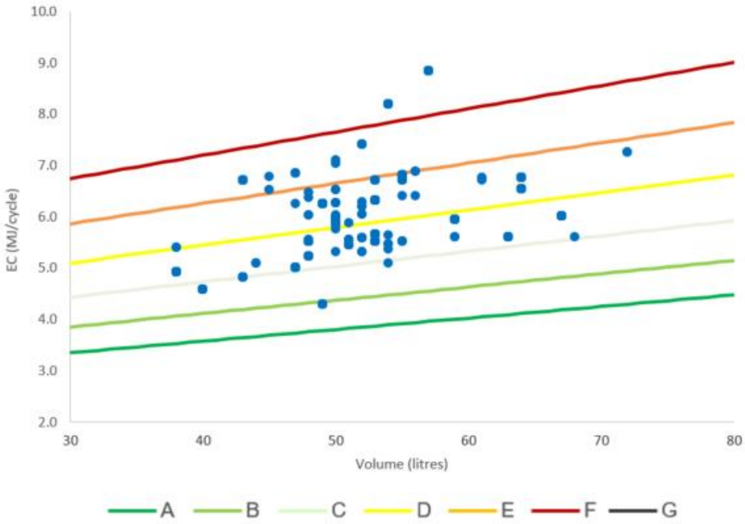



**Figure 259. Linear approach and rescaling to promote differentiation**

In Figure 260, the flat approach for SEC is evaluated for gas ovens (with a constant 13% gap between classes). With this approach, 1% would be B, 9% would be C, 43% would be D, 46% would be E and 2% would be F.

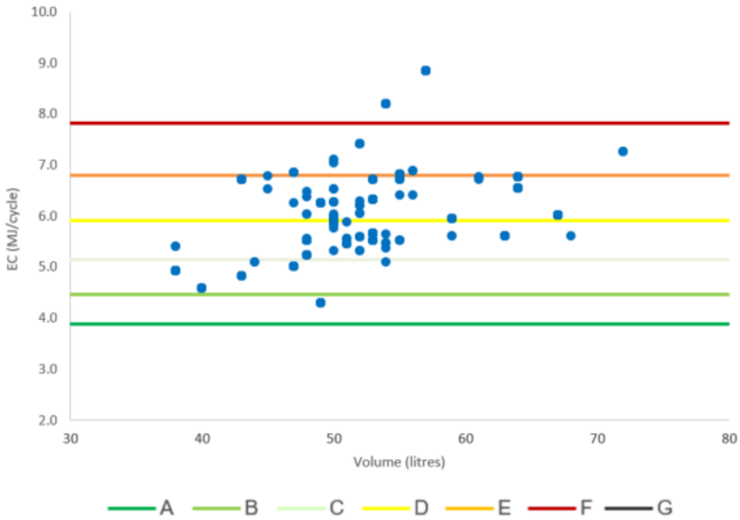



**Figure 260. Flat approach and rescaling to promote differentiation**

In Section 7.2.8, the ecodesign minimum energy performance requirements were presented for electric ovens, with two different approaches: taking into account the Least Life Cycle Cost of the design options presented in Task 6, and removal from the market the lowest energy classes.

The LLCC of gas ovens is BC2 (EEI = 91). According to this, the ecodesign minimum requirements for gas ovens in the new Regulation should be set at EEI = 91. Any ovens with an EEI higher than this value should be progressively removed from the market. (Figure 261). With this measure in place, only 7% of the ovens in CECED2012 would comply with them.

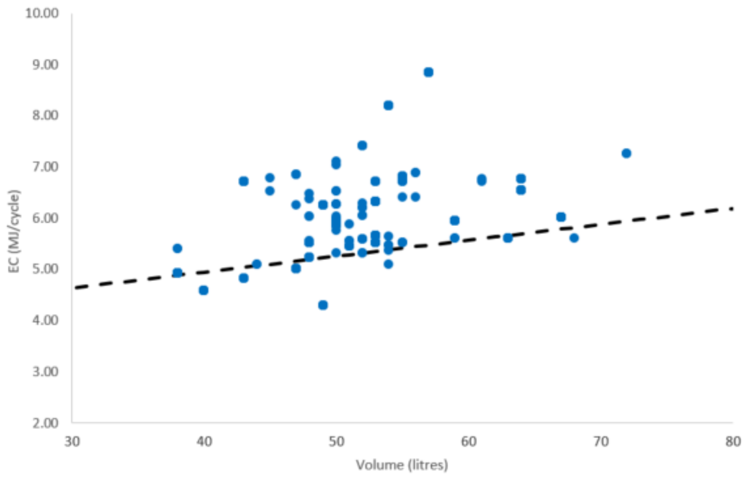



**Figure 261. Linear approach and ecodesign thresholds at EEI = 91**

If the same reasoning is taken to determine the ecodesign threshold, in this case with the flat approach (EEI = 96), then 40% of ovens would comply with the requirements (Figure 262).

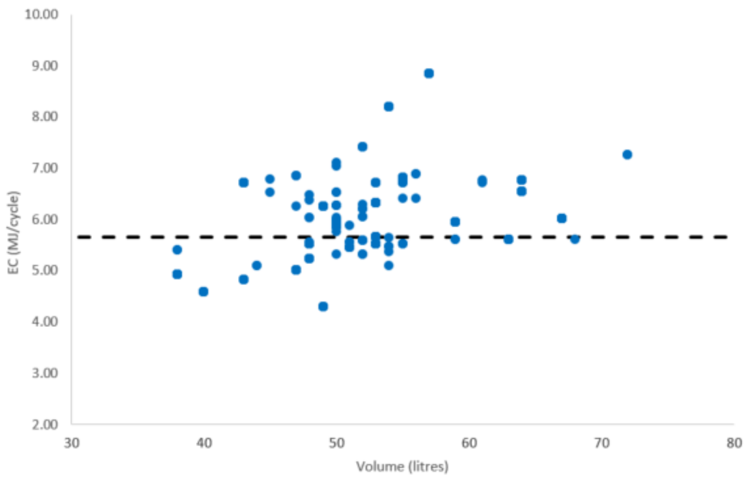



**Figure 262. Flat approach and ecodesign thresholds at EEI = 96**

The second option to set ecodesign thresholds is to link it to specific energy classes (the lowest). In Figure 263, linking it to the F energy class, with a linear approach, 97% of ovens would comply.

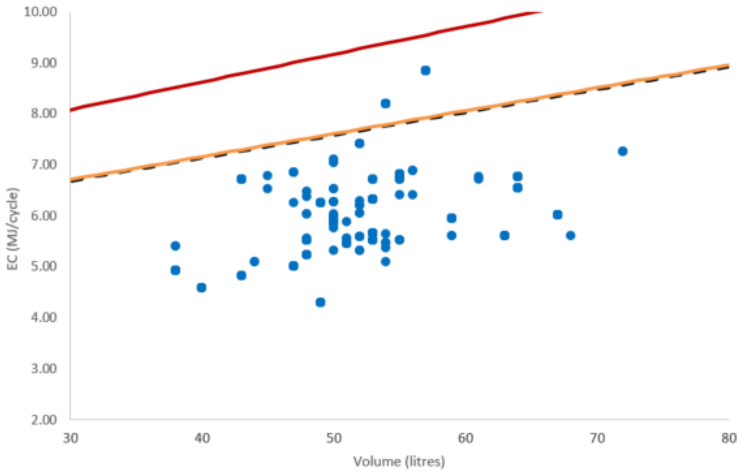



**Figure 263. Linear approach and ecodesign thresholds at EEI = 116**

As already indicated in this section, there is no available data on current gas ovens, so all analyses have been conducted using CECED2012. Therefore, it should be taken into account that the average energy consumption of gas ovens might have improved between 2012 and 2020. Ideally, the analyses conducted in this section should have been done with more up-to-date data.

As in the case of electric ovens, several different approaches are available for gas ovens. For simplification, it is recommended that the approaches taken for electric and gas ovens are equivalent (when possible).

Regarding the measurement method, it has already been discussed in this report that the most appropriate method for gas ovens is EN 15181 (not BM2.0).

If a weighted sum 80/20 approach is taken to declare the energy consumption of electric ovens, the same should be done with gas ovens. However, it needs to be taken into account that the vast majority of gas ovens do not use residual heat. Most gas appliances in the market have a bulb thermostat inside, which controls the temperature but there are no differentiations between heating functions. The only possibility is to set the temperature inside. The only function of the thermostat is to manage the gas flow rate in the cavity according to the temperature set. Therefore, the BPM for gas ovens does not really exist. All temperature settings are managed with the same functionality. Other configurations can have a specific fan in the cavity to generate conventional heating. Therefore their energy declaration would be based on only one heating mode (conventional).

In terms of rescaling energy classes, if the approach taken in electric ovens is "rescaling to promote differentiation", the same should be done for gas ovens. Equally, if a flat approach is followed for the definition of SEC in electric ovens, it should be done in the same way for gas ovens.

In relation to gas ovens, during the 2nd TWG stakeholder meeting (May 2021), some stakeholders indicated that, based on the current EU $CO_2$ emissions reduction plans, in the future no gas should be used for activities such as cooking. For the new Regulation, they supported ecodesign limits that would leave only the best gas ovens in the market. On this topic, manufacturers argue that a distinction needs to be made between "fossil gases" and "renewable gases" (such as biomethane or hydrogen). In their view, renewable gases like biomethane or hydrogen are basically carbon-neutral, so, when discussing the topic of gases, it is advisable to make the same differentiation as with electricity: renewable origin versus non-renewable origin.

Therefore, based on the analysis conducted in this section, different tiers could be used for the introduction of these minimum requirements for gas ovens (Table 120), in combination with the linear or flat options for the SEC.

**Table 122. Ecodesign minimum energy performance requirements for gas ovens**

| Ecodesign threshold option | Reasoning for EEI threshold | SEC | Tier 1: 2025 | Tier 2: 2027 | Tier 3: 2030 |
|---|---|---|---|---|---|
| 1 | Remove F/G | SEC = 0.034V+4.05 | EEI = 116 | EEI = 110 | EEI = 105 |
| 2 | Remove F/G | SEC = 5.89 | EEI = 116 | EEI = 110 | EEI = 105 |
| 3 | LLCC | SEC = 0.034V+4.05 | EEI = 91 | EEI = 86 | EEI = 82 |
| 4 | LLCC | SEC = 5.89 | EEI = 91 | EEI = 86 | EEI = 82 |

## 7.4 Policy options for hobs

### 7.4.1 Policy options related to the scope

As explained in Task 1, small (auxiliary) burners with a nominal heat input under 1.16 kW are not covered by the current standard, since the test procedure is not optimal for them (they are not normally used for boiling large amounts of water).

The inclusion of small burners within the scope of Ecodesign measures was discussed during the review process, since the minimum power threshold will be reduced in the next revision of EN 30-2-1, probably to 800 W. Most of the gas hobs in the market with more than two burners have one small burner. Even though they have low power, and therefore not low consumption, they are very common so overall their contribution is not negligible. A specific simmering test method is being studied in order to measure their efficiency.

In terms of the type of gases covered by the Ecodesign Regulation of cooking appliances, it is worth recalling at this point that the current Regulation leaves out of the scope those appliances designed for use only with gases of the 3rd family (butane and propane). However, this exception does not make sense nowadays, so it is recommended to include appliances which work with gases of the 3rd family in the scope.

### 7.4.2 Feasibility of energy labelling for hobs

An energy label classification is meaningful if there is enough differentiation between the products in the market in terms of energy efficiency. Manufacturers shared the range of energy consumption values that the three types of electric hobs (solid plate, radiant heater and induction) typically achieve (Figure 155). The red line shows the ecodesign limit for energy consumption after 2019 (195 Wh/kg).

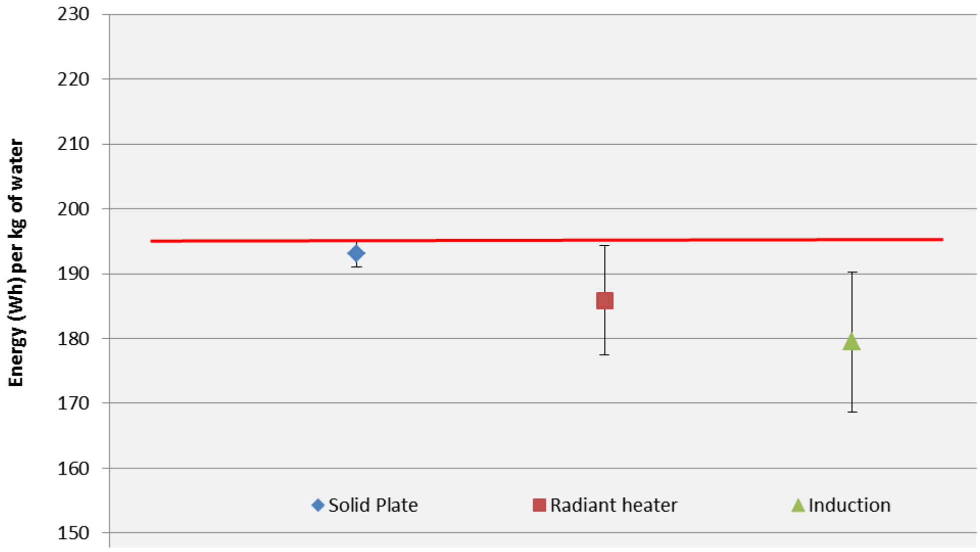



**Figure 264. Energy consumption ranges of electric hobs. Source:APPLIA**

As can be seen in Figure 155, there is a small difference between the energy consumption of the three technologies under comparison. It is important to note that this differentiation is also due to the number of heating zones, i.e. the graph shows the range of efficiencies of hobs with different numbers of heating zone. If the figure represented the efficiencies of hobs with the same number of heating zones, this range would be smaller. So, despite the fact that an energy label classification is important for consumers to be able to choose the most efficient product, in the case of hobs it does not make sense to establish one because of the small difference between the technologies.

### 7.4.3 Ecodesign minimum requirements

In this section, different options in terms of ecodesign minimum requirements will be evaluated.

The current Ecodesign Regulation establishes minimum requirements in terms of energy consumption for domestic hobs as seen in Table 123.

**Table 123: Minimum energy consumption requirements for hobs in the current Ecodesign Regulation**

| | **Electric hob (Energy consumption in Wh/kg)** | **Gas-fired hob (energy efficiency in %)** |
|---|---|---|
| February 2015 | < 210 | > 53 |
| February 2017 | < 200 | > 54 |
| February 2019 | < 195 | > 55 |

The current Regulation included the following indicative benchmarks.

**Table 124: Indicative benchmarks for hobs in the current Ecodesign Regulation**

| **Technology** | **Benchmark** |
|---|---|
| Electric | 169.3 Wh/kg |
| Gas | 63.5% |

It is important to highlight that these indicative benchmarks do not distinguish among the different numbers of heating zones, which has an influence on the efficiency of the hob.

The policy options proposed for the update of the minimum requirements are shown in Table 125.

**Table 125: Policy options proposed for electric and gas hobs**

<table>
<tr><td colspan="4">Option 1: Common minimum requirements for electric hobs</td></tr>
<tr><td></td><td colspan="2">Electric hob<br>(Energy consumption in Wh/kg)</td><td>Gas-fired hob<br>(Energy efficiency in %)</td></tr>
<tr><td>February 2023</td><td colspan="2">< 195</td><td>> 56</td></tr>
<tr><td>February 2025</td><td colspan="2">< 190</td><td>> 57</td></tr>
<tr><td>February 2027</td><td colspan="2">< 185(*)</td><td>> 58</td></tr>
<tr><td colspan="4">Option 2: Different minimum requirements for solid plates, radiant and induction hobs</td></tr>
<tr><td></td><td>Solid plates hob (Energy consumption in Wh/kg)</td><td>Radiant/induction hob (Energy consumption in Wh/kg)</td><td>Gas-fired hob (Energy efficiency in %)</td></tr>
<tr><td>February 2023</td><td>< 195</td><td>< 195</td><td>> 56</td></tr>
<tr><td>February 2025</td><td>< 195</td><td>< 190</td><td>> 57</td></tr>
<tr><td>February 2027</td><td>< 195</td><td>< 185(*)</td><td>> 58</td></tr>
</table>

(*) According to some manufacturers flex and free induction could be banned.

The market analysis shows that induction technology is steadily replacing radiant technology in EU households. The sales of induction hobs are double those of radiant hobs, and the stock projection shows that by 2030 the number of induction hobs will surpass radiant hobs. This technology replacement has been underpinned by the current Ecodesign Regulation, which sets a common requirement for electric hobs. This requirement is much easier to fulfil for induction hobs. At this point, stricter common requirements would mean banning solid plates and radiant hobs, since no further improvement is feasible. This would result in energy savings, though its impact on the consumer's choices would be severe. According to the user behaviour study, Purchase price and Convenience of use are features with a significant influence on the purchase decision, therefore induction technology may not correspond to the consumer's budget and/or cooking habits. However, setting different thresholds for radiant and induction hobs would deviate from the current technology-neutral approach, which would be deemed the appropriate approach for products delivering the same function and using the same type of energy.

The indicative benchmarks are proposed to remain unchanged. In the case of gas hobs, there is no evidence that the technology is able to go beyond the current benchmark without compromising the safety of the product. In the case of electric hobs, the improvement potential is linked to the induction technology, which is developing towards flexible cooking zone hobs. The flexible cooking area has an impact on the efficiency of the hob, increasing the energy consumption as measured by EN 60350-2. According to TopTen, there is no flexible hob within the group of most efficient induction hobs. However, the market penetration of this product is steadily increasing: it went from 500 000 units in 2015 to 800 000 in 2018.

Some stakeholders (NGOs) have proposed to set a technology-neutral approach for all types of hobs, i.e. common requirements for electric and gas hobs. This option is not recommended at the moment, since the test methods available for electric and gas hobs are completely different and not comparable.

In this sense, it is strongly recommended that manufacturers work on a common test method for gas and electric hobs to be ready for the next revision. Besides, the energy consumption would need to be expressed as primary energy, to allow for a fair comparison among the different energy sources. That would require the consideration of the evolution of the electricity and gas mixes in the EU and its shares of renewable energy sources. This would constitute an external factor that would dilute the impact of the product design and technology in the energy-saving potential.

#### 7.4.4 Possible policy options for future revisions

As explained in the previous sections, the improvement potential of induction hobs is reaching a peak and the technology is expected to plateau in the coming years. However, there is room for improvement if induction technology is considered as a cooking system that encompasses cookware.

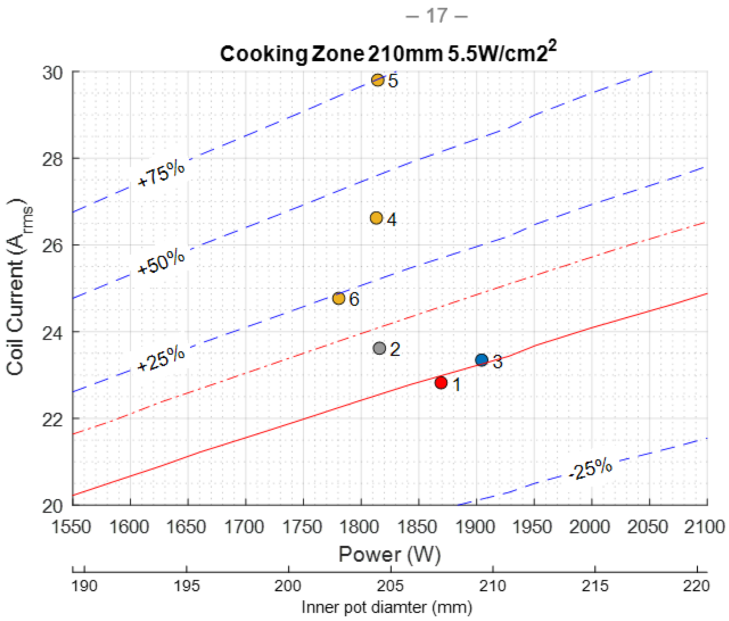
CLC TC 59X wg 5 "Induction Suitability" is currently working on a method to determine the electrical parameters for compatibility of cookware and induction hobs for household use.

According to an informative note provided by CLC TC 59X wg, this method will positively affect the induction supply chain:

- *Manufacturers of cookware and hobs can use the measurements to identify various properties of induction hobs and cookware.*
- *Standards application business, e.g. testing laboratories, can use the standard for product test clearly to identify the suitability of cookware for induction hobs and to assess the performance regarding the power output of induction hobs.*
- *Finally, the consumer benefit is on one hand a better-harmonized product range (cookware/hob) and on the other hand, a clear product information regarding suitability based on a standardized method.*

To illustrate the potential impact of cookware, CLC TC 59X wg provided the following extract of the draft standard:

*Figure 3 clearly shows that in comparison with the reference cookware No.1 different current levels are needed to supply the same power to the CUT (=cookware under test). E.g., cookware 5 causes up to 75 % more losses in the cooktop compared with No 1. The blue dashed lines are an indication of coil currents, which are equivalent to the additional* ***estimated*** *power losses in %, compared to losses of the reference cookware No 1. The specified test machine measures electric parameters and is not focusing on losses. The losses are calculated by a rough estimation and may vary among induction technologies.*



***Key***

*Sample 1 to 6 are pieces of cookware with following material:*

| | |
|---|---|
| *1* | *reference cookware* |
| *2* | *Stainless steel with ferromagnetic sidewall* |
| *3* | *Cast Iron* |
| *4* | *Aluminium with normal size ferromagnetic grid* |
| *5* | *Aluminium with small size ferromagnetic grid* |
| *6* | *Aluminium with ferromagnetic coating* |
| *Solid line* | $I_{coil}$ *(rms) vs Power for the reference cookware with a diameter of 210 mm* |
| *Dash-dot line* | $I_{coil}$ *(rms) vs Power for the reference cookware with a diameter of 180 mm* |
| *Dashed lines* | *Indication of coil current, which are equivalent to the additional estimated power losses in %, compared to the losses of the reference cookware* |

**Figure 4 - Test A - Coil current and estimated power losses comparison for a 210mm cooking zone (examples)**

The additional estimated power losses in % are calculated by formula (8):

$$\left[\left(\frac{I}{I_{ref}}\right)^2 - 1\right](\%) \qquad (8)$$

Where

*I* is the coil Irms for the CUT (see y axis);

$I_{ref}$ is the rms current measured with the reference cookware at the respective power.

A specific study on the energy-saving potential linked to the compatibility of cookware and induction hobs for household use would be beneficial, taking into account the timeline of the standard, which will be essential to propose any policy measure.

The health impact of electromagnetic technology will be considered in order to provide options for those who cannot use it.

## 7.5 Policy options for cooking fume extractors

### 7.5.1 Current situation

For the review of the ecodesign and energy labelling measures, APPLIAhas provided a dataset of 143 models of cooking fume extractors. Figure 265 shows the annual energy consumption (AEC) calculated with the current methodology versus the power measured at the best efficiency point. The figure distinguishes the three motor technologies.

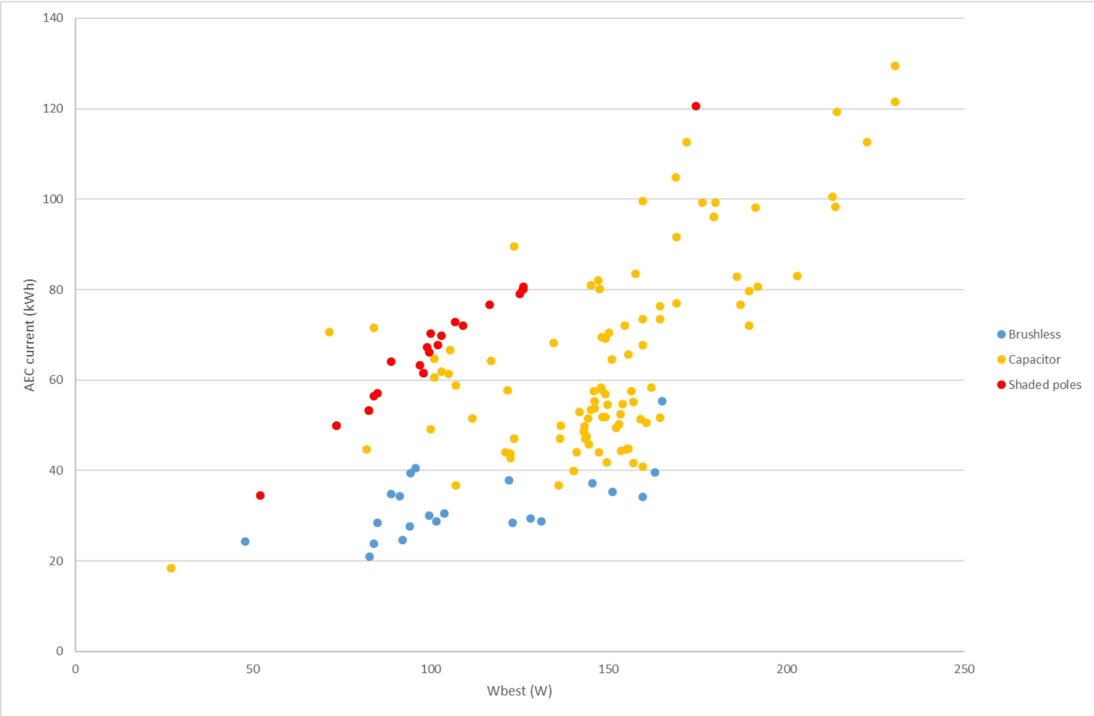



**Figure 265: AEC and Wbest calculated with existing methodology for the 143 models of the APPLIA dataset**

The most common technology is the capacitor motor, which achieves a large range of AEC and power consumption. The most efficient technology is brushless motors, and the least shaded poles motors.

Figure 266 shows the Energy Efficiency Index (EEI) calculated according to the current methodology versus the power at the best efficiency point.

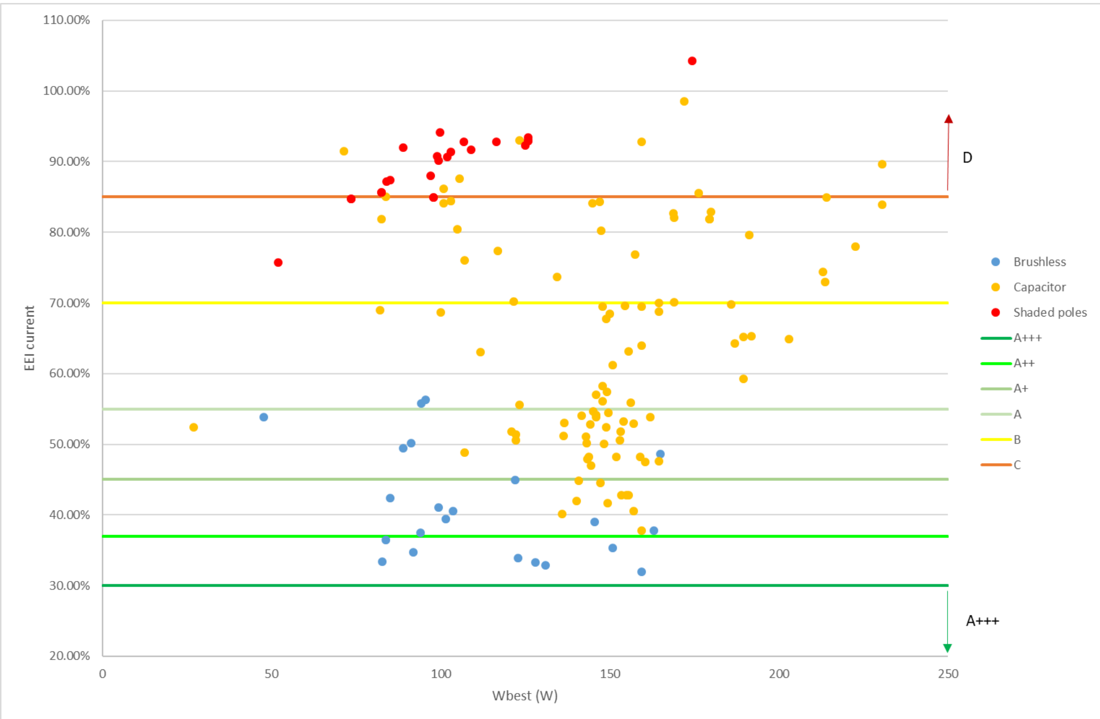



**Figure 266: EEI and Wbep calculated with existing methodology of the 143 models of the APPLiA dataset and current energy classes**

The distribution of the models among the different energy classes in presented in Table 126.

**Table 126: Distribution of the models among the different energy classes according to existing energy classes**

| Energy class | Shaded poles | Capacitor | Brushless | Total |
|---|---|---|---|---|
| A++ | 0 | 0 | 9 | 9 |
| A+ | 0 | 10 | 8 | 18 |
| A | 0 | 29 | 3 | 32 |
| B | 0 | 24 | 2 | 26 |
| C | 4 | 26 | 0 | 30 |
| D | 20 | 8 | 0 | 28 |

Figure 267 displays the same EEI as the previous figure, but versus the maximum airflow that the cooking fume extractor can deliver, usually at boost speed.

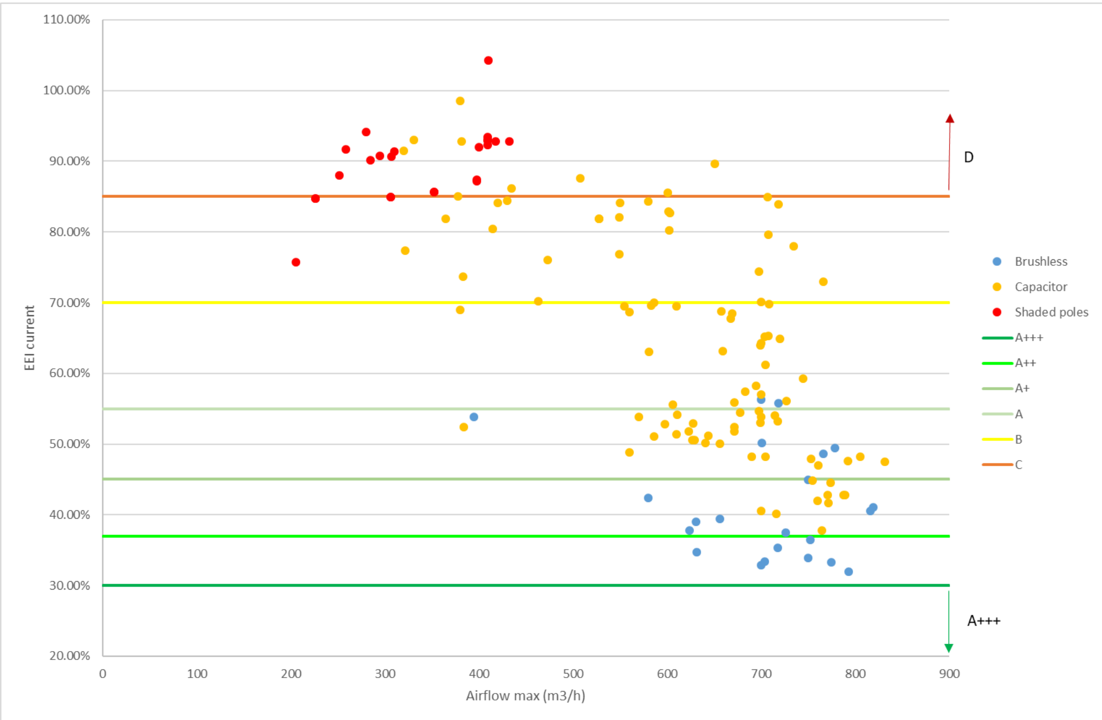



**Figure 267: EEI and maximum airflow calculated with existing methodology of the 143 models of the APPLiA dataset and current energy classes**

This figure suggests that the current EEI benefits those cooking fume extractors with larger airflow capacities. However, it is also possible that best technologies are able to provide large ranges of airflows. This is shown in Figure 268 where the current EEI versus the 9-point average airflow is displayed.

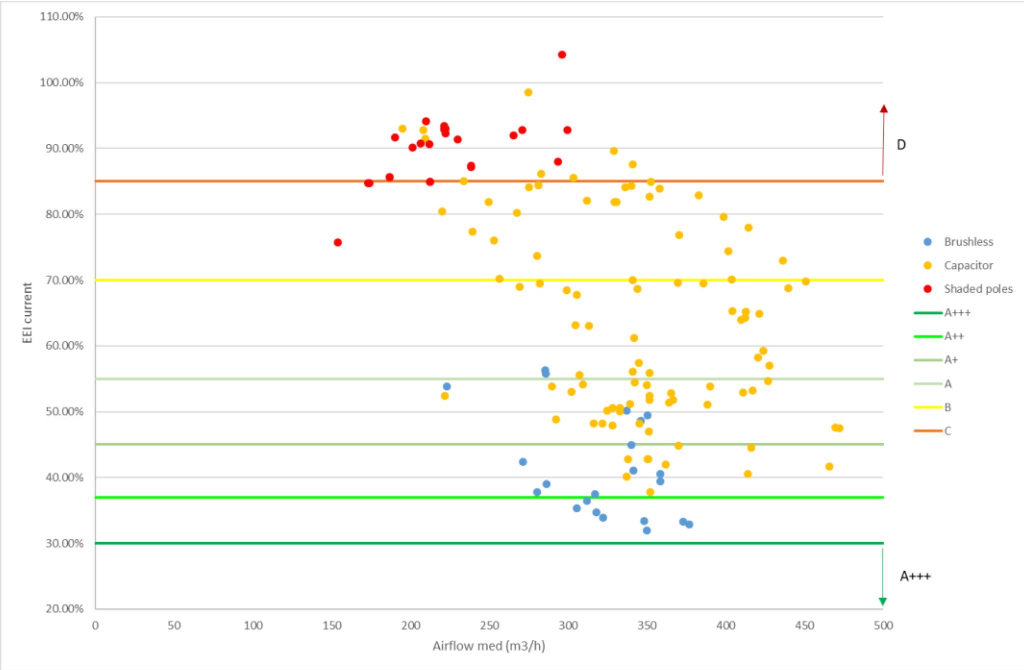



**Figure 268: EEI calculated with existing methodology and airflow 9-point average of the 143 models of the APPLiA dataset and current energy classes**

The 9-point method helps to better characterise the main parameters of cooking fume extractors, according to a representative usage of the three different speeds, and the different range of airflows. This effect is amplified if the EEI is also based on the 9-point AEC, as shown in the Figure 269.

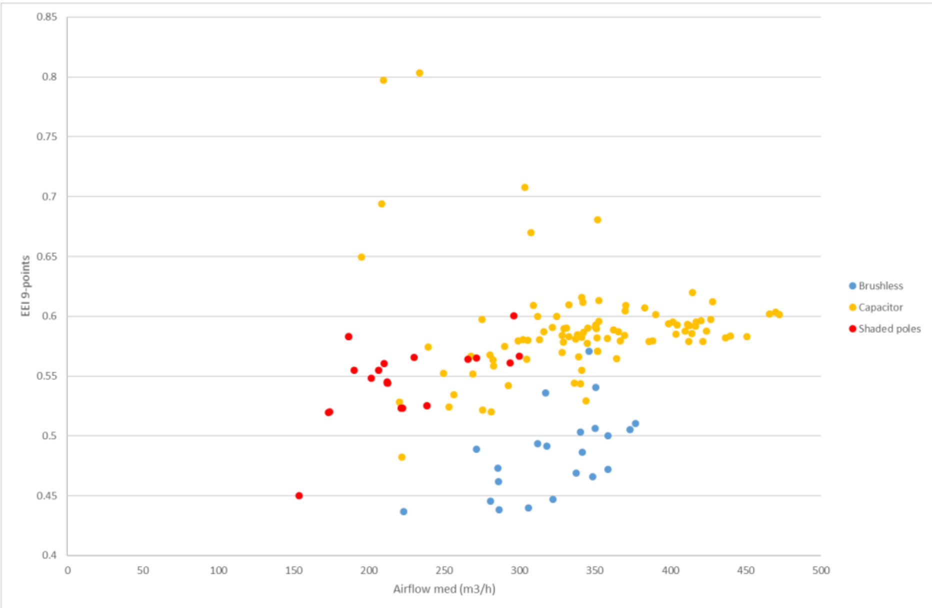



**Figure 269: EEI and airflow 9-point average of the 143 models of the APPLiA dataset and current energy classes**

### 7.5.2 Policy options related to odour reduction factor

As explained in previous sections, EN 61591 contains a test method for the odour reduction factor (ORF) with the substance MEK. There are several issues around this test method, mainly that it is only appropriate to measure the odour reduction efficiency of recirculation extractors. Apart from that, the odour reduction test should not only represent the removal of odorous substances, but the removal of all small pollutants in general that are emitted during cooking processes. However, this test method can be considered a good starting point to develop ecodesign measures for cooking fume extractors.

