

Assessment of the impact of EU climate-, energy and land use policies

Working paper (for internal use only)

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08/04/2020

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1 Introduction

The European Union acts on climate change by mitigating greenhouse gas emissions with implementation of a large portfolio of climate-, energy- and land use policies. Key targets are set in the 2020 climate & energy package and the 2030 climate & energy framework, and they also include some major policies and legislation, such as the Emission Trading System (ETS). In addition, other policies are implemented to ensure meeting these key targets, such as the CO₂ performance standard for cars and heavy-duty vehicles. Most of the individual policies from these frameworks have been implemented at this moment, only some of the 2030 are still planned policies. In addition, the EU has also put forward a 2050 long-term strategy that contains ambitions for the longer-term.

This working paper is written as part of the SENTINEL project¹ that aims to develop a modelling framework to support policymakers and the wider public in the European energy transition. The purpose of this paper is to highlight the main results of the assessment of EU climate policies, and to describe the methods used for the assesment with the IMAGE model and document outstanding issues. We will only assess the impact of policies from the 2020 and 2030 packages and supporting policies on greenhouse gas emissions and energy use, with a focus on 2030. This paper describes the results in terms of reductions of total greenhouse gas emissions. In addition, IMAGE/TIMER emission- and energy trends are compared to historical data from the European Energy Agency (EEA), International Energy Agency (IEA) or United Nations Framework for Climate Change (UNFCCC).

The assessment was done with the IMAGE model, which is an integrated assessment model that includes the TIMER energy model and a land-use model. The IMAGE model is divided into 26 regions, of which West-Europe (WEU) and Central-Europa (CEU) are two seperate regions. The regions together represent the Europe region, and it is assumed that EU28 policies are implemented in all countries from these two regions. The Europe region covers the EU28 countries, but also Serbia, Switzerland, Norway, Bosnia and Herzegovina, Iceland, Macedonia, Albania, Montenegro, San Marino, Liechtenstein and Monaco. Together, the countries outside the EU28 represent 190 Mt CO₂eq emissions in 2017, which is 4.5% of the Europe region. For now we still assume Great Britain is part of the EU28.

The main policy package is the 2030 energy & climate framework that has three key targets for 2030

1. Cut greenhouse gas emissions by 40% relative to 1990
2. Achieve at least a 32% share of renewable energy
3. Improve energy efficiency by 32.5%

The EU Climate action website (European Commission (2020)) describes all EU climate policies, that were implemented to achieve the key targets. Based on this list, we identified those with quantifiable targets (see Table 1). Some overall policies (e.g. Energy Efficiency Directive) were not explicitly implemented into the IMAGE model, but it was checked afterward whether the targets were achieved.

The policies from Table 1 that were not implemented in the IMAGE model are

- Effort sharing targets for non-CO₂ and AFOLU
- Innovation fund
- Fuel Quality
- Shipping
- Aviation
- AFOLU policies

¹<https://sentinel.energy/>

Table 1: EU climate-, energy and land use policies, I=implemented, C=checked, NI=not implemented

IMAGE	Policy	Coverage sectors	Policy goal
C	Energy Efficiency Directive	Economy-wide	20% energy efficiency improvement target for 2020 =1483 Mtoe of primary energy or 1086 Mtoe of final energy
C			32.5% energy efficiency improvement in 2030 =1273 Mtoe of primary energy and 956 Mtoe of final energy
NI	Effort sharing	Non-ETS: transport, buildings, agriculture, waste	10% reduction in total emissions from the sectors covered by 2020 compared with 2005 levels and of 30% by 2030 compared with 2005 levels
C	Renewable Energy Directive	Economy-wide	At least 32% of final energy consumption by 2030
I	F-gas Regulation	Economy-wide	By 2030 F-gas emissions are decreased by two-thirds compared with 2014 levels.
I	Emission Trading System		In 2020, emissions from sectors covered by the system will be 21% lower than in 2005 In 2030, emissions from sectors covered by the EU ETS will be cut by 43% from 2005 levels
NI	Innovation fund		ETS revenues are invested in innovations
I	CO2 performance standards cars and vans	cars	Average fleet-wide standard for new registrations of 95 gCO ₂ /km in 2021 15% reduction of average fleet-wide standard of new registrations relative to 2021 by 2025 37.5% reduction of average fleet-wide standard of new registrations relative to 2021 by 2030 15 % low emissions share of the new passenger cars by 2025 35 % low emissions share of the new passenger cars by 2030
NI		vans	Average fleet-wide standard for new registrations of 147 gCO ₂ /km in 2020 15% reduction relative to 2021 by 2025 31.5% reduction relative to 2021 by 2030 15% reduction of average fleet-wide standard of new registrations relative to 2020 by 2025 30% reduction of average fleet-wide standard of new registrations relative to 2020 by 2030
I	CO2 performance standards trucks and busses	large lorries	Start 2021 15% reduction relative to 2020 by 2025 30% reduction relative to 2020 by 2030 Credit system for low emission trucks
		smaller lorries, buses, coaches and trailers.	Start 2023 Targets are not decided yet
I	Renewable Energy Directive		10 % share of energy from renewable sources in transport in Community energy consumption by 2020 Renewable energy for final consumption of energy in the transport sector is at least 14 % by 2030
NI	Fuel Quality Directive		Reduction of the greenhouse gas intensity of transport fuels by a minimum of 6% by 2020 on a life-cycle basis against a 2010 baseline of 94.1 gCO ₂ eq/MJ Biofuels sustainability criteria
NI	Car Labelling Directive		Labelling
NI	Shipping Strategy		Labelling Supporting IMO greenhouse gas strategy
	Emission Trading System (Aviation)		CO ₂ emissions from aviation have been included in the EU ETS since 2012 (flights within EU)
I	Buildings Directive		all new buildings must be nearly zero-energy buildings (NZEB) from 31 December 2020
NI			Since 31 December 2018, all new public buildings already need to be NZEB

2 EU greenhouse gas emissions

Total greenhouse gas emissions in 2017 are 4,165 MtCO₂eq in Europe, and 4,065 MtCO₂eq in the EU28 (Portal (2019), UNFCCC (2019)). Figure 1 splits up the greenhouse gas emissions per sector and the categories ‘Total’ and ‘Total excluding LULUCF’. Differences in historical emissions between IMAGE and the UNFCCC are especially large for LULUCF emissions, which is due to differences in accounting.

