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Survey on Interoperability of Energy Smart Appliances

Supporting the development of policy proposals for Energy Smart Appliances

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Contents

Abstract

Energy Smart Appliances (ESA) are one of the instruments to transform houses or buildings into smart ones. They also empower consumers in becoming active players of the smart grid by controlling efficiently their consumption. However, a wide-scale deployment of ESA may induce interoperability (IOP) issues. Therefore, a concrete approach is needed in order to provide policy support and reassurance that IOP is preserved in the system while ESA are introduced in the market.

In this project, DG ENER and the Joint Research Centre (JRC) join their forces in order to provide support for the development of policy proposals for ESA. For this reason, several actions have been taken, namely:

1. Literature review and consolidation of input from relevant sources on the IOP of ESA such as the InterConnect project, standardisation efforts in other countries or regions (i.e. UK, California, etc.).
2. Development of Use Cases (UCs) for ESA.
3. Definition of principles of data sharing among appliances, home and building automation systems, electric vehicle chargers, aggregators, Distribution System Operators (DSOs), etc.

This TR builds upon the aforementioned tasks and aims at collecting information from all possible stakeholders with respect to smart appliances: the messages that they exchange with the rest of energy actors; the type of ESA that are being manufactured and forwarded to the market; IOP issues that have been encountered; societal issues related to ESA such as their acceptance by the broader public and barriers. In order to accomplish this task, and to include all possible stakeholders from industry to academia and NGOs, the JRC team carried out a dedicated survey aiming at collecting information and trying to depict, as realistic as possible, the current status of ESA.

This report presents the findings from our dedicated survey on the IOP of ESA, revealing the current situation of these products as it is portrayed through the stakeholders' replies and both the state-of-the-art features, or advantages, and the IOP barriers, or disadvantages, that may be present. Thus, this report is fundamental for the project and for providing policy support for ESA. Specifically, this TR, as the result of the first active contribution from ESA manufacturers, sets the basis for the creation a Code of Conduct (CoC) for IOP of ESA, to which the manufacturers will be able to adhere.

The future CoC will be based on the information here collected and will come after additional discussions with all interested parties. The intention is to have as many stakeholders as possible who will be willing to adhere to this CoC. Thus, they have been included and engaged since the start of the project through, collecting their feedback from: surveys, like the one here represented; discussions, which did and will take place in organised workshops; and direct contact though the project's website and/or the project's functional mailbox.

Acknowledgements

The authors of this TR would like to thank our colleagues from Directorate B "Just Transition, Consumers, Energy Efficiency and Innovation", in particular Georgios Takoudis, from Buildings and Products (ENER.B.3), for his support. Also, sincere thanks to our project manager, Ulrik Von Estorff, for his contribution particularly during the literature research and when trying to connect and promote the project (see Introduction) to other initiatives. Finally, we would also like to extend our thanks to all survey participants, without whom this report would not have been feasible.

Authors

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1 Introduction

1.1 Background

In the era of energy digitalization and of a continuously evolving smart grid, every actor plays a paramount role in upgrading the energy grid and in the transformation of the way energy is produced and consumed. Such transformation is fundamental for the future grid and its evolvement throughout the years. Therefore, the end-consumers play a key role in the smart grid and their involvement is crucial for the smart grid. To this direction, ESA are an important element for enabling consumers to become active in controlling their energy production and consumption and thus contributing actively in this grid transformation. Indeed, ESA are experiencing a boom with respect to their production and penetration in the overall market.

It is foreseen that the number of smart homes in Europe by 2026 will reach 86.3 million (Statista, 2022), which is an impressive number considering that the European Union has close to 450 million inhabitants. That is more than a third of the population, considering that the average size of a house is over 2 people ([1] Speaking in numbers, and referring to the whole globe, studies showed that the global home energy management systems market reached a value of US$ 2.1 Billion in 2021, whereas it is expected to reach US$ 6 Billion by 2027, (IMARCgroup, 2022).

From the above, the importance of ESA and their correct functionality and interaction with the rest of the actors is clear. Thus, it is important to have complete studies on these smart products and their functionalities, as well as the messages that can be exchanged. In the legislative framework of Ecodesign and Energy Labelling (ETSI, 2017), a preparatory study addressing ESA was performed. This study defined the economic benefits that can be achieved by a large scale deployment of ESA, determined aspects for future work, like for example product categories with a potential for demand response services. The conclusion of the study indicated that more detailed work is needed in order to achieve a regulatory proposal. This study is only one example of work focusing on smart appliances. Several projects have taken place, like the Interconnect project (InterConnect), which focuses on interconnecting digital homes and buildings with the energy sector.

The issues with ESA vary from the rapid development of a plethora of technological solutions to the adherence of industry to policy support. Particularly for the various technological solutions that can be applied to them, an issue that emerges is related to IOP, since many of these technologies may not be compatible with each other. On the other hand, there is a lack of coordinated policy support to which the industry may rely on or even adhere.

It is clear from the above that coherence is needed for future steps with respect to smart appliances penetration in the market, meaning that it is fundamental that the systems and appliances manufactured and forwarded to the market respect basic IOP rules. This TR represent one of the first steps taken by the EC to define and set the necessary basic rules to achieve such interoperability for ESA.

This TR is part of a broader project in the framework of an Administrative Arrangement (AA) between the DG ENER and DG JRC with the scope to provide technical and scientific assistance. The project is entitled “Support to the development, implementation and review of relevant provisions of EU Energy Efficiency legislative framework, related actions and related governance issues (JRC-TSEED III)”, and it is specifically related to WP2 - Technical and scientific support to the review of EU Energy Efficiency legislation including energy performance of buildings and prods under the Task 2.4: Support on the development of policy proposals for ESA.

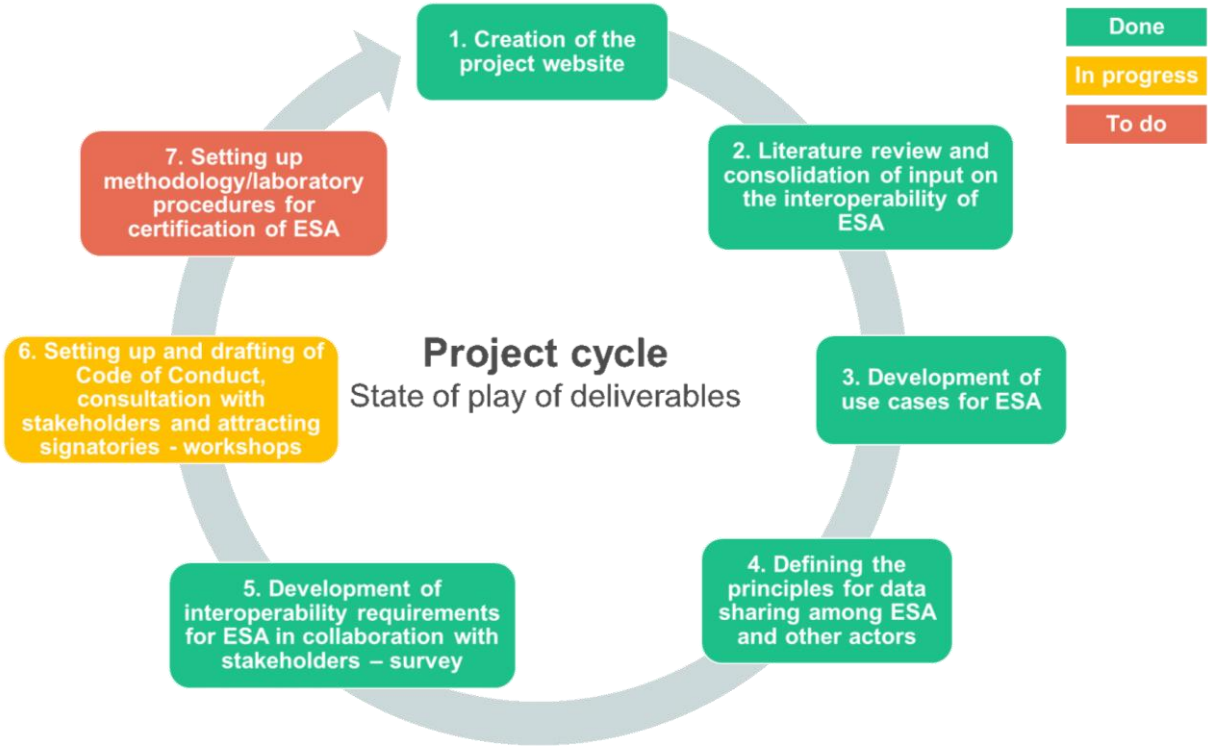
In the aforementioned task, one of the objectives is to perform an analysis of the ESA and a thorough literature review on the existing projects and Use Cases (UCs) on smart appliances. Another goal is to investigate the messages exchanged between smart appliances and the rest of the involved actors and to address IOP issues. In order to understand better the possible messages to be exchanged, it is necessary to research the existing state-of-the-art of ESA and the messages they already exchange with key actors, like the Energy Service Provider, the customer, and for control within devices or outside house premises, among other possible. For this purpose, it has been deemed necessary to carry out a survey in order to collect all possible information from all interested stakeholders, like the industry, the academia, NGOs, etc. Such information is related to the categorisation of ESA, the possible messages exchanged, IOP issues, for the sake of naming some. The scope is to have a global picture of what already exists in practice and use this information as the basis for further elaboration. Indeed, the

[1] https://www.statista.com/statistics/1231406/average-household-size-in-europe/

ultimate goal is to reach a consensus for a CoC, which will be proposed to manufacturers for adherence. Attracting as many signatories as possible for this CoC can reassure minimum market convergence for usage of open standards and protocols.

The status of the project progress, performed and future tasks are presented in Figure 1. The overall design of the project with respect to Task 2.4, the steps that have been followed and the future steps that need to be done are graphically represented in a clear way.

Figure 1. Project "Support on the development of policy proposals for IOP of ESA" cycle as of December 2022.



Source: JRC analysis, 2022.

This report analyses and presents the results of the open survey carried out for the IOP of ESA in order to collect information from all possible stakeholders. The answers provided will be included as part of the basis for future support on policies on smart appliances. Thus, this report is part of step no. 5 as it is depicted in Figure 1. In the rest of this Chapter, it is presented the link of this work to policy, its link to previous reports performed by our team, together with the future steps that will follow this work. Chapter 2 presents the survey carried out to collect the necessary information. In particular, Chapter 2 introduces how the survey was formulated and which participants were targeted. Chapter 3 gives the results of the survey with respect to the messages exchanged and the technical data collected, followed by Chapter 4, where other issues are presented, like the role of ESA in the future society (adherence to CoC, security issues, among others). Finally, Chapter 5 presents the conclusions of this report.

1.2 Link to Policy

The purpose of this work is to provide policy support for the implementation of ESA. Particularly, the JRC provides support related to the development, implementation and review of several provisions of EU energy efficiency legislative framework Energy Efficiency Directive (Directive 2012/27/EU as amended by Directive (EU) 2018/2002) and the Energy Performance of Buildings Directive (Directive 2010/31/EU as amended by Directive (EU) 2018/844), including aspects related to the framework of the Governance Regulation (Regulation (EU) 2018/1999).

Since this work is directly related to policy support, several other directive and regulations are taken into consideration, as they entail provisions for ESA directly or indirectly through provisions for smart buildings/ houses. They are listed as follows:

1. Energy Efficiency Directive, (Directive 2012/27/EU).
2. Energy Performance of Buildings Directive, (Directive (EU) 2018/844).
3. Governance Regulation, (Regulation (EU) 2018/1999).
4. Ecodesing Directive, (Directive 2009/125/EC).
5. Energy Labelling Regulation, (Regulation (EU) 2017/1369).

1.3 Link to previous reports from the same project

The work presented in this report is the continuation of the report: "ESA' Interoperability: Analysis on Data Exchange from State-of-the-art UCs", which was the first report under the aforementioned Task 2.4 and whose content analyses the following tasks:

1. Literature review and consolidation of input from relevant sources on the IOP of ESA such as the InterConnect project, standardisation efforts in other countries or regions (i.e. UK, California, etc.).
2. Development of UCs for ESA.
3. Definition of principles of data sharing among appliances, home and building automation systems, electric vehicle chargers, aggregators, Distribution System Operators, etc.

After defining the principles of data sharing among appliances, based on the literature review and on the development of UCs for ESA, it was still necessary to collect information about the actual situation regarding which ESA are currently manufactured and forwarded to the market. Therefore, a dedicated survey for this scope was created to collect such information. The information gathered in the report "ESA' Interoperability: Analysis on Data Exchange from State-of-the-art UCs" (Papaioannou, 2022) was used as the basis to formulate the questionnaire. This information directed us accordingly to search for the equivalent information and create an accurate questionnaire that addressed all the necessary fields and issues around ESA.

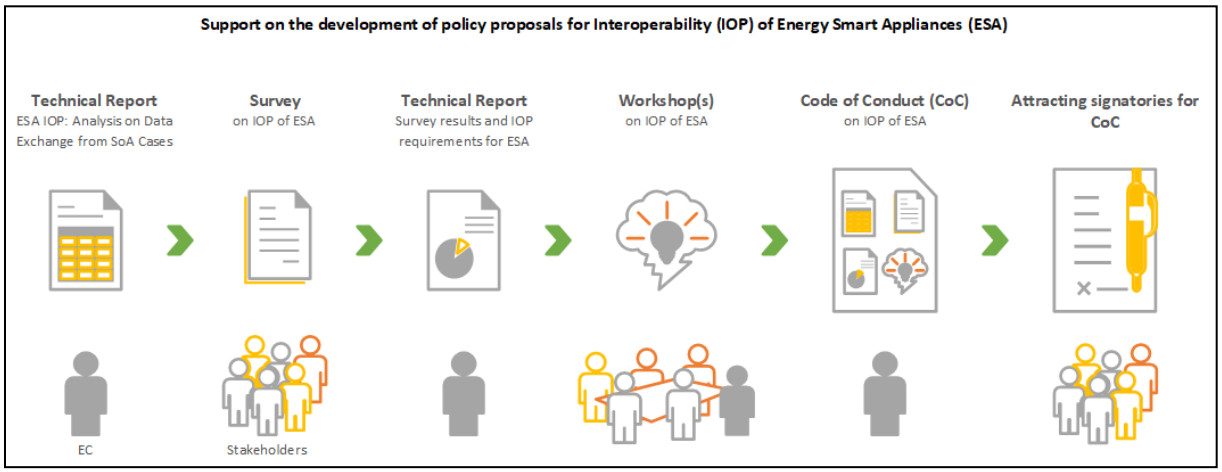
1.4 Next steps of the project

The results collected in the survey depict the views of all possible stakeholders in connection to ESA and the relevant issues that could arise from a massive deployment of such smart appliances. The analysis of these results constitute the first step for future discussions with all involved stakeholders. For this purpose, a dedicated workshop is scheduled to facilitate the discussion of the results with stakeholders from all interested sectors, like NGOs, industry and academia. The outcomes from these specific discussions will be elaborated in order to form a concrete proposal for a possible future regulation related to ESA. Such a concrete proposal, the so-called CoC, will only translate into a suggestion for adherence by ESA manufacturers and important stakeholders in the field. However, it could constitute the basis for possible future regulations to be proposed by the European Commission (EC) related to ESA. In the following list, the steps envisaged to reach the CoC are introduced:

1. Discussion and further elaboration of the results obtained from the dedicated survey for the IOP of ESA through workshop; collection of proposals from all interested stakeholders.
2. Analysis of the proposals collected and composition of a final joint proposal that would become the basis for the CoC.
3. Discussion of this final proposal and eventual acceptance by all possible stakeholders through a series of workshops.
4. Formulation of the final CoC for IOP of ESA, submission to DG ENER, and sharing the approved official final document to any other interested stakeholders in the field of ESA for its voluntary adherence.
5. Further utilization of the CoC for the formation of regulations in the field of smart appliances.

Current and future steps of the project are visualised in the following figure.

Figure 2. Project "Support on the development of policy proposals for IOP of ESA" cycle as of December 2022.



Source: JRC analysis, 2022.

It is clear from the above that the results presented here play a key role for the future of the final formulation of the CoC, because they will be the basis for all further discussions by the interested parties. In addition, it is important to highlight that involved stakeholders are being consulted (surveys) and summoned (workshops) from an early stage to attract as many signatories for this CoC as possible, which would ensure minimum market convergence.

2 The survey on interoperability (IOP) of Energy Smart Appliances (ESA)

The Chapter describes and explain the survey. It is divided into three sections: scope, questions and participants, which respectively explain the scope of the survey, present the survey's content and give a statistical description of the participants.

2.1 Scope of the survey

As mentioned previously, a first report about "ESA' Interoperability: Analysis on Data Exchange from State-of-the-Art UCs" was published in September 2022 (Papaioannou, 2022). Since the principles of data sharing by smart appliances were established in that report, the next step is to work on the IOP requirements.

The purpose of the survey is to understand the current available technology and to identify best practices for IOP of ESA to establish a CoC for IOP of ESA. The project foresees the survey as the first direct contact with the stakeholders involved to collect all the perspectives. However, a series of workshops, to discuss about these perspectives, are also planned. After both these two milestones, survey and workshops, the assessment and requirements will be integrated in the final CoC. Eventually, DG ENER and DG JRC aimed to propose the final CoC for IOP of ESA to manufacturers for their voluntary adherence.

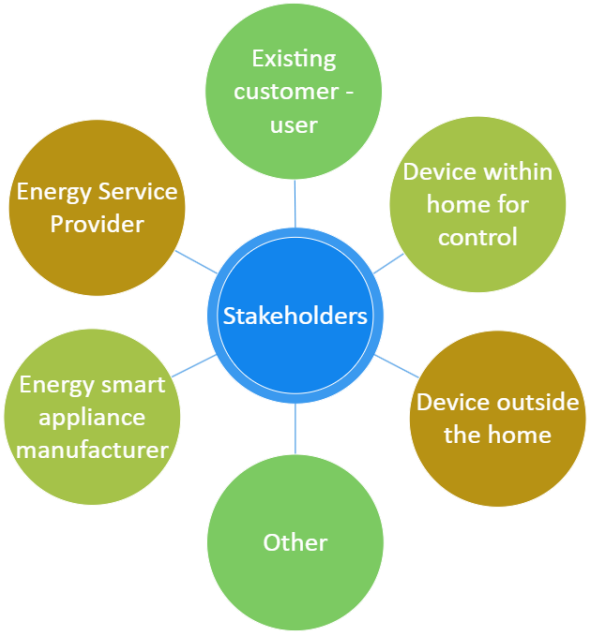
Figure 3. Steps to stablish a CoC and the role of our survey.

Source: JRC analysis, 2022.

With the aim of involving the main stakeholders (industry, NGOs, academia) and Member States authorities in this CoC, some entities were directly contacted about their interest in participating in the project. The survey on IOP for ESA was launched and additional stakeholders, who had expressed their interest, were also invited to complete the survey. The survey was kept open for participation to anyone for further contributions.

The survey starts by classifying the stakeholders into 6 different categories as shown in Figure 4. The rest of the survey contained three types of questions: Yes/No answers; multiple choice answers; free text answers, which was often included as "Others" and provided the participants the opportunity to give further explanations.

Figure 4. Type of stakeholder.



Source: JRC analysis, 2022.

2.2 Questions covered in the survey

The questions were divided in three sections, namely: General Data identifying the nature of the stakeholder providing feedback, Technical Data, and General Questions.

2.2.1 General Data

The General Data section was aimed at obtaining the contact data and identifying the type of entity completing the survey. Based on the replies given in this Section, specific questions were appearing or not in the second part (technical data). In other words, the survey was a dynamic one, meaning that not all questions were visible to all participants, according to their interests and their focus topics.

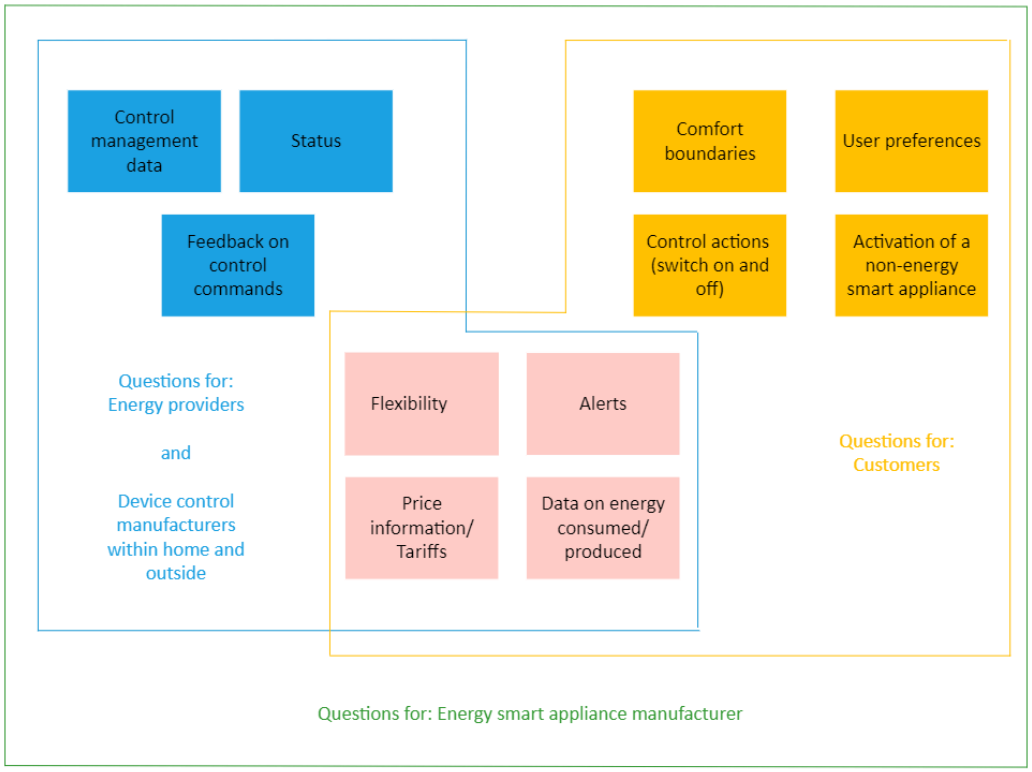
2.2.2 Technical Data

The Technical Data section began by asking a set of multiple questions about which type of device, appliance, and storage was manufactured by the entity.

