Seventh National Communication of Luxembourg under the United Nations Framework Convention on Climate Change

12 February 2018

Aménagement du territoire
Environnement
Transports
Travaux publics
Pour un développement durable

LE GOUVERNEMENT
DU GRAND-DUCHÉ DE LUXEMBOURG
Ministère du Développement durable
et des Infrastructures

Seventh National Communication of Luxembourg under the United Nations Framework Convention on Climate Change

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This Communication is presenting the situation in Luxembourg on the 1st January 2018.

Names of Ministries changed with the appointment of the latest Government on the 4th of December 2013. Present names are used throughout the report though reference documents could refer to Ministries' names at the time of publication. There is one exception: the former Ministry of the Environment became the Department of the Environment of the Ministry of Sustainable Development and Infrastructure in September 2009. Since it is the main Ministry/Department involved in climate change related activities, the distinction has been kept in the report but both terminologies are interchangeable. Nevertheless, the acronym used through the report is MDDI-DEV for *Ministère du Développement durable et des Infrastructures – Département de l'Environnement*.

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Chapter I

Executive Summary

National communications are designed to provide a consistent, comparable, accurate and complete account of action being taken by Parties to the United Nations Framework Convention on Climate Change (hereafter, UNFCCC) to address climate change. Luxembourg's Seventh National Communication on Climate Change (hereafter, NC7) provides an overview of the situation and actions undertaken for addressing the challenge of climate change and it reflects progress made since the submission of its Sixth National Communication in February 2014 [Ministry of Sustainable Development and Infrastructure, Department of the Environment (2014a)]. This NC7 also comprises the 3rd Biennial Report (hereafter, BR3) developed Parties under the Convention have to provide according to Decision 2/CP.17 and its Annex I.

Key developments since the last National Communication are listed in the box below.

Box ES-1 – Key achievements since Luxembourg's Sixth National Communication on climate change

1. preparation of Luxembourg's third national "Climate Plan" *[→ Section IV.1.3]*;
2. development of a revised and more comprehensive adaptation strategy to climate change *[→ Section VI.3.1]*;
3. new and revised set of policies and measures (PaMs) and of the section describing them *[→ Section IV.3]*;
4. revised greenhouse gases projections *[→ Sections V.2 & V.3]*;
5. revised National System for both greenhouse gases inventories and projections (including PaMs) *[→ Section III.2]*;
6. enhanced reporting for Chapters VI to IX;
7. it is expected that Luxembourg will not need to use Kyoto mechanisms in addition to its domestic PaMs to reach its CP2 target under the Kyoto Protocol for the period 2013-2020;
8. Luxembourg took strong commitments with regard to international climate finance; commitments which are new and additional to Luxembourg's Official Development Assistance.

The NC7 also addresses most of the recommendations of the 2014 UNFCCC Report of the In-Depth, Review of the Sixth National Communication of Luxembourg [UNFCCC (2014a)].

Luxembourg's Seventh National Communication provides:

- a detailed description of Luxembourg's national circumstances as context for Luxembourg's emissions profile and overarching responses to climate change *[→ Chapter II]*;
- the most recent inventory of greenhouse gas emissions and the methodologies used to calculate these emissions *[→ Chapter III]*;
- a description of Luxembourg's national climate change policies and measures *[→ Chapter IV]*;
- sectoral projections for Luxembourg's greenhouse gas emissions *[→ Chapter V]*;
- evidence of Luxembourg's vulnerability to climate change impacts and adaptation measures to address those impacts *[→ Chapter VI]*;
- Luxembourg's international efforts to assist developing countries through financial and capacity building support to address their specific climate change challenges and information on international technology cooperation *[→ Chapter VII]*;

- details of progress by Luxembourg in climate research and systematic observation *[→ Chapter VIII]*;
- an overview of efforts to increase knowledge of climate change issues through public awareness-raising education and training activities within the country but also in the developing countries *[→ Chapter IX]*.

I.1. CLIMATE CHANGE IN LUXEMBOURG

Annual mean temperatures for Luxembourg-City are now usually above the 30 years averages of the last century. Indeed, the 1951-1980, the 1961-1990, the 1971-2000 or the 1981-2010 mean yearly temperatures for the capital city – around 9°C – are nowadays regularly exceeded. Yearly averages increase is mainly driven by higher air temperatures during winter seasons. Other meteorological stations disseminated throughout the country show similar results. With regard to other meteorological parameters – rainfalls, sunshine hours, relative humidity – no clear trends can be identified yet, probably because the very small size of the country (2 586 km^2) limits the identification of such changes *[→ Section II.3]*.

Climate change effects are also witnessed by increasing frost-free periods, earlier blooming seasons and higher flood frequencies over the last 20 years. For the future, higher average yearly temperatures are anticipated with consequences on public health (heat waves), floods (higher frequency and intensity), vegetation cycles (longer periods with frost risks after early blooming) and forests (degradation of its phytosanitary state) *[→ Section VI.1]*.

I.2. GREENHOUSE GAS EMISSIONS: STATE, KEY DRIVERS AND PRESSURES

Luxembourg is a Party to the Kyoto Protocol. The Doha amendment to the Kyoto Protocol limits Luxembourg's greenhouse gas (GHG) emissions for the Kyoto period 2013-2020 – or second commitment period – to an average of 20% below their 1990 level.

In 2015,[1] carbon dioxide was the main source of GHG in Luxembourg. This source counted for 90.6% of the total GHG emissions calculated in CO_2e – total excluding LULUCF. The second source of GHG was methane with 6.1% of the total emissions. Nitrous oxide was the third source with 2.6%. Fluorinated gases only accounted for 0.7% of the total emissions, with hydrofluorocarbons representing 0.6% of the total and sulphur hexafluoride representing 0.1% of the total.

The very high share of carbon dioxide is the result of a GHG emissions structure that is vastly dominated by energy related releases in the atmosphere: in 2015, 86.3% of the total GHG emissions, excluding LULUCF, were generated by energy production, combustion or distribution. Industrial

[1] The latest official GHG inventory according to EU Regulation No 525/2013 as well as according to the UNFCCC requirements covers the period 1990-2015.

processes and product use related emissions only represented 6.1% of that total and agriculture (rearing, farming, soils) only 6.6%. The other sources of GHG emissions (waste and wastewater) were negligible (0.9%) *[→ Section III.1]*.

One element explaining the predominance of CO_2 and of energy sources in the total GHG emissions is the very high share of road transportation related emissions: in 2015, this source category was responsible for about 55% of the total emissions originating from Luxembourg (excluding LULUCF). With its location at the heart of the main traffic axes for Western Europe, Luxembourg is a focal point for international road traffic and has, therefore, had traditionally a high volume of road transit traffic for both goods (freight transport) and passengers (tourists on their way to or back from southern Europe). The latter has increased even further by the high number of commuter journeys observed every working day: 175 000 persons, i.e. about 30% of the residential population, that mostly (around 90% according to figures collected in 2010) commute by car. In comparison with international traffic, domestic traffic plays only a relatively small role since it is responsible for only one quarter of the total road fuels sold in Luxembourg. Consequently, in 2015, "road fuel sales to non-residents" (transit traffic, commuters and "fuel tourism") represented about 38.8% of the total GHG emissions (excluding LULUCF) *[→ Sections II.8 & II.12]*.[2]

With 15.0% of the total emissions in 2015 (excluding LULUCF), energy combustion in buildings (houses, offices and commercial activities) was the second main emitting sources of GHG, whereas industries (energy combustion, industrial processes, product use and fluorinated gases) represented 13.1% of that total. The fourth main source of emissions was agriculture (combustion and practices) with 6.9%. Public electricity and heat production represented only 3.6% of the total emissions excluding LULUCF in 2015. This share was not far from 10% between 2005 and 2010 when a combined heat-power installation was functioning at its full capacity. Later on, this plant started to decrease its operations and finally shut down in 2016. The latter is a perfect example on how, due to the small size of Luxembourg and of its economy, one individual project can have important effects on some key environmental parameters *[→ Sections II.12 & III.1]*.

I.3. GREENHOUSE GAS EMISSIONS: PAST TRENDS AND PROJECTIONS

Total GHG emissions amounted to 10.269 Mio. tonnes of CO_2-equivalents (t CO_2e) in 2015, i.e. 19.3% below their 1990 level and 22.0% below the Kyoto commitment period base year value of 13.167 Mio. t CO_2e. Several phases can clearly be distinguished over the period 1990 to 2015:

- firstly, from base year up to 1993, Luxembourg's emissions remained rather stable;
- then, between 1994 and 1998, they started to decrease significantly to reach their lowest value in 1998, when they were down by more than 30%;

[2] According to IPCC rules for GHG inventories, "road fuel sales to non-residents" are to be considered in Luxembourg's GHG balance since these rules are based on the "origin" principle.

- from 1999 up to 2004, emissions augmented recurrently;
- from 2004 to 2006, a stabilisation peaking at 13 Mio. t CO_2e is observed;
- a regular decrease since 2006 with a clear impact of the financial and economic crisis in 2008-2009.

The evolution during those years can essentially be explained by changes in production techniques, as well as by changes in the final "energy-mix" consumption: less solid fuels, more natural gas and ever increasing liquid fuels in line with increasing transport flows. Of course, increasing or decreasing activities for certain source categories also played a crucial role in Luxembourg's GHG emissions trend. As an example, the move from blast furnaces to electric arc furnaces in the steel industry between 1994 and 1998 explains the significant decrease observed for GHG emissions over that period ***[→ Section III.1.1]***.

Estimating GHG emissions for the coming year is a difficult exercise for Luxembourg. On the one side, the size of the country implies that emissions would be affected by a single plant that might start new activities, close them down or change its production processes. On the other side, the important weight of "road fuel sales to non-residents" in the total emissions exerts a high uncertainty on the estimates. This weight is depending on many factors such as price differentials, pay tolls for motorways, economic cycles, development of alternatives to road freight, and so on; i.e. a set of parameters on which Luxembourg alone cannot act. Nevertheless, Luxembourg will have to take more actions to comply with the "Climate & Energy package" objective that it has been assigned by the European Commission (EC) at the 2020 horizon, i.e. a 20% reduction in the non EU ETS sectors compared to 2005, and even more in view of the objective set for 2030 under the European Union "Climate & Energy framework", i.e. a 40% reduction in the non EU ETS sectors compared to 2005 ***[→ Sections IV.1.1 & V.1]***.

The challenge of bridging the gap

The actual level of GHG emissions, as well as the projected trends ***[→ Section V.3]***, would require important efforts in order to respect the Kyoto commitment, the "Climate & Energy package" and the "Climate & Energy framework" objectives that have been set for Luxembourg. The country is facing a critical challenge in this respect since, at national level; it has only limited emissions reduction potentials. Indeed, with the move from blast to electric arc furnaces in the steel sector during the 1990s, Luxembourg very soon exhausted its only major technical potential for GHG emissions reduction. Other industrial activities present relatively small mitigation potentials and those installations, which are emitting the most, are part of the actual EU ETS scheme.

Looking at energy production, the picture is similar with no mitigation potentials, on the contrary. In fact, up to the end of the last century, Luxembourg did not have any significant fossil-fuel plants and most of its electricity needs were satisfied by imports.[3] Consequently, any investments in power plants – whether they are using fossil fuels or renewable energy sources – is not replacing electricity production from inefficient existing fossil-fuel plants. In other terms, investing in its own electricity production capacities does not offer any mitigation potentials for Luxembourg.

Thus, any energy-efficient fossil fuel-based electricity generating plant that Luxembourg might decide to construct will automatically lead to an increase of its national GHG emissions. This was clearly illustrated by growing emissions in the public electricity and heat production during the first decade of the 21st Century after the starting up of highly efficient combined heat-power (CHP) installations and of a large gas and steam power station: they have led to an additional amount of approx. 1.2 Mio. t CO_2e in Luxembourg's GHG balance, i.e. around 10% of the total emissions. For this reason, Luxembourg primarily promotes production units based on renewable energy sources, with a special focus on biomass, wood and solar energy. This is achieved by adopting new instruments and reinforcing existing ones, such as special tariffs for electricity produced from renewable sources that are in place since 1994 *[→ Section IV.3.1.1]*. However, no GHG reductions could be expected from these measures, since encouraging electricity generation from renewable energy sources, which is associated with major investments, will mainly result in replacing imported electricity, which does not appear in Luxembourg's GHG balance according to IPCC rules for GHG inventories *[→ Section II.12]*.

Consequently, considering the main emissions source categories, room for manoeuvres left for deploying mitigation policies are lying in the fields of road transportation and buildings. These are two sectors identified as those to focus on in the 2013 second national "Action Plan for reducing CO_2 emissions" [Ministry of Sustainable Development and Infrastructure, Department of the Environment (2013b)] *[→ Section IV.1.2]*. Luxembourg has therefore implemented various policies and measures in these two domains.

I.3.1. Road transportation

- vehicle tax reform: since the 1st January 2007, the annual tax is based on CO_2 emissions;[4]
- "Kyoto-cent": climate cents are levied on both gasoline and diesel sold since the 1st January 2007 (2 ct€/litre for gasoline, 2.25 ct€/litre for diesel);
- promoting the use of biofuels of the second generation according to EU legal texts;
- promoting public transports: Luxembourg has an ambitious dual modal-split target at the 2020 horizon: attaining 25% of home-work journeys by public transport against 75% by private vehicles, as well as reaching 25% of daily trips by non-motorized traffic against 75% by

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[3] For which, according to IPCC rules, related emissions were counted in GHG balances of exporting countries, not in the one of Luxembourg.

[4] Other emissions are also considered: for instance, diesel vehicles – which emit less CO_2 than gasoline vehicles – must have a particle filter to benefit from a low tax.

motorized means. Instruments for achieving this goal, amongst other objectives in the transport sector, consist of a strategy called "MoDu" (for "*mobilité durable*").

[→ Section IV.3.1.2 & Box IV.1-5]

I.3.2. Buildings (residential, commercial, institutional)

Numerous policies, measures and incentives have been promulgated to increase energy-efficiency in buildings as well as for promoting the use of renewable energy sources. These measures concern old buildings (renovation) as well as new constructions that have to comply with more and more stringent energy constraints *[→ Section IV.3.1.1]*.

I.4. BRIDGING THE GAP – TARGET ASSESSMENT 2008-2012

As a conclusion, due to limited mitigation potentials and to considerations linked to the size and the location of the country, as well as to the anticipated economic and demographic growths that set off part of the energy-efficiency gains, national policies and measures showed not to be sufficient to bridge the gap between allocated emissions under the Kyoto Protocol and real emissions for the first Kyoto period 2008-2012 (CP1).

In fact, final numbers showed that, including the effects of implemented and additional policies and measures, GHG emissions reached an annual average of 12.023 Mio. t CO_2e over CP1; some 2.841 Mio. t CO_2e per year above the annual amount Luxembourg was supposed to emit to respect its -28% Kyoto reduction target.

Consequently, and since emission reductions from carbon sinks amounted to 0.373 Mio. t CO_2e only, Luxembourg made use of project-based mechanisms and international emissions trading of about 14.20 Mio. t CO_2e over CP1. The "Clean Development Mechanism" (CDM) provided 37% of the emission reductions, "Joint Implementation" (JI) and "International Emissions Trading" (IET) the remaining part *[→ Section V.6.1]*.

I.5. BRIDGING THE GAP – TARGET ASSESSMENT 2013-2020

The so-called "Doha amendment" extends the Kyoto Protocol, establishing a second commitment period from 2013-2020 (CP2).

Luxembourg submitted its instrument of acceptance to the United Nations Framework Convention on Climate Change on September 21, 2017.[5] According to recent announcements made in Bonn during COP23, the EU and its Member States intend to deposit simultaneously their ratification instruments of the Doha amendment latest by the end of 2017.

5 Source: https://treaties.un.org/Pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-7-c&chapter=27&clang=_en.

Independently of the setting into force of the Doha Agreement, the European Community has fixed its target in the so-called Effort Sharing Decision No 406/2009/EC[6] (ESD), with of a -20% cut of emissions below the 1990 emission level by 2020. The ESD also sets national emission targets for EU member states, "providing/leaving" Luxembourg with an emission reduction objective of −20% related to 2005 (not considering sectors/sources regulated by Directive 2003/87/EC on the EU ETS[7]) *[→ Section IV.1.1]*.

Transport sector emissions have a significant impact on the total GHG emission trends of Luxembourg and they can be very variable. At the end of CP1, the transport sector projections predicted high GHG emissions for the coming years and Luxembourg decided to enlarge its credit acquisition program to CP2 credits, focusing mainly on Gold Standard credits *[→ Section V.6.2]*.

However, the emission development in the transport sector was more moderate than expected, and from 2013 to 2016, Luxembourg's GHG emissions did not exceed its national targets. As of today, Luxembourg did not use any of the purchased CP2 credits. Similarly, based on the most recent WEM projections, it is expected that Luxembourg will not need to use Kyoto mechanisms in addition to its domestic PaMs to reach its CP2 target *[→ Sections V.3, V.4 & V.6.2]*.

I.6. Financing the use of Kyoto Flexible Mechanisms: the "Kyoto Fund"

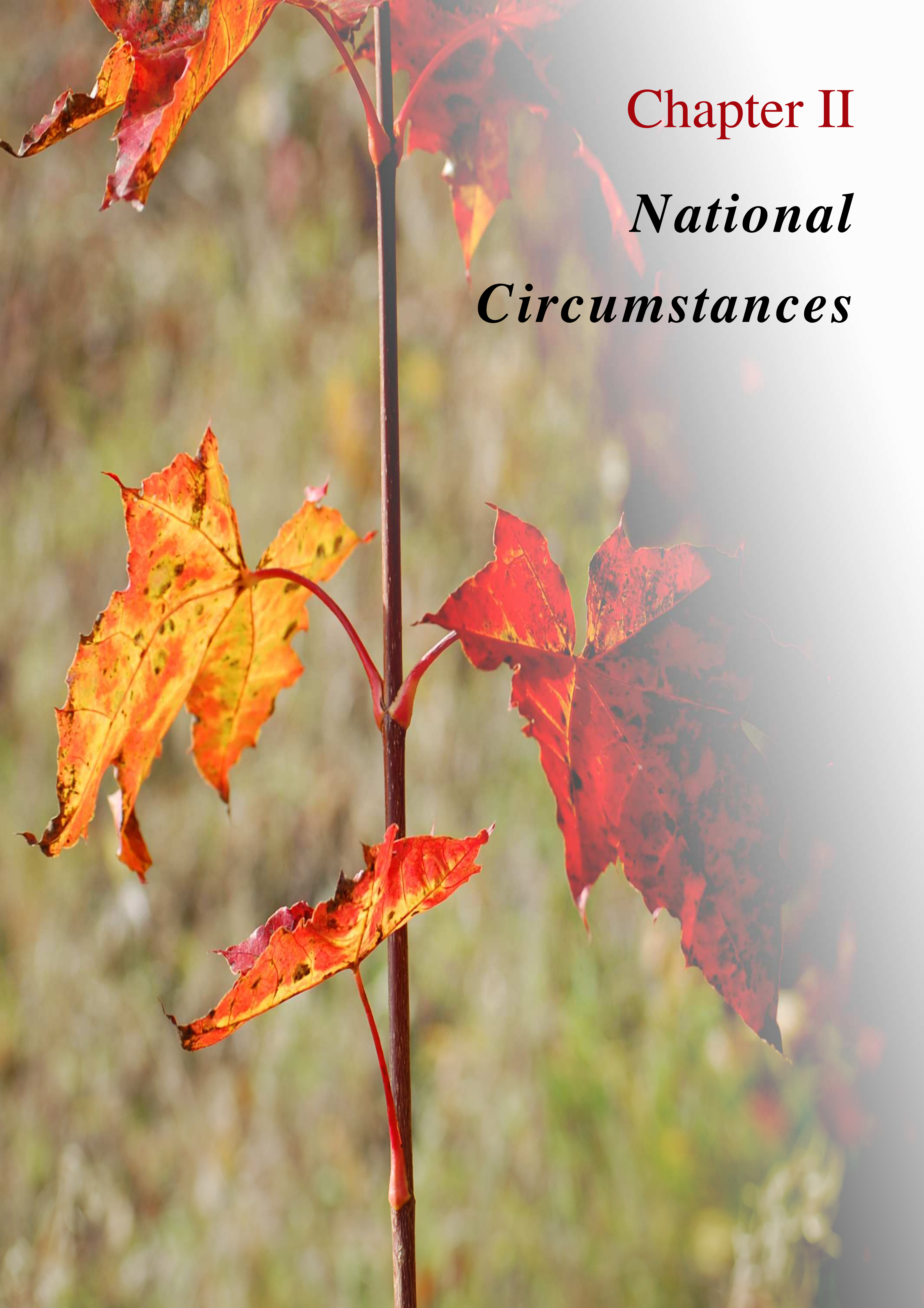
In order to finance the purchase of CO_2 credits in the framework of project-based mechanisms and international emissions trading, a fund was created by a Law of 23rd December 2004: the "Kyoto Fund"- later renamed "Climate & Energy Fund". Sources of revenue of this Fund are annual budgetary grants, 40% of the CO_2-based vehicle tax and 100% of the "Kyoto-cent". *[→ Section V.6.3]*

[6] Decision No 406/2009/EC of the European Parliament and of the Council of 23 April 2009 on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020 (http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0136:0148:EN:PDF).

[7] Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC (http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32003L0087&qid=1514287861312&from=EN).

Chapter II

National Circumstances



In line with paragraph 8 of the UNFCCC reporting guidelines, Chapter II provides a description of national circumstances and how they affect GHG emissions and removals, as well as how these circumstances and changes therein affected GHG emissions and removals over time.

Socio-economic developments and physical characteristics (geography and climate) are presented in the various sections of this chapter. They are complemented by a discussion of how both the UNFCCC and the Kyoto Protocol are challenging Luxembourg's action with regard to climate change *[→ Section II.12]*. The chapter concludes with an overview of the main developments of and drivers to GHG emissions in Luxembourg since 1990 *[→ Section II.13]*.

II.1. THE GRAND DUCHY OF LUXEMBOURG[8]

The Grand Duchy of Luxembourg has been an independent sovereign state since the Treaty of London was signed on 19 April 1839. The country is a **parliamentary democracy** in the form of a **constitutional monarchy** and is the second smallest Member State of the EU-28, after Malta. For many years, it has been characterized by **high economic and demographic growth rates**. The country is **located in the heart of North-Western Europe** and has direct borders with Belgium, Germany and France *[→ Figure II.1-1]*. It is therefore a crossroad for international trade and related transport flows, the most dynamic source of its GHG emissions.

The organisation of the Grand Duchy starts from the principle that the responsibilities of the different powers should be given to diverse apparatus of the state. As in every parliamentary democracy, the separation of powers is flexible in Luxembourg: many links exist between the legislative and executive branches, and solely the judicial power remains completely independent.

Legislative power resides in the joint action of the Parliament (*Chambre des Députés*), the Government and the Council of State *(Conseil d'Etat*); each entity serving a wholly separate function.

Parliament is made up of 60 members of Parliament (hereafter, MPs) elected for a five-year term combining a one-person-one-vote suffrage and a system of proportional representation. Its primary function is to vote on bills submitted by the Government and to control the executive branch. The MPs also possess a right of parliamentary initiative which is exercised by bringing in bills *(propositions de Loi*).

The Government has a right of initiative in legislative matters known as governmental initiative, which allows it to bring in bills (*projets de Loi*). After being examined by the Council of State, bills are put to the vote before Parliament, where the government normally holds a majority. After the parliamentary vote, the Grand Duke promulgates the legislative text, i.e. he commands its

8 Part of this section is based on texts from the "official portal of the Grand-Duchy of Luxembourg", "Political System" section (http://www.luxembourg.public.lu/fr/le-grand-duche-se-presente/systeme-politique/index.html), as well as on the following document: Press and Information Service of the Luxembourg Government (2012).

publication in the compendium of legislation known as the *Mémorial*, whereupon the text acquires legal status.

The Council of State is composed of 21 councillors. State councillors are formally appointed and dismissed by the Grand Duke on proposal by the Government, Parliament or the Council of State. In Luxembourg's unicameral system, the Council of State exerts the moderating influence of a second legislative assembly. It is required to voice its opinion on all items of legislation; that is to say on all bills brought in before the Parliament prior to voting by the MPs. Its opinion must entail a thorough examination to ensure compliance of the draft texts with the Constitution, international conventions and the rule of law. The role of the Council of State is one of persuasion rather than enforcement and is therefore advisory in nature.

Executive power is the prerogative of the Grand Duke, together with the Government and its members, i.e. the Ministers and, eventually, Secretaries of State. In practice, the Grand Duke chooses the Prime Minister based on election results, which takes place every five years jointly with the election of the members of the European Parliament (the "European Elections"). Then, the Prime Minister himself proposes the members of the Government. The Government appointed by the Grand Duke presents its political programme to the Parliament, which takes a vote of confidence, thereby giving the newly appointed Government a parliamentary majority on which it can rely. The actual Government, stemming from the general elections of the 20th of October 2013, has been appointed on the 4th of December 2013 and should remain in place up to the next general elections, in October 2018. It is made up of the Prime Minister, one Vice Prime Minister and 16 members having the title of Ministers (13) or of Secretary of State (3). It is worth noting that the number of ministerial departments generally exceeds the number of members of the Government called upon to serve in office; thus, a single minister normally holds more than one portfolio.[9]

As a conclusion, a parliamentary democracy in the form of a constitutional monarchy suits perfectly well to a country such as Luxembourg where social consensus and dialogue are key words. Consensus and dialogue have been, and will continue to be, of particular relevance for the definition of climate change related policies and action plans, as well as for the designing of related legislative texts. Luxembourg's first Action Plan for mitigating CO_2 emissions [Ministry of the Environment (2006b)] and the process leading to its revision up to May 2013 [Ministry of Sustainable Development and Infrastructure, Department of the Environment (2013b)] *[→ Section IV.1]* are good examples of bringing these two key words into play.

9 For more information on the Government in place in Luxembourg since December 2013, refer to http://www.gouvernement.lu/3311528/20131204-. Its political programme can be downloaded here: http://www.gouvernement.lu/3322796/Programme-gouvernemental.pdf. Climate change related actions are presented on pages 82 to 88.

Box II.1-1 – Legislative procedure in Luxembourg

Two types of legislative initiative are distinguishable:

> *Projet de Loi*: this preliminary draft of a law is drawn up by the relevant Ministry, approved by the Cabinet and then submitted to the Council of State for its opinion. It is then submitted to the Parliament.
>
> *Proposition de Loi*: one or more MPs may bring in a bill, which is submitted to the Conference of Presidents of the Parliament, which decides on its referral to a committee. The text of the proposal is submitted to the Council of State for its opinion and sent to the Government for its position.

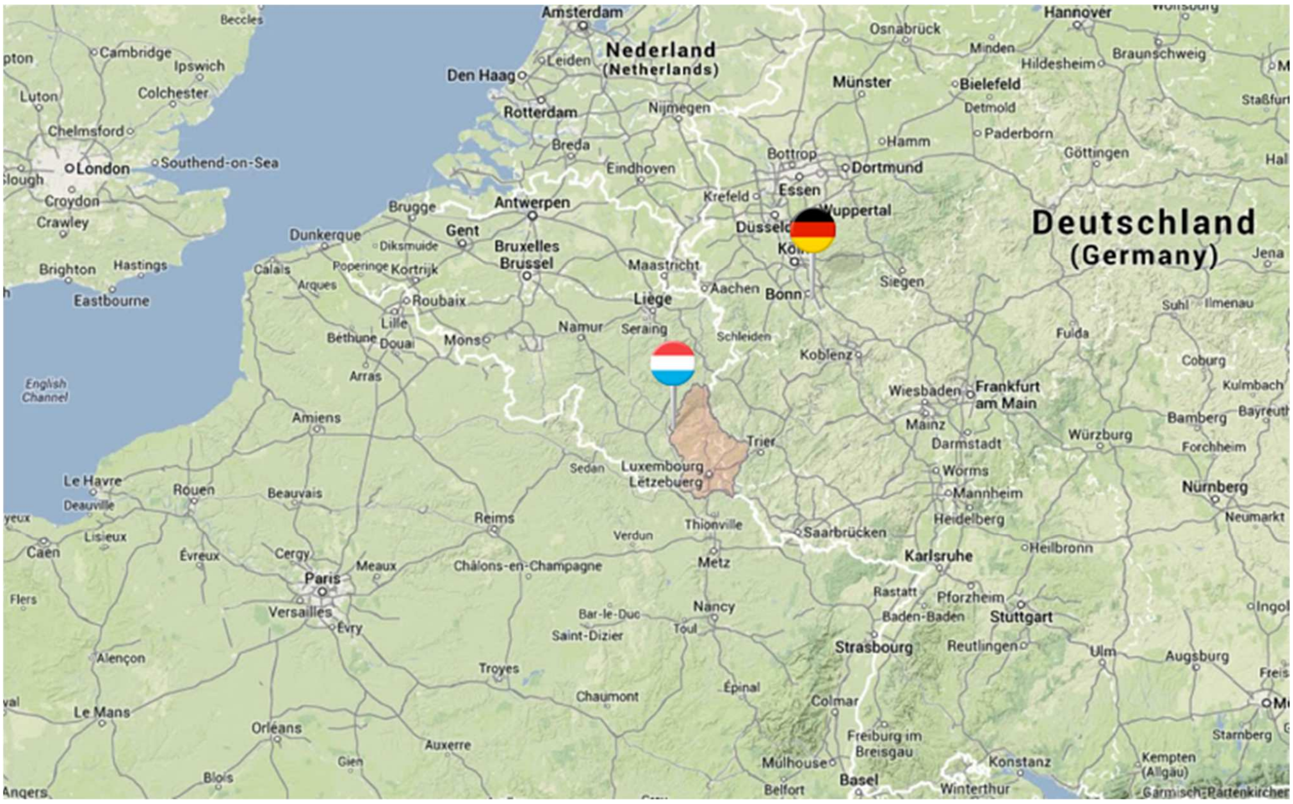
Once the Council of State has given its opinion, the bill is sent to the relevant parliamentary committee, which examines it and reports to the Parliament.

The debate in plenary session of the Parliament is conducted in two stages: a general discussion and a discussion article by article. Any deputy may propose amendments.

In Luxembourg's unicameral system, once the Parliament has voted on the draft, it must vote a second time on the whole text after a period of at least three months. It can however dispense with this vote if the Council of State accepts the waiver. If the latter does not give its consent, the Parliament must hold a second vote after a minimum period of three months.

The law finally adopted by the Parliament enters into force only after it has been promulgated by the Grand Duke, i.e. published in the *Mémorial* (compendium of legislation).

FIGURE II.1-1 – GEOGRAPHIC LOCATION OF LUXEMBOURG



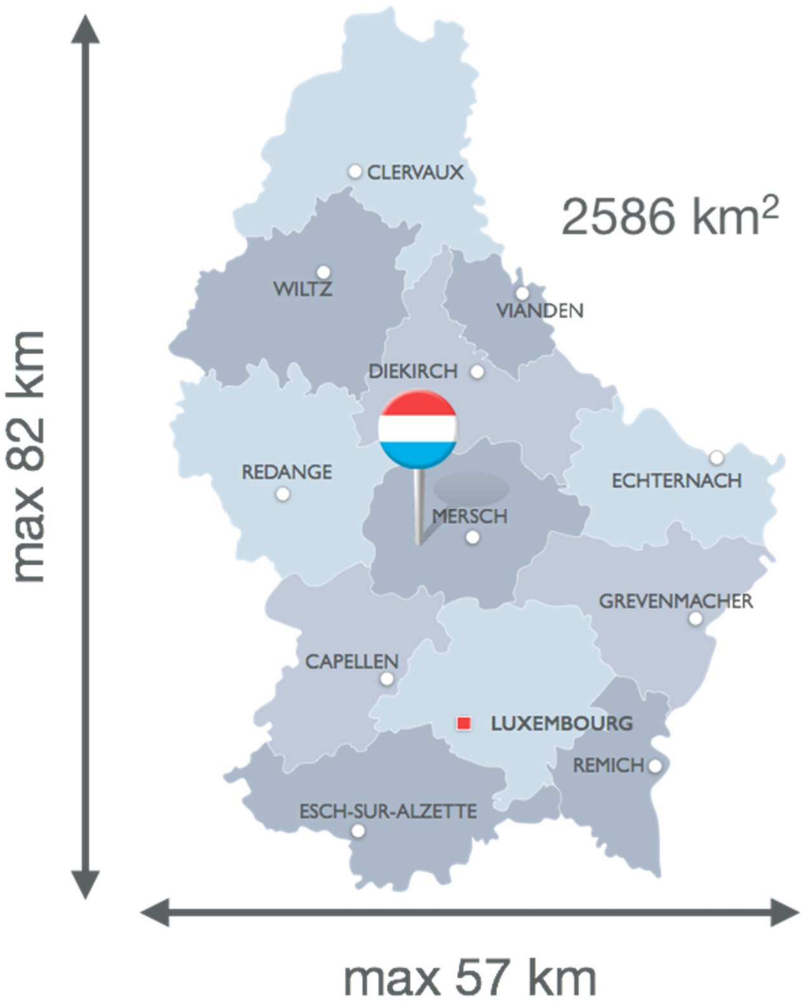
<u>Source</u>: Google Maps.

II.2. GEOGRAPHY

Luxembourg is a territory of 2 586 km². The maximum distance from north to south is some 82 km, from west to east about 57 km *[→ Figure II.2-1]*. Of the total area of Luxembourg, in 2012, 85.5% was agricultural land and land under forest – with around 51% for agriculture and 35% for forests. The built-up areas occupied 9.5% of the total surface and land covered by water and transport infrastructure about 5% *[→Table II.2-1 & Figure II.2-2]*.

The north of Luxembourg is a part of the Ardennes and is called "Ösling". Its altitude is at an average of 400 to 500 meters above sea level. The "Ösling" landscape is affected by hills and deep river valleys, as for instance the Sure River (Sauer). With 560 m, the highest elevation is called the "Kneiff" in Wilwerdange. In the South of Luxembourg lies the rank "Gutland", which belongs to the "Lothringer Stufenland". This area has higher population and industrial densities than "Ösling". The lowest point in the country, called "Spatz" (129 m above sea level), is located at the confluence of the Moselle and the Sure rivers in Wasserbillig. Most important rivers are the Moselle, the Sure, the Our – all three delimiting the border with Germany – and the Alzette.

FIGURE II.2-1 – LUXEMBOURG SIZE



Source: MDDI-DEV.

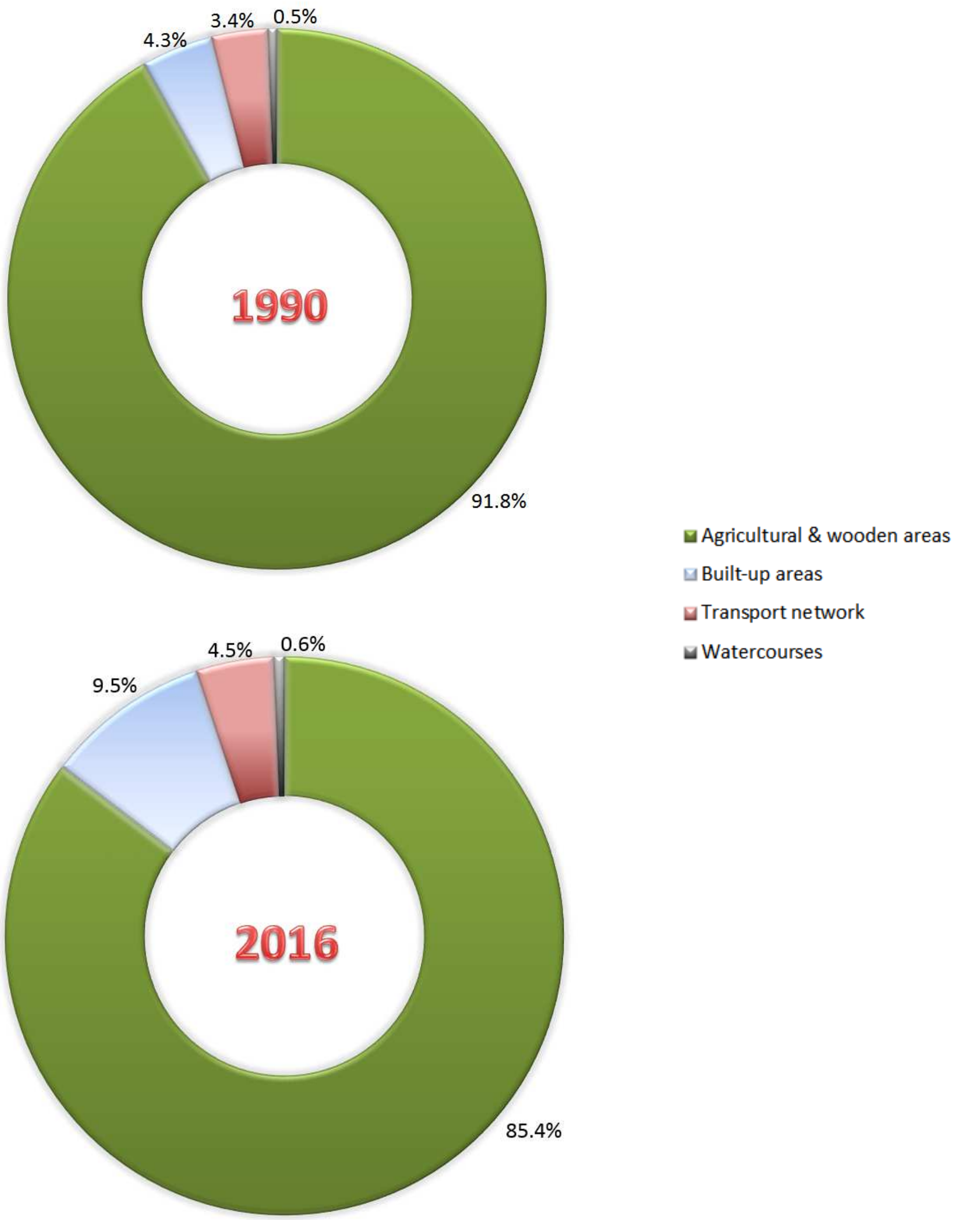
Table II.2-1 – Land use in Luxembourg: 1972-2016

percentages	1972	1990	2000	2010	2015	2016
Total land	100.0	100.0	100.0	100.0	100.0	100.0
Agricultural & wooden area	93.2	91.8	87.4	85.7	85.3	85.1
Built-up area	3.1	4.3	8.1	9.3	9.7	9.8
of which industrial area & other	*na*	*na*	*2.7*	*3.0*	*3.0*	*3.1*
Transport network & sheets of water	3.2	3.4	3.9	4.4	4.4	4.5
Watercourses	**0.5**	**0.5**	**0.6**	**0.6**	**0.6**	**0.6**

Source: STATEC, *Statistical Yearbook*, Table A.1101 (updated 08.03.2017): http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=12695&IF_Language=fra&MainTheme=1&FldrName=1.

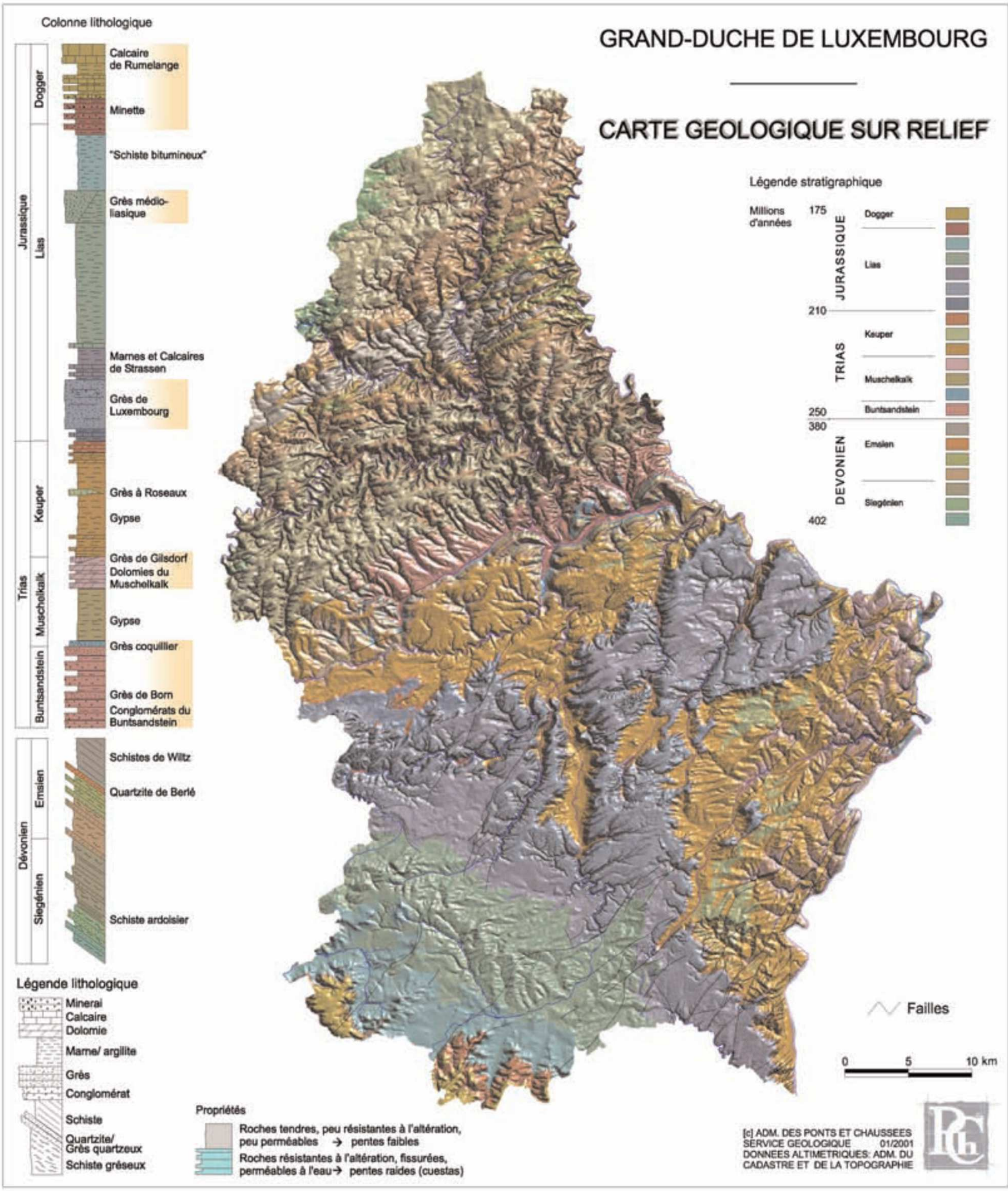
Note: na = not available.

Figure II.2-2 – Land use in Luxembourg: 1990 & 2016



Source: STATEC, *Statistical Yearbook*, Table A.1101 (updated 08.03.2017): http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=12695&IF_Language=fra&MainTheme=1&FldrName=1.

FIGURE II.2-3 – GEOLOGICAL MAP OF LUXEMBOURG'S TERRITORY



Source: STATEC, *Annuaire statistique du Luxembourg 2012*, page 39: http://www.statistiques.public.lu/fr/publications/series/annuaire-stat-lux/index.html.

II.3. CLIMATE[10]

II.3.1. Present climate: increasing average air temperatures and high variability in precipitation patterns during the last decades

The climate in Luxembourg can be characterized as a **moderate oceanic Western European climate** with mild winters and comfortable summers [Georgen et al., 2013].

As shown by the long-term annual means (WMO reference period from 1961-1990 and 1981-2010) measured at the Findel-Airport meteorological station WMO 06590 *[→ Table II.3-1a]*, temperatures have an unimodal distribution, with the lowest long-term mean values occurring during January (0.0°C for the period 1961-1990) and the highest air temperature in July (16.9°C for the period 1961-1990). Absolute minimum and maximum air temperatures ever recorded at Findel station until 31 December 2016 were -20.2°C (2 February 1956) and 37.9°C (8 and 12 August 2003)[11].

TABLE II.3-1A – LONG-TERM MEAN VALUES (1961-1990 & 1981-2010) OF AIR TEMPERATURE AND PRECIPITATION FOR FINDEL-AIRPORT STATION

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean air temperature [°C]	0.0 0.8	1.1 1.6	4.0 5.2	7.5 8.7	11.8 13.0	14.9 15.9	16.9 18.2	16.4 17.7	13.4 13.9	9.1 9.5	3.8 4.7	1.0 1.8	**8.3** **9.3**
Mean minimum air temperature [°C]	-2.3 -1.6	-1.8 -1.3	0.6 1.6	3.3 4.4	7.1 8.4	10.2 11.1	12.0 13.3	11.8 13.0	9.3 10.0	5.7 6.3	1.2 2.2	-1.3 -0.5	**4.7** **5.6**
Mean maximum air temperature [°C]	2.3 3.1	4.2 4.7	7.9 9.1	12.1 13.3	16.8 17.8	20.0 20.7	22.0 23.2	21.6 22.8	18.2 18.4	13.0 13.1	6.6 7.3	3.3 3.9	**12.3** **13.1**
Mean monthly precipitation sum [mm]	71.1 76.6	61.7 62.5	70.1 69.1	61.0 58.2	81.2 78.5	81.5 79.9	68.4 71.0	72.2 75.4	69.8 76.3	74.7 86.8	83.1 76.0	79.6 86.7	**874.4** **896.9**

Sources: 1961-1990 – MeteoLux (http://meteolux.lu/filedownload/73/2016_Informations_sur_le_climat_au_Luxembourg_en_2016_Anglais.pdf)
1981-2010 – MeteoLux (http://meteolux.lu/fr/climat/normales-et-extremes/).

According to definitions for GHG reporting, **Luxembourg is situated in a cool climate region** since its annual average air temperature is below 15°C: 8.3°C for the reference period 1961-1990 *[→ Table II.3-1]* and 9.3°C for the reference period 1981-2010.

A regional analysis of different stations operated by the Agriculture Technical Services Administration (*Administration des Services Techniques de l'Agriculture* – ASTA) throughout Luxembourg, shows that temperatures in the North of the country (Ösling) are on average up to 1°C lower than at Findel airport, whereas in the Moselle valley they are on average nearly 1°C higher *[→ Tables II.3-1b to 3-1d]*.

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10 The text of this Section has been prepared by Junk, J., Trebs, I., Hoffmann, L. of the *Luxembourg Institute of Science and Technology (LIST), Department Environmental Research and Innovation (ERIN)*, with additions by Andrew Ferrone of the *Administration des services techniques de l'agriculture (ASTA)*, Meteorological Service.

11 http://meteolux.lu/fr/climat/normales-et-extremes/.

TABLE II.3-1B – LONG-TERM MEAN VALUES (1981-2010) OF MEAN AIR TEMPERATURE FOR DIFFERENT ASTA STATIONS

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Asselborn	0.3	0.7	4.0	7.5	11.9	14.8	17.0	16.3	12.6	8.7	4.0	1.2	**8.3**
Clemency	1.0	1.5	5.0	8.5	13.1	16.2	18.2	17.4	13.4	9.4	4.7	2.0	**9.2**
Grevenmacher	1.7	2.5	5.9	9.5	13.9	17.0	19.1	18.2	14.1	10.1	5.5	2.7	**10.0**
Remich	1.6	2.5	6.2	9.8	14.2	17.1	19.3	18.5	14.5	10.3	5.5	2.7	**10.2**

TABLE II.3-1C – LONG-TERM MEAN VALUES (1981-2010) OF MAXIMUM AIR TEMPERATURE FOR DIFFERENT ASTA STATIONS

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Asselborn	2.7	3.9	7.9	12.2	16.7	19.5	21.9	21.5	17.3	12.5	6.6	3.2	**12.2**
Clemency	3.4	5.0	9.3	13.5	18.0	20.9	23.4	23.0	18.6	13.5	7.5	4.2	**13.4**
Grevenmacher	4.3	6.1	10.7	15.2	19.7	22.6	25.1	24.6	20.2	14.6	8.6	5.3	**14.7**
Remich	4.1	6.0	10.6	14.9	19.3	22.3	24.6	24.2	19.7	14.4	8.3	5.1	**14.5**

TABLE II.3-1D – LONG-TERM MEAN VALUES (1981-2010) OF MINIMUM AIR TEMPERATURE FOR DIFFERENT ASTA STATIONS

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Asselborn	-1.8	-2.0	0.6	2.9	6.9	9.5	11.6	11.0	8.4	5.5	1.8	-0.5	**4.5**
Clemency	-1.5	-1.5	1.2	3.2	7.4	10.1	12.1	11.6	8.7	5.8	2.3	-0.3	**4.9**
Grevenmacher	-0.8	-0.8	1.9	4.1	8.1	11.0	13.0	12.4	9.6	6.8	2.8	0.6	**5.7**
Remich	-0.7	-0.4	2.4	4.8	8.8	11.5	13.6	13.0	10.0	6.8	3.0	0.5	**6.1**

Source: ASTA, Agrimeteo (http://asta.public.lu/meteorologie/meteo.html).

The regional distribution of precipitation *[→ Table II.3-1e]* shows higher regional variability. A general gradient from the North-West to the South-East of the country can be noted, with highest annual average values recorded in Arsdorf (1055 mm) and lowest values in Remich (725 mm).

TABLE II.3-1E – LONG-TERM MEAN VALUES (1981-2010) OF PRECIPITATION FOR DIFFERENT ASTA STATIONS

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Altrier, Hersdorf	72	56	60	51	62	65	65	61	63	69	70	81	**775**
Arsdorf	120	84	88	69	75	75	74	78	76	100	96	120	**1055**
Asselborn	81	64	69	58	68	71	68	74	69	75	75	84	**856**
Berdorf	73	59	63	50	63	65	68	60	68	73	68	82	**791**
Beringen	76	58	61	53	64	63	59	64	64	69	66	85	**781**
Bettborn, Pratz	90	67	69	55	66	65	60	67	66	81	75	96	**857**
Clemency	92	73	73	52	64	65	62	63	64	78	77	94	**856**
Ermsdorf	78	62	64	55	68	66	73	70	66	76	68	83	**830**
Fourhen	77	56	62	51	61	61	64	62	63	72	68	82	**780**
Grevenmacher	66	53	54	46	58	67	61	61	60	69	63	73	**729**
Holler	86	69	79	59	73	73	76	74	73	76	76	89	**903**
Hosingen	93	71	78	67	72	67	73	70	75	84	83	97	**930**
Kehmen	102	75	78	65	73	67	67	74	71	86	86	106	**951**
Koerich	88	70	69	54	62	65	56	63	62	78	76	95	**834**
Lorentzweiler	83	67	66	55	68	70	64	66	66	75	72	90	**843**

Mamer	85	68	68	54	70	68	64	64	65	79	74	94	**852**
Mullendorf	84	66	67	54	65	69	60	63	66	77	73	93	**837**
Remerchen	70	56	58	51	63	67	71	60	64	75	65	78	**779**
Remich	63	51	55	47	58	68	61	59	62	70	60	71	**725**
Saeul	93	65	68	55	67	65	60	61	64	80	75	98	**852**
Troine, Wincrange	92	73	80	67	76	76	74	78	76	84	83	100	**959**

Source: ASTA, Agrimeteo (http://asta.public.lu/meteorologie/meteo.html).