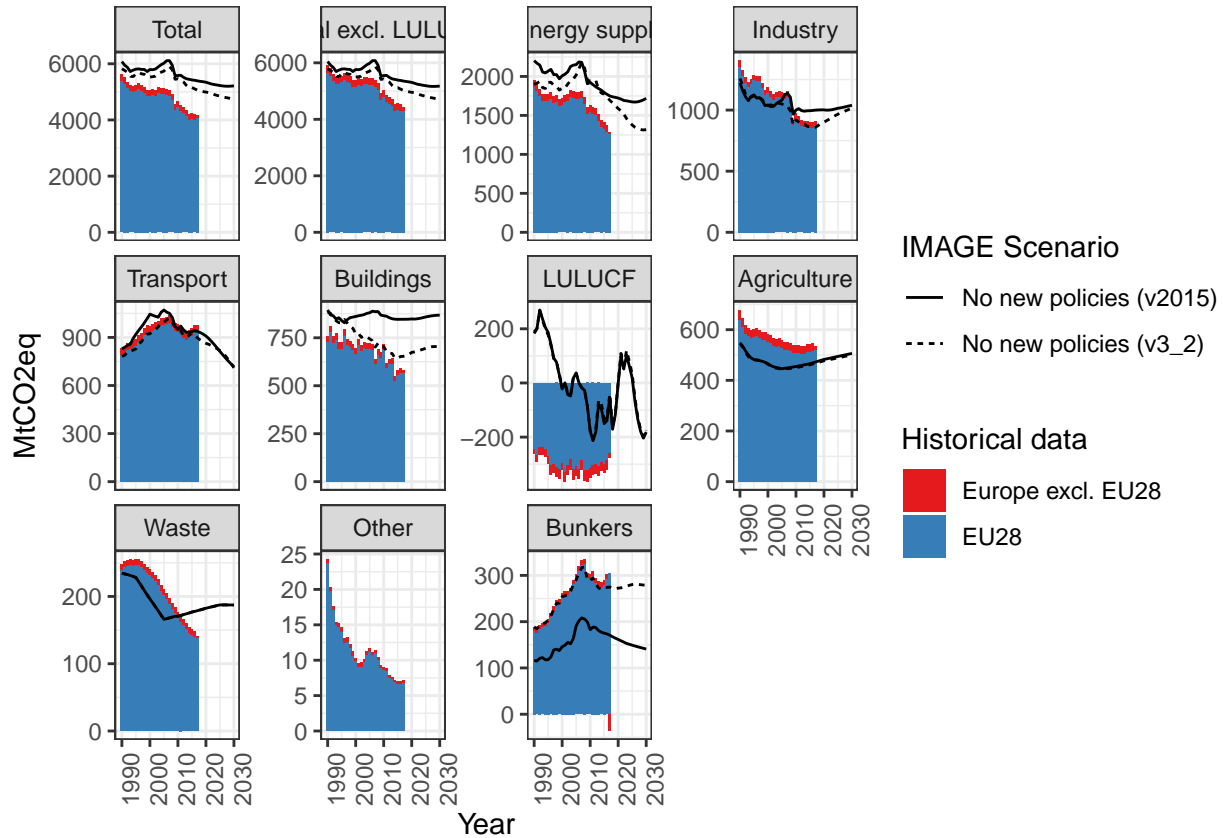


Figure 1: EU greenhouse gas emissions

3 EU Impact of climate policies

The EU has put forward a 20% reduction target for 2020, and a 40% reduction target by 2030 relative to 1990, excluding CO₂ land use emissions. These are key targets of the 2020 climate & energy package, and 2030 climate & energy framework. Based on UNFCCC data (UNFCCC (2019)) this would imply an emission level of 4,520 MtCO₂eq (excl. LULUCF) by 2020 and 3,390 MtCO₂eq by 2030. However, based on the IMAGE 1990 data, the emissions levels for the Europe region with the same percentage of reductions would be 4,837 and 3,628 MtCO₂eq. With current implemented policies (see Table 1), the EU is estimated to reduce greenhouse gas emissions (excluding LULUCF) by 32.5 % relative to 1990 by 2030.

Future improvements

- Implement remaining policies that have not been implemented yet in IMAGE, but might result in additional reductions. These are
 - Effort sharing directive. Find out whether this has already been accepted by Member States

- CO₂ performance standards for vans. Check if they should be included in cars or medium truck mode of the TIMER model
- Aviation, as European flights are part of the ETS
- Renovation of existing buildings
- Check what non-EU28 countries are participating in EU policies (e.g. ETS)

