Development of impact assessment methods for policies and measures carried out within the framework of the federal climate policy

Evaluation of emission reductions

Report

For the Federal Public Service (FPS) Health, food chain safety and environment

DG Environment – Climate Change Service

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1 Introduction

This report presents the (re)evaluation of emission reductions permitted by the implementation of existing and new PAMs of the federal climate policy and the socio-economic evaluation of the impacts of those PAMs. These assessments were carried out as part of the mission « Development of impact assessment methods and technical support for policies and measures carried out within the framework of the federal climate policy » for the FPS Health, food chain safety and environment (Tender specifications n° DG5/CC/ICS/15007).

2 Summary of impacts: emission reductions

The federal government has implemented several policies and measures (PAMs) for abating greenhouse gases emissions. This report presents the estimations of emissions reduction of these PAMs. As shown in Table 1, federal policies and measures for reducing climate change have been estimated to have a *cumulative* impact on the period 2013-2020 of around 108 million tons of CO2eq in a likely scenario. Approximately 86 million tons can be assigned to the federal level as they cover domains falling under federal competences. 61% of total reduction come from measures on sectors falling under ESD, the rest falling under the EU Emission trading scheme (ETS). For the period 2021-2030 cumulative emissions reduction of federal PAMs are estimated to reach 232 million tons of which 200 million can be assigned to the federal level. In terms of *yearly* emissions reduction these results correspond to an average reduction of around 11 million tons for the period 2013-2020 and 20 million tons for the period 2021-2030.

Table 1: Total Cumulative reduction of CO2eq emissions 2013-2020 and 2021-2030, kt, likely scenario

	Federal		**National**	
	ETS	ESD	ETS	ESD
2013-2020	33581.70	53027.96	45827.04	62053.27
2021-2030	85242.85	114905.28	99846.33	132485.80

Most of the reductions in emissions are the result of few PAMs. The five most important PAMs in terms of emission reduction are the Energy label (EC-A05), Tax incentive to promote energy efficiency in households (EC-B01), Biofuels (TR-D01), Offshore wind energy (EP-A01) and Tax deduction for energy saving (IP-A06). These five PAMs sum up to 88% of cumulative emissions reduction for the period 2013-2020. Table 2 and 3 show the cumulative emissions reductions for each PAM for the period 2013-2020 and 2021-2030 respectively.

Emissions reductions have been estimated as the difference between the current situation (whenever the PAM has been already implemented) and a baseline, which is a scenario without the PAM. Several assumptions are thus taken to calculate the effect of each PAM. In order to reduce the impact of uncertainties related to these assumptions, different scenarios (max, min and likely) have been calculated. A conservative approach has been taken in general in the choice and definition of assumptions behind the definition of the different scenarios. The limits of the estimation methodologies have been pointed out for each PAM and offer a base for ameliorating emissions in the future.

This study builds on the work on the estimation of federal PAMs that has been done previously, notably the study "Evaluation of the impact of policy instruments and measures implemented in the context of the Federal climate policy" (VITO, Econotec, 2015). Methodologies for the estimations have been updated and in some cases completely revised. Table 5 shows the differences between old and new estimations. The results of the new evaluation are lower than the old one for most of the PAMs and in particular for the most important PAMs, except for the Energy label one (it should be noted that the perimeter of this specific measure has been enlarged in the new estimation to include also the products consuming other fuels than electricity[1]). Those lower estimates are explained by the conservative approach taken, in particular for transport related PAMs.

[1] Comparison between 2015 evaluation and present evaluation is lower if based on the same scope

Table 2: Cumulative reduction of CO2eq emissions 2013-2020 by PAMs, kt, likely scenario

PAM code	**PAM titre**	**Federal**		**National**	
		ETS	ESD	ETS	ESD
APP-T01	Positive mobility allocation	0.0	51.8	0.0	51.8
APP-T02	Pedelecs	6.8	3.5	6.8	3.5
APP-T03	Rail traction	23.0	4.1	23.0	4.1
APP-T04	Rail non traction	6.1	10.5	6.1	10.5
EC-A05	Energy label (eco design)	19014.9	13162.5	19014.9	13162.5
EC-B01	Tax incentive to promote ee in households	339.1	17755.4	1878.5	24953.7
EC-B03	FRGE	0.7	131.3	10.3	180.0
EP-A01	Offshore wind energy	10618.0	0.0	10618.0	0.0
EP-A02	Energy taxation	643.9	0.0	11276.5	0.0
IP-A06	Tax deduction for energy savings	2473.1	2473.1	2473.1	2473.1
OB-A03	EMAS	7.1	14.2	7.1	14.2
OB-B01	Renewable energy fedesco and belgian railways	48.7	0.0	106.7	0.0
OB-B02	Energy efficiency fedesco	182.1	409.1	182.1	409.1
OB-C02	Free public transport federal civil servants	0.0	2.5	0.0	2.5
OB-C04	Teleworking	0.0	16.9	0.0	16.9
OB-C07	Energy efficient cars for federal public services	0.0	0.2	0.0	0.2
TR	Advantage in kind depending on CO2 emissions for company cars	0.0	577.3	0.0	577.3
TR-A02	Promotion of public transport	0.0	189.6	0.0	189.6
TR-A03	Promoting bicylce use	0.0	9.6	0.0	9.6
TR-A04	Promoting multimodal systems for goods	0.0	52.7	0.0	52.7
TR-A08	Free public transport for commuters	0.0	77.2	0.0	77.2
TR-B01	Promoting carpooling	0.0	18.1	0.0	18.1
TR-B05	Eco-driving	0.0	387.4	0.0	387.4
TR-C01	Tax deduction clean cars	0.0	347.7	0.0	347.7
TR-D01	Biofuels	0.0	10959.2	0.0	10959.2
XX-X01	Ecocheque	169.8	897.2	169.8	897.2
XX-X02	Green loan	48.3	980.3	60.9	1236.2
XX-X03	F Gases	0.0	4313.0	0.0	5828.6
XX-X04	Tax Shift	0.0	183.3	0.0	183.3

Table 3: Cumulative reduction of CO2eq emissions 2021-2030 by PAMs, kt, likely scenario

PAM code	**PAM titre**	**Federal**		**National**	
		ETS	ESD	ETS	ESD
APP-T01	Positive mobility allocation	0.0	0.0	0.0	0.0
APP-T02	Pedelecs	0.0	0.0	0.0	0.0
APP-T03	Rail traction	0.0	0.0	0.0	0.0
APP-T04	Rail non traction	0.0	0.0	0.0	0.0
EC-A05	Energy label (eco design)	52951.9	41445.7	52951.9	41445.7
EC-B01	Tax incentive to promote ee in households	420.3	19752.5	2325.2	31940.1
EC-B03	FRGE	0.9	180.4	14.0	247.1
EP-A01	Offshore wind energy	27463.4	0.0	27463.4	0.0
EP-A02	Energy taxation	752.9	0.0	13186.0	0.0
IP-A06	Tax deduction for energy savings	2884.7	2884.7	2884.7	2884.7
OB-A03	EMAS	9.1	18.2	9.1	18.2
OB-B01	Renewable energy fedesco and belgian railways	178.7	0.0	409.5	0.0
OB-B02	Energy efficiency fedesco	347.3	906.9	347.3	906.9
OB-C02	Free public transport federal civil servants	0.0	1.6	0.0	1.6
OB-C04	Teleworking	0.0	23.1	0.0	23.1
OB-C07	Energy efficient cars for federal public services	0.0	0.0	0.0	0.0
TR	Advantage in kind depending on CO2 emissions for company cars	0.0	1103.2	0.0	1103.2
TR-A02	Promotion of public transport	0.0	187.1	0.0	187.1
TR-A03	Promoting bicylce use	0.0	10.4	0.0	10.4
TR-A04	Promoting multimodal systems for goods	0.0	2.2	0.0	2.2
TR-A08	Free public transport for commuters	0.0	101.3	0.0	101.3
TR-B01	Promoting carpooling	0.0	20.1	0.0	20.1
TR-B05	Eco-driving	0.0	534.4	0.0	534.4
TR-C01	Tax deduction clean cars	0.0	0.0	0.0	0.0
TR-D01	Biofuels	0.0	23536.6	0.0	23536.6
XX-X01	Ecocheque	173.3	2309.0	173.3	2309.0
XX-X02	Green loan	60.4	1133.0	82.0	1499.2
XX-X03	F Gases	0.0	20635.2	0.0	25595.2
XX-X04	Tax Shift	0.0	119.7	0.0	119.7

Table 4: Status of PAM (July 2017)

PAM code	**PAM titre**	**Status**
APP-T01	Positive mobility allocation	Proposed
APP-T02	Pedelecs	Under study
APP-T03	Rail traction	Implemented
APP-T04	Rail non traction	Implemented
EC-A05	Energy label (eco design)	Implemented and to be implemented[2]
EC-B01	Tax incentive to promote energy efficiency in households	Implemented
EC-B03	FRGE	Implemented
EP-A01	Offshore wind energy	Implemented
EP-A02	Energy taxation	Implemented
IP-A06	Tax deduction for energy savings	Implemented
OB-A03	EMAS	Implemented
OB-B01	Renewable energy fedesco and belgian railways	Implemented
OB-B02	Energy efficiency fedesco	Implemented
OB-C02	Free public transport federal civil servants	Implemented
OB-C04	Teleworking	Implemented
OB-C07	Energy efficient cars for federal public services	Implemented
TR	Advantage in kind depending on CO2 emissions for company cars	Implemented
TR-A02	Promotion of public transport	Implemented
TR-A03	Promoting bicylce use	Implemented
TR-A04	Promoting multimodal systems for goods	Implemented
TR-A08	Free public transport for commuters	Implemented
TR-B01	Promoting carpooling	Implemented
TR-B05	Eco-driving	Implemented
TR-C01	Tax deduction clean cars	Implemented but no longer applied
TR-D01	Biofuels	Implemented and to be implemented[3]
XX-X01	Ecocheque	Implemented
XX-X02	Green loan	Implemented
XX-X03	F Gases	Implemented
XX-X04	Tax Shift	Implemented

[2] implementation dates vary according to the product

[3] Royal Decree in preparation to transpose directive 2015/652 / revision of law of 17-07-2013 in preparation

Table 5: Comparison with the previous results (VITO-ECONOTEC, 2015): total federal cumulative emissions reduction at 2020, kt, likely scenario

PAM code	**PAM titre**	2017	2015
APP-T01	Positive mobility allocation	51.8	NE
APP-T02	Pedelecs	10.4	NE
APP-T03	Rail traction	27.2	NE
APP-T04	Rail non traction	16.7	NE
EC-A05	Energy label (eco design)[1]	32177.4	21485.7
EC-B01	Tax incentive to promote ee in households	18094.5	18018.1
EC-B03	FRGE	132.0	96.4
EP-A01	Offshore wind energy	10618.0	14093.7
EP-A02	Energy taxation	643.9	1104.8
IP-A06	Tax deduction for energy savings	4946.2	7210.4
OB-A03	EMAS	21.2	23.4
OB-B01	Renewable energy fedesco and belgian railways	48.7	108.8
OB-B02	Energy efficiency fedesco	591.2	564.4
OB-C02	Free public transport federal civil servants	2.5	2.1
OB-C04	Teleworking	16.9	11.8
OB-C07	Energy efficient cars for federal public services	0.2	0.2
TR	Advantage in kind depending on CO2 emissions for company cars	577.3	NE
TR-A02	Promotion of public transport	189.6	2093.2
TR-A03	Promoting bicylce use	9.6	63.3
TR-A04	Promoting multimodal systems for goods	52.7	56.9
TR-A08	Free public transport for commuters	77.2	544.9
TR-B01	Promoting carpooling	18.1	77.8
TR-B05	Eco-driving	387.4	574.8
TR-C01	Tax deduction clean cars	347.7	568.0
TR-D01	Biofuels	10959.2	11134.5
XX-X01	Ecocheque	1067.0	1008.8
XX-X02	Green loan	1028.6	1028.4
XX-X03	F Gases	4313.0	NE
XX-X04	Tax Shift	183.3	NE

NE : not evaluated

[1] it should be noted that the perimeter of this specific measure has been enlarged in the new estimation to include also the products consuming other fuels than electricity. When taking into account the same perimeter the 2017 results are lower than 2015 ones.

3 Policy and measures: methodology, results and discussion

3.1 EP-A01 – EP-A05: Offshore wind energy and tidal energy

3.1.1 Description

The objective of this PAM is to stimulate the production of green electricity in the North Sea area under Belgian jurisdiction, which falls under the responsibility of the federal government. This results in a reduction of emissions in the ETS sector, and not in ESD.

Green electricity production in this area – based on offshore wind and tidal energy – is stimulated with a system of green (federal) certificates. Green certificates are used to certify that a given amount of green electricity is produced by an electricity producer, and can be sold at a guaranteed fixed minimum price. In 2013, this minimum price guarantee was adjusted to a system with a flexible price for new offshore wind energy locations.

On 21 March 2004, the federal government set a target of 2000 MW for electricity from offshore wind in 2020. Based on the permits granted, the offshore wind potential is between 2.200 and 2.300 MW (Source: SPF Economie, DG Energie, 2016).

3.1.2 Methodology

The emission reduction is calculated based on the electricity production and the assumption that this will result in a reduction of natural gas use for electricity production.

3.1.2.1 BAU scenario

Within the Business as usual scenario, no offshore wind parks are constructed. The electricity production from offshore wind is zero.

3.1.2.2 PAM scenario

Within the PAM scenario, we have calculated a minimum and a maximum annual emission reduction. The minimum emission reduction is calculated with the assumption that the installed capacity will not increase after 2021, because all available concessions have been allocated. It is also assumed that offshore wind turbines are replaced at the end of their life time. This is in line with a WEM scenario (with existing measures). The maximum emission reduction is calculated with the assumption that the capacity will increase towards 4000 MW in 2050, as assumed in the references scenario of 'Scenarios for a Low Carbon Belgium by 2050' (CLIMACT/VITO, 2013). The likely scenario is equal to the minimum scenario.

The emission reduction is calculated with the following formula:

$$\boldsymbol{ER_{FED} = AF \times P \times EF}$$

With:

ER_{FED}	Federal emission reduction (kton CO2-eq)
AF	Allocation factor (%)
P	Electricity production (MWh)
EF	Emission factor (kton CO2-eq/MWh)

The electricity production in future years is estimated by multiplying the installed capacity with average full load hours. The emission reduction in future years is calculated with the following formula:

$$\boldsymbol{ER_{FED} = AF \times C \times H \times EF}$$

With:

ER_{FED}	Federal emission reduction (kton CO2-eq)
AF	Allocation factor (%)
C	Installed capacity (MW)
H	Full load hours (h)
EF	Emission factor (kton CO2-eq/MWh)

3.1.3 Main assumptions

3.1.3.1 BAU scenario assumptions

It is assumed that no offshore wind farms are constructed and the electricity production from wind farms is zero.

3.1.3.2 PAM scenario assumptions

Electricity production (P)

The electricity production for future years is calculated by multiplying the expected installed capacity and the full load hours.

Installed capacity (C)

The installed capacity for future years (2016-2021) is based on information from the Elia adequacy report (see Table 5). For the minimum scenario, it is assumed that the capacity will not increase after 2021. For the maximum scenario, it is assumed that the capacity will increase towards 4000 MW in 2050, as assumed in the references scenario of Scenarios for a Low Carbon Belgium by 2050 (CLIMACT/VITO, 2013).

Table 5: Expected installed capacity for the years 2016-2021

year	Installed capacity (MW)
2016	713
2017	862
2018	1142
2019	1996
2020	2188
2021	2312

Full load hours (H)

An assumption of 3100 full load hours is used for the minimum and likely scenario, while 3500 full load hours is assumed for the maximum scenario.

In 2011, 2014 and 2015, almost no additional offshore wind capacity was installed, and therefore the electricity was produced by wind turbines that were already operational by the beginning of the year. The full load hours can be calculated by dividing the electricity production with the installed capacity. Table 6 shows the installed capacity, the electricity production and the calculated full load hours for a selection of years.

Table 6: Calculation of full load hours

	Installed capacity (MW)	Electricity production (GWh)	Calculated full load hours
2009	32	82	-
2010	197	190	-
2011	197	709	3599
2012	381	854	-
2013	708	1540	-
2014	708	2216	3130
2015	712	2613	3680

The full load hours have not been calculated for the years 2009, 2010, 2012 and 2013, because the installed capacity has expanded in these years. In 2015, the installed capacity expanded slightly. The full load hours are calculated by dividing the electricity production in 2015 with the installed capacity in 2015. If we would assume that the newly installed capacity in 2015 did not produce any electricity, than the calculated full load hours would be 2613 / 708 * 1000 = 3691 hours.

Similar to the Vito/Econotec report, we assumed the full load hours to be somewhat lower than the calculated full load hours for these three years, because the wind turbines are relatively new. Older wind turbines probably have less full load hours due to maintenance or technical malfunctioning.

<u>Emission factor</u>

In the Vito/Econotec study, it is assumed that the electricity would not have been produced in a combined cycle gas turbine (CCGT) power plant. In the Vito/Econotec study, an emission factor of 380 g CO_2/kWh is used. This EF has been used in the present assessment. This is based on the CO_2 emission factor from natural gas (55.8 kg/GJ (IPCC 1996 Guidelines) and an assumed efficiency of 53%, resulting in a net emission factor of 55.8 / 53% * 3.6 = 379 g CO_2/kWh. It is also possible that the reduction of electricity production takes place in coal fired power plants (with a higher emission factor) or in nuclear power plants (with a lower emission factor). When electricity transport and distribution losses (4,5%)

are also taken into account, then the gross emission factor of electricity consumption to be taken would be 397 g CO_2/kWh (Vito/Econotec, 2015).

3.1.4 Data sources

Data sources for each indicator are presented in Table 7.

Table 7: Description of data sources

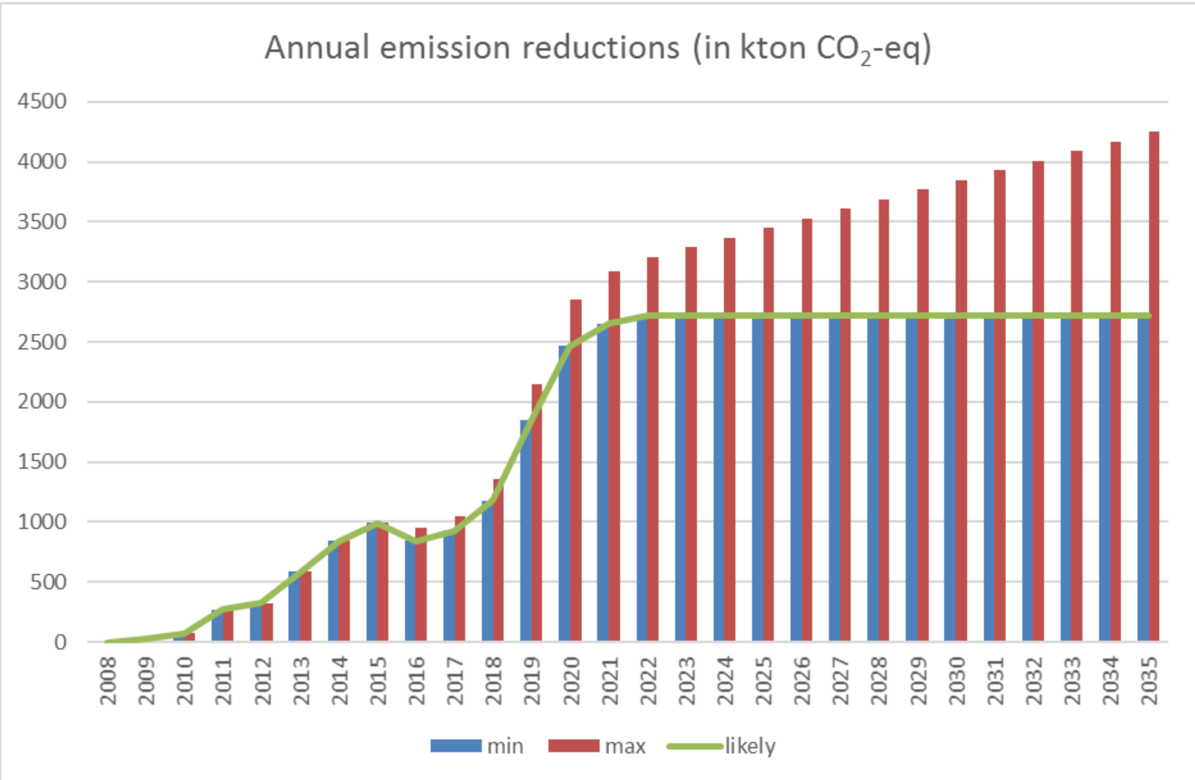
Indicators	Ex-ante values	Ex-post values
AF	100% for federal	
Electricity production (P)	2008-2009: Vito/Econotec (2015) 2010-2015: IEA, 2016	n.a.
Capacity (C)	n.a.	Elia adequacy report, See assumptions
Full load hours (H)	n.a.	See assumptions
Emission factor (EF)	Vito, Econotec (2015), see assumptions	

3.1.5 Results

In the Elia adequacy report, it is expected that the installed capacity will increase up to 2188 MW in 2020. This is more than the goal of 2000 MW by 2020.

The annual CO2 emission reduction due to off shore wind energy, will increase until 2021. After 2021, the CO2 emission reductions might increase even further if new offshore wind farms are planned and constructed. Figure 1 presents minimum and maximum scenario for the annual CO2 emission reductions

Figure 1: Annual emission reductions (minimum, maximum and likely scenarios)



3.1.6 Discussion

The main uncertainties in the emission reduction calculation include the amount full load hours and the future installed capacity. The likely scenario is equal to the minimum scenario, and could be an underestimation of the actual emission reductions.

3.1.7 References

Vito/Econotec, 2015. Evaluation of the impact of policy instruments and measures implemented in the context of the Federal climate policy. March 2015.

IEA, 2016. IEA Wind TCP. 2015 annual report. August 2016. Available via: https://www.ieawind.org/annual_reports_PDF/2015/Belgium.pdf

CLIMACT/VITO, 2013. Scenarios for a Low Carbon Belgium by 2050. November 2013.

3.2 EP-A02: Energy taxation

3.2.1 Description

The objective of this PAM is to increase the production of green electricity. This results in a reduction of emission in ETS sector, and not in ESD sectors.

Production of green electricity is stimulated at both the federal level and the levels of the three regions. The regions offer ecology grants that can be cumulated with the federal measures. The Federal government has also taken a number of additional measures which reduce the relative cost of electricity from renewable sources. The federal government has established a special excise tax on fossil fuel for electricity production (for heavy oil and for coal). Also the regions offer ecology grants that can be cumulated with the federal measures. (Vito/Econotec, 2015).

Due to these taxes, the use of biomass and natural gas are relatively cheaper.

Within this PAM, only the impact of these taxes on the use of biomass is quantified.

3.2.2 Methodology

The emission reduction is calculated based on the electricity production and the assumption that this will result in a reduction of coal combustion for electricity production.

3.2.2.1 BAU scenario

Within the Business as usual scenario, the coal fired power plants continue to produce electricity, without co-combustion of biomass. The use of biomass for electricity production is zero.

3.2.2.2 PAM scenario

Within the PAM scenario, biomass is used for electricity production (in plants for electricity production only). This does not include the combustion of the renewable fraction of waste. A minimum and a maximum annual emission reduction is calculated within this scenario. The minimum (and likely) emission reduction is calculated with the assumption that the biomass combustion does not increase compared to the amount combusted in 2014. The maximum emission reduction is calculated with the assumption that biomass combustion will increase with a linear trend (extrapolation of the trend between 2008 and 2014).

The emission reduction is calculated with the following formula:

$$ER_{FED} = AF \times P_{Bio} \times EF$$

With:

ER_{FED}	Federal emission reduction (kton CO2-eq)
AF	Allocation factor (%)
P_{Bio}	Electricity production from biomass (GWh)
EF	Emission factor (ton CO2-eq/MWh)

3.2.3 Main assumptions

3.2.3.1 BAU scenario assumptions

Within the Business as usual scenario, it is assumed that the coal fired power plants continue to produce electricity, without co-combustion of biomass. The use of biomass for electricity production is zero.

3.2.3.2 PAM scenario assumptions

Allocation factor

The allocation factor has been calculated in the Vito/Econotec report (2015), based on the relative size of the impact of these measures on the cost of electricity production. Other measures with an impact on the cost of electricity production are the carbon price and the green certificates for biomass. The tax on coal has a relative impact of 5.71% of the cost of electricity production. This is used as an allocation factor for the federal part.

Electricity production from biomass

Two scenarios were considered for the period 2015-2020:

- Minimum (and likely) scenario: no increase of biomass electricity production for 2015-2020 compared to 2014;
- Maximum scenario: a linear increase of co-combustion of biomass based on an extrapolation of the electricity production in the period 2008-2014.

These scenarios are equal to the scenarios in Vito/Econotec (2015), but the result is different due to the decreased electricity production from biomass in 2013 and 2014.

Emission factor

This measure will result in a decrease of coal combustion and an increase of natural gas and biomass combustion. It is assumed that the increased use of biomass will result in a reduced use of coal. Therefore, an emission factor of 950 gram CO2/kWh has been used (Vito/Econotec, 2015).

In 2016, the last coal fired power plant closed. Since the electricity production from biomass is lower than the electricity production from coal fired power plants in the last years, this emission factor is still valid. If the electricity production from biomass will increase in the future, then a new emission factor needs to be used (from natural gas, or from nuclear electricity production).

3.2.4 Data sources

Data sources for each indicator are presented in Table 8.

Table 8: Description of data sources

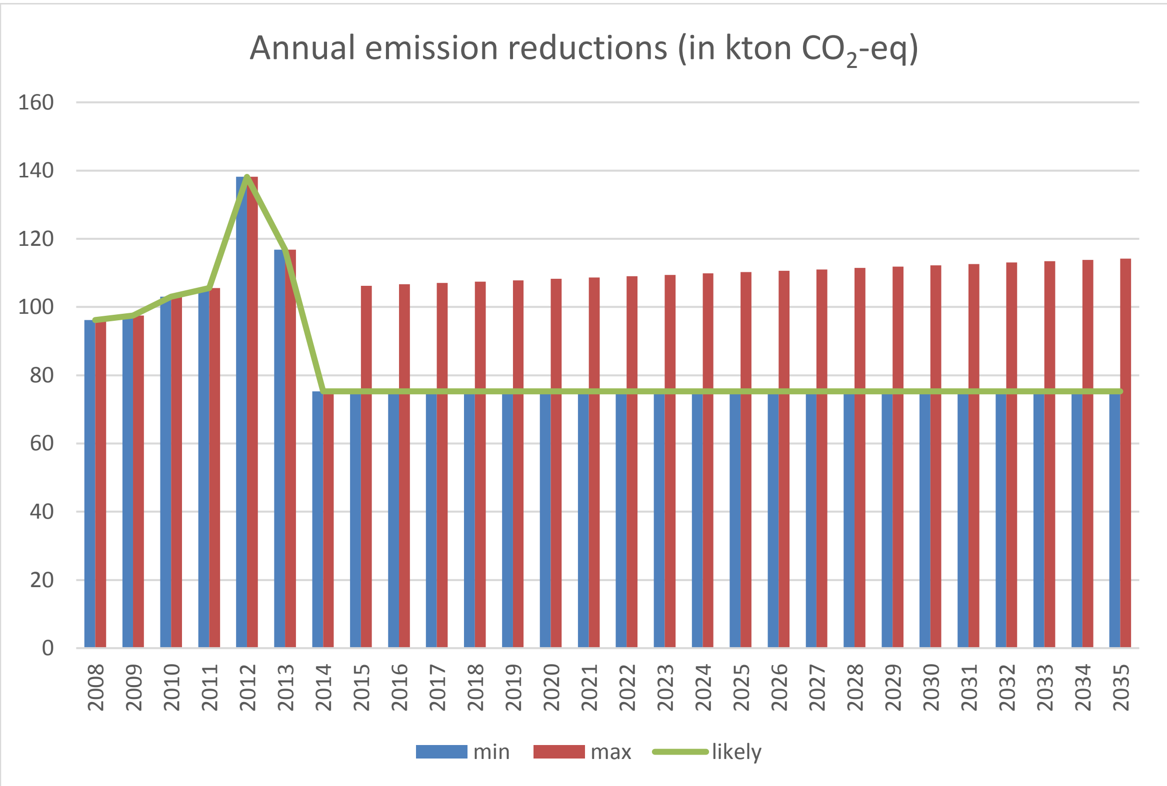
Indicators	Ex-ante values	Ex-post values
AF	See assumptions	See assumptions
Electricity production from biomass (P_{bio})	Eurostat table nrg_105a, http://ec.europa.eu/eurostat/web/products-datasets/-/nrg_105a	See assumptions
Emission factor (EF)	Vito, econotec (2015), see assumptions	Vito, econotec (2015), see assumptions

3.2.5 Results

Electricity production from biomass co-combustion increased in the period 2000-2012, but it decreased in 2013 and 2014. Coal prices were relatively low in Europe in these years, which could have influenced the smaller amount of biomass that has been combusted. Figure 2 shows the minimum, maximum and likely scenario for CO2 emission reduction due to biomass combustion.

In 2016, the last coal fired power plant in Belgium closed. Co-combustion of biomass in a coal fired plant is therefore not possible in the future, but Belgium also has power plants solely powered by biomass.

Figure 2: Annual emission reductions (minimum, maximum and likely scenarios)



3.2.6 Discussion

The electricity production from biomass in this study only includes the biomass combustion in electricity plants (only main activity electricity plants). It does not include the renewable fraction of waste and it does not include the electricity production in other installations. Therefore, the amount of electricity production from biomass in this PAM is lower than the electricity production from biomass in the Belgian energy statistics of renewable energy (as presented on: http://www.renouvelle.be/fr/statistiques/observatoire-belge-des-energies-renouvelables).

The main uncertainties in the emission reduction calculation include the future use of biomass in electricity production. The likely scenario is equal to the minimum scenario, and could be an underestimation of the actual emission reductions.

3.2.7 References

Vito/Econotec, 2015. Evaluation of the impact of policy instruments and measures implemented in the context of the Federal climate policy. March 2015.

Eurostat table nrg_105a: Supply, transformation and consumption of electricity - annual data. Available via: http://ec.europa.eu/eurostat/web/products-datasets/-/nrg_105a

3.3 EC-A05 Energy labelling (Ecodesign)

3.3.1 Description

The Federal government supports initiatives to assess the effectiveness of labels to inform consumers correctly. This is largely overlapping with the Ecodesign Directive at European level.

The responsible authority for preparing and implementing an integrated policy to promote sustainable products and consumption is the Federal Public Service Health, Food Chain Safety and Environment Division Products Policy. Among the tasks of this division is the maximisation of the implementation of the Ecodesign directive. The specific objective of this PAM is therefore to reduce the energy consumption from appliances using fuel or electricity as covered by the EU Ecodesign Directive.

The EU Ecodesign Directive establishes a "*framework under which manufacturers of energy-using products are obliged to reduce the energy consumption and other negative environmental impacts occurring throughout the product life cycle*"[4]. This means that the Ecodesign Directive requires new products to be more energy efficient, and due to the turnover of the fleet of products this gradually improves the energy efficiency of the appliances in the EU.

In this section, we analyzed the impacts of implementing the Directive Ecodesign on all fossil fuel- and electricity fueled products covered by the Ecodesign Directive, including also energy labelling. This results in a reduction of emissions in both ETS and ESD sectors.

[4] http://www.eceee.org/ecodesign/process/

3.3.2 Methodology

To assess the impact of this policy, an EU wide study of energy savings achieved with the Ecodesign Directive (VHK, 2016) has been used. This study provides energy savings for specific products and appliance types at EU28 level, on an annual basis. A BAU (Business As Usual) scenario and ECO scenario are developed, representing the situation without and with the measures enforced by the Ecodesign Directive. The difference between both is thus representative for the impact of the measures under the Ecodesign requirements. The VHK (2016) study is dynamic in the assumptions on market demand and increase in performance, including trends towards more and bigger appliances. Part of this trend can be explained by the rebound effect, which implies that the effect of lower energy consumption (resulting in lower costs) induce more abundant use of the product's services. Both the BAU and ECO scenario take into account this trend towards more and bigger appliances (which is partially explained for by the rebound effect) by assuming that this trend towards more and bigger continues in the future (VHK, 2016).

3.3.2.1 BAU scenario

The BAU scenario (without Ecodesign) is derived by extrapolating historical trends, including ongoing market trends in efficiency improvement and emission abatement (VHK, 2016). This applies mainly to the future years, while historical years in the model are based mostly on actual data (e.g. on the stock, load and energy consumption of products).

3.3.2.2 PAM scenario

For the ECO scenario, the Ecodesign impact is modelled. Generally, the demand for appliances is growing as the population increases, and the trend is towards more and bigger appliances (e.g. televisions, lamps, computers, etc.). This is partly related to the rebound effect, as the appliances use less energy there is a tendency to use the products more abundantly (VHK, 2016).

3.3.2.3 Calculation method

For the calculation of the energy consumption in the different scenarios, the stock and the sales of the different products are modelled. This is combined with the load of each of these appliances and the modelling of the energy efficiency (the ratio between energy input and output, or just the amount of energy use per unit of time), leading to the overall energy consumption per unit of time (here expressed per year). Implicitly all these parameters have their uncertainties and many include assumptions (for instance the future estimation of fuel prices, stock and load of specific appliances, etcetera). For the assessment of this PAM, we directly use the modelled energy consumption from the Ecodesign Impact Accounting study for both the BAU and ECO scenarios. For more details on the scenarios we refer to VHK (2016).

In this study, this impact is only available for the EU as a whole, as no country specific information is available from this study. Therefore, the savings achieved have been downscaled from EU28 level to Belgium, using proxy parameters such as GDP, number of households and final electricity consumption. For heating appliances, a correction for heating degree days was made, noting that the demand for heating in Belgium is different from other European countries under different climate conditions.

The emission reduction is calculated with the following formula:

$$ER_{FED} = AF \times P \times EF$$

With:

ER_{FED}	Federal emission reduction (kton CO2-eq)
AF	Allocation factor (%)
P	Electricity production (MWh)
EF	Emission factor (kton CO2-eq/MWh)

$$ER_{FED} = AF \times ER_{TOT}$$

$$ER_{FED} = AF \times \sum_i (ES_{BEL,i} \times EF)$$

$$ER_{FED} = AF \times \sum_i (ES_{EU,i} \times SF_i \times SF_{HDD} \times EF)$$

With:

ER_{FED}	Federal emission reduction (kton CO2-eq)
ER_{TOT}	Total emission reduction (kton CO2-eq)
AF	Allocation factor (%)
ES_{BEL}	Energy savings achieved in Belgium
EF	Emission factor
ES_{EU}	Energy savings achieved in EU
SF	Scaling factor

Notes:

- The allocation factor is 100%. There are regional subsidies for energy efficient refrigerators and dryers, but these are only for a specific target group (unprivileged households).
- The energy savings achieved in Europe (EU28) are taken from the study Ecodesign Impact Accounting, status January 2016 prepared by VHK Consultants for EU DG Energy
- The scaling factor to go from EU28 to Belgium is calculated for each technology based on the EU wide impact and an appropriate scaling factor. The scaling factor has been calculated based on either number of households, GDP, final electricity consumption and corrected for heating degree days in specific cases.

The product categories included in this assessment are listed in Table 9.

Table 9: Product categories included for PAM EC-A05

Application	**Fuel**	**Application**	**Fuel**
Water Heater	electricity	Personal computers	Electricity
Water Heater	fossil	Imaging equipment, electricity	Electricity
Central Heating combi, water heat	electricity	StandBy (rest)	Electricity

Application	Fuel	Application	Fuel
Central Heating combi, water heat	fossil	Battery Charged devices	Electricity
Central Heating boiler, space heat	electricity	Uninterrupted Power Supplies	Electricity
Central Heating boiler, space heat	fossil	Household Refrigerators & Freezers	Electricity
Solid Fuel Boiler	electricity	Commercial Refrigeration	Electricity
Solid Fuel Boiler	coal	PF Storage cabinets All types	Electricity
central Air Cooling	electricity	PF Process Chiller All MT&LT	Electricity
central Air Heating	electricity	PF Condensing Unit, All MT&LT	Electricity
central Air Heating	fossil	Cooking Appliances	Electricity
Local heaters	electricity	Cooking Appliances	Gas
Local heaters	coal	Household Coffee Makers	electricity
Local heaters	Oil	Household Washing Machine	electricity
Local heaters	gas	Household Dishwasher	electricity
Room Air Conditioner	electricity	Household Laundry Drier	electricity
Ventilation units (electricity only)	electricity	Vacuum Cleaner	electricity
Ventilation units (heat savings by ventilation)	fossil	Fan, industrial (excl. box & roof fans)	electricity
Lighting	electricity	Motors 0.75-375 kW	electricity
Electronic DisPlays	electricity	Water Pumps	electricity
Set top boxes (Complex & Simple)	electricity	Standard Air Compressors	electricity
Video	electricity	Total for energy sector	electricity
Enterprise Servers	electricity	Replacement Tyres	on-road fuels (diesel & gasoline)

It should be noted that the scope of EC-A05 has changed in comparison with previous assessment (VITO/Econotec 2015). It now covers more appliances compared to the VITO/Econotec (2015) estimation. Both electricity- and fossil fuel fired appliances are now included.

3.3.3 Main assumptions

3.3.3.1 General assumptions

Allocation factor

This PAM is about the impact of the European Ecodesign Directive for Belgium, the impact of this measure is completely federal. Therefore, the allocation factor is set to 100%.

Emission factors

Electricity: In the Vito/Econotec study, it is assumed that the electricity would not have been produced in a CCGT power plant. This results in an emission factor of 380 g CO2/kWh. It is also possible that the reduction of electricity production takes place in coal fired power plants (with a higher emission factor) or in nuclear power plants (with a lower emission factor).

When electricity transport and distribution losses (4,5%) are also taken into account, then the emission factor of electricity consumption is 397.1 g CO_2/kWh (Vito/Econotec, 2015). This last factor has been adopted for this study.

Road vehicles: the average value of diesel and gasoline has been assumed. Despite nowadays the majority of vehicles in Belgium drive on diesel, this may change in the future. It should be noted that once non-fossil fuel fired vehicles (e.g. electric) are being introduced, the effective emission factor (representing the entire fleet) reduces and the impact of this PAM for vehicles will be lower.

Fossil fuels: for coal an emission factor of 333.8 kg CO2/TWh has been used. For oil this factor amounted 264 kg CO2/TWh and for natural gas 201 kg CO2/TWh. Where fossil is mentioned as fuel, the assumption is used that 80% is natural gas and 20% oil, which yields an emission factor of 213.6 kg CO2/TWh.

Scaling from EU to BE situation

To translate the EU level results in the VHK study to Belgium, a downscaling is needed. This is done using proxy parameters such as GDP, number of households, final electricity consumption, etcetera. To derive these proxies, projections for parameters for the future years have been used, based on statistical information, assumptions and extrapolations.

Scaling factor for heating degree days (HDD)

Based on European data available from the EEA and Eurostat, an assessment of historical heating degree days at EU level and at individual country level has been made. It was found that despite year-to-year variation of the ratio between HDD in Belgium and the EU as a whole, the ratio there was no trend. The average ratio over all available years was used, which was calculated to be BE / EU = 1 / 1.137 (thus the demand for heating in Belgium in terms of HDD would be lower than the European average). This scaling is applied only for heating devices, as all other appliances are assumed to be largely independent of climatological conditions.

3.3.3.2 BAU scenario assumptions

In the BAU scenario, it is assumed that no additional policies are implemented with regard to the present day. This means that the BAU scenario reflects the situation without Ecodesign in place. For more information, see VHK study (VHK, 2016).

3.3.3.3 PAM scenario assumptions

There are no specific assumptions for the PAM scenario, for more information see VHK study (VHK, 2016).

3.3.4 Data sources

- VHK, Ecodesign Impact Accounting, Status January 2016. Report for EU DG Energy.

- Vito/Econotec, 2015. Evaluation of the impact of policy instruments and measures implemented in the context of the Federal climate policy. March 2015.

For the proxy data, Table 10 presents the data used and their source.

Table 10: Description of data sources

Proxy parameter	**Source Belgium**	**Source EU28**
POP (population)	Belgian Federal Statistical Agency (historical data and projections) http://statbel.fgov.be/fr/statistiques/chiffres/	Eurostat (historical data and projections) http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=proj_15npms&lang=en
HH (households)	Federal Planning Bureau (historical data and projections) http://www.plan.be/databases/data-49-nl-huishoudensvooruitzichten+2016+2060	Eurostat for historical years. For projections, the trend in the number of people per household from Belgium has been extrapolated to Europe (using population statistics).
GDP	Eurostat http://ec.europa.eu/eurostat/data/database	Eurostat, IIASA GAINS model GDP projections for future years (latest projections using scenario WPE_2014_CLE) calculated as relative change with respect to latest Eurostat year. Linear extrapolation beyond 2030. http://ec.europa.eu/eurostat/data/database
FINELEC (final electricity consumption)	Eurostat energy statistics, linear extrapolation for future years http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_100a&lang=en	Eurostat energy statistics, linear extrapolation for future years http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_100a&lang=en
VKM (vehicle kilometers)	Vehicle kilometers in future years by vehicle type: TREMOVE model v3.3.2 (TML) http://www.tmleuven.be/methode/tremove/home.htm	Vehicle kilometers in future years by vehicle type: TREMOVE model v3.3.2 (TML) http://www.tmleuven.be/methode/tremove/home.htm

3.3.5 Results

The calculated reduction using this methodology has been interpreted and presented as the maximum reduction. Main reasons are:

- Uncertainty in the calculations (both in the EU study itself and methodology of downscaling to Belgium presented in this sheet)
- Possibility that the Ecodesign Directive does not result in the projected reductions (non-performing to some extent)

- In New Member States (East Europe) the average installation age of the current stock is likely to be older, therefore the potential for reduction is likely to be higher in these countries

For specific products, other technology developments or mitigation measures may be taken which take away part of the reduction potential of the Ecodesign Directive. An example is the use of more efficient tyres which reduces fuel consumption in cars, but the CO2 reduction associated with that is likely to change in future years considering the ongoing developments in (a.o.) electric vehicles.

Given the main uncertainties described above, the exact quantification of the reduction that will be achieved through implementation of the Ecodesign Directive is rather uncertain. Since most of the uncertainties point towards a possible overestimation of the projected energy savings for Belgium, we have chosen to interpret the calculated reduction as the upper limit. The lower limit has been estimated at 50% of the calculated reduction, which is an expert judgement. For the likely value, the average between lower and upper estimate has been assumed (75% of the calculated reduction). It should be noted that the choice of 50% and 75% as the minimum and likely emission reduction are an expert judgement, and these values are debatable.

The results are shown in Table 11, Figure 3 and Figure 4. This PAM is expected to result in a reduction of 6512 kton CO2-eq by 2020, and 11762 kton CO2-eq by 2035.

Table 11: Projected emission reductions from implementation of the Ecodesign Directive in Belgium (in kton CO2-eq)

Year	Minimum	Maximum	Likely		
			Total	ETS	ESD
2008	253	507	380	77	303
2009	349	699	524	125	399
2010	464	928	696	165	531
2011	648	1295	972	285	686
2012	889	1778	1333	450	884
2013	1191	2382	1786	655	1132
2014	1561	3123	2342	914	1428
2015	1912	3823	2868	1174	1693
2016	2375	4751	3563	1477	2086
2017	2892	5784	4338	1785	2553
2018	3404	6808	5106	2112	2993
2019	3888	7775	5831	2417	3415
2020	4341	8683	6512	2696	3816
2025	6375	12751	9563	4111	5452
2030	7521	15043	11282	5216	6066
2035	7841	15682	11762	5507	6255

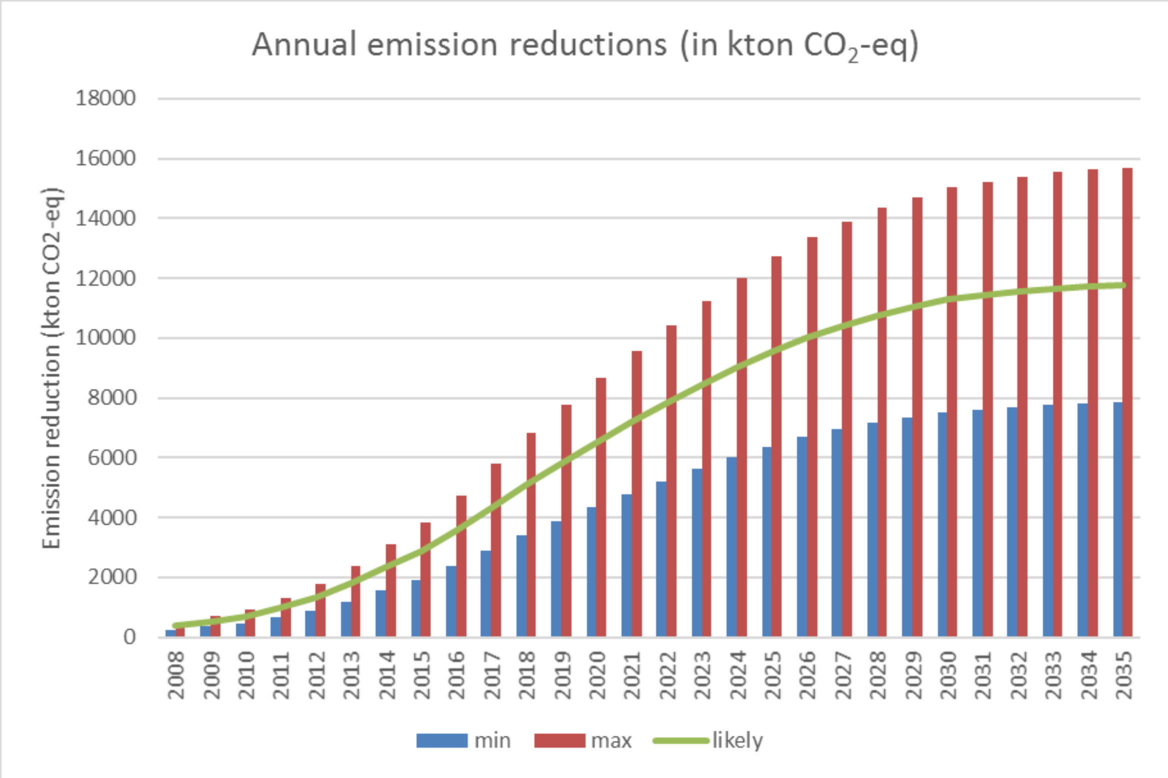


Figure 3: Annual emission reductions (minimum, maximum and likely scenarios)

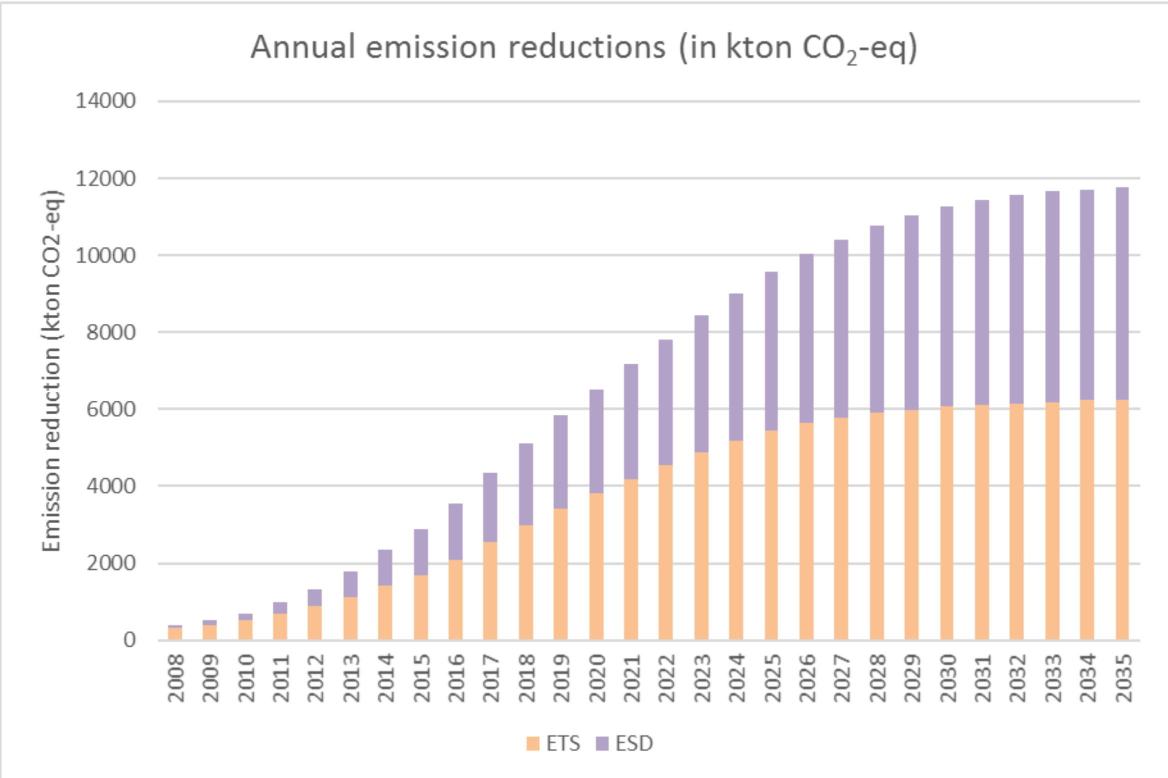


Figure 4: Share of ETS and ESD CO2 reductions from the implementation of the Ecodesign Directive (using the likely reduction from Figure 3)

3.3.6 Discussion

It is recognized that there are significant uncertainties with this approach. We have considered making an alternative bottom-up analysis for Belgium, however this would require availability of detailed datasets on the stock, use and energy efficiency of all the different products. Unfortunately, this information was not available for this assessment.

As one of the means to further assess the uncertainty of the calculated emission reduction, the results for Belgium have been compared to what has been calculated for the Netherlands. Two studies are listed here having estimated the impact of Ecodesign for the Netherlands.

- Natuur en Milieu (an environmental NGO in the Netherlands) has published in November 2015 a factsheet on Ecodesign[5] where the impact was assessed. In this study, the calculation was based on the VHK European study (a comparable methodology as presented in this report for Belgium), which resulted in an estimated possible reduction of 12 Mton CO2-eq by 2020.
- An earlier study performed by VHK for SenterNovem[6] in 2008 provided different reduction scenarios for 2010 and 2020. This shows for the combined scenario of Ecodesign and energy labelling a reduction of 1.6 Mton CO2 by 2020 compared to the "business as usual" scenario, which is substantially lower than calculated in this study. This can be explained by two main factors:
    - The timing of the study: the earlier VHK study was conducted in 2008, based on 2000-2006 data on economic development (prior to the economic crisis), while the EIA study (VHK, 2016) is based on recent data and concerns averages (sales/use/etc.) from the EU as a whole;
    - The scope of the studies is different: the 2008 VHK study only concerned electricity use while the EIA assessment also includes direct fuel use (e.g. residential heating) . Also, the 2008 study was conducted based on early drafts of the regulations, not including all products that are now considered in the final Ecodesign and energy labelling regulations.

These two alternative studies show that the estimate of the impact of Ecodesign has significant uncertainties. When comparing the results directly, it should be noted that a direct comparison between the Netherlands and Belgium is not straightforward because of the differences in fuel mix and the differences in the fuel mix for electricity generation.

In addition, Ecofys (2012)[7] also assessed the impact of the Ecodesign Directive on overall European energy consumption and related CO2 emissions by 2020. This study resulted in an estimated reduction of 400 Mton CO2 by 2020, which is slightly higher compared the estimated by VHK (319 Mton) but in the same order of magnitude.

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[5] https://www.natuurenmilieu.nl/wp-content/uploads/2015/11/Energylabels_factsheetNL4.pdf

[6] https://www.vhk.nl/downloads/Reports/2008/Elektrische%20apparatuur%20in%20Nederlandse%20Huishoudens%201980-2020.ZIP

[7] http://www.ecofys.com/files/files/ecofys_2012_economic_benefits_ecodesign.pdf

3.3.7 References

VHK, Ecodesign Impact Accounting, Status January 2016. Report for EU DG Energy. https://ec.europa.eu/energy/sites/ener/files/documents/Ecodesign%20Impacts%20Accounting%20%20-%20status%20January%202016%20-%20Final-20160607%20-%20N....pdf

Vito/Econotec, 2015. Evaluation of the impact of policy instruments and measures implemented in the context of the Federal climate policy. March 2015.

3.4 EC-B01: Tax incentive to promote energy efficiency in households

3.4.1 Description

The objective of this PAM is to improve the energy efficiency of buildings. This results in a reduction of emissions in both ETS and ESD sectors.

Tax reductions and subsidies have been granted for part of the cost of investments aiming to increase energy efficiency in households (Vito/Econotec, 2015). This includes investments to improve insulation (floor, wall, roof and glazing), to install efficient installations (condensing boilers, heat pumps, PV, solar thermal, thermostats). From 2012 onwards, only roof insulations are subsidised. From 2015 onwards, regions are responsible for the measure.

3.4.2 Methodology

The emission reduction is calculated based on the equipment installed in households and the expected lower energy use of these appliances. The emission reduction is calculated for each year of the life time of an investment. Emission reductions are no longer calculated once the life time is over and the installation is removed or replaced.

3.4.2.1 BAU scenario

Within the Business as usual scenario, no new investments are done for insulation or for installing efficient heat/electricity systems.

3.4.2.2 PAM scenario

Within the PAM scenario, new investments are done for improving energy efficiency. All of the investments from 2004 on are part of this scenario. After the expected lifetime of measures, it is assumed that the reduced CO_2 emissions are no longer a result of the tax incentives or subsidies from the federal government.

The BAU scenario does not take into account that some people will improve energy efficiency in their house even if no tax reductions and subsidies are available (freerider effect), while the PAM scenario does not take a possible multiplier effect into account. It is assumed that the freerider effect and the multiplier effect will compensate each other.

The rebound effect is not included in the emission reduction calculation, but it probably has an effect on the achieved emission reduction.

The emission reduction is calculated with the following formula:

$$ER_{FED} = \sum_i (AF_i \times N_i \times UER)$$

With:

ER_{FED}	Federal emission reduction (kton CO2-eq)
AF_i	Allocation factor per type of investment (%)
N_i	Number of application per type of investment
UER_i	Unit emission reduction per type of investment (kg CO2) (unit energy saving * EF)

The emission reduction is calculated for each year of the life time of an investment. Emission reductions are no longer calculated once the life time is over and the installation is removed or replaced.

3.4.3 Main assumptions

3.4.3.1 BAU scenario assumptions

It is assumed that no new investments are done for insulation or for installing heat/electricity systems.

3.4.3.2 PAM scenario assumptions

Allocation factor

The allocation factor differs per investment. It has been calculated following the same methodology as Vito/Econotec (2015) based on the average investment cost of the technology and the maximum amount that can be reduced compared to the premiums of the different regions. From 2015 onwards, the regions will be responsible for this tax reduction and the allocation factor for the federal government for new tax reductions and subsidies will be 0%. The CO2 emission reduction gained from measures before 2015 are still allocated to the federal government.

Unit energy savings

Table 12 shows the unit energy savings (in GJ per application per year) from Vito/Econotec (2015). The unit energy savings depend on the type of technology and the efficiency of the old and new situation. A more detailed description of the calculation of the unit energy savings is provided in Vito/Econotec (2015).

Table 12: Unit energy savings per application (GJ/year)

Year	Condensing boiler (GJ/unit)	Roof insulation (GJ/unit)	Heat pump (GJ/unit)	Double glazing (GJ/unit)	PV (kWh/unit)	Solar thermal (kWh/unit)	Wall insulation (GJ/unit)	Floor insulation (GJ/unit)	Thermostats (GJ/unit)	Passive house (kWh/unit)
2004	47,8	42,7	62,5	15,3	2125	520	33,3	3,5	4,5	9577
2005	47,8	38,1	62,5	14,5	2125	516	34,4	3,5	4,5	9577
2006	47,8	37,8	62,5	15,2	2125	511	48,6	3,5	4,5	9577
2007	47,8	37,0	62,5	16,0	2125	506	34,3	3,5	4,5	9577
2008	27,2	23,2	62,5	9,7	2125	501	28,7	3,1	3,9	9577
2009	27,2	23,1	62,5	8,7	2125	496	27,8	3,1	3,9	9577
2010	27,2	24,3	62,5	9,9	2125	492	31,9	3,1	3,9	9577
2011	27,2	24,3	62,5	9,9	2125	488	31,9	3,1	3,9	9577
2012	27,2	24,3	62,5	9,9	2125	485	31,9	3,1	3,9	9577
2013	27,2	24,3	62,5	9,9	2125	482	31,9	3,1	3,9	9577
2014	27,2	24,3	62,5	9,9	2125	469	31,9	3,1	3,9	9577
2015	27,2	24,3	62,5	9,9	2125	465	31,9	3,1	3,9	9577
2020	27,2	24,3	62,5	9,9	2125	448	31,9	3,1	3,9	9577
2025	27,2	24,3	62,5	9,9	2125	432	31,9	3,1	3,9	9577
2030	27,2	24,3	62,5	9,9	2125	416	31,9	3,1	3,9	9577
2035	27,2	24,3	62,5	9,9	2125	400	31,9	3,1	3,9	9577

The unit energy savings is comparable to key figures from other studies (see next paragraphs), and therefore the unit energy savings from Vito/Econotec (2015) has been used.

Energy reductions from insulation

SenterNovem (2007) and ECN (2012) provide several key figures for energy efficiency from insulation.

SenterNovem (2007) indicates a reduction of natural gas use of 4-27 m3 per m2 per year for roof insulation, 14-34 m3 per m2 per year for double glazing, 9-19 m3 per m2 per year for wall insulation and 3 m3 per m2 per year for floor insulation. ECN (2012) indicates a reduction of natural gas use of 13 m3 per m2 per year for roof insulation, 5-17 m3 per m2 per year for double glazing, 8-9 m3 per m2 per year for wall insulation and 2.5-2.8 m3 per m2 per year for floor insulation.

With an average size of 74 m2 for roof and floor insulation, 15 m2 for double glazing and 100 m2 for wall insulation, this results in a reduction of energy consumption presented in Table 13.

Table 13: Reduction of energy consumption

	Vito/Econotec	SenterNovem, 2007	ECN, 2012
Roof insulation	23.1 - 42.7	9.4 - 63.2	30.4
Double glazing	8.7 - 15.3	6.6 - 16.1	2.4 - 8.1
Wall insulation	27.8 - 48.6	28.5 - 60.1	25.3 – 28.5
Floor insulation	3.1 - 3.5	7	5.9 – 6.6

The unit energy savings from Vito/Econotec (2015) are in the same order of magnitude as the energy reduction from SenterNovem (2007) and ECN (2012). Only for floor insulation, the energy reduction differs by a factor of two. The difference can be explained by the fact that the average heat loss through floors in the Netherlands is much higher than in Belgium (data from Entranze), and therefore the possible energy savings in Belgium is lower.

Therefore, we continued to use the unit energy savings from Vito/Econotec (2015) for all type of insulation.

Condensing boiler

Compared to SenterNovem, 2007: When a boiler is replaced by a condensing boiler, then the maximum reduction of energy consumption is 7-18% (depending on the old boiler used). In ECN (2012), the maximum reduction of energy consumption is 3-20%. In 2014, Belgium used 256420 TJ for residential combustion (CRF tables from June 2016). Dividing this by 3 693 544 houses (http://statbel.fgov.be), results in an average 69.4 GJ per house. A reduction of 3-20% results in an energy reduction of 2.1-13.9 GJ per unit per year.

The unit energy reduction in the Vito/Econotec report (2015) is higher (27.2-47.8 GJ/unit) than the reduction calculated from the data from SenterNovem (2007) and from ECN (2012). This is mainly caused by the fact that in Belgium more fuels are used for residential heating and therefore a larger energy reduction can be achieved (data from Entranze). Therefore, we continued to use the unit energy savings from Vito/Econotec (2015) for the condensing boilers.

Heat pumps

The unit emission reduction for heat pumps has been taken from the VITO/Econotec (2015) report. This factor is based on an average capacity of 8 kW, 2000 full load hours and a COP of 3.5. Compared to the values found in other studies in literature, only the COP could be higher, which would mean a higher unit emission reduction. However, given that the average capacity and full load are typical values compared to other estimates in literature, there has been no reason to change to the Vito/Econotec (2015) estimate for the unit emission reduction for heat pumps.

PV

In Vito/Econotec (2015), the CO2 emission reduction from PV is calculated with an average PV installation size of 2.5 kWp and an efficiency of 850 kWh/kWp. An installation size of 2.5 kWp equals approximately 10 solar panels (depending on the capacity of the solar panel).

Unit emission reduction (UER)

The unit emission reductions have been calculated by multiplying the unit energy savings with an emission factor. The emission factor depends on the type of fuel that is saved. For heat related investments (insulation, boilers), the emission factor varies between 60 kg CO2/GJ and 65 kg CO2/GJ, depending on the average fuel type saved (natural gas (55.8 kg CO2/GJ) or and heating oil (73.3 kg CO2/GJ)). An emission factor of 380 g CO2/kWh is used for electricity related investments (PV).

Table 14 shows the unit emission reductions (in kg CO2 per application per year) from Vito/Econotec (2015). These values have been used in the calculation of CO2 emissions reduction from energy efficiency in households.

Table 14: Unit emission reductions per application (kg CO2/year)

Year	Condensing boiler	Roof insulation	Heat pump	Double glazing	PV	Solar thermal	Wall insulation	Floor insulation	Thermostats	Passive house
2004	3142	2507	1929	932	808	355	2070	226	288	2146
2005	3142	2242	1929	886	808	353	2144	226	288	2146
2006	3142	2242	1929	926	808	349	3027	226	288	2146
2007	3142	2174	1929	973	808	345	2133	226	288	2146
2008	1826	1449	1929	619	808	342	1872	198	254	2146
2009	1826	1439	1929	554	808	339	1813	198	254	2146
2010	1826	1517	1929	633	808	337	2079	198	254	2146
2011	1826	1517	1929	633	808	334	2079	198	254	2146
2012	1826	1517	1929	633	808	332	2079	198	254	2146
2013		1517								
2014		1517								

A comparison of the unit emission reductions with other studies is difficult due to differences in the fuel mix in the BAU scenario. Therefore, only a comparison is made for the unit energy savings (see paragraph above). The unit energy savings are comparable to several other studies and the emission factors are in the range of emission factors of natural gas and heating oil. Therefore, we concluded that the unit emission reductions are applicable for estimating the emission reduction of energy efficiency investments in Belgium.

Life time of investments

The life time of investments is presented in Table 15. These are from EC, 2010.

Table 15: Expected life time for each investment (years)

Investment	Life expectancy
Condensing boiler	20 years
Roof insulation	25 years
Heat pump	25 years
Double glazing	30 years
PV	23 years
Solar thermal	20 years
Wall insulation	30 years
Floor insulation	25 years
Thermostats	10 years

Minimum and maximum scenario

The emission reduction is calculated using average values for number of applications and UERs. In Vito/Econotec (2015), the minimum and maximum emission reduction is calculated using a Monte

Carlo analysis. The uncertainty range resulting from the Monte Carlo analysis in the Vito/Econotec report (2015) is presented in Table 16. The 95% uncertainty range has been used to calculate the minimum and maximum emission reduction.

Table 16: Emission reductions and uncertainty range

Year	Mean emission reduction (kton CO2eq)	Standard deviation	95% uncertainty range (%)
2004	122	28	± 45%
2005	245	42	± 34%
2006	396	56	± 28%
2007	636	76	± 23%
2008	883	91	± 20%
2009	1191	100	± 16%
2010	1610	111	± 14%
2011	2067	123	± 12%
2012	2119	123	± 11%
2013	2169	123	± 11%
2014	2218	124	± 11%
2015	2272	108	± 9%
2016	2272	108	± 9%
2017	2272	108	± 9%
2018	2272	108	± 9%
2019	2272	108	± 9%
2020	2272	108	± 9%
2021	2272	108	± 9%
2022	2204	106	± 9%
2023	2204	106	± 9%
2024	2161	103	± 9%
2025	2117	100	± 9%
2026	2071	98	± 9%
2027	1980	98	± 10%
2028	1852	97	± 10%
2029	1707	97	± 11%
2030	1517	95	± 12%
2031	1248	92	± 14%
2032	1182	90	± 15%
2033	1020	84	± 16%
2034	841	79	± 18%
2035	657	71	± 21%

3.4.4 Data sources

Data sources for each indicator are presented in Table 17.

Table 17: Description of data sources

Indicators	Ex-ante values	Ex-post values
AF	See assumptions	See assumptions (0% from 2015)
Number of applications (N)	FPS Finance	n.a. (no new applications)
Emission factor (EF)	See assumptions	See assumptions

3.4.5 Results

From 2015 onwards, the regions are responsible for this tax reduction and the allocation factor for the federal government for new tax reductions and subsidies will be 0%. The CO2 emission reduction gained from measures before 2015 are still allocated to the federal government.

After the expected lifetime of measures, it is assumed that the reduced CO2 emissions are no longer a result of the tax incentives or subsidies from the federal government. Therefore, the annual emission reductions decrease from 2022 on. Figure 5 presents the minimum and maximum scenario for the annual CO2 emission reductions.

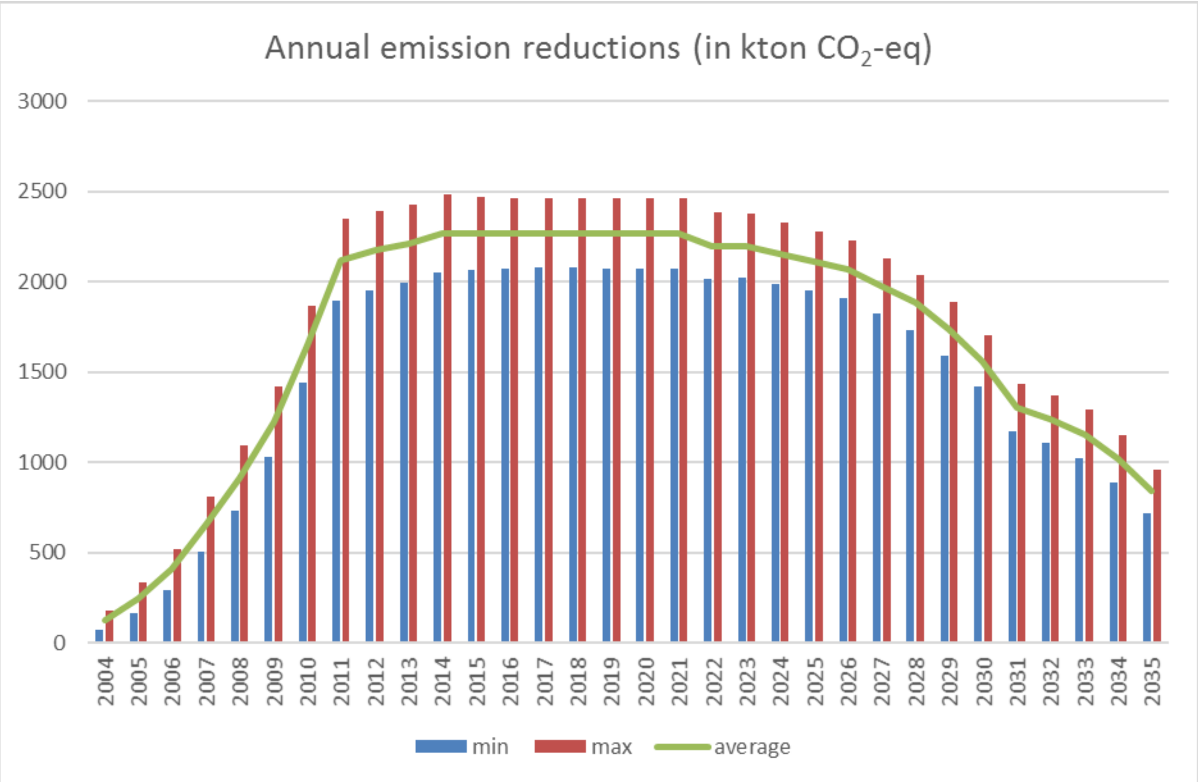


Figure 5: Annual emission reductions (minimum, maximum and likely scenarios)

3.4.6 Discussion

This emission calculation contains many variables and uncertainties. The main uncertainties in the emission reduction calculation include the emission reduction units and the average life time. The energy reduction units have been compared to energy reduction units in several other studies, which show similar values and therefore the average emission reduction is probably the most likely.

The possible largest variable that is not included in the emission reduction calculations is the rebound effect. Because the rebound effect is not taken into account, the calculated annual emission reduction could be an overestimation.

3.4.7 References

Vito/Econotec, 2015. Evaluation of the impact of policy instruments and measures implemented in the context of the Federal climate policy. March 2015.

CRF tables from Belgium (version June 2016). Available via: http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/9492.php

Entranze, data on energy consumption. Available via: http://www.entranze.enerdata.eu/#/share-heating-unit-consumption-per-dwelling-at-normal-climate.html

SenterNovem, 2007. Kompas energiebewust wonen en werken. Cijfers en tabellen 2007.

ECN, 2012. Besparingsgetallen energiebesparende maatregelen. ECN report number P15320, ECN-E-12-013.

EC, 2010. Recommendations on measurement and verification methods in the framework of directive 2006/32/EC on energy end-use efficiency and energy services – Preliminary Draft, 2010.

3.5 EC-B03: FRGE

3.5.1 Description

The objective of this PAM is to improve the energy efficiency of buildings. This results in a reduction of emissions in both ETS and ESD sectors.

The Fund for the Reduction of the Global cost of Energy (FRGE) was used to improve the energy efficiency of housings for disadvantaged people via cheap loans (Vito/Econotec, 2015). The FRGE is transferred to the regions on 1 January 2015, and therefore 2014 is the last year included in this PAM.

3.5.2 Methodology

The emission reduction is calculated based on the equipment installed in households and the expected lower energy use of these appliances. The emission reduction is calculated for each year of the life time of an investment. Emission reductions are no longer calculated once the life time is over and the installation is removed or replaced.

3.5.2.1 BAU scenario

Within the Business as usual scenario, no new investments are done for insulation or for installing efficient heat/electricity systems.

3.5.2.2 PAM scenario

Within the PAM scenario, new investments are done for improving energy efficiency. All of the investments from 2004 on are part of this scenario. After the expected lifetime of measures, it is assumed that the reduced CO2 emissions are no longer a result of the tax incentives or subsidies from the federal government.

In the previous assessment (Vito/Econotec, 2015) report, it was indicated that a significant number of people have used a loan from FRGE and also benefited from a tax reduction. To prevent double counting with measure EC-B01, this calculation only includes low income households that do not pay taxes and who therefore were not able to profit from a tax deduction under the present measure.

The BAU scenario does not take into account that some people will improve energy efficiency in their house even if no tax reductions and subsidies are available (freerider effect), while the PAM scenario does not take a possible multiplier effect into account. It is assumed that the freerider effect and the multiplier effect will compensate each other.

The rebound effect is not included in the emission reduction calculation, but it probably has an effect on the achieved emission reduction.

The emission reduction is calculated with the following formula:

$$\boldsymbol{ER_{FED}} = \boldsymbol{AF} \times \sum_{\boldsymbol{i}} (\boldsymbol{N_i} \times \boldsymbol{UER})$$

With:

$\mathbf{ER_{FED}}$	Federal emission reduction (kton CO2-eq)
$\mathbf{AF_i}$	Allocation factor per type of investment (%)
$\mathbf{N_i}$	Number of application per type of investment
$\mathbf{UER_i}$	Unit emission reduction per type of investment (kg CO2)

3.5.3 Main assumptions

3.5.3.1 BAU scenario assumptions

For the Business as usual scenario, it is assumed that no new investments are done for insulation or for installing efficient heat/electricity systems.

3.5.3.2 PAM scenario assumptions

Number of applications

For 2014 Vito/Econotec (2015) used a distribution based on the information for non-tax payers of 2008-2013. For this year, two scenarios with respect to the number of applications in 2014 were used:

- a minimum and likely scenario where the total number of applications in 2014 is the same as in 2013.
- a maximum scenario where there is a (moderate) increase in applications, similar to the increase between 2012 and 2013.

This approach has also been followed in the present assessment.

3.5.4 Data sources

Data sources for each indicator are presented in Table 18.

Table 18: Description of data sources

Indicators	Ex-ante values	Ex-post values
AF	Equal to EC-B01 (Vito/Econotec, 2015)	Equal to EC-B01 (Vito/Econotec, 2015)
Number of applications (N)	2008-2013: FRGE 2014: Vito/Econotec, 2015 (see assumptions)	n.a. (no new applications)
Emission factor (EF)	Equal to EC-B01 (Vito/Econotec, 2015)	Equal to EC-B01 (Vito/Econotec, 2015)

3.5.5 Results

From 2015 onwards, the regions are responsible for this tax reduction and the allocation factor for the federal government for new tax reductions and subsidies will be 0%. The CO2 emission reduction gained from measures before 2015 are still allocated to the federal government.

After the expected lifetime of measures, it is assumed that the reduced CO2 emissions are no longer a result of the tax incentives or subsidies from the federal government. Therefore, the annual emission reductions decrease from 2022 on. Figure 6 presents the minimum and maximum scenario for the annual CO2 emission reductions.

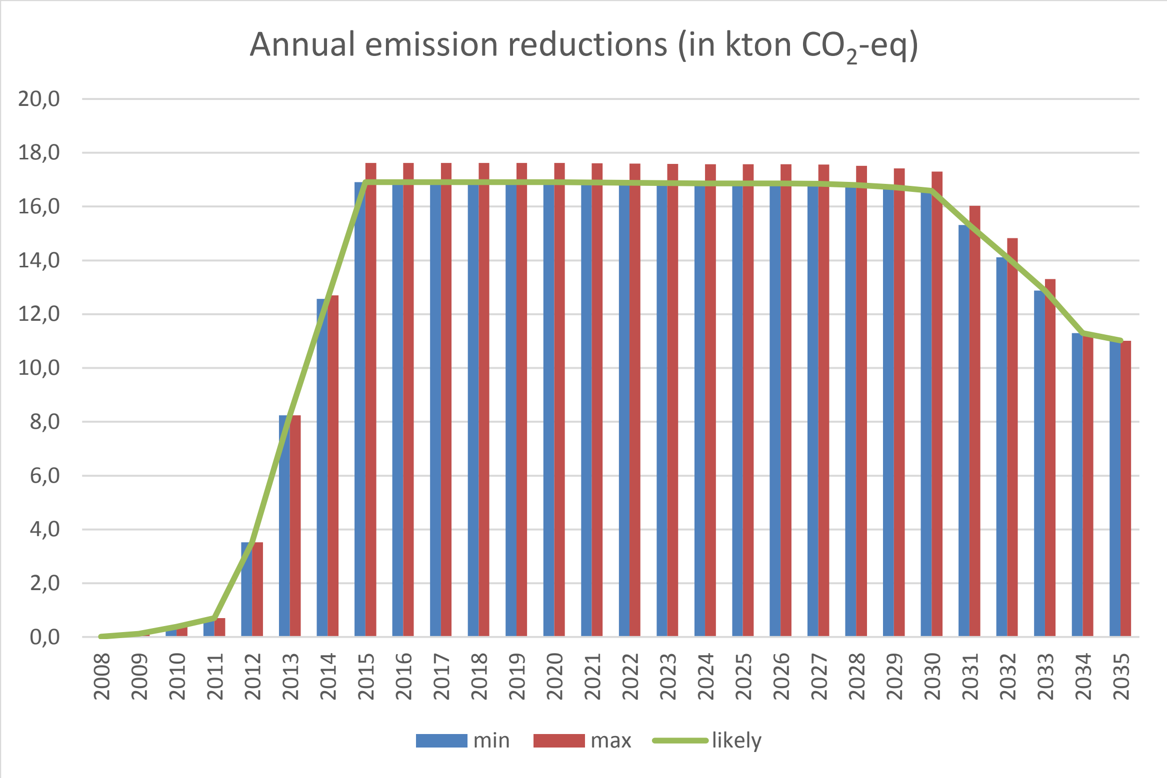


Figure 6: Annual emission reductions (minimum, maximum and likely scenarios)

3.5.6 Discussion

This emission calculation contains many variables and uncertainties. The main uncertainties in the emission reduction calculation include the emission reduction units and the average life time. The energy reduction units have been compared to energy reduction units in several other studies, which show similar values and therefore the average emission reduction is probably the most likely.