Climate conditions have significant impacts on energy use for heating or cooling purposes. An increase in average air temperature in the forthcoming years could have a positive impact on energy consumption, especially in the residential, commercial and institutional sectors. However, in case of a substantial increase of air temperatures, an increase in energy consumption related to a more frequent use of air conditioning systems could also be expected.

As shown by measurements at the Findel-Airport meteorological station *[→ Table II.3-2]*, two conclusions can be drawn: firstly, an increase in average air temperature is observed over the last decades *[→ Figure II.3-1 & II.3-2]*; secondly, annual precipitation does not show such clear trends *[→ Figure II.3-3 & II.3-4]*. Similar observations have been obtained in scientific studies on the climate in Luxembourg, notably in Goergen et al. (2013), Lokys et al. (2016) and Junk et al. (2016). From 1990 onwards, annual mean air temperatures for the Findel-Airport station started to increase rather sharply to systematically exceed the 1961-1990 mean value *[→ Figure II.3-1]*. Temperature maxima have mostly been observed during the last 25 years *[→ Figure II.3-2]*. Further analysis of the data suggests that the average air temperature in Luxembourg has increased mainly during the winter seasons, coupled with longer frost-free periods [Molitor et al., (2014)].

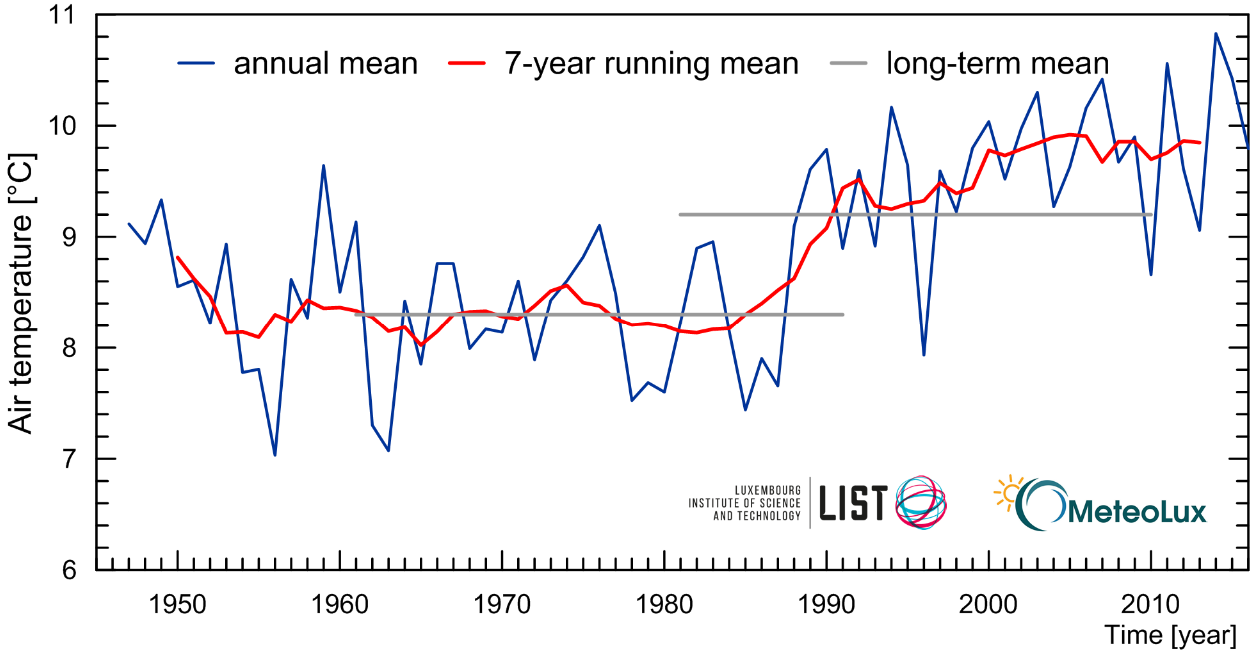
Further analysis of the data suggests that the average air temperature in Luxembourg has increased during the winter seasons, coupled with longer frost-free periods.

TABLE II.3-2 – MEAN VALUES OF AIR TEMPERATURE (DAILY MEAN. MAXIMUM & MINIMUM) AND PRECIPITATION FOR THE FINDEL-AIRPORT STATION FOR DIFFERENT TIME SPANS AND INDIVIDUAL YEARS

	1961-1990	1981-2010	2005	2010	2015	2016
Mean air temperature [°C]	8.3	9.3	9.6	8.7	10.4	9.8
Mean minimum air temperature [°C]	4.7	5.6	5.9	5.1	6.6	6.1
Mean maximum air temperature [°C]	12.3	13.1	13.6	12.4	14.3	13.7
Mean yearly precipitation sum [mm]	874.4	896.9	722.5	917.2	605.9	864.6

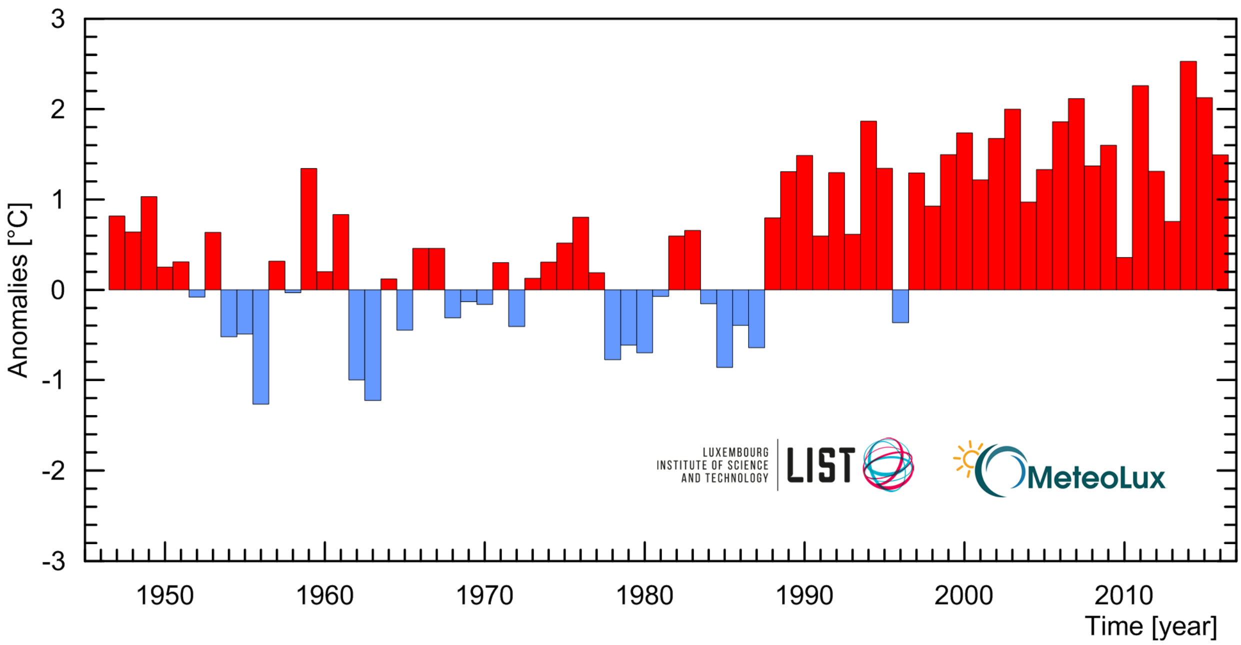
Sources: MeteoLux (http://meteolux.lu/filedownload/73/2016_Informations_sur_le_climat_au_Luxembourg_en_2016_Anglais.pdf)

FIGURE II.3-1 – AVERAGE ANNUAL AIR TEMPERATURE (BLUE LINE), 7-YEAR RUNNING MEAN (RED LINE) AND LONG-TERM ANNUAL MEAN 1961-1990 AND 1981-2010 (GREY LINES) FOR THE FINDEL-AIRPORT STATION: 1947-2016



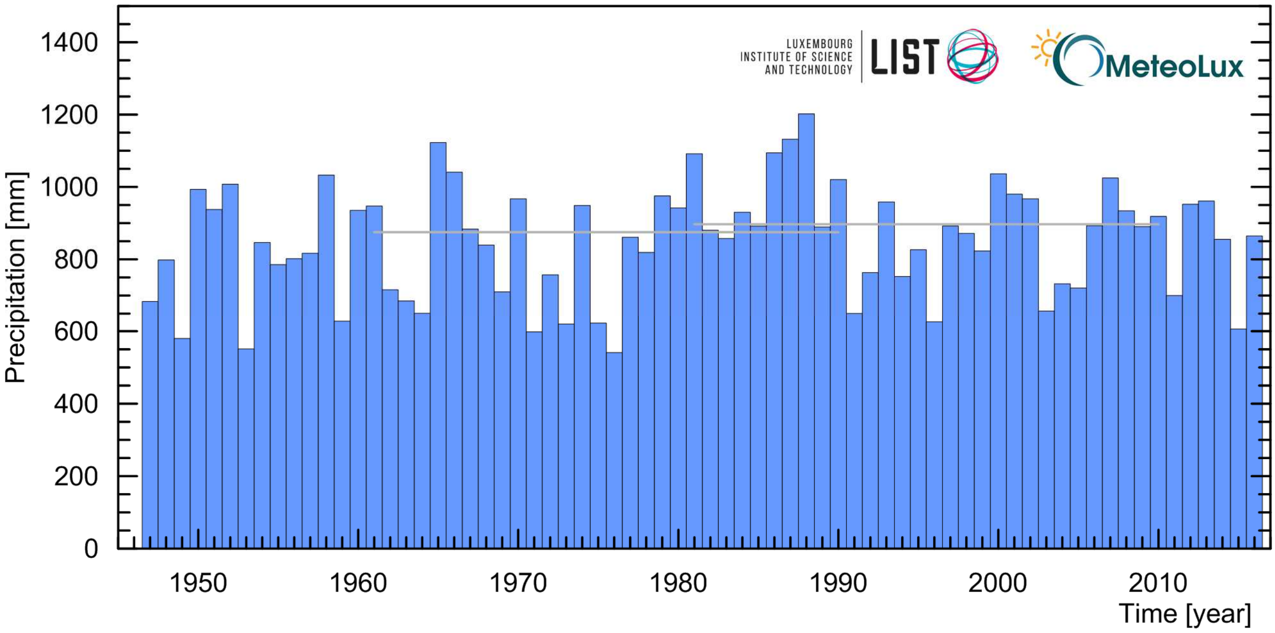
Sources: Findel-Airport station (MeteoLux) and Luxembourg Institute of Science and Technology (LIST). unpublished.

FIGURE II.3-2 – ANOMALIES OF ANNUAL AIR TEMPERATURE FROM THE REFERENCE PERIOD 1961-1990 FOR THE FINDEL-AIRPORT STATION: 1947-2016



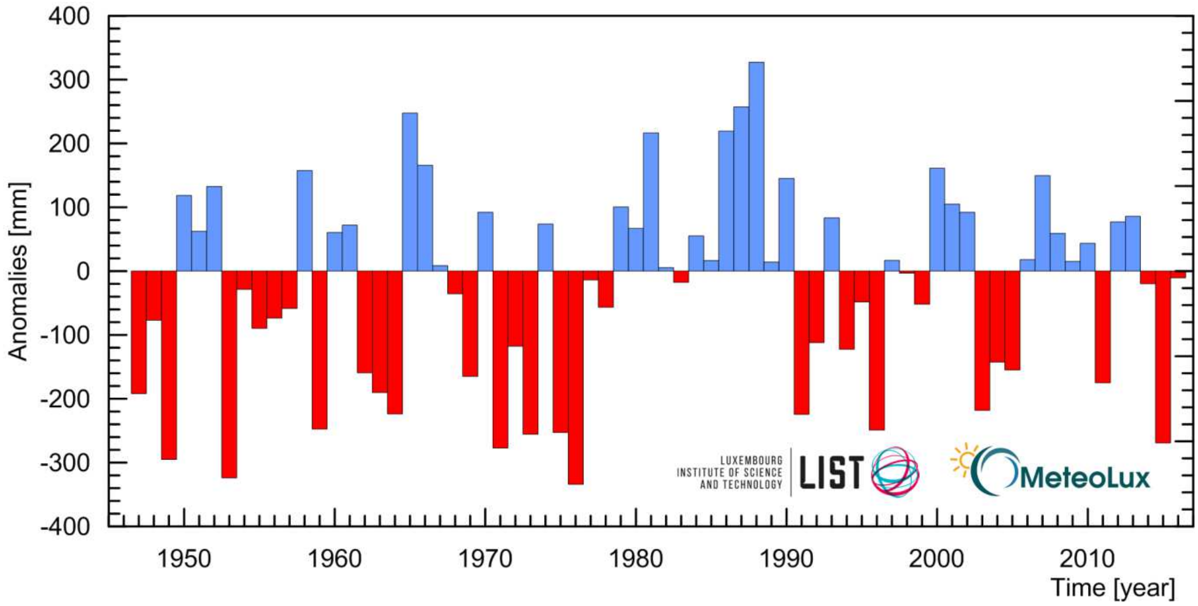
Sources: Findel-Airport station (MeteoLux) and Luxembourg Institute of Science and Technology (LIST). unpublished.
Note: anomalies from the reference period 1961 until 1990: long-term mean: 8.3°C.

FIGURE II.3-3 – ANNUAL PRECIPITATION TOTALS (BLUE COLUMNS) AND LONG-TERM ANNUAL MEAN 1961-1190 AND 1981-2010 (GREY LINES) FOR THE FINDEL AIRPORT STATION: 1947-2016.



Sources: Findel-Airport station (MeteoLux) and Luxembourg Institute of Science and Technology (LIST). unpublished.

FIGURE II.3-4 – ANOMALIES OF ANNUAL PRECIPITATION TOTALS FROM THE REFERENCE PERIOD 1961-1990 FOR THE FINDEL-AIRPORT STATION: 1947-2016

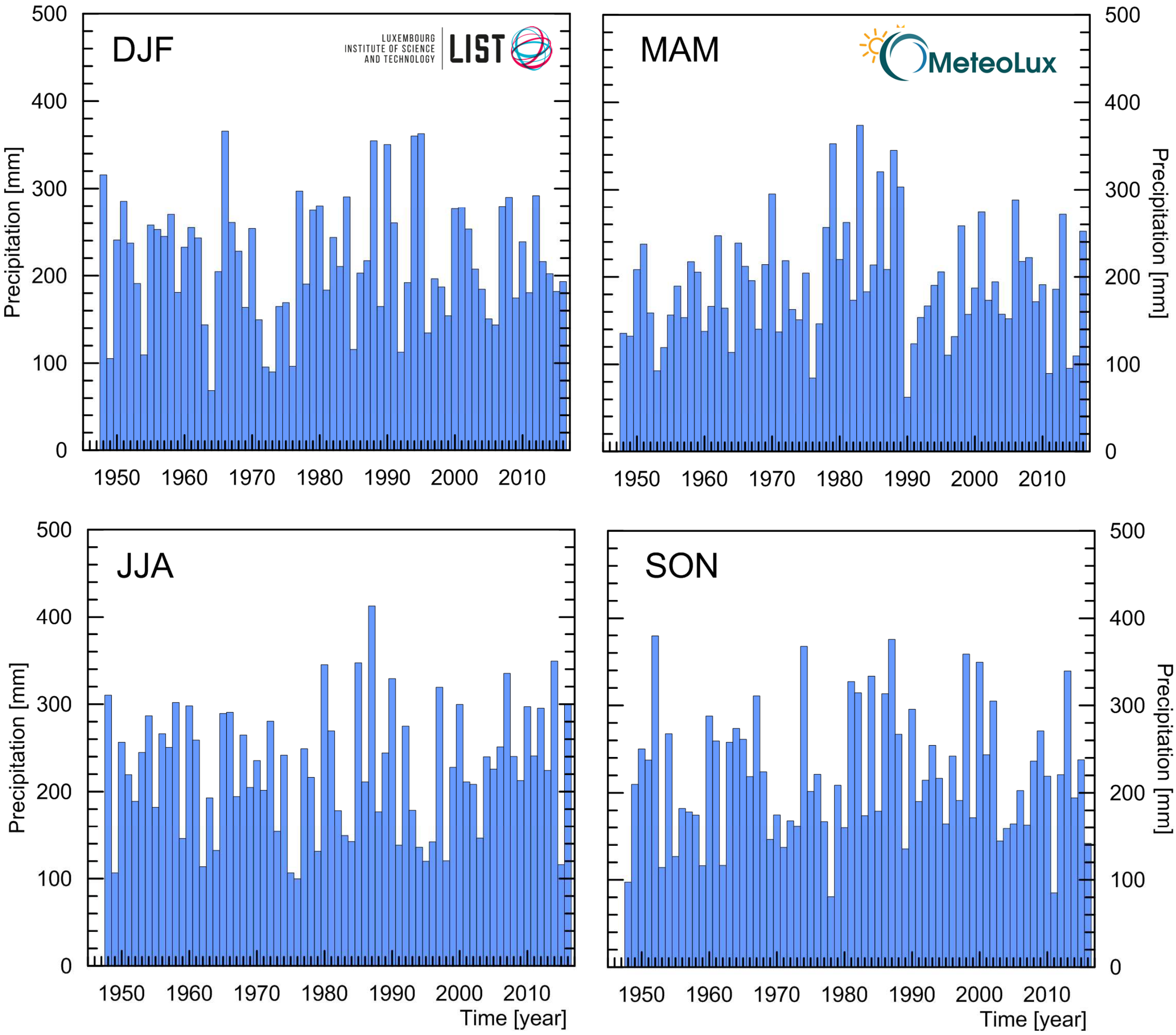


Sources: Findel-Airport station (MeteoLux) and Luxembourg Institute of Science and Technology (LIST). unpublished.
Note: anomalies from the reference period 1961 until 1990: long-term mean: 874 mm.

With regard to annual precipitation, no clear changes can be detected from the direct measurements *[→ Table II.3-2]*. During the hydrological winter half-year (October / November to March / April) evaporation is rather unimportant, which means that the precipitation falling during this period is almost completely discharged or stored underground. The most part of the precipitations falling during the summer half year evaporates and is very important for the development of the vegetation. However, the seasonal distribution of precipitation totals has shown substantial variability through the past 70 years *[→ Figure II.3-5]*.

Most of this variability can be attributed to changes in the large-scale atmospheric circulation patterns. An increase in westerly atmospheric fluxes during winter months was shown by Buchholz et al. (2010) for the past years. In combination with higher air temperatures, this has led to higher flood frequencies in most national river basins (Pfister et al. 2000 and 2004).

FIGURE II.3-5 – SEASONAL PRECIPITATION TOTALS (DJF = WINTER. MAM = SPRING. JJA = SUMMER. SON = AUTUMN) FOR THE FINDEL-AIRPORT STATION: 1947-2016

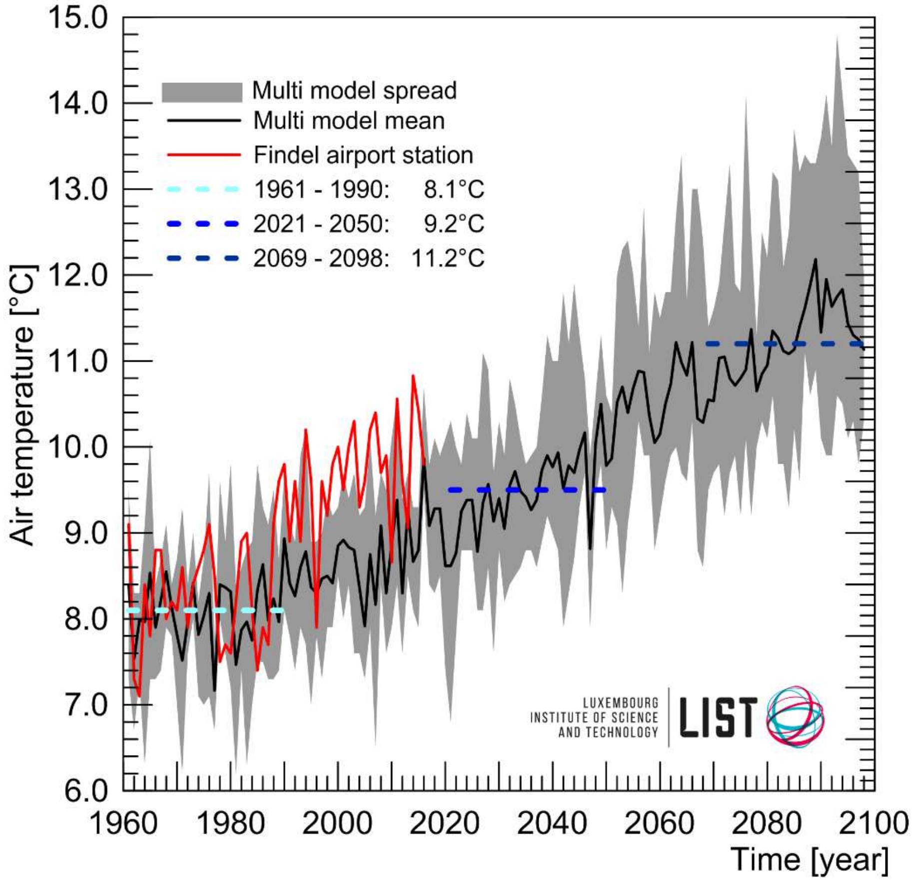


Sources: Findel-Airport station (MeteoLux) and Luxembourg Institute of Science and Technology (LIST). unpublished.

II.3.2. Climate projections for air temperature and precipitation

Results of a research project (FNR-CLIMPACT) show an increase in mean air temperature for the Grand Duchy of Luxembourg. Based on selected results of the FP6 ENSEMBLES project climate change projections,[12] mean annual temperatures are expected to reach up to 11.6°C for the period 2071 until 2100. This value refers to the GHG emission scenario A1B *[→ Figure II.3-5]*.[13]

FIGURE II.3-5 – PROJECTIONS OF MEAN ANNUAL AIR TEMPERATURE



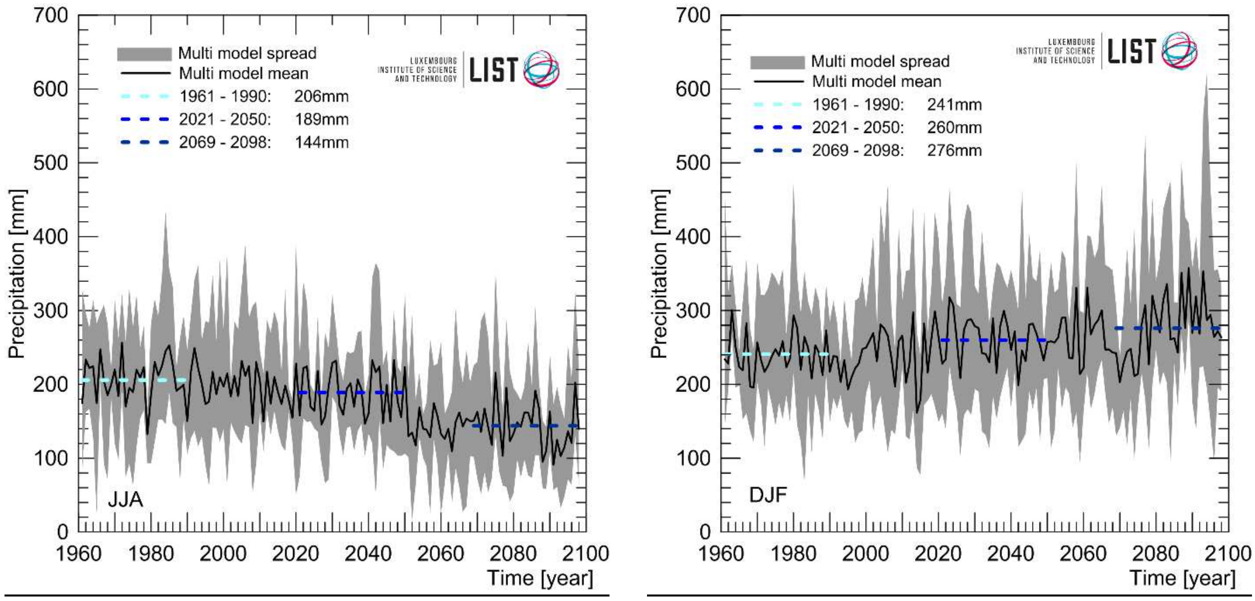
Source: Luxembourg Institute of Science and Technology (LIST). unpublished.
Notes: (1) based on selected ENSEMBLES data sets. A1B emission scenario.
(2) anomalies from the reference period 1961 until 1990: long-term mean: 8.9°C.

The results concerning changes in precipitation suggest a relative stability in annual totals until 2100 *[→ Figure II.3-6]*. However, a substantial redistribution of seasonal precipitation totals can be expected in the second half of the 21st century, with a decrease in summer rainfall and an increase in winter precipitation *[→ Figure II.3-7]*. It is also likely that there will be an increase in heavy rain events, especially during the summer months. In addition, the winter precipitation will probably fall more often as rain and less often as snow, whereby the risk for floods will increase especially during the winter months and spring.

12 More details on ENSEMBLE are provided in Box VI.1-1 in Section V.1.1. see also http://ensembles-eu.metoffice.com.

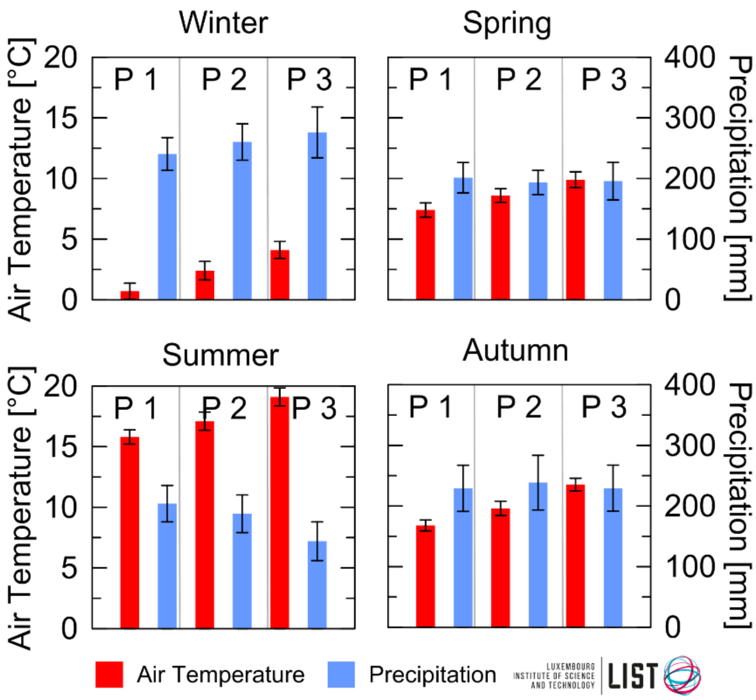
13 Results were published in a series of peer reviewed papers e.g.: Eickermann et al. (2014), Goergen et al. (2013), Junk et al. (2014), Junk et al. (2016), Matzarakis et al. (2013), Molitor et al. (2013), Molitor et al. (2014).

FIGURE II.3-6 – PROJECTIONS OF PRECIPITATION SUMS FOR THE METEOROLOGICAL WINTER AND SUMMER SEASONS



Source: Luxembourg Institute of Science and Technology (LIST). unpublished.
Notes: (1) based on selected ENSEMBLES data sets. A1B emission scenario.
(2) JJA = meteorological summer season (June – July – August); DJF = meteorological winter season (December – January – February).

FIGURE II.3-6 – PROJECTIONS OF MEAN ANNUAL AIR TEMPERATURE AND PRECIPITATION SUMS FOR THE METEOROLOGICAL SEASONS



Source: Luxembourg Institute of Science and Technology (LIST). Georgen et al. (2013).
Notes: (1) based on selected ENSEMBLES data sets. A1B emission scenario.
(2) periods: P1 = 1961-1990 // P2 = 2021-2050 // P3 = 2069-2098.

II.4. POPULATION AND WORKFORCE

II.4.1. A strong population growth driven by immigration

At the end of 2016, the **population of Luxembourg** amounted to 590 700 inhabitants. Within slightly more than 55 years, the residential population has grown by some 276 000 inhabitants or about 87.5% – 55.7% since 1990 ***[→Table II.4-1]***. The average annual growth rate of the resident population of Luxembourg is high compared to the rates of its neighbouring regions: between 1990 and 2016, the average annual growth rate for Luxembourg (1.7%) was about 4 times higher than its equivalent for the *Grande Région*.[14] It even reached 1.9% p. a. since 2000 ***[→Figure II.4-2]***.

Demographic growth in Luxembourg is actually dominated by **immigration**. Nationals themselves saw their number stagnating, and without immigrants taking the citizenship of Luxembourg they would even have fallen. At the end of 2016, 47.7% of the residential population did not have the citizenship of Luxembourg. This percentage was only around 30% in 1990 ***[→Figure II.4-1]***. The main driver behind these demographic trends is the economic restructuring and development of the country towards the tertiary sector coupled with attractive wages ***[→ Section II.5]***.

TABLE II.4-1 – CALCULATED POPULATION: 1960-2016

calculated on 31st December	1960	1990	1995	2000	2005	2010	2015	2016
Resident population (x 1000)	314.9	384.4	411.6	439.0	469.1	511.8	576.2	590.7

Source: STATEC, *Statistical Yearbook*, Table B.1100 (updated 05.05.2017): http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=12856&IF_Language=fra&MainTheme=2&FldrName=1.

Since population projections are based on scenarios derived from past statistical data, population forecasts is a continuation of the demographic trend in Luxembourg. Projections calculated by STATEC in 2010 forecast, under the "baseline" scenario, that almost 750 000 inhabitants could be living in Luxembourg by 2050.[15] Nevertheless, this forecast is now outdated. Indeed, latest projections under the "baseline" scenario, as reported by Eurostat, anticipate almost 940 000 inhabitants by 2050 ***[→Figure II.4-2]***. This number could even reach more than 1 million inhabitants under the "higher migration" scenario.[16] As it is the case for any forecasts, these predictions should be treated with caution because they cannot predict radical changes in the economic structure or demographics of a country, especially a small one whose economy relies heavily on a few economic sectors. However, since population growth is one of the key drivers for domestic energy use, mainly in the housing and transportation sector, these forecasts illustrate the scale of one of the many

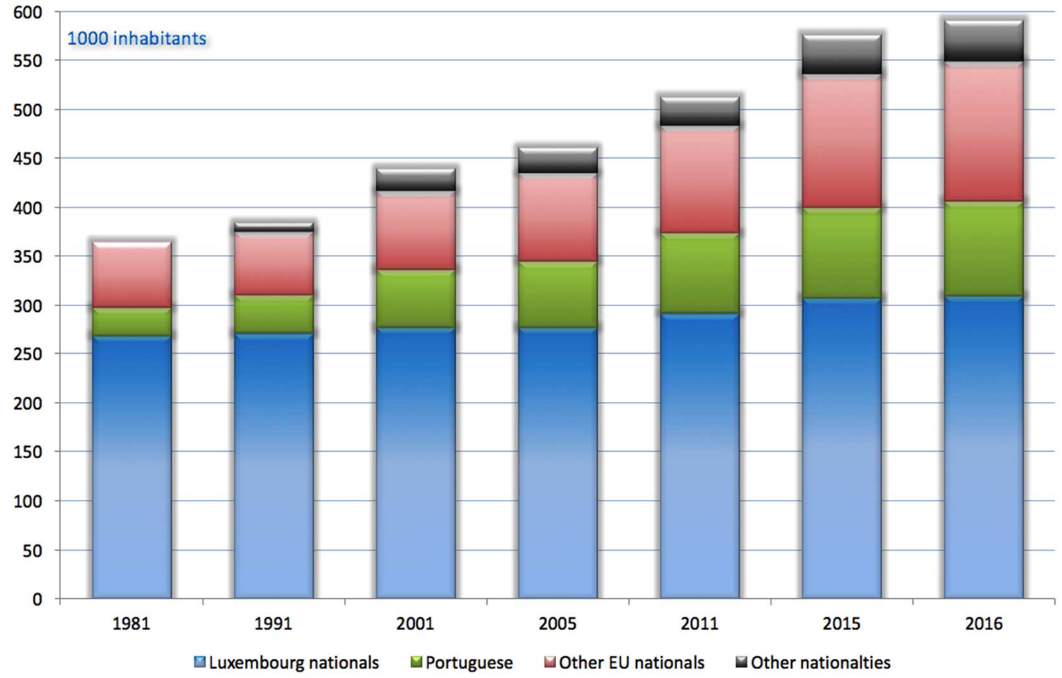
14 Refer to Box II.4-1 for a presentation of the *Grande Région*.

15 For details, see STATEC (2012), *Projections socio-économiques 2010-2060*, Bulletin du STATEC N° 5/2010, Luxembourg, pages 262-272 (http://www.statistiques.public.lu/fr/publications/series/bulletin-statec/2010/05-10-Projpop/index.html).

16 These projections were computed in 2015 upon invitation of the EU Council meeting of the Economic and Financial Affairs : http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=proj_15npms&lang=en as well as http://ec.europa.eu/eurostat/statistics-explained/index.php/People_in_the_EU_%E2%80%93_population_projections. They were produced in the framework of the European Commission Ageing Working Group: https://europa.eu/epc/working-group-ageing-populations-and-sustainability_en and https://europa.eu/epc/sites/epc/files/docs/pages/ageing_report_2015_en.pdf,

challenges Luxembourg is facing in the definition of measures aiming at reducing its GHG emissions.

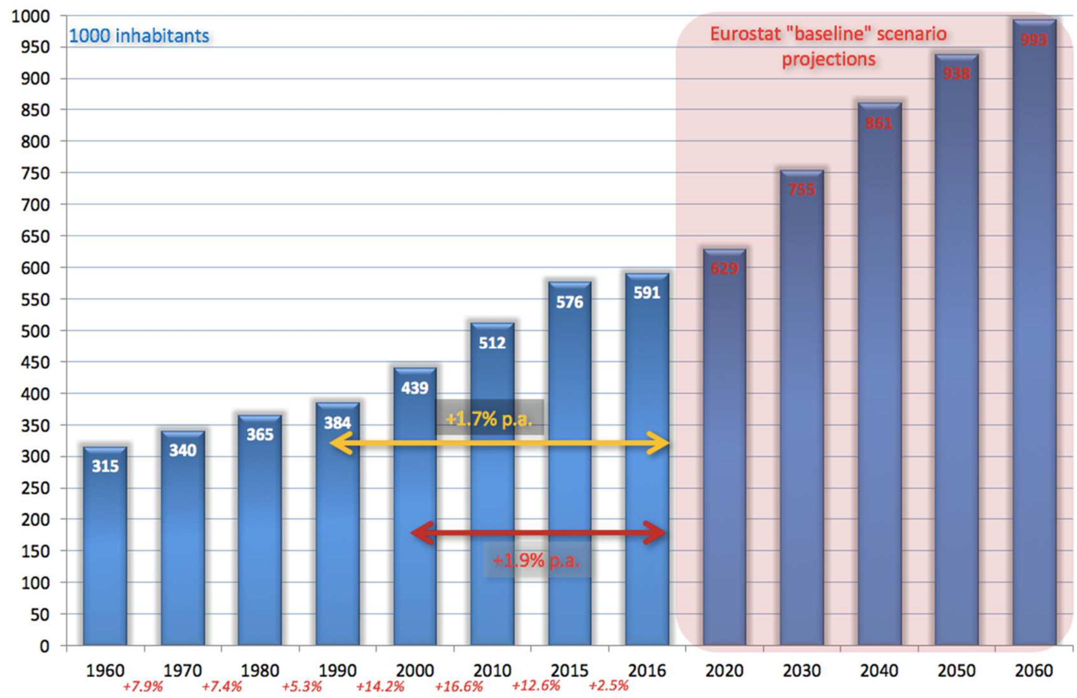
FIGUREII.4-1 – POPULATION STRUCTURE ON 31ST DECEMBER: 1981-2016



Source: STATEC, *Statistical Yearbook*, Table B.1101 (updated 05.05.2017): http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=12856&IF_Language=fra&MainTheme=2&FldrName=1.

Note: 1981, 1991, 2001 and 2011 data are coming from population censuses held every decade, other years are calculated by STATEC.

FIGURE II.4-2 – POPULATION ON 31ST DECEMBER: 1960-2060



Sources: STATEC, *Statistical Yearbook*, Table B.1101 (updated 05.05.2017): http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=12856&IF_Language=fra&MainTheme=2&FldrName=1.
Eurostat, *Population projections*, Table proj_15npms (updated 19.06.2017): http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=proj_15npms&lang=en.

It is also worth analysing **households** when discussing population growth. Based on population censuses that are usually taking place every 10 years, the number of households grew by 44.1% between the 1991 and 2011 censuses (from 144 696 households in 1991 to 208 565 in 2011); i.e. slightly more than the population (+34.7% between 1991 and 2011). Consequently, the average number of persons per household fell from 2.69 in 1991 to 2.52 in 2011.[17]

A projection calculated by STATEC in 2011 foresees an increase of households along with the population predicted growth, combined with a continuous decrease of the average number of persons per household (2.33 in 2020, 2.23 in 2030). *[→Figure II.4-3]*.

FIGURE II.4-3 – HOUSEHOLDS AND AVERAGE NUMBER OF PERSONS PER HOUSEHOLDS: 1991-2030

Sources: STATEC, *Statistical Yearbook*, Table B.1400 (updated 14.05.2013):
http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=12830&IF_Language=fra&MainTheme=2&FldrName=1&RFPath=72
STATEC, *Economie et Statistiques N° 55 – Projection des ménages privés et des besoins en logements 2010 - 2030* (published 26.10.2010), table 9, p. 26:
http://www.statistiques.public.lu/catalogue-publications/economie-statistiques/2011/55-2011.pdf

II.4.2. Workforce: the importance of cross-border commuters

The economic restructuring and development of Luxembourg led to a doubling of the workforce in the last 20 years. The resident population of Luxembourg nationality was unable to meet this increasing demand for labour. The number of Luxembourg nationals employed increased from some 103 700 units in 1995 to 140 770 in 2016, representing an average annual growth rate of only

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17 Data on households are gathered only during the population censuses. The last one took place in 2011. There are no updates for the subsequent years.

1.5%. How, therefore, could this urgent economic need be satisfied? The initial response was to resort to **immigration**. The number of foreign employees living and working in Luxembourg rose from 54 900 in 1995 to 100 430 in 2016 – an average annual growth rate of 2.9%. However, this was not enough. Therefore, the **cross-border commuters** came into play. Between 1995 and 2015, the number of cross-border workers increased from 56 900 to 171 200, at an average annual growth rate of 5.6% *[→Table II.4-2]*.[18]

TABLE II.4-2 – PERSONS EMPLOYED: 1995-2016

in thousand persons	1995	2000	2005	2010	2015	2016
Resident workers – Lux. nationals *(B.3106 & E.2309)*	103.7	106.3	108.5	118.0	134.5	140.8
Resident workers – foreigners *(B.3106 & B.3107)*	54.9	67.2	77.9	89.7	100.5	100.4
Cross-border workers *(B.3107)*	56.9	90.3	121.2	151.9	171.1	177.2
Total workers/employment *(B.3100)*	**215.5**	**264.0**	**307.6**	**359.6**	**406.1**	**418.4**

Sources: MDDI-DEV calculations on the basis of STATEC, *Statistical Yearbook*, Tables B.3100 (updated 10.05.2017), B.3107 (updated 06.12.2017) & E.2309 (version 10.2017):
http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=12951&IF_Language=fra&MainTheme=2&FldrName=3&RFPath=92
http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=12928&IF_Language=fra&MainTheme=2&FldrName=3&RFPath=92
http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=13161&IF_Language=fra&MainTheme=5&FldrName=2&RFPath=21

Notes: (1) due to revisions in the calculation of the various measures of employment, it is not possible to go back further than 1995.
(2) this table presents the total employment, i.e. paid workers and self-employed workers. Figures are annual cumulative averages.

For 2016, among the persons employed, 50.7% of the commuters came from France, 24.7% from Germany and 24.6% from Belgium. In total, the commuters accounted for 42% of the total workforce in Luxembourg and for 30% (i.e. more than a quarter) of the residential population *[→Figure II.4-4]*.[19] The commuting flows amongst the various regions of the *Grande Région* clearly show the economic attraction of Luxembourg *[→Figure II.4-5]*.

A vast majority of workers from abroad commute by car.[20] However, in order to alter the current modal split of home-work journeys, Luxembourg invests predominantly and jointly with the neighbouring regions into the public transport offer *[→ Section IV.1.4]*.

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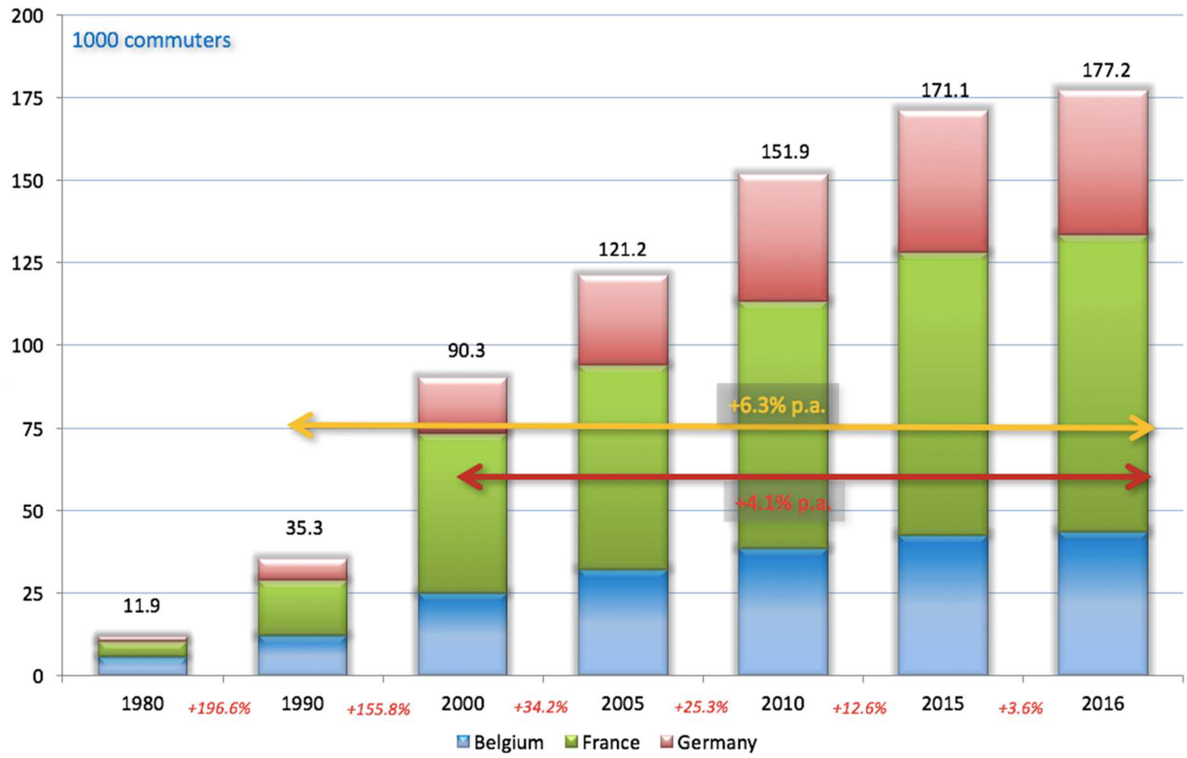
18 Figures indicated in this paragraph are annual cumulative averages.

19 Calculated from STATEC, *Statistical Yearbook*, Table B.3107: http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=12928&IF_Language=fra&MainTheme=2&FldrName=3&RFPath=92.

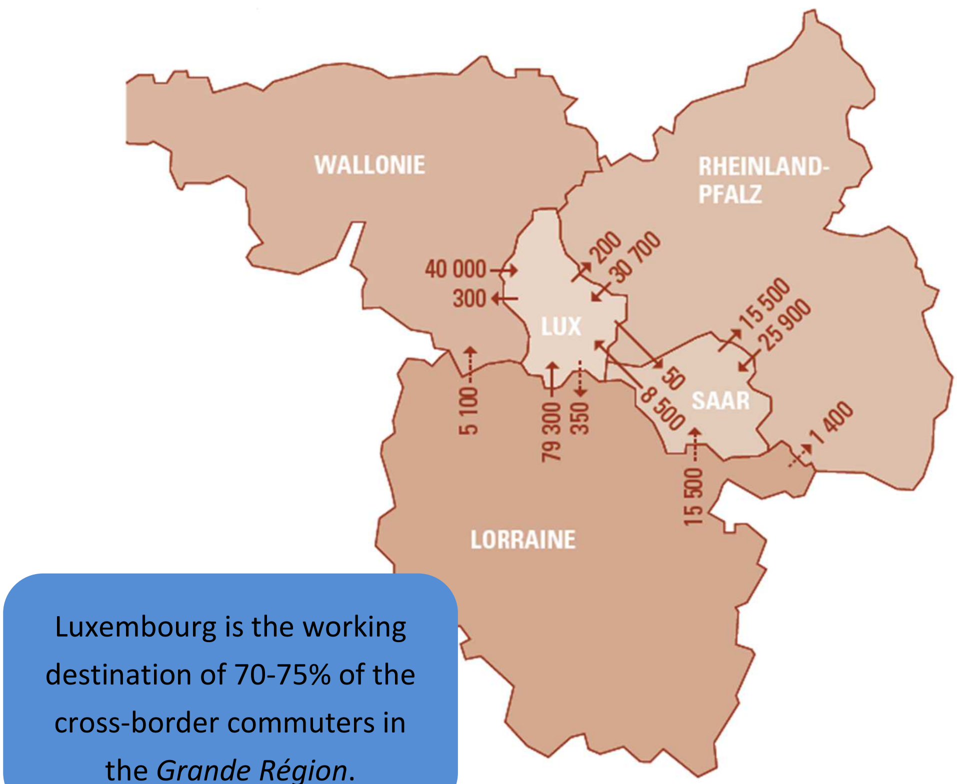
20 According to a study, for 2010, it was estimated that 86% of the cross-border commuters were only using their car for their home-work journeys. This percentage was 91% in 2007: https://www.liser.lu/?type=module&id=104&tmp=2730.

FIGURE II.4-4 – CROSS-BORDER COMMUTERS GROWTH: ANNUAL CUMULATIVE AVERAGES 1980-2016



Source: STATEC, *Statistical Yearbook*, Table B.3107 (updated 06.12.2017):
http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=12928&IF_Language=fra&MainTheme=2&FldrName=3&RFPath=92.

FIGURE II.4-5 – COMMUTING FLOWS 2015



Source: INSEE, IGSS, STATEC, IWEPS, Statistisches Amt Saarland, Statistisches Landesamt Rheinland-Pfalz:
http://www.grande-region.lu/portal//images/publications/documents/statistiques-en-bref-2016-version-web.pdf.

Box II.4-1 – The *Grande Région*

The *Grande Région* is the geographic unit that includes Luxembourg, the Region of Wallonia in Belgium, Lorraine in France and two German *Länder*: Saarland and Rheinland-Pfalz.

Today, this structure is more a cooperative space than an effective integrated region defining and modelling its own policies and development. This is the result of the diversity of the territories constituting the *Grande Région*, of its dimension and of the barriers created by institutional and administrative structures in each country. De facto, being a sovereign state amongst country regions, Luxembourg has a special status in this cooperative space: it is the main driving force behind the *Grande Région*, a position re-enforced by its demographic and economic development as shown by the figures in the table below.

Grande Région entity	Population change (1st January) *% 1990-2015*	Population annual average growth rate (1st January) *% 1990-2015*	GDP at current price annual average growth rate *% 1990-2015*	Total employment in 2015 *1990=100*
BE-Wallonia	10.67%	0.41%	3.57%	116
DE-Rheinland-Pfalz	8.37%	0.32%	2.35%	117
DE-Saarland	-7.12%	-0.29%	2.48%	116
FR-Lorraine	1.51%	0.06%	2.06%	102
Luxembourg	**48.42%**	**1.59%**	**7.23%**	**201**

More information on the *Grande Région* can be found on line:

http://www.granderegion.net/fr/index.html

http://www.grande-region.lu/eportal/pages/HomeTemplate.aspx

II.4.3. Effects on GHG emissions: rising emissions due to road transport flows

Both demographic and employment strong increases in Luxembourg should have impacts on GHG emissions. The 3 CRF sub-categories that are the most likely influenced by the demographic and workforce developments are the **residential sector** (CRF 1A4b), the **commercial & institutional sector** (CRF 1A4a) and **road transportation** (CRF 1A3b). For the latter, a distinction has been made between emissions due to residents and those generated by non-residents – whether they are in transit or commuting for work or leisure – i.e. "**road fuel sales to non-residents**" *[→ Figure II.4-5 & Box II.8-1]*.[21]

Emissions from **commercial and institutional sectors** (1A4a) decreased over the period 1990-2015,[22] what seems quite remarkable as economic activity in the tertiary sector have gone up during the whole period, hence offices building constructed surfaces too. Overall emissions in this sector have ranged between a minimum of 0.33 Mio. t CO_2e in 2011 and a maximum of 0.77 Mio. t CO_2e in 1998 *[→ Figure II.4-6]*.

Emissions development for the **residential sector** is, however, less favourable. Indeed, over the period 1990-2015, emissions increased by 57% whereas population augmented by almost 50%. This growth has to be put compared to the one accounted for the number of households: +44.1% between 1991 and 2011.[23] At the same time, the average number of persons per household diminishes from

21 The notion and the importance of "road fuel sales to non-residents" in GHG emissions are discussed in Section II.8 below.

22 Figures presented in this section are calculated on the basis of the GHG inventory submission 2017v1.2

23 Data on households are gathered only during the population censuses. The last one took place in 2011. There are no updates for the subsequent years.

2.69 to 2.52 *[→ Section II.4-1]*. For this sector, overall emissions have ranged between a minimum of 0.71 Mio. t CO_2e in 1994 and a maximum of 1.24 Mio. t CO_2e in 2004 *[→ Figure II.4-6].*

Nevertheless, there is a break in time series for building related energy statistics between 1999 and 2000 as the figure below clearly demonstrates. It is then more accurate to analyse the developments since 2000. This analysis gives the following results:

- for the commercial and institutional sectors (1A4a), emissions declined by 13.2% between 2000 and 2015 – range [0.33 ; 0.55] Mio. t CO_2e;
- for the residential sector (1A4b), emissions declined by 1.0% between 2000 and 2015 – range [0.97 ; 1.24] Mio. t CO_2e.

Gains in energy efficiency as well as the expansion in the use of natural gas as heating fuel in Luxembourg *[→ Section II.6]* are the main drivers behind these evolutions despite strong economic and population growths.