There is a need to develop measures on odour reduction to link the energy labelling to the real functionality of the CFE, which also depends on its design. The Danish Energy Agency and the Swedish Energy Agency have warned that some CFEs integrated in tabletops do not achieve good odour reduction factors in extraction mode. They have also proposed a threshold of 75% for the odour reduction factor for both recirculation and ducted cooking fume extractors. This figure is based on the tests carried out on a sample of ducted cooking fume extractors. They were tested according to relevant standards (EN 61591 and EN 13141-3).

However, according to manufacturers, a threshold of 75% based on EN 61591 will phase out the majority of recirculation modes in the market, while most extraction modes will be compliant. This threshold comes from EN 13141-3 “Ventilation for buildings – Performance testing of components / products for residential ventilation – Part 3: Range hood for residential use without fan”, which hinders comparison with EN 61591 test results. APPLIA shared the odour reduction factor of a sample of 10 recirculation CFEs, shown in Table 127.

**Table 127: Odour reduction factor of a sample of recirculation CFEs**

| Filter type | Consumer price range of the filter | Min ORF | Max ORF |
|---|---|---|---|
| **Charcoal filter** | EUR 40-80 | 20 | 35 |
| | EUR 80-120 | | 93 |
| | EUR 120-200 | | 90 |
| **Lifetime filter** | EUR 80-120 | 30 | 65 |
| | EUR 200-280 | 46 | 80 |
| **Other material filter** | > EUR 280 | 65 | 90 |

Source: APPLIA

Moreover, APPLiA shared the results of ORF according to the MEK test method of some CFEs in extraction mode, all of them reaching more than 90% reduction. Manufacturers do not consider this test meaningful for extraction mode. In their view, extraction mode requires the evaluation of the capture efficiency, i.e. including the airflow.

NGOs and some MS advocate for the development of energy labelling measures for recirculating CFEs, for which data on energy consumption would need to be provided. Besides, only recirculating CFEs cannot be tested according to the 9-point method, and they would require a specific test method similar to the 9-point method.

Another issue raised by manufacturers is that some recirculating cooking fume extractors are sold without an odour filter, which is purchased separately by the installation company, or by the user. In this case, it is recommended to test the recirculation cooking fume extractor with a standard odour filter, which will need to be defined. The manufacturer will inform the consumer that the odour reduction factor declared is only guaranteed if a similar filter is installed.

The functionality of a CFE is defined by its capacity to reduce the odour; therefore, it is of paramount importance to develop a test method to capture the performance of the CFE. For this purpose, a standardisation request needs to be submitted. However, in the meantime, the MEK test method can be used as a transitional method, for both recirculation and extraction modes, to provide this information to consumers. A minimum requirement of 35% will discard the least efficient charcoal filters when sold together with the CFE, though it will not prevent their being purchased separately by the CFE's user or installer.

### 7.5.3 Options for the revision of the EEI

Different options for the revision of the Energy Efficiency Index have been identified, in order to address the issues described in the sections above.

#### 7.5.3.1 Integrating odour reduction efficiency and heating/cooling in the annual energy consumption

The Danish and Swedish Energy Agencies proposed two modifications in the methodology to calculate the annual energy consumption and the EEI of cooking fume extractors:

First, the EEI should take into account the odour reduction, as a primary function of the cooking fume extractor. The objective is to limit the use of excessive air flow rates, which influence the indirect energy consumption for heating or cooling replacement air.

Besides, the annual energy consumption should include the indirect energy consumed for heating/cooling, due to air renewal. This indirect energy consumption would require an average EU climate factor.

The advantages, disadvantages and obstacles of these proposals are described in Table 128.

**Table 128: Advantages, disadvantages and obstacles of integrating odour reduction efficiency and heating/cooling in the annual energy consumption**

| Proposal | Advantages | Disadvantages/obstacles |
|---|---|---|
| Odour reduction efficiency | • Identify best products in terms of function, i.e. those that consume less energy to provide the same function.<br>• Take into account the product as a whole, i.e. considering the design, shape, etc. that may have an impact on the product performance.<br>• Cover recirculation modes. | • The test method currently available is only valid for recirculation modes. |
| Indirect energy consumption in heating and cooling | • Extend the boundaries of the system to include the indirect impact of excessive airflow. | • It requires the integration of the odour reduction efficiency.<br>• It dilutes the impact of the direct energy consumption, which may discourage technology improvement (15% to 60% of the total energy consumption).<br>• It may be argued that the indirect energy consumption will occur regardless of the CFE, since the kitchen needs ventilation to keep its health and comfort conditions. In the absence of any equipment, the ventilation will be achieved by opening the window. This need for cooking fumes ventilation is therefore part of the average usage cycle of a household HVAC system and it is questionable that could be allocated to the CFE. |

It is recommended that an appropriate odour reduction test for ducted cooking fume extractors is developed for the next revision of the Ecodesign and energy labelling measures for this product.

#### 7.5.3.2 EEI based on the fluid dynamic efficiency as an arithmetic mean

APPLiA proposed a methodology based on the fluid dynamic efficiency (FDE) together with the 9-point method.

The nine points to measure the cooking fume extractor parameters are plotted in Figure 270. PA curves represent different drawback pressures depending on the building and installation of the extractor. The parameters pressure, airflow and power are measured at minimum, maximum and boost speed, at those three drawback pressures, i.e. in nine points.

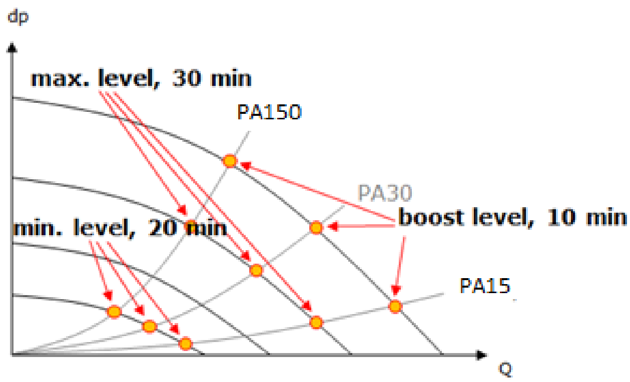



**Figure 270: P and Q curves and 9 points of measurement**

The FDE is the ratio between the power delivered by the cooking fume extractor (pressure multiplied by airflow) and the power consumed. The following formula expresses the FDE as the average of the three drawback pressures (arithmetic mean):

$$FDE_i = \frac{1}{3}\sum_{j=1}^{3} \frac{p_{i,j}}{3600}\frac{Q_{i,j}}{W_{i,j}}$$

Where:

- p means pressure delivered;
- Q means airflow delivered;
- W means power consumed;
- j = 1: Crossing point with pressure curve 150 Pa at 200 m³/h;
- j = 2: Crossing point with pressure curve 30 Pa at 200 m³/h;
- j = 3: Crossing point with pressure curve 15 Pa at 200 m³/h.

Like the previous option, the FDE would be the average of the three speeds:

$$FDE = \sum_{i=1}^{3} FDE_i \frac{t_i}{(t_1 + t_2 + t_3)}$$

The advantages and disadvantages of this proposal are gathered in Table 129.

**Table 129: Advantages and disadvantages of the proposal of an EEI based on the fluid dynamic efficiency**

| Advantages | Disadvantages |
|---|---|
| • The current method only takes into account the FDE as a time factor. This proposal provides a figure of real energy efficiency, as a ratio between power delivered and power consumed.<br>• The ratio airflow/power would help smooth the apparent benefits of large airflow extractors.<br>• FDE is strongly dependent on the drawback pressure, and varies significantly among the three selected drawback pressures. The harmonic mean evens the contribution of the three drawback pressures. | • The odour reduction efficiency is not considered.<br>• It is probable that motors that are more powerful achieve a better FDE. A reference FDE is required to compensate this effect. |

#### 7.5.3.3 EEI based on the fluid dynamic efficiency as a harmonic mean

ECOS proposed an alternative way to calculate the mean of the FDE at the three drawback pressures which consist of replacing the arithmetic mean by a harmonic mean, as follows:

$$FDE_i = \frac{3}{\sum_{j=1}^{3} \frac{1}{\frac{p_{i,j}}{3600} \frac{Q_{i,j}}{W_{i,j}}}}$$

Where:

- p means pressure delivered;
- Q means airflow delivered;
- W means power consumed;
- j = 1: Crossing point with pressure curve 150 Pa at 200 m$^3$/h;
- j = 2: Crossing point with pressure curve 30 Pa at 200 m$^3$/h;
- j = 3: Crossing point with pressure curve 15 Pa at 200 m$^3$/h.

Like the previous option, the FDE would be the average of the three speeds:

$$FDE = \sum_{i=1}^{3} FDE_i \frac{t_i}{(t_1 + t_2 + t_3)}$$

The advantages and disadvantages of this proposal are gathered in Table 129.

**Table 130: Advantages and disadvantages of an EEI based on the fluid dynamic efficiency**

| Proposal | Advantages | Disadvantages |
|---|---|---|
| EEI based on FDE | • The current method only takes into account the FDE as a time factor. This proposal provides a figure of real energy efficiency, as a ratio between power delivered and power consumed.<br>• The ratio airflow/power would help smooth the apparent benefits of large airflow extractors.<br>• FDE is strongly dependent on the back pressure, and varies significantly among the three selected drawback pressures. The harmonic mean evens the contribution of the three drawback pressures. | • The odour reduction efficiency is not considered.<br>• It is probable that motors that are more powerful achieve a better FDE. A reference FDE is required to compensate this effect. |

#### 7.5.3.4 EEI based on the AEC including heat losses and SAEC as a function of airflow

This option is based on the proposal from SEA and DEA to include the energy consumption for cooling or heating the renewed air. The annual energy consumption of the cooking fume extractor and the cooling and heating is calculated as follows:

$$AEC \quad = W_{med} \cdot \frac{365}{1000} \cdot (2 - 2 \cdot FDEmed) + Q_{med} \cdot \frac{C \cdot (1-k)}{eff_{heating}}$$

Where:

$W_{med}$ is the power measured with the 9-point method;

$FDE_{med}$ is the fluid dynamic efficiency with the 9-point method;

C is the climate factor: equal to 0.99 for an average climate, for a cold climate it would be 1.74 and for a warm climate it would be 0.57;

k is the heat recovery factor.

The proposal from SEA and DEA also puts forward a SAEC based on the odour reduction factor. However, it has not been possible to further develop this option due to the lack of odour reduction factor data.

The current EEI is based on the annual energy consumption (AEC) and the standard annual energy consumption (SAEC) as functions of the power consumed by the cooking fume extractors. Another option may be to develop a formula to calculate the SAEC as a function of the airflow measured as a 9-point average. The first step would be to represent the AEC versus the airflow, as shown in Figure 271. The first approximation for the SAEC could be a trendline for capacitor motors, as expressed in the formula within the figure.

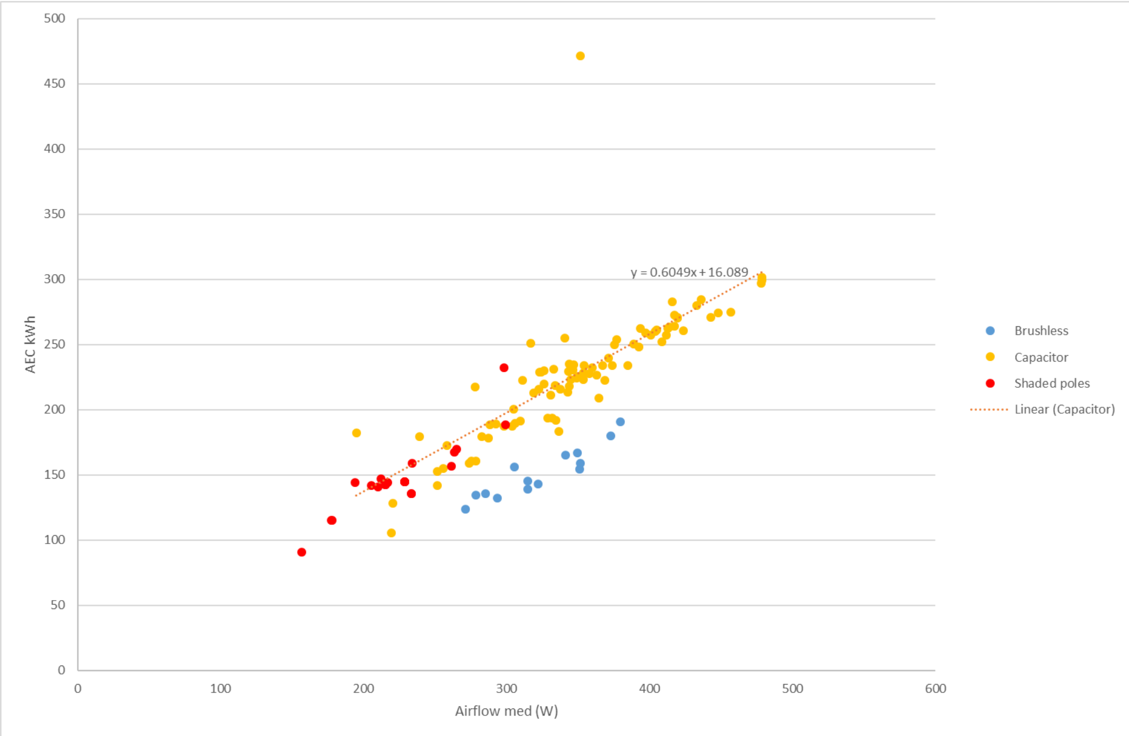



**Figure 271: AEC and airflow calculated as a 9-point average**

The advantages and disadvantages of this proposal are gathered in Table 131.

**Table 131: Advantages and disadvantages of the proposal of an EEI based on airflow**

| Advantages | Disadvantages |
|---|---|
| • The AEC is confronted to the airflow provided by the cooking fume extractor, which is a parameter related to functionality.<br>• The EEI distinguishes the three motor technologies.<br>• The boundaries of the system are extended to include the indirect impact of excessive airflow. | • The odour reduction efficiency is not considered.<br>• It is probable that motors that are more powerful achieve a better EEI, because their FDE is higher.<br>• It dilutes the impact of the direct energy consumption, which may discourage technology improvement. |

### 7.5.4 Development of an EEI and energy classes based on the different options

#### 7.5.4.1 EEI and energy classes based on the FDE as an arithmetic mean

For the review of the Ecodesign and energy labelling measures, APPLiA has provided a dataset of 143 models of cooking fume extractors. Figure 272 shows the FDE of these models versus power (9-pointaverage) for the three motor technologies.

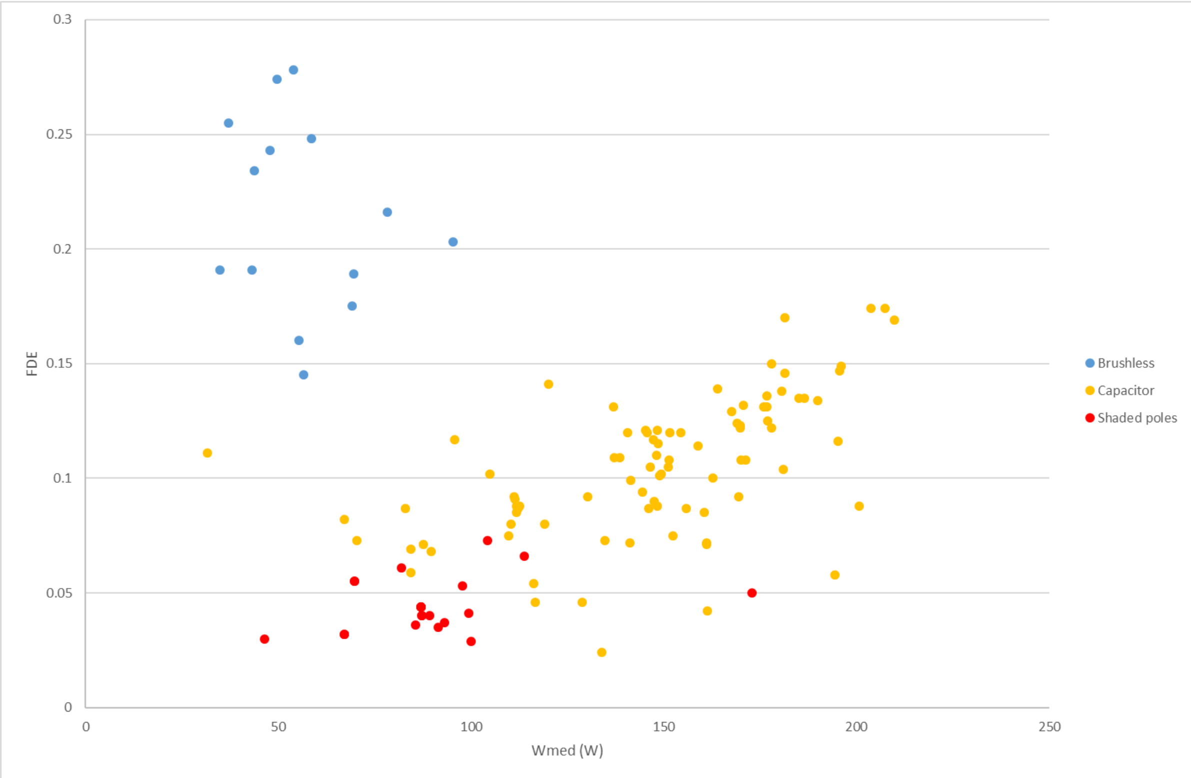



**Figure 272: FDE and power calculated as 9-point average**

As can be observed, shaded poles motors achieve the lowest FDE, followed by capacitor motors. Brushless is the best available technology and achieves a very high FDE at very low power. More powerful capacitor motors, which are the most common, tend to achieve a higher FDE. For this reason, there needs to be a reference FDE that takes into account the limitations of this technology. In this regard, APPLiA has proposed the following formula to calculate the EEI as a function of the FDE and reference FDE:

$$EEI = \sum_{i=1}^{3} \frac{FDE_i}{FDE_{refi}} \frac{t_i}{(t_1 + t_2 + t_3)} 100$$

The reference FDE would be a function of the power in order to normalise the higher efficiency or more powerful capacitor motors, as follows:

$$FDE_{refi} = 0.0003 \cdot W_i + 0.0629$$

However, this method hinders the use of the FDE for the modelling of scenarios, so the following option is proposed as an approximation:

$$EEI = \frac{FDE}{FDE_{ref}}$$

$$FDE_{ref} = 0.0003 \cdot W_{med} + 0.0629$$

$$W_{med} = \sum_{i=1}^{3} W_i \frac{t_i}{(t_1 + t_2 + t_3)}$$

The results are not exactly the same but are very similar, and would not significantly affect the EEI of the cooking fume extractor, as can be observed in Figure 273.

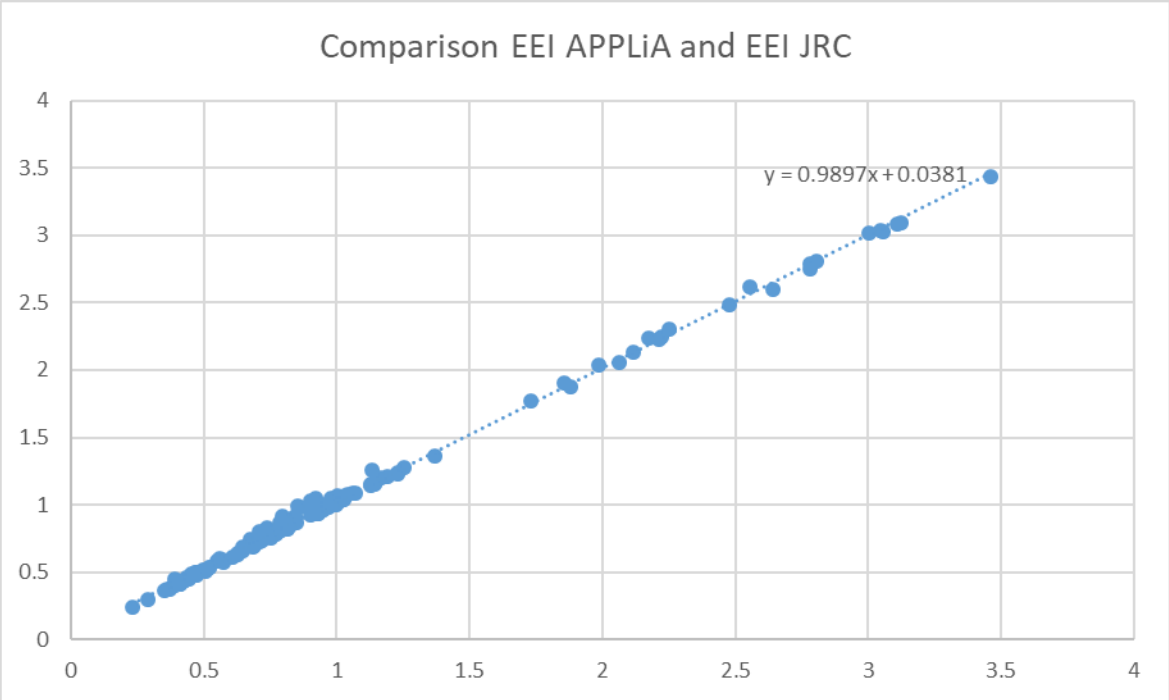



**Figure 273: Comparison between the EEI calculated with the APPLiA proposal and the EEI calculated with the JRC proposal**

The results of FDE and FDEref versus power as a 9-point average are shown in Figure 274.

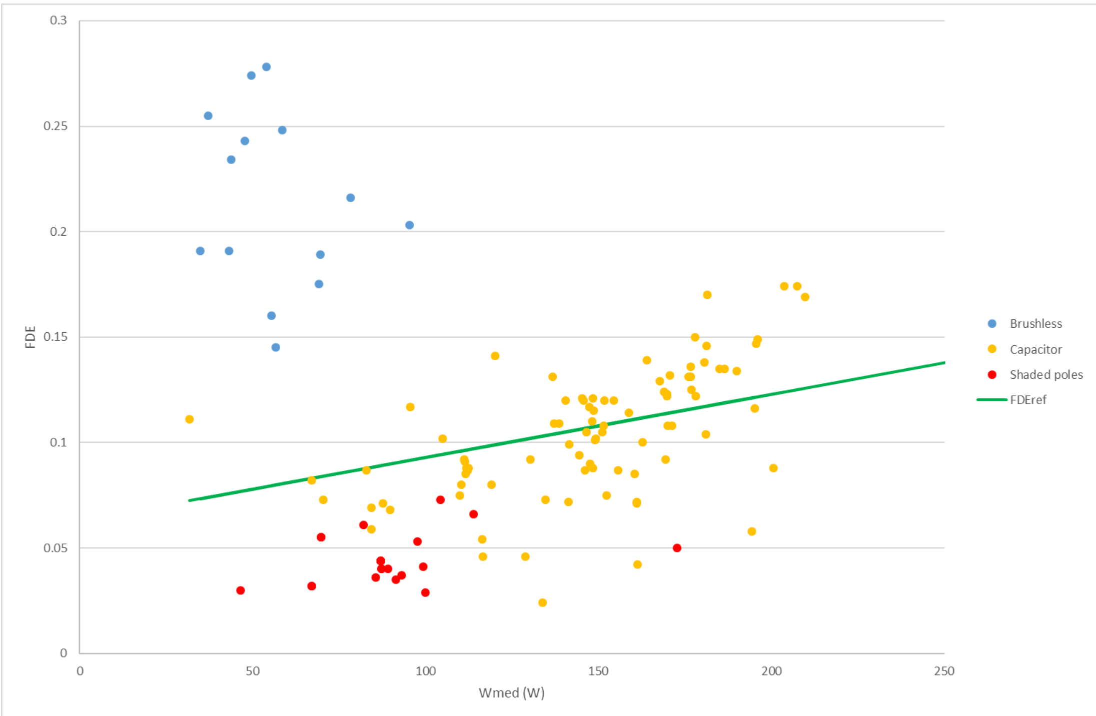



**Figure 274: FDE, FDEref versus power calculated as a 9-point average**

Figure 275 shows the results of the EEI according to the formulas explained above.

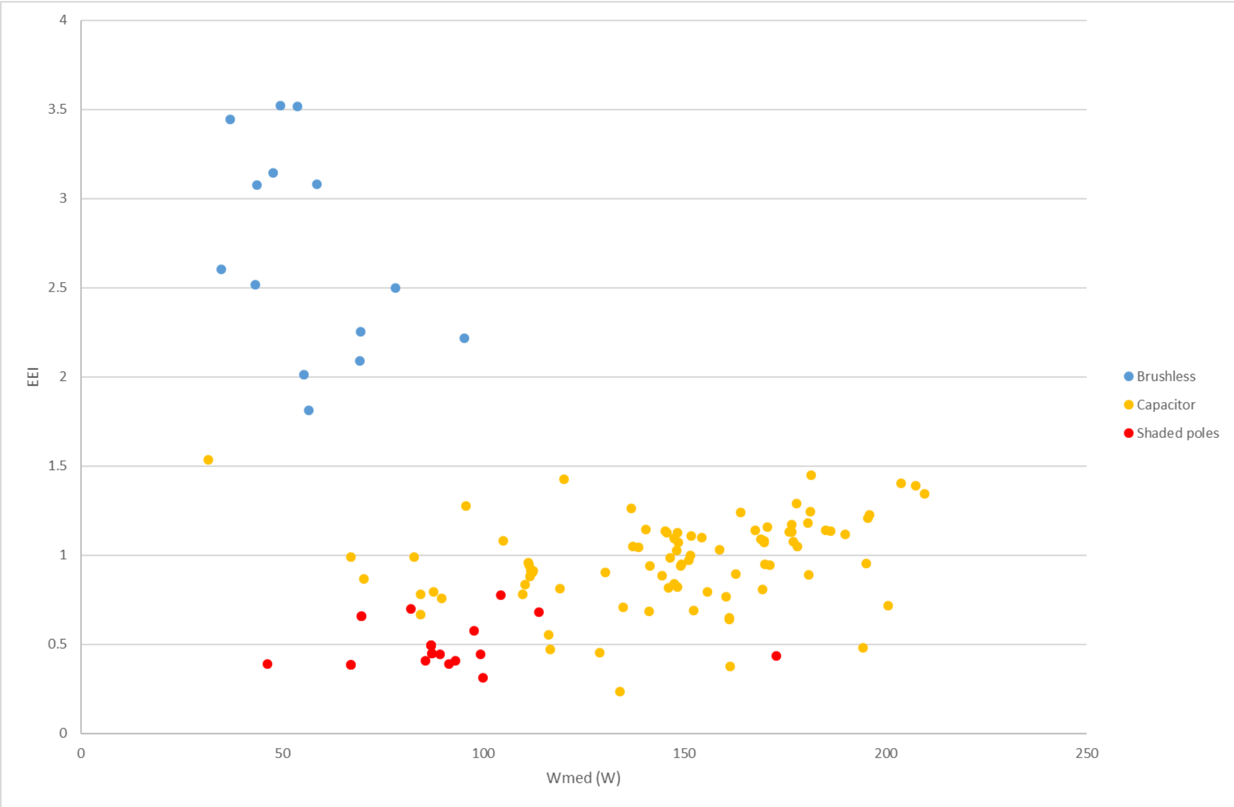



**Figure 275: EEI based on the FDE and power calculated as a 9-point average**

The new EEI would clearly differentiate the three motor technologies, in a way that only brushless motors would be able to reach the best energy classes. Capacitor motors would remain in the middle energy classes, regardless of the size of the motor. This would have two benefits: the energy classes would promote the shift of technology towards the BAT and they would be power-neutral, i.e. they would not penalise or benefit larger motors.

The results of the EEI show a significant difference between the BAT, i.e. brushless motor, and the other two motor technologies. The energy classes will be thus distributed so consumers can identify:

- first, those cooking fume extractors equipped with the BAT;
- second, within each technology, those that achieve the highest efficiency.

In order to come up with the ranges of the energy classes (B to G), cooking fume extractors have been divided and analysed according to their motor technology. The APPLiA database has been used for this purpose.

Two different options have been used to determine the thresholds of the energy classes:

- **Option a**: the thresholds of the energy classes are even along all energy classes, i.e. the difference of the EEI between energy classes is the same or very similar.
- **Option b**: the thresholds have been determined in a way that the number of models is evenly distributed among the energy classes.

**<u>Option a</u>**

Energy classes B, C, D and E identify brushless motor cooking fume extractors. Energy classes F and G identify capacitor and shade poles motor cooking fume extractors. The distribution of the different models is shown in Table 133 and Figure 277.

**Table 132: Distribution of models among the new energy classes based on FDE in option a**

| **Energy class** | **Brushless** | **Capacitor** | **Shaded poles** |
|---|---|---|---|

| | (total = 14) | (total = 88) | (total = 22) |
|---|---|---|---|
| A (EEI > 360) | 0 | 0 | 0 |
| B (360 ≥ EEI> 250) | 9 | 0 | 0 |
| C (250 ≥ EEI> 200) | 4 | 0 | 0 |
| D (200 ≥ EEI > 150) | 2 | 1 | 0 |
| E (150 ≥ EEI > 100) | | 39 | 0 |
| F (100 ≥ EEI > 50) | | 42 | 6 |
| G (EEI ≤ 50) | | 6 | 16 |

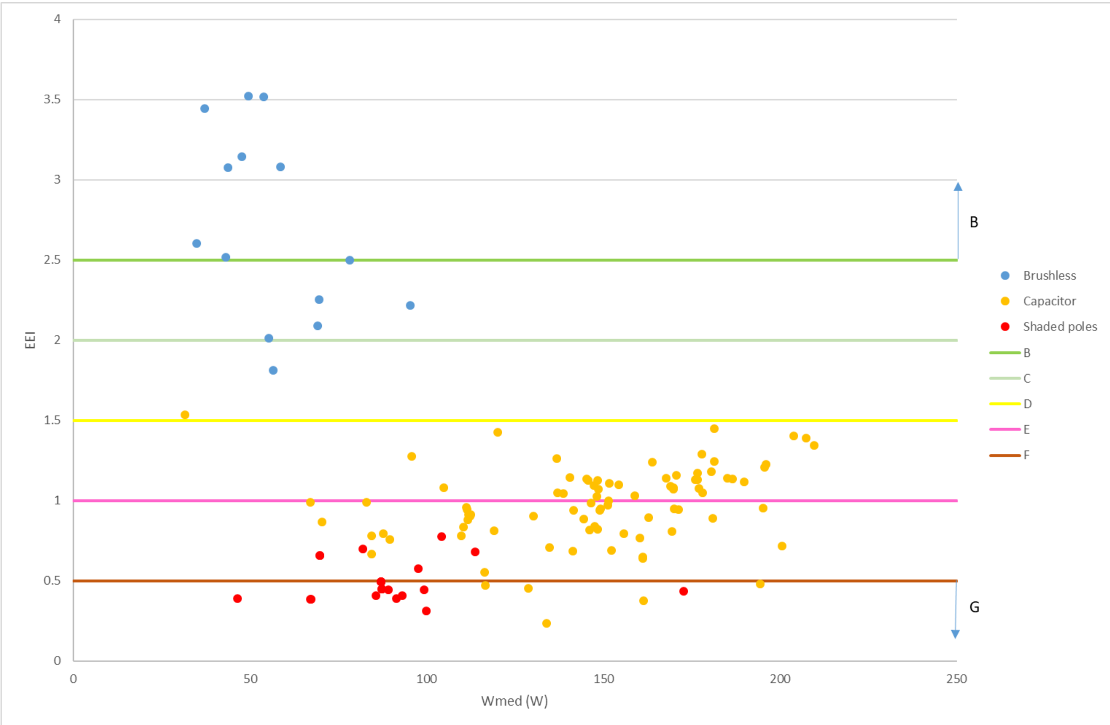



**Figure 276: Distribution of models among the new energy classes based on FDE in option a**

This option will allow consumers to identify the best technologies and to differentiate the leaps between energy classes with a similar EEI performance. The best and middle energy classes will be populated with the brushless motor cooking fume extractors, while capacitor and shaded poles will be labelled as the lowest energy classes. This option would push towards BATs, though it would not allow the comparison between the current most common technology, i.e. capacitor motors.

**Option b**

Energy classes B and C identify brushless motor cooking fume extractors. Energy classes D, E, F and G identify capacitor and shade poles motor cooking fume extractors. The distribution of the different models is shown in Table 133 and Figure 277.

**Table 133: Distribution of models among the new energy classes based on FDE in option b**

| Energy class | Brushless (total = 14) | Capacitor (total = 88) | Shaded poles (total = 22) |
|---|---|---|---|
| A (EEI > 360) | 0 | 0 | 0 |
| B (360 ≥ EEI> 258) | 7 | 0 | 0 |
| C (258 ≥ EEI> 155) | 7 | 0 | 0 |
| D (155 ≥ EEI > 111) | 0 | 26 | 0 |
| E (111 ≥ EEI > 92) | 0 | 27 | 0 |
| F (92 ≥ EEI > 68) | | 27 | 1 |
| G (EEI ≤ 68) | | 8 | 21 |

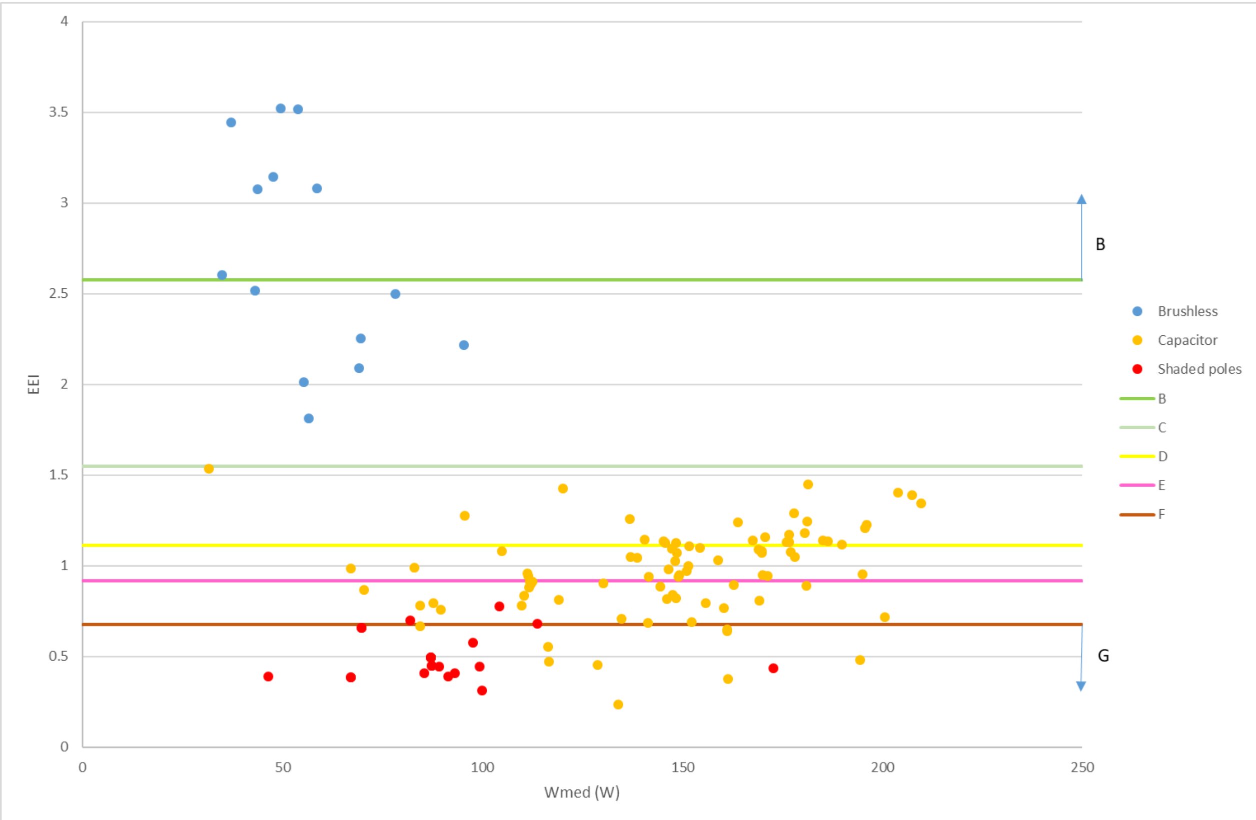



**Figure 277: Distribution of models among the new energy classes based on FDE in option b**

The steps that separate the energy classes are not even, since the brushless motors show a larger spread than capacitor and shade poles motors. The largest step matches classes B and C, which sets the border between technologies. The leap from class D to C will require a shift of technology which will significantly improve the energy efficiency.