3.5.7 References

Vito/Econotec, 2015. Evaluation of the impact of policy instruments and measures implemented in the context of the Federal climate policy. March 2015.

3.6 PAM OB-B01: Photovoltaic panels on roofs of Federal government buildings

3.6.1 Description

In March 2007, the Federal government decided an objective of 1 km² of photovoltaic panels on roofs of the public buildings. This is to be achieved by three measures:

1) roofs will be made available for installing PV panels
2) Installation of PV panels by government, via FEDESCO/Buildinsagency
3) the three companies of NMBS/SNCB group have committed themselves to consider building and installing renewable energy equipment (e.g. solar or wind) via partnerships.

This PAM results in a reduction of emissions in ETS sector.

3.6.2 Methodology

3.6.2.1 BAU scenario

The BAU scenario is considered as one without any photovoltaic panels being installed on roofs of the public buildings and no wind power being installed by SNCB.

3.6.2.2 PAM scenario

In the PAM scenario we consider the installation of PV by government via FEDESCO/Buildinsagency and by SNCB. We include also the installation of wind power by SNCB.

The annual emission reduction of this PAM is estimated as the sum of reductions from PV and wind which are calculated as follows:

$$\boldsymbol{Emission\ Reduction\ PV} = (\boldsymbol{P_{solar}} \cdot \boldsymbol{E_{solar}} \cdot \boldsymbol{A_{solar}}) \cdot \boldsymbol{EF}$$

$$\boldsymbol{Emission\ Reduction\ wind} = (\boldsymbol{P_{wind}} \cdot \boldsymbol{P_{wind}} \cdot \boldsymbol{A_{wind}}) \cdot \boldsymbol{EF}$$

Where:

$\boldsymbol{P_{solar}}$: Average yearly installed capacity of PV panels (kWp)
$\boldsymbol{E_{solar}}$: efficiency PV (kWh/kWp)
$\boldsymbol{A_{solar}}$: Allocation factor (to the federal measure) for PV panels (%)
$\boldsymbol{P_{wind}}$: Average yearly installed capacity of windmills (MW)
$\boldsymbol{E_{wind}}$: Average annual equivalent number of full load hours (h)
$\boldsymbol{A_{wind}}$: Allocation factor (to the federal measure) for windmills (%)
EF: emissions factor (ton CO^2eq/MWh)

3.6.3 Main assumptions

3.6.3.1 PAM scenario assumptions

- **Average yearly installed capacity of PV panels** (kWp):
  - Fedesco/ buildingsagency : for the period 2010-2018 we have the data on actual installed capacity (see below "data sources"). For the period 2019-2020 data come from a linear extrapolation of 2010-2018 data. For the period 2021 onwards as we do not have any information on future plans/objective of the measure we keep the 2020 value constant.
  - SNCB : for the period 2010-2017 we have the data on actual installed capacity (see below "data sources"). For the period 2018 onwards as we do not have any information on future plans/objective of the measure we keep the 2017 value constant.
- **efficiency PV** (kWh/kWp) has been set to 900 kWh/kWp (instead of 850 of previous evaluation). Data from Fedesco/Régie des bâtiments show an average efficiency of PV panel at 946 kWh/kWp. As the data is not complete and since we don't have an historical view of the production of their projects, we prefer to set a lower efficiency parameter (900 kWh per kWp).

- **Average yearly installed capacity of windmills** (MW): for the period 2008-2017 we use the actual data (see below "data sources"). As the objective of the SNCB is to have 50 MW of installed wind capacity (source: previous assessment), we set a progressive augmentation of installed capacity as to reach 50 MWh in 2025.
- **Average annual equivalent number of full load hours** (h) is set at 2000 hours.
- **Allocation factor** (to the federal measure) for PV panels (%): the following allocation factors from the previous evaluation have been taken:

Year	AF
2008-09	66.00%
2010	64.00%
2011	66.00%
2012	73.00%
2013-35	89.00%

- **Allocation factor** (to the federal measure) for windmills (%): 42% of the reductions have been allocated to the Federal government (source: previous assessment).
- **Emissions factor** (ton CO^2eq/MWh): this is the emission factor of a CCGT power station.

3.6.4 Data sources

- Average yearly installed capacity of PV panels (kWp) for Fedesco/buildingagency has been provided by a personal communication of Buildingagency (February 2016). The data is detailed by site of installation and include for some sites also data on production of electricity. The table below sum up the data received.

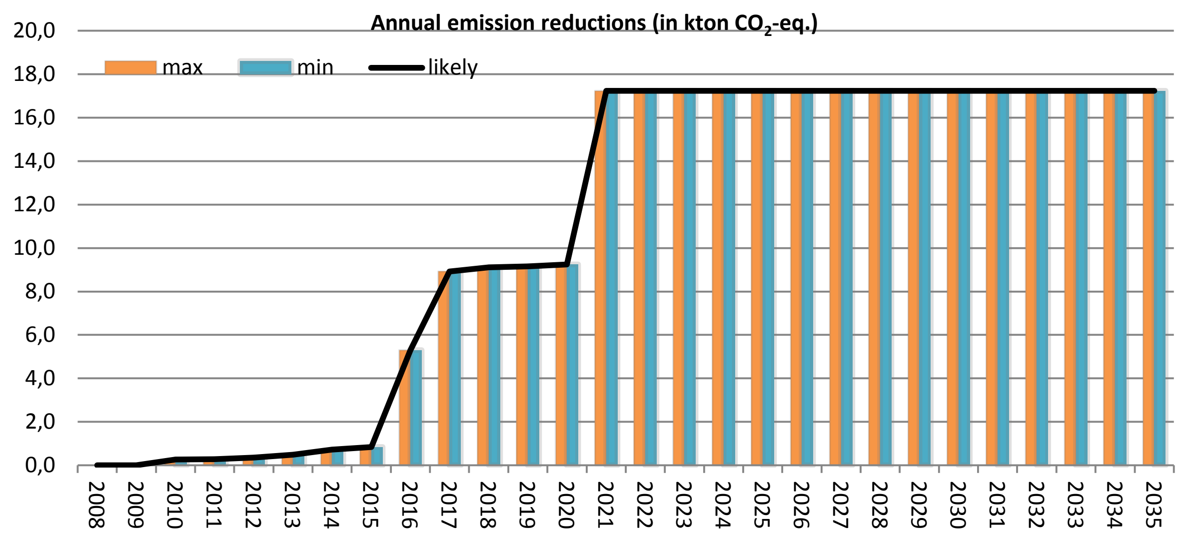
Table 19: Average yearly installed capacity of PV panels

ID	POWER	PROVISION DATE
Woluwé	99.60	2010
Brugge	548.80	2010
Beveren	196.20	2010
Wilrijk	391.44	2010
Ciney	40.40	2011
Bertix	9.87	2012
Kortrijk	124.12	2012
Melle	47.47	2013
Laeken	110.11	2013
Haren	54.54	2013
Marche en Famenne	96.67	2014
Leuze en Hainaut	400.00	2014
Beveren	236.36	2014
Libramont	27.27	2014
Dourbes	306.31	2015
Bruxelles (IRSNB)	62.40	2015
Beveren (Justitie)	301	2017
Hasselt (Federale Politie)	27	2017
Hasselt	26.8	2018
Bornem (Finshop)	621	2018

- Average yearly installed capacity of PV panels (kWp) for SNCB and Infrabel: Annual report SNCB 2014 and 2015, Annual sustainability report Infrabel 2015, Infrabel website (https://www.infrabel.be/en/about/sustainable-development/tune-environment-planet accessed on 22/12/2016), SNCB website (http://www.belgianrail.be/fr/corporate/Durabilite/Planet/Energie.aspx accessed on 22/12/2016)
  Average yearly installed capacity of windmills (MW): Infrabel website (https://www.infrabel.be/en/about/sustainable-development/tune-environment-planet accessed on 22/12/2016), LivingRail website (http://81.47.175.201/livingrail/index.php?option=com_content&view=article&id=689:wind-energy-to-power-the-rail-network&catid=37:technologies&Itemid=126 accessed on 22/12/2016).
  To sum up, the information used for PV and windmills for SNCB/Infrabel:
    - PV: we considered the installation at Aywaille Station (5 kWp in 2010), Logistic Centre Infrastrusture in Arlon (8;4 kWp in 2011), on the tunnel along the E19 highway - Brasschaat (4098 kWp) and at ateliers de Schaarbeek (341 kWp in 2017).
    - Windmills: Infrabel participates to the development of the Gingelom wind park which has currently installed 7 turbines and which should grow up to 25 turbines (totalling 50 MW)

3.6.5 Results

Figure 7: Annual emission reduction of the PAM OB-B01



Most of the reduction are related to the windmills of SNCB/Infrabel. Thus, the annual emissions reductions profile follows the date of installation of windmills. No max/min scenario have been developed as the information on the targets of PV and windmills from SNCB and Regie de Batiment did not allow to agree on a max/min objective of PV and windmills.

3.6.6 Discussion

Estimations up to 2020 are quite accurate. For the period 2020-2035 estimations are very conservative as no information could be found on commitments/objectives/plans to implement this measure.

Eventually one could use the max, min, likely scenarios for setting up different targets for the PV surfaces and windmills capacity to be installed.

The objective of 50 MW of installed wind capacity for SNCB/Infrabel and the calendar of the installation for the additional 50 minus 14 MW capacity is to be validated by FPS mobility and SNCB/Infrabel.

Allocation factors are explicitly described in the previous evaluation. They should be revised or at least explained.

There can be problems of overlapping with regional green certificate scheme. No corrections were foreseen for this problem in this estimation (as well as in the previous estimation).

3.6.7 References

Infrabel, 2015, Annual sustainability report, https://www.infrabel.be/en/about/sustainable-development/tune-environment-planet accessed on 22/12/2016

SNCB, 2015, Annual report SNCB 2014, http://www.belgianrail.be/fr/corporate/Durabilite/Planet/Energie.aspx accessed on 22/12/2016

SNCB, 2016, Annual report SNCB 2015, http://www.belgianrail.be/fr/corporate/Durabilite/Planet/Energie.aspx accessed on 22/12/2016

3.7 OB-B02: Third party financing in public buildings

3.7.1 Description

To improve energy efficiency in public buildings, the Federal government created in 2005 FEDESCO. FEDESCO was financed by the government and invested in projects to increase energy efficiency via e.g. energy performance contracts, energy monitoring systems and PV panels in the buildings used by the Federal government. At the same time, the buildings agency (Regie der gebouwen/Régie des batiments) have also funded actions to improve the renovation of public buildings, including improvements in energy efficiency. The government agreement of October 2014 stipulated that FEDESCO was to be dissolved and its activities (and personnel) to be incorporated to the buildings agency. The emission reductions due to the investments made by FEDESCO/ buildings agency from 2005 to 2014 and by buildings agency since 2014 are estimated within this PAM. The investments in PV panels are already covered by OB-BO1, so this PAM only covers energy efficiency investments made/to be made by FEDESCO/buildings agency.

In addition to the measures taken by FEDESCO/Building Agency, this PAMs takes into account also the measures taken to reduce energy consumption by the Defence sector (broader scope than in the previous assessment – Vito/Econotec 2015).

This PAM results in a reduction of emissions in both ETS and ESD sectors.

3.7.2 Methodology

3.7.2.1 BAU scenario

The BAU scenario is considered as one without any energy efficiency measure taken.

3.7.2.2 PAM scenario

With regards to the FEDESCO/Building Agency, the annual emission reduction of this PAM is estimated as follows:

$$\boldsymbol{Emission\ Reduction} = (\boldsymbol{B} \cdot \boldsymbol{UES} \cdot \boldsymbol{AF}) \cdot \boldsymbol{EF}$$

With:

B	Total budget invested in concrete changes to the building (€)
UES	Energy savings per € invested (kWh/€)
AF	Allocation factor (to the federal measure) (%)
EF	Emissions factor (ton CO2eq/MWh)

With regards to the measures in the Defense sector, the annual emission reduction of this PAM is estimated on the base of the energy consumption reduction as follows:

$$Emission\ Reduction = \left(\sum_i ER_i \cdot EF_i\right) AF$$

Where:

ER: Energy consumption reduction
EF: emissions factor (ton CO2eq/MWh)
I= electricity, gas, heating oil
AF: Allocation factor (to the federal measure) (%)

3.7.3 Main assumptions

3.7.3.1 General assumptions

For FEDESCO/Building Agency measures:

- **Total budget invested in concrete changes to the building (€)**: we used the data transmitted by the Régie des Bâtiments (see below “data sources”) on the budgets of FEDESCO and of the Régie de Bâtiments for renovation of public buildings. The aggregated results are shown in the table below.

Table 20: Total budget invested

Year	Fedesco	Régie	Total	Fedesco (previous evaluation)*
2007	187,973.16 €	1,300,000.00 €	1,487,973.16 €	740,520.00 €
2008	251,566.30 €	1,300,000.00 €	1,551,566.30 €	- €
2009	715,090.76 €	1,300,000.00 €	2,015,090.76 €	1,733,689.00 €
2010	3,234,523.81 €	1,300,000.00 €	4,534,523.81 €	1,779,093.00 €
2011	2,485,243.43 €	1,300,000.00 €	3,785,243.43 €	4,072,309.00 €
2012	5,346,162.24 €	1,300,000.00 €	6,646,162.24 €	3,988,336.00 €
2013	1,476,805.33 €	1,300,000.00 €	2,776,805.33 €	4,347,564.00 €
2014	968,396.26 €	1,300,000.00 €	2,268,396.26 €	4,706,792.00 €
2015		3,300,000.00 €	3,300,000.00 €	5,066,020.00 €
2016		3,300,000.00 €	3,300,000.00 €	5,425,247.00 €
2017		3,300,000.00 €	3,300,000.00 €	
2018		3,300,000.00 €	3,300,000.00 €	

*Data 2012-2016 were estimated data in the previous evaluation exercise

- With regards to the types of renovation (which affect the split between fuels which are saved), we could not distinguish them and we keep the assumption from the previous assessment that 16% of savings are electricity and the rest natural gas / oil (83% / 17% respectively, these data are from the previous evaluation of OB-A03).

  With regards to budget from 2017 onwards we make only one scenario (on the basis of discussions with the Régie des Bâtiments): expenditures are kept constant at the value of the period 2015-2018.

- **Unit energy savings (kWh/€) per € invested**: we used the value of 8 €/kWh calculated in the previous evaluation exercise using data from FEDESCO (2012) ('rapportage energiebesparende projecten in federale overheidsgebouwen' - versie Q2) which is as follows:

Table 21: Unit energy savings per € invested

	Number of projects	total investment	Total annual savings (MWh)	Efficiency (MWh/k€)
2012	45	2496733	19883	8.0

- **Allocation factor** (to the federal measure) (%): the PAM is strictly federal, so the allocation factor was set to 100%.
- **Emissions factor** (ton CO^2eq/MWh): the emission factor was calculated based on assumptions on type of energy savings achieved according to the fuel (electricity, natural gas, heating oil) (see above the point on Total budget invested in concrete changes to the building (€))

For the defence sector:

- **Energy consumption reductions**: we used the data on energy consumption transmitted by the Defence for the period 2007-2015 to calculate actual energy consumption reduction per year. For the period 2016 onwards we assume in the likely scenario a reduction of energy consumption of 1% per year as stated in the information transmitted by the Defence. In the min and max scenario the reduction is fixed at 0.5% and 1.5% respectively.

- Emissions factors are standard as in the estimations of other PAMs, that is:

heating oil (kg/GJ)	natural gas (kg/GJ)	éléc (ton/MWh)	natural gas (t/MWh)
73,33	55,82	0,38	0,2010

- **Allocation factor** (to the federal measure) (%): the PAM is strictly federal, so the allocation factor was set to 100%.

3.7.4 Data sources

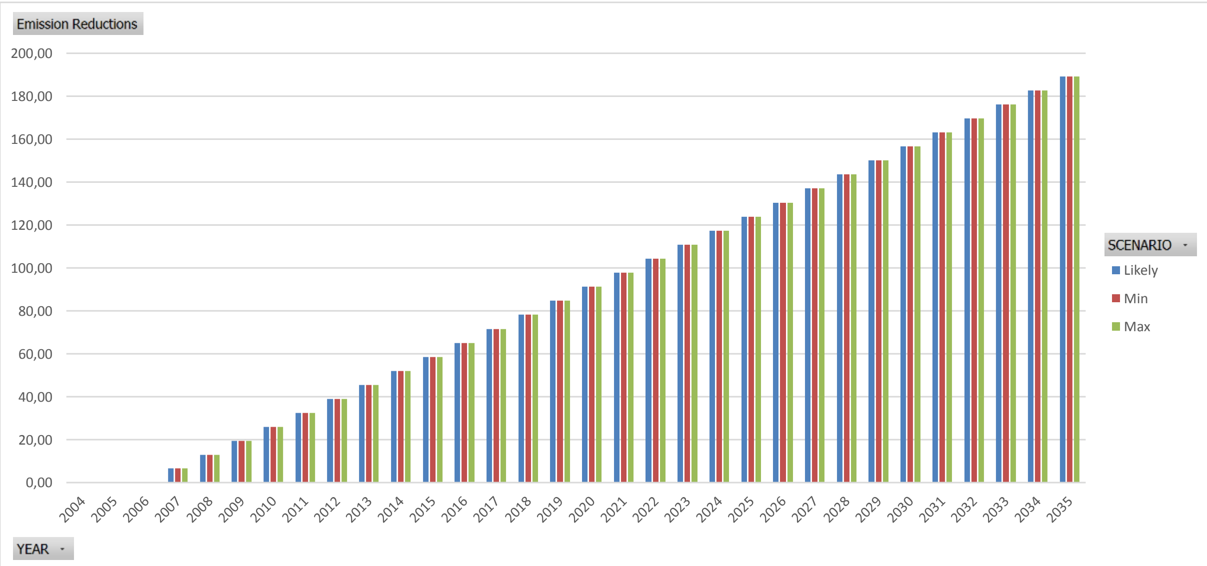
The data sources used for the estimation of the PAM are presented in the following table:

Measure	Indicators	Source
FEDESCO/Building Agency	Total budget invested in concrete changes to the building (€)	Personal communication of Régie des bâtiments (February 2016)
Defence	Energy Consumption (kWh and l)	data transmitted by the defence for the energy balances of the three regions. Only the buildings are taken into account.

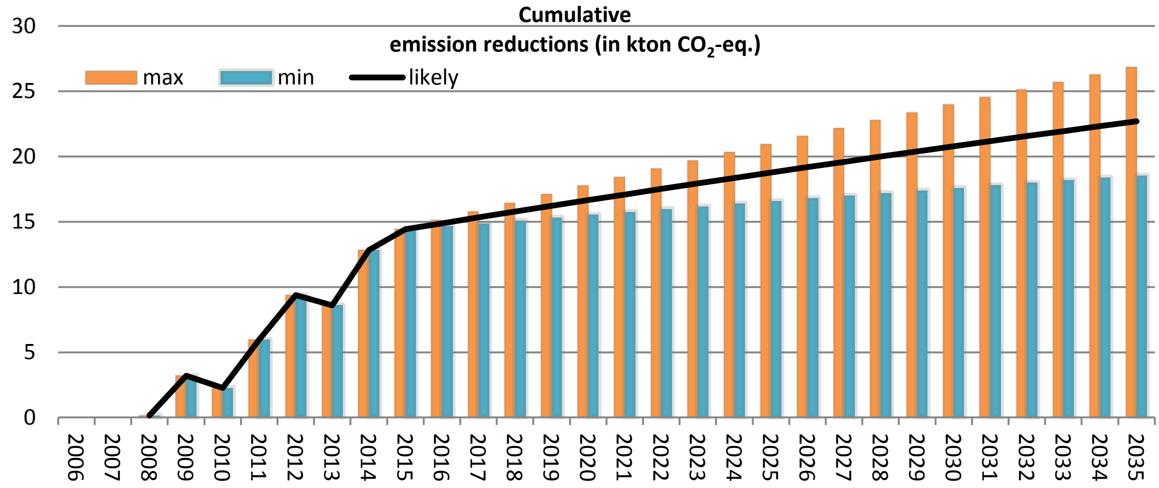
3.7.5 Results

For Fedesco/Building Agency measures, the emission reductions achieved by the implementation of the PAM increase from 3 kt CO2-eq in 2007 to 187 kt CO2-eq in 2035. The following figure illustrate the emission reductions achieved from 2004 to 2035 by the PAM. No max/min scenarios have been defined as no assumptions on the man/mix objectives of the Building agency could be agreed on.

Figure 8: Annual emission reductions (minimum, maximum and likely scenarios)



For the Defence sector the emissions reductions are given in the graph below.



The evolution 2008-2015 is based on historical data on energy consumption of defence buildings.

3.7.6 Discussion

For Fedesco/Building Agency measures, estimations rely on the data on expenditure from the Buildingsagency. Data on savings of a set of projects could help in revising the UES (which is based on 2012 data).

For the Defence measure, scenarii are based on a reduction objective of 1% per year not taking into account different reduction potentials.

There can be problems of overlapping with EMAS PAMs. As in the previous assessment (Vito/Econotec 2015), no corrections were foreseen for this problem.

3.7.7 References

Personal communication of Régie des bâtiments (February 2016)

Data transmitted by the Defence for the energy balances of the three regions.

3.8 TR-A02: Improve and promote public transport

3.8.1 Description

Through Royal Decrees of 29 June 2008, the "management contracts" of the three companies of the NMBS/SNCB group impose a 3,8% annual growth in the number of passengers transported (to achieve 25% over the period 2006-2012[8]), to be reached through investments in infrastructure, the strengthening of the transport capacity and the quality of service (enhancing timeliness, safety, accessibility and information to travelers), the further development of an attractive pricing policy, the promotion of combinations between railway and other soft transport modes through specific

[8] This goal achievement will be checked in order to be able to balance the PAM impacts

investments (parking spaces for cars and bicycles with safety cameras, lighting…) and awareness raising campaigns.

The SNCB mentioned following measures that have been taken:

- Measures increasing capacity,
  - 492 M6 coaches (delivery in 2002-2008) 64.000 seats
  - 305 new Desiro triple EMU's (delivery 2008-2014) 85.000 seats
  - 108 new locomotives T18. improved reliability
- Measures increasing frequency with new transportation plan in Dec 2014
- Measures increasing speed around Brussels national airport Zaventem
- Measures increasing comfort
  - New rolling stock
- Improved accessibility of information via apps/website
- Improved system of ticket selling via apps/website
- Gradual introduction of the Mobib card from 2013 on
- Improved connections with other transport modes
  - Bike parking: from 58.703 in 2007 up to 93.432 in 2015
  - Car parking: form 45.949 in 2007 up to 62.766 in 2015

The impact of measure TR-A08 (Free public transport for commuters) is assumed not to be comprised in this measure, as its impact has been estimated separately.

We remark that although some measures were taken to improve rail transport other elements deteriorate the attractiveness of using the train.

- train travel times were made longer the last years. The FPS couldn't provide general figures on it, but it is made clear from observation of for example the time tables between Ottignies and Brussels over the last years.
- After some years of improvement between 2013 and 2015 punctuality was worse in 2016 than in 2015, from 89.3% in 2015 to 86.5% in 2016 for the evaluation item "suppressed train included before neutralization". The main reason is the increase in suppressed trains. Still 1 train in 7 is not punctual and in the peak this can increase in the worst case up to 1 train in 4 on the line Brussels-Luxemburg and Mons-Liège7 (Infrabel website https://www.infrabel.be/fr/propos/chiffres-de-ponctualite).
- The foreseen investments of the investment plan 2016-2020 were reduced by 20% in 2016.

All the emission reductions are in the non-ETS sector except for the emissions due to the eventual increase in electricity production.

3.8.2 Methodology

We determine the passengerkm that were done by car previously AND that were attracted thanks to the measures described above.

We then see how much emissions were gained by making the difference between the emission per carkm and trainpkm and multiplying this difference by the number of car drivers that switched thanks to the measure.

The formula below expresses this:

ER = Ntpkm * (EFcar-EFtrain)

with

ER: emission reduction

Ntpkm: new train pkm thanks to the policy AND previously done by car

EF: emission factor

The most difficult part in the methodology is to determine the amount of passengerkm that were done by car previously AND that were attracted thanks to the measures described above (Nptkm).

Therefore, we start by subtracting the number of commuterkm attracted thanks to the TR-A08 from the total trainpkm.

For the next step we work with different scenarios. The assumptions for the scenarios are given under the assumption section.

The previous VITO report states that the increase in passengerkm corresponds to a modal shift from cars to railway on a one to one pkm basis. VITO provides however no source for this assumption.

To clarify this point, we did a literature research on the possible switch from car to rail when making rail more attractive. We provide the literature research annexed and the conclusions in the next section.

Based on the information we got, it was impossible to know how exactly the railway offer was improved. We got no resources to investigate more the impact of the different measures. The only measure that improved the quality of the railway offer in a clear and easy to estimate way was the increase in bicycle and car parking. Without clear indications on how the railway offer improved, it is impossible to determine its impact. It is important to take this into account when interpreting the results.

Another critic on the initial VITO methodology is that it takes a constant baseline over the years. It assumed that without the measure, the amount of railpkm would remain the same between 2005 and 2035. This seems unrealistic taking into account the external environment. In the absence of a clearly defined baseline, we worked with different assumptions concerning the baseline (see assumptions)

3.8.3 Conclusions of the literature research on modal shift from car to rail:

We conclude following based on the literature research:

- While improving train and PT performances, the number of train and PT passengers will increase.

- There will however be only a little part of those new passengers that were previously car drivers.
- There is nearly no evidence from real world experience, that by improving train and PT supply a modal shift from car to rail or PT takes place, except in cases with a significant improvement, much more significant than what was done in Belgium. Available evidence suggests that an attraction of 20 to 30% of car drivers among new train and PT users is a huge success (Savelberg, 2015). Car drivers for whom journey times of PT is not more than 1.5 the car journey time have most change for shifting to train.
- A cross price elasticity between train and car between 0 and 0.1 is probably realistic. This means that by a 10% price decrease of train, 1% of car users on a similar link will switch to train.
- The European BiTiBi project on improving rail services by providing cycle services found that between 40 and 70% of the new railway users would have made the journey by car in the absence of the improved rail service. (BiTiBi, 2016).
- The most effective way to reduce car use is to make it less attractive, by decreasing parking possibilities and make the PT journey time competitive with car and in parallel ensuring enough PT capacity.

Remark:

In their climate emission reporting, the Walloon region counts each extra pkm from public transport as a reduction of one carpkm. They furthermore don't take into account any rebound effect. We didn't find any evidence for this assumption in the literature research.

Price elasticities are calculated for a certain range of the demand curve, in other words for price changes of 10% to 20%. This means, conclusions on big price changes, like transport for free, should always be looked at very cautiously.

3.8.4 Main assumptions

3.8.4.1.1 Assumptions concerning policy impact

Based on the available data and literature, it is very difficult to link the increasing number of rail passengers to a modal shift from car to rail thanks to the railway policy (TR-A02). The improvement in the railway offer is too vaguely described and some factors contributed to a deterioration of the railway offer. So, it is clear that we cannot link the increase in railkm 1 to 1 to a decrease in carkm.

To take into account that uncertainty, we introduce three scenarios with different assumptions on the modal shift from car to rail and different assumptions on the base case:

High impact scenario:

70% of all increase in railpkm beyond the commuters travelling for free is there thanks to the policy. 70% of those new railway users would use the car if they couldn't use the train. These 70% are based on the most positive evaluation we found in our literature research (BiTiBi – Blue-bike, 2016). It doesn't take into account any rebound effect.
Finally, **49%** of new rail users can be taken into account for CO2 reductions

Intermediate scenario:

70% of all increase in railpkm beyond the commuters travelling for free is there thanks to the policy. 50% of those new railway users would use the car if they couldn't use the train. These 50% are based on the experience in the BiTiBi project (TML, 2017).
40% of road capacity that was made free by car users switching to rail is filled up by other car users. This is a conservative estimate especially when new car users use train in the peak. The rapport "rebound effect met impact op het milieu (Delhaye, 2013 p53)" made a literature research on this rebound effect (road capacity that is filled up again by new road users). It is unclear how these figures take into account the "natural" increase in mobility. This shows that after 3 year, between 50 and 100% of road capacity is filled up by new car users again. We choose here 40% here as we have an intermediate scenario and rebound effects are small in the very short term. In the low impact scenario, we use a higher % of rebound effect.
Finally **21%** of new rail users can be taken into account for CO2 reductions
Low impact scenario:

70% of all increase in railpkm beyond the commuters travelling for free and beyond economic growth is there thanks to the policy. Economic growth on its own increases transport demand, also rail demand. This could be considered as conservative as one can argue that without more rail capacity, this growth wouldn't be possible.
25% of those new railway users would use the car if they couldn't use the train. Literature states that 30% is an optimistic
75% of road capacity that was made free by car users switching to rail is filled up by other car users. 75% is chosen as the middle between 50 and 100% (based on rapport "rebound effect met impact op het milieu (Delhaye, 2013 p53)").
Finally **4.4%** of new rail users can be taken into account for CO2 reductions.

3.8.4.1.2 Other assumptions

We consider the growth in railpkm of 1% instead of 2% taken into account by VITO. The reason is that the observed trainpkm have been stagnating since 2011. The trainpkm without the commutingtrainkm are even decreasing since 2011, but the level is still higher than the 2005 level.

We assume an economic growth in the future equivalent to that of the past.

3.8.5 Data sources

- Past Railpkm: NMBS via FPS Mobility, Delhaye, 2016, Internalisatie van externe kosten, MIRA
- Past economic growth: EUROSTAT website, http://ec.europa.eu/eurostat/statistics-explained/index.php/File:Real_GDP_growth,_2005%E2%80%932015_(%C2%B9)_(%25_change_compared_with_the_previous_year;_%25_per_annum)_YB16.png
- Emission factors: NMBS via FPS Mobility, Delhaye, 2016, Internalisatie van externe kosten, MIRA

3.8.6 Results

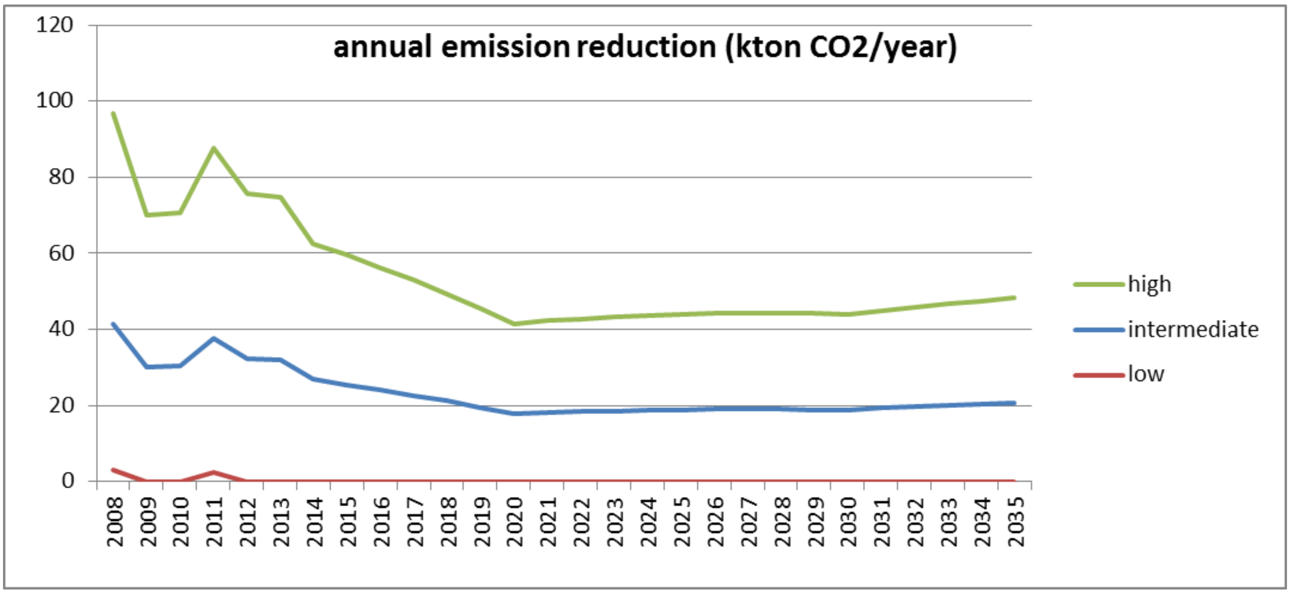


Figure 9: updated estimate of emission reduction thanks to promotion public transport

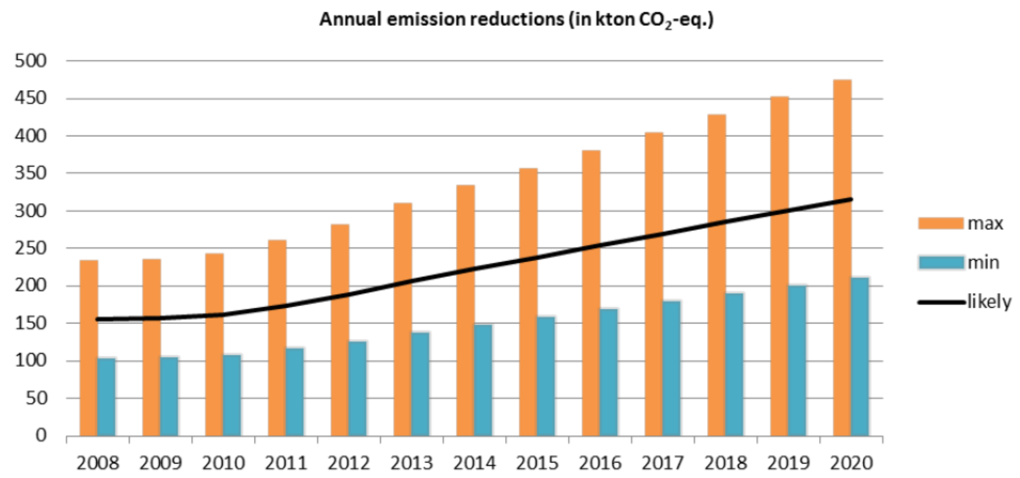


Figure 10: initial estimate of emission reductions thanks to promotion public transport

3.8.7 Discussion

As explained above, it is extremely difficult, maybe impossible to provide a good estimate of the impact of the policy.

We tried to provide an indication of what the impact of the policy could be. We remark in any case that the impact of this policy is decreasing until 2020 because since 2011, the growth in trainpkm is to be attributed completely to free public transport (TRA-08).

In other words,

- the trainkm apart from the free commuting km are decreasing since 2011.

- If the baseline would be constant for all the years equal to the trainpkm done at the start of the federal climate plan in 2008, this policy would not provide any CO2 reductions as trainkm beyond free public transport km have been lower over the whole period than the 2008 km.

It would be very interesting to know the reasons for this decrease.

In the *intermediate scenario*, the estimated impact of the policy in the early years is between 30 and 40 ktons. In 2020 the impact is reduced to less than 20 ktons. This is significantly less than the likely VITO scenario.

The *high impact scenario* has double the intermediate scenario. The main reason is that no rebound effect is taken into account.

The *low impact scenario* has no impact as the growth in rail passengers is smaller than economic growth.

Impact of bicycle parking

While trying different ways of evaluating this policy, we estimated also the impact of improved car and bicycle parking. We estimated that probably 5100 extra previous car drivers took the car thanks to this measure. This could be the equivalent of around 13 ktons of CO2.

We found this result based on evidence we found that 10% of the new bicycle parking users replace their former car journey by train. We assume the same number for users of carparking.

We counted all the new car and bike parkings as new car and bicycle parking users. This is an overestimation as not all parking spots are used.

Over the period 2007-2015 bike parking went up with 35 000 spots and car parking with 16.000 spots. We count this for 5100 extra train users that were previously car drivers in 2015, 10% of the sum of 35 000 and 16 000.

Taking into account the more general results above however, we need to assume that these extra rail users are mainly free commuters counted under TRA-08 OR that these are compensated by a decrease in other train users.

3.8.8 References

Delhaye, 2013, rebound effecten, MIRA, p53

Delhaye, 2016, Internalisatie van externe kosten, MIRA

Van Zeebroeck, 2017, Final report BiTiBi project, EC

3.9 TR-A03 : Promote the use of bicycles

3.9.1 Description

This federal measure has the following components:

* the allowance paid by employers for home-work travel by bicycle is free of tax and social security charges up to 0,15 €/km (Art. 38 of the Income Tax Code);

* home-work travel expenses for using a bicycle are deductible at the lump sum rate of 0,15 €/km (Art. 66bis of the Income Tax Code, applicable from the revenues of 2001). This rate has been raised up to 0,22€/km from 2009 and up to 0,23€/km from 2017.

* the management contract of NMBS/SNCB holding, the company committed itself to the promotion of the use of bicycles, in particular through an objective of 78 000 parking spaces for bicycles in stations, compared with 59 000 in 2008.

We estimate the impact of the bicycle free tax allowance. The impact of extra bicycle parkings is part of the TR-A02 policy.

This PAM results in a reduction of emissions in ESD sector.

3.9.2 Methodology

We work in three steps, first we obtain the extra bicyclepkm since 2005, then we calculate which part of these km are due to the policy and done by previous car drivers, then we apply the difference in emission factors.

- We want to obtain the increase in pkm travelled by bicycle since 2005.

Pkmbi =wmodSharebi_hw/wmodSharecar_hw * (hwShareintotalcar * carkmB) * Occ_car

With

Pkmbi: pkm travelled by bicycle

wmodSharebi_hw: modal share of bicycle in home work weighted for average home work bicycle

wmodSharecar_hw: modal share of car in home work weighted for average home work distance car

hwShareintotalcar: The share of home work travel in total carkm travelled in Belgium

carkmB_hw: driven km in Belgium

Occ_car: The occupancy rate of cars for home-work journeys

- From the extra pkm travelled by bicycle we estimate the part was done thanks to the measure and we estimate what part are ex car users

Pkmbi_pol = Sharepol*share_excar

With

> **Pkmbi_pol**: The extra pkm travelled by bicycle thanks to the policy (previous calculation)
>
> **Sharepol**: The share obtained thanks to the policy
>
> **Share_excar**: The share of ex-car drivers

- We apply the difference in emission factor between car and bicycle

ER = Pkmbi_pol * (EF car – EF bi)

We remark that we neglected the impact of reduced public transport use thanks to the policy.

3.9.3 Main Assumptions

The initial VITO assessment assumes that all the extra bicycle km are due to the bicycle fee free of tax (see VITO report).

There are a lot of things to say in favor of changing this assumption:

- Modal shift towards bicycle comes more often from bus than from car. Most often, cyclists are in general in only 20% of cases former car users. They are most often former public transport users or pedestrians and probably car poolers. (Van Zeebroeck-TML, 2014)
- Only a part of the people shifting from car to cycle does it because of the fee they get. In most companies paying a fee, other measures in favor of cycling are also applied. The federal diagnostic observes that companies that introduced a tax free have an increase in the share of cyclists by 1.4%, while companies doing nothing in favor of the bicycle have an increase of 1%. (diagnostic federal 2011 p52). Also diagnostic federal 2015 p33 states +34% of cyclists thanks to paying the fee. We take 35% into account.
- The part of companies providing a tax free fee is not very different in Flanders (88%) compared to Wallonia (76%) and Brussels (77%) (diagnostic federal 2015 p29), while the increase in the share of cyclists is very different in the three regions. Between 2005 and 2014, the increase in cyclists was respectively:
  - In Flanders from 12.3% to 14.9% or an increase of 21%
  - In Brussels from 1.2% to 3.0% or an increase of 148%
  - In Wallonia from 1.3% to 1.5% or an increase of 13%. The differences in the figures among regions does not proof that the assumption of attributing the increase of cyclists to the one federal is wrong. The figures enable us however to assume that other factors than the only tax free fee play their role in the increasing bicycle use.
- There is a general growth in mobility, so part of the growth in bicycle km comes from this autonomous growth.

We assume that only 35% of the increase in cycling is there thanks to the cycling allowance and that 20% of the new cyclists were previously car drivers.

3.9.4 Data sources

- historical vehkm: statbel http://statbel.fgov.be/nl/statistieken/cijfers/verkeer_vervoer/verkeer/afstand/
- impact of cycle policy in companies: FPS Mobility, Diagnostic federal 2014, 2016
- sift from car to cycle: Van Zeebroeck (TML), Fietsen in Brussel, wat brengt het op?, 2014
- emissiefactoren: Delhaye, 2016, Internalisatie van externe kosten, MIRA

3.9.5 Results

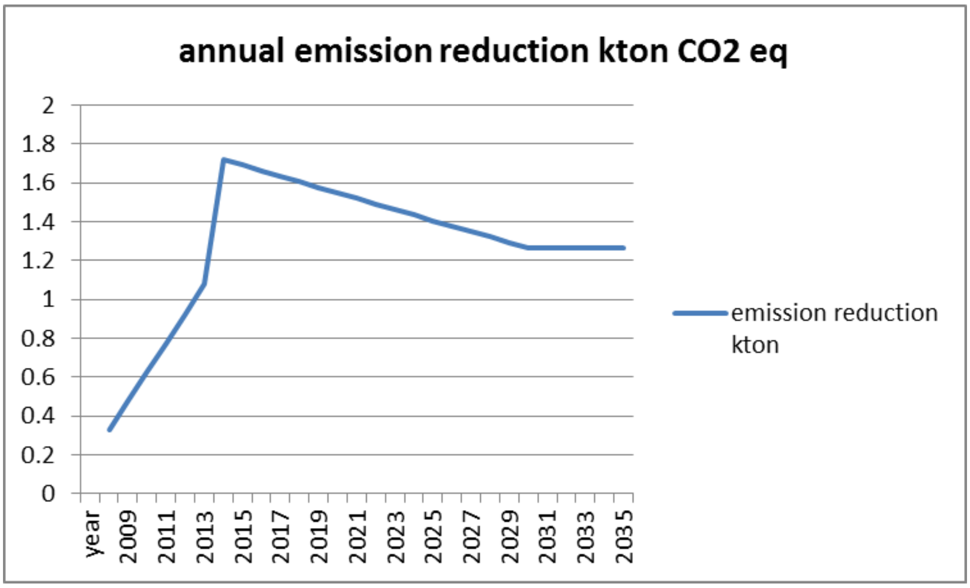


Figure 11 updated estimate of emission reduction thanks to bicycle use

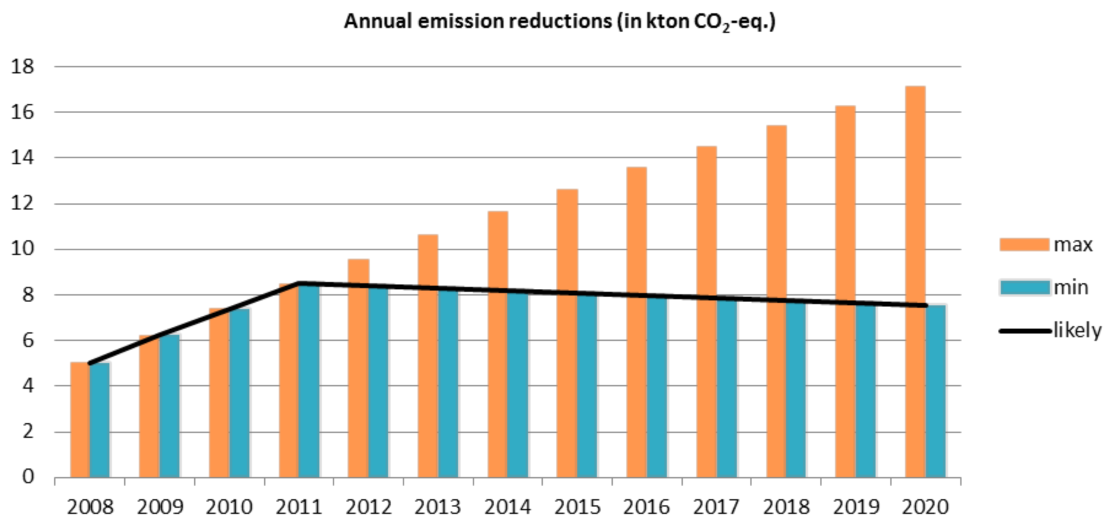


Figure 12 initial estimate of emission reduction thanks to bicycle use

3.9.6 Discussion

The updated estimate is lower than the initial due to the fact that not all bicycle kilometers can be taken into account as a result of the measure and as previous car km. The estimate is however much higher than 7% of the initial estimate. The reason is that general mobility increased much faster than foreseen in the initial estimate and that the modal share of cycling increased more rapidly than foreseen.

We remark however that the result is still an optimistic view of reality as no rebound effect was taken into account. Rebound effects are indirect effects from the policy. In modal shift policies these effects concern typically the fact that new car users are attracted when road capacity comes available thanks to car users shifting to other modes of transport. It means that the policy effect is not that large as initially expected.

3.9.7 References

- Delhaye, 2016, Internalisatie van externe kosten, MIRA
- FPS Mobility, Diagnostic federal 2014, 2016
- FPS Mobility, Diagnositic federal 2011, 2013
- Van Zeebroeck, 2014, Fietsen in Brussel, wat brengt het op?, Brussel Mobiliteit

3.10 TR-A04: Promote multimodal freight transport

3.10.1 Description

For goods, the development of multimodal platforms occurs through the improvement of river and rail transport (logistics area, infrastructure, investment...). The Federal government has supported the NAIADES programme (2006-2013) of the European Commission to promote inland navigation. This includes fiscal support for the modernization of the Belgian fleet: when selling a vessel, no taxes for capital gain have to be paid if the money is reinvested in a new vessel. For rail, internal intermodal transport (departure and arrival within Belgium) has been supported by federal subsidies from January 2005 until end 2008 (Royal Decree of 30/9/2005, later extended to end 2008). This has been extended from the 01/01/2009 (Programme-Law of 22/12/2008, chapter 3, extended to 30/6/2013 by the Programme-Law of 28/6/2013) and the Council of Ministers of 19/12/2013 has decided to prolong it to 31/12/2014. The aim was to help maintain the existing rail traffic level and to increase it by 20% over a period of three years.

Since 2014, there is also a subsidy for single wagon load transport of goods by rail. It is however very hard to see what will be the impact of this.

Based on the information we got in November 2016, the measure will very probably be prolonged until 2020. This is what we simulate below.

All the emission reductions are in the non-ETS sector except for the emissions due to the eventual increase in electricity production.

3.10.2 Methodology

We stick to the initial VITO methodology and update the ITU's based on figures form the FPS Mobility. We don't change the baseline. The subsidies are prolonged until 2020. This means the slow trend of less transport via rail is continued.

We update the figures for the years we have new data for, this means until 2015.

ER= Change ITU*t*d*(EFhdv-EFtrain)

With

Change ITU: increase in number of ITU (intermodal transport units)

t: average number of tons/ITU

d: average distance of transport

EFhdv: emission factor HDV(heavy duty vehicle)

EF train: emission factor train

3.10.3 Main assumptions

For the years 2015-2020 we take a small decrease of 5% per year into account as the competitiveness of road transport is very high. Even with the subsidy, we assume volumes will further decrease in the future by on average 5% a year until 2020.

If the subsidy stops in 2020, we assume a phase out in 2 years to the baseline level. Also the Athus-Antwerp line will however continue to decrease at a rate of 3% a year as was foreseen by VITO previously.

Concerning the measure for single wagon load in place since 2014, we are not able to take its effects into account as this asks a completely other methodology than the actual methodology. It is furthermore very difficult to estimate the impact of it. In a study, TML did for the FPS mobility, it couldn't define a precise effect (TML 2016).

3.10.4 Data sources

- personal communication with FPS Mobility
- Emission factors: VITO

3.10.5 Results

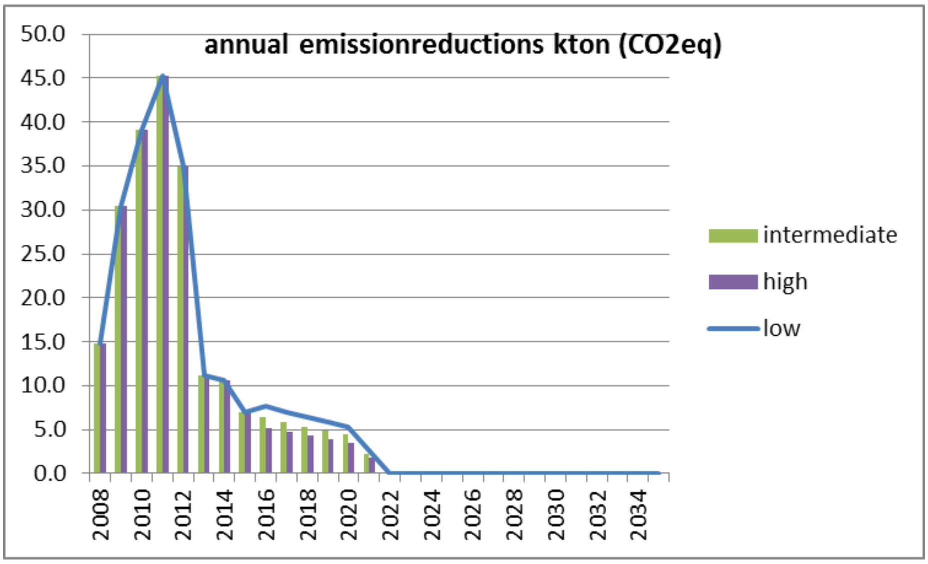


Figure 13: updated estimate of emission reduction thanks to promotion of multimodal systems for goods

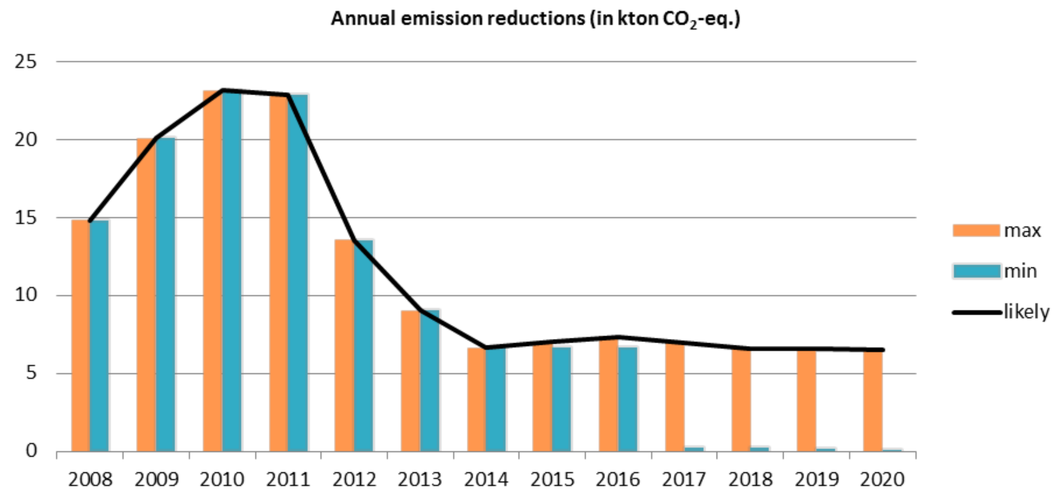


Figure 14:initial estimate of emission reduction thanks to promotion of multimodal systems for goods

3.10.6 Discussion

The updated estimate of the emission reduction is larger than in the previous assessment (VITO/Econotec, 2015) for the beginning of the period. The reason is that the updated figures we got from the FPS Mobility are higher for the years around 2010, than the initial VITO/Econotec figures.

From the information we got, it's not sure that without the subsidy the Antwerp-Zeebruges traffic would have taken place by route. (Breemersch –TML, 2016)

We remark furthermore that no rebound effect was taken into account.

3.10.7 References

Breemersch et al (TML), Studie over het “level playing field” tussen de vervoerswijzen spoorvervoer, wegvervoer en vervoer via waterwegen met betrekking tot het goederenvervoer, 2016 (vertrouwelijk rapport)

3.11 TR-A08: Free public transport for commuters

3.11.1 Description

"TR-A08 and TR-A02 are both promoting public transport. TR-A08 applies only to commuters. We have assumed that TR-A02 applies to all other passengers. Based on new available data related to the commuters the overall impact has been split between TR-A02 and TR-A08.

The federal and regional PAMs to promote modal shift encompass a series of measures like free train service for commuters, extension of the tax deduction for expenses incurred for home-work travel when using alternative transport, … To achieve free public transport by train to and from work for all employees, the Federal government has decided in 2008 to prolong the 80/20 system for private sector employees. It is still applied currently. In this system, 80% of the season ticket of the NMBS/SNCB is paid by the employer and 20% is paid by Federal government. The system of free commuting by train for employees of the Federal government has been permanently extended by a Royal Decree of 3 May 2007.

The simulation below takes into account the fact that

- the federal government pays 20% of season ticket if the employer pays 80% of the ticket
- and that the reimbursement is tax free

It is however important to keep in mind that the federal government provides also tax advantages for people using their car. The advantages are of course much more important for people using a company car.

In the future, it could be therefore interesting to take also a general look at mobility policy and to not only pick out the policies that have a positive climate impact.

All the emission reductions are reductions in the non ETS sector except for the emissions due to the eventual increase in electricity production.

3.11.2 Methodology

We estimate the commuters that wouldn’t have taken the train in the absence of the measure. Then we estimate the trainpkm they do and the emissions reduced thanks to it.

We estimate the commuters that wouldn’t have taken the train without the measure in two ways:

- We estimate the difference in generalized costs with and without the measure. We do this based on the difference in price experienced by the final user and the cross price elasticity for car use in function of train price. The cross price elasticity provides the amount of car users that become train users in function of the change in price.
- We use the result of the simulation done by the federal planning bureau estimating the impact of the measure.

The uncertainty among those estimates is very high, it is therefore important to investigate further the assumptions below.

3.11.3 Main assumptions

3.11.3.1 Assumptions for cross price elasticity methodology

For a large number of commuters, there is a third payment system. Based on the change in price this third payment system causes and the cross price elasticity, we calculate the number of new commuters thanks to the measure.

We assume the highest long term cross price elasticity of 0.2 that literature provides. This provides a higher end estimate as other literature estimates that cross price elasticity is rather close to 0.

We make a very rough estimate of the generalized price for a 40 km commuter in the table below. The generalized price takes into account the time cost and the monetary cost. Actually the monetary cost the commuter pays is 0 as the government and his employer pay the cost.

The average commuting distance for a car commuter is 20 km, but train is more competitive on longer distances, so we assume shifters to train have on average a longer commuting distance. We assume 40 km on average. Actual train users have an average commuting distance of nearly 50 km.

The upper part of the table shows the actual situation. The lower part of the table shows the situation in the case the government would no longer intervene. This means, the government doesn't pay any longer 20% of the season ticket (1.4 cent) and the amount paid by the employer is no longer tax free (2.4 cent). Without government intervention, the season ticket would increase by 12%.

Table 22: calculation of average travel cost for commuting and impact of the 20% federal subsidy.

	value	source
home work commuting distance (km)	40	OVG
first and last mile (min)	20	
average speed (km/h)	60	MIRA,2016
journey time (hour)	1.0	
value of time (EUR/h)	12.4	MIRA,2016
time cost	12.4	MIRA, 2016
monetary unit price for user/km	0.07	NMBS, MIRA 2016
monetary price	0	commuter doesn't pay
total cost (time+monetary) (EUR)	12.4	
change in situation if government stops interventions		
advantage thanks to fed gov. EUR/km	0.04	Fplanning Bureau
total cost after gov.intervention(EUR)	13.9	
increase in generalised traincost %	**12%**	
increase in fare train cost	unlimited	

When we apply the 0.2 crossprice elasticity on the approximate 12 % price decrease to the car users, it means that 2.4% of car users become train users. The difficult thing is to know on what amount of car drivers we need to apply those 2.4%. It makes no sense to apply the cross price elasticity to all car commuters in Belgium as for a large majority among those, train is not an option. We make following assumptions to determine the amount of car users we need to apply the 2.4% to:

We consider a transport market where the share of rail and car are rather close to one another. Shares that are close together mean that the transport modes have a competitive position close to one another and that switch between modes can reasonably be expected. We assume 40% rail share and 60% car share. These 60% of car users corresponds to 114 052 car users (76035 train commuters in 2005 /0.4*0.6). The increase in train commuters thanks to the measure will be 2.4 % or 2737 in 2005. This figure increases with the number of commuters.

It is clear that these assumptions are not very robust and that in future, further research via surveys and study of statistics is an absolute necessity.

3.11.3.2 Assumptions via Federal Planning Bureau estimate

The federal planning bureau working paper on commuting subsidies (Laine, 2016) estimates that without the reimbursement measure, 4.8% less pkm would be commuted by train. It is not clear whether those people would continue to commute without the subsidy or whether they would choose another mode like car or carpooling. Therefore we introduce two scenarios.

We assume that 30% of those pkm deserted from train would be done by car drivers which is an optimistic assumption if we consider literature and the diagnostic federal for home work commuting (see section 5.1). The estimate following this estimation is therefore optimistic.

Scenario FPB high

- Estimates that 70% of new rail users thanks to this policy would use the car in absence of the policy. This is an optimistic estimate (see TR-A02).
- Takes a rebound effect of 40% into account. This means that 4 out of 10 rail users that abandoned their car are replaced by another car driver. (Delhaye, 2013)

Scenario FPB low:

- Estimates that 30% of new rail users thanks to this policy would use the car in absence of the policy.
- Takes a rebound effect of 75% into account. This means that 7.5 out of 10 rail users that abandoned their car are replaced by another car driver. (Delhaye, 2013)

We know that in 2016, 56% train commuters get a third payment reimbursement (CRB, 2016). For reasons of simplicity, we assume that on average 50% of train commuters get a third payment reimbursement over the considered period. This is probably an overestimation for the first years of the measure and an underestimation for the latter years of the measure, especially for the years beyond 2020.

If

- the total amount of commuting pkm by train is reduced by 4.8% due to the suppression of the measure as the simulation of the FPB estimates (Laine, 2016),

- 50% of train commuters get the third payment reimbursement
- train commuters with third payment reimbursement do on average a similar commuting distance as train commuters without a third payment reimbursement

then the total reduction in pkm thanks to the measure is 9.8% of the trainkm done by commuters with third party reimbursement.

Concerning the future growth of commuter traffic, we adapted slightly the VITO figures. The reason is that the last years, the growth in third payment commuters increased significantly compared to what was expected a few years ago. Between 2004 and 2015, third payment commuters increased by 8%/year instead of the expected 4%. For the 2016-2020 period we assume a 4% growth instead of 3% previously and for the latter period 2020-2035 a growth of 2% instead of 2.1%.)

We adapted average daily distance from 70 to 90. On average a (one way) train journey is 50km, however we assume with increasing number of ex car users taking the train, the average train journey will shorten.

3.11.4 Data sources

People benefiting from third payment system: SNCB via FPS mobility
Emission factors: NMBS via FPS mobility and Delhaye, 2016, Internalisatie van externe kosten, MIRA

3.11.5 Results

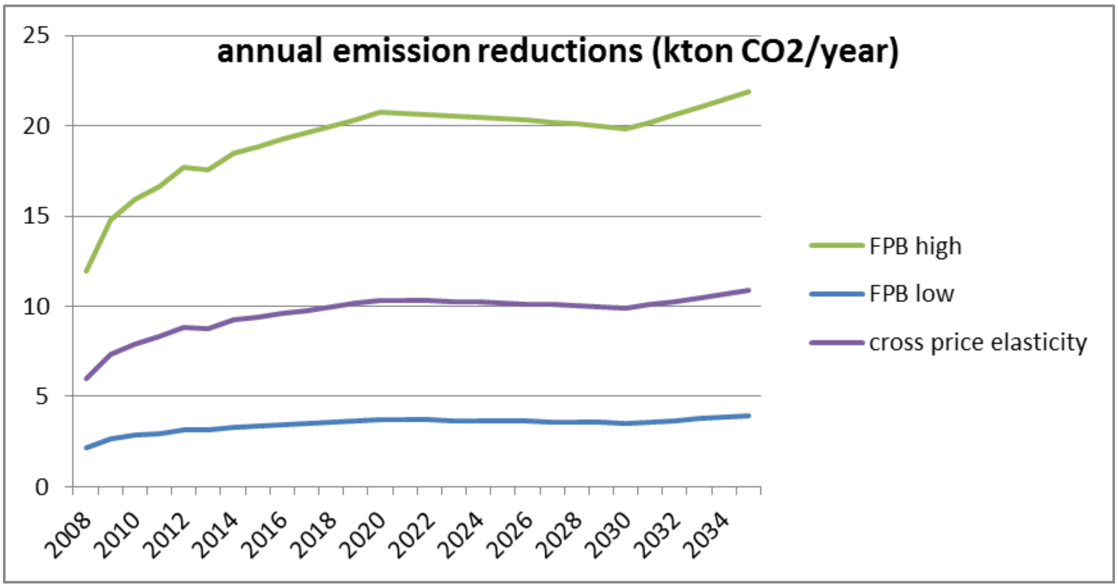


Figure 15: update of the estimated emission reductions from cheaper commuter transport

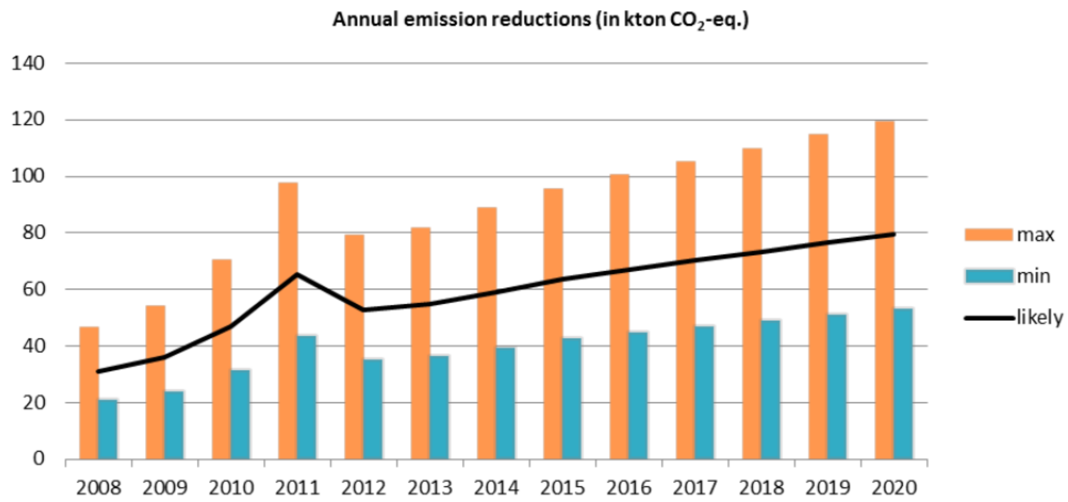


Figure 16:original estimated emission reduction by VITO

3.11.6 Discussion

In 2020, emission reductions are significantly lower in the updated figures. The updated maximum reduction is a fourth of the initial likely estimate.

The main reason for the drastic reduction in the estimate for the emission reductions is again that you cannot assume that each new commuter with a third payment arrangement was previously a car driver.

3.11.7 References

- Centrale Raad voor het Bedrijfsleven, Inventaris van de secretariaten met informatie en cijfergegevens die beschikbaar zijn om de huidige kostprijs van het woon-werkverkeer in België te berekenen, 2016
- Delhaye, 2016, Internalisatie van externe kosten, MIRA
- Delhaye, 2013, Reboundeffecten, MIRA
- Laine B, Working Paper 11-16 Commuting subsidies in Belgium, Oct 2016
- SNCB, we got an update of the number of people benefiting from the third payment system from 2009 on. For the previous years, we didn't got an update of the figures, so we used the same figures as used in the previous exercise.

3.12 TR-B01: Promotion of carpooling

3.12.1 Description

Carpooling is being supported fiscally. Home-work travel expenses for using carpooling are deductible at the lump sum rate of 0,15 €/km, up to a maximum distance of 25 km (later increased to 50 and 100 km one-way) (Art. 66bis of the Income Tax Code from 2002 - updated in Art. 38 from 2008).

This PAM results in a reduction of emissions in ESD sector.

3.12.2 Methodology

To calculate the emissions saved by carpooling we calculate the carkm saved by carpooling thanks to the measure.

- **ER = KM carpool* (EF car-EFcarpool)*Corr**

  With

  KMcarpool: Km travelled through carpooling

  EF car: emissionfactor car (occupancy 1.2, VITO estimation)

  EFcarpool: emissionfactor carpool (occupancy 2 , VITO estimation)

  Corr: correction factor TML as not all carpooling is there thanks to the measure

- **KMcarpool =Shcarpool*Workers*Distcarpool**

  With

  Shcarpool: Share of carpoolers in large companies (diagnostic fédéral)

  Workers: Number of workers (employees + civil servants, not self-employed)

  Distcarpool: Average carpool distance (VITO, probably OVG, onderzoek verplaatsingsgedrag)

The number of workers and the share of car poolers have been updated. Both were smaller than in the initial estimate.

3.12.3 Main assumptions

- VITO assumed that all carpool km were done thanks to the fiscal advantage. It will certainly have an impact, but other factors are probably also relevant. For example,
  - if an employer provides information about carpooling, the number of carpoolers is 7 times higher than without the information provision. The same is through for the provision of parking spaces for car poolers (diagnostic federal, 2015, p31)

    - since the introduction of the measure, the number of carpoolers is decreasing. It is unclear what was the situation before the introduction of the measure OR what would have been the situation without the measure.
    - It is unclear what was the previous transportation mode of carpoolers before carpooling. It is probable that part of them used public transport, a bicycle or didn't work yet.
- Therefore, we think it is not reasonable to attribute all gains of carpooling to the introduction of the fiscal measure. Based on the previous elements we introduce a correction factor of 40%. This means only 40% of the carpooling can be attributed to the fiscal measure AND were previous single car drivers. The **low scenario** assumes that 20% of car poolers are there thanks to the policy, the **high scenario** assumes 60% attributable to policy
- Another possible critic on the estimate that the number of carpoolers is decreasing since the introduction of the measure.
- We assume also that self-employed don't do carpooling as in most cases it is much more difficult for them organize.
- We have taken into account a correction factor for rebound effects of 25% as we assume carpooling takes place in places that are less congested than places where trains are an alternative. The rebound effect of 25% means that 25% of avoided carkm are replaced by other cars.

3.12.4Data sources

The share of carpoolers: diagnostic fédéral déplacement domicile travail2014, 2016.
Carpooling distance: VITO-Econotec
The number of workers: FPB via SPF emploi

- FPB perspectives économiques http://www.plan.be/databases/PVarModal.php?VC=PRFRESL2&DB=PRF&lang=fr&XT=1
- report of the comité on aging http://www.plan.be/databases/database_det.php?lang=fr&ID=33

Emission factors: Delhaye, 2016, Internalisatie van externe kosten, MIRA
Occupancy rates: VITO-econotec

3.12.5 Results

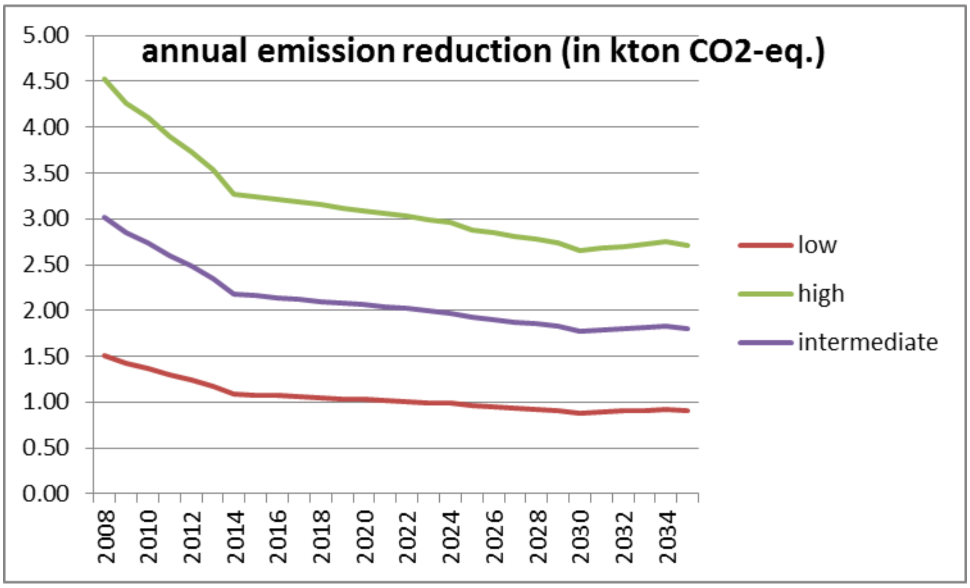


Figure 17:updated estimate of emission reductions with car-pooling policy

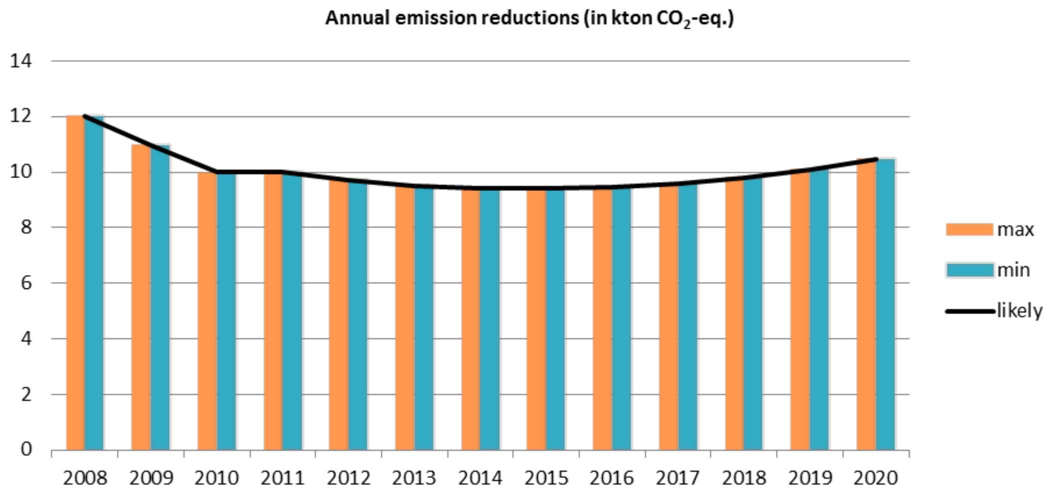


Figure 18:initial estimate of emission reductions thanks to car-pooling policy

3.12.6 Discussion

The updated estimate provides significantly lower values. The reasons are that we didn't take into account the independent workers as potential carpoolers and that the share of carpoolers is falling more rapidly than foreseen by VITO. We assume that only 40% of carpoolers were previously car drivers and changed thanks to the federal policy (intermediate scenario). Parts of these avoided cars are replaced by other cars due to the rebound effect.

3.12.7 Data sources

FPS Mobility, diagnostic fédéral déplacement domicile travail2014, 2016.
Delhaye, 2016, Internalisatie van externe kosten, MIRA

3.13 TR-B05 Eco-Driving

3.13.1 Description

This measure on eco-driving corresponds to the application of directive 2003/59/EC, on the initial qualification and periodic training of drivers of driver license categories C (trucks) and D (buses). The latter has been transposed by a Royal Decree of 4 May 2007. It consists in the inclusion of optimization of fuel consumption in the list of subjects of the qualification tests and periodic training for the Certificate of Professional Competence (CPC).

This is different from the eco driving training in the general driving course lessons. The latter is a regional competence, while the organization of the certificate of professional competence is a federal competence.

All the emission reductions are in the non-ETS sector.

3.13.2 Methodology

- Calculation of emission reductions through the following equation:

$$ER = ERrate * EChdv*EFdiesel$$

With

ERrate: eco driving emission reduction

EChdv: HDV energy consumption .

EFdiesel: CO2 diesel emission factor

- The maximum eco driving reduction is reached in 2016. The maximum level is reached gradually.
- We kept the evolution in diesel consumption constant as VITO did in the initial evaluation.

3.13.3 Main Assumptions

We keep following VITO assumptions

- Maximal reduction of eco driving is 5.8%.
- Only applicable to 40% of driven km as on motorways there will be no gains of eco driving (VITO);
- There was no effect in 2008. Between 2008 and 2016, the effect increased linearly.

We adapt the assumption on the share of drivers applying eco driving.

Although older literature is quite optimistic on the long run impact of eco driving (4 to 8% for professional category B drivers), recent literature is much more critical. To have a sustained impact over time, it seems to be important to have regular practical training, ideally combined with reminders while driving. If not, the effect fades away after a few months even if there is an incentive repeated after half a year. Theoretical eco drive training doesn't seem to be effective in any case (see literature sources below).

We therefore assume that the initial VITO estimate is the very maximum that can be obtained. A more realistic estimate is probably half and even less than this. Half means still that 35% of drivers apply eco driving.

We use as the likely estimate 50% of the initial VITO estimate. The maximum estimate is 50% higher, the minimum estimate, 50% lower.