Concerning **road transportation**, both emissions generated by the national vehicles fleet – i.e. by vehicles owned by people living or business settled in Luxembourg – and by the non-residents – "**road fuel sales to non-residents**" – showed dramatic increases over the period 1990-2015: +97.4% and +135.2% respectively *[→ Figure II.4-6]*. For the national fleet, the evolution is correlated with both the population and economic activity growth. It is also explained by an increasing rate for passenger cars per inhabitants (from 477 to 661 passenger cars per 1000 inhabitants between 1990 and 2015, i.e. the highest rate within the EU[24]). Regarding "**road fuel sales to non-residents**", the rise is undoubtedly linked to the growing number of commuters crossing the borders every working day as well as to the general increase of road freight traffic in Europe – amongst which an important share transit through Luxembourg because of its location and grasps the opportunity to fill up due to lower road fuel prices in Luxembourg compared to its neighbouring countries. Lower road fuel prices in Luxembourg are essentially the result of lower excise rates. These, though inferior than in the neighbouring countries (Belgium, France and Germany), are not the lowest within the EU *[→ Section II.8]*.[25]

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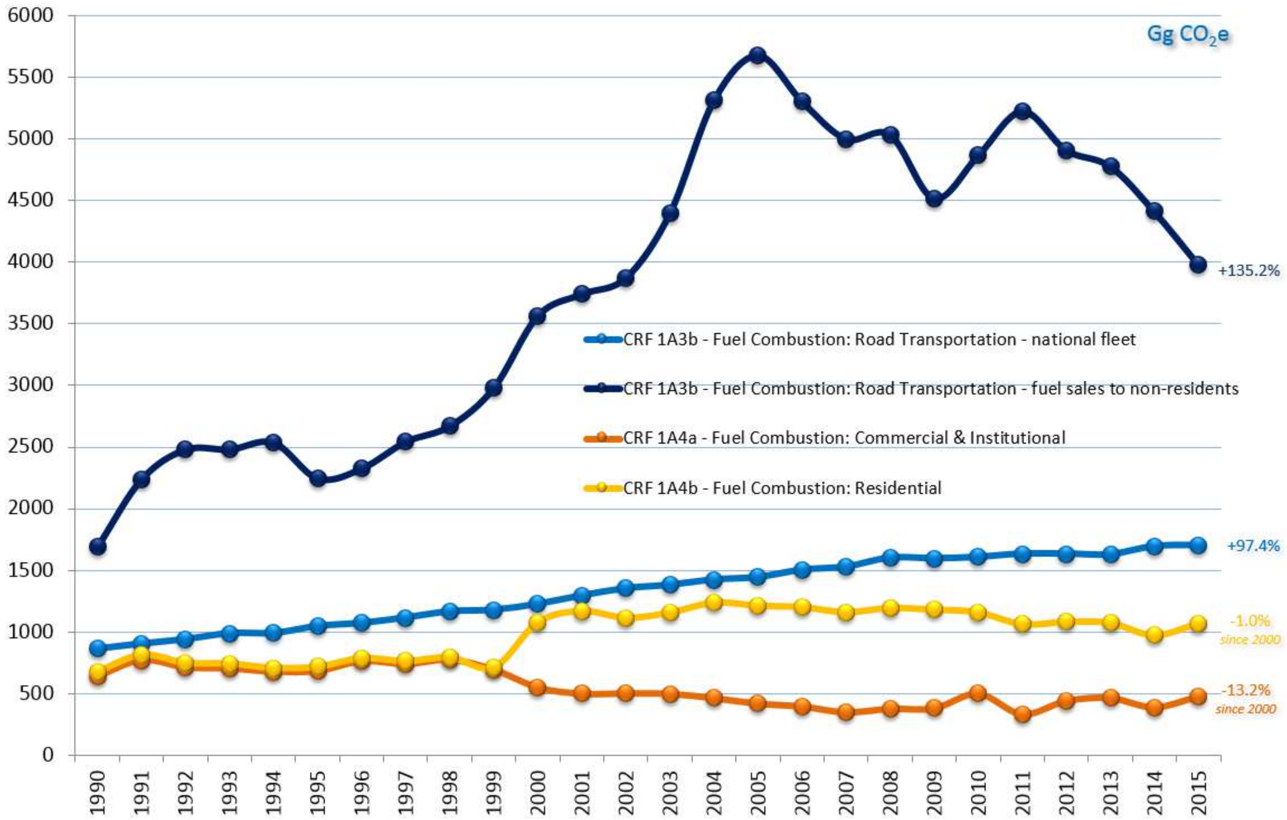
24 Data extracted from European Commission (DG MOVE), *EU transport in figures – Statistical pocketbook*, 2017 edition, p.86. https://ec.europa.eu/transport/sites/transport/files/pocketbook2017.pdf.

25 See, e.g., http://www.energy.eu/fuelprices/. Nevertheless, since a few years diesel prices for professional use are very similar, or even lower, in Belgium compared to Luxembourg. The reason stems from the fact that, in Belgium, professionals can reclaim the VAT.

FIGURE II.4-6 – GHG EMISSIONS FOR SELECTED CRF FUEL COMBUSTION ACTIVITIES SUB-CATEGORIES: 1990-2015



Source: Environment Agency – Submission 2017v1.2.
Note: CRF 1A4a&b: there are breaks in time series between 1999 & 2000, hence the growth rates are calculated based on the year 2000.

II.5. ECONOMIC PROFILE

One of the main characteristics of economic growth in Luxembourg is its volatility. Generally speaking, the economic cycle in Luxembourg follows that of other European countries, but the amplitude of the GDP variations is more pronounced. This is a common feature of small economies, open to the outside world, and therefore more vulnerable to external shocks.

II.5.1. A bit of history

The turn of the 20th century up to the First World War was characterized by a sustained growth in the steel industry that attracted new inhabitants, which induced a population concentration in the city of Luxembourg and the canton of Esch-sur-Alzette (mining region) while, up to then, Luxembourg was rather a rural country. Afterwards, up to the 1950s, economic development was mostly flat (annual average GDP growth of 1.6%) due to the crises associated with the two World Wars and the economic recession in the early 1930's.

Following the Second World War, during the "*Trente glorieuses*" (i.e. 1945-1975), GDP growth reached levels of almost 4% a year. The 1975-1985 world economic crisis brought a temporary end to these years of exceptional growth. The average annual GDP growth was “only” 2.3% during this period.

Nevertheless, during the 1960s, Luxembourg’s economic growth had been slightly beneath the percentages recorded for the, at that time, European Community Member States.[26] This is one of the reasons that encouraged authorities to diversify the economy, which gradually shift from an industry-dominated structure to a services one. This led to an exceptional growth in Luxembourg as from the mid-1980s, largely due to a boom in the financial sector: both the GDP level per inhabitant and the GDP growth then exceeded those of the majority of industrialised countries in Europe at that time.[27]

More precisely, when looking at labour productivity and employment respective contributions to economic growth in Luxembourg, a clear hiatus between the periods 1960-1985 and 1985 and after appears. This reveals a real change of “economic regime” in the country.[28] Up until the mid-1980s, annual GDP variations were largely due to variations in productivity. The period between the end of the Second World War and the 1980’s is marked by what could be called an “industrial regime”. Steelmaking was at the core of the Luxembourg economy at that time and, consequently, the economic somersaults could be attributed to this sector. Then, starting in the mid-1980s, variations in GDP and in labour productivity started to diverge and employment became the main driver of economic growth. Moreover, productivity showed a tendency to subside. That is the period when the economy shifted towards a service economy boosted by the financial sector and that Luxembourg began, from the second half of the 1980’s, to substantially outstrip growth in neighbouring countries. This period is also the one characterized by the beginnings of high population and cross-border commuters growths (as depicted in ***Section II.4***).

II.5.2. Recent economic development: the industrial decline and the increasing weight of financial & corporate services

The economic restructuring and development of the country towards the tertiary sector described in the previous section led to the following **economic cycles** since 1990:

- up to 1992, the continuation of the exceptional growth initiated around 1985;
- the effects of the economic slowdown in Luxembourg during the period between 1992 and 1996 and the economic downturn in 2001 – as well as the less impressive growth in 2002-2004 – which is mirrored by a stagnation of the GDP level per inhabitant in Luxembourg in comparison with the EU-15;

26 Annual average GDP growth 1960-1974: Luxembourg: +4.1%, UE-15: +4.6%.

27 Annual average GDP growth 1985-2007: Luxembourg: +5.3%, UE-15: +2.3%.

28 This is clearly illustrated by graphics published in Ministry of the Economy, Service Central de la Statistique et des Etudes Economiques – STATEC (2009), graphics 1.1.15, and Ministry of the Economy, Service Central de la Statistique et des Etudes Economiques – STATEC (2012), graphic 6.

- the good economic performance of Luxembourg between 2005 and 2008;
- the financial and economic crisis that started end 2008 and that has been particularly pronounced in the first semester of 2009
- from 2010 onwards, a very slow recovery could be observed, though it flattened quickly for the industry and commercial sectors *[→ Section II.5-3]*.

Nowadays, **gross value added** is mainly generated in the financial intermediation (banking and insurances), real estate and services to business sector. The share of total gross value added in this branch has increased from about 39% in 1995 to 46% in 2015.[29] While the commercial sector has maintained a relatively constant share at about 15 to 18%, the share of the industry sector has decreased significantly from 15% in 1995 to 7% in 2015. Other service activities ranged between a share of 20 to 25% and construction kept a rather constant share in total gross value added between 5 and 6%. The contribution of the agricultural sector is negligible with less than 1% *[→ Table II.5-1 & Figure II.5-1]*.

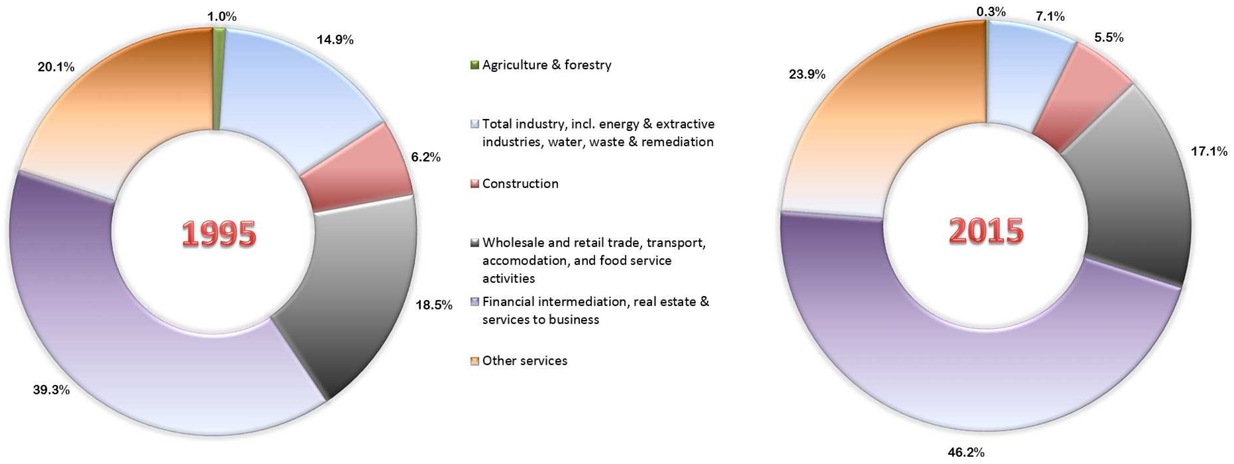
TABLE II.5-1– SECTORAL GROSS VALUE ADDED AT CURRENT PRICES: 1995-2015

mio. EUR		1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Agriculture, forestry & fishing (A)		144.0	143.8	106.7	114.9	152.0	119.1	93.7	99.3	108.9	158.5	128.7	132.6	120.0
	%	1.0%	0.7%	0.4%	0.4%	0.5%	0.3%	0.3%	0.3%	0.3%	0.4%	0.3%	0.3%	0.3%
Total industry, including extractive industries, energy production & distribution, water supply, sewerage, waste management and remediation		2130.6	2594.1	2885.6	2948.0	3584.8	3185.0	2346.2	2660.7	2705.8	2673.3	2942.1	3251.1	3345.4
activities (B to E)	%	14.9%	12.6%	10.8%	9.7%	10.8%	9.3%	7.1%	7.4%	7.0%	6.8%	7.1%	7.3%	7.1%
Construction (F)		891.7	1239.9	1527.3	1662.8	1943.4	1915.3	1914.2	1930.7	2123.7	2033.8	2128.6	2394.8	2576.5
	%	6.2%	6.0%	5.7%	5.5%	5.8%	5.6%	5.8%	5.3%	5.5%	5.2%	5.1%	5.4%	5.5%
Wholesale and retail trade, transport,		2635.8	3599.1	4256.9	4737.6	4910.3	5835.0	5374.4	6145.3	7261.6	7017.0	7698.5	7960.4	8063.4
accomodation and food service activities (G to I)	%	18.5%	17.5%	16.0%	15.6%	14.8%	17.1%	16.2%	17.0%	18.7%	17.8%	18.5%	17.9%	17.1%
Financial and insurance activities; real estate activities; professional, scientific and technical activities; administrative and support service		5602.6	8657.5	11744.6	14238.2	15514.0	15606.2	15345.6	16737.6	17435.6	17782.5	18613.9	20258.1	21825.2
activities (K to N)	%	39.3%	42.0%	44.0%	46.9%	46.6%	45.6%	46.3%	46.3%	45.0%	45.1%	44.8%	45.4%	46.2%
Other services: information and communication; public administration, defence, education, human health and social work activities; arts, entertainment and recreation; other service		2865.2	4385.1	6147.0	6637.4	7171.1	7542.2	8061.0	8563.4	9103.3	9721.4	10015.4	10575.8	11261.2
activities; activities of household (J & O to U)	%	20.1%	21.3%	23.0%	21.9%	21.6%	22.1%	24.3%	23.7%	23.5%	24.7%	24.1%	23.7%	23.9%
Total: all NACE rev2 branches		**14270.1**	**20619.4**	**26668.2**	**30338.9**	**33275.5**	**34202.8**	**33135.1**	**36137.2**	**38739.0**	**39386.4**	**41527.4**	**44572.7**	**47191.6**
Annual growth rate - current prices					**13.8%**	**9.7%**	**2.8%**	**-3.1%**	**9.1%**	**7.2%**	**1.7%**	**5.4%**	**7.3%**	**5.9%**
Annual growth rate - constant prices/ in volume					**5.7%**	**8.5%**	**-1.5%**	**-4.6%**	**5.0%**	**2.0%**	**-0.8%**	**3.6%**	**5.5%**	**3.0%**

Source: STATEC, *Statistical Yearbook*, Tables E.2304 (current prices) & E.2305 (constant prices) (updated 10.2017): http://www.statistiques.public.lu/stat/TableViewer/document.aspx?ReportId=13135&IF_Language=fra&MainTheme=5&FldrName=2

29 Data prior to 1995 are and will not be translated into the new European System of Accounts (ESA).

FIGURE II.5-1 – SECTORAL GROSS VALUE ADDED AT CURRENT PRICES: 1995 & 2015



Source: STATEC, *Statistical Yearbook*, Table E.2304 (updated 10.2017): http://www.statistiques.public.lu/stat/TableViewer/document.aspx?ReportId=1497&IF_Language=fra&MainTheme=5&FldrName=2

It is therefore obvious that the financial sector has been the principal engine driving the economy for almost three decades. Luxembourg is a global leader in the investment fund industry as well as the Euro area's private banking centre. When it comes to the amount of assets managed by undertakings for collective investment, Luxembourg ranks as the largest EU fund domicile jurisdiction and the second largest fund domicile jurisdiction globally.[30] However, the radical shift from an industrial economy based on steel to a service economy based on banking and finance initiated in the 1960s has led to an economy that is again dominated by a few activities. It is the case to such a point that there is, at the present, a high correlation between evolutions in banking activities and in GDP. In 2002, the Government, therefore, initiated a new process of diversification via the "**Luxembourg Cluster Initiative**" that actively encourages networking between the private and the public sectors in domains Luxembourg might have comparative advantages. The focus is placed on key technologies that have been identified as being important for the future sustainable development of the Luxembourg economy. The eight "clusters" are (i) auto-mobility, (ii) bio-health, (iii) creative industries, (iv) eco-innovation, (v) information and communication technologies (ICT), (vi) materials and manufacturing, (vii) space and (viii) wood.[31] The auto-mobility, eco-innovation and, to a lesser extent, the materials and manufacturing as well as wood "clusters" might have implications with regard to measures for reducing GHG emissions in Luxembourg.

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30 This concerns UCITS (Undertakings for Collective Investment in Transferable Securities Directives – http://en.wikipedia.org/wiki/Undertakings_for_Collective_Investment_in_Transferable_Securities_Directives). Some statistics available in the Luxembourg Bankers' Association (ABBL) Facts & Figures publication: https://www.ebf.eu/facts_and_figures-2016/, as well as in the European Fund and Asset Management Association (EFAMA) Asset Management in Europe latest report (May 2017), Exhibit 28, p. 26 - http://www.efama.org/statistics/SitePages/Asset%20Management%20Report.aspx.

31 For more details, see the portal and the website presenting the "innovative clusters": http://www.clusters.lu/.

II.5.3. Effects on GHG emissions: it is not so much modifications in the economic structure than particular changes that affect the GHG emissions trend

Since the main structural changes affecting Luxembourg's economic profile took place before 1990 (→ *Section II.5.1*), they do not come out in the GHG emissions trends for some emblematic CRF sub-categories: total GHG excluding LULUCF, public electricity and heat production (CRF 1A1a), manufacturing industries and construction combustion and processes emissions (CRF 1A2+2A+2C1) and "road fuel sales to non-residents" (CRF 1A3b, part) *[→ Figure II.5-2]*.

While the increasing shares in gross value added from less energy and carbon intensive sectors (as financial and services) has a positive effect on the carbon intensity of the Luxembourg economy, the overall GHG emissions trend is mostly determined by the developments of the 3 CRF (sub-) categories displayed in ***Figure II.5-2***. The residential, commercial and institutional sectors do not really influence the general trend, as we have seen in *Section II.4.3*.

Regarding electricity and heat production, the jump in 2002 is the result of a new power plant that started its operation that year *[→ Section II.6]*.

Manufacturing industries and construction sharp fall up to 1998 is linked to structural changes in one industrial sector, the steel industry *[→ Section II.7]*.

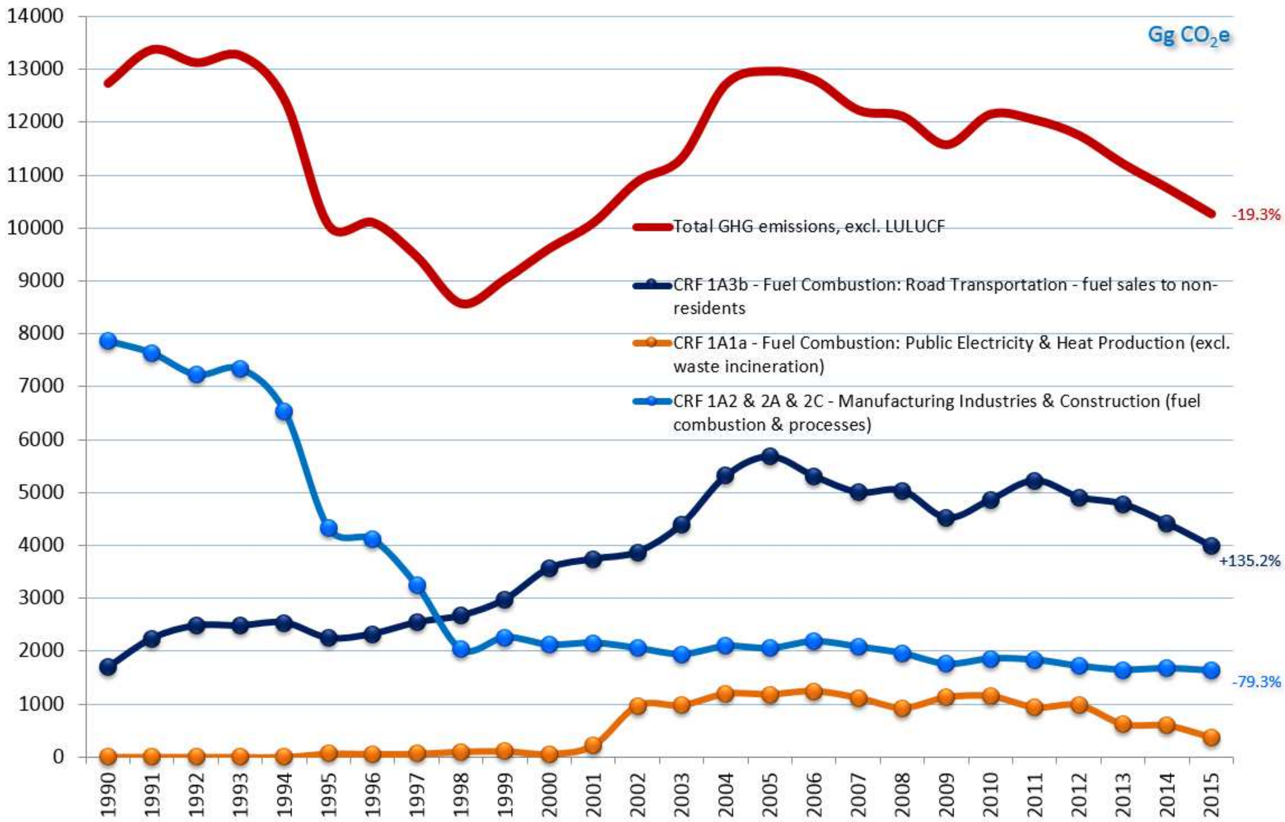
With regard to "road fuel sales to non-residents", the evolution has been briefly described in *Section II.4.3* and will be exposed in detail in *Section II.8* below.

Finally, the year 2009 – and to a lesser extent the year 2011 – have been impacted by the financial and economic crisis. Emission reductions were mostly due to a decrease in "road fuel sales to non-residents" and not to lower emissions for manufacturing industries and construction. This reduction was in line with a sharp decline of road freight transport throughout Europe during that year.

To conclude, GHG emissions trends in Luxembourg are not so much influenced by the economic profile of the country, but for the most part by:

- the energy-mix for both production and consumption of fuels (liquid, solid, gaseous, biomass) *[→ Section II.6]*;
- due to its size and the size of its energy and industrial sector, structural changes in these sectors that could be initiated by a single entity *[→ Sections II.6 & II.7]*;
- road transportation related fuel sales *[→ Section II.8]*.

FIGURE II.5-2 – GHG EMISSIONS FOR SELECTED CRF FUEL COMBUSTION ACTIVITIES SUB-CATEGORIES: 1990-2015



Source: Environment Agency – Submission 2017v1.2.
Note: public electricity & heat production (excl. waste incineration) increased by 21 775% since 1990.

II.6. ENERGY

CRF sub-category covered	1A1a		
share in total GHG emissions, excl. LULUCF	***1990***	0.3% =	35.64 Gg CO_2e
	2015	4.3% =	457.22 Gg CO_2e

II.6.1. A total change in Luxembourg's energy-mix

Primary and final energy consumption in Luxembourg experienced dramatic changes since 1990. Overall **primary energy consumption** increased by 18.5% between 1990 and 2015. Whereas solid fuels and coal declined by more than 96% over the period, liquid fuels (incl. kerosene) and natural gas consumptions increased by 167% and 180% respectively *[→ Table II.6-1 & Figure II.6-1]*.

Final energy consumption increased by 18% between 1990 and 2015. As for primary energy consumption, all the energy sources have seen their consumption increase over the period, except solid fuels and coal *[→ Table II.6-2 & Figure II.6-2]*.

However, over the period 1990-2015, the final energy-mix of Luxembourg changed considerably with a dropping share for solid fuels – for which the main part was used in the iron and steel industry – in favour of liquid fuels and natural gas and, to a lesser extent, to new energy sources based on the biomass. Indeed, in 2015, 81.7% of the **final energy consumption** was covered by fossil fuels – 64.1% by liquid fuels including the important volume of road fuels as well as kerosene,[32] 15.6% by natural gas and 1.2% by coal. The remaining 18.3% of the consumption were either electricity (13.2%) and heat (1.4%) or renewable energy sources, including organic waste incineration with energy recovery, biogas, and biofuels (3.7%). Going back to 1990, 23.8% of the final energy consumption was stemming from solid fuels and coal, 46% from liquid fuels, 13.5% from natural gas and 10.4% from electricity *[→ Table II.6-2 & Figure II.6-2]*. What did happen?

- regarding **solid fuels and coal**, the important decline (-94.0%) is the result of a change in production processes in the steel industry sector: the production process was moved from blast furnaces to electric arc furnaces between 1994 and 1998 and, therefore, solid fuels (mainly imported coke, but also imported anthracite) were replaced, to a very large extent, by electricity and natural gas;
- **liquid fuels** increase (+164.4%) was driven by road fuel sales and kerosene, but with the former being 4 to 5 times higher in quantity than the latter. This is especially "road fuel sales to non-residents" that explains a great deal of the sharp increase *[→ Section II.8]*;
- the 143.0% increase in **natural gas** final consumption followed the continuous extension of the natural gas network in Luxembourg so that this fuel ranked second after the consumption of liquid fuels in 2015 – and even first if "road fuel sales to non-residents" and kerosene are not considered.

Natural gas has also become the main energy source of Luxembourg's national electricity production capacity. In 1990, more than 90% of Luxembourg's electric energy consumption was imported and one medium size power plant of about 70 MW was run by the iron and steel company Arbed.[33] That power plant was mainly run on blast furnace gas – a side product of the blast furnaces in the steel industry – and was phased out in 1998 after the last blast furnace went out of service. In the early 1990s, small combined heat-power (CHP) installations (or cogeneration) plants appeared. Their installation was encouraged financially by the Government. This development was followed later by some industrial companies that installed gas turbines to produce electricity and heat simultaneously. In mid-2002, the ultra-modern TWINerg power plant started its commercial operation. Located in Esch-sur-Alzette, TWINerg was a gas and steam turbine power station running on natural gas, with an electrical output of 376 MWel (efficiency 55.7%). If almost all of these cogeneration plants run on natural gas, gas oil remains the emergency fuel in case of a natural gas supply disruption.

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32 Diesel being the first liquid fuel in terms of volumes sold. The liquid fuel consumption in Luxembourg is much lower than the level of fuel sales, because large amounts of road fuels are bought by foreign commuters and transit traffic passing through Luxembourg: see section II.8.1 below.

33 Then Arcelor and now, Arcelor-Mittal.

The impact of TWINerg in the primary energy consumption mix is clearly visible in ***Table II.6-1*** and its associated ***Figure II.6-1***: electricity imports dropped and natural gas primary consumption increased in 2002, while in 2015 they reverted back to values similar than those recorded in 2001. After a few years of reduced activity, the TWINerg plant was finally shut down in 2016. To complement this analysis, an energy balance for electric power provided ***[→ Table II.6-3 & Figure II.6-3].***

II.6.2. Effects on GHG emissions: a sharp increase between 2001 and 2002

GHG emissions of the public electricity and heat production (CRF 1A1a) are somewhat reflecting the changes described above. A sharp increase occurred in 2002 when the TWINerg power plant started to operate at full capacity. The impact of this installation on GHG emissions is around 0.9 to 1 Mio. t CO_2e per year, i.e. about 8% of the total GHG emissions, excluding LULUCF. The rather important decreases observed between 2007 and 2008, and again between 2010 and 2011, are the result of maintenance operations of TWINerg over several months, i.e. months with no substantial production. However, from 2012 onwards, TWINerg started to reduce its production up to its closure in 2016 ***[→ Figure II.6-4]***.

Figure II.6-4 does include GHG emissions due to waste incineration since the sole incinerator of the country recovers energy during the process. Therefore, and according to the inventory accounting rules, related emissions for the non-organic part of waste incineration have to be reported under CRF sub-category 1A1a ***[→ Section II.11].***

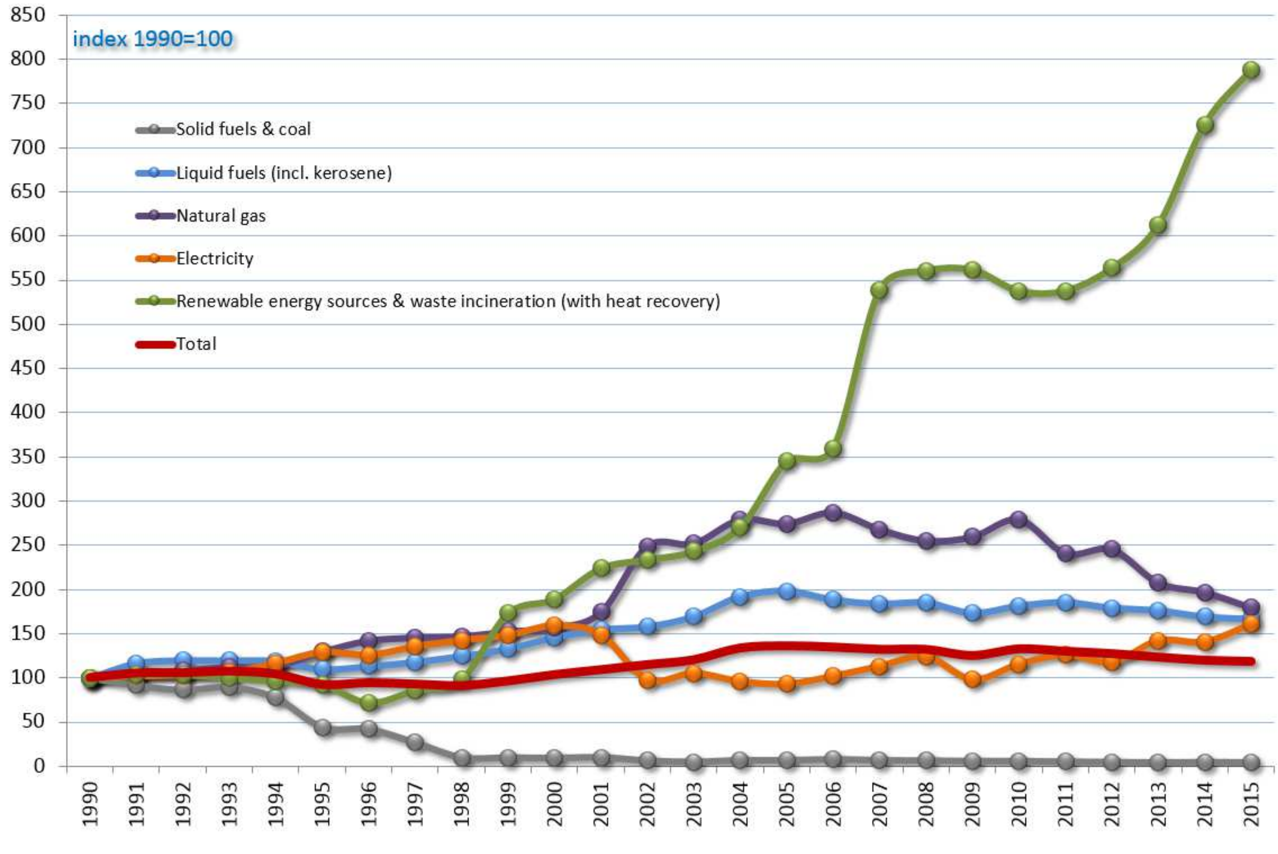
The decline observed in the 1990s for the industrial sector related emissions – mostly the result of the move from blast furnaces to electric arc furnaces in the steel industry – does not appear in ***Figure II.6-4***. Indeed, and according to the inventory accounting rules, since those manufacturing industries that produce energy do it for their own needs – i.e. an auto-production that is not primarily intended to supply public networks – related emissions have to be recorded under CRF sub-category 1A2 (manufacturing industries).

TABLE II.6-1 – PRIMARY ENERGY CONSUMPTION: 1990-2015

TJ	1990 (base year)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Solid fuels & coal	49939.83	45812.91	43145.01	44770.76	38726.29	22010.21	20893.02	13306.17	4861.42	4814.73	4594.52	4957.84	3083.62
	33.23%	*28.98%*	*27.20%*	*27.75%*	*24.76%*	*15.90%*	*14.78%*	*9.57%*	*3.57%*	*3.33%*	*2.96%*	*3.02%*	*1.79%*
Liquid fuels (incl. kerosene)	66030.62	76910.67	79078.34	78994.97	78578.11	72455.60	74715.90	77882.37	82209.79	87715.26	96236.54	102063.69	104261.62
	43.94%	*48.66%*	*49.86%*	*48.97%*	*50.24%*	*52.35%*	*52.85%*	*56.00%*	*60.30%*	*60.72%*	*61.99%*	*62.27%*	*60.42%*
Natural gas (1)	19925.91	20717.94	21593.35	22427.07	22593.81	25819.65	28324.39	29023.46	29305.68	30397.85	31231.01	34718.00	49629.00
	13.26%	*13.11%*	*13.61%*	*13.90%*	*14.45%*	*18.65%*	*20.03%*	*20.87%*	*21.50%*	*21.04%*	*20.12%*	*21.18%*	*28.76%*
Electricity	13256.15	13464.58	13631.32	14006.50	15423.82	17083.75	16644.80	17889.96	18859.16	19580.75	21059.69	19649.82	12952.77
	8.82%	*8.52%*	*8.59%*	*8.68%*	*9.86%*	*12.34%*	*11.77%*	*12.86%*	*13.83%*	*13.55%*	*13.56%*	*11.99%*	*7.51%*
Heat	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.03	2.02	6.47
	NA	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*0.00%*	*0.00%*	*0.00%*
Renewable energy sources & w	1125.52	1167.21	1167.21	1125.52	1083.84	1042.15	808.71	964.61	1100.93	1946.32	2128.82	2520.68	2630.06
Incineration (with heat recover	*0.75%*	*0.74%*	*0.74%*	*0.70%*	*0.69%*	*0.75%*	*0.57%*	*0.69%*	*0.81%*	*1.35%*	*1.37%*	*1.54%*	*1.52%*
Total	**150278.03**	**158073.31**	**158615.23**	**161324.82**	**156405.87**	**138411.36**	**141386.82**	**139066.58**	**136336.98**	**144454.91**	**155250.60**	**163912.04**	**172563.53**

TJ	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Solid fuels & coal	2369.15	3328.54	3248.87	3876.79	3280.32	3136.57	2801.27	2806.63	2443.45	2249.59	2005.86	2234.78	2052.95
	1.31%	*1.65%*	*1.58%*	*1.91%*	*1.65%*	*1.58%*	*1.49%*	*1.41%*	*1.25%*	*1.17%*	*1.08%*	*1.24%*	*1.15%*
Liquid fuels (incl. kerosene)	111789.85	126709.57	130884.49	124308.27	121227.03	122120.30	114419.02	119823.60	122367.06	118245.32	116275.75	111686.26	109986.68
	61.74%	*62.91%*	*63.82%*	*61.24%*	*60.92%*	*61.40%*	*60.75%*	*59.99%*	*62.53%*	*61.76%*	*62.65%*	*61.98%*	*61.75%*
Natural gas (1)	50238.00	55632.00	54720.18	57237.24	53426.14	50856.70	51751.75	55665.22	48021.10	48894.89	41398.28	39223.62	35770.96
	27.74%	*27.62%*	*26.68%*	*28.20%*	*26.85%*	*25.57%*	*27.48%*	*27.87%*	*24.54%*	*25.54%*	*22.31%*	*21.77%*	*20.08%*
Electricity	13931.02	12698.58	12323.47	13490.64	14981.85	16412.67	12987.43	15290.40	16677.00	15567.70	18791.88	18634.29	21238.39
	7.69%	*6.30%*	*6.01%*	*6.65%*	*7.53%*	*8.25%*	*6.90%*	*7.66%*	*8.52%*	*8.13%*	*10.13%*	*10.34%*	*11.92%*
Heat	9.85	13.60	17.53	21.62	28.95	41.54	62.85	87.53	122.76	165.96	220.21	247.12	205.62
	0.01%	*0.01%*	*0.01%*	*0.01%*	*0.01%*	*0.02%*	*0.03%*	*0.04%*	*0.06%*	*0.09%*	*0.12%*	*0.14%*	*0.12%*
Renewable energy sources & w	2736.22	3041.45	3883.23	4049.26	6063.63	6310.98	6320.76	6052.85	6054.97	6343.76	6893.28	8175.12	8868.42
Incineration (with heat recover	*1.51%*	*1.51%*	*1.89%*	*1.99%*	*3.05%*	*3.17%*	*3.36%*	*3.03%*	*3.09%*	*3.31%*	*3.71%*	*4.54%*	*4.98%*
Total	**181074.09**	**201423.74**	**205077.78**	**202983.83**	**199007.92**	**198878.76**	**188343.07**	**199726.22**	**195686.34**	**191467.22**	**185585.25**	**180201.19**	**178123.02**

FIGURE II.6-1 – PRIMARY ENERGY CONSUMPTION: 1990-2015



Source: STATEC, *Statistical Yearbook*, Table A.4200 (updated 31.03.2017): http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=12759&IF_Language=fra&MainTheme=1&FldrName=4&RFPath=54

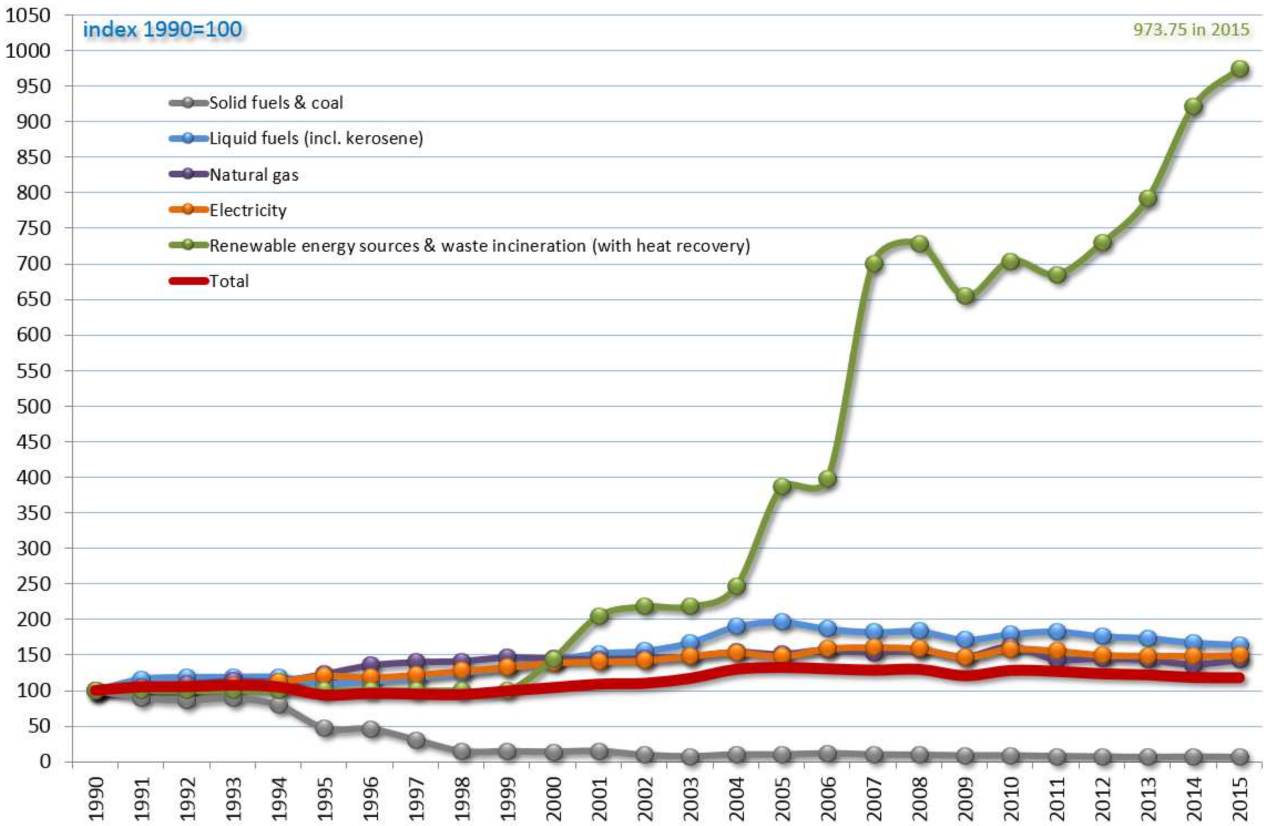
Notes: (1) natural gas is expressed in GCV;
(2) only the organic fraction of waste is counted. The biogas included as renewable energy source is expressed in GCV that also comprises blended biofuels. There is a break in time series between 1999 & 2000 (II).

TABLE II.6-2 – FINAL ENERGY CONSUMPTION: 1990-2015

TJ	1990 (base year)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Solid fuels & coal	34331.76	30814.85	29475.07	30689.24	27268.21	16035.03	15670.77	10422.20	4882.65	4835.75	4594.52	4957.84	3083.62
	23.83%	*20.38%*	*19.46%*	*19.85%*	*18.05%*	*11.91%*	*11.35%*	*7.64%*	*3.60%*	*3.39%*	*3.07%*	*3.16%*	*1.95%*
Liquid fuels (incl. kerosene)	66193.31	76911.52	78669.97	78837.44	78753.71	72682.85	74734.38	78046.98	82554.07	88082.74	94644.90	100723.34	103120.21
	45.95%	*50.87%*	*51.93%*	*51.00%*	*52.14%*	*53.99%*	*54.13%*	*57.20%*	*60.90%*	*61.67%*	*63.27%*	*64.30%*	*65.18%*
Natural gas (1)	19426.75	20389.72	21227.08	22064.44	21989.91	23906.63	26251.24	27155.58	27436.94	28435.91	28125.74	27997.84	28258.28
	13.49%	*13.49%*	*14.01%*	*14.27%*	*14.56%*	*17.76%*	*19.01%*	*19.90%*	*20.24%*	*19.91%*	*18.80%*	*17.87%*	*17.86%*
Blast furnaces gas	8 457.34	7 234.79	6 196.46	6 514.24	5 503.55	2 731.89	2 511.66	1 347.31	NO	NO	NO	NO	NO
	5.87%	*4.79%*	*4.09%*	*4.21%*	*3.64%*	*2.03%*	*1.82%*	*0.99%*	*NA*	*NA*	*NA*	*NA*	*NA*
Electricity	14988.74	15198.08	15281.82	15826.10	16747.20	18045.11	17710.16	18254.45	19091.81	19835.80	20790.21	21033.19	21260.54
	10.41%	*10.05%*	*10.09%*	*10.24%*	*11.09%*	*13.40%*	*12.83%*	*13.38%*	*14.08%*	*13.89%*	*13.90%*	*13.43%*	*13.44%*
Heat (2)	NO	NO	NO	NO	125.60	586.15	547.21	563.54	949.98	986.41	503.93	624.35	1086.98
	NA	*NA*	*NA*	*NA*	*0.08%*	*0.44%*	*0.40%*	*0.41%*	*0.70%*	*0.69%*	*0.34%*	*0.40%*	*0.69%*
Renewable energy sources & waste	644.77	644.77	644.77	644.77	644.77	644.77	644.77	644.77	644.77	644.77	929.70	1321.31	1405.98
Incineration (with heat recovery) (3)	*0.45%*	*0.43%*	*0.43%*	*0.42%*	*0.43%*	*0.48%*	*0.47%*	*0.47%*	*0.48%*	*0.45%*	*0.62%*	*0.84%*	*0.89%*
Total	**144042.67**	**151193.72**	**151495.17**	**154576.24**	**151032.95**	**134632.42**	**138070.20**	**136434.83**	**135560.21**	**142821.38**	**149589.00**	**156657.87**	**158215.60**

TJ	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Solid fuels & coal	2369.15	3328.54	3248.87	3876.79	3280.32	3136.57	2801.27	2806.63	2443.45	2249.59	2005.86	2234.78	2052.95
	1.41%	*1.78%*	*1.71%*	*2.07%*	*1.77%*	*1.68%*	*1.61%*	*1.52%*	*1.34%*	*1.27%*	*1.14%*	*1.31%*	*1.21%*
Liquid fuels (incl. kerosene)	110821.65	125715.23	130171.42	123605.43	120541.81	121487.76	113538.02	118810.49	121233.69	116795.59	114952.35	110728.16	108814.71
	65.83%	*67.37%*	*68.35%*	*65.86%*	*65.21%*	*65.10%*	*65.36%*	*64.45%*	*66.45%*	*65.80%*	*65.54%*	*65.06%*	*64.12%*
Natural gas (1)	28673.98	29942.32	29338.04	30622.60	29822.71	30616.00	28658.82	31411.99	27916.40	28262.17	27789.82	26536.40	27835.84
	17.03%	*16.04%*	*15.40%*	*16.32%*	*16.13%*	*16.41%*	*16.50%*	*17.04%*	*15.30%*	*15.92%*	*15.84%*	*15.59%*	*16.40%*
Blast furnaces gas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	NA	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
Electricity	22252.42	23007.38	22149.43	23806.48	24097.50	23750.44	22004.89	23734.71	23343.11	22449.55	22315.52	22256.43	22390.44
	13.22%	*12.33%*	*11.63%*	*12.68%*	*13.04%*	*12.73%*	*12.67%*	*12.88%*	*12.79%*	*12.65%*	*12.72%*	*13.08%*	*13.19%*
Heat (2)	2818.44	3036.13	3055.77	3210.55	2581.94	2922.39	2483.81	3036.59	3102.44	3045.38	3230.12	2511.90	2330.57
	1.67%	*1.63%*	*1.60%*	*1.71%*	*1.40%*	*1.57%*	*1.43%*	*1.65%*	*1.70%*	*1.72%*	*1.84%*	*1.48%*	*1.37%*
Renewable energy sources & waste	1406.76	1586.77	2489.86	2562.50	4518.54	4697.03	4219.33	4539.12	4414.70	4700.15	5103.19	5938.32	6278.42
Incineration (with heat recovery) (3)	*0.84%*	*0.85%*	*1.31%*	*1.37%*	*2.44%*	*2.52%*	*2.43%*	*2.46%*	*2.42%*	*2.65%*	*2.91%*	*3.49%*	*3.70%*
Total	**168342.40**	**186616.37**	**190453.38**	**187684.35**	**184842.82**	**186610.19**	**173706.13**	**184339.52**	**182453.78**	**177502.42**	**175396.86**	**170205.98**	**169702.93**

FIGURE II.6-2 – FINAL ENERGY CONSUMPTION: 1990-2015



Source: STATEC, *Statistical Yearbook*, Table A.4300 (updated 24.02.2016): http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=12771&IF_Language=fra&MainTheme=1&FldrName=4&RFPath=51

Notes: (1) natural gas is expressed in GCV;
(2) from 2000 onwards, heat that is consumed by the cogeneration power plants themselves is no longer included, hence the break in time series (||);
(3) only the organic fraction of waste is counted. The biogas included as renewable energy source is expressed in GCV that also comprises blended biofuels. There is a break in time series between 1999 & 2000 (||).