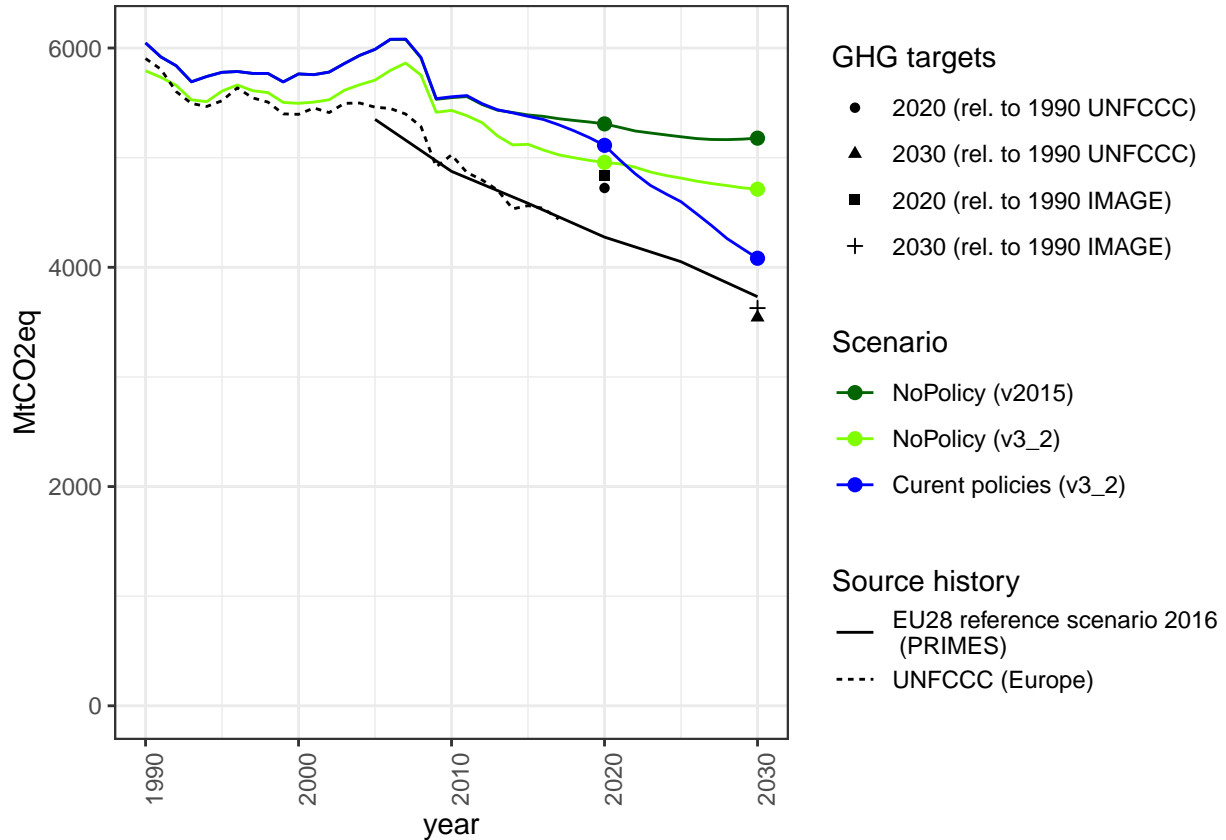


Figure 2: The impact of EU emission reduction targets for 2020 and 2030 on greenhouse gas emissions

4 Energy efficiency directive

The Energy Efficiency Directive includes measures that together would need to achieve the 20% efficiency target from the 2020 energy & climate package and the 32.5% efficiency target from the 2030 climate & energy framework. The targets are set relative to the PRIMES baseline from 2007, and would result in no more than 1,483 Mtoe² primary energy or 1,086 Mtoe final energy by 2020 and 1,273 Mtoe primary energy or 956 Mtoe final energy by 2030.

This economy-wide target is not directly implemented in the IMAGE model, but should be achieved by the implementation of the Emission Trading System (ETS), the Buildings Directive and transport efficiency policies. Figure 3 shows the efficiency improvement in the current policies scenario. It compares the historical data with primary and final energy from the International Energy Agency (IEA) (IEA (2018)). In addition, it compares the results for 2030 with the absolute efficiency goal from the Energy Efficiency Directive, and with the percentage efficiency improvement relative to 2010 from the PRIMES policy scenario (Commission

²Mega tonnes of oil equivalent

(2016)) applied to the TIMER 2010 energy use. The absolute targets only cover the EU28 countries, for which primary and final energy use in 2015 are around 5% lower compared to the Europe region (IEA (2018)). The latter relative target to 2010 is almost achieved in the IMAGE model.