The Eco driving competence remained a federal competence. VITO assumed previously that it would become a regional competence in 2016. Therefore, we assumed the 2016 impact will continue also over the coming years. http://mobilit.belgium.be/nl/wegverkeer/rijbewijs/wie_mag_wat_besturen/vrachtwagen_bus_autocar/vakbekwaamheid

3.13.4 Data Sources

Diesel consumption HDV: previous VITO evaluation

3.13.5 Results

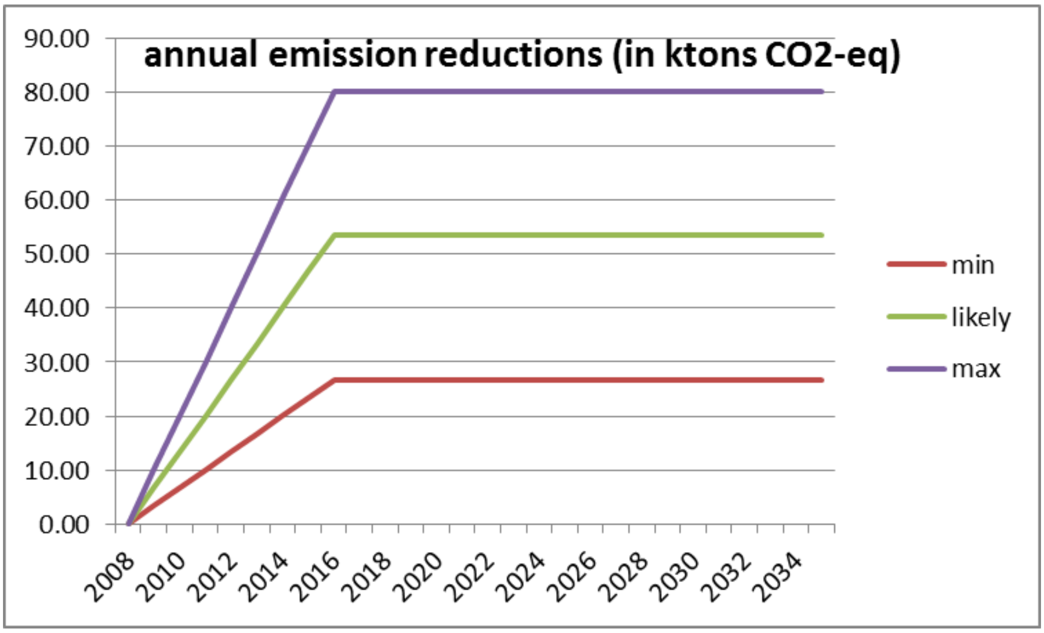


Figure 19: update of the emission reduction estimate thanks to eco driving

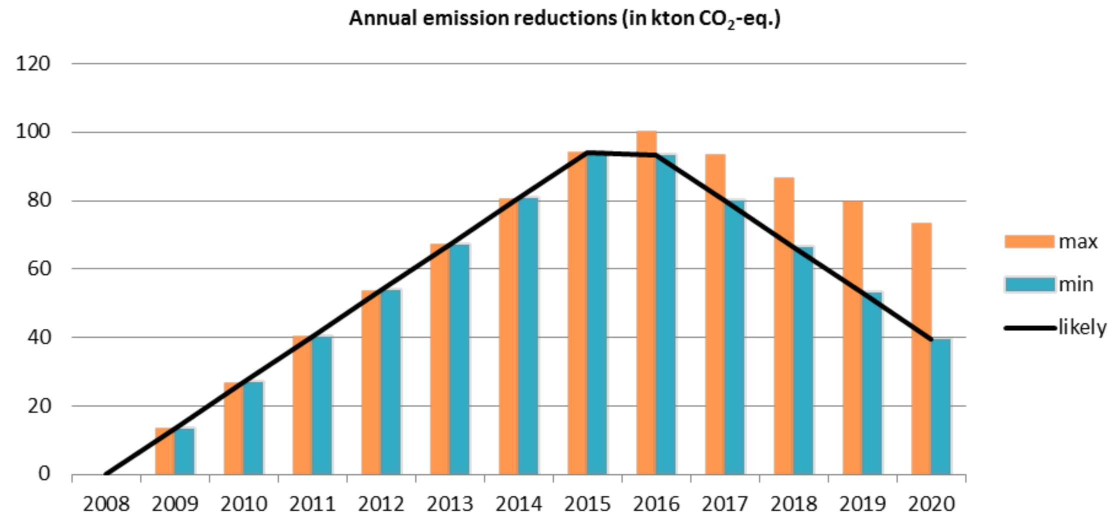


Figure 20: initial estimate of the emission reduction estimate thanks to Eco driving

3.13.6 Discussion

The update estimate takes the likely estimate from VITO Econotec as the maximum estimate and provides other likely and minimum estimates. As the policy remains federal policy, the effect continues over time. Remark that the increase in total fuel consumption was NOT taken into account in the initial methodology and we didn't change. If we would take the increasing fuel consumption into account we would have increasing emission reductions at the same rate as fuel consumption is increasing or in other words, the calculated savings would increase while in reality the CO2 emissions are increasing.

3.13.7 References

- Senternovem Referenced CIECA internal project on Eco-driving in category B driver draining & the driving test (2007). Final Report.
- Barla et al, Eco driving and fuel consumption: impact, heterogeneity and sustainability, Transport Research Board 94 th annual meeting,2014
- Lauper et al, Psychological predictors of eco-driving: A longitudinal study, Transportation research F, 2015
- Dominik L. "Do effects of theoretical training and rewards for energy-efficient behavior persist over time and interact? A natural field experiment on eco-driving in a company fleet," Energy Policy, Volume 97, Pages 291-300.2016

3.14 TR-C01: Tax deductions for the purchase of new clean vehicles

3.14.1 Description

This measure concerns private citizen cars

• From 1 January 2005 till 30 June 2007, the purchase of environmentally friendly cars was promoted via a tax advantage: for cars with a CO_2 emission of less than 115 g/km, 3% of the purchase price could be recovered via a tax reduction and for cars with a CO_2 emission of less than 105 g/km, 15% (with a maximum of 3280 €) of the purchase price could be recovered.

• From July 2007 to 31-12-2011, this tax reduction (which used to be recovered only after a long delay) has been replaced by an immediate discount on the invoice, of the same amount.

• Additionally, a tax reduction of 150 € is given since 2007 for new diesel cars equipped with a particulate filter, a CO_2 emission of less than 130 g/km and particulate emission of less than 0,005 g/km.

• The Income Tax Code 92 (Art. 145/28) allows a 30% tax reduction for the purchase of electric vehicles and battery recharge installation, from 2010 to 2012.

• For the period 2010-2035, a 15% tax reduction for the purchase of an electrical 4- or 2-cycles has been considered.

We did not take into account the adaptation in the deductibility of company cars in favor of electric cars as it does not concern private citizen cars. Taking the adaptation in the deductibility of company cars into account would go beyond a simple update of the policies.

This PAM results in a reduction of emissions in ESD sector.

3.14.2 Methodology

We did not change the methodology of VITO.

This means we calculated the emission reductions as

ER = (Nclean cars policy – Nclean cars base) *(EFb-EF)*d

With

(**Nclean cars policy – Nclean cars base**) : The difference in number of clean cars thanks to the measure (cumulative number of cars with measure minus cumulative number of cars in the baseline)

(**EFb-EF**): The difference in emission factors/km between clean cars and "normal" cars

D: average amount of km driven per year

We add a correction factor that reduces the impact by 5% as a correction for the fact that the difference between real world and theoretical emissions are bigger for “clean cars’ than for other cars (see complementary assumptions below).

3.14.3Main Assumptions

- The only measure that is still in force is the 15% tax reduction for electrical 4-or2- cycles. VITO estimated the effect too small to take into account. We didn’t investigate further this category of vehicles as it was not possible within a simple update of the measure. We assume however the impact is low taking into account the electric 4-or2 cycles actually sold. It is furthermore unclear if these vehicles replace cars or rather bicycles or public transport or carpooling.
- Vito assumed a car is used for 5 years, which is an underestimation as the average car age is 8 year and the lifetime is 18 years (conversation with SPF Mobility). It estimated however also that a car drives 20 000 km/year which is an overestimation. An average car drives between 150 and 200 000km over his life time (Delhaye, 2016). The estimated km are thus only half of the km that are driven in reality over the lifetime of the vehicle. Instead of adapting in depth the calculation method, we only adapt (double) the yearly km driven to 40.000 instead of 20 000 km. This means the impact is overestimated at the beginning of the period and underestimated at the end of the period as we assume 200 000 km (5*40 000) driven during the first 5 years, 0 km during the next years . Over the whole period however, the estimated mileage corresponds to reality.
- We assume that the number of cars registered under this policy measure didn’t evolve since the VITO evaluation.
- The baseline, however, has been re-estimated based on the EEA database of CO2 emissions for newly registered cars.
  The EEA database provides all new registered vehicles including their CO2 emissions.

  The table below provides the amount of cars in the category <105 and between 105 and 115 g. For the <105g there is a clear reduction in sales between 2011 and 2012. This is very probably due to the abolition of the measure. There has however been an exceptional increase in the sales in 2011, probably, due to announcement of the abolition of the measure. The decrease between 2011 and 2012 is therefore probably overestimated. A more “normal” registration figure for 2011 seems to us 145 000, this is 25 000 units above the 2010 figure. 25 000 units is the “normal” growth figure of that market in the years 2012-2015.

Table 23: registrations of vehicles with official CO2emissions <105 gr and between 105 and 115g (EEA, http://www.eea.europa.eu/data-and-maps/data/co2-cars-emission-11)

	<105 g	105-115g
2010	118299	64544
2011	167285	69512
2012	95422	77412
2013	121169	93263
2014	141534	
2015	166028	

We assume a normal "reduction" in sales between 2011 and 2012 of around 50 000 unit, from 145 000 to 95 000 or a relative reduction of nearly 35%. We will take this reduction as the effect of the abolition of the policy, or in other words, 35% of the vehicles sold between 2005 and 2011 have been sold thanks to the measure. For the first years 2005 – 2007, this is probably an overestimation as people got the reduction only via a reduction on their income taxes. The 35% effect is also considered as a rather high estimate by people of the FPS Sustainable mobility as lots of other factors influence car sales like the economic situation, the amount of models available,… It was not possible to take all those latter factors into account in the simple analysis.

For the vehicles in the 105-115 class, no real effect of the policy can be observed.

We limit ourselves to the effect of the <105 vehicles

- VITO didn't use real world emission factors but theoretical emissions from test cycle for its simulation. We know however that real world emissions are much higher than theoretical emissions. VITO assumed implicitly that the difference between real world emissions and test cycle emissions are similar for "clean" and "normal" cars. In that case the absolute difference between both "clean" and "normal" cars is the same for real world and test cycle.

- However, due to the fact that "clean" cars obtain the biggest reductions in emissions when driving rather slowly, while in practice, vehicles drive relatively more at higher speed than in the theoretical cycle foreseen. The Dutch research institute TNO assumed in 2010 following relation between emission factors in theory and in practice (see table below). For a diesel car with a test cycle emission of 130 g/km, the real world emission is 169g/km for a diesel car and 167 for a gasoline car.

  Based on this table we assume that for a 140 g/km test cycle emission, the real world emission is 177 g/km or 37 g/km more than the test cycle. For the "clean low level" 100g/km emission, the real world emission is 142, the difference is 42g/km.
  This means, VITO assumes an emission reduction of 40 grams where in reality the emission reduction is only 35 grams, on overestimation 5g/km or 12.5%. For the "clean middle level" clean car the difference is 4g/km less or 10%. *Table 24: Difference between standard and real world emissions depending on the standard emission value*

Normwaarde CO_2 [g/km]	Praktijk diesel [g/km]	Praktijk benzine [g/km]
160	193	188
130	169	167
100	142	142

- On the other hand, the emission factors of "normal cars" didn't decrease as fast as expected as the EF of the car park remain constant at 168 between 2008 and 2013 while VITO took into account a reduction of the emission factors of the "normal cars". We therefore assume prudently that the overestimation is only 5% instead of 10%. The correction factor could be further detailed for each year, but this is beyond the scope of this exercise.

- VITO didn't expect an increase in the increase of sales of "clean middle level cars" beyond the increase due to the measure. It would probably have been reasonable to take into account a higher increase in the baseline for the sales of these type of vehicles. We didn't do this as this would go beyond the scope of this study.

We didn't take into account any rebound effect while there is probably one as the measure makes car driving cheaper.

3.14.4 Data sources

Sold vehicles: VITO, probably FPS Finance or Mobility.
Emission factors: VITO-Econotec

3.14.5 Results

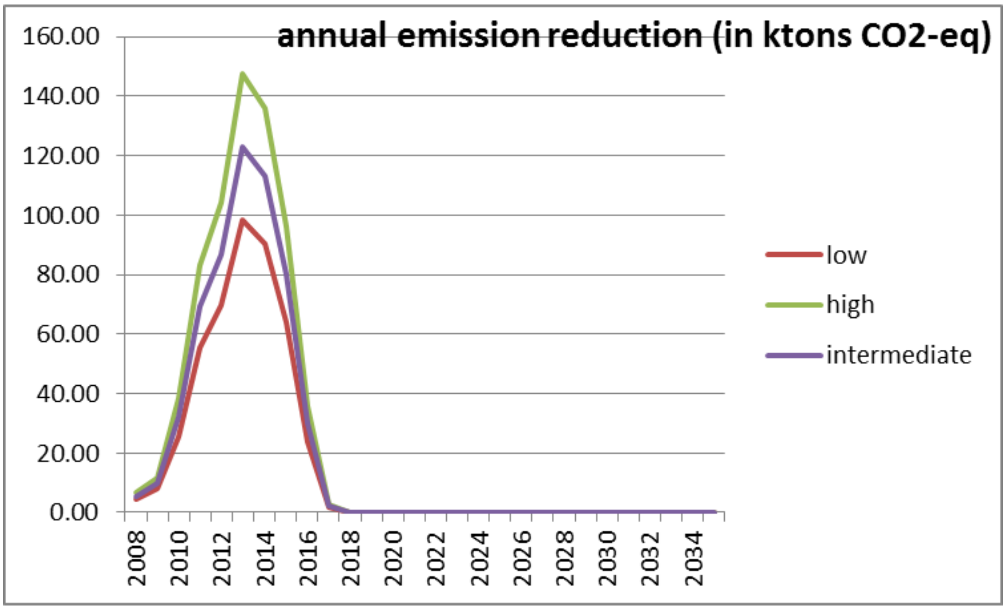


Figure 21 : update of the emission reduction estimate thanks to eco driving

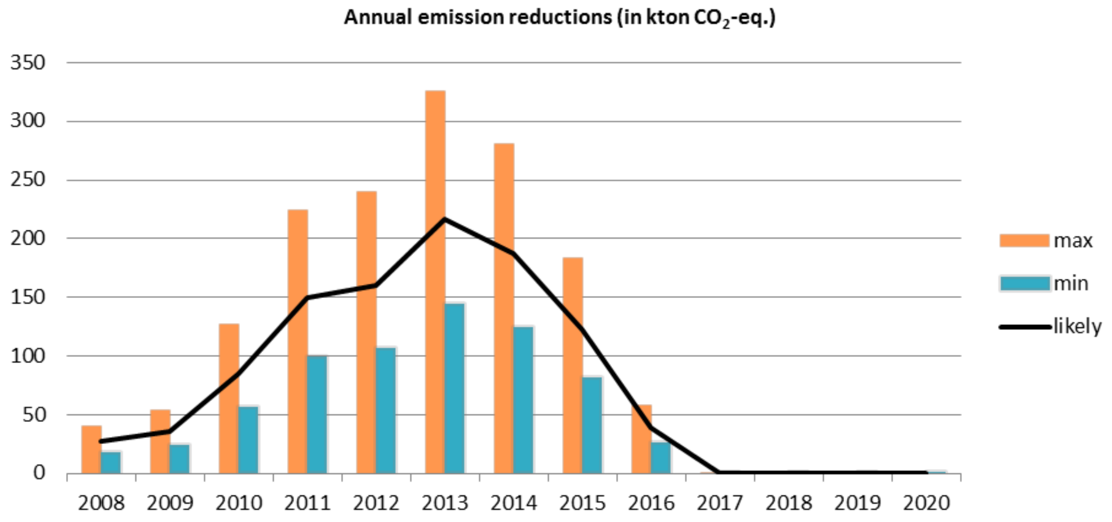


Figure 22: initial estimate of the emission reduction estimate thanks to (fiscal)l deduction for clean cars

3.14.6Discussion:

The differences between both estimates are due to an initial overestimation of the impact of the measure. Thanks to the difference in registration with the measure or without the measure in 2011 and 2012, we estimated the impact for the < 105 g vehicles. The impact was nearly only one third of the initial estimate. This was partly compensated by the increase in estimated vehkm.

The impact of both estimates is too much concentrated in the indicated period. There is also still an impact in the later years as a car lifetime is longer than the estimated 5 years. The total impact is however correct as we increased the yearly mileage.

3.14.7Data Sources:

- Ligterink (TNO), CO2 uitstoot van personenwagens in norm en praktijk – analyse van gegevens van zakelijke rijders, 2010.
- Delhaye, 2016, Internalisatie van externe kosten, MIRA

3.15 TR-D01: Promoting biofuels

3.15.1 Description

- The biofuel policy is based on following Belgian legislation:
    - Law of 17-07-2013 concerning minimal volumes of sustainable biofuels in fossil fuels. A modification of this law is in preparation with a view to achieve the 2020-goals.
    - RD (Royal Decree) 21 July 2016 on the minimal required volumes of sustainable biofuels in gasoline. It foresees 8.5 volume % of bioethanol (5.7% energy)
    - RD 26-11-2011on biofuels, which sets environmental criteria (energy efficiency, GHG balances), agriculture (use of pesticides and fertilizers), proximity (shortest distance between production biomass and production unit), etc.).
    - RD in preparation to transpose directive 2015/652

At European level, the European renewable energy directive and the European fuel quality directive set a framework for the use of biofuels. The Federal government puts a biofuel policy in place to decarbonize transport in this framework. As to the 2030 time horizon, the framework is under debate on European level.

We simulated the impact of the biofuel content of fuel as provided by the FPS Health, Food Chain Safety and Environment as we assume without policy no biofuels would have been used (precise % of assumed biofuels are provided below).

We use different scenarios to estimate the impact as explained below.

Last years, different reports critical for the environmental impacts of biofuels came out. Especially the Globium study, commissioned by the EC is very critical for the environmental impacts of biofuels and biodiesel in particular due to the impacts of indirect land use changes.

We are fully aware of the fact that life cycle greenhouse gas emissions will not have to be reported in the transport sector under the UNFCC framework. However, we think that it is important to be aware of what the impact of a biofuel policy can be on global greenhouse gas emissions.

Emissions of biofuels exist while producing biofuels, but also due to changes in land use. Changes in land use can cause extra greenhouse gas emissions. For example, if for producing biofuels, (tropical) forest needs to be destroyed or if land for food production is used for biofuel production and that food production needs new land for which (tropical) forest needs to be destroyed.

None of these direct (production) and indirect (land use change) emissions needs to be taken into account in the UNFCCC reporting for the Belgian transport sector. The land use changes take place outside Belgium, the production of biofuels can take place in Belgium or not. In the case of Belgian production it is reported in another sector, if not produced in Belgium, it is not reported by Belgium. Internationally, allocation of responsibility for reducing greenhouse gas emissions is currently based on the production-based accounting method, which measures emissions generated in the place where goods and services are produced (this approach is applied for inventory and for identification of reduction potential of PAMs). However, it is important to be aware of the impact of a biofuel policy on global greenhouse gas emissions, outside the country, this is illustrated in the section 'indirect impacts'. Considering those indirect impacts would imply using totally different accounting methods (using consumption-based approach) also for the national inventory.

We therefore add a (too) simple estimate of what the impact of the Belgian biofuel policy is when taking into account those direct and indirect emissions. However far from perfect, this estimate will provide a global view [closer to reality than the official reporting].

This PAM results in a reduction of emissions in ESD sector.

3.15.2Methodology

Formula:

$$ER= C_g *(EF_g-EF_{bg}) * B_g + C_d*(EF_d-EF_{bd})*B_d$$

With

C_g	gasoline consumption (PJ)
C_d	diesel consumption (PJ)
EF_g	CO_2 emission factor of gasoline (kt/PJ)
EF_d	CO_2 emission factor of d) diesel oil (kt/PJ)
EF_{bg}	CO2 emissionfactor of biofuel replacing gasoline (kt/PJ)
EF_{bd}	CO2 emissionfactor of biofuel replacing diesel (kt/PJ)
b_g	biofuel content of Gasoline (energy share)
b_d	biofuel content of Diesel oil (energy share)

The formula shows that the emission reduction thanks to biofuels is the share of biofuels in the fuels for transportation multiplied by the difference in GHG emissions per unit (EF or emission factor). The emission factor for biofuels is 0 under the UNFCCC framework but is different from in the real world, due to production and land use change emissions.

We start from total energy consumption in the transport sector and make a division between diesel and gasoline. The energy consumption is updated based on figures from the Federal Planning Bureau as shown in the table below. We took the federal figures concerning the fuel sales rather than the regional energy balances because the figures VITO used were closest to these figures. For the future, we used also figures from the federal planning bureau, based on the EC REF2016 scenario.

The federal planning bureau estimates approximately 15% of gasoline and 85% of diesel use in the transport sector.

Table 25: Energy use in transport sector as provided by federal planning bureau (past and future)

Road transport fuel consumption (TJ)			
		Gasoline	Diesel
2000		100800	222737
2001		98151	236594
2002		93706	241613
2003		94514	248777
2004		85175	270484
2005		77542	265766
2006		64207	270871
2007		61019	276616
2008		63504	306266
2009		60802	305395
2010		54982	314528
2011		55441	311071
2012		51759	288150
2013		51939	284620
2014		51206	286283
2015		50473	287945
2016		49740	289608
2017		49007	291270
2018		48274	292933
2019		47541	294595
2020		46808	296258
2021		46632	296476
2022		46456	296693
2023		46281	296911
2024		46105	297129
2025		45929	297347
2026		46340	298611
2027		46750	299875
2028		47160	301140
2029		47570	302404
2030		47981	303669
2031		47981	303669
2032		47981	303669
2033		47981	303669
2034		47981	303669
2035		47981	303669
source		**Federal Planning**	

To estimate the impact of biofuels, we apply the share (energy%) of biofuels present in diesel (biodiesel) and gasoline (ethanol) to the total energy consumption.

From this biofuel share, we estimate the GHG emission gain. This is the difference between the emissions of the biofuels burnt and the emissions of the fossil fuels that would have been burnt if no biofuels had been burnt.

- For three scenarios we calculate the GHG emission reduction for reporting under the UNFCCC framework as well as the greenhouse gas emission reduction when taking into account the real life cycles GHG emissions. The scenarios are defined taking into account the goals to achieve as set in the relevant directives and the proposal of the European Commission for recasting the RED. As to achieve the 2020-goals, federal legislation is in preparation.

- Scenario 1:
  - 2020: 7,0%en of first generation biofuels
  - 2030: 7,2%en of biofuels of which 3,4% BB_{2G}
- Scenario 2: (most likely)
  - 2020: 7,75%en of biofuels of which 0,75% BB_{2G}
  - 2030: 10,6%en of biofuels of which 6,8% BB_{2G}
- Scenario 3:
  - 2020: 10,0%en of biofuels of which 1,5% BB_{2G}
  - 2030: 14,0%en of biofuels of which 10,2% BB_{2G}

Scenario 2 is considered the most likely scenario.

Second generation biofuels (BB_{2G}) are not made from food crops but from lignocellulosic biomass or waste vegetal or animal oil. Their negative environmental impact is much lower than that of first generation biofuels.

The table below shows the biofuel shares taken into account for the different years. For the 2008-2014 years, the shares are the observed shares. For the years 2015-2020, these are assumed shares. Concerning the distribution between bioethanol and biodiesel:

- In 2020 the energy share of bioethanol is 5.7%. The biodiesel share is chosen to reach the average biofuel share indicated in the table below.
- In 2030 the bioethanol and biodiesel share are equal.
- In the period between 2020 and 2030 the bioethanol share is linearly interpolated between the 2020 and 2030 value.
- The shares of second generation biofuels are linearly interpolated between 2020 and 2030. After 2030 these are kept constant.

3.15.3 Main assumptions

The main assumptions we make concern

- the shares of biofuels from 2015 on are based on estimations by FPS Economy and FPS Health, Food Chain Safety and Environment. The table below illustrates these.
- The figures we use for energy use for the years beyond 2030, we assume same figure as for 2030. The FPB doesn't provide figures beyond 2030
- The iLUC emissions as provided by the Globiumstudy increasing from 0 in 2008 to their value in 2020. The Globium study models the iLUC impacts of EU policy around 2020 taking into account the additional biofuels produced since 2008 in EU and the rest of the world. We assume therefore, these iLUC will appear completely in 2020 as a consequence of the EU policy (and other countries policies). We assume that in previous years, the iLUC changes were lower as less biofuels were produced and competition for land was less strong. We assumed the LUC emissions 0 in 2008 increasing up to the results of the Globiumstudy in 2020. This is probably a conservative estimate as probably already in 2008 LUC emissions were present.

Table 26: Energy shares of biofuels as provided/assumed by FPS (2008-2014 real world shares – 2014-2035 assumed shares)

year	scen1	scen2	scen3
2008	1.2%	1.2%	1.2%
2009	3.7%	3.7%	3.7%
2010	4.2%	4.2%	4.2%
2011	4.1%	4.1%	4.1%
2012	4.2%	4.2%	4.2%
2013	4.2%	4.2%	4.2%
2014	5.0%	5.0%	5.0%
2015	5.3%	5.3%	5.3%
2016	5.4%	5.4%	5.4%
2017	5.5%	5.5%	5.5%
2018	5.5%	5.5%	5.5%
2019	5.5%	5.5%	5.5%
2020	7.0%	7.8%	10.0%
2021	7.0%	7.8%	10.4%
2022	7.0%	7.8%	10.8%
2023	7.1%	7.8%	11.2%
2024	7.1%	7.8%	11.6%
2025	7.1%	7.9%	12.0%
2026	7.1%	7.9%	12.4%
2027	7.1%	7.9%	12.8%
2028	7.2%	7.9%	13.2%
2029	7.2%	7.9%	13.6%
2030	7.2%	10.6%	14.0%
2031	7.2%	10.6%	14.0%
2032	7.2%	10.6%	14.0%
2033	7.2%	10.6%	14.0%
2034	7.2%	10.6%	14.0%
2035	7.2%	10.6%	14.0%

3.15.4 Data sources

Life cycle emissions:

- gasoline and diesel: fuel quality directive (Directive 2015/652 20-04-2015 p35 and following.
- Production and transportation of biofuels: renewable energy directive (RED) (Directive 2009/28/EC 23-04-2009 p58 and following)
- second generation biofuels: renewable energy directive and Globium study (Ecofys, 2015)
- ILUC emissions: the Globium study ((indirect)Land use change impact of biofuels consumed in the EU, study for EC, Ecofys, 2015)

For the biofuel components:

- actual biofuel mix: FPS Economy, DG Energy and FPS Environment

Energy use until 2030:

- Federal Planning bureau (personal communication)

Emission factors car:

- Delhaye, 2016, Internalisatie van externe kosten, MIRA

3.15.5Results

Results of the UNFCC scenario's (a-scenarios)

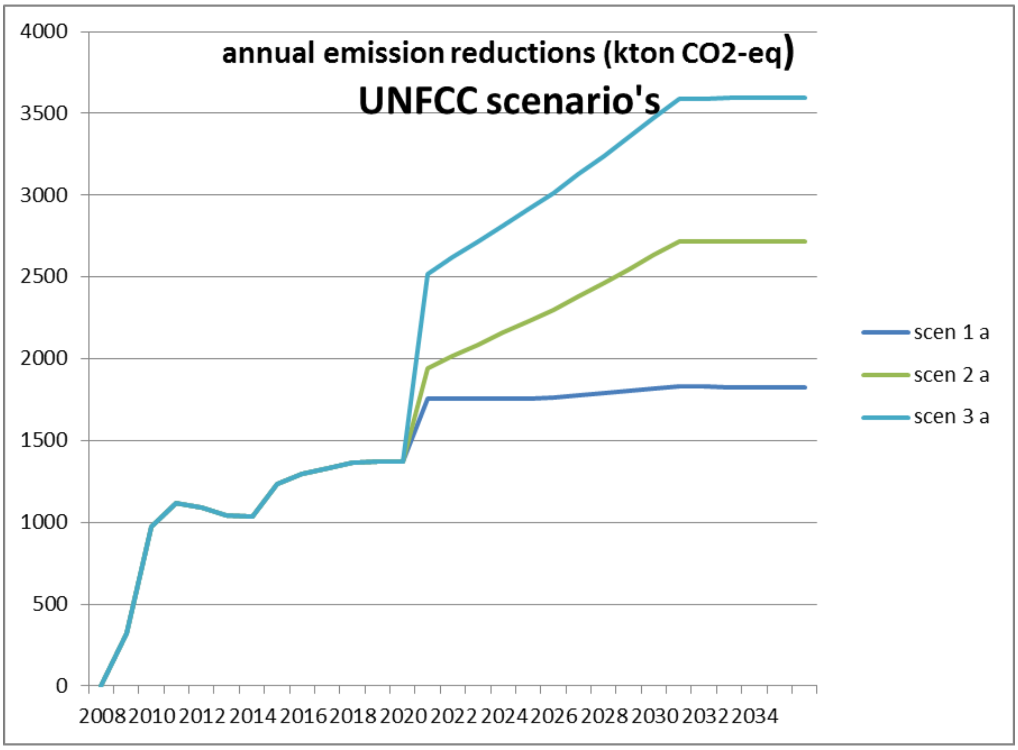


Figure 23: annual emission reductions thanks to biofuels (UNFCC scenario's)

Table 27: overview of emission reduction in kton for UNFCC scenario's

year	scen 1 a UNFCC 7% in 2020 7.2% in 2030	scen 2 a UNFCC 7.75% - 2020 10.6% - 2030	scen 3 a UNFCC 10%-2020 14%2030
2008	321	321	**321**
2009	972	972	**972**
2010	1117	1117	**1117**
2011	1088	1088	**1088**
2012	1042	1042	**1042**
2013	1036	1036	**1036**
2014	1235	1235	**1235**
2015	1299	1299	**1299**
2016	1333	1333	**1333**
2017	1366	1366	**1366**
2018	1370	1370	**1370**
2019	1374	1374	**1374**
2020	1753	1945	**2519**
2021	1753	2016	**2619**
2022	1755	2088	**2718**
2023	1757	2159	**2817**
2024	1760	2229	**2915**
2025	1764	2300	**3013**
2026	1776	2382	**3127**
2027	1789	2465	**3242**
2028	1802	2548	**3357**
2029	1816	2632	**3474**
2030	1830	2717	**3591**
2031	1829	2717	**3592**
2032	1828	2718	**3593**
2033	1827	2719	**3595**
2034	1826	2720	**3596**
2035	1825	2720	**3597**

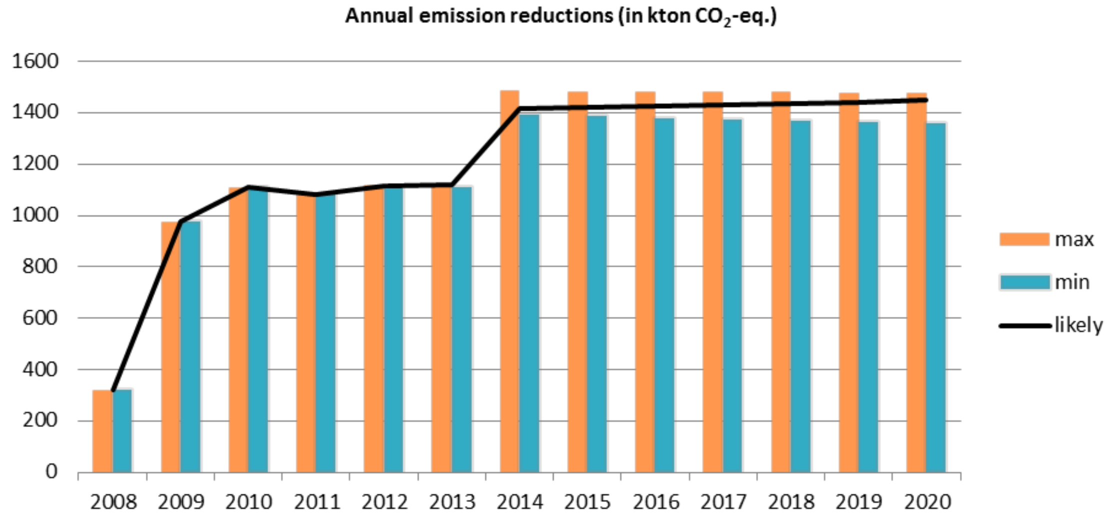


Figure 24: initial estimate of annual emission reductions thanks to biofuels

Results of the world impact scenarios (b-scenarios)

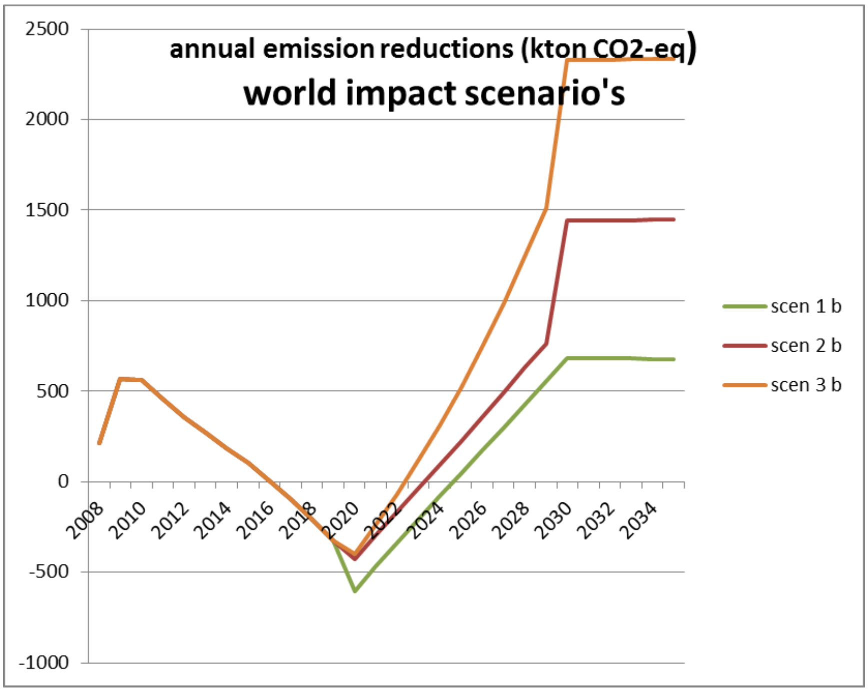


Figure 25:annual emission reductions thanks to biofuels (world impact scenarios)

Table 28: overview of emission reduction in kton for world impact scenario's

year	scen 1 b world impact 7% in 2020 7.2% in 2030	scen 2 b world impact 7.75% - 2020 10.6% - 2030	scen 3 b world impact 10%-2020 14%2030
2008	214	214	214
2009	570	570	570
2010	562	562	562
2011	460	460	460
2012	354	354	354
2013	268	268	268
2014	184	184	184
2015	104	104	104
2016	7	7	7
2017	-95	-95	-95
2018	-210	-210	-210
2019	-326	-326	-326
2020	-605	-428	-398
2021	-471	-298	-239
2022	-339	-167	-67
2023	-209	-37	117
2024	-81	93	313
2025	45	224	521
2026	172	357	747
2027	299	492	987
2028	426	627	1243
2029	553	765	1513
2030	680	1444	2330
2031	680	1444	2331
2032	679	1445	2332
2033	679	1445	2333
2034	679	1446	2334
2035	679	1446	2334

3.15.6 Discussion

In the classical UNFCC reporting approach, the gains are important, and in the same order of magnitude as in the previous assessment (VITO/Econotec, 2015) except for the year 2020 and beyond. VITO/Econotec estimate assumed significantly less biofuels from 2020 on, slightly more than 5.5% while the actual exercise assumes at least 7%. This is due to the evolution of the legal European framework.

In 2020 the gains for the scenarios are respectively 1753, 1945 and 2519 ktons of CO2. The differences are due to the different assumed shares of biofuels.

The world impact scenarios start from the same assumptions concerning biofuel shares as the UNFCC scenarios. Those world impact scenarios take however also the indirect emissions (production and land use change) into account. Those take most of the time place in other parts of the world and other sectors and are not part of the Belgian transport emissions. These emissions are however present and contribute to climate change. Therefore it is interesting to have a look at those results.

The figure above shows that the world impact of biofuels is significantly lower than what the UNFCC reporting shows.

In 2020, CO2 reductions are negative between 400 and 600 ktons. This means that the biofuel policy increases the emissions of CO2 instead of reducing it. The UNFCC reporting reports a reduction between 1700 and 2500 ktons.

Only when second generation biofuels are used, we observe a reduction in CO2 emissions. In 2030 reductions are between 680 and 2330 ktons of CO2 which is significantly less than the 1800 to 3500 ktons of CO2 in the UNFCC scenarios.

The scenarios make it clear that first generation biofuels increase global climate emissions while second generation will probably have a positive climate impact. The impact of second generation biofuels need however to be closely monitored as few practical experience on large scale production of second generation biofuels is actually available.

3.15.7 References

Delhaye, 2016, Internalisatie van externe kosten, MIRA
Ecofys, 2015, (indirect)Land use change impact of biofuels consumed in the EU, EC

3.16 OB-C02: Stimulation of alternative modes of transport

3.16.1 Description

All Federal employees benefit from free public transport, to and from work. Some federal public services have a bicycle park for employees to cover small distances. New buildings are preferentially built or bought near railway stations.

This PAM results in a reduction of emissions in ESD sector.

3.16.2 Methodology and Assumptions

The methodology to calculate the annual emission reduction of this measured was not adapted compared to the previous evaluation.

The annual emission reduction is calculated by multiplying the extra number of km done by public transport with the difference in the emissions per km by PT and car. A formula can express this as follows:

$$ER = \mathbf{NP \times D \times WD \times (EFpt - EFcar)}$$

With:

D: Average distance to and from work (km)

WD: Average annual work days per year

NP: Increase in number of passengers with tram, bus or metro

EF: Emission factor of public transport (pt) (average for bus, tram, metro) and car (g/km)

Employees using train to commute to work are included under measure TR-A08. Therefore we only focus for this measure on public civil servants using other modes of public transport, i.e. tram, metro and bus. The average distance to and from work is based on the average distance in Brussels, 10 km We assume that most federal civil servants using public transport (except train) will live in Brussels and closely around Brussels.

3.16.3 Data sources

All sources are similar to VITO

3.16.4Results

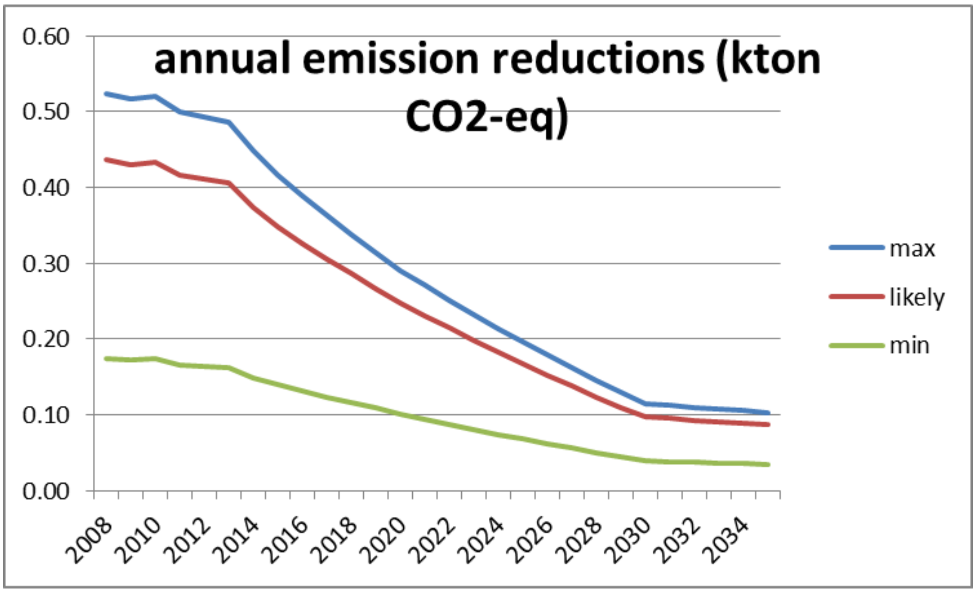


Figure 26:estimate of annual emission reductions from promotion of Public Transport among federal civil servants (ktons)

3.16.5 Discussion

The results are exactly the same as those of the previous assessment (VITO/Econotec, 2015) as we didn't adapt methodology nor inputs. The emission reduction is due to the fact that the emissions of public transport are not decreasing. This is probably a too conservative estimate and emission reductions could be higher than the estimated ones.

However other factors overestimate the impact of the measure. The methodology assumes that each new user of public transport was a car user before. This is a strong overestimation as literature states that individual car use and public transport are generally bad substitutes. There are furthermore rebound effects that attract new car users as soon as road capacity is made free by disappearing car users.

The calculation from the previous assessment (VITO/Econotec, 2015) doesn't counts with real world emissions. If real world emissions would have been taken into account, the effect would have been more important, but still marginal.

All these effects have not been investigated in detail for this measure as its impacts is very marginal.

3.16.6 References

All references are similar to VITO

3.17 OB-C04 Teleworking for federal civil servants

3.17.1 Description

In a Royal Decree (November 2008) teleworking is allowed for Federal civil servants. A number of federal public services have introduced teleworking for their employees.

The previous assessment (VITO/Econotec, 2015) allocated part of the gains to ETS (rail emissions) and another part to non-ETS (car emissions). We didn't follow this methodology as the emissions are extremely marginal and it was not done for previous measures like the promotion of public transport (train) or the free public transport for commuters. Therefore this PAM results in a reduction of emissions in ESD sector.

3.17.2 Methodology and Main Assumptions

The annual emission reduction is calculated by calculating the avoided travel distance by car by the teleworkers. Therefore average distance, number of teleworkers, number of teleworking days and the average emission factor of a car are multiplied. This can be expressed by the following formula:

$$\mathrm{EF} = T \times D \times DD \times EFcar$$

With:

T: Number of teleworkers
D: Average distance to and from work (km)
DD: Average number of days teleworking per year
EFcar: Average emission factor of a car (kg/km)

According to the National Climate Plan, 400 civil servants were teleworking in 2008. The Fedweb website (http://www.pdata.be/) also report number of teleworkers and this showed that this number has increased to an average of 4644 in 2013 and 19678 in 2016. For the period 2017-2020 we assumed two scenarios:

- a minimum scenario where number of teleworkers remain constant at the 2016 level.
- a likely scenario taking into account an average number of teleworkers (between min. and max.)
- a maximum scenario where the number of teleworkers increases further following linear extrapolation, with a maximum of 35% of total federal civil servants.

Based on data of http://www.pdata.be/ we also could calculate the average number of days per week that employees worked from home. This was 1,33 days in 2013. For the period 2014-2020 we used the average over the years 2011-2013.

Teleworkers traditionally live far from work so we assume that they commute either by car (20%) or by train (80%) and not by other public transport (i.e. bus, tram or metro) or bicycle. Following a study of Verbeke et al. (Verbeke, 2006) the average distance teleworkers commute is 51 km per day.

However 2 crucial indirect effects have not been taken into account:

- The increased energy consumption in private houses
- The filling up of freed (mainly car) capacity on the roads by new users

A 2013 study estimates that the positive environmental effect taking into account rebound effects of teleworking is limited. From an energy consumption point of view there would nearly be no reduction. However, as the greenhouse gas intensity of energy sources in transport and house or office heating is lower for the latter, there will remain a positive effect on greenhouse gases. The study expects that 25% of the initial greenhouse gas reduction will remain. Remark that a shift to other transport fuels (gas, electricity) will reduce the 25%. Also on other pollutants like fine dust, there will remain a positive impact from teleworking. But also here, a shift towards more wood burning in housing will reduce that positive effect (Delhaye, 2013).

3.17.3Data sources:

Teleworkers in federal administration: http://www.pdata.be/

3.17.4Results

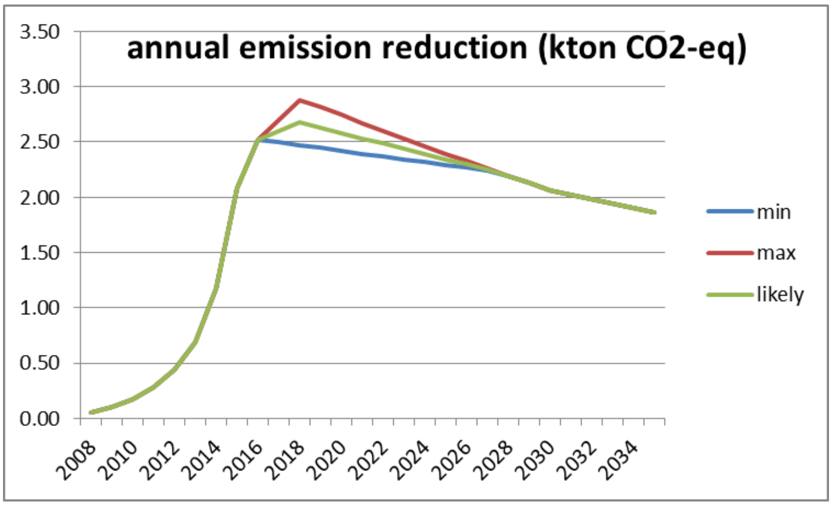


Figure 27: estimate of annual emission reductions thanks to teleworking

3.17.5Discussion

The result is slightly higher than the previous assessment (VITO/Econotec, 2015) as there are and will be more teleworkers in the federal administrations. The reduction in gains is due to the decrease in federal civil servants and to a reduction in the average car emission factor.

The fact that min, max and likely scenario are similar from 2026 on is due to the fact that there is a limit at 35% of teleworkers in the federal administration.
The figure takes only the reduction in transport thanks to teleworking into account. It doesn't take into account the fact that extra heating of houses is needed and that part of the freed (road) capacity is filled up again by other users. We remark however that due these types of indirect effects, the effect on energy use is probably zero or very close to zero. The impact on greenhouse gas emissions will remain positive, estimated at 25% (Delhaye; 2013) as the greenhouse gas intensity of heating fuels is lower than that of transport fuels.

We remark furthermore that we didn't update the emission factors to real world emissions. An update would increase the impact.

3.17.6 References

Verbeke, "De impact van telewerken op de verkeersexternaliteiten in Vlaanderen," VUB, 2006.
Delhaye, 2013, Reboundeffecten, MIRA

3.18 OB-C07: energy efficient cars for federal public services

3.18.1 Description

In 2004, environmental criteria were included in the purchase specifications of vehicles for Federal institutions (including Federal civil services, federal public and scientific organizations). This was put forward in a circular letter, which stipulates that 50% of vehicle fleet must be conforming the environmental specifications. In February 2008 a revision of the circular letter was requested. The circular letter has been again revised on 21 April 2017. It requests that 5% of cars bought or leased or electric, hybrid or CNG and 10% of cars bought and leased have an ecoscore of 75. Those percentages are increased by 5% each year. This buying policy needs to be followed until, 25% of the vehicle fleet has an ecoscore of 75 or more and 25% the vehicle fleet consists of be electric, hybrid or CNG vehicles.

This PAM results in a reduction of emissions in ESD sector.

3.18.2 Methodology and main assumptions

The same methodology as the one used in the previous assessment (VITO/Econotec, 2015) is used.

ER = **(EFcar-EFpolcar)*vkm**

With

EFcar: emissionfactor of car without policy

EFpolcar: emissionfactor of car with policy

Vkm: vehiclekm driven

This means we calculate the number of vehicles that are replaced by at the federal administration. We then calculate the difference between the more efficient car bought and the car that would have been bought in absence of the measure. This per km difference is then multiplied by the km driven by those cars. The methodology takes into account that the car remains in the park during 5 years.

The methodology takes following data into account:

- Average annual distance traveled by a car: 21505 km
- Annual number of cars replaced: 140 (VITO mentions Interdepartmental commission for sustainable development and SPPDD)

- Federal Vehicle park: 1788 vehicles of which 51% cars (cf. previous assessment VITO/Econotec, 2015)
- In 2008, already 70% of cars fulfilled guidelines
- Emission factor: VITO/Econotec assessment (2015) see below. All emission factors taken into account are theoretical emission factors, not real world emission factors.

In the previous assessment (VITO/Econotec, 2015), three emission factors were used for the calculation:

- emission factor of baseline: the theoretical average emission factor for new cars that would have been bought in absence of the policy. This equals the national fleet average.
- emission factor for max. impact: the theoretical average emission factor for cars bought with a regular further update/adjustment of the guidelines beyond the guidelines existing today
- emission factor for min. impact: the theoretical average emission factor for cars bought without a further update of guidelines.

We remark that these emission factors are theoretical emission factors and not real world emission factors. The implicit assumption behind it, is then that the difference between theoretical baseline and policy emissions are the same as the difference between real world theoretical emissions and real world policy emissions. Under policy TR-C01, we calculated that this is probably not the case and introduced a correction. However as the impact of this policy is already very small, it is not worth the effort to improve slightly the result.

Calculations are done for two scenarios:

- A likely similar to the maximum scenario based on the circular letter, without a regular further adjustment of the circular letter.
- A min scenario where the guidelines are not respected.

3.18.3 Data sources

All sources have been copied from the VITO evaluation

3.18.4 Results

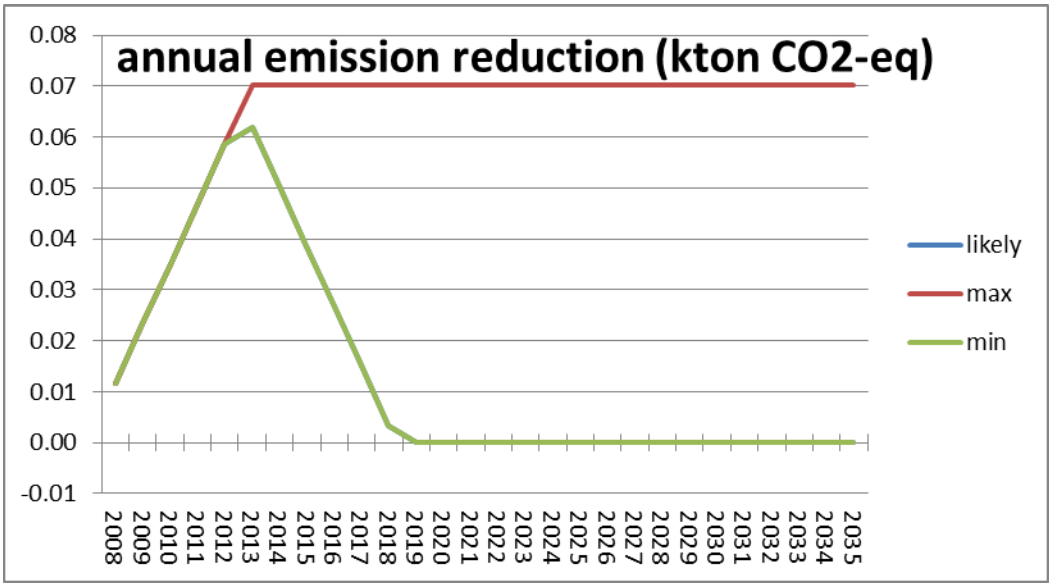


Figure 28: estimate of annual emission reduction for energy efficient cars for federal public services (kton)

3.18.5 Discussion

The figure shows the impact of the measure. The impact is marginal.

The impact of the min and likely scenario decreases from 2013 on as the guidelines are not updated/adjusted to the evolution towards cleaner cars in the car market.

The impact of the max scenario remains constant over time as the assumption is that the guidelines for buying cars are updated in a way that newly bought cars remain cleaner than the average cars that would have been bought in the absence of the policy.

We remark that the emission reduction is probably underestimated as lifetime of cars is estimated at only 5 years while in reality this is probably higher at the federal administration. As the gains are very marginal however, it is not worth adapting the calculation methodology.

3.18.6 References

All references similar to VITO evaluation.

Policies with first evaluation

Policies below got a first evaluation in the framework of this study. The structure is slightly different from the previous chapters. The reason is that we got a first evaluation and commented further on that evaluation.

3.19 TR-XXX: Advantage in kind depending on CO2 emissions for company cars

3.19.1 Description

Employees benefiting from a company car are taxed on the value of that advantage in kind. A formula determines the value of the advantage in kind in the personal income tax declaration of the employee.

On 1-01-2012, a new formula determining the advantage in kind for company cars was introduced taking into account the theoretical CO_2 emissions of the car. The previous formula didn't take into account CO_2 emissions. The reference CO_2 levels are fixed each year by royal decree. The advantage can never be below 820 EUR/year (amount for 2017 is still unknown).

The parameters of the formula are adapted each year to keep an incentive for choosing lower emission cars. The table below illustrates the calculation for the year 2017.

Table 29: formula to calculate emissions in kind (2017) with "CO2" corresponding to the official CO2 emission of car in g/km (https://finances.belgium.be/fr/particuliers/transport/voitures_de_societe)

	formula to calculate emissions in kind (2017)
Diesel	(5.5%+(CO2-87) X 0.1%) X official price X 6/7
Gasoline	(5.5%+(CO2-105) X 0.1%) X official price X 6/7
Elektricity	(4% X official price X 6/7

This PAM results in a reduction of emissions in ESD sector.

3.19.2 Methodology and main assumptions

Two important steps need to be taken to determine the impact of the measure:

- Determine the impact on the per km CO_2 emissions of newly registered company cars based on an analysis of the evolution in CO_2 emissions/km
- Determine how many km these cars drive during all their lifetime, and how many CO_2 emissions can be avoided. The latter is done via the formula :

ER = vkm*SHleg*(EFbc-EFpol)

Vkm = Total km driven by cars

SHleg = share of legal entity cars

EFbc = emission factor base case

EFpol = emission factor with policy

We detail further those steps.

Determine the impact of the measure on the per km CO2 emissions of newly registered company cars

Based on observation of the evolution in CO2 emissions of the newly registered company cars we want to see whether we observe evolutions that wouldn't have been there without the measure. We can only guess what would have been the emissions without the measure. Therefore we try to see

- how CO2 emissions of company cars evolved in other years compared to 2012, the year of introduction of the measure. We consider the period 2008 – 2016, as well years before as years beyond 2012 as we the major impact should be visible in 2012 itself.
- how CO2 emissions of non-company cars evolved in the same period to see whether company cars evolved in different way thanks to the measure between 2008 and 2016.

This exercise is however very challenging as

- different measures to orient the choice of company cars towards cleaner company cars have been taken previously:
    - From 1-01-2005, the solidarity contribution paid by the employer for providing a company car to its employee is determined depending on the theoretical CO2 emissions
    - From 1-04-2007 the deductibility for cars bought by legal persons is dependent on theoretical CO2 emissions (memento fiscal 2008 p69). From 1-01-2010 the dependency on CO2 emissions of the deductibility of cars bought by legal persons is strengthened. (Belgian national policy framework, part 5 federal level Belgium (draft),2016)
- non company cars got incentives to choose for lower emitting cars. This implies that comparison with the other category becomes difficult:

    - From 1-07-2007 the fiscal incentive for clean vehicles bought by natural persons is immediately reduced from the invoice, and not only one year later via the taxes (memento fiscal 2008 p36). This measure was abandoned on 31-12-2011, coinciding with the introduction of the measure we are investigating here.

• separate data on CO2 emissions of newly registered company cars are not available for a long enough period,

- Only from 2013 we got data for company cars, while the new measure was introduced on 1-01-2012. Therefore we use the cars of legal persons as a proxy although only approximately 1/3 of newly registered cars of legal persons are company cars.

ALL THESE ABOVE ELEMENTS ARE REASONS TO CONSIDER THIS EXERCICE WITH CAUTION

The table below illustrates the data used. The yellow years correspond to years when a measure with an objective of reducing CO2 was applied.

The first part of the table shows the evolution of the **theoretical CO2 emissions** of newly registered cars for natural persons (in g CO2/km), legal persons and company cars for the years 2013, 2014 and 2015. The company cars are part of the legal person's cars. The source for this information are the databases of the federal planning bureau.

The line "absolute evolution" shows the absolute CO2 reductions in grams/km from one year to another for legal entity cars (emissions in g/km of year x - emissions in g/km of year x+1).

The lower part of the table shows the same type of information for **real world emissions**.

Table 30: overview of theoretical emissions (FPB database) and real world emissions (ICCT factors applied) in g CO2/km

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
theoretical emissions (databases FPB)										
natural person	152.7	149.7	149.3	144.6	139.7	131.1	123.5	130.1	126.4	124.2
legal person	162.1	161.7	158.4	153.9	149.1	139.9	133.6	124.9	120.8	118.1
salary car									115.0	111.7
absolute reduction in emission legal person		0.4	3.2	4.5	4.8	9.2	6.4	8.7	4.1	2.7
real world emissions										
natural person	174.1	167.7	171.7	169.9	167.7	159.9	154.4	162.7	164.3	168.9
legal person	184.8	181.1	182.2	180.9	179.0	176.3	173.7	168.6	169.1	171.2
salary car									161.0	162.0
absolute reduction in emission legal person		3.7	-1.1	1.3	1.9	2.6	2.7	5.0	-0.5	-2.1

We estimated real world emissions based on the ICCT report From Laboratory to Road, 2015. We applied the deviation for company cars of the ICCT report to the legal person car registrations. This is for sure another exercise that needs to be considered with caution as we apply average EU deviations to Belgian figures. It's sure that those figures can be much improved. On the other hand, it is important to realize that emission reductions aren't that important as one could think. Deviations between theoretical and real world emissions are provided below.

Table 31: % difference between theoretical CO2 emissions and real world emissions as derived from the ICCT report form Laboratory to Road, 2015

difference between real world and theoretical (Laboratory to road 2015, ICCT) in %										
natural person	14	12	15	17.5	20	22	25	25	30	36
company car	14	12	15	17.5	20	26	30	35	40	45

The graphs below present the data of table 30.

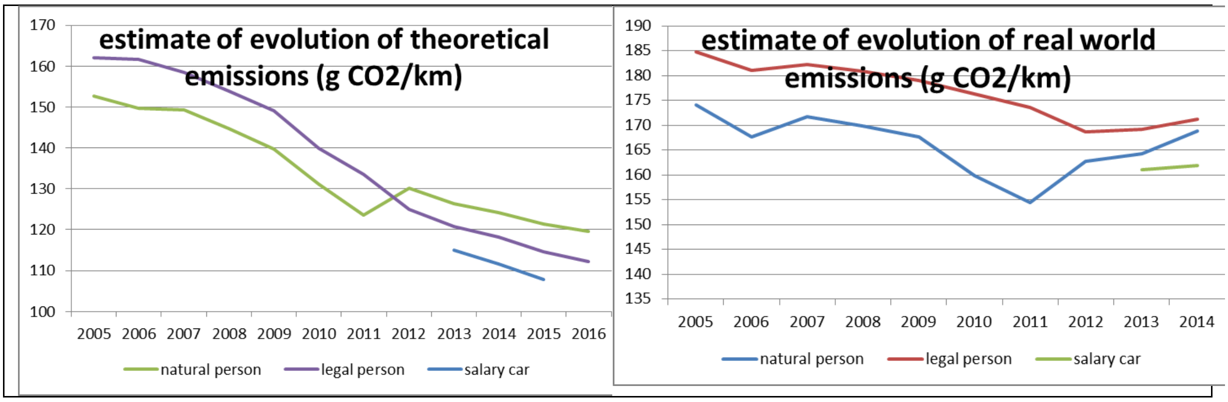


Figure 29: evolution in theoretical (left) and real world (right) CO2 emissions per km of different types of cars (g/km)

We observe clearly that real world emission reductions in CO2 per km stopped somewhere around 2011 – 2012. Natural person's cars start even to emit more than before.

The *theoretical* emissions of legal person cars are getting lower, more rapidly than that of natural person cars. In 2012, the legal person cars do even get cleaner than the natural person cars. The main reason for natural person cars to start emitting more is probably the abolition of the subsidy (tax reduction) for the purchase of a clean car for natural persons. It is also the time when the new calculation for the advantage in kind for company cars comes into place.

For the *real world* emissions, we also see that legal person and natural person cars are getting closer one to another, but natural person cars remain however cleanest. We have unfortunately no data beyond 2014 on the deviation between real world and theoretical emissions.

To estimate the impact of the new calculation method determining the advantage in kind for company cars we finally look at the average evolution in emission reduction in the years where no new measures had been taken and compare it with the emission reduction for legal cars in 2012. We do this first based on the theoretical emissions, then based on the real world emissions.

- The average theoretical emission reduction of the years 2008, 2009, 2011, 2013, 2014, 2015 and 2016 is 4.1 g CO2/km. The improvement in 2012 is 8.7 g CO2/km. This would mean that the measure "advantage in kind" is responsible for an additional reduction of 4.6 gCO2/km. (8.7-4.1 = 4.6)
- If we apply the same method for the real world emissions we arrive at a reduction of 4.3 g CO2/km.
- The estimated impact of the policy (around 4.5 g CO2/km) is very similar between the calculation based on real world emissions and the one based on theoretical emissions.

This seems to be a number that is on the high side as it means that the emissions from company cars are reduced by approximately 12.5 gCO2/km only thanks to the policy. This estimate of a 12.5 gCO2/km reduction for company cars is based on:

- the facts that company cars represent 36% of the cars registered by legal persons
- the fact that legal person cars as a whole reduce their emissions by approximately 4.5 g CO2/km.
- the assumption that the whole of this reduction can be attributed to company cars, and not to the other legal cars, as no policy is in place for these other cars.

This seems an important effect keeping in mind that the impact on the company of the new calculation of the advantage in kind is not that important. Based on some simple examples we see that the calculation of the advantage in kind comes with a value of approximately 20 EUR gross wage per gram of CO2. For 10 g CO2/km difference between cars, the advantage for the employee is then 200 EUR gross wage or 100 EUR net each year. It is strange that people let influence their choices so strongly for a 100 EUR/year they get only later.

An explanation for this high result (12.5g) is maybe that employers also encourage employees to choose for the low emitting car as it is also in their interest.

We tried to see how emission figures influences preferences for company cars of the compact middle class (C-segment). We however didn't find the data to make this exercise in sound way however. We only provide this exercise as an indication.

- We found a list of popular company cars for 2015 but unfortunately not the 2015 emissions of those cars.
- We considered as a proxy for the 2015 CO2 emissions for these cars, the today theoretical emissions. Theoretical average emissions of Renault Megane are today 98, for VW Golf, 108 and for the Peugeot 308, 96. The difference in emissions is max 12 g.
- While looking at the 2015 popular company cars we observe that the Renault Megane (13775 sales) is most popular, but the VW Golf (8193 sales) remains popular. The low emitting Peugeot 308 (4874 sales) is less popular.
- This is not what we would expect if the calculation of the advantage in kind would have a real impact.
- However, as already said above, this is a dangerous exercise as we compare emissions of 2017 with popularity figures of 2015. It could however also be an indication that the estimated impact of 12.5 g reduction thanks to the measure seems at the rather high side, as low emitting cars are not necessary more popular than high emitting cars..

IT IS CLEAR THAT TO COME UP WITH MORE ROBUST ESTIMATES, A MORE DETAILED ANALYSIS IS AN ABSOLUTE NECESSITY. THIS IS IMPOSSIBLE IN THE FRAMEWORK OF THIS STUDY.

We will take the 4.5g CO2/km gain as an upper bound of the measure and as a lower bound we take 2.5 g CO2/km but more research is necessary to confirm these figures.

Determine how these newly registered cars are used during all their lifetime

To see how the reduction of CO2 emissions of newly registered cars influences total CO2 emissions, we need to know how the km driven with these cars evolves. Therefore, we use the information on vehicle stocks and km driven used by the regions to calculate their emission inventories. We have used those data in a simplified/aggregated form. Those data are not publicly available but can be obtained from the regions.

To determine the CO2 reductions, we assume that:

- 47% of new car registrations are done by a legal persons (based on federal plan bureau data http://www.plan.be/databases/data-14-fr-base+de+donnees+transport)
- the per km reduction thanks to the measure is 4.5 g CO2/km between 2012 and 2025 for the upper bound (maximum) and 2.5g CO2/km for the lower bound (minimum) (section above).
- the impact for new cars reduced in the years after 2020. The reasons therefore are that:
    - the estimated effect seems really a the high end
    - mobility and vehicles will need to undergo strong changes in the future. We assume therefore that it will be difficult to keep similar effects of the measure if it is not profoundly adapted.

- The company cars are sold to Belgian citizens once they are too old to be a company car. This means, the emission gain of the initial company cars has an effect during the whole lifetime of the car, also when it is no longer a company car.

As there is high uncertainty in the estimates, we prefer not to come up with a likely scenario. This would only provide a wrong impression of likeliness.

3.19.3 Data sources

Average theoretical per km CO2 emissions: number of newly registered cars in each emission category with a difference between vehicles of physical persons and legal persons from the Federal planning bureau http://www.plan.be/databases/data-14-fr-base+de+donnees+transport

Difference between real world emissions and theoretical emissions: ICCT, From laboratory to road, 2015

Formula to determine advantage in kind: Memento fiscal 2016

Vehkm per vehicle age class: Vehicle stock Database for the emission calculations by the regions (available from regions)

Most popular company cars in 2015: http://www.jobat.be/nl/artikels/de-20-populairste-bedrijfswagens-van-2015/

3.19.4 Results

The figure below illustrates the results.

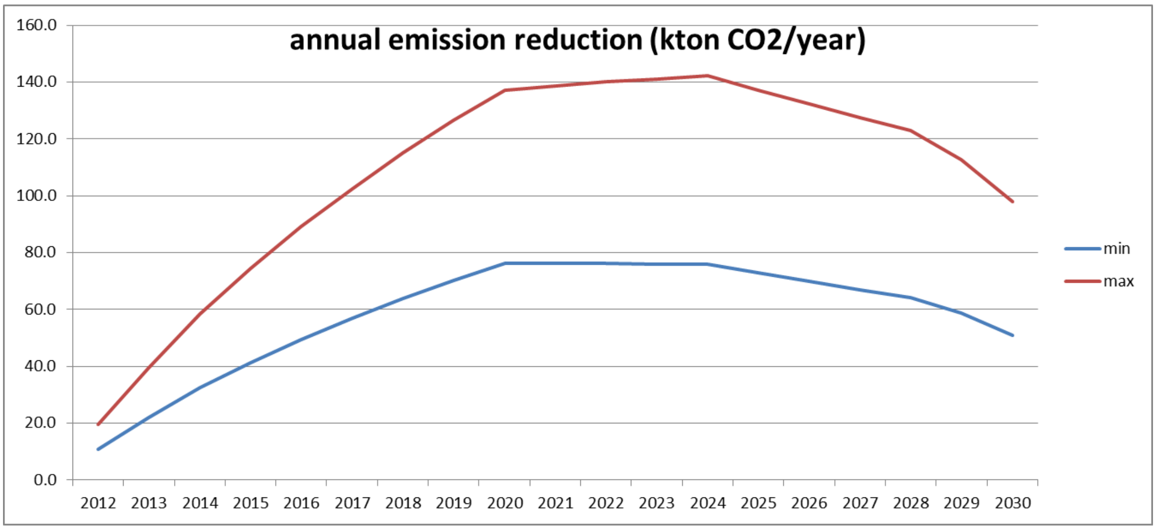


Figure 30: annual emission reductions of the adapted advantage in kind for salary cars in ktons CO2/year

3.19.5 Discussion

In 2025, the reduction reaches nearly 200 ktons in the optimistic scenario, while it is only half in the minimum scenario. From 2025 the impact is reduced as we assumed the measure will stop in 2025. Results have been calculated till 2030 as no car fleets are not readily available beyond 2030. Remark

It is very difficult to allocate precisely the reductions to one of the different measures that have been taken to make salary and company cars cleaner.

The fact that company cars drive on average more km than other cars is not taken into account here. In that sense this estimation is an underestimation of reality..

We remark also that the higher the number of km driven is, the higher will be the reduction as the reduction is proportional to the km driven.

3.19.6 Data sources

- Emissions and km driven to calculate average Federal planning bureau http://www.plan.be/databases/data-14-fr-base+de+donnees+transport
- ICCT, From laboratory to road, 2015
- Memento fiscal 2016
- http://www.jobat.be/nl/artikels/de-20-populairste-bedrijfswagens-van-2015/

3.20 APP-T01 – Positive Mobility allocation

3.20.1 Description of the PAM:

Proposed measure (currently on hold): establish a permanent system where workers whose wage package contains a company car can choose between a company car, a mobility budget, or a net salary increase.

The net salary increase will be subject to similar fiscal rules as the actual company car. The measure will be established following the principle of budget neutrality for the federal government (and the company).

This PAM results in a reduction of emissions in ESD sector.

ATTENTION: no details of the policy were available when the evaluation was made. The evaluation has to be considered as very preliminary on a measures that could be put in practice in reality with different modalities.

3.20.2 Analysis of the estimated effects

3.20.2.1 Number of actual company car owners that will abandon their company car:

The FPS estimates the number at 100 000 based on an estimate of the FPS finance. This means the measure will have a huge success as more than 1 in 4 company car owners will abandon his or her car. There is however no information at all on how this amount has been determined.

Our comments:

It is very difficult, nor impossible to evaluate this figure as no real information is available.

Available studies provide no clear indication of who many people would replace their company car by cash. Studies in general come up with the conclusion that, if they replace the company car, they will keep a car in any case.

We furthermore consulted different experts to get their opinion on which many company cars could be replaced. We got following answers:

- If people replace the company car by cash, they will in the large majority of cases keep another car, maybe smaller and/or second hand.
- Company cars are very well appreciated by Belgians:
    - It’s good value for money. As a private person you won’t be able to buy/use a private car for the same annual budget as the company car budget. Lease companies providing company cars get huge price reductions from car manufacturers, tyre manufacturers,…. that people buying a car as a private person will never be able to get.
    - It’s a nice symbol of status
    - It’s easy. You don’t need to bother about maintenance, insurance, assistance,…. Everything is arranged for you.

- Company cars are a kind of fixed advantage independent of the number of km travelled. In other words, the more km travelled, the cheaper each km driven km gets. One of the reasons is that the large majority of company cars get fuel in Belgium for free and the leasing is independent of km driven. People driving lots of km have much more to lose from replacing their company car by cash than people driving less. Therefore it is very probable that people driving less will be more eager to choose for cash to replace the company car.
- Approximately 1/3 of company cars are "real" company cars. These are cars for people that need to drive a lot for their job like sales representatives or mobile technicians for example. Those people will for sure not replace their company car.
- Last years, company cars got a boom thanks to cafeteria plans. Cafetaria plans are plans for company employees where they can customize certain of their benefits like for example extra-legal pension, more holidays, company car,…. In these plans, company cars are also very popular. For one expert, among people that opted for a company car in a cafetaria plan, chances are probably higher that they choose for replacing the company car by cash. For the other expert, it was however not sure at all. Also among the "cafeteria plan company cars", most are well appreciated by their users.
- People most eager to replace their company car are probably people where for the moment now, 2 company cars are available in the family.

Having in mind the fact that people driving less will be more keen on abandoning their company car, we tried to make an estimate on the number of company cars driving less than 15 000 km/year. We did this by combining GOCA data (technical car inspection) and div Data base on km driven during one year. The problem we have here however is that in the very large majority of cases, cars go only after 4 years to the car inspection. This is exactly the moment when most salary cars are replaced by another new salary car. So data quality for km driven by salary cars is therefore not very good and the number of km driven is therefore largely underestimated, we assume an underestimation of nearly 50%. The average km driven of the company cars studied is only 17 000km, nearly half the average of all company cars.

This analysis comes up with a figure of 30 to 40% of company cars driving 15 000 km or less. As we know the km driven is largely underestimated, we assume that in reality 10 to 20% of company cars drive 15 000 km or less. We assume furthermore that people using these company cars least will be most eager to replace the company car by cash.

In an absolute optimistic case, we assume that all those people, not driving much, replace their company car for cash. We assume 20%.

In a rather pessimistic case, we assume that only 25% of those people will abandon their company car, this means around 5% of actual company cars.

Number of company cars.

The federal planning bureau counts with 383 000 salary cars in its study on company cars (FPB-Laire, 2016) while the FPS mobility counts 424 000 salary cars (FPS mobility-Kanten, 2016). We will count with 400 000 salary cars.

Conclusion:

We propose to work with 2 scenarios on company car replacement:

- an absolute optimistic scenario where 20% of company car users abandon their company car. Based on 400 000 company cars, this means 80 000 company cars.
- a more pessimistic scenario where 5% of company car users abandon their company car. Based on 400 000 company cars, this means 20 000 company cars.

3.20.2.2 Decrease in km driven

FPS estimates the extra km driven by a company car at nearly 5800 km/year (5787). This amount includes nearly 3000 private km (2993km) and nearly 2800 commuting km (2794km) . These estimates are based on the FPB working paper.

An FPS mobility statistical document on km driven sees a difference of 13 000 km, however correction for socio economic differences not been made properly (km afgelegd door Belgische voertuigen in 2015, FOD Mobiliteit (Mark Kwanten)).

A KPMG study for Febiac sees only a difference of 800 km (KPMG, studie rapport company vehicles, een vlag die vele ladingen dekt, juni 2012.

Our comments:

The Federal Planning Bureau estimate seems to be most reasonable. We will take this estimate into account.

Based on our contacts with one lease company and a social secretariat, we assume that people abandoning their company car will drive less than the average company car driver. We have however no data to calculate how much less these people will drive.

We assume that the gain for people that abandon their company car will only be half.

In an absolute pessimistic scenario, we could assume that people abandoning their company car are simply not very keen on driving and only drive when it is necessary. There will be no difference between their mileage driven with a company car and a normal private car.

Some of the people abandoning their company car could also simply stop using a car. This seems however to be a rather marginal phenomenon. Therefore we don't take this phenomenon into account. However, if extra efforts concerning assistance in mobility choices could be provided in the company, the impact on km driven could be probably more important.

Our conclusion

We assume that for people abandoning their company car the gain in carkm will only be half, 2900 km. For the optimistic scenario we assume that km gains remain at 5800 km.

Remark that the 5800 km is really optimistic as we assume people abandoning their company car will drive on average between 10 000 and 15 000 km/annually.

3.20.2.3 Emissions of non-company cars

FPS estimates the emissions of the cars replacing company cars at 117,9 g CO_2/km or approximately 10 g CO_2 higher than the former company cars. This data is based on the DIV data base.

Our comments:

People that abandon their company car will mainly not be people where the car is the main family car. This means those people could choose another smaller (less emitting) car that at the same time could be older (more emitting, although last year's real emission reductions stagnated). We could eventually assume that the gap between the actual company car and the vehicle replacing a company car should be less. On the other hand, people driving few km could choose a gasoline vehicle emitting generally more CO_2.

Another important element is that difference between test cycle and real world emissions seems to be larger for company cars than for private cars. ICCT estimates the difference for company cars at 45% and for private cars at 35%. If we take this difference in difference between company cars and private cars into account real world emissions come close to one another.

Real world emissions become then:

- Company cars: 107 *1.45= 156 g/km
- Private cars: 117*1.35= 159 g/km

Our conclusion:

We assume that the difference in emission factor between the abandoned company cars and cars replacing those is 0 due to:

- the different deviations between company cars and private cars between real world and test cycle emissions
- the assumption that people abandoning the company car will opt for a smaller car.
- We use the 2020 car emission factor to calculate the emission reduction.

We agree that also there is a lot of uncertainty about this assumption.

3.20.3Results

Based on the above analysis, we propose results for three scenarios:

- Optimistic scenario with 20% of company car users reducing their average yearly mileage by 5800 km/year.
- Intermediate scenario with 12.5% of company car users reducing their mileage by 2900 km/year
- Pessimistic scenario with 5% of company car users reducing their average yearly mileage by 2900 km/year.

The results are presented in the table below in yearly CO2 gains in ktons. The table shows for example that if 20% of company car users would abandon their company car and reduce at the same their annual mileage by 5800 km, the CO2 gains would be 74ktons annually.

All these emissions reductions are emissions in the transport sector and therefore non-ETS reductions.

Table 32: overview of assumed emission reductions in ktons CO2 in 2020 for different scenario's based on a 159 gCO2/km for new cars

emission reduction in ktons in 2020 for different combinations of assumptions			
share of company cars	annual reduction in km driven		
	5800	2900	0
20%	69	35	0
2.5% (averag		22	
5%	17	9	0

The most probably results are in the column with a 2900 annual mileage reduction. Based on the contacts we had with the sector, we assume the emission reduction will be rather around 12.5% company car owners abandoning their company cars.