TABLE II.6-3 – ENERGY BALANCE FOR ELECTRIC POWER: 1990-2015

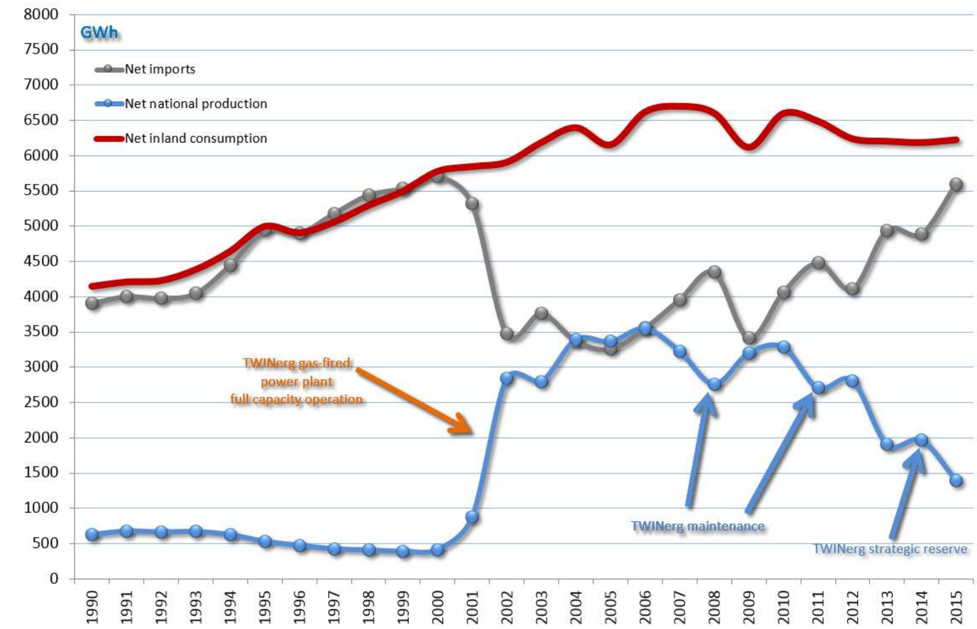
	GWh	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Imports		**4665.46**	**4718.45**	**4523.56**	**4440.97**	**5015.24**	**5693.47**	**5712.33**	**6026.52**	**6366.60**	**6193.53**	**6445.38**	**6383.25**	**6413.64**
National production		**626.24**	**676.37**	**662.49**	**669.79**	**625.07**	**529.86**	**473.71**	**424.10**	**406.88**	**390.00**	**416.79**	**877.20**	**2840.97**
	cogeneration	NO	NO	NO	NO	33.00	102.00	114.00	118.00	195.00	205.00	216.48	269.02	367.26
	thermic power stations	558.72	622.11	594.14	607.83	505.96	346.53	306.24	213.96	104.76	51.62	51.50	457.25	2333.31
	hydro-electricity	67.52	54.26	68.35	61.96	86.11	81.33	53.46	89.28	101.98	115.23	119.49	118.97	106.79
	wind	NO	NO	NO	NO	NO	NO	NO	2.74	4.61	17.14	24.74	23.74	24.48
	biomass & biogas	NO	NO	NO	NO	NO	NO	NO	0.12	0.52	1.01	4.54	8.18	9.08
	gas from WWTPs	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	gas from landfill sites	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	photovoltaic	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.04	0.05	0.06
Total		**5291.70**	**5394.82**	**5186.04**	**5110.76**	**5640.32**	**6223.33**	**6186.04**	**6450.62**	**6773.48**	**6583.53**	**6862.17**	**7260.45**	**9254.62**
Exports		**754.92**	**715.17**	**542.95**	**394.41**	**565.57**	**744.15**	**808.06**	**846.96**	**924.12**	**654.97**	**736.85**	**1066.79**	**2939.92**
Conversion uses and losses		**389.32**	**395.43**	**334.28**	**318.06**	**364.83**	**434.15**	**431.95**	**418.98**	**428.05**	**340.97**	**359.49**	**414.82**	**450.53**
Net inland consumption		**4149.00**	**4211.00**	**4231.00**	**4385.00**	**4644.00**	**4996.00**	**4907.00**	**5057.00**	**5292.00**	**5495.00**	**5775.00**	**5843.00**	**5904.00**
Total		**5293.25**	**5321.59**	**5108.23**	**5097.46**	**5574.40**	**6174.30**	**6147.00**	**6322.94**	**6644.17**	**6490.94**	**6871.34**	**7324.60**	**9294.45**

	Summary in GWh	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Net imports		**3910.54**	**4003.28**	**3980.61**	**4046.57**	**4449.67**	**4949.32**	**4904.28**	**5179.56**	**5442.48**	**5538.56**	**5708.52**	**5316.46**	**3473.72**
Net national production (1)		**626.24**	**676.37**	**662.49**	**669.79**	**625.07**	**529.86**	**473.71**	**424.10**	**406.88**	**390.00**	**416.79**	**877.20**	**2840.97**
Net inland consumption		**4149.00**	**4211.00**	**4231.00**	**4385.00**	**4644.00**	**4996.00**	**4907.00**	**5057.00**	**5292.00**	**5495.00**	**5775.00**	**5843.00**	**5904.00**
Net inland consumption in Mio. MJ **(3)**		14936.40	15159.60	15231.60	15786.00	16718.40	17985.60	17665.20	18205.20	19051.20	19782.00	20790.00	21034.80	21254.40
Net inland consumption in 1000 toe		356.75	362.08	363.80	377.04	399.31	429.58	421.93	434.82	455.03	472.48	496.56	502.41	507.65

	GWh	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Imports		**6562.18**	**6506.31**	**6391.61**	**6823.54**	**6846.58**	**6829.87**	**6022.47**	**7279.51**	**7096.34**	**6732.10**	**6851.52**	**6961.18**	**7518.76**
National production		**2798.99**	**3393.35**	**3363.45**	**3550.93**	**3226.13**	**2761.89**	**3201.55**	**3284.47**	**2704.70**	**2810.51**	**1904.26**	**1964.41**	**1394.88**
	cogeneration	396.88	441.39	444.66	470.07	398.30	421.64	389.88	439.08	446.44	437.31	416.76	381.36	349.89
	thermic power stations	2285.48	2787.37	2736.60	2866.49	2598.86	2089.25	2571.43	2607.40	2048.75	2103.93	1156.90	1240.64	679.91
	hydro-electricity	73.94	95.64	85.03	102.67	107.19	121.23	97.02	100.25	58.40	88.73	110.37	100.29	90.99
	wind	26.17	39.40	52.25	57.99	64.29	60.59	63.47	55.08	64.05	77.47	83.03	79.88	101.85
	biomass & biogas	15.13	20.34	27.22	32.60	36.59	43.83	53.33	55.96	55.31	57.80	56.46	60.51	61.51
	gas from WWTPs	NO	NO	NO	NO	NO	5.32	5.85	5.14	6.00	6.00	6.00	6.00	6.00
	gas from landfill sites	NO	NO	NO	NO	NO	NO	0.26	0.41	0.00	1.00	1.00	1.00	1.00
	photovoltaic	1.40	9.20	17.70	21.11	20.90	20.03	20.32	21.15	25.74	38.28	73.74	94.74	103.72
Total		**9361.17**	**9899.66**	**9755.06**	**10374.46**	**10072.71**	**9591.76**	**9224.02**	**10563.98**	**9801.04**	**9542.60**	**8755.79**	**8925.59**	**8913.64**
Exports		**2799.41**	**3131.58**	**3131.31**	**3266.55**	**2886.84**	**2483.53**	**2604.48**	**3216.07**	**2614.39**	**2621.78**	**1907.52**	**2067.39**	**1919.43**
Conversion uses and losses		**475.68**	**366.33**	**453.13**	**472.35**	**466.47**	**474.25**	**423.09**	**674.15**	**608.00**	**593.24**	**593.24**	**593.24**	**765.00**
Net inland consumption		**6182.00**	**6393.00**	**6150.00**	**6614.00**	**6695.00**	**6598.00**	**6114.00**	**6593.00**	**6485.00**	**6236.00**	**6201.00**	**6182.00**	**6221.00**
Total		**9457.09**	**9890.91**	**9734.43**	**10352.90**	**10048.31**	**9555.78**	**9141.57**	**10483.22**	**9707.39**	**9451.02**	**8701.76**	**8842.63**	**8905.43**

	Summary in GWh	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Net imports		**3762.77**	**3374.73**	**3260.30**	**3556.99**	**3959.74**	**4346.34**	**3417.99**	**4063.44**	**4481.96**	**4110.32**	**4944.01**	**4893.79**	**5599.32**
Net national production (1)		**2798.99**	**3393.35**	**3363.45**	**3550.93**	**3226.13**	**2761.89**	**3201.55**	**3284.47**	**2704.70**	**2810.51**	**1904.26**	**1964.41**	**1394.88**
Net inland consumption		**6182.00**	**6393.00**	**6150.00**	**6614.00**	**6695.00**	**6598.00**	**6114.00**	**6593.00**	**6485.00**	**6236.00**	**6201.00**	**6182.00**	**6221.00**
Net inland consumption in Mio. MJ **(3)**		22255.20	23014.80	22140.00	23810.40	24102.00	23752.80	22010.40	23734.80	23346.00	22449.60	22323.60	22255.20	22395.60
Net inland consumption in 1000 toe		531.56	549.70	528.80	568.70	575.67	567.33	525.71	566.90	557.61	536.20	533.19	531.56	534.91

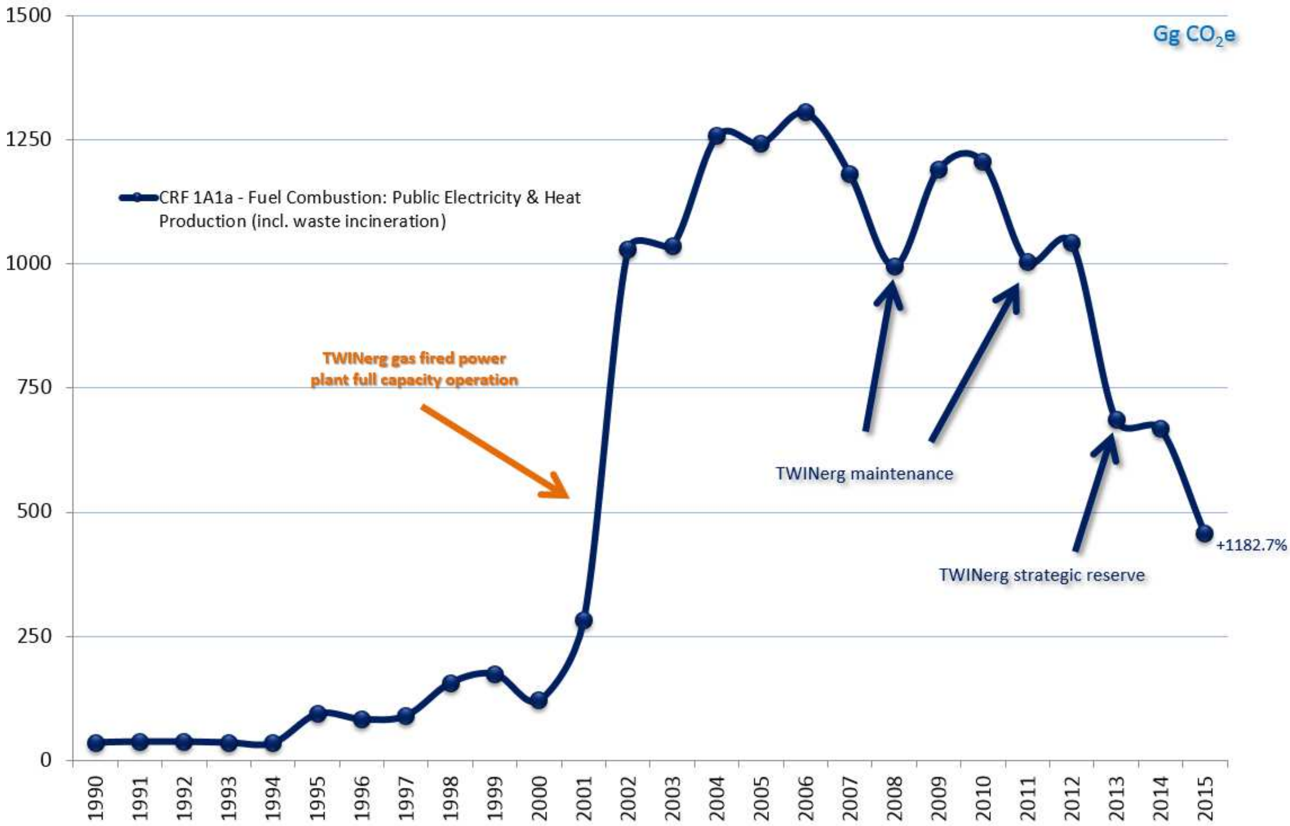
FIGURE II.6-3 – ENERGY BALANCE FOR ELECTRIC POWER: 1990-2015



Sources: compiled by the Environment Agency on 25.02.2016 using data published by the Ministry of the Economy – Energy Department, the *Institut Luxembourgeois de Régulation* and STATEC (Table A.4203).

Notes: (1) the net national production is the difference between the national production and the conversion process uses and losses.
(2) as indicated in the main text, the TWINerg power plant started its commercial operation in 2002. The recorded value for 2001 corresponds to a testing phase in production.
(3) net inland consumption expressed in TJ (Mio. MJ) differs slightly from the corresponding figures in Table II.6-2 – less than 2% – because data sources, units and calculations are not exactly the same.

FIGURE II.6-4 – GHG EMISSIONS FOR PUBLIC ELECTRICITY & HEAT PRODUCTION (CRF SUB-CATEGORY 1A1A): 1990-2015



Source: Environment Agency – Submission 2017v1.2.

II.7. INDUSTRY

CRF (sub-)categories covered		1A2 & 2		
share in total GHG emissions, excl. LULUCF		***1990***	62.1% =	7905.63 Gg CO_2e
		2015	17.0% =	1742.43 Gg CO_2e
	1A2	***1990***	49.2% =	6265.38 Gg CO_2e
		2015	10.9% =	1116.35 Gg CO_2e
	2	***1990***	12.9% =	1640.25 Gg CO_2e
		2015	6.1% =	626.08 Gg CO_2e

II.7.1. An activity branch dominated by the metallurgy

Over the period under review, **metallurgy** – steel and aluminium in Luxembourg – usually represented around one third of the manufacturing industry total gross value added. Nevertheless, after reaching a peak in both 2007 and 2008 – with almost 40% of the manufacturing industry total gross value added – the share of metallurgy dropped to about 20 to 25% since 2009 when the financial and economic crisis started to affect Luxembourg’s industrial activities, and principally its steel industry. Looking at the metallurgy weight in manufacturing industry production, from 2009 onwards, it dropped from around 40% to 30%.

Consequently, it would be expected that GHG emissions trends in the industrial sector were driven by the activities and changes that occurred in these two branches. Nevertheless, aluminium production in Luxembourg is a secondary production using aluminium scraps. Since there are no transformation activities from bauxite, this branch only records emissions related to combustion activities, i.e. there are no emissions stemming from industrial processes. Then, as underlined in *Section II.6*, the iron and steel industry has been characterized by a move from blast furnaces to electric arc furnaces between 1994 and 1998. Consequently, industrial emissions are nowadays depending on changes in activities or processes in a various number of manufacturing branches as illustrated below.

Industrial processes and product use emissions include emissions from industrial installations pertaining to three sectors only: clinker, flat glass, iron and steel. They also cover consumption of halocarbons (HFCs) and sulphur hexafluoride (SF_6)[34] – the fluorinated gases or F-gases – as well as the use of solvent and other products.

II.7.2. Effects on GHG emissions: iron & steel used to set the pace

Overall emissions related to fuel combustion and processes in the manufacturing industry and construction sector were dominated by emissions generated by the iron and steel production plants up to 1998: from 1990 to 1998, GHG emissions in Luxembourg were reduced by one third due to the move from blast furnaces to electric arc furnaces. 1998 is also the year with the lowest GHG emissions, excluding LULUCF, ever recorded for Luxembourg since 1990 *[→ Figure II.7-1]*.

When the move from blast furnaces to electric arc furnaces was completed, iron and steel was no longer the main emitter of GHG and the overall emissions trend started to fluctuate according to changes in the various manufacturing and construction sub-categories. Excluding iron and steel from the picture shows that, in some cases, emissions produced by the other manufacturing industries and construction activities did evolve in an erratic way. This is particularly the case for CRF sub-category 1A2f. Though such irregular developments are explained by the small size of Luxembourg's industrial activities,[35] for sub-category 1A2f, the reason also lies in the way the emissions have been estimated. CRF sub-category 1A2f is a sector where unallocated activity data for the manufacturing industries and construction are reported. These unallocated activity data stem from discrepancies between the top-down overall statistics and the bottom-up information used to build the inventory.[36]

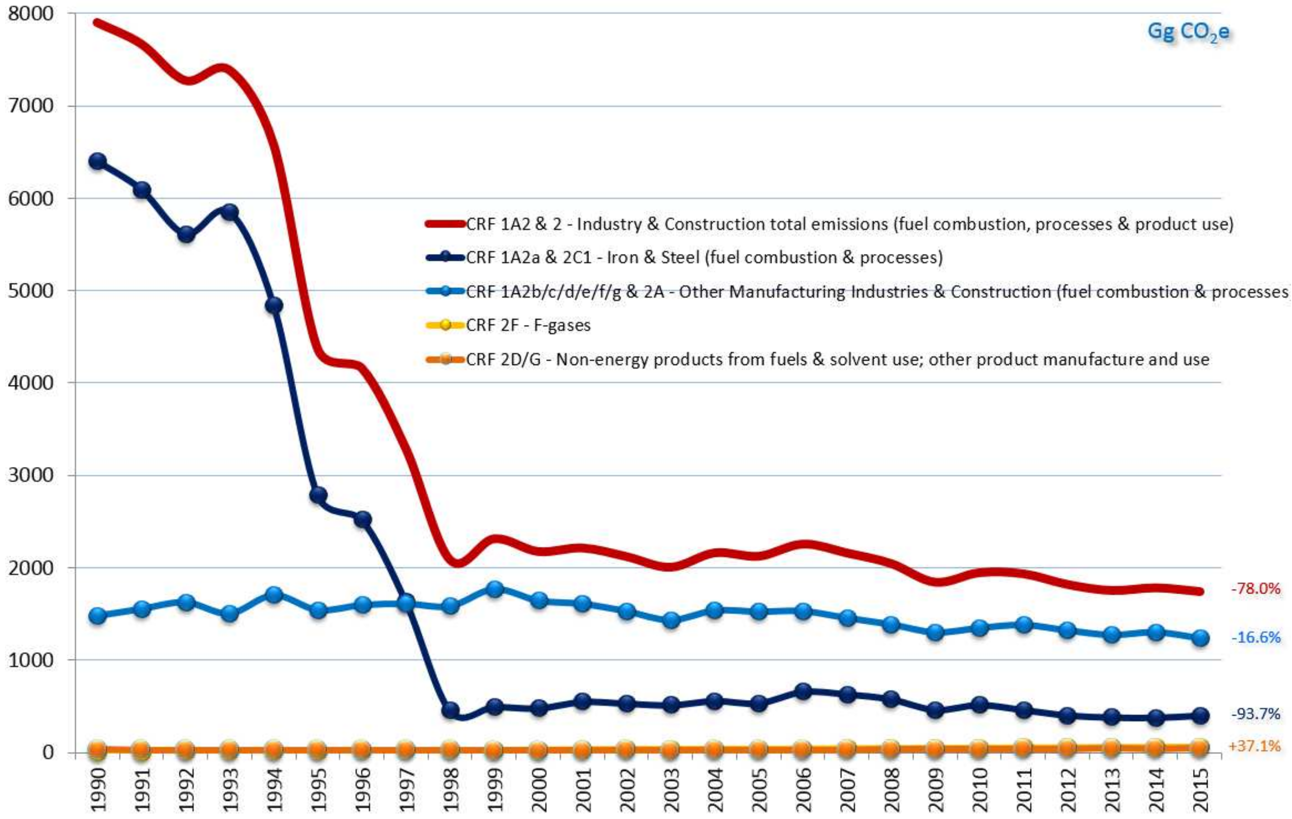
34 There are no emissions stemming from perfluorocarbons (PFCs) and nitrogen trifluoride (NF_3) in Luxembourg.

35 A change in one unit might have important impact on an aggregated trend: see discussion in Section II.12.2 below.

36 Ministry of Sustainable Development and Infrastructure, Environment Agency (2017), p. 211-214.

The striking increase of F-gases emissions *[→ Figure II.7-1]* is the consequence of growing use in the country, notably due to an increasing use of air conditioning, but also of better estimating procedures and activity data.[37]

FIGURE II.7-1 – GHG EMISSIONS FOR SELECTED CRF INDUSTRIAL SUB-CATEGORIES: 1990-2015



Source: Environment Agency – Submission 2017v1.2.
Note: F-gases emissions increased by 255.3% since 1995 (base year for F-gases).

II.8. ROAD TRANSPORTATION

CRF sub-category covered		1A3b	
share in total GHG emissions, excl. LULUCF		***1990***	20.1% = 2555.71 Gg CO_2e
		2015	55.4% = 5684.11 Gg CO_2e
	national fleet	***1990***	6.8% = 862.85 Gg CO_2e
		2015	16.6% = 1703.20 Gg CO_2e
	“road fuel sales to	***1990***	13.3% = 1692.86 Gg CO_2e
	non-residents”	**2015**	38.8% = 3980.90 Gg CO2e

II.8.1. Diverse inland and cross-border road transport flows

Luxembourg's location and its economic development have made it a **focal point for international road traffic**. Luxembourg is located at the heart of the main traffic axes for Western Europe

37 Ministry of Sustainable Development and Infrastructure, Environment Agency (2013), p. 249-254.

[→ Figure II.8-1] and, therefore, has traditionally had a high volume of road transit traffic for both goods (freight transport) and passengers (tourists on their way to or back from southern Europe). The latter has increased even further by the **high number of commuter journeys** observed every working day. In comparison with international traffic, domestic traffic plays only a relatively small role since it responsible for only about 30% of the total road fuels sold in Luxembourg.[38]

Road traffic is also the largest source of emissions in Luxembourg's GHG balance. Fuel quantities sold at Luxembourg's petrol stations, after having been converted into GHG volumes, are, according to IPCC reporting rules, totally included in the GHG balance, although around 70% of the emissions cannot be assigned to vehicles registered in Luxembourg and are actually emitted mostly abroad.[39] This phenomenon is referred to as "**road fuel sales to non-residents**" whether they are in transit or commuting for work or leisure. Indeed, due to lower taxed fuel (gasoline and diesel),[40] Luxembourg is an attractive "fuelling station" for daily commuters from neighbouring countries and cross-border shoppers, but, in first instance, for international road transit traffic crossing its territory (mainly freight transport). "Road fuel sales to non-residents" is briefly defined in Box II.8-1.

With numerous trucks transiting through Luxembourg, as well as a passenger cars market dominated by diesel vehicles in at least two of its neighbouring countries – namely Belgium and France – it is not surprising that diesel oil is the first liquid fuel in terms of volumes sold *[→ Figure II.8-2]*.

The allocation of fuel sales between residents ("domestic") and non-residents ("exports") is not made on the basis of statistics or counting, but well using the NEMO model *[→ Section V.2.4.3]*.

Box II.8-1 – "Road fuel sales to non-residents"

It covers fuel sales to non-residents, i.e.:

1. road vehicles in transit: freight trucks, buses & coaches, passenger cars, whose an important share fills up in Luxembourg because of lower fuel prices;
2. cross-border commuters who are also benefiting of the cheaper fuel prices;
3. "fuel tourism", known as "*Tanktourismus*" in Luxembourg: people driving especially to Luxembourg for benefiting of lower fuel prices, as well as lower prices on other commodities such as non-alcoholic & alcoholic beverages, tobacco, etc. (Luxembourg applies rather law taxation rates, though always in the limits adopted at EU levels, e.g. VAT is set at 17%).

II.8.2. Effects on GHG emissions: an untypical situation

Combining the size of the country and of its economy, on the one side, and lower road fuel prices that implies a disproportionate volume of road fuel sales compared to its resident population, on the other side, Luxembourg presents a completely untypical and unique structural feature in its

38 Percentages have vary through time. They ranged between 20% in 2005 (the peak year for road fuel sales) and 34%in 1990. These last years the percentage regularly climbed to reach 30% in 2015.

39 See previous note.

40 Relatively low excises rates – but not the lowest within the EU – and low VAT rate: see last paragraph of Section II.4.3 above.

GHG emissions balance. In 2015, some 5.68 Mio. t CO_2e were produced by the road transportation sector and out of these, 4 Mio. t CO_2e, or 70%, was the result of road fuels bought by non-residents and were, consequently, merely emitted abroad. That last amount represented around 38.8% of the total 2015 GHG emissions for Luxembourg (excluding LULUCF) – this share is 55.4% for the whole CRF sub-category 1A3b ***[→ Figure II.8-3]***.

Both emissions generated by the national vehicles fleet and by the non-residents – "road fuel sales to non-residents" – showed dramatic increases over the period 1990-2015: +97.4% and +135.2% respectively.[41] For the national fleet, the evolution is correlated with both the population and economic activity growth. It is also explained by an increasing rate for passenger cars per inhabitants (from 477 to 661 passenger cars per 1000 inhabitants between 1990 and 2015, i.e. the highest rate within the EU[42]). Regarding "**road fuel sales to non-residents**", the rise is undoubtedly linked to the growing number of commuters crossing the borders every working day as well as to the general increase of road freight traffic in Europe.

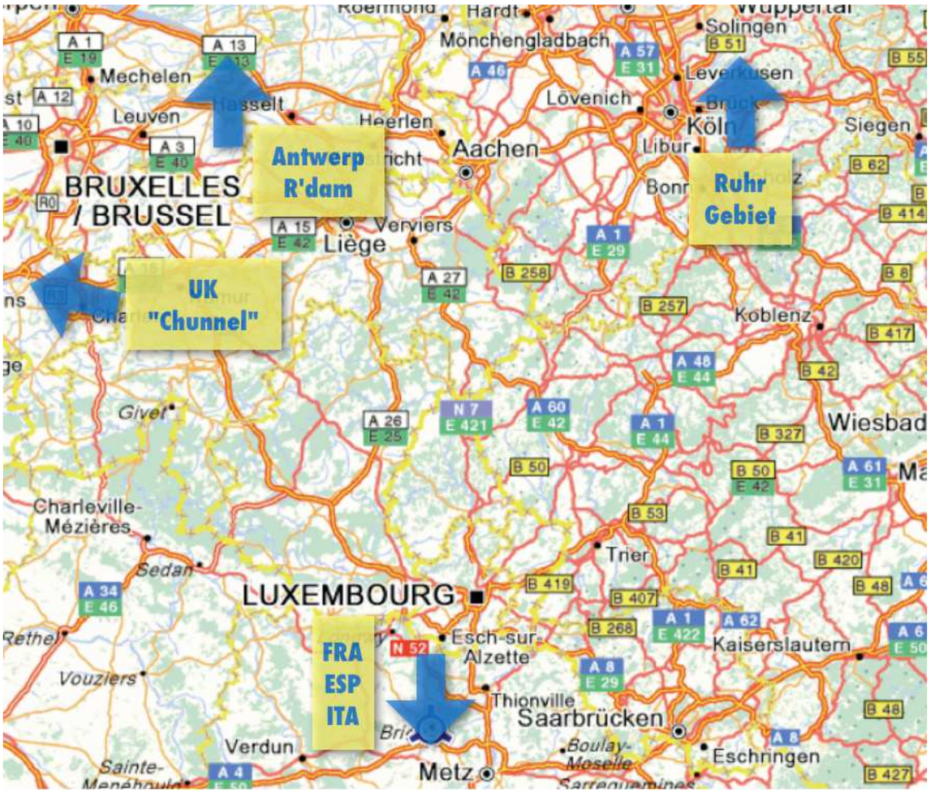
However, an important decrease has been observed since 2005, which was the peak year for road fuel sales ***[→ Figure II.8-2]***. Various reasons are being reported to explain this downward trend whilst overall road fuel prices were also falling:

- probably the main reason is the "professional" diesel price applied in Belgium, i.e. transport companies can reclaim VAT paid on diesel sales. Taking this reimbursement into account the gap between diesel price in Luxembourg and in Belgium has become negligible;
- from 1 January 2015 onward, Luxembourg is applying a VAT rate of 17% instead of 15%, which de facto narrowed the price gap;
- petrol stations on motorways have to pay a concession fee. This fee has been increased which limits now the opportunities for these stations to offer some rebates to frequent/important customers;
- finally, both gasoline and diesel are now cheaper than a few years ago. This might have led to less road fuel sales despite falling prices. This "law of offer and demand paradox" might be explained as follows: it is less attractive to make a detour to fuel in Luxembourg than when prices were higher. Indeed the potential saving in euros of such a detour is now much smaller. Therefore, it is perhaps no longer worth the time and distance to do it (knowing also that other products attracting consumers such as alcohol and cigarettes have de facto experienced a price rise with the VAT change).

41 Corresponding percentages were +66.3% and +208% in 2005, the peak year with regard to road transportation related emissions.

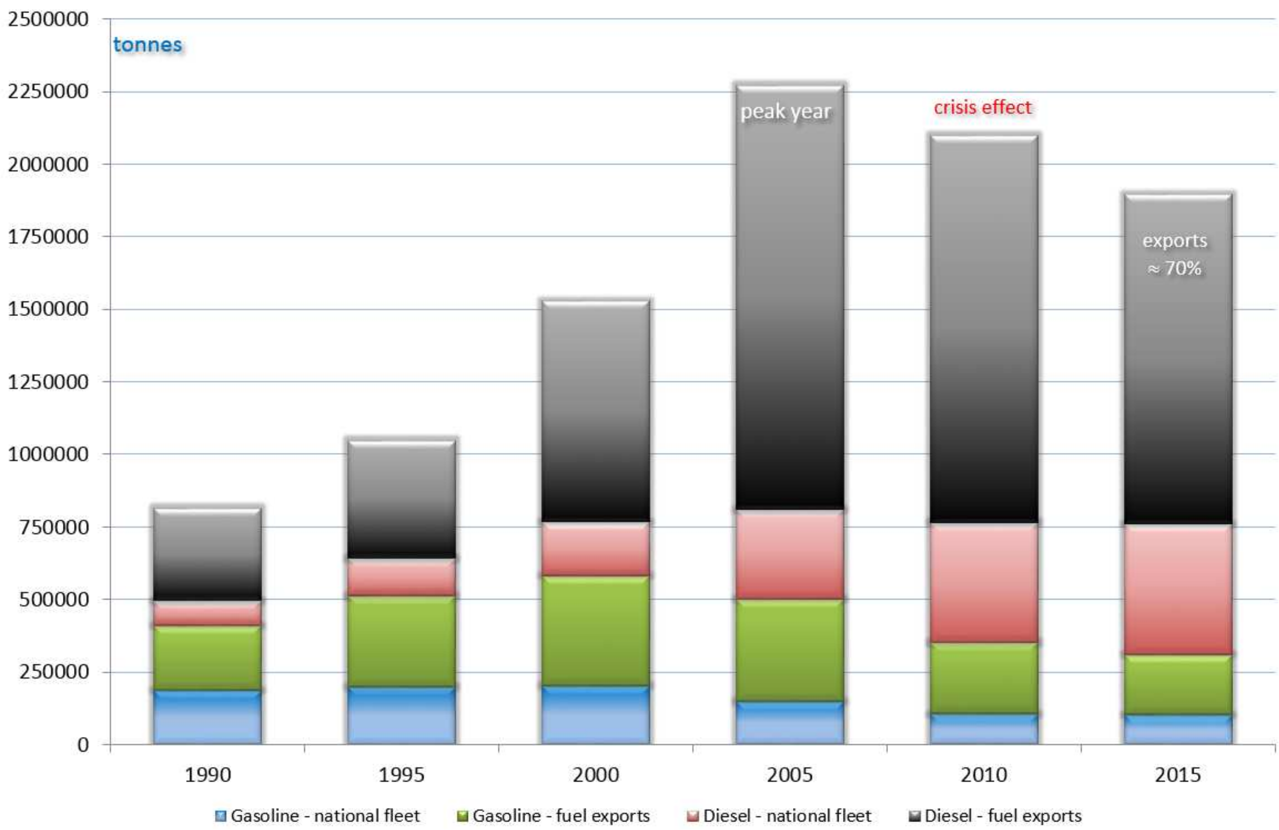
42 Data extracted from European Commission (DG MOVE), *EU transport in figures – Statistical pocketbook*, 2017 edition, p.86. https://ec.europa.eu/transport/sites/transport/files/pocketbook2017.pdf.

FIGURE II.8-1 – MAIN ROAD FREIGHT AXES CROSSING LUXEMBOURG



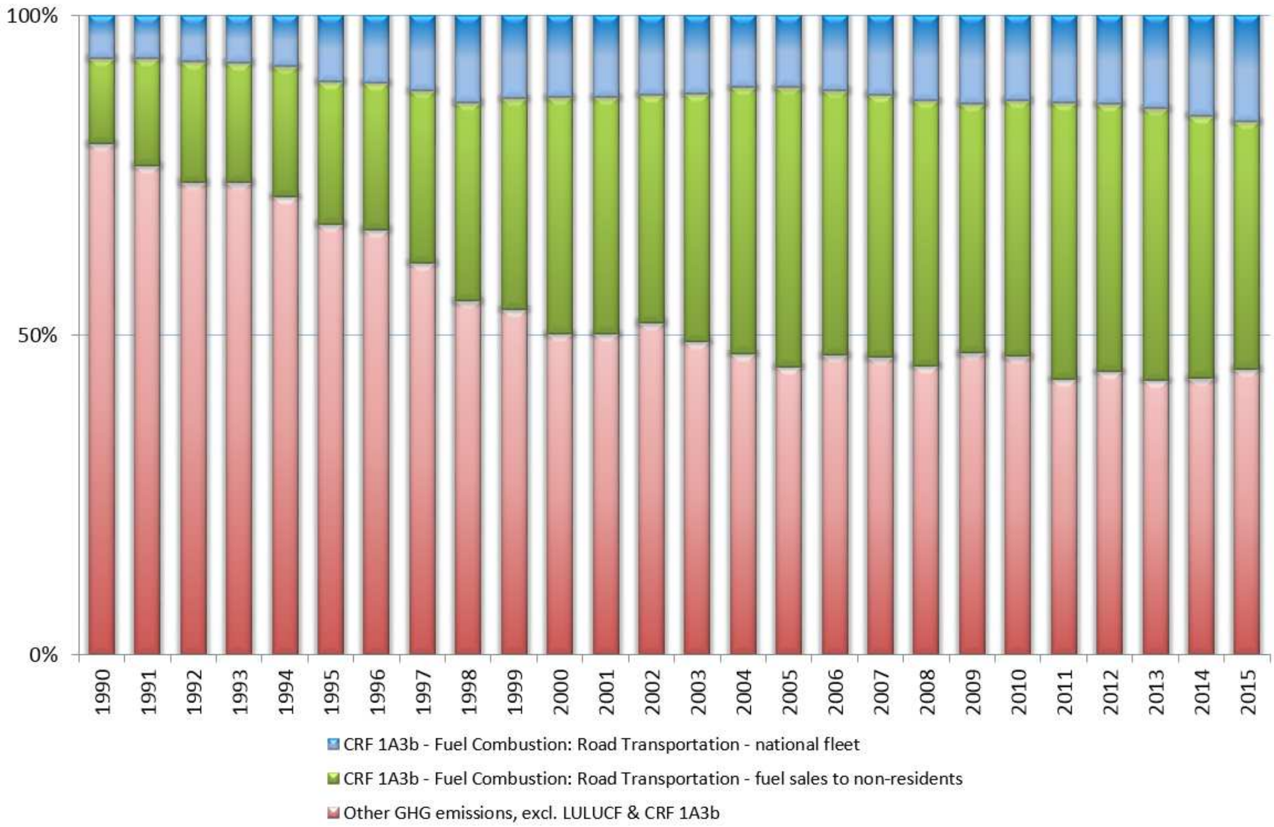
Source: ViaMichelin.

FIGURE II.8-2 – ROAD FUEL SALES: 1990-2015 IN TONNES



Source: Ministry of Sustainable Development and Infrastructure, Environment Agency (2017), Table 3-51, section 3.2.8.3.

FIGURE II.8-3 – GHG EMISSIONS FOR ROAD TRANSPORTATION (CRF SUB-CATEGORY 1A3b): 1990-2012



Sources: Environment Agency – Submission 2017v1.2.
Note: excluding CO_2 emissions from biofuels, which are reported as "memo item".

II.9. AGRICULTURE

CRF (sub-)categories covered	1A4c & 3		
share in total GHG emissions, excl. LULUCF	***1990***	5.9% =	751.06 Gg CO_2e
	2015	6.9% =	706.03 Gg CO_2e
1A4c	***1990***	0.3% =	36.65 Gg CO_2e
	2015	0.2% =	25.20 Gg CO_2e
3	***1990***	5.6% =	714.41 Gg CO_2e
	2015	6.6% =	680.83 Gg CO_2e

II.9.1. A sector that concentrates in fewer units but shows stability in land consumption

In 2015,[43] 2 022 farms were counted. They were managing a **utilized agricultural area** (UAA) of 131 384 ha, i.e. a bit more than 50% of the territory of Luxembourg. The UUA was divided almost equally between arable land (62 798 ha) and permanent pasture and meadows (66 923 ha). With

43 Agriculture yearly censuses are reflecting the situation on the 15th of May. The latest census is available here: http://www.statistiques.public.lu/stat/ReportFolders/ReportFolder.aspx?IF_Language=fra&MainTheme=4&FldrName=2&RFPath=7274.

1 550 ha, permanent crops represented only 1.2% of the total UUA. The remaining surfaces were dedicated to horticulture and family gardens.

About a half of the arable land was covered by cereals in 2015 (mostly wheat and barley and, to a lesser extent, triticale). Permanent pasture and meadows were mainly grazing land (57 193 ha) and permanent crops related to vineyards for their most part *[→ Table II.9-1]*.

Since 1990, the UAA did not change a lot: a 4% increase. However, arable land surfaces climbed by 12.4%, whereas permanent pastures & meadows stepped back by about 2.8%. Permanent crops increased by 7.6%.

Since the 1950s, agriculture has undergone profound structural changes, with the **number of farms** falling by 92.9% between 1950 and 2015 (i.e., a 4% decline annually on average). Since 1990, 1 781 farms closed down, which corresponds to around 71 farms on average per year. In percentage, the reduction reached -46.8% (i.e., a 2.5% decline annually on average). This reduction in the number of units touches all the size classes. Only those farms with more than 100 ha have seen their number increase between 1990 and 2015: from 106 to 457 agricultural holdings. The farms over 50 ha are the only one seeing their numbers increase since 1950.[44]

In 2015, 4 239 ha were classified under **organic farming** – i.e. 3.2% of the total UAA – and 83 farms were active in this field – i.e. 4.1% of all the farms.[45] In 2000 (first data collected on organic farming), the corresponding percentages were 0.8% of the UUA and 1.1% of all the farms. It has to be stressed that incentives are given for organic farming. Further on, the preservation and the development of natural zones in the rural landscapes is supported via the agri-environment support scheme.[46] The most important **agri-environmental measure** is the "premium for the upkeep of the landscape and the countryside", designed to maintain agricultural activity on lands suitable for farming, vineyards and horticulture, using forms of exploitation that are adapted to the natural setting and landscape and respectful of the environment. This premium was introduced in 1997 in the context of Regulation (EC) 2078/1992.

Livestock population in Luxembourg has also undergone some changes since 1990. With regard to cattle, its total population size declined by almost 8% throughout the period 1990-2015. However, the decline was stronger for dairy cattle (-20.3%) *[→ Table II.9-2]*. In fact, cattle population and its evolution are strongly influenced by changes in the agricultural policy and, more precisely, in the Common Agricultural Policy of the EU (CAP). This is the case for dairy cows, whose declining

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44 Data mentioned in this paragraph are extracted from STATEC, *Statistical Yearbook*, Table D.2101: http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=13349&IF_Language=fra&MainTheme=4&FldrName=2&RFPath=7274.

45 Farms that are converted or in the process of being converted and recognized by the ASTA* in accordance with Council Regulation (EC) 834/2007 of 28 June 2007 on organic production and labelling of organic products and repealing Regulation (EEC) 2092/91, and that are above the minimum criteria for STATEC.
*ASTA = Agriculture Technical Services Administration (*Administration des Services Techniques de l'Agriculture*).

46 Rural Development Plan 2014-2020: http://www.ma.public.lu/actualites/communiques/2015/07/031/PDR14-20.pdf, p. 106-107.

population results from the combination of increasing milk yields and the introduction of a milk production cap (administrative quota system for milk production). Furthermore, several reductions in the milk quota were decided in the framework of the CAP. Another factor influencing cattle population is, of course, prices (which, themselves are affected by agricultural policy changes and targets). As an example, the peak in the non-dairy cattle population observed in 1991 can be explained by a sharp price fall of the bovine meat price that year. This price fall led farmers to postpone slaughtering until early 1992.

Table II.9-2 presents the population for a selection of livestock categories, those that are the main sources of methane and nitrous oxide emissions. Actually, in 2015, cattle accounted for 98% of methane emissions due to enteric fermentation and for 80% of the emissions of the same gas stemming from manures. Cattle were also responsible of 488% of the direct nitrous oxide emissions due to manure management schemes.

More detailed data on agricultural activities are compiled in a booklet - *the agriculture of Luxembourg in figures* published by the *Service d'Economie Rurale* (SER)[47] – and are available on the SER website[48] and in STATEC's *Statistical Yearbook*.[49]

II.9.2. Effects on GHG emissions: slow decrease in emissions

In Luxembourg, emissions are recorded for five CRF categories and sub-categories: fuel combustion - agriculture, forestry & fisheries (CRF 1A4c), enteric fermentation (CRF 3A), manure management (CRF 3B), agricultural soils (CRF 3D) and liming (CRF 3G).

Total GHG emissions related to agricultural activities slowly decline by 6.0% between 1990 and 2015, i.e. at an annual average rate of -0.2%. Enteric fermentation related emissions remained rather stable – a one percent decrease over the period – whereas for manure management, they increased by 9%. For agricultural soils, emissions decreased by almost 23% between 1990 and 2015 and, during the same time, liming related emissions experienced a dramatic increase (from 0.6 Mio. t CO_2e to 5.8 Mio. t CO_2e). Fuel combustion related emissions decreased by almost 9% since 2000 – there is a break in time series for agriculture related energy statistics between 1999 and 2000 as *Figure II.9-1* below clearly demonstrates.

As *Figure II.9-1* shows, the evolution of enteric fermentation methane emissions mostly shapes the overall agriculture emission pattern since it is the biggest contributor to agriculture related emissions (around 60% over the period 2000-2015). Agricultural soils emissions present an erratic evolution. This is explained mainly by important changes in crops, as well as in N-fertilizer use, which showed a slack in 2003 and a peak in 2004. The lower N-fertilizer use in 2003 was the result

47 http://www.ser.public.lu/publikationen/Landwirtschaft_in_Luxbg/lux_landw_zahl_en.pdf.

48 http://www.ser.public.lu/statistics/index.html.

49 Tables D series: http://www.statistiques.public.lu/stat/ReportFolders/ReportFolder.aspx?IF_Language=fra&MainTheme=4&FldrName=2.

of the drought that characterized that year's summer. Excluding fuel combustion related emissions characterized by a break in time series, it is also worth noting that the shares in the total agricultural emissions of each category for which emissions have been reported have not changed much over the period.

TABLE II.9-1 – AGRICULTURAL UTILIZED AREA: 1950-2015

ha		1950	1970	1990	2000	2005	2010	2015
Arable land		79628	64228	55891	60927	60017	61951	62798
	%	*55.3%*	*47.5%*	*44.3%*	*47.7%*	*46.5%*	*47.3%*	*47.8%*
cereals		*52699*	*45341*	*32980*	*28639*	*28497*	*29713*	*29288*
dried pulses		*407*	*423*	*537*	*431*	*467*	*336*	*588*
tubers & roots		*13083*	*3302*	*1057*	*906*	*659*	*642*	*707*
industrial plants & plants for energy purpose		*14*	*62*	*1999*	*3344*	*4685*	*4867*	*5199*
forage plants		*11070*	*13528*	*19024*	*26079*	*22869*	*25536*	*25953*
other crops		*146*	*13*	*22*	*2*	*978*	*717*	*784*
fallow land		*2209*	*1559*	*272*	*1527*	*1861*	*139*	*280*
Permanent pastures & meadows		60893	69094	68827	65277	67245	67593	66923
	%	*42.3%*	*51.1%*	*54.5%*	*51.1%*	*52.1%*	*51.6%*	*50.9%*
pastures (grazing land)		*32276*	*39509*	*41070*	*44407*	*57747*	*58608*	*57193*
Kitchen gardens		1483	317	121	53	27	10	11
	%	*1.0%*	*0.2%*	*0.1%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*
Horticulture		145	63	19	21	34	48	102
	%	*0.1%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.1%*
Permanent crops		1904	1441	1440	1365	1546	1503	1550
	%	*1.3%*	*1.1%*	*1.1%*	*1.1%*	*1.2%*	*1.1%*	*1.2%*
vineyards		*1188*	*1180*	*1326*	*1249*	*1275*	*1266*	*1295*
Agricultural utilized area (UAA)		**144053**	**135143**	**126298**	**127643**	**129128**	**131106**	**131384**

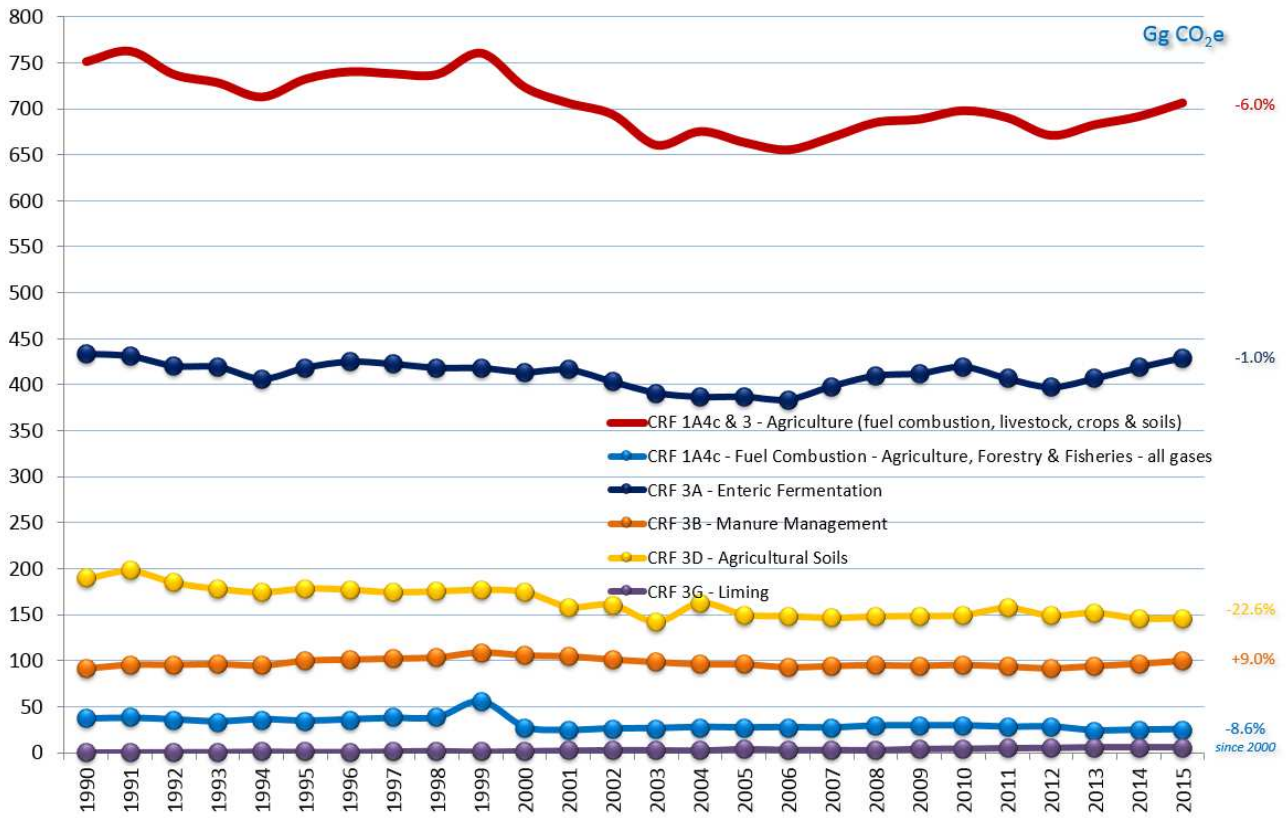
Sources: SER: http://www.ser.public.lu/statistics/agr_structures/statec_15_mai_pluriannuel.pdf
STATEC, *Statistical Yearbook*, Table D.2100 (updated 28.04.2016):
http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=13352&IF_Language=fra&MainTheme=4&FldrName=2&RFPath=7274

TABLE II.9-2 – LIVESTOCK POPULATION FOR SELECTED ANIMALS' CATEGORIES: 1990-2015

heads	1990	2000	2005	2010	2015
Dairy cattle	58840	43346	39340	45008	46903
Non-dairy cattle	80666	86091	78863	81390	82174
suckler cows	*17563*	*27610*	*27615*	*32485*	*29223*
other cows	*63103*	*58481*	*51248*	*48905*	*52951*
Swine	75463	80141	90147	83774	95337
Sheep	7281	7971	10277	9084	9453
Horses, mules & asses	1722	3154	4193	4601	4717

Sources: SER: http://www.ser.public.lu/statistics/agr_structures/statec_15_mai_pluriannuel.pdf
STATEC, *Statistical Yearbook*, Table D.2107 (updated 28.04.2016):
http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=13355&IF_Language=fra&MainTheme=4&FldrName=2&RFPath=7274

FIGURE II.9-1 – GHG EMISSIONS FOR AGRICULTURE (CRF SUB-CATEGORY 1A4C & CRF SECTOR 3): 1990-2015



Source: Environment Agency – Submission 2017v1.2.
Notes: (1) CRF 1A4c: there are breaks in time series between 1999 & 2000, hence the growth rates are calculated based on the year 2000
(2) CRF 3G: liming emissions increased by 885.1% since 1990.

II.10. FORESTRY

CRF sub-category covered	4A		
share in total GHG emissions, incl. LULUCF	***1990***	|1.9%| =	-239.80 Gg CO_2e
	2015	|4.9%| =	-479.66 Gg CO_2e

II.10.1. Forests in Luxembourg: an old asset under a shared responsibility

With the retreat of farming over the last century, the forest area has increased to reach nowadays some 90 000 ha, covering a bit less than 35% of the national territory as a whole (ranging from 42% in Ösling to 31% in Gutland, with the 55% of the forests located in the Ösling region) *[→ Section II.2]*.

Forests are managed by the public authorities – the Nature and Forests Agency (*Administration de la Nature et des Forêts* – ANF) – and by private forest owners represented by an association – *Lëtzebuerger Privatbësch – Groupement des Sylviculteurs*.[50] ANF administers municipal woods (32.8% of the forests of Luxembourg), woods owned by the state (10.7%) and those belonging to public administration

50 http://www.privatbesch.lu/.

(1.3%). **Public forests** are managed according to Resolutions, criteria and indicators of the "Forest Europe Process",[51] as well as by national close to nature forestry guidelines.

The remaining 55% are **private forests**, which are extremely fragmented[52] and only partially managed. However, professional foresters have been assigned to *Lëtzebuerger Privatbësch* to promote sustainable forestry in private forests. This is notably done under the "Luxembourg Certification Scheme for Sustainable Forest Management".[53]

Two **certification schemes**, FSC® and PEFC, are used in Luxembourg.[54] The choice of one or the other scheme is under the responsibility of the forest owner, whether he is public or private.

The **different forests types** are:

- broadleaved forests – mostly beech & oak – for around two thirds of the total (around 60% of these trees are located in public forests);
- coniferous stands – mostly spruces – for around a quarter of the total (around 70% of these trees are located in private forests);
- mixed forests – broadleaved trees and coniferous trees – for around 10% of the total (almost equally located in both public and private forests); but also:
- coppices and bark hedges (almost 90% being placed in private forests);
- non-forested areas – shrubs, forest roads, quarries, clear cuttings, etc.

Luxembourg's forest contains no natural forest and has been strongly stamped by human activity.[55] Old-growth forests (over 100 years) cover around two thirds of the broadleaved forest. Conifer groves are younger, because their production cycle is shorter. As a whole, the Luxembourg forest is relatively old.

Observations on the **phytosanitary state of Luxembourg forest** show sharp degradation of the forest, which appears today to have stabilised, but at an unsatisfactory level:[56] if 30% of the trees do not show any major damages, one third are lightly damaged and the remaining part, i.e. around 38%, are severely damaged (figures for 2016).

The declining health of these forests results from complex factors that include air pollution (causing acidification and eutrophication), climate change, diseases due to insect infestations, impoverishment of forest soils, and deficiencies in magnesium and calcium. The situation has been

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51 www.foresteurope.org.

52 In particular, because of the pattern of transmission through successive generations.

53 http://www.privatbesch.lu/der-wald/nachhaltigkeit/ and http://www.pefc.lu/. The latter is a joint web portal of and for the public authorities and the private owners.

54 http://environnement.public.lu/fr/natur/forets/certification_forets.html Details: https://lu.fsc.org/fr-lu and http://www.pefc.lu/.

55 The beech stands of Gutland, for instance, have been overexploited to produce charcoal for the iron industry.

56 http://environnement.public.lu/content/dam/environnement/documents/natur/forets/aktiounsplang-besch.pdf.

aggravated by replanting with a poor choice of species and inappropriate forestry activities in private forests. Finally, the ageing of the forest also increases the risk of infestation by insects and other parasites.

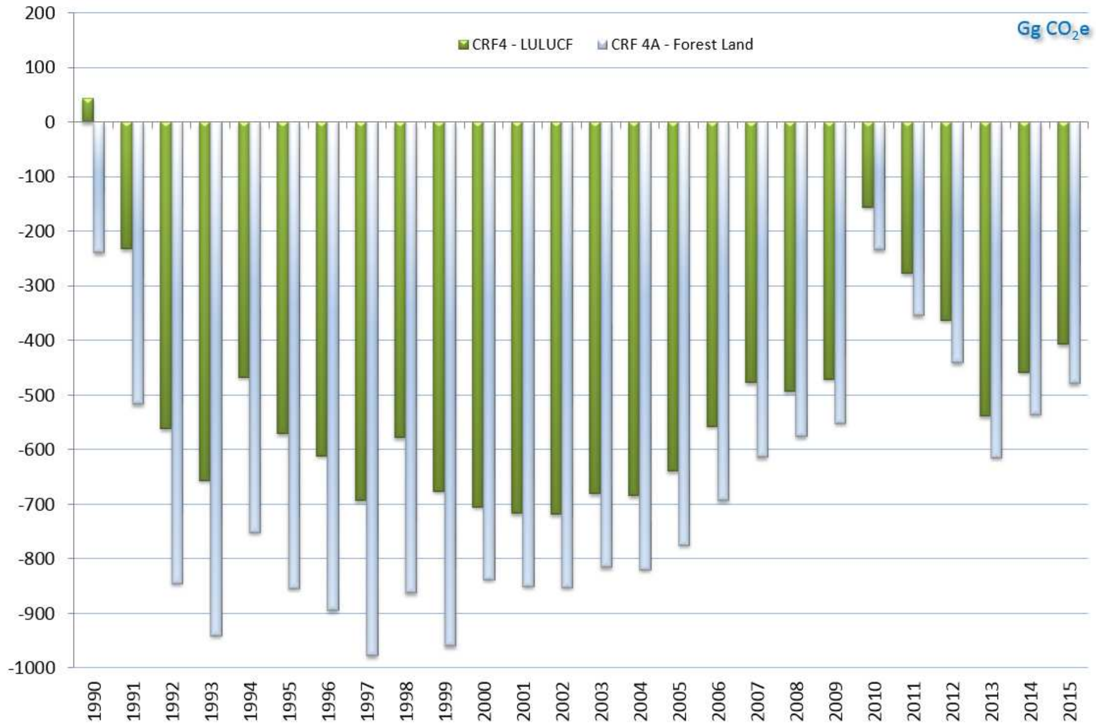
II.10.2. GHG emissions: forests act as a sink in Luxembourg

Emissions estimates for CRF sub-category 4A shows that "forest land remaining forest land" (4A1) and "land converted to forest land" (4A2) acts as a sink *[→ Figure II.10-1]*. The key driver behind emissions development over the period 1990-2015 is the ongoing increase in net removals in forest land remaining forest land following the recovery from the important storms that touched the country during the winter 1990-1991 and that severely hit Luxembourg's forests – for which two-thirds consists of single-story stands, which are more unstable than multi-storied forests in the face of storms.