Afterwards, specific characteristics were inquired, like the types of messages exchanged among ESA and the rest of critical actors in the ecosystem (i.e. smart home). Not all of these questions were visible to all participants, depending on preceding choices in the questionnaire. For example, a stakeholder taking the survey that was not an Energy Service Provider and did not manufacture an ESA, would not be offered questions related to messages exchanged between these actors.

The focus was on data collection of information about: flexibility offered, alerts, data of consumption available, and information about prices or tariffs. These were addressed to all stakeholders that belong to all categories of Figure 4, except for the ones defining themselves as “Others”. The participants that were defining themselves as ESA manufacturers were offered many more questions to reply than other actors, because they interact with all the rest and can provide valuable information about the messages that ESA exchange with other actors. For Energy Service Providers and manufacturers of control devices there were extra questions related to: control management data, status, and feedback on control commands. Energy customers were also asked about: comfort boundaries, control actions, and user preferences. In Figure 5, the content of the survey questions for each stakeholder is outlined.

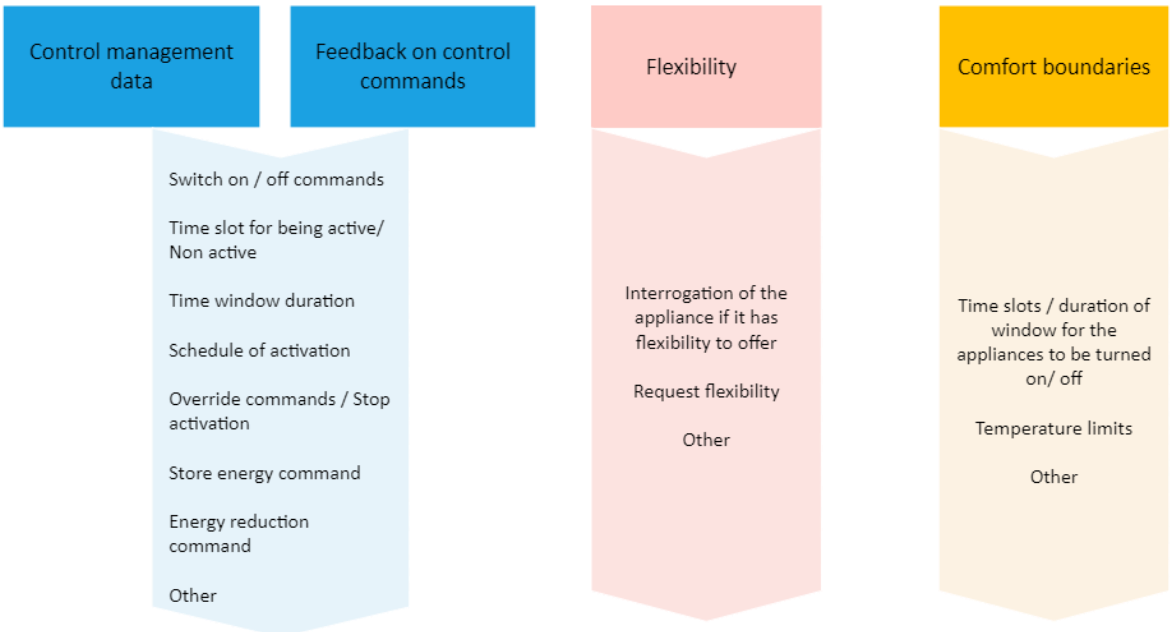
Figure 5. Technical data questions asked according to entity type.



Source: JRC analysis, 2022.

In some of these questions it was also possible to specify more details, such as the characteristics and functionalities, as it is shown in Figure 6.

Figure 6. Technical data asked for each entity.



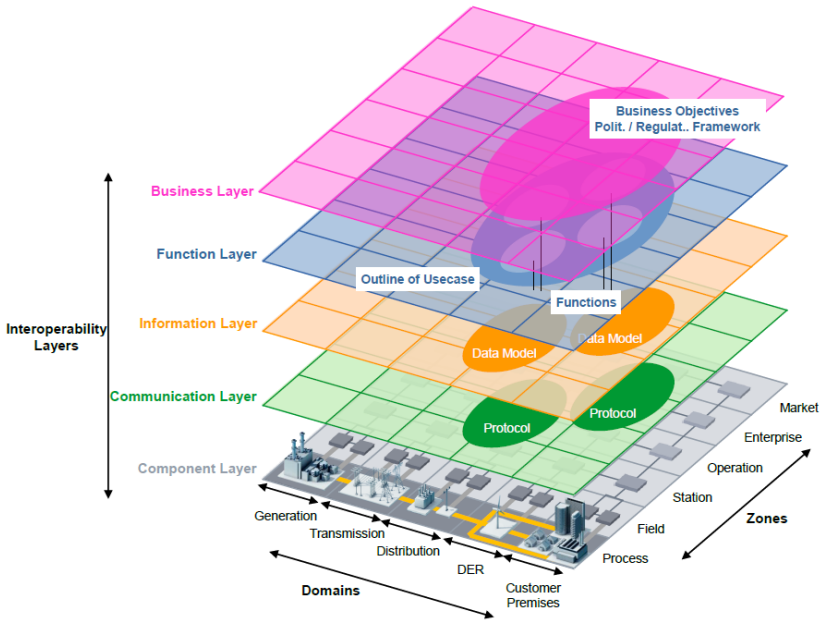
Source: JRC analysis, 2022.

With respect to the data collected about alerts, it was the type of device that determined such data.

Further, there were two questions related to the communications, namely about standards/ protocols used and whether or not SAREF ontology is used by the participants.

The survey also collected data about previous (including negative) experiences with IOP and in which layer of the Smart Grid Architecture Model (SGAM) -proposed by CEN-CENELEC-ETSI- these were focused. In order to explain the IOP layers from this framework, Figure 7 was included in the survey.

Figure 7. SGAM framework.



Source: (ETSI, 2017).

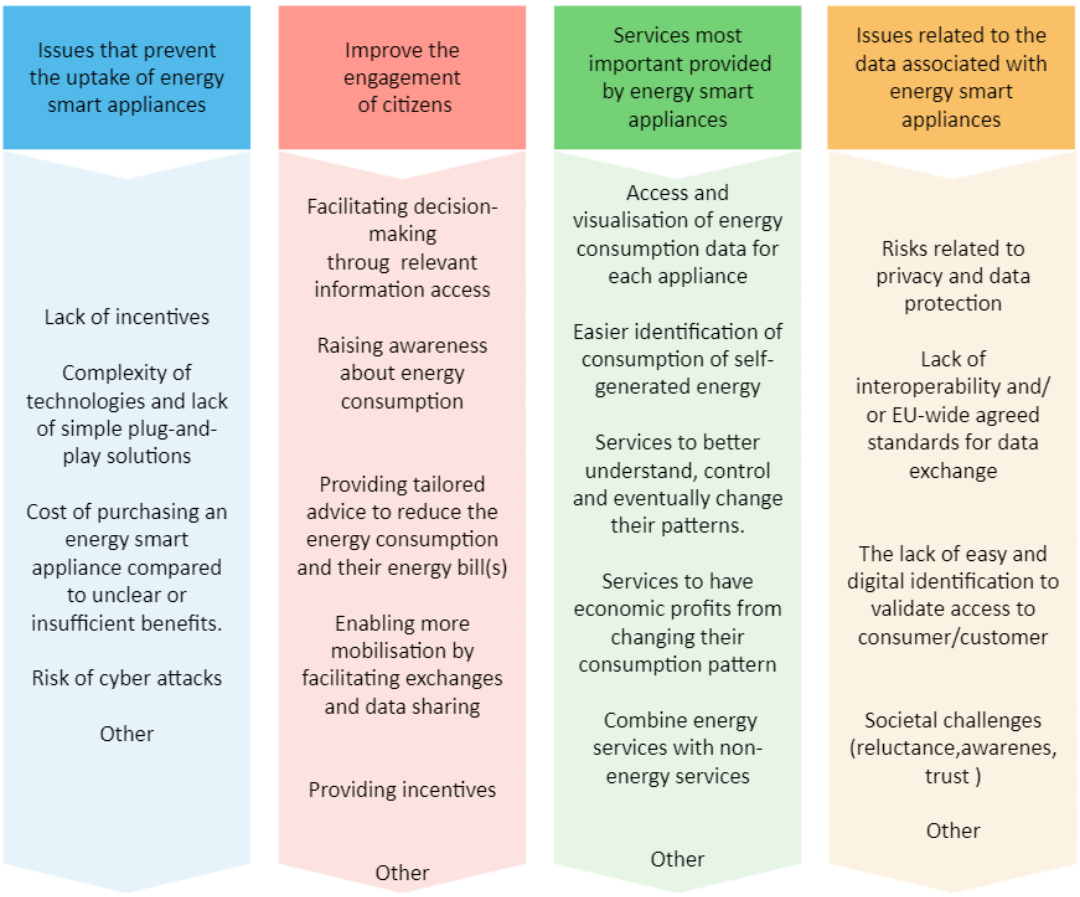
Finally, some information about the ability to solve the IOP issue(s) and about the performance of IOP tests for ESA was also collected. In case such tests were performed, the participants were asked to specify the methodology used, if any was employed. An example is provided by citing the in-house developed *Smart Grid Interoperability Testing Methodology* (Papaioannou I., 2018).

2.2.3 General Questions

This section started with three questions about the CoC: interest in participating, possible adherence, and whether it is enough to promote IOP.

Additionally, there were 4 multiple choice questions to analyse the state of the ESA and the most important issues to tackle in order to improve their deployment. Those questions and their multiple-choice answers are shown in Figure 8.

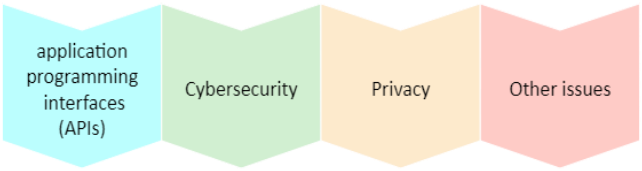
Figure 8. Questions collecting general information about ESA.



Source: JRC analysis, 2022.

Finally, there were 4 open question to allow participants to express their opinion about specific topics. They are presented in Figure 9.

Figure 9. Open questions to participants – free text answers.



Source: JRC analysis, 2022.

2.3 Survey participants

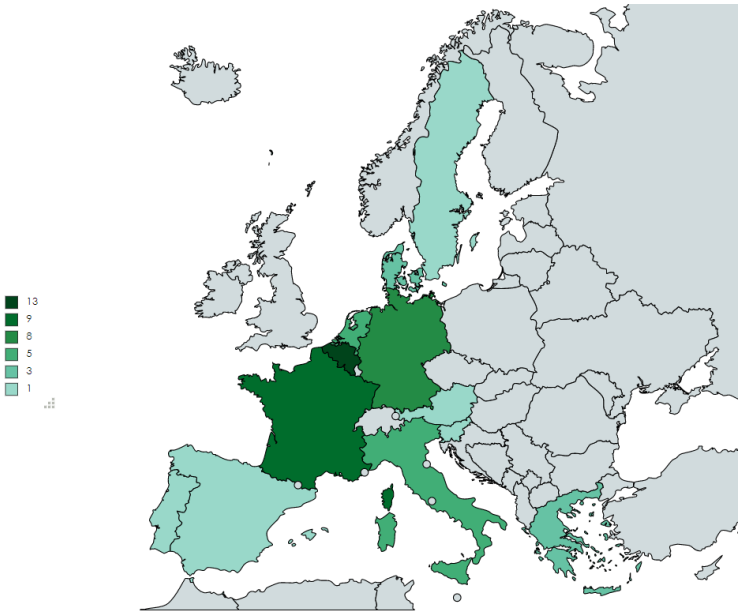
The survey was completed by a total of 56 participants. In order to guarantee the privacy of participants and their organisations, no personal identification data are published; nor were requested except for a bare minimum information of the organisation/associations/company: name, country, location, email, and website. Nevertheless, with the general data collected, some assessment can be made as shown in this section.

In terms of the participant countries, the majority came from Belgium with 13 answers (Figure 10). This is explained by the fact that many associations are set in Belgium but have a European perspective. After Belgium, the most represented countries were France and Germany, with 9 and 8 contributions respectively. The Netherlands had 5 participants, and both Greece and Italy had 3. Finally, there were several countries with a single contribution: Austria, Portugal, Slovenia, Spain and Sweden.

The survey was open to the European Economic Area (EEA), aiming to attract as many participants as possible. Although an open survey was considered beneficial to obtain data from all possible sources, the post-Brexit agreements and the relationship with third countries, only allowed us to accept contributions from the EEA.

In summary, through the participants' replies the survey allowed us to obtain a better understanding of what exists in the EEA, especially from a technical point of view. This ensures reaching better conclusions and creating the future CoC for IOP of ESA in the best way possible.

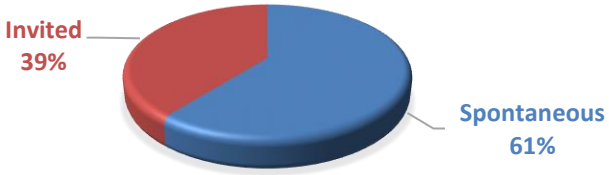
Figure 10. Number of contribution from each European State Member.



Source: JRC analysis, 2022.

As mentioned before, some of the main stakeholders had already confirmed their interest in participating in the CoC and the survey was mainly addressed to them. However, the survey was open for new participants, non-invited. In fact, the survey had a high rate of spontaneous participation, as it is shown in the Figure 11.

Figure 11. Stakeholders invited or spontaneous.

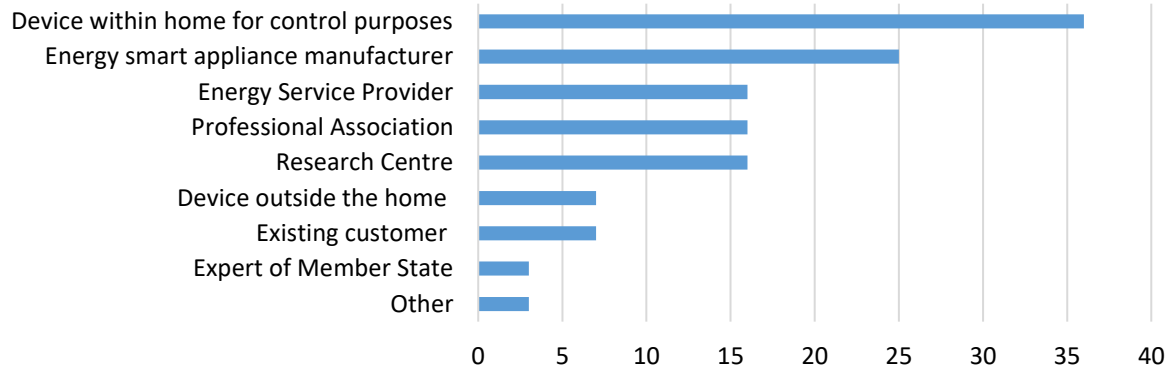


Source: JRC analysis, 2022.

Finally, it is interesting to see which type of stakeholders took part in the survey. As shown in Figure 4, six categories of stakeholders were defined, including the generic option: "Other". By analysing the replies given under this latter category and adding it to the information collected from the other five categories, a final categorization of the participants was obtained; see illustrated in Figure 12.

The main participation came from the manufacturers of device for control purposes located within the home, which gathered 26% of the participants. The second category was ESA manufacturers with a 20%. Add these two to the manufacturers of devices for control purposes outside the home, with 6%, it can be concluded that manufacturers accounted for more than half of the contributions, a significant achievement for the survey.

Figure 12. Survey participants and the categorization of their business expressed in percentage (%).



Source: JRC analysis, 2022.

The overall percentage added from the above categories (Figure 12) is greater than 100%. The reason for this is that participants may be identified by more than one of the categories depicted in Figure 4. One line of business does not exclude the other, and it was possible for each participant to choose more than one category. For instance, many participants hold business in more than one sectors, meaning that they may be ESA manufacturers and also manufacture devices for control within the house. Therefore, the percentages represent the share of participants that are active in one category with respect the total number of stakeholders taking part in this survey.

On the one hand, as it can be seen from the above graph in Figure 12, the majority of participation comes from the manufacturers of device within home for control purposes, with a 36%. By contrast, only the 7% of the participants holds business related to devices outside the house. Coincidentally, the same amount declared themselves as active customer of ESA; number that should improve in later phases of this project. A quarter of the participation, 25%, comes from ESA manufacturers, which would equal to 14 survey replies. Although the number may seem relatively small, having the feedback from 14 ESA manufacturers at this early stage can be regarded as a success. Considering the two categories of devices related to control purposes and ESA manufacture, there were 34 replies received from stakeholders that are related to manufacturing devices.

On the other hand, the participants representing energy service providers, research groups, and professional associations have an equal weight of contribution, 16% each. The number may seem low for the last two, but these are either interconnected with other research centres or represent several parties, respectively. Whereas a true disappointing representation can be seen from the experts of Member States, with a mere 3%, or, in other words, just 2 respondents. This will need to be addressed for future steps of the project, together with the low consumer representation already mentioned. However, it is positive to have at least some representation from these categories at this early stage.

Initially, five categories had been defined, as the different actors involved with energy smart appliances, namely: energy service provider; energy smart appliances manufacturer; manufacturer of device within the house for control; manufacturer of device outside the house for control; existing customer/ user. In addition to the five defined categories (see Figure 4), close to the half of the participants chose the undefined class “other”. Some of the replies have been explicitly defined in Figure 12: Professional Association, Research Centre, Expert of Member state. We left some of this self-categorisations within the “other” class in Figure 12. These participants, who do not set their business in any of the explicitly defined classes shown in Figure 12, represent the 3% and they are related to design and manufacturer components for ESA and Energy Management System (EMS).

3 Technical Data – Actors involved and messages exchanged with ESA

The Chapter presents the main part of the technical data collected. First of all, it introduces the categories of actors involved, according to how they were presented in the proposed survey. The details of the categories of devices manufactured are given, provided by the replies given by the participants who act as manufacturers of ESA. Then, the Chapter presents the information with respect to the messages exchanged between ESA and the other actors. This is based on the answers collected by all actors that exchange messages with ESA. In addition, some information about communication standards and protocols employed is given, again provided by the participants, as well as IOP issues that they might have in the pass.

As stated in the previous Chapter, 56 replies from stakeholders of different countries were received; some of the participants represent multiple actors (i.e. associations with members in multiple fields of activities). The Chapter also presents detailed information for each one of the categories previously shown. This means each one of the different roles that an actor can have and the relevant information messages that this actor can exchange with ESA.

3.1 Smart Devices Manufacturers

This Section provides information with respect to survey participants that, manufacture smart products. A vast field of information is covered here, because not only detailed information from ESA is included, but also from all kind of devices manufactured that can interact with them. That is why the Section covers all devices that are manufactured under the following scopes or survey categories (see Figure 4): devices for control purposes within the house; devices for control purposes outside the house; ESA.

Table 1 shows the numbers of participants that actually manufactures the aforementioned device categories in comparison to the numbers presented in Figure 12. Please note that the numbers in the Figure are in percentages; the absolute numbers are needed for our calculations, i.e. percentage x total number of participants. Specifically for column 1: The percentage of ESA manufacturers is related to the participants that have ties with ESA manufacturing, i.e. 13 out of 14 stakeholders; Similarly for manufacturers of devices for control within the house, i.e. 17 out of 20 stakeholders holding business with such devices; Finally the devices for control outside the house; i.e. 2 out of 4 stakeholders holding business with these devices. The second column shows the percentage of manufacturers related to the number of participants that declare to be linked to this activity (i.e. the absolute number declared in third column divided by the total number of participants).

Table 1. Number of participants that manufacture a specific category of devices.

Manufacturers	**Percentage related to the number of participants active in the field (as from Figure 12)**	**Percentage of Manufacturers from total absolute number of participants (56)**	**Absolute number of manufacturers of this sort of devices**
Devices for control within the house	85%	30%	17
Devices for control outside the house	50%	4%	2
ESA	93%	23%	13

Source: JRC analysis, 2022.

Although the number of manufacturers expressed in Table 1 for each category of devices is small related to the overall number of participants (56), it should be noted that this number (overall number of participants) comprises also numerous stakeholders that do not manufacture devices, but still are related to ESA. Thus, it would not be fair to solely compare the number of manufacturers of a specific category to the overall number of participants. Additionally, the majority of participants linked their business with a specific category of devices, are also manufacturers of such devices. For instance, 85% and 93% of the participants declared to manufacture devices for control inside the house and ESA, respectively. On the other hand, few participants have declared that they actually manufacture devices for control outside the house, which is in accordance to the overall number that holds business in this sector. In general, by looking at the absolute numbers and taking into account

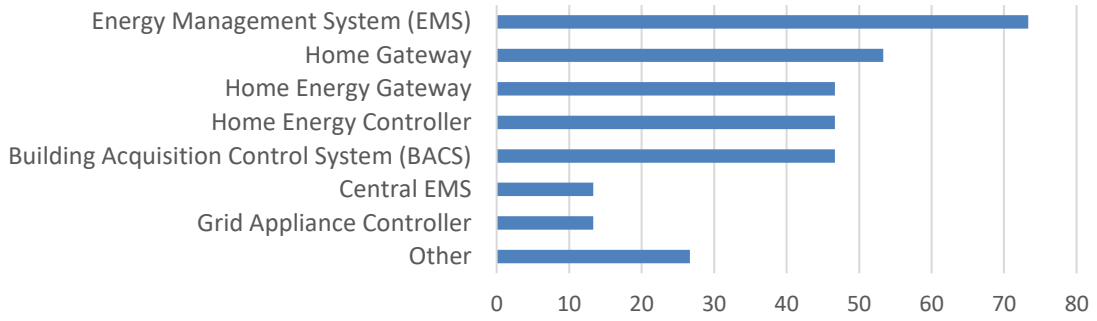
this first attempt to collect information from the industry, having 17 manufacturers of devices for control within the house and 13 manufacturers of ESA on-board can be considered a good number of contributions.