#### 7.5.4.2 EEI and energy classes based on the FDE as a harmonic mean

As explained in previous sections, ECOS proposed an alternative way to calculate the mean of the FDE at the three back pressures which consists of replacing the arithmetic mean by a harmonic mean, as follows:

$$FDE_i = \frac{3}{\sum_{j=1}^{3} \frac{1}{\frac{p_{i,j}}{3600} \frac{Q_{i,j}}{W_{i,j}}}} = \frac{\frac{1}{FDE_{i,1}} \cdot FDE_{i,1} + \frac{1}{FDE_{i,2}} \cdot FDE_{i,2} + \frac{1}{FDE_{i,3}} \cdot FDE_{i,3}}{\frac{1}{FDE_{i,1}} + \frac{1}{FDE_{i,2}} + \frac{1}{FDE_{i,3}}}$$

Where:

- p  means pressure delivered;
- Q means airflow delivered;
- W means power consumed;
- j = 1: Crossing point with pressure curve 150 Pa at 200 $m^3/h$;
- j = 2: Crossing point with pressure curve 30 Pa at 200 $m^3/h$;
- j = 3: Crossing point with pressure curve 15 Pa at 200 $m^3/h$.

Like the previous option, the FDE would be the average of the three speeds:

$$FDE = \sum_{i=1}^{3} FDE_i \frac{t_i}{(t_1 + t_2 + t_3)}$$

Figure 272 shows the FDE calculated as the harmonic mean of the models provided by Applia and the power for the three motor technologies.

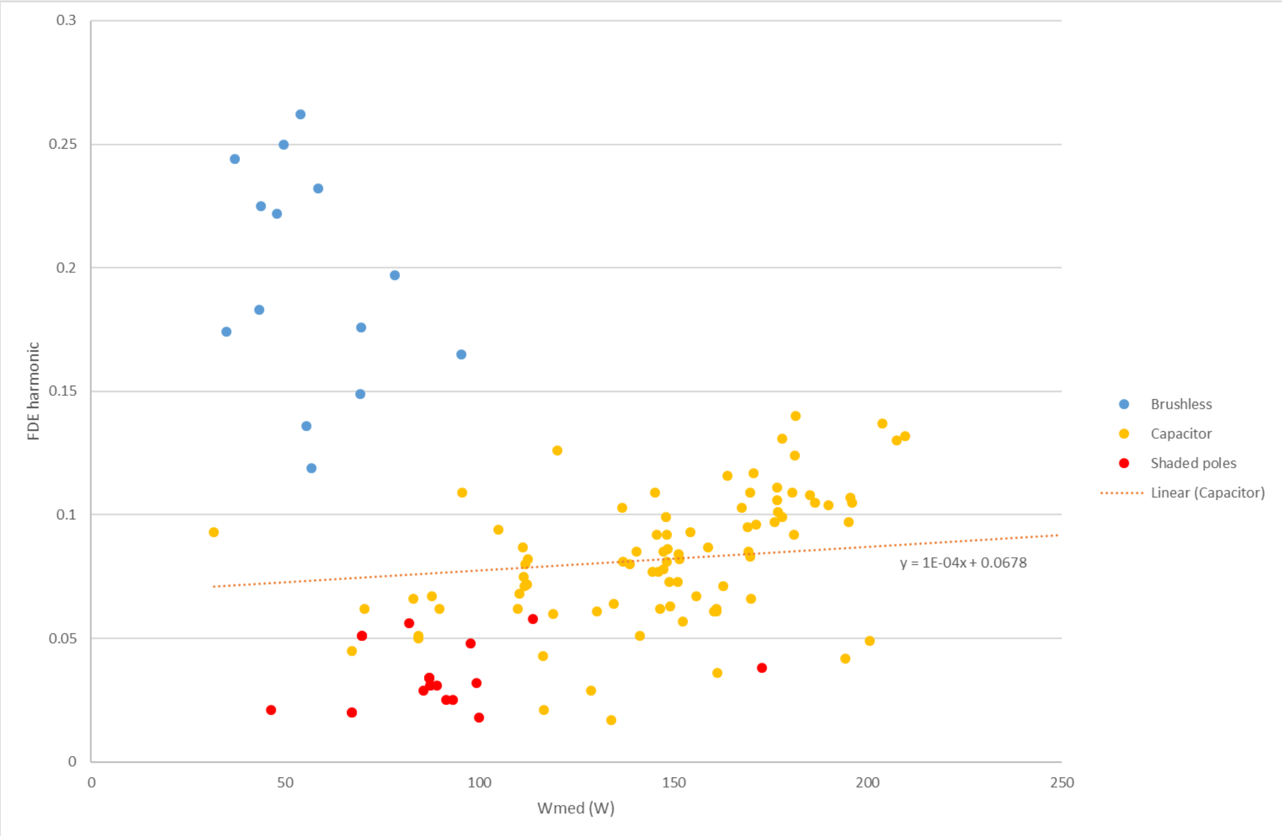



**Figure 278: FDE and power calculated as a 9-point average**

The EEI is calculated as follows:

$$EEI = \frac{FDE}{FDE_{ref}}$$

$$FDE_{ref} = 0.0001 \cdot W_{med} + 0.0678$$

$$W_{med} = \sum_{i=1}^{3} W_i \frac{t_i}{(t_1 + t_2 + t_3)}$$

Figure 275 shows the results of the EEI according to the formulas explained above.

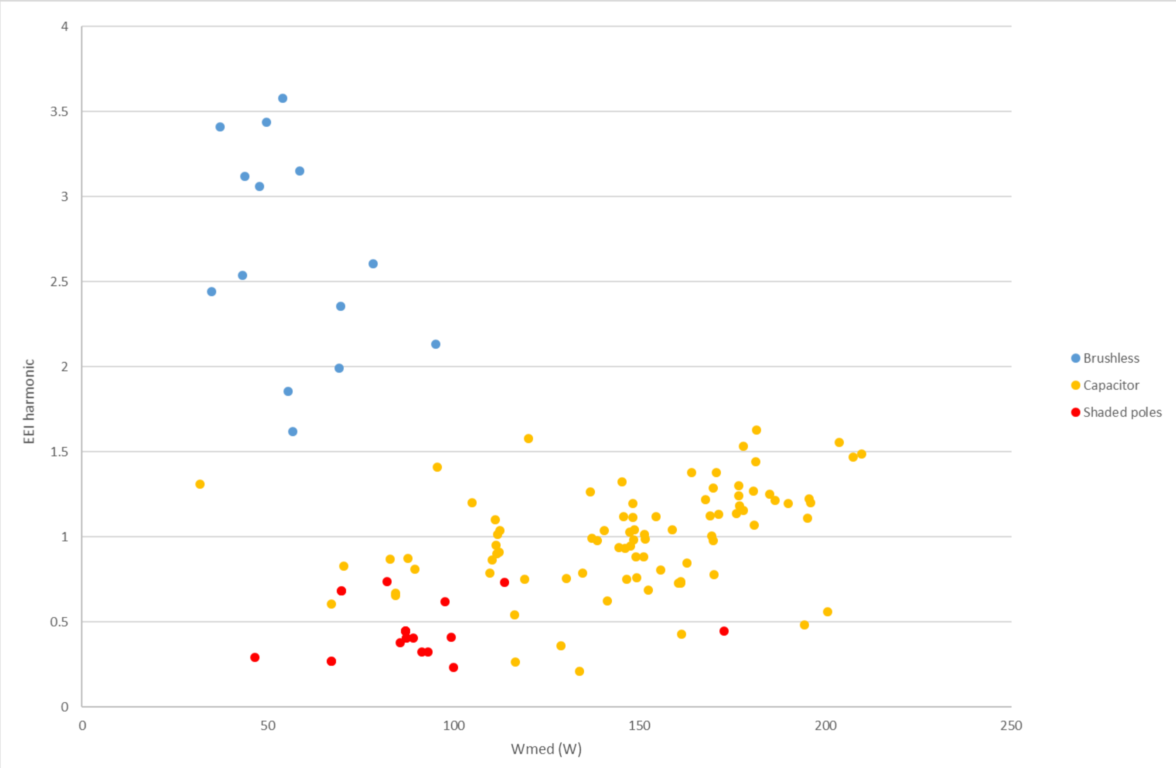



**Figure 279: EEI based on the FDE and power calculated as a 9-point average**

The results are similar to the arithmetic mean, though as expected the values of the FDE are a bit lower.

The same two options have been used to determine the thresholds of the energy classes:

- **Option a**: the thresholds of the energy classes are even along all energy classes, i.e. the difference of the EEI between energy classes is the same or very similar.
- **Option b**: the thresholds have been determined in a way that the number of models is evenly distributed among the energy classes.

**Option a**

Energy classes B, C, D and E identify brushless motor cooking fume extractors. Energy classes F and G identify capacitor and shade poles motor cooking fume extractors. The distribution of the different models is shown in Table 134 and Figure 280. The number in brackets indicates the variation compared to the arithmetic mean.

**Table 134: Distribution of models among the new energy classes based on FDE in option a**

| Energy class | Brushless (total = 14) | Capacitor (total = 87) | Shaded poles (total = 21) |
|---|---|---|---|

| | | | |
|---|---|---|---|
| A (EEI > 360) | 0 | 0 | 0 |
| B (360 ≥ EEI> 258) | 8 (=) | 0 | 0 |
| C (258 ≥ EEI> 155) | 3 (+1) | 0 | 0 |
| D (155 ≥ EEI > 111) | 3 (-1) | 4 (+3) | 0 |
| E (111 ≥ EEI > 92) | | 40 (+1) | 0 |
| F (92 ≥ EEI > 68) | | 37 (-4*) | 5 (=*) |
| G (EEI ≤ 68) | | 6 (=) | 16 (=) |

** Two models that were discarded due to lack of data for the harmonic means.*

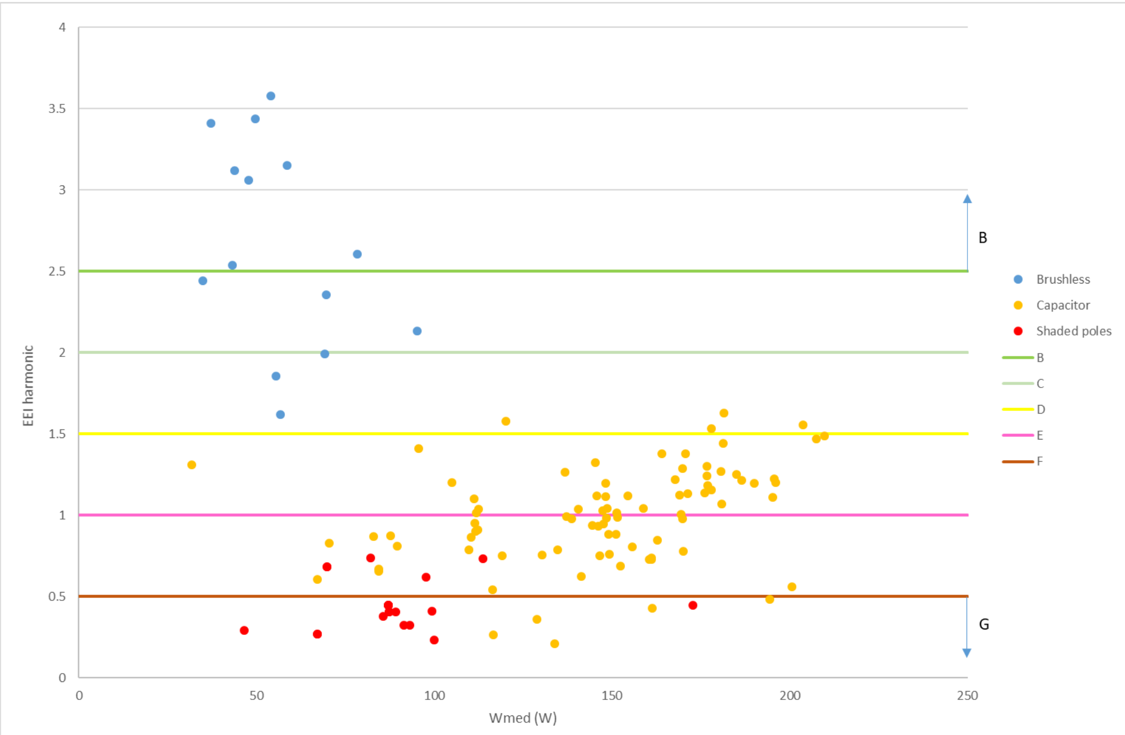



**Figure 280: Distribution of models among the new energy classes based on FDE in option a**

The results are similar to the option based on FDE as an arithmetic mean, the main difference is that more capacitor motors are able to reach classes D and E.

**Option b**

Energy classes B and C identify brushless motor cooking fume extractors. Energy classes D, E, F and G identify capacitor and shade poles motor cooking fume extractors. The distribution of the different models is shown in Table 135 and Figure 281.

**Table 135: Distribution of models among the new energy classes based on FDE in option b**

| Energy class | Brushless (total = 14) | Capacitor (total = 87) | Shaded poles (total = 21) |
|---|---|---|---|
| A (EEI > 360) | 0 | 0 | 0 |

| | | | |
|---|---|---|---|
| B (360 ≥ EEI> 260) | 7 (=) | 0 | 0 |
| C (260 ≥ EEI> 150) | 7 (=) | 0 | 0 |
| D (150 ≥ EEI > 110) | 0 | 26 (=) | 0 |
| E (110 ≥ EEI > 90) | 0 | 27 (=) | 0 |
| F (90 ≥ EEI > 70) | | 23 (-3*) | 4 (+3) |
| G (EEI ≤ 70) | | 11 (+3) | 17 (-3*) |

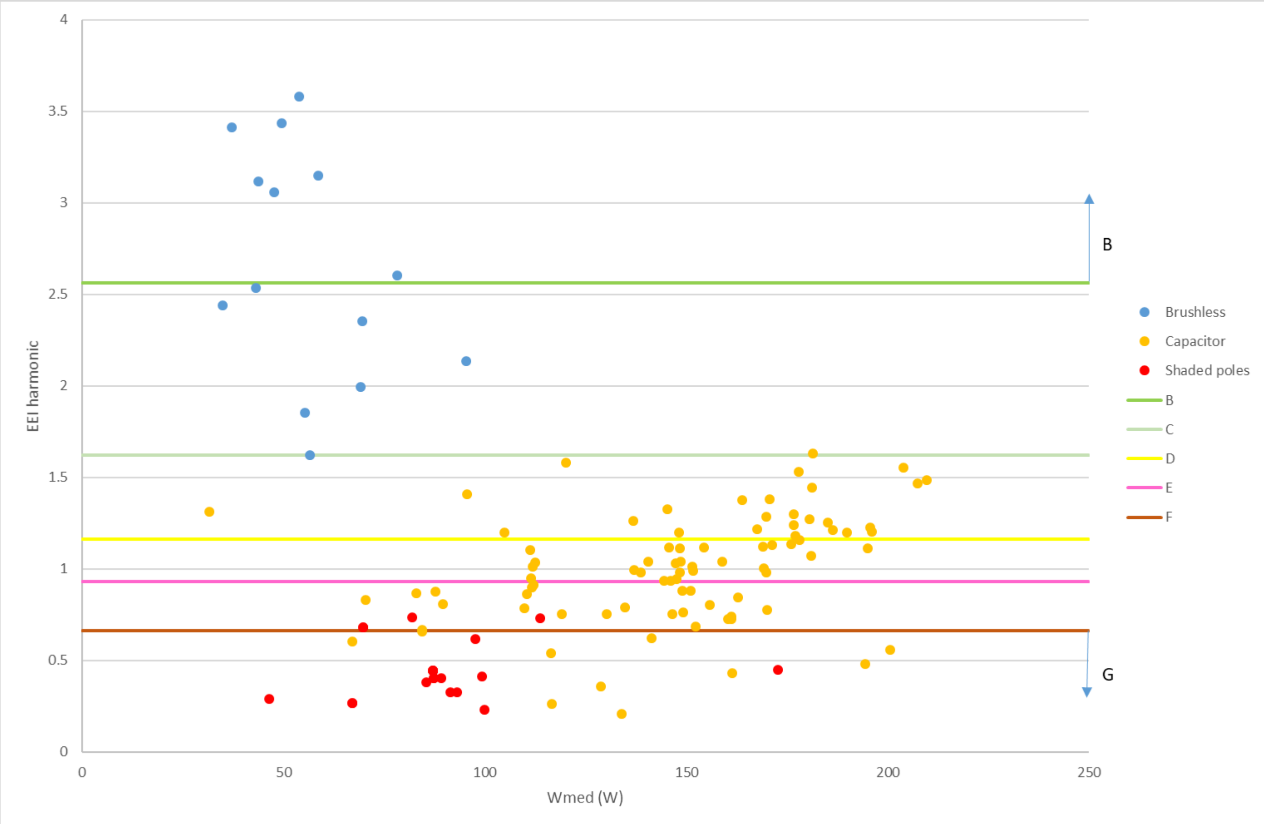



**Figure 281: Distribution of models among the new energy classes based on FDE in option b**

The steps that separate the energy classes are not even, since the brushless motors show a larger spread than capacitor and shade poles motors. The largest step matches classes B and C, which sets the border between technologies. The leap from class D to C will require a shift of technology which will significantly improve the energy efficiency.

The results are similar to the option based on the FDE as an arithmetic mean, the main difference is that less capacitor motors are able to reach class F while more shaded poles motors reach class F.

#### 7.5.4.3 EEI based on AEC including heat losses and SAEC as a function of airflow

The current EEI is based on the annual energy consumption (AEC) and the standard annual energy consumption (SAEC) as functions of the power consumed by the cooking fume extractors. Another option may be to develop a formula to calculate the SAEC as a function of the airflow measured as a 9-point average. This option integrates the proposal from SEA and DEA to include the energy consumption for cooling or heating the renewed air. The annual energy consumption of the cooking fume extractor and the cooling and heating is calculated as follows:

$$AEC = AEC_{CFE} + AEC_{heating}$$

$$AEC = W_{med} \cdot \frac{365}{1000} \cdot (2 - 2 \cdot FDEmed) + Q_{med} \cdot \frac{C \cdot (1-k)}{eff_{heating}} \cdot \frac{365}{1000}$$

Where:

$W_{med}$ is the power measured with the 9-point method;

$Q_{med}$ is the airflow measured with the 9-point method;

$FDE_{med}$ is the fluid dynamic efficiency with the 9-point method;

C is the is a climate factor: equal to 0.99 for an average climate, for a cold climate it would be 1.74 and for a warm climate it would be 0.57;

k is the heat recovery factor;

$eff_{heating}$ is the efficiency of the heating system.

The first step to build up the EEI would be to represent the AEC vs the airflow, as shown in Figure 282.

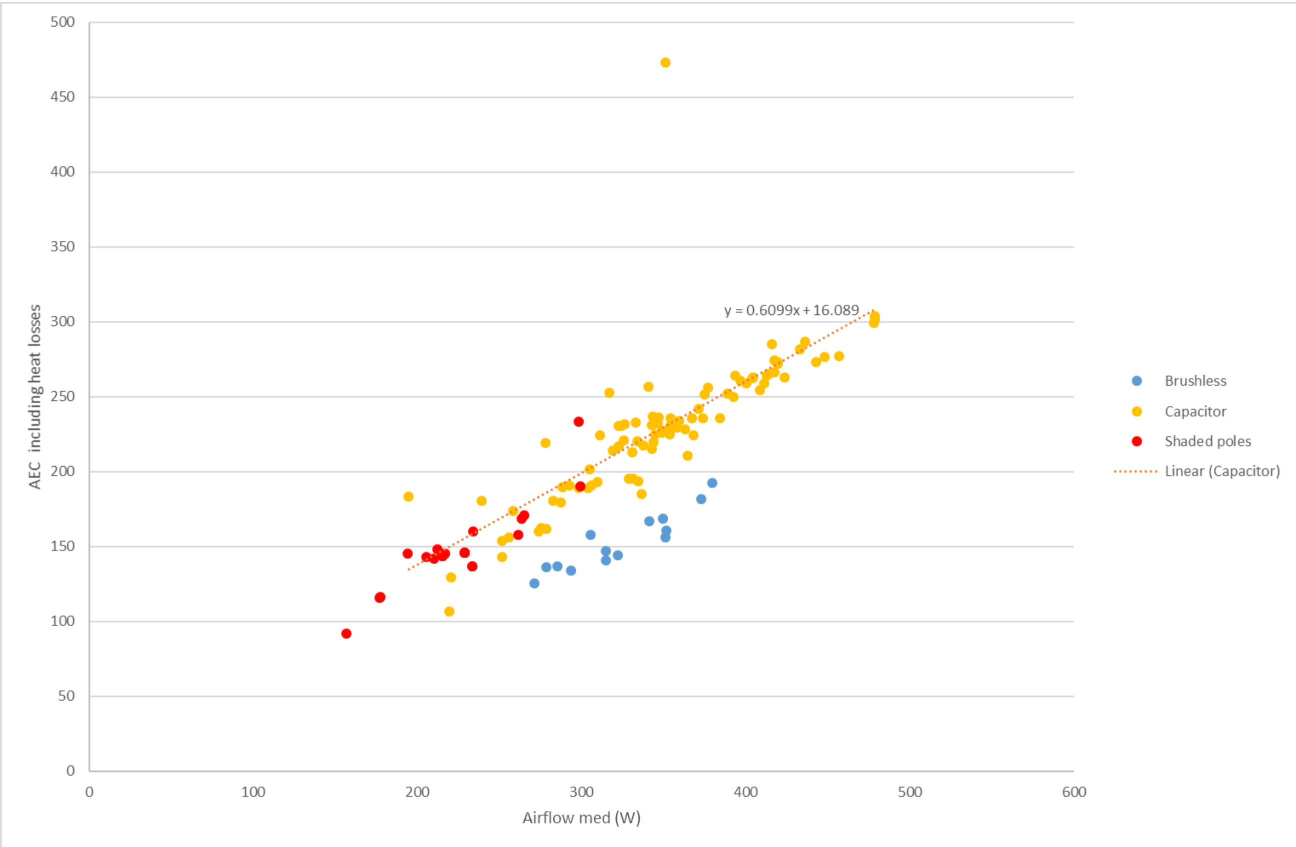



**Figure 282: AEC and airflow calculated as a 9-point average**

The first approximation for a SAEC could be a trendline for capacitor motors, as expressed in the formula within the figure, as follows:

$$SAEC = 0.6049 \times Q_{med} + 16.089$$

where Qmed means airflow as a 9-point average in m³/h.

Figure 283 shows the results of the EEI calculated as the AEC/SAEC ratio.

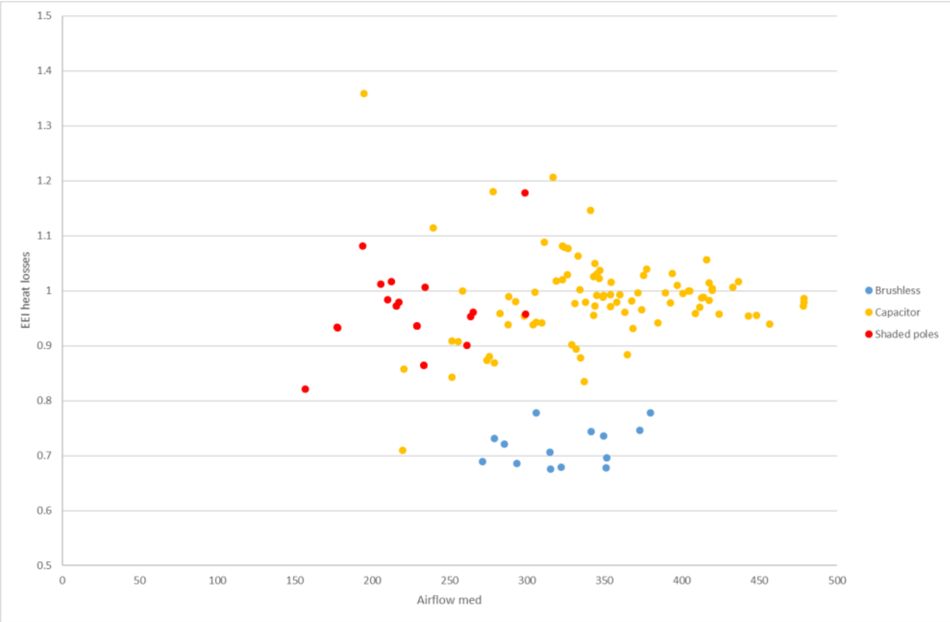



**Figure 283: EEI based on airflow calculated as the AEC/SAEC ratio**

The new EEI would differentiate BAT from the rest of technologies. Capacitor motors and shaded poles motors would not be distinguished, remaining middle energy classes.

In order to come up with the ranges of the energy classes (B to G), cooking fume extractors have been divided and analysed according to their motor technology. The APPLiA database has been used for this purpose.

Two different options have been used to determine the energy classes' thresholds.

- **Option a**: the thresholds of the energy classes are even along all energy classes, i.e. the difference of the EEI between energy classes is the same or very similar.
- **Option b**: the thresholds have been determined in a way that the number of models is evenly distributed among the energy classes.

**Option a**

Energy classes B and C correspond mainly to brushless motor cooking fume extractors. The rest of the energy classes identify capacitor and shade poles motor cooking fume extractors. The distribution of the different models is shown in Table 136 and Figure 284.

**Table 136: Distribution on models among the new energy classes based on airflow in option a**

| **Energy class** | **Brushless (total = 14)** | **Capacitor (total = 88)** | **Shaded poles (total = 22)** |
|---|---|---|---|
| A (EEI < 60) | 0 | 0 | 0 |
| B (60 ≤ EEI < 70) | 6 | 0 | 0 |
| C (70 ≤ EEI < 80) | 8 | 1 | 0 |
| D (80 ≤ EEI < 90) | 0 | 9 | 3 |
| E (90 ≤ EEI < 100) | 0 | 45 | 14 |
| F (100 ≤ EEI < 110) | 0 | 9 | 22 |

| G (EEI ≥ 110) | 0 | 4 | 1 |
|---|---|---|---|

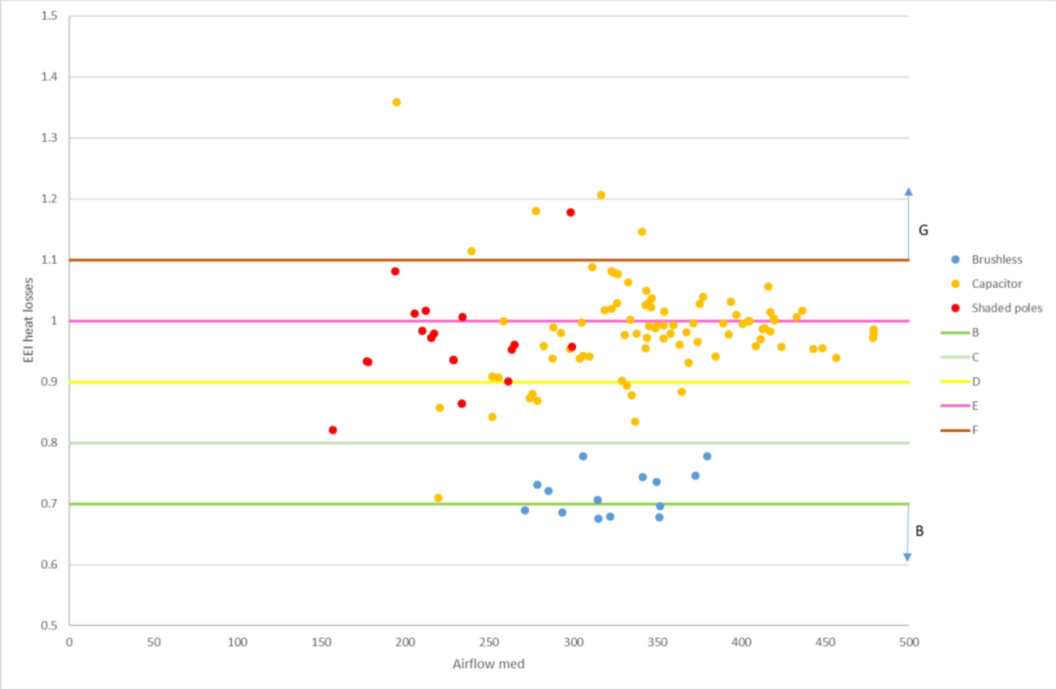



**Figure 284: Distribution of models among the new energy classes based on airflow in option a**

In contrast to the EEI based on FDE, this option allows differentiation of the best models with capacitor and shaded pole motors, though the best classes could be reached by capacitor motors, meaning that the best energy classes may not require a change in technology. Besides, shaded poles motor CFEs are present in the middle classes instead of being concentrated in G class. These motors usually deliver low airflow and therefore they benefit from the inclusion of heat losses.

**Option b**

Energy class B corresponds mainly to brushless motor cooking fume extractors. The rest of the energy classes identify capacitor and shade poles motor cooking fume extractors. The distribution of the different models is shown in Table 137 and Figure 285.

**Table 137: Distribution of models among the new energy classes based on airflow in option b**

| **Energy class** | **Brushless (total = 22)** | **Capacitor (total = 96)** | **Shaded poles (total = 25)** |
|---|---|---|---|
| A (EEI < 60) | 0 | 0 | 0 |
| B (60 ≤ EEI < 71) | 6 | 0 | 1 |
| C (71 ≤ EEI < 79) | 7 | 1 | |
| D (79≤ EEI < 94) | | 16 | 10 |
| E (94 ≤ EEI < 98) | | 20 | 7 |
| F (98 ≤ EEI < 100) | | 25 | 3 |
| G (EEI ≥ 100) | | 26 | 2 |

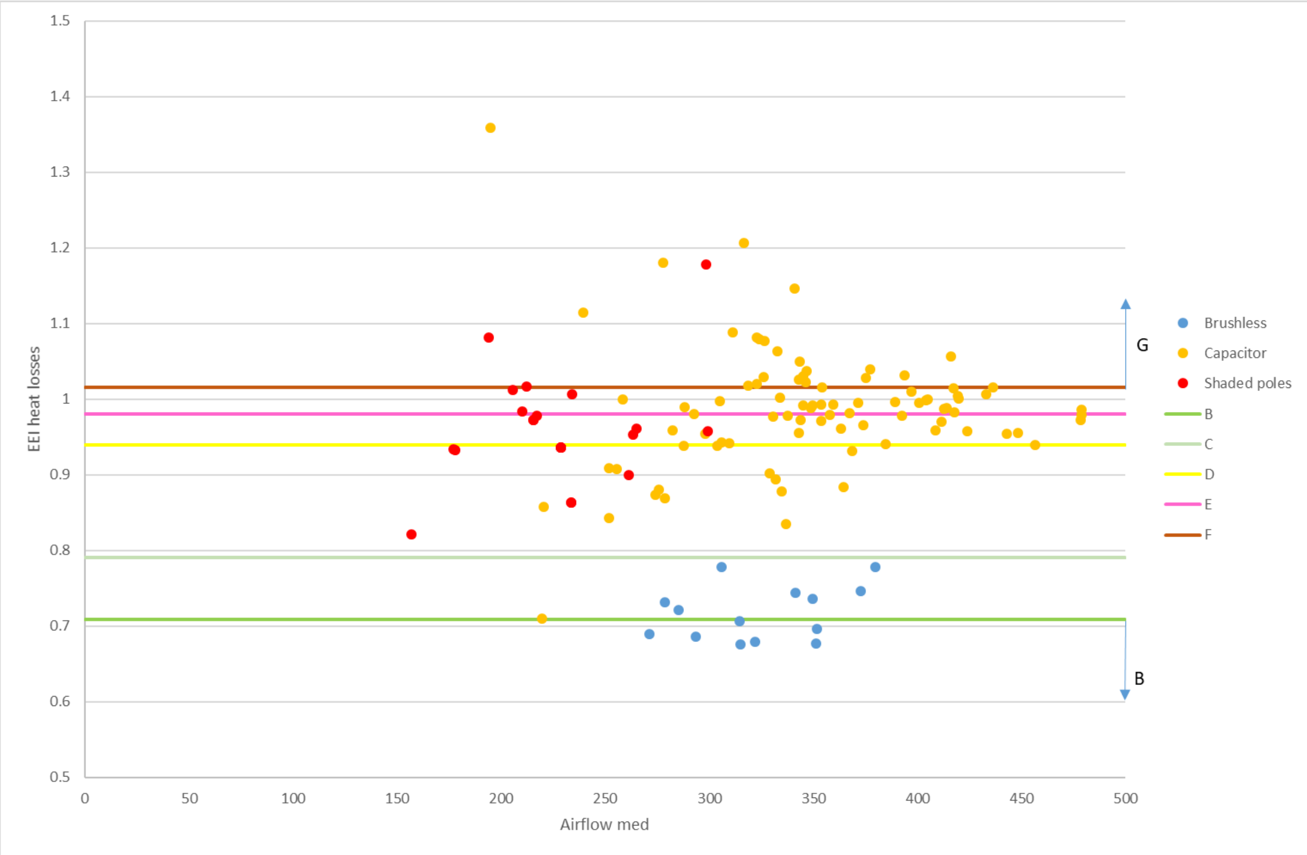



**Figure 285: Distribution of models among the new energy classes based on airflow**

In contrast to option a, this alternative would allow more comparison among capacitor and shaded poles motors, since the leaps between classes are adapted to the range of the EEI achieved by these CFEs.

### 7.5.5 Ecodesign minimum requirements

The existing Ecodesign minimum requirements for cooking fume extractors are summarised in Table 138.

**Table 138: Ecodesign minimum requirements for cooking fume extractors**

| | |
|---|---|
| February 2015 | $EEI_{hood}$<120 $FDE_{hood}$ >3 |
| February 2017 | $EEI_{hood}$<110 $FDE_{hood}$ >5 |
| February 2019 | $EEI_{hood}$<100 $FDE_{hood}$ >8 |
| February 2015 | Air flow ≤ 650m³/h |
| February 2015 | $E_{middle}$ > 40 lux |

There are also requirements on low power modes, which were suggested to be replaced by including the cooking fume extractors within the scope of Ecodesign Regulation (EC) No 1275/2008 for standby and off mode.