The net carbon stock changes in forest biomass also have a major impact on the overall trend. These changes vary considerable between single years mainly due to fluctuating harvest rates. The harvest rates in their turn are influenced by timber demand and prices, insect infestation or wind throws (salvage logging after windfalls).

For the LULUCF sector in general, the trend is similar to that for CRF sub-category 4A, which represents the main part of LULUCF emissions & removals *[→ Figure II.10-1]*.

FIGURE II.10-1 – GHG EMISSIONS & REMOVALS FOR FOREST LAND (CRF SUB-CATEGORY 4A) AND THE LULUCF SECTOR: 1990-2015



Source: Environment Agency – Submission 2017v1.2.
Note: positive values correspond to net emissions and negative values to net removals.

II.11. WASTE

CRF (sub-)categories covered	1A1a part & 5		
share in total GHG emissions, excl. LULUCF	***1990***	1.1% =	145.87 Gg CO_2e
	2015	1.7% =	177.62 Gg CO_2e
1A1a pt	***1990***	0.3% =	33.94 Gg CO_2e
	2015	0.8% =	84.65 Gg CO_2e
5	***1990***	0.9% =	111.92 Gg CO_2e
	2015	0.9% =	92.97 Gg CO_2e

II.11.1. Managed waste streams bearing concrete results[57]

Luxembourg has for many years been pursuing an active policy of **waste management** based on prevention and recovery with a view to minimising environmental impact and supplying high-quality secondary raw materials. It gives priority to recovering materials for reintroduction into the economic circuit.

The legislative and regulatory framework is based on the amended "Waste Prevention and Management Act" (*Plan Général de Gestion des Déchets*, PGGD) of 2010, which calls for full-cost pricing at every stage of waste management and sets the following goals:

- preventing and reducing waste production and pollution from waste;
- recovery through reuse, recycling or any other environmentally appropriate method;
- disposal of final waste in environmentally and economically appropriate ways.

This PGGD is currently being revised to become a **wider strategy with regard to waste and resources management**: "*Plan National de Gestion des Déchets et des Ressources*" (PNGDR). The overall objective of the PNGDR is primarily to protect the environment and human health by preventing and reducing the harmful effects of waste. In addition, long-term goals, including conservation of resources, climate protection and impacts for future generations, are set within the PNGDR. The underlying concept is the one of a "circular economy", following the principles of a sober and responsible consumption of natural resources, alongside the enhancement of the duration of the life cycle of materials by their re-use or their recycling.[58]

Other laws and grand-ducal regulations concerning specific waste flows supplement the PGGD Act and transpose European legislation into national law (movements of hazardous waste, packaging waste, waste oils, PCBs, waste incineration, sewage sludge, waste electrical and electronic equipment (WEEE), batteries etc.). European legislation plays an increasing role in determining policies and establishing objectives. Luxembourg must also comply with other international

57 Some texts of this section have been extracted from OECD (2010).

58 For more details on the PNGDR, see http://environnement.public.lu/fr/offall-ressourcen/principes-gestion-dechets/Plan_national_de_gestion_des_dechets_PNGD.html.

commitments relating to cross-border waste movements and to the ecological management of waste and resource productivity.

II.11.1.1. Municipal waste: high generation but also high recovery rate

Under the impact of **separate collection and recovery measures**, there has been a continuous decoupling between municipal waste, residual waste for disposal and GDP over the last years. The volume of waste that must be dealt with has been growing less quickly than GDP, although at a rate close to growth in private consumption, while both population and cross-border employment have been rising *[→ Section II.2]*. However, **waste generation per capita** (at 607 kg in 2015) is among the highest in Western Europe. But, it is including waste generated by cross-border commuters and by (small) services businesses whose numbers increased considerably since 1990.

Collection and recovery rates of **municipal waste** are among the best in Europe. With separate collection, almost 50% of total municipal waste can now be recovered – a rate of around 60% for organic waste. Recovery volumes are rising, reflecting the growing network of recycling centres and active public awareness about trash sorting. Separate municipal waste collection amounts to around 300 kg per capita every year, making Luxembourg's performance among the best in Western Europe. Most of the waste collected is exported for recycling (primarily to Germany, Belgium, France and the Netherlands).

There has been a slight decrease of **municipal waste being incinerated or stored in landfill** sites since 1990: -5%. But at the same time, the amount of waste to be treated augmented by almost 45%, i.e. waste collected to be recycled or recovered has increased by 2.5 times. In 2015, two-thirds of non-recovered waste were incinerated with energy recovery, while the remainder ended up in landfills. This is explained by the fact that Luxembourg favours recovery, either through recycling or through incineration with energy recovery. Since 1990, several landfills have been closed and nowadays only one site is still operational and equipped for methane recovery.

II.11.1.2. Industrial, commercial and service waste: important volumes but declining

Industrial, commercial and service waste are generally exported to Germany, France, Belgium and the Netherlands for treatment. Indeed, Luxembourg does not have recycling or recovery installations on its small territory. The same holds for municipal waste collected through recycling centres or schemes, which are, therefore, mostly sent abroad for valorisation or other treatments.

Final industrial waste declined during the period under review, reflecting the combined impact of the closure of a mill and of the implementation of "Waste Prevention and Management Plans" (*Plan de Prévention et de Gestion des Déchets*, PPGDs) by businesses, which have diverted many types of waste from disposal to recovery. In fact, companies are to appoint a "waste management officer" and prepare a PPGD that requires firms to evaluate their prevention and recycling potential and to institute ecological management of their waste.

II.11.1.3. Other waste streams are also subject to valorisation

There are about between 10 and 15 000 tonnes of **sewage sludge** generated each year, most of which is used in agriculture (50 to 55%) as fertilizer (sludge spreading) or composted (around 40%). There are also around 10 Mio. t of **inert waste generated these last years**, consisting primarily of construction materials (including excavated earth), demolition waste and road maintenance waste that have to go to dedicated disposal sites where they are recovered, notably via grinding operations. The volume of inert waste generated, which is closely linked to construction activity, has risen in recent years.

II.11.1.4. Waste reduction and materials recovery: the solution for Luxembourg waste management policy

Luxembourg has few levers available for influencing the design or composition of products. It can however act on consumer habits and on household and business participation in selective sorting and in waste prevention and ecological management programmes. Its policy is to introduce separate collection and appropriate management systems, together with information targeted at households and consumers, as well as advisory services, training and assistance to businesses.

For around 25 years now, separate collection of **municipal waste** has been based on both mobile and fixed collection, a network of 22 recycling centres (2015) and a programme of regular public information. Separate collection applies to all recoverable items and "problem waste". The volumes collected by voluntary delivery to recycling centres have more than doubled since 1999.

To prevent the **generation of consumer waste**, the emphasis is on informing the public about the products that generate waste, components that are hazardous to the environment and health, and available substitutes. These efforts rely on joint public- and private-sector initiatives and on economic instruments.

With regard to **industrial, commercial and service waste**, the main instruments for achieving waste prevention targets and reintroducing materials into the economic circuit are the PPGDs and the advice provided to businesses by the *SuperDrecksKëscht® fir Betriber* programme (see Box II.11-1).

II.11.1.5. Treatment and disposal of final waste

Municipal waste treatment, as well as separate collection and recycling centres, is under the responsibility of three inter-communal syndicates operating, respectively, one controlled landfill and an incineration plant with energy recovery.

Regarding **industrial, commercial and service waste**, thanks to the PPGDs, remaining quantities to be eliminated are such that domestic facilities are less justified than in the past. Non-household waste for disposal is exported to specialised facilities in neighbouring countries, primarily in Germany. Due to the size of the country and of its economy, total quantities exported may vary sharply from one year to the next.

Box II.11-1 – The *SuperDrecksKëscht*® (SDK): a success story in managing hazardous waste (1)

SDK is a programme for managing problem waste sponsored by the Environment Agency in co-operation with the communes – household component – and the *Chambre des Métiers* (Trades Council) – business component. The programme is based on the principles of prevention, reduction and recovery of waste:

i) all recyclable materials are processed to recover a maximum of secondary materials, and all problem substances are treated to minimise their impact on the environment; and

ii) substance flows, from generation to transformation into new raw materials or until their disposal in an environmentally friendly manner, must be clearly presented so that they can be audited at any time.

The SDK programme is ISO 14001 certified and has had a legal basis since 2005.

The household component (*SuperDrecksKëscht® fir Birger*) has been handling household waste since 1985. It includes:

- collection by mobile containers, collection at fixed recycling centres, and home pickup on request;
- actions targeting particular flows of waste, organised in co-operation with private partners (e.g. for batteries, medications and syringes);
- numerous information and awareness campaigns, in the schools and elsewhere.

The business component (*SuperDrecksKëscht® fir Betriber*), in place since 1992, concerns non-household waste generated by businesses and by public and private establishments. Participation is voluntary and is done by contract. It includes:

- assistance and advice for certifying ecological management of waste, with (i) a situation report on waste management in the firm, and help in preparing the waste balance sheets; (ii) assistance in preparing the firm's Waste Prevention and Management Plan (PPGD); (iii) assistance in implementing the PPGD (separate collection, storage, treatment, finding of licensed enterprises, prevention of waste generation through use of durable materials or introduction of environmentally friendly production methods); and (iv) information, training and awareness activities for employees;
- collection of small quantities of waste on request;
- collection of particular flows in co-operation with public and private sector partners.

A quality label is awarded service firms and waste transport companies that manage their waste in an environmentally responsible manner consistent with the SDK concept. Compliance with management criteria is audited once a year. Firms that have had the label for five consecutive years are audited only every two years. The list of certified firms is published on the Internet.

The cost of the household component is fully covered by the government through the Environment Protection Fund. The cost of the business component is shared: assistance, advisory and training services are financed by the government, while waste collection and treatment is covered by the firms.

Since 2007, the SDK concept has been exported in the form of franchise contracts that are available to public authorities and to public and private establishments in other countries seeking to institute a waste management system along the lines of the Luxembourg model **(2)**. Finally, the SDK has been awarded with "Best Practice in Europe" by the European Commission **(3)**.

(1) this box is an extract from OECD (2010). More information available at http://www.sdk.lu/.
(2) see http://www.superdreckskescht.com/.
(3) see http://ec.europa.eu/environment/waste/prevention/pdf/SDK_Factsheet.pdf.

II.11.2. Effects on GHG emissions: a yearly increase of 0.6% on average since 1990

In Luxembourg's GHG inventory, emissions are recorded for four CRF sub-categories: incineration and open burning of waste (CRF 5C but part of CRF 1A1a since energy is recovered and no open burning of waste is allowed in Luxembourg), solid waste disposal (CRF 5A), biological treatment of solid waste (CRF 5B) and wastewater treatment and discharge (CRF 5D) *[→ Figure II.11-1]*.

Total waste related GHG emissions have increased by 14.1% between 1990 and 2012. Excluding waste incineration, the emissions have decreased by 28.4%. This latter evolution was mainly driven by the fact that for **solid managed waste disposal on land** (CRF 6A1) emissions have been reduced by 55.2% between 1990 and 2012 *[→ Figure II.11-1]*. This development is due to:

- a decrease in the quantity of waste being landfilled, notably through the development of recycling schemes and the expansion of both the numbers of and the various waste categories collected by recycling centres;
- the aerobic pre-treatment before landfilling;
- the recent installation of methane recovery systems at waste dumping sites.

However, **waste incineration** related emissions[59] – that are presented under CRF sub-category 1A1a – public electricity and heat production – in the inventory because energy from waste burning is recovered in the sole incinerator of the country and injected in the electric public network – did increase a lot, setting the upward trend for the overall waste emissions. The big jump in the series between 1997 and 1998 *[→ Figure II.11-1]*, which is responsible of the increasing waste incineration emissions, is due to methodological reasons and to the fact that incinerated waste composition data are only available for some years, requesting interpolations. Therefore, the overall trend presented in this section for waste, including incineration, should be looked at with caution. In the inventory, it is mostly hidden since, for the last years, waste incineration represents between 5% and 7% of the total public electricity and heat production category emissions (CRF 1A1a) and around 0.5% of the total GHG emitted in Luxembourg, excluding LULUCF.

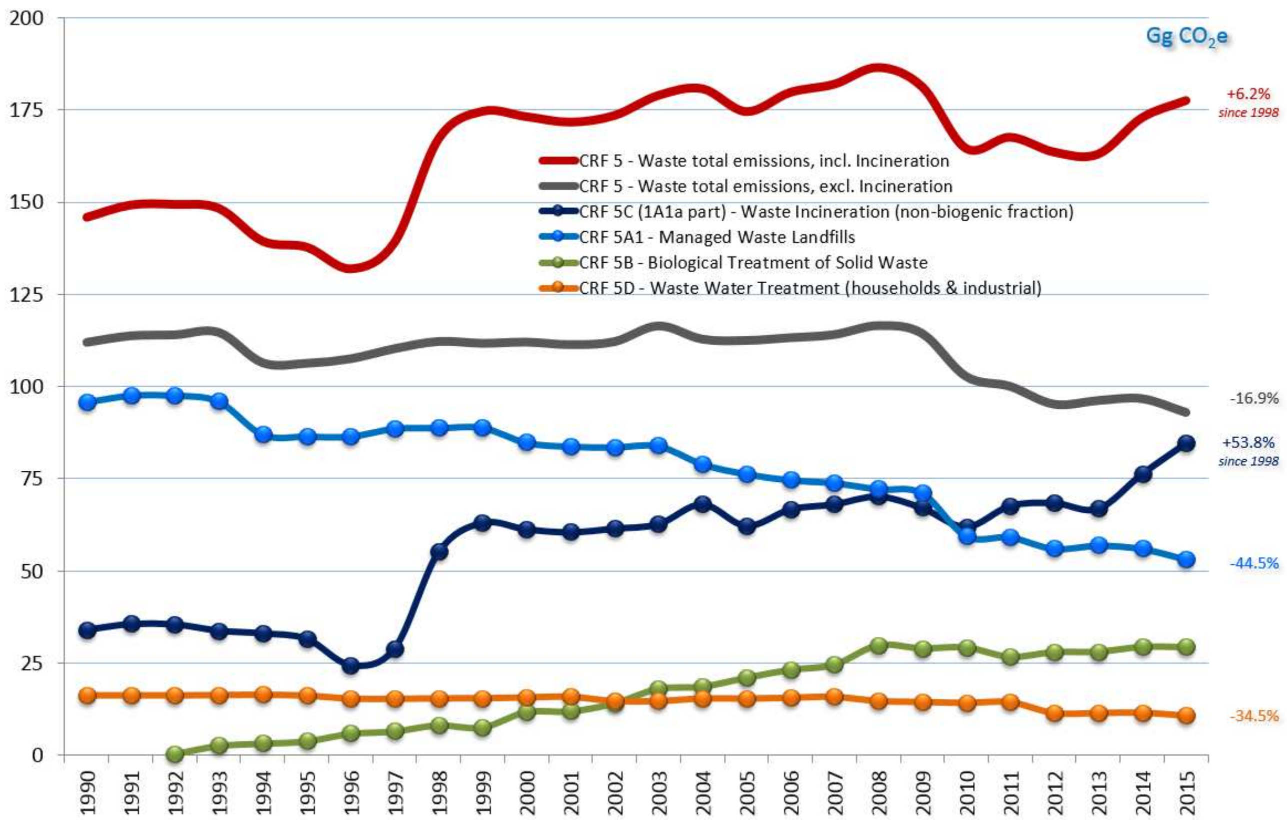
Wastewater handling emissions have decreased by 9.3% between 1990 and 2012. Wastewater treatment plant (WWTP) capacities expressed in population-equivalents have steadily grown since

59 Emissions commented here cover only the "non-biogenic" fraction of waste to be incinerated – the "biogenic" fraction is reported under memo items for CO_2 and under biomass for the other gases.

1990. This justifies, but only partly, the increasing N_2O emissions for this source category. Indeed, WWTP capacities grew by some 80% over the period 1990 to 2012, whereas nitrous oxide emissions increased by 17.4%. Therefore, technical changes, with regard to wastewater treatment, have an unquestionable role too.

Concerning **compost production**, this activity started on an "industrial scale" only in the early 1990s. It experienced a steady growth from 1993 to 2006 and then stabilizes.

FIGURE II.11-1 – GHG EMISSIONS FOR WASTE (CRF SUB-CATEGORY 1A1A, PART & CRF SECTOR 6): 1990-2012



Sources: Environment Agency and Water Agency – Submission 2017v1.2.
Notes: (1) CRF 1A1a, part: there is a break in time series between 1997 & 1998, hence the growth rate is calculated based on the year 1998.
(2) CRF 5B: biological treatment of solid waste emissions increased by 11 500% since 1992.

II.12. UNFCCC AND KYOTO PROTOCOL: A DEMANDING CHALLENGE FOR LUXEMBOURG

II.12.1. The road transportation dilemma

Since Luxembourg is a small open economy integrated in the European internal market **where mobility of tax bases are likely to be high**, only marginal variations in the price differentials for petrol and diesel can be initiated by the authorities. Indeed, if Luxembourg's rates of taxation and prices were higher than those in the surrounding countries, it would be rather easy for any citizen of Luxembourg to avoid domestic taxation and to practise arbitrage: no location in Luxembourg is further than a maximum of 25-30 km away from a border with a neighbouring country. Lower taxation rates for certain goods – such as fuels, e.g. – have therefore always been part of Luxembourg fiscal policy and will remain crucial in the future, because of the country's geographical location and its small area. Whereas in larger neighbouring states, increasing certain tax rates would result in a slight shift in demand and in arbitrage deals at the outer fringes of their national territory – with a corresponding relatively slight reduction in tax revenues – this would not be the case for Luxembourg where such a policy may result in big losses in tax incomes. However, since road transportation, and more precisely "road fuel sales to non-residents", is the main contributor to GHG emissions in Luxembourg, as underlined in the second national "Action Plan for reducing CO_2 emissions" [Ministry of Sustainable Development and Infrastructure, Department of the Environment (2013b)], Luxembourg will use a policy mix of instruments with the aim of progressively reducing road transport related emissions.

With regard to the instrument of excise duties, Luxembourg will gradually increase road fuels excise rates following a cautious approach based on a better knowledge of the factors determining road fuel sales in Luxembourg that also takes into account the impact on the public finances of the country. Furthermore, in its programme, the actual Government that took office early December 2013 *[→ Section II.1]* underlines that a **feasibility study on the progressive way out of "fuel tourism"** – and more generally of "road fuel sales to non-residents" – should be realized so to evaluate the economic impacts of such a decision on the medium and long terms [Government of the Grand Duchy of Luxembourg (2013), p. 84]. This study has been released in November 2016.[60] Its outcomes led to the setting-up of an inter-ministerial working group with the aim to inform the Government on possible venues to reduce the weight of road fuel sales in the GHG balance of Luxembourg, as well as making public finances less dependent from that source of income. In parallel, STATEC is working on evaluating price-elasticities of road fuel sales.

With regard to other instruments, the Luxembourg Government considers the organization of transport and the necessity to overcome existing problems linked to the traffic intensity as primary objectives. In this context, it promotes sustainable ways of transport consisting of public and non-motorized modes of transport. The re-organisation is intended to encompass both the national territory and the neighbouring regions of Germany, France and Belgium where many commuters come from, leading to a doubling of the workforce in Luxembourg during the day. All this is done in a conceptual way where new modes of transport such as electro-mobility and car sharing are promoted.

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60 *Ermittlung und Bewertung der positiven und negativen Wirkungen des Treibstoffverkaufs unter besonderer Berücksichtigung negativer externer Umwelt-und Gesundheitseffekte – Status quo 2012 und maßnahmeninduzierte Veränderungen, Bericht für das Ministerium für Nachhaltige Entwicklung und Infrastrukturen des Großherzogtums Luxemburg*, Königswinter, 2016. (http://environnement.public.lu/fr/actualites/2016/11/etude_tt.html)

II.12.2. Country and economy sizes

Special attention must also be made for the **small size of the country's economy** in a different context: it is a contributory factor to the fact that, in spite of the healthy economic situation, the courses of the overall development of the country, of the demand for energy and of the emissions balance are often affected by a single plant which is starting its activities, closing them down or changing its production processes. This became particularly clear when the steel industry switch from blast furnaces to electric arc furnaces was completed during the 1990s: from 1990 to 1998, GHG emissions in Luxembourg were reduced by one-third ***[→ Section II.7]***.

Furthermore, the construction of a single power station, the TWINerg gas and steam plant, represents a further illustrative example as depicted in ***Section II.6***. When TWINerg started its operation in mid-2002, Luxembourg, which did not have so far any substantial electricity generating capacity, saw, at once, its GHG emissions increasing by 0.9 to 1 Mio. t CO_2e per year. To give another illustration on how this project affected the GHG emissions pattern in Luxembourg, one can underline that it represents 35% of the allocated emissions volume of the whole GHG EU Emissions Trading System sector (EU ETS) for the first commitment period under the Kyoto Protocol.

The impact that single industrial projects might have, plays also the other way round when a production unit or a plant is closed down. After a few years of reduced activity, the TWINerg power plant was finally shut down in 2016, which is having a high impact on Luxembourg's total GHG emissions. In addition, a sufficiently long breakdown in one of the main industrial unit of the country could have impacts on the total GHG emissions, such as the long maintenance operations of the TWINerg plant in 2008 and 2011 demonstrated ***[→ Section II.6.2]***.

If these issues might not be a major concern for large economies, it is for Luxembourg, as shown by the examples discussed above.

II.12.3. Limited GHG emissions reduction potentials

As of today, Luxembourg **does not have those significant technical potentials** that exist in other countries where residual "old-technology" industrial and power plants still operate. In Luxembourg, there were almost none, and there still is none of those GHG reduction potentials stemming from the modernisation or the replacement of existing national industrial or power plants. In fact, with the move from blast to electric arc furnaces in the steel sector during the 1990s, Luxembourg very soon exhausted its only major technical potential for GHG emissions reduction. With the process change in the steel industry – an activity that accounted for 50% of Luxembourg's total GHG emissions in 1990 (excluding LULUCF)[61] – total emissions from industry and electricity generation – i.e. largely the sectors covered by the EU ETS – decreased to just 2.1 Mio. t CO_2e in 2015

61 Sum of CRF sub-categories 1A2a and 2C1. This percentage is 3.9%for 2015.

– or 20% of total GHG emissions (excluding LULUCF) – coming from slightly more than 7.9 Mio. t CO_2e in 1990 - or about 62% of total GHG emissions (excluding LULUCF) *[→ Table III.1-3]*.[62]

In addition, any ultramodern fossil fuel-based electricity generating plant that Luxembourg might decide to construct will automatically lead to an increase of its national GHG emissions, since there are no existing power plants that can be stopped in return. Thus, those highly efficient CHP installations – as well as the gas and steam power station (TWINerg) when it was operating – that have been promoted and are operating in Luxembourg since 1998, and that use natural gas and, sometimes, gas oil as inputs, have led to an additional amount of approx. 1.2 Mio. t CO_2e in the GHG balance.[63] It is therefore clear that any new fossil-fuel power generating installation that might be constructed will inevitably lead to a deterioration of Luxembourg's GHG balance. This also implies that the implementation of the EU CHP installation guidelines, which in other countries may lead to CO_2 reductions thanks to increased efficiency, is counterproductive for Luxembourg. For this reason, Luxembourg's authorities only promote heat production from renewable energy sources, focusing mainly on biomass, wood and solar energy.[64] More precisely, CHP installations using renewable energies, biogas addition in distribution networks and the mobilization of wood resources are favoured.

II.12.4. The "origin" principle of the IPCC reporting Guidelines vs. the "polluter pays" principle

The "origin" or "territorial" principle applied for reporting GHG emissions under the IPCC Guidelines generates a GHG balance for Luxembourg that looks significantly less favourable than would a "consumer" or "polluter pays" approach produce. The "origin" principle is in favour of Luxembourg in that its imports of electricity are excluded from its GHG emission balance: those emissions are attributed to the electricity producing countries. However, as indicated above, "road fuel sales to non-residents" related emissions are reported in Luxembourg's GHG balance.

Now, if the "polluter pays" principle is used as a yardstick, Luxembourg's assessment reveals that GHG emissions according to the IPCC Guidelines are higher from 2002-2012 (the period during which the TWINerg power plant was fully operational), but about 1.6 Mio. t CO_2e lower for 2015 *[→ Figure II.12-1]*.[65] This illustrates that the presence of a single power plant – even though it was highly efficient – has a significant impact on Luxembourg's national total GHG emissions.

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62 Sum of CRF sub-categories 1A1a, 1A2 and 2, excluding solvent use (2D) and F-gases (2F).

63 1 Mio. t CO_2e for the TWINerg and 0.2 Mio. t CO_2e for CHP installations.

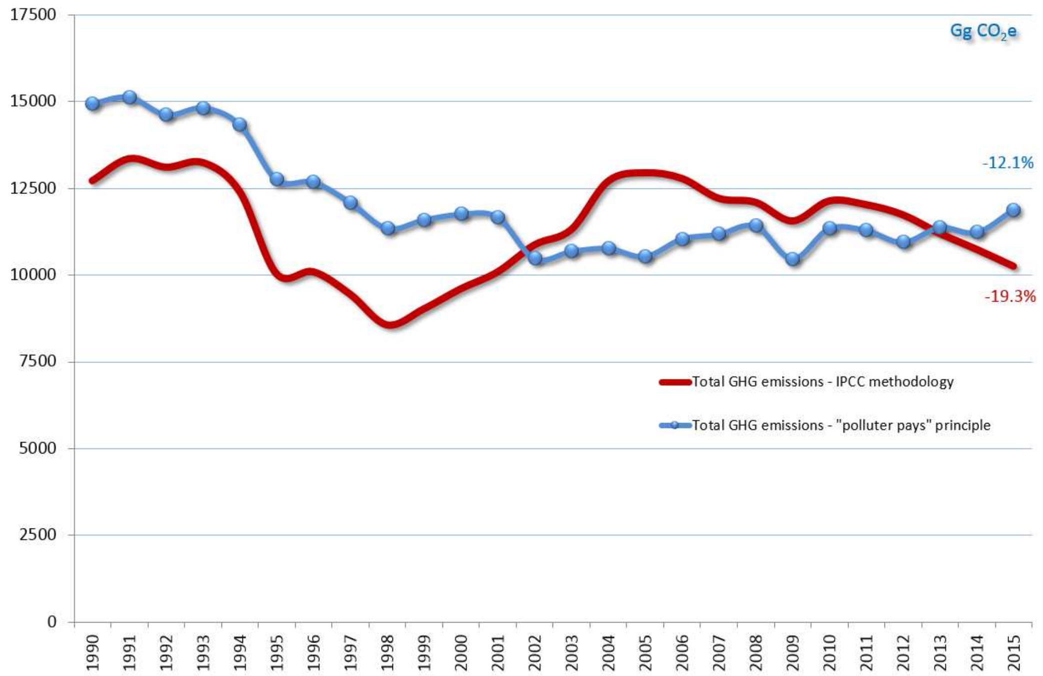
64 See the second national "Action Plan for reducing CO_2 emissions" [Ministry of Sustainable Development and Infrastructure, Department of the Environment (2013b)].

65 After having reached a "surplus" of 1.8 Mio. t CO_2e in 2005.

Thus, Luxembourg's efforts to develop efficient, low-carbon electricity production are not rewarded in the actual reporting system for GHG emissions. For many years, Luxembourg has promoted the construction and the development of highly efficient CHP installations and of a modern gas and steam power plant. Luxembourg has also actively supported power generation and uses based upon renewable energies and, for all these policies, further developments are still in the offing. A few years ago, the impact of these policies were evaluated using GEMIS 4.2:[66] at that time, it was estimated that electricity imports – with an average emission factors of around 0.75 (kt CO_2 per GWh) – felt by more than 1 200 GWh since 2001 – the last year before the TWINerg power plant operates at full capacity – and were replaced by national electricity generation with a current average emission factor of 0.41 (kt CO_2 per GWh).

Therefore, in terms of the GHG balance, the promotion of renewable energies in the electricity sector, which is associated with major investments, is of little interest. Moreover, additional capacities based upon renewable energies cannot actually be used to replace any electricity from inefficient existing fossil-fuel plants in Luxembourg. Nor will they substitute the highly efficient national production plants that have just been constructed. In reality, they will replace the imported electricity that does not appear in Luxembourg's GHG balance. In this sense, the existing system provides Luxembourg with the incentive not to earmark the generally scant subsidies for Europe's priority investments in renewable energies but, instead, to invest these in measures which might improve its GHG balance.

FIGURE II.12-1 – TOTAL GHG EMISSIONS, EXCLUDING LULUCF – IPCC AND "POLLUTER PAYS" APPROACHES: 1990-2015



Sources: Environment Agency and MDDI-DEV – Submission 2017v1.2.

Notes: the "polluter pays" principle figures have been obtained from the total GHG emission according to the IPCC methodology by excluding emissions from "road fuel sales to non-residents" and for electricity generated that is exported, and by adding an estimate for electricity production emissions generated abroad for satisfying Luxembourg consumption (i.e. emissions relating to electricity imports):
emissions "polluter pays" principle = emissions IPCC methodology – emissions "road fuel sales to non-residents" + emissions electricity net imports

66 GEMIS stands for "Global Emission Model for Integrated Systems": http://www.iinas.org/gemis-de.html.

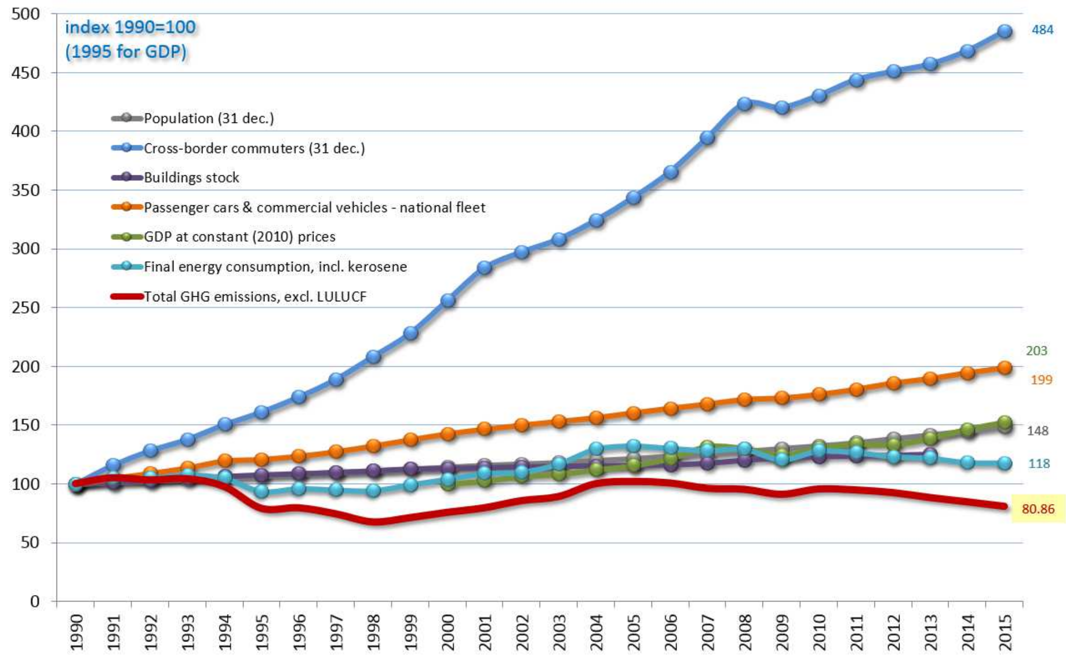
II.13. NATIONAL CIRCUMSTANCES: OVERVIEW

Key points that plays a role on GHG emissions trends in the past and in the future are:

- a country characterized for most of the years covered by this Communication by both **high demographic** and **high economic growth** in a stagnating region, hence an **attractive economic destination**;
- **strong population growth** due to immigration and that is expected to go on;
- **even stronger cross-border commuters growth** that is expected as well to go on;
- **increase of built-up areas** (housing, offices, services, infrastructures) as a consequence of the previous statements;
- location at the **heart** of the main Western Europe **transit routes** for both **goods and passengers**;
- **increase of transport flows** as a consequence of the previous statements;
- **small** size and open economy: a new industrial project, a technological change, a closure or a breakdown of a production unit might have significant impacts on the GHG emissions and increase the overall uncertainty of GHG projections;
- **limitations in taxation policies** due to short distances to neighbouring countries;
- a country that **needs to co-operate and to interact with its neighbours** since environmental issues quickly become cross-border issues;
- **limited national** GHG emissions reduction potential.

Figures II.13-1a & b & II.13.2 provide a quick overview of the trends of some key variables since 1990.

FIGURES II.13-1a – KEY VARIABLES TRENDS – 1: 1990-2015



FIGURES II.13-1b – KEY VARIABLES TRENDS – 1: 1990-2015 (EXCL. CROSS-BORDER COMMUTERS)

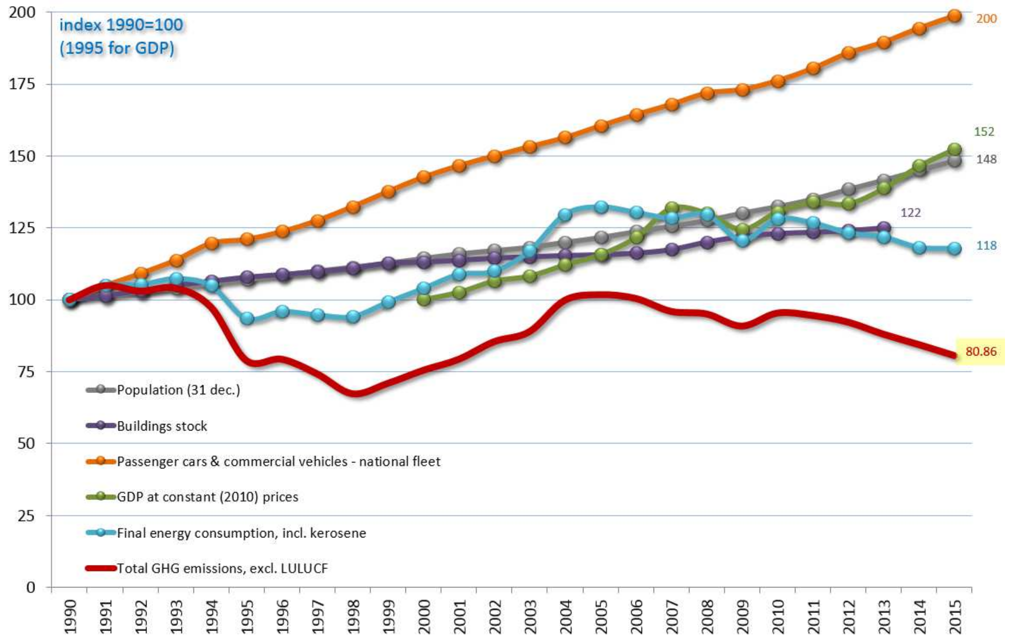
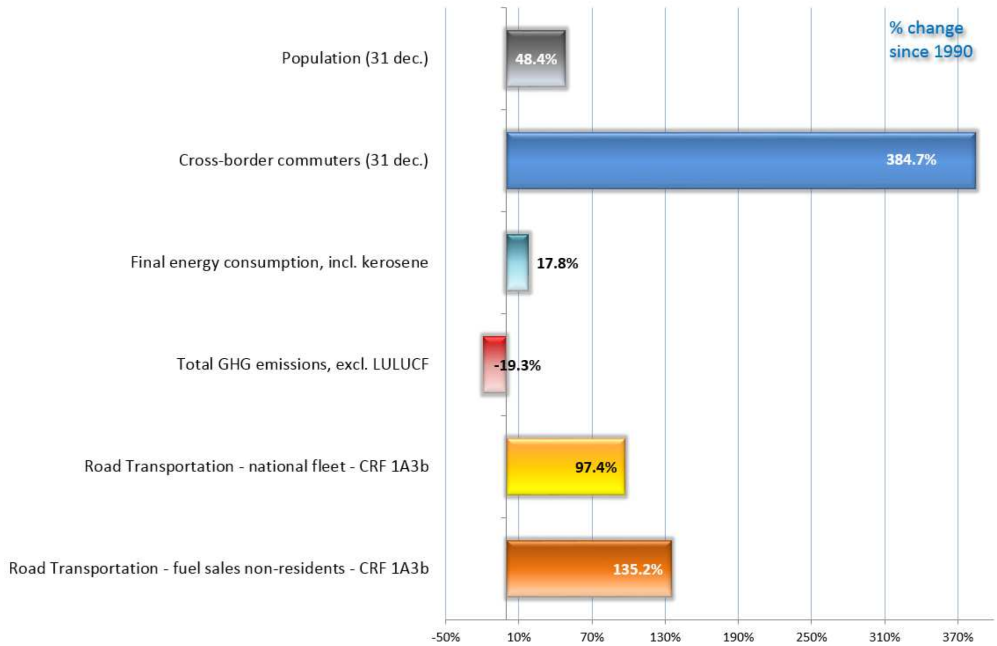


FIGURE II.13-2 – KEY VARIABLES TRENDS – 2: 1990 & 2015



Sources: population: STATEC, *Statistical Yearbook*, Table B.1100 (updated 05.05.2017).
http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=12856&IF_Language=fra&MainTheme=2&FldrName=1
commuters: STATEC, *Statistical Yearbook*, Table B.3107 (updated 06.12.2017).
http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=12928&IF_Language=fra&MainTheme=2&FldrName=3&RFPath=92
buildings stock: MDDI-DEV estimates based on STATEC, *Statistical Yearbook*, Table D.4200 & results from the 2011 population census.
http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=13443&IF_Language=fra&MainTheme=4&FldrName=4&RFPath=35
http://www.statistiques.public.lu/stat/tableviewer/document.aspx?ReportId=8624
cars & vehicles: STATEC, *Statistical Yearbook*, Table D.6102 (updated 30.01.2017).
http://www.statistiques.public.lu/stat/ReportFolders/ReportFolder.aspx?IF_Language=fra&MainTheme=4&FldrName=7&RFPath=7049%2c13898
GDP: STATEC, *Statistical Yearbook*, Table E.2101 (updated 10.2017).
http://www.statistiques.public.lu/stat/TableViewer/document.aspx?ReportId=13135&IF_Language=fra&MainTheme=5&FldrName=2
energy: STATEC, *Statistical Yearbook*, Table A.4300 (updated 31.03.2017).
http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=12771&IF_Language=fra&MainTheme=1&FldrName=4&RFPath=51
GHG: Environment Agency – Submission 2017v1.2.

Notes: (1) energy: there is a break in time series between 1999 & 2000.
(2) buildings stocks = stock of permanently occupied dwellings.

Chapter III

GHG Inventory Information, including National System and the National Registry

Chapter III comprises three main sections. Firstly, GHG emissions as reported in the latest inventory submission to the UNFCCC Secretariat are analysed in details, as suggested in UNFCCC reporting guidelines, paragraphs 10 to 12. The years covered are 1990 to 2015 *[→ Section III.1]*. Then, in line with paragraphs 30 and 31 of the Kyoto Protocol reporting guidelines, a general description of the National System under Article 5, paragraph 1 of the Protocol is provided *[→ Section III.2]*. This section is complemented by some additional information relating to requests formulated in Article 10, paragraph (f), of the Kyoto Protocol *[→ Section III.2.8]*. Finally, this chapter concludes by a description of the National Registry as demanded by paragraph 32 of the Kyoto Protocol reporting guidelines *[→ Section III.3]*.

III.1. MAIN TRENDS IN GHG EMISSIONS[67] [68]

This section presents Luxembourg's GHG emissions trends between the base year (1990) and the latest year covered by **submission 2017v1.2**, i.e. 2015. Submission 2017v1.2 is the latest submission officially submitted to the UNFCCC Secretariat;[69] the next one (2018v1.x) has to be delivered to the UNFCCC before the 15th of April 2018 and will cover the years 1990 to 2016. However, a first version of this submission had to be delivered by EU Member States to the European Commission (EC) by the 15th of January 2018.

Luxembourg being a small country, its GHG inventory is characterized by a rather high number of CRF (sub-)categories which do not occur or are not applicable. ***Table III.1-1*** gives an overview of those CRF (sub-)categories for which emissions or removals are recorded and those for which emissions or removals are either not occurring or not applicable or not (yet) estimated.

67 This section of the NC7 covers sections III.A and III.B of the Outline and General Structure of the NC5 according to IPCC reporting guidelines (para. 5), which are still valid for the NC7.

68 The text of this section has benefited from inputs by the Environment Agency (Tim Mirgain, Isabelle Naegelen and Marc Schuman).

69 http://unfccc.int/files/national_reports/annex_i_ghg_inventories/national_inventories_submissions/application/zip/lux-2017-crf-06apr17.zip.

TABLE III.1-1 – LIST OF GHG SOURCES OR SINKS WITH RELATED GHG EMISSIONS OR REMOVALS – SUBMISSION 2017V1.2

GHG source & sink categories (CRF nomenclature)	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
1. Energy	X	X	X				
A. Fuel Combustion	**X**	**X**	**X**				
1. Energy Industries	X	X	X				
a. public electricity & heat production	X	X	X				
b. petroleum refining	NO	NO	NO				
c. manufacture of solid fuels and other energy industries	NO	NO	NO				
2. Manufacturing industries & construction	X	X	X				
a. iron & steel	X	X	X				
b. non-ferrous metals	X	X	X				
c. chemicals	X	X	X				
d. pulp, paper & print	X (2000-2015)	X (2000-2015)	X (2000-2015)				
e. food processing, beverages & tobacco	X	X	X				
f. non-metallic minerals	X	X	X				
g. other	X	X	X				
3. Transport	X	X	X				
a. civil aviation	X	X	X				
b. road transportation	X	X	X				
c. railways	X	X	X				
d. navigation	X	X	X				
e. other transportation	NO	NO	NO				
4. Other sectors	X	X	X				
a. commercial/institutional	X	X	X				
b. residential	X	X	X				
c. agriculture/forestry/fish farms	X	X	X				
5. Other non-specified	X	X	X				
a. stationary	X (1990-2003)	X (1990-2003)	X (1990-2003)				
b. mobile	X	X	X				
B. Fugitive Emissions from Fuels	**X**	**X**	**NO**				
1. solid fuels	NO	NO	NO				
a. coal mining & handling	NO	NO	NO				
b. solid fuel transformation	NO	NO	NO				
c. other	NO	NO	NO				
2. oil & natural gas	NA	NA	NO				
a. oil	NA	NA	NO				
b. natural gas	X	X					
c. venting & flaring	NO	NO	NO				
d. other	NA	NA	NA				
C. CO_2 transport and storage	**NO**						
2. Industrial Processes and Product Use	X	NO	X	X	NO	X	NO
A. mineral products	**X**						
1. cement production	X						
2. lime production	NO						
3. glass production	X						
4. other process uses of carbonates	NO						
B. chemical industry	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
1. ammonia production	NO	NO	NO				
2. nitric acid production			NO				
3. adipic acid production	NO		NO				
4. caprolactam, glyoxal and glyoxylic acid production	NO		NO				
5. carbide production	NO	NO					
6. titanium dioxide production	NO						
7. soda ash production	NO						
8. petrochemical and carbon black production	NO	NO					
9. fluorochemical production				NO	NO	NO	NO
10. other	NO	NO	NO	NO	NO	NO	NO
C. metal production	**X**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
1. iron and steel production	X	NO					
2. ferroalloys production	NO	NO					
3. aluminium production	NO				NO	NO	
4. magnesium production	NO			NO	NO	NO	
5. lead production	NO						
6. zinc production	NO						
7. other	NO	NO	NO	NO	NO	NO	NO
D. non-energy products from fuels and solvent use	**X**						
1. lubricant use	X	NO	NO				
2. paraffin wax use	X	NO	NO				
3. other (solvent use & urea based catalysts)	X	NO	NO				
E. Electronics industry				**NO**	**NO**	**NO**	**NO**
1. integrated circuit or semiconductor				NO	NO	NO	NO
2. TFT flat panel display				NO	NO	NO	NO
3. photovoltaics				NO	NO	NO	NO
4. heat transfer fluid				NO	NO	NO	NO
5. other				NO	NO	NO	NO

GHG source & sink categories (CRF nomenclature)	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
F. Product uses as substitutes for ODS				**X**	**NO**	**X**	**NO**
1. refrigeration and air conditioning				X	NO	NO	NO
2. foam blowing agents				X	NO	NO	NO
3. fire protection				NO	NO	NO	NO
4. aerosols				X (1992-2015)	NO	NO	NO
5. solvents				NO	NO	NO	NO
6. other applications				NO	NO	NO	NO
G. other product manufacture and use	**NO**	**NO**	**X**	**NO**	**NO**	**X**	**NO**
1. electrical equipment				NO	NO	X	NO
2. SF_6 and PFCs from other product use				NO	NO	X	NO
3. N_2O from product uses			X				
4. other	NO	NO	NO	NO	NO	NO	NO
H. Other	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
3. Agriculture	X	X	X				
A. Enteric Fermentation		**X**					
1. cattle		X					
2. sheep		X					
3. swine		X					
4. other livestock (poultry, horses, deer, mules and asses, goats, other)		X					
B. Manure Management		**X**	**X**				
1. CH_4 emissions		X					
1. cattle		X					
2. sheep		X					
3. swine		X					
4. other livestock (poultry, horses, deer, mules and asses, goats, other)		X					
2. N_2O and NMVOC emissions			X				
1. cattle			X				
2. sheep			X				
3. swine			X				
4. other livestock (poultry, horses, deer, mules and asses, goats, other)			X				
5. indirect N_2O emissions			X				
C. Rice Cultivation		**NO**					
D. Agricultural Soils			**X**				
1. direct emissions from managed soils			X				
2. indirect emissions from managed soils			X				
E. Prescribed Burning of Savannas		**NO**	**NO**				
F. Field Burning of Agricultural Residues		**NO**	**NO**				
G. Liming	**X**						
H. Urea Application	**NE**						
I. Other Carbon-containing Fertilisers	**NO**						
J. Other	**NO**						
4. Land Use, Land-Use Change and Forestry	X	NO	X				
A. Forest Land	**X**	**NO**	**NO**				
1. forest land remaining forest land	X	NO	NO				
2. land converted to forest land	X	NO	NO				
B. Cropland	**X**	**NO**	**X**				
1. cropland remaining cropland	X	NO	X				
2. land converted to cropland	X	NO	X				
C. Grassland	**X**	**NO**	**X**				
1. grassland remaining grassland	NO	NO	NO				
2. land converted to grassland	X	NO	X				
D. Wetlands	**X**	**NO**	**X**				
1. wetlands remaining wetlands	NE,NO	NO	NO				
2. land converted to wetlands	X	NO	X				
E. Settlements	**X**	**NO**	**X**				
1. settlements remaining settlements	NE	NO	NE				
2. land converted to settlements	X	NO	X				
F. Other Land	**X**	**NO**	**X**				
1. other land remaining other land							
2. land converted to other land	X	NO	X				
G. Harvested Wood Products	**NO**						
H. Other	**NO**	**NO**	**NO**				
5. Waste	**NO, IE**	X	X				
A. Solid Waste Disposal	**NO**	**X**					
1. Managed waste disposal sites	NO	X					
2. Unmanaged waste disposal sites	NO	NO					
3. Uncategorized waste disposal sites	NO	NO					
B. Biological Treatment of Solid Waste		**X**	**X**				
1. Composting		X (1993-2015)	X (1993-2015)				
2. Anaerobic digestion at biogas facilities		X (1992-2015)	NE				
C. Incineration and Open Burning of Waste	**IE**	**IE**	**IE**				
1. Waste incineration	IE	IE	IE				
2. Open burning of waste	NO	NO	NO				
D. Wastewater Treatment and Discharge		**X**	**X**				
1. Domestic wastewater		X	X				
2. Industrial wastewater		NO	X				
3. Other		NO	NO				
E. Other	**NO**	**NO**	**NO**				
6. Other	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**

GHG source & sink categories (CRF nomenclature)	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
Memo Items	X	X	X				
International Bunkers	X	X	X				
aviation	X	X	X				
marine	X	X	X				
Multilateral Operations	NA	NA	NA				
CO_2 emissions from biomass	X						
CO_2 captured	NO						

Source: Environment Agency – Submission 2017v1.2.
Legend: X indicates that emissions from this sub-category have been estimated and reported
IE = included elsewhere
NA = not applicable
NE = not estimated
NO = not occurring
The blue shaded cells are those also shaded in the CRF tables.

III.1.1. GHG trend: the supremacy of CO_2 and of the energy sector

In 2015, carbon dioxide was the main source of GHG in Luxembourg. This source counted for 90.6% of the total GHG emissions calculated in CO_2e – total excluding LULUCF.[70] The second source of GHG was methane with 6.1% of the total emissions. Nitrous oxide was the third source with 2.6%. Fluorinated gases only accounted for 0.7% of the total emissions, with hydrofluorocarbons representing 0.6% of the total and sulphur hexafluoride representing 0.1% of the total *[→ Table III.1-2 & Figures III.1-2a-b]*.

In 2015, total GHG emissions amounted to 10.3 Mio. t CO_2e, 19.3% below their level in 1990 and 19.5% below the level retained for the base year under the Kyoto Protocol.[71] Several phases can clearly be distinguished over the period 1990 to 2015 *[→ Figures III.1-1a & III.1-1b]*:

- firstly, from base year up to 1993, Luxembourg's emissions remained rather stable;
- then, between 1994 and 1998, they started to decrease significantly to reach their lowest value in 1998, when they were down by more than 30%;
- from 1999 up to 2004, emissions augmented recurrently;
- from 2004 to 2006, a stabilisation peaking at 13 Mio. t CO_2e is observed;
- a regular decrease since 2006 with a clear impact of the financial and economic crisis in 2008-2009.

As portrayed in *Chapter II* presenting Luxembourg's national circumstances, the evolution during these last 25 years can essentially be explained by **changes in production techniques**, as well as by **changes in the final "energy-mix" consumption**. Of course, **increasing or decreasing activities** for certain source categories also played a crucial role in Luxembourg's GHG emissions trend. During the years 2008-2010, **the financial and economic crisis and its aftermaths** also played a part. The

70 In Section III.1, when it is referred to "total (GHG) emissions" it is meant "total GHG emissions excluding LULUCF". Reference is made to total emissions excluding LULUCF since this is the one that counts for the reduction target under the Kyoto Protocol.