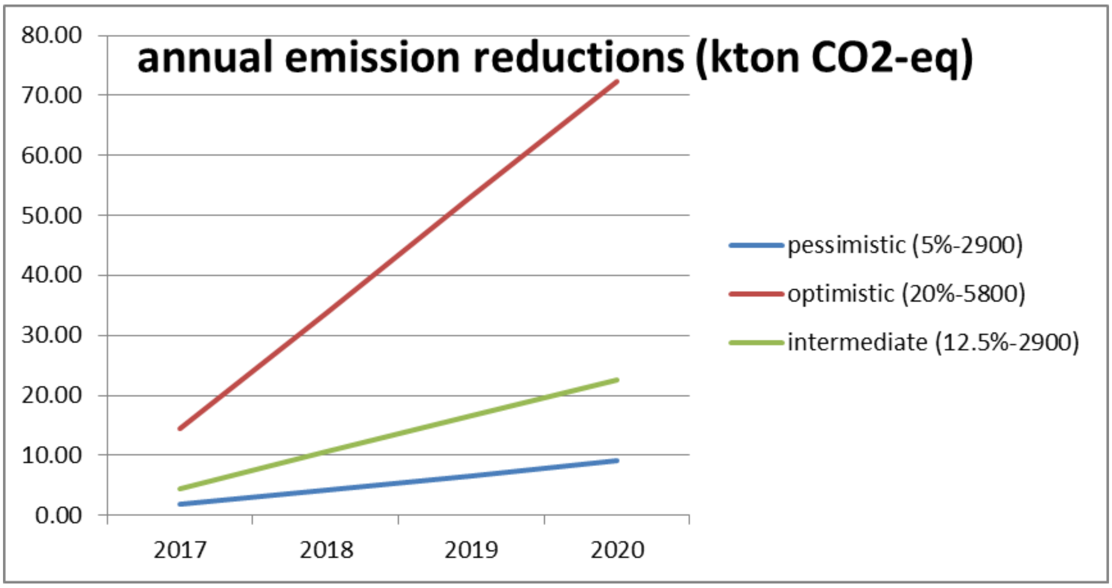
Compared to the proposed FPS Mobility evaluation method, our proposition reduced the annual mileage reduction but increased the CO2/km gain as the latter is based on real world emissions and not on test cycle emissions.

The table below provides the estimated impact for the years until 2020. We estimate the impact for 2020 at 20% of the max impact. The impact increases gradually until 2020.

Table 33:overview of results between 2017 and 2020 in ktons.

year	optimistic (20%-5800)	intermediate (12.5%-2900)	pessimistic (5%-2900)
2017	13.82	4.32	1.73
2018	32.25	10.08	4.03
2019	50.68	15.84	6.33
2020	69.10	21.59	8.64

Figure 31: overview of estimated emission reductions for the positive mobility allocation between 2017 and 2020 in ktons



3.20.4 Sources and references

- Interview with Pieter Goossens from Athlon Car lease, Wies Pairoux from Acerta and Jan Christiaens from Mobiel 21
- FPS Sustainable mobility and rail policy, Kilometers afgelegd door Belgische voertuigen in 2015, 2016
- ICCT, fact sheet, real world fuel consumption and CO2 emissions of new passenger cars in Europe, 2015
- VIM, Eindrapport Intelligent Mobiilteitsbudget, 2016
- FPB, the fiscal treatment of company cars in Belgium, 2016
- Zijlstra, On the mobility budget for company car users in Flanders, 2016

3.21 APP-T02 – Incentives for pedelecs

3.21.1 Description of the PAM:

The evaluation which follows is based on just a first tentative to come with some elements for evaluating incentives for pedelecs.

*speedpedelec gets fiscal deductibility of 120% for buying and 22 cent/km for using it

*A 15% income tax reduction for all pedelecs and speed pedelec when bought is added

This PAM results in a reduction of emissions in ESD sector.

At the end of the study, it was decided that the 15% tax reduction for pedelecs and speed pedelecs when bought won't be implemented. As this part of the policy generated the largest part of the impacts, only this part of the policy has been calculated. The calculation below has therefore only to be considered as an indicative thought. If only the 15% tax reduction for pedelecs is implemented (not those for speed pedelecs) the results of the policy will be 10 to 20% lower than our estimations.

3.21.2 The methodological formula used

$$ER = Sale_{extra} * SH_{pol} * SH_{funct} * D * EF_{car} * SH_{repl}$$

$Sale_{extra}$:Extra sales of (speed) pedelecs

SH_{pol} : Share of extra sales due to policy

SH_{funct}: Share of sales used for functional cycling

D : Average commuting/functional cycling distance annual

EF_{car} : Emission factor of car

SH_{repl} : Share of km replacing a car

3.21.3 Analysis of the estimated effects

Thanks to the measures, each year sales increase by 6% cumulatively, this means that in 2020, 26% more pedelecs are sold in 2020 than without the measure (37 000 units sold more).

Our comments :

For the 15% reduction when buying:

If we compare with the 15% tax reduction for the -105 g/km cars between 2005 and 2011, based on EEA data, we assumed that 35% of sales were due to the tax reduction. In other words this meant an assumed increase in sales of 50% of the initial sales. This was probably a quite high assumption, however significantly lower than the previous VITO assumption.

It is not sure that a reduction of few 100 EUR for pedelecs will have a similar effect as a few 1000 EUR for cars. It will be in any case important to get the reduction immediately on the invoice.

It would be nice to get an idea on how actual subsidies from cities or provinces influence the sales of pedelecs. The subsidies are in general a big success, but it is difficult to know how these influence sales.

An effect that has not been taken into account is the eventual abolition of subsidies by local authorities. If this would be the case, the impact of the measure would be limited to localities where no subsidy was previously available

The market for pedelecs will increase from its own, even without subsidies or other incentives. There was already an increase in the sales of pedelecs (-25km/h) in the previous years. We can assume that the increase in sales will continue from its own.

For the particular supplementary speed pedelec increase

The diagnostic on home –workplace commuting states that the 22 cent tax free fee increases bicycle use by 34%. We can assume that half of the companies that pay the tax free fee today will pay it in future also for speed pedelecs. We take only half as the amounts will be much higher for speed pedelec users than for normal bicycle users. Today, approximately 80% of the large companies pay a tax free bicycle fee. We assume a non-cumulative increase of people using the speed pedelec by 80%*0.5*34% = 13.6%. The number of speed pedelecs sold today is however still low (only 5% market share), a 13.6% presents therefore only a small, probably too small amount to estimate the increase in speed pedelec users thanks to the policy.

Our conclusion: cumulative effect of 26% in 2020 seems to be a realistic estimate

- We estimate that a 6% increase in sales is rather at the lower end. However the cumulative effect in 2020 of 26% seems a realistic estimate. We think the effect will be rather similar during the different years, maybe a bit smaller the first year, and much bigger the year before the suppression of the measure.
- The absolute figure could be higher as there will also be an autonomous growth of the pedelec market.
- The estimate can probably be refined if we could get an idea on the impact of sales of subsidies of local authorities.
- The estimate could be lower if due to this measure local authorities suppress their subsidy.

This latter point is important to take into account.

3.21.4 The assumptions

3.21.4.1 Average km for home-work travel

FPS uses based on Mobiel 21 surveys of pedelec commuters

Pedelec < 25 km/h: 13,9 km/jour

Pedelec < 45 km/h: 20,5 km/jour

Our comments:

The Mobiel 21 survey provides these figures per trip and per day. The per day figures should be double these figures then.

Dutch research provide figures that are slightly lower for the pedelec <25km/h: 11, 7 for pedelec driver that were previously car drivers and 7,6 for pedelec drivers that were previously “ordinary” cyclists. The average cycling distance for a pedelec in Suisse is between 8 and 9 km.

It is not impossible that the Mobiel21 figures are biased due to the survey panel. The market share of speedpedelecs is also more than double the real market share. Maybe the Mobiel21 survey is biased towards longer than average distance e-bike commuters.

The Mobiel21 survey states even 15km as commuting distance for ex-car drivers, but his is probably the average of pedelec <25 and <45.

Our Conclusion:

We increase the daily average commuting distance to 28 and 41 km.

This is double the figure of the Mobiel21 survey as that figure provides the distance of one way trip. These are quite high compared to figures in other countries. We therefore also use an alternative with 20 and 35 km.

3.21.4.2 Number of cycling days

FPS uses based on Mobiel 21

Number of average cycling days estimated is 151 based on 43% uses 4 days or more a week, 40% uses 2 to 3 days a week and 10% 1 day a week.

Our comments:

Former car drivers use the pedelec slightly less, 50% 2 to 3 days a week, 29% 4 days and more/week, we assume 20% 1 day/week

Our conclusion:

We propose to use a slightly lower estimate of 121 days.

3.21.4.3 Pedelecs not used for home work traffic

The proposed figure is 26%, in other words, 74% of pedelec users uses pedelecs for home work traffic.

Our comments:

We don’t find a source for the 26%. We find two other sources. A summarizing document form CROW-fietsberaad in the Netherlands states that the most frequent motive to use a pedelec was recreation in 2012 (CROW-fietsberaad, 2013 p33). Next are shopping and visit someone.

We also wonder how a large majority of pedelecs can be primarily used for commuting as it is the most sold type of bicycle before the city bike while we have the impression the pedelec is not the most used bike for commuting (own “nonscientific” observation).

A Swiss study however mentions that the main motive for using a pedelec is home-work traffic. 25% of pedelec are pensioners that don't use the pedelec for commuting. 16% or 400 km on average of the 2600 km average driven by a pedelec are pure recreation. The remaining 84% 2200 are transferred from other modes. Main transfers come from cars, approximately 1000 km on average, 570 km from public transport and 420 km from conventional bicycle. The basis for this data is a survey. It is therefore not impossible that there is some bias towards overestimation of driven km and car substitution.

It is not because a pedelec is not used for commuting that it cannot replace a car trip. However, for these trips it could be more probable that it replaces a "normal" (not pedelec) bike trip but we don't have information on this.

The main point here is not whether the pedelec is used for commuting, but rather whether it replaces a car trip whether it is for commuting of for other motives. In this view, it is better to consider the 26% as a share of pedeleckm that is not used for functional cycling. However, on the non-commuting functional pedelec driving, pedelec could substitute less carkm.

Our conclusion: the 26% seems a reasonable estimate

We see the 26% as an estimate for the cyclekm that are not done for functional cycling that also corrects for the fact that for non-commuting, the substitution of car driving is probably lower.

We assume also that the market evolved and will evolve by 2020 since the Dutch survey.

We integrate however a sensitivity analysis where 40% of pedelecs is not for functional uses integrating the fact that for certain functional uses substitution rate is lower. This estimate will us also bring closer to the smaller Dutch estimate of total km driven

3.21.4.4 Average yearly km driven with a pedelec

Based on the previous figures, we adapted the FPS figure and come up with 3370 km for the pedelec <25km/h and 4970 km for the pedelec < 45km/h.

Our comments:

These figures are very high compared to what is reported in the Netherlands and in Switzerland , respectively 1612 km and 2600 km. Mira (Delhaye-MIRA, 2016) estimated the figure based on the Dutch figure. The Dutch figure is based on an analysis of 150 000 pedelec computers.

The high estimates based on the FPS methodology are a consequence of the high commuting distances from the Mobiel21 survey. Different explanations are possible:

- There is some bias in the Mobiel21 survey towards people commuting over longer distances.
- Commuters drive much more kilometers than non-commuters. The Swiss and Dutch figures show an average of commuters and non-commuters while the FPS figure shows only commuter.
- The Belgians drive much more km than the Swiss and the Swiss.

A combination of the two first reasons seems most plausible to us. Only the second reason seems not possible, as with only 25% of pedelec owners not using it for commuting, their average distance should be 0 to reach the Swiss average or much lower to reach the Dutch average.

Our conclusion:

We keep a figure based on the Mobiel21 survey (probably too high) and add a scenario based on a lower number of km driven.

This based on lower average daily cycling distances, respectively 20 and 30 km/day. These are still high as the average Dutch weekly distance is 31 km.

3.21.4.5 The shares of pedelec <25 and <45

The FPS assumes a similar share of pedelecs <25 and < 45km/h of 50%

Our comments:

In the Mobiel21 survey, 13% were speed pedelecs and 76.2% pedelecs. If we consider only these then is the market share of speed pedelecs nearly 15%.

Although the market share of new sold pedelecs seems to be only 5,3% while 93,9% are "normal pedelecs" (press release Belgian Cycling 11-01-2016). It is possible that their market share increases in the future thanks to the legal framework. We can take 10% market share for 2020.

Our conclusion: we propose to take into account a market share of 10%.

We assume that with promoting measures and the clearer legislative framework, the market share increases.

3.21.4.6 Replaced number of car km

The FPS assumes

- 46% of pedelec km replaces carkm
- 66% of speed pedelec km replace car km

Based on the mobile 21 survey.

Our comments:

40% of carkm replaced by pedelecs is what the Dutch and Swiss study provide as figure. The Dutch study adds, that especially for car drivers financial incentives can help to switch behavior (CROW-fietsberaad p 46).

The FPS takes into account that 26% of pedelecs are not used for commuting (and we added sensitivity at 40%).

Our conclusion: we keep the provided shares for replacement of carkm

Although these figures seem to be quite high, especially if these are also applied for non-commuting journeys. To take into account that those figures are relatively high, we introduce the sensitivity analysis with 40% pedelec for non-functional driving.

3.21.4.7 CO2 emissions

FPS takes into account well to wheel emissions

- 271 g/km for the car
- 22 g/km for the pedelec

based on the ECF study

Our comments

The approach including life cycle emissions is interesting to get the global picture. We also used this approach for the reevaluation of the biofuel policy.

However, for the CO2 reporting, well to tank emissions are not reported. Therefore we propose to add a pure tank to wheel approach based on the emission factors used for our exercise on actual PAMs. Therefore, the tank to wheel emissions of cycling, the calories burnt by the cyclist (6g/km) are not taken into account (nor is the electricity production)

To be coherent with the PAM reevaluation, we prefer to use emission factors we used for that exercise, 149 g CO2/km in 2020 (Delhaye-MIRA; 2016). The complete life cycle emission would be 197 gCO2/km (adding 32% to the tank to wheel emissions based on the fuel quality directive 2015/652, 20 April 2015). This is lower compared to the used estimate by FPS based on the ECF, probably because of the evolution in efficiency of cars. However, one could argue that cars don't get more efficient in real world emissions.

The pkm emissions are then respectively 124 (tank to wheel) and 164(well to thank) gCO2/pkm, based on an occupancy rate of 1.2 as we used in most of the reevaluations of the PAMs.

The pedelec lifecycle emissions remain at 22g/km (ECF, 2012)

Our conclusion: add an estimate based on tank to wheel analysis and adapt the emission factors to those used for the PAM exercise

Emissions are at 164g CO2/pkm (lifecycle) or 124g CO2/pkm (use) for the car and 22g/km (lifecycle) and 0 gCO2/pkm (use) for the bicycle

3.21.4.8 Annual CO2 gain

FPS multiplies average daily commuting distance with the average number of days cycled, the share of carkm replaced and the average CO2 emission per km.

Our comments:

The number of days cycled needs to be number of days effectively cycled, not the number of working days/year.

Our conclusion:

We replace the number of working days/year by the number of working days peoples cycled.

3.21.5Results

As there are some uncertainties in the estimate, we did a sensitivity analysis and come therefore up with 3 different estimates. The differences between scenarios are summarized in the table below. The maximum scenario is the closest to the initial inputs from the FPS mobility and sustainable transport. The average commuting distances are higher than for the other scenarios.

The minimum scenario takes into account a lower share of speed pedelecs and a lower share of functional cycling among the (speed) pedelecs.

The intermediate scenario takes the lower average commuting/functional cycling into account and the higher share of functional cycling.

Table 34: main assumptions in three scenarios

	max	likely	min	source
increase in sales by 2020	26%	26%	26%	proposition FPS mobility
daily commuting pedelec	27.8	20	20	mobiel 21 survey
daily commuting speedpedelec	41	30	30	mobiel 21 survey
days cycling	120	120	120	mobiel 21 survey
share of pedelec among new sold	90%	90%	95%	TML assumption
share of speed pedelec among new sold	10.0%	10.0%	5%	TML assumption
pedelecs only used for leisure	26%	26%	40%	FPS assumption
VAE <25km share replacing carkm	46%	46%	46%	mobiel 21 survey
VAE <45km share replacing car km	66%	66%	66%	mobiel 21 survey
EF g/pkm (only tank to wheel)	124	124	124	emission factor used elsewhere (MIRA, 2016)
EF g/pkm (only well to wheel)	164	164	164	32% above tank to wheel emission factor (EU fuel quality directive)

The table below provides the results. We estimate the potential CO2 gains thanks to the measure between 3 and 6 ktons CO2 for the emissions directly caused by driving (tank to wheel emissions). Tank to wheel emissions don't take into account life cycle emissions or indirect emissions (well to tank) of fuels. Life cycle emissions or indirect emissions of fuels are emissions caused by production and transport of fuels. These are not part of the transport emissions under UNFCC convention. These are therefore only provided for information.

All these emission reductions are transport emission reductions and thus non-ETS reductions.

Table 35: overview of '(adapted) estimates of the policy in ktons for 2020

	max	intermediate	min
total emissions saved *tank to wheel* - 2020	5.74	4.14	3.18
total emissions saved *well to wheel* - 2020	7.57	5.47	4.20

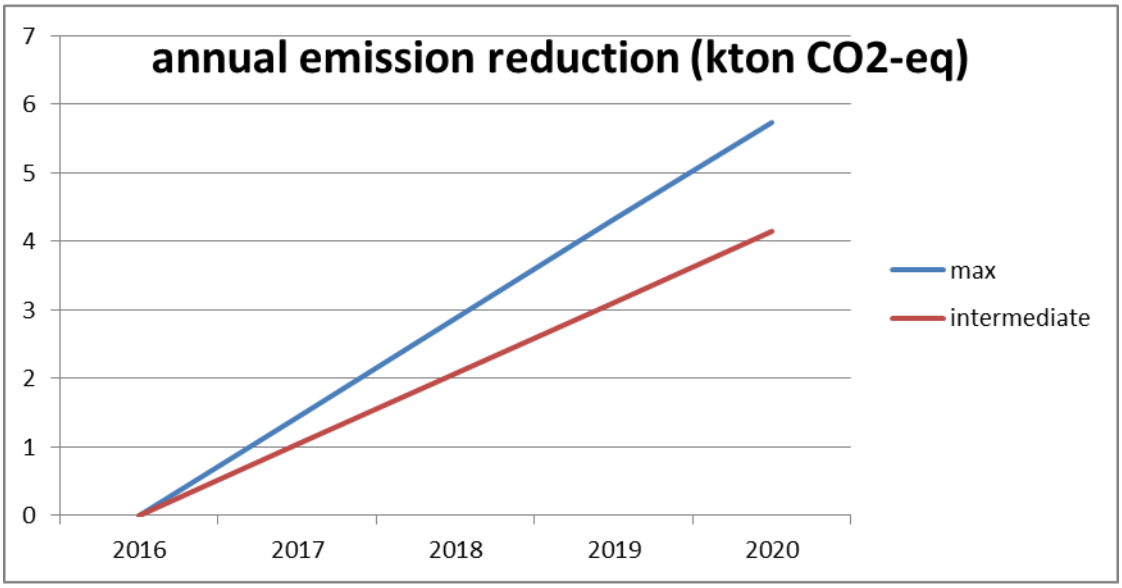
The emission potential seems rather low, but it is important to realize that the main gains of pedelecs and cycling in general are not in CO2 emissions but in health and livability. Reductions in CO2 emissions are only by product of these elements. If we count with a societal gain of 1 EUR/bicyclekm (Van Zeebroeck, 2013), the measure would have a benefit of 239 M EUR even if we count only 40% of pedeleckm calculated in this exercise. We explain what is behind the different types of calculation.

We made also an estimate of the potential impact of the measure for the years between 2016 and 2020. The figure and the graph below illustrate this.

Table 36: overview of emission reductions between 2016 and 2020 in ktons of pedelec PAM

year	max	intermediate	min
2016	0	0	0
2017	1.43	1.04	0.80
2018	2.87	2.07	1.59
2019	4.30	3.11	2.39
2020	5.74	4.14	3.18

Figure 32:overview of emission reductions between 2016 and 2020 in ktons of pedelec PAM



3.21.6Sources

EUROPEAN BICYCLE MARKET, 2015 edition, CONEBI -

Mobiel 21, Het e-fietspotententieel, resultaten online bevraging e-fietspendelaar, 2014

Van Zeebroeck (TML), impact en potentieel van fietsgebruik voor de economie en de werkgelegenheid in het Brussels Gewest voor het BHG, mei 2014,

3.22 APP-T03 – Reduction energy use of railways

3.22.1 Description of the PAM:

The SNCB wants to reduce primary energy consumption by 3 to 4% per passengerkm via different measures (2020 compared to 2015):

- Increase train occupancy
- Reduce energy losses while at stop
- Use more efficient rolling stock

SNCB states that this is equivalent to an absolute reduction of 3% of traction energy, which means 7.76 ktons of CO_2 (1.18 ktons of diesel and 6.58 ktons of electricity)

This PAM results in a reduction of emissions in both ETS and ESD sectors.

3.22.2 Analysis of impacts and assupmtions:

We cannot make much comments as provided info is very limited.

3.22.2.1 Increase train occupancy

Increasing train occupancy says nothing about the absolute energy savings and or CO_2 savings. We can only say that:

- Increased train occupancy will not reduce the energy use of the rail sector except if the increased occupancy allows for reduced use of rail stock implying less trainkm. It is not clear to TML whether trainkm are reduced, but the impression is that rather the opposite seems to be the case.
- Increased train occupancy can, and most probably, will reduce the energy use and contribute to CO_2 savings in other sectors, like for example road transport. The question however is to what extent.
  As illustrated in the report on reevaluation of PAMs and by the table below, it is not that straightforward that an increase in train use reduces car use. The table below shows for example that train use in Flanders and Wallonia increased, but that car use didn't decrease. Even if we assume that increased train use is obtained thanks to better train occupancy, there is no guarantee that CO_2 emissions of the road transport will be reduced. One can of course always assume that without railway efforts, road transport would have grown faster.

Table 37: evolution in modal shares for commuting in Belgian large companies (diagnostic federal, 2015)

	BELGIQUE			BRUXELLES			FLANDRE			WALLONIE		
Mode	2005	2014		2005	2014		2005	2014		2005	2014	
Voiture (seul)	66,8%	65,6%	- 2%	45,1%	37,9%	- 16%	68,7%	68,5%	- 0%	80,4%	81,7%	+ 2%
Covoiturage	4,7%	2,9%	- 38%	2,5%	1,2%	- 49%	5,2%	3,3%	- 36%	5,2%	3,4%	- 35%
Moto	1,7%	1,2%	- 33%	0,8%	1,1%	+ 38%	2,2%	1,3%	- 41%	1,5%	1,0%	- 31%
Train	9,5%	10,9%	+ 15%	32,2%	34,1%	+ 6%	4,1%	5,3%	+ 31%	4,4%	5,0%	+ 13%
Métro, tram, bus	5,9%	6,9%	+ 16%	15,0%	19,0%	+ 27%	3,9%	3,9%	+ 0%	3,6%	4,0%	+ 9%
TCE	1,2%	0,8%	- 34%	0,7%	0,3%	- 59%	1,6%	1,1%	- 31%	0,5%	0,4%	- 8%
Vélo	7,8%	9,5%	+ 21%	1,2%	3,0%	+ 148%	12,3%	14,9%	+ 21%	1,3%	1,5%	+ 13%
Marche	2,4%	2,4%	- 2%	2,6%	3,4%	+ 33%	2,1%	1,7%	- 19%	3,2%	3,1%	- 2%

3.22.2.2 Reduce energy losses while at stop

It is not clear what concrete measures will be taken to reach this goal. It is therefore not possible for us to analyse or comment on the measure.

3.22.2.3 Use more efficient rolling stock

Using more efficient rolling stock will indeed reduce the energy use of the rail sector and reduce its CO2 emissions and those of the electricity sector.

The FPS Mobility however didn't provide any detail on the assumptions on the use of more efficient rolling stock like for example the number of new rail stock and its gains in energy use.

3.22.2.4 Overall figure

To get an idea on the realism of the 3% energy consumption reduction per passengerkm, we compared to assumptions in the MOVEET model. MOVEET (MObility, Vehicle fleet, Energy use and Emissions forecast Tool) is an analytical tool based on systems dynamics that analyses policy challenges related to transport and climate change.

The model also counts with a reduction of energy consumption per passengerkm in the same order of magnitude, 2.5% for each year between 2015 and 2020. This gain of 2.5% is made up for the major part by an increase in passengers. 0.5% each year is due to fuel efficiency gains. The source for this estimate is unfortunately quite old as it dates from 2002. Landwehr, M., Marie-Lilliu, C., 2002. Transportation projections in OECD regions. International Energy Agency, Paris.

If the figure of 0.5% gain in fuel efficiency is still valid, over a 6 year period, the gains will sum up to approximately 3% over 6 years.

3.22.3 Conclusion

A reduction of 3% in absolute energy use per TRAINkm is possible. It would be good to provide more information on the reasons behind it, like the replacement of the rolling stock and the evolution in trainkm.

An absolute reduction in energy use of the rail sector and a reduction in the energy use per passengerkm are not synonyms. It is possible to realize entertains per passengerkm without realizing energy gains per trainkm or without realizing energy gains for the rail sector.

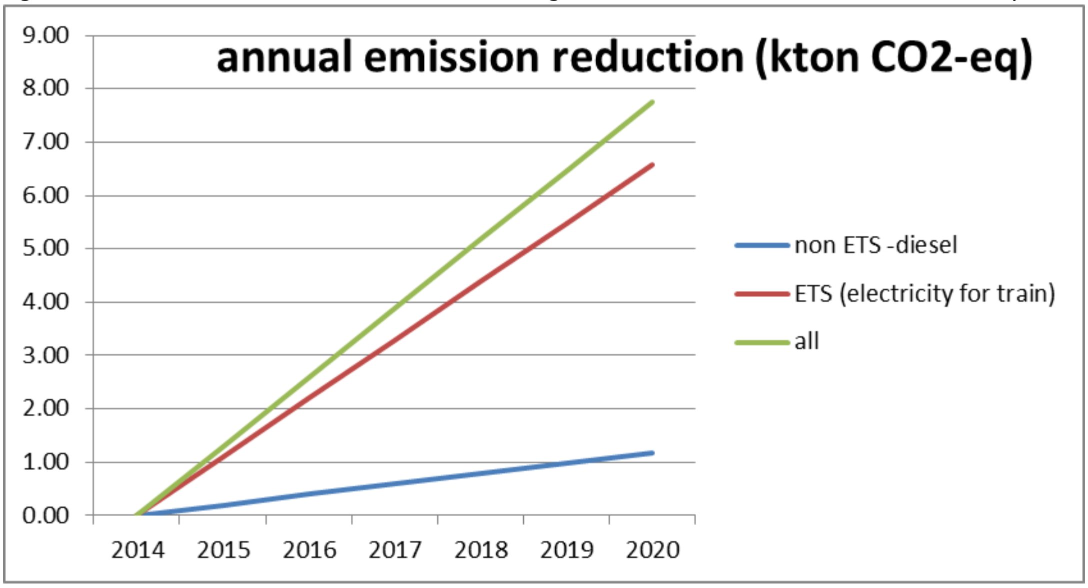
The proposed absolute reduction in energy use of 3% equivalent to 7.76 ktons (1.18 for diesel (non ETS) and 6.58 for electricity (ETS) are possible. It is however not possible to tell that the envisaged measures will reach this reduction as there could be a confusion between an absolute reduction in energy use (CO2 emissions) and a relative reduction of energy use per passenger km.

The table below illustrates the impact per year if the SNCB estimates are correct.

Table 38: Estimated emission reductions if SNCB estimates are correct between 2014 and 2020 (in ktons).

ktons	non ETS - diesel	ETS (electricity for train)	all
2014	0.00	0.00	0.00
2015	0.20	1.10	1.29
2016	0.39	2.19	2.59
2017	0.59	3.29	3.88
2018	0.79	4.39	5.17
2019	0.98	5.48	6.47
2020	1.18	6.58	7.76

Figure 33:estimated emission reductions if SNCB figures are correct between 2014 and 2020 (in ktons)



3.23 APP-T04 Reduction non-traction energy use of railways

3.23.1 Description of the PAM

Between 2005 and 2015, the NMBS/SNCB group has reached a 20% reduction of energy consumption for non-traction activities. A new goal of seven additional percent of energy consumption reduction in the period 2014-2020 was set. The main actions implemented to reach this goal are the following:

- Renewal and modernization of lighting installation systems for railway stations, offices and other building services
- Continuation of the renewal of heating systems in buildings
- Replacement of old production facilities with more energy efficient one
- Restoration of existing buildings (isolation, etc.)

This PAM results in a reduction of emissions in both ETS and ESD sector.

3.23.2 Methodology and assumptions

The estimation of SNCB was done by making the assumption that the goal of 7% reduction of energy consumption for non-traction activities for 2020 will be reached. They assumed that this total of 7% may be reached through a 10% reduction of heating energy consumption and a 4% reduction of electricity consumption.

Again, we cannot make many comments as the provided information is very limited. However, we made an estimation based on the data available in a SNCB report of 2016 (Table 39) and contrasted assumptions regarding the future energy consumption.

As shown in the table below, the energy consumption found for 2014 and 2015 is slightly different from those provided in the estimation of NMBS/SNCB. As the SNCB report 2016 stipulated that a degree days correction was made, we decided to keep this information instead of the one provided by the NMBS/SNCB estimation.

Table 39: Data on energy consumption for non-traction activities

Year	Energy consumption (non-traction) (GWh)		
	heating	electricity	Comment
2014	149	114	Data from SNCB report 2016, taking into account degree days correction
2015	148	112	
2014	142	110	Data used for the NMBS/SNCB estimation, no information on degree days

We then made an estimation of future energy consumption for non-traction activities based on the following assumptions:

- *Share in heating*

To assess the emission reduction linked to a reduction of energy consumption for heating, it is primordial to identify the share in heating between heating oil and natural gas as their emission factors are different. The share in heating between heating oil and natural was calculated through a linear projection of data available for 2007-2012. The results of this calculation are presented in the table below.

Table 40: Share in heating between heating oil and natural gas

	Share in heating	
	Heating oil	**Natural gas**
Raw data		
2007	37%	63,4%
2008	34%	66,3%
2009	30%	70,0%
2010	29%	71,4%
2011	32%	68,0%
2012	26%	74,0%
Calculations		
2013	25%	74,8%
2014	24%	76,5%
2015	22%	78,2%
2016	20%	79,9%
2017	18%	81,5%
2018	17%	83,2%
2019	15%	84,9%
2020	13%	86,6%

- *Emission factors*

As there is no definition of the direct and indirect impacts considered in the emissions factors used by the NMBS/SNCB, we decided to use the emissions factors commonly used in the past estimations of climate federal PAMs for heating oil and natural gas (VITO-ECONOTEC, 2015). With regards to electricity, we used the Belgian emission factor calculated by AWAC. The Table below presents a comparison of factors used in the NMBS/SNCB estimations and in our update.

Table 41: Emission factors

	Emission Factor (kg/kWh)		
	heating oil	**natural gas**	**electricity**
NMBS/SNCB estimation	0,30	0,22	0,21
Our estimation	0,27	0,20	0,28

- *Energy consumption reduction*

As the energy consumption reduction isn't easy to estimate without more precise information on the means implemented to allow for emissions reductions, we propose estimating three scenarios with contrasted assumptions:

1. The maximum scenario

   For the maximum scenario, we allowed for a total reduction of 7% of energy consumption in 2020 in comparison with 2014. We assumed a linear reduction and we allocated this consumption reduction to both heating and electricity, based on their past share of energy consumption. In other words, we made the assumption that the total energy reduction was allocated following the proportion of heating and electricity in 2014 and 2015 into the total energy consumption for non-traction activities (see Table below).

Table 42: Calculation of an allocation coefficient of energy consumption reduction between heating and electricity

Year	Energy consumption (non-traction) (GWh)		
	heating	electricity	Share heating (%)
2014	149	114	57%
2015	148	112	57%

2. The minimum scenario

   For the minimum scenario, we made the assumption that no additional reduction in energy consumption was possible for electricity. Indeed, new technologies and new devices (information panel, security camera, etc.) need higher electricity consumption. We kept the energy consumption reduction for heating equal to the one calculated for the maximum scenario.

3. The likely scenario

   This scenario corresponds to the mean between the maximum and minimum scenario results.

3.23.3Results

The results are presented in the figure below. The maximum scenario shows a 5.49 ktCO2 emissions reduction in comparison with 2014, enabling a 7% reduction of energy consumption. Without the assumption that additional reductions in energy consumption can be made for electricity consumptions, a reduction of 4.5% can be expected if the same evolution of energy consumption for heating as for the maximum scenario is kept. It corresponds to a reduction of 3.65 ktCO2 emitted. As a consequence, the emission reduction permitted by the likely scenario is 4.57 ktCO2. This result is very close to the NMBS/SNCB scenario (4.69 ktCO2). The distinction between ETS and non-ETS emissions is presented in Table 43.

Figure 34: Total Federal Emission reductions (kton CO2) per scenario (maximum, minimum, likely)

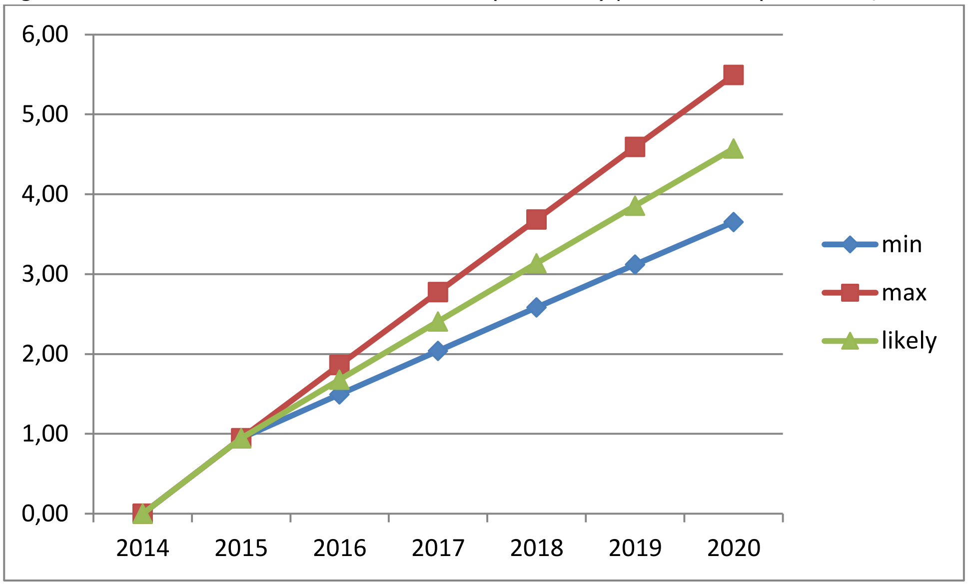


Table 43: Results by ETS and ESD emission reduction

YEAR	Federal Emission Reduction ETS (kton CO2)			Federal Emission Reduction ESD (kton CO2)		
	min	max	likely	min	max	likely
2015	0,55	0,55	0,55	0,39	0,39	0,39
2016	0,55	0,92	0,74	0,94	0,94	0,94
2017	0,55	1,29	0,92	1,49	1,49	1,49
2018	0,55	1,66	1,11	2,03	2,03	2,03
2019	0,55	2,03	1,29	2,57	2,57	2,57
2020	0,55	2,39	1,47	3,10	3,10	3,10

3.23.4Discussion

As the information regarding this PAM is limited, it is difficult to provide a more detailed critical analysis. However, with two contrasted sets of assumptions regarding the evolution of the energy consumption in non-traction activities of the NMBS/SNCB, we evaluated a range of emissions reductions of 3.65 ktCO2 - 5.49 ktCO2. To discuss this evaluation in more details, it should be interesting to identify and discuss if the means implemented at the NMBS/SNCB will permit these energy reductions.

3.24 IP-A06: Tax deduction for energy savings

3.24.1 Description

For decades, companies have been enjoying a tax advantage when they invest in energy savings, at a percentage tax deduction level that has varied in time. Information from FPS Finance revealed that the annual amount of investments benefiting from this tax deduction ranged between 40 to 180 million €. For 2004, the tax deduction was of 13.5% for energy saving investments by companies (instead of 3.5% for standard investments). For the year 2009 the deduction level has been raised to 15.5% for energy saving investments, while standard investments no longer benefit from a tax deduction. From 2013 the deduction level for energy saving investments has undergone a progressive decrease, reaching a rate of 14.5% in 2013 and of 13.5% from years following.

This PAM results in a reduction of emissions in both ETS and ESD sectors.

3.24.2 Methodology

The impact of the measure is not easy to evaluate, because there is no information available about the types of investments made, nor about the sectors. Consequently, the evaluation is based on amounts invested.

The evaluation is based on an estimate of the average payback time, using the formula:

$$\boldsymbol{ER_{FED} = AF \times ER_{TOT}}$$

$$\boldsymbol{ER_{FED} = AF \times \left(\frac{I}{PB_{time} \times E_{price}}\right) \times EF}$$

With

$\mathbf{ER}_{FED} =$ Emission reduction within the framework of the federal climate policy
$\mathbf{ER}_{TOT} =$ Emission reduction projected for the PAM
$\mathbf{PB}_{time} =$ Payback time
$\boldsymbol{AF} =$ Allocation factor
$\mathbf{EF} =$ Emission factor
$\mathbf{E}_{prices} =$ Energy prices

3.24.3 Main assumptions

3.24.3.1 General assumptions

- Even though the tax deduction is an existing measure from 1992, the effect of the measure has been considered for investments starting from 2004.
- It should be noted that the deduction rate considered from 2004 for the calculation of the energy saving is the whole rate, and not only the increase in deduction rate since 2004 (i.e. the measure has been fully estimated)

- PAM effect has been assumed to be allocated in equal proportion within the ETS and ESD policy frameworks.
- Annual amount of energy savings is assumed constant for the period projected as long as annual investments (since 2012) and tax discounts (since 2015) are kept steady.
- The expected time life of the investments is assumed to be 10 years.
- Energy savings due to these investments are assumed to be adopted for all the main energy carriers in the industrial sector (electricity, natural gas, gas/heavy oil) in a weighted way, thus keeping the energy shares estimated for the industrial sector in the BAU scenario.
- Since the deduction rate is small, the free rider effect[9] can be expected to be high. Therefore, it is important to exclude the savings corresponding to the free riders. This has been done with the following assumptions:

  - All investments with a payback time up to two years, and only those, a*re carried out spontaneously;* all energy saving investment possibilities are evenly dist*ributed over the payback time.*
  - The impact of the measure is to increase the payback-time ceiling, which rises from two years to 2/(1-td) years, where it is the company profit tax rate and *d the net tax deduction rate.*
  - The net tax deduction rate is the difference between the deduction rate for energy saving investments (13.5% until 2008, 15.5% from 2009 to 2012, 14.5% in 2013, 13.5% from 2014) and that for other investments (3% until 2007, 0% from 2008).

3.24.4Data sources

The data sources used for the estimation of the PAM are presented in the following table:

Table 44: Description of data sources

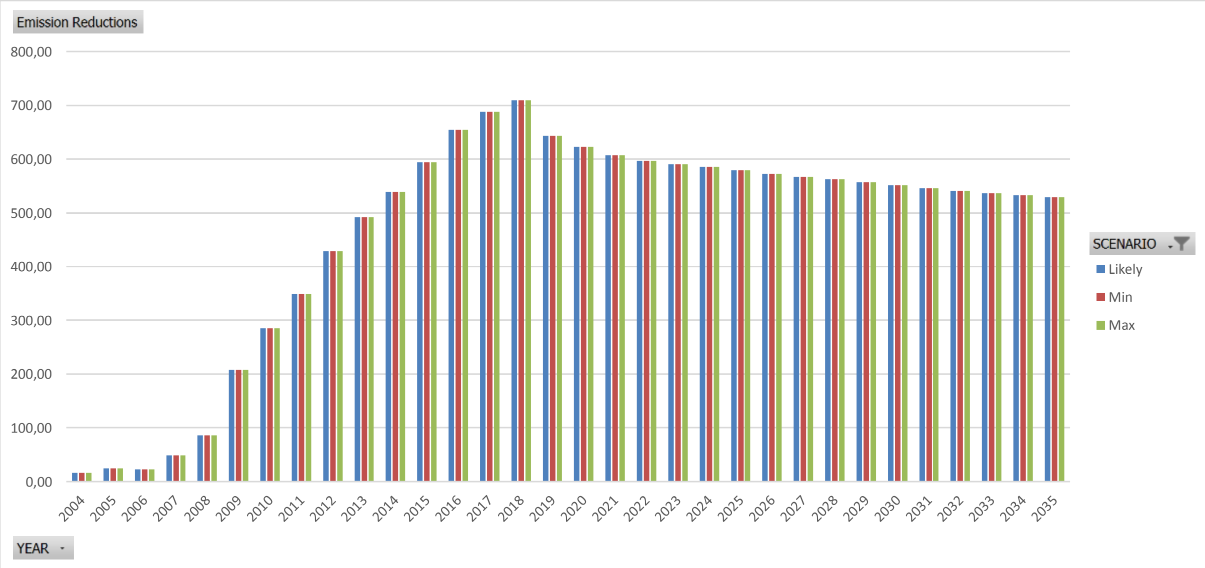
Indicators	Source
Annual Investment	Personal communication of FPS - FPS Finance
Tax deduction	Personal communication of FPS - FPS Finance
Tax deduction rate	Personal communication of FPS - FPS Finance
Emission factors	1996 IPCC Guidelines
Energy prices	Eurostat
Energy consumption split by energy carrier	Statistics Belgium

3.24.5Results

The emission reductions achieved by the implementation of the PAM increase from 16 kt CO2-eq in 2004 to 710 kt CO2-eq in 2018. From 2018 onwards the reductions achieved slightly decrease until 2035, where they reach 529kt CO2-eq. The following figure illustrate the emission reductions achieved from 2004 to 2035 by the PAM:

[9] The free rider effect occurs when investors (e.g. households or companies) benefit from a financial incentive for an investment that would have been made even without the support

Figure 35: Annual emission reductions (minimum, maximum and likely scenarios)



3.24.6 Discussion

The current methodology estimates energy savings from the total amount invested and energy prices. This methodology should be updated on a calculation of energy savings based on the amount invested by sector. Information on the use of the investment would enable a calculation of a BaU and a PAM scenarios of energy consumption, which in principle, should be considered a more robust methodology for assessing the overall effect and a more precise procedure for distinguishing the emission reduction allocated within the ETS and ESD policy framework.

However, no information is available on the use of the investments, so it has not been possible to update the methodology for this edition of the PAMs.

3.24.7 References

IPCC, 1996. Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

Eurostat, 2017. Electricity prices for domestic consumers - bi-annual data (from 2007 onwards).

Statistics Belgium, 2017. Energy consumption statistics - Electricity – GWh.

3.25 OB-A03: EMAS certification

3.25.1 Description

The federal government has fixed as objective that by 2007 all public services should be EMAS certified. EMAS certified entities set themselves objectives on the reduction of their energy consumption and an increasing use of bicycle and public transport for their employees. Besides, the management contracts of the SNCB group of companies foresee the establishment and implementation of an environmental policy plan.

This PAM results in a reduction of emissions in both ETS and ESD sectors.

3.25.2 Methodology

In the absence of additional information on the individual impact of this measure, the current estimation is based on an estimation of the total emission reduction achieved by EMAS per employee:

$$\textbf{Emission Reduction}_{\boldsymbol{t}} = Unitary\ Emission\ Reductions_t \cdot Employees_t$$

$$\boldsymbol{Unitary\ Emission\ Reductions_t} = BAU\ Energy\ Consumption_{\ t} \cdot Impact\ EMAS \cdot EF_t$$

With

Impact EMAS	emission reductions due to the implementation of EMAS
EF	emission factor

Despite the methodology relies on the calculation of a BaU energy consumption, the estimation of an entire BaU and with measures scenarios was not carried out. Due to the absence of data of employees from 2012, they have been estimated using the number of buildings certified as a proxy.

The list of federal organizations registered in EMAS in 2015 is the following:

- Federal Planning Bureau
- FPS Mobility and Transport
- Belgian Federal Science Policy Office
- FPS Chancellery of the Prime Minister
- National Pensions Office
- FPS Economy, SMEs, Self-Employed and Energy
- FPS Employment, Labour and Social Dialogue
- FPS Public Health, Food Chain Safety and Environment
- FPS Service for Social IntegrationFPS Personnel and Organisation
- FPS Budget and Management ControlNational Employment Office

3.25.3 Main assumptions

3.25.3.1 General assumptions

- The expected number of institutional buildings certified is kept constant throughout the period projected for the most likely (and minimum) scenario. The aim of EMAS certification for all the buildings with more than 100 FTE (132 buildings, keeping the data from 2014 report) would be achieved in the maximum scenario by following the mean penetration noted in the historical period.
- The Unitary Emission reduction and the impact of EMAS are kept constant throughout the period projected.
- It is not expected a change over time in the share of each fuel type for heating in the EMAS buildings regarding the percentages reported for 2012.
- For the maximum scenario (optimistic) the target for 2020 is assumed to be fully achieved, whilst the effective reductions projected in the minimum and likely scenarios are adjusted according to the historical time series, i.e. emission reduction are kept constant from year 2015.

3.25.4 Data sources

The data sources used for the estimation of the PAM are presented in the following table:

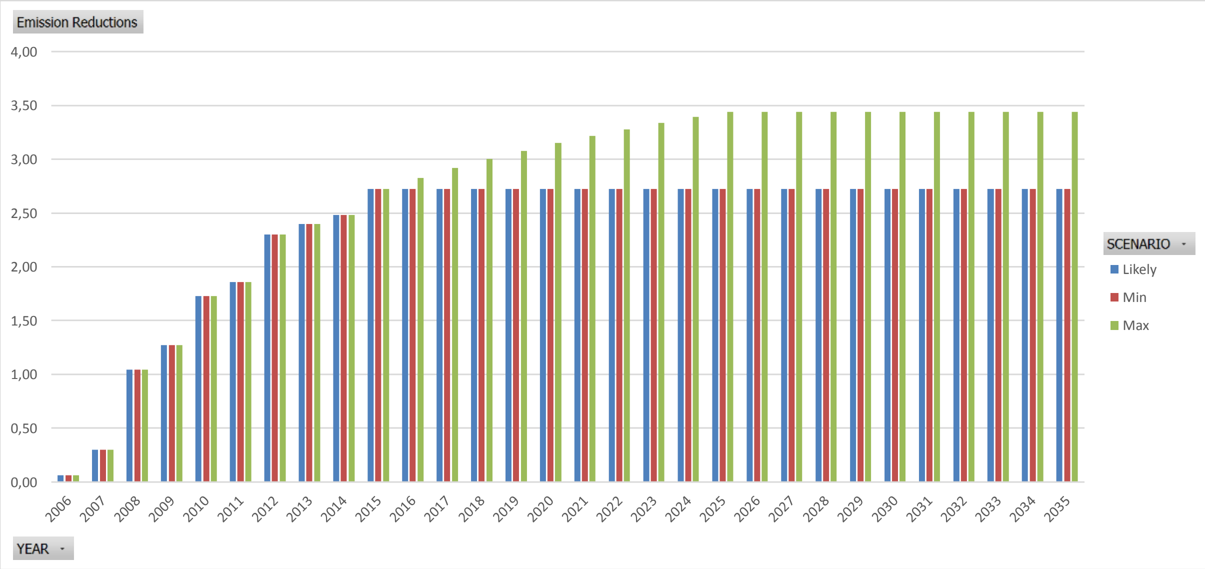
Table 45: Description of data sources

Indicators	Source
Employees under EMAS	VITO/ECONOTEC 2015
Buildings certified	2014 EMAS report
BaU Energy consumption per employee	VITO/ECONOTEC 2015
Impact of EMAS	2014 EMAS report
EF	VITO/ECONOTEC 2015

3.25.5 Results

The emission reductions achieved by the implementation of the PAM increase from 0,07 kt CO2-eq in 2006 to 3,03 kt CO2-eq since 2014 (likely scenario). The following figure illustrate the emission reductions achieved from 2004 to 2035 by the PAM:

Figure 36: Annual emission reductions (minimum, maximum and likely scenarios)



3.25.6 Discussion

More updated information on number of employees working under organizations EMAS certified and/or updated energy consumption of the buildings could enable a better approximation to the PAM.

3.25.7 References

2014 EMAS report

3.26 XX-X01: Ecocheque

3.26.1 Description

The eco-cheque is a new extra-legal advantage that the employer can provide to workers, in the similar way as the gift cheque. This eco-cheque is dedicated to ecological products or services. Its application area is very wide, from the "economy light bulb" to "ecological cleaning products".

As for the gift cheque, the eco-cheque is exempt from taxes and social contributions.

The eco-cheque mechanism has been fully defined in the CCT (Convention Collective du Travail) n°98 of the “Conseil National du Travail”.

This PAM results in a reduction of emissions in both ETS and ESD sectors.

3.26.2 Methodology

In the absence of additional information, the current estimation is based on expected emission reductions estimated by CO2logic by type of appliance, following the same general methodology described in the previous assessment (VITO/Econotec 2015).

The annual emission reduction is calculated as *follows*:

$$ER_t = \sum_i N_{t,i} \cdot ER_i \cdot A_i$$

With

$\mathbf{ER_t}$ = Annual emission reduction
$\mathbf{N_{t,i}}$ = cummulative number of efficient appliances of type i
$\mathbf{ER_i}$ = Unit CO2 reduction per appliance of type i (efficient appliance respect to the usual one)
$\mathbf{A_i}$ = Allocation factor to federal measure per appliance of type i

As the estimation is based on the study of CO2logic, it has not been possible to estimate different minimum and maximum scenarios, being the effect of the PAM and its corresponding uncertainties those estimated by CO2logic.

3.26.3 Main assumptions

3.26.3.1 General assumptions

- Annual reductions in CO2 emissions are estimated based on a constant level of substitution per type of appliance (new units in operation).
- For economy light bulb, it is assumed that there is no effect after 2013 because it becomes the standard
- For television, the expected effect will be reduced throughout the period as the offer and the price reduction will naturally lead the purchase choice to the LED technology

- For freezers, the standard for freezer becomes A+ and will soon become A++;
- The use of the bicycle has been assumed to be used once a week for a short travel (7.5 km).

3.26.4 Data sources

The data sources used for the estimation of the PAM are presented in the following table:

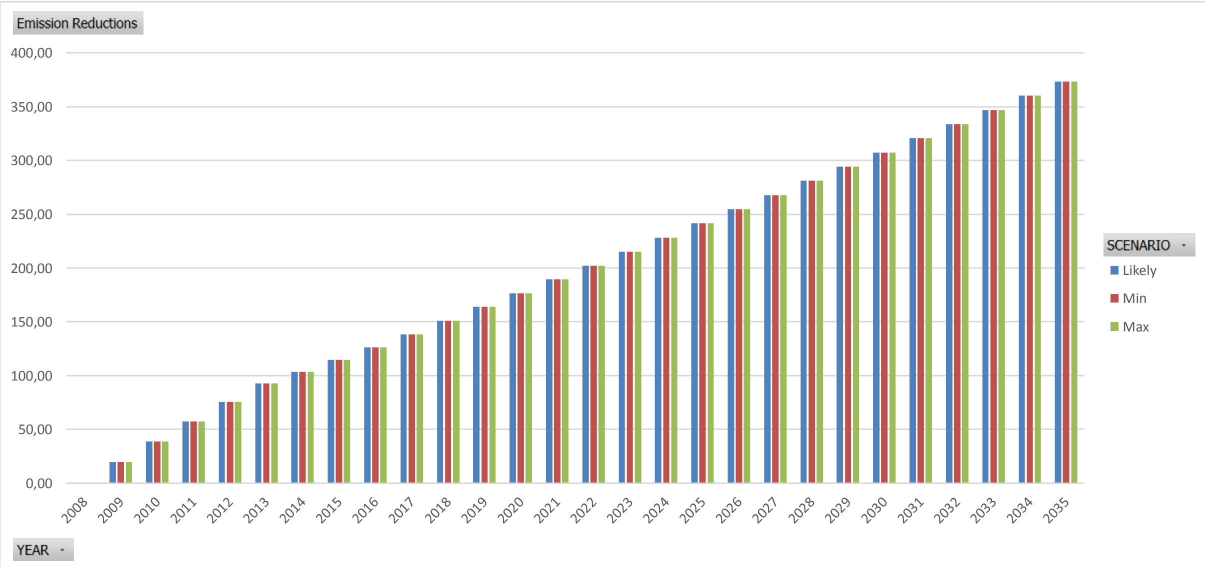
Table 46: Description of data sources

Indicators	**Source**
Unit CO2 reduction per appliance of type i (efficient appliance respect to the usual one)	CO2logic, 2010

3.26.5 Results

The emission reductions achieved by the implementation of the PAM increase from 20 kt CO2-eq in 2009 to 373 kt CO2-eq in 2035. The following figure illustrate the emission reductions achieved from 2004 to 2035 by the PAM:

Figure 37: Annual emission reductions (minimum, maximum and likely scenarios)



3.26.6 Discussion

Information on the use of the ecocheques could enable an update on the methodology, that now strictly depends on the study made by CO2 logic.

3.26.7 References

CO2logic, 2010. Analyse des avantages CO2 des produits éco-chèques. Sodexo.

3.27 XX-X02: Green loans

3.27.1 Description

The measure consists in a subsidy of the federal government reducing by 1.5% the interest rate of bank loans for energy saving investments of households that are mentioned in a list including thermal insulation, double glazing, condensing boilers, heat pumps and solar panels. It is part of the economic law of 27 March 2009. It is a temporary measure, only applicable to loans awarded between 1st January 2009 and 31st December 2011.

This PAM results in a reduction of emissions in both ETS and ESD sectors.

3.27.2 Methodology

This PAM completely overlaps with measure EC-B01, because green loans can be combined with a tax reduction. Therefore, the impact of this measure cannot be added to the total emission re*ductions by all federal PAMs.*

The annual emission reduction is calculated as *follows*:

$$ER_t = \sum_i N_t \cdot P_i \cdot ER_i \cdot A_i$$

With

$\mathbf{ER_t}$ = Annual emission reduction
$\mathbf{N_t}$ = cummulative number of green loans
$\boldsymbol{P}_\mathbf{i}$ = Distribution between investments or technologies
$\mathbf{ER_i}$ = Unit CO2 per investment
$\mathbf{A_i}$ = Allocation factor to federal measure per investment

FPS Economy provided information on the number of green loans in the period October 2009 – September 2011. Personal communication with FPS Finance however showed that the number of requests per month fluctuates, yet that there is no continuous increasing trend in 2011. It is therefore assumed that the number of applications will remain constant for the rest of 2011. Based on previous information this gave an estimated number of new applications of 6791 in 2009, 36676 in 2010 and 78951 in 2011.

To allocate the number of loans to the different technologies, the distribution observed in measure EC-B03 (FRGE, all applications) was used. This is a different distribution than for measure EC-B01, which reflects the fact that costly investments (e.g. PV panels) are more likely to occur proportionally for a loan.

The unit emission reductions of measure EC-B01 are used also in this PAM.

Finally, part of the emission reduction was allocated to the regional level (corresponding to financial support provided by grants and green certificates). To estimate the financial contribution of the

Federal government, we calculated the benefit of a 1.5% reduction of the interest rate on a loan (mean cost for different technologies based on information of FRGE) for a period of 5 years.

3.27.3 Main assumptions

3.27.3.1 General assumptions

- Unit emission reductions and federal allocation factors per technology match with the factors applied in the PAM EC-B01 (Financial incentives for rational use of energy).
- Number of applications for green loans will remain constant for the rest of 2011, for which information is not made available.
- For the financial contribution of the Federal government, the benefit of a 1.5% reduction of the interest rate on a loan was estimated (mean cost for different technologies based on information of FRGE) for a period of 5 years.
- To allocate the number of loans to the different technologies, the distribution observed in measure EC-B03 (FRGE, all applications) was used.
- Once the investments are made, the emission reductions attributable to the investments are accounted until the end of the life expectancies of the technologies which have been funded with the investments. The life expectancies of the different technologies are extracted from the National Energy Efficiency Action Plan.

3.27.4 Data sources

The data sources used for the estimation of the PAM are presented in the following table:

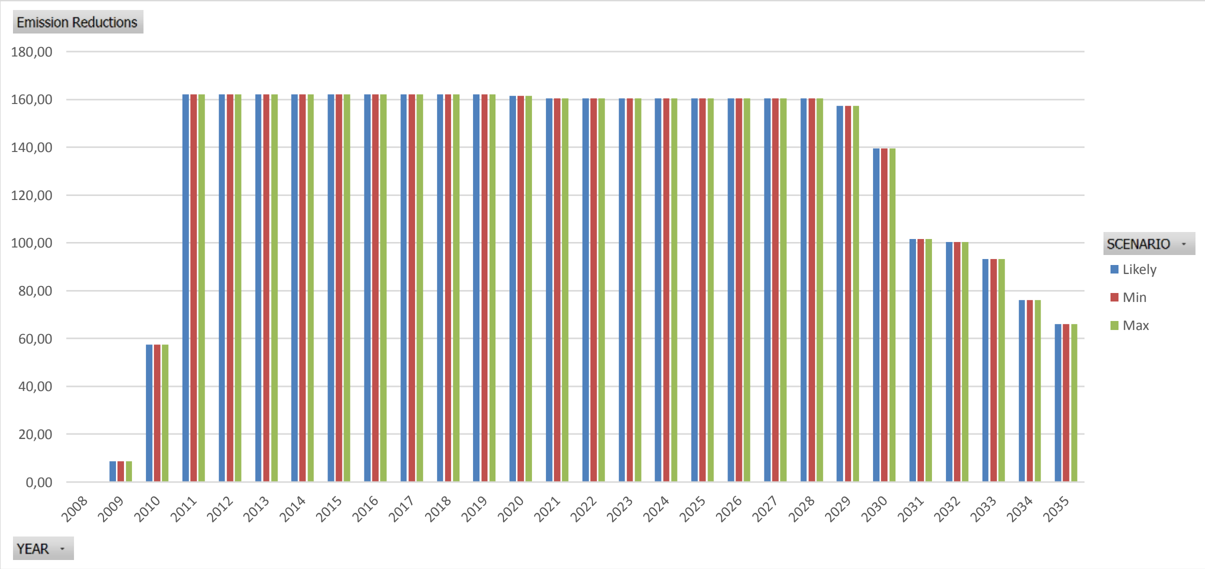
Indicators	**Source**
Number of green loans	Personal communication of FPS - FPS Economy
Life expectancies	National Energy Efficiency Action Plans
ERi	PAM EC-B01

3.27.5 Results

The emission reductions achieved by the implementation of the PAM increase from 7 kt CO2-eq in 2009 to 162 kt CO2-eq in 2011 (national total emissions). From 2011 to 2029, the emission reductions achieved are almost constant. The temporal evolution of the emission reductions is driven by the life expectancies of the technologies that have been funded with the investments, as the emission reductions are accounted until the end of the lifetime of the technologies.

The following figure illustrate the emission reductions achieved from 2004 to 2035 by the PAM:

Figure 38: Annual emission reductions (minimum, maximum and likely scenarios)



3.27.6 Discussion

From 2012, the emission reductions are still above zero because there are technologies still in use, i.e. their lifetime goes beyond 2030.

The scope of this measure and its overlapping with other PAMs should be clarified.

3.27.7 References

European Commission, 2017. National Energy Efficiency Action Plans and Annual Reports. Available at : https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive/national-energy-efficiency-action-plans

3.28 XX-X03: EU Regulation of F-gases

3.28.1 Description

The use of fluorinated gases (F-gases) is widespread in industrial and commercial applications. F-gases are greenhouse gases which have a very high global warming effect. To control emissions of F-gases, the EU adopted in 2006 the F-gas Regulation (842/2006), intended to control the production and the consumption of F-gases and ***incentivize*** the use of alternatives with less impact on climate change. In 2014, the original F-gases Regulation was replaced by Regulation 517/2014, which strengthen the existent measures and introduced new provisions on F-gases consumption and production, applicable from 2015. The main provisions of the new F-gases Regulation are the following:

- Limitation of the total amount of gases that can be sold in the EU, with the target of reaching an amount of one-fifth of 2014 sales. In the description of the PAM this provision is named provision 1.
- Banning the use of F-gases in certain application where less harmful alternatives are available in the market. In the description of the PAM this provision is named provision 2.
- Preventing the emissions from existent equipment by enhanced maintenance, quality control checks and recovery of gases. In the description of the PAM this provision is named provision 3.

The F-gases regulation impacts on the future evolution of GHG emissions in the following IPCC categories:

- Commercial refrigeration
- Industrial refrigeration
- Stationary refrigeration
- Domestic refrigeration
- Transport refrigeration
- Foam blowing agents – closed cells
- Fire protection
- Technical aerosols

This PAM results in a reduction of emissions in the ESD sector.

3.28.2 Methodology

3.28.2.1 Background information – Consumption and emissions of F-gases

F-gases are used in a wide range of industrial, commercial and domestic applications. Generally, F-gases are introduced in the equipment with the purpose of using the refrigeration, isolation or conductivity characteristics of these gases. Emissions of F-gases occur in different stages of the useful life of the equipment, as follows:

Manufacturing: when the equipment is manufactured, F-gases are introduced in the equipment. In the process of introducing gas into the equipment, leakages occur, resulting in F-gases emissions.

When a freezer is manufactured, F-gases are incorporated into the device before it is sold, with the purpose of refrigerating food after the sale. In the process of introducing the gas in the freezer (in the manufacturing plant), leakages occur, leading to F-gases emissions.

Useful life of equipment: During the regular use of the equipment, leakages occur, resulting in F-gases emissions. The sum of gases that are contained in all devices form a **bank of F-gases**. This bank of gases represents the sum of gases which is contained in all equipment in use, from which leakages of F-gases occur during the regular use of each device. For estimating the bank of gases several variables need to be considered, as follows:

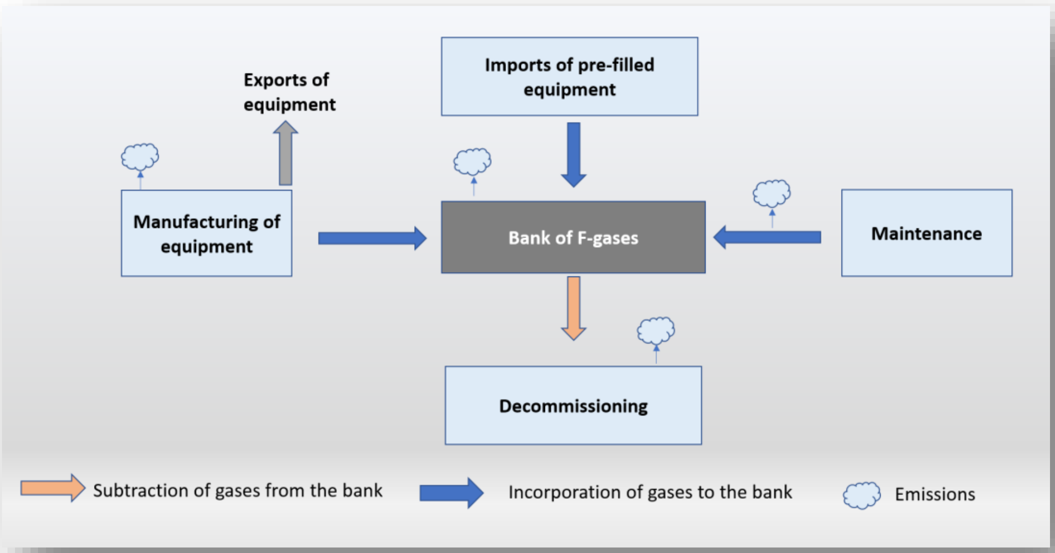
a) The devices that are manufactured within the country can either be sold in Belgium or **exported**. If they are sold in Belgium, they will increase the **bank of gases**.
b) Imports of devices (pre-filled with F-gases) also increase the **bank of gases**.
c) In the bank of gases (in the regular functioning of the equipment), leakages occur (emissions). These leakages diminish the **bank of gases**.
d) The leakages from the regular use of the equipment causes the need of re-filling of gases, in maintenance operations. This re-filling also increases the bank of gases.
e) When the equipment reaches the end of its useful life, the gases that are contained in the equipment are extracted from the **bank of gases**.

Maintenance: Due to the F-gases leakages that occur in the regular use of the equipment, the content of F-gases diminishes hindering the appropriate functioning of the device. Due to this issue, new gas is incorporated into the equipment for maintenance purposes. In the process of incorporating gas into the equipment, leakages occur, resulting in F-gases emissions. *When the F-gas contained in the air conditioning system of your vehicle run out, new F-gas is incorporated to enable the appropriate functioning of the air conditioning. When the technician incorporates F-gas into the vehicle, leakages of F-gases occur, leading to F-gases emissions.*

Decommissioning: When the useful life of the equipment ends, the devices are retired from service. When this happen, the devices have F-gases remaining, which have not been leaked yet. These gases can be recovered, valorized and/or disposed. In these processes occur leakages that lead to F-gases emissions. *The F-gases contained in the air conditioning systems are commonly recovered by waste agents. In the process of recovery, amounts of F-gases are lost, leading to F-gases emissions.*

The following figure illustrate the overall process which lead to F-gases emissions

Figure 39: Emissions of F-gases



The countries that are Parties to the UNFCCC estimate the emissions of F-gases using the methodologies provided in the IPCC Guidelines.

IPCC methodologies

For developed countries, the most common methodological alternatives for estimating F-gas emissions are the Tier 2 methods. IPCC 2006 defines the following two steps as the foundation of the Tier 2 methodologies:

> *"*
>
> - *Calculation or estimation of the time series of net consumption of each individual HFC and PFC chemical at a relatively detailed product and equipment level to establish the consumption basis for emission calculations. (e.g., refrigerators, other stationary refrigeration/AC equipment, appliance foams, insulated panels, pipe insulation, etc.).*
> - *Estimation of emissions using the activity data and resulting bank calculations derived from step (i), and either emission factors that reflect the unique emission characteristics related to various processes, products and equipment (Tier 2a) or, relevant new and retiring equipment information at the sub application level to support* ***a mass balance approach****. (Tier 2b)."*

Once the countries estimate the activity data and emissions, the main series of the methodology are reported in the CRF tables. The methodology used is explained in the National Inventory Report (NIR). Both the CRF tables and the NIR are available at http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/9492.php).

What information is available in the CRF tables?

The CRF tables contains activity data and emissions for several categories and stages, as follows:

For Belgium, the main categories on F-gases consumption reported are: Refrigeration and air conditioning (commercial refrigeration, domestic refrigeration, industrial refrigeration, transport refrigeration, mobile air conditioning, stationary air conditioning), Foam blowing agents (closed cells, open cells), aerosols (metered dose inhalers, other), electrical equipment and SF6 consumption in soundproof windows.

The stages reported are: manufacturing, useful life and decommissioning

The following is an extract of the data reported by Belgium for year 2014 on refrigeration and air conditioning.

Figure 40: CRF table 2(II). B-H. Year 2014, submission 2016.

TABLE 2(II).B-H SECTORAL BACKGROUND DATA FOR INDUSTRIAL PROCESSES AND PRO
Sources of fluorinated substances
(Sheet 2 of 2)

Inventory 2014
Submission 2016 v3
BELGIUM

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Gas *(please specify)*	ACTIVITY DATA *Amount*			IMPLIED EMISSION FACTORS(1)			EMISSIONS(2)			
	One row per substance	Filled into new manufactured products	In operating systems (average annual stocks)	Remaining in products at decommissioning	Product manufacturing factor	Product life factor	Disposal loss factor	From manufacturing	From stocks	From disposal	Recovery(3)
		(t)			%			(t)			
F. Product uses as substitutes for ODS											
1. Refrigeration and airconditioning											
Commercial refrigeration											
HFC-32	HFC-32	435,26	841,02	35,16	0,39	5,60	70,82	1,71	47,10	24,90	10,26
HFC-125	HFC-125	530,24	2198,73	84,83	0,68	8,05	73,20	3,60	176,99	62,09	22,73
HFC-134a	HFC-134a	149,66	1591,32	105,53	1,73	8,77	73,58	2,59	139,51	77,65	27,88
HFC-143a	HFC-143a	91,09	1426,90	54,53	2,00	9,61	75,00	1,82	137,17	40,90	13,63
HFC-152a	HFC-152a	NO	0,29	0,07	NO	20,00	75,00	NO	0,06	0,05	0,02
C3F8	C3F8	0,25	2,19		2,00	9,59		0,01	0,21	NO	
Domestic refrigeration											
HFC-134a	HFC-134a	NO	39,68	4,05	NO	1,00	26,55	NO	0,40	1,08	2,98
Industrial refrigeration											
HFC-32	HFC-32	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
HFC-134a	HFC-134a	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
HFC-143a	HFC-143a	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
HFC-125	HFC-125	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Transport refrigeration											
HFC-134a	HFC-134a	NO	14,12	0,98	NO	25,00	30,00	NO	3,53	0,29	0,69

As illustrated by the extract, for each category, the activity data and emissions of each gas consumed and emitted are reported by stage of useful life (only manufacturing, useful life and decommissioning). The implied emission factor is the result of dividing the emissions by the activity data for each stage, category and gas (this implied emission factor represents the average emission factor used by the country for estimating the emissions of each gas within each category and stage).

The reported activity data, implied emission factors and emissions have a different interpretation in each stage, as described in the name used in each case in the CRF tables. The following table provides a description of each parameter in each of the stages of the useful life, for enabling a better interpretation of the data available:

Table 47.. Interpretation of the data reported in the CRF tables for each category and gas

	Activity data		Emission factor		Emissions	
Stage of the useful life	Name in CRF tables	Description	Name in CRF tables	Description	Name in CRF tables	Description
Manufacturing	"(gases) Filled into new manufactur ed products"	Amount of gases incorporated in new equipment manufactured this year	"product manufacturin g factor"	Emission factor for the manufacturing stage, which represents the average leak factor for incorporating gas in new equipment manufactured.	"(emissions)fr om manufacturin g"	Emission produced in the stage of manufacturing
Useful life	"(gases accumulate d) in operating systems"	This is the **bank of gases**, the gases accumulated	"product life factor"	Emission factor for the useful life stage, which represents the average leak factor for the useful life of the equipment	"(emissions)fr om stocks"	Emission produced in the stage of useful life
Decommissioning	"(gases) Remaining in products at decommissi oning"	These are the gases that are remaining at the end of the useful life, and will be subject to leak	"disposal loss factor"	Emission factor for the decommissioning stage, which represents the average leak factor for the process that are carried out after the useful life of the equipment.	"(emissions)fr om disposal"	Emission produced in the stage of decommissioning

Henceforth, references to activity data, emissions and emission factors for the stages of manufacturing, useful life, and decommissioning are to be understand in the same sense than in the CRF tables.

It is to be noted that imports, exports and maintenance data **is not reported in the CRF tables**.

What information is available NIR?

The Belgian NIR contain an overall description (not very detailed) of the methodology used. A general methodology for all F-gases categories can be summarized in the following extract of the Belgian NIR "*The emissions are mainly estimated on the basis of the consumption of the different substances for each application, the consumption of products containing such substances, figures on external trade in substances or products containing substances, as well as on emission modelling by application and assumptions on leakage rates.*".

Considering the background presented, what is the approach taken for estimating the PAM?

We have information available on activity data and emissions of the stages of **manufacturing, useful life and decommissioning**, by category and gas. This information can be used for reproducing a complete methodology, following the methodological steps defined by IPCC 2006. This methodology can be then extended to future years (2015-2035). This was the first objective of the estimation: **reproduce the historical years for modelling the future**. Therefore, an IPCC methodology was developed for obtaining the activity data of each stage, gas and category. This activity data multiplied by emission factors led to F-gases emissions. Default methodological coefficients were extracted from the inventory (implied emission factors from CRF tables), IPCC 2006 and a report of national projections of F-gases.

What are the main assumption taken for reproducing the IPCC methodology based on the CRF data?

- The gases introduced in the bank with maintenance purposes are contained in the activity data of manufacturing. The emissions attributable to the maintenance stage would be split between the stages of manufacturing and useful life. *Why? The process of introducing gas into the equipment would involve a leak of F-gases (considered in the manufacturing stage). The gases that are incorporated in the bank would then be considered as bank, suffering the same leaks as the other gases that compose the bank (useful life stage).*
- Imports and exports are calculated from differentials between series of manufacturing and stock. *If the bank (activity data useful life) of the previous year plus the gas introduced (activity data manufacturing) in current year is lower than the bank of the current year, the difference is assumed to be an import of gases. If the difference is higher, there has been an export.*
- The useful life and the quantities of gases remaining at the end of useful life were taken from projections and IPCC 2006. Using these coefficients, differences between the inventory and this estimation were found on the calculated decommissioning activity data and emissions.
- The re-use of gases (after recycling) was not considered.

3.28.2.2 General methodology

Using the same IPCC methodology for reproducing the historical period (1990-2014), four scenarios have been estimated for the projected period (2015-2035): one Business as Usual (BaU) scenario, which does not consider the impact of the Regulation on the forecasted emissions, and three WeM scenarios, which are three alternatives estimated for obtaining the impact of the Regulation on forecasted emissions.

This section contains the description of the IPCC methodology used for reproducing the historical period. Following section "Definition of scenarios" describes how was the historical methodology extended to future years in each of the scenarios.

Scope of the estimation

To be able to consider different emission factors, evolution of the bank of gases and useful life of the equipment, the CRF data reported within commercial refrigeration has been disaggregated into the following categories: commercial refrigeration (small commercial and supermarkets), industrial refrigeration and stationary air-conditioning[10]. The coefficients of disaggregation applied were extracted from the 2016 French submission to the UNFCCC. The following table illustrates the categories considered and the gases contained within each category:

10 Data within categories domestic refrigeration, transport refrigeration, mobile air conditioning, foam blowing agents – closed cells, fire protection and technical aerosols was not further disaggregated.

Table 48. CRF categories and gases considered

CRF Categories and sub-applications	Gases
2F. Product uses as substitutes for ODS 2F1. Refrigeration and air conditioning Commercial refrigeration	
Supermarkets - centralised systems	HFC-32, HFC-125, HFC-134a, HFC-143a, HFC-152a and PFC-218.
Small commercial - condensing units	HFC-32, HFC-125, HFC-134a, HFC-143a, HFC-152a and PFC-218
Industrial refrigeration	HFC-32, HFC-125, HFC-134a, HFC-143a, HFC-152a and PFC-218.
Stationary refrigeration	HFC-32, HFC-125, HFC-134a, HFC-143a, HFC-152a and PFC-218.
Domestic refrigeration	HFC-134a
Transport refrigeration	HFC-32, HFC-125, HFC-134a, HFC-143a, HFC-152a and PFC-218.
2F2. Foam blowing agents Closed cells	HFC-134a, HFC-152a, HFC-227ea, HFC-245fa, HFC-365mfc.
2F3. Fire protection	HFC-125 and HFC-227ea
2F4. Aerosols Other non-specified	HFC-134a and HFC-152a

For these categories and gases, activity data and emissions are calculated for the stages of **manufacturing**, **useful life** and **decommissioning**.