There are different options to set minimum energy performance standards according to the EEI described in the previous section. If a **minimum energy class** F is required, the models in Table 139 would be affected.

**Table 139: Models affected by a minimum energy class F for the different options**

| EEI | Brushless | Capacitor | Shaded poles |
|---|---|---|---|
| G based on FDE arithmetic | 0 | 6 | 16 |

| | | | |
|---|---|---|---|
| option a (EEI ≤ 50) | | | |
| G based on FDE arithmetic option b (EEI ≤ 70) | 0 | 8 | 21 |
| G based on FDE harmonic option a (EEI ≤ 50) | 0 | 6 | 16 |
| G based on FDE harmonic option b (EEI ≤ 70) | 0 | 11 | 17 |
| G based on airflow and heat losses option a (EEI ≥ 110) | 0 | 3 | 1 |
| G based on airflow and heat losses option b (EEI ≥ 100) | 0 | 27 | 2 |

In order to establish **FDE minimum requirements**, the following figures show the three options of EEI and the respective FDE of the models.

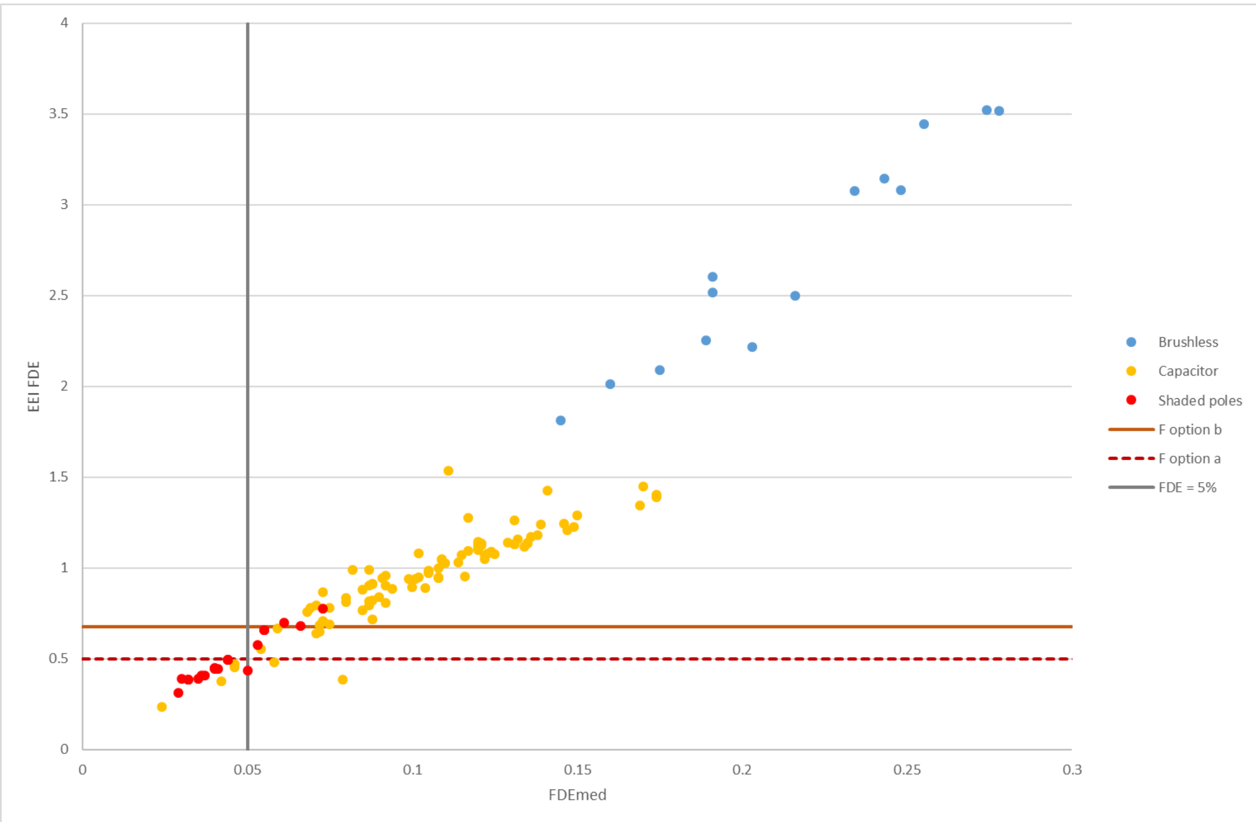



**Figure 286: EEI based on FDE arithmetic vs FDE arithmetic**

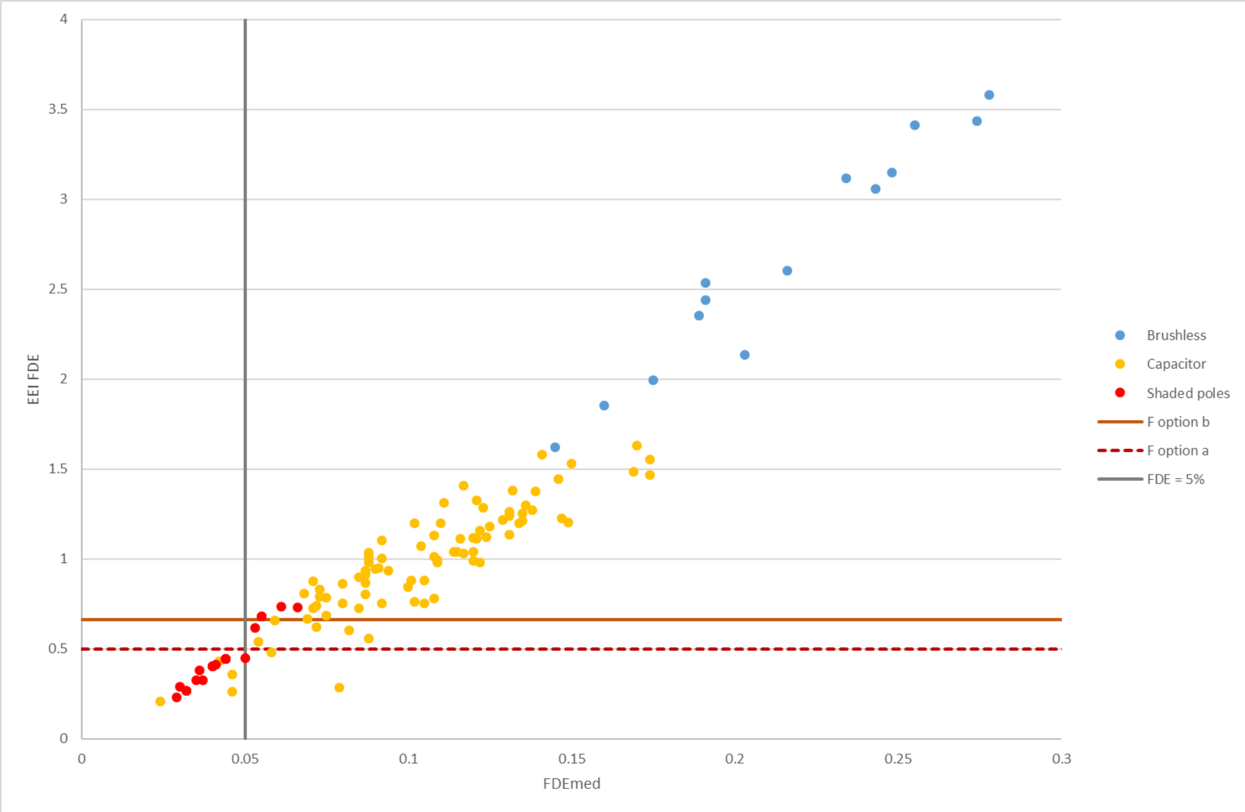



**Figure 287: EEI based on FDE harmonic vs FDE harmonic**

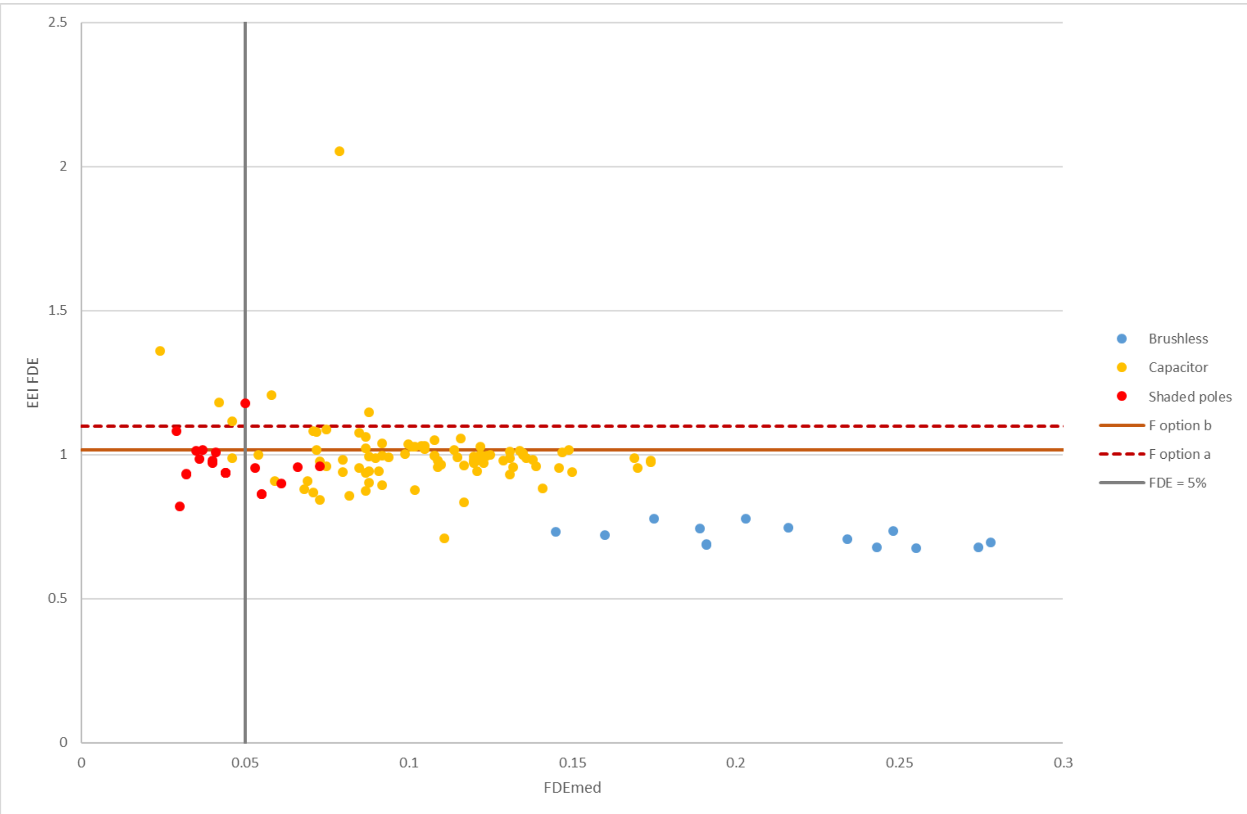



**Figure 288: EEI based on airflow vs FDE**

As can be observed, a minimum requirement on FDE calculated as a 9-point average of 0.05 or 5% would affect cooking fume extractors equipped with shaded pole motors. The energy class G based on FDE covers all these cooking fume extractors, while using EEI based on airflow the removal of shade poles motors from the market would be additional to the minimum energy class required.

The current Ecodesign requirments cover a **maximum airflow** set at 650 $m^3/h$ measured at BEP to which CFEs with airflows above this figure must revert after a defined period of time. In order to update this figure, it is necessary to analyse the airflow of the CFE as a 9-point average. Figure 289 shows the airflow and the power at a 9-point average.

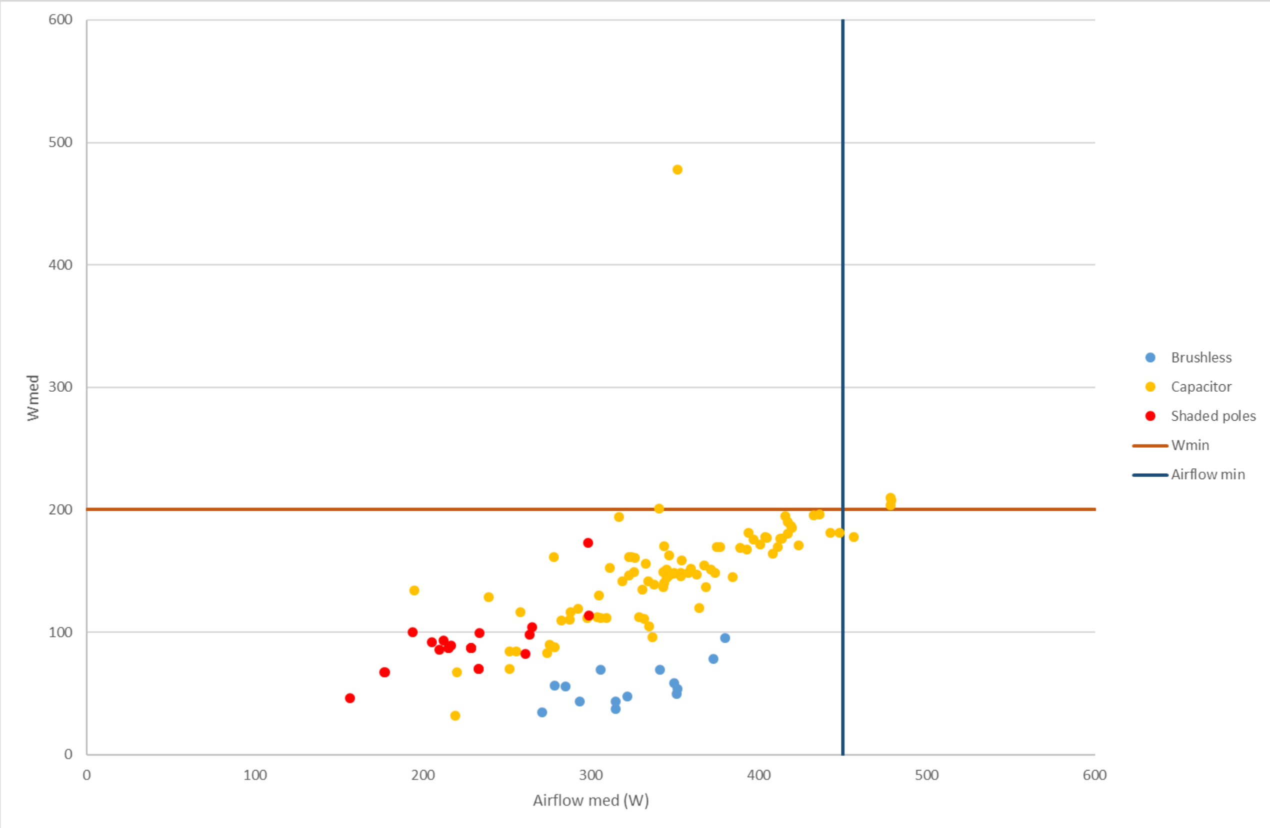



**Figure 289. Power average at 9-points vs airflow average at 9-points**

It has also been suggested to have a maximum airflow as a requirement to avoid excessively large CFEs in the market. In this regard, capacitor motors and shaded poles motors show a strong correlation between AEC and airflow; however, brushless motors deliver air flows larger than 300$m^3/h$ at low power. In order to optimise the dimensions of the CFE, it may be more appropriate to set a **maximum power as a 9-point average**, instead of airflow. This limit would target capacitor and shaded poles motors, and the evolution towards more efficient motors (more airflow delivered at lower power) would not be affected.

### 7.5.6 Lighting

Cooking fume extractors contain products according to the product Regulations for lighting (EU) 2019/2020 and (EU) 2019/2015 applicable from 1 September 2021. This means that the light sources used have their own requirements and only LED lights will be used in the future. An icon on the label is no longer necessary from our point of view because suppliers of products containing lighting have to provide information on the light sources according to the aforementioned Regulations.

Regarding whether lighting should be included in the calculation of the EEI, most models in the APPLiA database are equipped with LED lights. However, its contribution to the total energy consumption can be significant (up to 35%), particularly for brushless motor CFEs with low power and low energy consumption, where the share of lighting is increased (Figure 290).

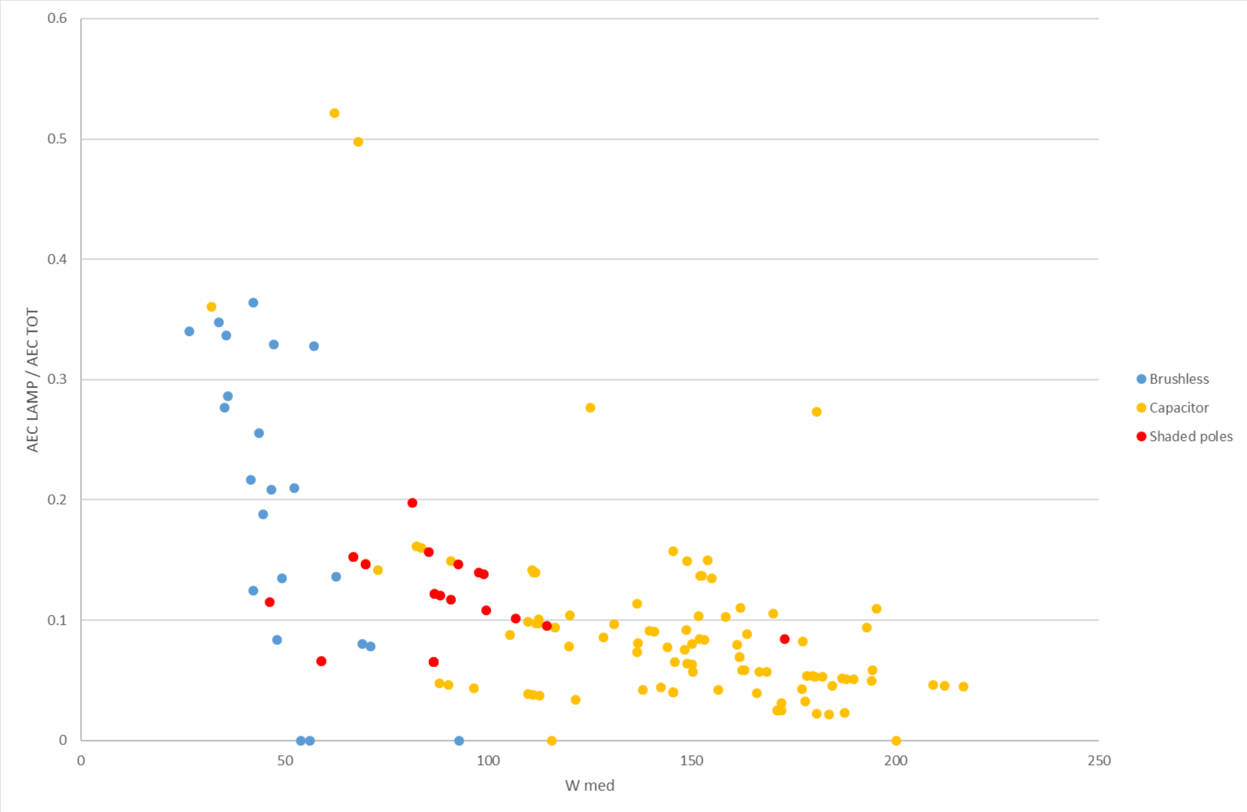



**Figure 290. Ratio Annual Energy Consumption Lighting / Annual Energy Consumption CFE + Lighting**

Displays which are integrated into range hoods need to be assessed as well as they are exempted from Regulation 2019/2021 according to Article 2 g) thereof:

“This Regulation shall not apply to [...] electronic displays that are components or sub-assemblies as defined in point 2 of Article 2 of Directive 2009/125/EC.”

Currently, the Ecodesign Regulation states that the average illumination of the lighting system on the cooking surface (E middle) shall be higher than 40 lux when measured under standard conditions. Some comments suggest that this value should be increased to 100 lux for proper lighting in cooking.

Some manufacturers also recommend not including lighting in the annual energy consumption, but setting a minimum energy efficiency, e.g. 20 lux per watt, which is currently class B for lighting

### 7.5.7 Noise

The Noise Value (in dB) is measured as the airborne acoustical A-weighted sound power emissions (weighted average value — L WA ) of a domestic range hood at the highest setting for normal use, intensive or boost excluded, and rounded to the nearest integer.

Some CFEs are currently available on the market with more than one boost level, allowing the highest setting for normal use to correspond to a lower load than with only one boost level. It is recommended that only one boost or intensive level is allowed in CFEs.

## 7.6 Horizontal policy options

### 7.6.1 Commercial and professional cooking appliances

The current Regulations do not include commercial or professional cooking appliances in the scope. The potential inclusion of professional cooking appliances under the project scope was considered from the very beginning of this preparatory study, as in its Article 7, Ecodesign Regulation 66/2014 indicates that:

*The review of the regulation shall assess, amongst others, the inclusion of professional and commercial appliances.*

The first of the aspects to consider was whether commercial and/or professional cooking appliances should have ecodesign and energy labelling regulation at all. Against the development of regulation, three main arguments were provided: different usage patterns, wider variability of products and the fact that commercial products are commonly part of a wider system (see Task 1 for more detail). In favour of developing regulation, two main arguments were provided: the professional sector may be potentially high in terms of energy consumption, and it could be a driver for improvement in energy efficiency.

If ED/EL regulation was developed, it could be either together with the regulation for domestic appliances or separated. The advantages of separating regulation is that it would be easier to address the different usage patterns and needs of consumers, and it would also give time for the development of testing standards in the professional sector. However, separating would potentially delay the introduction of energy efficiency measures in the sector.

Considering the reasoning above provided by relevant stakeholders, it has been concluded that regulation for commercial/professional cooking appliances is necessary, since it is potentially a high-impact energy consumption sector with potential for improvement. Regulation in the commercial/professional sector could boost innovation and be a driver for efficiency.

In order to provide appropriate ecodesign requirements, the Regulation for commercial/professional cooking appliances is proposed to be specific and separated from the domestic cooking appliances Regulation. This will ensure that every requirement and energy labelling category defined are suitable and meaningful, considering sector-specific user needs.

This approach is supported by most of the consulted stakeholders. According to one stakeholder, in a 2011 report concerning the Ecodesign Regulation for cookers, it was underlined that most of energy savings could be achieved by modifying the cooks behaviour (for example, by not switching on appliances too early in the morning, by teaching cooks how to use the energy-saving options of appliances, etc.). Not taking into account these energy-consuming behaviours could reduce the impact of any energy efficiency work carried out on products. They added that for most catering equipment (except for cooktops and ovens), there is no existing energy efficiency/rational use of energy tests. Some new tests of rational use of energy are in development in standardisation committee CEN TC 106, but they have only been tested on very few appliances. Thus, it should be considered that they have to be tested on more appliances in order to check their representativeness and reliability and in order to have a clear idea of the performances of appliances before choosing any requirement. As a consequence, we think that it should be appropriate to regulate first cooktops and ovens and to allow a little more time to develop, test and validate energy consumption methods for other appliances.

Another stakeholder highlighted that a precise and tight timeline should be defined in order to avoid delays. Test methods are almost ready for certain appliances (like professional ovens).

### 7.6.2 Low power modes

In Section 1.3.1.1 of this report, different aspects of low power modes (standby and off mode) are detailed for cooking appliances. A particular aspect of low power modes in these product groups is that currently it is covered horizontally for two of them (ovens and hobs under Regulation 1275/2008), whereas a vertical approach is taken for cooking fume extractors: specific requirements are given in REG 66/2014.

For new regulation, a common recommendation from different stakeholders is to have a uniform approach for the three product groups, either horizontally under Regulation 1275/2008 or vertically with specific requirements in the new cooking appliances Ecodesign Regulation.

Currently, most of the product groups are covered under the horizontal regulation (REG 1275/2008). Specific requirements are given for complex products in terms of low power modes. For instance, electronic displays may have functions such as presence detection, touch functionality or HiNA (High Network Availability) that are related to low power modes and for which specific requirements need to be given. A similar case are appliances that have a delay start functionality, such as washing machines, washer dryers or dishwashers. With this functionality, the appliance needs to remain in a low power mode until it starts the delayed operation, so a minimum power consumption needs to be provided for that period (as well as a maximum time for the delayed start).

As in the case of washing machines, washer dryers, dishwashers, etc., it is recommended that low power modes are covered in vertical regulation. For new regulation on cooking appliances, the following recommendations are made (Table 140).

**Table 140. Low power mode requirements for cooking appliances**

<table>
<tr><th></th><th>Off mode limit (W)</th><th>Standby limit (W)</th><th>Networked standby (W)</th><th>Exceptions and other low power requirements</th></tr>
<tr><td>Ovens</td><td>Mandatory available, max 0.5 W</td><td>Mandatory available, max 0.5 W</td><td>If available, max 2 W</td><td rowspan="3">-If the standby mode includes the display of information or status, the power consumption of this mode shall not exceed 1.00 W.<br>-If the standby mode provides for a connection to a network and provides networked standby, the power consumption of this mode shall not exceed 2.00 W.<br>-After 15 minutes of inactivity, the appliance shall switch automatically to off mode or standby mode<br>-If the appliance provides for a delayed start, the power consumption of this condition, including any standby mode, shall not exceed 4.00 W. The delayed start shall not be programmable by the user for more than 24 h later.<br>-Any appliance that can be connected to a network shall provide the possibility to activate and deactivate the network connection(s). The network connection(s) shall be deactivated by default.</td></tr>
<tr><td>Hobs</td><td>Mandatory available, max 0.5 W</td><td>Mandatory available, max 0.5 W</td><td>If available, max 2 W</td></tr>
<tr><td>Range hoods</td><td>Mandatory available, max 0.5 W</td><td>Mandatory available, max 0.5 W</td><td>If available, max 2 W</td></tr>
</table>

### 7.6.3 Material efficiency

Since 2009, EU ecodesign and energy labelling are gradually introducing requirements on material efficiency, initially of an informational character only, but lately also including specific thresholds. Material efficiency requirements are also present in a number of examples of voluntary agreements and labels such as EU Ecolabel, German Blue Angel or the Nordic Swan. This development has been accompanied by the increasing importance of research on the feasibility of implementing resource efficiency aspects into product policies, as reflected in at least six European research studies published since 2013 (Ardente & Talens Peirò, 2015; Benton et al., 2015; Bobba et al., 2015; Deloitte, 2016; Prakash et al., 2016; Ricardo-AEA, 2015).

There are various causes for the slower uptake of requirements in mandatory policies, including for instance the lack of enforceable and relevant metrics, the lack of proper standards to measure the requirements, and the lack of data demonstrating the benefits of minimum material efficiency requirements, to justify the thresholds. It is widely accepted that any new resource efficiency requirement should be measurable, enforceable and relevant and should not hinder innovation and competitiveness. Additionally, any new requirements should have a proven environmental benefit and thus be based on robust data, methodologies and widely recognised standards that confirm this. Generic standard methods related to material efficiency applicable to energy-related products have been published recently and are described in Section 1.2.4 of this report.

Manufacturers have also stressed the need to make sure that ecodesign product measures do not overlap with other existing regulations that are already imposing end-of-life provisions and material/resource provisions, such as the REACH, RoHS, WEEE and F-Gas Directives.

Policy options related to material efficiency have already been presented in preparatory studies for other energy-related products (dishwashers, washing machines, etc.). The assessment of those preparatory studies shows that there is general agreement on the need for requirements that improve durability, such as information about the technical lifetime of the products, of spare part availability, or of design for upgrades and repairs. This section describes an array of policy options for extending the durability of domestic cooking appliances and facilitating reparability, as well as proper management of the appliance during the end-of-life stage.

In Section 4.4.3 of this report, some information was provided regarding critical parts and failures in domestic cooking appliances specifically. In external reports, some data is provided regarding the frequency of failure and main components requiring attention (see Task 4 of report). According to manufacturers, they have no reliable data available about the most frequently occurring failures and defects. In terms of the most common failures in components for ovens, hobs and cooking fume extractors, their feedback is as follows:

**Ovens**: a very wide variety of technologies is used, from very basic models up to highly complex appliances with an integrated microwave and/or steam function with TFT displays and Wifi connection for example. Therefore, a general recommendation about the most frequently failing components cannot be made.

**Hobs**: as there are many hob technologies available (radiant, gas, induction) and different solutions are offered within one technology, a general solution to occurring failures/defects cannot be given.

**Cooking fume extractors**: the main recurrent complaints are “the appliance is too loud” and “does not evacuate well”. In most cases, this is due to incorrect installation.

#### 7.6.3.1 Material efficiency requirements for domestic cooking appliances

In terms of **availability of spare parts**, it is recommended that the manufacturers of cooking appliances make available at least the following spare parts, for the indicated period of time (Table 141).

**Table 141. Recommended spare part availability of cooking appliances**

| | Spare part availability | | | |
|---|---|---|---|---|
| | **Available for** | **List of parts** | **Available when** | **Available for a period of** |
| **Electric ovens** | Professional repairers | Door hinges, door springs, door glass, door seals, thermostats, sensors, regulators, fans, fan blades, fan motors, displays, heating elements, grill elements, wires & cables, electrical fittings, switches, printed circuit boards, software & firmware | At least 2 years after placing on the market the first unit | 10 years |
| | Professional repairers & End users | Cooking racks, side racks, pans, light bulbs, knobs, door handles, | When placing on the market the first unit of a model | 10 years |
| **Gas ovens** | Professional repairers | Door hinges, door springs, door glass, door seals, thermostats, sensors, regulators, fans, fan blades, fan motors, displays, burners, grill elements, igniters, burner valves, safety valves, gas fittings, gas injectors, nozzles, gas pipes, thermocouples, printed circuit boards, software & firmware | At least 2 years after placing on the market the first unit | 10 years |
| | Professional repairers & End users | Cooking racks, side racks, pans, light bulbs, knobs, door handles | When placing in the market the first unit of a model | 10 years |
| **Steam ovens (solo & combi)** | Professional repairers | Door hinges, door springs, door glass, door seals, thermostats, sensors, regulators, fans, fan blades, fan motors, displays, heating elements, grill elements, wires & cables, electrical fittings, switches, water tanks, water pipes & hoses, printed circuit boards, software & firmware | At least 2 years after placing on the market the first unit | 10 years |
| | Professional repairers & End users | Cooking racks, side racks, pans, light bulbs, knobs, door handles | When placing in the market the first unit of a model | 10 years |
| **Combi MW ovens** | Professional repairers | Door hinges, door springs, door glass, door seals, thermostats, sensors, regulators, fans, fan | At least 2 years after placing on the market the | 10 years |

| | | | | |
|---|---|---|---|---|
| | | blades, fan motors, displays, heating elements, grill elements, wires & cables, electrical fittings, switches, turntable motors, magnetrons, printed circuit boards, software & firmware | first unit | |
| | Professional repairers & End users | Cooking racks, side racks, pans, light bulbs, knobs, door handles | Wwhen placing in the market the first unit of a model | 10 years |
| **Solo MW ovens** | Professional repairers | Wires & cables, electrical fittings, switches, displays, turntable motors, magnetrons, printed circuit boards, software & firmware | At least 2 years after placing on the market the first unit | 10 years |
| | Professional repairers & End users | Knobs, door handles, turntable couplers, glass turntables, turntable roller rings, lamps, feet, waveguide covers | When placing in the market the first unit of a model | 10 years |
| **Hobs** | Professional repairers | Grill pans, pan support, burner caps, burners, hotplates, ignitors, knobs, lamps, PCB, wwitches, thermocouples, hob top, valves | At least 2 years after placing on the market the first unit | 10 years |
| | Professional repairers & End users | Switches | When placing in the market the first unit of a model | 10 years |
| **Cooking fume extractors** | Professional repairers | Motor and motor brushes, fan, printed circuit boards, electronic displays, motor protection switches and fuses, software and firmware including reset software, cabinet | At least 2 years after placing on the market the first unit | 10 years |
| | Professional repairers & End users | Speed switches, on/off switches, filters, lighting, plastic peripherals | When placing in the market the first unit of a model | 10 years |

Manufacturers shall ensure that the spare parts mentioned above can be replaced with the use of commonly available tools and without permanent damage to the appliance.

The list of spare parts and the procedure for ordering them shall be publicly available on the free-access website of the manufacturer, importer or authorised representative, at the latest 2 years after the placing on the market of the first unit of a model and until the end of the period of availability of these spare parts.

During the period mentioned in Table 141, the manufacturer shall ensure the delivery of the spare parts within 15 working days after having received the order.

In terms of **access to repair and maintenance information**, after a period of 2 years after the placing on the market of the first unit of a model, and until the end of the period mentioned in Table 141, the manufacturer, importer or authorised representative shall provide access to the appliance repair and maintenance information to professional repairers.

The manufacturer's website shall indicate the process for professional repairers to register for access to information. To accept such a request, the manufacturers may require the professional repairer to demonstrate that the professional repairer has the technical competence to repair cooking appliances and complies with the applicable regulations for repairers of electrical equipment in the Member States where it operates; and that the professional repairer is covered by insurance covering liabilities resulting from its activity.

The manufacturers shall accept or refuse the registration within 5 working days from the date of the request.

The manufacturers may charge reasonable and proportionate fees for access to the repair and maintenance information or for receiving regular updates. A fee is reasonable if it does not discourage access by failing to take into account the extent to which the professional repairer uses the information.

Once registered, a professional repairer shall have access, within 1 working day after requesting it, to the requested repair and maintenance information. The information may be provided for an equivalent model or model of the same family, if relevant.

The available repair and maintenance information shall include:

- the unequivocal appliance identification;
- a disassembly map or exploded view;
- a list of necessary repair and test equipment;
- component and diagnosis information;
- wiring and connection diagrams;
- diagnostic fault and error codes;
- instructions for installation of relevant software and firmware including reset software;
- information on how to access data records of reported failure incidents.

The user instructions shall also include instructions for the user to perform maintenance operations. Such instructions shall as a minimum include instructions for:

- periodic cleaning, including optimal frequency;
- periodic checks of filters, including optimal frequency, and procedure;
- identification of errors, the meaning of the errors, and the action required, including identification of errors requiring professional assistance;
- how to access professional repair (internet webpages, addresses, contact details).

Such instructions shall also include information on any implications of self-repair or non-professional repair for the safety of the end user and for the guarantee; the minimum period during which the spare parts for the appliances are available.

In terms of **dismantling requirements** for material recovery and recycling, manufacturers shall ensure that cooking appliances are designed in such a way that the materials and components referred to in Annex VII to Directive 2012/19/EU (WEEE Directive) can be removed with the use of commonly available tools. Moreover, manufacturers shall fulfil the obligations laid down in Article 15, Point 1 of Directive 2012/19/EU (WEEE Directive, Information for treatment facilities).

In terms of **mandatory marking**, this requirement on marking is aimed to better identify the presence of Annex VII WEEE (2012/19/EU) components that need separate treatment. For the components applicable, the marking shall be readable for operators in treatment/recycling, as well as for direct visual inspection and control for market surveillance purposes. The F-gas marking shall be on the back panel. The capacitor marking shall be on the capacitor itself. Both markings shall be identifiable and legible to the naked eye from a distance of approximately 2 m. The marking must be indelible and durable for at least the average lifetime of the appliance. Standardisation bodies are given the task of defining the adequate material characteristics, size, shape, etc. for the purpose described.

Similarly, in terms of **design for dismantling for the purpose of depollution**, this requirement is aimed to help recyclers to better comply with the WEEE Directive (2012/19/EU). It is proposed that access to and extraction of the components of concern (WEEE Annex VII, 2012/19/EU) is ensured without the need for any tools that are either proprietary or not commonly available, in order to disassemble the fixings of these WEEE-related components.

In terms of **critical raw materials**, this information requirement will help recyclers to identify the critical raw materials present in the appliance, and promote their recovery and recycling. The manufacturers will provide a list of components and critical raw materials, ensuring the access and extraction of those components according to the previous section.