71 The base year for CO_2, CH_4 and N_2O is 1990. For the F-gases, the base year is 1995. When the assigned amount under the Kyoto Protocol was determined, F-gases emissions were equal in 1990 and 1995 due to a lack of background data and methods at that time. Now, as Table III.1-2 shows, F-gases emissions are no longer the same in 1990 and 1995.

decreasing trend in emissions since 2012 is mainly due to the progressive shutdown of the TWINerg power plant ***[→ Sections II.6]*** and slowly declining sales of road fuels ***[→ Section II.8.2]***.

A good example for a **technological change** in production took place in the iron and steel industry, where the steel production process was moved from blast furnaces to electric arc furnaces between 1994 and 1998 and, therefore, solid fuels (coke) were replaced largely by electricity and natural gas. Due to that technological change, the total energy consumption in steel industry was significantly reduced and the "energy-mix" greatly modified ***[→ Section II.6.1]***. This process change was the main driver for the reduction in GHG emissions observed between 1994 and 1998 ***[→ Figure III.1-1b]***. Changes also occurred in the industrial and residential-commercial-institutional sectors, where the consumption of liquid fuels (residual oil, gasoil) was reduced in favour of natural gas in conjunction with the extension of the natural gas network in Luxembourg.

The road transport sector, on the other hand, is a clear example on **how activity levels of a source category can influence the overall GHG emission trend**. Indeed, the upward trend for GHG emissions recorded from 1999 to 2004 was merely justified by increasing energy consumption and fuel sales in the transport sector. The stabilization spotted for the inventory years 2004 to 2006 was largely the result of relatively steady sales of road fuels that peaked in 2005. Finally, the regular decrease in total emissions spotted from 2006 onwards was driven by a "road fuel sales to non-residents" related emissions reduction, with a remarkable low level in 2009 (financial and economic crisis) ***[→ Figures II.6-4 & III.1-1b]***.

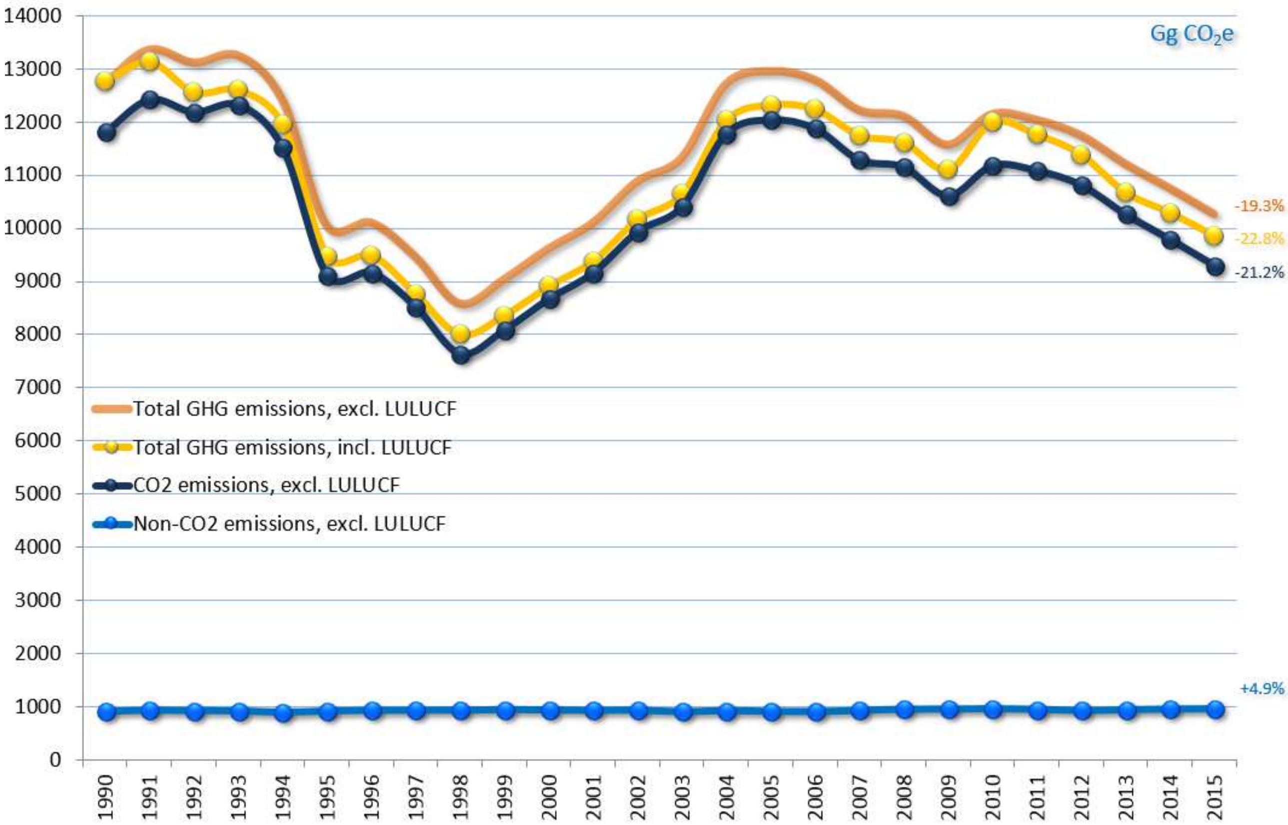
More explanations are provided in ***Sections III.1.2*** (dealing with gases) ***& III.1.3*** (dealing with CRF sectors).

A fundamental point worth mentioning when analysing Luxembourg's GHG emission trends and their composition over time, is **the small size of Luxembourg**, and therefore, the special nature of its economy. Indeed, the structure of the economy, the related energy demand and the energy and emission balances may vary significantly, whether a new economic activity starts its operations or an existing one ceases them. This characteristic explains, for instance, the reduction of emissions pertaining to the industrial sector: with 7.9 Mio. t in 1990, CO_2e emissions from industrial processes and fuel combustion in industry accounted for 62% of total GHG emissions. They could eventually be reduced to 2.1 Mio. t in 1998 – i.e. 26% of total GHG emissions – mainly after the reorganization of the steel industry took place in the mid-nineties (move from blast furnaces to electric arc furnaces indicated above) ***[→ Section II.7]***. At that time, GHG emissions of Luxembourg were almost one third below the base year level. Another illustrative example is the building of the TWINerg power plant. This plant started its operation in mid-2002 and, by 2010, was responsible of about

0.96 Mio. t CO_2, i.e. around 8% of the total GHG emissions.[72] In the last few years, the plant's activity level progressively decreased until its final shutdown in 2016.

These considerations can easily be identified in ***Tables III.1-3 & III.1-4***, and their associated figures, which assemble CRF source categories in such a way that GHG and individual gas emission sources are distributed between main emitters – such as energy production, industry, road transportation – and other categories.

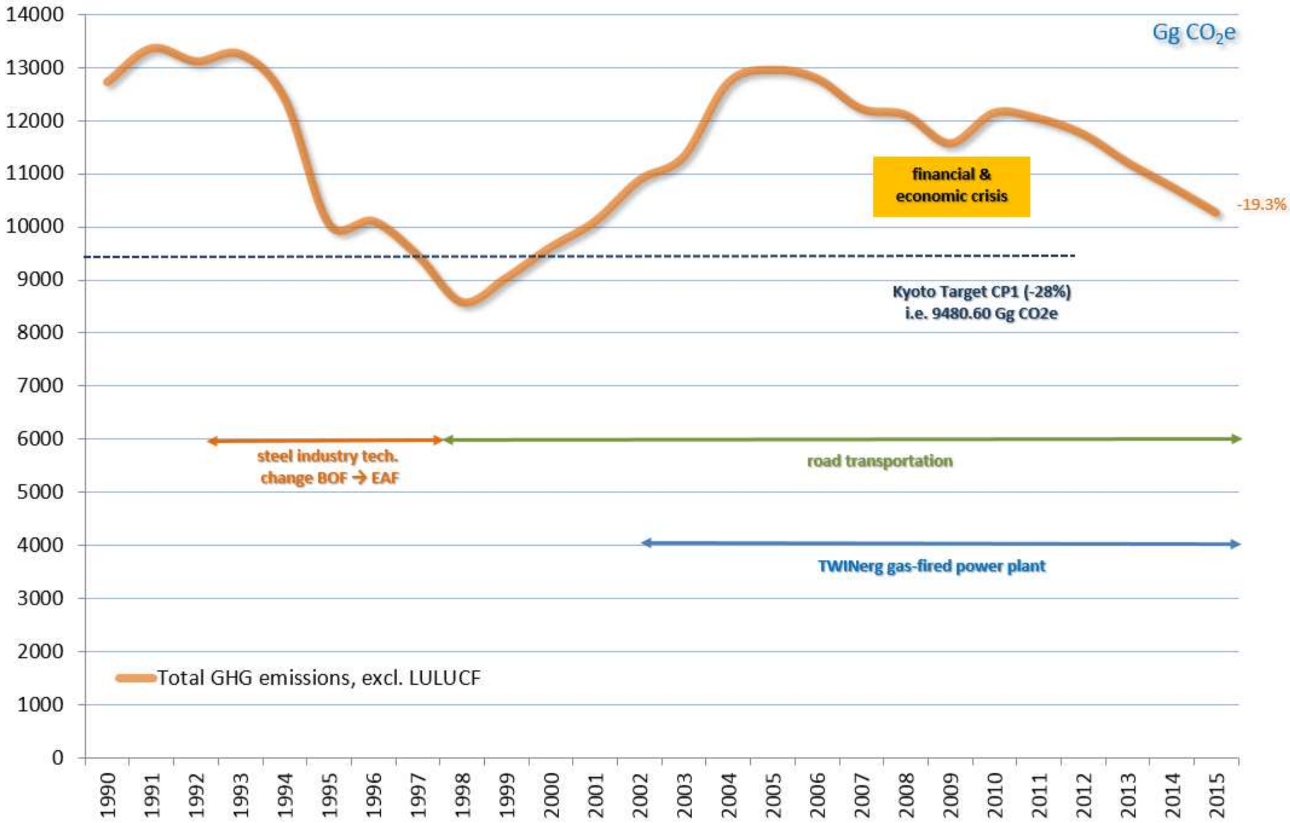
FIGURE III.1-1a – GHG EMISSIONS AND REMOVALS – OVERVIEW CO_2 VS. NON-CO_2: 1990-2015



Source: Environment Agency – Submission 2017v1.2.

72 The highest emissions recorded for the TWINerg plant were 1.02 Mio. t CO_2 in 2006, i.e. around 8% of the total GHG emissions reported for that year. In this analysis, the "outlier" years 2008 and 2011 are "excluded" due to several months without substantial production (maintenance).

FIGURE III.1-1b – GHG EMISSIONS (EXCL. LULUCF): 1990-2015



Source: Environment Agency and MDDI-DEV – Submission 2017v1.2.

TABLE III.1-2 – GHG EMISSIONS AND REMOVALS – OVERVIEW BY MAIN GASES AND CRF SECTORS: 1990-2015

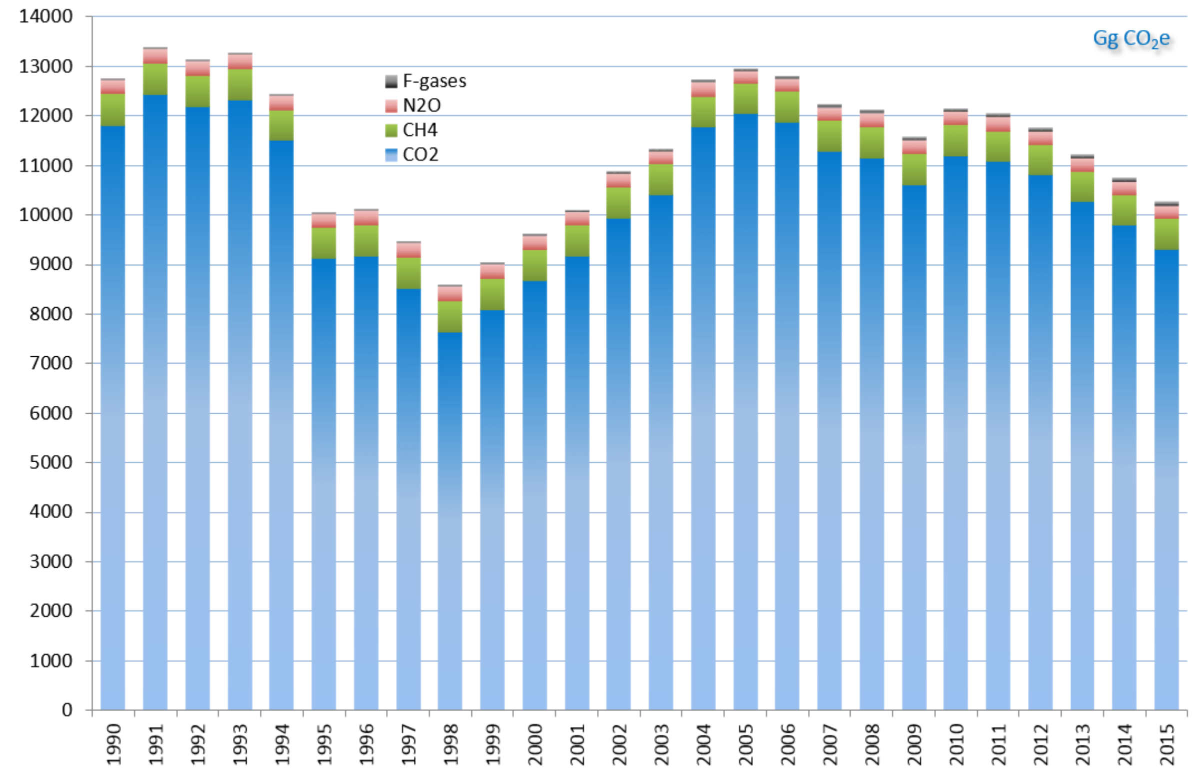
Gg (1000 t.) CO_2 equivalent	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
CO_2 emissions, incl. net CO_2	**11839.06**	**12177.98**	**11609.42**	**11653.46**	**11030.92**	**8536.07**	**8542.35**	**7811.50**	**7043.50**	**7397.32**	**7950.14**	**8431.72**	**9206.90**	**9713.87**	**11084.28**	**11389.31**	**11309.69**	**10798.23**	**10647.21**	**10131.58**	**11015.36**	**10797.45**	**10440.30**	**9716.02**	**9326.83**	**8887.60**
from LULUCF (1)	*92.65%*	*92.69%*	*92.42%*	*92.47%*	*92.26%*	*90.02%*	*89.91%*	*89.06%*	*88.00%*	*88.40%*	*89.18%*	*89.80%*	*90.56%*	*91.24%*	*92.10%*	*92.41%*	*92.37%*	*91.89%*	*91.62%*	*91.23%*	*91.82%*	*91.76%*	*91.67%*	*90.99%*	*90.55%*	*90.10%*
CO_2 emissions, excl. net CO_2	**11812.05**	**12428.21**	**12188.83**	**12327.93**	**11516.20**	**9124.44**	**9171.13**	**8523.01**	**7639.44**	**8090.96**	**8673.16**	**9166.12**	**9942.38**	**10411.66**	**11785.51**	**12044.64**	**11882.64**	**11290.95**	**11155.91**	**10616.84**	**11184.97**	**11088.43**	**10816.35**	**10266.72**	**9797.16**	**9305.96**
from LULUCF	*92.79%*	*92.98%*	*92.90%*	*93.00%*	*92.72%*	*90.79%*	*90.73%*	*90.08%*	*89.05%*	*89.50%*	*90.19%*	*90.73%*	*91.37%*	*91.94%*	*92.67%*	*92.93%*	*92.85%*	*92.36%*	*92.11%*	*91.74%*	*92.06%*	*92.08%*	*92.06%*	*91.56%*	*91.09%*	*90.62%*
CH_4 (2) emissions, incl. net CH_4	**634.97**	**641.56**	**630.76**	**629.56**	**605.20**	**620.68**	**630.29**	**631.08**	**628.50**	**633.85**	**626.10**	**630.97**	**630.42**	**618.77**	**614.43**	**612.34**	**609.15**	**620.07**	**631.34**	**632.38**	**633.18**	**608.81**	**598.19**	**602.96**	**614.86**	**621.50**
from LULUCF (1)	*4.97%*	*4.88%*	*5.02%*	*5.00%*	*5.06%*	*6.55%*	*6.63%*	*7.20%*	*7.85%*	*7.58%*	*7.02%*	*6.72%*	*6.20%*	*5.81%*	*5.11%*	*4.97%*	*4.98%*	*5.28%*	*5.43%*	*5.69%*	*5.28%*	*5.17%*	*5.25%*	*5.65%*	*5.97%*	*6.30%*
CH_4 (2) emissions, excl. net CH_4	**634.97**	**641.56**	**630.76**	**629.56**	**605.20**	**620.68**	**630.29**	**631.08**	**628.50**	**633.85**	**626.10**	**630.97**	**630.42**	**618.77**	**614.43**	**612.34**	**609.15**	**620.07**	**631.34**	**632.38**	**633.18**	**608.81**	**598.19**	**602.96**	**614.86**	**621.50**
from LULUCF	*4.99%*	*4.80%*	*4.81%*	*4.75%*	*4.87%*	*6.18%*	*6.24%*	*6.67%*	*7.33%*	*7.01%*	*6.51%*	*6.25%*	*5.79%*	*5.46%*	*4.83%*	*4.72%*	*4.76%*	*5.07%*	*5.21%*	*5.46%*	*5.21%*	*5.06%*	*5.09%*	*5.38%*	*5.72%*	*6.05%*
N_2O (3) emissions, incl. net N_2O	**303.89**	**317.26**	**307.15**	**303.89**	**302.49**	**306.43**	**306.63**	**304.23**	**305.22**	**307.88**	**307.21**	**290.48**	**289.82**	**271.52**	**291.90**	**278.96**	**277.31**	**280.05**	**286.78**	**283.86**	**288.25**	**297.65**	**284.34**	**288.31**	**282.47**	**278.98**
from LULUCF (1)	*2.38%*	*2.41%*	*2.45%*	*2.41%*	*2.53%*	*3.23%*	*3.23%*	*3.47%*	*3.81%*	*3.68%*	*3.45%*	*3.09%*	*2.85%*	*2.55%*	*2.43%*	*2.26%*	*2.26%*	*2.38%*	*2.47%*	*2.56%*	*2.40%*	*2.53%*	*2.50%*	*2.70%*	*2.74%*	*2.83%*
N_2O (3) emissions, excl. net N_2O	**282.56**	**295.94**	**285.82**	**282.57**	**281.17**	**285.11**	**285.31**	**282.91**	**283.90**	**286.56**	**286.21**	**269.79**	**269.45**	**251.46**	**272.16**	**259.54**	**258.21**	**261.26**	**268.70**	**266.50**	**271.49**	**281.56**	**268.89**	**273.54**	**268.39**	**265.56**
from LULUCF	*2.22%*	*2.21%*	*2.18%*	*2.13%*	*2.26%*	*2.84%*	*2.82%*	*2.99%*	*3.31%*	*3.17%*	*2.98%*	*2.67%*	*2.48%*	*2.22%*	*2.14%*	*2.00%*	*2.02%*	*2.14%*	*2.22%*	*2.30%*	*2.23%*	*2.34%*	*2.29%*	*2.44%*	*2.50%*	*2.59%*
HFCs (4)	**0.00**	**0.00**	**13.68**	**14.70**	**15.98**	**18.31**	**20.06**	**22.54**	**24.98**	**26.78**	**29.58**	**33.49**	**36.38**	**38.70**	**40.78**	**39.79**	**42.77**	**47.37**	**49.77**	**51.16**	**53.46**	**56.34**	**58.73**	**62.36**	**67.12**	**67.03**
	0.00%	*0.00%*	*0.10%*	*0.11%*	*0.13%*	*0.18%*	*0.20%*	*0.24%*	*0.29%*	*0.30%*	*0.31%*	*0.33%*	*0.33%*	*0.34%*	*0.32%*	*0.31%*	*0.33%*	*0.39%*	*0.41%*	*0.44%*	*0.44%*	*0.47%*	*0.50%*	*0.56%*	*0.62%*	*0.65%*
PFCs (4)	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
	NA	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
SF_6 (4)	**0.88**	**0.98**	**1.08**	**1.19**	**1.30**	**1.39**	**1.56**	**1.70**	**1.74**	**1.83**	**1.93**	**2.54**	**3.15**	**3.73**	**4.28**	**4.85**	**5.27**	**5.69**	**6.10**	**6.49**	**6.87**	**7.31**	**7.68**	**8.05**	**8.44**	**8.89**
	0.01%	*0.01%*	*0.01%*	*0.01%*	*0.01%*	*0.01%*	*0.02%*	*0.02%*	*0.02%*	*0.02%*	*0.02%*	*0.03%*	*0.03%*	*0.03%*	*0.03%*	*0.04%*	*0.04%*	*0.05%*	*0.05%*	*0.06%*	*0.06%*	*0.06%*	*0.07%*	*0.07%*	*0.08%*	*0.09%*
NF_3 (4)	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
	NA	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
1. Energy	**10263.87**	**10966.43**	**10801.12**	**10965.53**	**10247.29**	**8214.19**	**8319.54**	**7780.67**	**7055.50**	**7472.60**	**8030.26**	**8584.48**	**9355.53**	**9880.33**	**11203.15**	**11487.42**	**11277.84**	**10693.98**	**10618.52**	**10148.88**	**10703.60**	**10588.26**	**10379.26**	**9842.25**	**9359.67**	**8869.05**
	80.62%	*82.04%*	*82.32%*	*82.72%*	*82.51%*	*81.73%*	*82.30%*	*82.24%*	*82.25%*	*82.66%*	*83.50%*	*84.97%*	*85.97%*	*87.25%*	*88.09%*	*88.63%*	*88.12%*	*87.47%*	*87.67%*	*87.69%*	*88.10%*	*87.92%*	*88.34%*	*87.77%*	*87.02%*	*86.37%*
2. Industrial Processes & Product Use	**1640.25**	**1561.67**	**1503.97**	**1481.51**	**1389.81**	**1031.71**	**977.24**	**869.97**	**711.96**	**750.89**	**779.35**	**725.92**	**746.81**	**694.04**	**754.04**	**725.49**	**779.76**	**775.92**	**721.51**	**651.30**	**675.52**	**692.17**	**632.90**	**616.96**	**633.08**	**626.08**
	12.88%	*11.68%*	*11.46%*	*11.18%*	*11.19%*	*10.27%*	*9.67%*	*9.20%*	*8.30%*	*8.31%*	*8.10%*	*7.19%*	*6.86%*	*6.13%*	*5.93%*	*5.60%*	*6.09%*	*6.35%*	*5.96%*	*5.63%*	*5.56%*	*5.75%*	*5.39%*	*5.50%*	*5.89%*	*6.10%*
3. Agriculture	**714.41**	**724.90**	**701.13**	**694.30**	**676.37**	**697.77**	**704.09**	**700.39**	**698.93**	**704.84**	**695.38**	**681.24**	**667.34**	**633.59**	**647.20**	**635.84**	**627.26**	**641.42**	**655.35**	**658.86**	**668.17**	**662.00**	**642.50**	**658.25**	**666.53**	**680.83**
	5.61%	*5.42%*	*5.34%*	*5.24%*	*5.45%*	*6.94%*	*6.97%*	*7.40%*	*8.15%*	*7.80%*	*7.23%*	*6.74%*	*6.13%*	*5.59%*	*5.09%*	*4.91%*	*4.90%*	*5.25%*	*5.41%*	*5.69%*	*5.50%*	*5.50%*	*5.47%*	*5.87%*	*6.20%*	*6.63%*
4. LULUCF (1)	**44.42**	**-232.82**	**-562.00**	**-657.06**	**-467.88**	**-570.96**	**-611.38**	**-694.11**	**-578.53**	**-676.24**	**-705.87**	**-717.51**	**-718.84**	**-681.42**	**-685.12**	**-639.48**	**-557.35**	**-477.38**	**-493.94**	**-471.09**	**-155.93**	**-277.84**	**-363.44**	**-538.64**	**-458.83**	**-407.41**
	0.35%	*-1.77%*	*-4.47%*	*-5.21%*	*-3.91%*	*-6.02%*	*-6.43%*	*-7.91%*	*-7.23%*	*-8.08%*	*-7.92%*	*-7.64%*	*-7.07%*	*-6.40%*	*-5.69%*	*-5.19%*	*-4.55%*	*-4.06%*	*-4.25%*	*-4.24%*	*-1.30%*	*-2.36%*	*-3.19%*	*-5.04%*	*-4.45%*	*-4.13%*
5. Waste	**111.92**	**113.69**	**113.95**	**114.60**	**106.38**	**106.25**	**107.48**	**110.21**	**112.16**	**111.66**	**111.98**	**111.29**	**112.10**	**116.36**	**112.77**	**112.43**	**113.17**	**114.02**	**116.45**	**114.33**	**102.68**	**100.02**	**95.19**	**96.18**	**96.69**	**92.97**
	0.88%	*0.85%*	*0.87%*	*0.86%*	*0.86%*	*1.06%*	*1.06%*	*1.16%*	*1.31%*	*1.24%*	*1.16%*	*1.10%*	*1.03%*	*1.03%*	*0.89%*	*0.87%*	*0.88%*	*0.93%*	*0.96%*	*0.99%*	*0.85%*	*0.83%*	*0.81%*	*0.86%*	*0.90%*	*0.91%*
6. Other	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
	NA	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
Total GHG including LULUCF	**12778.80**	**13137.78**	**12562.08**	**12602.79**	**11955.88**	**9482.88**	**9500.89**	**8771.05**	**8003.94**	**8367.66**	**8914.96**	**9389.21**	**10166.68**	**10646.59**	**12035.66**	**12325.27**	**12244.20**	**11751.41**	**11621.20**	**11105.47**	**11997.12**	**11767.56**	**11389.24**	**10677.71**	**10299.72**	**9863.99**
	100.00%	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*
Total GHG excluding LULUCF	**12730.46**	**13366.69**	**13120.17**	**13255.94**	**12419.85**	**10049.92**	**10108.35**	**9461.25**	**8578.56**	**9039.99**	**9616.97**	**10102.92**	**10881.78**	**11324.32**	**12717.16**	**12961.17**	**12798.04**	**12225.34**	**12111.83**	**11573.37**	**12149.97**	**12042.45**	**11749.85**	**11213.64**	**10755.97**	**10268.93**
	100.00%	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*

Source: Environment Agency – Submission 2017v1.2.

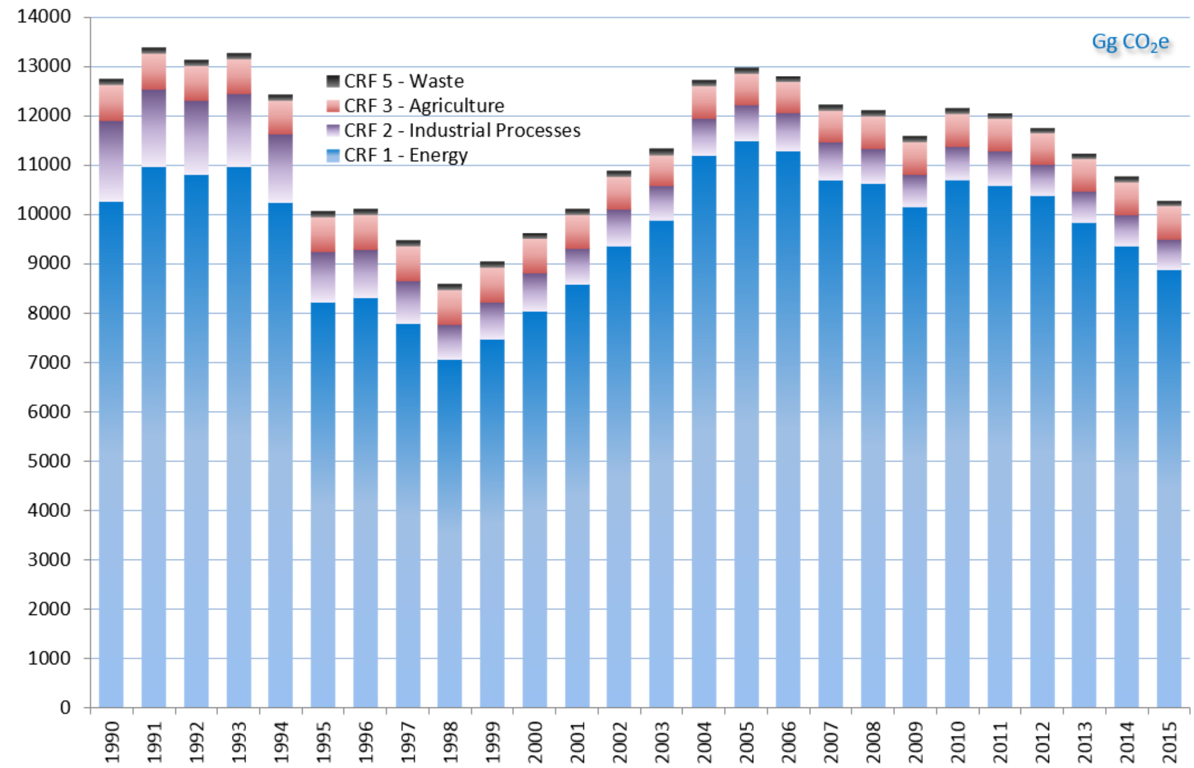
Notes: (1) these percentages are relative to the total GHG emissions, including LULUCF.
(2) the methane emissions are converted in CO_2 equivalents by multiplying the emissions by 25, i.e. the global warming potential (GWP) value for methane based on the effects of GHG over a 100-year time horizon.
(3) the nitrous oxide emissions are converted in CO_2 equivalents by multiplying the emissions by 298, i.e. the global warming potential (GWP) value for nitrous oxide based on the effects of GHG over a 100-year time horizon.
(4) the F-gases are those not covered by the Montreal Protocol, i.e. only HFCs and SF_6 for Luxembourg, expressed in CO_2 equivalents using the global warming potential (GWP) values based on the effects of GHG over a 100-year time horizon.

FIGURES III.1-2a – GHG EMISSIONS (EXCL. LULUCF) – MAIN GASES & SECTORS: ABSOLUTE VALUES 1990-2015

GHG



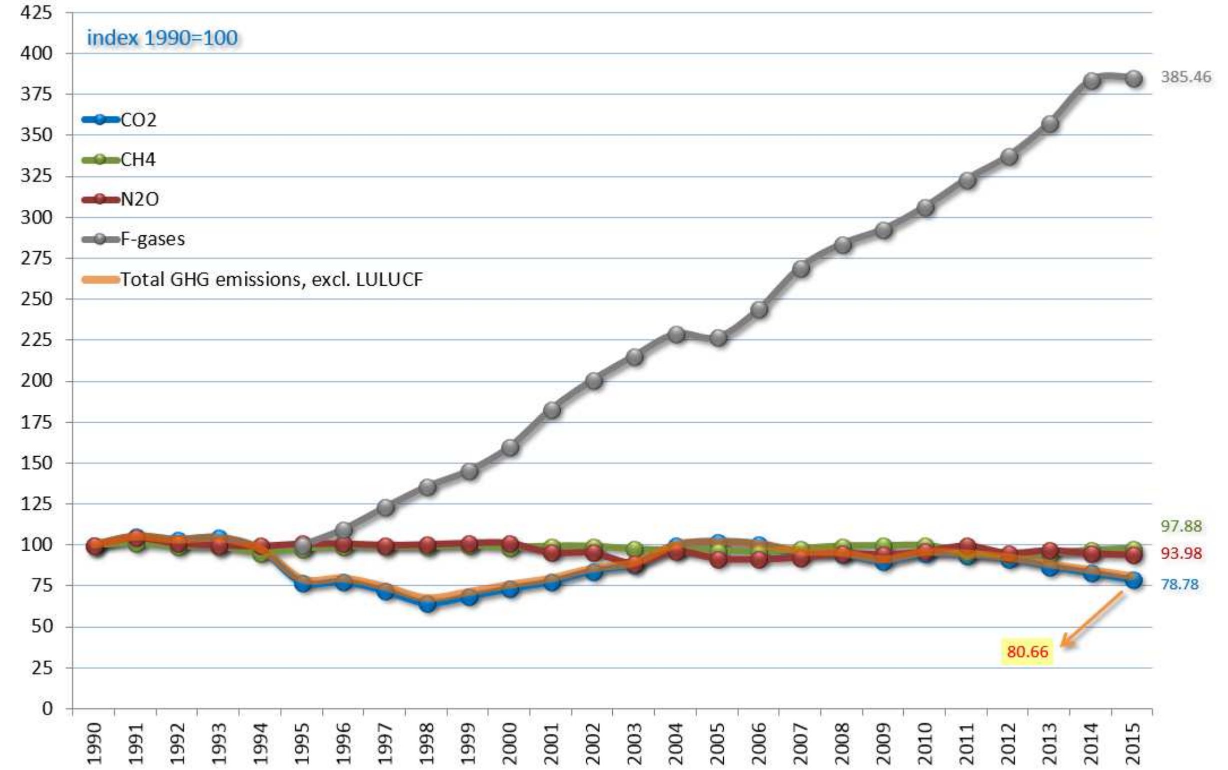
CRF sectors



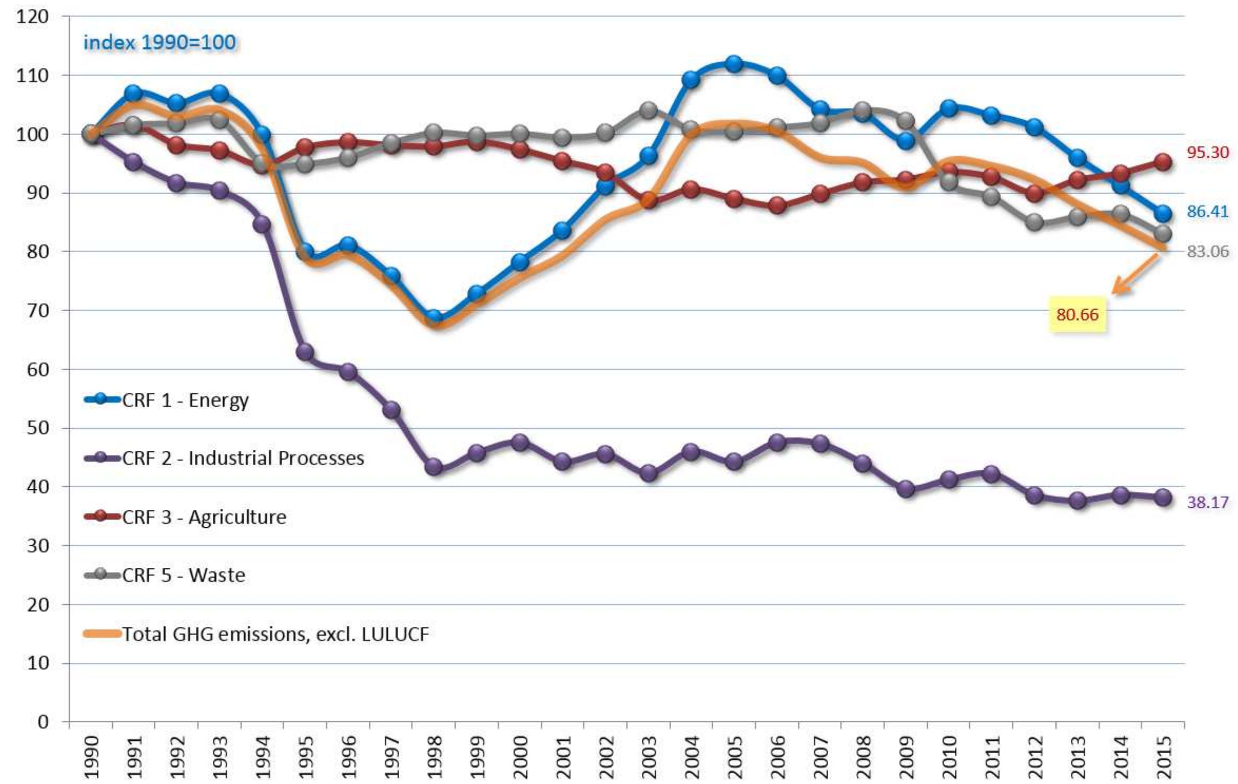
Source: Environment Agency – Submission 2017v1.2.

FIGURES III.1-2b – GHG EMISSIONS (EXCL. LULUCF) – MAIN GASES & SECTORS: INDEXES 1990-2015

GHG



CRF sectors



Source: Environment Agency – Submission 2017v1.2.

III.1.2. GHG trends by gas: reduction for CO_2, CH_4 and N_2O emissions, rise for F-gases

For the different GHG, trends over the period 1990-2015 (and 2014-2015) were as follows:

CO_2:	-21.2%	(-5.0%)
CH_4:	-2.1%	(+1.1%)
N_2O:	-6.0%	(-1.1%)
F-gases:	+8563.9%	(+0.5%)
Total GHG emissions, excl. LULUCF:	***-19.3%***	***(-4.5%)***

For **carbon dioxide**, the development between 1990 and 2015 hides a U-shape evolution over the period as well as important changes in the sources of CO_2 emissions: declining emissions in industrial combustion, increasing emissions from transport and natural gas fired power plants – as underlined in *Section III.1.1*.

Methane emissions have slightly declined over the period due to the conjunction of reduced methane emissions in waste and wastewater management (-25.0%) that surpasses growing emissions in energy use (+9.6%). Methane emissions in agriculture increased slightly (+1.6%).

Nitrous oxide emissions development is the result of declining emissions from the agriculture and various other sources such as anaesthesia, wastewater handling and composting. Agricultural soils emissions dropped by 22.6% over the period 1990-2015. This decrease has more than balanced the sharp increase – +77.9% – recorded for fossil fuels related N_2O emissions from combustion activities (mainly for the road transportation and the other sectors).

The rather important differences reported for methane and nitrous oxide emissions changes over the period 1990-2011 or 2012 is also illustrative of the inherent volatility of the emissions for the “smaller” source categories due to the size of the activities concerned. This is typical of a small country and economy.

Finally, with regard to **F-gases**, HFC emissions were about 2.8 times higher in 2015 than in the base year (1995), whereas SF_6 emissions showed a 6.4-fold increase. There are **no emissions reported for both perfluorocarbons (PFCs) and nitrogen trifluoride (NF_3)**.

These evolutions can be visualized in ***Tables III.1-3 & III.1-4***, which distribute, for each GHG, emissions amongst the main source categories, as well as in the associated figures. These tables and figures offer the opportunity to analyse further emission trends for each of the gases.

Table III.1-3 – GHG emissions (excl. LULUCF) – Sector-based breakdown: 1990-2015

Gg (1000 t.) CO_2 equivalent	CRF Categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Main Emitting Source Categories																											
Public Electricity & Heat Production	1A1a	1.70	1.78	1.78	1.69	1.65	62.06	58.00	60.88	100.88	110.43	58.94	221.80	967.87	974.05	1189.34	1181.02	1238.61	1113.67	925.83	1123.74	1144.07	936.54	974.30	619.05	592.27	372.56
(excl. waste incineration)		0.01%	0.01%	0.01%	0.01%	0.01%	0.62%	0.57%	0.64%	1.18%	1.22%	0.61%	2.20%	8.89%	8.60%	9.35%	9.11%	9.68%	9.11%	7.64%	9.71%	9.42%	7.78%	8.29%	5.52%	5.51%	3.63%
Iron & Steel	1A2a + 2C1	6396.29	6090.21	5608.07	5844.00	4837.99	2781.92	2518.25	1629.12	451.44	493.16	478.70	548.43	530.66	512.64	558.40	534.25	657.05	630.55	576.48	461.98	515.71	461.10	402.43	380.64	377.78	401.29
(fuel combustion & processes)		50.24%	45.56%	42.74%	44.09%	38.95%	27.68%	24.91%	17.22%	5.26%	5.46%	4.98%	5.43%	4.88%	4.53%	4.39%	4.12%	5.13%	5.16%	4.76%	3.99%	4.24%	3.83%	3.42%	3.39%	3.51%	3.91%
Other Manufacturing Industries &	1A2b/c/d/e/f + 2A	1477.45	1552.52	1625.94	1503.03	1704.33	1541.31	1595.39	1610.36	1583.24	1769.96	1644.01	1608.68	1527.84	1430.13	1535.83	1522.45	1529.32	1453.15	1383.20	1296.03	1343.46	1377.56	1317.23	1267.72	1297.89	1232.39
Construction (fuel combustion & processes)		11.61%	11.61%	12.39%	11.34%	13.72%	15.34%	15.78%	17.02%	18.46%	19.58%	17.09%	15.92%	14.04%	12.63%	12.08%	11.75%	11.95%	11.89%	11.42%	11.20%	11.06%	11.44%	11.21%	11.31%	12.07%	12.00%
Road Transportation - national fleet	1A3b	862.85	903.28	939.50	987.54	989.70	1045.77	1071.21	1114.49	1165.17	1177.46	1225.36	1294.36	1351.97	1380.06	1422.61	1442.80	1502.04	1527.06	1600.28	1594.82	1606.10	1632.64	1632.35	1627.59	1693.69	1703.20
		6.78%	6.76%	7.16%	7.45%	7.97%	10.41%	10.60%	11.78%	13.58%	13.02%	12.74%	12.81%	12.42%	12.19%	11.19%	11.13%	11.74%	12.49%	13.21%	13.78%	13.22%	13.56%	13.89%	14.51%	15.75%	16.59%
Road Transportation - road fuel sales to	1A3b	1692.86	2239.97	2479.70	2481.06	2535.18	2244.16	2325.65	2543.01	2670.22	2980.76	3566.95	3741.18	3873.86	4397.94	5315.39	5679.26	5305.42	5001.22	5035.17	4518.41	4865.64	5226.24	4910.05	4778.73	4412.53	3980.90
non-residents		13.30%	16.76%	18.90%	18.72%	20.41%	22.33%	23.01%	26.88%	31.13%	32.97%	37.09%	37.03%	35.60%	38.84%	41.80%	43.82%	41.45%	40.91%	41.57%	39.04%	40.05%	43.40%	41.79%	42.62%	41.02%	38.77%
Residential Fuel Combustion	1A4b	678.85	813.59	747.72	741.78	706.14	716.08	785.96	761.62	792.10	711.22	1077.55	1169.82	1113.50	1156.69	1237.43	1211.99	1199.93	1160.15	1193.15	1179.67	1158.09	1061.32	1079.92	1072.61	970.61	1067.06
		5.33%	6.09%	5.70%	5.60%	5.69%	7.13%	7.78%	8.05%	9.23%	7.87%	11.20%	11.58%	10.23%	10.21%	9.73%	9.35%	9.38%	9.49%	9.85%	10.19%	9.53%	8.81%	9.19%	9.57%	9.02%	10.39%
Commercial & Institutional Fuel	1A4a	640.16	770.15	710.60	702.46	676.83	682.30	761.54	738.29	772.36	692.13	548.23	498.40	500.43	497.13	462.90	418.25	395.34	348.55	376.96	380.45	498.51	332.51	439.55	464.17	388.76	475.67
Combustion		5.03%	5.76%	5.42%	5.30%	5.45%	6.79%	7.53%	7.80%	9.00%	7.66%	5.70%	4.93%	4.60%	4.39%	3.64%	3.23%	3.09%	2.85%	3.11%	3.29%	4.10%	2.76%	3.74%	4.14%	3.61%	4.63%
Agriculture (fuel combustion,	1A4c+3	751.06	762.39	736.90	727.91	712.37	732.06	740.02	737.77	737.06	760.30	722.95	705.61	693.30	659.84	674.84	662.83	654.74	668.37	684.51	688.12	697.49	689.85	670.49	682.20	691.12	706.03
livestock, crops, soils)		5.90%	5.70%	5.62%	5.49%	5.74%	7.28%	7.32%	7.80%	8.59%	8.41%	7.52%	6.98%	6.37%	5.83%	5.31%	5.11%	5.12%	5.47%	5.65%	5.95%	5.74%	5.73%	5.71%	6.08%	6.43%	6.88%
Other Source Categories																											
Municipal Waste Incineration	1A1a (5C)	33.94	35.51	35.41	33.69	32.96	31.47	24.35	28.85	55.06	63.03	61.23	60.46	61.45	62.66	68.07	62.18	66.67	68.05	70.18	67.05	61.91	67.62	68.42	66.84	76.25	84.65
(with energy & heat recovery)		0.27%	0.27%	0.27%	0.25%	0.27%	0.31%	0.24%	0.30%	0.64%	0.70%	0.64%	0.60%	0.56%	0.55%	0.54%	0.48%	0.52%	0.56%	0.58%	0.58%	0.51%	0.56%	0.58%	0.60%	0.71%	0.82%
Other Transport	1A3a/c/d	28.96	29.20	29.27	29.47	28.71	23.52	26.09	25.74	25.60	25.76	25.32	27.29	24.44	21.74	17.53	11.96	9.24	12.07	13.68	12.94	13.88	13.76	12.57	10.84	12.15	8.73
		0.23%	0.22%	0.22%	0.22%	0.23%	0.23%	0.26%	0.27%	0.30%	0.28%	0.26%	0.27%	0.22%	0.19%	0.14%	0.09%	0.07%	0.10%	0.11%	0.11%	0.11%	0.11%	0.11%	0.10%	0.11%	0.09%
Other Energy Sources	1A5 + 1B2b	22.51	23.24	47.79	45.42	43.99	35.79	45.89	51.01	62.31	92.27	42.19	57.55	61.26	51.63	53.81	53.00	55.61	52.04	49.76	50.31	54.09	46.91	47.98	40.87	38.60	34.73
		0.18%	0.17%	0.36%	0.34%	0.35%	0.36%	0.45%	0.54%	0.73%	1.02%	0.44%	0.57%	0.56%	0.46%	0.42%	0.41%	0.43%	0.43%	0.41%	0.43%	0.45%	0.39%	0.41%	0.36%	0.36%	0.34%
Non-energy products from fuels	2D + 2G	31.89	31.16	29.85	28.58	27.64	28.91	28.45	27.36	26.00	25.06	23.99	24.54	26.70	24.75	27.45	28.97	28.12	29.10	36.41	34.39	34.89	40.04	40.63	46.40	42.21	43.70
solvent use & other product manufacture and use		0.25%	0.23%	0.23%	0.22%	0.22%	0.29%	0.28%	0.29%	0.30%	0.28%	0.25%	0.24%	0.25%	0.22%	0.22%	0.22%	0.22%	0.24%	0.30%	0.30%	0.29%	0.33%	0.35%	0.41%	0.39%	0.43%
F-gases	2F	0.00	0.00	13.68	14.70	15.98	18.31	20.06	22.54	24.98	26.78	29.58	33.49	36.38	38.70	40.78	39.79	42.77	47.37	49.77	51.16	53.46	56.34	58.73	59.80	65.42	65.05
		0.00%	0.00%	0.10%	0.11%	0.13%	0.18%	0.20%	0.24%	0.29%	0.30%	0.31%	0.33%	0.33%	0.34%	0.32%	0.31%	0.33%	0.39%	0.41%	0.44%	0.44%	0.47%	0.50%	0.53%	0.61%	0.63%
Solid waste disposal	5A	95.76	97.54	97.56	95.90	86.95	86.45	86.45	88.58	88.76	88.82	84.76	83.72	83.53	83.86	78.96	76.26	74.63	73.85	72.19	71.12	59.47	59.16	56.02	56.89	56.02	53.17
		0.75%	0.73%	0.74%	0.72%	0.70%	0.86%	0.86%	0.94%	1.03%	0.98%	0.88%	0.83%	0.77%	0.74%	0.62%	0.59%	0.58%	0.60%	0.60%	0.61%	0.49%	0.49%	0.48%	0.51%	0.52%	0.52%
Biological treatment of solid waste	5B	-	-	0.25	2.49	3.12	3.74	5.79	6.42	8.08	7.47	11.66	11.82	13.99	17.92	18.51	20.90	23.07	24.43	29.67	28.86	29.12	26.57	27.86	27.96	29.26	29.21
		NA	NA	0.00%	0.02%	0.03%	0.04%	0.06%	0.07%	0.09%	0.08%	0.12%	0.12%	0.13%	0.16%	0.15%	0.16%	0.18%	0.20%	0.25%	0.25%	0.24%	0.22%	0.24%	0.25%	0.27%	0.28%
Wastewater treatment and discharge	5D	16.16	16.15	16.13	16.21	16.30	16.07	15.25	15.21	15.32	15.37	15.57	15.75	14.58	14.59	15.30	15.26	15.47	15.74	14.58	14.35	14.09	14.29	11.31	11.33	11.41	10.59
		0.13%	0.12%	0.12%	0.12%	0.13%	0.16%	0.15%	0.16%	0.18%	0.17%	0.16%	0.16%	0.13%	0.13%	0.12%	0.12%	0.12%	0.13%	0.12%	0.12%	0.12%	0.12%	0.10%	0.10%	0.11%	0.10%
Total GHG excluding LULUCF		12730.46	13366.69	13120.17	13255.94	12419.85	10049.92	10108.35	9461.25	8578.56	9039.99	9616.97	10102.92	10881.78	11324.32	12717.16	12961.17	12798.04	12225.34	12111.83	11573.37	12149.97	12042.45	11749.85	11213.64	10755.97	10268.93
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Memo Items																											
International Bunkers - Aviation		407.04	425.44	411.32	406.79	516.04	584.97	635.63	760.42	921.82	1040.09	991.33	1072.20	1161.66	1210.17	1316.77	1337.97	1252.16	1345.90	1354.79	1297.93	1327.05	1246.22	1149.85	1155.61	1254.37	1414.01
		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
International Bunkers - Marine		0.12	0.13	0.12	0.15	0.14	0.14	0.15	0.15	0.15	0.18	0.20	0.21	0.22	0.23	0.23	0.29	0.30	0.26	0.28	0.23	0.23	0.26	0.25	0.23	0.25	0.25
		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CO_2 Emissions from Biomass		159.05	163.07	163.73	159.33	157.46	153.78	135.56	146.84	139.67	148.82	150.04	164.85	166.20	182.13	195.94	294.24	297.72	440.04	452.89	425.22	443.38	451.16	446.49	475.26	558.97	613.56
		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Source: Environment Agency – Submission 2017v1.2.

Notes: (1) the methane emissions are converted in CO_2 equivalents by multiplying the emissions by 25, i.e. the global warming potential (GWP) value for methane based on the effects of GHG over a 100-year time horizon.
(2) the nitrous oxide emissions are converted in CO_2 equivalents by multiplying the emissions by 298, i.e. the global warming potential (GWP) value for nitrous oxide based on the effects of GHG over a 100-year time horizon.
(3) the F-gases are those not covered by the Montreal Protocol, i.e. only HFCs and SF_6 for Luxembourg, expressed in CO_2 equivalents using the global warming potential (GWP) values based on the effects of GHG over a 100-year time horizon.