The following subsection gives detailed information about each of the types summarised in Table 1.

3.1.1 Devices within the house for control purposes

Figure 13 shows the devices that are manufactured within the category of devices for control purpose within the house. The percentages given represent the number of the participants that declare that they manufacture a specific device compared to the number of participants that actually manufactures such devices, as extracted from Table 1, (i.e. the percentage of manufacturers of EMS related to the number of manufacturers of devices within the house for control purposes are shown).

Figure 13. Manufacturers of devices for control purposes within the house.



Source: JRC analysis, 2022.

As discussed for Figure 12, manufacturers of devices for control purposes within the house depicted in Figure 13 can manufacture several devices within this category, and for this reason the percentage in the graph will not add up to 100%. Each category listed should be considered with respect of the absolute number presented in Table 1.

Similarly, most participants represented in Figure 13 manufacture more than one device for control purposes inside the house. In addition, it should also be noticed from the same figure that some terms may refer to the same device, i.e. the EMS entails the sub-category of central EMS. The reason for that was to cover all possible categories and terminologies, and the participants were given the option to declare all possible devices (generic or particular).

It is important to stress that the 73% of the manufacturers of such control devices manufacture EMS. The percentage of manufacturers producing Home Gateways, either specific to energy or not, are close to the 50%, with 53% and 47%, respectively. Again, close to half of the participants, with a 47%, declare to manufacture both Home Energy Controller and Building Acquisition Control System. All these devices serve similar purposes and this is why the percentages are nearly equal. Moreover, there were two additional categories registered: Grid Appliance Controller, with around 13%, and other non-specified devices, with a share close to 25%.

3.1.2 Devices outside the house for control purposes

With respect to manufacturers of devices of control purposes outside house premises, based on Table 1, only two manufacturers provided feedback, which is a sample size too small to extract meaningful statistics. It is nonetheless interesting to inspect the type of devices they manufacture. Table 2 reports this information.

Table 2. Devices manufactured for control purposes outside the house.

Device manufactured	Number	Device manufactured	Number
Smart App	2	Linear Pilot Backend	1
Smart Charging App	2	Signal Receiver	1

Smart Storage System	2	VPP – intelligent load manager	1
Smart orchestrator	1	Platform	1

Source: JRC analysis, 2022.

As it can be noted from Table 2, both of the manufacturers that replied to the survey in this device category provide some smart apps for control purposes outside the house to their customers. Platforms, signal receivers, or similar software/hardware are also offered by the manufacturers for control purposes as it is shown in this Section.

3.1.3 Energy Smart Appliances (ESA) categories

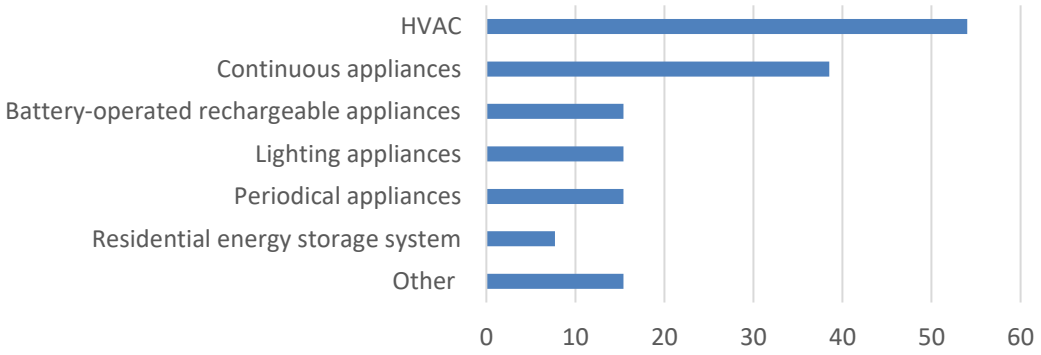
Having covered both types of control devices, the remaining results presented in this Section relate to ESA and the feedback received from their manufacturers. As displayed in Table 1, 13 ESA manufacturers replied with their feedback. The ESA devices that are manufactured according to our survey participants are displayed in Table 3. The percentages refer to the participants that declared to manufacture a specific category of device within the total number of ESA manufacturers. The information introduced in Table 3 is depicted in Figure 14.

Table 3. ESA manufactured.

ESA categories	Percentage over total ESA	Absolute number
Heating, ventilation, and air conditioning (HVAC)	54%	7
Continuous appliances	38.5%	5
Periodical appliances	15.4%	2
Lighting appliances	15.4%	2
Battery-operated rechargeable appliances	15.4%	2
Residential energy storage system	7.7%	1
Other	15.4%	2

Source: JRC analysis, 2022.

Figure 14. ESA that are manufactured in percentage related to the active participants in the field.



Source: JRC analysis, 2022.

We deemed interesting to further develop the above-listed categories of appliances (Table 3 and Figure 14) by showing which kind of appliances are manufactured in each of them. This information is reported in the Tables below (Table 4 to Table 9).

Table 4. Heating, ventilation, and air conditioning (HVAC) manufactured.

HVAC subcategories	Percentage over HVAC total	Absolute number

Heating appliances	100%	7
Ventilation appliances	71%	5
Air conditioning appliances	71%	5

Source: JRC analysis, 2022.

It is remarkable that the heating appliances are manufactured by all survey participants. It is also worth mentioning that this category of devices is offered mainly for demand response programs, where remote load control is important. Thus, it attracts the interest of ESA manufacturers.

Table 5. Continuous appliances manufactured.

Continuous ESA	Percentage over continuous ESA total	Absolute number
Water heaters/ kettles	80%	4
Electric storage water heater	80%	4
Electric ovens	40%	2
Electric hobs	40%	2
Vacuum cleaners	40%	2
Range hoods	40%	2
Refrigerators	40%	2
Freezers	40%	2

Source: JRC analysis, 2022.

Analysing Table 5, it can be identified that almost all manufactures of continuous appliances produce water heaters and/ or electric storage water heaters. On the other hand, for the rest of the continuous appliances, different appliances are produced by different manufacturers. In overall, all subcategories of continuous appliances gather the 40% of the participants.

Table 6. Periodical appliances manufactured.

Periodical ESA	Percentage over periodical ESA total	Absolute number
Dishwashers	100%	2
Washing machines	100%	2
Tumble dryers	100%	2
Washer dryers	100%	2

Source: JRC analysis, 2022.

Analysing Table 6, it is interesting to notice that the two sole manufacturers that replied positively about manufacturing periodical appliances manufacture all the appliances suggested under this category.

Table 7. Lighting appliances.

Lighting ESA	Percentage over Lighting ESA total	Absolute number
LFL - Linear fluorescent lamp	100%	2
CFL - Compact fluorescent light	100%	2
GLS - general lighting service	100%	2
LED - light emitting diode	100%	2
High intensity discharge (HID) lamp	100%	2

Source: JRC analysis, 2022.

From Table 7 we can derived that all proposed lighting devices are manufactured, except for those made out of tungsten. For simplicity, only subcategories that were mentioned by the participants are included in the table.

For the category of appliances displayed in Table 8, battery-operated rechargeable appliances, both participating manufactures declared to produce household appliances, such as fans, vacuum cleaners, or shaving appliances. In contrast, neither manufactures appliances such as IT equipment (mobile phones, tablets, laptops etc.) or power tools (garden machinery, screwdrivers, etc.). Again, the subcategories not referred to by the participants are not included to simplify the presentation of results.

Table 8. Battery-operated rechargeable ESA.

Battery-operated rechargeable ESA	**Percentage over battery-operated rechargeable ESA total**	**Absolute number**
Household appliances (shaving appliances, fans, vacuum cleaners etc.)	100%	2

Source: JRC analysis, 2022.

For the last ESA category, only one manufacturer replied positively in manufacturing this specific category. No participant declared to manufacture solar or home batteries, residential energy storage systems or a storage battery for home use.

Table 9. Residential energy storage system.

Residential energy storage system ESA	**Percentage over residential energy storage system ESA total**	**Absolute number**
Solar energy storage unit	100%	1

Source: JRC analysis, 2022.

In addition to the devices' categories and subcategories listed so far, the participants had the opportunity to propose additional ones; they may manufacture some specific ESA that were not originally envisaged in the survey. The following additional suggestions were received, with each answer having been declared by at least one manufacturer:

- EV charger;
- Solar PV smart inverter;
- Shading door gates motors.

In addition, and under the same option, Specific devices manufactured within the HVAC category were also received. These are:

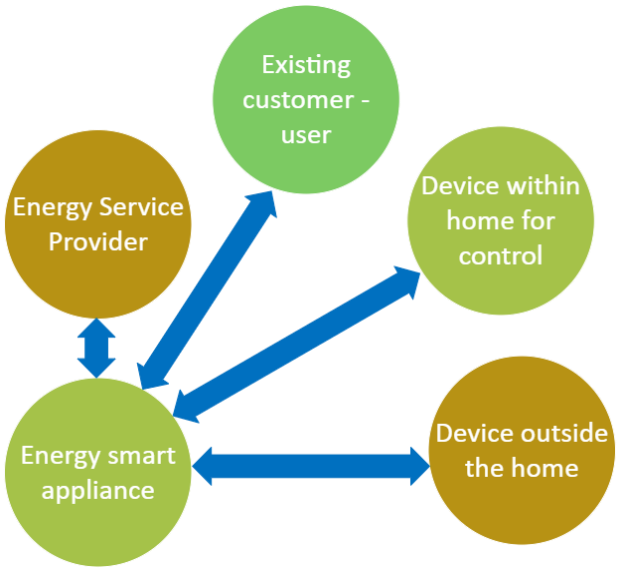
- Heat pumps: electric; thermally driven; hybrid;
- Hydronic space and water heaters;
- Boilers;
- Solar thermal systems;
- Radiators;
- Hot water storage tanks;
- Other components of the heating system.

With the current survey, very valuable information was collected from all sorts of ESA, spread across a wide range of categories. Moreover, by covering such large range, important information concerning almost every existing ESA was retrieved. Although this information could always be refined, it can already be employed as a good sample of the actual market of ESA.

3.2 Messages Exchanged

This Section shows the results of the survey with respect to the messages exchanged between ESA and the main actors, namely the Energy Service Provider, the customer, and the devices for control purposes both within the and outside the house. Thus, in the following four sub-Sections, it presents the four categories of messages exchanged, one for each actor interacting with the ESA (see Figure 4 and 15), with the exception of the "Others" category.

Figure 15. Messages exchanged between the ESA and the different stakeholders.



Source: JRC analysis, 2022.

For each category of messages exchanged, we first identify the type of messages exchanged and subsequently delve into the details about what particular type of messages are exchanged. The section concludes with a discussion of the results in sub-Section 3.2.5.

3.2.1 Messages exchanged between ESA and Control Device within the house

With respect to the messages exchanged between ESA and the control device within the house, we identified seven types of messages. They are the following:

- Control management data;
- Control of flexibility;
- Alerts;
- Price information;
- Data on energy produced;
- Availability status;
- Feedback on control commands.

For each of the proposed data types, feedback was received on whether or not the actual participants involved use them. At this point, we should mention that the specific subgroup of participants whose responses have been considered are two: the stakeholders with businesses control devices within the house and those manufacturing ESAs. Table 10 shows the 22 responses obtained for both types of stakeholders. Once again the table includes a distinction from manufacturers that declare their business to fall within one category or within both. This sample is the source for all information displayed along the current category of messages exchanged. Figure 16 shows the weighting of the type of messages used in the interaction between ESA and control device within the house.

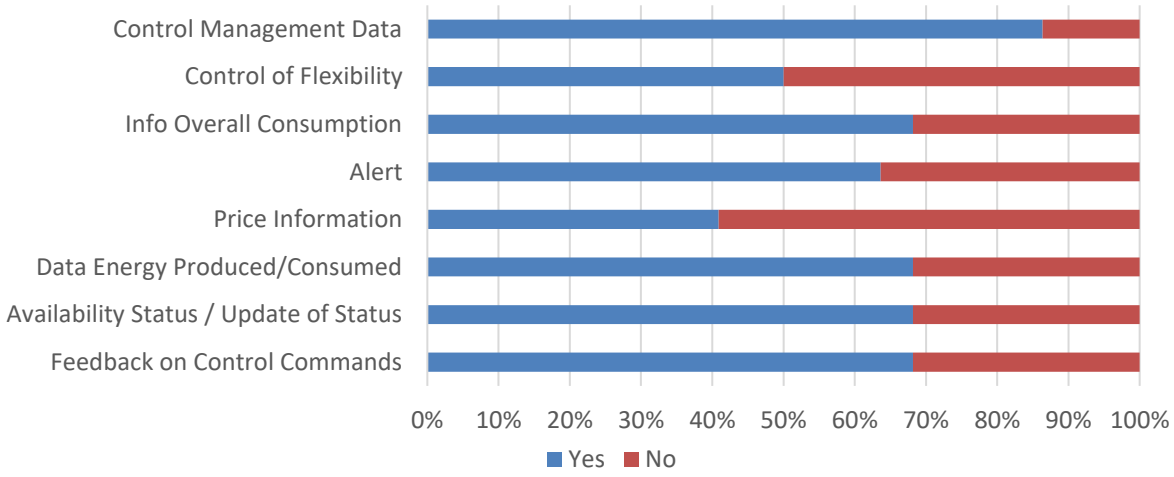
As it can be observed from Figure 16, almost all types of messages are exchanged by at least a 50% of the participants, apart from the type: "Price Information". This was anticipated, since there is no need to involve exchange of pricing information between the ESA and the control device within the house. By contrast, the messages that are exchanged the most, are "Control Management Data", with a 86%, followed by "Information Overall Consumption", "Data Energy Produced/Consumed", "Availability Status / Update of Status", and "Feedback on Control Commands; all of them with an equal percentage of 68%. It is obvious that the majority of the messages are related to control commands of ESA, which is the fundamental purposed of the devices that communicate with them in this category of messages exchanged.

Table 10. Number of received responses for the category of the messages exchanged between Control Device within the House and ESA.

Type of stakeholder	**Number of received responses**
Control Device within the Home	9
ESA Manufacturer	4
Both	9
Total answers	22

Source: JRC analysis, 2022.

Figure 16. Messages exchanged between ESA and Control device within the house.



Source: JRC analysis, 2022.

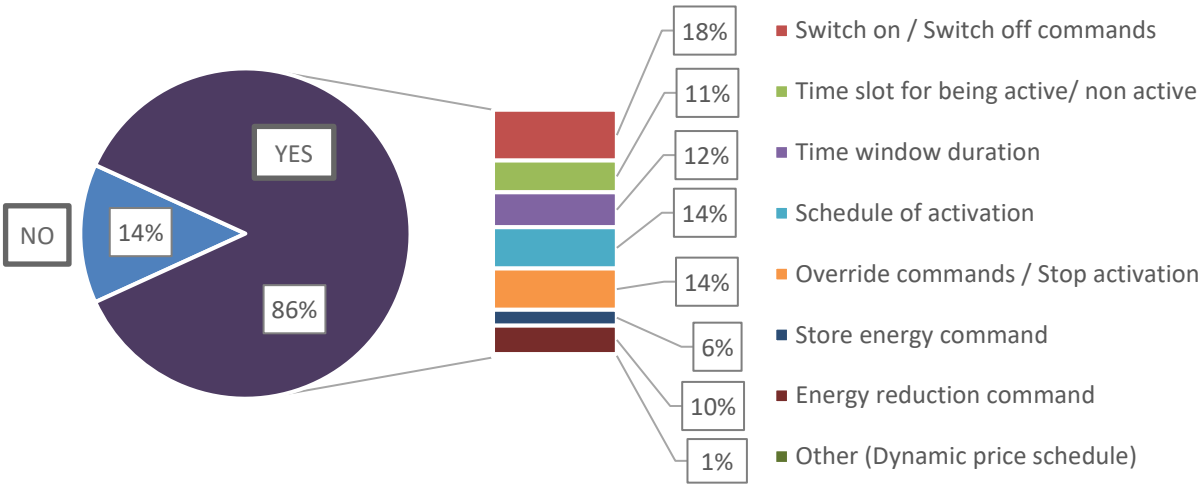
In addition, we identified specific messages (or sub-types) for four of the listed data-types displayed in Figure 16. In particular, we identified sub-types for the messages: Control Management Data, Control of Flexibility, Alerts, and Feedback on Control Commands. The percentages shown in Figure 17, Figure 18, Figure 19, and Figure 20 are derived according to the total responses received (see Table 10) from the participants that declared to use the regarded type of message. They are the percentage of the ratios obtained when dividing the number of times that a sub-type message exchanged is employed in comparison to the overall number of messages exchanged for the considered message type listed.

Control management data

Figure 17 shows what kind of (sub-types) messages can be exchanged between ESA and the device for control purpose within the house that fall into the type: "Control Management Data". The percentages shown, are derived by calculating the number of such specific messages exchanged in relation to the overall number of messages exchanged, according to the replies obtained in the survey. As it can be detected, the majority of control management data that are being sent are related to switching on/off commands (18% of total messages

exchanged), followed by scheduling of activation (14%), overriding commands or stop activation (14%) and the time window duration (12%). All the messages exchanged have to do with the automation of ESA functions within a house, which was expected as we are dealing with the device for control purposes.

Figure 17. Messages exchanged under Control Management Data type between ESA and control devices within the house.

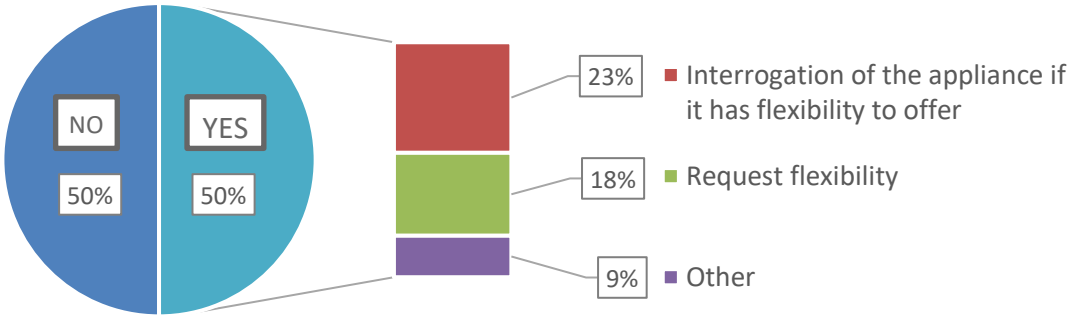


Source: JRC analysis, 2022.

Control of flexibility

When it comes to analyse the flexibility messages, and considering the data reported in Figure 18, it is interesting to see that half of the participants do exchange such messages, whereas the other half does not. For the calculations of the specific messages exchanged, it was taken into account the number of such specific messages (sub-types) exchanged against the total number of messages exchanged under this type. It can be observed that the majority of messages are related to the flexibility that can be offered by ESA and the requests for this flexibility.

Figure 18. Messages exchanged under Control of flexibility between ESA and control devices within the house.

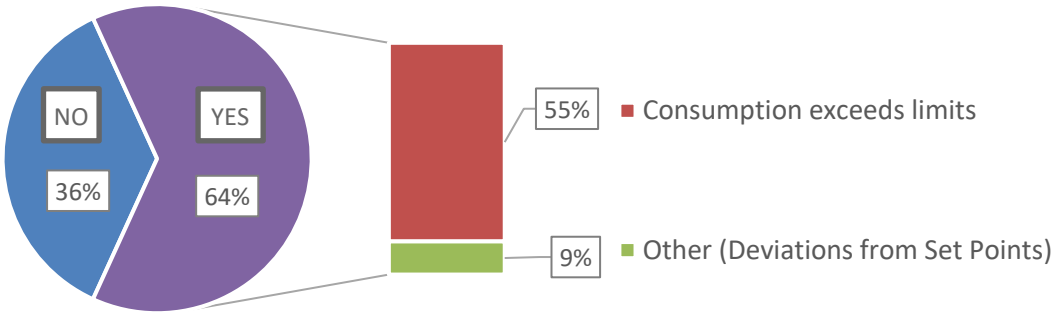


Source: JRC analysis, 2022.

Alerts

As it can be identified in Figure 19, two thirds of the manufacturers include alert message features in their devices, and most of them consider announcing when the consumption has overcome a certain threshold. As a particular sub-type, there is a more generic alert that refer to the deviation of the pre-set values of the ESA. It is not specified what this deviation covers, but it is assumed that the range is wider than consumption limits, and that the consumption is also included as a pre-setting.

Figure 19. Messages exchanged under Alerts between ESA and control devices within the house.

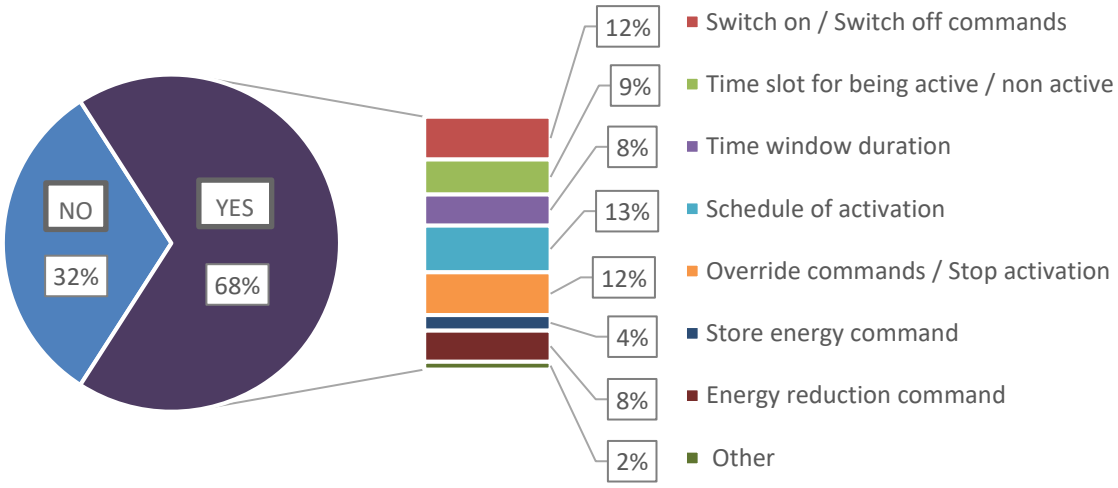


Source: JRC analysis, 2022.