Description of the estimation

For each category, gas and stage, the emissions are calculated as follows:

$$Emissions_{C,G,S} = AD_{C,G,S} \cdot EF_{C,G,S}$$

AD= Activity data category C, Gas G, stage S.
EF= Emission factor category C, Gas G, stage S.

3.28.2.2.1 *Activity data*

Manufacturing stage

The activity data for the manufacturing stage (**AD manufacturing**) of the cycle has been maintained as reported in the CRF tables. It is assumed that this data represents the amount of gases introduced in new equipment plus the gases introduced in equipment for maintenance purposes.

Imports

Imports of gases have been derived from the series of gases introduced in the equipment (manufacturing) and the series of bank of gases reported in the CRF tables. If the bank of gases of previous year plus the gases introduced in the equipment in the current year (activity data manufacturing) are lower than the bank of the current year, the difference would be attributed as import.

Export

Exports of gases have been derived from the series of gases introduced in the equipment (manufacturing) and the series of bank of gases reported in the CRF tables. If the bank of gases of previous year plus the gases introduced in the equipment in the current year (activity data manufacturing) are higher than the stock of the current year, the difference would be attributed as export.

Use of the equipment stage: bank of gases

The activity data of the useful life of the equipment is the bank of gases (**AD useful life**), what is to say the total quantity of gases in use, which eventually leak to the atmosphere producing F-gases emissions.

This bank is calculated as the gases incorporated in the equipment each year (gases used in national production plus gases incorporated for maintenance purposes) minus the gases contained in the equipment which is sold to other countries (exports) plus the gases contained in the pre-charged equipment purchases from other countries (imports) minus the gases which are subtracted from the stock for its disposal/recycling.

Through the years, the stock evolves as follows:

$$Bank_{C,G,t} = (Bank_{\ C,G,t-1} \cdot (1 - EF_{C,G,t-1})) + AD\ manufacturing_{C,G,t} + Imports_{C,G,t} - Exports_{C,G,t} - AD\ decommisioning_{C,G,t}$$

$Bank_{\ C,G,t} = Bank\ of\ gases\ in\ category\ C, gas\ G, year\ t$

$Bank_{\ C,G,t-1} = Bank\ of\ gases\ in\ category\ C, gas\ G, year\ t-1$

$EF_{C,G,t-1} = emission\ factor\ category\ C, gas\ G, year\ t-1$

$AD\ manufacturing_{C,G,t} = activity\ data\ manufacturing\ category\ C, gas\ G, year\ t$

$Imports_{C,G,t} = gases\ imported$ in category C, gas G, year t

$Exports_{C,G,t} = gases\ exported$ in category C, gas G, year t

$$AD\ decommisioning_{C,G,t} = gases\ substracted\ from\ the\ stock\ to\ be\ disposed\ o\ recycled, category\ C, gas\ G, year\ t$$

As can be seen in the equation, for calculating the stock the activity data of the other two stages (AD manufacturing and AD decommissioning) is used.

Decommissioning stage:

At the end of the useful life of the equipment, F-gases may remain within the devices (**AD decommissioning**). These gases, which are subtracted from the bank in use, are supposed to be recycled or disposed. Two important variables for calculating the activity data of this stage are the **number of years of useful life of the equipment**, the **amount of gases remaining at the end of the useful life of the equipment**. Both components are considered within the methodology.

$$AD\ decommisioning_{C,G,t} = (AD\ manufacturing_{C,G,t-UL} + Imports_{C,G,t-UL} - Exports_{C,G,t-UL}) \cdot PRD_C$$

$$AD\ decommisioning_{C,G,t} = gases\ which\ are\ substracted\ from\ the\ stock, category\ C, gas\ G, year\ t$$

$$AD\ manufacturing_{C,G,t-UL} = Activity\ data\ manufacturing\ of\ the\ year\ t - Useful\ life\ of\ the\ equipment$$

$$Imports_{C,G,t-UL} = imports\ of\ the\ year\ t - Useful\ life\ of\ the\ equipment$$

$$Exports_{C,G,t-UL} = exports\ of\ the\ year\ t - Useful\ life\ of\ the\ equipment$$

$PRD = percentage\ of\ gases\ remaining\ at\ decomisioning.$ *It is generally be provided as an average for each category*

In a category with an average useful lifetime of 10 years and 50% of initial charge remaining at the end of useful life, the activity data of decommissioning in 2020 would be the 50% of the gases introduced in the bank in 2010.

It has to be noted that the recovery of gases is implicit in the coefficient of gases remaining at the end of the useful life and the emission factor for decommissioning.

The following table illustrates the coefficients used for lifetime of equipment and initial charges remaining at the end of the useful life of the equipment.

Table 49. Lifetimes and initial charges remaining at the end of the useful life of the equipment.

Activity	Lifetime (years)	Source	Initial charge remaining at the end of life (%)	Source
Supermarkets - centralised systems	12	F-gases Projections (Vito/Econotec, 2015)	75	IPCC 2006
Small commercial - condensing units	15	F-gases Projections (Vito/Econotec, 2015)	40	IPCC 2006
Industrial refrigeration	27	F-gases Projections (Vito/Econotec, 2015)	75	IPCC 2006
Stationary refrigeration	15	F-gases Projections (Vito/Econotec, 2015)	65	IPCC 2006
Domestic refrigeration	15	Assumption	40	IPCC 2006
Transport refrigeration	15	Assumption	25	IPCC 2006
Closed cells	20	IPCC 2006	0	IPCC 2006
Fire protection	20	2016 NIR	50	Implicit value 2016 CRF submission

3.28.2.2.2 Emission factors and Useful life of the equipment

The emission factors used for the historical period are extracted from the national inventory (annual implicit emission factors of the CRF tables). The emission factors used for the projected period depends on the scenario. Regarding the end of useful life, the figures used in projections have been applied for the historical and projected periods (in BaU, WeM2 and WeM3 scenarios).

Once the activity data is reproduced and the emission factors for each period (and stage) are identified, the emissions are obtained just multiplying both components for each of the stages:

$$Emissions_{G,C,S} = AD_{G,C,S} \cdot EF_{G,C,S}$$

AD= Activity data category C, Gas G, stage S.
EF= Emission factor category C, Gas G, stage S.

3.28.2.3 BAU scenario

This scenario represents the emissions of F-gases that would have happened without the implementation of Regulation 517/2014 (in the categories and gases defined above in "Scope of the estimation").

This scenario is built on the historical data of years 1990-2014 from the national Inventory. The impact of previous regulation 842/2006 in years 2006-2014 is already incorporated in the inventoried years. No further assumptions have been taken beyond 2014 for estimating the impact that Regulation 842/2006 would have had in the case of not implementing a new Regulation on F-gases[11].

In this scenario, the historical methodology is extended until 2035 through an *exogenous projection* of the introduction of gases in the bank. The activity data of manufacturing, imports and exports were projected through a regression with **population.** Specifically, the total emissions of category 2F (CRF submission 2016) were regressed with population[12]. This regression, with appropriate statistical results, led to an estimation of a series of overall 2F emissions for the period 2015-2035. The inter-annual variation of the overall 2F emissions resulting from this regression has been used to project the introduction of gases into the bank, as follows:

$$GI_{C,G,t} = GI_{C,G,t-1} \cdot IVR_t$$

$GI_{C,G,t} = gases\ introduced\ (AD\ manufacturing, import\ and\ exports), category\ C, gas\ G, year\ t$

$IVR_t = Interannual\ variation\ rate\ of\ the\ results\ of\ regression\ betwen\ aggregated\ 2F\ emissions\ and\ population \cdot$

Table 50. Results of regression of CRF emissions, category 2F, with population

Year	Emissions GHG (kt CO2eq) CRF 2F1	Population	IVRt
2015	2.866	11.220.674	1,14766
2016	2.918	11.281.160	1,040512
2017	2.966	11.337.070	1,035989
2018	3.011	11.389.696	1,032698
2019	3.054	11.440.217	1,030396

[11] In fact, despite the implementation of Regulation 842/2006, the aggregated amount of F-gases cointaned in the bank (the main driver of F-gases emissions) increased a 54% from 2006 to 2014. Therefore, the analysis of the performance of the previous Regulation does not indicate that further emission reduction would have been achieved.
[12] The reason for regressing the whole series of emissions against the population (instead of the new gases incorporated each year), is that the series of new gases incorporated into the bank was very volatile, so it was more complex to obtain appropriate statistical results. Using the population and the total emissions it is ensured that all variables with relevance for explaining the inter-annual evolution of the gases are considered in the regression.

Year	Emissions GHG (kt CO2eq) CRF 2F1	Population	IVRt
2020	3.096	11.489.541	1,028801
2021	3.137	11.538.542	1,027811
2022	3.177	11.585.866	1,026133
2023	3.215	11.631.281	1,02444
2024	3.251	11.674.637	1,022775
2025	3.285	11.715.960	1,021224
2026	3.318	11.755.339	1,019805
2027	3.349	11.792.791	1,01847
2028	3.378	11.828.433	1,017259
2029	3.406	11.862.341	1,01614
2030	3.432	11.894.652	1,015136
2031	-	-	1,015136
2032	-	-	1,015136
2033	-	-	1,015136
2034	-	-	1,015136
2035	-	-	1,015136

The bank of gases and the decommissioning activity data evolve according to the equations posed above (general methodology), driven by the useful life of the equipment, amount of gases introduced in the historical period and percentage of gases remaining at the end of the useful life.

The emissions are calculated by applying the implied emission factors of 2014 to the calculated activity data, by category, gas and stage of the useful life.

3.28.2.4 PAM scenario

Three alternative WeM scenarios have been developed for representing the F-gases emissions under the Regulation 517/2014. In this section, the methodology and main assumptions taken in each scenario are described in detail (see section *Discussion* below for information on the rationale followed for the choice of each scenario).

Scenario WeM 1: Projections

The Federal Public Service of Public Health, Food Chain Safety and Environment publishes projections (henceforth referred as **projections**) for the years 2015, 2020, 2025 and 2030 of the consumption and emissions of F-gases in the country, using the data and methodologies provided by the latest national inventory available. The latest edition of projections is based on the 2015 inventory submitted by Belgium to the UNFCCC, covering the period 1990-2013.

There are methodological differences that hamper the coherency between estimations (national inventory 1990-2014 *vs* projections). The main methodological differences are the following:

Table 51. methodological differences between the national inventory and projections.

Issue	Description
Categories disaggregation	In the Inventory the emission of categories Commercial refrigeration, Industrial refrigeration and Stationary refrigeration are estimated and reported in an aggregated way in category Commercial refrigeration. In Projections, commercial emissions are split between Industrial, Commercial (centralized systems and small commercial) and stationary refrigeration.
Methodological coefficients	The inventory applies emission factors, useful life of equipment and disposal factors for aggregated categories. In projections, specific coefficients are applied to disaggregated categories.
Approach	In the inventory, the estimates are based on quantity of gases consumed by stage of useful life of the products. In projections, numerous estimates are based on data on products (refrigerants, cars fleet, etc).
Different historical evolution	Projections are based on historical data from the national inventory 1990-2013. In the next inventory edition, 1990-2014, the inventory was substantially recalculated.

Despite the differences between approaches, both estimates (inventory & projections) are considered quality estimates, based on consistent assumptions and data collected from national specific sources. Therefore, the estimation of this scenario intends to bridge the gap between estimations and use the estimates performed by both sources.

The scenario WeM1 has been built by applying an index based on projections to the **emission** estimation developed in the scenario BAU, as follows:

$$WeM_t = BAU_{t-1} \cdot Index_t$$

The index has been calculated for each category and gas from the emissions estimated in projections. These emissions are provided in the projections report by category, in terms of kt CO2eq, and by gas (in an aggregated way), in terms of t of emissions of each F-gas. The index has been built weighting the contribution of each gas in the emission evolution of each category, as follows:

$$Index_{C,G,t} = CO2eq\ Emissions_{c,t} * \ Weight_{it}$$

$Index_{itc} = index\ for\ category\ c, gas\ G, year\ t$

$CO2eq\ Emissions_{itc} = CO2eq\ emissions\ of\ category\ c, year\ t$

$Weight_{it} = weigth\ of\ gas\ G, year\ t$

The weight has been estimated based on the GWP of each gas, subtracting the gases in which there are no emissions in specific years and categories. The index was built for the years 2020, 2025 and 2030; the intermediate years of the index have been interpolated (pivot years 2014-2020; 2020-2025;2025-2030).

Scenario WeM 2: Maximum quantities

As described in section 1 of this document, the F-gases regulation has three main provisions: provisions 1, 2 and 3, as defined in section description above.

The scenario WeM 2 considers only the expected evolution of the F-gases consumption and emissions as a consequence of provision 1 the limitation of maximum quantity of gases introduced in the EU market. The scenario ***WeM3***, described below, considers the three components of the F-gases regulation.

The reason for estimating an independent scenario considering only the establishment of maximum values for placing F-gases on the market is the high uncertainty of the estimations of provisions 2 and 3 of the F-gas Regulation, due to the numerous assumptions taken.

Regarding provision 2, the ban of gases in specified categories and equipment is provided by the regulation for detailed products and equipment. Our estimations are based on the national Belgian inventory, in which the information is provided for aggregated categories, as explained above. For this reason, numerous assumptions needed to be made on the coverage of activities affected by each provision of the Regulation.

Regarding component 3, the provisions of the Regulation affect the future evolution of emission factors and recovery efficiencies and standards. To translate the provisions of the Regulation to reductions in the emission factors, assumptions needed to be make on the increasing penetration of good practices as a result of the implementation of the Regulation.

In this context, scenario WeM2 has been estimated for comparison purposes, to assess the future evolution of emissions only due to the limitation of f-gases sales (and consumption). WeM3 incorporates the limitation of f-gases sales, but also the estimation of provisions 2 and 3 of the regulation, which have higher emission uncertainties.

Concerning the methodology used, the general methodology used for the estimation of the BaU is the base of the estimation. As explained in the "General Methodology" section, the quantity of gases introduced in the bank annually (activity data manufacturing, imports and exports) are projected by means of a regression with the population series. In the case of WeM2, the gases introduced in the stock are estimated using the percentages given in Annex V[13] of the F-gases Regulation.

Table 52*. Percentages to calculate the maximum quantity of F-gases sales.*

Years	Percentage to calculate the maximum quantity of hydrofluorocarbons to be placed on the market and corresponding quotas
2015	100
2016-2017	93
2018-2020	63
2021-2023	45
2024-2026	31
2027-2029	24
2030	21

[13] The F-gases Regulation specifies that "the quantity of hydrofluorocarbons that producers and importers are entitled to place on the market in the Union each year does not exceed the maximum quantity y for the year in question calculated in accordance with Annex V."

Source: Annex V, F-gases Regulation

The maximum quantity of F-gases to be placed on the market shall be estimated by applying the following percentages to the annual average of the total quantity placed on the market into the Union during the period from 2009 to 2012. For the purpose of this estimation, the projected amount of gases introduced in the bank each year (the series of AD manufacturing and imports) has been calculated as follows:

$$GI_{C,G,t} = \overline{GI}_{\ C,G,2009-2012} \cdot P_t$$

$GI_{C,G,t} = gases\ incorporated, \quad category\ C, gas\ G, year\ t$

$\overline{GI}_{\ C,G,2009-2012} = average\ of\ gases\ incorporated, category\ C, gas\ G, years\ 2009-2012$

$P_t = percentages\ given\ by\ Annex\ V\ F-gases\ Regulation, year\ t$

As this estimation lead to the maximum quantity of gases introduced into the market, **it is only applicable when the corresponding BaU estimation is higher than this maximum amount**. By default, the introduction of gases will evolve in the same way as in the BaU.

As a clarification, it has to be noted that for this estimation, we start from observed data of 1990-2014 (the historical period). By definition[14], the estimation of the PAM starts in 2015. By 2014, the industry and consumers have probably reduced the F-gases that are introduced in the bank in view of an anticipated compliance with the F-gas Regulation. However, we cannot assume that all reductions in the introduction of gases into the bank in the years before 2015 are due to an adaptation to the F-gas Regulation that was not in place. Therefore, we have only attributed to the PAM the differences in the introduction of gases into the bank above the percentages specified in the Regulation.

Regarding the calculation of the bank of gases, decommissioning activity data, and emissions, the same methodology used in the BaU has been followed, so the only difference between scenarios (WeM2 vs BaU) is the way in which the gases incorporated each year to the stock are calculated.

Scenario WeM 3:

This WeM scenario includes the estimation of the three provisions of the F-gases Regulation: the maximum quantity of gases sold into the EU, the ban of certain gases in specific activities and improved maintenance and recovery efficiencies.

As in the previous two scenarios, the scenario WeM3 follows the general methodology described in the “General Methodology” section. In the case of this scenario WeM3, the quantity of gases incorporated in the bank each year is calculated as described in scenario WeM2, using the percentages provided by Annex V of the F-gases Regulation.

[14] As the Regulation motivating the PAM is adopted in 2014, the effect of the PAM cannot be attributed to years before 2014.

Besides the estimation of the gases incorporated into the bank, this WeM3 assesses the impact of the prohibitions set in Annex III of the F-gas Regulation. Several assumptions have been made for all relevant provisions of Annex III, as described in following table:

Table 53. Prohibitions set in the F-gas Regulation and assumptions taken in scenario WeM3

Prohibition set in F-gas Regulation			Assumptions taken in WeM3
Code used in F-gas Regulation	**Description**	**Date**	
3	Fire protection equipment that contain HFC-23	1 January 2016	There is no HFC-23 consumption in this category, there is no effect of this provision
10	Domestic refrigerators and freezers that contain HFCs with GWP of 150 or more	1 January 2015	In Domestic refrigeration only HFC 134a is consumed (GWP of 1430), there is no effect of this provision
11	Refrigerators and freezers for commercial use (hermetically sealed equipment)		
	that contain HFCs with GWP of 2 500 or more	1 January 2020	This affects the category commercial refrigeration and gases HFC-125, HFC-143a and PFC-218 (PFC-238). We assume that there are no more gases introduced in the stock from 2020 to 2030. From 2015 to 2020 the series of gases introduced into the stock are interpolated
	that contain HFCs with GWP of 150 or more	1 January 2022	This provision only affects to equipment with capacity > 40kw in category commercial refrigeration. We assume this provision applies to supermarkets and to 5% of the gases included in small commercial. The provision affects to the gas HFC 134a. We assume that there are no more gases introduced in the stock from 2020 to 2030. From 2015 to 2020 the series of gases introduced into the stock are interpolated

Prohibition set in F-gas Regulation			Assumptions taken in WeM3
Code used in F-gas Regulation	**Description**	**Date**	
12	Stationary refrigeration equipment, that contains, or whose functioning relies upon, HFCs with GWP of 2 500 or more except equipment intended for application designed to cool products to temperatures below – 50 °C	1 January 2020	This affects category stationary refrigeration, gases HFC-125, HFC-143a and PFC-218. We assume that there are no more gases introduced in the stock from 2020 to 2030. From 2015 to 2020 the series of gases introduced into the stock are interpolated
13	Multipack centralised refrigeration systems for commercial use with a rated capacity of 40 kW or more that contain, or whose functioning relies upon, fluorinated greenhouse gases with GWP of 150 or more, except in the primary refrigerant circuit of cascade systems where fluorinated greenhouse gases with a GWP of less than 1 500 may be used	1 January 2022	Already covered in provision 4
14	Movable room air-conditioning equipment (hermetically sealed equipment which is movable between rooms by the end user) that contain HFCs with GWP of 150 or more	1 January 2020	This provision affects to domestic refrigeration, to gas HFC 134a. We assumed a reduction of 5% in the gas estimated to be filled in the equipment after the cap&trade adjustment

Prohibition set in F-gas Regulation			Assumptions taken in WeM3
Code used in F-gas Regulation	Description	Date	
15	Single split air-conditioning systems containing less than 3 kg of fluorinated greenhouse gases, that contain, or whose functioning relies upon, fluorinated greenhouse gases with GWP of 750 or more	1 January 2025	This provision affects to domestic and commercial air conditioning. For domestic, we assume that the 30% of the domestic equipment is single split with less than 3kg. This affects to gas HFC 134a, with an additional reduction of 30% For commercial air conditioning, as these emissions are included within the category stationary air conditioning and refrigeration, and this category is affected by the assumption taken in provision 12 above, there are no more gases introduced in the stock from 2020 to 2030.
16	Foams that contain HFCs with GWP of 150 or more except when required to meet national safety standards		
	Extruded polystyrene (XPS)	1 January 2020	We assume 50% of the activity data is affected by this provision
	Other foams	1 January 2023	We assume that no gas is filled into the stock of gases from 2023

Prohibition set in F-gas Regulation			Assumptions taken in WeM3
Code used in F-gas Regulation	**Description**	**Date**	
17	Technical aerosols that contain HFCs with GWP of 150 or more, except when required to meet national safety standards or when used for medical applications	1 January 2018	Aerosols for medical applications are covered by a specific category of the inventory "Methered dose inhalers" which is not in the scope of this estimation (we assumed there is no effect of the Regulation to this category). For the category of technical aerosols, we assume that only a 10% of emissions remain from 2020, attributed to manufacturing emissions. From 2018 to 2020 there is a reduction of emissions, assuming this 2 years' period as a consumption from aerosols sold in previous years but consumed in 2018 and 2019. Exceptions for meting national safety standards are considered marginal.

Regarding provision 3 of the F-gas Regulation, the enhanced maintenance and recovery of gases, we have assumed an average annual reduction of 5% in the emission factors starting in 2014, in all categories and gases for the **useful life and decommissioning stages**.

As the results of the WeM3 are very affected for this reduction in the emission factors, a sensitive analysis has been carried out to illustrate the differences in terms of CO2eq reduced because of the choice of the coefficient of reduction in the emission factor. The following table shows the emissions of the WeM3 scenario with three different average annual reduction in the emission factor: 5%, 10% and 15%.

Table 54. *Sensitivity analysis*

Year	5%	10%	15%
2015	1.976	1.875	1.775
2016	1.763	1.593	1.431
2017	1.683	1.451	1.240
2018	1.572	1.293	1.051
2019	1.300	1.025	795
2020	1.139	858	633
2021	993	717	504
2022	942	642	425
2023	949	611	383
2024	893	548	324
2025	777	458	258
2026	759	426	227
2027	702	375	190
2028	600	308	149
2029	624	302	138
2030	534	248	108
2031	405	184	78
2032	343	152	62
2033	296	128	50
2034	282	116	44
2035	232	95	35

The introduction of new products in exchange of the bank of F-gases is not estimated in this WeM3. As the GWP of the alternatives to the F-gases currently used is very low (products as hydro-fluoro-olefines (HFO), CO_2, hydrocarbons or ammonia have GWP´s lower than 100), the emissions and bank of these new gases are not estimated, i.e. considered as not significant (also, the bank of gases estimated in the BaU minus the stock of gases of WeM3 will represent the stock of new alternative gases).

3.28.3 Main assumptions

3.28.3.1 General assumptions

The main assumptions taken are already described in the description of the general methodology and the definition of each scenario.

3.28.3.2 BAU scenario assumptions

The main assumptions taken are already described in the description of the general methodology and the definition of each scenario.

3.28.3.3 PAM scenario assumptions

The main assumptions taken are already described in the description of the general methodology and the definition of each scenario.

3.28.4 Data sources

The data sources used for the estimation of the PAM are presented in the following table:

Table 55: Description of data sources

Indicators	Sources
Belgian 2016 CRF submission to the UNFCCC	http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/9492.php
F-gas Projections (Vito and Econotec, 2015). Update of the national emission inventory of ozone depleting substances and fluorinated greenhouse gases (1995-2013) and projections for the years 2015, 2020, 2025 and 2030. Final report Part B: Projections.	Study provided by the FPS
Population	http://statbel.fgov.be/fr/modules/publications/statistiques/population/downloads/population_au_1er_janvier_2017-2061.jsp
2006 edition of the IPCC Guidelines. Vol. 3, Chapter 7 Emissions of Fluorinated Substitutes for Ozone depleting substances.	http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html

3.28.5 Results

The WeM 3 scenario has been selected for the final PaM estimation obtained as follows:

$$PAM_t = WeM3_t - BaU_t$$

$PAM_t = emission\ reduction\ due\ to\ the\ PAM, year\ t$

$WeM3_t = emissions\ estimated\ in\ WEM3\ scenario, year\ t$

$BaU_t = emissions\ estimated\ in\ BaU\ scenario, year\ t$

The total emissions and the results of the estimation of the PAM are illustrated in the following tables.

Figure 41: Federal Annual emission reductions (minimum, maximum and likely scenarios)

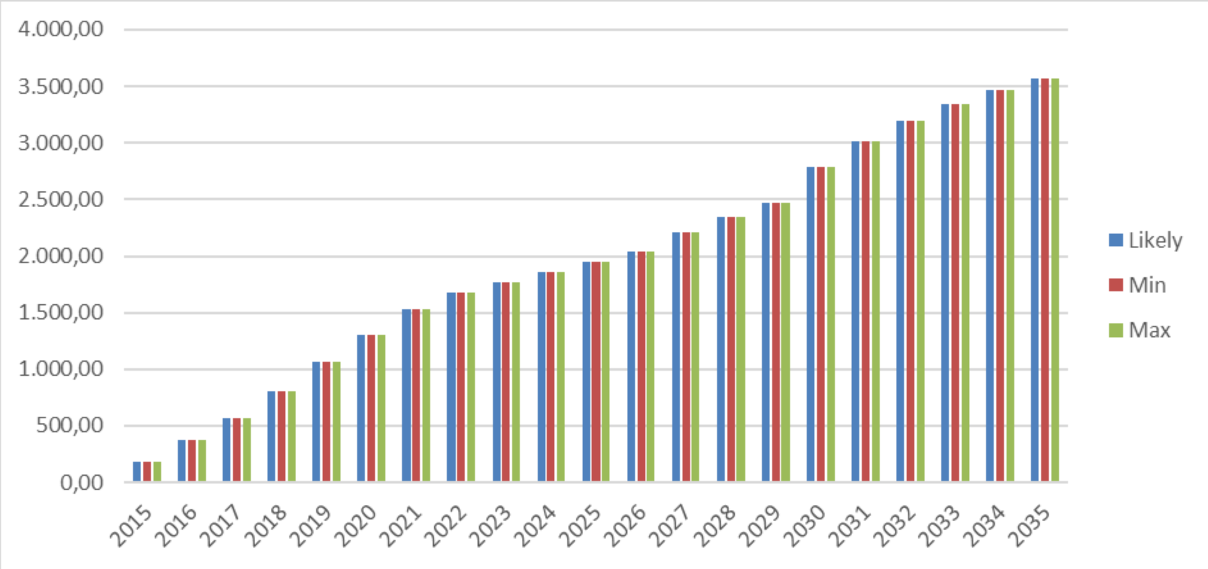
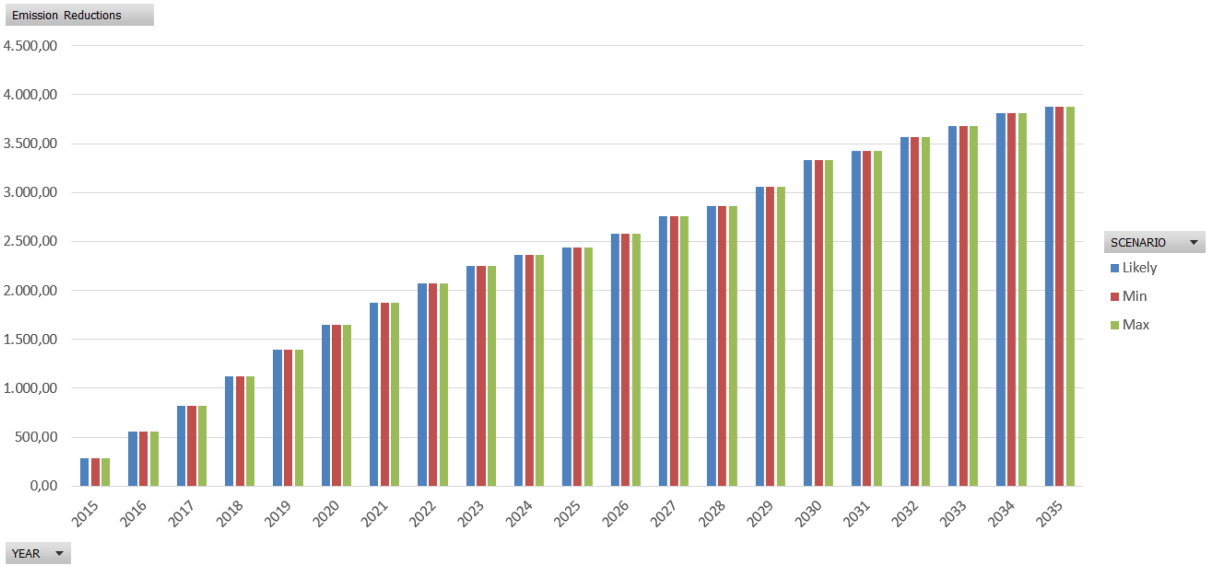


Figure 42: National Annual emission reductions (minimum, maximum and likely scenarios)



3.28.5.1 Allocation of results

As it described in the methodology section above, the WeM3 scenario considers all the provisions contained in the F-gas Regulation 517/2014 in Belgium.

The impact in terms of ktCO2eq of the implementation of each provision is detailed in the following table:

Table 56. *Impact of the PAM by provision of the F-gas Regulation*

Year	Provision 1	Provision 2	Provision 3	Total impact
2015	-95	-90	-101	-286

2016	-204	-174	-178	-556
2017	-298	-269	-254	-821
2018	-568	-239	-317	-1.124
2019	-743	-328	-323	-1.394
2020	-914	-392	-342	-1.647
2021	-1.140	-387	-347	-1.874
2022	-1.320	-356	-400	-2.076
2023	-1.468	-300	-479	-2.248
2024	-1.660	-193	-509	-2.363
2025	-1.825	-129	-488	-2.442
2026	-1.935	-106	-537	-2.578
2027	-2.107	-101	-553	-2.761
2028	-2.213	-135	-511	-2.859
2029	-2.288	-178	-594	-3.060
2030	-2.603	-190	-541	-3.334
2031	-2.761	-249	-418	-3.428
2032	-2.854	-341	-369	-3.564
2033	-3.181	-165	-330	-3.676
2034	-3.254	-212	-347	-3.813
2035	-3.312	-253	-308	-3.873

Provision 1: Limitation of the total amount of gases that can be sold in the EU, with the target of reaching an amount of one-fifth of 2014 sales. Annex V if the F-gas Regulation.

Provision 2: Banning the use of F-gases in certain application where less harmful alternatives are available in the market. Annex III of the F-gas Regulation.

Provision 3: Preventing the emissions from existent equipment by enhanced maintenance, quality control checks and recovery of gases. F-gas Regulation except for Annex III and Annex V.

The rationale for attributing each of the provisions to the federal or regional level was provided by the FPS, in personal communication, as follows:

The administration responsible for the implementation of provision 1 is the EU Commission (they hold the registry and issue the quotas. The federal controls the POM (Placing on the market) through custom controls, and should react to reports or alerts from the Cion. Provision 1 can therefore be attributed to federal authority

The administration responsible for the implementation of provision 2 is mainly the federal level. Provision 2 can be attributed to the federal authority

The administration responsible for the implementation of provision 3 is mainly the regional level. The main interaction with the federal level could occur from the prohibition of selling gas to technicians or companies not holding the appropriate certification. This provision can be attributed to regional authority

Table 57. *Impact of the PAM by administrative level*

Year	Federal impact	Regional impact	Total impact
2015	-185	-101	-286
2016	-378	-178	-556
2017	-567	-254	-821
2018	-807	-317	-1.124
2019	-1.071	-323	-1.394
2020	-1.306	-342	-1.647
2021	-1.527	-347	-1.874
2022	-1.676	-400	-2.076
2023	-1.768	-479	-2.248
2024	-1.853	-509	-2.363
2025	-1.954	-488	-2.442
2026	-2.041	-537	-2.578
2027	-2.208	-553	-2.761
2028	-2.348	-511	-2.859
2029	-2.466	-594	-3.060
2030	-2.793	-541	-3.334
2031	-3.010	-418	-3.428
2032	-3.195	-369	-3.564
2033	-3.346	-330	-3.676
2034	-3.466	-347	-3.813
2035	-3.565	-308	-3.873

It is also to be noted that the emissions reduced are under the Effort sharing Decision (ESD) scope.

3.28.5.2 Sectoral results

The sectoral provisions of the F-gas Regulation and results are shown in the following:

3.28.5.2.1 Commercial refrigeration

Specific provisions of the F-gases Regulation on this activity

Prohibition of F-gases use, as follows:

- From January 2020, refrigerators and freezers for commercial use (hermetically sealed equipment) that contain HFCs with GWP of 2 500 or more. (see annex III.11)
- From January 2022, refrigerators and freezers for commercial use (hermetically sealed equipment) that contain HFCs with GWP of 150 or more. (see annex III. 11)
- From January 2022, multipack centralised refrigeration systems for commercial use with a rated capacity of 40 kW or more that contain, or whose functioning relies upon, fluorinated greenhouse gases with GWP of 150 or more, except in the primary refrigerant circuit of cascade systems where fluorinated greenhouse gases with a GWP of less than 1 500 may be used. (see annex III.12)
- From January 2025, single split air-conditioning systems containing less than 3 kg of fluorinated greenhouse gases, that contain, or whose functioning relies upon, fluorinated greenhouse gases with GWP of 750 or more. (see annex III.15)

BaU Assumptions

	Lifetime (years)	Source	Initial charge remaining	Source
Supermarkets - centralised systems	12	Projections	0,75	IPCC 2006 edition of the IPCC Guidelines, table 7.9
Small commercial - condensing units	15	Projections	0,4	IPCC 2006 edition of the IPCC Guidelines, table 7.9

Note- the initial charge remaining after lifetime, is the activity data for decommissioning. Using this activity data, emissions are calculated by applying the corresponding decommissioning emission factors from the CRF.

The emission factors used are the implicit emission factors for the last year of the historical period, category commercial refrigeration.

Results

Figure 43. *Emissions in supermarkets – centralised systems*

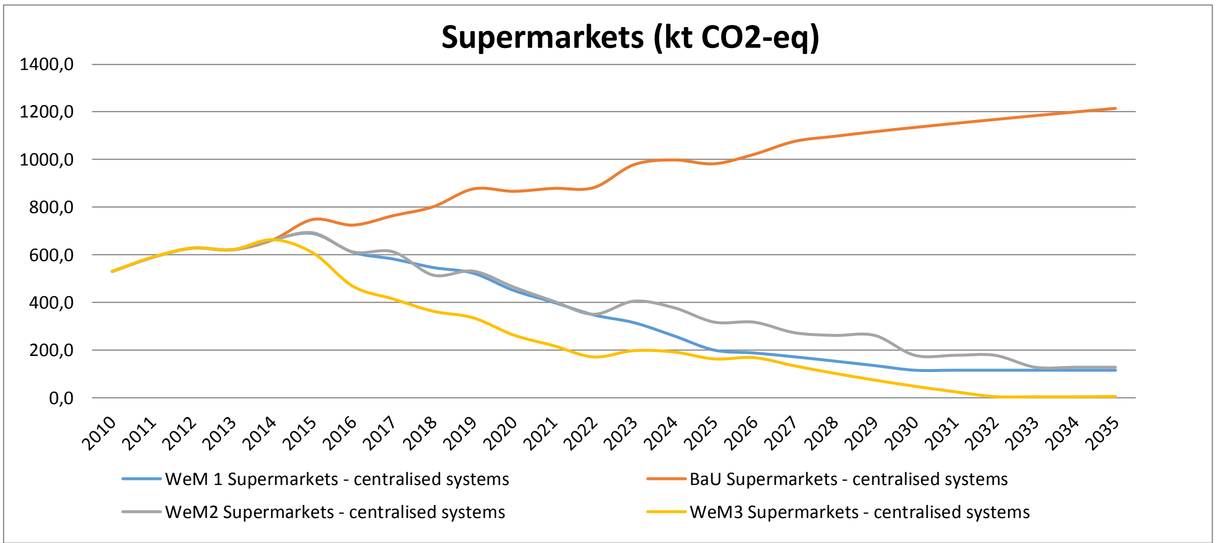
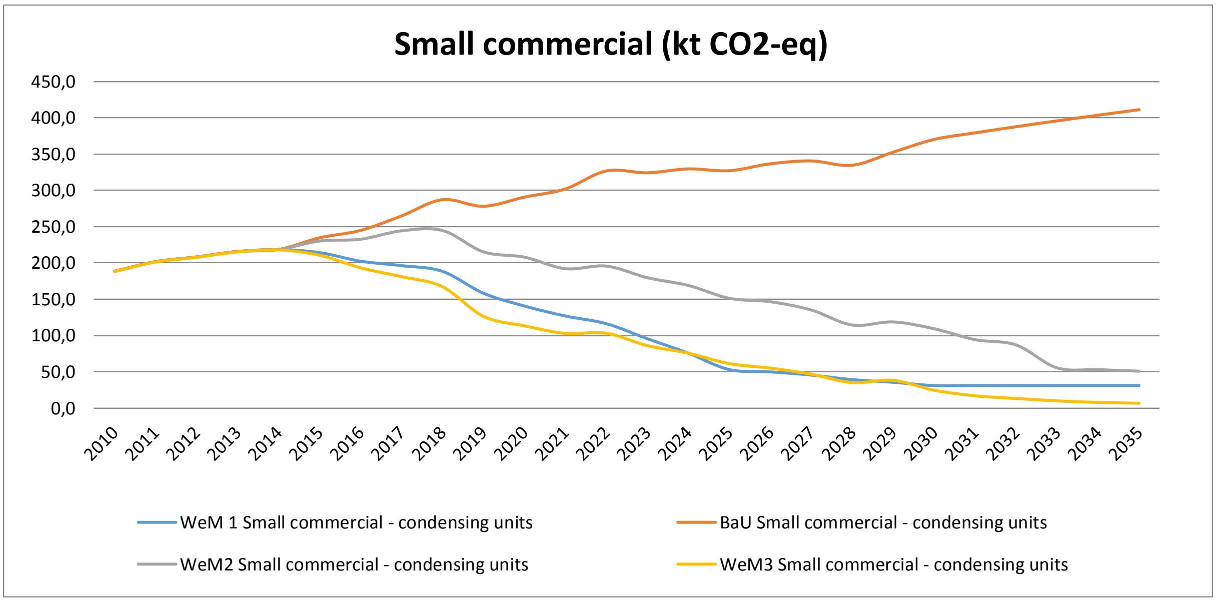


Figure 44. *Emissions in small commercial– condensing units*



3.28.5.2.2 Industrial refrigeration

Specific provisions of the F-gases Regulation on this activity

No specific provisions affect this sector.

BaU Assumptions

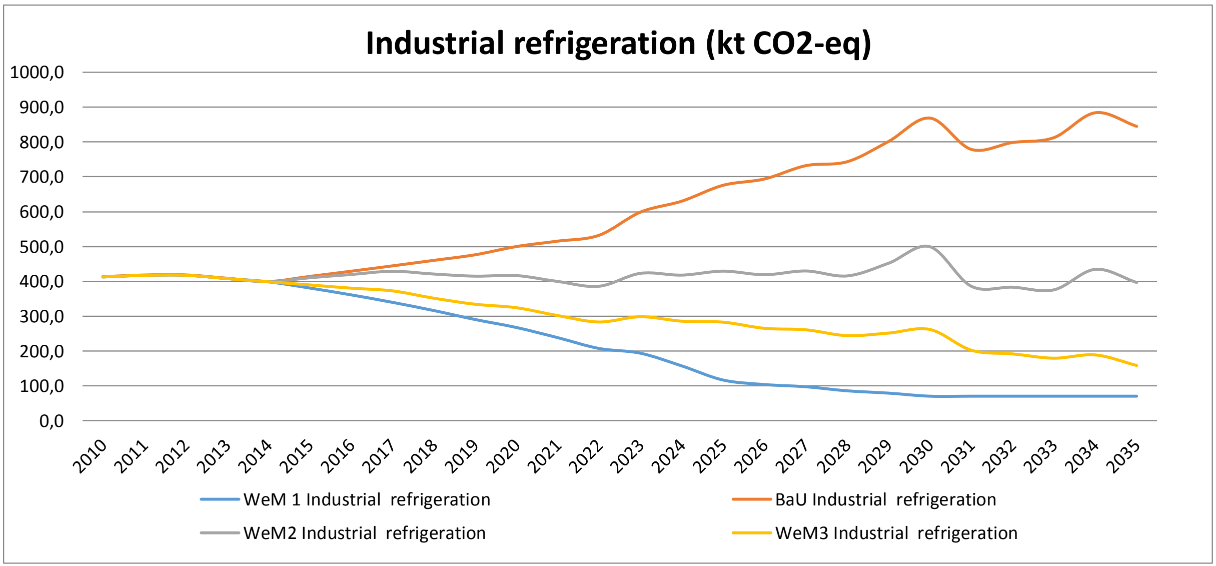
	Lifetime (years)	**Source**	**Initial charge remaining**	Source
Industrial refrigeration	27	Projections	0,75	IPCC 2006 edition of the IPCC Guidelines, table 7.9

Note- the initial charge remaining after lifetime, is the activity data for decommissioning. Using this activity data, emissions are calculated by applying the corresponding decommissioning emission factors from the CRF.

The emission factors used are the implicit emission factors for the last year of the historical period, category commercial refrigeration.

Results

Figure 45. *Emissions in industrial refrigeration*



3.28.5.2.3 Stationary refrigeration

Specific provisions of the F-gases Regulation on this activity

Prohibition of F-gases use, as follows:

- From January 2020, stationary refrigeration equipment, that contains, or whose functioning relies upon, HFCs with GWP of 2 500 or more except equipment intended for application designed to cool products to temperatures below – 50 °C. (See Annex III.12)

BaU Assumptions

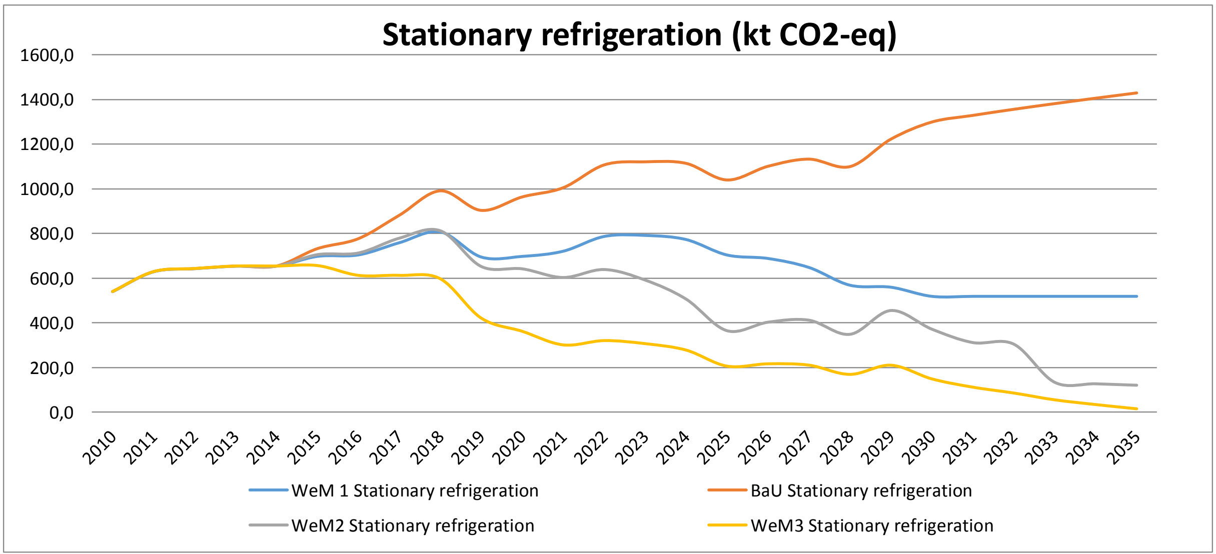
	Lifetime (years)	**Source**	**Initial charge remaining**	Source
Stationary refrigeration	15	Projections	0,65	IPCC 2006 edition of the IPCC Guidelines, table 7.9

Note- the initial charge remaining after lifetime, is the activity data for decommissioning. Using this activity data, emissions are calculated by applying the corresponding decommissioning emission factors from the CRF.

The emission factors used are the implicit emission factors for the last year of the historical period, category commercial refrigeration.

Results

Figure 46. *Emissions in stationary refrigeration*



3.28.5.2.4 Domestic refrigeration

Specific provisions of the F-gases Regulation on this activity

Prohibition of F-gases use, as follows:

- From January 2020, movable room air-conditioning equipment (hermetically sealed equipment which is movable between rooms by the end user) that contain HFCs with GWP of 150 or more. (See Annex III.14)
- From January 2025, single split air-conditioning systems containing less than 3 kg of fluorinated greenhouse gases, that contain, or whose functioning relies upon, fluorinated greenhouse gases with GWP of 750 or more. (See Annex III.15)

BaU Assumptions

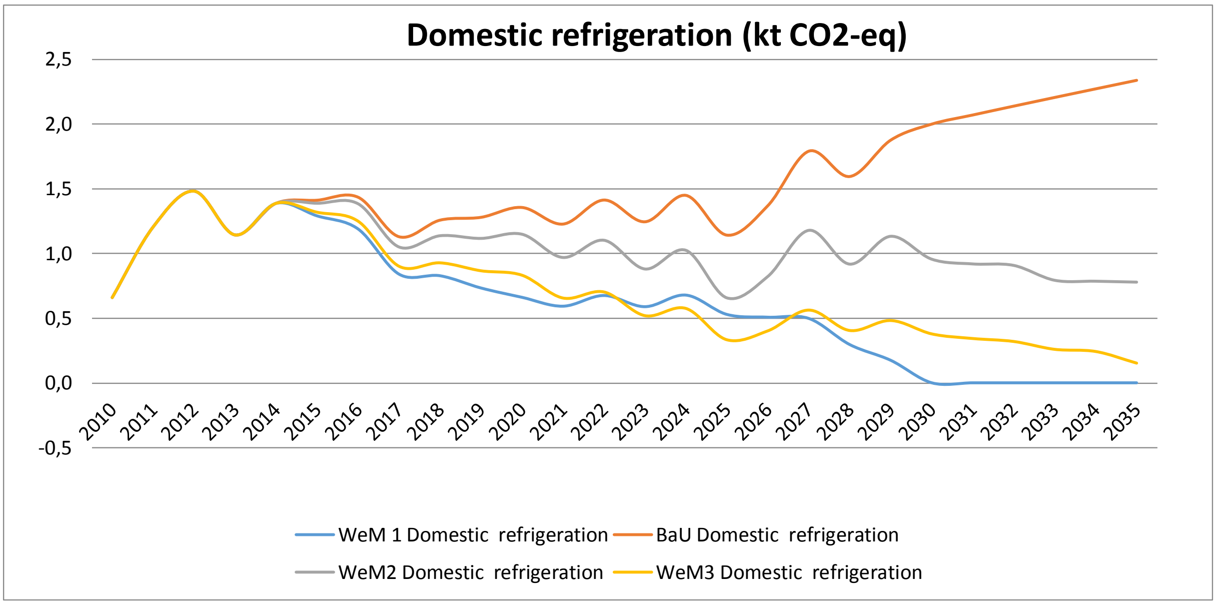
	Lifetime (years)	**Source**	**Initial charge remaining**	**Source**
Domestic refrigeration	15	Projections assume a lifetime between 10 and 25. Here we have assumed a lifetime equal to small commercial & stationary	0,65	IPCC 2006 edition of the IPCC Guidelines, table 7.9

Note- the initial charge remaining after lifetime, is the activity data for decommissioning. Using this activity data, emissions are calculated by applying the corresponding decommissioning emission factors from the CRF.

The emission factors used are the implicit emission factors for the last year of the historical period, category commercial refrigeration.

Results

Figure 47. *Emissions in domestic refrigeration*



3.28.5.2.5 Transport refrigeration

Specific provisions of the F-gases Regulation on this activity

Transport refrigeration is not affected by either the maximum amount of F-gases defined in Annex V of the Regulation or the specific provisions of the F-gas regulations.

BaU Assumptions

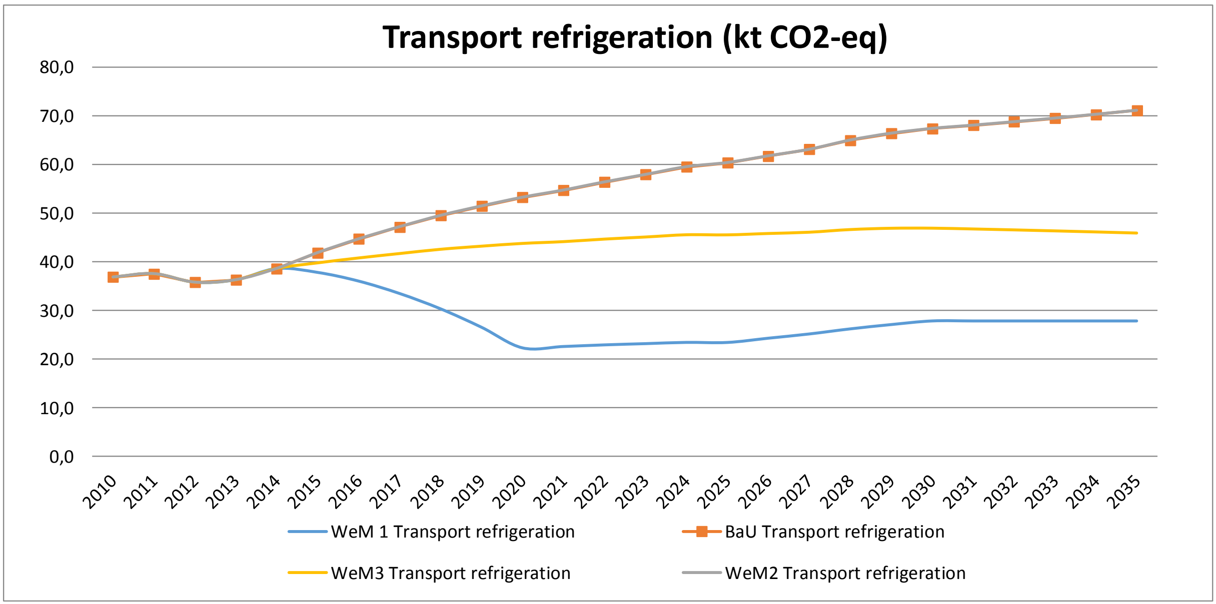
	Lifetime (years)	**Source**	**Initial charge remaining**	**Source**
Transport refrigeration	15	Projections	0,25	IPCC 2006 edition of the IPCC Guidelines, table 7.9

Note- the initial charge remaining after lifetime, is the activity data for decommissioning. Using this activity data, emissions are calculated by applying the corresponding decommissioning emission factors from the CRF.

The emission factors used are the implicit emission factors for the last year of the historical period, category commercial refrigeration.

Results

Figure 48. *Emissions in transport refrigeration*



The BaU and the WeM2 scenarios are equal as we assume the allocation of F-gases sales does not impact this activity.

3.28.5.2.6 Foam blowing agents – closed cells

Specific provisions of the F-gases Regulation on this activity

Prohibition of F-gases use, as follows:

- From January 2020, Foams that contain HFCs with GWP of 150 or more except when required to meet national safety standards - Extruded polystyrene (XPS). (See Annex III.16)
- From January 2023, Foams that contain HFCs with GWP of 150 or more except when required to meet national safety standards – other foams. (See Annex III.16)

BaU Assumptions

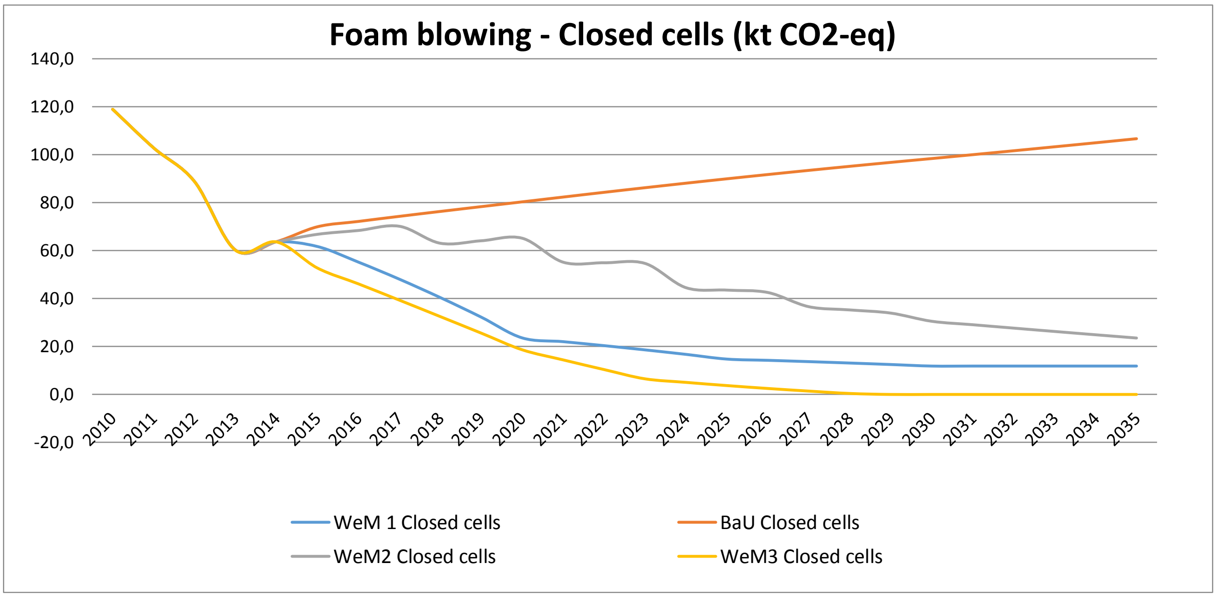
	Lifetime (years)	**Source**	**Initial charge remaining**	**Source**
Foam blowing	20	IPCC 2006	0	IPCC 2006 edition of the IPCC Guidelines, table 7.9

Note- the initial charge remaining after lifetime, is the activity data for decommissioning. Using this activity data, emissions are calculated by applying the corresponding decommissioning emission factors from the CRF.

The emission factors used are the implicit emission factors for the last year of the historical period, category commercial refrigeration.

Results

Figure 49. *Emissions in foam blowing – closed cells*



3.28.5.2.7 Fire protection

Specific provisions of the F-gases Regulation on this activity

Prohibition of F-gases use, as follows:

From January 2016, fire protection equipment that contain HFC-23 (See Annex III.3)

BaU Assumptions

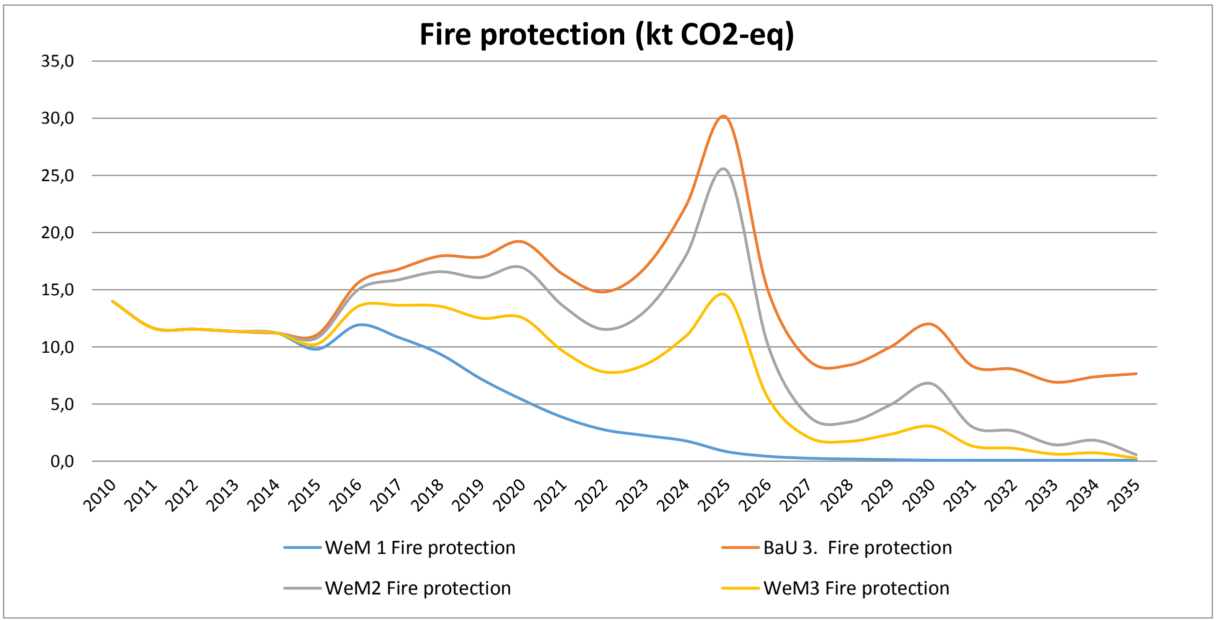
	Lifetime (years)	Source	Initial charge remaining	Source
Foam blowing	20	IPCC 2006	0	IPCC 2006 edition of the IPCC Guidelines, table 7.9

Note- the initial charge remaining after lifetime, is the activity data for decommissioning. Using this activity data, emissions are calculated by applying the corresponding decommissioning emission factors from the CRF.

The emission factors used are the implicit emission factors for the last year of the historical period, category commercial refrigeration.

Results

Figure 50. *Emissions in fire protection*



Note – The emission increase of 2025 is explained by the high amount introduced in the bank in 2005.

3.28.5.2.8 Technical aerosols

Specific provisions of the F-gases Regulation on this activity

Prohibition of F-gases use, as follows:

From January 2018, technical aerosols that contain HFCs with GWP of 150 or more, except when required to meet national safety standards or when used for medical applications. (See Annex III.17)

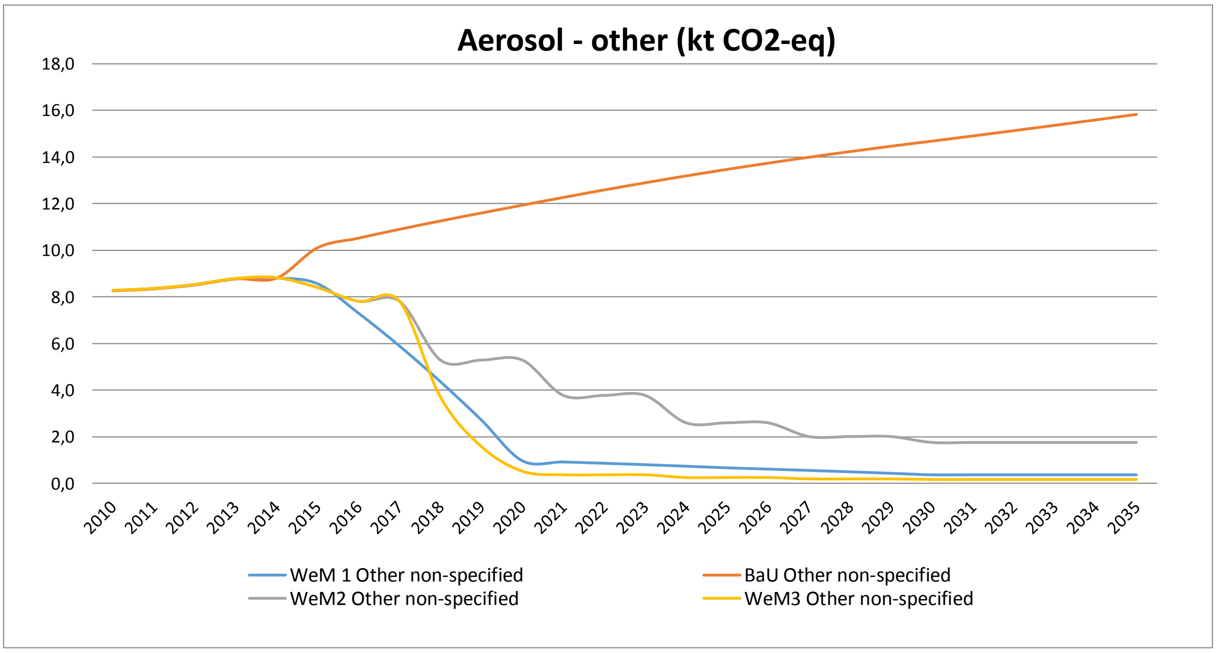
BaU Assumptions

	Lifetime (years)	**Source**	**Initial charge remaining**	**Source**
Foam blowing	20	IPCC 2006	0	IPCC 2006 edition of the IPCC Guidelines, table 7.9

Note- the initial charge remaining after lifetime, is the activity data for decommissioning. Using this activity data, emissions are calculated by applying the corresponding decommissioning emission factors from the CRF.

This category is estimated by a regression of historical emissions with the series of **Error! Reference source not found.**, as no activity data have been reported in the CRF tables (the mass balance approach could not be estimated).

Figure 51. *Emissions in technical aerosols*



3.28.6 Discussion

For the development of the BaU scenario, the best approach for the methodological choice is to project the methodology and data used by the national inventory in the historical period. This will ensure an appropriate estimation of the evolution of the bank of gases and decommissioning variables in the projected years.

The information available on the national inventory are the CRF tables (see figure 02), which contain the annual amount of activity data and emissions, and the national inventory report, where the overall methodology used is described.

For obtaining an approximation to the emissions reported in the CRF based on the corresponding activity data, the working team had to take several assumptions in the development of its General Methodology, as follows:

- Maintenance emissions are contained in the activity data of manufacturing.
- Imports and exports are calculated from differentials between series of manufacturing and bank of gases.
- The useful life and the quantities of gases remaining at the end of useful life were taken from projections and IPCC 2006. Using these coefficients, differences were found on the calculated decommissioning activity data and emissions.
- The re-use of gases (after recycling) was not considered.

Despite the assumptions taken and the differences that might exist with the national inventory, the General Methodology is considered a good approximation to the detailed methodology used by the inventory for the historical period.

It is highlighted that the main drivers for the emissions of F-gases are i) the bank of gases in use in the historical period; and ii) the introduction of new gases in the bank.

Regarding i), the approach followed in the general methodology of the estimation (using inventoried data and reproducing the inventory methodology) ensures the track of gases (input-output of gases into and from the bank) based on the data observed by the inventory in the historical series.

Regarding ii), due to the high increase in the bank of gases in use from years 2000-2014 (due to a very high trend of new gases incorporated into the bank), all projections models tested for projecting the entrance of new gases into the bank resulted in increasing trends.

Regarding the choice of method for the WeM´s scenarios, several alternatives were considered by the working team. These scenario needs to follow the same methodology than the BaU, and also translate the F-gas regulation to an impact in the methodological variables considered. Apart from that, there is a need of translating provisions from the Regulation, specific to products, to the activity data used in the inventory, in terms of gases consumed.

The Projections report (see Data used), is based on surveys to national producers and stakeholders. In projections, refrigerants consumption and alternatives to F-gases were analyzed in detail. This is considered a good approach, as the real products sales (refrigerants) are analyzed in detail by activity sector. However, several issues constraint the PAMs working team of using this approach:

- Coherency with the inventory. There is an issue of coherency in the correspondence between F-gases (inventory) and sales of refrigerant and allocation between inventory sectors.
- Retrofit estimates for refrigerants, including R-22 and other HCFC´s.
- The need of F-gases would need to be projected independently. This need would be satisfied by products (refrigerants currently used or low GWP alternatives), converted then to gases for obtaining emissions. Assumptions on the refrigeration potential of each refrigerant and correspondences between refrigerants in mass terms would be needed.
- In general, there will be a tendency to exchange quantities of gases retired from the stock for new refrigerant alternatives. This would require a differentiation between maintenance and manufacturing of gases.

Despite the issues identified, the working team decided to create a WeM (WeM 1) based on the estimation made by projections, at least with comparative purposes. For doing so, the estimated emission evolution (index, see Index_t) of the projections report was applied to the BaU, trying to cut the gap that is likely to exist between estimations. This WeM, although is just an approximation to the projections estimate, is considered a feasible alternative for estimating the PAM.

Another two WeM scenarios were estimated to be compared with the WeM1. WeM2 was estimated to provide an overall approximation to the impact of the Regulation. This scenario only considers the adoption of the maximum quotas of F-gases to be placed in the market, so the impact of this WeM would not be the 100% of the Regulation. However, it does not introduce the high uncertainty values coming from the assumptions taken in WeM3, which are based on the expert judgment of the working team and could have been taken mistakenly. In any case, WeM 2 is considered a good scenario for quality control purposes, as the evolution of the emissions and the final impact of the Regulation should be in the same order of magnitude than this WeM.

Finally, the working team decided to estimate a third scenario (WeM 3), which cover the totality of provisions of the Regulation and use the same methodology of the BaU . This estimation, despite the uncertainty of the assumptions taken, is considered the better approximation (among the scenarios WeM estimated) to the F-gases emissions evolution resulting from the implementation of the Regulation.

Further Discussion

Discussions have been maintained on the comparison between this PAM evaluation and the last F-gas Projections study, named under this study as *projections* (see section *data sources* for the full reference*)*. Along the document, this report has been cited repeatedly, as it is one of the main data sources used for the estimation. Among others, it is important to note that the projections study has been used in this estimation as:

- A source of data for the lifetime of equipment (see section general methodology above)
- As the scenario WeM1, which is described in detail in this report.
- As a comparative source, as described in section discussion.

It is again highlighted that projections study is considered a quality estimate, based on consistent assumptions and data collected from national specific sources. However, the projections study does not estimate the effect of the Regulation 517/2014 specifically; the projections consider the impact of the regulation together with other policy instruments and circumstances. This led to the objective of the PAM evaluation: estimating the specific effect of Regulation 517/2014 in terms of emission reductions, in a coherent way with the latest inventory and projections published by the country. With this objective, the latest inventory edition and the projections report were analyzed in the first place to understand how are both estimates related. This analysis found differences between estimates which are summarized in section *WeM1: projections*. Acknowledging the differences between the inventory 1990-2014 and projections, the PAM evaluation intended to bridge the gap between them and **use the estimates performed by both sources (inventory 1990-2014 and projections)**.

In the following, more information is provided on the differences between the PAM evaluation and projections, aiming to provide more clarification on the issue. As a summary, next table illustrates the main differences between estimations:

Figure 52: Main differences between estimates

	PAM	***Projections***
Scope - Objective	Estimating the specific impact of the EU Regulation 517/2014 until 2035.	Obtaining a forecast of the emissions of the entire F-gas Inventory until year 2030.
Scope - Legal framework	Only the impact of Regulation 517/2014 is considered.	The projections consider other legal instruments that could impact on all the emissions of F-gases.
Scope - CRF categories covered	• Commercial refrigeration • Industrial refrigeration • Stationary refrigeration • Domestic refrigeration • Transport refrigeration • Foam blowing agents – closed cells • Fire protection • Technical aerosols	• Commercial refrigeration • Industrial refrigeration • Stationary refrigeration • Domestic refrigeration • Transport refrigeration • **Room air conditioners and heat pumps** • **Mobile air conditioning** • Foam blowing agents – closed cells • **Foam blowing agents – polyurethane cans** • Fire protection • **Methered dose inhalers** • Technical aerosols • **Semiconductor industry** • **SF6 double glazing** • **Electricity sector** • **Chemical industry**
Methodology - Inventory edition used	1990-2014	1990-2013
Methodology - Approach	The estimates are strictly based on quantity of gases consumed by stage of useful life of the products.	Numerous estimates are based on data on products (refrigerants, cars fleet, etc).

Methodology - Historical evolution	In the inventory edition 1990-2014, the inventory was substantially recalculated.	Projections are based on historical data from the national inventory 1990-2013.

Scope

For comparing estimates, the differences in the scope of both sources need to be taken into account.

First, an aggregated comparison between the emissions projected in both estimates is not appropriate as the CRF categories considered in both estimations are different. The comparison could be made at CRF category level; in case of such comparison, it should be noted that the starting point of the estimates is not the same, as different inventory editions are used (this issue will be discussed just below under the epigraph on methodology).

Second, in case of comparison at CRF category level, it should also be noted that the emission projections could take into account other policy instruments that could affect national projections (and could have a positive or negative effect in terms of emission reductions). This is due to the primary objective of the estimates, as the PAM objective is to estimate the effect of the PAM individually, and the objective of projections is to provide a full forecast of the F-gas inventory given the current circumstances (the circumstances of the year in which the estimate was developed) and all expected impacts.

Methodology

For comparing estimates, it is also very important to note the different methodological characteristics of both sources.

Different inventory editions are used in both estimates. The national F-gas inventory substantially changed from the edition 1990-2013 to the edition 1990-2014. The following figure is an extract of the national inventory report (NIR) submitted in 2016[15] describing significant changes (recalculations) in category 2F *Product uses as substitutes for ODS* between these editions:

[15] Available at: http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/9492.php

Figure 53:. Extract of the 2016 National inventory Report, page 112.

Recalculations in category 2F mainly due to:

- The emissions of refrigeration and air conditioning installations have been revised for the whole time series, in order to improve the calculation of disposal emissions. The modification has essentially consisted in recalculating the 'Amounts charged into new systems'.
- For rail transport, the time series has been adjusted. New information from the NMBS/SNCB made it possible to estimate the stock of HFCs in trains based on specific quantities of HFC per model of train.
- For room air conditioning emissions in 2012 and 2013 were adjusted to account for new statistics on the number of appliances.
- For refrigerated transport emissions in kt CO_2-eq have been adjusted, because an incorrect GWP value was used. Emissions in tonnes remain the same.
- 2013 HFC emissions for technical aerosols have been adjusted to take into account more recent information on consumption.

This lead to a comparability issue, as projections were made using the 1990-2013 inventory, and now the new edition changed substantially the data. The PAM evaluation has used the inventory edition 1990-2014, and so, **the historical period data (the starting point) used in both estimates is different**.

So, if the starting point (the inventory) used in the PAM evaluation and projections is different, how can the results be compared?

Recognizing that there might be differences arising from the different scope of the estimations, within the PAM evaluation one scenario (scenario WeM1) was estimated for representing the emissions estimated by projections, but overcoming the gap that exists between inventory editions 1990-2013 and 1990-2014. The objective of this scenario was to have a comparative scenario for calibration purposes. The detailed description of the approach followed for estimating the WeM 1 scenario is provided is section *WeM1: projections* above.

And how is the scenario WeM1, which represents projections, related to the other scenarios estimated?

The sectoral results (at CRF category or below) can be consulted in section *Sectoral Results*. As can be seen in that section WeM1 and WeM3 follow similar trends in all sectors: in some cases, WeM1: projections result in higher emissions (commercial refrigeration, stationary refrigeration, foam blowing, technical aerosols), in other cases in lower emissions (industrial refrigeration, domestic refrigeration, transport refrigeration and fire protection).

3.28.7 References

IPCC 2006, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan.

F-gas Projections (Vito/Econotec, 2015). Federal Public Service of Public Health, Food Chain Safety and Environment. Update of the national emission inventory of ozone depleting substances and fluorinated greenhouse gases (1995-2013) and projections for the years 2015, 2020, 2025 and 2030. Final report Part B: Projections.

3.29 XX-X04: Increase of excise duty on diesel

3.29.1 Description

The PAM is motivated by the implementation of the "Royal Decree of 26 October 2015". Published on the 30th October 2015" and law of 27 June 2016. Through this law, the special excise duty for diesel for non-commercial use is increased from 2015 to 2018. The law also establishes the aim of achieving an equality of excises for diesel and gasoline. This modification of taxes influences final automotive fuel consumption (in terms of amount of fuel consumed by car type) that is estimated by this PAM.

This PAM results in a reduction of emissions in the ESD sector.

3.29.2 Methodology

A general model has been developed for building two scenarios: the **BaU scenario**, which does not include the effect of the PAM; and a **WeM scenario**, which includes the effect of the PAM.

The modification of the tax affects primarily the price, and indirectly the amount of fuel consumed in passenger cars (PC) by means of the composition of the PC fleet and the fleet mobility. These three variables, **stock, fleet mobility** and **fuel consumption for passenger cars**, are the three key factors that have been considered for estimating the impact in terms of GHG emissions of this PAM as the difference between both scenarios.

$$GHG = \sum_f FC_f \, EF_f$$

$$\mathrm{FC}_f = \sum_f KM_f \sum_{s,e,a} VEH_{f,s,e,a} \;\; CF_{f,s,e,a}$$

With

$GHG = GHG\ emissions\ for\ passenger\ cars$ (PC)

$\mathrm{EF}f = \text{GHG emission factor } for\ PC\ propelled\ by\ fuel\ type\ f$

$\mathrm{FCf} = \text{Energy consumption from fuel } f$

$\mathrm{KM}f = distance\ travelled\ by\ PC\ propelled\ by\ fuel\ type\ f$

$\mathrm{VEH}_{f,s,e,a} = stock\ of\ PC\ of\ size\ s\ and\ age\ class\ a\ with\ engine\ type\ e\ propelled\ by\ fuel\ type\ f$

$\mathrm{CF}_{f,s,e,a} = \text{ Consumption factor per } km\ for\ PC\ of\ size\ s\ and\ age\ class\ a\ with\ engine\ type\ e\ propelled\ by\ fuel\ type\ f$

The methodology starts from the estimation of the **projected stock** by fuel type, vehicle size, technology type (conventional vs. hybrid) and vehicle age for years 2015-2030. This procedure has been implemented on the time series of fleet for the period 2006-2014 provided by TML (see section 2.3 below).

The method used for estimating the fleet is composed by six steps, as follows:

1. Projection of the **total stock**. The total number of vehicles (annual stock) has been projected by adjusting a linear regression with population as follows:

$$VEH_t = \propto \, + \beta Pob_t$$

   With

$$VEH_t = \ Stock, year\ t$$

$$Pob_t = \ Population, year\ t$$

2. Projection of the **deregistration of vehicles**. Historical deregistration rate for each fuel type, vehicle size and age has been derived for conventional engine vehicles from the detailed information available on the historical stock. The fleet scrapped in year t has been calculated by applying directly these rates on the stock existing in year t-1:

$$DV_{f,s,e,a,t} = \overline{DVR^H_{f,s,a}} \ VEH_{f,s,e,a-1,t-1}$$

   With

$$DV_{f,s,a,t} = \ Fleet\ scrapped, size\ s, engine\ e, age\ a, year\ t$$

$$\overline{DVR^H_{f,s,a}} = \ Mean\ historical\ deregistration\ rate, size\ s, engine\ e, age\ a$$

$$VEH_{f,s,a-1,t-1} = \ Stock, size\ s, engine\ e, age\ a-1, year\ t-1$$

3. Projection of the **series of total new vehicles**. Annual new fleet is directly projected from the total passenger car stock (step 1) and the overall deregistered vehicles (step 2) projected for the reference year.

$$NV_t = \ VEH_t - DV_t$$

   With

$$NV_t = \ \ New\ vehicles, year\ t$$

$$VEH_t = \ \ Stock, year\ t$$

$$DV_t = \ \ Deregistration\ of\ vehicles, year\ t$$

4. Characterization of **new fleet per fuel type**. Time series of new vehicles per fuel type have been projected based on the historical elasticities of the percentages of each fuel in the overall stock with respect to the rate of fuel prices (gasoline price vs diesel price):

$$\frac{\Delta \, {}^{NV_{f,t}}\!/_{NV_t}}{{}^{NV_{f,t}}\!/_{NV_t}} = \alpha_f \frac{\Delta \frac{Gasoline\ price}{Diesel\ price}}{\frac{Gasoline\ price}{Diesel\ price}}$$

5. Characterization of **new fleet per fuel type and car size**. New fleet composition projected in step 4 has additionally been subdivided by car size by applying the projected size composition for each fuel type. Rate for each fuel type and vehicle size has been projected according to its observed temporal evolution.
6. Characterization of **new fleet per fuel type, car size and engine type** (conventional vs hybrid). Distinction between conventional and hybrid engines has been achieved by estimating the **penetration projected of the hybrids**. Projection of the participation rates of conventional vehicles in the new fleet per fuel type and car size has been carried out by analysing the historical penetration and adjusting the series to sigmoidal functions for the projected years[16].