TABLE III.1-4 – GHG EMISSIONS AND REMOVALS – DETAILS BY MAIN GASES: 1990-2015

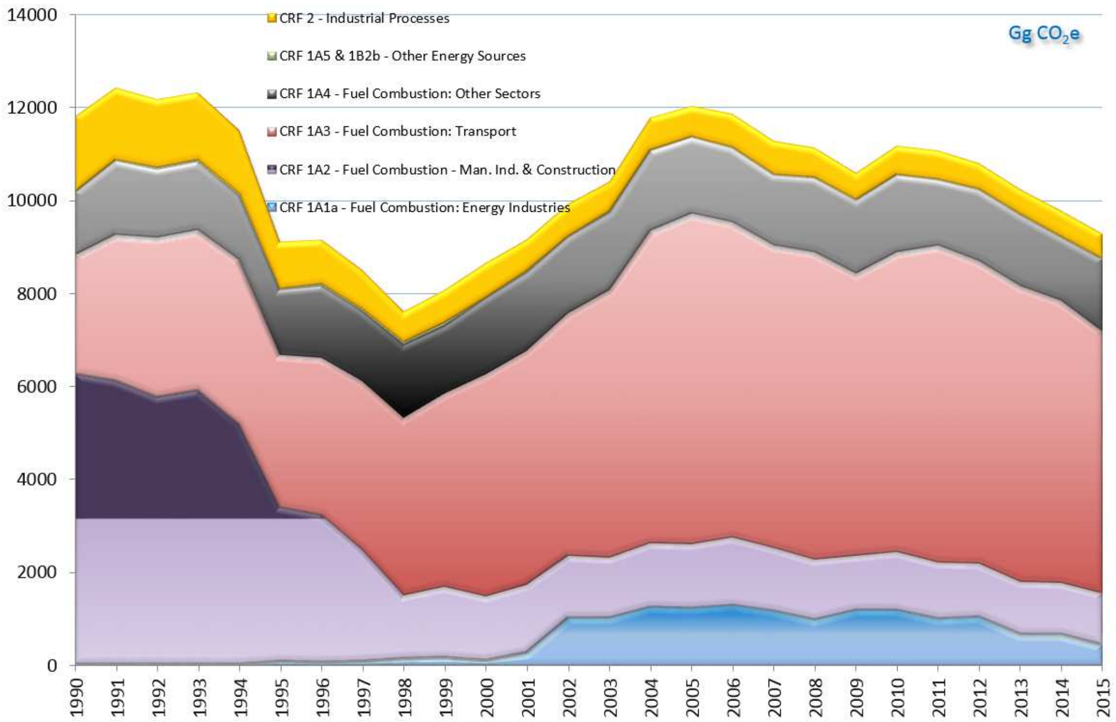
Gg (1000 t.) CO_2 equivalent	1990 (base year)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
CO_2	**11812.05**	**12428.21**	**12188.83**	**12327.93**	**11516.20**	**9124.44**	**9171.13**	**8523.01**	**7639.44**	**8090.96**	**8673.16**	**9166.12**	**9942.38**	**10411.66**	**11785.51**	**12044.64**	**11882.64**	**11290.95**	**11155.91**	**10616.84**	**11184.97**	**11088.43**	**10816.35**	**10266.72**	**9797.16**	**9305.96**
	92.79%	*92.98%*	*92.90%*	*93.00%*	*92.72%*	*90.79%*	*90.73%*	*90.08%*	*89.05%*	*89.50%*	*90.19%*	*90.73%*	*91.37%*	*91.94%*	*92.67%*	*92.93%*	*92.85%*	*92.36%*	*92.11%*	*91.74%*	*92.06%*	*92.08%*	*92.06%*	*91.56%*	*91.09%*	*90.62%*
of which																										
CRF 1 - Energy	10181.27	10875.67	10707.30	10869.56	10150.20	8118.88	8221.78	7682.75	6958.78	7373.83	7929.34	8479.49	9237.78	9762.66	11079.05	11364.51	11152.78	10570.25	10493.11	10024.18	10569.54	10458.81	10248.47	9717.73	9237.41	8753.47
	79.98%	*81.36%*	*81.61%*	*82.00%*	*81.73%*	*80.79%*	*81.34%*	*81.20%*	*81.12%*	*81.57%*	*82.45%*	*83.93%*	*84.89%*	*86.21%*	*87.12%*	*87.68%*	*87.14%*	*86.46%*	*86.64%*	*86.61%*	*86.99%*	*86.85%*	*87.22%*	*86.66%*	*85.88%*	*85.24%*
CRF 1A1 - Fuel Combustion from Energy Industries	33.29	34.83	34.73	33.04	32.32	91.29	80.61	87.66	153.38	170.54	117.37	279.33	1025.62	1032.90	1253.26	1239.18	1301.09	1177.54	991.94	1186.67	1202.05	1000.20	1038.72	682.30	664.65	453.05
	0.26%	*0.26%*	*0.26%*	*0.25%*	*0.26%*	*0.91%*	*0.80%*	*0.93%*	*1.79%*	*1.89%*	*1.22%*	*2.76%*	*9.43%*	*9.12%*	*9.85%*	*9.56%*	*10.17%*	*9.63%*	*8.19%*	*10.25%*	*9.89%*	*8.31%*	*8.84%*	*6.08%*	*6.18%*	*4.41%*
CRF 1A2 - Fuel Combustion from Manuf. Industries & Construction	6249.95	6096.36	5757.50	5892.13	5179.38	3324.81	3171.10	2406.43	1361.75	1550.71	1382.99	1474.29	1359.69	1297.60	1393.61	1384.22	1461.69	1368.79	1310.70	1180.01	1259.38	1230.86	1174.96	1126.32	1138.33	1105.38
	49.09%	*45.61%*	*43.88%*	*44.45%*	*41.70%*	*33.08%*	*31.37%*	*25.43%*	*15.87%*	*17.15%*	*14.38%*	*14.59%*	*12.50%*	*11.46%*	*10.96%*	*10.68%*	*11.42%*	*11.20%*	*10.82%*	*10.20%*	*10.37%*	*10.22%*	*10.00%*	*10.04%*	*10.58%*	*10.76%*
CRF 1A3 - Fuel Combustion from Transport	2556.05	3138.61	3411.45	3460.08	3513.75	3275.79	3384.73	3644.81	3823.62	4146.70	4779.47	5025.60	5214.90	5764.62	6720.41	7099.29	6782.31	6502.22	6605.85	6083.26	6437.63	6818.83	6501.85	6363.40	6065.44	5642.56
	20.08%	*23.48%*	*26.00%*	*26.10%*	*28.29%*	*32.60%*	*33.48%*	*38.52%*	*44.57%*	*45.87%*	*49.70%*	*49.74%*	*47.92%*	*50.90%*	*52.85%*	*54.77%*	*52.99%*	*53.19%*	*54.54%*	*52.56%*	*52.98%*	*56.62%*	*55.34%*	*56.75%*	*56.39%*	*54.95%*
of which, "road fuel export" (1)	1692.86	2239.97	2479.70	2481.06	2535.18	2244.16	2325.65	2543.01	2670.22	2980.76	3566.95	3741.18	3873.86	4397.94	5315.39	5679.26	5305.42	5001.22	5035.17	4518.41	4865.64	5226.24	4910.05	4778.73	4412.53	3980.90
	13.30%	*16.76%*	*18.90%*	*18.72%*	*20.41%*	*22.33%*	*23.01%*	*26.88%*	*31.13%*	*32.97%*	*37.09%*	*37.03%*	*35.60%*	*38.84%*	*41.80%*	*43.82%*	*41.45%*	*40.91%*	*41.57%*	*39.04%*	*40.05%*	*43.40%*	*41.79%*	*42.62%*	*41.02%*	*38.77%*
CRF 1A4 - Fuel Combustion from Other Sectors	1338.86	1602.75	1476.95	1460.78	1402.79	1416.24	1566.89	1520.90	1586.07	1443.10	1637.31	1676.06	1624.02	1664.22	1711.59	1641.64	1607.50	1521.52	1584.44	1574.05	1670.29	1408.74	1532.76	1545.54	1368.82	1552.32
	10.52%	*11.99%*	*11.26%*	*11.02%*	*11.29%*	*14.09%*	*15.50%*	*16.08%*	*18.49%*	*15.96%*	*17.03%*	*16.59%*	*14.92%*	*14.70%*	*13.46%*	*12.67%*	*12.56%*	*12.45%*	*13.08%*	*13.60%*	*13.75%*	*11.70%*	*13.04%*	*13.78%*	*12.73%*	*15.12%*
CRF 1A5 & 1B2b - Other Energy Sources	3.13	3.13	26.67	23.53	21.95	10.74	18.46	22.94	33.96	62.77	12.21	24.21	13.55	3.31	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.18	0.18	0.17	0.17	0.17
	0.02%	*0.02%*	*0.20%*	*0.18%*	*0.18%*	*0.11%*	*0.18%*	*0.24%*	*0.40%*	*0.69%*	*0.13%*	*0.24%*	*0.12%*	*0.03%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
CRF 2 - Industrial Processes & Product Use	1630.19	1551.83	1480.69	1457.42	1364.63	1004.43	948.36	838.80	678.64	716.01	741.93	684.34	701.69	646.19	704.04	676.23	726.81	717.62	659.95	588.59	611.24	624.73	562.82	543.19	553.94	546.69
	12.81%	*11.61%*	*11.29%*	*10.99%*	*10.99%*	*9.99%*	*9.38%*	*8.87%*	*7.91%*	*7.92%*	*7.71%*	*6.77%*	*6.45%*	*5.71%*	*5.54%*	*5.22%*	*5.68%*	*5.87%*	*5.45%*	*5.09%*	*5.03%*	*5.19%*	*4.79%*	*4.84%*	*5.15%*	*5.32%*
Other Sources (2)	0.59	0.71	0.83	0.95	1.37	1.12	0.99	1.47	2.02	1.13	1.89	2.29	2.90	2.82	2.42	3.91	3.05	3.08	2.86	4.07	4.18	4.88	5.06	5.81	5.81	5.81
	0.00%	*0.01%*	*0.01%*	*0.01%*	*0.01%*	*0.01%*	*0.01%*	*0.02%*	*0.02%*	*0.01%*	*0.02%*	*0.02%*	*0.03%*	*0.02%*	*0.02%*	*0.03%*	*0.02%*	*0.03%*	*0.02%*	*0.04%*	*0.03%*	*0.04%*	*0.04%*	*0.05%*	*0.05%*	*0.06%*
CH_4 (3)	**634.97**	**641.56**	**630.76**	**629.56**	**605.20**	**620.68**	**630.29**	**631.08**	**628.50**	**633.85**	**626.10**	**630.97**	**630.42**	**618.77**	**614.43**	**612.34**	**609.15**	**620.07**	**631.34**	**632.38**	**633.18**	**608.81**	**598.19**	**602.96**	**614.86**	**621.50**
	4.99%	*4.80%*	*4.81%*	*4.75%*	*4.87%*	*6.18%*	*6.24%*	*6.67%*	*7.33%*	*7.01%*	*6.51%*	*6.25%*	*5.79%*	*5.46%*	*4.83%*	*4.72%*	*4.76%*	*5.07%*	*5.21%*	*5.46%*	*5.21%*	*5.06%*	*5.09%*	*5.38%*	*5.72%*	*6.05%*
of which																										
CRF 1 - Energy	45.90	48.63	47.80	47.22	45.43	46.16	47.65	47.34	46.67	47.19	47.72	51.50	65.02	65.36	71.16	70.05	72.15	67.35	65.27	65.69	69.86	60.53	62.81	56.05	54.08	50.29
	0.36%	*0.36%*	*0.36%*	*0.36%*	*0.37%*	*0.46%*	*0.47%*	*0.50%*	*0.54%*	*0.52%*	*0.50%*	*0.51%*	*0.60%*	*0.58%*	*0.56%*	*0.54%*	*0.56%*	*0.55%*	*0.54%*	*0.57%*	*0.57%*	*0.50%*	*0.53%*	*0.50%*	*0.50%*	*0.49%*
CRF 3A+3B - Enteric Fermentation and Manure Management	486.01	488.26	478.21	478.13	464.32	479.39	486.53	485.38	482.56	487.92	481.27	483.23	468.18	453.36	447.62	447.71	442.53	458.02	469.84	471.78	479.83	466.18	455.58	466.39	480.21	493.80
	3.82%	*3.65%*	*3.64%*	*3.61%*	*3.74%*	*4.77%*	*4.81%*	*5.13%*	*5.63%*	*5.40%*	*5.00%*	*4.78%*	*4.30%*	*4.00%*	*3.52%*	*3.45%*	*3.46%*	*3.75%*	*3.88%*	*4.08%*	*3.95%*	*3.87%*	*3.88%*	*4.16%*	*4.46%*	*4.81%*
Other Sources (4)	103.07	104.66	104.75	104.21	95.45	95.14	96.11	98.37	99.27	98.74	97.11	96.24	97.21	100.04	95.65	94.58	94.47	94.70	96.23	94.92	83.49	82.11	79.80	80.52	80.56	77.41
	0.81%	*0.78%*	*0.80%*	*0.79%*	*0.77%*	*0.95%*	*0.95%*	*1.04%*	*1.16%*	*1.09%*	*1.01%*	*0.95%*	*0.89%*	*0.88%*	*0.75%*	*0.73%*	*0.74%*	*0.77%*	*0.79%*	*0.82%*	*0.69%*	*0.68%*	*0.68%*	*0.72%*	*0.75%*	*0.75%*
N_2O (5)	**282.56**	**295.94**	**285.82**	**282.57**	**281.17**	**285.11**	**285.31**	**282.91**	**283.90**	**286.56**	**286.21**	**269.79**	**269.45**	**251.46**	**272.16**	**259.54**	**258.21**	**261.26**	**268.70**	**266.50**	**271.49**	**281.56**	**268.89**	**273.54**	**268.39**	**265.56**
	2.22%	*2.21%*	*2.18%*	*2.13%*	*2.26%*	*2.84%*	*2.82%*	*2.99%*	*3.31%*	*3.17%*	*2.98%*	*2.67%*	*2.48%*	*2.22%*	*2.14%*	*2.00%*	*2.02%*	*2.14%*	*2.22%*	*2.30%*	*2.23%*	*2.34%*	*2.29%*	*2.44%*	*2.50%*	*2.59%*
of which																										
CRF 1 - Energy	36.71	42.13	46.01	48.76	51.67	49.15	50.10	50.58	50.05	51.58	53.20	53.48	52.72	52.30	52.94	52.86	52.92	56.38	60.15	59.02	64.19	68.92	67.98	68.48	68.17	65.30
	0.29%	*0.32%*	*0.35%*	*0.37%*	*0.42%*	*0.49%*	*0.50%*	*0.53%*	*0.58%*	*0.57%*	*0.55%*	*0.53%*	*0.48%*	*0.46%*	*0.42%*	*0.41%*	*0.41%*	*0.46%*	*0.50%*	*0.51%*	*0.53%*	*0.57%*	*0.58%*	*0.61%*	*0.63%*	*0.64%*
CRF 3D - Agricultural Soils	188.73	197.58	184.66	177.97	174.29	178.38	177.15	174.34	175.38	176.99	174.58	158.39	160.63	142.04	162.69	149.87	148.37	146.41	147.99	148.53	149.36	157.25	148.95	151.98	145.76	146.15
	1.48%	*1.48%*	*1.41%*	*1.34%*	*1.40%*	*1.77%*	*1.75%*	*1.84%*	*2.04%*	*1.96%*	*1.82%*	*1.57%*	*1.48%*	*1.25%*	*1.28%*	*1.16%*	*1.16%*	*1.20%*	*1.22%*	*1.28%*	*1.23%*	*1.31%*	*1.27%*	*1.36%*	*1.36%*	*1.42%*
Other Sources (6)	57.13	56.23	55.15	55.84	55.21	57.58	58.06	57.98	58.46	58.00	58.42	57.92	56.10	57.12	56.53	56.81	56.92	58.47	60.56	58.95	57.94	55.39	51.96	53.09	54.46	54.11
	0.45%	*0.42%*	*0.42%*	*0.42%*	*0.44%*	*0.57%*	*0.57%*	*0.61%*	*0.68%*	*0.64%*	*0.61%*	*0.57%*	*0.52%*	*0.50%*	*0.44%*	*0.44%*	*0.44%*	*0.48%*	*0.50%*	*0.51%*	*0.48%*	*0.46%*	*0.44%*	*0.47%*	*0.51%*	*0.53%*
F-gases (7)	**0.88**	**0.98**	**14.76**	**15.88**	**17.28**	**19.70**	**21.62**	**24.24**	**26.72**	**28.61**	**31.50**	**36.04**	**39.53**	**42.43**	**45.06**	**44.65**	**48.04**	**53.06**	**55.87**	**57.66**	**60.33**	**63.65**	**66.41**	**70.41**	**75.56**	**75.92**
	0.01%	*0.01%*	*0.11%*	*0.12%*	*0.14%*	*0.20%*	*0.21%*	*0.26%*	*0.31%*	*0.32%*	*0.33%*	*0.36%*	*0.36%*	*0.37%*	*0.35%*	*0.34%*	*0.38%*	*0.43%*	*0.46%*	*0.50%*	*0.50%*	*0.53%*	*0.57%*	*0.63%*	*0.70%*	*0.74%*
Total GHG excluding LULUCF	**12730.46**	**13366.69**	**13120.17**	**13255.94**	**12419.85**	**10049.92**	**10108.35**	**9461.25**	**8578.56**	**9039.99**	**9616.97**	**10102.92**	**10881.78**	**11324.32**	**12717.16**	**12961.17**	**12798.04**	**12225.34**	**12111.83**	**11573.37**	**12149.97**	**12042.45**	**11749.85**	**11213.64**	**10755.97**	**10268.93**
	100.00%	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*
LULUCF	**44.42**	**-232.82**	**-562.00**	**-657.06**	**-467.88**	**-570.96**	**-611.38**	**-694.11**	**-578.53**	**-676.24**	**-705.87**	**-717.51**	**-718.84**	**-681.42**	**-685.12**	**-639.48**	**-557.35**	**-477.38**	**-493.94**	**-471.09**	**-155.93**	**-277.84**	**-363.44**	**-538.64**	**-458.83**	**-407.41**

Source: Environment Agency – Submission 2017v1.2.

Notes: (1) estimation done using NEMO *[→ Section V.2.4.3]* and the quantities of road fuels sold in Luxembourg.
(2) the other CO_2 sources are emissions from liming (CRF 3G).
(3) the methane emissions are converted in CO_2 equivalents by multiplying the emissions by 25, i.e. the global warming potential (GWP) value for methane based on the effects of GHG over a 100-year time horizon.
(4) the other CH_4 sources are emissions from solid waste disposal on land (CRF 5A), wastewater handling (CRF 5B) and composting (CRF 5D).
(5) the nitrous oxide emissions are converted in CO_2 equivalents by multiplying the emissions by 298, i.e. the global warming potential (GWP) value for nitrous oxide based on the effects of GHG over a 100-year time horizon.
(6) the other N_2O sources are emissions from anaesthesia (CRF 2G), manure management (CRF 3B), wastewater handling (CRF 5B) and composting (CRF 5D).
(7) the F-gases are those not covered by the Montreal Protocol, i.e. only HFCs and SF_6 for Luxembourg, expressed in CO_2 equivalents using the global warming potential (GWP) values based on the effects of GHG over a 100-year time horizon.

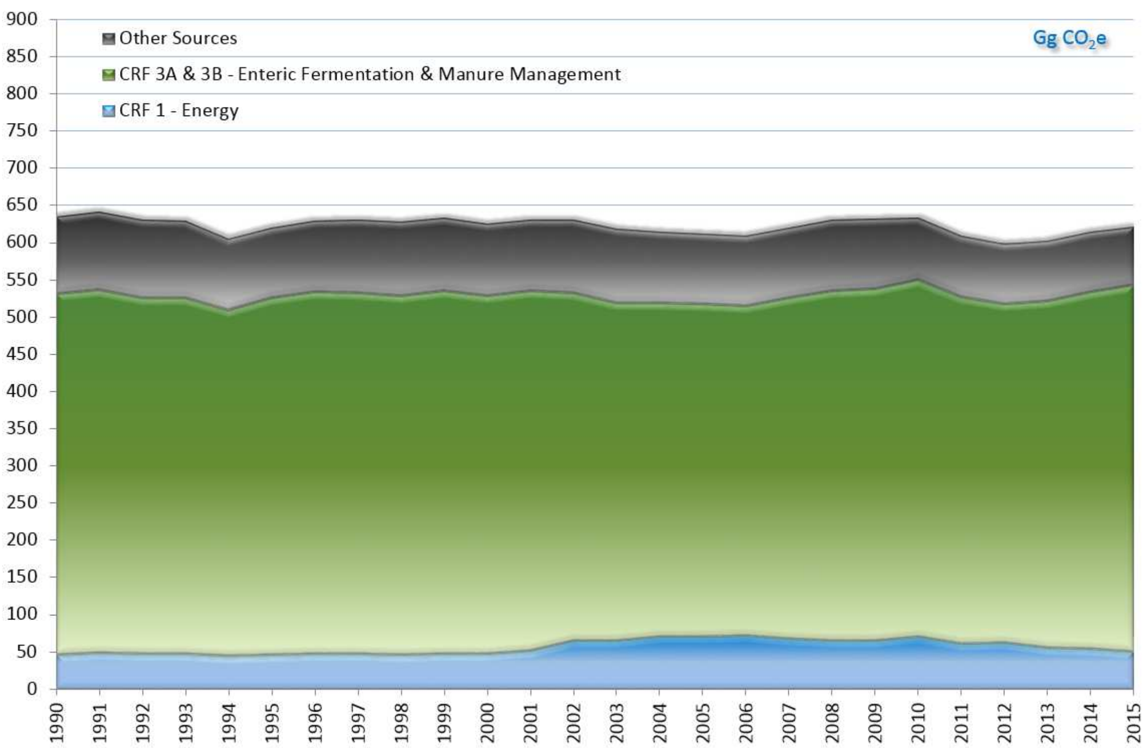
FIGURES III.1-4a – GHG EMISSIONS (EXCL. F-GASES & LULUCF) – DETAILS BY MAIN GASES: ABSOLUTE VALUES 1990-2015

CO_2



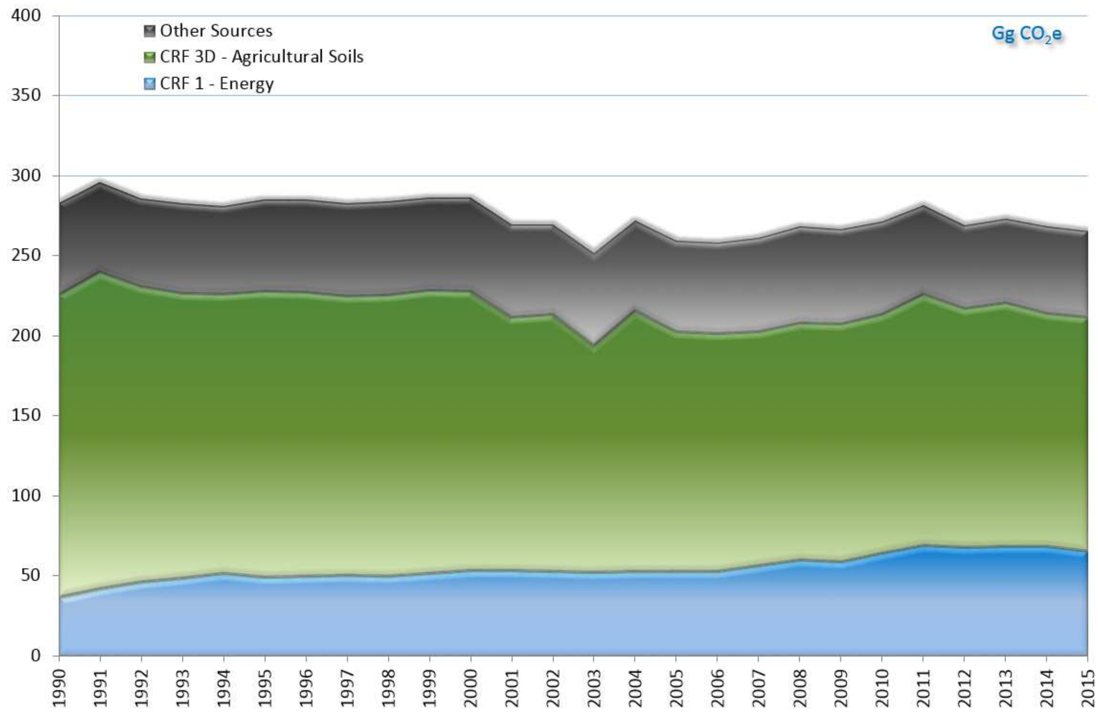
Source: Environment Agency – Submission 2017v1.2.
Note: the other CO_2 sources are emissions from liming (CRF 3G).

CH_4



Source: Environment Agency – Submission 2017v1.2.
Note: the other CH_4 sources are emissions from solid waste disposal on land (CRF 5A), wastewater handling (CRF 5B) and composting (CRF 5D).

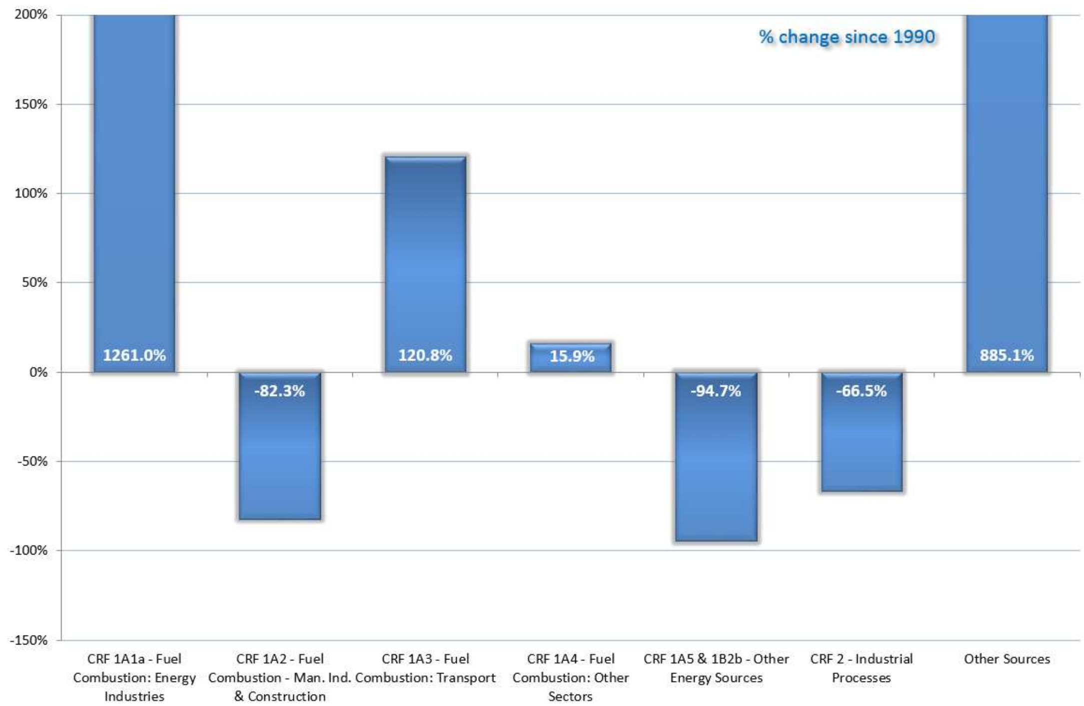
N_2O



Source: Environment Agency – Submission 2017v1.2.
Note: the other N_2O sources are emissions from anaesthesia (CRF 2G), manure management (CRF 3B), wastewater handling (CRF 5B) and composting (CRF 5D).

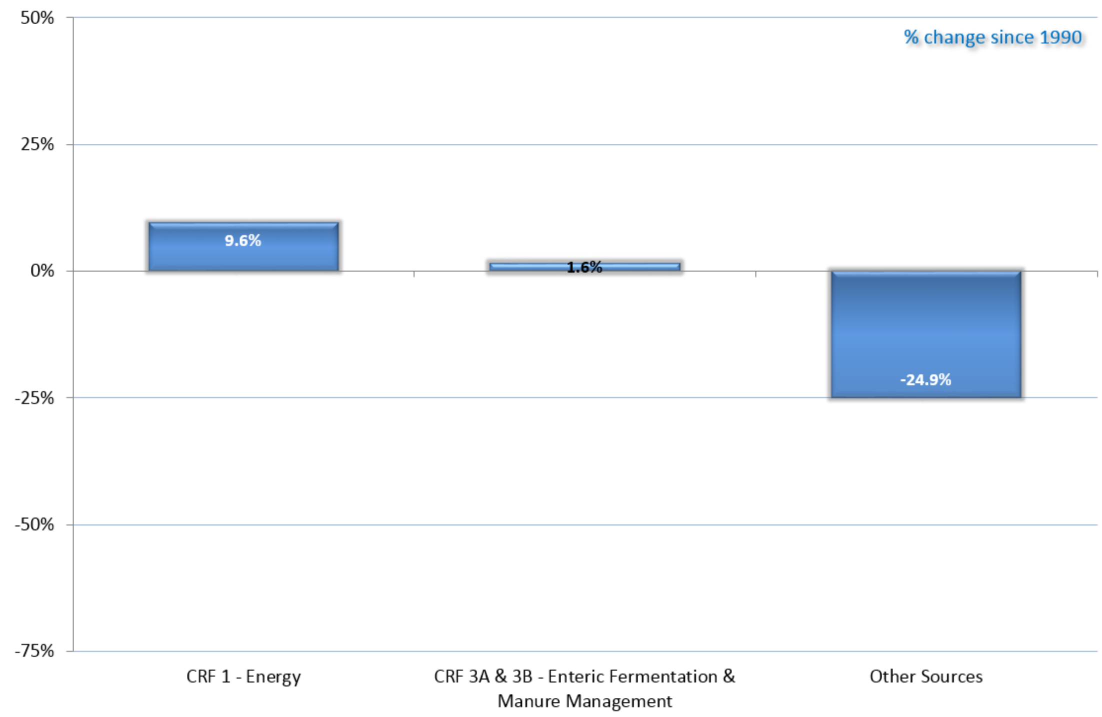
FIGURE III.1-4b – GHG EMISSIONS TRENDS (EXCL. LULUCF) – MAIN GASES' TRENDS: 1990-2015

CO_2



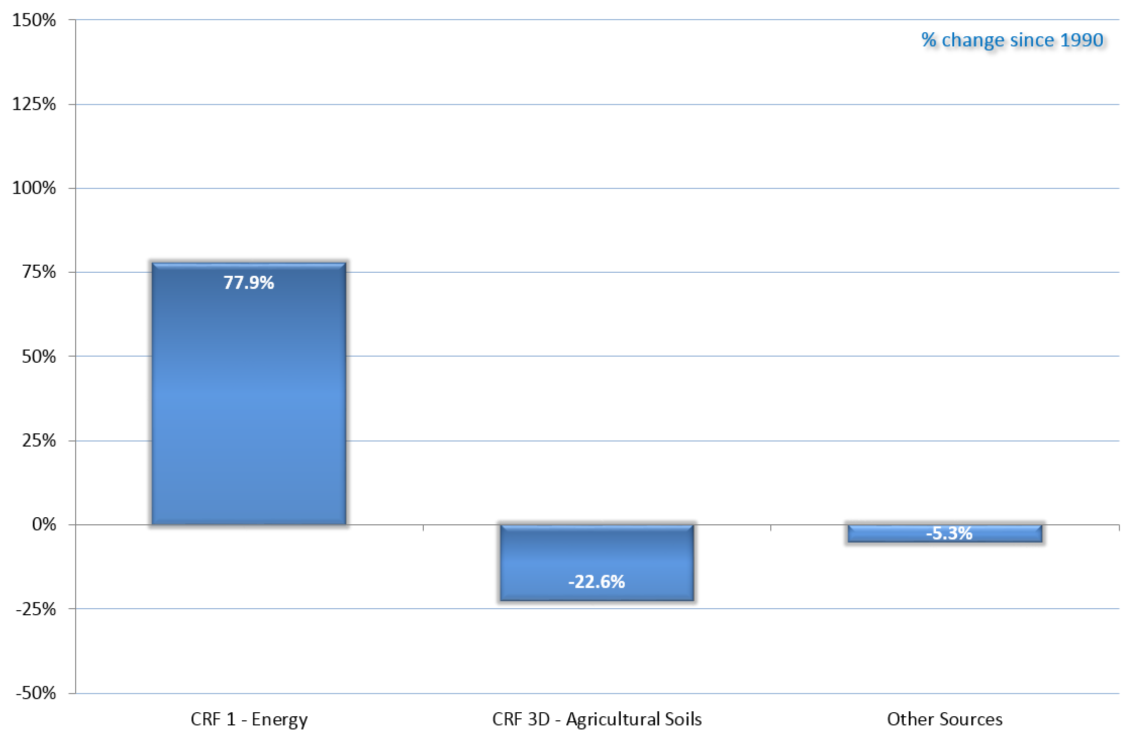
Source: Environment Agency – Submission 2017v1.2.
Note: the other CO_2 sources are emissions from liming (CRF 3G).

CH4



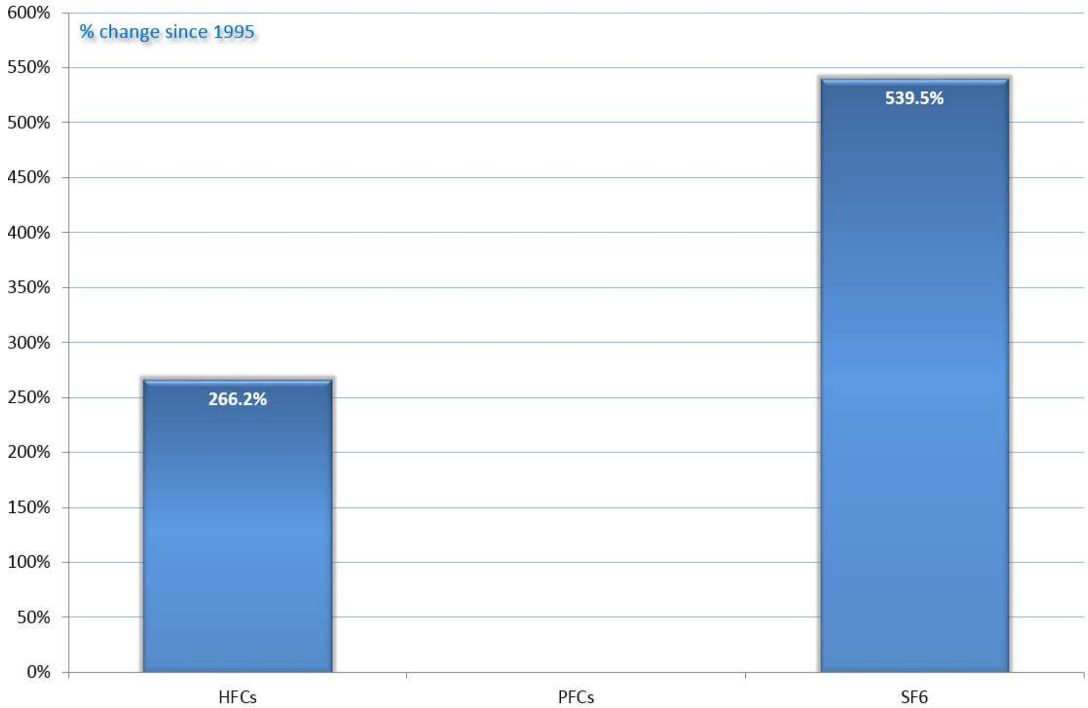
Source: Environment Agency – Submission 2017v1.2.
Note: the other CH_4 sources are emissions from solid waste disposal on land (CRF 5A), wastewater handling (CRF 5B) and composting (CRF 5D).

N2O



Source: Environment Agency – Submission 2017v1.2.
Note: the other N_2O sources are emissions from anaesthesia (CRF 2G), manure management (CRF 3B), wastewater handling (CRF 5B) and composting (CRF 5D).

F-gases



Source: Environment Agency – Submission 2017v1.2.

III.1.2.1. Carbon dioxide – CO_2

CRF (sub-)categories covered	1A1a, 1A2, 1A3, 1A4, 1A5, 1B2b, 2A1, 2A3, 2C1, 2C7, 2D, 3G	
share in total GHG emissions, excl. LULUCF	***1990***	92.8% = 11 812.05 Gg CO_2e
	2015	90.6% = 9 305.96 Gg CO_2e

Throughout the period 1990-2015, the main GHG has remained carbon dioxide, which accounted between 89.0% and 93.0% of the total GHG emissions. However, the structure of CO_2 emissions has evolved with an increase in fuel combustion, which accounted for 80.0% of total GHG emissions for the base year (1990) and climbed up to 86.2% in 2015, after having reached a maximum of 87.7% in 2005.

Road transport, and more precisely "road fuel sales to non-residents", is, with **electricity production**, one of the culprits for this development. Indeed, in 1990, fuel combustion from the transport sector accounted for 20.1% of total GHG emissions. Then, with 5.64 Mio. t CO_2, this percentage reached 54.9% in 2015.[73] CO_2 emissions due solely to "road fuel sales to non-residents" amounted to about 1.7 Mio. t in 1990 and reached 4.0 Mio. t in 2015,[74] i.e. roughly a threefold increase (the same comparison shows only a twofold increase for road fuel consumed by the national

73 The highest amount of emissions was recorded for the year 2005: 7.10 Mio. t CO_2 but "only" 54.8% of total GHG emissions. In fact, percentages are somewhat over-estimated in 2015 compared to the latest years for two reasons: (1) lower than "usual" emissions in electricity and heat production (CRF 1A1a) due to very low production for the TWINerg power plant for some months and (2) rather lower – compared to the previous years – emissions in the other sectors (CRF 1A4).

74 5.7 Mio. t in 2005.

vehicle fleet). In 2015, "road fuel sales to non-residents" represented 70.5% of CO_2 emissions of the transport sector and 38.8% of the total CO_2 emissions.[75] In 1990, these percentages were 67.5% and 14%, respectively.

Another important source of CO_2 in Luxembourg is **industrial processes**, mainly carbon oxidizing of pig iron from steel industry (basic oxygen furnace steel production) and decarbonisation of mineral input in clinker and glass industry. The steel production process change described above was the main driver behind declining emissions for this sector.

III.1.2.2. Methane – CH_4

CRF (sub-)categories covered	1A1a, 1A2, 1A3, 1A4, 1A5, 1B2b, 3A, 3B, 5A, 5B & 5D		
share in total GHG emissions, excl. LULUCF	***1990***	4.99% =	634.97 Gg CO_2e
	2015	6.05% =	621.50 Gg CO_2e

Methane emissions originate above all from the agricultural sector, and more precisely from **enteric fermentation** and from **manure production and management**: around 75.9% of methane emissions over the period 1990-2015. As these emissions have been rather stable, total methane emissions have not varied very much.

For the other methane emitting source categories, there is a decline in **waste and wastewater management** related emissions (-25.0%) and growing emissions in **energy use** (+9.6%). The decrease noted for waste is the result of reduced methane emissions from waste landfill sites. The increase observed for energy is mainly due to fugitive emissions from natural gas distribution and use.

III.1.2.3. Nitrous oxide – N_2O

CRF (sub-)categories covered	1A1a, 1A2, 1A3, 1A4, 1A5, 2G, 3B, 3D, 5B & 5D		
share in total GHG emissions, excl. LULUCF	***1990***	2.38% =	303.89 Gg CO_2e
	2015	2.80% =	278.98 Gg CO_2e

A large part of nitrous oxide emissions is caused by **agricultural soils** that drive the -22.6% decline observed for this gas over the period 1990-2015. Another important source, generating increasing N_2O emissions since 1990, is **road transportation**, where incomplete NO_X reduction in catalytic converters of diesel oil motor vehicles leads to N_2O emissions that were almost multiplied by a factor 3 over the period, following the increasing share of diesel vehicles on the roads. The drop in emissions observed for the **other sources** is principally the result of diminishing nitrous oxide emissions from manure management.

75 For 2005, these percentages were respectively 80.0% and 47.1%.

III.1.2.4. Hydrofluorocarbons – HFCs and sulphur hexafluoride – SF_6

CRF (sub-)categories covered	2F 2G		
share in total GHG emissions, excl. LULUCF	***1990***	0.01% =	0.88 Gg CO_2e
	2015	0.74% =	75.92 Gg CO_2e

The increase in **HFCs** emissions between 1990 and 2015 is explained by a more wide spread use of mobile and stationary cooling equipment as well as of aerosols.

No use of **PFCs** and **NF_3** is reported.

SF_6 emissions increased from 1990 onwards following a raising use of high voltage electrical devices and a higher amount of gas emitted from noise reduction windows.

III.1.3. GHG trends by sector: reductions in all sectors

This section should be read together with ***Chapter II***, where changes and developments that occurred since 1990 in the various sectors and the socio-economic profile of Luxembourg have been described and analysed with regard to their impacts on GHG emissions.

In 2015, the energy sector accounted for almost 86.3% of the total GHG emissions, excluding LULUCF. Two sectors represent between 6.1% and 6.6% of the total emissions, excluding LULUCF: industrial processes (6.1%) and agriculture (6.6%). The remaining sector[76] (waste[77] (0.9%) was not even reaching 1.0% of the total GHG emitted in Luxembourg *[→ Table III.1-2]*.

For the different sectors, trends over the period 1990-2015 (and 2014-2015) were as follows:

Energy:	-13.6%	(-5.2%)
Industrial Processes and Product Use:	-61.8%	(-1.1%)
Agriculture:	-4.7%	(+2.1%)
LULUCF:..	-917.2%	(-14.51%)
Waste:	-16.9%	(-3.8%)
Total GHG emissions, excl. LULUCF:	***-19.3%***	***(-4.5%)***

76 The sector "Others" is not reported for Luxembourg.

77 The waste sector covers only landfilled waste, wastewater handling and composting activities. Waste incineration, which is the main treatment method for municipal waste in Luxembourg, is carried out in the sole incinerator of the country where energy is recovered. Consequently, waste incineration related emissions are accounted for in CRF sector 1 – Energy.

III.1.3.1. CRF 1 – Energy

GHG covered	CO_2, CH_4 & N_2O	
share in total GHG emissions, excl. LULUCF	***1990***	79.98% = 10 181.27 Gg CO_2e
	2015	85.24% = 8 753.47 Gg CO_2e

Energy production and consumption related GHG emissions have decreased by 14.0% between 1990 and 2015 from 10.2 Mio. t CO_2e in 1990 to 8.8 Mio. t CO_2e in 2015. For carbon dioxide, methane and nitrous oxide, the changes over the period 1990-2015 were -14.0%, +9.5% and +77.9%, respectively.

However, the overall trends at sector level hide very different developments at the CRF sub-category level. Within the energy sector, the fastest growing sub-sectors were **energy industries** (1A1) (due to the operational start of the TWINerg gas turbine in 2001) and **transport** (1A3): +1206.0% and +120.7%, respectively between 1990 and 2015 (-31.8% and -2.9% from 2014 to 2015) with, as a result, shares in the total energy related GHG emissions rising from 0.3% to 4.4% and 20.1% to 54.9%, respectively. For the other sub-sectors, the observed trends between 1990 and 2015 are -82.2% for **manufacturing industries and construction** (1A2), +15.6% for the **other sectors** (1A4), and +78.3% for **fugitive emissions from fuels** (1B).[78]

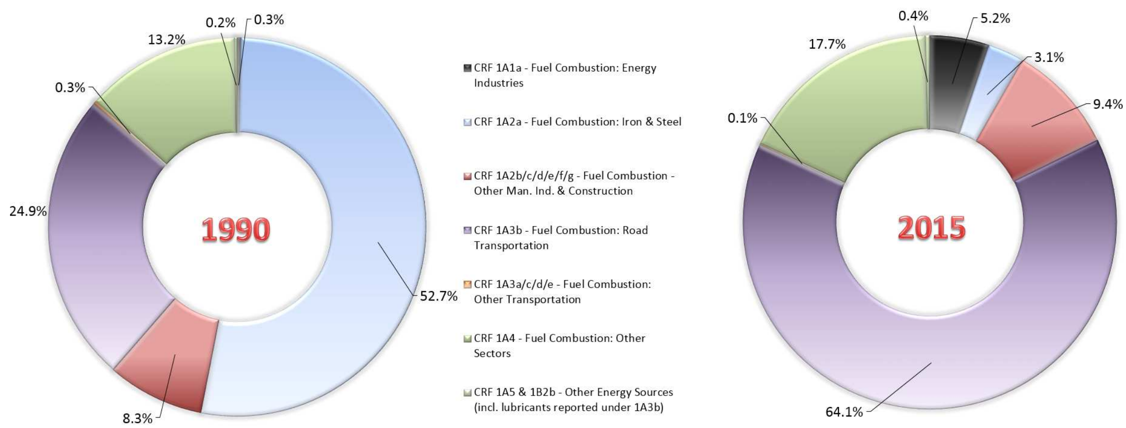
In fact, over the period, GHG emissions have been strongly influenced by varying fuel consumption levels in industry, in particular in the energy and the iron and steel industries, as well as in the road transport sector as percentage growths recorded for CRF sub-categories 1A1, 1A2 and 1A3 demonstrate. There are several industrial sites which had relatively high levels of GHG emissions, and which, therefore, have had a large impact on the national total of GHG emissions. The TWINerg power plant, and to a lesser extent several cogeneration (CHP) plants had an impact on the energy related GHG emissions, as already stressed in previous paragraphs. In the transport sector, road fuel consumption, and even more so road fuel sales, have a very important weight in the national energy balance, and, consequently, have also a very important impact on the total GHG emissions.

In the iron and steel industry, the passage from blast furnaces to electric arc furnaces allowed to significantly reducing GHG emissions between 1994 and 1998. Due to the importance of iron and steel industry in Luxembourg, this evolution hid many other emission trends between 1990 and 1998. After 1998, the increase of road fuel sales and, to a lesser extent, of electric energy production has led to a rather steep increase of GHG emissions in these sectors and, by extension, of the national total for GHG emissions up to 2005. Then these same sectors explain the downward trend observed from 2006 onwards.

78 Fugitive emission growth is closely linked to natural gas use in Luxembourg.

All these changes briefly presented in the previous paragraphs – as well as in *Sections II.6, II.7 & II.8* – completely modified the pattern of the energy related GHG emissions with regard to CRF sub-categories share *[→ Figure III.1-5]* and to the "energy-mix" or fuel usage for energy production and consumption *[→ Tables & Figures II.6-1 & II.6-2]*.

FIGURE III.1-5 – CRF SUB-CATEGORIES SHARE IN GHG EMISSIONS FOR CRF 1 – ENERGY: 1990 & 2015



Source: Environment Agency – Submission 2017v1.2.

III.1.3.2. CRF 2 – Industrial Processes and Product Use

GHG covered	CO_2 & F-gases	
share in total GHG emissions, excl. LULUCF	***1990***	12.8% = 1 640.25 Gg CO_2e
	2015	6.0% = 626.08 Gg CO_2e

Industrial processes and product use represent the third largest sector in Luxembourg with regard to GHG emissions. The sector includes emissions from industrial installations and from consumption of halocarbons and SF_6 (the fluorinated gases or F-gases). In Luxembourg, when leaving F-gases out, only three companies and their various production installations are part of CRF sector 2:

- CRF sub-categories 2A1 & 2A3: one cement works unit and one flat glass manufacturing company;
- CRF sub-category 2C1: the iron and steel manufacturing company Arcelor-Mittal.

Emissions from industrial processes show a declining trend between 1990 and 1998, then a relative stabilisation. This evolution was mainly driven by **process changes that occurred in the iron & steel industry**. As indicated above, this industry moved from blast to electric arc furnaces between 1994 and 1998. Consequently, steel industry process emissions in CO_2e decreased by 93.8% over the period 1990-2015. Overall sector emissions in CO_2e fell by about 61.8% between 1990 and 2015, reducing the weight of this sector in total GHG emissions from 12.9% to 6.1% over the period. By gas, however, the picture is different. For carbon dioxide, the decrease over the period 1990-2015 was -66.5%: -36.7% for 2A1, +21.5% for 2A3 and -87.5% for 2C1. F-gases emissions, on the contrary, increased regularly: +285.5% over the period 1995-2015 but they are minor compared to the total emissions *[→ Figure III.1-6]*.

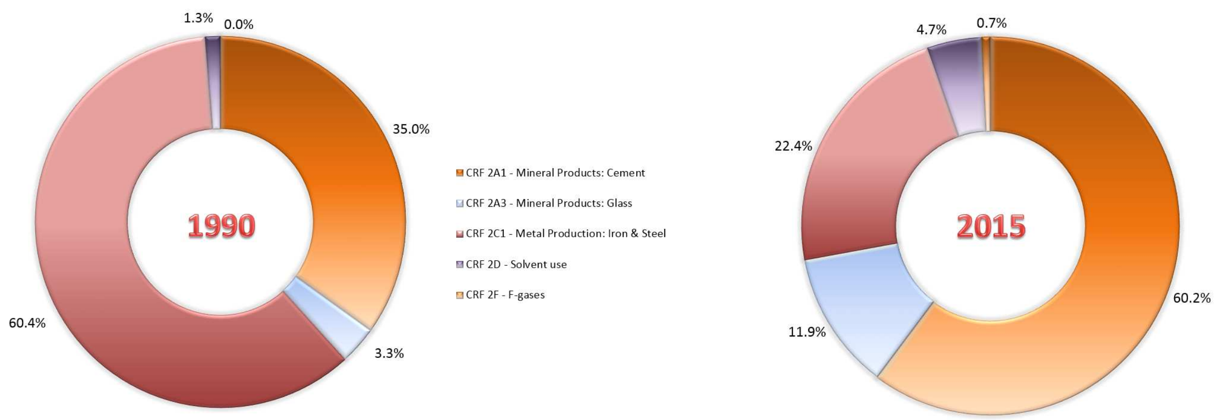
The striking increase of **F-gases emissions** is the consequence of supposedly growing use in the country, notably due to an increasing use of air conditioning and noise reduction windows *[→ Section III.1.2.4]*.

Carbon dioxide emissions from solvent use have been estimated from related NMVOC emissions. These NMVOC emanations have been calculated using both a bottom-up and a top-down approach. This is detailed in Ministry of Sustainable Development and Infrastructure, Environment Agency (2017), section 4.5.3, p. 300-321. Nitrous oxide emissions reported for this sector are very low and are stemming from anaesthesia usage as well as propellant for pressure and aerosols products that have been estimated by combining reported emissions per capita in Germany (anaesthesia) or Belgium (propellant) with the relative population in Luxembourg [Ministry of Sustainable Development and Infrastructure, Environment Agency (2017), section 4.8.4., p. 345-351].

Emissions of solvent use decreased by 11.0% between 1990 and 2015, due to the positive impact of diverse enforced laws and regulations in Luxembourg.[79]

The emission trends briefly described in the previous paragraphs led to a significant change in the composition of industrial processes' GHG emissions *[→ Figure III.1-6]*.

FIGURE III.1-6 – CRF SUB-CATEGORIES SHARE IN GHG EMISSIONS FOR CRF 2 – INDUSTRIAL PROCESSES: 1990 & 2015



Source: Environment Agency – Submission 2017v1.2.

[79] These legal texts are listed in Ministry of Sustainable Development and Infrastructure, Environment Agency (2017), section 4.5.3, p. 302.

III.1.3.3. CRF 3 – Agriculture

GHG covered	CO_2, CH_4 & N_2O		
share in total GHG emissions, excl. LULUCF	***1990***	5.56% =	714.41 Gg CO_2e
	2015	6.24% =	680.83 Gg CO_2e

Trends in agriculture were also favourable between 1990 and 2015: in general, GHG related to agricultural activities have decreased by 6.2% (+1.6% for methane and -22.6% for nitrous oxide). Enteric Fermentation (3A) saw its emissions declining by 1.1%, whereas for agricultural soils (3D), the decrease reaches 22.6%. For manure management (3B), emissions increased by 9.0% between 1990 and 2015, though opposite variations are observed for the two GHG emitted by this activity: methane increased by 23.5% and nitrous oxide decreased by 10.2%.