Feedback on control commands.

For this sub-type of messages, the data of Figure 20 shows that there is a wider variety of messages that can be exchanged with respect to the first sub-type analysed. There is a higher representation of messages for schedule of activation, with a 13% of total messages, followed by switch on/off commands and override commands, each one with a 12% share. Other messages that are close to a 10%, but slightly lower are: "Time slot for being active / non active" (9%), and with an equal usage (8%), "Time windows duration" and "Energy reduction command". Lastly, it can be seen that the other category is marginal and with a low percentage (4%) the energy commands are regarded as less important.

Figure 20. Messages exchanged under Feedback on control commands between ESA and control devices within the house.



Source: JRC analysis, 2022.

3.2.2 Messages exchanged between ESA and Control Device outside the house

The Section presents the messages exchanged between the ESA and the control device outside the house. As a first step and following the previous section, the messages that can be exchanged have been identified as:

- Control management data;
- Control of flexibility;
- Alerts;
- Price information;
- Data on energy produced;

— Availability status;

— Feedback on control commands;

— Comfort boundaries.

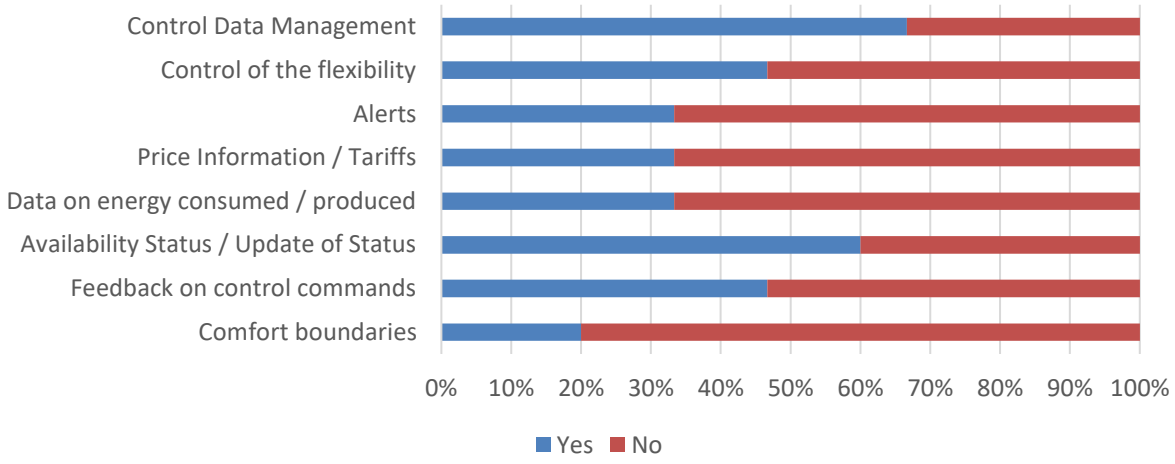
For the messages exchanged between these two actors, less replies than in the previous category have been collected, 15 in total. They are presented in Table 11. Figure 21 shows the percentage of stakeholders that exchange or not the above categories of messages.

Table 11. Number of received responses for the category of the messages exchanged between Control Device outside the House and ESA.

Type of stakeholder	Number of received responses
Control Device outside the Home	2
ESA Manufacturer	11
Both	2

Source: JRC analysis, 2022.

Figure 21. Messages exchanged between ESA and Control device outside the house.



Source: JRC analysis, 2022

Although the type of device here interacting with the ESA is similar to the one developed in the previous section (device for control within the house), it can be discerned that the situation is drastically different. The most representative type of messages, "Control data management", is still dominant but with a 67%, meaning 20 percentage points less than what we observed for the device for control within the house (previous section). In terms of flexibility control the current category, with a 50%, is similar to what can be seen with the devices within the home. Instead of the overall consumption, we have included comfort boundaries, which might not have been the best approach because only 20% of the participants within this category declare to use this type of message. The messages that obtain the availability status of the ESA are similarly, but slightly lower, represented by a 60%; for the control devices within the home this was 8% higher. Significantly lower is the usage of messages that provide feedback on the control command, now at 47%, which includes a reduction of more than 20%. At the bottom end of the scale, messages related to price information, energy consumption, and alerts can be found, all of them with a 33% share. The first one is somehow at the same level than it was for the control devices with the home category, but the other two had suffered a significant decrease, as they were employed by more than the 60% of the participants of the previous category.

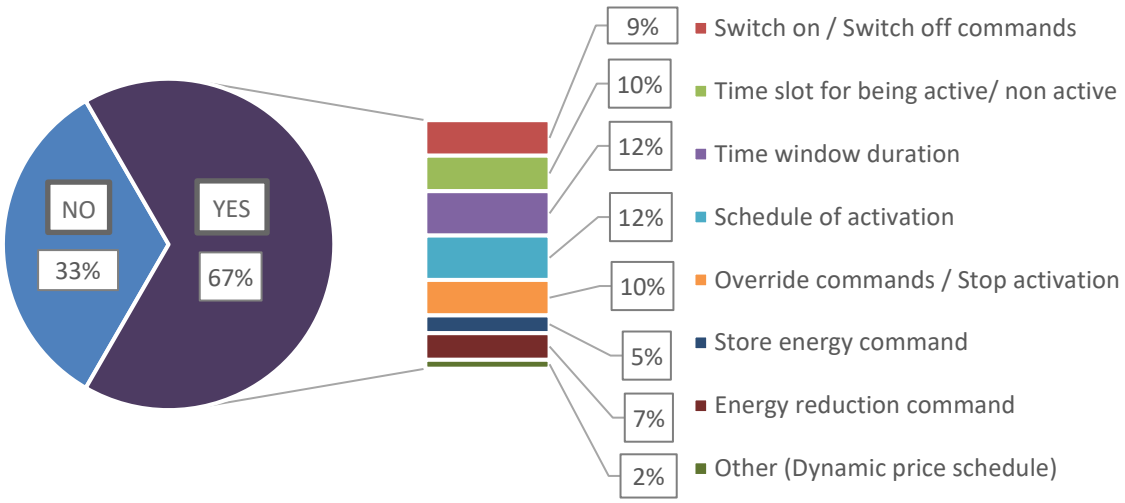
Similarly to the previous subsection, the same specific messages that can be exchanged under 4 types are identified: Control management data, Control of flexibility, Alerts, and Feedback on control commands. This is obvious, as the objective remains the same: to achieve control of the ESA; although now it is done from outside

the house. Again, for their extraction we have considered the number of messages that are indeed exchanged by the participants in relation to the overall number of messages that are exchanged by the participants.

Control management data

For control management data messages, there is a variety of specific messages that can be exchanged, as it can be examined depicted in Figure 22. The weight or distribution of each sub-type of messages represented in this figure is quite homogeneous, as it was for the previous section. However, the "Schedule of activation" and "Time window duration" are the two sub-types that have a bigger share, both with a 12% of total messages exchanged. They are followed by the sub-types "Time slot for being active/ non active" and "Override commands / Stop activation", with an equal share of 10% of total messages exchanged. Close to the latter and with a similar purpose (power interruption) come the messages related to Switching on/off command messages, with a 9%. The remaining 20% of the 67% exchanged messages regarding control management are: "Energy reduction", "Store energy command", and "Dynamic price schedule (Other)", with a 7%, 5%, and 2% of the representation. Although with a smaller share, the first two are not much different when comparing with control devices within the house. Overall, it is important to highlight that one third of the participants (no answers) does not exchange such messages.

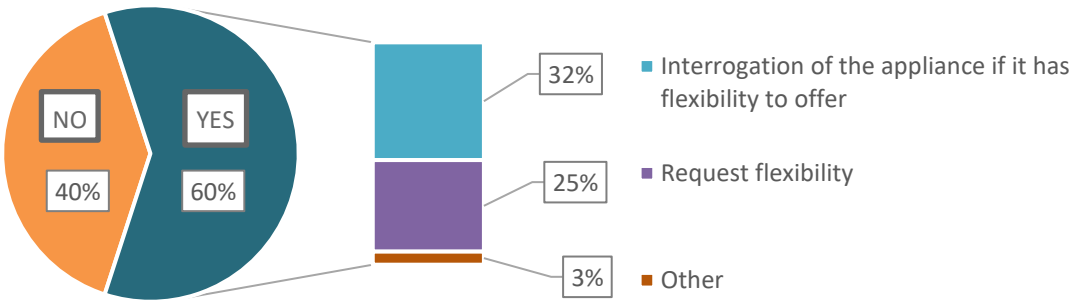
Figure 22. Messages exchanged under Control Management Data between ESA and control devices outside the house.



Source: JRC analysis, 2022.

Control of flexibility

Figure 23. Messages exchanged under Control of flexibility between ESA and control devices outside the house.



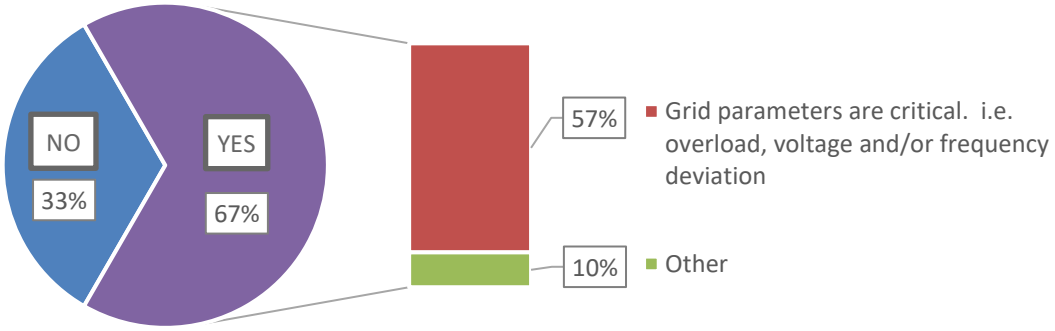
Source: JRC analysis, 2022.

Regarding control of flexibility, which is depicted in Figure 23, the majority of messages exchanged are related to the interrogation of the appliance for its flexibility and requests of this flexibility. Therefore, the same message exchanged in the two possible different direction between the two parties. The percentage of participants that use them is quite similar in the two categories that refer to control devices, either within or outside the home. There was no additional information about the sub-type "Other", as it was simply selected but not specified further.

Alerts

Once more, when it comes to alert messages and as it is depicted in Figure 24, only a third of participants does not exchange such messages. The vast majority of the messages that are exchanged, close to the 80% of the two thirds that do use this type of message, have to do with critical grid parameters and their violation (i.e. overload, voltage or frequency deviation). Unfortunately, although the "Other" category was once more included, no specific feedback was provided.

Figure 24. Messages exchanged under Alerts between ESA and control devices outside the house.

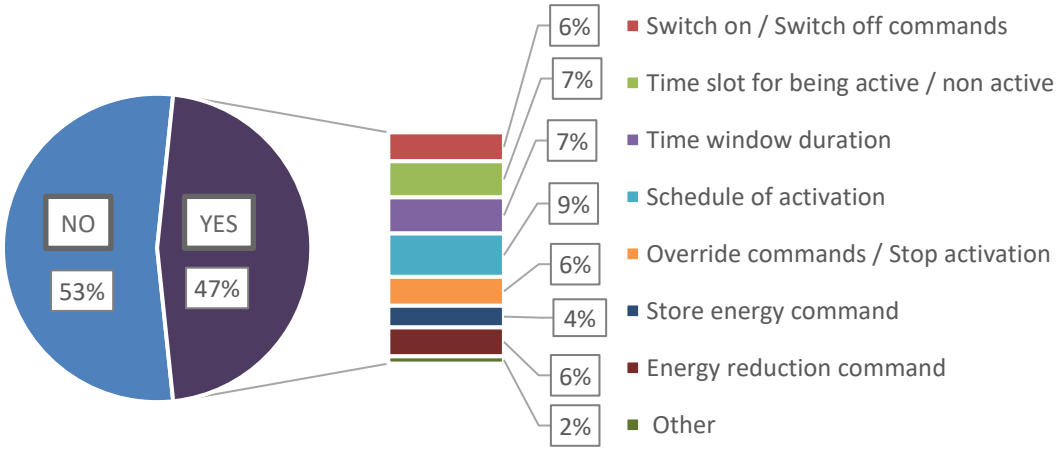


Source: JRC analysis, 2022.

Feedback on control commands

For the feedback on control commands sub-types, displayed in Figure 25, it can be detected that over the half of participants does not exchange such messages (53%). On the other hand, for the messages that are exchanged, there is a variety regarding their type with schedule of activation, time window duration, time slot for activity, switch on/ off commands and energy reduction commands being some of these categories.

Figure 25. Messages exchanged under Feedback on control commands between ESA and control devices outside the house.



Source: JRC analysis, 2022.

3.2.3 Messages exchanged between ESA and the energy provider

This subsection shows the messages exchanged between ESA and the energy provider. The following types can be identified:

- Control management data;
- Control of flexibility;
- Alerts;
- Price information;
- Data on energy produced;
- Availability status;
- Feedback on control commands;
- Request of price information;

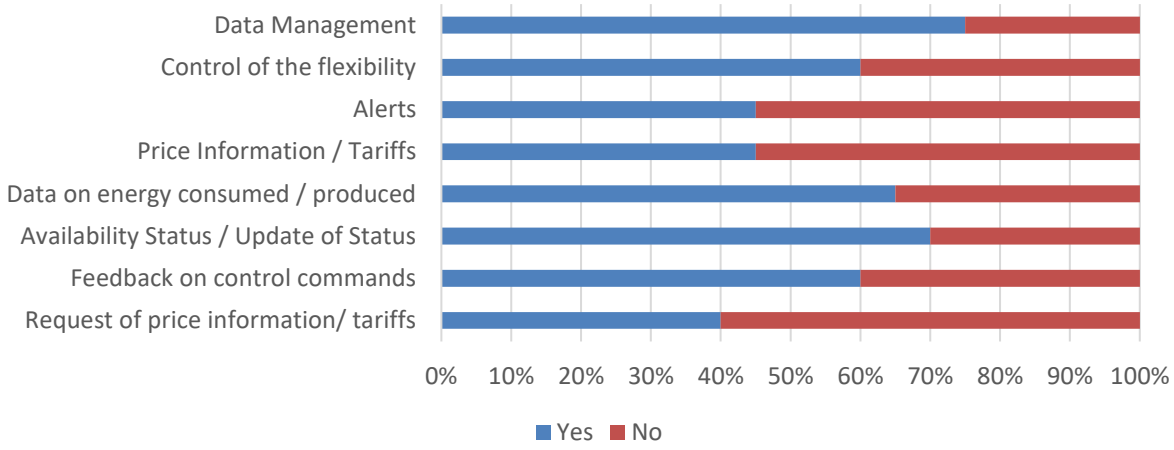
In total, 20 responses were received. Positive replies are classified in Table 12, differentiating the number of responses received from ESA manufacturers, Energy Service Providers, and stakeholders that are linked to both. In addition, Figure 26 shows the comparison between positive and negative responses for each type of message exchanged between ESA and Energy Service Providers.

Table 12. Number of received responses for the category of the messages exchanged between Energy Service Providers and ESA.

Type of stakeholder	Number of received responses
Energy Service Provider	8
ESA Manufacturer	11
Both	1

Source: JRC analysis, 2022.

Figure 26. Messages exchanged between ESA and Energy Service Providers.



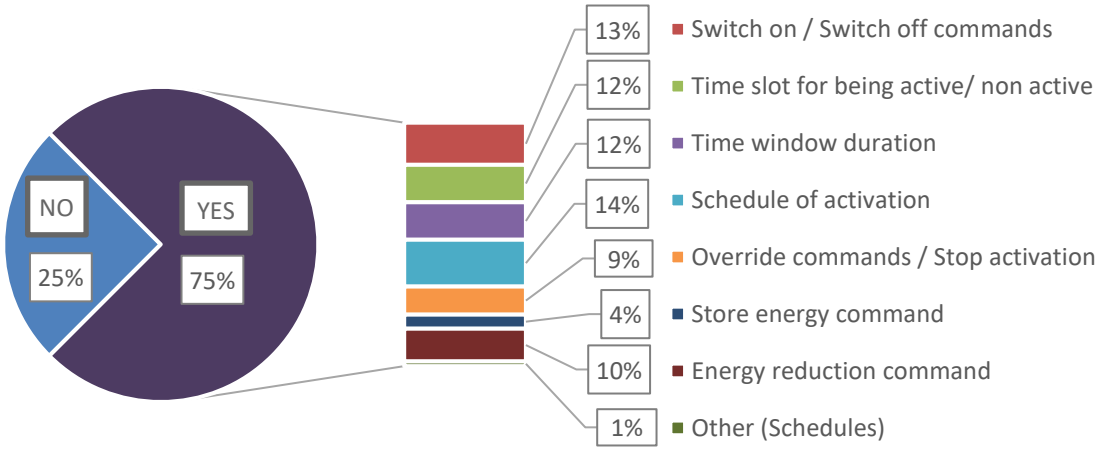
Source: JRC analysis, 2022.

As it can found in Figure 26, the message type that come first in this category, with a 75% share, is the one related to data management. This is totally expected, as the EMS is trying to control/manage the home ESA ecosystem complying with the user definitions. Since the communication between an Energy Service Provider and ESA is here considered, and management has the highest weight, it is also normal that other important types of messages include ESA status, energy consumption, control of flexibility, and the feedback to this and other control commands. By analysing the figure it is possible to see that “Availability status / Update of status” has a 70% representation, followed by “Control of the flexibility” with a 65%, and both ”Control of the flexibility” and

"Feedback on control commands" are considered by 60% of the participants of this category. Below the half of the participants of this category include messages related to price information, "Price information / tariffs" and "Request of price information" with respectively 45% and 40%; and "Alerts" also with a 45%. Perhaps the latter are more related to control devices, as seen in the previous categories, where this type of message had a larger share of representation.

Control management data

Figure 27. Messages exchanged under Control Management Data between ESA and Energy Service Providers.



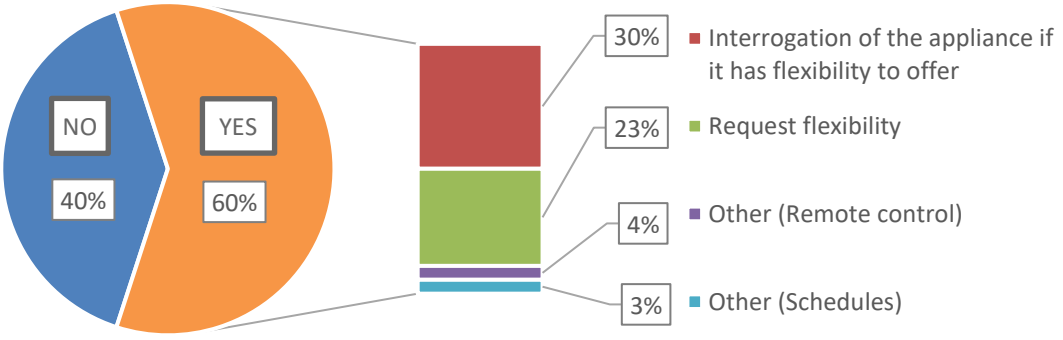
Source: JRC analysis, 2022.

As it can be checked in Figure 27, there are four sub-types with similar representation shining brighter than the rest. Combined, they gather 70% of the ¾ of participants that declare to use these types of messages. By weighting order, the messages exchanged for data management are related to: "Schedule of activation", with 14%; "Switch on / Switch off commands", with a 13% share; and both "Time slot for being active / non active" and "Time window duration" gathering a 12%. Once again the commands related to storage and energy reduction are lower, but the second one has a more significant representation. Probably due to its possible link to the energy price information or tariff. There is also a significant representation of overriding or emergency stop commands, and a very marginal contribution from the sub-type "Other", where Schedules was mentioned.

Control of flexibility

Similarly to what was showed in the two previous categories related to control devices within the house (Figure 18) and outside the house (Figure 23), the majority of messages under the control of flexibility category are related to the interrogation of the appliance for its flexibility and to requesting this flexibility. Beside this fact, it does not seem to be much difference other than the two suggested "Other" sub-type messages, which include "Remote control" and, as in the previous type data management, "Schedules".

Figure 28. Messages exchanged under Control of flexibility between ESA and Energy Service Providers.

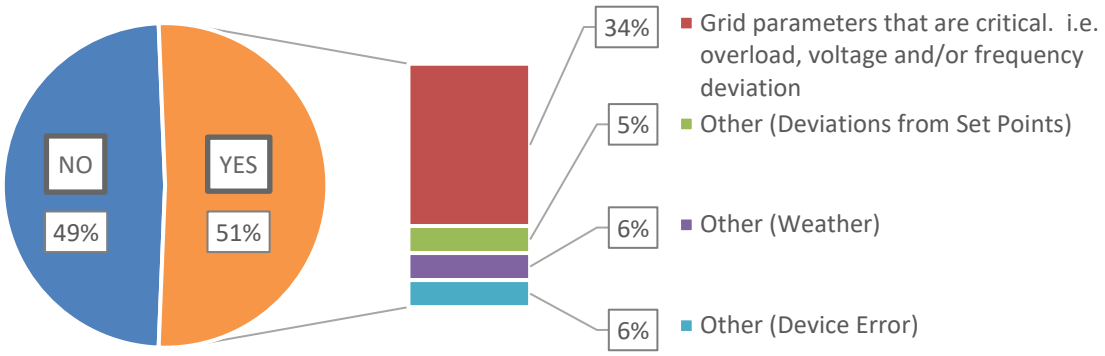


Source: JRC analysis, 2022.