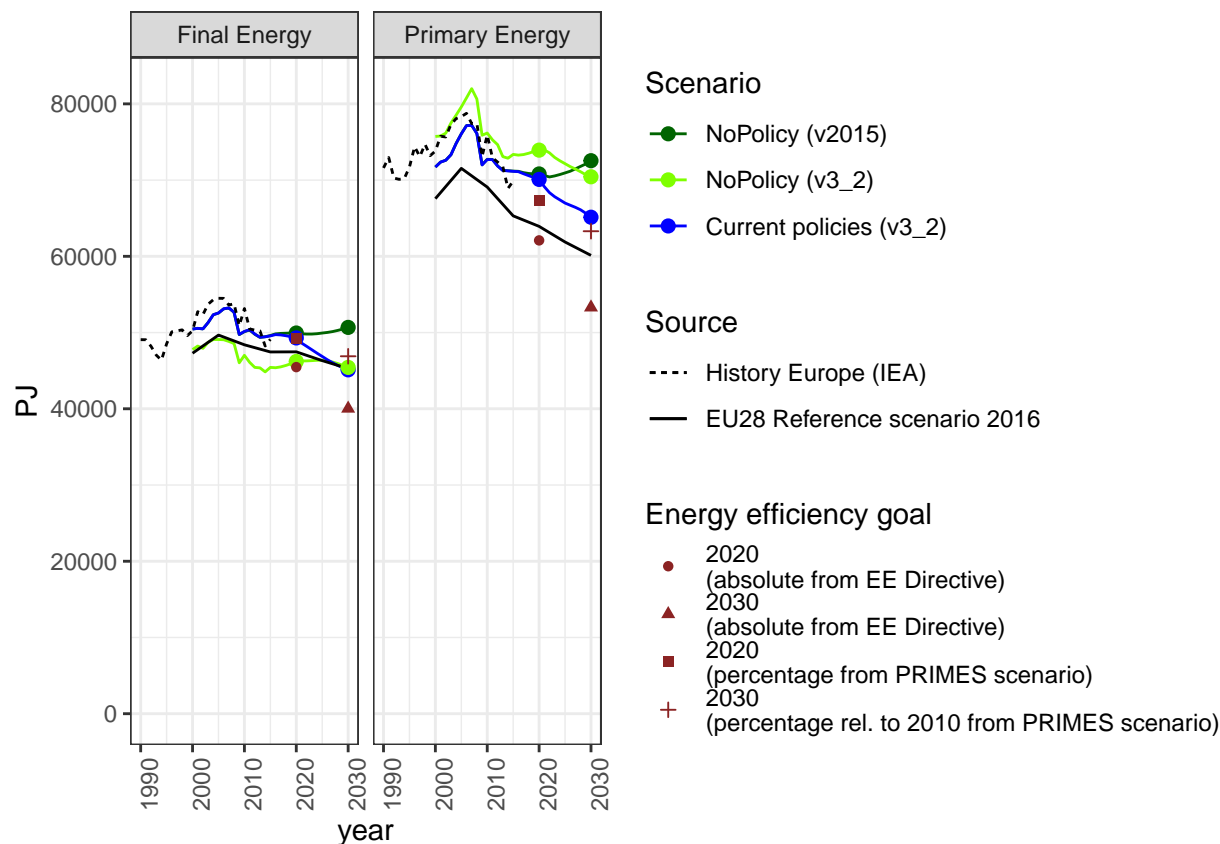


Figure 3: Impact of EU Energy Efficiency directive on energy use

Future improvements

- It is unclear which 2007 projections are referred to in the EU 2012 Directive, or if numbers have been changed or updated after the publication. The published ‘European Energy and Transport - update 2007’ contains a much higher primary energy consumption, even given the fact that it is for the EU27 region (excluding Croatia) and not for the EU28 region. In addition, it is also not clear if the amendment of the EU Energy Efficiency Directive in 2018 refers to the same baseline.
- These measures from the Energy Efficiency Directive have not been implemented in the IMAGE model
 - Energy efficient renovation of at least 3% per year for government buildings
 - Long-term renovation strategies for individual Member States
 - Mandatory energy efficiency certificates
 - Smart metering
 - Obligation scheme for energy companies to save 1.5% energy for final consumers
 - Energy audits for large companies

5 Renewable energy directive

The Renewable Energy Directive is linked to the key renewable targets from the 2020 energy & energy package and 2030 energy & energy framework. The directives require a 20% renewable share of gross final

energy consumption by 2020, and 32% by 2030. In addition, it includes a renewable transport share of 10% by 2020 and 14% by 2030. The biofuels in the transport sector are bound to sustainability criteria.

The overall renewable target is not implemented directly in the IMAGE model, but achievement is checked afterwards. The overall renewable target for 2030 is almost met (see Figure 4). The renewable target for 2020 has been implemented in the IMAGE model, and is enforced in both the travel and freight subsectors (see Figure 5). As the renewable fuel target applies to road transport, the targeted travel modes in the model are ‘cars’, ‘busses’, ‘medium trucks’, and ‘heavy trucks’. The 2030 target is already met in the ‘No policy baseline’ (see 5).

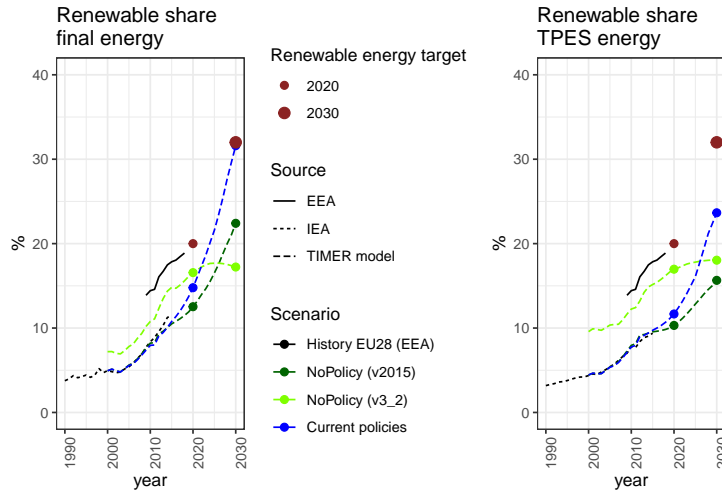


Figure 4: Impact of EU Renewable Energy directive on renewable final energy share

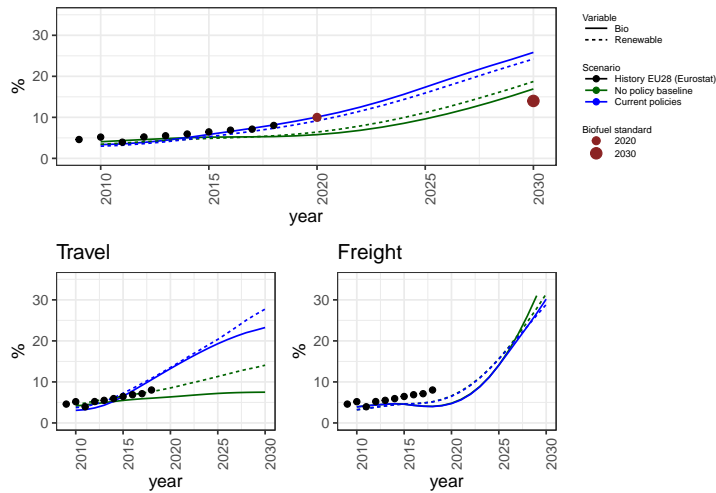


Figure 5: Impact of achieving EU renewable transport target on renewable transport share

Future improvements

- Find out how ‘gross final energy consumption’ is defined. This would explain the difference in renewable share of final energy between EEA and IEA
 - Is there a different definition of gross final energy consumption from EEA and final energy from IEA?