Finally, in terms of **recycled content**, for future revisions, it is recommended to explore the possibility to set Ecodesign measures on minimum recycled content.

### 7.6.4 Policies related to hydrogen as an energy source

For coherence with other product groups where hydrogen is also being considered as an energy source, the following measures might be considered by the Commission, regarding both gas hobs and ovens:

- A requirement stating that from a specific date after this Regulation entering into force, gas hobs and ovens shall be able to operate safely and efficiently with a blend of a fossil gas and up to at least 20% hydrogen.
- For gas ovens and hobs marketed as hydrogen-ready (able to operate with 100% hydrogen), some sort of voucher and/or converstion kit might be provided –for free– that guarantees that the appliance might be easily converted from using the current blend, to 100% hydrogen.
- For gas ovens marketed as hydrogen-ready, energy consumption shall be calculated using a PEF = 1.6 for hydrogen, in order to account for energy losses that occur during the production of this energy source. With this measure, the same oven might have a different energy class when it operates with natural gas to when it operates with hydrogen.

## 7.7 Scenario analysis

The objective of this section is to set up a stock model (2020-2040) and calculate the impact of different policy scenarios regarding resource use (energy), greenhouse gas (GHG) emissions ($CO_2$eq) and consumer expenditure, depending on the market evolution of domestic cooking appliances. The different policy options are defined in the previous sections.

Note that the calculated impacts for the different scenarios are indicative. The scenarios defined in this section are a simplification and are not intended as a forecast of the future market behaviour in this sector. A full impact assessment will be developed later in the policy process where the findings from this study can be refined.

### 7.7.1 Policy scenarios for ovens

This section aims to define and evaluate different policy scenarios for domestic ovens. The scenarios will consist of a combination of the different policy options presented in previous sections. The implementation of certain policies will have consequences for the market. The aim of this section is not to conduct a comprehensive market analysis of the domestic oven sector or to forecast the market evolution, but to evaluate the potential consequences of some of the presented policies, as well as their benefits and drawbacks in terms of overall EU energy consumption, GHG emissions or consumer expenditure.

Before defining the different scenarios to evaluate, different aspects related to previous sections need to be established. For instance, it has been observed that the adoption of BM2.0 has certain benefits and there is a significant level of agreement within industry about them.

In addition, for the declaration of energy consumption and determination of the energy class, based on feedback received from stakeholders, the weighted sum approach seems to be accepted by different members of the industry, with a preference for the 80/20 option. Therefore, in this section, every scenario will be evaluated with the energy consumption measured with BM2.0, declaring it as a weighted sum at 80/20 between a conventional mode and the best performing mode (BPM).

The calculation of the overall EU energy consumption is conducted in the following manner. As an example, the formulas show the overall energy consumption of Class A ovens in 2020:

*Overall Energy Consumption Class A (kWh) in 2020 =*

*Stock Ovens 2020 (units) * Market Penetration Class A 2020 (%) * Annual Energy Consumption Class A (kWy/year)*

Identical calculations are then made for every year between 2020 and 2040, and for every energy class in the market. To conduct the above operations, a value for Annual Energy Consumption is required for each energy class. For ovens, this will be related with the base cases and design options presented in Tasks 5 and 6.

Base cases and design options in Tasks 5 and 6 were presented using the current measurement method for energy consumption (BM1.0). However, the scenario evaluation will be conducted assuming that BM2.0 has been adopted. The base cases and design options cannot be measured with BM2.0 because these are hypothetical appliances: an average representation of the market. Therefore, in order to use these base cases in the scenario evaluation, their energy consumption values will need to be *translated* to BM2.0. To do that, the correction factors below will be used. These correction factors have been calculated using APPLIA2020.

**Table 142. Conversion factors BM1.0 to BM2.0**

| **Conventional** | **Fan-forced** |
|---|---|
| 0.95 | 1.04 |

When the design options are defined, they are presented as an individual technology isolated from the rest. That means that the energy consumption savings of each technology are considered separately. For instance, the benefits of DO1 are not considered together with the benefits of DO6. It can be assumed that combinations of the design options presented could achieve higher energy savings, obtain a lower EEI and therefore reach higher energy classes.

In terms of the Annual Energy Consumption (AEC) of each energy class and stock at reference year, the following estimations and assumptions have been made (Table 143). The stock has been estimated based on data from APPLIA2020.

**Table 143. Energy class, AEC and stock at reference year**

| Energy class | AEC (kWh/year) | Stock at reference year (%) |
|---|---|---|
| G | 198.5 | 0% |
| F | 185.8 | 1.9% |

| | | |
|---|---|---|
| E (BC1) | 156.8 | 42.6% |
| D (DO1) | 150.0 | 36.3% |
| D (DO2) | 143.9 | 10.4% |
| D (DO5) | 141.3 | 2.6% |
| D (DO6) | 134.3 | 2.6% |
| C | 123.9 | 3.7% |
| B | 107.5 | 0% |
| A | 100.2 | 0% |

Every scenario defined in this section will have as a starting point the data presented in this section, in terms of energy class market penetration and annual energy consumption. The scenarios presented will mostly change the market penetration of each energy class and therefore the overall energy consumption. Energy savings will be estimated, considering a business as usual (BAU) situation and the different scenarios.

#### 7.7.1.1 Business as usual scenario electric ovens

The definition of the business as usual (BAU) scenario for domestic ovens is based on the assumption that no additional regulation is implemented. The BAU scenario is only used for reference as it is highly unlikely that nothing will change in the energy label given.

The sales evolution for the period 2020-2040 has been estimated using GfK data (Figure 291). In BAU, the sales percentage of each energy class remains constant for that period. The only change in this scenario would be the rescaling of the energy classes to the new A-G scale.

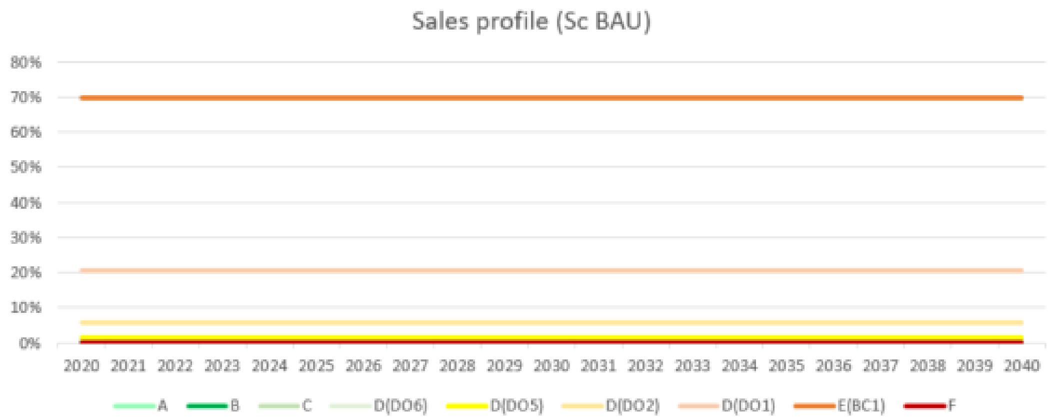



**Figure 291. BAU electric ovens – Estimated sales**

In the BAU scenario it is assumed that the current stock is approximately the same as the one represented by APPLIA2020. Based on that data and on the estimated sales profile, the estimated stock of ovens between 2020 and 2040 and the distribution of energy classes for the BAU scenario will be as in Figure 292. The stock of electric ovens between 2020 and 2040 is shown in Figure 292.

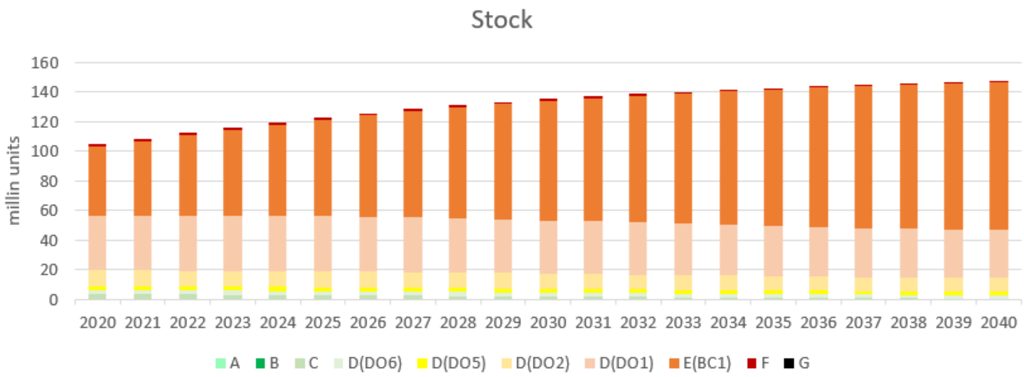



**Figure 292. BAU electric ovens – Estimated stock**

The total energy consumption of the above stock of ovens is presented in Figure 293. Energy consumption follows a similar pattern to the stock, a growth during the period 2020-2040, from 15.9 TWh to 22.6 TWh.

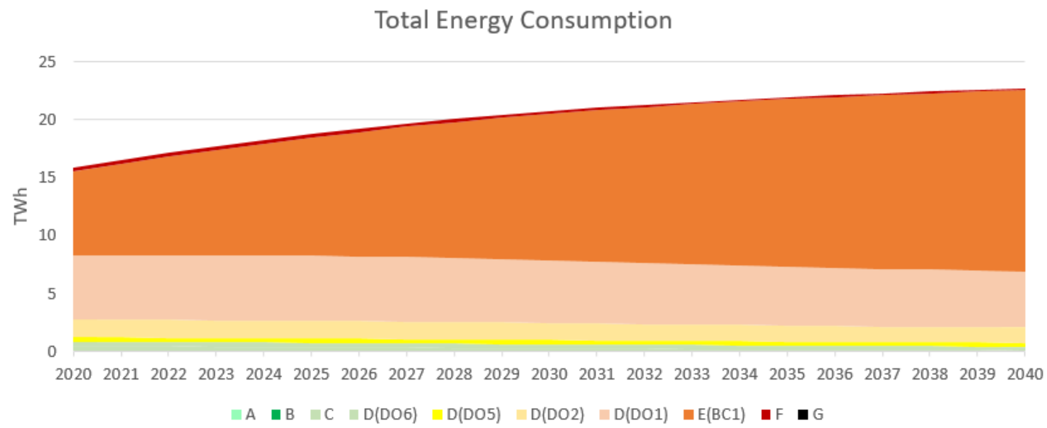



**Figure 293. BAU electric ovens – Estimated energy consumption**

In the following sections, alternatives to the BAU scenario will be presented and evaluated.

#### 7.7.1.2 Definition of scenarios for electric ovens

In Section 7.2.6, policy options for the declaration of energy consumption are presented and evaluated based on feedback from stakeholders. In Section 7.2.7, different alternatives for rescaling energy classes are presented. Based on that, different options for ecodesign minimum energy performance thresholds are presented in Section 7.2.8. The combination of these aspects allows the definition of four different scenarios, which will be evaluated in the following sections. Scenarios 1 to 4 are presented in Table 144.

**Table 144. Scenario definition for electric ovens**

<table>
<tr><th rowspan="2">Scenario</th><th rowspan="2">SEC</th><th colspan="3">Ecodesign</th><th rowspan="2">Energy classes (1)</th></tr>
<tr><th>Tier 1: 2025</th><th>Tier 2: 2027</th><th>Tier 3: 2030</th></tr>
<tr><td>1</td><td>Linear</td><td>EEI < 116</td><td>EEI < 110</td><td>EEI < 105</td><td rowspan="3">A EEI < 66<br>B 66 ≤ EEI < 77<br>C 77 ≤ EEI < 88<br>D 88 ≤ EEI < 101<br>E 101 ≤ EEI < 116</td></tr>
<tr><td>2</td><td>Flat</td><td>EEI < 116</td><td>EEI < 110</td><td>EEI < 105</td></tr>
<tr><td>3</td><td>Linear</td><td>EEI < 101</td><td>EEI < 96</td><td>EEI < 91</td></tr>
</table>

| | | | | | |
|---|---|---|---|---|---|
| 4 | Flat | EEI < 101 | EEI < 96 | EEI < 91 | **F** 116 ≤ EEI < 134<br>**G** EEI > 134 |

(1) Energy classes to promote differentiation. See Section 7.2.7.2.

#### 7.7.1.3 Scenario 1 electric ovens – Linear SEC and EEI = 116 in 2025

In Scenario 1, the SEC is defined using a linear regression. Energy consumption is declared with an 80/20 weighted sum (80% conventional, 20% BPM). Ecodesign thresholds are based on the removal of the two worst energy classes in Tier 1. Energy class thresholds are defined to promote differentiation between appliances.

A potential evolution of the sales of electric ovens for that scenario is shown in Figure 294. The sales of the starting point (2020) are based on market data from GfK.

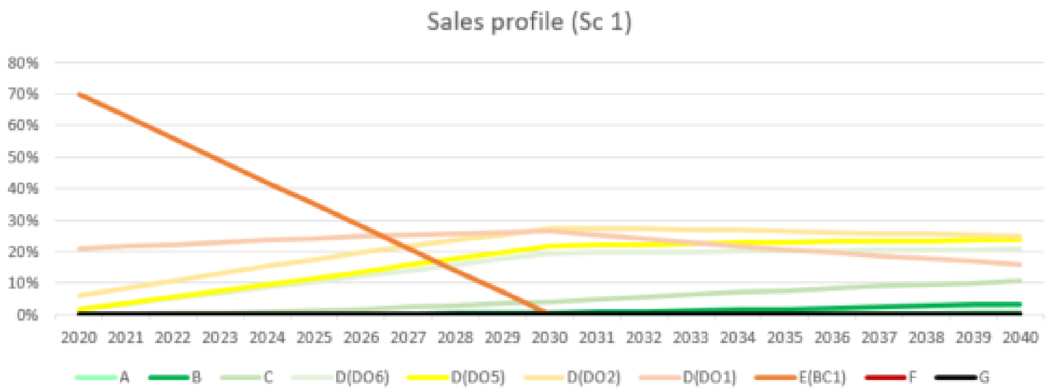



**Figure 294. Scenario 1 electric ovens – Estimated sales**

Ecodesign thresholds in this scenario only affect the lowest energy classes. F and G ovens will be removed from the market by 2025, although their market share is already very low. E ovens (represented by Base Case 1, BC1) will be removed from the market by 2030.

Since ecodesign thresholds do not affect classes D and above, it has been assumed that the sales of E ovens are shared in equal parts by the sales of D ovens (DO1, DO2, DO5, DO6), and not higher. On top of that, it has been assumed that each year 5% of the sales of every energy class jumps to the one above.

The effect of those sales on the stock can be seen in Figure 295. The stock of E ovens is progressively replaced by D ovens. Ecodesign thresholds affecting only the lowest energy classes mean that most of the ovens in households during 2020-2040 are D. There is also a small increase in the stock of A, B and C ovens over that period.

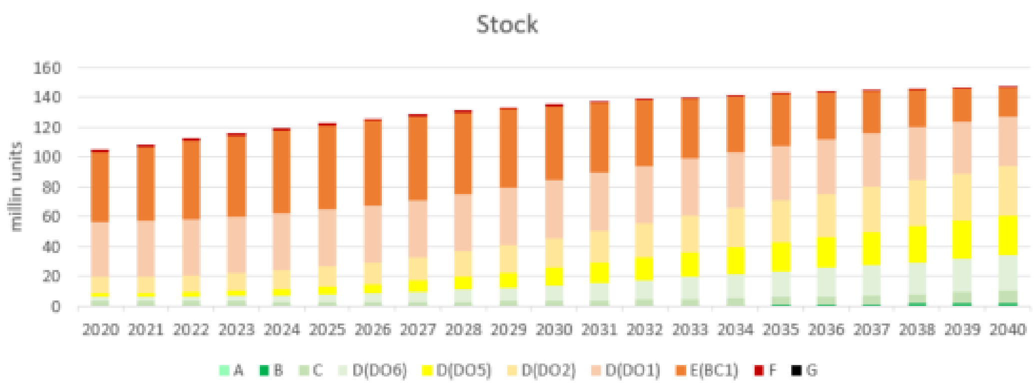



**Figure 295. Scenario 1 electric ovens – Estimated stock**

The total energy consumption of the above stock can be seen in Figure 296.

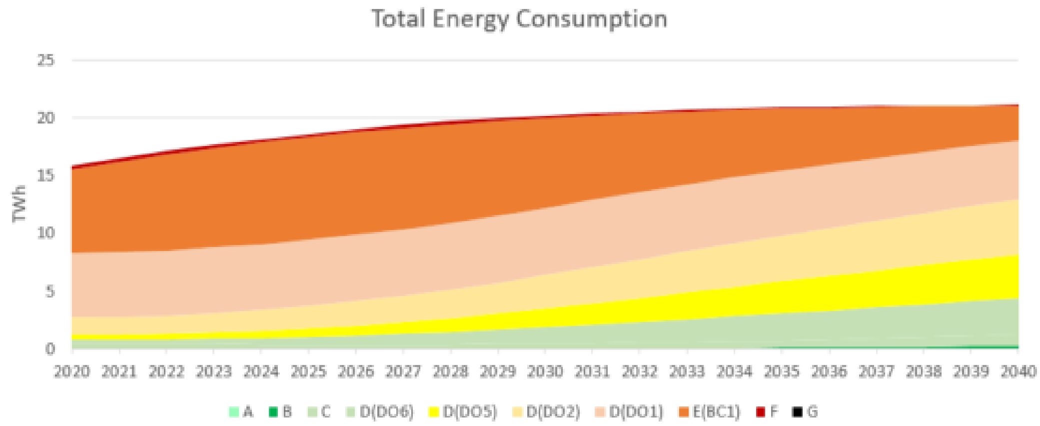



**Figure 296. Scenario 1 electric ovens – Total Energy Consumption**

Energy consumption shows an increase during the period 2020-2040, from 15.9 TWh to 21.1 TWh. In 2020, most of energy consumption is associated with E and D (DO1) ovens. Over that period, this situation changes and by 2040 most of the energy consumption is associated with D ovens (DO1, DO2, DO5 and DO6).

#### 7.7.1.4 Scenario 2 electric ovens – Flat SEC and EEI = 116 in 2025

In Scenario 2, the SEC is defined using a flat approach. Energy consumption is declared with an 80/20 weighted sum (80% conventional, 20% BPM). Ecodesign thresholds are based on the removal of the two worst energy classes in Tier 1. Energy class thresholds are defined to promote differentiation between applianes.

The sales and stock in terms of energy class are equivalent to the sales and stock of Scenario 1 (Figure 294 and Figure 295).

In Scenario 1, it was assumed that every oven in the market had a cavity volume of 70 litres (the same as the base case). To model the effect of the flat approach (which benefits smaller ovens), it has been assumed for Scenario 2 that the cavity volume of ovens changes progressively from 70 litres in 2020 to 50 litres in 2040 (with the energy consumption reduced accordingly).

As a result, the total energy consumption of Scenario 2 grows from 15.9 TWh in 2020 to 18.2 TWh in 2040 (Figure 297).

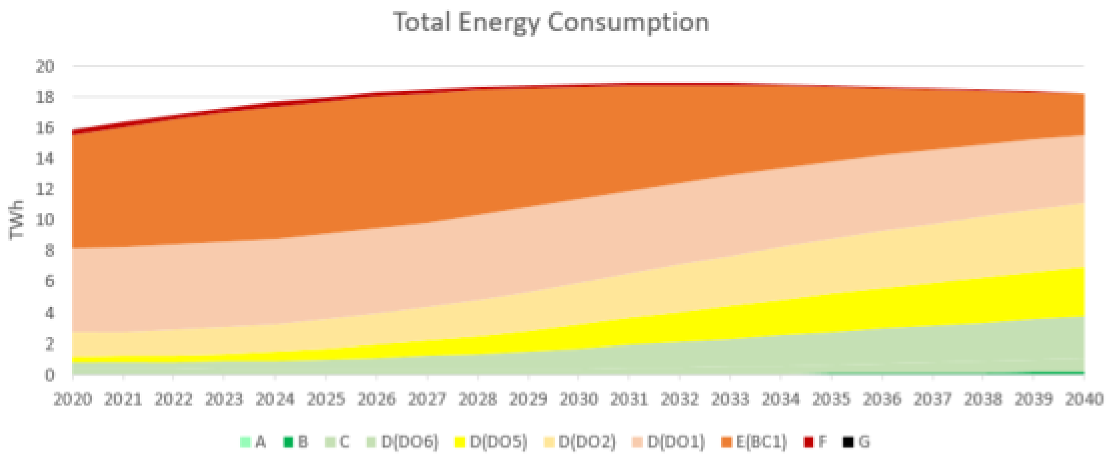



**Figure 297. Scenario 2 electric ovens – Total Energy Consumption**

Again, in 2020, most of the energy consumption is associated with E and D (DO1) ovens. Over that period, this situation changes and by 2040 most of the energy consumption is associated with D ovens (DO1, DO2, DO5 and DO6).

#### 7.7.1.5 Scenario 3 electric ovens – Linear SEC and EEI = 101 in 2025

In Scenario 3, the SEC is defined using a linear regression. Energy consumption is declared with an 80/20 weighted sum (80% conventional, 20% BPM). Ecodesign thresholds are based on the Least Life Cycle Cost in Tier 1. Energy class thresholds are defined to promote differentiation between appliances.

A potential evolution of the sales of electric ovens for that scenario is shown in Figure 298.

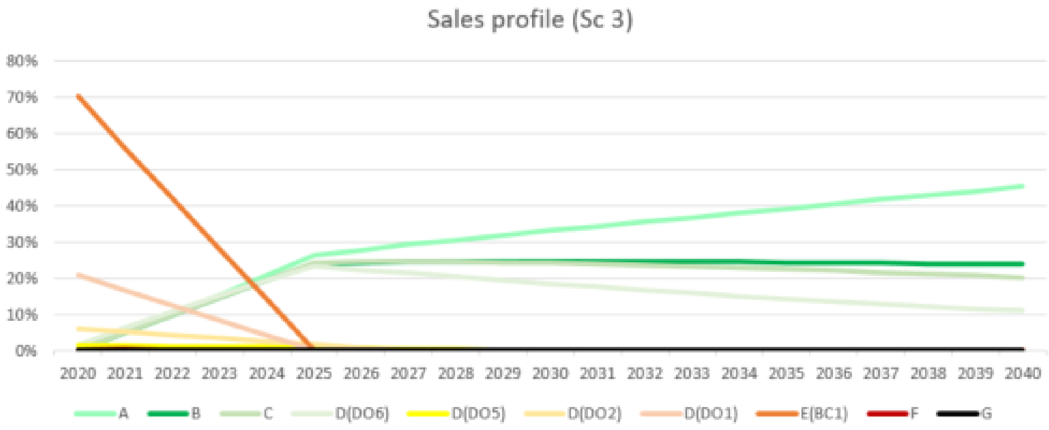



**Figure 298. Scenario 3 electric ovens – Estimated sales**

Ecodesign thresholds in this scenario affect the lowest and medium energy classes. F, G, E and D (DO1) ovens will be removed from the market by 2025. D (DO2) ovens will be removed by 2027 and D (DO5) will be removed by 2030.

It has been assumed that the sales of ovens removed from the market are shared in equal parts by the sales of A, B, C and D (DO6) ovens. On top of that, it has been assumed that each year 5% of the sales of every energy class jumps to the one above.

The effect of those sales on the stock can be seen in Figure 299.

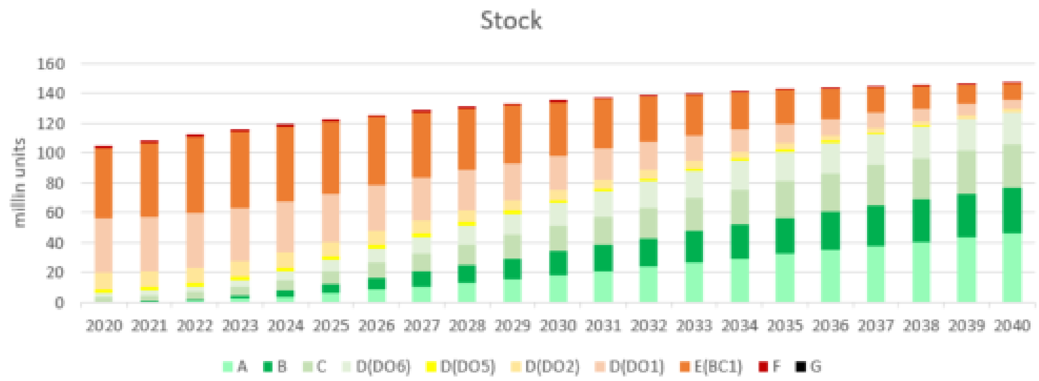



**Figure 299. Scenario 3 electric ovens – Estimated stock**

The stock of E, D (DO1), D (DO2) and D (DO5) ovens is progressively replaced by A, B, C and D (DO6) ovens. Therefore, in Scenario 3 there is a higher increase in the stock of A, B and C ovens over the 2020-2040 period.

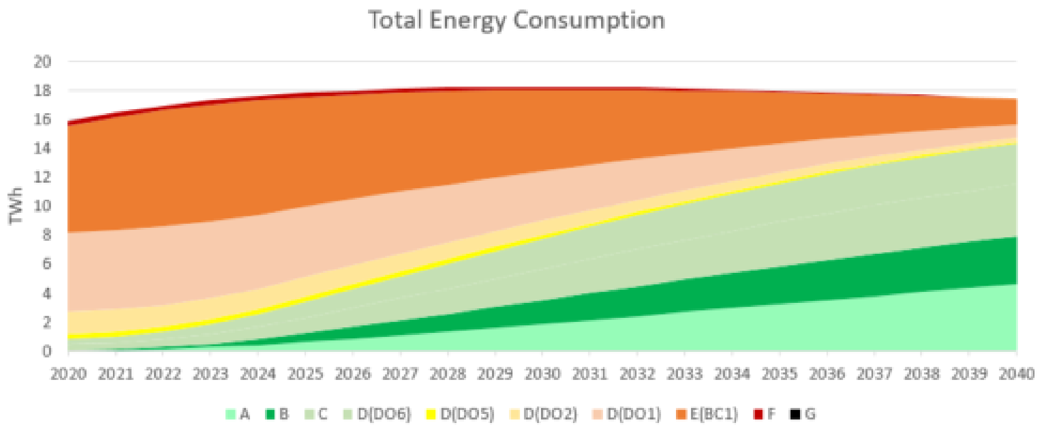



**Figure 300. Scenario 3 electric ovens – Total Energy Consumption**

As a result, the total energy consumption of Scenario 3 increases from 15.9 TWh in 2020 to 17.5 TWh in 2040. Most of the energy consumption in 2020 is associated with E and D (DO1) ovens, whereas in 2040 most of the energy consumption is associated with A, B and C ovens.

#### 7.7.1.6 Scenario 4 electric ovens – Flat SEC and EEI = 101 in 2025

In Scenario 4, the SEC is defined using a flat approach. Energy consumption is declared with an 80/20 weighted sum (80% conventional, 20% BPM). Ecodesign thresholds are based on the removal of the two worst energy classes in Tier 1. Energy class thresholds are defined to promote differentiation between appliances.

The sales and stock in terms of energy class are equivalent to the sales and stock of Scenario 3 (Figure 298 and Figure 299). As in Scenario 2, in Scenario 4 it has been assumed that the cavity volume of ovens changes progressively from 70 litres in 2020 to 50 litres in 2040 (with the energy consumption reduced accordingly).

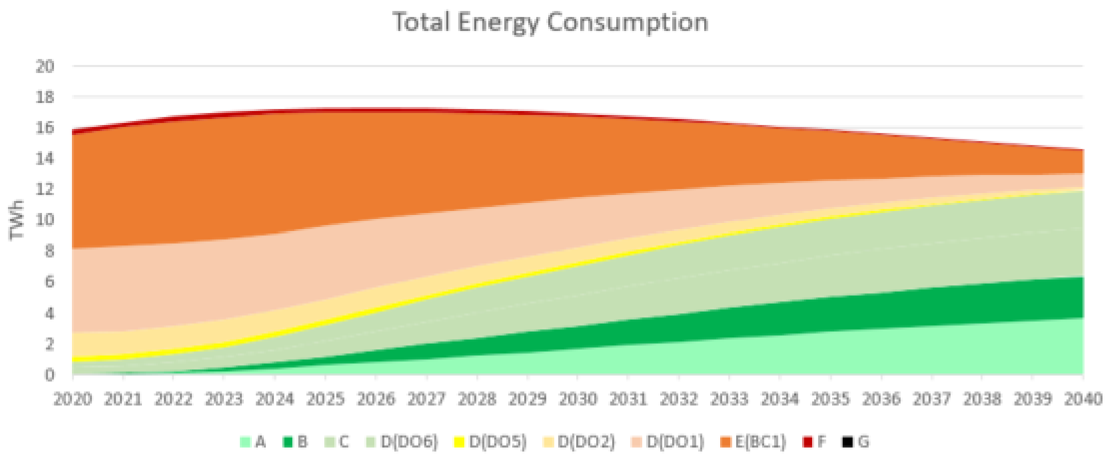



**Figure 301. Scenario 4 electric ovens – Total Energy Consumption**

As a result, the total energy consumption of Scenario 2 decreases from 15.9 TWh in 2020 to 14.6 TWh in 2040 (Figure 301).

#### 7.7.1.7 Impacts on energy consumption electric ovens

In this section, an analysis is conducted on the impact on energy consumption of the different scenarios presented earlier. Figure 302 summarises the total energy consumption of the stock of ovens between 2020 and 2040 of those scenarios.

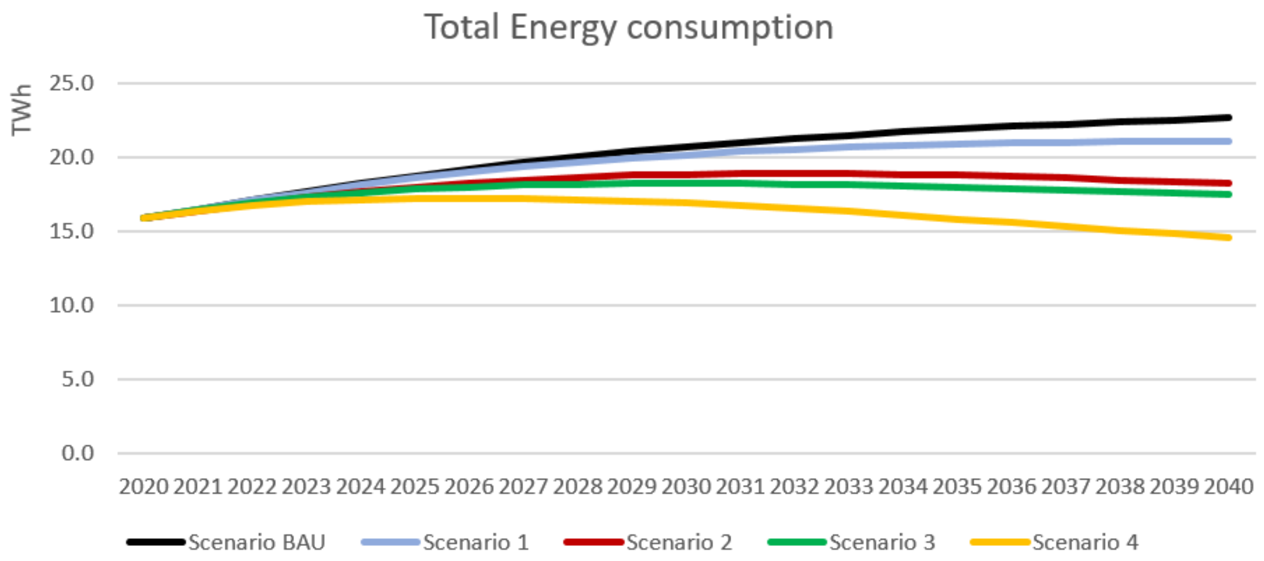



**Figure 302. Energy consumption electric ovens – Summary of scenarios**

If no changes are made (BAU scenario), it is estimated that the total energy consumption attributable to electric ovens will grow from 15.9 TWh in 2020 to 22.6 TWh in 2040. This increase in energy consumption is mostly related to the slight growth in sales and in stock of ovens in that period.

In Scenario 1, new ecodesign requirements were considered. After 2025, ovens with an EEI > 116 would not be allowed. After 2027, the threshold would be lowered to 110 and finally to 105 after 2030. It has been assumed that these measures would cause the substitution in sales of the least efficient ovens by slightly better ovens in terms of energy consumption. Under these conditions, it has been estimated that the total energy consumption attributable to ovens would grow from 15.9 TWh in 2020 to 21.1 TWh in 2040. The adoption of Scenario 1 would mean total savings of 12.9 TWh for the 2020-2040 period compared to the BAU scenario.

In Scenario 2, the same ecodesign requirements were considered as in Scenario 1. In this case, it has been assumed that the cavity volume of ovens decreases progressively from 70 litres to 50 litres between 2020 and 2040 due to the implementation of the flat approach. Under these conditions, it has been estimated that the total energy consumption attributable to ovens would grow from 15.9 TWh in 2020 to 18.2 TWh in 2040. The adoption of Scenario 2 would mean total savings of 41.6 TWh for the 2020-2040 period compared to the BAU scenario.

In Scenario 3, new ecodesign requirements were considered. After 2025, ovens with an EEI > 101 would not be allowed. After 2027, the threshold would be lowered to 96 and finally to 91 after 2030. It has been assumed that these measures would cause the substitution in sales of the least efficient ovens by the best ovens in terms of energy consumption. Under these conditions, it has been estimated that the total energy consumption attributable to ovens would grow from 15.9 TWh in 2020 to 17.5 TWh in 2040. The adoption of Scenario 3 would mean total savings of 51.7 TWh for the 2020-2040 period compared to the BAU scenario.

Finally, in Scenario 4, the same ecodesign requirements were considered as in Scenario 3. In this case, it has been assumed that the cavity volume of ovens decreases progressively from 70 litres to 50 litres between 2020 and 2040 due to the implementation of the flat approach. Under these conditions, it has been estimated that the total energy consumption attributable to ovens would decrease from 15.9 TWh in 2020 to 14.6 TWh in 2040. The adoption of Scenario 4 would mean total savings of 80.4 TWh for the 2020-2040 period compared to the BAU scenario.

#### 7.7.1.8 Impacts on GHG emissions electric ovens

The annual emissions of $CO_2$eq related to the use of domestic ovens are estimated based on the annual electricity consumption. Emission factors (g $CO_2$eq/kWh) were considered to convert electricity consumption into greenhouse gas (GHG) emissions. The value of the emission factor depends on the electricity mix at EU level. Historical data series show that this value has been changing over the years due to the higher proportion of renewable energy sources and the European targets to reduce GHG emissions. The forecast for future emission factors was calculated with data from PRIMES, assuming average losses of 6.75% (CEER, 2020). This data is represented in Figure 303.

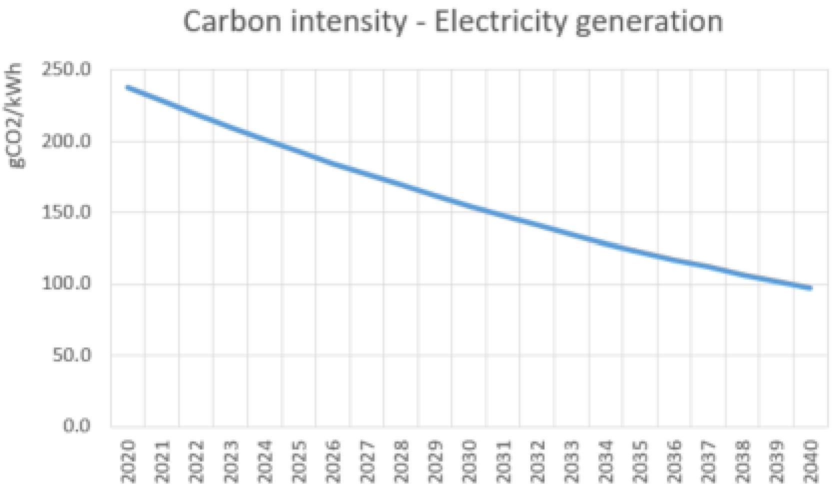



**Figure 303. Carbon intensity of grid**

Based on the above carbon intensity of the EU grid, the GHG emissions associated with the different policy scenarios for ovens are presented in Figure 304.