Alerts

Differently from what was displayed for control devices (Figure 19 and Figure 24), in Figure 29 almost half of the participants do not send or consider such alerts messages. The majority of the messages under this category are linked with grid parameters, like overload, voltage and frequency deviation; as it was for control devices outside the home (Figure 24). In contrast, the contribution from the participants to the "Other" was richer than in previous categories, where messages regarding "Deviation from set point", "Weather", and "Device error" were suggested.

Figure 29. Messages exchanged under Alerts between ESA and Energy Service Providers.

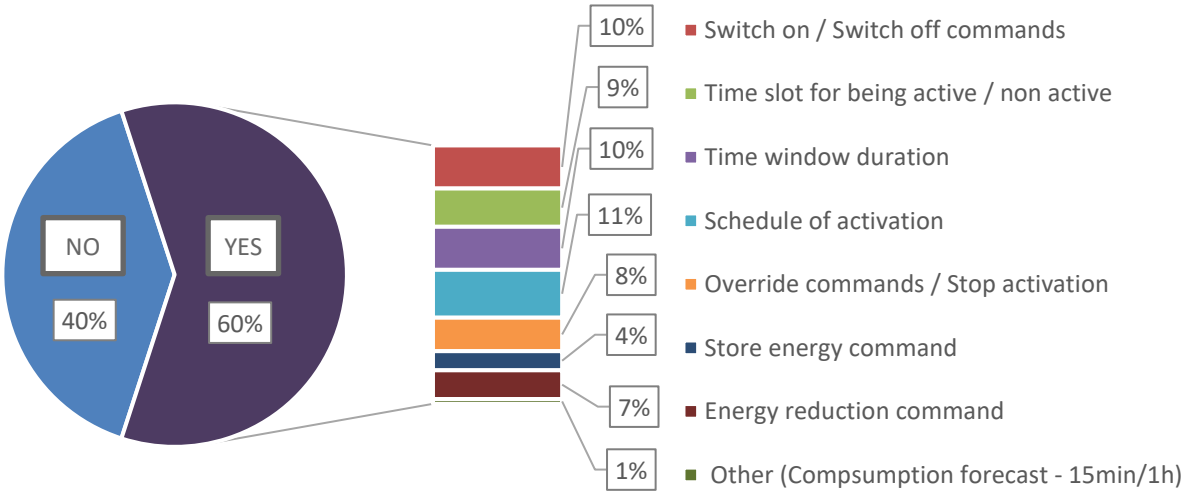


Source: JRC analysis, 2022.

Feedback on control commands

Related to the messages sub-types of the type "Feedback on control commands", the responses gathered in Figure 30 are distributed quite homogeneously among the different options provided. In particular, the schedule of activation is first in the list, with an 11% share of the total messages exchanged, that adds up to 60%. This is followed closely by switching on/ off commands and the time window duration, which is collecting 10% each.

Figure 30. Messages exchanged under Feedback on control commands between ESA and Energy Service Providers.



Source: JRC analysis, 2022.

3.2.4 Messages exchanged between ESA and the customer

The sub-section presents the category concerning messages exchanged between the ESA and customers. Similarly to previous categories, the types of messages that can be exchanged are identified. They are:

- Comfort boundaries;
- User presence;
- Control actions;
- Activation of a non-energy smart appliance;
- Price information/ tariffs;
- Consumption/ generation data;
- Information about flexibility;
- Alerts.

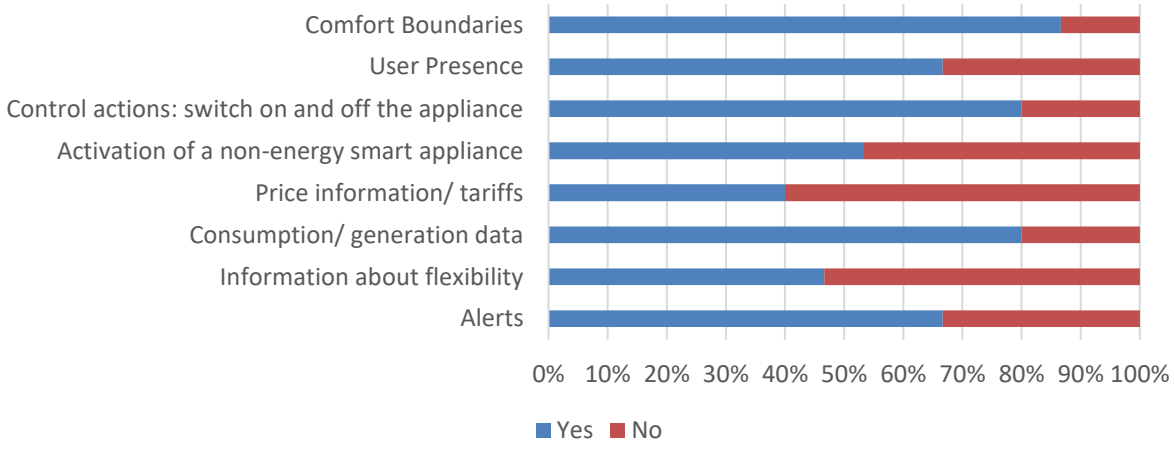
On the one hand, Table 13 shows the total number of responses received from 15 different stakeholders involved in this category. All further results are based on these 15 replies received and their classification; no overlapping between Costumer and ESA Manufacturer was registered. On the other hand, Figure 31 shows the messages that this group of participants regards important or uses when ESA and customers interact.

Table 13. Number of received responses for the category of the messages exchanged between Costumers and ESA.

Type of stakeholder	Number of received responses
User / Costumer	3
ESA Manufacturer	12
Both	0

Source: JRC analysis, 2022.

Figure 31. Messages exchanged between ESA and customer.



Source: JRC analysis, 2022.

As it is revealed in Figure 31, the message type that has the heaviest weight is the one related to comfort boundaries, which are exchanged by 87% of the participants. This is somehow expected, as the consumers are the ones interacting with the ESA, and they want to be as comfortable as possible. This comfort requires controlling the appliances and their consumption. That is why the types of messages representing these two parameters are those with the second highest representation, both reaching 80%. These two categories of messages are: “Control actions: switch on and off appliances” and “Consumption / generation data”. ESA are

made actively aware of the user presence (67%) and consumer/user are able to check on them with a system of alerts (also 67%).

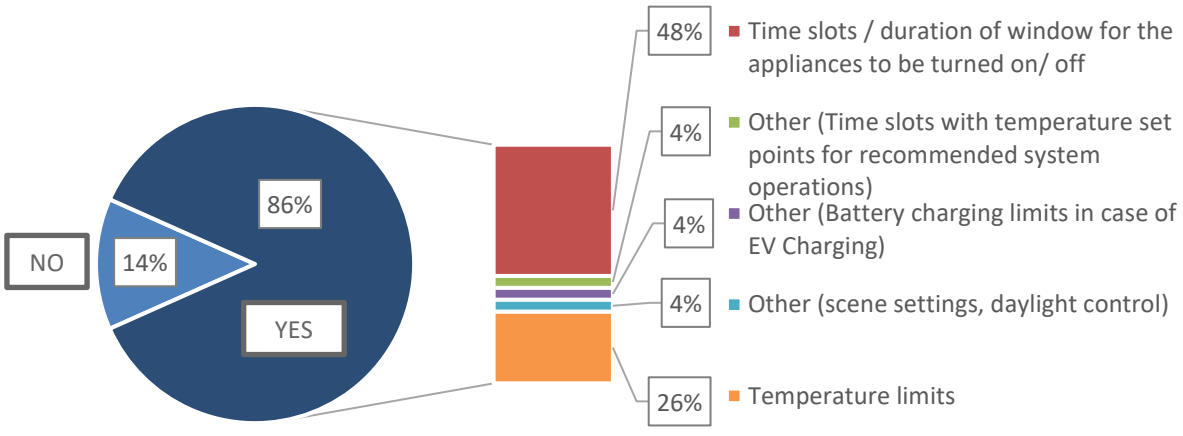
Setting a pleasant temperature in a HVAC system comes attached to a certain consumption, hence price. It is interesting to see that the type of message with the least representation is the one related to price information and tariffs. Related to information about flexibility, about half of the participants (47%) state that they exchange such messages. Both price information and tariffs fall deep into the concern of the consumer and a possible EMS or Energy Service Provider that wants to manage flexibility. However, in the coming years and with the electrification of the grid, users may be more interested in checking them. Due to the energy crisis triggered by geopolitical developments in 2022, prices are already a main concern for the consumer.

Among the messages exchanged between ESA and customer there are similar message types with respect to the ones employed in other categories, but there exist also some new types that only concern this category. Figure 31 display the aforementioned price information and tariffs, alerts, and control actions (like activation of non-ESA -53%- or switch on/off of ESA), which are common messages exchanged between ESA and all the interacting actors. On the other hand, this category has messages like “Comfort boundaries”, “User presence”, which are of major importance when considering the interaction between ESA and customers. Like in other sub-sections, specific sub-types that can be exchanged under alerts and information about flexibility are identified; whereas the new comfort boundaries are also considered. The message sub-types of the three types regarded in this category are introduced in Figure 32, Figure 33, and Figure 34.

Comfort boundaries

Observing Figure 32, it can be immediately spotted that the most important messages are related to time slots or duration of window for ESA to be turned on/off (48%), as well as temperature limits (26%); the weighted percentage of these two types of messages in the overall messages exchanged under this category results in 86% (calculated as follows: 74% out of 86% of messages for comfort boundaries corresponds to 86% of the 100% messages for comfort boundaries). In addition to these, there are three suggestions under the “Other” sub-type, related to: optimal temperature settings (”Time slot with temperature set points for recommended system operations”), adjustable electrical vehicle (EV) charging levels (“Battery charging limits in case of EV Charging”), and programmable ambient light (“scene settings, daylight control”). Each of them have a share of around 5% among all messages exchanged for this type. Once again, one of them is related to temperature, so we could add to the weighted percentage calculated for the two main messages (86%); the others, although important, are two very specific sub-type messages. In summary, 90% of all messages exchanged regarding comfort boundaries are related to temperature and activations times.

Figure 32. Messages exchanged under comfort boundaries between ESA and customers.



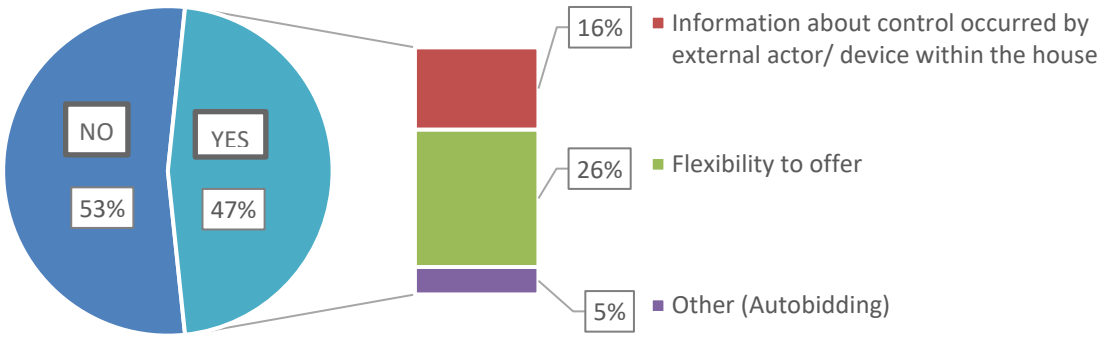
Source: JRC analysis, 2022.

Information about flexibility

According to the responses received from the participants in this category, information about flexibility is delivered to the end customer in a bit less than half of the cases; meaning that only half of the stakeholders involved in this category use flexibility type messages. The prevalent messages sub-type showed for this type in

Figure 33 are related to “Flexibility to offer”, which represent 26% of the total messages exchanged under the flexibility type, and the information about control that takes place by an external device within the house. The latter sub-type messages collect 16% of the total messages exchanged under the information about flexibility, showing that there is room for improvement, since it is important that the customer is aware of control occurred within his/ her house by external actor. Some additional contribution linked to automatic bidding under “Other” was suggested.

Figure 33. Messages exchanged under information about flexibility between ESA and customers.

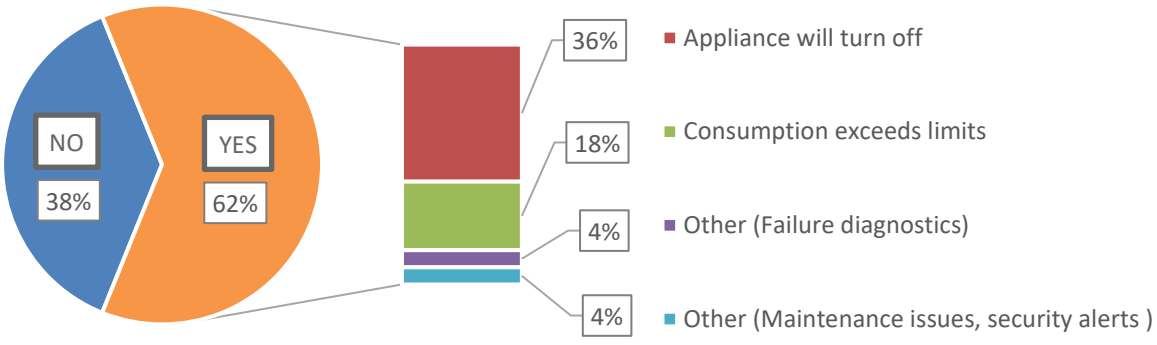


Source: JRC analysis, 2022.

Alerts

Under the alerts messages that arrive to the customers, the most relevant messages used for the interaction between ESA and costumers are related to the turning off of the appliance (36%). They actually represent almost 60% of the messages exchanged within this type (weighted percentage calculated as follows: 36% out of 62% of messages for appliance turning off corresponds to 58% of the 100% messages for such type of messages). The second contribution, accounting close to a third of the messages of this category, is linked to the alerts received when the consumption exceeds a certain limit (18%). The sub-types suggested within “Other” are related to failure and maintenance alerts, both representing a 4%; a bit more than 6% each of all messages exchanged.

Figure 34. Messages exchanged under alerts between ESA and customers.



Source: JRC analysis, 2022.

3.2.5 Discussion

We now proceed to summarise the content extensively analysed in the preceding sub-Sections of this Chapter.

Firstly, the messages exchanged are divided into 4 categories, depending on the actor involved. These are messages exchanged between ESA and the actors as listed below:

- Device for control within the house;
- Device for control outside the house;
- Energy Service Provider;
- Customer.

Secondly, the types of messages that can be exchanged for each of the above categories are identified. Furthermore, some of these types are also extended with additional messages sub-type that show even more specific messages that can be exchanged. It is important to highlight for all the above categories except for one (costumers), that the types of messages are similar. These types are:

- Control management data;
- Control of flexibility;
- Alerts;
- Price information;
- Data on energy consumed/ produced;
- Availability status;
- Feedback on control commands.

For the last category, which deals with messages exchanged between ESA and customer, emphasis is given to different kind of messages. They are more related to the comfort boundaries, user presence, and activation of non-ESA. In addition, the control devices within home include some information on the overall consumption of the home and disregard the request of price information, while we have included comfort boundaries for those devices that control ESA outside the home.

Table 14 summarises the results for the most common types of messages for each category of messages exchanged between ESA and another actor, as identified in the two lists above. Table 14 gives information about each type of messages in each of the four categories of exchanged messages, weighted to the total number of participants (100%). Therefore, the percentages shown in the table refer to the share of participants that stated to exchange that specific type of message. Each participant should be confronted with a 100% individually, because one participant can use more than one message type (row) in each message exchanged category (column). Table 14 gives a comparison of the messages exchanged between ESA and the other actors.

Table 14. Most common type of messages and percentile at which they are exchanged between ESA and different actors.

	Category of messages exchanged - ESA ↔ other actor			
Type of message	***Control device within the house***	***Control device outside the house***	***Energy Service Provider***	***Customer***
Control management data	86%	67%	75%	87%
Control of flexibility	50%	47%	60%	47%
Alerts	63%	33%	45%	66%
Price information	41%	33%	45%	40%
Data on energy consumed / produced	68%	33%	65%	80%
Availability status	68%	60%	70%	N/A
Feedback on control commands	68%	46%	60%	N/A

Request of price information / tariff	N/A	N/A	40%	N/A
Overall consumption	68%	N/A	N/A	N/A
Comfort boundaries	N/A	20%	N/A	86%
User presence	N/A	N/A	N/A	67%
Activation of non-ESA	N/A	N/A	N/A	53%

Source: JRC analysis, 2022.

From Table 14, it can be detected the importance of specific messages for the interaction between ESA and the various actors. For example, it is fundamental for the device for control within the house to exchange information regarding control management data with ESA. This category of messages is also the most important to be exchanged for the Energy Service Provider. On the one hand, for the device for control outside the house, it is important to know the status of all ESA as well as their flexibility and their answers to commands. On the other hand, these types of messages are not the most important between the customer and the ESA, for whom other metrics are crucial, for instance comfort boundaries.

Table 15. Sub-types of messages identified for four types of messages exchanged between ESA and another actor.

Message exchanged: ESA ↔ actor	**Type**	**Data Management**	**Feedback on control commands**	**Control of flexibility**	**Alerts**
	Sub-type	Switch on/off commands		Interrogation of appliance (if it has flexibility to offer)	Grid parameters
		Time slot for being active		Request of flexibility	Other
		Time window duration		Other	
		Schedule of activation			
		Override commands / Stop activation			
		Store energy command			
		Energy reduction command			
		Other			

Source: JRC analysis, 2022.

As for the defined sub-types of messages exchanged, we have mainly identified subcategories for four of the five shared types above (types 1, 2, 3, and 7). In most cases, the messages subtypes have been properly identified, as most participants have declared to exchange such messages. There are some additional sub-types that have been declared by some participants; they are always gathered within the "Other" message sub-type option. These identified sub-types of messages are summarised in Table 15.

Table 14 and Table 15, respectively show how important each of the most common type messages exchanged, between the four main actors and ESA, were; and announced several sub-types for four of these messages types. Although more information about each type of messages for each pair of actors can be found in each part of the current Sub-Section, some additional data for a comparison of a specific message sub-type between two categories of messages exchanged are displayed from Table 16 to Table 19. The sum of all percentages of all message sub-type within one of the four extended types of messages in any of the four selected category of messages exchanged between an actor and the ESA, results in a different percentage of participants declaring to use such sub-type of message. For examples, summing the number of all messages exchanged between ESA and Energy Service Provider for Control Management data results in a percentage of 75%, which is the amount that have declared to use this kind of messages. However, if the control devices within the house is considered, the total is 86%. Therefore, the weighting system is not unique. By scaling both categories to a 100% scale, we give a fair comparison between the different sub-types messages presented for the four categories of exchanged messages provided.

Table 16. Comparison among the four categories of messages exchanged, between ESA and different actors, for each messages sub-types within the Data management type.

Sub-type of messages for Data Management	Exchange between ESA and device for control within the house	Exchange between ESA and device for control outside the house	Exchange between ESA and the Energy Service Provider	Exchange between ESA and the customer (Comfort boundaries sub-types)
Switch on/ off	21%	9%	17%	N/A
Time slot - active	13%	15%	16%	N/A
Time window duration	14%	18%	16%	56%
Activation schedule	16%	18%	19%	N/A
Override command	16%	15%	12%	N/A
Storage energy command	7%	7%	5%	N/A
Energy reduction command	12%	10%	13%	N/A
Other	1%	3%	1%	14%
Temperature limits	N/A	N/A	N/A	30%

Source: JRC analysis, 2022.

As it is exhibited in Table 16, the messages that prevail regarding data management for the exchange between ESA and the device for control within the house are switch on/ off messages. For the rest of the messages, it can be noted that they are equivalently important for the pairs of actors exchanging information with small deviations. Only the types related to storage and others are the ones with lower representation.

Table 17. Messages for Control of flexibility and percentage at which they are exchanged between ESA and different actors.

Sub-type of messages for Control of Flexibility	Exchange between ESA and device for control within the house	Exchange between ESA and device for control outside the house	Exchange between ESA and the Energy Service Provider	Exchange between ESA and the customer
Interrogation of appliance if it has flexibility to offer	46%	53%	50%	55%
Request of flexibility	36%	42%	38%	N/A
Information external actor control (device within the house)	N/A	N/A	N/A	34%
Other	18%	5%	12%	11%

Source: JRC analysis, 2022.

As observed from Table 17, there are mainly two sub-categories of messages exchanged regarding the control of flexibility, either its request or its demand (interrogation); being the interrogation of appliances for flexibility to offer the main sub-type of messages for all categories of exchanging information. It is also noticeable that such messages are exchanged at a lower extent between ESA and the device for control within the house rather than for the other categories. That could be anticipated, because the control of flexibility is primarily done by the Energy Service Provider or a device that controls the appliances outside the house premises.

Table 18. Messages for Alerts and percentage at which they are exchanged between ESA and different actors.

Sub-type of messages for Alerts	Exchange between ESA and device for control within the house	Exchange between ESA and device for control outside the house	Exchange between ESA and the Energy Service Provider	Exchange between ESA and the customer
Consumption exceeds limits	86%	N/A	N/A	29%
Grid parameters are critical	N/A	85	67	N/A
Appliance will turn off	N/A	N/A	N/A	58
Others	14%	15%	33%	13%

Source: JRC analysis, 2022.

Table 18 shows that there are messages that prevail for the alerts messages in each of the examined pairs of actors. Between ESA and the device for control within the house, the main alert message to be exchanged is related to consumption exceeding limits. The same goes for the messages between ESA and customers. On the other hand, the categories including the device for control outside the house and the Energy providers consider alerts messages related to grid parameter being critical. There are several messages under the type "Others" that represent a small share (less than 15%) far all categories of exchanged messages, except for the one linked to Energy providers. For the latter, this type of information represents a third of the messages.

Table 19. Messages for Feedback on control commands and percentage at which they are exchanged between ESA and different actors.