- Is there a different assumption of renewables (for IEA we have included biomass (not traditional) and renewable electricity (for IEA: hydro, solar PV/CSP, wind, biomass))
- It is not clear whether renewable fuels also include renewable electricity or only target biofuels.

6 Emission Trading System

The Emission Trading System (ETS) has an overall target of 21% emission reduction relative to 2005 by 2020, and 43% by 2030. It covers 11,000 heavy energy-using installations from the energy supply and industry sector, and also airlines operating between participating countries. It covers 46.8% of total greenhouse gas emissions excl. LULUCF CO₂ (European Commission (2020)) and 80% of greenhouse gas emissions from the energy supply and industry sector (European Environment Agency (2019), UNFCCC (2019)).

Implementation in the IMAGE model occurs with one carbon tax on the industry and energy supply sector, assuming that the percentage reduction targets apply to 80% of the greenhouse gas emissions from these two sectors in 2005 (see Figure 6). We assume that no surplus emissions exist anymore at 2030. Figure 6 compares the greenhouse gas emissions from the industry and energy supply sector of the IMAGE Europe region with the EU28 ETS greenhouse gas emissions from the EU Reference Scenario 2016 (Commission (2016)) and the greenhouse gas emissions from the ETS registry (European Environment Agency (2019)).

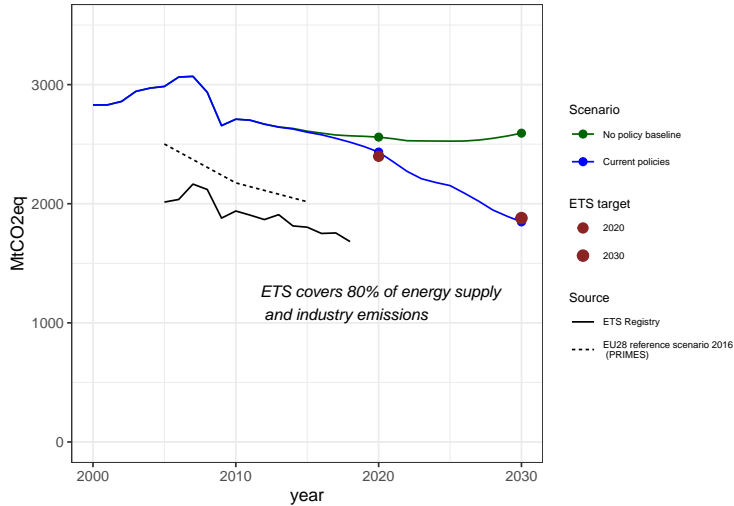


Figure 6: Impact of Emission Trading System on EU greenhouse gas emissions

7 Transport sector

Several EU policies exist in the transport sector, such as the CO₂ performance standards (including benchmarks for electric vehicles), renewable fuel regulation (including sustainability criteria), fuel quality regulation, and policies for air transport and shipping (see Table 1). The following were included in our assessment (see Table 2)

- Renewable target for road transport (biofuels, electric cars)
- CO₂ performance standards for new passenger cars
- Benchmark for new electric cars
- CO₂ performance standards for heavy trucks (large lorries)

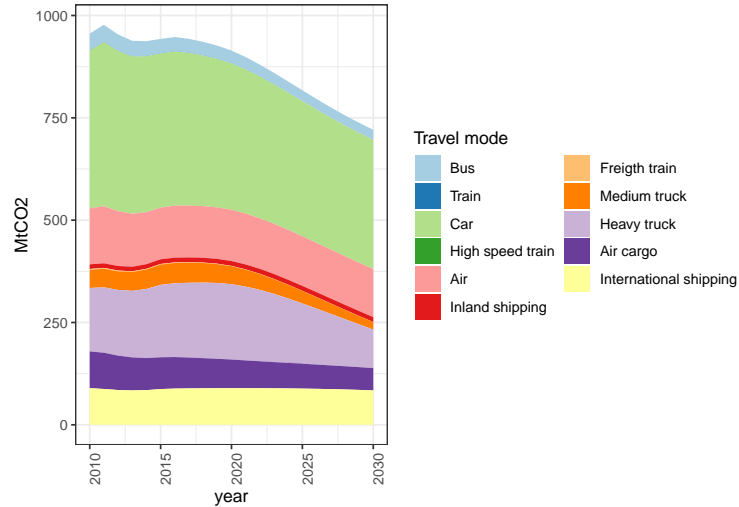


Figure 7: EU transport greenhouse gas emissions per mode

Table 2: EU Transport policies included in the assessment

Policy	Year	Target
Renewable fuel target	2020	10% share of renewable fuels
	2030	14% share of renewable fuels
CO2 performance standard cars	2021	95gCO ₂ /km
	2025	15% reduction relative to 2021
	2030	37.5% reduction relative to 2021
Electric cars benchmark	2025	15% share of new registrations
	2030	35% share of new registrations
CO2 performance standard heavy trucks	2025	15% reduction relative to 2020
	2030	30% reduction relative to 2020

The following transport policies were not included in the current assessment

- Policies for light commercial vehicles, as it is unclear if they should be mapped to cars or medium-trucks
- CO₂ performance standards for busses, smaller lorries, coaches and trailers, as these have not been decided yet and targets will be set after the review in 2022 (planned policy)
- Policies for aviation (part of ETS) and shipping (IMO standards)

7.1 Renewable fuel target and benchmarks for electric vehicles

The IMAGE transport module includes different transport modes for travel and freight transport. The modes that were included in the policy assessment are cars and heavy trucks. Only for the renewable fuel target more modes were included. The freight module also contains medium trucks, but more insights are necessary on how to map EU transport modes to the IMAGE transport modes³