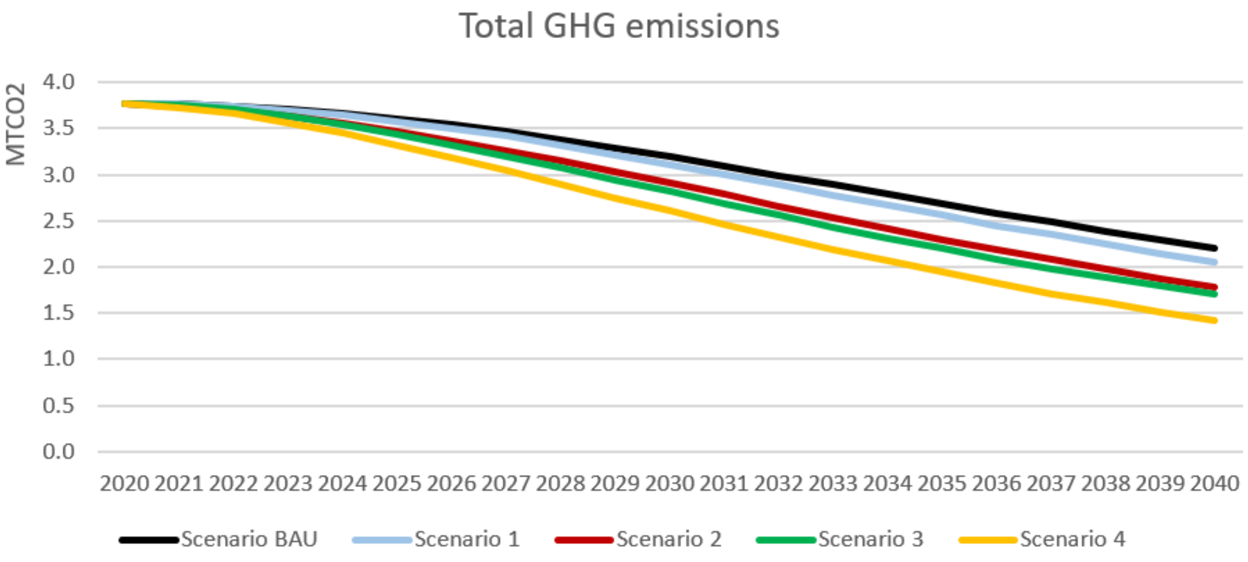



**Figure 304. GHG emissions electric ovens – Summary of scenarios**

With the BAU scenario, GHG emissions decrease from 3.8 Mt $CO_2$eq to 2.2 Mt $CO_2$eq between 2020 and 2040. The reduction of the carbon intensity of the EU grid between those years helps reduce the total GHG emissions.

With Scenario 1, GHG emissions decrease from 3.8 Mt $CO_2$eq to 2.1 Mt $CO_2$eq between 2020 and 2040, for a total saving of 1.6 Mt in comparison to BAU.

With Scenario 2, GHG emissions decrease from 3.8 Mt $CO_2$eq to 1.8 Mt $CO_2$eq between 2020 and 2040, for a total saving of 5.4 Mt in comparison to BAU.

With Scenario 3, GHG emissions decrease from 3.8 Mt $CO_2$eq to 1.7 Mt $CO_2$eq between 2020 and 2040, for a total saving of 6.7 Mt in comparison to BAU.

Finally, with Scenario 4, GHG emissions decrease from 3.8 Mt $CO_2$eq to 1.4 Mt $CO_2$eq between 2020 and 2040, for a total saving of 10.5 Mt in comparison to BAU.

#### 7.7.1.9 Impacts on consumer expenditure electric ovens

The impacts of policy measures on consumer expenditure are analysed in this section. These impacts include a change in the operating costs (which are usually lower because of more energy-efficient machines) and a change in the purchase price. The consumer expenditure is calculated as the life cycle cost (LCC), i.e. including purchase costs and operating costs (energy repair and maintenance costs). The purchase price of each type of oven is estimated using data from GfK, presented in Table 145.

**Table 145. Estimated price of ovens (in EUR)**

| G oven | F oven | E oven (BC1) | D oven (DO1) | D oven (DO2) | D oven (DO5) | D oven (DO6) | C oven | B oven | A oven |
|---|---|---|---|---|---|---|---|---|---|
| 245 | 330 | 446 | 602 | 813 | 1200 | 903 | 1097 | 1481 | 2000 |

Product prices presented in Table 145 correspond to the initial year of the period 2020-2040. Prices tend to decrease over the years, due to new technologies becoming more mature and therefore reducing manufacturing- and marketing-related costs. It has been assumed that there is no purchase price change associated with the decrease in oven cavity volume.

The operating costs consist of the electricity, maintenance and repair costs. The electricity price can be seen in Figure 61. It is assumed that the cost of maintenance and repair does not change over the period 2020-2040. Considering the assumptions above, the estimated consumer expenditure of the different scenarios is presented in Figure 305.

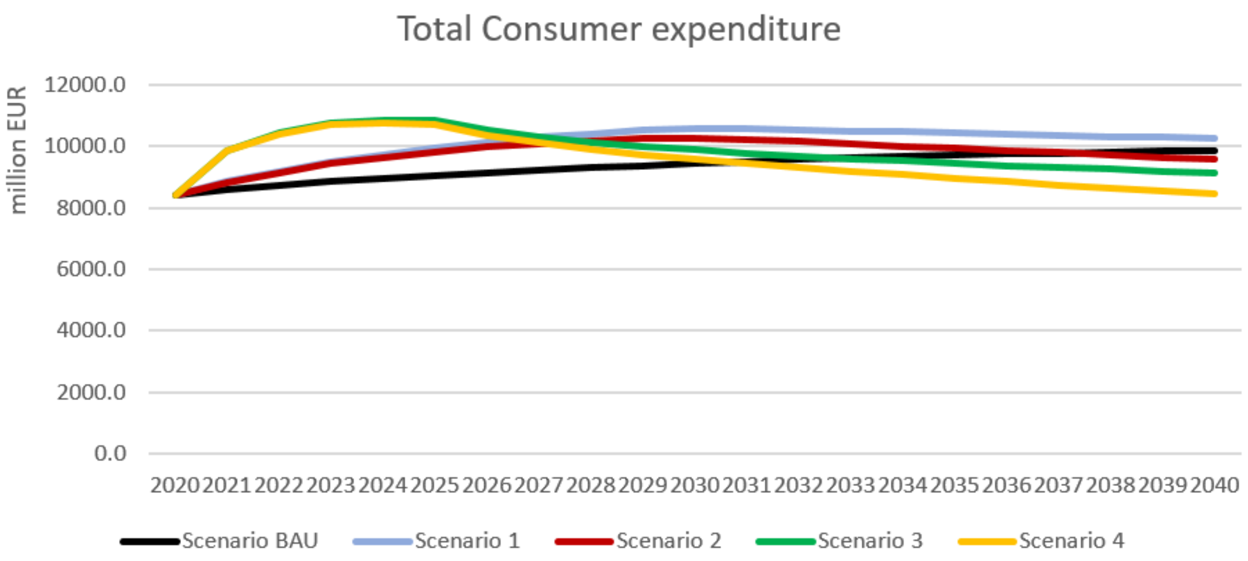



**Figure 305. Consumer expenditure electric ovens – Summary of scenarios**

The consumer expenditure of the BAU Scenario grows over the period 2020-2040, from EUR 8 420 million to EUR 9 882 million. This increase is explained by the increase in electricity price and by the increase in stock of ovens.

In Scenario 1, consumer expenditure increases from EUR 8 420 million to EUR 10 262 million, for a total accumulated increase of EUR 15 532 million.

In Scenario 2, consumer expenditure increases from EUR 8 420 million to EUR 9 575 million, for a total accumulated increase of EUR 8 846 million.

In Scenario 3, consumer expenditure decreases from EUR 8 420 million to EUR 9 143 million, for a total accumulated increase of EUR 10 151 million.

Finally, In Scenario 4, consumer expenditure decreases from EUR 8 420 million to EUR 8 456 million, for a total accumulated increase of EUR 3 464 million.

#### 7.7.1.10 Summary of impacts electric ovens

A summary of the different policy scenarios analysed and their cumulative impact over 2020-2040 is shown in Table 146. Negative values indicate a decrease over time and positive values indicate an increase.

**Table 146. Summary of the policy scenarios and their impacts for electric ovens**

| | **Technology impact** | **Energy cumulative impact (TWh electricity)** | **GHG cumulative impact (Mt $CO_2$)** | **LCC cumulative impact (billion EUR)** |
|---|---|---|---|---|
| **Scenario 1.**<br><br>Linear SEC, ecodesign threshold at EEI = 116 in 2025. | Removal of G and F ovens by 2025. Slow substitution of E ovens by D ovens. Average cavity volume of ovens remains constant. | -12.9 | -1.6 | +15.5 |
| **Scenario 2.**<br><br>Flat SEC, ecodesign | Removal of G and F ovens by 2025. Slow substitution of E | -41.6 | -5.4 | +8.8 |

| | | | | |
|---|---|---|---|---|
| threshold at EEI = 116 in 2025. | ovens by D ovens. Average cavity volume of ovens is reduced. | | | |
| **Scenario 3.** Linear SEC, ecodesign threshold at EEI = 101 in 2025. | Removal of G, F, E and some D ovens by 2025. Additional D ovens removed by 2027 and 2030. Fast substitution of ovens by A, B and C ovens. Average cavity volume of ovens remains constant. | -51.7 | -6.7 | +10.1 |
| **Scenario 4.** Flat SEC, ecodesign threshold at EEI = 101 in 2025. | Removal of G, F, E and some D ovens by 2025. Additional D ovens removed by 2027 and 2030. Fast substitution of ovens by A, B and C ovens. Average cavity volume of ovens is reduced. | -80.4 | -10.5 | +3.4 |

### 7.7.2 Policy scenarios for gas ovens

Following the same approach as in previous sections, in this section different scenarios for gas ovens are presented. Since the characteristics of the scenarios are the same, results are presented in a summarised way for gas ovens. Table 147 shows the characteristics of scenarios for gas ovens.

**Table 147. Definition of scenarios for gas ovens**

| Scenario | SEC | Ecodesign | | | Energy classes |
|---|---|---|---|---|---|
| | | Tier 1: 2025 | Tier 2: 2027 | Tier 3: 2030 | |
| 1 | Linear | EEI < 116 | EEI < 110 | EEI < 105 | **A** EEI < 66<br>**B** 66 ≤ EEI < 77<br>**C** 77 ≤ EEI < 88<br>**D** 88 ≤ EEI < 101<br>**E** 101 ≤ EEI < 116<br>**F** 116 ≤ EEI < 134<br>**G** EEI > 134 |
| 2 | Flat | EEI < 116 | EEI < 110 | EEI < 105 | |
| 3 | Linear | EEI < 91 | EEI < 86 | EEI < 82 | |
| 4 | Flat | EEI < 91 | EEI < 86 | EEI < 82 | |

The evolution of the sales and stock of gas ovens has been modelled in an equivalent way to the evolution of electric ovens, as detailed in Sections 7.7.1.3 to 7.7.1.6.

As a result of the defined scenarios and estimated stocks for gas ovens, the impact on energy consumption can be seen in Figure 306. Every scenario presented in this section means an improvement in terms of the overall energy consumption, mainly due to the reduction in the stock of gas ovens. Scenario 4 is the one with the highest potential for improvement (263 567 TJ versus BAU), followed by Scenarios 2, 3 and 1.

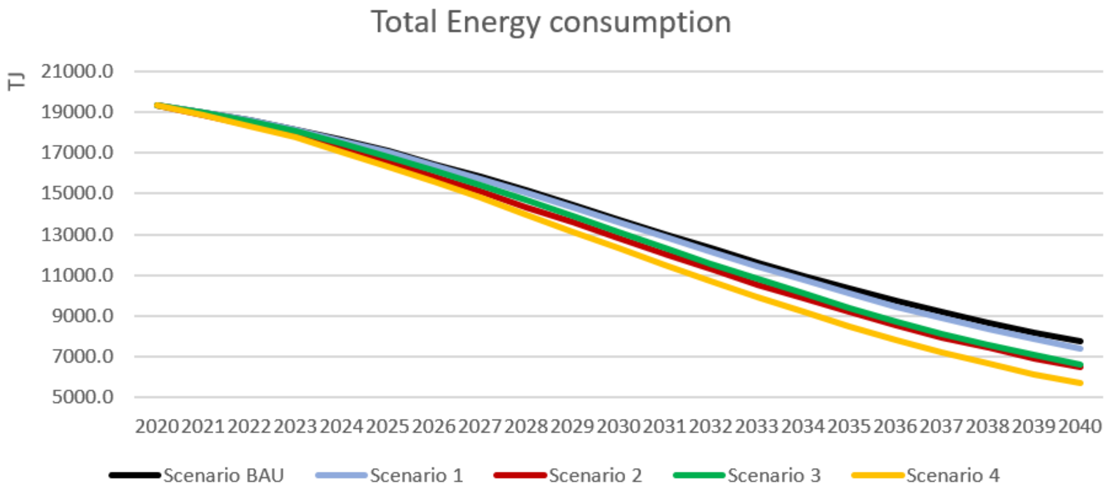



**Figure 306. Energy consumption gas ovens – Summary of scenarios**

The impact on consumer expenditure can be seen in Figure 307. The early introduction of new technologies due to ecodesign restrictions initially increases consumer expenditure. As the prices of new technologies decrease, consumer expenditure decreases accordingly. Scenario 2 is the one with the highest potential for savings.

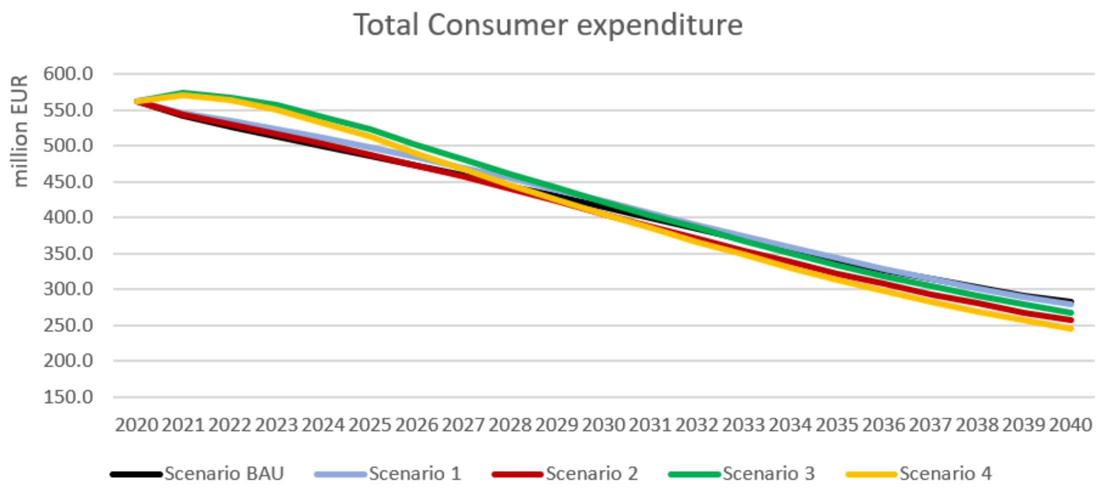



**Figure 307. Consumer expenditure gas ovens – Summary of scenarios**

Finally, the impact on GHG emissions can be seen in Figure 308. Following the trend of energy consumption, every scenario presented means an improvement in terms of overall GHG emissions, mainly due to the reduction in the stock of ovens. It has been estimated that $CO_2$ emissions of natural gas are 63 kg $CO_2$/GJ. Scenario 4 is the one with the highest potential for improvement (1.7 Mt $CO_2$eq versus BAU).

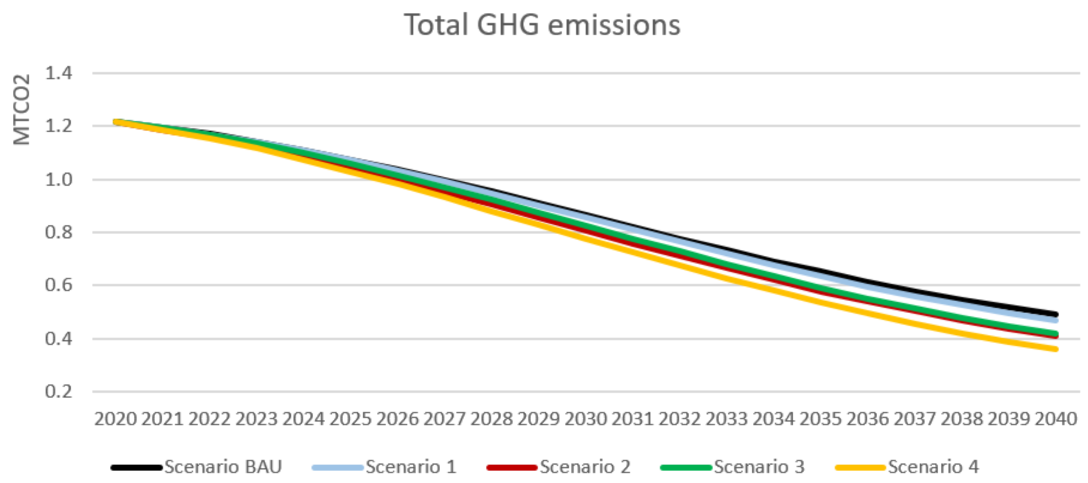



**Figure 308. GHG emissions gas ovens – Summary of scenarios**

A summary of the different impacts caused by the scenarios for gas ovens can be seen in Table 148.

**Table 148. Summary of the policy scenarios and their impacts for gas ovens**

| | **Technology impact** | **Energy cumulative impact (TJ electricity)** | **GHG cumulative impact (Mt $CO_2$)** | **LCC cumulative impact (billion EUR)** |
|---|---|---|---|---|
| **Scenario 1.** Linear SEC, ecodesign threshold at EEI = 116 in 2025. | Removal of G and F ovens by 2025. Slow substitution of E ovens by D and C ovens. Average cavity volume of ovens remains constant. | -3217 | -0.2 | +0.12 |
| **Scenario 2.** Flat SEC, ecodesign threshold at EEI = 116 in 2025. | Removal of G and F ovens by 2025. Slow substitution of E ovens by D and C ovens. Average cavity volume of ovens remains constant. | -17110 | -1.1 | -0.19 |
| **Scenario 3.** Linear SEC, ecodesign threshold at EEI = 91 in 2025. | Removal of G, F, E and D ovens by 2025. Fast substitution of ovens by A and B ovens. Average cavity volume of ovens remains constant. | -12464 | -0.8 | +0.21 |
| **Scenario 4.** Flat SEC, ecodesign threshold at EEI = 91 in 2025. | Removal of G, F, E and D ovens by 2025. Fast substitution of ovens by A and B ovens. Average cavity volume of ovens is reduced. | -26356 | -1.7 | -0.09 |

#### 7.7.3 Policy scenarios for hobs

This section aims to define and evaluate different policy scenarios for domestic hobs. The scenarios will consist of a combination of the different policy options presented in previous sections. The implementation of certain policies will have consequences for the market. The aim of this section is to evaluate the potential consequences of some of the presented policies, as well as their benefits and drawbacks in terms of overall EU energy consumption, $CO_2$ emissions or consumer expenditure.

Apart from that, the comparison of life cycle energy of induction and radiant hobs has shown induction hobs to have a larger impact.

##### 7.7.3.1 Business as usual scenario

The definition of the business as usual (BAU) scenario for domestic hobs is based on the assumption that no additional regulation is implemented.

**Electric hobs**

The sales evolution for the period 2020-2040 has been estimated using GfK data (Figure 309). The sales of induction hobs increases at the expense of radiant hob sales, so induction is expected to be the dominant technology in the market.

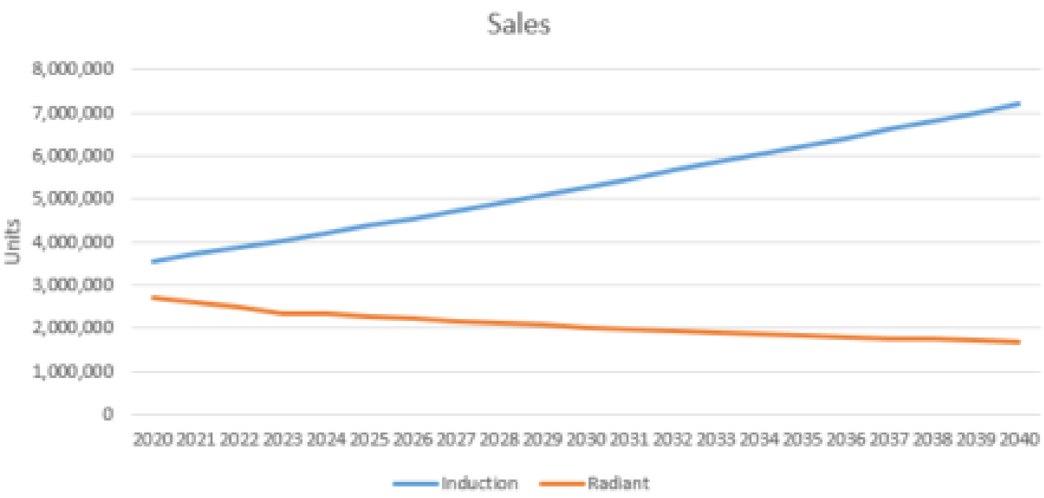



**Figure 309: BAU electric hobs – Estimated sales**

In the BAU scenario it is assumed that the current stock (2020) consumes around 15% more energy than the new products, due to the technology improvement developed in recent years. The total energy consumption of the BAU scenario for electric hobs is presented in Figure 310.

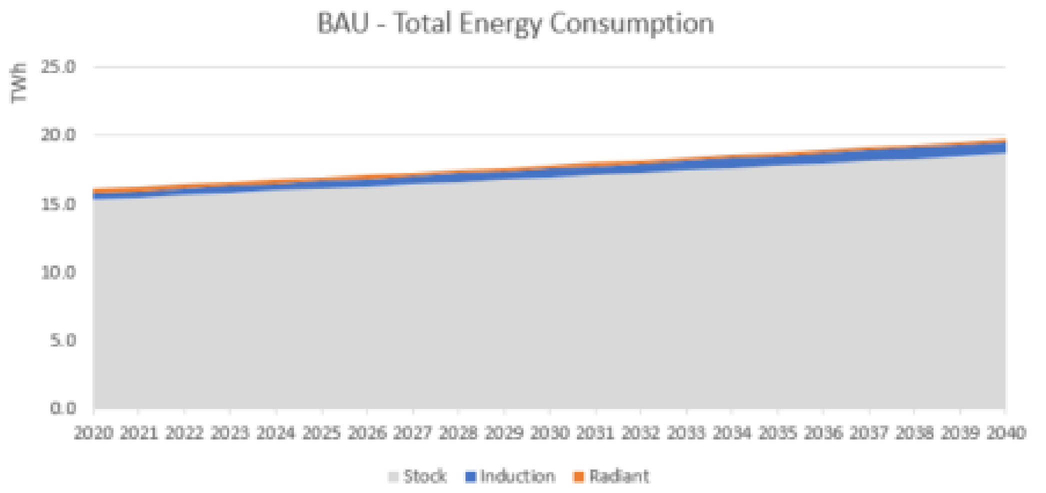



**Figure 310: BAU electric hobs – Total Energy Consumption**

**Gas hobs**

The sales evolution for the period 2020-2040 has been estimated using GfK data (Figure 47). Gas hob sales are expected to remain stable for the period 2020-2040. In the BAU scenario it is assumed that the current stock (2020) achieves an efficiency of 50% according to the existing Ecodesign minimum requirements. The total energy consumption of the BAU scenario for gas hobs is presented in Figure 311.

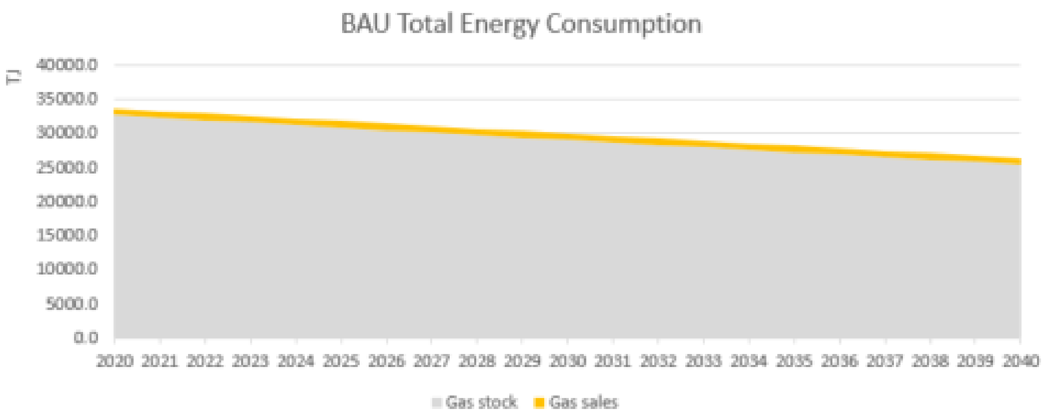



**Figure 311: BAU gas hobs – Energy consumption**

#### 7.7.3.2 Scenario 1 electric hobs: same ecodesign requirements for induction and radiant hobs

The first option proposed for electric hobs follows the same approach as the existing Ecodesign Regulation and sets common requirements for both induction and radiant hobs.

**Table 149: Proposed common requirements for both induction and radiant hobs**

| | **Electric hob (Energy consumption in Wh/kg)** |
|---|---|
| February 2023 | < 195 |
| February 2025 | < 190 |
| February 2027 | < 185 (*) |

(*) According to some manufacturers, flex and free induction could be banned.

Stricter common requirements would equate to banning radiant hobs, since no further improvement beyond 185 Wh/kg is expected to be feasible. The total energy consumption of Scenario 1 for electric hobs is presented in Figure 312.

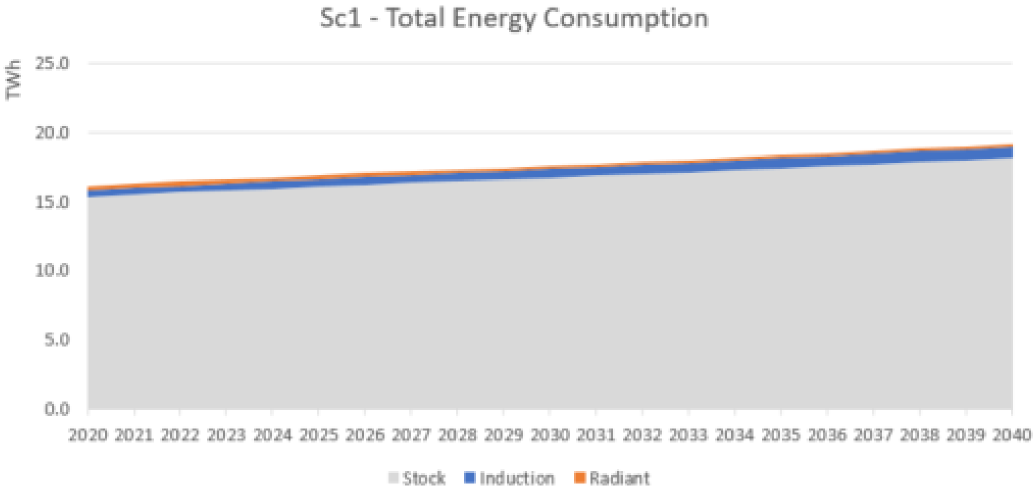



**Figure 312: Scenario 1 electric hobs – Total energy consumption**

#### 7.7.3.3 Scenario 2 electric hobs: different ecodesign requirements for solid plates, radiant and induction hobs

The second option proposed for electric hobs sets different minimum requirements for solid plates, radiant and induction hobs.

**Table 150: Proposed different minimum requirements for solid plates, radiant and induction hobs**

| | **Solid plates hob** (Energy consumption in Wh/kg) | **Radiant/induction hob** (Energy consumption in Wh/kg) |
|---|---|---|
| February 2023 | < 195 | < 195 |
| February 2025 | < 195 | < 190 |
| February 2027 | < 195 | < 185(*) |

(*) According to some manufacturers, flex and free induction could be banned.

This would allow solid plates and radiant hobs to remain in the market and leave the decrease in sales to the natural evolution of the market towards induction hobs. The total energy consumption of Scenario 2 for electric hobs is presented in Figure 313.

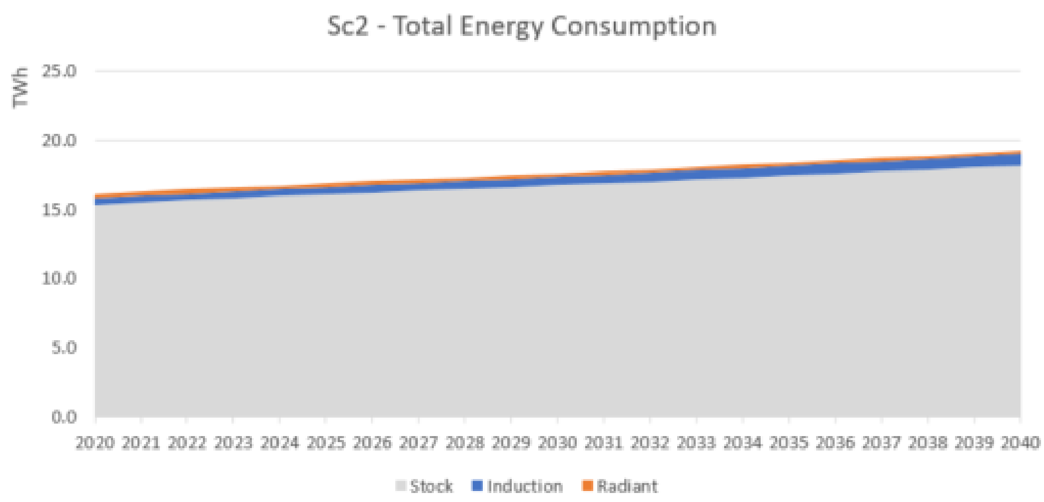



**Figure 313: Scenario 2 electric hobs – Total energy consumption**

#### 7.7.3.4 Scenario 1 gas hobs: ecodesign requirements

The option proposed for gas hobs continues the path of improving energy efficiency, setting yearly tiers for efficiency.

**Table 151: Proposed energy efficiency tiers for gas hobs**

| | **Gas-fired hob (energy efficiency in %)** |
|---|---|
| February 2023 | > 56 |
| February 2025 | > 57 |
| February 2027 | > 58 |

The total energy consumption of Scenario 1 for gas hobs is presented in Figure 314.

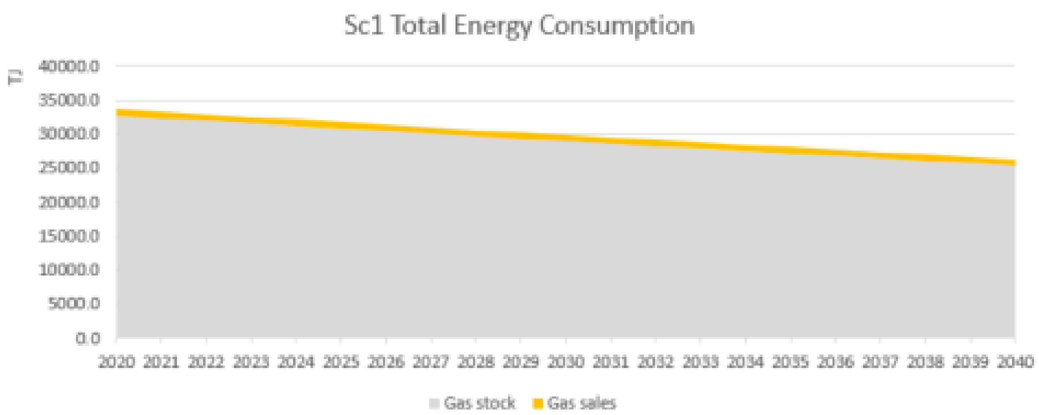



**Figure 314: Scenario 1 gas hobs – Total energy consumption**

#### 7.7.3.5 Impacts on energy consumption

In this section, an analysis is conducted on the impact on energy consumption of the different scenarios presented earlier.

**Electric hobs**

Figure 315 summarises the total energy consumption of the stock of electric hobs between 2020 and 2040 of those scenarios.

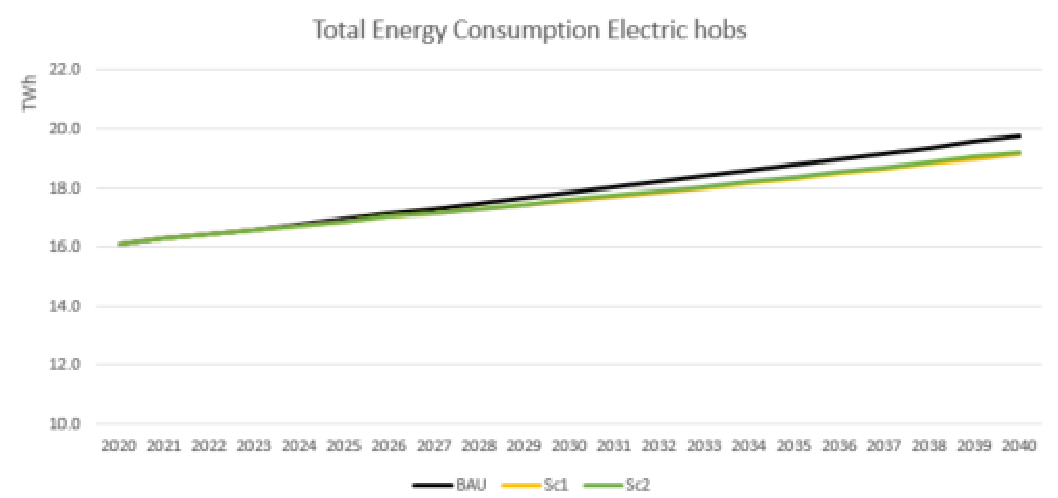



**Figure 315: Energy consumption electric hobs – Summary of scenarios**

If no changes are made (BAU scenario), it is estimated that the total energy consumption attributable to electric hobs will grow from 16.1 TWh in 2020 to 19.8 TWh in 2040. This increase in energy consumption is mostly related to the growth in the sales and stock of hobs in that period.

In Scenario 1, common ecodesign requirements for induction and radiant hobs were considered. Under these conditions, it has been estimated that the adoption of Scenario 1 would mean total cumulative savings of 5.8 TWh for the 2020-2040 period compared to the BAU scenario.

In Scenario 2, different ecodesign requirements for solid plates, radiant and induction hobs were considered. Under these conditions, it has been estimated that the total cumulative savings over the 2020-2040 period would be 5.2 TWh.

**Gas hobs**

Figure 316 summarises the total energy consumption of the stock of gas hobs between 2020 and 2040 of those scenarios.