Following the implementation of these 6 steps, the historical detailed data on stock (by fuel type, vehicle size, engine type and vehicle age) have been projected until 2030 for gasoline and diesel passenger cars.

Once the stock is calculated, the second step in the methodology is the estimation of the **fleet mobility**. With this purpose, the Statbel[17] historical data on annual kilometers travelled per vehicle has been used and projected. The projection of these series is different in the BaU and WeM scenarios, and is therefore described below in section on specific methodology according to the scenario.

In order to project the fuel consumption, series of **annual consumption factors** have been estimated by applying Tier 2 consumption factors from EMEP/EEA & COPERT 4[18]. These consumption factors are referred to the distance travelled and they are differentiated by size, fuel, EURO technology and engine type. The collection of factors gathered from this guideline has been completed for all the vehicles types (combination of fuel type, size, age class, engine) and, in so doing, the factors for hybrid engines has been calculated by scaling the respective ones for conventional engines with a fuel consumption efficiency rated derived from the comparison of factors for an EURO medium size (1.4-2.0 l) gasoline passenger cars propelled by the both engine types.

It has been assumed that the original consumption factors, expressed in terms of g/km, are referred to fossil fuel consumption, i.e. without any biogenic content. We have assumed that the energy requirement should be kept for vehicles that consume fuel with a non-zero biogenic fraction and, therefore it has been calculated annual consumption factors in terms of energy units as follows:

$$CF_{f,s,e,a,t}[\frac{GJ}{km}] = \frac{CF^{EMEP}_{f,s,e,tech}\,[\frac{g\ fossil}{km}]\ NCV_f[\frac{GJ}{t}]}{FF_{f,t}[\%\ energy]}$$

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[16] The sigmoidal functions estimate non-negative values and show a good adjustment to the expected evolution (progressive decrease, with no backward evolution). The sigmoid functions analyzed for this assessment have been the logistic, Weibull and Gompertz function. Assuming a high hybrid penetration rate according to the BFP studies on Belgian transport forecast, it has been adopting for each year, fuel type and vehicle size the minimum annual rate among the results from three abovementioned sigmoid functions.

[17] Belgian Federal Government - Directorate-general Statistics

[18] http://www.eea.europa.eu/themes/air/emep-eea-air-pollutant-emission-inventory-guidebook/emep.

With

$$CF_{f,s,e,a,t} = \ Consumption\ factor, fuel\ f, size\ s, engine\ type\ e, year\ t$$

$$CF^{EMEP}_{f,s,e,tech} = \ EMEP - EEA\ consumption\ factor, fuel\ f, size\ s, engine\ type\ e, \\ EURO\ technology\ tech\ associated\ to\ age\ a$$

$$NCV_f = \ Net\ calorif\ value\ (only\ fossil\ part), fuel\ f$$

$$FF_{f,t} = \ Fossil\ fraction, fuel\ f, year$$

Time series projected on stock composition resulting from the previous steps has been used to calculate the annual consumption factors for each fuel. These annual consumption factors multiplied by the distances travelled have led to the final fuel consumption series.

These estimate of consumption per fuel type projections have been multiplied by GHG emission factors for obtaining **GHG emissions**. These emission factors are the implied emissions factors by fuel type extracted from the National Emissions Inventory (Belgian CRF submission 2016). These reported factors have been adjusted in order to consider the biogenic content in the automotive fuels. So, the CO_2 emission factors have been corrected by the evolution of the fuels projected in the BFP study "Perspectives de l'évolution de la demande de transport en Belgique à l'horizon 2030. Décembre 2015".

$$EF_{CO2,f}\left[\frac{kg}{GJ}\right] = \ EF_f^{CRF}\left[\frac{kg}{GJ\ fossil}\right] FF_{f,t}[\%\ energy]$$

For non-CO_2 GHG, emission factors by fuel type have been estimated by weighting the emissions factors for the fossil part and the emission factor for biomass reported in CRF according to its biogenic content in the last historical year available (year 2014). This biogenic content type has been derived for each fuel from the data of fossil automotive fuel consumption reported in CRF and the biofuel (renewable fraction) consumption published in EUROSTAT energy balance for Belgium.

The resulting emission factors are shown in the following table.

Table 58: *GHG emission factors*

	CO2 (t/TJ)		CH4 (kg/TJ)		N2O(kg/TJ)	
	GASOLINE	DIESEL	GASOLINE	DIESEL	GASOLINE	DIESEL
2015	68.17	69.62	6.62	0.31	0.67	2.65
2016	67.54	69.23	6.62	0.31	0.67	2.65
2017	66.91	68.83	6.62	0.31	0.67	2.65
2018	66.28	68.43	6.62	0.31	0.67	2.65
2019	65.64	68.03	6.62	0.31	0.67	2.65
2020	65.01	67.64	6.62	0.31	0.67	2.65
2021	64.98	67.60	6.62	0.31	0.67	2.65
2022	64.95	67.57	6.62	0.31	0.67	2.65
2023	64.91	67.54	6.62	0.31	0.67	2.65
2024	64.88	67.50	6.62	0.31	0.67	2.65
2025	64.85	67.47	6.62	0.31	0.67	2.65
2026	64.82	67.44	6.62	0.31	0.67	2.65
2027	64.78	67.40	6.62	0.31	0.67	2.65
2028	64.75	67.37	6.62	0.31	0.67	2.65
2029	64.72	67.34	6.62	0.31	0.67	2.65
2030	64.69	67.30	6.62	0.31	0.67	2.65

It is also worth highlighting the estimation of the **fuel price series** and its role in the methodology. Regarding the calculation of the series, the price has been calculated in two parts. The annual taxes have been projected for each scenario on the basis of the index rate and, for the scenario WeM, the implementation of the ratchet system for gasoline and diesel, whilst the prices without taxes have been projected on the forecast of crude oil prices.

Time series of fuel prices (with taxes) are used for the projection of the composition of the fleet (see *projection of the series of new vehicles* per fuel type above) and also for the estimation of kilometres travelled by type of car. The different price series used in the BaU and WeM scenarios ultimately led to fuel consumption differences and therefore differences in the GHG emissions projected in each scenario.

The methodology above described has been used for estimating both scenarios. The only difference between scenarios is the way in which **kilometers traveled** are calculated, as follows

BAU scenario

In this scenario, the kilometers travelled depends on the diesel price as described in the following equation:

$$\frac{\Delta\, km}{km} = \beta \frac{\Delta\, Diesel\ price}{Diesel\ price}$$

The high correlation in the historical period between diesel and gasoline prices series indicate that kilometers traveled of cars using both fuels can be estimated using only one variable, in this case diesel price.

WeM scenario

In this scenario, the kilometers traveled are calculated independently for gasoline and diesel cars, with the objective of reflecting the impact of the tax in the **fuel price** and **fuel consumption** which will be translated in a different amount of kilometers traveled in diesel and in gasoline cars. For gasoline cars, kilometers traveled are calculated by applying the WeM/BaU price elasticity to the kilometers traveled calculated in the BaU scenario, as follows:

$$\frac{\Delta\, km^G{}_s}{km^G{}_s} = \gamma_s \frac{\Delta\, Gasoline\ price}{Gasoline\ price}, s\ scenario$$

$$km_{Gasoline,t,WeM} = km_{Gasoline,t,BaU} \cdot \left(\frac{km^G{}_{t,WeM}}{km^G{}_{t,BAU}}\right)$$

With

$$km^G{}_s = kilometers\ travelled\ per\ vehicle, gasoline\ cars, scenario\ s\ \big(s\ \epsilon\ \{BAU, WeM\}\big)$$

$$projected\ on\ the\ gasoline\ price\ (elasticity)$$

$km_{\boldsymbol{Gasoline,t,BAU}} = kilometers\ travelled\ per\ vehicle, gasoline\ cars, year\ t, BAU\ scenario$

$km_{Gasoline,t,WeM} = kilometers\ travelled\ per\ vehicle, gasoline\ cars, year\ t, WeM\ scenario$

3.29.3Main assumptions

3.29.3.1 General assumptions

- Projected period: From 2031 onwards, it has been assumed the reduction effect projected for 20130
- Scenarios Likely, Min (minimum reduction) and Max (maximum reduction): For the assessment of this PAM one reduction scenario have been projected. It has been opted to equalize the reductions associated to the three reduction scenarios in the following section of results.

- Vehicle types: The PAM has been evaluated as the effect on the mobility and consumption of the passenger cars. The contributions of other vehicles types directly affected by the law (motorcycles or mopeds) or indirectly (via a modal change) on the overall impact are considered to be negligible.
- Alternative energy carriers: This assessment contemplates the effect on the vehicles propelled by gasoline or diesel, either by conventional engines or by hybrids (fuel and electricity) ones. PAM´s impact on the electricity consumption by hybrid vehicles is considered to be negligible.
- Subjects affected by the PAM (fuel prices): Components in the emissions resulting that have been estimated to be directly affected by the fuel prices are: i. share of the gasoline (conventional or hybrid engine) vehicles in the overall passenger car fleet and ii. annual distance travelled per vehicle.
- Deregistration rate: Constant rates per fuel engine, size and vehicle age have been applied for all the years projected.
- Biogenic content in the automotive fuels: Projected linear increase taking estimates from BFP study (for 2020 and 2030) as reference years
- Non-CO2 emission factors: Constant factors per fuel type have been applied for all the years projected. These factors have been calculated, on the basis of the implicit emissions factors reported for 2014 in the CRF Submission 1990-2014 (Belgium Emission Inventory), by weighting by the consumption estimates the emission factor for the respective fossil fraction and the one for biomass (that includes all biofuel types).

3.29.3.2 BAU scenario assumptions

- Index Rate for Diesel and Gasoline: Rates of 2017 have been applied for subsequent years (till 2020). From 2020 onwards, the interannual change has been assumed zero (i.e. same tax from 2020).

3.29.3.3 PAM scenario assumptions

- Index Rate for Diesel and Gasoline: We consider that the index rate will be equal to the inflation rates estimated for the following years (2018 to 2020). From 2020 onwards the interannual change has been assumed zero (i.e. same tax from 2020)
- Ratched system for diesel: It has been estimated that the maximum increase for 2018 will be 55.6 eur/100l.
- Ratched system for gasoline: As the coefficient of decrease is related to the turnover of diesel and the turnover on diesel is expected to decrease (and those of gasoline will increase), the coefficient is expected to decrease slightly. A coefficient of decrease for gasoline of 3 has been assumed for 2018, in concertation with Nico Missant.

3.29.4 Data sources

The main data sources used for the estimation of the PAM are presented in the following table:

Table 59: Description of data sources

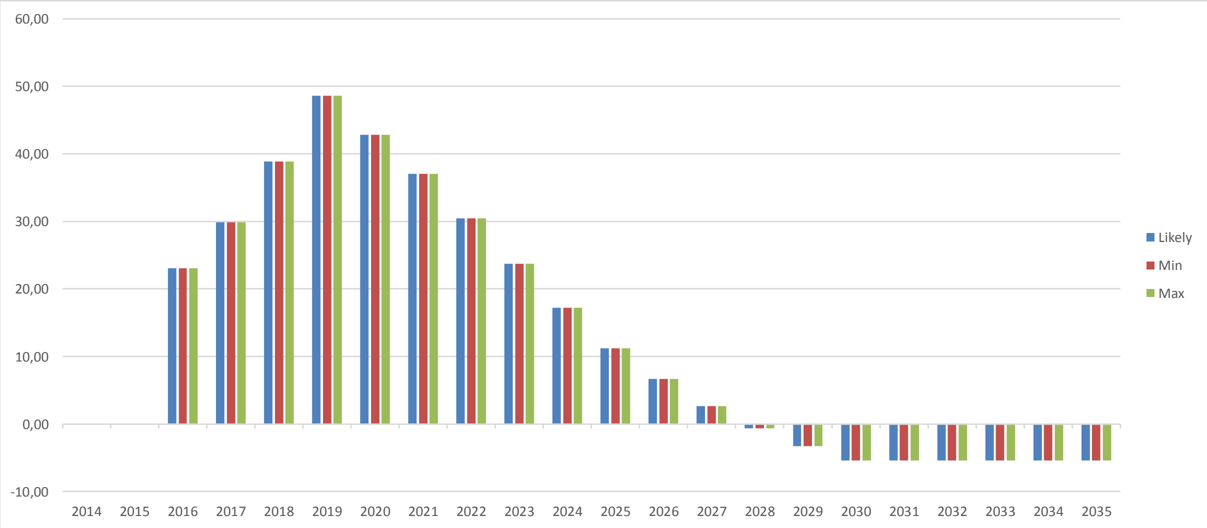
Indicators	Sources
Population	http://statbel.fgov.be/fr/modules/publications/statistiques/population/downloads/population_au_1er_janvier_2017-2061.jsp
GHG emission factors (EF)	Belgian 2016 submission to the UNFCCC

Crude brent	US Energy Information Administration
	World Bank Commodities Price **Forecast** (Crude oil, avg, spot)
Inflation rates – forecast	Banque Nationale Bank de Belgique
Index rates – historical	Belgian Petroleum Federation
	Official document with excise rates for energy products
Prices wo.taxes - historical	Weekly Oil Bulletin by Energy Statistics of the European Commission
Vehicle stock (VEH) - historical	Based on the historical data on vehicle fleet provided by TML
New vehicles (NV)– historical	Based on the historical data on vehicle fleet provided by TML
Deregistration rate (DV) – historical	Based on the historical data on vehicle fleet provided by TML
Distance travelled (km) – historical	Statistics Belgium (Statbel)
Consumption factor (CF)	EMEP/EEA, 2016
Biogenic content - forecast	BFP, 2012

3.29.5Results

The total federal emissions and the result of the estimation of the PAM is illustrated in the following table.

Figure 54: Annual emission reductions (minimum, maximum and likely scenarios)



3.29.6References

EMEP/EEA 2016. 2016 EMEP/EEA air pollutant emission inventory guidebook 2016 - Update Dec. 2016.

BFP, 2012. Perspectives de l'évolution de la demande de transport en Belgique à l'horizon 2030. Septembre 2012. Version corrigéeen décembre 2012. Published by: Bureau fédéral du Plan and Service public federal Mobilité et Transports.

4 Socio-economic impacts evaluations

4.1 General framework

There is no consensus on socio-economic evaluation of PAMS. Several different methods are used both in research and in practical national evaluation experiences. Although pros and cons of each method of evaluation are perfectly clear and acknowledged, no guidelines or best practices emerge clearly from recent experience (ICEDD, 2016).

Furthermore, even if some concepts were defined to better characterize the scope of analysis (as direct, indirect, net and gross impacts) their use aren't transparent and the scope of analysis may differ from one study to another.

To cope with this lack of transparency and clearly define the scope of analysis, we propose in this section to build a simple framework of evaluation based on economic theory.

In this section, we first present the theoretical background necessary to understand the impacts a public policy may have on markets. We then propose a framework of evaluation based upon the main important characteristics highlighted in the economic theory (Section 4.1.2). Then this framework is applied in section 4.1.2.5 to some federal PAMs.

4.1.1 Market of goods and services: theoretical background

In a competitive market, our economic model may be represented by the equilibrium between supply and demand (Figure 55). This equilibrium will determine the price P of goods, i.e. the point where the quantity demanded equals the quantity supplied (Q). In a theoretical way, there are as many markets as the number of goods and services.

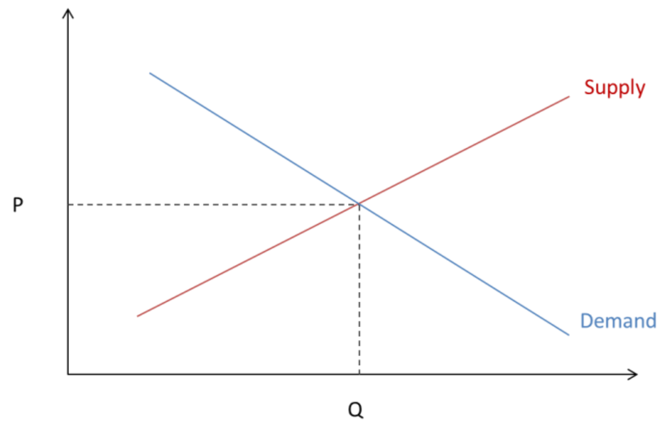


Figure 55 : Equilibrium between supply and demand

The supply corresponds to the quantity of goods and services that a producer wants to sell at a given price. The supply can be represented as an increasing function of the price (Figure 55). In other words, the higher the price, the more the producer is willing to sell. A contrary, if the price is lower, the producer is willing to sell a lower quantity of goods and services.

The demand side corresponds to the quantity of goods and services that the consumers are willing to purchase at a given price. The demand can be represented as a decreasing function of the price (Figure 55). As a consequence, the quantity purchased by the consumers will decrease if the price is higher and increase if the price is lower[19].

Looking at the Figure 1, we may easily understand that:

- A modification of the supply or the demand will impact the market equilibrium
- The slope, i.e. the elasticity, of the supply and the demand will determine the level of impact when there is a modification of the supply or the demand.

These elements may be illustrated by the Figure 56. For instance, if the supply moves towards the left, it will also move the market equilibrium: the quantity of goods and services sold will decrease while the price of theses goods and services will increase.

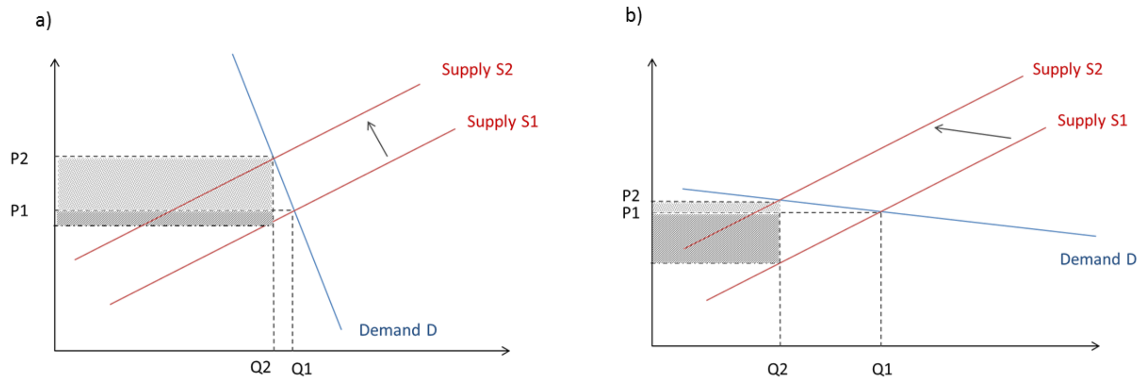


Figure 56 : Incidence of supply shift on producers (dark grey) and consumers (light grey) when the demand is inelastic (a) and when the demand is elastic (b).

Figure 56 also illustrates that the demand and the supply elasticities determine how the producers and the consumers are impacted. When the demand is inelastic, then a modification of the supply will mainly impact the consumers as (light grey, Figure 2a). Indeed, as the consumer demand is quite inelastic, the modification of the price will not greatly impact the quantity purchased: there are willing to pay more to have the goods and services concerned. The contrary is true if the demand is elastic (Figure 2b). Indeed, the quantity purchased will decrease a lot with a slight increase in price. The elasticities of demand and supply depend on the market of good and supplies considered.

The movements in supply and demand may be due to two kinds of elements. First, natural shocks on the market may occur. For instance, regarding the demand side, a mode effect may increase the demand for a given good (translation of the demand curve to the right). A contrary a decrease of revenue for consumer may diminish the quantity demanded (translation of the demand curve to the left, Figure 55). Regarding the supply side, if a firm increase its productivity, it will reduce its production costs and the firm will be able to propose its goods at a lower price (translation of the supply curve to the right). A contrary if the price of a raw material used by a firm increase (as fossil fuel) then the production costs of the firm will increase and the quantity of goods sold for the same price will

[19] However, it has to be noted that these figures aren't right for some specific goods and services. For instance, for luxury goods, the quantity purchased may increase if the price increases. We won't speak about these kind of good and services here.

decrease. In all cases, the market will thus reach a new equilibrium that is function of the elasticities of both curves. According to the liberal economists, this new equilibrium will be reached naturally: the price of goods and services will vary according to the modification of supply and demand.

However, this theory is applicable only if markets follow a model of pure and perfect competition, which is not always the case in practice. For instance, non-competitive markets may occur when there is only one supplier for a lot of consumers (monopoly) or when the goods and services are produced by few global firms (oligopoly). In both cases, the prices will not be defined by the market mechanisms described here above since the firms may define – or at least largely influence – the market price. In the same manner, this theory doesn't take into account potential externalities arising from the market, as pollution.

In those cases, the public authorities play an important role by defining policies to prevent non-competitive behavior or excessive negative externalities. These policies will regulate the market equilibrium by defining – for instance - taxes, subsidies or regulation measures on the production side as well as awareness-raising measures on the consumption side. According to the measure implemented, it will thus primarily imply a move of the supply curve or the demand curve.

As set before, in function of the movement of the curve and the characteristic of the market, the incidence of the policy will be distributed differently on the producer and on the consumer. A main question arising from a policy implementation is thus to identify who will be impacted and at which level. However, the evaluation of a policy impact in practice is not as easy as described here above, i.e. by a modification of quantity sold and price of the goods. Indeed, it's difficult to assess the elasticities of supply and demand and to take into account additional indirect and induced impacts on the supply and demand that may modify the market equilibrium.

Various operational frameworks of policy evaluation have been defined but none of them closely fit to the theory. In this document, we propose a new operational framework, based on the concept developed in previous studies and by linking the impacts considered with the economic theory.

4.1.2 *From theory to practice*

In practice, the estimation of the impact of a public policy isn't as evident as stated by economic theory. Indeed, assessing all impacts on the market arising from a measure is a huge work. Few studies make the whole evaluation of impacts because it would need a myriad of data and the development and use of macroeconomic models: it's often too time consuming and resource intensive.

The problem arising from this is that the scopes of policy impact analysis are not well defined. Indeed, some concept were developed to define a scope of analysis but the definition of these concepts may vary a lot according to the study.

In this part of the report, we will act a definition for each concept found in the literature and will propose a coherent operational framework of analysis that permits better identifying the scope of our analysis.

4.1.2.1 Definition of general concepts to identify impacts on producers and consumers

Three types of impacts may occur – direct, indirect and induced impacts – at two different scale of analysis: gross and net.

Direct impact refers to socio-economic changes occurring in the production or consumption of goods and services directly linked to PAM implemented. For instance, a PAM oriented on the product P2 may impact the producer of P2 and/or the consumer of P2 in Figure 57. Those impacts may be analyzed as **gross** impacts or **net** impacts. Gross impacts analysis implies that the impacts are strictly referred to the product P2 whereas net impacts consider effects on other goods and services (Figure 57).

Indirect impact concerns socio-economic effects occurring in the value chain of the product considered. Again, those impacts may be analyzed as **gross** impacts or **net** impacts. Gross impacts analysis implies that the impacts are strictly analyzed in the same value-chain as the product P2 whereas net impacts consider effects occurring in other value chains (Figure 57). For instance, in the example illustrated on Figure 57, gross indirect impacts correspond to impacts on the upstream and downstream value chain of P2. Upstream value chain corresponds to all the firms from the extraction of raw materials (MP) to the production of the set of inputs (P1) necessary to produce P2. Downstream value chain corresponds to all uses (including storage and distribution) of the product P2 as input of other production and final consumption.

Induced impact corresponds to the socio-economic impacts induced by the new socio-economic context. For instance, if a PAM results in extra-revenue for households – increasing their consumption – it will lead to associated extra-production and extra-employment to ensure this extra-production. These effects are called induced impacts (Vito and Econotec, 2015).

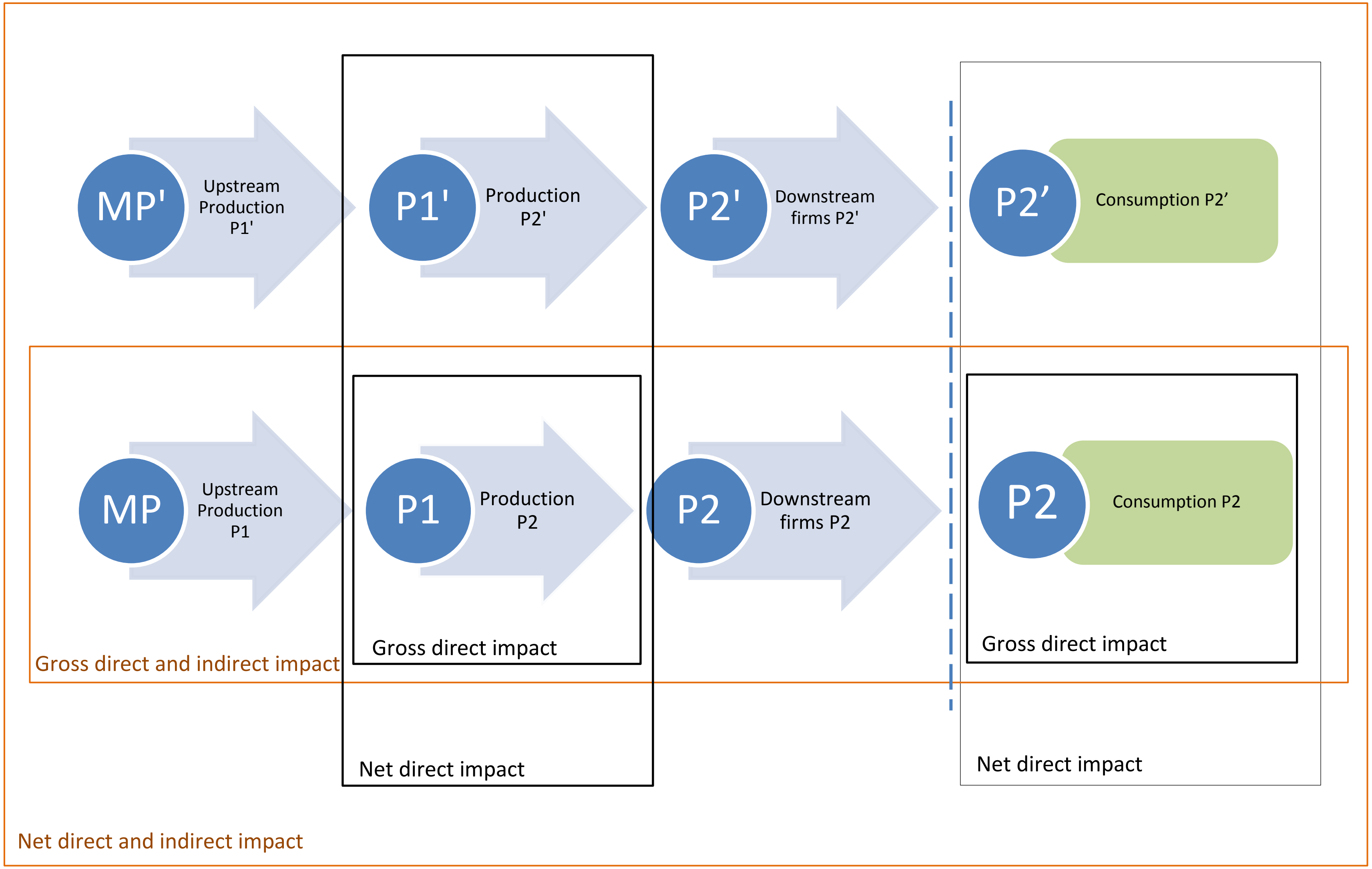


Figure 57 : Characterization of gross, net, direct and indirect impacts

The concept of gross, net, direct and indirect impacts are useful to depict the impacts that a PAM may have on the whole economy. These concepts may for instance be helpful to define the level of details of an analysis. Three categories of evaluations may be defined (Table 60):

- **Quick evaluation**, focusing on the evaluation of gross direct impacts: this category is suited to socio-economic evaluations that have to be conducted quickly and/or with few resources. This kind of evaluation is also suited to cases where a comparison between several alternatives for a specific PAM exists.

- **Standard evaluation**: this category concerns evaluation of gross direct to net direct and indirect impacts. However, net impacts refer only to the net impacts between substitutable goods and services, and not into the whole economy. This kind of assessment is suited to socio-economic evaluations of PAMs for which no complex macro-economic models exists but where time and data are available to conduct more detailed analysis.

- **In-depth evaluation**: this category refers to study assessing net direct, indirect and induced impacts on the whole economy. This kind of evaluation is suited to socio-economic evaluations for which a lot of resources are available: time, data, and modelling experts. Indeed, in-depth evaluations necessitate building and/or using complex models to apprehend the interlinkages between sectors and/or micro and macro levels.

Table 60 : Definition of categories of evaluations in relation to the impacts on producers and consumers considered

Impact on producers and/or consumers of goods and services impacts by the PAM	**Categories of evaluation**		
	Quick	**Standard**	**In-depth**
Gross direct	x	x	x
Gross indirect		x	x
Net direct		x^a	x^b
Net indirect		x^a	x^b
Induced impacts			x

Legend: x^a – between substitutable goods and services, ^{b} – between all markets.

However, used alone, these concepts fail to characterize/identify the socio-economic impacts under study as well as the actors impacted by the PAM. To cope with this, we propose linking the concepts of gross, net, direct and indirect impacts with theoretical concepts in section 4.1.2.2

4.1.2.2 A framework to identify impacts on producers and consumers[20]

The framework we propose is organized in five main steps: (i) the gross direct impact identification and definition, (ii) the net direct impact identification and definition, (iii) the gross indirect impact identification and definition, (iv) the net indirect impact identification and definition, and (v) the identification of the impact that are relevant to consider in a standard approach.

4.1.2.2.1 Step 1: Gross direct impact identification and definition

This first step of the operational framework is composed of four sub-steps (Figure 58):

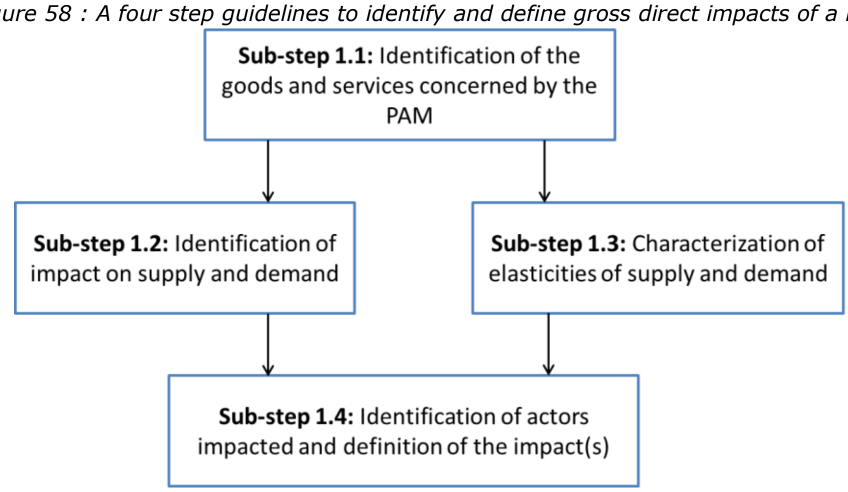
(1.1) It is primordial to first clearly identify the goods and services impacted by the PAM. It has to be noted that a PAM may impact a range of goods and services for two main reasons: (i) because the PAM may directly concern various goods (as the PAM "Increase of excise duty on diesel" that also defines new rules for the gasolines excise duty) and/or (ii) because a good impacted may be directly linked with the use of another good as for instance diesel and cars or eco-design products and energy consumption. All these goods have to be identified in this first sub-step.

(1.2) Second, the evaluator has to identify how the markets of the identified goods are impacted: is it the supply or the demand that is impacted by the PAM?

(1.3) Third, the assessor has to characterize the elasticities of supply and demand

(1.4) Finally, with the identification of the way each product is impacted (supply or demand) and with the assumptions made on elasticities, it is possible to identify which actors are impacted by the PAM (producer and/or consumer) and how.

Figure 58 : A four step guidelines to identify and define gross direct impacts of a PAM



The application of this step to a PAM permits having a global figure of assumptions made for the evaluation regarding the effects of the PAM on supply and demands of specific goods and services, and an information on the likely direction of changes for some general socio-economic indicators defined for producers and consumers. More concretely, we defined two types of contrasted and

[20] We propose a framework of evaluation that is very close to the economic theory, in order to allow for a better identification of the scope of the assessment. This framework is relevant for quick and standard evaluation as the in-depth evaluation category is out of scope of this project, given the time- and resource-consuming approaches it would need. As a consequence, when we speak of net impacts, we only consider the net effect between substitutable goods and services.

simplified impacts on supply and demand that may be identified for each product and service impact: (a) demand shift with inelastic supply and (b) supply shift with elastic demand (Figure 59).

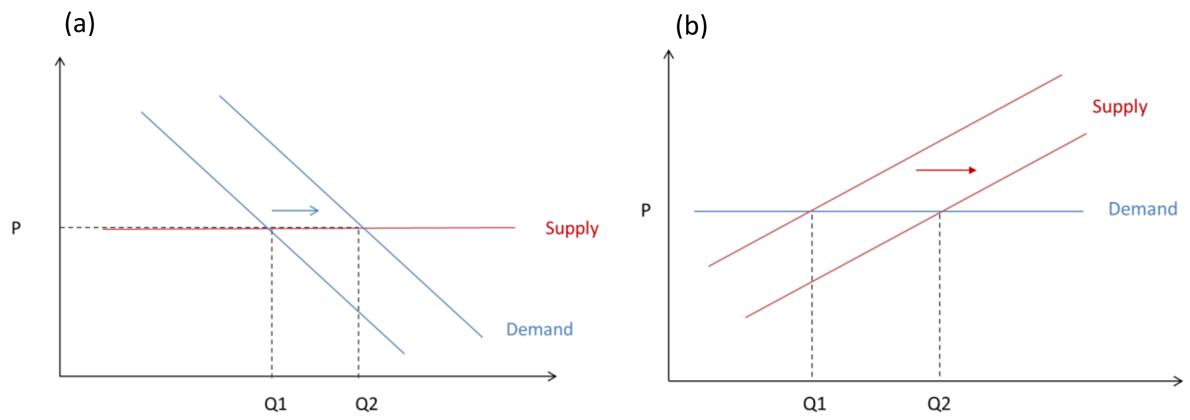


Figure 59 : Representation of two simplified and contrasted impacts on supply and demand

In both cases, the increase of demand or supply implies an increase of the total quantity purchased without any impact on prices. These simplified impacts concern indeed only a part of the economy. For instance, an increase of supply with an elastic demand may be assumed for the green electricity when new offshore winds are constructed. In fact, demand for electricity is quite inelastic but as we are focussing on green electricity, we may represent the effect on this specific product as showed in Figure 59 (b). An impact may indeed be observed on prices but as the objective of this work is to make first rough and simplified evaluations, the assumption of elastic demand may be done.

Then, the expected direction of changes on generic socio-economic indicators defining the impacts on producers and consumers are set. The objective is to set a likely direction without making any other assumption on the significance of the impacts. The generic socio-economic indicators used are defined in Section 4.1.2.4.

4.1.2.2.2 Step 2: Net direct impact identification and definition

The identification of net direct impacts consists in identifying what is going to occur in the market of similar goods and services as those identified in step 1 (substitutable goods). The same sub-steps as in sub-step 1 may thus be followed to identify and define the net direct impacts of a PAM (Figure 58).

4.1.2.2.3 Step 3: Gross indirect impact identification and definition

In this step, the objective is to identify, for each good and service identified in step 1, if other producers from the value chain will be impacted by the eventual changes defined in step 1. If yes, these impacts must be defined (see section 4.1.2.4 for a definition of relevant socio-economic indicators to be considered).

4.1.2.2.4 Step 4: Net indirect impact identification and definition

The identification of net indirect impacts consists in identifying what is going to occur in the market of similar goods and services as those identified in step 2 (substitutable goods). For each substitutable goods and services, the same sub-steps as in sub-step 1 may thus be followed to identify and define the net indirect impacts of a PAM (Figure 58).

4.1.2.2.5 Step 5: Identification of relevant and evaluable indicators

4.1.2.3 The last step consists in analysing the impacts identified and defined in the previous steps and to discuss the more relevant impacts that have to be assessed to have a coherent evaluation of the impact of the PAMs.

4.1.2.4 Summary: impacts and socio-economic indicators considered

As a summary, Table 61 presents the main impacts and indictors that we propose to consider in our framework of evaluation.

The process of identification of the impacts on producers and consumers was defined in section 4.1.2.2. Regarding producers, the general impacts are defined with three generic socio-economic indicators: the economic activity, the gross margin and employment. The indicator "**Economic activity**" permits giving an information on the evolution of an activity (development or decrease). The quantification of this indicator is then specific to each PAM and the information available. It will generally be expressed as a percentage of evolution of another socio-economic indicator available as for instance, production costs or sales quantities. The indicator "**Gross Margin**" corresponds to the evolution of production costs compared to the sales prices of the product. The indicator "**Employment**" permits giving an information on the expected evolution of number of employees in a given sector.

Regarding the impacts on public sector, we distinguish two sources of costs and/or revenue: the impacts linked to the policy implementation and the impacts linked to the evolution of markets (Table 61). Regarding the **policy implementation** impacts, it could be only costs if it requires additional workforce or investments as for regulation PAMS for instance. In case of market-based instruments, both costs and benefits may arise: only costs if it concerns an economic incentive based on subsidies and essentially benefits if the economic incentive is based on taxes (but some costs may arise from the administrative implementation of the instrument). Regarding the impacts linked to the evolution of markets, it corresponds to the increase or decrease of taxes perceived from production and consumption units. This indicator, called "**Tax revenue**", corresponds thus to transfers. This information **must be interpreted carefully** as a lower consumption of a specific good for consumers will imply a lower tax revenue for the public sector: this result must not be considered as a cost for the public sector as we may assume that the any savings made by a consumer will be spend in another good or service, bailing out the public sector.

Two last categories of impacts are considered: the externalities and other macroeconomic impacts. The **externalities** as environmental and welfare impacts may occur when implementing a public policy. This category of impacts concerns the household as consumers. It has to be noted that it may also impact the other consumers or a producer if the externality is specific to a production sector. We won't consider the impacts on these producers as it is too specific. We propose integrating in this framework four categories of **macro-economic impacts**: the impacts on supply, on demand, on prices and on the country performances. These macro-economic impacts concern producers and consumers.

To characterize the socio-economic impacts assessed, we recommended filling in the Table 62 with the products under study and socio-economic indicators assessed for each actor.

Table 61 : Impacts and socio-economic indicators

<table>
<tr><th colspan="2">Impacts</th><th>Indicators</th></tr>
<tr><td colspan="2">Impact on producers</td><td>• Economic activity (volume of production)
• Gross margin (modification of costs of production without a modification of the associated sell prices – and vice-versa)
• Employment</td></tr>
<tr><td colspan="2">Impact on consumers</td><td>• Total quantity purchased
• Purchase costs (of goods and services)</td></tr>
<tr><td rowspan="2">Impacts on public sector</td><td>Policy implementation impacts</td><td>• Investments costs
• Administrative costs
• (of which employment)
• Subsidies
• Tax</td></tr>
<tr><td>Tax revenue impact</td><td>• Impacts linked to the evolution of the markets</td></tr>
<tr><td colspan="2">Externalities</td><td>Dependant on the PAM studied</td></tr>
<tr><td colspan="2">Other macroeconomic indicators</td><td>Dependant on the PAM studied</td></tr>
</table>

Table 62 : summary of impacts considered

			Gross direct impact	Gross indirect impact	Net direct impact	Net indirect impact
Product 1	**Producer**	**Producer P1**				
		Upstream Prod.				
		Downstream Prod.				
	Consumer	**Households**				
		Industry				
		Public sector				
Product n	**Producer**	**Producer Pn**				
		Upstream Prod.				
		Downstream Prod.				
	Consumer	**Households**				
		Industry				
		Public sector				
Public sector	**Policy implementation costs**					
	Tax revenue impacts					
Externalities						
Other macro-economic indicators						

4.1.2.5 Conclusion

The framework of evaluation we propose is based on economic theory, ensuring a clear definition and justification of the socio-economic impacts considered. Furthermore, the detailed and step by step process of evaluation we propose permits ensuring:

- The use of a similar approach for making socio-economic evaluations of PAMs
- The consideration of the same socio-economic indicators between PAMs
- A transparent definition of assumptions and impacts evaluated/non-evaluated
- An intuitive framework easy to use for any evaluator

4.2 Implementation of the framework

In this section, the framework for socio-economic evaluation of policies and measures is implemented on a panel of federal climate PAMs. Owing to the limited time provided for the implementation of the framework, a lot of simplifying assumptions have been implemented. As a consequence, the evaluations we made only give an order of magnitude of socio-economic impacts and should be regarded as first rough evaluation.

A summary of the results is provided in Table 63 for 2020 and in Table 64 for 2035. The assumptions made for these evaluations are explained in each PAM section.

Table 63 : Summary results of socio-economic impacts related to PAM implementation for 2020

PAM	Public sector			Producers			Households as consumers		Tertiary sector as consumers	
	Implementation costs (M€)	Savings as consumer (M€)	Tax revenue (M€)	Costs (M€)	Savings (M€)	Economic activity (%)	Costs (M€)	Savings (M€)	Costs (M€)	Savings (M€)
IP-A06	-114.9	10.0	NE	0.0	0.0	NE	NA	NA	39.0	313.1
IP-B01	0.3	NA	NE	0.0	0.0	-0.5	NA	NA	NE	NE
EC - A05 - elec	see EC-A05 - non elec	NA	-501.5	N	N	N	0.0	1354.5	0.0	1390.3
EC - A05 - non-elec	-1.0	NA	-402.3	N	N	N	0.0	645.5	0.0	373.4
EC - B01	0.0	NA	NE	NE	NE	NE	0.0	0.8	NA	NA
EP-A01	224.8	NE	NE	713.1	NE	0.1	NE	NE	NE	NE
TR-A02	NE	9.4	NE	N	N	N	0.0	9.3	-9.4	0.0
TR-D01	N	NA	NE	621.8	NE	NE	NA	NA	NA	NA
TR-XXX	-39.4	NA	NE	N	N	N	12.4	10.0	27.0	10.0
APP-T01	N	NA	NE	N	N	N	86.1	81.6	NA	NA
APP-T02	368.2	NA	-17.7	NE	NE	NE	0.0	405.9	NA	NA
APP-T03	NE	2.7	NA	N	N	N	NA	NA	NA	NA
APP-T04	NE	1.3	NA	N	N	N	NA	NA	NA	NA
XX-X04	N	N	-494.9	N	N	N	0.0	569.2	0.0	N

Legend: N – Negligible, NE – impact not evaluated, NA – not applicable.

Table 64 : Summary results of socio-economic impacts related to PAM implementation for 2035

PAM	Public sector			Producers			Households as consumers		Tertiary sector as consumers	
	Implementation costs (M€)	Savings as consumer (M€)	Tax revenue (M€)	Costs (M€)	Savings (M€)	Economic activity (%)	Costs (M€)	Savings (M€)	Costs (M€)	Savings (M€)
IP-A06	-114.9	25.0	NE	0.0	0.0	NE	NA	NA	39.0	300.3
IP-B01	0.4	NA	NE	0.0	0.0	-0.9	NA	NA	NE	NE
EC - A05 - elec	see EC-A05 - non elec	NA	-894.6	N	N	N	0.0	2452.1	0.0	2393.4
EC - A05 - non-elec	-1.0	NA	-829.5	N	N	N	0.0	1347.3	0.0	806.4
EC - B01	0.0	NA	NE	NE	NE	NE	0.0	0.8	NA	NA
EP-A01	0.0	NE	NE	4.2	NE	0.0	NE	NE	NE	NE
TR-A02	NE	13.9	NE	N	N	N	0.0	14.9	-13.9	0.0
TR-D01	N	NA	NE	658.9	NE	NE	NA	NA	NA	NA
TR-XXX	-38.4	NA	NE	N	N	N	12.1	25.0	26.3	25.0
APP-T01	N	NA	NE	N	N	N	NE	NE	NA	NA
APP-T02	NE	NA	NE	NE	NE	NE	0.0	NE	NA	NA
APP-T03	NE	NE	NA	N	N	N	NA	NA	NA	NA
APP-T04	NE	NE	NA	N	N	N	NA	NA	NA	NA
XX-X04	N	N	NE	N	N	N	0.0	NE	0.0	N

Legend: N – Negligible, NE – impact not evaluated, NA – not applicable.

4.2.1 PAM « IP-06 – Tax deduction for energy savings »

For decades, companies have been enjoying a tax advantage when they invest in energy savings, at a percentage tax deduction level that has varied in time. From 2013 the deduction level for energy saving investments has undergone a progressive decrease, reaching a rate of 14.5% in 2013 and of 13.5% for the following years.

4.2.1.1 Identification and description of the socio-economic impacts

4.2.1.1.1 Impacts on consumers and producers

4.2.1.1.1.1 Step 1: Gross direct impacts identification and definition

Two categories of products are identified: the works related to the investments in energy savings and energy (Table 65). The quantity of works demanded is expected to increase thanks to the implementation of the PAM. We consider that the supply is inelastic to this increase of demand, implying no price changes for these works. Regarding energy, as the number of works is expected to increase, a decrease of energy consumption is expected. We also assume that the supply is inelastic.

Table 65: Presentation of results of sub-steps 1.1, 1.2 and 1.3

Sub-steps	Product 1	Product 2
1.1 Identification of goods and services concerned by the PAM	Works related to energy savings	Energy
1.2 Identification of impact on supply and demand	Increase of demand	Decrease of demand
1.3 Characterization of elasticities of supply and demand	Supply inelasticity	Supply inelasticity

Regarding the works related to energy savings, the economic activity of the companies in this sector may increase thanks to the PAM, as well as the number of employees (Table 66). However, no increase of gross margin per work is expected given that no price change is considered. In the same way, the price costs for consumers will remain constant whereas the total quantity demanded will increase (number of investments). Regarding energy, the decrease of total quantity purchased may imply a decrease in economic activity and employment for producers.

- *Table 66 : Presentation of results of sub-steps 1.4*

Gross direct impacts	Works related to energy savings	Energy
Impact on producers		
• Economic activity (volume of production)	↗	↘
• Gross margin (modification of costs of production without a modification of the associated sell prices – and vice-versa)	=	=

• Employment	↗	↘
Impact on consumers		
• Total quantity purchased	↗	↘
• Purchase costs (of goods and services)	=	=

Legend: ↗ – Increasing impact, ↘ – Decreasing impact, = – No impact.

4.2.1.1.1.2 Step 2: Net direct impact identification and definition

Net direct impacts concern potential substitution effects related to the impact on products identified in step 1. For this PAM, we didn't identify any potential substitution impacts.

4.2.1.1.1.3 Step 3: Gross indirect impact identification and definition

Regarding the first product, the economic activity of producers in the value chain is expected to increase proportionally to the increase of works. The reverse effect is attended for the second product considered, i.e. energy.

4.2.1.1.1.4 Step 4: Net indirect impact identification and definition

As no substitution effect has been identified in Step 2, there is no net indirect impact.

4.2.1.1.1.5 Step 5: Summary of impacts on consumers and producers

A summary of the impact of the PAM on the consumers and producers is presented in Table 67.

▪ *Table 67 : Summary of impacts on producers and consumers*

			Gross direct impact	Gross indirect impact	Net direct impact	Net indirect impact
Product 1: Works	**Producer**	**Producer P1**	↗EA, ↗E			
		Upstream Prod.		↗EA, ↗E		
		Downstream Prod.		↗EA, ↗E		
	Consumer	**Households**	NA			
		Industry	↗ Q			
		Public sector	NA			
Product 2: Energy consumption	**Producer**	**Producer P2**	↘EA, ↘E			
		Upstream Prod.		↘EA, ↘E		
		Downstream Prod.		↘EA, ↘E		
	Consumer	**Households**	NA			
		Industry	↘Q			
		Public sector	NA			

Legend: ↗ – Increase, ↘ – Decrease, EA – Economic Activity, E – Employment, Q – Quantity, N – Negligible, NA – No applicable.

4.2.1.1.2 *Impacts on public sector*

The implementation of the PAM will imply expenditure related to the tax deductions. Impacts on tax revenues are also expected.

4.2.1.1.3 *Summary of impacts considered*

A summary of the socio-economic impacts considered in our evaluation to run a net direct and indirect impacts assessment is presented in Table 68.

No impact is evaluated on producer as we assume that the decrease of energy consumption will not be sufficiently significant to impact producers.

- *Table 68 : Assessed impacts of the tax deduction for energy savings on producers, consumers and the public sector*

			Net direct and indirect impacts
Product 1: Works	**Producer**	**Producer P1**	NE
		Upstream Prod.	NE
		Downstream Prod.	NE
	Consumer	**Households**	NA
		Industry	Evaluated (IC)
		Public sector	NA
Product 2: Energy consumption	**Producer**	**Producer P2**	N
		Upstream Prod.	N
		Downstream Prod.	N
	Consumer	**Households**	NA
		Industry	Evaluated (ES)
		Public sector	NA
Public sector	**Policy implementation costs**		Evaluated
	Tax revenue impacts		NE
Externalities			NE
Other macro-economic indicators			NE

Legend: N – Negligible impact, NA – Non-Applicable, NE – not evaluated, IC – Investment costs, ES – Economic savings.

4.2.1.2 Methodology of evaluation

The methodology of evaluation of implementation costs and operational impacts of households is presented in Table 69. Both methodologies are based on the investments of free-riders. This indicator was calculated in the "Emission reduction" Part of the report, and significates that all the tax deduction received aren't implied by the PAM: some households, i.e. free-riders, would have done works to improve their energy efficiency without the PAM.

- *Table 69: Method of estimation of the socio-economic impacts identified*

Identified impacts		Method
Public sector		
Implementation costs	Other administrative costs	$- \quad C_{TAX\text{-}DEDUCT} * (I_{FREE\text{-}RIDERS} + I_{PAM})$
Consumers		
Households (€)	Operational impacts	$C_{TAX\text{-}DEDUCT} * (I_{FREE\text{-}RIDERS}) + ES_{PAM} - I_{PAM}$

Legend: $C_{TAX\text{-}DEDUCT}$ – coefficient of net tax deduction (%), $I_{FREE\text{-}RIDERS}$ – investments of free-riders (€), I_{PAM} – Investments induced by the PAM implementation (€), ES_{PAM} – Energy savings induced by the investments I_{PAM} (€).

The data used to make theses evaluations are derived from the emission reduction calculation part of the project. More concretely, coefficients on tax deduction and investments costs come from FPS personal communications.

4.2.1.3 Results

Consumer savings may rise up to about 300 M€ in 2018, and 260 M€ in 2035. Implementation costs reach 225 M€ in 2009 and 115 M€ from 2014 to 2035 (Figure 60).

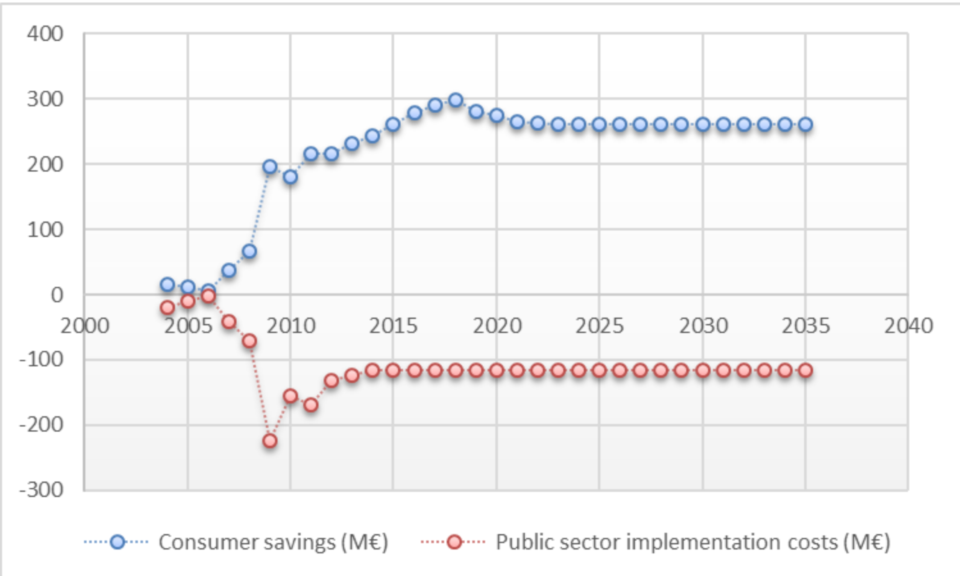


Figure 60 : Socio-economic impacts of the PAM IP-A06 "Tax deduction for energy savings"

4.2.2 PAM « IP-B01 – F gases »

F-gases are greenhouse gases which have a very high global warming effect. The F-gas Regulation 417/2014 aims at limiting the F-gases emission and is based on the following measures:

- **Provision 1**: Limitation of the total amount of gases that can be sold in the EU, with the target of reaching an amount of one-fifth of 2014 sales. Annex V of the F-gas Regulation.
- **Provision 2**: Banning the use of F-gases in certain application where less harmful alternatives are available in the market. Annex III of the F-gas Regulation.
- **Provision 3**: Preventing the emissions from existent equipment by enhanced maintenance, quality control checks and recovery of gases. F-gas Regulation except for Annex III and Annex V.

The F-gas Regulation 842/2006 is encompassed into the F-gas Regulation 417/2014, and thus into the PAM evaluation scenario.

4.2.2.1 Identification and description of the socio-economic impacts

4.2.2.1.1 *Impacts on consumers and producers*

4.2.2.1.1.1 Step 1: Gross direct impacts identification and definition

The products directly impacted by the PAMS are F-gases, for which a decrease of demand is expected given the PAM Regulation (Table 70). We assume an inelastic supply: unitary costs of F-gases will remain the same.

- *Table 70 : Presentation of results of sub-steps 1.1, 1.2 and 1.3*

Sub-steps	Product 1
1.1 Identification of goods and services concerned by the PAM	F-gases
1.2 Identification of impact on supply and demand	Decrease of Demand
1.3 Characterization of elasticities of supply and demand	Inelastic supply

The economic activity and employment of producers of F-gases are expected to decrease given that the level of F-gases sold in EU will decrease by the implementation of the PAM (Table 71). As we assumed the supply inelastic, their gross margin will remain the same. Regarding consumers, mainly the tertiary sector, the total consumption will thus decrease and the purchase costs are expected to increase. Indeed, even if the unitary price of F-gases is assumed to remain the same, additional costs linked to the use of F-gases will appear as for instance, certification costs and reporting costs.

- *Table 71 : Presentation of results of sub-steps 1.4*

Gross direct impacts	F-gases
Impact on producers	
• Economic activity (volume of production)	↘
• Gross margin (modification of costs of production without a modification of the associated sell prices – and vice-versa)	=
• Employment	↘
Impact on consumers	
• Total quantity purchased	↘
• Purchase costs (of goods and services)	↗

Legend: ↗ – Increasing impact, ↘ – Decreasing impact, = – No impact.

4.2.2.1.1.2 Step 2: Net direct impact identification and definition

Net direct impacts concern potential substitution effects related to the impact on products identified in step 1, i.e. the F-gases. Indeed, the F-gases will be replaced by a variety of climate-friendly, energy efficient, safe and proven alternatives are available today[21]. As a consequence, the total consumption of these substitutes is expected to increase and the economic activity of the producers is expected to increase proportionally to the decrease observed for producers of F-gases (as well as for employments). We may assume that these alternatives are available at the same costs than F-gases because climate friendly alternatives are readily available for many of the products and equipment in which F-gases are commonly used today[22].

4.2.2.1.1.3 Step 3: Gross indirect impact identification and definition

Gross indirect impacts correspond to the propagation of impacts identified in Step 1 into the value chain of F-gases. In other words, we consider as gross indirect impacts, impacts occurring during the manufacturing phase if other primary products must be used, during the maintenance and decommissioning phase. These impacts are expected to be proportional to the decrease in economic activity and employment for the products "F-gases".

4.2.2.1.1.4 Step 4: Net indirect impact identification and definition

[21] https://ec.europa.eu/clima/policies/f-gas/alternatives_en
[22] https://ec.europa.eu/clima/policies/f-gas/legislation_en

Net indirect impacts correspond to the propagation of impacts identified in Step 2 into the value chain of the identified products, i.e. the climate-friendly alternatives. Again, we expect an increase of economic activities (and thus employments) in the upstream and downstream producers of climate-friendly alternatives that is proportional to the decrease observed in the F-gases production chain.

4.2.2.1.1.5 Step 5: Summary of impacts on consumers and producers

A summary of the impact of the PAM on the consumers and producers is presented in Table 72.

▪ *Table 72 : Summary of impacts on producers and consumers*

			Gross direct impact	Gross indirect impact	Net direct impact	Net indirect impact
Product 1: F-gases	**Producer**	**Producer P1**	↘EA & E		↗EA & E	
		Upstream Prod.		↘EA & E		↗EA & E
		Downstream Prod.		↘EA & E		↗EA & E
	Consumer	**Households**	NA		NA	
		Industry	↘Q		↗Q	
		Public sector	NA		NA	

Legend: ↗ – Increase, ↘ – Decrease, EA – Economic Activity, E – Employment, Q - Quantity

4.2.2.1.2 *Impacts on public sector*

The policy implementation costs concern administrative costs linked to public awareness, campaigns of controls and inspection, etc.

4.2.2.1.3 *Summary of impacts considered*

A summary of the socio-economic impacts considered in our evaluation to run a net direct and indirect impacts assessment is presented in Table 73.

We are going to estimate two kinds of effects: the impact on economic activity of producers and the impact on administrative costs for the public sector. The impact on industry as consumers can't be evaluated at this stage. We found some relevant information but its use necessitates a more detailed analysis (See Box below).

- *Table 73 : Assessed impacts of the F-gas Regulation on producers, consumers and the public sector*

<table>
<tr><th colspan="3"></th><th>Net direct and indirect impacts</th></tr>
<tr><td rowspan="6">Product 1: F-gases</td><td rowspan="3">Producer</td><td>Producer P1</td><td>Evaluated (EA),</td></tr>
<tr><td>Upstream Prod.</td><td>Evaluated (EA)</td></tr>
<tr><td>Downstream Prod.</td><td>Evaluated (EA)</td></tr>
<tr><td rowspan="3">Consumer</td><td>Households</td><td>NA</td></tr>
<tr><td>Industry</td><td>NE</td></tr>
<tr><td>Public sector</td><td>NA</td></tr>
<tr><td rowspan="2">Public sector</td><td colspan="2">Policy implementation costs</td><td>Evaluated (AC)</td></tr>
<tr><td colspan="2">Tax revenue impacts</td><td>NE</td></tr>
<tr><td colspan="3">Externalities</td><td>NE</td></tr>
<tr><td colspan="3">Other macro-economic indicators</td><td>NE</td></tr>
</table>

Legend: AC - impact on administrative costs, EA - impact on economic activity, NA – Non-Applicable, N – not evaluated.

Box « Relevant information for an evaluation of costs for industries as consumers »

A study led by Öko-Recherche GmbH et al. (2011) permitted estimating five categories of costs for industries as consumer of F-gases. These costs were estimated under the F-gas Regulation 842/2006. We assume that this evaluation may still be relevant under the Regulation 217/2014:

- Costs for certification of personnel and companies (€/person)
- Costs of containment provisions (€/device)
- Costs of recovery (€/device)
- Costs of reporting (€/company)
- Costs of labelling, instruction manuals, etc. (€/company)

The use of this information would necessitate further detailed information on the number of companies concerned by the Regulation, their number of employees and the number of devices concerned.

4.2.2.2 Methodology of evaluation

The methodology of evaluation of the impacts of the PAM is presented in Table 74. Data sources used are detailed in Table 75.

- *Table 74: Method of estimation of the socio-economic impacts identified*

Identified impacts		Method
Public sector		
Implementation costs	Employment costs Other administrative costs	RC^{2006}*Coeff_RC^{2014} + OC^{2006}*Coeff_OC^{2014}
Producers		
Economic activity (%)		$[(E^{BAU}-E^{PAM})/E^{BAU}]*AF$

Legend: RC^{2006} – Recurring costs estimated for Regulation 2006, OC^{2006} – Recurring costs estimated for Regulation 2006, Coeff_RC^{2014} – coefficient defining the percentage applicable for recurring costs for the Regulation 2014, Coeff_OC^{2014} – coefficient defining the percentage applicable for one-off costs for the Regulation 2014, E^{BAU} – Total emissions of the BAU scenario, E^{PAM} – Total emissions of the PAM scenario, AF – Allocation factor for federal impact.

- *Table 75 : Data sources*

Identified impacts	Data	Source
Public sector	RC^{2006}, OC^{2006}	https://ec.europa.eu/clima/sites/clima/files/f-gas/docs/2011_study_en.pdf
	Coeff_RC^{2014} Coeff_OC^{2014}	Own estimation
Producers> Economic activity	E^{BAU}, E^{PAM}, AF	Calculation files

4.2.2.3 Results

The impacts of the PAM EC-B01 "Tax incentives to promote energy efficiency" are presented in Figure 61 and Figure 62. The expected implementation costs for the public sector will be of approximatively 0.35 M€ per year between 2017 and 2035. At the same time, the economic activity of the F-gas sector is expected to decrease due to the new Regulation. This decrease is expected to more and more important each year in comparison with a scenario without any Regulation, reaching -47% in 2020 and -87% in 2035.

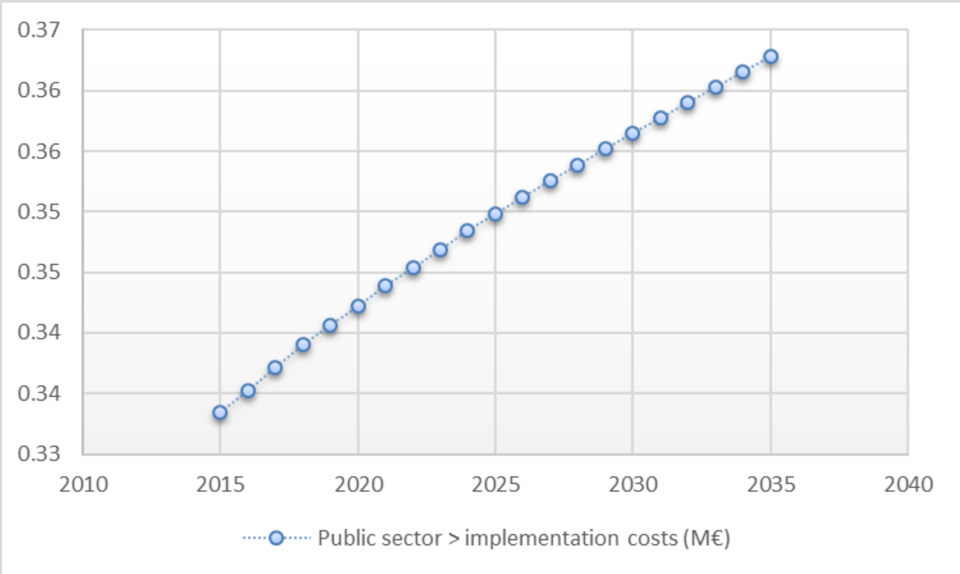


Figure 61 : Implementation costs of the PAM IP-B01 "F-gas Regulation"

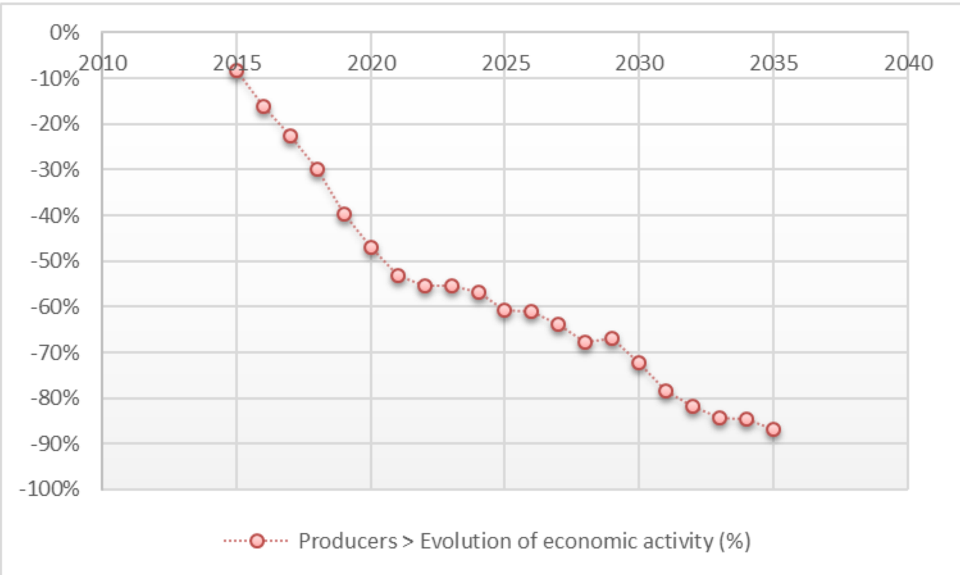


Figure 62 : Impact of the PAM IP-B01 "F-gas Regulation" on the economic activity of producers of F-gases.

4.2.3 PAM « EC-A05 – Ecodesign – Non-electricity energy sources »

This PAM concerns Ecodesign products functioning with non-electricity energy sources. For ease of processing, we will refer to "Ecodesign products" as for eco-design products that are more efficient.

4.2.3.1 Identification and description of the socio-economic impacts

4.2.3.1.1 Impacts on consumers and producers

4.2.3.1.1.1 Step 1: Gross direct impacts identification and definition

The implementation of the Ecodesign Directive will impact two categories of products: the eco-design products and the associated energy consumption. In both case, the impact on the market we focus on is a demand shift: increase of demand for the higher efficient products and decrease of demand for energy. In both case, for simplicity we assume that the supply is inelastic, i.e. the demand shift will not affect the price of products (see Table 76).

Table 76 : Presentation of results of sub-steps 1.1, 1.2 and 1.3

Sub-steps	Product 1	Product 2
1.1 Identification of goods and services concerned by the PAM	Ecodesign products	Energy consumption
1.2 Identification of impact on supply and demand	Demand shift	Demand shift
1.3 Characterization of elasticities of supply and demand	Supply inelasticity	Supply inelasticity

The last sub-step consists in identifying and defining the impacts on producers and consumers of products identified in sub-step 1 in the conditions defined in sub-step 2 and 3 (Table 77).

We assume there is no additional cost of production for the producers of the eco-design products due to the new legislation: the gross margin is thus expected to be the same. However, we assume an increase of economic activity given that a higher volume of production will be needed to satisfy the increasing demand.

Regarding the consumers of eco-design products, additional costs may arise from the higher investments needed for buying more efficient eco-design products.

With regards to energy consumption, the opposite impact may me observed: a decrease in total consumption of energy and in turn a decrease of economic activity (and thus of employment) for the producer of energy. Again, we assume that the gross margin and the purchase costs are not affected by the PAM.

Table 77 : Presentation of results of sub-steps 1.4

Gross direct impacts	Ecodesign products	Energy consumption
Impact on producers		
• Economic activity (volume of production)	↗	↘
• Gross margin (modification of costs of production without a modification of the associated sell prices – and vice-versa)	=	=
• Employment	↗	↘
Impact on consumers		
• Total quantity purchased	↗	↘
• Purchase costs (of goods and services)	↗	=

Legend: ↗ – Increasing impact, ↘ – Decreasing impact, = – No impact.

4.2.3.1.1.2 Step 2: Net direct impact identification and definition

Net direct impacts concern potential substitution effects related to the impact on products identified in step 1, i.e. the eco-design products and the energy consumption. Regarding the more efficient products, there is a substitution effects with similar products that aren't more efficient products. A contrary, there is no substitution effect regarding energy consumption: it is a decrease of consumption without an increase of consumption of other energy resources.

As for the eco-design products, the impact on similar non-ecodesign products corresponds to a demand shift, but to the left in this case, while the supply side is assumed to be inelastic. The related expected impacts on consumer and producer are presented in Table 78.

Table 78 : Definition of net direct impacts on producers and consumers

Net direct impacts	Non -Ecodesign products
Impact on producers	
• Economic activity (volume of production)	↘
• Gross margin (modification of costs of production without a modification of the associated sell prices – and vice-versa)	=
• Employment	↘
Impact on consumers	
• Total consumption	↘
• Purchase costs (of goods and services)	=

Legend: ↗ – Increasing impact, ↘ – Decreasing impact, = – No impact.

4.2.3.1.1.3 Step 3: Gross indirect impact identification and definition

Gross indirect impacts correspond to the propagation of impacts identified in Step 1 into the value chain of identified products, i.e. the eco-design products and energy. As in both cases an impact is expected on the economic activity, this impact will be transferred proportionally to the upstream and downstream firms.

For instance, a decrease of the economic activity of the producers in the sector of refinery and gas distribution may be expected given that this PAM will imply lower energy consumption. As this energy (coal, gas and oil) is imported, we could also expect a positive impact on the balance of payments.

4.2.3.1.1.4 Step 4: Net indirect impact identification and definition

Gross indirect impacts correspond to the propagation of impacts identified in Step 3 into the value chain of the identified products, i.e. the non-ecodesign products. As an impact is expected on the economic activity, this impact will be transferred proportionally to the upstream and downstream firms.

4.2.3.1.1.5 Step 5: Summary of impacts of the PAM on consumers and producers.

A summary of the impact of the PAM on the consumers and producers is presented in Table 79.

Box 1: Potential induced impacts

It has also to be noted that two kinds of induced impacts (rebound effects) may occur: (1) the consumer may consume more energy (for heating for instance) because he knows he is saving money with the eco-design products (operational costs) and (2) the consumer may decide to spend the money saved elsewhere. These behaviours will also imply an induced effect for the producers. In the first case, it will counterbalance the decrease in economic activity of the energy producers/distributors identified before. In the second case, it will enhance the economic activity of producers (for potentially all kind of sectors). In the same way, the public sector could recover the indirect implementation costs of the PAM by retrieving taxes on the induced consumption of consumers. In our evaluation, we assume there are no rebound effects because we don’t have enough data to make any assumption on the consumer behaviour.

Table 79 : Summary of impacts on producers and consumers

			Gross direct impact	Gross indirect impact	Net direct impact	Net indirect impact
Product 1: Ecodesign product	**Producer**	**Producer P1**	↗ EA, ↗ E		↘EA, ↘E	
		Upstream Prod.		↗ EA, ↗ E		↘EA, ↘E
		Downstream Prod.		↗ EA, ↗ E		↘ EA, ↘ E
	Consumer	**Households**	↗Q		↘Q	
		Industry	↗Q		↘Q	
		Public sector	↗Q		↘Q	
Product 2 : Energy consumption	**Producer**	**Producer P2**	↘EA,E			
		Upstream Prod.		↘EA,E		
		Downstream Prod.		↘EA,E		
	Consumer	**Households**	↘Q			
		Industry	↘Q			
		Public sector	↘Q			

Legend: ↗ – Increase, ↘ – Decrease, EA – Economic Activity, E – Employment, Q - Quantity

4.2.3.1.2 Impacts on public sector

Two categories of impacts are distinguished for the public sector, the policy implementation costs and the tax revenue impacts.

Regarding the policy implementation costs, the implementation of the PAM will imply a need to enforce the directive and its implementing regulations and to control the compliance of producers to the regulation. Mobilization of existing personnel resources will not be sufficient and new jobs will need to be created in the field of Market Surveillance. This implementation will thus imply a cost that will be related to the working time that will be necessary for the implementation and a cost for testing appliances. Both impacts are assessed in the next section. No specific investment in equipment will be needed.

Regarding the tax revenue impacts, as discussed in section 4.2.3.1, only the net impact on energy consumption is considered relevant. The decrease of energy consumption identified will decrease the revenue linked to the tax on energy for the public sector. This impact will be evaluated in the next sub-section.

4.2.3.1.3 Summary of impacts considered

A summary of the socio-economic impacts considered in our evaluation to run a net direct and indirect impacts assessment are presented in Table 80.

Regarding the eco-design products, as the increase in quantity sold is assumed to be proportional[23] to the decrease of quantity of conventional equivalent products sold (and thus of the subsequent economic activity), we assume that the net direct and indirect impact of the PAM on producers of eco-design and similar products will be neutral. Regarding consumers, the same assumptions may be done regarding the total quantity purchased, but as state before, a higher price for more efficient eco-design products may be expected. However, Vito and Econotec (2015) argue that the Ecodesign Directive don't result in an increase of the equipment price compared to business as usual. This argument may be consolidated by an estimate made by the US department of energy for solar water heater. In their evaluation, even if they consider a higher price for the energy efficient product, they conclude that the payback time is 1.5 years[24]. By assuming the same payback level for the other equipment, we decided not to treat these impacts as a priority given that they appear to be negligible with regards to our timeframe of evaluation.

Regarding the energy consumption, the decrease of the quantity consumed by eco-design products isn't compensated by an increase of consumption by other products as an indirect impact (some induced impacts may however occur – See Box 1). Regarding the impacts on production, we however consider the PAM will not impact significantly the energy sector (and thus the level of economic activity and of employment). However, for individual consumers, the impact may be significant.

As a conclusion, to run a net direct and indirect impact assessment of the PAM "Ecodesign" on consumers and producers, the relevant indicators to assess are the savings related to the decrease of

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[23] Indeed, we assume that their purchasing behaviour is not impacted by the PAM. In other words, the PAM will not affect change the replacement rate of products.

[24] http://energy.gov/energysaver/estimating-cost-and-energy-efficiency-solar-water-heater

consumption of energy by using eco-design products, the administrative and employment costs for the public sector and the impact on the tax revenue of public sector.

Table 80 : Assessed impacts of the Ecodesign Regulation on producers, consumers and the public sector

			Net direct and indirect impacts
Product 1: Ecodesign product	**Producer**	**Producer P1**	=
		Upstream Prod.	=
		Downstream Prod.	=
	Consumer	**Households**	N
		Industry	N
		Public sector	N
Product 2 : Energy consumpti on	**Producer**	**Producer P2**	N
		Upstream Prod.	N
		Downstream Prod.	N
	Consumer	**Households**	Evaluated (ES)
		Industry	Evaluated (ES)
		Public sector	N
Public sector	**Policy implementation costs**		Evaluated (AC & E)
	Tax revenue impacts		Evaluated
Externalities			NA
Other macro-economic indicators			NA

Legend: = - Neutral impact, N – Negligible impact, ES – Economic savings, AC – impact on administrative costs, E – impact on employment, NA – Non-Applicable.

4.2.3.2 Methodology of evaluation

The methodology of evaluation of the five socio-economic impacts identified is described by actor.