The renewable transport target is part of the Renewable Energy Directive (see Figure 5) and mainly deals with biofuels and renewable electricity. This policy target overlaps with the benchmark for electric cars that is part of regulation on CO₂ performance standards for new cars, commercial vehicles and heavy trucks. The

³See <https://www.transportpolicy.net/standard/eu-vehicle-definitions/>

benchmarks for electric cars is set to a share of 15% low-emission vehicles (cars and commercial vehicles) by 2025, and a 35% low-emissions share for new cars and 30% for new commercial vehicles by 2030. Low-emission vehicles are defined as those that have tailpipe emissions up to 50gCO₂/km. In contrast, there is no benchmark set for electric heavy trucks, although there is a credit system in place which is part of the CO₂ performance standards regulation that gives higher weights to zero- or low-emission vehicles. This credit system also exists for cars and commercial vehicles.

The benchmarks for electric cars were implemented in the IMAGE model by enforcing this share in the model. As explained before, the model target is only applied to electric cars, and not to commercial vehicles (vans). Also, the credit system as part of the CO₂ performance standard was not included in the assessment. The focus for implementation in the IMAGE model was 2030, and the 2020 target was therefore overachieved (see Figure 8).

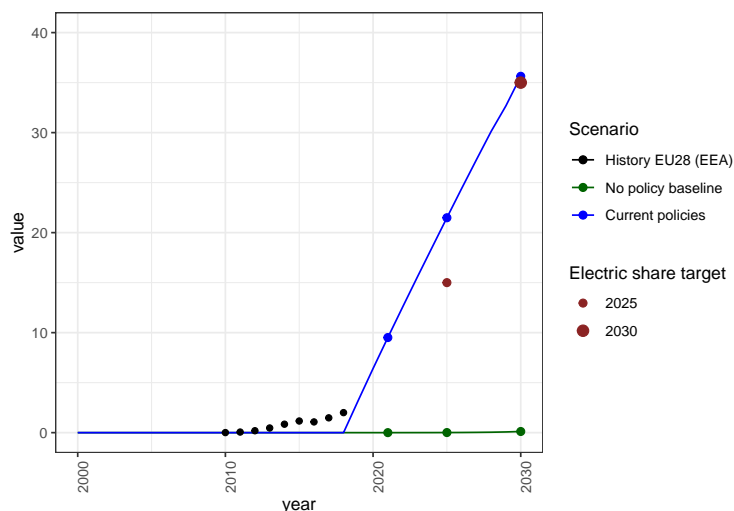


Figure 8: Impact of achieving EU targets for electric cars on electric car share

Future improvements

- EU electric share target also includes plug-ins. Change TIMER indicator to include plug-ins
- Include the electric benchmark for commercial vehicles
- Take into account the credit system for electric vehicles in the CO₂ performance standards

7.2 CO₂ performance standards for cars and trucks

The CO₂ performance standard for cars sets a fleet-wide standard for new car registrations. This means that car manufacturers are obliged to make sure that the average CO₂ emissions of their sold cars per year meet a certain target. This target is defined in terms of tailpipe emissions, so does not include CO₂ emissions from electricity consumption of electric cars. The target for 2021 is set to 95gCO₂/km. The 2025 and 2030 targets are set relative to this year, and aim for a fleet-wide reduction of 15% by 2025 and 37.5% by 2030. This is 15% and 30% for commercial vehicles.

The CO₂ standard for cars is implemented in the IMAGE model by increasing the energy tax on fossil fuels to the level that the average CO₂ intensity for new cars is equal to the target. By increasing the energy tax, the model changes the annual composition of new cars in comparison to the No new policies baseline and favours non-fossil fueled cars. The CO₂ intensity for gasoline and diesel cars is shown in Figure 9. In practice car manufacturers will achieve these targets by improving the efficiency of existing fossil-fuel cars, and develop electric or hydrogen cars. Implementing both at the same time in the TIMER model is not straightforward, and we have therefore only modelled the switching to more efficient car types. As energy

use for cars in TIMER is described in terms of MJ/pkm, the CO₂ intensity cars needed to be calculated afterwards in terms of gCO₂/km. For this we have made the following assumptions

- CO₂ intensity fuels is calculated based on the assumption that there are only gasoline and diesel cars, and they have a fixed ratio (gasoline=43%⁴). This CO₂ intensity is also used for biofuel and gas fueled cars. Electric cars have no tailpipe CO₂ emissions.
- For this calculation, we use a CO₂ intensity for gasoline of 2.4 gCO₂/l, and CO₂ intensity for diesel of 2.7 gCO₂/l
- The assumed energy intensity for these fuels is 34.841 MJ/l
- The average load for cars is 1.6 persons

Figure 9 shows the impact the standards on CO₂ intensity, and compares it with historical data of the Energy Environmental Agency (EEA) and the Odyssee-MURE database. The average CO₂-intensity of new cars by 2030 improves from 102.8 to 58.8 gCO₂/km