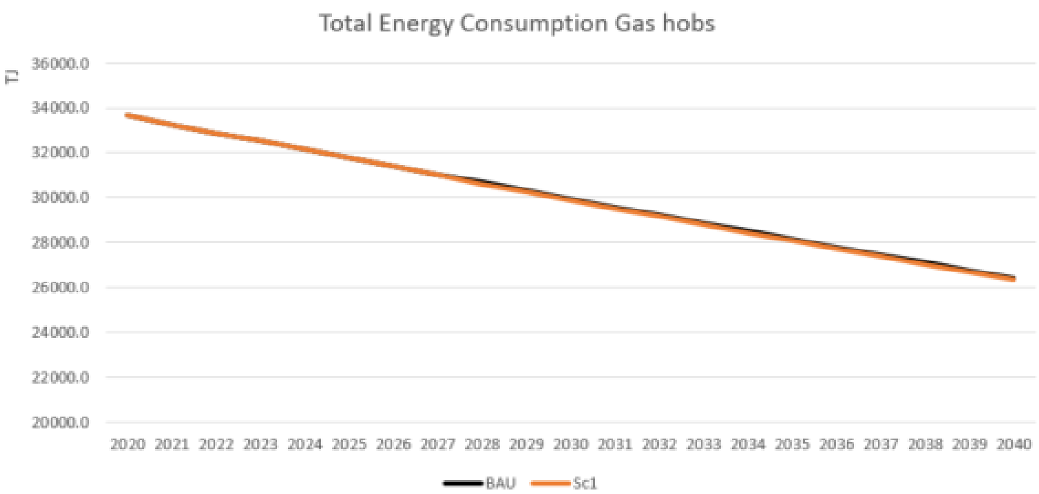



**Figure 316: Energy consumption gas hobs – Summary of scenarios**

If no changes are made (BAU scenario), it is estimated that the total energy consumption attributable to gas hobs will decrease from 32 879 TJ in 2020 to 26 397 TJ in 2040 (21% decrease). This decrease in energy consumption is mostly driven by stable sales and stock and the natural replacement of old hobs with new and more efficient ones.

In Scenario 1, stricter ecodesign requirements for gas hobs were considered. Under these conditions, it has been estimated that the adoption of Scenario 1 would mean total cumulative savings of 944.1 TJ for the 2020-2040 period compared to the BAU scenario.

#### 7.7.3.6 Impacts on GHG emissions

**Electric hobs**

Based on the above carbon intensity of the EU grid, the $CO_2$ emissions associated with the different policy scenarios for electric hobs are presented in Figure 317.

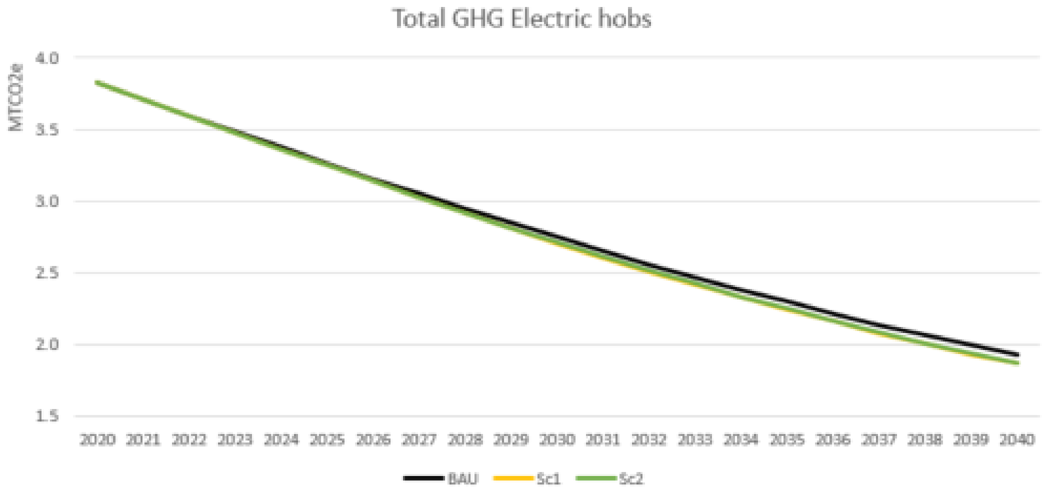



**Figure 317: GHG emissions electric hobs – Summary of scenarios**

With the BAU scenario, GHG emissions decrease from 3.8 Mt $CO_2$eq to 1.9 Mt $CO_2$eq between 2020 and 2040.

With Scenario 1, GHG emissions total savings will be 0.75 Mt in comparison to BAU.

With Scenario 21, GHG emissions total savings will be 0.67 Mt in comparison to BAU.

**Gas hobs**

Based on the carbon intensity of natural gas from the Ecoreport tool, the GHG emissions associated with the different policy scenarios for gas hobs are presented in Figure 318.

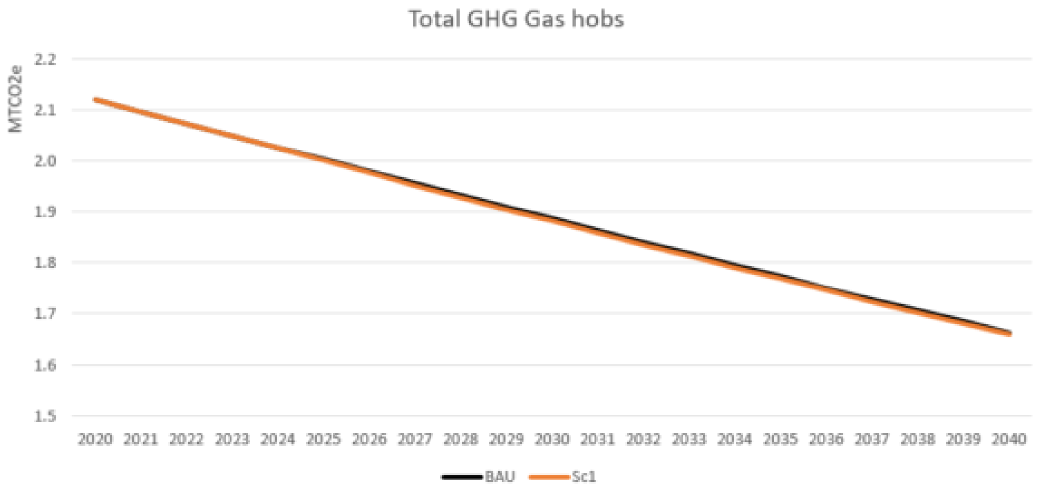



**Figure 318: GHG emissions gas hobs – Summary of scenarios**

In the BAU scenario, GHG emissions decrease from 2.1 Mt $CO_2$eq to 1.7 Mt $CO_2$eq between 2020 and 2040. This decrease in energy consumption is mostly driven by stable sales and stock and the natural replacement of old hobs with new and more efficient ones. In Scenario 1, total savings of 0.06 Mt may be achieved in comparison to BAU.

#### 7.7.3.7 Impacts on consumer expenditure

The impacts of policy measures on consumer expenditure are analysed in this section. These impacts include a change in the operating costs (which are usually lower because of more energy-efficient machines) and a change in the purchase price. The consumer expenditure is calculated as the life cycle cost (LCC), i.e. including purchase costs and operating costs (energy repair and maintenance costs). The purchase price of each type of hob is described in Tasks 5 and 6. The potential purchase cost impact due to the disappearance of radiant hobs in Scenario 1 has not been modelled due to the uncertainty of the evolution of the induction technology price.

**Electric hobs**

Figure 319 shows the consumer expenditure for the different scenarios considered for electric hobs.

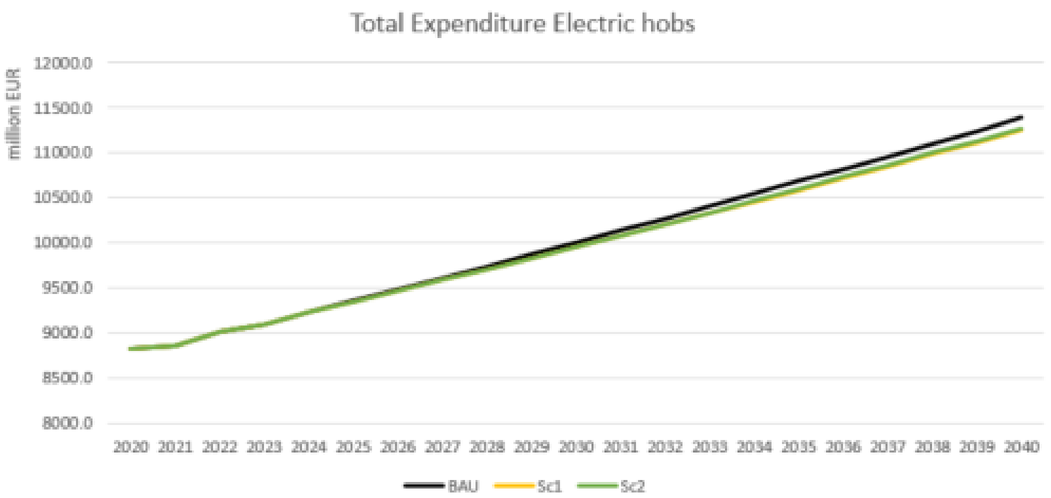



**Figure 319: Consumer expenditure electric hobs – Summary of scenarios**

In the estimation presented in Figure 319, the consumer expenditure of the BAU scenario grows over the period 2020-2040, from EUR 8.8 billion to EUR 11.4 billion.

In Scenario 1, common ecodesign requirements for induction and radiant hobs were considered. Under these conditions, the adoption of Scenario 1 would mean total cumulative savings of EUR 1.2 billion for the 2020-2040 period compared to BAU.

In Scenario 2, different ecodesign requirements for solid plates, radiant and induction hobs were considered. Under these conditions, the adoption of Scenario 2 would mean total cumulative savings of EUR 1.1 billion for the 2020-2040 period compared to BAU.

**Gas hobs**

Figure 320 shows the consumer expenditure for the different scenarios considered for gas hobs.

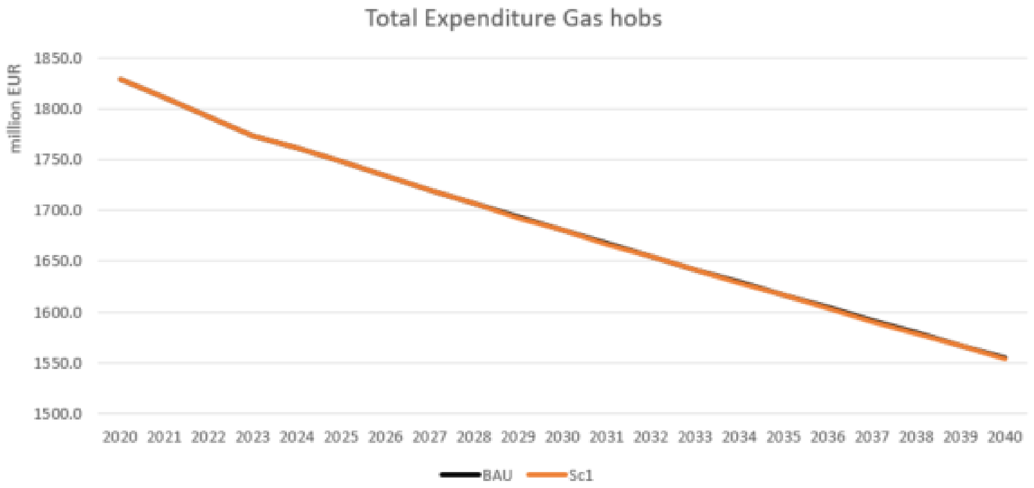



**Figure 320: Consumer expenditure gas hobs – Summary of scenarios**

In the estimation presented in Figure 320, the consumer expenditure of the BAU scenario decreases over the period 2020-2040, from EUR 1.8 billion to EUR 1.5 billion. The adoption of Scenario 1 would mean total cumulative savings of EUR 0.01 billion for the 2020-2040 period compared to BAU.

#### 7.7.3.8 Summary of impacts hobs

A summary of the different policy scenarios analysed and their cumulative impact over 2020-2040 is shown in Table 152. Negative values indicate a decrease over time and positive values indicate an increase.

**Table 152: Summary of the policy scenarios and their impacts for hobs**

| **Scenario** | **Technology impact** | **Energy cumulative impact (TWh electricity / TJ natural gas)** | **GHG cumulative impact (Mt $CO_2$)** | **LCC cumulative impact (billion EUR)** |
|---|---|---|---|---|
| Scenario 1: electric hobs: same ecodesign requirements for induction and radiant hobs | According to some manufacturers, flex and free induction could be banned as of 2027. | -5.8 | -0.75 | -1.1 |
| Scenario 2: electric hobs: different ecodesign requirements for solid plate, radiant and induction hobs | Solid plates and radiant hobs would remain in the market, and eventually be replaced by induction hobs by market evolution.<br><br>According to some manufacturers, flex and free induction could be banned as of 2027. | -5.2 | -0.67 | -1.1 |
| Scenario 1: gas hobs: ecodesign requirements | Gas hobs would be driven to reach their improvement potential, though it is very marginal. | -944.1 | -0.06 | -0.01 |

### 7.7.4 Policy scenarios for cooking fume extractors

This section aims to define and evaluate different policy scenarios for domestic cooking fume extractors. The scenarios will consist of a combination of the different policy options presented in previous sections.

#### 7.7.4.1 Business as usual scenario

The definition of the business as usual (BAU) scenario for cooking fume extractors is based on the assumption that no additional regulation is implemented. The BAU scenario is only used for reference as it is highly unlikely that anything will change in the energy label given. The sales evolution for the period 2020-2040 has been estimated using GfK data (Figure 321 and Figure 322).

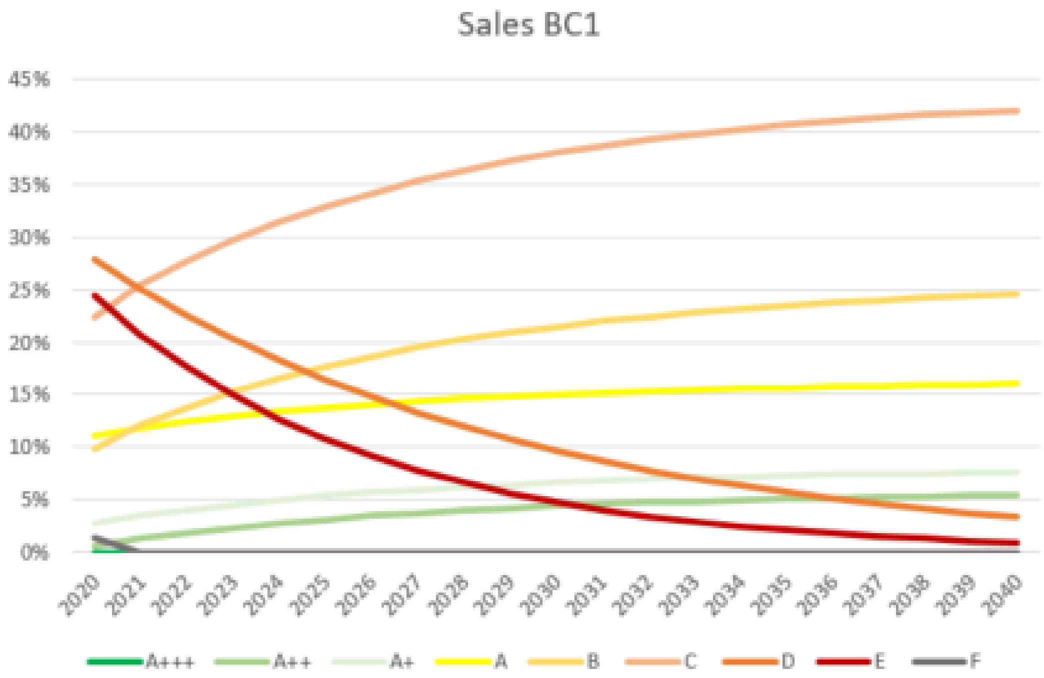



**Figure 321. BAU cooking fume extractors – Estimated sales BC1**

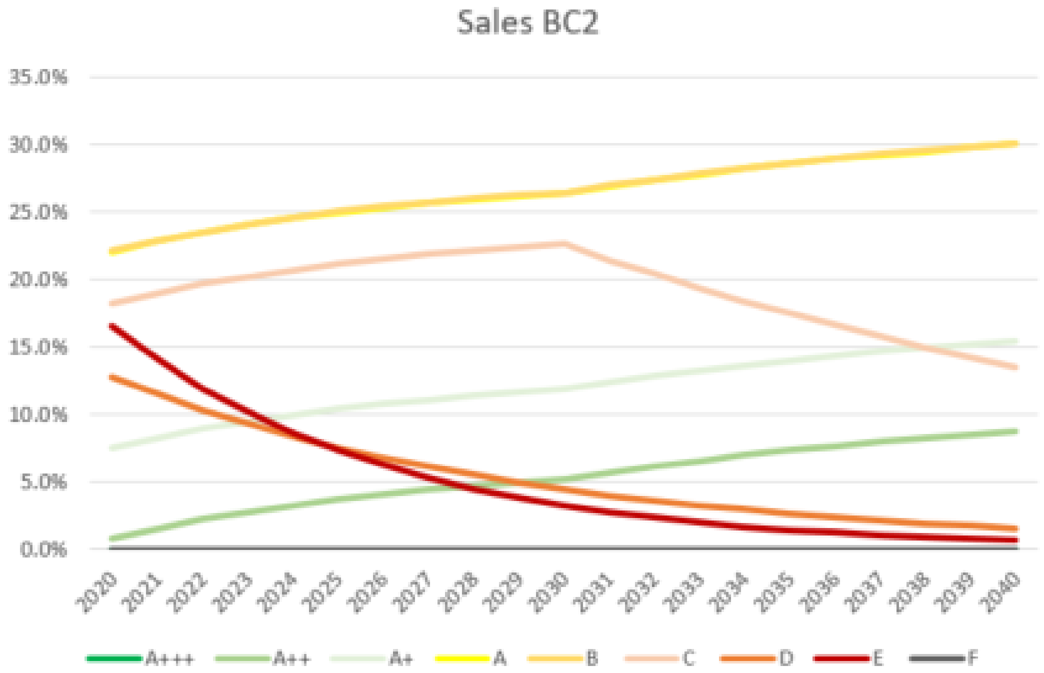



**Figure 322: BAU cooking fume extractors – Estimated sales BC2**

In the BAU scenario it is assumed that the current stock has an average annual energy consumption 10% higher than the new products placed on the market. The total energy consumption of the BAU scenario for cooking fume extractors is presented in Figure 323.

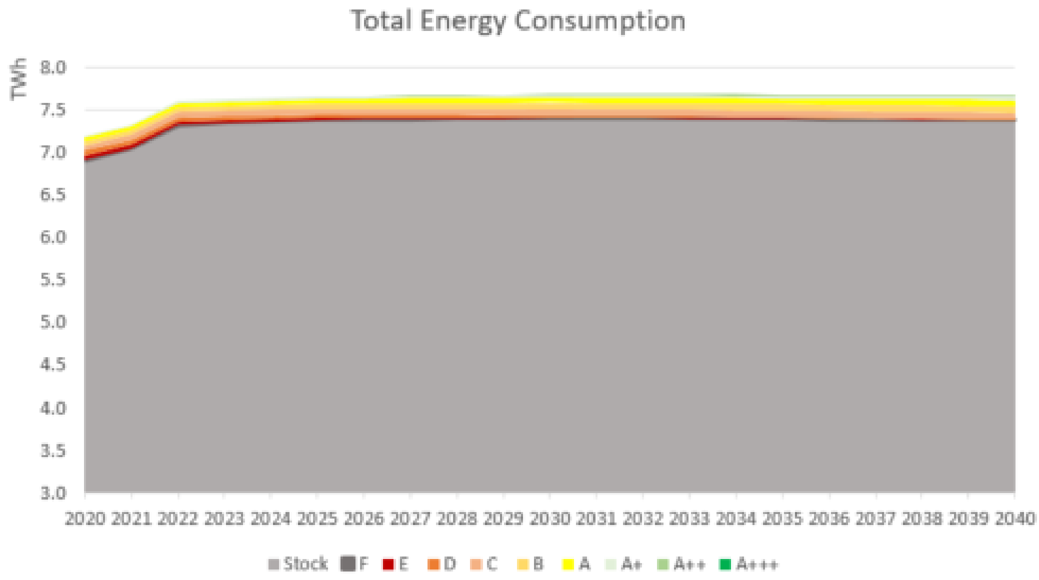



**Figure 323: BAU cooking fume extractors – Total Energy Consumption**

#### 7.7.4.2 Scenario 1a: EEI based on arithmetic mean FDE, Option a

Scenario 1a is determined by a shift of the existing EEI and energy classes based on AEC to a methodology based on FDE as an arithmetic mean, using *option a* for defining EEI thresholds, as explained in Section 7.5.3.2. This is combined with a MEPS requiring a minimum class F. The estimated evolution of the new energy classes' sales is presented in Figure 326.

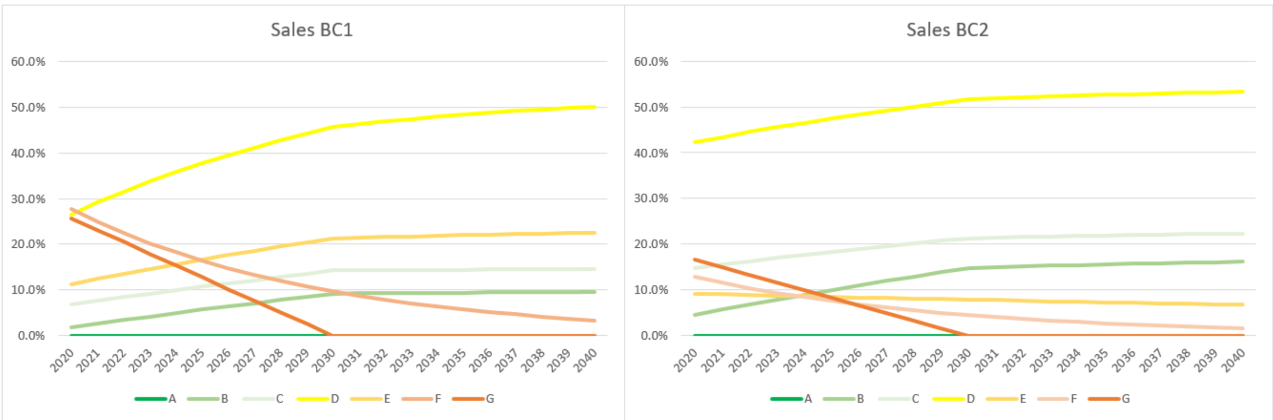



**Figure 324: Scenario 1a cooking fume extractors – Estimated sales**

The MEPS proposed (minimum energy class F required by 2030) would result in the sales of class G cooking fume extractors being zero by that year. It is assumed that those products would be replaced mainly by classes F and E.

Energy classes B and C would correspond to brushless motors, whose sales are assumed to correspond to current classes A++ and A+.

The annual energy consumption of each energy class has been calculated assuming that each one would deliver the same airflow and pressure as the base case. Since energy classes are based on the FDE, a better energy class product would provide the same pressure and airflow at lower power. The total energy consumption of the stock can be seen in Figure 325.

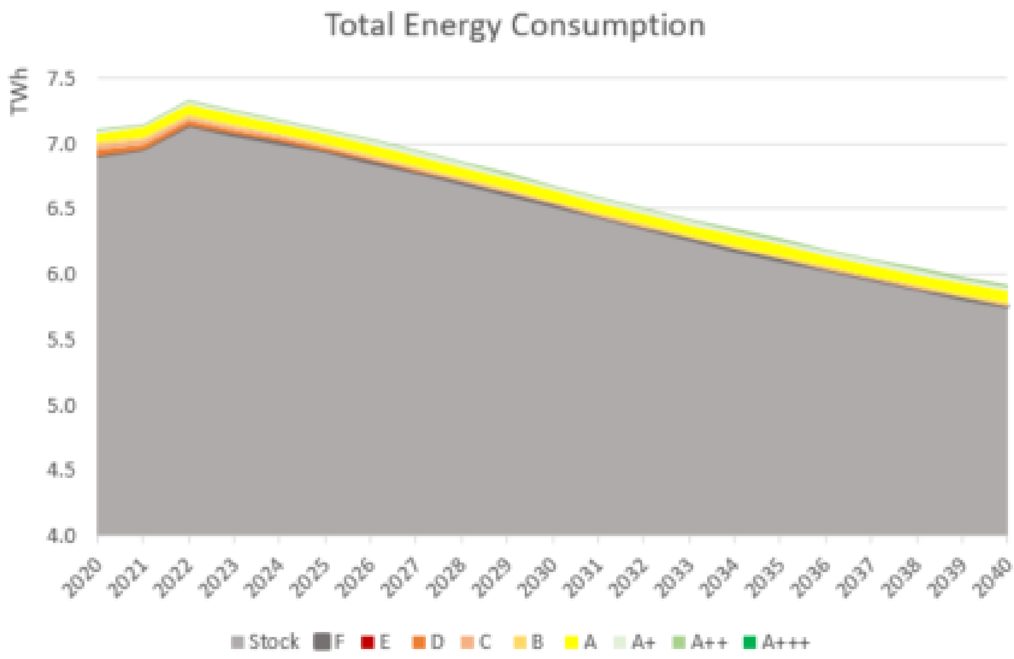



**Figure 325: Scenario 1a cooking fume extractors – Total Energy Consumption**

#### 7.7.4.3 Scenario 1b: EEI based on arithmetic mean FDE, Option b

Scenario 1b is determined by a shift of the existing EEI and energy classes based on AEC to a methodology based on FDE as an arithmetic mean, using *option b* for defining EEI thresholds, as explained in Section 7.5.3.2. This is combined with a MEPS requiring a minimum class F. The estimated evolution of the new energy classes' sales is presented in Figure 326.

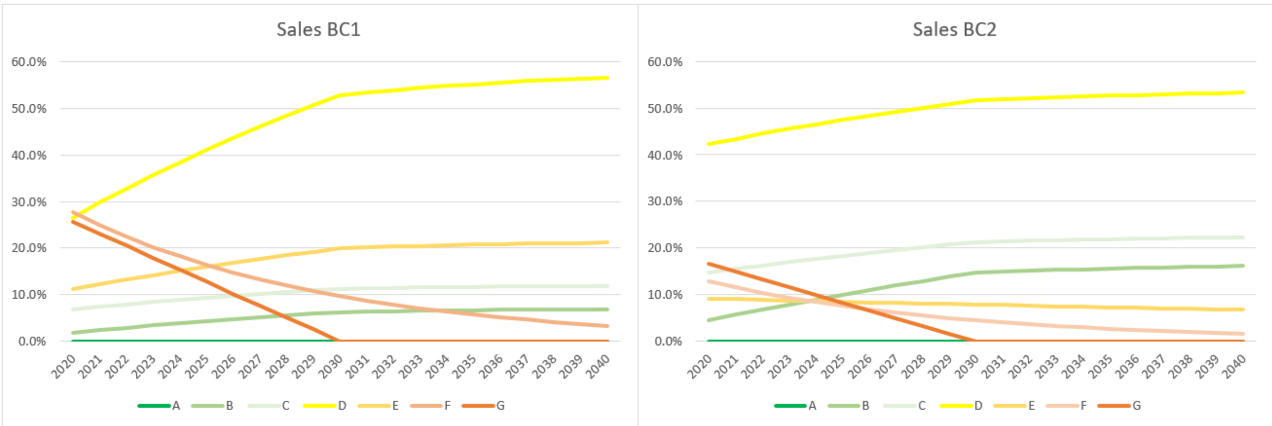



**Figure 326: Scenario 1b cooking fume extractors – Estimated sales**

The MEPS proposed (minimum energy class F required by 2030) would result in the sales of class G cooking fume extractors being zero by that year. It is assumed that those products would be replaced mainly by classes F and E, and partly by class D.

Energy classes B and C would correspond to brushless motors, whose sales are assumed to correspond to current classes A++ and A+. Class D is assumed to be more populated than in *option a*.

The annual energy consumption of each energy class has been calculated assuming that each one would deliver the same airflow and pressure as the base case. Since energy classes are based on the FDE, a better energy class product would provide the same pressure and airflow at lower power. The total energy consumption of the stock can be seen in Figure 327.

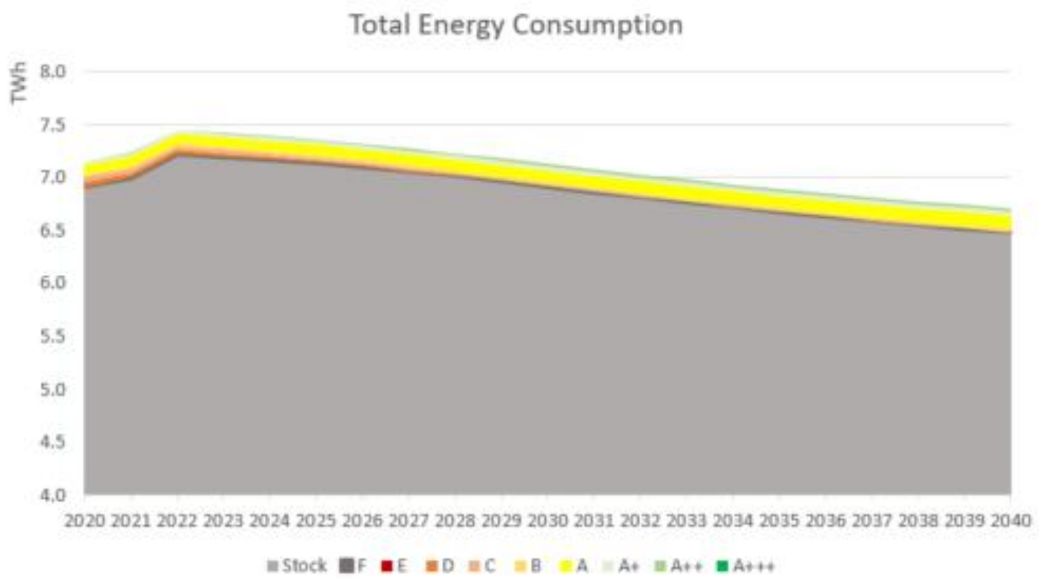



**Figure 327: Scenario 1b cooking fume extractors – Total Energy Consumption**

#### 7.7.4.4 Scenario 2a: EEI based on harmonic mean FDE, Option a

Scenario 2a is determined by a shift of the existing EEI and energy classes based on AEC to a methodology based on FDE as a harmonic mean, using *option a* for defining EEI thresholds, as explained in Section 7.5.3.2. This is combined with a MEPS requiring a minimum class F.

The estimated evolution of the new energy classes' sales is assumed to be the same as in Scenario 1. The annual energy consumption of each energy class has been calculated assuming that each one would deliver the same airflow and pressure as the base case. Since energy classes are based on the FDE, a better energy class product would provide the same pressure and airflow at lower power. The total energy consumption of the stock can be seen in Figure 328.

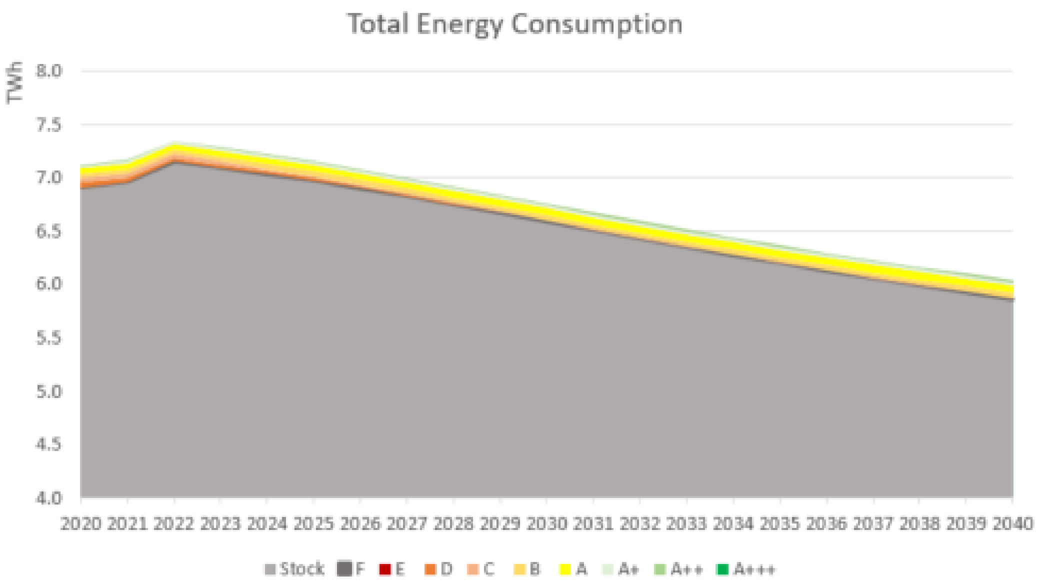



**Figure 328: Scenario 2a cooking fume extractors – Total Energy Consumption**

Scenario 2b is determined by a shift of the existing EEI and energy classes based on AEC to a methodology based on FDE as a harmonic mean, using *option b* for defining EEI thresholds, as explained in Section 7.5.3.2. This is combined with a MEPS requiring a minimum class F.

The estimated evolution of the new energy classes' sales is assumed to be the same as in Scenario 1.

The annual energy consumption of each energy class has been calculated assuming that each one would deliver the same airflow and pressure as the base case. Since energy classes are based on the FDE, a better energy class product would provide the same pressure and airflow at lower power. The total energy consumption of the stock can be seen in Figure 329.

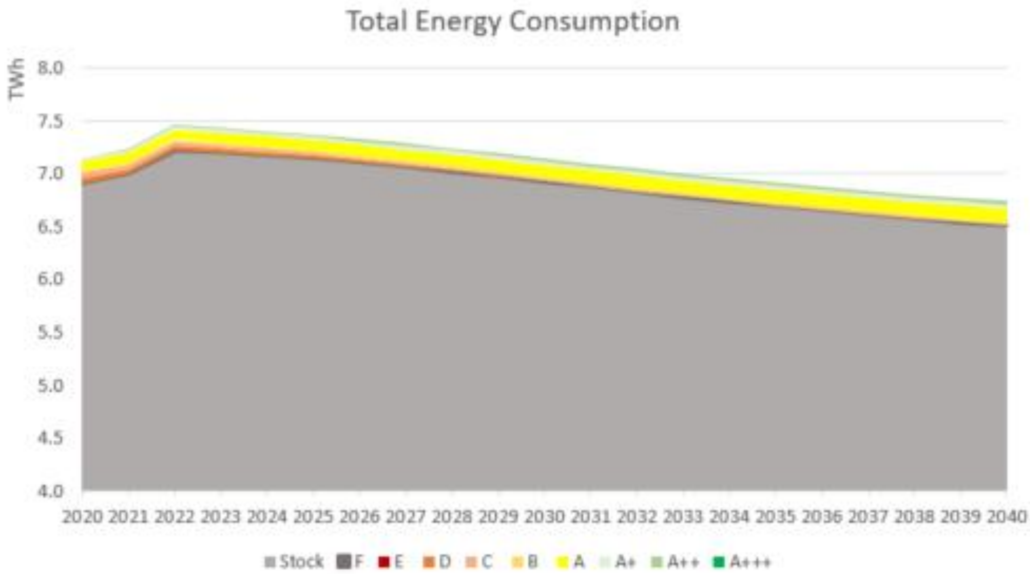



**Figure 329: Scenario 2b cooking fume extractors – Total Energy Consumption**

#### 7.7.4.5 Scenario 3a: EEI based on SAEC as a function of airflow, Option a

Scenario 3a is determined by a shift of the existing EEI and energy classes based on AEC to a methodology based on indirect energy consumption and airflow for calculating the SAEC, using *option a* for defining EEI thresholds, as explained in Section 7.5.3.4. This is combined by a MEPS requiring a minimum class F and a minimum FDE of 5%.

The estimated evolution of the new energy classes' sales is presented in Figure 330.