Sub-type of messages for Feedback on control commands	Exchange between ESA and device for control within the house	Exchange between ESA and device for control outside the house	Exchange between ESA and the Energy Service Provider	Exchange between ESA and the customer
Switch on/ off	18%	13%	17%	N/A
Time slot - active	13%	15%	15%	N/A
Time window duration	12%	15%	17%	N/A
Activation schedule	19%	19%	18%	N/A
Override command	18%	13%	13%	N/A
Storage energy command	6%	9%	7%	N/A
Energy reduction command	12%	13%	12%	N/A
Other	3%	4%	2%	N/A

Source: JRC analysis, 2022.

The data of Table 19 allows us to conclude that for feedback on control commands and between ESA and the device for control within the house, the messages that prevail are related to the schedule of activation, switch on/ off commands and override commands. For the other two categories of exchanging messages, for which the message type is employed, the difference among the sub-categories of messages are slimmer. However, the activation schedule seems to be the most represented, with 18%.

In the above tables (from Table 16 to Table 19), we have given a summary of the messages that can be exchanged among the different actors. We have provided a more meaningful comparison, based on a 100% total for each category of messages exchanged and sub-type (each of the columns of all four tables). It has to be noticed that the summary and comparison are solely provided for similar messages exchanged among the four different categories. For specific messages that are unique on each category, we recommend the reader to address to the particular section discussing each category (3.2.1 to 3.2.4).

3.3 Communication standards / protocols used

This Section gives information about the communication standards/ protocols used by the survey participants. Regarding on which modes are used for communication purposes, 26 answers were received. Table 20 shows the results in terms of different standards/protocols used by different participants. Many of the survey participants declared to be using multiple communication solutions. All possible answers have been taken under consideration. On the other hand, Table 21 shows a list of communication standards/ protocols that are used by at least one participant.

Table 20. Communication standards / protocols used.

Communication standards/ protocols used	Number of participants	Communication standards/ protocols used	Number of participants
Modbus	9	OCCP	2
SAREF	8	OpenADR	2
EEBus	6	IEEE 2030.5	2
Application Programming Interfaces (Rest, Local, etc)	6	BACnet	2
KNX	4	WiFi	2
ZigBee	3		

Source: JRC analysis, 2022.

Table 21. Communication standards / protocols used at least by one participant.

Communication standard/ protocol used		
Bluetooth	IO-HOME	Profibus
HTTP/TCP/IP	FlexOffer	BIM
OPC	ASHRAE 223P	

Source: JRC analysis, 2022.

From Table 20 it can be noticed that the most popular communication protocols are Modbus and SAREF, respectively used by 9 and 8 survey participants, followed by EEBus and APIs (6 replies) and ZigBee (3 replies). The rest of the solutions are chosen by different participants, resulting in a total of 13 technological solutions used by at least one or two participants (see third and fourth column from Table 20 and the whole Table 21).

From the above it can be concluded that there are a plethora of solutions used by different stakeholders. All participants gave multiple answers in this question, meaning that more than one solution is used.

Particularly for SAREF, the survey participants were asked to give their feedback for potential improvements in the ontology. Some suggestions for improvement are listed below:

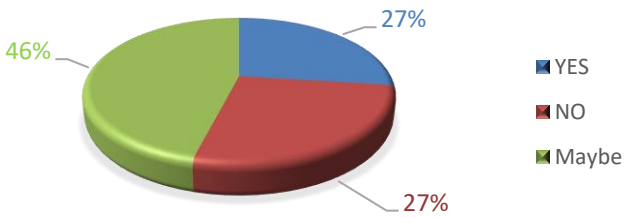
- Plug-ins should be added to reduce customization effort by non-experts;
- It should include the notion of time series and its support;
- It should contribute with UCs for energy flexibility;
- The specification needs to be covered by EEBus;

— The ontology needs to expand to be able to encapsulate all data structures inherited from the IEC/CIM ontologies (particularly the IEC62325 for market data exchanges and IEC61968 for DSO communication).

One of the participant mentioned that many actors involved in the ESA industry do not use SAREF, but they prefer instead (and are satisfied with) other technological solutions, as these are listed in Table 20 and Table 21. Anticipating this possible outcome, the survey's participants were asked whether they would be willing to use SAREF ontology for communication with ESA. A total of 15 replies were collected. This number is relatively low but is enough to give a good indication of the existing trends.

The answers to this questions are summarised in Figure 35, where 27% of the answers received were positive, whereas another 27% were negative. The remaining 46% gave "maybe" as a reply, meaning that nearly half of the participants would be willing to use it if one or some of the aforementioned suggestions were addressed, especially with respect to SAREF including the essence from other ontologies. Although only a quarter of the participants explicitly expressed their willingness to work with SAREF as it is, the number could triple reaching the 75%, if some improvements were made in the ontology (this is concluded, because the participants made specific suggestions for SAREF and addressed problematic issues impeding its adoption).

Figure 35. Willingness to work with SAREF ontology for communication ESA.



Source: JRC analysis, 2022.

In relation to SAREF's improvement, one participant mentioned that this is treated in the Interconnect project, whereas the suggestions made in this project are found useful by another participant. The Interconnect project has been considered during literature review of this TR, as well as during the generation of UCs categories. Representatives from Interconnect are also included and will be invited in future workshops for collecting information about ESA.

To complete the picture of the communication technologies/standards used, a question was asked related to what protocol, ontology or interface the participants currently use. We received 13 replies to this question. The answers received are presented in Table 22 and Table 23 , and are similar to those of Table 20 and Table 21.

Table 22. Protocols/ontologies used.

Protocols/ontologies used	No of participants
Modbus	4
BACnet	2
EEBus	2

Source: JRC analysis, 2022.

Table 23. Protocols/ontologies used by at least one participant.

Protocols/ontologies used at least by one participant			
REST API	Brick	Webservices	WiFi
IEEE 2030.5	IEC 104	OpenTherm	ZigBee
KNX	TCP/IP	OCPP	DALI
Haystack			

Source: JRC analysis, 2022.

Again, Modbus is among the most popular solutions, followed by BACnet and EEBus. Similarly to the communication standards/protocols used, there is a variety of protocols/ ontologies used by participants.

This abundance of technological solutions (provided from Table 20 to Table 23) can potentially lead to IOP problems, as it can result in ESA systems using different communication options that are not compatible with each other. It is also noticeable that some of these solutions are not standardised.

The present situation makes it imperative to follow a structured plan like the one indicated by the current project, which can lead to a CoC for IOP of ESA. An initiative that can bring coherence in the field and have coordinated efforts for the future of ESA, especially given their predicted vast penetration in the market for the near future.

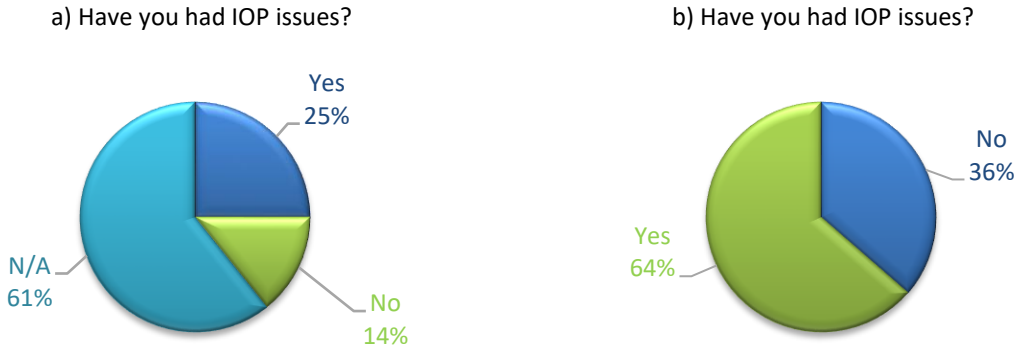
3.4 Interoperability

This Section gives information about Interoperability (IOP) issues related to ESA. The participants were asked whether they had ever experienced IOP issues and in which IOP layer. In case of positive replies, they were asked to specify which kind of problems they encountered, with which appliances and if they had been able to tackle with these issues. All this information is critical in order to understand the picture with respect to IOP and the ESA actors.

First of all, we see that many actors encounter IOP issues. Secondly, in order to better extract information, the answers were summarised according to two perspectives: first considering the whole sample of participants (56) and subsequently considering only the participants that replied to the question (Yes/No). We remind the reader that some participants were not eligible to reply to this question (i.e. simple customers by definition do not perform IOP tests).

In total, related to this issue, 22 replies were registered. These replies were considered to obtain the percentages reported in Figure 36.

Figure 36. Percentages of participants that have encountered or not IOP issues: a) sample of 56 participants, b) sample of eligible participants to reply.



Source: JRC analysis, 2022.

The majority of the participants who were eligible to reply to this question had indeed encountered IOP issues. This shows that IOP is a major issue in the field and all potential action to minimize IOP problems in the ESA field, i.e. a CoC, would be valuable.

Related to the question asking in which devices such IOP issues were encountered, 13 replies were obtained, with the respondents listing variety of devices, as reported in Table 24 and Table 25.

Table 24. Devices with which IOP issues have been encountered.

Devices with which IOP issues have been encountered	No of participants
Heat pumps	4
Smart meters	4
EV charger	3

Boilers	2

Source: JRC analysis, 2022.

Table 25. Devices with which IOP issues have been encountered at least by one participant.

Devices with which IOP issues have been encountered		
Heat exchanger.	Storage system	Dish washer
Internet of things (IoT) devices from different vendors.	PV inverter	Washing machine

Source: JRC analysis, 2022.

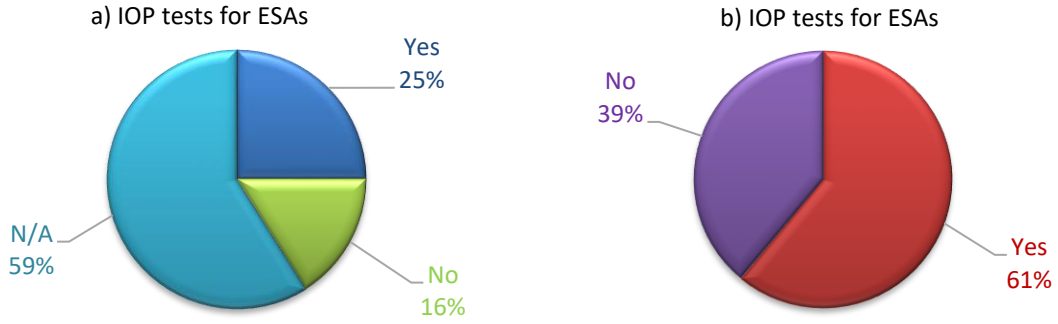
As it can be noted, several types of devices were involved in creating IOP problems for our participants. HVAC devices are among those featuring more prominently in the list. This is also explained by the fact that HVAC manufacturers were the most numerous among the survey participants (see Table 3). Smart meters were also among the devices experiencing IOP issues, together with devices belonging to the periodical appliances category as well as chargers and storage system devices. The survey participants had also the opportunity to express specific problematic issues that they have encountered, which we summarize as follows:

- Standards interpretation;
- Struggle with proprietary interfaces that are not common;
- There are missing conformity tests around most of standards available today;
- No overarching protocol distributed in the market, so it becomes difficult for suppliers to communicate with devices;
- Devices using other protocols.

It is clear from the above that IOP issues do exist. They are mainly due to the different solutions used by ESA systems, making them incompatible and unable to communicate properly with each other or even among components of the same system. Another problem that was raised in the survey has to do with missing conformity tests for most standards, meaning that even under the presence of standards, there is a lack in sufficient testing or in a concrete testing methodology.

Moreover, the participants were asked specifically if they perform IOP tests for ESA (see Figure 37). Again, we use the two perspectives to display the responses: firstly showing the overall picture from the total sample of participants (Figure 37.a) and secondly considering only the replies that correspond to a Yes/No answer. For this question 23 replies were received, and the percentages presented in Figure 37.b are based on this number.

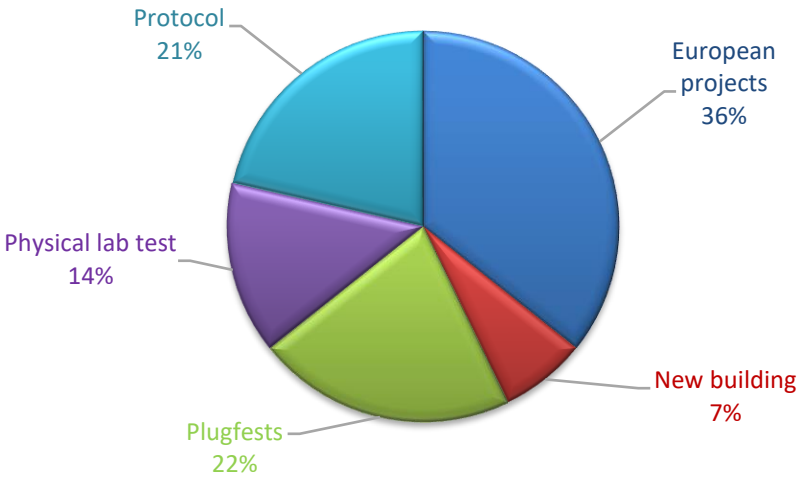
Figure 37. Percentage of participants that perform IOP tests for ESA, a) sample of 56 participants, b) sample of eligible participants for this question.



Source: JRC analysis, 2022.

Most of the participants do perform IOP tests for ESA. This is a positive facts, as it signifies an increase of interest in IOP issues and that actions are performed in order to solve them. Figure 38 shows what kind of tests have been performed to assess IOP in ESA.

Figure 38. What kind of tests have been performed related to IOP of ESA.



Source: JRC analysis, 2022.

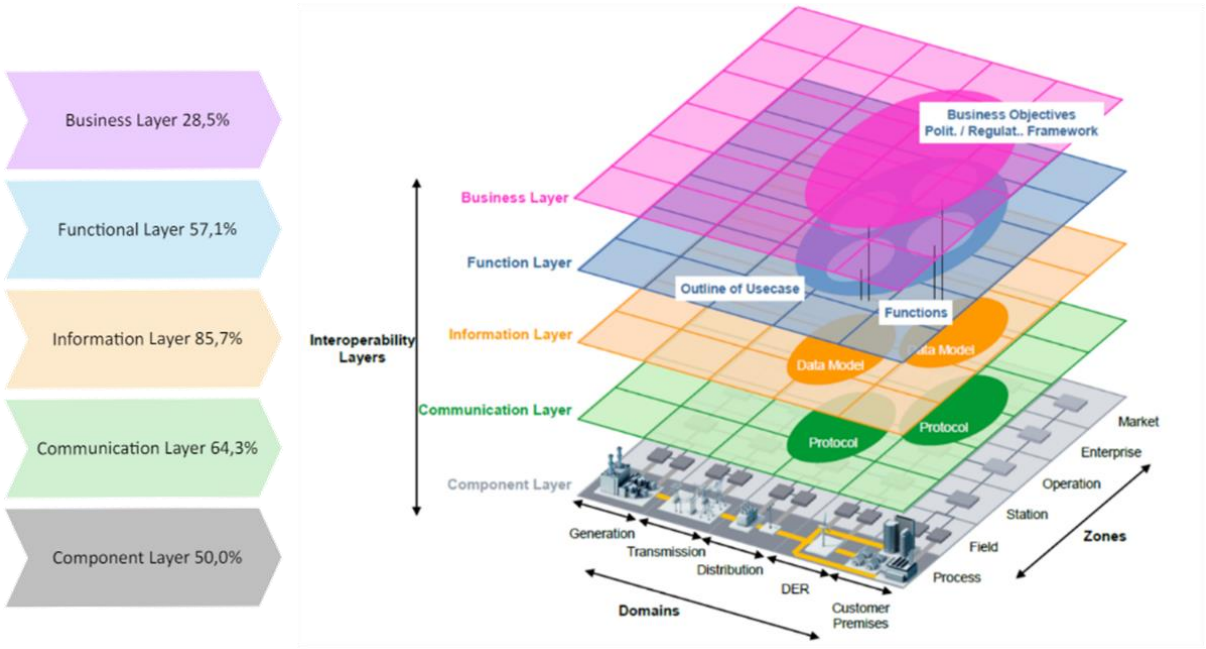
As is can be extracted from the above graph, we have:

- IOP tests for Plugfests;
- Tests for EMS integration;
- IOP tests for a variety of white goods in buildings.

The highest percentage resulted for the "European projects", meaning that thanks to some of those projects some entities have reached a way to test IOP in a proper way. Another participant mentioned that they perform IOP tests in the form of physical lab tests.

Apart from the devices entailed in IOP issues, we deemed important to highlight in which SGAM framework layer (see Figure 39) the problems are encountered. For this question, 14 replies were registered by the participants, thus all percentages presented, are based on these replies. Figure 39 shows the layers of IOP in which problems are encountered.

Figure 39. SGAM Interoperability layers in which problems are encountered.



Source: (ETSI, 2017) and JRC analysis, 2022.

Based on the SGAM layers (see Figure 7), Figure 39 shows the percentage of IOP issues encountered by the survey participants in each layer; a 100% in a layer would mean that all respondents encounter issues at that level. Almost the totality of participants replied that they encountered IOP problems in multiple layers. The information layer (entailing data exchange formats and models for common understanding of data exchanged) obtained the highest percentage (85%). The communication layer, entailing communication technology (PLC, Ethernet…) and protocols for data transmission, followed with 64%. The functional layer, entails functions and interactions, services specifications, UCs, was third with 57%. The last two layers, namely the component layer (physical connections and structure, hardware to connect systems or devices, power cables, media) and the business layer (business model, market structures, business portfolios) also gathered a significant percentage of the respondent, respectively with 50% and 29%. In conclusion, IOP issues are spread to all possible layers and thus cover a wide range of problems.

Another interesting fact to know is whether or not the IOP issues mentioned had been solved. Figure 40 shows the results for the 14 replies registered. There is a total equality when comparing the positive and negative replies, meaning that whereas 50% of the participants had solved IOP problems occurred and the other half had not been able to do so.

Figure 40. Percentage of participants that have solved IOP issues.

Source: JRC analysis, 2022.

In the question asking how IOP issues were solved by participants, several answers were received, listed as follows:

- By assuring compatibility through a certification scheme;
- By completing the missing parts of the standard;
- Manually, in most cases;
- With use of gateways and collaboration between suppliers;
- By developing a proxy.

From these replies it is obvious that one of the main problems with IOP is the incompatibility among components of the same system or among different systems. We point out that one participant explicitly emphasised that, although they managed to solve some of the IOP issues occurred, they had not succeeded in solving all problems in all layers. Indeed, when asked what the main problem with respect to IOP was, the participants highlighted the following:

- The protocols cannot communicate with each other;
- Lack of unified standards or interoperable communication protocols;
- Lack of deployment of associated standards so far for behind the meter assets.

This shows to what extent the lack of standards, communication and coherent solutions can affect IOP among systems.

Another important issue was the question of whether or not a specific methodology is followed to perform IOP tests. There were 14 responses on this matter, with the results showed in Figure 41. In order to plot this graph

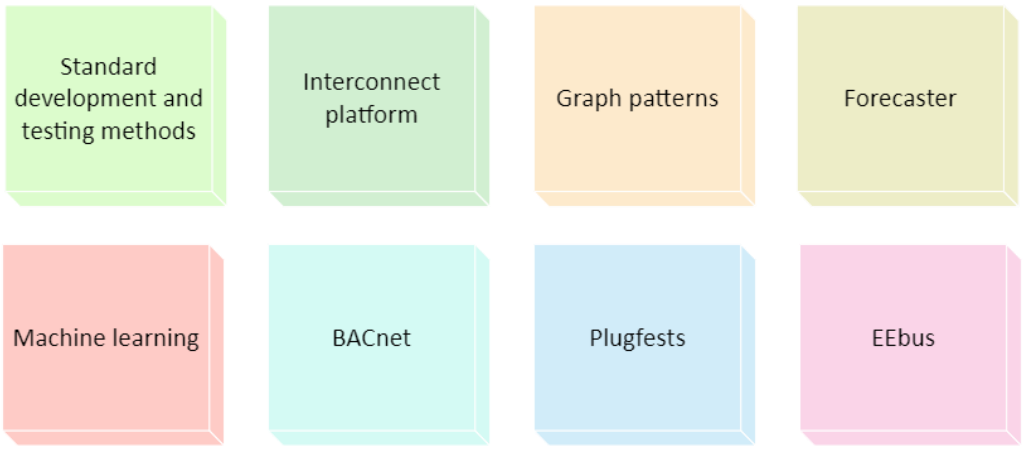
the participants who do not perform IOP tests at all were not taken into consideration, but only those that are active in this matter. Half of the participants that do perform IOP tests were not following any structured methodology. This is another issue that needs improvement, where a well-structured methodology can lead to well-organised IOP test outcomes that are verified in a well-planned manner.

Figure 41. Percentage of participants that have used a structured methodology for IOP testing.

Source: JRC analysis, 2022.

Figure 42 shows the structured methodologies used by the participants. Several methodologies were reported as being used. The Interconnect project was mentioned, together with proprietary methodologies for IOP testing. In addition, we note that for different standard or protocols, different accredited centres or different methodologies were used. It is somehow disappointing that that none of the participants mentioned using the *Interoperability Testing Methodology for Smart Grids* (Papaioannou I., 2018), developed by our team in the JRC. We believe this to be a well-structured methodology that can be applied in all SGAM interoperability layers, for all kind of ESA and standards/protocols to be tested and that also follows CEN/CENELEC procedures. Perhaps, the participating entities have one of their own.

Figure 42. Structured methodologies used by our participants for IOP testing.



Source: JRC analysis, 2022.

We found that IOP issues are present for most of the ESA categories and all IOP layers. Furthermore, we found a variety of different methodologies for IOP testing. This indicates that IOP problems for ESA are a significant issue that needs to be solved. Once more, these results show the critical importance to have a coordinated effort to develop a CoC. As many as possible stakeholders should commit to the goal of ensuring that future systems will communicate smoothly with each other and that replacing one component with another will not lead to unresolved IOP issues.

4 ESA and their role in the society

This chapter analyses of the answers to the rest of the questions of the survey. These were general questions aimed at all participants concerning general issues regarding IOP in ESA, such as potential CoC, public engagement, as well as privacy and security issues.