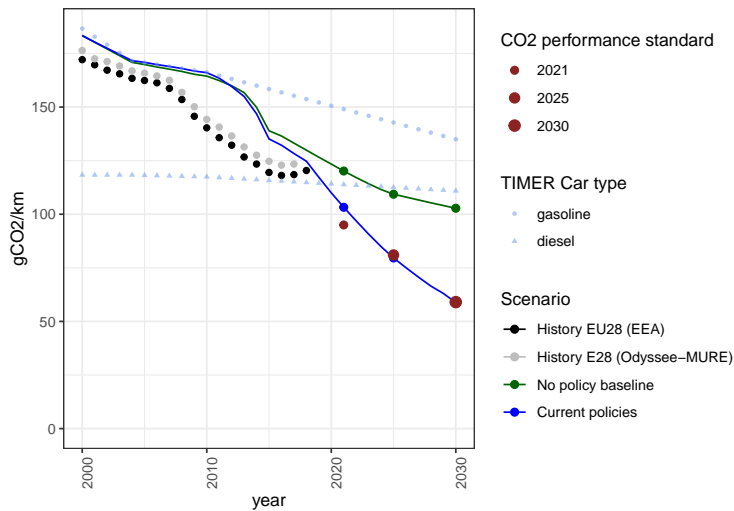


Figure 9: Impact of CO₂ standards car co₂ efficiency

Future improvements

- Check weight gasoline in fossil fuels mix. See
 - <https://www.acea.be/statistics/tag/category/passenger-car-fleet-by-fuel-type>
 - http://ec.europa.eu/eurostat/statistics-explained/images/3/3c/New_passenger_cars_by_type_of_engine_fuel%2C_2013.png
- Add other fuels (e.g. gas) to the CO₂ intensity calculations
- Use load per region, which is available in TIMER
- Include CO₂ standards for commercial vehicles
- Add the credit system for electric cars to the assessment of CO₂ performance standards
- Let TIMER choose the composition of new cars by adding a constraint to the multinomial logit function that determines the investments in new cars
- Make it possible to let TIMER decide on both improving efficiency of fossil-fueled cars, and switch to other non-fossil fuel car types

⁴http://ec.europa.eu/eurostat/statistics-explained/images/3/3c/New_passenger_cars_by_type_of_engine_fuel%2C_2013.png

The CO₂ performance standards for heavy trucks are divided into large lorries, small lorries, coaches, trailers and busses. Currently, there is only a CO₂ performance standard for large lorries, and standards for the other categories will be set after an EU review in 2022. The current standard apply to large lorries that have a mass between 3.5 tonnes and higher (categorie N2 and N3⁵). The CO₂ performance standards aim for an average CO₂ intensity reduction for new large lorries of 15% relative to 2020 by 2025, and 30% at 2030. The 2020 data is based on the average between 1 July 2019 and June 2020, and has not been fixed yet.

In the IMAGE model, the performance standards for large lorries are mapped to heavy trucks transport mode. Similar to new cars, the energy tax is increased until the target is met. The reduction in CO₂ intensity is calculated relative to the IMAGE 2020 values for new heavy trucks. The focus is on achieving the 2030 target (see Figure 10)

Future improvements

- Check the categorisation of EU trucks and map them to the TIMER implementation (medium- and heavy trucks)
- Add busses, small lorries, coaches and trailers (after 2022)

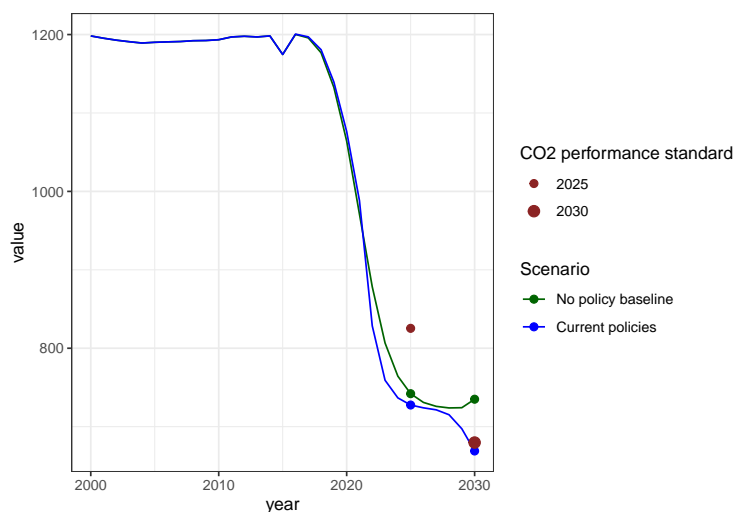


Figure 10: Impact of EU CO₂ standards on heavy truck co₂ efficiency

8 Energy performance of buildings directive

The Building Directive includes a broad range of policies and measures, of which the main obligation is that all new buildings are nearly zero-energy (ZNEB) by 31 December 2020. For public buildings this holds already since December 2018. In addition, large renovation will also need to lead to ZNEB buildings. According to the directive, an EU assessment showed that around 3% of the buildings stocks needs to be renovated to accomplish the EU efficiency ambitions in a cost-effective manner. Near zero-energy is described as very high energy performance and most energy is covered by renewable resources (JRC (2016)). The Member States determine themselves what the exact definition of ZNEB is in terms of Kwh/m²/y primary energy use. Based on four countries that defined both a minimum energy requirement and a renewable share target for 2020, the range is between 0 and 220 Kwh/m²/y. However, more countries had set intermediate energy requirement targets (around 2015), and most were below 100 Kwh/m²/y. The energy performance is calculated on the national level with different definitions, and each Member States sets its

⁵See <https://www.transportpolicy.net/standard/eu-vehicle-definitions/>

own minimum requirements. They also need to ensure that major renovations meet a minimum energy performance, but there is no explicit target except for the notion that an average rate of 3% annually is needed in the EU to accomplish the Union's energy efficiency ambitions in a cost-effective manner.

The residential TIMER model is able to set a ceiling for the amount of space heating (per square metre). It was assumed that near zero-energy buildings would use on average 100 Kwh/m² of primary energy. In addition, we assume that 67.9 % of residential energy (excluding appliances) comes from space heating (based on 2015 IMAGE values in the Europe region). If we would then also assume that the main energy carrier is gas and gas boilers have an efficiency of 80%⁶, the target for final energy heating from new buildings would be around 55 KWh/m² (=0.20 GJ/m²). This target is enforced in the model. The residential renewable target is not explicitly implemented, but as part of the renewable target on gross final energy consumption. In addition, as the IMAGE model version 2015 does not have a detailed service sector, we have assumed that public buildings would reach half of the reductions of the residential buildings (conservative assumption), which was implemented with a carbon tax in the service sector.