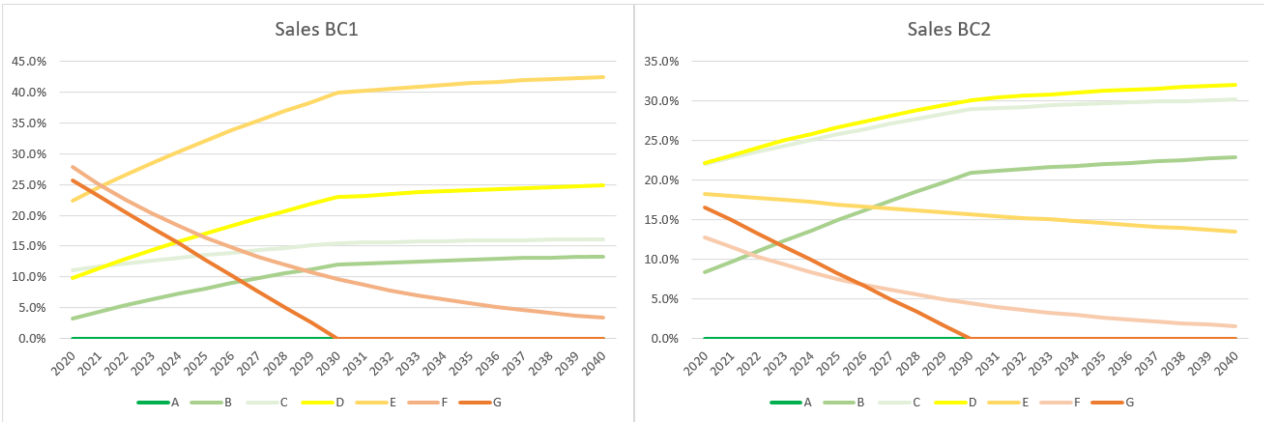



**Figure 330: Scenario 3a cooking fume extractors – Estimated sales**

Similarly to Scenario 1, the MEPS proposed (minimum energy class F required by 2030) would result in the sales of class G cooking fume extractors being zero by that year. It is assumed that those products would be replaced mainly by classes F and E.

Energy classes B and C would correspond to brushless motors, whose sales are assumed to correspond to current classes A++, A+ and A, since other technologies seem capable of achieving those classes. Classes D, E and F are assumed to correspond to current classes B, D and E.

The annual energy consumption of each energy class has been calculated assuming that each would deliver the same airflow as the base case. Since energy classes are based on airflow, a better energy class product would provide the same airflow at lower power. The indirect energy consumption has not been considered in the modelling to allow comparison with the BAU scenario.

The main difference from Scenarios 1a and 2a is that there is only one class (B) that encompasses brushless motors, so the sales of cooking fume extractors equipped with brushless motors are assumed to be less promoted. Besides, the brushless motors can easily achieve energy class B, and probably capacitor and even shade poles motors could achieve it. The total energy consumption of the stock can be seen in Figure 331.

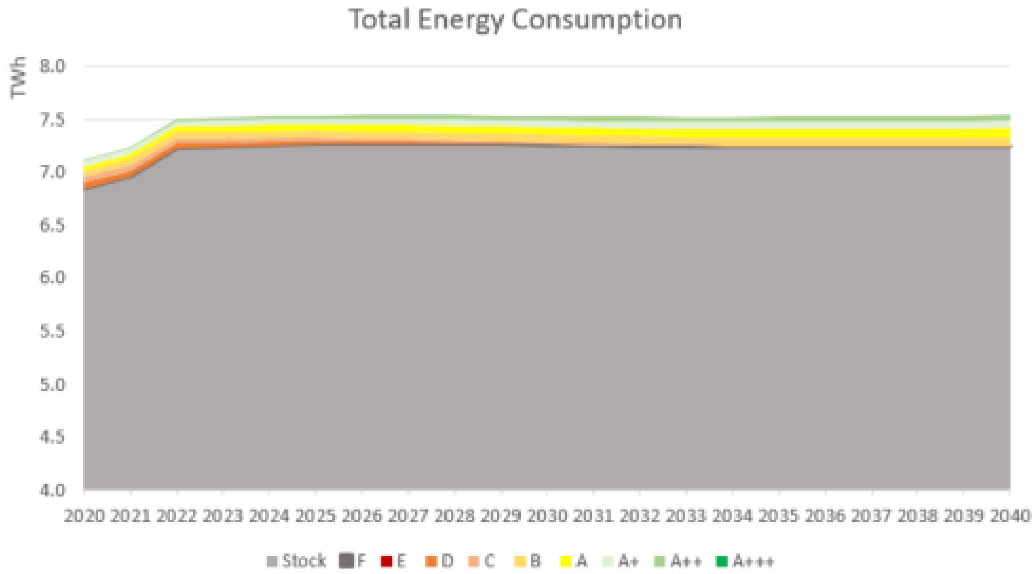



**Figure 331: Scenario 3a cooking fume extractors – Total Energy Consumption**

#### 7.7.4.6 Scenario 3b: EEI based on SAEC as a function of airflow, Option b

Scenario 3b is determined by a shift of the existing EEI and energy classes based on AEC to a methodology based on indirect energy consumption and airflow for calculating the SAEC, using *option b* for defining EEI thresholds, as explained in Section 7.6.3.3. This is combined by a MEPS requiring a minimum class F and a minimum FDE of 5%.

The estimated evolution of the new energy classes' sales is assumed to be the same as *option a*.

The annual energy consumption of each energy class has been calculated assuming that each would deliver the same airflow as the base case. Since energy classes are based on airflow, a better energy class product would provide the same airflow at lower power. The indirect energy consumption has not been considered in the modelling to allow comparison with the BAU scenario.

The main difference from Scenarios 1b and 2b is that there is only one class (B) that encompasses brushless motors, so the sales of cooking fume extractors equipped with brushless motors are assumed to be less promoted. Besides, the brushless motors can easily achieve energy class B, and probably capacitor and even shade poles motors could achieve it. The total energy consumption of the stock can be seen in Figure 332.

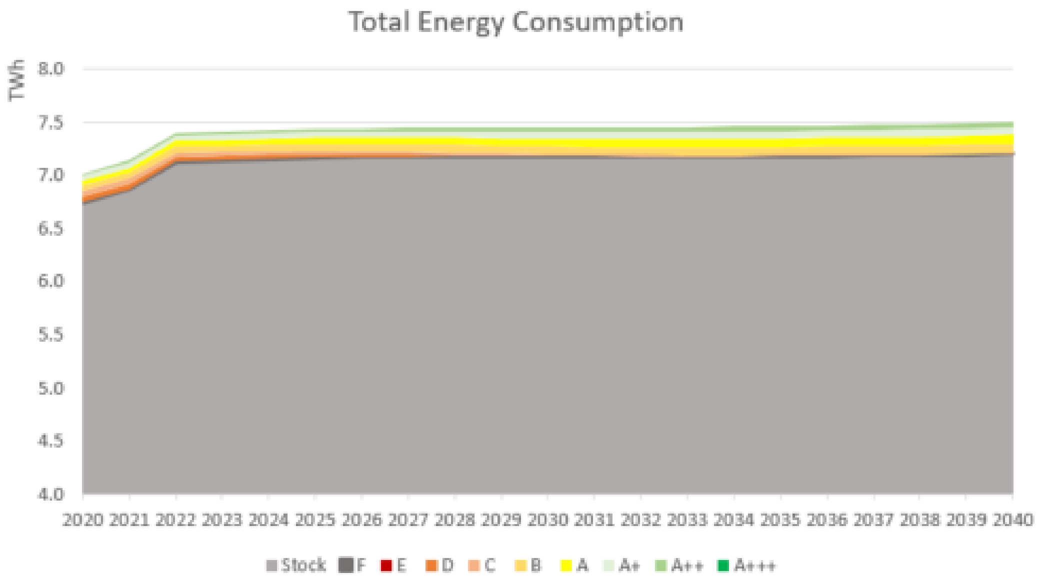



**Figure 332: Scenario 3b cooking fume extractors – Total Energy Consumption**

#### 7.7.4.7 Impacts on energy consumption

In this section, an analysis is conducted on the impact on energy consumption of the different scenarios presented earlier. Figure 333 summarises the total energy consumption of the stock of cooking fume extractors between 2020 and 2040 of those scenarios.

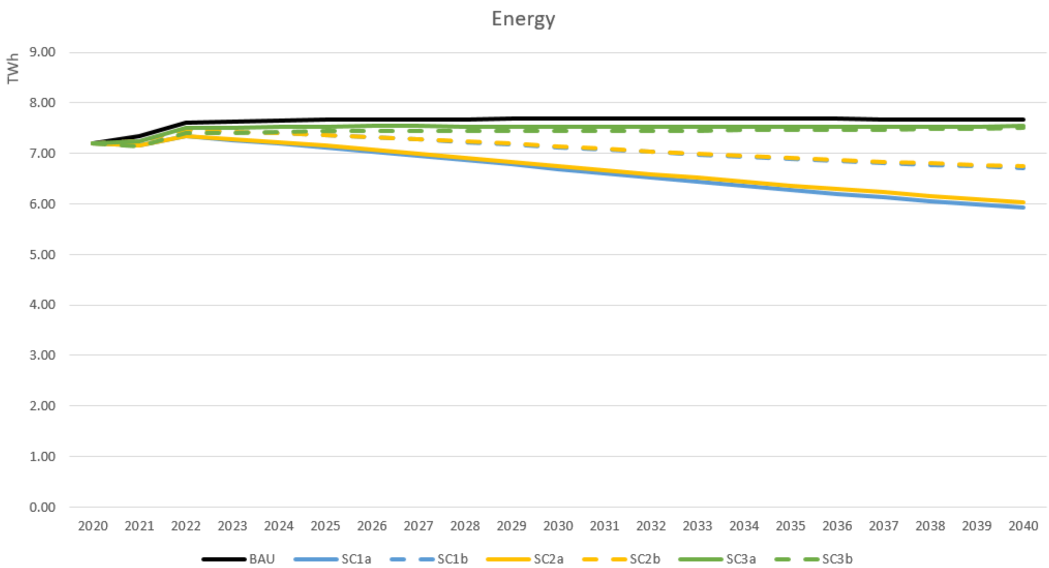



**Figure 333: Energy consumption CFEs – Summary of scenarios**

If no changes are made (BAU scenario), it is estimated that the total energy consumption attributable to cooking fume extractors will grow from 7.2 TWh in 2020 to 7.6 TWh in 2040 (6% increase). This increase in energy consumption is mostly related to the growth in the sales and stock of cooking fume extractors within that period.

Scenario 1a consists of a new methodology for the EEI and energy classes based on arithmetic FDE and a distribution based on identical EEI thresholds. After 2030, cooking fume extractors with an energy class worse than F would not be allowed. Under these conditions, it has been estimated that the total energy consumption attributable to cooking fume extractors would decrease from 7.2 TWh in 2020 to 5.9 TWh in

2040 (17.7% decrease). The adoption of Scenario 1a would mean total cumulative savings of 20.2 TWh for the 2020-2040 period compared to BAU.

Scenario 1b is similar to Scenario 1a, with a distribution based on the number of models. After 2030, cooking fume extractors with an energy class worse than F would not be allowed. Under these conditions, it has been estimated that the total energy consumption attributable to cooking fume extractors would decrease from 7.2 TWh in 2020 to 6.7 TWh in 2040 (6.8% decrease). The adoption of Scenario 1b would mean total cumulative savings of 11.3 TWh for the 2020-2040 period when compared to BAU.

Scenario 2a consists of a new methodology for the EEI and energy classes based on harmonic FDE and a distribution based on identical EEI thresholds. After 2030, cooking fume extractors with an energy class worse than F would not be allowed. Under these conditions, it has been estimated that the total energy consumption attributable to cooking fume extractors would decrease from 7.2 TWh in 2020 to 6.0 TWh in 2040 (16.1% decrease). The adoption of Scenario 2a would mean total cumulative savings of 18.9 TWh for the 2020-2040 period compared to BAU.

Scenario 2b consists of a new methodology for the EEI and energy classes based on harmonic FDE and a distribution based on the number of models. After 2030, cooking fume extractors with an energy class worse than F would not be allowed. Under these conditions, it has been estimated that the total energy consumption attributable to cooking fume extractors would decrease from 7.2 TWh in 2020 to 6.7 TWh in 2040 (6.4% decrease). The adoption of Scenario 2b would mean total cumulative savings of 11.0 TWh for the 2020-2040 period compared to BAU.

Scenario 3a consists of a new methodology for the EEI and energy classes based on airflow and a distribution based on the number of models. After 2030, cooking fume extractors with an energy class worse than F and FDE below 5% would not be allowed. Under these conditions, it has been estimated that the total energy consumption attributable to electric hobs would grow from 7.2 TWh in 2020 to 7.5 TWh in 2040 (4.7% increase). Total cumulative savings over the 2020-2040 period would be 2.8 TWh when compared to scenario BAU.

Scenario 3b consists of a new methodology for the EEI and energy classes based on airflow and a distribution based on the number of models. After 2030, cooking fume extractors with an energy class worse than F and FDE below 5% would not be allowed. Under these conditions, it has been estimated that the total energy consumption attributable to electric hobs would grow from 7.2 TWh in 2020 to 7.5 TWh in 2040 (4.2% increase). Total cumulative savings over the 2020-2040 period would be 4.3 TWh when compared to the BAU scenario.

#### 7.7.4.8 Impacts on GHG emissions

In this section, an analysis is conducted on the impact on GHG emissions of the different scenarios presented earlier. Figure 334 summarises the total GHG emissions of the stock of cooking fume extractors between 2020 and 2040 of those scenarios.

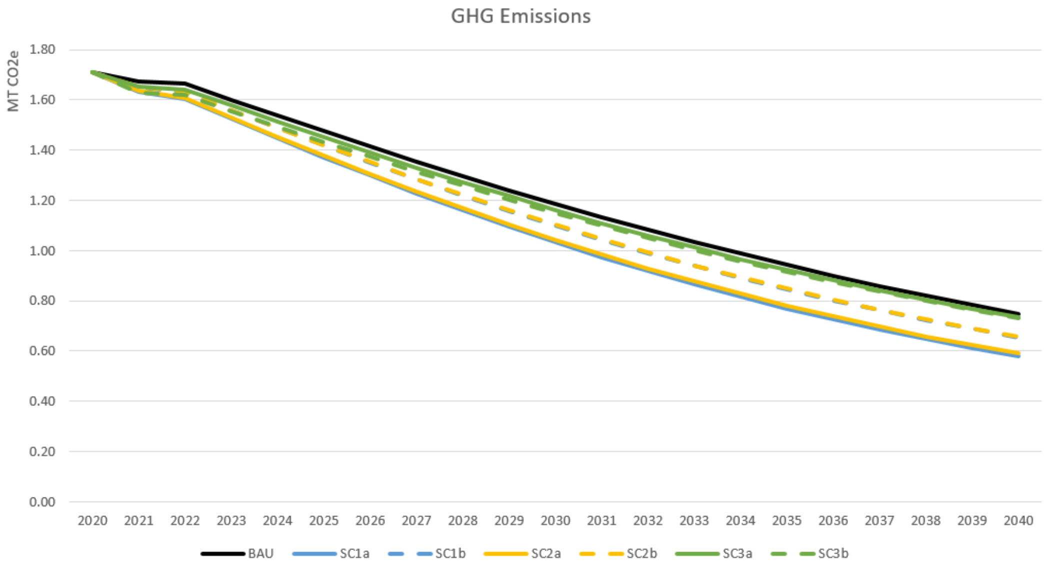



**Figure 334: GHG emissions CFEs – Summary of scenarios**

If no changes are made (BAU scenario), it is estimated that the total GHG emissions attributable to cooking fume extractors will decrease from 1.71 Mt $CO_2$ in 2020 to 0.75 Mt $CO_2$ in 2040 (56% decrease).

Scenario 1a consists of a new methodology for the EEI and energy classes based on arithmetic FDE and a distribution based on identical EEI thresholds. After 2030, cooking fume extractors with an energy class worse than F would not be allowed. Under these conditions, it has been estimated that the total GHG emissions attributable to cooking fume extractors would decrease from 1.71 Mt $CO_2$ in 2020 to 0.58 Mt $CO_2$ in 2040 (66% decrease). The adoption of Acenario 1a would mean total cumulative savings of 2.7 Mt $CO_2$ for the 2020-2040 period compared to BAU.

Scenario 1b is similar to Scenario 1a, with a distribution based on the number of models. After 2030, cooking fume extractors with an energy class worse than F would not be allowed. Under these conditions, it has been estimated that the total energy consumption attributable to cooking fume extractors would decrease from 1.71 Mt $CO_2$ in 2020 to 0.65 Mt $CO_2$ in 2040 (62% decrease). The adoption of Scenario 1b would mean total cumulative savings of 1.5 Mt $CO_2$ for the 2020-2040 period compared to BAU.

Scenario 2a consists of a new methodology for the EEI and energy classes based on harmonic FDE and a distribution based on identical EEI thresholds. It has been estimated that the total energy consumption attributable to cooking fume extractors would decrease from 1.71 Mt $CO_2$ in 2020 to 0.59 Mt $CO_2$ in 2040 (66% decrease). The adoption of Scenario 2a would mean total cumulative savings of 2.6 Mt $CO_2$ for the 2020-2040 period compared to BAU.

Scenario 2b consists of a new methodology for the EEI and energy classes based on harmonic FDE and a distribution based on the number of models. It has been estimated that the total energy consumption attributable to cooking fume extractors would decrease from 1.71 Mt $CO_2$ in 2020 to 1.5 Mt $CO_2$ in 2040 (62% decrease). The adoption of scenario 1b would mean total cumulative savings of 1.5 Mt $CO_2$ for the 2020-2040 period compared to BAU.

Scenario 3a consists of a new methodology for the EEI and energy classes based on airflow and a distribution based on the number of models. After 2030, cooking fume extractors with an energy class worse than F and FDE below 5% would not be allowed. Under these conditions, it has been estimated that the GHG emissions attributable to cooking fume extractors would decrease from 1.71 Mt $CO_2$ in 2020 to 0.74 Mt $CO_2$ in 2040 (57% decrease). Total cumulative savings over the 2020-2040 period would be 0.4 Mt $CO_2$.

Scenario 3b consists of a new methodology for the EEI and energy classes based on airflow and a distribution based on the number of models. After 2030, cooking fume extractors with an energy class worse than F and FDE below 5% would not be allowed. Under these conditions, it has been estimated that the total GHG emissions attributable to cooking fume extractors would decrease from 1.71 Mt $CO_2$ in 2020 to 0.73 Mt $CO_2$ in 2040 (57% decrease). Total cumulative savings over the 2020-2040 period would be 0.7 Mt $CO_2$.

#### 7.7.4.9 Impacts on consumer expenditure

The impacts of policy measures on consumer expenditure are analysed in this section. These impacts include a change in the operating costs (which are usually lower because of more energy-efficient machines) and a change in the purchase price. The consumer expenditure is calculated as the life cycle cost (LCC), i.e. including purchase costs and operating costs (energy repair and maintenance costs). The purchase price of each type of range hoods is based on the motor technology (see Task 6) and the evolution of prices has been estimated according to a learning curve.

The operating costs consist of the electricity, maintenance and repair costs. The electricity price is assumed as in Figure 61. Figure 335 summarises the total consumer expenditure of cooking fume extractors between 2020 and 2040 of those scenarios.

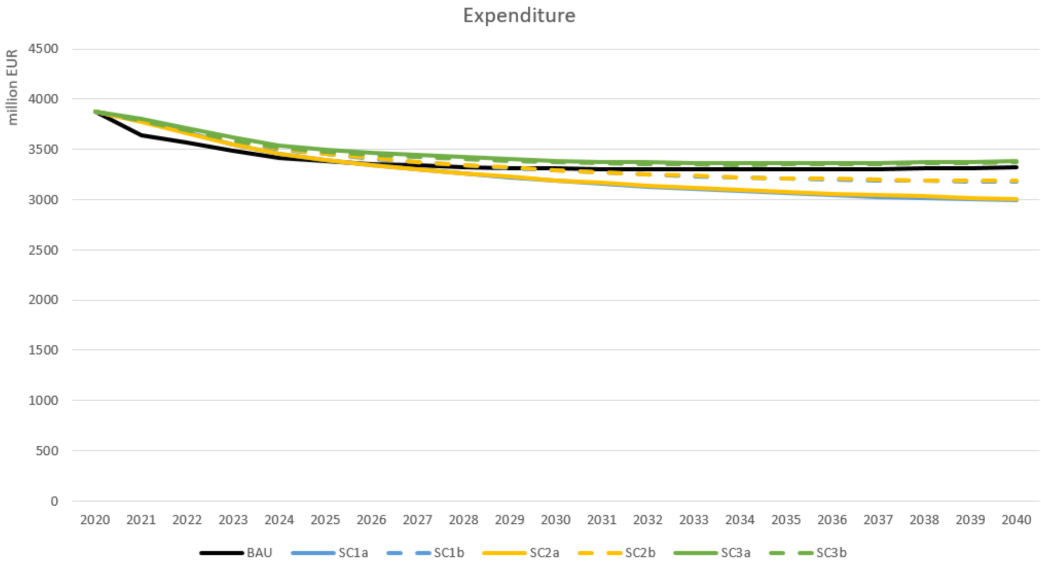



**Figure 335: Consumer expenditure CFEs – Summary of scenarios**

If no changes are made (BAU scenario), it is estimated that the total consumer expenditure attributable to cooking fume extractors will decrease from EUR 3.9 billion in 2020 to EUR 2.8 billion in 2040 (19% increase).

Scenario 1a consists of a new methodology for the EEI and energy classes based on arithmetic FDE and a distribution based on identical EEI thresholds. After 2030, cooking fume extractors with an energy class worse than F would not be allowed. Under these conditions, it has been estimated that the total consumer expenditure attributable to cooking fume extractors would decrease from EUR 3.9 billion in 2020 to EUR 2.9 billion in 2040. The adoption of scenario 1a would mean a total cumulative decrease of EUR 2.4 billion for the 2020-2040 period compared to BAU.

Scenario 1b is similar to Scenario 1a, with a distribution based on the number of models. After 2030, cooking fume extractors with an energy class worse than F would not be allowed. Under these conditions, it has been estimated that the total consumer expenditure attributable to cooking fume extractors would decrease from EUR 3.9 billion in 2020 to EUR 3.1 billion in 2040. The adoption of Scenario 1b would mean a total cumulative decrease of EUR 0.3 billion for the 2020-2040 period when to BAU.

Scenario 2a consists of a new methodology for the EEI and energy classes based on harmonic FDE and a distribution based on even EEI thresholds. Under these conditions, it has been estimated that the total consumer expenditure attributable to cooking fume extractors would decrease from EUR 3.9 billion in 2020 to EUR 2.2 billion in 2040. The adoption of Scenario 1b would mean a total cumulative decrease of EUR 2.3 billion for the 2020-2040 period compared to BAU.

Scenario 2b consists of a new methodology for the EEI and energy classes based on harmonic FDE and a distribution based on the number of models. Under these conditions, it has been estimated that the total consumer expenditure attributable to cooking fume extractors would decrease from EUR 3.9 billion in 2020 to EUR 3.2 billion in 2040. The adoption of Scenario 1b would mean a total cumulative decrease of EUR 0.2 billion for the 2020-2040 period compared to BAU.

Scenario 3a consists of a new methodology for the EEI and energy classes based on airflow and a distribution based on the number of models. After 2030, cooking fume extractors with an energy class worse than F and FDE below 5% would not be allowed. Under these conditions, it has been estimated that the total consumer expenditure attributable to electric hobs would decrease from EUR 3.9 billion in 2020 to EUR 3.4 billion in 2040. The total cumulative decrease over the 2020-2040 period would be EUR 1.8 billion.

Scenario 3b consists of a new methodology of EEI and energy classes based on airflow and a distribution based on number of models. After 2030, cooking fume extractors with an energy class worse than F and FDE below 5% would not be allowed. Under these conditions, it has been estimated that the total consumer expenditure attributable to electric hobs would decrease from 3.9 billion EUR in 2020 to 3.3 billion EUR in 2040. The total cumulative decrease over the 2020-2040 period would be EUR 1.4 billion.

#### 7.7.4.10 Summary of scenarios cooking fume extractors

A summary of the different policy scenarios analysed and their impact over 2020-2040 is shown in Table 153. Negative values indicate an increase over time and positive values indicate a decrease.

**Table 153. Summary of the policy scenarios and their impacts for cooking fume extractors**

| Scenario | Technology impact | Energy cumulative impact (TWh) | GHG cumulative impact (Mt $CO_2$) | LCC cumulative impact (billion EUR) |
|---|---|---|---|---|
| Sc1a | Energy classes B, C and D identify BAT, which is significantly promoted. EEI is able to compare the efficiency of cooking fume extractors delivering the same airflow and pressure. The most common technologies are concentrated in the lowest energy classes, which does not allow comparison within them. | 20.22 | 2.75 | 2.4 |
| Sc1b | Energy classes B and C identify BAT, which is moderately promoted. EEI is able to compare the efficiency of cooking fume extractors delivering the same airflow and pressure. The most common technologies are placed in medium and low energy classes, which allows the comparison within them. | 11.31 | 1.54 | 0.3 |
| Sc2a | Energy classes B, C and D identify BAT, which is significantly promoted. EEI is able to compare the efficiency of cooking fume extractors delivering the same airflow and pressure. The most common technologies are | 18.89 | 2.57 | 2.3 |

| | | | | |
|---|---|---|---|---|
| | concentrated in the lowest energy classes, which does not allow comparison within them. | | | |
| Sc2b | Energy classes B and C identify BAT, which is moderately promoted. EEI is able to compare the efficiency of cooking fume extractors delivering the same airflow and pressure. The most common technologies are placed in medium and low energy classes, which allows comparison within them. | 10.98 | 1.50 | -0.2 |
| Sc3a | Energy classes B and C correspond mainly to BAT. However, conventional technologies are able to reach best classes. EEI is able to compare the efficiency of cooking fume extractors delivering the same airflow. The most common technologies are placed in medium and low energy classes, which allows comparison within them. | 2.83 | 0.43 | -1.8 |
| Sc3b | Energy class B identifies BAT, which is less promoted than Sc1. EEI is able to compare the efficiency of cooking fume extractors delivering the same airflow. The most common technologies are placed in high, medium and low energy classes, which allows comparison within them. | 4.35 | 0.68 | -1.4 |

# 8 Conclusions

The energy used for the main cooking appliances (ovens, hobs and cooking fume extractors) represents around 6% of a household energy consumption. Aimed at increasing energy efficiency of these appliances, Ecodesign and Energy Labelling Regulation entered into force in 2015. A revision is due according to current ecodesign and energy labelling regulation. The Commission launched the revision of current Regulation for this product group, and a preparatory study has been conducted by the JRC.

Since current regulation entered into force, the market has evolved and new technologies are more often available, and their advantages and disadvantages need to be considered. For instance, energy saving heating functions in ovens are one of the main opportunities for improvement in terms of energy efficiency. There is also energy saving potential in microwave combi modes, observed in tests with real food, which can vary between 5% and 20%. Automatic functions may also reduce the energy consumption of the oven by approximately 15%. In cooking fume extractors, there is a significant improvement potential related to the electric motors of the blower. Brushless motors are more efficient and are able to reach the highest efficiencies; however, they are the most expensive and therefore they are currently only present in high-end models. The improvement potential of hobs is smaller at this point. The market of domestic cooking appliances is still growing and the stock of ovens, hobs and cooking fume extractors is expected to increase in the following years.

Based on those market changes, the JRC has recommended a series of products that might be included in the scope of new regulation, at various levels (ecodesign and energy labelling), such as solo microwave ovens, combi microwave ovens, steam ovens, auxiliary hobs, or recirculation cooking fume extractors, among others.

This study has also provided more detail on the European consumer cooking behaviour. For instance, 87.5% of European households have a conventional oven, 75.3% have a microwave oven, 74.9% have a cooking fume extractor, 71.5% have a hob and 4.8% have a steam oven. The average frequency of use of domestic ovens is 3.5 times per week. The hob is used an average of 11.7 times per week. The overall average use is for 3.8 hours per week. About 80% of the respondents use the fan of the cooking fume extractor often or almost always when the hob is in use and about 60% use the light of the cooking fume extractor. About 14% of the respondents claim to also use the cooking fume extractor when not cooking.

Circumvention issues have been detected by surveillance authorities. For instance, the current energy consumption test method for electric ovens has been used since 2012. Recent publications have shown that some manufacturers may be exploiting some of the characteristics of this test to declare energy consumption figures that are considerably lower than real-life use. In response to this issue, the industry and standardisation experts have been developing a new method that addresses these circumvention issues. New regulation can ensure that the most recent and representative of real-life measurement methods are adopted. To address those issues, the JRC has recommended a series of measures, such as the adoption of the new version of EN 60350-1 that is under development by CENELEC (publication expected in June 2023) as the reference method to measure energy consumption of domestic electric ovens, as soon as it is published. For gas ovens, carry on measurements with current version of EN 15181 until a common and comparable method is defined for both energy sources. In the ovens energy label, the JRC has recommended to declare two energy consumption values: standard mode and best performing mode.

The declared energy consumption is not always representative of real-life use. The current Ecodesign and Energy Labelling Regulations state that the energy consumption of ovens is declared with the best-performing mode of the appliance. This has created an incentive for manufacturers to design heating modes with the lowest energy consumption possible (commonly known as eco modes), in order to obtain the highest energy classes. Some of these eco modes cannot cook properly and are rarely used by consumers. Therefore, the JRC has recommended to use an 80/20 weighted sum approach (80% for standard and 20% for best performing mode) for the energy declaration of ovens.

Similarly, energy efficiency in cooking fume extractors is measured at the best efficiency point, usually achieved with a function –boost mode- that consumers do not use very often. This may have pushed the market towards high-airflow appliances, rather than to more energy-efficient ones. In response to this issue, the industry has been developing a new measurement method that better represents the real use of cooking fume extractors. With new regulation, it can be ensured that the energy consumption values declared by manufacturers are more representative of consumers than today. The JRC has also recommended to use Fluid Dynamic Efficiency as the main efficiency parameter, using an harmonic mean between relevant working points of the appliances, since it may promote the market evolution towards the best available technologies.

Energy classes of ovens and cooking fume extractors are less meaningful today. Most ovens today are shared between two energy classes only, so it is difficult for consumers to establish differences in terms of the energy efficiency of ovens. Current energy labelling dates from 2015. Over this period, the industry has adapted to regulation by removing from the market the worst-performing appliances and by consolidating most of their models among the A and A+ energy classes. A trend has also been observed towards larger cavity ovens (even though the full capacity is rarely used). Based on that, the JRC has recommended a re-scale of energy classes. A new approach has also been recommended to measure energy efficiency, in order to compare the real energy consumption of devices (rather than relying on cavity volume as a factor) and promote the right sizing of ovens. In terms of hobs, the small differences in energy consumption of different hob electric technologies suggests that an energy class for these appliances would not be meaningful for the consumer.

Relevant performance parameters are not taken into account. The current Ecodesign Regulation for cooking fume extractors does not take into account one of the main performance parameters of these devices: the capacity to absorb odour. Available measurement methods are suitable for a very small market segment (recirculation) but not for the most part (extraction). New regulation can help with the development of new energy consumption measurement methods that take into account relevant performance parameters such as odour reduction efficiency. The JRC has made recommendations regarding current standard EN 61591, which contains a test method for odour reduction with methyl ethyl ketone (MEK).

New energy sources are available. It is likely that the use of gases such as hydrogen will increase in the midterm. Consequently, appliances such as gas hobs and ovens will have to adapt to these new gas mixtures, keeping a high level of safety, reliability and performance. The JRC has made some proposals in terms of compatibility, adaptability and information requirements, which may help for a gradual introduction of hydrogen as an energy source in the domestic cooking appliances sector.

Material efficiency requirements can be more ambitious. Current regulation includes some material efficiency requirements in the product information section. However, these requirements are not in line with the level of ambition of the Circular Economy Action Plan 2020. The JRC has given recommendations in terms of updated lists of spare parts, access to repair and maintenance information, dismantling requirements, mandatory marking, critical raw materials and recycled content, among others.

Finally, additional clarity can be provided regarding low power modes. Current regulation has different approaches in terms of low power modes for the cooking appliances within the scope of this project. Whereas ovens and hobs are covered horizontally under REG 1275/2008, range hoods are addressed vertically with specific requirements in REG 66/2014. This situation has created confusion for manufacturers. The JRC has recommended to establish new specific low power mode requirements that provides clarity on this situation and that raises the level of ambition of cooking appliances, to be in line with other domestic appliances.

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AC – Alternating Current
ACD – Acidification
AEC – Annual Energy Consumption
ASTM – American Society for Testing and Materials
BAT – Best Available Technology
BAU – Business as Usual
BC – Base Case
BEP – Best Efficiency Point
BM – Brick Method
BNAT - Best Not Available Technology
CE – Circular Economy
CE – Conformité Européene
CFL – Compact Fluorescent Light
CLP – Classification, Labelling and Packaging
CO – Carbon monoxide
CUT – Cookware Under Test
DG – Directorate-General
DO – Design Option
DOE – Department of Energy
EC – European Commission
ECD – Environmental conscious design
ECHA – European Chemicals Agency
ED – Ecodesign
EE – Energy Efficiency
EEE – Electrical and Electronic Equipment
EEI – Energy Efficiency Index
EF – Energy factor
EL – Energy labelling
EMC – Electromagnetic compatibility
EN - European Norm
EOL – End of Life
EPA – Environmental Protection Agency
EPCA – Energy Policy and Conservation Act
EPS – Expanded Polystyrene
EU – European Union
EUR – Euro
FDE – Fluid Dynamic Efficiency
GFE – Grease Filtering Efficiency
GHG – Greenhouse Gas
GOST – Gosudarstvennyy Standart
GPP – Green Public Procurement
HDPE – High-density polyethylene
HM – Heavy metals
ICT – Information and Communication Technology
IEC – International Electrotechnical Commission
ISO – International Standardization for Organisation
JRC – Joint Research Centre
LCA – Life Cycle Assessment
LCC – Life Cycle Cost
LDPE – Low-density polyethylene
LED – Light-Emitting Diode
LLCC – Least Life Cycle Cost
LPG – Liquified Petroleum Gas
LVD – Low Voltage Directive

MADE – Manufacture, assembly, disassembly and end of life
MAX – Maximum
ME – Material Efficiency
MEErP – Methodology for Ecodesign of Energy-related Products
MEK – Methyl ethyl ketone
MEPS – Minimum Efficiency Performance Standards
MIN – Minimum
MW – Microwave
NRVU – Non-residential ventilation unit
NTP – Non-thermal Plasma
OE – Operating Expense
OEM – Original Equipment Manufacturer
PAH – Polycyclic Aromatic Hydrocarbon
PBB – Polybrominated biphenyls
PBDE – Polybrominated diphenyl ethers
PCBA – Printed Circuit Board Assembly
PEF – Primary Energy Factor
PET – Polyethylene terephthalate
PM – Particulate Matter
PM – Permanent magnet
POP – Persistent Organic Pollutants
PP – Purchase Price
PV - Photovoltaic
PVC – Polyvinyl chloride
PWF – Present Worth Factor
REACH – Registration, evaluation, authorisation and restriction of chemicals
REG – Regulation
RFID – Radio Frequency Identification
RRR – Recyclability, recoverability, reusability
RVU – Residential ventilation unit
SAEC – Standard Annual Energy Consumption
SEC – Specific Energy Consumption/Standard Energy Consumption
SMR – Steam Methane Reforming
SVHC – Substance of very high concern
TFT – Thin Film Transistor
TWG – Technical working group
UN-GHS – Globally Harmonised System
USA – United States of America
USB – Universal Serial Bus
VOC – Volatile Organic Compounds
VSD – Variable speed drive
VU – Ventilation unit
WEEE – Waste Electrical and Electronic Equipment
WG – Working Group
WHO – World Health Organization

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