Regarding the **consumers**, we assessed the total savings – related to the decrease in energy consumption – by distinguishing the households and the other consumers:

- For **households,** the benefits correspond to the avoided costs coming from the decrease of energy consumption, i.e. their avoided energy consumption multiplied (EC^H) by the price for household (p_T^H) all taxes included (Table 81).
- For **other consumers** (tertiary sector), the benefits also correspond to the avoided costs coming from the decrease of energy consumption, i.e. their avoided energy consumption (EC^O) multiplied by the price for the tertiary sector (p_{HVAT}^O), VAT excluded as they retrieve it (Table 81).

Regarding the **public sector**, the impact related to the decrease of energy consumption correspond to the taxes that would have been paid by the consumers if they hadn't consumed less energy by using eco-design products (Table 81). Concretely, we estimated these costs by identifying the part of the energy price that correspond to the taxes perceived by the public sector and the decrease of energy consumption related to the use of eco-design products. As the prices are related to the type of consumer, we distinguished the decrease of consumption made by the households (EC^H) and the other consumers (EC^O). The prices are related to the type of consumer, the household or other consumers. Regarding the households, this price corresponds to the difference between the price all taxes included (p_T^H) and the price all taxes excluded (p_{HT}^H) for household. Regarding the other consumers, the price to the difference between the price VAT excluded (p_{HVAT}^O) (as the tertiary sector retrieve the VAT) and the price all taxes excluded (p_{HT}^O) for the tertiary sector.

With regards to the PAM implementation costs, employment costs and other administrative costs are necessary to run additional verification tests. For employment costs, a number of additional employees needed has to be identified and multiplied by the subsequent salary needed. An estimated need exists for 1 supervising and coordinating Inspector (class A) and 4 Inspectors (Class B) for field work (shop visits, sample taking) in 2017. Currently it is estimated that less than one FTE is spend on market surveillance on Ecodesign. It has to be taken into account that the products here are only part of all energy related products covered by Ecodesign regulations.

For other administrative costs, the number of additional verification tests has to be estimated, as well as their average costs. A linear increase of additional verification tests is needed from 100 in 2017 to 200 in 2020. Verification tests for appliances cost on average €4.000 (including VAT and logistical costs). Tested appliances don't need to be purchased and sampling can be done for free.

Table 81: Method of estimation of the socio-economic impacts identified

Identified impacts		Method
Public sector		
Implementation costs	Employment costs	- [$J^{FTE\text{-}A}*P^{FTE\text{-}A} + J^{FTE\text{-}B}*P^{FTE\text{-}BE}$]
	Other administrative costs	- [$VT*P^{VT}$]
Tax revenue impacts		- [$EC^H*(p_T^H - p_{HT}^H) + EC^O*(p_{HVAT}^O - p_{HT}^O)$]
Consumers		
Household (€)	Operational impacts	+ $EC^H*p_T^H$
Others (€)	Operational impacts	+ $EC^O*p_{HVAT}^O$

Legend: EC^H – estimated decrease of energy consumption for household, EC^O – estimated decrease of energy consumption for other consumers (tertiary sector), p_{HT}^H – energy price for household (all taxes excluded), p_{HT}^O – energy price for other consumers (all taxes excluded), p_T^H – energy price for household (all taxes included), p_{HVAT}^O – energy price for other consumers (VAT excluded), J^{FTE} – Number of FTE job creation (class A or B),P^{FTE} – Cost for a FTE job (class A or B), VT – Number of verification tests, P^{VT} – Cost of verification tests.

The data used to make theses evaluations are presented in Table 82. The data on energy consumption comes from our own evaluations (see previous section). The data on passed energy prices come from Eurostat, from a technical report published by the Walloon Public Service and from the DG Statistics (EPMECME - DGSIE). The data on future energy prices were calculated by applying the same coefficient of evolution than the future costs of energy estimated by the FPB. It has to be noted that we couldn't find the detail of the prices of gasoil and coal: we only have the price all taxes and levies included. As a consequence, the benefits of the other consumers are overestimated and the costs for the public sector underestimated.

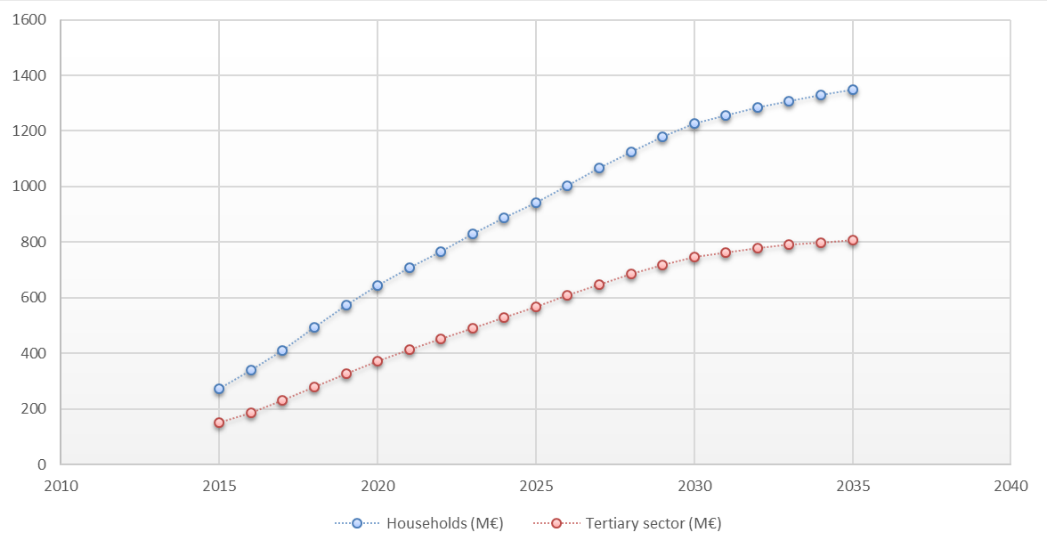
Table 82 : Data sources

<table>
<tr><th>Identified impacts</th><th colspan="2">Data</th><th>Source</th></tr>
<tr><td rowspan="4">Public sector > Tax revenue impacts
&
Consumers > Operational costs</td><td colspan="2">Energy consumption</td><td>Our evaluation (see Section “Emission reduction”)</td></tr>
<tr><td rowspan="3">Energy price</td><td>Natural gas</td><td>Eurostat, FPB</td></tr>
<tr><td>Gasoil</td><td>DG statistics</td></tr>
<tr><td>Coal</td><td>Report Wallon Public Service (DGO4) – Bilans énergétiques 2014, volet « Facture énergétique » 2016.</td></tr>
<tr><td>Public sector > PAM implementation > Employment costs</td><td colspan="2">Job creation (FTE)
Salary</td><td>Personal communication FPS envi (product policy), Statbel</td></tr>
<tr><td>Public sector > PAM implementation > Other administrative costs</td><td colspan="2">Increase of operational impact (verification test)
Cost of the operational impact</td><td>Personal communication FPS envi (product policy)</td></tr>
</table>

4.2.3.3 Results

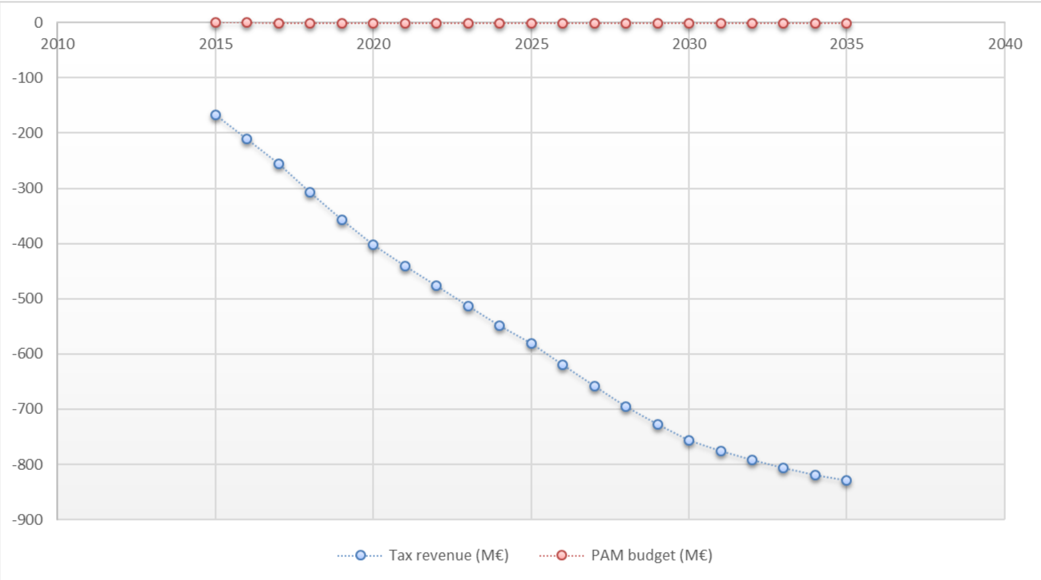
The impacts of the Ecodesign Directive on consumer expenditures in Belgium is presented in Figure 63. The Ecodesign Directive may imply savings from 645.5M€ and 373.4 M€ in 2020 to 1347.3 M€ and 806.4M€ in 2035 for households and the tertiary sector respectively.

Figure 63 : Socio-economic impacts of the Ecodesign Directive on consumers



The impacts of the Ecodesign Directive on the public sectors expenditures are presented in Figure 64. First, we can observe that the implementation costs correspond to 1M€ annually[25], of which 19% corresponds to employment costs and 81% verification test costs. Second, higher impacts are expected due to a decrease in tax revenue (from 403.3M€ in 2020 to 829.5M€ in 2035). However, these costs have to be interpreted carefully because induced impacts may be expected that would counterbalance this tax revenue decrease (See Box 1).

Figure 64: Socio-economic impacts of the Ecodesign Directive on public sector



[25] 0.5M€ would have be more realistic but ideally a higher budget should effectively be necessary. This cost cover Ecodesign and Energy Labelling (FPS envi and FPS econ).

4.2.4 PAM « EC-A05: Ecodesign – Electricty energy source »

This PAM concerns Ecodesign products functioning with electricity. For ease of processing, we will refer to "Ecodesign products" as for eco-design products that are more efficient.

4.2.4.1 Identification and description of the socio-economic impacts

4.2.4.1.1 Impacts on consumers and producers

4.2.4.1.1.1 Step 1: Gross direct impacts identification and definition

The implementation of the Ecodesign Directive will impact two categories of products: the eco-design products and the associated energy consumption (Table 83). In both case, the impact on the marker can be translate as a demand shift: increase of demand for the eco-design products and decrease of demand for energy. In both case, we assume that the supply is inelastic, i.e. the demand shift will not affect the price of products.

Table 83 : Presentation of results of sub-steps 1.1, 1.2 and 1.3

Sub-steps	Product 1	Product 2
1.1 Identification of goods and services concerned by the PAM	Ecodesign products	Energy consumption
1.2 Identification of impact on supply and demand	Demand shift	Demand shift
1.3 Characterization of elasticities of supply and demand	Supply inelasticity	Supply inelasticity

We assume there is no additional cost of production for the producers of the eco-design products may arise due to the new legislation: the gross margin is thus expected to be the same. However, we assume an increase of economic activity given that a higher volume of production will be needed to satisfy the increasing demand (Table 84).

Regarding the consumers of eco-design products, we assume that the purchase costs aren't higher. Additional costs may arise from the higher investments needed for buying eco-design products. However, Vito and Econotec (2015) argue that the Ecodesign Directive don't result in an increase of the equipment price compared to business as usual (Table 84).

With regards to the energy consumption, the opposite impact may be observed: a decrease of economic activity for the producer of energy (of which employment) and decrease total consumption of consumers. Again, we assume that the gross margin and the purchase costs are affected by the PAM (Table 84).

Table 84 : Presentation of results of sub-steps 1.4

Gross direct impacts	Ecodesign products	Energy consumption
Impact on producers		
• Economic activity (volume of production)	↗	↘
• Gross margin (modification of costs of production without a modification of the associated sell prices – and vice-versa)	=	=
• Employment	↗	↘
Impact on consumers		
• Total quantity purchased	↗	↘
• Purchase costs (of goods and services)	=	=

Legend: ↗ – Increasing impact, ↘ – Decreasing impact, = – No impact.

4.2.4.1.1.2 Step 2: Net direct impact identification and definition

Net direct impacts concerns potential substitution effects related to the impact on products identified in step 1, i.e. the eco-design products and the energy consumption. Regarding the eco-design products, there is a substitution effects with similar products that aren't eco-design products. On the contrary, there is no substitution effect regarding energy consumption: it is a decrease of consumption without an increase of consumption of other resources.

As for the eco-design products, the impact on similar non-ecodesign products corresponds to a demand shift, but to the left in this case, while the supply side is assumed to be inelastic. The related expected impacts on consumer and producer are presented in Table 85.

Table 85 : Definition of net direct impacts on producers and consumers

Net direct impacts	Non -Ecodesign products
Impact on producers	
• Economic activity (volume of production)	↘
• Gross margin (modification of costs of production without a modification of the associated sell prices – and vice-versa)	=
• Employment	↘
Impact on consumers	
• Total consumption	↘
• Purchase costs (of goods and services)	=

4.2.4.1.1.3 Step 3: Gross indirect impact identification and definition

Gross indirect impacts correspond to the propagation of impacts identified in Step 1 into the value chain of identified products, i.e. the eco-design products and energy. As in both cases an impact is expected on the economic activity, this impact will be transferred proportionally to the upstream and downstream firms.

For instance, a decrease of the economic activity of the producers in the sector of refinery and gas distribution may be expected given that this PAM will imply lower energy consumption. As this energy (coal, gas and oil) is imported, we could also expect a positive impact on the balance of payments.

4.2.4.1.1.4 Step 4: Net indirect impact identification and definition

Net indirect impacts correspond to the propagation of impacts identified in Step 2 into the value chain of the identified products, i.e. the non-ecodesign products. As an impact is expected on the economic activity, this impact will be transferred proportionally to the upstream and downstream firms.

4.2.4.1.1.5 Step 5: Summary of impacts on consumers and producers

A summary of the impact of the PAM on the consumers and producers is presented in Table 86.

Box 2: Potential induced impacts

It has also to be noted that two kind of induced impacts (rebound effects) may occur: (1) the consumer may consume more energy (for heating for instance) because he knows he is saving money with the eco-design products (operational costs) and (2) the consumer may decide to spend the money saved elsewhere. These behaviours will also imply an induced effect for the producers. In the first case, it will counterbalance the decrease in economic activity of the energy producers/distributors identified before. In the second case, it will enhance the economic activity of producers (for potentially all kind of sectors). In the same way, the public sector could recover the indirect implementation costs of the PAM by retrieving taxes on the induced consumption of consumers. In our evaluation, we assume there are no rebound effects because we don't have enough data to make any assumption on the consumer behaviour.

Table 86 : Summary of impacts on producers and consumers

			Gross direct impact	Gross indirect impact	Net direct impact	Net indirect impact
Product 1: Ecodesign product	**Producer**	**Producer P1**	↗ EA, ↗ E		↘EA, ↘E	
		Upstream Prod.		↗ EA, ↗ E		↘EA, ↘E
		Downstream Prod.		↗ EA, ↗ E		↘ EA, ↘ E
	Consumer	**Households**	↗Q		↘Q	
		Industry	↗Q		↘Q	
		Public sector	↗Q		↘Q	
Product 2 : Energy consumption	**Producer**	**Producer P2**	↘EA,E			
		Upstream Prod.		↘EA,E		
		Downstream Prod.		↘EA,E		
	Consumer	**Households**	↘Q			
		Industry	↘Q			
		Public sector	↘Q			

Legend: ↗ – Increase, ↘ – Decrease, EA – Economic Activity, E – Employment, Q - Quantity

4.2.4.1.2 Impacts on public sector

Two categories of impacts are distinguished for the public sector, the policy implementation costs and the tax revenue impacts.

Regarding the policy implementation costs, the implementation of the PAM will imply a need to enforce the directive and its implementing regulations and to control the compliance of producers to the regulation. Mobilization of existing personnel resources will not be sufficient and new jobs will need to be created in the field of Market Surveillance. These implementation costs are yet considered in Section 4.2.3.

Regarding the tax revenue impacts, as discussed in section 4.2.3.1, only the net impact on energy consumption is considered relevant to study. The decrease of energy consumption identified will decrease the revenue linked to the tax on energy for the public sector. This impact will be evaluated in the next sub-section.

4.2.4.1.3 Summary of impacts considered

A summary of the socio-economic impacts considered in our evaluation to run a net direct and impacts assessment are presented in

Table 87.

Regarding the eco-design products, as the increase in quantity sold is assumed to be proportional[26] to the decrease of quantity sold of conventional equivalent products (and thus of the subsequent economic activity), we assume that the net direct and indirect impact of the PAM on the consumers and producers of eco-design and similar products will be neutral.

Regarding the energy consumption, the decrease of the quantity consumed isn't compensate by an increase of consumption as an indirect impact (some induced impacts may however occur – See Box 2). Regarding the impacts on production, we however consider the PAM impact will not impact significantly the energy sector (and thus the level of economic activity and of employment). However, for individual consumers, the impact may be significant.

As a conclusion, to run a net direct and indirect impact assessment of the PAM "Ecodesign" on consumers and producers, the relevant indicators to assess are the savings made related to the decrease of consumption of energy by using eco-design products. We will distinguish two kinds of consumers: industries and households.

[26] Indeed, we assume that their purchasing behaviour is not impacted by the PAM. In other words, the PAM will not affect change the replacement rate of products.

Table 87 : Assessed impacts of the Ecodesign Regulation on producers, consumers and the public sector

			Net direct and indirect impacts
Product 1: Ecodesign product	**Producer**	**Producer P1**	=
		Upstream Prod.	=
		Downstream Prod.	=
	Consumer	**Households**	=
		Industry	=
		Public sector	=
Product 2 : Energy consumption	**Producer**	**Producer P2**	N
		Upstream Prod.	N
		Downstream Prod.	N
	Consumer	**Households**	↘Q
		Industry	↘Q
		Public sector	N
Public sector	**Policy implementation costs**		↗AC, ↗E
	Tax revenue impacts		↘
Externalities			NA
Other macro-economic indicators			NA

Legend: = - Neutral impact, N – Negligible impact, Q – impact on quantity consumed, AC – impact on administrative costs, E – impact on employment, NA – Non-Applicable, ↗ – increasing impact, ↘ – decreasing impact

4.2.4.2 Methodology of evaluation

The methodology of evaluation of the five socio-economic impacts identified is described by actor.

Regarding the **consumers**, we assessed the total savings – related to the decrease in energy consumption – by distinguishing the households and the other consumers:

- For **households,** the benefits correspond to the avoided costs coming from the decrease of energy consumption, i.e. their avoided energy consumption multiplied (EC^H) by the price for household (p_T^H) all taxes included (Table 81).
- For **other consumers** (tertiary sector), the benefits also correspond to the avoided costs coming from the decrease of energy consumption, i.e. their avoided energy consumption (EC^O) multiplied by the price for the tertiary sector (p_{HVAT}^O), VAT excluded as they retrieve it (Table 81).

Regarding the **public sector**, the impact related to the decrease of energy consumption correspond to the taxes that would have been paid by the consumers if they hadn't consumed less energy by using eco-design products (Table 81). Concretely, we estimated these costs by identifying the part of the energy price that correspond to the taxes perceived by the public sector and the decrease of energy consumption related to the use of eco-design products. As the prices are related to the type of consumer, we distinguished the decrease of consumption made by the households (EC^H) and the other consumers (EC^O). The prices are related to the type of consumer, the household or other consumers. Regarding the households, this price corresponds to the difference between the price all taxes included (p_T^H) and the price all taxes excluded (p_{HT}^H) for household. Regarding the other consumers, the price to the difference between the price VAT excluded (p_{HVAT}^O) (as the tertiary sector retrieve the VAT) and the price all taxes excluded (p_{HT}^O) for the tertiary sector.

With regards to the PAM implementation costs, employment costs and other administrative costs are necessary to run additional verification tests. For employment costs, a number additional employers needed has to be identified and multiplied by the subsequent salary needed. An estimated need exists for 1 supervising and coordinating Inspector (class A) and 4 Inspectors (Class B) for field work (shop visits, sample taking) in 2017. Currently it is estimated that less than one FTE is spend on market surveillance on Ecodesign. It has to be taken into account that the products here only are part of all energy related products covered by Ecodesign regulations.

For other administrative costs, the number of additional verification tests has to be estimated, as well as their average costs. A linear increase of additional verification tests is needed from 100 in 2017 to 200 in 2020. Verification tests for appliances cost on average €4.000 (including VAT and logistical costs). Tested appliances don't need to be purchased and sampling can be done for free.

Table 88: Method of estimation of the socio-economic impacts identified

Identified impacts		Method
Public sector		
Implementation costs	Employment costs	- [$J^{FTE-A} * P^{FTE-A} + J^{FTE-B} * P^{FTE-BE}$]
	Other administrative costs	- [$VT * P^{VT}$]
Tax revenue impacts		- [$EC^{H} * (p_T^H - p_{HT}^H) + EC^{O} * (p_{HVAT}^O - p_{HT}^O)$]
Consumers		
Household(€)	Operational impacts	+ $EC^{H} * p_T^H$
Others (€)	Operational impacts	+ $EC^{O} * p_{HVAT}^O$

Legend: EC^H – estimated decrease of energy consumption for household, EC^O – estimated decrease of energy consumption for other consumers (tertiary sector), p_{HT}^H – energy price for household (all taxes excluded), p_T^H – energy price for household (all taxes included), p_{HVAT}^O – energy price for other consumers (VAT excluded), J^{FTE} – Number of FTE job creation (class A or B),P^{FTE} – Cost for a FTE job (class A or B), VT – Number of verification tests, P^{VT} – Cost of verification tests.

The data used to make theses evaluations are presented in Table 82. The data on energy consumption comes from our own evaluations (see previous section). The data on passed energy prices come from Eurostat and technical report of FPS. The data on future energy prices were calculated by applying the same coefficient of evolution than the future costs of energy estimated by the FPB. It has to be noted that we couldn't find the detail of the prices of gasoil and coal: we only have the price all taxes and levies included. As a consequence, the benefits of the other consumers are overestimated and the costs for the public sector underestimated.

Table 89 : Data sources

Identified impacts	Data		Source
Public sector > Tax revenue impacts & Consumers > Operational costs	Energy consumption		Our evaluation (see Section "Emission reduction")
	Energy price	Natural gas	Eurostat, FPB
		Gasoil	FPS EPMECME, DGSIE, FPB
		Coal	FPS EPMECME, DGSIE, FPB
Public sector > PAM implementation > Employment costs	Job creation (FTE) Salary		Personal communication FPS envi, Statbel
Public sector > PAM implementation > Other administrative costs	Increase of operational impact (verification test) Cost of the operational impact		Personal communication FPS envi

4.2.4.3 Results

The impacts of the Ecodesign Directive on consumer costs is presented in Figure 65. The Ecodesign Directive may imply savings for consumers of 2.7 M€ in 2020 and 4.8 M€ in 2035. The decrease of tax revenue from lower electricity consumption for the public sector is of -0.5 M€ in 2020 and 0.9 M€ in 2035.

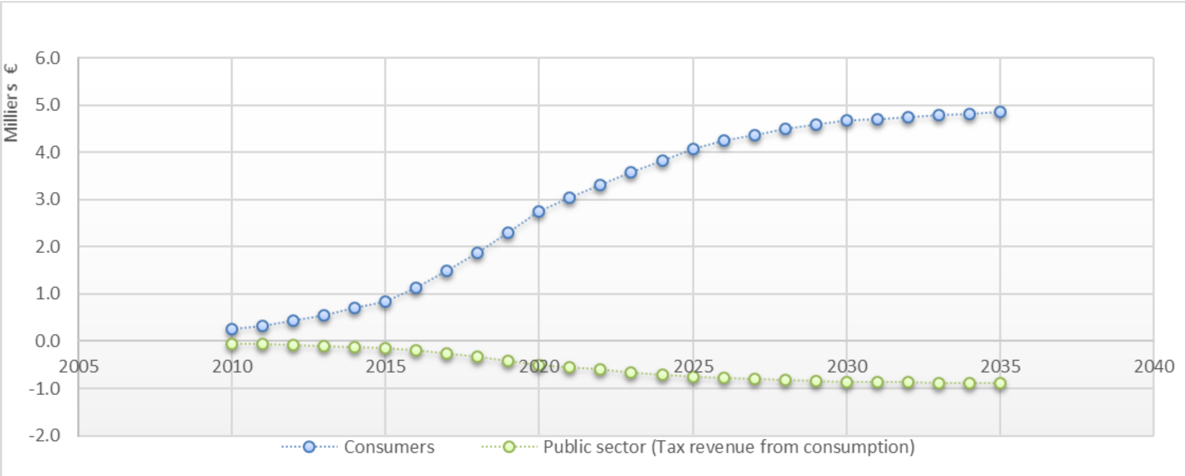


Figure 65 : Socio-economic impacts of the Ecodesign Directive on consumers and public sector (tax revenue)

4.2.5 PAM « EC – B01 – Tax incentive to promote energy efficiency in households »

Tax reductions and subsidies have been granted for part of the cost of investments aiming to increase energy efficiency in households (including the use of renewable energy resources). Based on the government agreement of December 2011, tax reduction measures will come to an end from 2012 onwards with one exception. The tax reduction for roof insulation has been retained, but the maximum of 40% of the investment has been reduced to 30% and the reduction can no longer be spread over several years. From 2015 onwards, regions are responsible for this tax reduction and can decide independently to continue, alter or stop the measure.

4.2.5.1 Identification and description of the socio-economic impacts

4.2.5.1.1 Impacts on consumers and producers

4.2.5.1.1.1 Step 1: Gross direct impacts identification and definition

Two categories of products are impacted by the PAM: the products and services improving energy efficiency concerned by the PAM (roof insulation, etc.) and the consumption of energy (Table 90). The implementation of the PAM implies an increase of demand for the first category of product, and a decrease of demand for the second category of product. In both cases, we consider an inelastic supply.

- *Table 90 : Presentation of results of sub-steps 1.1, 1.2 and 1.3*

Sub-steps	Product 1	Product 2
1.1 Identification of goods and services concerned by the PAM	Products and services improving energy efficiency (roof insulation, etc.)	Energy
1.2 Identification of impact on supply and demand	Increase of Demand	Decrease of Demand
1.3 Characterization of elasticities of supply and demand	Supply inelasticity	Supply inelasticity

The increase of demand for products and services improving energy efficiency is expected to increase the economic activity and employment of the concerned products and services (Table 91). As a subsidy is provided by the PAM, the purchase costs will decrease for households. Regarding energy, as demand decrease, the economic activity and employment may decrease but the impact is expected to be negligible with regards to the total production of the sector.

- *Table 91 : Presentation of results of sub-steps 1.4*

Gross direct impacts	Products and services improving energy efficiency (roof insulation, etc.)	Energy
Impact on producers		

• Economic activity (volume of production)	↗	↘
• Gross margin (modification of costs of production without a modification of the associated sell prices – and vice-versa)	=	=
• Employment	↗	↘
Impact on consumers		
• Total quantity purchased	↗	↘
• Purchase costs (of goods and services)	↘	=

Legend: ↗ – Increasing impact, ↘ – Decreasing impact, = – No impact.

4.2.5.1.1.2 Step 2: Net direct impact identification and definition

Net direct impacts concern potential substitution effects related to the impact on products identified in step 1, i.e. the products and services improving energy efficiency concerned by the PAM (roof insulation, etc.) and the consumption of energy. No substitution effect is expected for this PAM.

4.2.5.1.1.3 Step 3: Gross indirect impact identification and definition

Gross indirect impacts correspond to the propagation of impacts identified in Step 1 into the value chain of identified products, i.e. the products and services improving energy efficiency concerned by the PAM (roof insulation, etc.) and the consumption of energy. As a consequence, the impacts on the upstream producers are expected to be proportional to the impacts identified for producers in Table 91, i.e. increase of economic activity and employment in the upstream production chain of products and services improving energy efficiency (construction of primary materials, etc.).

4.2.5.1.1.4 Step 4: Net indirect impact identification and definition

Net indirect impacts correspond to the propagation of impacts identified in Step 2 into the value chain of the identified products. As no product was identified, there is no net indirect impact.

4.2.5.1.1.5 Step 5: Summary of impacts on consumers and producers

A summary of the impact of the PAM on the consumers and producers is presented in Table 92.

▪ *Table 92 : Summary of impacts on producers and consumers*

			Gross direct impact	Gross indirect impact	Net direct impact	Net indirect impact
Product 1: Products and services improving energy efficiency	**Producer**	**Producer P1**	↗ EA & E			
		Upstream Prod.		↗ EA & E		
		Downstream Prod.		↗ EA & E		
	Consumer	**Households**	↗ Q			
		Industry	NA			
		Public sector	NA			
Product 2 : Energy consumption	**Producer**	**Producer P2**	↘ EA & E			
		Upstream Prod.		↘ EA & E		
		Downstream Prod.		↘ EA & E		
	Consumer	**Households**	↘ Q			
		Industry	NA			
		Public sector	NA			

Legend: ↗ – Increase, ↘ – Decrease, EA – Economic Activity, E – Employment, Q – Quantity, N – negligible, NA – Non-applicable.

4.2.5.1.2 Impacts on public sector

The policy implementation costs correspond to tax reductions and subsidies delivered as incentives to improve energy efficiency for households.

4.2.5.1.3 Summary of impacts considered

A summary of the socio-economic impacts considered in our evaluation to run a net direct and indirect impacts assessment is presented in Table 93. The impacts on the energy producers is assumed to be negligible. The impacts on producers of products and services improving energy efficiency can't be evaluated without more in-depth analysis. Three impacts are evaluated: (i) the impact on investment costs of households, (ii) the energy savings related to the decrease of energy consumption expected and (iii) the administrative costs linked to the PAM implementation.

- *Table 93 : Assessed impacts of the PAM EC-B01 on producers, consumers and the public sector*

<table>
<tr><th colspan="3"></th><th>Net direct and indirect impacts</th></tr>
<tr><td rowspan="6">Product 1: Products and services improving energy efficiency</td><td rowspan="3">Producer</td><td>Producer P1</td><td>NE</td></tr>
<tr><td>Upstream Prod.</td><td>NE</td></tr>
<tr><td>Downstream Prod.</td><td>NE</td></tr>
<tr><td rowspan="3">Consumer</td><td>Households</td><td>Evaluated (IC)</td></tr>
<tr><td>Industry</td><td>NA</td></tr>
<tr><td>Public sector</td><td>NA</td></tr>
<tr><td rowspan="6">Product 2 : Energy consumption</td><td rowspan="3">Producer</td><td>Producer P2</td><td>N</td></tr>
<tr><td>Upstream Prod.</td><td>N</td></tr>
<tr><td>Downstream Prod.</td><td>N</td></tr>
<tr><td rowspan="3">Consumer</td><td>Households</td><td>Evaluated (ES)</td></tr>
<tr><td>Industry</td><td>NA</td></tr>
<tr><td>Public sector</td><td>NA</td></tr>
<tr><td rowspan="2">Public sector</td><td colspan="2">Policy implementation costs</td><td>Evaluated (AC)</td></tr>
<tr><td colspan="2">Tax revenue impacts</td><td></td></tr>
<tr><td colspan="3">Externalities</td><td></td></tr>
<tr><td colspan="3">Other macro-economic indicators</td><td></td></tr>
</table>

Legend: N – Negligible impact, IC – impact on investment costs, AC – impact on administrative costs, ES – impact on costs related to energy savings, NA – Non-Applicable, NE – Non-evaluated.

4.2.5.2 Methodology of evaluation

The methodology of evaluation of the impacts of the PAM is presented in Table 94. Data sources used are detailed in Table 95.

- *Table 94: Method of estimation of the socio-economic impacts identified*

<table>
<tr><th colspan="2">Identified impacts</th><th>Method</th></tr>
<tr><td colspan="3">Public sector</td></tr>
<tr><td>Implementation costs (€)</td><td>Other administrative costs</td><td>FS*NTR*AF</td></tr>
</table>

Consumers		
Household (€)	Investment costs	(CC-FS)*NTR*AF
	Energy savings	UES*NTR*AF*EC

Legend: FS - Mean Federal support, NTR – Number of tax reduction, AF – Allocation factor for Federal, CC – Capital costs, UES – Unitary Energy savings, EC – Energy costs.

- *Table 95 : Data sources*

Identified impacts	Data	Source
Public sector > Implementation costs (& Households)	FS – Mean Federal support	FPS personal communications and own estimations (See calculation part)
	NTR – Number of tax reduction	
	AF – Allocation factor Federal	
Households > Investment costs	CC – Capital costs	
Households> Energy savings	UES – Unitary Energy savings	
	EC - Energy costs	

4.2.5.3 Results

The impacts of the PAM EC-B01 "Tax incentives to promote energy efficiency" are presented in Figure 66. As from 2012 onwards, the tax reduction come to an end except for the roof insulation that was a federal competence till 2015, the PAM impacts in terms of costs and benefits were mostly seen before 2012, with implementation costs raising up to 790 M€ in 2011 and household's costs raising up to 1510 M€ (investment costs). Then, between 2012 and 2015, these costs decreased to about 20-30 M€ per year for the public sector and 30-50 M€ per year for households.

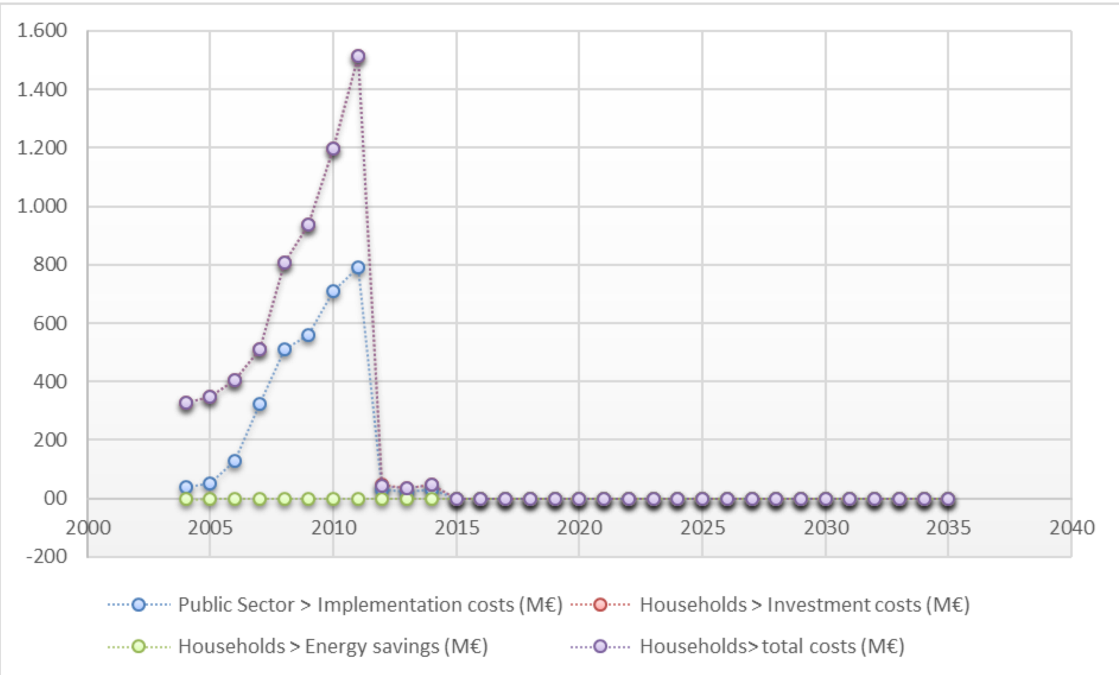


Figure 66 : Socio-economic impacts of the PAM "EC-B01"

4.2.6 PAM « EP-A01 – Offshore wind »

With a view to ensuring the placing on the market of a minimum volume of green electricity, this PAM corresponds to a subsidy system.

4.2.6.1 Identification and description of the socio-economic impacts

4.2.6.1.1 Impacts on consumers and producers

4.2.6.1.1.1 Step 1: Gross direct impacts identification and definition

As presented in section 4.1.2.2.1, the identification and definition of the gross direct impacts of a PAM may be done by a four sub-steps process. The results of the three first sub-steps are presented in

This PAM will impact one kind of product "the green electricity production" through the construction of offshore winds. Its implementation is expected to increase the supply of green electricity. We assume an elastic demand (Table 96).

- *Table 96 : Presentation of results of sub-steps 1.1, 1.2 and 1.3*

Sub-steps	Product 1
1.1 Identification of goods and services concerned by the PAM	Offshore wind construction/Green electricity production
1.2 Identification of impact on supply and demand	Increase of supply
1.3 Characterization of elasticities of supply and demand	Demand elasticity

The economic activity of producers will increase proportionally to the construction of new offshore wind farms (Table 97). We assume that the gross margin will be constant on the long run. In the same way, we assume no impact on sell prices (and thus on purchase costs for consumers). However, the total consumption of green electricity will increase.

- *Table 97 : Presentation of results of sub-steps 1.4*

Gross direct impacts	Offshore wind Green electricity production
Impact on producers	
• Economic activity (volume of production)	↗
• Gross margin (modification of costs of production without a modification of the associated sell prices – and vice-versa)	=
• Employment	↗
Impact on consumers	
• Total quantity purchased	↗
• Purchase costs (of goods and services)	N

Legend: ↗ – Increasing impact, ↘ – Decreasing impact, = – No impact.

4.2.6.1.1.2 Step 2: Net direct impact identification and definition

Net direct impacts concern potential substitution effects related to the impact on products identified in step 1, i.e. the green electricity produced by offshore wind farms. We can expect an impact on producers and consumers of other sources of electricity. Again, we don't consider an impact on prices.

The related expected impacts on consumer and producer are presented in Table 98.

- *Table 98 : Definition of net direct impacts on producers and consumers*

Net direct impacts	
Impact on producers	
• Economic activity (volume of production)	↘
• Gross margin (modification of costs of production without a modification of the associated sell prices – and vice-versa)	N
• Employment	↘
Impact on consumers	
• Total quantity purchased	↘
• Purchase costs (of goods and services)	N

Legend: ↗ – Increasing impact, ↘ – Decreasing impact, = – No impact.

4.2.6.1.1.3 Step 3: Gross indirect impact identification and definition

Gross indirect impacts correspond to the propagation of impacts identified in Step 1 into the value chain of identified products, i.e. the production of green electricity (offshore wind farms). The construction of new offshore wind will imply an increase of activity of the upstream enterprises.

4.2.6.1.1.4 Step 4: Net indirect impact identification and definition

Net indirect impacts correspond to the propagation of impacts identified in Step 2 into the value chain of the identified products, i.e. the other sources of electricity production. Indeed, as the consumption of the other sources of electricity is expected to decrease, a decrease of economic activity may be expected in the upstream and downstream enterprises.

4.2.6.1.1.5 Step 5: Summary of impacts on consumers and producers

A summary of the impact of the PAM on the consumers and producers is presented in Table 99.

▪ *Table 99 : Summary of impacts on producers and consumers*

			Gross direct impact	Gross indirect impact	Net direct impact	Net indirect impact
Product 1: Green electricity production (offshore wind)	**Producer**	**Producer P1**	↗EA & E		↘ EA & E	
		Upstream Prod.		↗ EA & E		↘ EA & E
		Downstream Prod.		↗ EA & E		↘ EA & E
	Consumer	**Households**	↗ Q		↘ Q	
		Industry	↗ Q		↘ Q	
		Public sector	↗ Q		↘ Q	

Legend: ↗ – Increase, ↘ – Decrease, EA – Economic Activity, E – Employment, Q – Quantity.

4.2.6.1.2 *Impacts on public sector*

The implementation of this PAM will imply some costs for the public sector, related to the economic support provided by GWh installed.

4.2.6.1.3 *Summary of impacts considered*

A summary of the socio-economic impacts considered in our evaluation to run a net direct and indirect impacts assessment is presented in Table 100.

- *Table 100 : Assessed impacts of the Ecodesign Regulation on producers, consumers and the public sector*

			Gross impacts	Net impacts
Product 1: Green electricity production (offshore wind)	**Producer**	**Producer P1**	↗ EA, ↗I, ↗ E	NE
		Upstream Prod.	↗ E	NE
		Downstream Prod.	↗ E	NE
	Consumer	**Households**	NE	NE
		Industry	NE	NE
		Public sector	NE	NE
Public sector	**Policy implementation costs**		↗ AC	NA
	Tax revenue impacts		NE	NE
Externalities			NE	NE
Other macro-economic indicators			NE	NE

Legend: = NE – Not evaluated, N – Negligible impact, Q – impact on quantity consumed, AC - impact on administrative costs, EA – impact on economic activity, E – impact on employment, I – impact on investments, NA – Non-Applicable, ↗ – increasing impact, ↘ – decreasing impact

4.2.6.2 Methodology of evaluation

The methodology of evaluation of socio-economic indicators is presented in Table 101. Data sources used are detailed in Table 102.

- *Table 101: Method of estimation of the socio-economic impacts identified*

Identified impacts		Method
Public sector		
Implementation costs	Administrative costs (€)	NIC*E_Support
Producers		
Gross direct & indirect employment (€)		$NIC*(DEC^{CONSTRUCTION}+IEC^{CONSTRUCTION}) + NIC^{CUMUL}*DEC^{PRODUCTION}$
Economic activity (%)		$NIC^{(n)}/IC^{(n-1)}$

Legend: NIC – New installed capacity (Gwh), E_Support – Economic support (€ per Gwh), $DEC^{CONSTRUCTION}$ – Direct employment costs during the construction phase (€/Gwh), $IEC^{CONSTRUCTION}$ – Indirect employment costs during the construction phase (€/Gwh), $DEC^{PRODUCTION}$ – Direct employment costs during the production phase (€/Gwh), NIC^{CUMUL} – Cumlative new installed capacity (Gwh), IC – Installed capacity (Gwh), $^{(n)}$ – year n, $^{(n-1)}$ – year n-1.

- *Table 102 : Data sources*

Identified impacts	Data	Source
Public sector > Administrative costs	E_support	Data "Norther", L'ECHO (16/12/16)
Producers > Gross direct & indirect employment (€)	$DEC^{CONSTRUCTION}$, $IEC^{CONSTRUCTION}$ & $DEC^{PRODUCTION}$	Estimation from data "Norther", L'ECHO (16/12/16) and STATBEL (FTE costs for industry)
Producers >Economic activity (%)	$IC^{(n-1)}$	Own estimation (see emission calculation part)
For each impact	NIC	Own estimation (see emission calculation part)

Legend: E_Support – Economic support (€ per Gwh), $DEC^{CONSTRUCTION}$ – Direct employment costs during the construction phase (€/Gwh), $IEC^{CONSTRUCTION}$ – Indirect employment costs during the construction phase (€/Gwh), $DEC^{PRODUCTION}$ – Direct employment costs during the production phase (€/Gwh), NIC – New installed capacity (Gwh).

4.2.6.3 Results

The impacts of the PAM EP-A01 "Offshore wind" are presented in Figure 67. The implementation costs fluctuate between 19 M€ in 2017 and 225 M€ in 2020.The costs for producers start from 551 M€ in 2017 till 3160 M€ in 2020. The costs decrease then to about 4 M€ from 2022 till 2035. Those costs are mostly due to investment costs, translating a year-by-year increase of economic activity (of +21% in 2017 and +75% in 2020 for instance).

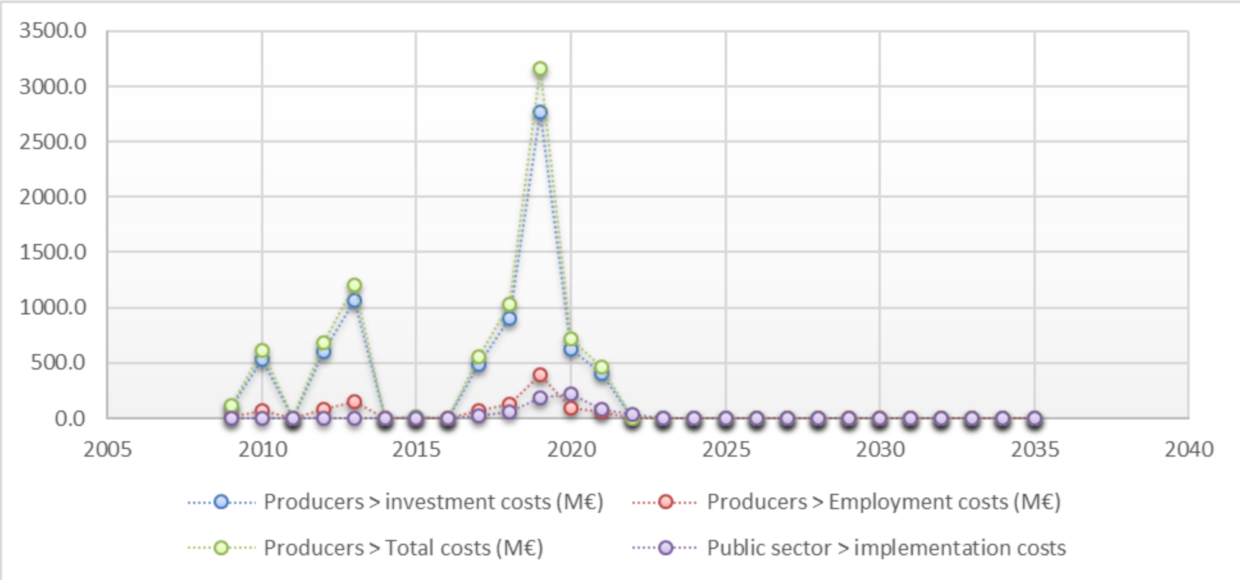


Figure 67 : Socio-economic impacts of the PAM EP-A01 "Offshore wind"

4.2.7 PAM « TR-A02 – Improve and promote public transport »

This PAM consists in improving and promoting public transports of the NMBS/SNCB group through:

- Investments in infrastructures
- The strengthening of the transport capacity and the quality of service (enhancing timeliness, safety, accessibility and information to travelers),
- The further development of an attractive pricing policy
- The promotion of combinations between railway and other soft transport modes through specific investments (parking spaces, cameras, lighting, etc.)
- Awareness raising campaigns

4.2.7.1 Identification and description of the socio-economic impacts

4.2.7.1.1 Impacts on consumers and producers

4.2.7.1.1.1 Step 1: Gross direct impacts identification and definition

We can classify the impacted goods and services in two categories:

- The goods and services concerned by the actions of improvement and promotion: new infrastructures, new parking, new cameras and lighting, etc. For these goods and services, an increase of demand is expected while no impact on prices is predicted (supply inelasticity). As no information is provided on the level of works to be done to improve and promote public transport, it's not possible to assess the impacts related to these goods and services. Consequently, we won't consider this category of goods and services in the following evaluation steps.
- The goods and services impacted by these actions, i.e. related to the shift from car to train. In other words, these goods and services concern mainly diesel and gasoline consumptions and train pkm. A decrease of demand is expected for diesel and gasoline whereas an increase of railways subscriptions is expected. In both cases, we consider that the supply is inelastic. We also assume there is no impact on the number of cars: we assume that people that already have a car will use it either to go the car park in railways stations either for other private travels that can't be done with public transports.

Table 103 : Presentation of results of sub-steps 1.1, 1.2 and 1.3

Sub-steps	Product 1	Product 2	Product 3
1.1 Identification of goods and services concerned by the PAM	new infrastructures, new parking, new cameras and lighting, etc.	diesel and gasoline consumptions	train pkm (train subscription)
1.2 Identification of impact on supply and demand	Increase of demand	Decrease of demand	Increase of demand
1.3 Characterization of elasticities of supply and demand	Supply inelasticity	Supply inelasticity	Supply inelasticity

A decrease of diesel and gasoline consumption will decrease (but not significantly) the economic activity (and thus employment) of producers (Table 104). Regarding train subscription, as the consumption will increase, the gross margin of SNCB/NMBS is expected to increase proportionally to the number of new subscription, assuming that the service remains the same (same quantity of train). In other words, the costs for SNCB/NMBS will be the same but the benefits related to train subscription will be higher). However, as we have no idea of the costs related to improvement and promotion, their impacts aren't considered.

- *Table 104 : Presentation of results of sub-steps 1.4*

Gross direct impacts	Diesel and gasoline consumptions	Train pkm (train subscription)
Impact on producers		
• Economic activity (volume of production)	↘	=
• Gross margin (modification of costs of production without a modification of the associated sell prices – and vice-versa)	=	↗
• Employment	↘	=
Impact on consumers		
• Total quantity purchased	↘	↗
• Purchase costs (of goods and services)	=	=

Legend: ↗ – Increasing impact, ↘ – Decreasing impact, = – No impact.

4.2.7.1.1.2 Step 2: Net direct impact identification and definition

Net direct impacts concern potential substitution effects related to the impact on products identified in step 1, i.e. diesel, gasoline and train subscription.

The impacts related to the substitution between cars and train are discussed as direct impacts in the case of this PAM. We don't consider any other substitution impacts.

4.2.7.1.1.3 Step 3: Gross indirect impact identification and definition

Gross indirect impacts correspond to the propagation of impacts identified in Step 1 into the value chain of identified products. As we consider the impacts on producers negligible for diesel and gasoline, we can consider that the indirect impacts are also negligible. There is no indirect impacts due to new train subscriptions.

4.2.7.1.1.4 Step 4: Net indirect impact identification and definition

Net indirect impacts correspond to the propagation of impacts identified in Step 2 into the value chain of the identified products. As no impact was identified in Step 2, we won't consider any net indirect impact.

4.2.7.1.1.5 Step 5: Summary of impacts on consumers and producers

A summary of the impact of the PAM on the consumers and producers is presented in Table 105. Regarding the decrease of diesel and gasoline consumptions, impacts on producers are considered negligible. We consider that the decrease of costs related to the decrease of diesel and gasoline consumptions only concerns households (work travels). Regarding the higher train subscription, we will consider the related higher benefits for the public sector as producer (SNCB) and the higher costs for enterprises that must finance train subscriptions for work travels.

▪ *Table 105 : Summary of impacts on producers and consumers*

			Gross direct impact	Gross indirect impact	Net direct impact	Net indirect impact
Product 1: Diesel and gasoline	**Producer**	**Producer P1**	N			
		Upstream Prod.		N		
		Downstream Prod.		N		
	Consumer	**Households**	↘ Q			
		Industry	NA			
		Public sector	NA			
Product 2: Train subscription	**Producer**	**Producer P2**	↗ GM			
		Upstream Prod.		NA		
		Downstream Prod.		NA		
	Consumer	**Households**	NA			
		Industry	↗ Q			
		Public sector	NA			

Legend: ↗ – Increase, ↘ – Decrease, EA – Economic Activity, GM – Gross margin, Q – Quantity, N - Negligible, NA – Non-Applicable

4.2.7.1.2 Impacts on public sector

Two categories of impacts are distinguished for the public sector, the policy implementation costs and the tax revenue impacts.

The implementation of the PAM will imply costs related to works and actions of improvement and promotion of public transport. However, as there is no information on works and actions to be conducted, it's not possible to quantify the subsequent implementation costs.

Impacts on tax revenue are expected due to the lower quantity of diesel and gasoline purchased.

4.2.7.1.3 Summary of impacts considered

A summary of the socio-economic impacts considered in our evaluation to run a net direct and indirect impacts assessment is presented in Table 106. Three impacts are evaluated: (i) the economic savings for households linked to their decrease of diesel and gasoline consumption, (ii) the increase of gross margin for SNCB and (iii) the increase of costs related to new train subscriptions for companies.

- *Table 106 : Assessed impacts of the PAM on producers, consumers and the public sector*

<table>
<tr><th colspan="3"></th><th>Net direct and indirect impacts</th></tr>
<tr><td rowspan="6">Product 1: Diesel and gasoline</td><td rowspan="3">Producer</td><td>Producer P1</td><td>N</td></tr>
<tr><td>Upstream Prod.</td><td>N</td></tr>
<tr><td>Downstream Prod.</td><td>N</td></tr>
<tr><td rowspan="3">Consumer</td><td>Households</td><td>Evaluated (ES)</td></tr>
<tr><td>Industry</td><td>NA</td></tr>
<tr><td>Public sector</td><td>NA</td></tr>
<tr><td rowspan="6">Product 2: Train subscription</td><td rowspan="3">Producer</td><td>Producer P2</td><td>Evaluated (GM)</td></tr>
<tr><td>Upstream Prod.</td><td>NA</td></tr>
<tr><td>Downstream Prod.</td><td>NA</td></tr>
<tr><td rowspan="3">Consumer</td><td>Households</td><td>NA</td></tr>
<tr><td>Industry</td><td>Evaluated (SC)</td></tr>
<tr><td>Public sector</td><td>NA</td></tr>
<tr><td rowspan="2">Public sector</td><td colspan="2">Policy implementation costs</td><td>NE</td></tr>
<tr><td colspan="2">Tax revenue impacts</td><td>NE</td></tr>
<tr><td colspan="3">Externalities</td><td>NA</td></tr>
<tr><td colspan="3">Other macro-economic indicators</td><td>NA</td></tr>
</table>

Legend: = N – Negligible impact, ES – Economic savings, GM – impact on gross margin, NA – Non-Applicable, SC – train subscription costs, NE – Not Evaluated.

4.2.7.2 Methodology of evaluation

The methodology of evaluation of costs and savings for consumers is presented in Table 107. Data sources used are detailed in Table 108.

- *Table 107: Method of estimation of the socio-economic impacts identified*

Identified impacts	Method
Producers	
Benefits SNCB/NMBS (new subscriptions)	$\frac{P_{Subscription}}{pkm^{estimated}} * pkm^{PAM} * C^{EMPLOYERS}$
Consumers	
Costs for industries SNCB/NMBS (new subscriptions)	$- \frac{P_{Subscription}}{pkm^{estimated}} * pkm^{PAM} * C^{EMPLOYERS}$
Benefits for Household(€) (fuel consumption)	$pkm^{PAM} * P_{FUEL}$

Legend: $P_{SUBSCRIPTION}$ – price for annual train subscriptions, $pkm^{ESTIMATED}$ – estimated annual pkm done per subscription, pkm^{PAM} – additional pkm permitted by the PAM, $C^{EMPLOYERS}$ – Coefficient of employer charges, P_{FUEL} – price of fuel per km.

- *Table 108 : Data sources*

Identified impacts	Data	Source
Benefits SNCB/NMBS (new subscriptions) **&** Costs for industries SNCB/NMBS (new subscriptions)	$P_{Subscription}$	www.ucm.be/content/.../file/Les-frais-de-deplacement-2013.pdf
	$pkm^{estimated}$	Estimated per subscription on a basis of 200 worked days
	$C^{EMPLOYERS}$	http://www.emploi.belgique.be/detailA_Z.aspx?id=11796
	pkm^{PAM}	Calculated in the « Emission reductions » Part of this project
Benefits for Household (€) (fuel consumption)	P_{FUEL}	Average gasoline and diesel prices calculated from the PAM "Increase of excise duty"

4.2.7.3 Results

Consumer benefits increase till 14.9 M€ in 2035, and the SNCB benefits till 13.9 M€ (Figure 68). Employers costs equals SNCB benefits.

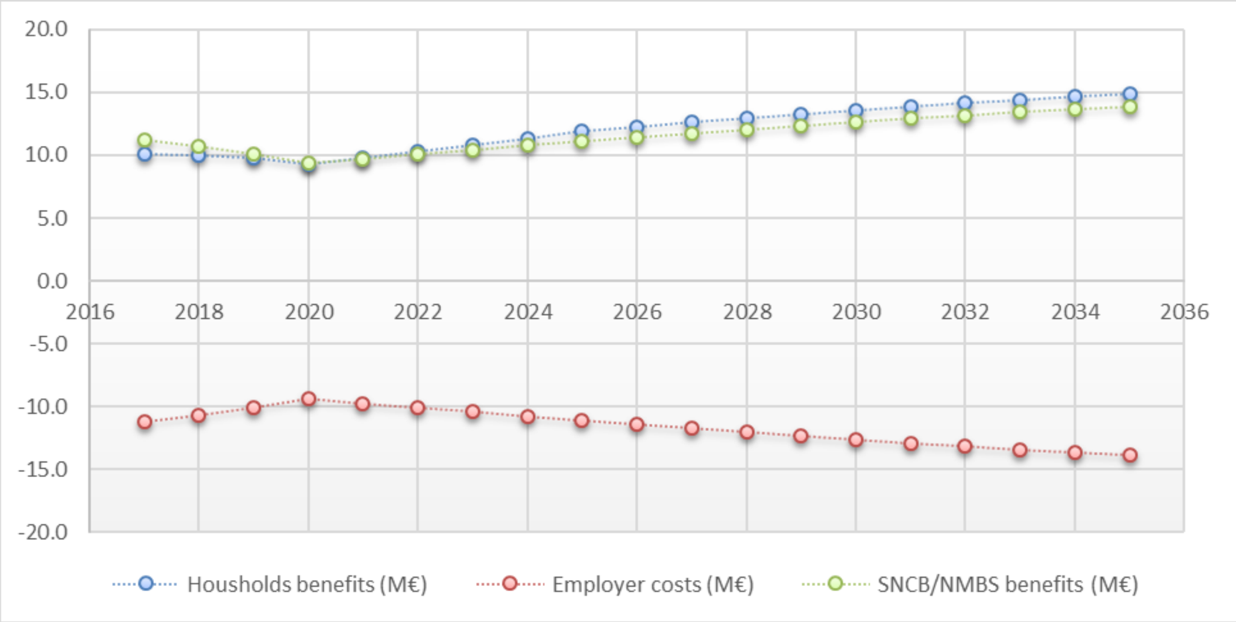


Figure 68 : Impacts of improvement and promotion of public transport on consumer costs and SNCB/NMBS benefits from new subscriptions

4.2.8 PAM « TR-D01 – Biofuels»

Biofuel policy is based on European and Belgian legislation. Regarding the European legislations, there is the renewable energy directive 2009/28/EC (which requests biofuels in transport) and the fuel quality directive 98/70/EC (which requests a reduction of the carbon content in transport fuels). Regarding the Belgian legislation, there is the KB 21 July 2016 on the minimal required volumes of sustainable biofuels in gasoline (It foresees 8.5 volume % of bioethanol (5.7% energy)) and the KB 26-11-2011on biofuels, which sets environmental criteria (energy efficiency, GHG balances), agriculture criteria (use of pesticides and fertilizers), proximity criteria (shortest distance between production biomass and production unit), etc.).

4.2.8.1 Identification and description of the socio-economic impacts

4.2.8.1.1 Impacts on consumers and producers

4.2.8.1.1.1 Step 1: Gross direct impacts identification and definition

The implementation of the PAM TR-D01 is expected to increase the demand of ethanol and biodiesel. We assume an inelastic supply (Table 109).

- *Table 109 : Presentation of results of sub-steps 1.1, 1.2 and 1.3*

Sub-steps	Product 1
1.1 Identification of goods and services concerned by the PAM	Ethanol and biodiesel
1.2 Identification of impact on supply and demand	Increase of demand
1.3 Characterization of elasticities of supply and demand	Supply inelasticity

An increase of economic activity and employment is expected given that the consumption is going to increase (Table 110). However, we assume that the gross margin will remain the same. In the same way, we assume that the purchase costs for consumers will not be impacted. Indeed, we are aware that purchase costs may vary accordingly to the new biofuel share but we have no information to quantify this potential impact.

- *Table 110 : Presentation of results of sub-steps 1.4*

Gross direct impacts	Ethanol and biodiesel
Impact on producers	
• Economic activity (volume of production)	↗
• Gross margin (modification of costs of production without a	=

modification of the associated sell prices – and vice-versa)	
• Employment	↗
Impact on consumers	
• Total quantity purchased	↗
• Purchase costs (of goods and services)	=

Legend: ↗ – Increasing impact, ↘ – Decreasing impact, = – No impact.

4.2.8.1.1.2 Step 2: Net direct impact identification and definition

Net direct impacts concern potential substitution effects related to the impact on products identified in step 1, i.e. the biofuels. The products substituted are gasoline and diesel. The impacts on these fuels are similar to the gross direct impacts but in an opposite way (see Table 111).

- *Table 111 : Definition of net direct impacts on producers and consumers*

Net direct impacts	
• Economic activity (volume of production)	↘
• Gross margin (modification of costs of production without a modification of the associated sell prices – and vice-versa)	=
• Employment	↘
Impact on consumers	
• Total quantity purchased	↘
• Purchase costs (of goods and services)	=

Legend: ↗ – Increasing impact, ↘ – Decreasing impact, = – No impact.

4.2.8.1.1.3 Step 3: Gross indirect impact identification and definition

Gross indirect impacts correspond to the propagation of impacts identified in Step 1 into the value chain of ethanol and biodiesel production.

4.2.8.1.1.4 Step 4: Net indirect impact identification and definition

Net indirect impacts correspond to the propagation of impacts identified in Step 2 into the value chain of diesel and gasoline.

4.2.8.1.1.5 Step 5: Summary of impacts on consumers and producers

A summary of the impact of the PAM on the consumers and producers is presented in Table 112.

▪ *Table 112 : Summary of impacts on producers and consumers*

			Gross direct impact	Gross indirect impact	Net direct impact	Net indirect impact
Product 1: Ethanol and biodiesel	**Producer**	**Producer P1**	↗EA,E		↘ EA,E	
		Upstream Prod.		↗EA,E		↘ EA,E
		Downstream Prod.		↗EA,E		↘ EA,E
	Consumer	**Households**	↗ Q		↘ Q	
		Industry	↗ Q		↘ Q	
		Public sector	↗ Q		↘ Q	

Legend: ↗ – Increase, ↘ – Decrease, EA – Economic Activity, E – Employment, Q - Quantity

4.2.8.1.2 *Impacts on public sector*

Implementation costs may arise for the implementation of this PAM, related to some administrative costs. However, we have no information to quantify these costs and we assume that they are negligible in comparison with the other socio-economic indicators quantified in the next subsection.

4.2.8.1.3 *Summary of impacts considered*

A summary of the socio-economic impacts considered in our evaluation to run a net direct and indirect impacts assessment is presented in Table 113. Only one indicator is evaluated: the increase of economic activity of producers.

- *Table 113 : Assessed impacts of the PAM TR-D01 on producers, consumers and the public sector*

			Net direct and indirect impacts
Product 1: Ethanol and biodiesel	**Producer**	**Producer P1**	Evaluated (EA)
		Upstream Prod.	NE
		Downstream Prod.	NE
	Consumer	**Households**	NA
		Industry	NA
		Public sector	NA
Public sector	**Policy implementation costs**		NA
	Tax revenue impacts		NA
Externalities			NA
Other macro-economic indicators			NA

Legend: EA – Economic activity, NA – Non-Applicable, ↗ – increasing impact, NE – Not Evaluated.

4.2.8.2 Methodology of evaluation

The increase in economic activity is evaluated through the additional costs (operational and capital costs) related to the increase of biofuel consumption (Table 114). The data used to make this evaluation is presented in Table 115.

- *Table 114: Method of estimation of the socio-economic impacts identified*

Identified impacts		Method
Producers		
Economic activity	Capital costs	consumption*coefficient CC
	Operational impacts	consumption*coefficient OC

Legend: coefficient CC - capital costs per TJ consumed, coefficient OC - operational costs per TJ consumed

- *Table 115 : Data sources*

Identified impacts	Data	Source
Producers > Economic activity	Consumption of biofuels	Own estimation (see emission calculation part)
	Coefficient CC	IISD (Vito econotec)
	Coefficient OC	IISD (Vito econotec)

4.2.8.3 Results

The impacts of the PAM TR-D01 "Biofuels" on the producer costs are presented in Figure 69. These costs will increase up to 622 M€ in 2020 and 660 M€ in 2035, corresponding to capital and operational costs for ethanol and biodiesel. This cost increase is due to an increase of economic activity for these products.

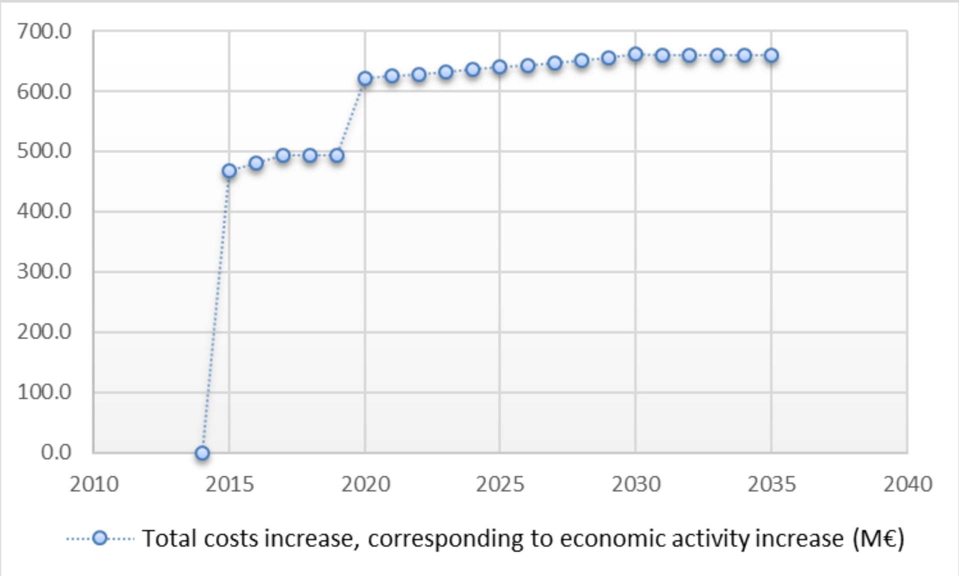


Figure 69 : Impact of PAM TR-D01 « Biofuels » on the economic activity of producers of ethanol and biodiesel

4.2.9 PAM « TR-XXX– Advantage in kind »

Employees benefiting from a company car and their employers are taxed on the value of the advantage in kind of the vehicles. This socio-economic evaluation estimates the difference in costs for employee and employers between the system in place in 2010 and the reform of 2012.

Indeed, on 01-01-2010, the value of the advantage in kind (€) was equal to fixed km value (5000 km or 7500 km if the distance to work is less or higher than 25 km respectively), multiplied by the CO2 emissions per km and a coefficient linked to this emission.

On 1-01-2012, a new formula determining the advantage in kind for company cars was introduced taking into account the theoretical CO2 emissions of the car. The parameters of the formula are adapted each year to keep an incentive for choosing lower emission cars.

4.2.9.1 Identification and description of the socio-economic impacts

4.2.9.1.1 *Impacts on consumers and producers*

4.2.9.1.1.1 Step 1: Gross direct impacts identification and definition

The implementation of the PAM is going to increase the demand for company cars with lower CO2 emissions. We assume an inelastic supply (Table 116).

- *Table 116 : Presentation of results of sub-steps 1.1, 1.2 and 1.3*

Sub-steps	Product 1
1.1 Identification of goods and services concerned by the PAM	Company cars with lower CO2 emissions
1.2 Identification of impact on supply and demand	Increase of demand
1.3 Characterization of elasticities of supply and demand	Supply inelasticity

As de demand for company cars with lower CO2 emissions is expected to increase (with an inelastic supply), an increase of economic activity and employment is forecasted for producers, linked to the increase of purchase from consumers (Table 117). Another impact is expected for consumers, the implementation of the reform has an impact on the taxation scheme and thus to the costs of having a company cars. We distinguish two kind of consumers impacted by the PAM, employers and employees. The objective of this evaluation section is to estimate the impact of the PAM on their costs.

Table 117 : Presentation of results of sub-steps 1.4

Gross direct impacts	Company cars with lower CO2 emissions
Impact on producers	
• Economic activity (volume of production)	↗
• Gross margin (modification of costs of production without a modification of the associated sell prices – and vice-versa)	=
• Employment	↗
Impact on consumers	
• Total quantity purchased	↗
• Purchase costs (of goods and services)	Impact of the PAM to be estimated

Legend: ↗ – Increasing impact, ↘ – Decreasing impact, = – No impact.

4.2.9.1.1.2 Step 2: Net direct impact identification and definition

Net direct impacts concern potential substitution effects related to the impact on products identified in step 1, i.e. the company cars with lower CO2 emissions. There is a substitution effect with company cars with higher CO2 emissions.

The related expected impacts on consumer and producer are presented in Table 118. In summary, the PAM is expected to have an opposite effect on cars that are substituted.

Table 118 : Definition of net direct impacts on producers and consumers

Net direct impacts	Company cars with lower CO2 emissions
• Economic activity (volume of production)	↘
• Gross margin (modification of costs of production without a modification of the associated sell prices – and vice-versa)	=
• Employment	↘
Impact on consumers	
• Total quantity purchased	↘
• Purchase costs (of goods and services)	Impact of the PAM to be estimated

Legend: ↗ – Increasing impact, ↘ – Decreasing impact, = – No impact.

4.2.9.1.1.3 Step 3: Gross indirect impact identification and definition

Gross indirect impacts correspond to the propagation of impacts identified in Step 1 into the value chain of identified products, i.e. the producers of cars with low CO_2 emissions. The impacts into the value chain are expected to be proportional (increase of economic activity and employment).

4.2.9.1.1.4 Step 4: Net indirect impact identification and definition

Net indirect impacts correspond to the propagation of impacts identified in Step 2 into the value chain of the identified products, i.e. the producers of cars with higher CO_2 emissions. The impacts into the value chain are expected to be proportional (decrease of economic activity and employment).

4.2.9.1.1.5 Step 5: Summary of impacts on consumers and producers

A summary of the impact of the PAM on the consumers and producers is presented in Table 119.

▪ *Table 119 : Summary of impacts on producers and consumers*

<table>
<tr><th colspan="3"></th><th>Gross direct impact</th><th>Gross indirect impact</th><th>Net direct impact</th><th>Net indirect impact</th></tr>
<tr><td rowspan="6">Product 1: Low CO2 vehicles</td><td rowspan="3">Producer</td><td>Producer P1</td><td>↗EA, ↗E</td><td></td><td>↘EA, ↘E</td><td></td></tr>
<tr><td>Upstream Prod.</td><td></td><td>↗EA, ↗E</td><td></td><td>↘EA, ↘E</td></tr>
<tr><td>Downstream Prod.</td><td></td><td>↗EA, ↗E</td><td></td><td>↘EA, ↘E</td></tr>
<tr><td rowspan="3">Consumer</td><td>Households</td><td>↗Q, ± C</td><td></td><td>↘Q, ± C</td><td></td></tr>
<tr><td>Industry</td><td>↗Q, ± C</td><td></td><td>↘Q, ± C</td><td></td></tr>
<tr><td>Public sector</td><td>↗Q, ± C</td><td></td><td>↘Q, ± C</td><td></td></tr>
</table>

Legend: ↗ – Increase, ↘ – Decrease, ± - Impact expected but to be defined, EA – Economic Activity, E – Employment, Q – Quantity, C – Costs

4.2.9.1.2 Impacts on public sector

As implementation costs for the public sector, we consider the changes in taxation for employees having a company car and their employers.

4.2.9.1.3 Summary of impacts considered

A summary of the socio-economic impacts considered in our evaluation to run a net direct and indirect impacts assessment is presented in Table 120. As impacts on cars with low and higher CO2 emissions are opposite, we assume that the net impact is negligible. Indeed, we assume that the PAM has no impact on the total fleet of company cars.

- *Table 120 : Assessed impacts on producers, consumers and the public sector*

<table>
<tr><th colspan="3"></th><th>Net direct and indirect impacts</th></tr>
<tr><td rowspan="6">Product 1: Low CO2 vehicles</td><td rowspan="3">Producer</td><td>Producer P1</td><td>N</td></tr>
<tr><td>Upstream Prod.</td><td>N</td></tr>
<tr><td>Downstream Prod.</td><td>N</td></tr>
<tr><td rowspan="3">Consumer</td><td>Households</td><td>±</td></tr>
<tr><td>Industry</td><td>±</td></tr>
<tr><td>Public sector</td><td>N</td></tr>
<tr><td rowspan="2">Public sector</td><td colspan="2">Policy implementation costs</td><td>±</td></tr>
<tr><td colspan="2">Tax revenue impacts</td><td>NA</td></tr>
<tr><td colspan="3">Externalities</td><td>NE</td></tr>
<tr><td colspan="3">Other macro-economic indicators</td><td>NE</td></tr>
</table>

Legend: N – Negligible, ± - Impact expected but to be defined, NA – not applicable, NE – not evaluated.

4.2.9.2 Methodology of evaluation

The socio-economic evaluation was made by calculating a BAU and a PAM scenario. The BAU scenario corresponds to the taxation scheme defined by the 01/01/2010 reform. The application of the equation defined by the reform permits calculating a Benefit In Kind (BIK^{BAU}) per vehicle. In the same way, the Benefit In Kind for the PAM scenario (BIK^{PAM}) is estimated by applying the rules defined by the reform 01/01/2012 and the annual updates (reference of CO2 emissions). A coefficient is then applied to estimate the subsequent costs for employers and employees, and an extrapolation to the Belgian fleet is made. The Table 121 presents this methodology in details.

- *Table 121: Method of estimation of the socio-economic impacts identified*

Identified impacts		Method
Public sector		
Implementation costs	Administrative costs	- (Employer costs + Employee costs)
Consumers		
Employer costs> Costs related to the new taxation scheme		[(BIK^{BAU}-BIK^{PAM})* fleet*Age]*Coeff_Employer With BIK^{BAU} = km * E_CO2 * coeff With BIK^{PAM} = Catalogue_value*Coeff_CO2*6/7 With Coeff_CO2 = (((E_CO2 – E_CO2_ref)*0.1)+5.5)/100
Employee costs > Costs related to the new taxation scheme		[(BIK^{BAU}-BIK^{PAM})* fleet*Age]*Coeff_Employee With BIK^{BAU} = km * E_CO2 * coeff With BIK^{PAM} = Catalogue_value*Coeff_CO2*6/7 With Coeff_CO2 = (((E_CO2 – E_CO2_ref)*0.1)+5.5)/100

Legend: BIK^{BAU} – Benefit in kind per vehicle of the BAU scenario, BIK^{PAM} – Benefit in kind per vehicles of the PAM scenario, fleet – total gasoline and diesel cars, Age – taxation percentage related to the age of the fleet, Coeff_Employer – Coefficient determining the costs for the employers related to taxation, km – average number of reference km, E_CO2 – CO2 emissions of a reference vehicle, coeff – coefficient defined by the reform 01/01/2010, Catalogue_value – catalogue value of a reference vehicle, E_CO2_ref – reference of CO2 emissions from the reform 01/01/2012, Coeff_Employee – Coefficient determining the costs for employees related to taxation.

A lot of assumptions have been made:

- Constant diesel and gasoline fleet among scenarios
- Constant % of company cars among scenarios and years
- Constant age proportion of the fleet among scenarios and years
- Constant taxation rates for employers and employees among scenarios and years
- Constant CO2 gain (PAM impact) among years and types of cars.

The data used to make theses evaluations are presented in Table 122.

- *Table 122 : Data sources*

Identified impacts	Data	Source
Employer and employer costs> Costs related to the new taxation scheme	fleet	See PAM "increase of excise duty"
	Age	Own estimation
	Coeff_Employer and Coeff_Employee	http://www.aldautomotive.be/car-leasing/choosing-a-vehicle/bik-calculator
	E_CO2	www.peugeot.be
	Catalogue_value	www.peugeot.be
	Km, E_CO2_ref, coeff	Defined by the legislations 01/01/2010 and 2012

4.2.9.3 Results

In average, additional costs per company car equals to 6.6 € for employers and 3.0 € for employee. The average benefit for the public sector equals to 9.6 € per company car. The results, year by year, and extrapolated to the Belgian fleet are presented in the Figure below.