First, it presents the CoC and questions related to its implementation (Section 4.1). Then moves on to discussing public engagement related to ESA, especially the main issues preventing their uptake, and ways to improve their usage and increase their purchase (Section 4.2). The last Section (4.3) discusses the final questions of the survey, covering APIs and improving the data exchange among different actors, aspects of the cybersecurity and privacy concerns, and any other issues that could impact IOP in ESA that were not previously tackled in the survey.

This part of the survey questions was open to everyone so that all participants had the opportunity to give their feedback. Hence, all results presented in the following are shown as percentages of the whole survey sample size (56 participants). It also shows the share of the survey's participants that chose not to reply to these questions.

4.1 Code of Conduct (CoC)

The CoC for IOP of ESA is an initiative launched by the EC, intended mainly for the ESA manufacturers and other actors in the industry aiming to achieve IOP of different smart home actors with ESA, as mentioned in Chapter 3.

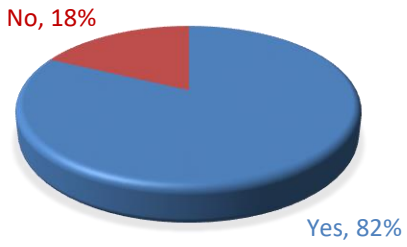
The CoC refers to a pre-agreed set of rules, guidelines, principles, standards and frameworks on how to achieve and maintain IOP, as well as mentioning collaborative initiatives which companies can consult in making the ESA interoperable with other actors in and out of Smart Homes. On a completely voluntary basis, it can be signed by associations and companies, which commit to take actions to support the IOP solutions for, and related to, ESA.

The contents of such CoC have yet to be drafted and agreed upon. This is a task which will be carried out in the next phases of the project as explained in the introduction.

4.1.1 Interest to participate in the design of CoC

A question was aimed at each participant to express their interest in drafting the CoC. The drafting is intended to take place mainly during a planned Workshop, and possibly more to come further. The main guiding principles of the Workshop(s) are the respectful collaboration of all interested parties, constructive teamwork and sharing of ideas in the drafting exercises facilitated by EC. The results of the question are shown in Figure 43.

Figure 43. Would you be interested in participating in the design of CoC on IOP of ESA?



Source: JRC analysis, 2022.

A very high proportion of the respondents (82% of the survey participants, or 46 in absolute terms) expressed interest in collaborating to the co-design of the CoC. Considering the stakeholder distribution, among those who answered "Yes" to the question, more than half are not in the manufacturing business. Out of these 46 participants, 20 identified themselves as manufacturers of ESA and/or other related devices inside or outside home (as per categorization described in previous Chapters), while the rest (26) fell into all other categories, notably ESPs, professional associations, research centres and existing customers. As for the reasons why some participants answered "No", some specific answers can be singled out: "*preferring the standards over CoC*", "*scope of the CoC not being clear*", but also that the CoC, and in the case drafting of one, is "*out of scope of their business*".

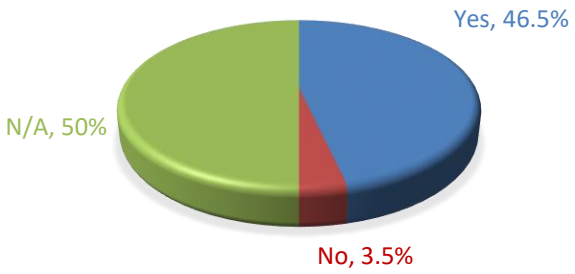
These results clearly show that almost all actors are concerned with how the adoption of a CoC would in the end affect them. Even though half of participants were not directly related to the manufacturing business, meaning that they will not be invited to adhere to the CoC, they clearly recognised its importance and would like to have a say into its design. The document is expected to impact their business or their private domain in one way or another.

4.1.2 Willingness to adherence to a future CoC on IOP of ESA

The final step related to this project is adherence to the CoC. After it is designed, the EC intends to propose it to the ESA manufacturing community of the EU. Associations and companies will then be able to sign the document, thus committing to take all appropriate actions to support the IOP solutions proposed therein. We emphasis the fact that adhering to this text will be completely voluntary.

A question was thus included in the survey, aimed mostly at the actors in the industry, and most notably at the manufacturers of ESA and other affected stakeholders, inquiring over the willingness to sign a proposed CoC. The N/A (not applicable) answer was left for all participants not concerned by this issue. The results can be found in Figure 44.

Figure 44. Would you be willing to adhere to a future CoC on the IOP of ESA?



Source: JRC analysis, 2022.

Half of the participants were not concerned with this question. Of those concerned, only 2 out of 28 answered negatively (3.5% of the participants). The reasons offered were: "*scope of the CoC is not clear*" and that "*CoC does not guarantee IOP*". Both these participants also answered that they are not interested in the design of a CoC in the previous question.

These two respondent raise two points that are worth addressing. Regarding the first comment, it is clear that no assurances can be given that the scope of the CoC will satisfy everyone. Nonetheless, the EC (DG JRC and DG ENER) guarantees that the most serious attempts to avoid this issue will be done, by giving all the opportunity to speak their minds and by drafting the document in strict and open collaboration between all interested parties.

Regarding the second comment, its observation is correct: a CoC will not guarantee IOP. However, the goal of such a document is not to guarantee IOP or to replace the standards in any way, but to pave the way to the possible harmonisation of (hypothetical) future EU legislation which will aim to tackle and take into account both of these issues.

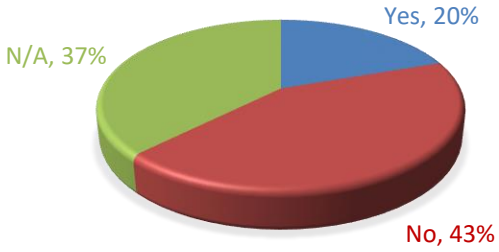
In conclusion, based on the answer to this question, we can safely assume that the general manufacturing community has recognised the importance of a CoC and are open-minded regarding adherence to it.

4.1.3 CoC sufficiency towards promoting IOP of ESA?

The last question in this section of the survey was about asking all participants to give their opinion on whether the CoC can be recognized as the sole promotor of IOP in ESA. While being aware that this document would probably not be the only solution in achieving IOP in Smart Homes, it could be very useful if used as a precursor to a more standardised approach under EU legislation that, as already mentioned, may come in the future. A CoC will consist of a pre-agreed set of requirements and good practises for EU manufacturers to follow, which will have the goal of achieving the IOP in and with ESA.

We gauged the participants' opinion on whether a CoC would be sufficient towards promoting IOP of ESA. The answers are shown in Figure 45.

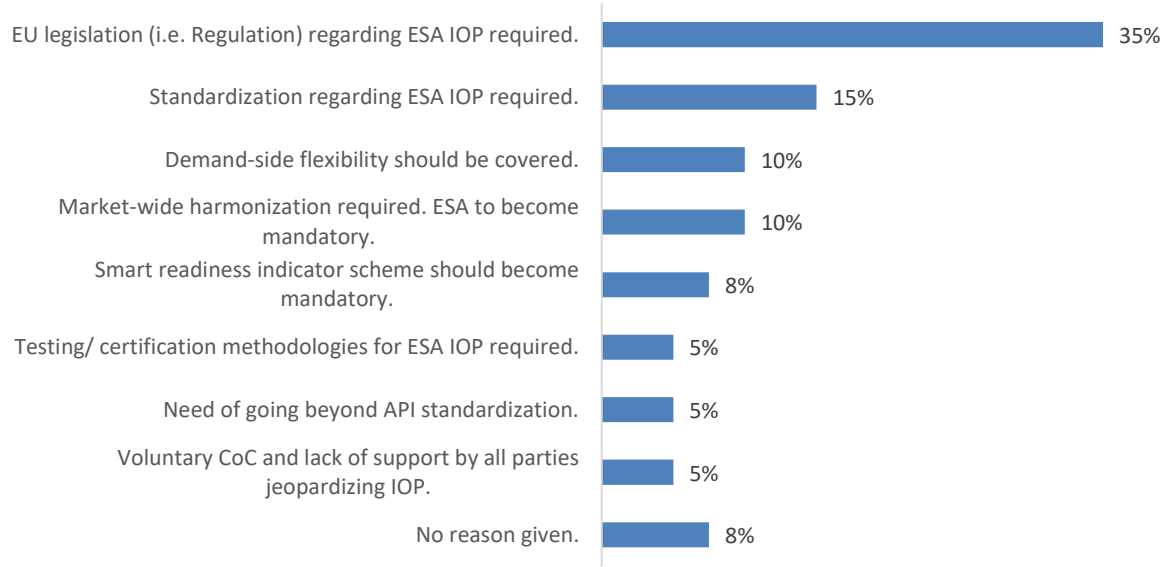
Figure 45. Do you think that a CoC is sufficient in promoting the IOP of ESA?



Source: JRC analysis, 2022.

Even though most of the participants said (section 4.1.2,) that they are willing to adhere to a future CoC, more than one third stated that this document is not enough and hence that the issues related to the IOP of ESA have to be tackled further. The participants voiced their concerns in different ways, sometimes giving multiple reasons, as summarised in Figure 46.

Figure 46. Reasons given by participants answering on why a CoC is insufficient to achieve IOP of ESA and what is needed beyond such document.



Source: JRC analysis, 2022.

It can observed that most participants were in favour of achieving IOP with some kind of binding legislation such as EU Regulations, based on new or existing standards, "*for example IEC/CLC EN50631*", (Directive 2012/27/EU), (CENELEC, 2017). For most of the respondents, the CoC is a very important (first) step, with many calling it a minimum requirement and some considering it as "*one piece of the puzzle*" in the IOP for ESA. Additionally, it is important that all actors are engaged, from users of ESA to Energy Service Providers, and that all these actors communicate in a standardised way.

One of the reasons suggested regarding why proper legislation is needed was that "*the market of ESA is already mature*" and so, to harmonize it EC-wide, it has to be properly addressed and imposed. Some of the participants

are going even further, stating that the ESA, carrying "smart" label, should be the "*only such products on the market*", mainly for the purpose of achieving and fully developing demand-side flexibility (DSF).

Furthermore, one participant mentioned that these devices will have to be "*compliant with product-level cybersecurity requirements, General Data Protection Regulation (GDPR), and data sharing*" and they should be "*semantically interoperable*". Taking that into account, a smart readiness indicator (SRI) scheme, which is now optional, "*should become mandatory*". One comment drew a parallel between "*the unique USB charger with single hardware interface*" which has to be supported by all portable devices and "*the universal semantic plug*", further saying that "*it should be mandated to provide semantic interoperability that goes beyond API standardization*". In relation to this, the EC has been asked to "*further mandate a minimum use of standardized APIs at grid operator levels which would facilitate the use of reference data structures behind the meter*".

Fears were expressed regarding the fact that a voluntary CoC could be "*a barrier to true interoperability*" and that some actors are not in favour of IOP to begin with. One comment mentioned that if "*the CoC will take into account already existing legislation acts (such as Cyber Resilience Act, GDPR, Digital Market Act, etc.*), and if the CoC is going to be "*complete enough*", there would be no need for additional legislation acts.

Quite significantly, a couple of participants mentioned that the testing and certification methodologies are still "*missing*", but are considered as an important step. There was also a recommendation that the SAREF can be used as a basis for such methodologies, but also "*to make certification in a simple and quick, not too technical, way*". Some of the participants are further recommending that it could also "*become part of, or complement, already existing SRI methodology for buildings*". Providentially, the EC's last phase of this project is tackling exactly this issue – testing and certification methodologies – for which there will be a need for additional cooperation between the EC and all other interested parties.

In conclusion, from all feedback received, we can deduce that the CoC as a recommendation to the manufacturers is not sufficient. All stakeholders hope that it is a first step towards more substantial initiatives, such as EU legislation based on existing/ new standards, but also certification and testing methodologies. To achieve such goal, close coordination is needed between all interested parties, considering it a joint effort.

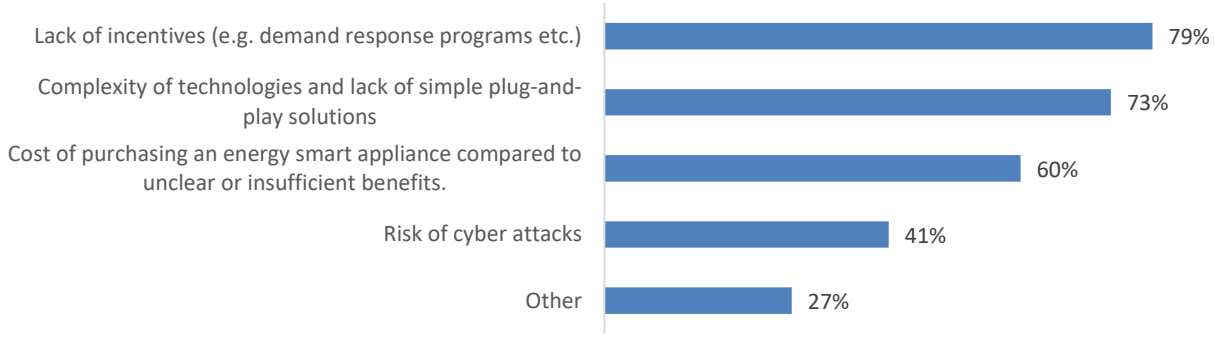
4.2 ESA and engagement of the general public

This section presents issues with respect to the uptake of ESA, the engagement of the general public and the services that ESA can offer to consumers. The scope was to investigate the main obstacles linked to the uptake of ESA, thus giving a clear picture of what can be done in order to improve the engagement of the public. In addition, we wanted to gauge the opinion of stakeholders towards improving this engagement.

The stakeholders had the opportunity to give multiple answers to this question. Figure 47 shows the main issues that were identified. The lack of incentives came top of the list. For example, demand response programs addressed to customers to promote the acquisition of ESA gathered 78% of the replies (44 answers). The complexity of technologies and lack of simple plug-and-play solutions was second, gathering 73% of the participants (41 answers). Cost of acquiring a smart device and the risk of cyber-attacks were third and fourth with 60% and 41% respectively.

All answers gathered relatively high percentages, meaning that the overall situation needs to be improved so as to facilitate the deployment of ESA. On the one hand, regarding the incentives, the number of demand response programs have been increasing over the last years. These programmes could translate in important facilitators for the uptake of ESA, provided that these targeted programs take place. On the other hand, it is also clear that there is a need to have simple ESA, which are easily managed by the broader public. To achieve this simplicity, technologies need to be advanced to provide the consumers with such easy-managing options. The cost of ESA will decrease when the technologies are more widespread, following the usual market trend of demand and supply. The more produced and more wide-spread, the cheaper they will become. Cyberattacks are on the rise, but so are the mechanisms and tools that help to prevent them. The latter is indeed a hot topic that will see great developments in the coming years.

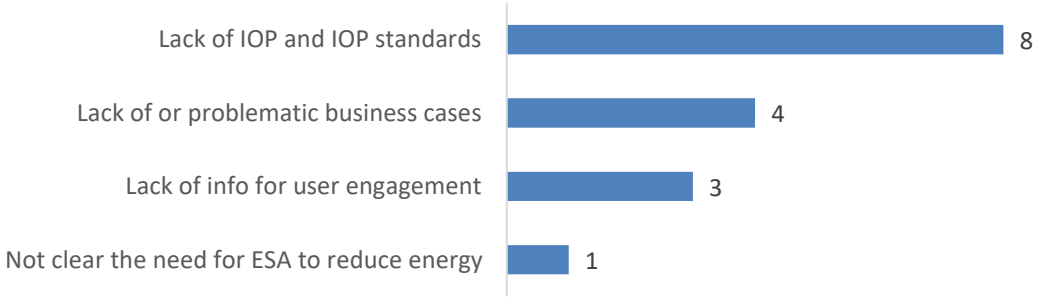
Figure 47. Issues preventing the uptake of ESA.



Source: JRC analysis, 2022.

In addition to the four issues identified above, the answers received under the "Other" option have been grouped. These are displayed in Figure 48. IOP problems are at the top of this list, meaning that there is a need for a coordinated effort in the field of ESA. Few respondents offered other reasons: the lack of coordinated business cases, the lack of information available for the general public, and the benefits that could bring the uptake of ESA. These issues should also be considered. In general, it is important to highlight the role of ESA for the wider public. Currently, the definition of "smart" is limited to smartphones, tablets and similar devices, whereas washing machines, heat pumps, HVAC are excluded. Therefore, it is important to increase awareness of the potential of ESA and overcome existing barriers.

Figure 48. Other reasons preventing the uptake of ESA.

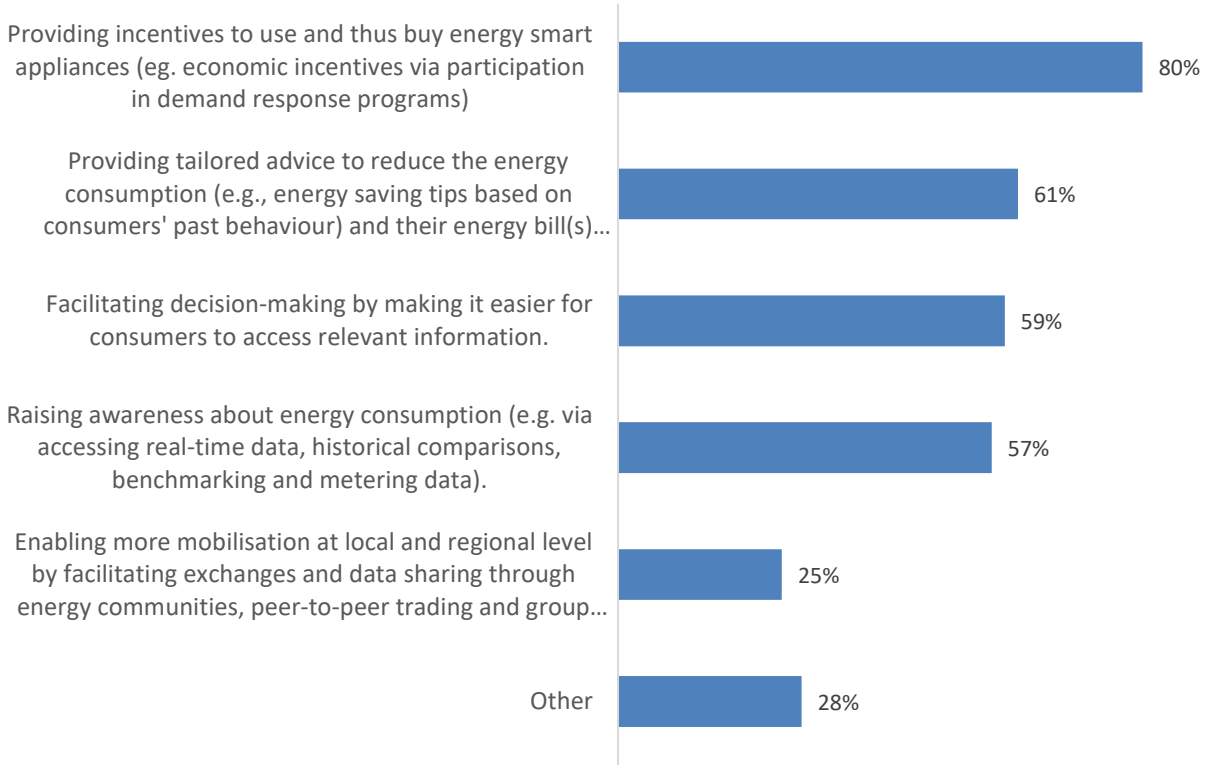


Source: JRC analysis, 2022.

After reviewing the obstacles for the uptake of ESA, it is important to find out what can be done to improve the engagement of citizens in buying or using ESA. Figure 49 displays the stakeholders' opinions on this regard. Providing incentives for ESA came first, with 80% of the survey participants (45 replies) supporting this view. Providing tailored advice to reduce the energy consumption and the energy bills came second with a 61% (34 replies). The third and fourth improvement, "facilitating decision making by rendering information easily accessible" and "raising awareness about energy consumption" were slightly below with 59% (33 replies) and 57% (32 replies) respectively. Last item in the list was "improving data sharing through energy communities" with a 25% (14 replies) of the participants' support.

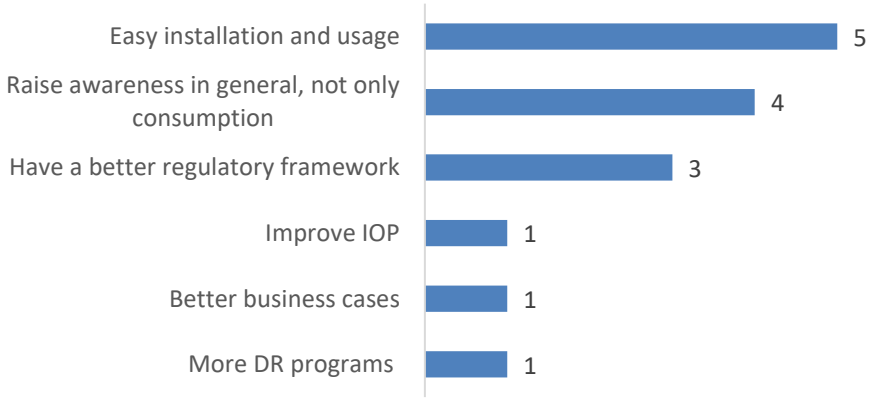
Complementing the information presented in Figure 49, the replies under the "Other" option in Figure 50 have been expanded. For example, providing the final user with an easy installation of ESA and their usage was the most popular suggestion proposed to improve the uptake of ESA. In addition, there were also some stakeholders that deemed important to have a better regulatory framework. There were also individual answers proposing that addressing IOP issues, adding more demand response programs, and employing better business cases can positively contribute. A number of participants believed in the potential of raising awareness in general, not only related to reducing energy consumption but also linked to other motivations like contributing in avoiding peaks in the grid.

Figure 49. Ways for improving the uptake of ESA.



Source: JRC analysis, 2022.