The building directive target for near zero buildings results -20 % reductions for the whole building stock by 2030 relative to the NoPolicy scenario (see Figure 11).

Future improvements

- Residential model in IMAGE 3.2 is better suited to implement the building code
- Make the translation of primary energy target to final energy dependent on the composition of energy carriers for heating in the model
- Explicitly model renewable energy (residential PV)
- Include insulation, water heating, cooking, lighting
- Include the buildings in the service sector

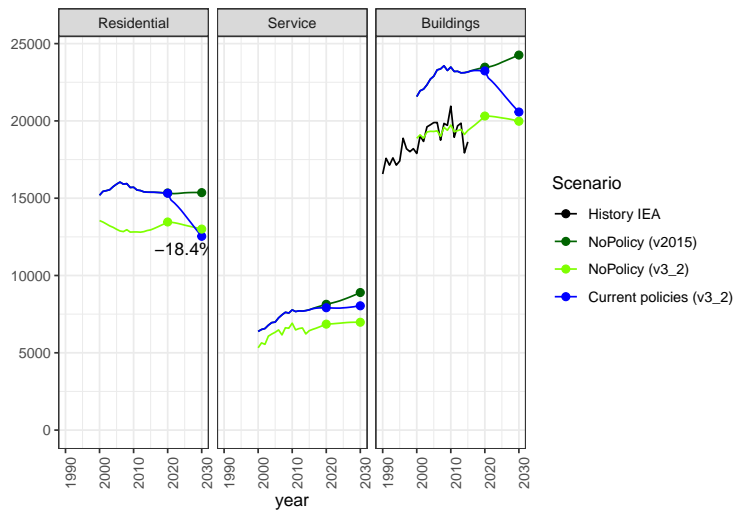


Figure 11: Impact of EU Buildings directive on energy use of buildings

9 Labelling energy efficient products

The EU has introduced energy labelling and ecodesign to promote more efficient energy use of appliances. There are labels for 15 different product groups. The product labelling was implemented in the IMAGE model by applying the energy reductions for 'A' label appliances from Deetman et al. (2012). Figure @ref((fig:LabellingAppliances)) shows the impact on energy use of appliances.

⁶<https://www.energy.gov/energysaver/home-heating-systems/furnaces-and-boilers>

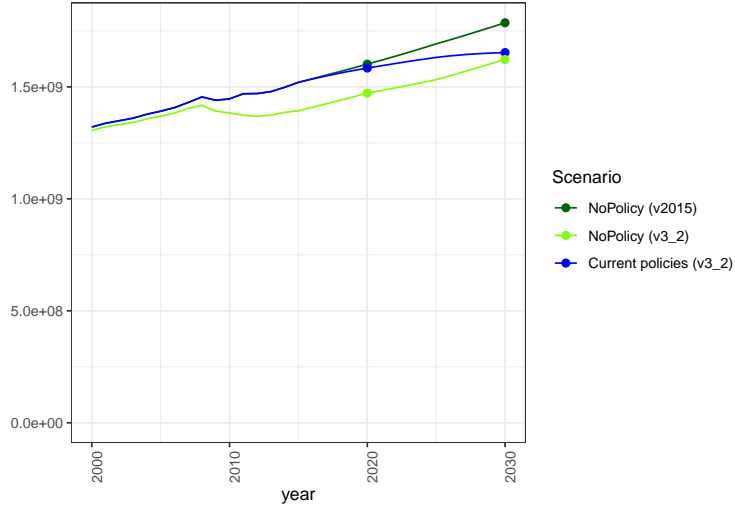


Figure 12: Impact of EU product energy labelling

Future improvements

- Investigate whether the real EU energy requirements per product can be translated into the IMAGE model

10 F-Gas regulation

The current EU F-gas Regulation was implemented in 2015 and aims to reduce fluorinated gases by two-thirds compared to the 2014 level by 2030. This Regulation also helps the EU to implement the Kigali Amendment that went into force in 2019. This amendment added HFCs to the list of controlled substances in the Montreal Protocol, and defined a phase down that started in 2019.

The F-Gas regulation goal is implemented in the IMAGE model by setting a carbon tax on f-gases to the level forcing a reduction of 66.6% by 2030 relative to 2014 (see Figure 13).

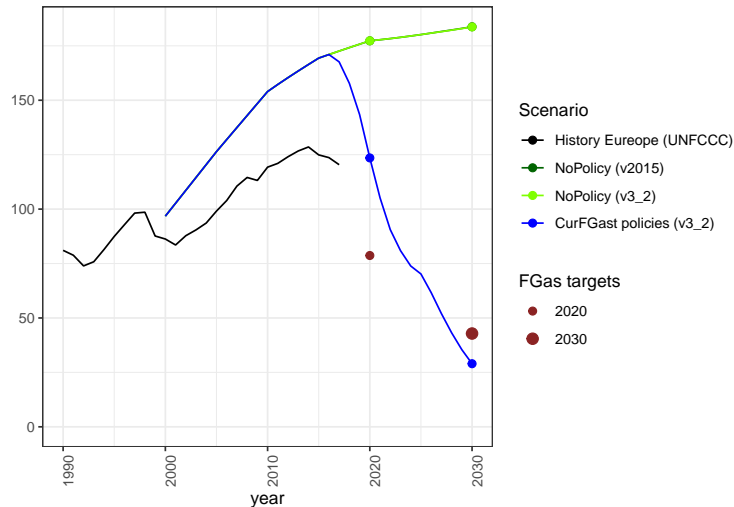


Figure 13: Impact of EU F-gas regulation EU on f-gas emissions

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