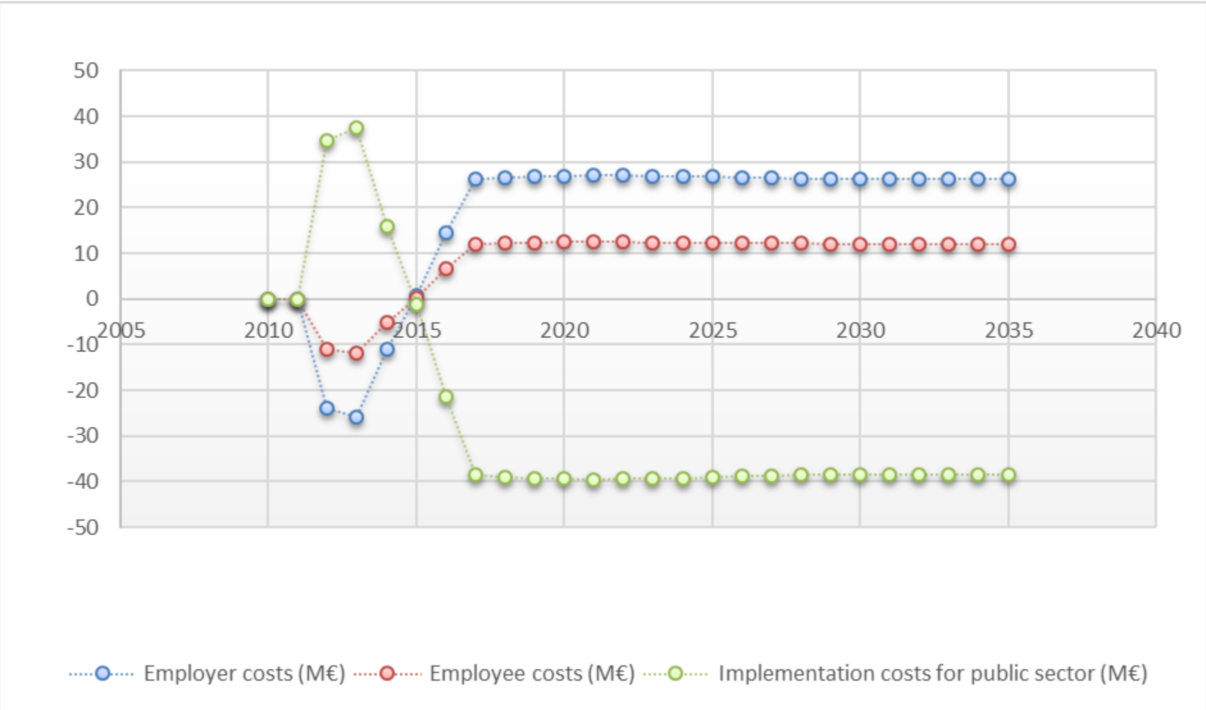


Figure 70 : Impacts of the PAM « Advantage in kind » for employers, employees and the public sector.

4.2.10PAM « APP-T01 – Positive Mobility allocation »

This PAMs permits proposing workers an alternative option than a company car, as a mobility budget or a net salary increase. The net salary increase will be subject to similar fiscal rules as the actual company car. The measure will be established following the principle of budget neutrality for the federal government (and the company).

4.2.10.1 Identification and description of the socio-economic impacts

4.2.10.1.1 Impacts on consumers and producers

4.2.10.1.1.1 Step 1: Gross direct impacts identification and definition

As presented in section 4.1.2.2.1, the identification and definition of the gross direct impacts of a PAM may be done by a four sub-steps process. The results of the three first sub-steps are presented in Table 123. In this table, we decided first to consider the impact of the product "Fuel for consumption at own charges". Indeed, we decided not to focus on the net impact of consumption of fuel as we won't consider the impacts on producer (impact on economic activity assumed to be negligible). The only effect that is non-negligible regarding fuel consumption is the fact that more fuel will be at charge of consumers if they decide having a net salary increase (Table 124). We don't consider the impacts of reducing use of fuel consumption linked to the decrease in km driven because these costs were covered by the companies and we know that the net impact for these companies will be neutral[27].

The same justification may be done for cars: the decreasing use of company cars isn't expected to impact significantly the producers and there is no impact for companies (as they offer an increase of net salary in compensation). However, the investment costs for second hand vehicles may be important at the consumer scale (second impact considered of the PAM). Some people may nevertheless decide to use alternative mobilities. We consider there is no significant impact on producers (Table 124).

In both cases, the impact is an increase of demand at a constant price (inelastic supply).

Table 123 : Results of sub-steps 1.1, 1.2 & 1.3

Sub-steps	Product 1	Product 2
1.1 Identification of goods and services concerned by the PAM	Fuel consumption at own charge of the consumer	Second hand vehicles
1.2 Identification of impact on supply and demand	Demand shift	Demand shift
1.3 Characterization of elasticities of supply and demand	Inelastic supply	Inelastic

[27] It has to be noted that another effect could arise: as probably the people driving a small amount of km will opt for the salary increase instead of the company car, the company will only keep the most expensive company cars (burning the most fuel). However, we have no information to quantify this potential effect.

Table 124 : Results of sub-step 4

Gross direct impacts	Fuel consumption at own charge of the consumer	Second hand vehicles
Impact on consumers		
• Total quantity purchased	↗	↗
• Purchase costs (of goods and services)	=	=

Legend: ↗ – Increasing impact, ↘ – Decreasing impact, = – No impact.

4.2.10.1.1.2 Step 2: Net direct impact identification and definition

Net direct impacts concern potential substitution effects related to the impact on products identified in step 1. There is no substitution effect.

4.2.10.1.1.3 Step 3: Gross indirect impact identification and definition

Gross indirect impacts correspond to the propagation of impacts identified in Step 1 into the value chain of identified products. As mentioned in step 1, we consider these effects negligible.

4.2.10.1.1.4 Step 4: Net indirect impact identification and definition

As no substitution effect has been identified in Step 2, there is no net indirect impact.

4.2.10.1.1.5 Step 5: Summary of impacts on consumers and producers

A summary of the impact of the PAM on the consumers and producers is presented in Table 125.

Table 125 : Summary of net, gross direct and indirect impact considered

			Gross direct impact	Gross indirect impact	Net direct impact	Net indirect impact
Product 1: Fuel consumption	**Producer**	**Producer P1**	Negligible			
		Upstream Prod.		Negligible		
		Downstream Prod.		Negligible		
	Consumer	**Households**	↗ Q			
		Industry	NA			
		Public sector	NA			
Product 2 : Second-hand car	**Producer**	**Producer P2**	Negligible			
		Upstream Prod.		Negligible		
		Downstream Prod.		Negligible		
	Consumer	**Households**	↗ Q			
		Industry	NA			
		Public sector	NA			

Legend: Q – impact on quantity consumed, NA – Non-Applicable, ↗ – increasing impact, ↘ – decreasing impact

4.2.10.1.2 Impacts on public sector

Two categories of impacts are distinguished for the public sector, the policy implementation costs and the tax revenue impacts. In this case, there are no policy implementation costs as the rule for policy implementation is a neutral impact on the government budget. We won't estimate the tax revenue impact as by taking into account only the perspective of the consumer changing from company to private car, the subsequent information provided by the tax revenue indicator would not be relevant (increase of tax revenue related to fuel consumption of this category of consumers whereas there is a net decrease in fuel consumption).

4.2.10.1.3 Summary of impacts considered

A summary of the socio-economic impacts considered in our evaluation to run a net direct and indirect impacts assessment are presented in Table 126. Costs arising from the use of second-and cars aren't evaluated because there is no information easily available to quantify this effect. Only to indicators are quantified for households: costs arising from fuel consumption and benefits arising when the option "Company car" isn't chosen

Table 126 : Assessed impacts on producers, consumers and the public sector

			Net direct and indirect impacts
Product 1: Fuel consumption	**Producer**	**Producer P1**	N
		Upstream Prod.	N
		Downstream Prod.	N
	Consumer	**Households**	Evaluated (PFC)
		Industry	NA
		Public sector	NA
Product 2: Second-hand cars	**Producer**	**Producer P2**	N
		Upstream Prod.	N
		Downstream Prod.	N
	Consumer	**Households**	NE
		Industry	NA
		Public sector	NA
Public sector	**Policy implementation costs**		NA
	Tax revenue impacts		NA
Externalities			NA
Other macro-economic indicators			Evaluated (SB)

Legend: N – Negligible impact, PFC – Private fuel consumption costs, SB – Salary benefits for households, NA – Non-Applicable.

4.2.10.2 Methodology of evaluation

The methodology of evaluation of costs and savings for consumers is presented in Table 127. Data used are detailed in Table 128.

Table 127 : Methodology of evaluation

Identified impacts	Method
Consumers costs > increase of private fuel consumption	$Km*P^{FUEL}$
Consumers savings > increase salary	Km*Salary_increase

Legend: km – increasing driven km at charge of consumers, P^{FUEL} - average price of diesel and gasoline

Table 128 : Data sources

<table>
<tr><th>Identified impacts</th><th colspan="2">Data</th><th>Source</th></tr>
<tr><td rowspan="3">Consumers costs > increase of private fuel consumption</td><td colspan="2">Km driven with private cars</td><td>Own estimation (TML)</td></tr>
<tr><td rowspan="2">Fuel</td><td>Diesel</td><td>Own estimation (see PAM « Increase of excise duty »)</td></tr>
<tr><td>Gasoline</td><td>Own estimation (see PAM « Increase of excise duty »)</td></tr>
<tr><td>Consumers savings > increase salary</td><td colspan="2">Average value of a company cars for companies</td><td>Securex 28/01/2016 on http://www.jobat.be/fr/articles/que-sont-les-avantages-dune-voiture-de-societe/</td></tr>
</table>

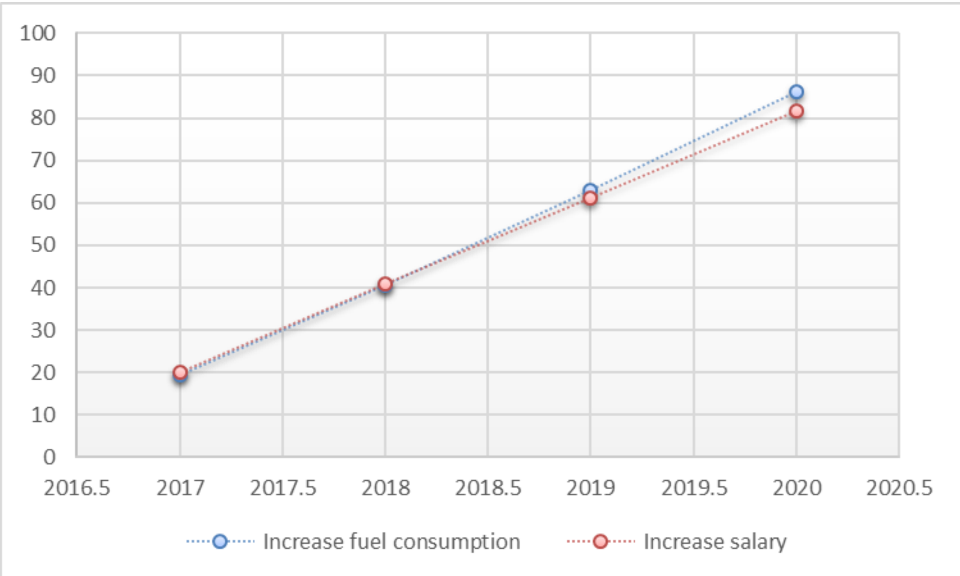
4.2.10.3 Results

The results are presented in Figure 71. The results show that the increase salary may compensate the costs related to the fuel consumption of private consumers in the first years of PAM implementation. However, in the 2020 a difference of approximatively 5M€ is observed, i.e. it is a net cost for households to change from a company car to an increase in net salary. The fact that the gap is increasing across the years is due to the PAM increase of excise duty of diesel (and we assume here that the share between diesel and gasoline was equivalent). It should also be kept in mind that other additional costs related to the purchase and maintenance of a second-hand car (in replacement of the company cars) aren't considered in this Figure.

This surprising result may be due to a poor estimation of the increase salary: perhaps another source has to be found. Another conclusion may be that this change from company car to increase salary may not arise without additional subsidies to enable consumers having a second-hand cars and have private travels.

It has to be noted that the results presented concern only a part of the reality, i.e. increase in fuel consumption at charge of households while at societal level, there is a decrease in fuel consumption).

Figure 71 : Impacts of Positive Mobility Allocation on consumers



4.2.11 PAM « APP-T02 – Incentives for pedelecs »

This PAM permits providing economic advantages when using pedelecs: a fiscal deductibility of 120% for buying pedelecs, 22 cent/km for using it and 15% income tax reduction. The business as usual scenario considers the 120% fiscal deductibility and a 22 cent/km for using it as this part of the PAM already exists.

4.2.11.1 Identification and description of the socio-economic impacts

4.2.11.1.1 Impacts on consumers and producers

4.2.11.1.1.1 Step 1: Gross direct impacts identification and definition

Two categories of products are considered: pedelecs and diesel/gasoline consumption. We assume that this PAM have no impact on car purchase, only on the km driven by car and thus on the quantity of diesel and gasoline consumed (decrease of demand). In both cases, we consider the supply inelastic.

Table 129 : Results of sub-steps 1.1, 1.2 and 1.3

Sub-steps	Product 1	Product 2
1.1 Identification of goods and services concerned by the PAM	Pedelecs	Diesel and gasoline
1.2 Identification of impact on supply and demand	Demand shift	Demand shift
1.3 Characterization of elasticities of supply and demand	Supply inelastic	Supply inelastic

Regarding pedelecs, as the total quantity purchased is expected to increase, the subsequent economic activity (and thus employments) will also increase (Table 130). The reverse effects may be assumed for diesel and gasoline.

Table 130 : Result of sub-step 1.4

Gross direct impacts	Pedelecs	Diesel/Gasoline
Impact on producers		
• Economic activity (volume of production)	↗	↘
• Gross margin (modification of costs of production without a modification of the associated sell prices – and vice-versa)	=	=
• Employment	↗	↘
Impact on consumers		
• Total quantity purchased	↗	↘
• Purchase costs (of goods and services)	=	=

Legend: ↗ – Increasing impact, ↘ – Decreasing impact, = – No impact.

4.2.11.1.1.2 Step 2: Net direct impact identification and definition

Net direct impacts concern potential substitution effects related to the impact on products identified in step 1. In this case, there is no substitution effect.

4.2.11.1.1.3 Step 3: Gross indirect impact identification and definition

Gross indirect impacts correspond to the propagation of impacts identified in Step 1 into the value chain of identified products. In this case, it concerns the value chains of pedelecs and diesel/gasoline.

4.2.11.1.1.4 Step 4: Net indirect impact identification and definition

As no substitution effect has been identified in Step 2, there is no net indirect impact.

4.2.11.1.1.5 Step 5: Summary of impacts on consumers and producers

A summary of the impact of the PAM on the consumers and producers is presented in Table 131.

Table 131 : Summary of impacts on producers and consumers

			Gross direct impact	Gross indirect impact	Net direct impact	Net indirect impact
Product 1: Pedelecs	**Producer**	**Producer P1**	↗ EA, ↗ E			
		Upstream Prod.		↗ EA, ↗ E		
		Downstream Prod.		↗ EA, ↗ E		
	Consumer	**Households**	↗Q			
		Industry				
		Public sector				
Product 2 : Diesel/Gasoline	**Producer**	**Producer P2**	↘EA, ↘E			
		Upstream Prod.		↘EA, ↘E		
		Downstream Prod.		↘EA, ↘E		
	Consumer	**Households**	↘Q			
		Industry				
		Public sector				

Legend: ↗ – Increase, ↘ – Decrease, EA – Economic Activity, E – Employment, Q – Quantity.

4.2.11.1.2 Impacts on public sector

Two categories of impacts are distinguished for the public sector, the policy implementation costs and the tax revenue impacts.

Regarding implementation costs, it corresponds to the 15% income tax reduction allowed to pedelecs. Regarding tax revenue impacts, it corresponds to the balance of additional and non-received taxes from higher consumption of pedelecs and lower consumption of pedelecs respectively.

4.2.11.1.3 Summary of impacts considered

A summary of the socio-economic impacts considered in our evaluation to run a net direct and indirect impacts assessment are presented in Table 132. We consider that the investments costs for a pedelec are negligible for consumers with regards to the benefits.

Table 132 : Assessed impacts on producers, consumers and the public sector

			Net direct and indirect impacts
Product 1: Pedelecs	**Producer**	**Producer P1**	NE
		Upstream Prod.	NE
		Downstream Prod.	NE
	Consumer	**Households**	N
		Industry	N
		Public sector	N
Product 2: Diesel & Gasoline	**Producer**	**Producer P2**	N
		Upstream Prod.	N
		Downstream Prod.	N
	Consumer	**Households**	Evaluated (TD + FS)
		Industry	NA
		Public sector	NA
Public sector	**Policy implementation costs**		Evaluated
	Tax revenue impacts		Evaluated
Externalities			NA
Other macro-economic indicators			NA

Legend: NE – Not evaluated, N – Negligible impact, Q – impact on quantity consumed, impact on administrative costs, impact on employment, NA – Non-Applicable, TD – Tax deduction impact, FS – Savings linked to fuel consumption.

4.2.11.2 Methodology of evaluation

The methodology of evaluation of costs and savings for consumers is presented in Table 133. Data sources used are detailed in Table 134.

Table 133 : Presentation of methods used to assess the identified impacts

Identified impacts	Method
Consumers savings > decrease of fuel consumption	$(Km^{<25}+ Km^{<45})*P^{FUEL}$
Consumers savings > tax deduction	$N^{pedelecs}$*Average_tax_reduction
Public sector > PAM implementation	

Legend : km – cars kilometers avoided by the use of pedelecs (<25 and <45), P^{FUEL} – Average price of fuel, $N^{pedelecs}$ – Number of pedelecs.

Table 134 : Data sources

Identified impacts	Data		Source
Consumers savings > decrease of fuel consumption & Public sector > tax revenue	Number of pedelecs		FPS
	Number of car km avoided /pedelec		FPS
	Fuel	Diesel	Own estimation
		Gasoline	Own estimation
Consumers savings > tax deduction & Public sector > PAM implementation	Average income tax		Enquête des salaires K.U.Leuven/Références/Vacature, novembre 2012

4.2.11.3 Results

Results are presented in Table 135. Thanks to the implementation of this PAM, savings made by consumers may raise up to 405.9 M€ in 2020. About 90% of these savings are due to income tax reduction. The last 10% are explained by a lower fuel consumption. Regarding the public sector, implementation costs – related to the income tax reduction – may raise up to 368.2 M€. The tax revenue will be slightly impacted due to the lower fuel consumption (up to 17.7 M€).

Table 135 : Results

Impacts (M€)	2015	2016	2017	2018	2019	2020
Consumers						
• **Savings**	320.1	334.6	352.4	370.1	388.2	405.9
Public sector						
• **Implementation costs**	-291.6	-306.9	-322.2	-337.5	-352.8	-368.2
• **Tax revenue**	-11.8	-12.9	-14.1	-15.1	-16.7	-17.7

4.2.12 PAM « APP-T03 – Reduction of traction energy use in railways »

The SNCB wants to reduce primary energy consumption by 3 to 4% per passengerkm via different measures (2020 compared to 2015): increase train occupancy, reduce energy losses while at stop and use more efficient rolling stock.

4.2.12.1 Identification and description of the socio-economic impacts

4.2.12.1.1 Impacts on consumers and producers

4.2.12.1.1.1 Step 1: Gross direct impacts identification and definition

Three products are impacted by the PAMS. First, the goods and services that will be used by the SNCB to reduce its energy use as more efficient rolling stock, materials to reduce energy losses while at stop, etc. The second and third products impacted by the PAM are diesel and electricity consumptions.

In all cases, we see the effect of the PAM as a demand shift: increase of demand for product 1 and decrease of demand for product 2 and 3. We assume the supply inelastic: the demand shift will not influence the prices.

Table 136 : Presentation of results of sub-steps 1.1, 1.2 and 1.3

Sub-steps	Product 1	Product 2	Product 3
1.1 Identification of goods and services concerned by the PAM	Energy efficient materials	Diesel	Electricity
1.2 Identification of impact on supply and demand	↗ Demand	↘ Demand	↘ Demand
1.3 Characterization of elasticities of supply and demand	Inelastic supply	Inelastic supply	Inelastic supply

The last sub-step consists in identifying and defining the impacts on producers and consumers of products identified in sub-step 1 in the conditions defined in sub-step 2 and 3. These impacts are presented in Table 137.

Table 137 : Presentation of results of sub-steps 1.4

Gross direct impacts	Energy efficient materials	Diesel	Electricity
Impact on producers			
• Economic activity (volume of production)	↗	↘	↘
• Gross margin (modification of costs of production without a modification of the associated sell prices – and vice-versa)	=	=	=
• Employment	↗	↘	↘
Impact on consumers			

• Total quantity purchased	↗	↘	↘
• Purchase costs (of goods and services)	=	=	=

Legend: ↗ – Increasing impact, ↘ – Decreasing impact, = – No impact.

4.2.12.1.1.2 Step 2: Net direct impact identification and definition

Net direct impacts concern potential substitution effects related to the impact on products identified in step 1. There are no substitution effects.

4.2.12.1.1.3 Step 3: Gross indirect impact identification and definition

Gross indirect impacts correspond to the propagation of impacts identified in Step 1 into the value chain of identified products, i.e. energy efficient materials, diesel and electricity. The economic activity (and employment) in the upstream and downstream firms are expected to increase for the products "Energy efficient materials" or decrease for the products "Diesel" and "Electricity".

4.2.12.1.1.4 Step 4: Net indirect impact identification and definition

As no substitution effect has been identified in Step 2, there is no net indirect impact.

4.2.12.1.1.5 Step 5: Summary of impacts on consumers and producers

A summary of the impact of the PAM on the consumers and producers is presented in Table 138.

Table 138 : Summary of impacts of the PAM on producers and consumers

			Gross direct impact	Gross indirect impact	Net direct impact	Net indirect impact
Product 1: Energy efficient materials	**Producer**	**Producer P1**	↗EA & E		NA	
		Upstream Prod.		↗EA & E		NA
		Downstream Prod.		↗EA & E		NA
	Consumer	**Households**	NA		NA	
		Industry	NA		NA	
		Public sector	↗Q		NA	
Product 2: Diesel	**Producer**	**Producer P2**	↘EA & E		NA	
		Upstream Prod.		↘EA & E		NA
		Downstream Prod.		↘EA & E		NA
	Consumer	**Households**	NA		NA	
		Industry	NA		NA	
		Public sector	↘Q		NA	
Product 3: Electricity	**Producer**	**Producer P3**	↘EA & E		NA	
		Upstream Prod.		↘EA & E		NA
		Downstream Prod.		↘EA & E		NA
	Consumer	**Households**	NA		NA	
		Industry	NA		NA	
		Public sector	↘Q		NA	

Legend: EA – Economic activity, E – Employment, NA – non-applicable – Q – Impact on quantity consumed, ↗ – increasing impact, ↘ – decreasing impact

4.2.12.1.2 Impacts on public sector

Two categories of impacts are distinguished for the public sector, the policy implementation costs and the tax revenue impacts. Regarding implementation costs, they correspond to the investments costs for the public sectors as consumers highlighted in Table 138. Regarding tax revenue, the balance between lower diesel and electricity consumption and higher consumption of energy efficient materials must be evaluated.

4.2.12.1.3 Summary of impacts considered

A summary of the socio-economic impacts considered in our evaluation to run a net direct and indirect impacts assessment are presented in Table 139.

We assume that the impacts on producers in terms of economic activity and employment are negligible relatively to the sector. As a consequence, only three indicators are relevant: (i) the investments costs related to the higher quantity of goods and services purchased for using more energy efficient materials (public sector > SNCB), (ii) savings from reduction of diesel consumption (public sector > SNCB) and (iii) savings from reduction of electricity consumption (public sector > SNCB).

However, investments costs for energy efficient materials weren't evaluated since no data was available at FPS mobility. A deeper investigation at SNCB should be necessary to make this evaluation.

It is not relevant to study tax revenue impacts given that they all concern the public sector.

Table 139 : Assessed impacts on producers, consumers and the public sector

			Net direct and indirect impacts
Product 1: Energy efficient materials	Producer	Producer P1	N
		Upstream Prod.	N
		Downstream Prod.	N
	Consumer	Households	NA
		Industry	NA
		Public sector	NE (IC)
Product 2 & 3: Diesel and electricity	Producer	Producer P2	N
		Upstream Prod.	N
		Downstream Prod.	N
	Consumer	Households	NA
		Industry	NA
		Public sector	Evaluated (ES)
Public sector	Policy implementation costs		NE (IC)
	Tax revenue impacts		NA
Externalities			NE
Other macro-economic indicators			NE

Legend: N – Negligible impact, NA – Non-Applicable, IC – Investment costs, ES – Economic savings.

4.2.12.2 Methodology of evaluation

As stated before, the implementation costs aren't evaluable because there is no information on the means that have to be implemented to reach the goal of energy consumption reduction. However, as a reduction in consumption has been quantified, it's possible to assess the savings made by the SNCB, and the subsequent tax revenue impacts. The methodology of evaluation is described in Table 140 and data sources in Table 141.

Table 140: Method of evaluation of socio-economic indicators

Identified impacts	Method
Consumers (SNCB)	
Fuel expenditure reduction (€)	+ EC* p_T^e

Legend: EC – estimated decrease of energy consumption, p_T^e – energy price (all taxes included)

Table 141 : Data sources

Identified impacts	Data		Source
Consumers > Public sector (SNCB) > Fuel expenditure reduction	Decrease in electricity and diesel consumption		Our evaluation (see Section "Emission reduction")
	Energy price	Diesel	Own estimation (consideration of increase excise duty)
		Electricity	Eurostat, FPB

4.2.12.3 Results

The implementation of the PAM would permit saving up to 2.7 M€ in 2020 (Table 142).

Table 142 : Socio-economic impacts

SNCB (M€)	2017	2018	2019	2020
Fuel expenditure reduction	0,6	1,2	1,9	2,7

4.2.13PAM « APP-T04 – Reduction of non-traction energy use in railways »

Between 2005 and 2015, the NMBS/SNCB group has reached a 20% reduction of energy consumption for non-traction activities. A new goal of seven additional percent of energy consumption reduction is set for the period 2014-2020.

4.2.13.1 Identification and description of the socio-economic impacts

4.2.13.1.1 Impacts on consumers and producers

4.2.13.1.1.1 Step 1: Gross direct impacts identification and definition

Two types of products are impacted by the PAMS. First, the goods and services that will be implemented by the SNCB to reduce its energy use:

- Renewal and modernization of lighting installation systems for railway stations, offices and other building services
- Continuation of the renewal of heating systems in buildings
- Replacement of old production facilities with more energy efficient one
- Restoration of existing buildings (isolation, etc.)

The second product impacted by the PAM is energy consumption.

In both cases, it corresponds to a demand shift: increase of demand for product 1 and decrease of demand for product 2. We assume the supply inelastic: the demand shift will not influence the prices.

Table 143 : Presentation of results of sub-steps 1.1, 1.2 and 1.3

Sub-steps	Product 1	Product 2
1.1 Identification of goods and services concerned by the PAM	Renewal, Replacement, Restoration, etc.	Energy
1.2 Identification of impact on supply and demand	Demand	Demand
1.3 Characterization of elasticities of supply and demand	Inelastic supply	Inelastic supply

The last sub-step consists in identifying and defining the impacts on producers and consumers of products identified in sub-step 1 in the conditions defined in sub-step 2 and 3 (Table 144).

Table 144 : Presentation of results of sub-steps 1.4

Gross direct impacts	Renewal, Replacement, Restoration, etc.	Energy
Impact on producers		
• Economic activity (volume of production)	↗	↘
• Gross margin (modification of costs of production without a modification of the associated sell prices – and vice-versa)	=	=

• Employment	↗	↘
Impact on consumers		
• Total quantity purchased	↗	↘
• Purchase costs (of goods and services)	=	=

Legend: ↗ – Increasing impact, ↘ – Decreasing impact, = – No impact.

4.2.13.1.1.2 Step 2: Net direct impact identification and definition

Net direct impacts concern potential substitution effects related to the impact on products identified in step 1. There are no substitution effects.

4.2.13.1.1.3 Step 3: Gross indirect impact identification and definition

Gross indirect impacts correspond to the propagation of impacts identified in Step 1 into the value chain of identified products, i.e. products for renewal, restoration, etc. and energy. The economic activity (and employment) in the upstream and downstream firms are expected to increase or decrease respectively.

4.2.13.1.1.4 Step 4: Net indirect impact identification and definition

As no substitution effect has been identified in Step 2, there is no net indirect impact.

4.2.13.1.1.5 Step 5: Summary of impacts on consumers and producers

A summary of the impact of the PAM on the consumers and producers is presented in Table 145.

Table 145 : Summary of impacts of the PAM on producers and consumers

			Gross direct impact	Gross indirect impact	Net direct impact	Net indirect impact
Product 1: Renewal, Restoration, etc.	**Producer**	**Producer P1**	↗ EA & E		NA	
		Upstream Prod.		↗ EA & E		NA
		Downstream Prod.		↗ EA & E		NA
	Consumer	**Households**	NA		NA	
		Industry	NA		NA	
		Public sector	↗Q		NA	
Product 2 : Energy	**Producer**	**Producer P2**	↘EA & E		NA	
		Upstream Prod.		↘EA & E		NA
		Downstream Prod.		↘EA & E		NA
	Consumer	**Households**	NA		NA	
		Industry	NA		NA	
		Public sector	↘Q		NA	

Legend: EA – Economic activity, E – Employment, NA – non-applicable – Q – Impact on quantity consumed, ↗ – increasing impact, ↘ – decreasing impact

4.2.13.1.2 Impacts on public sector

Two categories of impacts are distinguished for the public sector, the policy implementation costs and the tax revenue impacts. Regarding implementation costs, they correspond to the investments costs for the public sectors as consumers highlighted in Table 145. Regarding tax revenue, the balance between lower energy consumption and higher consumption of restoration works has to be evaluated.

4.2.13.1.3 Summary of impacts considered

A summary of the socio-economic impacts considered in our evaluation to run a net direct and indirect impacts assessment are presented in Table 146.

We assume that the impacts on producers in terms of economic activity and employment are negligible relatively to the sector. It is not relevant to study tax revenue impacts on the public sector because impacts concern only the public sector (SNCB). As a consequence, only two indicators are relevant: (i) the investments costs related to the higher quantity of goods and services purchased for renewal, restoration etc., and (ii) savings from reduction of energy consumption. However, the investments costs, i.e. the implementation costs, aren't evaluable because there is no information on the means that should be implemented to reach the goal of energy consumption reduction.

Table 146 : Assessed impacts on producers, consumers and the public sector

<table>
<tr><th colspan="3"></th><th>Net direct and indirect impacts</th></tr>
<tr><td rowspan="6">Product 1: Renewal, Restoration, etc.</td><td rowspan="3">Producer</td><td>Producer P1</td><td>N</td></tr>
<tr><td>Upstream Prod.</td><td>N</td></tr>
<tr><td>Downstream Prod.</td><td>N</td></tr>
<tr><td rowspan="3">Consumer</td><td>Households</td><td>NA</td></tr>
<tr><td>Industry</td><td>NA</td></tr>
<tr><td>Public sector</td><td>NE</td></tr>
<tr><td rowspan="6">Product 2 : Energy</td><td rowspan="3">Producer</td><td>Producer P2</td><td>N</td></tr>
<tr><td>Upstream Prod.</td><td>N</td></tr>
<tr><td>Downstream Prod.</td><td>N</td></tr>
<tr><td rowspan="3">Consumer</td><td>Households</td><td>NA</td></tr>
<tr><td>Industry</td><td>NA</td></tr>
<tr><td>Public sector</td><td>Evaluated (ES)</td></tr>
<tr><td rowspan="2">Public sector</td><td colspan="2">Policy implementation costs</td><td>NE</td></tr>
<tr><td colspan="2">Tax revenue impacts</td><td>NA</td></tr>
<tr><td colspan="3">Externalities</td><td>NA</td></tr>
<tr><td colspan="3">Other macro-economic indicators</td><td>NA</td></tr>
</table>

Legend: N – Negligible impact, NA – Non-Applicable, ES – Energy savings.

4.2.13.2 Methodology of evaluation

As a reduction in energy consumption has been quantified in the section "Emission reductions", it's possible to assess the savings made by the public sector. The methodology of evaluation is described in Table 147 and data sources in Table 148.

Table 147 : Method of evaluation of socio-economic indicators

Identified impacts	Method
Consumers	
Public sector (€)	+ EC* p_T^e

Legend: EC – estimated decrease of energy consumption, p_T^e – energy price (all taxes included)

Table 148 : Data sources

<table>
<tr><th>Identified impacts</th><th colspan="2">Data</th><th>Source</th></tr>
<tr><td rowspan="4">Public sector > Consumers</td><td colspan="2">Energy consumption</td><td>Our evaluation (see Section "Emission reduction")</td></tr>
<tr><td rowspan="3">Energy price</td><td>Natural gas</td><td>Eurostat, FPB</td></tr>
<tr><td>Heating oil</td><td>Eurostat, FPB</td></tr>
<tr><td>Electricity</td><td>Eurostat, FPB</td></tr>
</table>

4.2.13.3 Results

The implementation of the PAM would permit saving up to 1.3 M€ in 2020 for SNCB due to savings made from a lower energy consumption (Table 149).

Table 149 : Socio-economic impacts on the public sector

Public sector (M€)	2015	2016	2017	2018	2019	2020
Savings from decrease energy consumption	0,3	0,4	0,6	0,8	1,1	1,3

4.2.14 PAM « XX-X04 – Increase of excise duty on diesel »

The PAM is motivated by the implementation of the "Royal Decree of 26 Octobrer 2015", published on 30th Octobrer 2015, and the law of 27 June 2016. Through this law, the special excise duty for diesel in passenger cars (non-commercial use) is increased from 2015 to 2018. The primary objective of this PAM is to improve air quality.

4.2.14.1 Identification and description of the socio-economic impacts

4.2.14.1.1 Impacts on consumers and producers

4.2.14.1.1.1 Step 1: Gross direct impacts identification and definition

The implementation of an increase of excise duty on diesel will impact four categories of products: diesel, gasoline, diesel cars and gasoline cars. With regards to diesel and gasoline, the impact on the market can be seen as a demand shift: decrease of demand for diesel (shift to the left) because of the increasing tax and an increase of demand for gasoline (shift to the right) because of the decreasing tax. In both case, we assume that the supply is inelastic, i.e. the supply shift will not affect the gross margin of producer (tax incidence on producer). With regards to the diesel and gasoline cars, the impact on the market can be traduced as a demand shift: a decrease in diesel cars purchase and an increase in gasoline cars purchase. Again, in both case we assume an inelastic supply: the demand shift will not affect cars prices.

Table 150 : Presentation of results of sub-steps 1.1, 1.2 and 1.3

Sub-steps	Product 1	Product 2	Product 3	Product 4
1.1 Identification of goods and services concerned by the PAM	Diesel	Gasoline	Diesel cars	Gasoline cars
1.2 Identification of impact on supply and demand	Demand shift	Demand shift	Demand shift	Demand shift
1.3 Characterization of elasticities of supply and demand	Supply inelasticity	Supply inelasticity	Supply inelasticity	Supply inelasticity

The decrease and increase in fuel consumptions/cars purchases are expected to impact the economic activity of the **producers**. Employments will be affected proportionally. Given the supply inelasticity, we expect no impact on gross margin (Table 151).

Regarding the **consumers**, higher costs may arise from the increase in the price of diesel. However, as the total consumption is decreasing in favour of gasoline consumption (whose purchase price is decreasing), the total effect is not known. Regarding cars purchases, no variation in price is expected but as the evolution of the fleet is impacted by the PAM, we may assess the variation in purchase costs for consumers (decreasing for diesel cars and increasing for gasoline cars). It has to be noted that we assume that their purchasing behaviour is not impacted by the PAM. In other words, the consumers will not buy new vehicles if theirs aren't amortized.

Table 151 : Presentation of results of sub-steps 1.4

Gross direct impacts	Diesel	Gasoline	Diesel cars	Gasoline cars
Impact on producers				
• Economic activity (volume of production)	↘	↗	↘	↗
• Gross margin (modification of costs of production without a modification of the associated sell prices – and vice-versa)	=	=	=	=
• Employment	↘	↗	↘	↗
Impact on consumers				
• Total quantity purchased	↘	↗	↘	↗
• Purchase costs (of goods and services)	↗	↘	=	=

Legend: ↗ – Increasing impact, ↘ – Decreasing impact, = – No impact.

4.2.14.1.1.2 Step 2: Net direct impact identification and definition

Net direct impacts concern potential substitution effects related to the impact on products identified in step 1, i.e. diesel, gasoline and associated cars. For each product, there might be a substitution effects with similar products as other fuels (biofuels, natural gas, electricity) and associated types of cars (hybrid cars, electric cars, etc.). However, as this substitution impact was identified to be very low, we consider that these net direct impacts are negligible.

4.2.14.1.1.3 Step 3: Gross indirect impact identification and definition

Gross indirect impacts correspond to the propagation of impacts identified in Step 1 into the value chain of identified products, i.e. diesel, gasoline and associated cars. As in all cases an impact is expected on the economic activity, this impact will be transferred proportionally to the upstream and downstream value chain.

4.2.14.1.1.4 Step 4: Net indirect impact identification and definition

As net direct impacts were identified to be negligible, the net indirect impacts may also be considered negligible.

4.2.14.1.1.5 Step 5: Summary of impacts on consumers and producers

A summary of the impact of the PAM on the consumers and producers is presented in Table 152.

Table 152 : Summary of impacts on producers and consumers

			Gross direct impact	Gross indirect impact	Net direct impact	Net indirect impact
Product 1: Gasoline	**Producer**	**Producer P1**	↗ EA, ↗ E		Negligible	
		Upstream Prod.		↗ EA, ↗ E		Negligible
		Downstream Prod.		↗ EA, ↗ E		Negligible
	Consumer	**Households**	↗Q		Negligible	
		Industry	↗Q		Negligible	
		Public sector	↗Q		Negligible	
Product 2: Diesel	**Producer**	**Producer P2**	↘EA, ↘E		Negligible	
		Upstream Prod.		↘EA, ↘E		Negligible
		Downstream Prod.		↘EA, ↘E		Negligible
	Consumer	**Households**	↘Q		Negligible	
		Industry	↘Q		Negligible	
		Public sector	↘Q		Negligible	
Product 3: Diesel cars	**Producer**	**Producer P3**	↘EA, ↘E		Negligible	
		Upstream Prod.		↘EA, ↘E		Negligible
		Downstream Prod.		↘EA, ↘E		Negligible
	Consumer	**Households**	↘Q		Negligible	
		Industry	↘Q		Negligible	
		Public sector	↘Q		Negligible	
Product 4: Gasoline cars	**Producer**	**Producer P4**	↗ EA, ↗ E		Negligible	
		Upstream Prod.		↗ EA, ↗ E		Negligible
		Downstream Prod.		↗ EA, ↗ E		Negligible
	Consumer	**Households**	↗Q		Negligible	
		Industry	↗Q		Negligible	
		Public sector	↗Q		Negligible	

Legend: ↗ – Increase, ↘ – Decrease, EA – Economic Activity, E – Employment, Q – Quantity.

4.2.14.1.2 Impacts on public sector

Two categories of impacts are distinguished for the public sector, the policy implementation costs and the tax revenue impacts. Regarding the policy implementation costs, we consider the impact negligible as the PAM implementation only necessitates updates of the tax level. The tax-revenue will be modified due to the evolution of the excise duties on diesel and gasoline but also to the evolution of the fuel consumption.

4.2.14.1.3 Externalities

The primary objective of this PAM is to improve air quality. We assessed this positive externality and its monetary implications by focusing on the estimation of two elements impacting air quality: NOx and $PM_{2,5}$[28].

[28] Particulate Matter, fine particles with diameters lower or equal to 2.5 micrometers.

4.2.14.1.4 Summary of impacts considered

A summary of the socio-economic impacts considered in our evaluation to run a net direct and indirect impacts assessment are presented in Table 153. It has to be noted that impacts on producers weren't evaluated as producers both produce gasoline and diesel cars: we assume the net impact will be negligible. Regarding consumers, we assumed the impacts negligible for non-household's consumers.

Table 153 : Assessed impacts of the Ecodesign Regulation on producers, consumers and the public sector

			Net direct and indirect impacts
Product 1: Gasoline	**Producer**	**Producer P1**	NE
		Upstream Prod.	NE
		Downstream Prod.	NE
	Consumer	**Households**	Evaluated (PC)
		Industry	N
		Public sector	N
Product 2: Diesel	**Producer**	**Producer P2**	NE
		Upstream Prod.	NE
		Downstream Prod.	NE
	Consumer	**Households**	Evaluated (PC)
		Industry	N
		Public sector	N
Product 3: Diesel cars	**Producer**	**Producer P2**	NE
		Upstream Prod.	NE
		Downstream Prod.	NE
	Consumer	**Households**	Evaluated (PC)
		Industry	N
		Public sector	N
Product 4: Gasoline cars	**Producer**	**Producer P2**	NE
		Upstream Prod.	NE
		Downstream Prod.	NE
	Consumer	**Households**	Evaluated (PC)
		Industry	N
		Public sector	N
Public sector	**Policy implementation costs**		N
	Tax revenue impacts		Evaluated
Externality costs			Evaluated
Other macro-economic indicators			NE

Legend: NE – Not Evaluated, N – Negligible impact, PC – impact on purchase costs.

4.2.14.2 Methodology of evaluation

The impact of the PAM in terms of fuel consumption and prices were already estimated in the emission calculation part of the report. The impact of the PAM on the public sector and the consumers may be calculated from these estimations.

First, we compared the consumer expenditures in the business-as-usual and in the PAM scenario (Table 154). Second, we evaluated the change in the tax revenue for the public sector as described in Table 154. Investments costs related to change of fleet and externality costs related to the impacts on air quality are also estimated. Regarding investments costs, it has to be noted that the calculation is very approximate because we don't have a stock model (investment costs may be lower).

Table 154 : Method of estimation of the socio-economic impacts identified

Identified impacts	Method
Public sector (€) > Tax revenue impact	$[(p^{ed\text{-}DIES\text{-}PAM} * C^{DIES\text{-}PAM}) + (p^{ed\text{-}GAS\text{--}PAM} * C^{GAS\text{-}PAM})]$ $- [(p^{ed\text{-}DIES\text{--}BAU} * C^{DIES\text{-}BAU}) + (p^{ed\text{-}GAS\text{--}BAU} * C^{GAS\text{-}BAU})]$ ⇨ **If <0, then it is a cost for the public sector**
Consumers(€) > Reduction fuel consumption	$[(p^{T\text{-}DIES\text{--}BAU} * C^{DIES\text{-}BAU}) + (p^{T\text{-}GAS\text{--}BAU} * C^{GAS\text{-}BAU})]$ $- [(p^{T\text{-}DIES\text{-}PAM} * C^{DIES\text{-}PAM}) + (p^{T\text{-}GAS\text{--}PAM} * C^{GAS\text{-}PAM})]$ ⇨ **If >0, then it is a saving for the consumers**
Consumers(€) > Investments costs change due to fleet variation	$(EvF^{DIES}) * p^{DIES\text{-}CAR}$ $+(EvF^{GAS}) * p^{GAS\text{-}CAR}$ **If >0, then it is a saving for the consumers**
Externality	$TC * (EF^{NOX} * MV^{NOX} + EF^{PM25} * MV^{PM25})$

Legend: p^T – total price, P^{ed} – excise duty price, DIES – diesel, GAS – gasoline, BAU – Business as usual, PAM – Scenario with PAM implementation, EvF – Evolution of Fleet, TC – Total reduction in fuel consumption, EF – Emission factor, MV – Monetary value, C – Consumption.

4.2.14.3 Results

An increase in excise duty for diesel will imply savings for consumers: up to 487.8 M€ in 2025 for fuel consumptions and up to 84.7 M€ in 2025 for car purchases (Figure 72). Economic savings are also expected due to positive externalities arising from PAM implementation (increase in air quality): up to 97.4 M€ in 2025. Regarding the public sector, the decrease in tax will imply a decrease in tax revenue up to 533.9 M€ in 2025. However, again, savings made by consumers may imply induced purchased that may counterbalances this decrease in tax revenues. The year-by-year impacts are presented in Table 155.

Table 155 : Socio-economic impacts on consumers and the public sector (net present values)

Year	Consumers savings Fuel consumption - M€	Consumers savings Car investments - M€	Public sector Tax revenue (M€)	Externality savings M€
2015	0.0	0.0	0.0	0.0
2016	108.9	0.0	-134.3	0.0
2017	192.9	89.1	-240.0	8.6
2018	227.6	140.0	-294.8	21.0
2019	409.9	137.7	-474.4	32.4
2020	432.9	136.2	-494.9	44.5
2021	446.8	121.8	-505.2	55.7
2022	459.1	108.6	-514.1	66.7
2023	469.9	98.4	-521.7	77.3
2024	479.4	91.0	-528.2	87.5
2025	487.8	84.7	-533.9	97.4

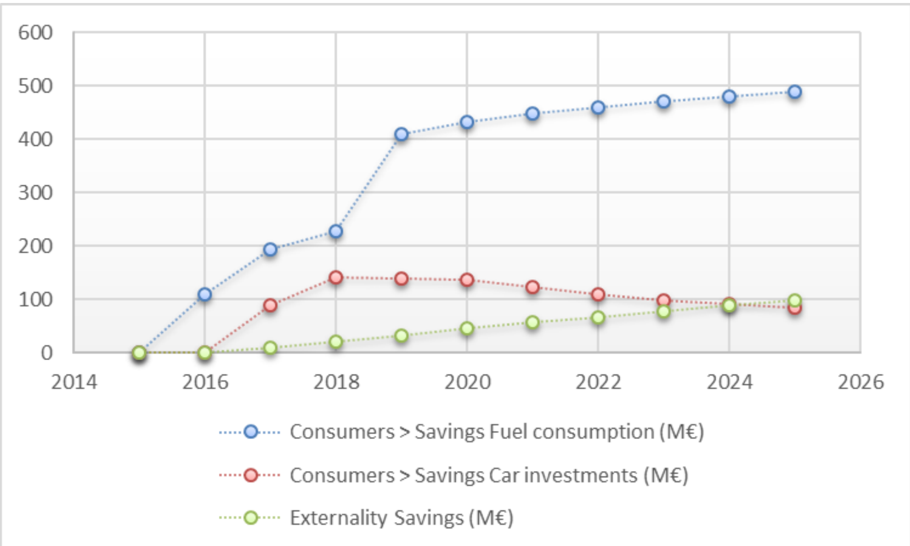


Figure 72 : Savings for households and society related to the implementation of the PAM (M€)

5 Appendix

5.1 Appendix on Literature research on modal shift from car to train

FPS Mobility and the SNCB couldn't provide any data neither to determine the number of people who used the car before switching to the train thanks to measures mentioned above. We asked for data on the origin of the SNCB passengers, on the most frequent travel journey, on the most frequent travel destinations, etc.

In the sections below we describe the relevant literature on this topic. We investigated the literature, but even there, is not much information is available.

In general, literature states that the substitution between train (and public transport in general) is very limited. We inspire ourselves on Dutch reports (see sources) that based themselves on an extensive literature research. Two conclusions come out:

- Making railway use more attractive increases railway use
- New train users are only marginally car users as train (or PT in general) and car are bad substitutes

5.1.1 Making railway use more attractive increases railway use

- The Dutch railways:

Between 2000 and 2012, the Dutch rail pkm increased by 19%. This was due to: population increase (+5%), economic growth (+2%), use of student card (financially interesting) (+4%), changes in fuel price (+3%), punctuality (+2%), higher frequency (+4%), increase of train tariff (-6%), unexplained (+5%). (Mobiliteitsbalans, 2013)

Interesting to observe is that increasing congestion had no impact on pkm by train which is different from what literature states.

The important question here is, how did those new train users made their journeys before using the train. In other words, did train use increase thanks to a model shift away from car?

- The federal diagnostic home-work transport

The 2014 federal diagnostic home work transport shows that companies providing public transport for free have significantly more people using public transport, nearly 25% instead of only 10%. But, once again, we don't know

  - how these people would have made their journey in the absence of free public transport
  - whether the external factors of the company providing public transport for free induce more public transport use from their own. Ex Brussels companies could do more to encourage their people to come by public transport.

5.1.2 But new train users are only marginally car users as Train (or PT in general) and car are bad substitutes

- Journey time of PT generally compares badly compared to car journeys. On average PT journey time is 3 times longer than car journey time in the Netherlands, e**xcept for** longer distances PT, and for short distances with departure close to station the ratio between both is better.
- In the past there was no relation in the Netherlands between congestion and rail growth.
- Lots of latent car drivers use PT during peak, however, when there is a slight reduction in congestion, those well switch back to car with reduced congestion. It is strange to see that literature states the link between congestion and higher train use, while in the past this link was not observed in the Netherlands.
- The impact of higher speed or extension of PT on substitution is limited
- 90% of car drivers don't consider using the train within the next 5 years, car users don't like to switch, except for longer distances or departures close to a station (see first bullet).

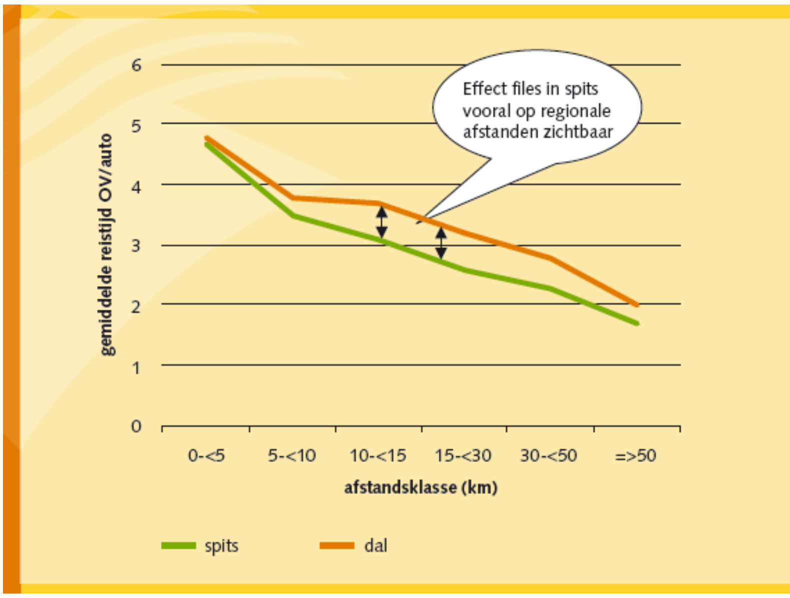


Figure 73: Ratio of public transport journey time and car journey time depending on travel distance

As the graph illustrates, the journey time ratio is on average unfavorable for public transport on distances shorter than 30km (32) From a ratio journey time for PT /journey time for car of 1.5, PT gets competitive. Where the ratio is 2 today, improvements can reduce the ratio probably to 1.5. With the resources foreseen for this study we were not able to find data on this ratio for the Belgian situation, nor do we know how the policy measures have influenced this ratio.

Furthermore, people assess the waiting time and the before and after transport very negatively . The subjective waiting time and last and first mile time is perceived as twice the real world time (33). If travelling to the station takes 5 minutes, it is perceived as 10 minutes. It is difficult to change this. It is however possible to decrease the travel time to the station by using a bicycle (or a car).

Providing better cycling conditions and facilities is however not the silver bullet. The European BiTiBi project about the promotion of bike train bike combination states that 10% (in some cases 20%) of people using the bicycle to reach the railway station would use the car for the whole train journey if the bike-train combination would not be available (bitibi.eu -final report to be published February 2017).

Except from the last paragraph, the above section is based on Savelberg, 2015.

5.1.3 Economic theory confirms low substitution,

Economic theory uses cross price elasticities. Cross price elasticizes are a classic way to see how changes in the price of one mode influence the use of the other mode. Price has to be seen as general price, containing a financial component and a time component. A cross price elasticity of 0.1 of car use with respect to the train price for example means that if the price of the train decreases by 10%, car use will decrease by 1%.

The figures below illustrate some cross price elasticities from car and train. We observe from cross price elasticities below that a change in car driver conditions will influence train use, but that a change in train conditions will not, or only marginally influence car use. So, there is nearly no shift from car to train with an improvement in rail conditions. However, there is a shift from car to train if the car conditions deteriorate.

A 1% increase in car travel time leads to a 1.2% increase in train km in the short run and 0.4% in the long run. The figures below illustrate this. We remark that cross price elasticities need to be applied to “competing” traffic links. The KIM study mentions Koncept-elasticiteitenhandboek DVK 1990, gebaseerd op LMS1995 as source .

Remark however that in real world, from the passenger increase at NS in the past 0% could be attributed to increasing congestion (see above).

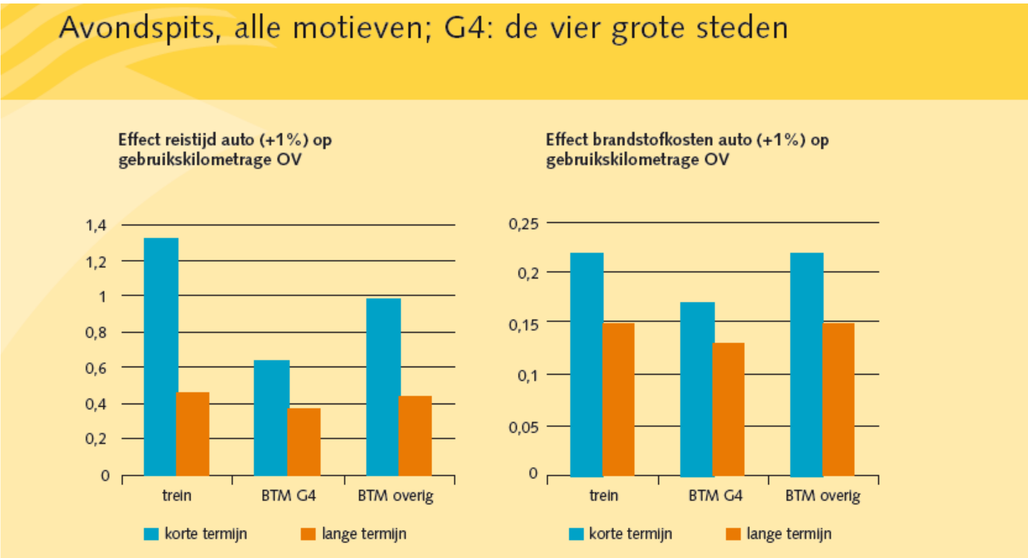


Figure 74: cross price elasticity between car and train in evening peak with a deterioration of car driving conditions (Savelberg, 2015 based on Koncept-elasticiteitenhandboek DVK 1990, gebaseerd op LMS1995)

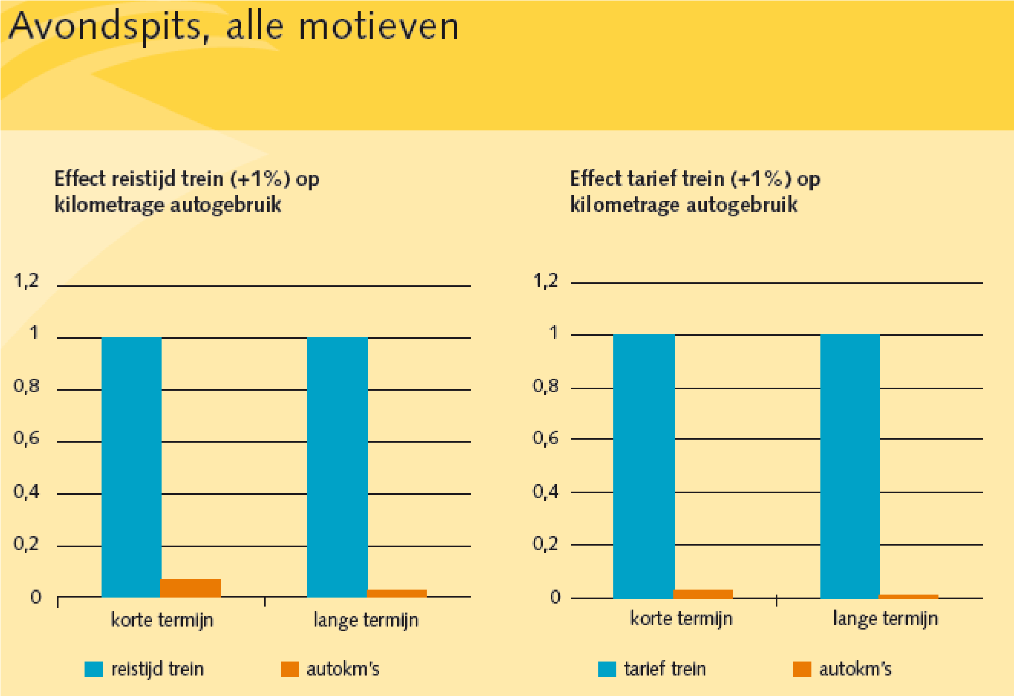


Figure 75: cross price elasticity between car and train in evening peak with a deterioration of train conditions improvement (Savelberg, 2015 based on Koncept-elasticiteitenhandboek DVK 1990, gebaseerd op LMS1995)

Litman (Litman, 2004) comes up with figures for cross price elasticities that are more favorable for public transport. This is however for PT in cities (transit systems). In the long term, a 1% reduction in cost could lead to a 0.15 to 0.3% increase in transit travel. For the Belgian trains, the cross price elasticity could be at the lower end and probably even below as the rail and car are not as good substitutes as car and public transport in a city. The table below provides elasticities for urban public transport. The last line provides cross price elasticities for car compared to urban public transport.

Table 156: Elasticities for urban public transport

	Market Segment	*Short Term*	*Long Term*
Transit ridership WRT transit fares	Overall	−0.2 to −0.5	−0.6 to −0.9
Transit ridership WRT transit fares	Peak	−0.15 to −0.3	−0.4 to −0.6
Transit ridership WRT transit fares	Off-peak	−0.3 to −0.6	−0.8 to −1.0
Transit ridership WRT transit fares	Suburban commuters	−0.3 to −0.6	−0.8 to −1.0
Transit ridership WRT transit service	Overall	0.50 to 0.7	0.7 to 1.1
Transit ridership WRT auto operating costs	Overall	0.05 to 0.15	0.2 to 0.4
Automobile travel WRT transit costs	Overall	0.03 to 0.1	0.15 to 0.3

Note: WRT = With Respect To

To illustrate the difficulty of getting modal shift between rail and car, we mention the effect of the simulated road charging system in the Netherlands. Trainpkm would only increase by around 3%, while carpkm decrease by 10%. Remind that the absolute differences are even much more important and that half of the carkm simply disappear, this means are not replaced by another mode (Savelberg; 2015).

5.1.4 Documented real world experiences are scarce but confirm low substitution (Savelberg 2015, Diagnostic 2015, Bakker 2015)

- Flevospoorlijn Amsterdam-Almere: up to 20 minutes journey time gain, 10% of car drivers switched to train, but 25% of former bus passenger switched to car (longer first and last mile for rail compared to previous bus network and there is extra space on the road). In the end, the PT share didn't change.
- Opening of Zuidtak Amsterdam: journey time gains of up to 30 minutes, but only 3% of those passengers were previous car drivers, 95% were PT users on before.
- The evaluation of some big Dutch rail projects in the 90 ies didn't show any impact on car use.
- The very low tariff policy of De Lijn in the years 2000 had no significant impact on car use in Flanders.
- The evolution in the transport modes for commuting in the federal diagnostic of home-work traffic in large companies (+100 employees) gives an indication that more train users doesn't mean less cars on the road:
    - In Flanders, the diagnostic observed a status quo in car use, but an increase in train use of 36%. The number of carpoolers was drastically reduced.
    - In Wallonia, train use was up 13%, and car use increased also by 2%. The absolute increase in car users is even greater than the increase in train users. We also had a decrease in car poolers.
    - The only region where car use is reduced is Brussels, but taking into account the evolution in Flanders and Wallonia, we assume that the reason is rather the external environment that is more car hostile than the SNCB policy. We also observe a dramatic decrease in carpoolers.

This doesn't provide however scientific evidence as we don't know what would have happened without the SNCB policy.

Table 157: evolution in modal shares for commuting in Belgian large companies (diagnostic federal, 2015)

	BELGIQUE			BRUXELLES			FLANDRE			WALLONIE		
Mode	2005	2014		2005	2014		2005	2014		2005	2014	
Voiture (seul)	66,8%	65,6%	- 2%	45,1%	37,9%	- 16%	68,7%	68,5%	- 0%	80,4%	81,7%	+ 2%
Covoiturage	4,7%	2,9%	- 38%	2,5%	1,2%	- 49%	5,2%	3,3%	- 36%	5,2%	3,4%	- 35%
Moto	1,7%	1,2%	- 33%	0,8%	1,1%	+ 38%	2,2%	1,3%	- 41%	1,5%	1,0%	- 31%
Train	9,5%	10,9%	+ 15%	32,2%	34,1%	+ 6%	4,1%	5,3%	+ 31%	4,4%	5,0%	+ 13%
Métro, tram, bus	5,9%	6,9%	+ 16%	15,0%	19,0%	+ 27%	3,9%	3,9%	+ 0%	3,6%	4,0%	+ 9%
TCE	1,2%	0,8%	- 34%	0,7%	0,3%	- 59%	1,6%	1,1%	- 31%	0,5%	0,4%	- 8%
Vélo	7,8%	9,5%	+ 21%	1,2%	3,0%	+ 148%	12,3%	14,9%	+ 21%	1,3%	1,5%	+ 13%
Marche	2,4%	2,4%	- 2%	2,6%	3,4%	+ 33%	2,1%	1,7%	- 19%	3,2%	3,1%	- 2%

- When observing the NMBS data, we see stagnation in the absolute railpkm over the last 4 years with available data (2011-2014), while the number of commuters travelling for free is increasing heavily. This could indicate that deteriorating car travel conditions are a better incentive for people to travel by train than the improved offer as commuters travel in the peak while car travel conditions are worse. However, this is far from a scientific conclusion and needs much more investigation.

- Examples from abroad show modest share of ex-car users among important metro and light rail developments. These developments and improvements are significantly more important than what happened in the Belgian railways. They take also place in cities, places where conditions to drive a car are worse. On average, in the abroad examples, 11% of improved PT are car users, with peaks up to 25%. (Bakker, 2015).

5.1.5 Under what circumstances is modal shift feasible?

The above section showed that modal shift from car to rail is difficult to obtain. Literature provides some conditions under which modal shift from car to rail are more likely:

- high parking tariffs and/or difficulties to find parking
- if substantial changes take place in ratios of journey times between car and public transport and if this ratio is around 1.5 or lower
- And often as a consequence, when market shares of car and PT are close to one another on links.

5.1.6 Conclusions of the literature research on modal shift from car to rail:

We conclude following based on the literature research:

- While improving train and PT performances, the number of train and PT passengers will increase.
- There will however be only a little part of those new passengers that were previously car drivers. The older literature research from Litman is less pessimistic, especially in the long term, more attractive public transport could attract extra passengers.
- There is nearly no evidence from real world experience, that by improving train and PT supply a modal shift from car to rail or PT takes place, except in cases with a significant improvement, much more significant than what was done in Belgium. Available evidence suggests that an attraction of 20 to 30% of car drivers among new train and PT users is a huge success (Savelberg, 2015). Car drivers for whom journey times of PT or not more than 1.5 the car journey time have most change for shifting to train.
- A cross price elasticity between train and car between 0 and 0.1 is probably realistic. This means that by a 10% price decrease of train, 1% of car users on a similar link will switch to train. Litman provides values for cross price elasticity of up to 0.3 for transit. (between 0.1 and 0.3 in the long run and only 0.05 in the short run).
- There is some evidence that 10% of people using bicycle parking are former car users for the whole train journey (BiTiBi, 2017).
- The most effective way to reduce car use is to make it less attractive, by decreasing parking possibilities and make the PT journey time competitive with car. Litman adds that car drivers are generally responsive to service quality and higher automobile costs.

Remark:

The Walloon region counts each extra pkm from public transport as a reduction of one carpkm. They furthermore don't take into account any rebound effect. We didn't find any evidence for this assumption in the literature research.

Price elasticities are calculated for a certain range of the demand curve, in other words for price changes of 10% to 20%. This means, conclusions on big price changes, like transport for free, should always be looked at very cautiously.

5.1.7 Sources

- Bakker et al (KIM), Uitwisseling gebruikersgroepen "auto-ov", 2015
- Litman, transit price elasticities and cross elasticities, 2004
- Mobiliteitsbalans 2013, Kennisinstituut voor mobiliteit, p41

- Savelberg et all (KIM), het scheiden van de markt, vraagontwikkelingen in het personen- en goederenvervoer, 2015
- Van Zeebroeck et al, 2017, BiTiBi final report, EC
- SPF Mobilité, Diagnostic des déplacements domicile – lieu de travail 2014, 2016

5.2 Appendix PAM "Positive mobility allocation" : sources on mobility budget

5.2.1 Interview with Pieter Goossens (Athlon car lease)

It is very difficult to estimate the impact of an adaptation of the company car rules.

The main influencing element will be the exact shape of the framework. Precise rules aren't known yet.

- Can people opting for the cash also get a third payment arrangement for their public transport?
- Can people still get a km reimbursement for their km driven for the company and/or home work commuting.
- How much assistance does the company provides in choosing other transport modes?

People with a company car pay a lump sum for it and can use as much as they want. In most cases people get also a national fuel card. The more km you drive the better you are off in a certain sense. People driving a lot will therefore be less attracted by abandoning their company car than people driving less. People driving only a few km will be attracted by abandoning their car, buying a smaller (maybe second hand car) and keeping a non-negligible amount of cash to invest in other stuff.

Among the more recent adopters of company cars, often via "cafeteria plans", people didn't really change their mobility behavior in most cases. Cafetaria plans have been popular in recent years and were a means for employers to reduce their wage costs. Employees had the choice to get a company car by getting their gross salary reduced by for example 3%.

These "cafeteria plan people" will probably be relatively likely to abandon their company car for cash and come back to their ancient situation. Another factor that goes against this trend could be that a similar car bought as a private person will be more expensive than when people take it as company car. You can get an Audi A4 or BMW3 for 300 EUR/month while you can't get this as a private person. When you would lease as a private person you could maybe come closer to it.

These later group of "cafeteria plan people" can be estimated at around 50 000. This is approximately the growth in salary cars during the last 5 years.

The group of people that has "always" had a company car is people that are driving a lot, often in mobile functions like sales people, technicians and executives. Those are the people that already had a company car in the 90 ies. The number can be estimated at around 150 000 and maybe a bit more. In some of those sectors, company cars are also a kind of status symbol and employees sometimes pay even part of their "normal"wage to get a bigger or nicer car. In general, these people will not abandon their car.

If we count with approximately 400 000 salary cars these days, we can roughly estimate that 150 000 will be reluctant to abandon their company car, 50 000 will probably consider to abandon their company car.

200 000 salary cars remain. For those, the km driven will probably be the major influencing factor.

This makes it already clear that people ready to abandon their company car will be people using driving less km than the average company car driver.

For certain niche groups, also other factors will come into consideration like the presence of another company car in the family or the fact that people live and work in the same city (the latter element will probably be included in km driven).

All the above mentioned elements are rather based on gut feeling than on statistics. To make a better estimate on the impact, a database with the km driven, the amount paid and the vehicle type would be an interesting tool. Within the framework of this brief analysis this is unfortunately not possible.

FEW PEOPLE WILL REALLY ABONDON THEIR COMPANY CAR

5.2.2 Interview with Wies Pairoux from Acerta

It is very difficult to get an objective view on the share of actual company car users that will abandon their company car once the new government measure will come in to place. Our discussion does not reflect scientific evidence, but rather indications and gut feelings. The main things coming out of our discussion are:

- Cafeteria plans:

There is today a tendency among companies to come up with "cafeteria plans". These are plans in which companies leave a choice to their employees on how to get part of their salary. This could be extra pension contribution, a company car, other mobility interventions, extra holidays, and simple cash. These cafeteria plans may not be simple "optimization" of the salary payment, but there is some flexibility from the "RSZ" (federal service for social security). So 1,2 or 3% and maybe slightly more of the gross salary can be converted into benefits for the employee. In these cafeteria plans, the company car is very popular. These people will not necessary be keen on replacing their company car by cash.

- Popular (company) car

The company car today is very popular in general. Employees are not very keen on changing their company car by other benefits or salary. With lots of awareness rising and personal information provision, probably 10% of company car users can be expected to change their mobility behavior. In most cases, even if people would abandon the company car, people would continue to use (another) car.

It is however true that most people like their company car. It is for part of them a good value for money status symbol. People opting for cash instead of a company car will not be able to buy and maintain a similar car. They 'll need to choose a smaller and/or second hand car.

- Roughly 1/3 of company cars are real company cars

These are cars driving lots of km for due to the function of the employee, for example sales person, technician,…. These people drive up to 100 000 km/year and will logically keep their company car.

5.2.3 VIM project

A test project from VIM, with 123 participants in 23 companies concluded that

- 45% of participants adopted his mobility behavior

- 56% of participants would adapt their behavior if rest would be paid as net salary (39% if it wouldn't be net wage). Especially when you get rest of wage as net wage, you could get an incentive to make most sustainable
- Lot is dependent on the way the mobility budget is introduced. It seems interesting that also other persons of the family can make use of it
- The problem of this kind of micro studies is that the sample has probably been biased because participants and companies presented themselves. Companies stepped in based on availability of alternatives, if not enough alternatives, companies didn't step in. Employees got also extensive help on their mobility choices which will not be necessarily be the case in each company using company cars today.

5.3 Appendix PAM "Increase of Excise duty" : Rule of increase of the Excise duty

5.3.1 Anticipated indexation of the excise duty on diesel

Total amount of excise is composed by the excise duty, the special excise duty and the levy on energy. This total amount for diesel is indexed at 0,63%. More concretely, this implies that the special excise duty for diesel will increase by the total amount for diesel indexed at 0,63%

For this reason, the 1st of November 2015, the special excise duty increased in this way:

Old special excise tax on 01/11/2015 (€/1000 l at 15°C)	New special excise tax on 01/11/2015 (€/1000 l at 15°C)	Gasoil Code (Soufre < 10 mg/kg)
230,6949	233,4914	NC 2710 19 41, 2710 19 45 and 2710 19 49
215,6544	218,3561	NC 2710 19 41

The minister of Finance has to publish an official opinion to the Moniteur Belge that stipulates the next evolutions of indexation percentage, i.e. on 01/01/2017 and 01/01/2018. These new indexation percentages will be calculated by making the difference between the consumer price indexes of June 2016 and 2015, and of June 2017 and 2016 respectively.

5.3.2 Definition of the increase/decrease in excise duties

The rules of increase from the 1st of July 2016 till the 31th of december 2018 are determined by a ratchet system. These rules are defined by period and are composed of 2 steps.

Step 1 – Definition of the increase of the special excise duty for diesel

The level of increase is defined by the evolution of the maximum sell price of the associated petroleum products. This maximum sell price is defined by a program contract between Belgium and the petroleum sector. Concretely, the special excise duty will increase if this maximum sell price diminished. The level of increase will correspond to the half of the diminution observed (HTVA).

However, it has to be noted that there is a maximum level of increase per period:

Period	Maximum increase (€/1000 l at 15°C)	Gasoil Code (Sulfur < 10 mg/kg)
01/07/2016 – 31/12/2016	***32,0849*** *(33,29 previously)*	NC 2710 19 41, 2710 19 45 and 2710 19 9
01/01/2017 – 31/12/2017	**22,3197** *(34,60 previously)*	
01/01/2018 – 31/12/2018	***54,5197*** *(50 previously)*	

Step 2 – Definition of the decrease of the special excise duty for gasoline

There is a decrease of the special excise duty for gasoline if the increase for diesel has reached a given level for each period:

Period	Minimum level of increase of the special excise duty on diesl (€/1000 l at 15°C)
01/07/2016 – 31/12/2016	**29,15** (26,09 *in the previous version)*
01/01/2017 – 31/12/2017	***16,45*** *(27,4 in the previous version)*
01/01/2018 – 31/12/2018	***48,65*** *(42,80 in the previous version)*

If these levels of increase of the special excise duty on diesel are reached, then a decrease of the special excise duty for gasoline will be applied. This decrease will correspond to [3,09*X], with X the level of increase of the special excise duty on diesel.

When the excise duty of diesel and gasoline are equals, this ratchet system is no longer applied

It has also to be noted that each time that there is a decrease in the maximum sell price that implies an increase of the special excise duty for diesel, the Minister of Finance published an official opinion in the Moniteur Belge with the new amounts that have to be considered. Here are some information about the last official opinion:

- l'avis officiel du 19 novembre 2015 (gasoil),
- l'avis officiel du 3 décembre 2015 (gasoil),
- l'avis officiel du 11 décembre 2015 (gasoil),
- l'avis officiel du 11 décembre 2015 (essence sans plomb),
- l'avis officiel du 5 juillet 2016 (gasoil),
- l'avis officiel du 12 juillet 2016 (gasoil),
- l'avis officiel du 26 juillet 2016 (gasoil),
- l'avis officiel du 3 août 2016 (gasoil), et
- l'avis officiel du 3 août 2016 (essence sans plomb).

5.3.3 Sources

- http://www.legalworld.be/legalworld/content.aspx?id=95870&LangType=2060
- http://www.legalworld.be/legalworld/content.aspx?id=96612&LangType=2060

5.4 Appendix: evaluation of the quality of estimation

The following table presents an overview of the quality of the estimations for each PAM. "1" means that the results of the estimation are uncertain given the uncertainty in the data used and the choice of the hypothesis. "2" labels estimations of an average quality. "3" indicates robust estimations.

PAM code	PAM titre	Quality of the estimation
APP-T01	Positive mobility allocation	2
APP-T02	Pedelecs	3
APP-T03	Rail traction	1
APP-T04	Rail non traction	1
EC-A05	Energy label (eco design)	3
EC-B01	Tax incentive to promote ee in households	1
EC-B03	FRGE	2
EP-A01	Offshore wind energy	2
EP-A02	Energy taxation	2
IP-A06	Tax deduction for energy savings	1
OB-A03	EMAS	2
OB-B01	Renewable energy fedesco and belgian railways	2
OB-B02	Energy efficiency fedesco	2
OB-C02	Free public transport federal civil servants	2
OB-C04	Teleworking	2
OB-C07	Energy efficient cars for federal public services	2
TR	Advantage in kind depending on CO2 emissions for company cars	2
TR-A02	Promotion of public transport	2
TR-A03	Promoting bicylce use	2
TR-A04	Promoting multimodal systems for goods	2
TR-A08	Free public transport for commuters	2
TR-B01	Promoting carpooling	2
TR-B05	Eco-driving	1
TR-C01	Tax deduction clean cars	2
TR-D01	Biofuels	2
XX-X01	Ecocheque	1
XX-X02	Green loan	1
XX-X03	F Gases	3
XX-X04	Tax Shift	2