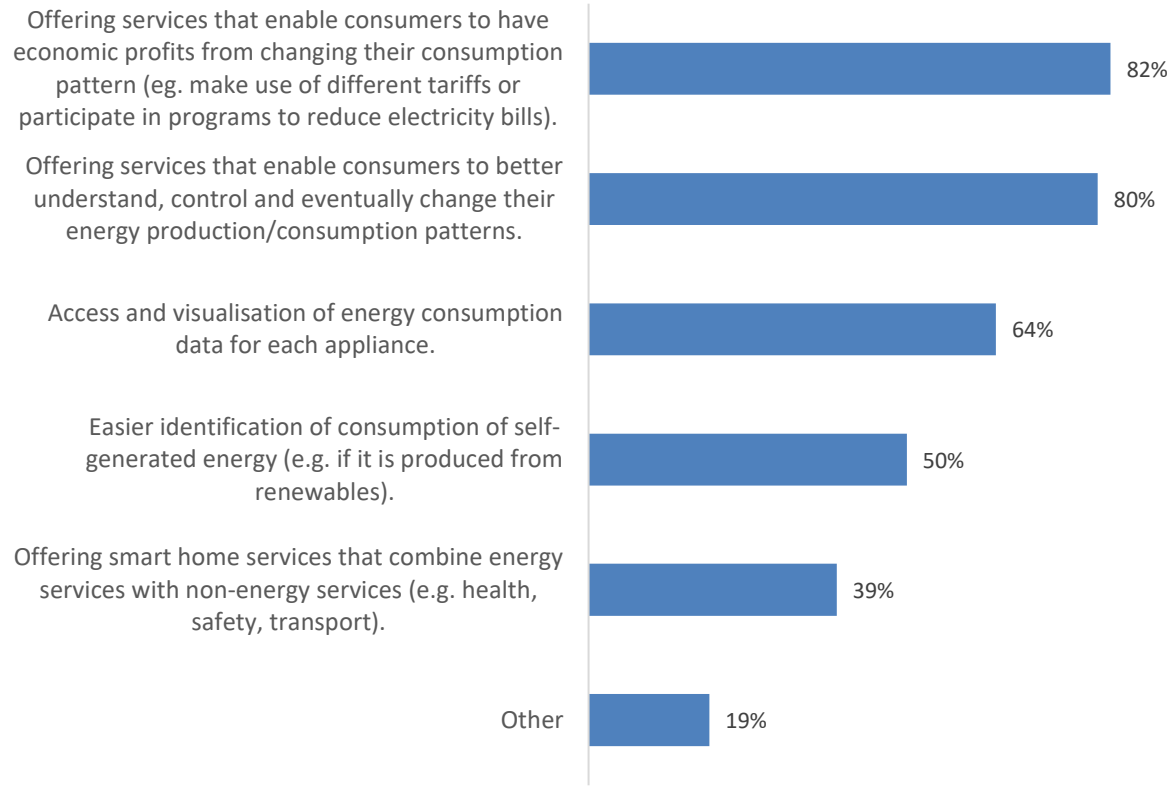
Figure 50. Other ways of improving citizens' engagement in buying/ using ESA.



Source: JRC analysis, 2022.

Another issue that was addressed in the survey has to do with the most important services that ESA can provide to engage citizens in the energy transition. This is an important aspect, as the ESA are expected to contribute to the so-called energy transition. Figure 51 shows these most important services offered by the ESA to the citizens according to the replies in our survey.

Figure 51. Most important services offered by the ESA to the citizens.



Source: JRC analysis, 2022.

The main services offered by ESA to citizens are related with enabling them to have economical profit from changing their consumption pattern (82% of the participants, or 46 replies) and enabling them to better understand, control and change their energy patterns (80%, or 45 replies). These two services are top in the list, followed by offering access and visualisation of energy consumption data for each appliance (64%, or 36 replies). The two last reasons, "easier identification of consumption of self-generated energy" and "offering smart home services combining energy and non-energy services", gathered 50% and 39% of the replies, respectively.

Table 26. Other services that can be offered by ESA.

Services offered by ESA	
Use better critical resources, like water.	Contribute in better integration of renewable energy.
Inform on the state of electrical network, management of electrical peak.	Facilitate collaboration of service providers.
Ensuring better thermal comfort and in-door air quality.	

Source: JRC analysis, 2022.

This shows the potential of ESA and the fact that the citizens can benefit from them. Once more, to show the whole picture of the services that can be offered by ESA, the replies under the "Other" option have been expanded; in Table 26. The options presented in the table were each suggested by a single participant, except for the one regarding service to "use better critical resources, like water", which was proposed by two different participants.

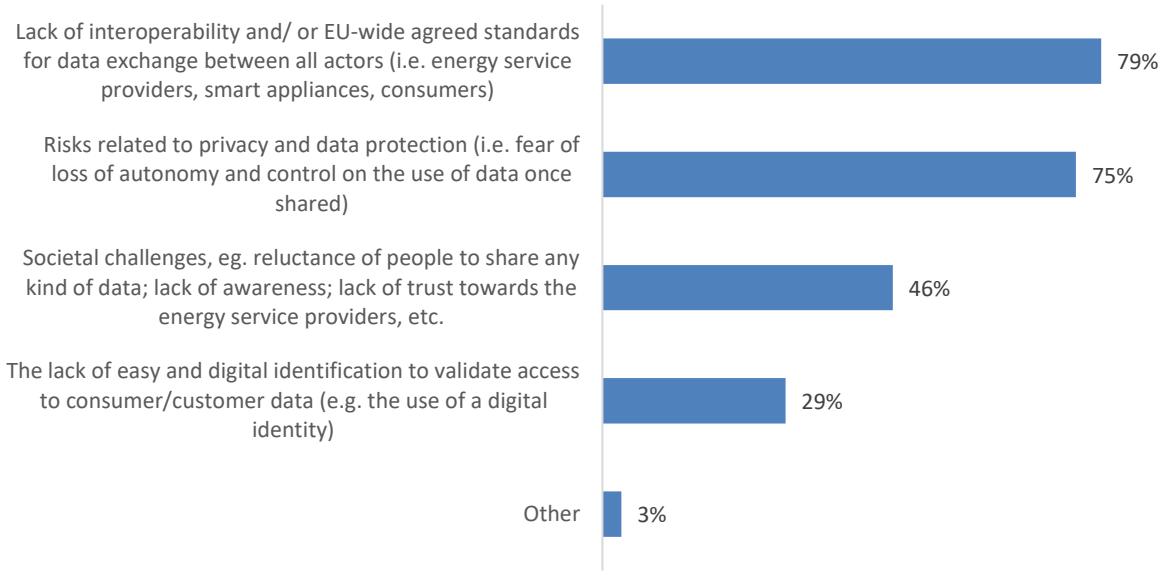
In summary, we can state that ESA can play a key role in the society and especially in critical matters, like handling resources and contributing to improve energy efficiency of the grid.

4.3 Other issues including security and privacy.

On the one hand, ESA can make end-consumer's life easier, but on the other hand they may bring additional issues in several important aspects of security and privacy. To avoid overlooking any of such issues, all participants were asked about on their general feeling on cybersecurity, privacy issues, ease of use, and other issues that could impact IOP in ESA but were not mentioned in the survey.

Data Issues

Figure 52. Data issues related to ESA data.



Source: JRC analysis, 2022.

First of all, we asked about the main issues related to ESA messages, with the answers shown in Figure 52. The main issue was the "lack of IOP and/or standards for data exchange between the interested actors", which gathered almost 80% of the survey participants. The "risk related to privacy and data protection" was second which 75% and "societal challenges, like reluctance of people to share any kind of data or lack of awareness" came third, gathering 46%. Another issue was the "lack of easy and digital identification to validate access to customer data", with was chosen by nearly a third of the stakeholders (29%). Among "Others", participants mentioned: "concern about a potential closure of the company responsible for such data" and the fact that "any future CoC should not duplicate already existing work in the data field".

Open Application Programming Interface (API)

The rest of the issues covered in this section of the survey were in the form of text answers, with no predefined options to choose among the possible answers, so that participants had the chance to freely express their opinion. To begin with, we asked to the participants how open APIs could improve data exchange among ESA and other actors. For this question 39 replies were collected. The majority of the answers highlighted the importance of open APIs and how they can play a key role in facilitating data exchange, but also enhance the role of all actors involved in the field. The topics mentioned by the participants in relation to the role of open APIs are summarised in Table 27.

Table 27. Areas where Open APIs can contribute.

Area where open APIs can contribute	Number of participants
Data exchange is facilitated/ improved/ enabled: among all actors; decentralised energy data registry is enabled; sharing of information is enabled at information level.	12
Facilitate the role of all actors involved: they allow players to provide services and build own control functions; manufacturers can concentrate on other issues; communication is ensured among actors.	11
Link to standards: they should be linked to / based on already existing standards (follow EN50631); they should be a prerequisite / should be standardised.	9
Can act as a common hub for appliances: appliances can request actions among them and upper level services; devices can be enrolled.	5
Improve topics of common interest: business models; IOP; maintaining the cost of ESA at acceptable levels.	2

Source: JRC analysis, 2022.

Regarding Open APIs, 5 areas where they can play a decisive role were identified: data exchange among all actors; facilitating the role of all interesting players in the field; their link to standards; facilitating the role of ESA; and improve aspects of common interest.

The area of data exchange was highlighted by multiple participants, mentioning among others that sharing information among all interested players can be facilitated via open APIs and that they can be the means for ensuring customers to allow an aggregator to have access to their data. A second highlighted issue, with only a slight difference in the number of replies received, was that in general the role of all actors can be facilitated. This can be done by allowing all players to provide services and allowing manufacturers to concentrate on topics different from communication, where the role of open APIs was emphasized. Particularly for the ESA's interactions among each other, as well as the interaction between them and other upper level services. The need to have relevant standards in the field was noted by several stakeholders. Specifically, it was pointed out that open APIs should follow existing standards, like the EN 50631. On the other hand, it was also suggested that open APIs should become a prerequisite in the field of ESA and they should be standardised.

From these replies and from a general perspective, we understand the importance of open APIs in the field, since they facilitate data exchange and communication among different actors. They can facilitate many issues in the field and they can play a key role in topics of common interest, like IOP. Therefore, their role is fundamental and special attention needs to be paid to open APIs that are available in the market.

Cybersecurity

Another topic that was addressed concern the cybersecurity aspects that need to be implemented when considering IOP of ESA, receiving 39 replies. The answers are summarised in Table 28.

Many participants (15) stated that already existing regulations, as well as future ones, should be followed in order to tackle possible issues of cybersecurity concerning the IOP of ESA. Not all respondents referred to the same regulations, however, and all regulations together are grouped to give an overall picture of the current situation. We state the examples of the regulations quoted by the participants. The same approach was also used for other issues featured for cybersecurity. For instance, 14 participants declared that data protection is important and should be number one priority when implementing cybersecurity techniques. All sub-topics mentioned under this umbrella are also given as explanation in the same table. Other cybersecurity issues that were underlined are: IOP, the importance of the end user security, the potential of using web cybersecurity, and other existing security schemes.

Table 28. Aspects of cybersecurity that should be considered for the IOP of ESA.

Aspects of cybersecurity	Number of participants
Existing and future regulations need to be followed: Cyber Resilience Act; Radio Equipment Directive; EU cybersecurity concepts; Commission delegated regulation (EU) 2022/30; European certification scheme under GDPR umbrella; Cybersecurity network code; cybersecurity standards; cybersecurity regulation; safety related requirements of EN 50631.	15
Data protection is above all: encryption should be followed; consumer data protection should take place; communication channel protection should be followed; reduce flow of unnecessary data.	14
End user security is important: IoT WiFi network can be used; home networks should be robust.	4
IOP: IOP of security protocols.	2
Web cybersecurity should be used: HTTPS, TLS.	2
Other existing security schemes should be used: BACNet, KNX.	2

Source: JRC analysis, 2022.

In summary, we acknowledge that it is vital to follow relevant regulations and that cybersecurity should serve above all data protection and end user security.

Privacy

In the area of privacy, the participants were asked to express their main concerns about specific issues concerning the IOP of ESA. The 42 replies received are presented in Table 29. Many of the participants gave multiple replies.

The participants considered useful to follow existing standards and cybersecurity rules to maintain privacy, both the GDPR and the Data Act are good examples. This topic gathered 15 replies from the participants. In addition, many participants remarked the importance of correct data handling. In particular, data categorization is seen as necessary, meaning that data should be divided into the data that cannot be shared, and the data that can be shared under measures, or under looser, measures. Specific rules should be there for data sharing, access, control, protection and quality. Different parties should know where data is sent and with whom it is shared. The issues linked to the ruling of the data sharing was highlighted by 13 participants as important. Another issue emphasised in relation to data was the anonymization and storage of data when this is under analysis and encryption for transit (4 replies). Other issues mentioned were: ownership of data by the customer (5 replies), their consent for data usage (8 replies) and consumer digital identification has also been mentioned (3 replies).

Table 29. Main concerns about privacy for IOP of ESA.

Issues about privacy for IOP of ESA	Number of participants
Follow existing standards and cybersecurity rules, i.e. Data Act, GDPR (General Data Protection Regulation).	15
Rules for data sharing, data access, data control, data protection, data quality: parties should know where data is sent; personal data should not be shared; categorization of data - cannot be shared, can be shared under strict measures or under looser measures.	13
Consent of customers for: data usage, connecting device.	8
Ownership of data by the customer.	5
Anonymization and storage of data when under analysis; encryption when in transit.	4
Consumer digital identification.	3

Source: JRC analysis, 2022.

In summary, specific rules are needed for data, whereas already existing regulations should be followed. A potential future CoC should take into consideration these issues and have clear rules on how data has to be communicated and shared.

Additional concerns

The survey concluded with a final question asking participants to indicate other any other issue that have not been covered. Indeed, we considered any additional ideas for topics that should be covered under the future CoC to be very useful. Table 30 shows the additional issues and concerns highlighted by the participants. Some of the topics summarised in Table 30 were already covered elsewhere in the survey, but here the respondent added a different perspective.

Table 30. Additional concerns.

Concerns and additional issues about the IOP of ESA	
Interference that can be created by ESA in the network – concern that they can disturb the Power Line Communications network – there should be a standard that limits these interferences	The CoC should consider that it is the ESA that give quality of life services to occupants.
What happens to the device or software if company closes or if cloud disappears?	IOP issues: — IOP tests should come with certification, like in California through IEEE 2030-5 CSIP; — Too rigid focus on IOP can hamper innovation; — Ontologies as driver for IOP.
How ESA connect to the IoT of the home?	Data concerns: — Extra approval if data is used for research purposes; — Data Integrity;
Is there going to be also a Business to business focus instead of Business to consumer focus?	Regulations concerns: — Limited applicability of legislation.
Grid short term peak load demand when switching on and off the devices.	Open APIs concerns: — Available between ecosystem and not between equipment.
Solar PV smart inverters and EVs should be considered together with ESA.	

Source: JRC analysis, 2022.

Some of the issues raised are worth discussing for the IOP of ESA. For instance, the interference that they could cause to the network, or the way they are connected to the Internet of Things of the home. An interesting suggestion was that IOP tests should come along with a certification procedure. This means that tests to verify IOP should be performed in a structured way and following a concrete methodology. On the other hand, innovation should not be blocked by applying too rigid regulations and IOP rules.

From the above discussion, we conclude that ESA are a hot topic for the scientific community, as well as the future society at large. We believe that this work will contribute towards improving the existing situation and make the transition to a full implementation of ESA much smoother.

5 Conclusions

5.1 Conclusions about the survey

First of all, it can concluded that the interest in participating in the survey and in the project has been promising for the future CoC. However, it is unfortunate not having received feedback from all EEA countries. Additional contributions, would have help to have a better overview of the European status of ESA. In any case, we know that some organisations are operating from one country (e.g. Belgium) other branches located in other countries.

The willingness of participating was specially demonstrated by the number of spontaneous replies received from several stakeholders. As it is shown in the Figure 11, these spontaneous participations were more numerous than those coming from invited stakeholders.

Related to the structure of the survey, we conclude that the proposed categorization of actors have been accepted by most of the stakeholders. Few participants made some proposal for a different categorization, which was asked by activating the "other" section in many questions, and these have been incorporated in this report. The categorization of the ESA is considered to be accurate and it likewise is assumed that the different options of messages exchanged are correct.

A weak point of this study was the absence of end-user participation. It should therefore be important to involve more consumer associations in the next steps of the project. Moreover, we had no participants involved in the manufacture of solar or home batteries, residential energy storage systems or a storage battery specifically for home use. Again, we consider important to have such stakeholders on board to understand their expectations and necessities related to IOP.

5.2 Conclusions about the IOP of ESA

Thanks to the answer provided related to the messages exchanged between the ESA and different devices and/or actors, we can corroborate that the classification of messages proposed is accurate. However, we also see that there are a lot of divergences among the answers collected because sometimes the exchanged messages are offered and some others not. A similar situation is given when analysing the type of information exchanged between actors, which can vary significantly depending on the actors involved. However, we can report the main message exchanged in each category (Table 31).

Table 31. Message most offered between the ESA and the different stakeholders.

Between	**Message most offered**
ESA and Energy Provider	Data management
ESA and Device control within home manufacturer	
ESA and Device control outside home manufacturer	
ESA and customer	Comfort boundaries

Source: JRC analysis, 2022.

There was a rich variety of the communication standards and protocols used by participants. Their answers revealed that all the lines of work are not exactly the same, therefore the need to define protocols becomes crucial. One possible approach to converge could be using the same ontology. In this sense, the survey also asked about the SAREF ontology, which is used relatively little, by around a quarter of the stakeholders taking the survey but with half of the participants stating that they would be willing to adopt it. This leads us to believe that SAREF could be used as an effective tool for homogenization.

Around two out of three participants have experienced problems related to IOP of ESA. We give great value to those responses which indicated that there might be problems in all the different layers of interoperability (SGAM), particularly in the information layer; close to 90% of the participants pointed as this layer when describing their IOP issues. In effect, addressing IOP issues is essential, as it registered by another question of the survey, in which only half of the stakeholders stated that were able to solve them.

Through the answers of the participants able to solve an IOP issue, we learnt that one of the main barriers linked to IOP was the incompatibility among components of different systems, as well as among components of the

same system. The participants stated the need of establishing protocols to be able to communicate with each other and unified standards.

At the current moment, IOP has not been tested with a specific methodology. Nevertheless, the replies showed that testing and certifying IOP is essential, and using a structured methodology would definitely help to perform valid and verifiable tests.

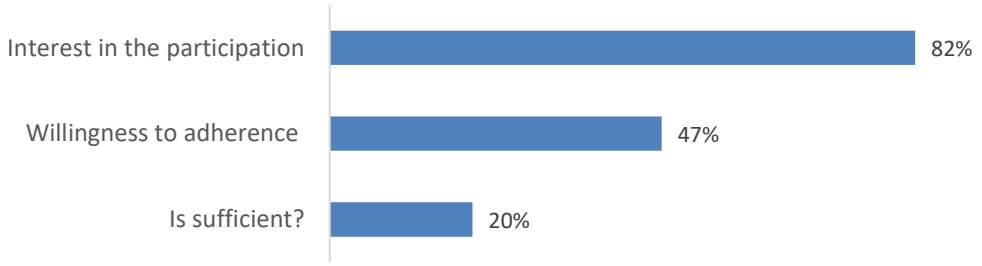
The current IOP issues arise with this survey reinforces the ongoing work to develop a CoC for IOP of ESA, which will ensure that systems will communicate seamlessly with each other. In parallel, encouraging manufacturers to adhere would favour the deployment of ESA.

5.3 Conclusions about the CoC

In the survey, there were 3 questions related to the CoC and the percentage of positive answers received is displayed in Figure 53. The question asking about the interest of participants in participating in the design of a CoC gathered 82% of the replies, while 46% of the participants showed their willingness to adhere to a future CoC. Only 20% of the respondent thought that the CoC would be sufficient to promote IOP.

One of the main reasons for not showing interest in the CoC was that the scope is not clear, which in turn suggests that more stakeholders will be willing to adhere to a CoC when its scope becomes better defined,. On the other hand, most of participants expect that this document represents a first step or a precursor of something more standardized under the EU legislation. Participants overwhelmingly expressed a belief that a CoC would not able to guarantee in itself the IOP of ESA Taking an overall picture of these three questions, we conclude that the CoC will help the harmonization within manufacturing community and serve as a basis for the possible EU legislation.

Figure 53. Three questions related to the CoC.



Source: JRC analysis, 2022.

Regarding the deployment of the ESA, the survey showed that incentives will have a predominant role. Further, to improve public engagement, the ESA should clearly display prices and show the energy savings achieved, and their use should become simple and clearly understandable.

Another important conclusion is that it is necessary to address information security in the CoC. In relation to questions related to cybersecurity, a concern for data protection and privacy in the use of information to control or operate ESA has been confirmed.

In summary, the future CoC will consist of pre-agreed set of requirements for certain functionalities of ESA; such functionalities are based on established standards. The manufacturers will be asked to assure that their appliances comply with the document. The mere purpose of the CoC is to lay down the foundations of an ecosystem of interoperable ESA.

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List of abbreviations and definitions

AA	Administrative Arrangement
API	Application Programming Interface
APP	Application
BACS	Building Acquisition Control System
CFL	Compact fluorescent light
CoC	Code of Conduct
CRA	Cyber Resilience Act
DSF	Demand Side Flexibility
EC	European Commission
EEA	European Economic Area
EMS	Energy Management System
ESA	Energy Smart Appliance
ESP	Energy Service Provider
EV	Electric Vehicle
FSP	Flexibility Service Provider
GDPR	General Data Protection Regulation
GLS	General lighting service
HID	High intensity discharge lamp
HVAC	Heating, Ventilation and Air-Conditioning
IOP	Interoperability
IoT	Internet of Things
JRC	Joint Research Centre
LED	Light emitting diode
LFL	Linear fluorescent lamp
NGO	Non-Governmental Organisation
PV	Photovoltaic
RES	Renewable Energy Sources
SAREF	Smart Applications Reference
SGAM	Smart Grid Architecture Model
TR	Technical Report
UC	Use Case
VPP	Virtual Power Plant

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