However, the evolution of nitrous oxide emissions stemming from agricultural soils (3D) shapes the overall agriculture emission pattern. Indeed, for both the years 1990 and 2015, CRF category 3D is the biggest contributor to agriculture related emissions, though it is also, as for other Annex I Parties, the agriculture category that shows the highest uncertainty in the inventory. It is also worth noting that the shares of each CRF category under CRF sector three for which GHG emissions are reported have barely changed over the period *[→ Figure III.1-7]*.

Looking at each CRF category in more detail, generally the decrease in **enteric fermentation** related **methane** emanations over the period 1990-2015 is mainly the result from declining emissions generated by cattle (-8.6%), whilst increasing emissions were recorded for the other livestock categories, except rabbits. With regard to cattle, its total population size declined throughout the period 1990-2015 driven by a decline in dairy cattle heads – non-dairy cattle population in 2015 is only 4.4% below its 1990 level. However, a shift did occur within the cattle population with a reduction for dairy cattle (-20.0%) and an increase for female mature non-dairy cattle (+18.8%). In fact, cattle population and its evolution are strongly influenced by changes in the agricultural policy and, more precisely, in the Common Agricultural Policy of the EU (*CAP*). Another factor influencing cattle population is, of course, meat and milk prices (which, themselves are affected by agricultural policy changes and targets).[80] Finally, if the dairy cattle population decreased by 20.0% between 1990 and 2015, related methane emissions only declined by 3.2%. This is explained by increasing milk yield over the period that, in turn, led to an augmentation of the gross energy intake for dairy cattle and, consequently, of the methane implied emission factors.

Looking at **methane** emissions from **manure management**, an increase by 23.5% can be observed for the period 1990-2015. Animals who contributed the most to these emissions were cattle and swine. As far as **nitrous oxide** emissions from **manure management** are concerned, a decrease of 10.2% is observed for the period 1990-2015. These emissions are mainly due to cattle. However, if

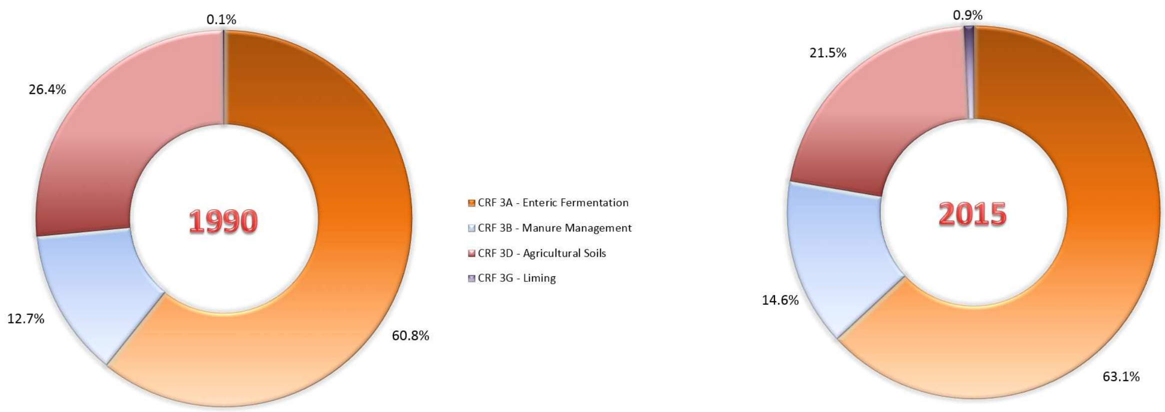
80 As an example, the peak in the non-dairy cattle population observed in 1991 can be explained by a sharp price fall of the bovine meat price that year. This price fall led farmers to postpone slaughtering until early 1992.

cattle were responsible for 91.0% of manure related N_2O emissions in 1990, this share dropped to a bit less than 88.0% in 2015. This evolution is the result of a declining (dairy) cattle population at the same time as other farm animal categories saw their number grow and as liquid system share in the animal waste management systems (AWMS) more than doubled at the expense of solid storage systems.

Finally, **nitrous oxide** emissions from **agricultural soils** are mainly driven by:

- nitrogen input to soils (such as application of synthetic fertilizers and manure) as well as nitrogen fixed by crops or crop residues;
- nitrogen excretion on pasture, range and paddock;
- by indirect soil emissions due to atmospheric deposition as well as to nitrogen from fertilizers and animals that is lost through leaching and run-off.

FIGURE III.1-7 – CRF SUB-CATEGORIES SHARE IN GHG EMISSIONS FOR CRF 3 – AGRICULTURE: 1990 & 2015



Sources: Environment Agency and SER – Submission 2017v1.2.

III.1.3.4. CRF 5 – Waste

GHG covered	CH_4 & N_2O		
share in total GHG emissions, excl. LULUCF	***1990***	0.88% =	111.92 Gg CO_2e
	2015	0.91% =	92.97 Gg CO_2e

In the waste sector, the main source of GHG was solid waste disposal on land (5A), but its weight decreased over the period 1990-2015 due to the combination of reduced amounts of waste disposed of in landfills and of increased emissions arising from composting activities (5D). However, GHG emission reduction for solid waste disposal on land between 1990 and 2015 (-44.5%) still drove a reduction for the overall waste sector despite composting rising emissions. Wastewater handling emissions (5D) experienced a 34.5% decline in emissions between 1990 and 2015. This decrease was driven by domestic and commercial wastewater treatment – and, more specifically methane related emissions – since industrial wastewater, management remained fairly stable throughout the period.

For **solid waste disposal on land**, methane emissions have been reduced due to:

- a decrease in the quantity of waste being stored in authorised landfill sites (two as of today, three in the early 1990s), notably through the development of recycling schemes and the expansion of both the numbers of and the various waste categories collected by recycling centres;
- the aerobic pre-treatment before storage in one of the two landfill sites;
- the recent installation of methane recovery systems at waste dumping sites.

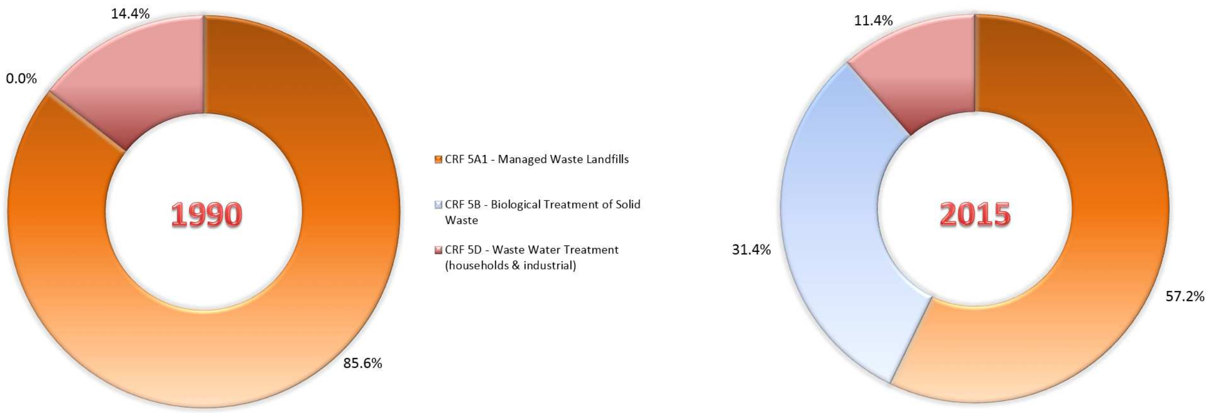
Wastewater treatment plant (WWTP) capacities expressed in population-equivalents have steadily grown since 1990. However, methane and nitrous oxide emissions decreased by 25.0% since 1990. Therefore, technical changes, with regard to wastewater treatment, have had an undeniable role too.

Concerning **compost production**, this activity started on an "industrial scale" only in the early 1990s. It experienced a steady growth from 1993 to 2003 and then more or less stabilizes. Nowadays, seven composting installations operate in Luxembourg, plus one that co-compost sewage sludge. The latter uses active ventilation and fully operates aerobically – without methane formation. The other plants operate in part under anaerobic conditions, with a residence time in the "composter" of a few weeks.

It is recalled that waste incineration related emissions are part of CRF sub-category 1A1a (public electricity and heat production) since energy is recovered in the sole incinerator of the country and injected in the network.

The emission trends briefly described in the previous paragraphs led to a significant change in the composition of waste related GHG emissions *[→ Figure III.1-8]*.

FIGURE III.1-8 – CRF SUB-CATEGORIES SHARE IN GHG EMISSIONS FOR CRF 5 – WASTE: 1990 & 2015



Sources: Environment Agency and Water Agency – Submission 2017v1.2.

III.1.3.5. CRF sectors – overview

The fact that the iron and steel industry has abandoned blast furnaces between 1994 and 1998, that the TWINerg power plant started fully its operations in 2002, and that fossil fuel consumption as well as road fuel sales have experienced a continuous increase up to 2005, hide many other emission trends and, due to their importance in the national total GHG emissions, they shape the overall pattern of Luxembourg's GHG emissions trend.

More details for each CRF sector are available in Ministry of Sustainable Development and Infrastructure, Environment Agency (2017).

III.1.4. LULUCF

In Luxembourg, LULUCF was a net sink every year, except in 1990 and 1991.[81] An important sub-category is forest land, in particular its sub-source forest land remaining forest land (4A1). This sub-category, as well as the sub-category land converted to forest land (4A2), are net sinks for CO_2, whereas other categories and sub-categories reported in the inventory are generally sources of emissions (both CO_2 and N_2O).

The latest inventory shows potential net sinks over the second Kyoto commitment period 2013-2020. Indeed, from the "Accounting" KP-LULUCF table, the expected net carbon sequestration from LULUCF activities (or "Removal Units" – RMUs) reaches 528.85 Gg CO_2e.[82] Consequently, forestry and land use changes will not contribute much to Luxembourg's ways of meeting its Kyoto commitment. The latter would therefore be reached **mainly via national policies and measures and the use of "Kyoto flexible mechanisms"** and not via carbon sinks.

With regard to the KP-LULUCF activities, in 2015, CO_2e removals from **afforestation and reforestation** (AR) in Luxembourg amounted to -173.2 Gg CO_2e. Out of this amount, 123.7 Gg CO_2e resulted from accumulation of biomass, 4.8 Gg CO_2e resulted from accumulation of dead wood, 16.3 Gg CO_2e from accumulation of litter, and 28.4 Gg CO_2e from accumulation of carbon stock in soils.

Emissions from **deforestation** (D) activities amounted in 2015 to 42.4 Gg CO_2e. Out of this amount, 17.0 Gg CO_2e resulted from loss of biomass, 0.8 Gg CO_2e from loss of dead wood, 2.7 Gg CO_2e from loss of litter, and 21.9 Gg CO_2e from loss of carbon stock in soils.

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[81] Net emissions in 1990 and 1991 are the consequence of the important storms that severely hit Luxembourg's forests in early 1989-90.

[82] In the "Accounting" KP-LULUCF table, take the sum of A1 & A2, column "Accounting quantity", and divide it by 5: (-482.22+129.58)/5 = -70.5289 Gg or 0.0705289 Mt CO_2e). In the SEF tables, no RMUs are accounted for yet.

Due to the nature and permanence of ARD areas, there is from 1990 on:

- a steady increase in ARD areas, and related to that,
- a steady increase of removals and emissions, respectively, at these areas.

LULUCF will not be discussed intensively in this National Communication and for more details on the emission trends and their calculation, reference is made to the National Inventory Report - NIR [Ministry of Sustainable Development and Infrastructure, Environment Agency (2017), chapters 6 and 11].

III.1.5. Additional information

III.1.5.1. Uncertainty analysis

Uncertainty estimates are an essential element of a complete inventory of GHG emissions and removals and requires a detailed understanding of the uncertainties of the respective input parameters. They should be derived for both the national level and the trend estimate, as well as for the component parts such as emission factors, activity data and other estimation parameters for each category.[83] Principally, two different Tiers for the estimation of combined uncertainties are presented in the *2000 IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*: Tier 1 uses simple error propagation equations, while Tier 2 uses Monte Carlo.

In autumn 2011, the Environment Agency contracted a second time *Austrian Research Centers GmbH – ARC*[84] to perform a detailed uncertainty analysis of Luxembourg's GHG inventory, using both Tiers approaches, based on submission 2011v1.3 and its associated NIR [Winiwarter et al (2011)]. This study was an update of the 2007 uncertainty analysis of Luxembourg's GHG inventory [Winiwarter et al (2008)]. As there have been major revisions to Luxembourg's inventory, it was worthwhile to revisit the calculations performed in 2007. For more details, consult the latest NIR [Ministry of Sustainable Development and Infrastructure, Environment Agency (2017), section 1.7, p. 80-85]

For submission 2017v1.2, only a Tier 1 uncertainty analysis has been carried out. As important methodological changes have occurred in several sectors since the last Tier 2 uncertainty analysis in 2011, a Tier 2 analysis is currently under preparation.

Consequently, the Tier 1 uncertainty analysis, including LULUCF, resulted in an overall level uncertainty of total national emissions in 2015 of 3.90%, and excluding LULUCF of 2.75%. Respective

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83 *2000 IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*, Chapter 6 ("Quantifying Uncertainties in Practice").

84 Now "AIT Austrian Institute of Technology GmbH": http://www.ait.ac.at/.

percentages for the uncertainty introduced into the trend in total national emissions were 4.53%, including LULUCF, and 3.07% excluding LULUCF.

Compared to the results of other countries, level and trend uncertainties in Luxembourg are on the lower end of the range. This is plausible, as the situation in Luxembourg is characterized by high-energy consumption and emission density, compared to other countries. With respect to GHG emissions, energy data are among the best known, and also CO_2 emission factors are much better understood (can be derived from material balances) than emission factors of CH_4 or N_2O. Moreover, the fact that, in the total inventory, N_2O and CH_4 are less pronounced leads to a structurally lower uncertainty.

For more details, refer to the latest NIR [Ministry of Sustainable Development and Infrastructure, Environment Agency (2017), table 1-11, p. 83-85].

III.1.5.2. Indirect GHG and SO_2

Indirect GHG – NO_x, CO, NMVOCs – and SO_2 emissions as recorded in the inventory were extracted from the air pollutants emission inventory Luxembourg is compiling for the UNECE CLRTAP. Please refer to the Informative Inventory Report for more information on the estimation of the air pollutant emissions.[85]

III.2. NATIONAL SYSTEM[86]

III.2.1. Institutional arrangement for inventory preparation

III.2.1.1. Applicable international legal requirements

Some obligations are directly linked with GHG emission reporting:

- Annual obligations under Regulation 525/2013/EC of the European Parliament and of the Council of 21 May 2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change (known as Monitoring Mechanism Regulation, MMR) and repealing Decision 280/2004/EC of the European Parliament and of the Council of 11 February 2004 concerning a mechanism for monitoring Community GHG emissions and for implementing the Kyoto Protocol and Commission Decision 2005/166/EC of 10 February 2005 laying down rules implementing Decision 280/2004/EC;

85 http://www.ceip.at/ms/ceip_home1/ceip_home/status_reporting/2016_submissions/.

86 Part of the text of this section (III.2.1 to III.2.4) has been written by Nora Becker and Marc Schuman from the Environment Agency and is directly extracted from Ministry of Sustainable Development and Infrastructure, Environment Agency (2017), sections 1.2 to 1.6.

- Obligations under the UNFCCC. Relevant COP Decisions and Guidelines are:
    - Decision 3/CP.5 – Guidelines for the preparation of National Communications by Parties included in Annex I to the Convention, Part I: UNFCCC Reporting Guidelines on Annual Inventories (referring to Document FCCC/CP/1999/7) revised with Decision 18/CP.8 (referring to Document FCCC/CP/2002/8);
    - Decision 4/CP.5 – Guidelines for the preparation of National Communications by Parties included in Annex I to the Convention, Part II: UNFCCC Reporting Guidelines on National Communications (referring to Document FCCC/CP/1999/7) revised with Decision 19/CP.8 (referring to Document FCCC/CP/2002/8);
    - Document FCCC/CP/1999/7 – Review of the Implementation of Commitments and of other Provisions of the Convention – UNFCCC Guidelines on Reporting and Review revised with Document FCCC/CP/2002/8;
    - Decision 11/CP.4 – National communications from Parties included in Annex I to the Convention;
    - Document FCCC/CP/2001/13/Add.3 – Report of the Conference of the Parties on its seventh session, held at Marrakech from 29 October to 10 November 2001, Addendum, Part two: Action taken by the Conference of the Parties, Volume III (Decision 20/CP.7: Guidelines for national systems under Article 5, paragraph 1, of the Kyoto Protocol; Decision 21/CP.7: Good practice guidance and adjustments under Article 5, paragraph 2, of the Kyoto Protocol; Decision 22/C.7: Guidance for the preparation of the information required under Article 7 of the Kyoto Protocol; Decision 23/CP.7: Guidelines for review under Article 8 of the Kyoto Protocol).
    - Decision 24/CP.19 - Revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention – introducing the 2006 IPCC Guidelines.

Some provide, indirectly, information that can be used to produce GHG inventories:

- Annual obligations under the UNECE Convention on Long-Range Transboundary Air Pollution (CLRTAP) and its Protocols comprising the annual reporting of national emission data on SO_2, NOx, NMVOCs, NH_3, CO, TSP, PM_{10}, and $PM_{2.5}$ as well as on the heavy metals Pb, Cd and Hg and persistent organic hydrocarbons (PAHs), dioxins and furans and hexachlorobenzene (HCB);
- Annual obligations under Directive (EU) 2016/2284 of the European Parliament and of the Council of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC (known as the “NEC Directive”) comprising, among others, the annual reporting of national emission data on SO_2, NOx, NMVOCs and NH_3;

- Obligations under the European Pollutant Emission Register (EPER), which was the first Europe-wide register for emissions from industrial facilities into both air and water. The legal basis of EPER is Article 15 of the IPPC Directive (EPER Decision 2000/479/EU), which stipulates that information on environmental pollution has to be provided to the public. The reporting years under EPER were 2001 or 2002 and 2004. EPER was replaced by the European Pollutant Release and Transfer Register (E-PRTR) in 2007, which was established by the E-PRTR Regulation No 166/2006.
- Obligations under the framework of the European Union Emission Trading Scheme (EU-ETS) established by Directive 2003/87/EC of the European Parliament. It includes heavy energy-consuming installations in power generation and manufacturing. The activities covered are energy activities, the production and processing of ferrous metals, the mineral industry and some other production activities. From 2012 onwards, CO_2 emissions from aviation have also been included. For the trading period 2013–2020, the scope of the EU ETS has been further extended to include additional installations from the metal and chemical industry and compressor stations.

III.2.1.2. National Inventory System

A Grand-Ducal Regulation[87] - hereafter the "Regulation" – of April 2017 designates a **Single National Entity**, the **National Inventory Compiler** and the **National GHG Inventory Focal Point**. It also defines and allocates specific responsibilities for the realization of the GHG inventories both within the Single National Entity and within the other administrations and/or services that will be involved in the inventory preparation in the future. This Regulation also sets up a system for reporting on emissions of certain atmospheric pollutants under Directive (EU) 2016/2284, and more largely under the UNECE LRTAP Convention (CLRTAP). Consequently, the system put in place aims at reporting under both the UNFCCC and CLRTAP. Moreover, the Regulation proposes a national system for reporting on policies and measures and for reporting on projections of anthropogenic GHG emissions by sources and removals by sinks as required by Article 12 of the MMR Regulation (Regulation 525/2013/EC).

This new Regulation of April 2017 repealed the one from 1st August 2007. The system that this new Regulation defines will be applied for reporting from the 1st of January 2018 on. Consequently, submission 2017v1.2 has been realized under the former Regulation. Nevertheless, in the subsequent sections this is the new Regulation that is presented because now in place. Therefore, for the old Regulation refer to the description provided in the second Biennial Report of Luxembourg [Ministry

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87 *Règlement grand-ducal du 24 avril 2017 relatif à la mise en place d'un système national pour la surveillance, l'évaluation et la déclaration des émissions de gaz à effet de serre et des polluants atmosphériques et la déclaration d'autres informations ayant trait au changement climatique et à la pollution atmosphérique* (http://data.legilux.public.lu/eli/etat/leg/rgd/2017/04/24/a446/jo).

of Sustainable Development and Infrastructure, Department of the Environment (2016b), Section 1.3.1].

Single National Entity and other cross-cutting roles

The Grand-Ducal Regulation designates the Minister having environment in his or her attributions as the "**Single National Entity**" (SNE). The SNE designates both the UNFCCC and CLRTAP **National Focal Points** (NFPs), but also the **Inventory and Projections Focal Points as well as the Inventory and Projections Sectoral Experts.** With regard to GHG inventory reporting under the UNFCCC and the MMR Regulation, the overall management of the SNE is assigned to the **Inventory Focal Point** that is presently located at the Environment Agency – *Unité surveillance et évaluation de l'environnement* – and which also acts as **National Inventory Compiler** (NIC) compiling and checking the information and GHG emission estimates coming from sector experts working in other administrations or services *[→ Table III.2-1]*. The Inventory Focal Point and the NIC are actually the same person.[88]

The Environment Agency has therefore the "technical" knowledge and responsibility for the GHG inventories, but the "political" responsibility is staying with the **Department of the Environment** of the Ministry of Sustainable Development and Infrastructures – hereafter designated as MDDI-DEV – acting as UNFCCC **National Focal Point** (NFP). Thus, it is the Department that officially submits the inventories and their related reports to the UNFCCC Secretariat and to the EC (see Article 11 of the Regulation).

Thus, Luxembourg has adopted an **integrated approach** to avoid redundant and overlapping activities in different administrative services. This concentration of air emissions reporting in one department also allows an improved consistency between different reporting schemes. As an example, indirect GHG and SO_2 emissions that are to be recorded in the GHG inventory are extracted and adapted from the CLRTAP/NEC reporting schemes.

With regard to inputs for the monitoring of GHG emissions, having E-PRTR and EU ETS managed by the *Unité surveillance et évaluation de l'environnement* of the Environment Agency ensures easy access to facilities' reported fuel and/or emissions that are subsequently integrated in GHG emissions calculations. The Environment Agency also gathers information from establishments and installations subordinated to operational permits to carry out certain activities, the so-called "*établissements classés*". There, too, valuable information for the inventories is found. More details on these AD and, sometimes, EF sources are presented in *Section III.2.3*.

With regards to outputs from the *Unité surveillance et évaluation de l'environnement*, not only are they used for the various inventory reporting obligations (GHG, CLRTAP, NEC), but also for other

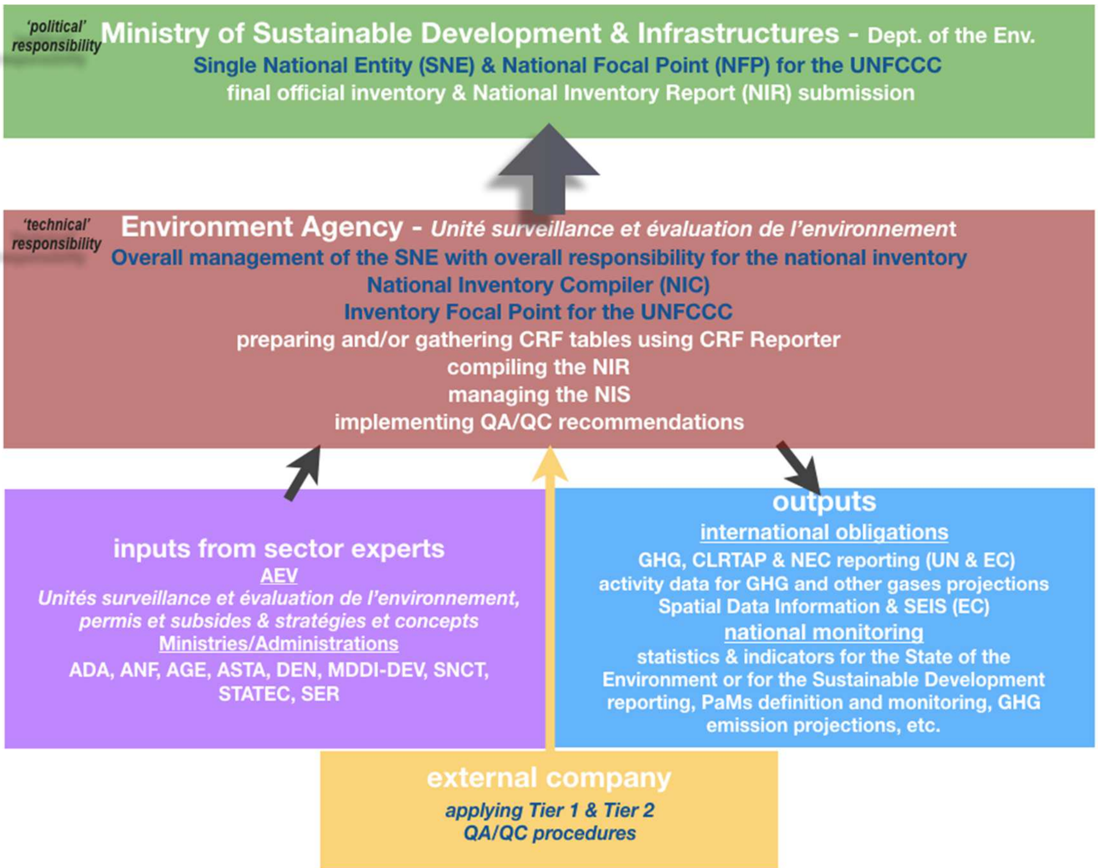
[88] Luxembourg being a small country, its administrations and public services are small too. Hence, it is frequent that its staff members wear different hats. Nevertheless, this conjunction of responsibilities makes sense.
The Environment Agency is also the Inventory Focal Point for reporting under the CLRTAP and Directive (EU) 2016/2284.

reporting activities, such as those linked to Spatial Data Information (such as the EC INSPIRE Directive[89]) and under the Shared Environmental Information System.[90] Of course, these are also used for various national publications, as well as, for defining policies and measures (PaMs).

Finally, although the national regulation, setting up the NIS, only indicates that an agent, belonging to the Environment Agency, should develop, implement and maintain a QA/QC plan, it has been decided that QA/QC activities should be performed by an external company so to guarantee an independent review process *[→ Section III.2.6]*.

Figure III.2-1 summarizes the organisation of the GHG reporting in Luxembourg in accordance with the national Regulation for setting-up a National Inventory System (NIS), whereas *Figure III.2-2* goes over the data flow process that is implied by the setting-up of the NIS. The *Unité surveillance et évaluation de l'environnement* of the Environment Agency not only collects and validates AD, EFs, parameters and emission estimates from sector experts, but also produces emission estimates. This flexibility is introduced in Luxembourg's system to ensure a better quality for the reporting of GHG emissions.

FIGURE III.2-1 – LUXEMBOURG'S NIS ACCORDING TO THE REGULATION OF 24 APRIL 2017



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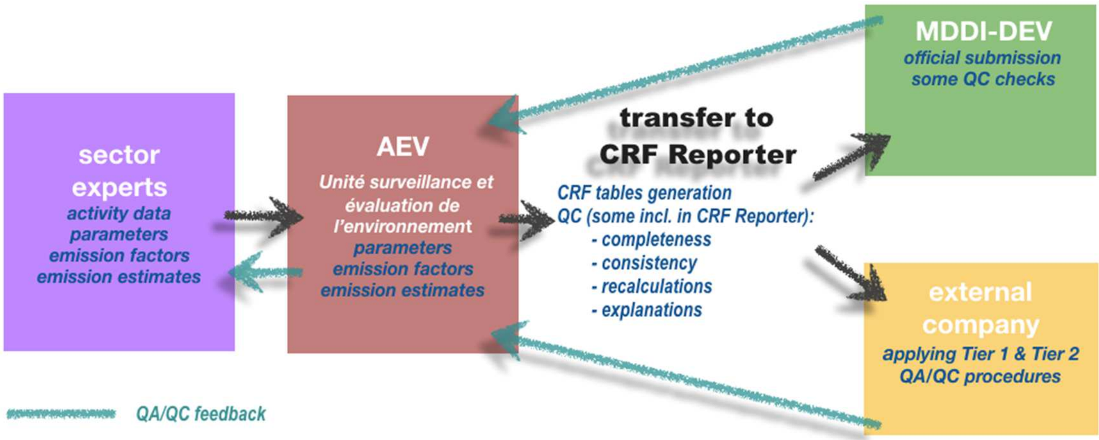
89 http://inspire.jrc.it/.

90 http://ec.europa.eu/environment/seis/index.htm.

FIGURE III.2-2 – THEORETICAL DATA FLOW ACCORDING TO LUXEMBOURG'S NIS



Specific responsibilities for the GHG Inventory compilation and development process

Article 4 of the Regulation indicates that the Single National Entity designates sectoral experts. Articles 6 and 8 describe the tasks of the Inventory Focal Point and of the Sectoral Experts. In a few words, the Inventory Focal Point – i.e. the Environment Agency – provides sector experts for all the IPCC Sectors except Agriculture, LULUCF and Wastewater Handling *[→ Table III.2-1]*. It is also the Agency that:

- manages the NIS and coordinates the work on GHG Inventories by informing the experts of any changes and evolutions in the Guidelines;
- as National Inventory Compiler (NIC), compiles the GHG emissions estimates produced by sector experts;
- prepares the NIR (notably on the basis of chapters received from the sector experts), including the Key Category Analysis (KCA) and the calculation of the uncertainties;
- prepares and defines work plans to secure timely data supply;
- assists sector experts in their assignments and their training;
- defines and approves, together with sector experts, activity/background data (AD), emission factors (EF), methods to estimate GHG emissions;
- archives the relevant information on the inventories and the NIS;
- implements recommendations from the quality assurance/quality control (QA/QC) annual exercise *[→ Section III.2.6]*.

Article 8 describes the tasks that fall to sector experts, among others:

- choice of the best methods to evaluate GHG emissions, using IPCC Guidelines (these methods have to be approved by the Single National Entity as indicated above);
- collection of the necessary AD and EFs;
- calculation of emission estimates;

- recalculation of emission estimates when possible and desirable: new AD sources, new parameters, new methods, etc.;
- proceeding with first quality checks (using, inter alia, tools embedded in CRF Reporter that allow to verify completeness and consistency);
- preparation of the NIR relevant chapters.

Finally, Article 10 indicates that activity/background data providers have to transmit quality AD using formats, and respecting the deadlines, defined by the Single National Entity.

TABLE III.2-1 – CRF SECTOR RESPONSIBILITIES WITHIN THE NIS

CRF Sector	AD	Choice of EFs	Emissions estimation methods
Energy, excl. road transportation – CRF 1 except 1A3b	AEV – STATEC	AEV	AEV
Road transportation – CRF 1A3b	AEV – STATEC – SNCT	AEV	AEV
Industrial Processes – CRF 2	AEV	AEV	AEV
Agriculture – CRF 3	ASTA – SER	ASTA – SER	ASTA – SER
LULUCF – CRF 4	ANF – SER – ASTA - AEV	ANF – SER – ASTA - AEV	ANF – SER – ASTA – AEV
Waste – CRF 5A, 5B & 5D	AEV	AEV	AEV
Wastewater Handling – CRF 5B	AGE	AGE	AGE

Abbreviations used in Table III.2-1:

Ministry of Agriculture:

ASTA = Agriculture Technical Services Administration (*Administration des Services Techniques de l'Agriculture*): http://www.asta.etat.lu/

SER = Agriculture Economic Service (*Service d'Economie Rurale*): http://www.ser.public.lu/

Ministry of Economic Affairs & External Trade:

STATEC = National Statistical Institute: http://www.statec.public.lu/fr/index.html

Ministry of Sustainable Development and Infrastructure – Department of the Environment (*Ministère du Développement durable et des Infrastructures – Département de l'environnement*): http://www.emwelt.lu/:

ANF = Nature & Forestry Administration (*Administration de la Nature et des Forêts*)

AEV = Environment Agency (*Administration de l'Environnement*)

AGE = Water Management Administration (*Administration de la Gestion de l'Eau*): http://www.eau.public.lu/

Ministry of Sustainable Development and Infrastructure – Department of Transport:

SNCT = Technical Vehicle Inspection Administration (*Société Nationale de Contrôle Technique*): http://www.snct.lu/

Luxembourg's emissions trading registry

Luxembourg's emissions trading registry has been operational since 2005 and serves both as registry for the EU Emissions Trading Scheme, and as the national registry for Luxembourg as a Party of the Kyoto Protocol.

Since July 2012, Luxembourg's national registry was migrated to a European based consolidated system operated by the European Commission. Please refer to *Section III.3* for more information on the consolidated system.

III.2.2. Inventory preparation process

III.2.2.1. Overview of inventory planning, preparation and management, including for supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol

GHG inventory submissions are produced under the provisions of the National Regulation for the setting-up of a NIS in Luxembourg *[→ Section III.2.1.2]*. That means that the three usual stages for a GHG inventory preparation – i.e. (i) inventory planning, (ii) inventory preparation and (iii) inventory management – are applied.

The main planning of Luxembourg's GHG inventory is performed once a year during summer at the so called "**Decision Making Body**" meeting: a meeting between the Director of the Environment Agency, the Head of the *Unité surveillance et évaluation de l'environnement*, the quality manager, and the NIC.

During the meeting, the quality manager and the NIC present an overview of the activities throughout the previous reporting year, including information on audits and fulfilments of last year's "**Improvement Plan**". Based on this report, the "**Quality Management System"** (QMS) is judged by the Director and the Head of the *Unité surveillance et évaluation de l'environnement*, in collaboration with the quality manager and the NIC. If required, measures to optimize the QMS are defined. Finally, the "Improvement Plan" is elaborated based on the previously conducted discussions. It consists of two parts:

- a **quality management improvement plan**: based on findings of internal and external audits; it also includes a training plan for sector experts;
- an **inventory improvement plan**: based on particular findings of reviews of the GHG inventory.

The "Decision Making Body" prioritises the recommended improvements (including a timeline and responsibilities) and cares for associated resources.

Table III.2-2 summarizes the **inventory preparation tasks**, whereas *Table III.2-3* gives an overview on the registry related tasks for providing the **supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol**. Both tables present a typical timeline.

TABLE III.2-2 – INVENTORY PREPARATION TIMELINE

Task	Description	Deadline
Decision Making Body meeting	a) evaluation of the fulfilment of the previous improvement plan b) preparation of a plan for QMS and inventory improvement, i.a. based on audit and review findings	Summer
Kick-Off	meeting of sector experts, quality manager and NIC; definition of a work plan	Summer
Activity data collection	collection of activity data, including contracting out studies	1st of November
Inventory preparation	estimation of emissions for all sources, including collection of background data	1st of December
Compilation of national inventory	stocking the database and transfer to CRF reporter ; key category analysis and uncertainty assessment	31st of December
Quality checks	Tier 1 and Tier 2 QA/QC activities *[→ Section III.2.6]*	December
Compilation of a report for the EC (the "Short-NIR")	compilation of an inventory report "Short NIR" and submission to the European Commission (Regulation 525/2013)	15th of January
Preparation of the NIR	compilation of the National Inventory Report	January - March
EU Submission – NIR	submission of the National Inventory Report to the EC	15th of March
UNFCCC Submission – NIR	submission of CRF tables and of the National Inventory Report to the UNFCCC	15th of April
Archive submission	all relevant calculation and documentation files as well as the NIR are archived on a dedicated central repository - CIRCALUX *[→ Sections III.2.2.2 & III.2.6]*	May

TABLE III.2–3– TIMELINE FOR REGISTRY RELATED TASKS

Task	Description	Deadline
Standard Electronic Format (SEF)	compilation of the SEF for the previous year	15th of January
Information on changes in the national registry	preparation of the chapter on the changes in the national registry, which is part of the NIR	15th of March
Information on accounting of Kyoto Protocol units	preparation of the chapter on information on the accounting of Kyoto Protocol units, which is part of the NIR. Compilation of the files for the Standard Independent Assessment Report (SIAR), which are submitted together with the NIR	15th of March

Finally, an official approval process has been established between the Inventory Focal Point – i.e. the Environment Agency – and the National Focal Point (NFP) for the UNFCCC – i.e. the Department of the Environment (MDDI-DEV) *[→ Figure III.2-1]*.[91] The Inventory Focal Point notifies the NFP, in writing, that the inventory has been compiled according to the rules established by the UNFCCC and uploads the submission onto the dedicated central repository CIRCALUX *[→ Section III.2.2.2.]*. The NFP informs the Minister in charge of the environment accordingly. Upon acceptance, the NFP uploads the submission from the dedicated central repository onto the UNFCCC Submission Portal and onto the European Central Data Repository hosted by the European Environment Agency (EEA).[92]

III.2.2.2. Inventory preparation

GHG inventory and KP-LULUCF inventory

Luxembourg's latest GHG inventory for the period 1990 to 2015 – submission 2017v1.2 – was compiled according to the recommendations for inventories set out in the revised UNFCCC

91 Implementation of a recommendation from the 2008 in-country review [UNFCCC (2009), § 31(b)].

92 See also article 11 of the National Regulation for the setting-up of a NIS in Luxembourg.

Reporting Guidelines according to Decision 24/CP.19. IPCC Guidelines have been applied as much as possible. These Guidelines are:

- the *2006 IPCC Guidelines for National GHG Inventories* (2006 IPCC-GL);[93]
- the *2013 Revised Supplementary Methods and Good Practices Guidance Arising from the Kyoto Protocol*.[94]

Information on the methods and sources used for preparing the inventory are presented in details in Ministry of Sustainable Development and Infrastructure, Environment Agency (2017). They are also summarized in *Section III.2.3*.

During the inventory preparation process, sector experts collect activity data, emission factors and all relevant information needed for estimating the emissions. The sector experts also have specific responsibilities regarding the choice of methods, data processing and archiving and for contracting studies, if needed. As part of the QMS, the NIC approves the methodological choices. Sector experts are also responsible for performing quality control (QC) activities that are incorporated in the QMS. All data collected together with emission estimates are archived on a central archiving system *[→ Section III.2.6]*, together with detailed documented data sources in order to be able to perform future reconstructions of the inventory.

Supplementary information required under Article 7 of the Kyoto Protocol regarding KP-LULUCF is prepared by the same sector experts as for UNFCCC-LULUCF. Other Article 7 supplementary information is requested from Luxembourg's Emission Trading Registry, which is also located at the Environment Agency *[→ Section III.3]*.

Data collection, processing and storage, including for KP-LULUCF inventory

For estimating GHG emissions, Luxembourg mostly used Micro-soft Excel™ spreadsheets *[→ Table III.2-4]*.

TABLE III.2-4 – PROGRAMS AND SOFTWARE USED FOR GENERATING EMISSION ESTIMATES

CRF sector	Emissions calculated using ...
Energy, excl. road transportation – CRF 1 except 1A3b	MS Excel 2010
Road Transportation – CRF 1A3b	NEMO IV and MS Excel 2010
Industrial Processes – CRF 2	MS Excel 2010
Agriculture – CRF 3	MS Excel 2010
LULUCF – CRF 4	MS Excel 2010
Waste – CRF 5	MS Excel 2010

93 https://www.ipcc-nggip.iges.or.jp/public/2006gl/.

94 https://www.ipcc-nggip.iges.or.jp/public/kpsg/pdf/KP_Supplement_Entire_Report.pdf.

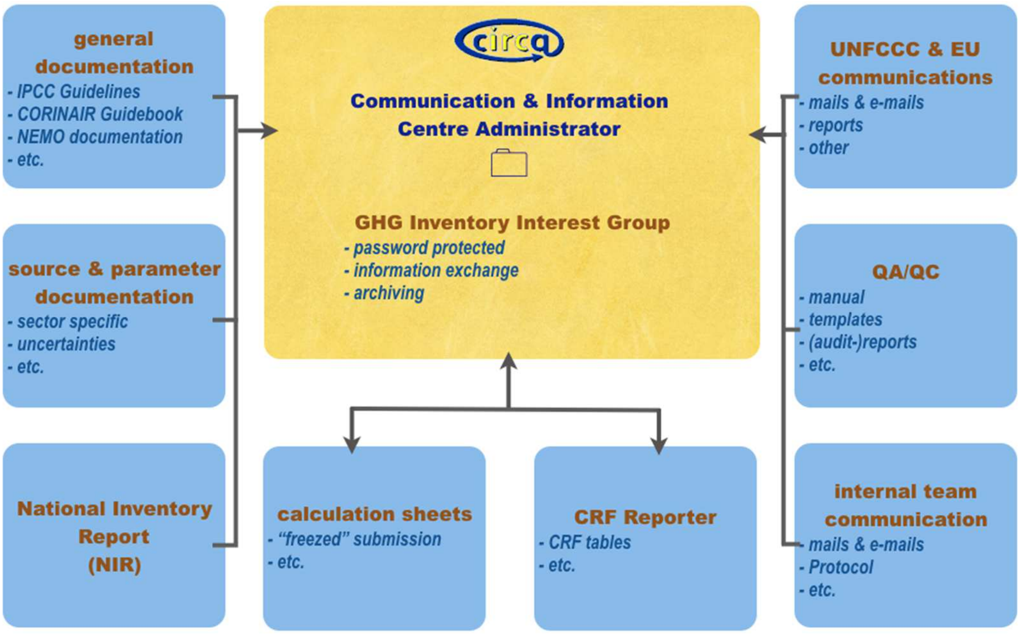
This way of proceeding offers a very flexible system that can be easily adjusted to new requirements. It is only for the estimation of road transportation emissions, where a dedicated model is used, i. e. NEMO IV.[95]

***NEMO IV v10.0** is a Microsoft Windows™ software tool for the calculation of emissions from road transport. The emissions calculated include all major pollutants (CO_2, CO, CH_4, NO_x, VOC, and PM) and several more (N_2O, NH_3, SO_2...). Data produced is then transformed using MS Excel spreadsheets into the UNFCCC common reporting format, according to the IPCC Guidelines, to comply with the reporting obligations under the UNFCCC.*

GHG emission estimates produced by the sector experts are then being centralized and verified by the Inventory Focal Point acting as the NIC (i.e. the Environment Agency).

A centralised data management and archiving system (based on the former European Data Exchange and Storage System CIRCA) has been implemented *[→ Figure III.2-3]*. This system is hosted by the National IT Administration, and access is password protected. This system enables sector experts to quickly and easily exchange and store data between administrations, which are not connected through a single network. The data stored on this system are backed up daily for the needs of data security. Furthermore, as part of the QMS, backups of the entire inventory information are made regularly on write-protected DVDs. This ensures the necessary documentation and archiving for future reconstruction of the inventory and for the timely response to requests during the review process.

FIGURE III.2-3 – DATA MANAGEMENT AND ARCHIVING SYSTEM (CIRCALUX)



95 NEMO IV v10.0 is a Microsoft Windows™ software tool for the calculation of emissions from road transport. The emissions calculated include all major pollutants (CO_2, CO, CH_4, NOx, VOC, and PM) and several more (N_2O, NH_3, SO_2...). Data produced is then transformed using MS Excel spreadsheets into the UNFCCC common reporting format, according to the IPCC Guidelines, to comply with the reporting obligations under the UNFCCC.

For the generation of the CRF tables and the XML submission file, Luxembourg used the latest version of the UNFCCC's CRF-Reporter, i.e. version 3.6.2. As a large number of GHG source categories are not occurring in Luxembourg, only around a hundred values per inventory year – other than notation keys – need to be transferred to the CRF-Reporter. This is why, so far, CRF Reporter has been "manually" populated by having recourse to "copy-paste" from Microsoft Excel™ inventory work files.

However, with the increasing number of LULUCF data, which needs to be transferred to the CRF-Reporter, this manual data transfer becomes prone to errors. Therefore, it is foreseen to centralise the emission estimates (and all the associated data such as EFs, AD, documentation, etc.) in a centralised database. Specific software tools embedded in this database would then allow the automatic data transfer into the CRF Reporter software, without the need of the "copy-paste" procedure. Currently, Luxembourg is in the process of switching to the centralised database, and it is expected that the automatic transfer will be used for the next submission. Nevertheless, this is not an absolute "must do" for Luxembourg since, as underlined above, yearly data to be included in CRF Reporter are not numerous. Furthermore, "manually" populating CRF Reporter offers concrete advantages compared to automated operations: mistakes and missing values can be directly identified, recalculations cross-checked, explanations for notation keys or recalculations not forgotten and documentation boxes filled accordingly when needed.

Quality assurance/quality control (QA/QC) procedures and extensive review of the GHG inventory and the KP-LULUCF inventory

QA/QC procedures are performed as defined in the QMS plan ***[→ Section III.2.6]***.

Quality assurance, control and plausibility assessments of the estimates are being performed through internal audits covering all sectors by the SNE in collaboration with the QA/QC manager.[96]. In addition, various checking procedures, included in the CRF Reporter software are undertaken.

The NIR is circulated after publication to experts – as identified by the NIC and the QA/QC manager – that are involved in estimating GHG emissions in Luxembourg.

Comments received from experts are considered for the inventory improvement plan.

96 Currently contracted from SEG-Umwelt Service GmbH (Mettlach, Germany).

III.2.3. Methodologies and data sources used for submission 2017v1.2

III.2.3.1. GHG inventory

Table III.2-5 briefly presents the activity data (AD) sources, the types of emission factors (EFs) used, as well as the methods applied for estimating GHG emissions reported in submission 2017v1.2. A much more detailed table is provided in Annex A.I as an excerpt of summary tables of submission 2017v1.2.

Table III.2-5 – Methodologies, data sources and EFs used by Luxembourg for submission 2017v1.2 – main CRF sectors

CRF Sector	CO_2 Method applied	CO_2 AD	CO_2 EF	CH_4 Method applied	CH_4 AD	CH_4 EF	N_2O Method applied	N_2O AD	N_2O EF
Energy, excl. road transportation – CRF 1 except 1A3b	Tier 1 Tier 2	NS PS Q TÜV	D CS PS	Tier 1	NS PS Q TÜV	D	Tier 1	NS PS Q TÜV	D
Road transportation – CRF 1A3b	CIV CS	NS SNCT	CS	CIV	NS SNCT	OTH	CIV	NS SNCT	OTH
Industrial Processes – CRF 2	Tier 2 CS	NS PS	CS PS	NA	NO	NA	NA	NO	NA
Agriculture – CRF 3	NA	NA	NA	Tier 1 Tier 2	EJ NS	CS D OTH	Tier 1	EJ NS	D
LULUCF – CRF 4	Tier 1 Tier 2	NS EJ	CS D	NA	NA	NA	Tier 1	NS EJ	D
Waste – CRF 5	NA	NA	NA	Tier 1 Tier 2	NS Q PS	CS D	Tier 1	NS Q PS	PS D

Note: for F-gases (CRF category 2F) methods applied = CS; AD = NS & Q; EF = CS.

Abbreviations:
C = CORINAIR; CS = Country Specific; CIV = NEMO IV; D = IPCC Default
EJ = Expert Judgement; NS = National Statistics; OTH = Other; PS = Plant Specific Data
Q = Specific Questionnaire/Survey; TÜV = TÜV Rheinland (1990), *Emissionskataster für das Großherzogtum Luxemburg*, Köln.

Detailed information on data sources for activity and emission data, as well as for EFs used by sector, can be found in Ministry of Sustainable Development and Infrastructure, Environment Agency (2017). However, a few general comments are presented in the next paragraphs.

Activity and background data

Data used to produce the annual air emission (including GHG) inventories are mainly:

- taken from official statistics published by the National Statistical Institute (STATEC). Concerning energy data (energy balance), STATEC has recently developed a new system for data collection, treatment, checking and compilation. This new system was implemented in such a way to ensure that both the needs of public administrations dealing with energy questions and the reporting obligations to the European regulation 1099/2008/EC on energy statistics and to the IEA (IEA Joint Questionnaires)[97] are fulfilled. The data sources and methodologies for preparing Luxembourg's energy balance as well as the new compilation system are described in a STATEC Bulletin;[98]

- extracted from statistical information received by other ministries and public administrations;
- coming from information supplied directly by facilities (annual reports, emission measurement reports);
- on occasion, from specific surveys or questionnaires and from expert judgements.

For large point sources – and after careful assessment of data plausibility – activity data that are reported by facilities are preferably used. Indeed, these data usually reflect the actual consumptions better than aggregated national statistics data, because the facility is supposed having the best information about its own emissions. Such plant specific data have been used for CRF sectors 1 and 2.

Besides plant specific data collected under EU legal requirements, national obligations are also a source of activity and emission data for single facilities. This is the case under the law for "*établissements classés*"[99] that imposes regular reporting obligations to those units – the "*établissements classés*" – which, by their activities, could represent a risk concerning security, public health and convenience for both the citizens and the workers occupied in these units, as well as regards the environment.[100] These "*établissements classés*" could be public or private industrial or commercial establishments and craft industries, as well as single specific equipment or processes within an installation.

Most of the plant specific data, whether they are collected for European or national obligations, are actually transmitted and managed by the Environment Agency which eases a more systematic use of data provided directly by facilities. In particular, it is investigated whether it will be feasible, both technically and legally, that facilities would report only once for various purposes – such as EU-ETS, E-PRTR, permitting activities, etc. – in order to avoid extra and unnecessary burden for them.

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97 The energy balance is based on several databases mainly prepared by:
- Ministère de l'Economie et du Commerce Extérieur
- Ministère du développement durable et des infrastructures (département de l'environnement, département du transport)
- Administration de l'environnement: *Unité surveillance et évaluation de l'environnement*, *Unité permis et subsides*, *Registre des quotas d'émissions à effet de gaz de serre (ETS);*
- Administration des Douanes et Accises (Ministère des Finances);
- Service Central de la Statistique et des Etudes Economiques (STATEC);
- Société Nationale des Chemins de fer Luxembourgeois (CFL)
- all relevant fuel importers and distributors;
- plant operators;

The methodology used to compile the enrgey balance follows the International Energy Agency (IEA) and Eurostat conventions. The aggregated balances are harmonised with the IEA tables.

98 http://www.statistiques.public.lu/catalogue-publications/bulletin-Statec/2010/PDF-Bulletin-8-2010.pdf.

99 See http://environnement.public.lu/fr/emweltprozeduren/Autorisations/Etablissements_classes.html (in French).

100 "Permitting activities", i.e. activities subordinated to a permit.

Emission factors

For EFs, besides country-specific and plant specific factors derived from emission data transmitted by facilities (see above), it is also made use of default IPCC values published in the 2006 IPCC Guidelines, as well as in the 2013 KP Supplement for LULUCF. Other sources for EFs are the EMEP/EEA air pollutant emission inventory guidebook – 2016[101] and national / international studies or calculations leading to country-specific EFs.

III.2.3.2. KP-LULUCF inventory

Land use and land use change data are based on commercial satellite imagery, land cover maps held by the Nature and Forestry Administration (ANF) and on information on agricultural practices from the Department for Rural Economy (SER). These two institutions are the main data providers for the greenhouse gas reporting in the frame of the KP-LULUCF inventory.

Accordingly, the area of forest land reported for Afforestation/Reforestation and Deforestation (ARD) under the Kyoto Protocol has the same basis as the area reported for Land use changes from and to forests in the UNFCCC GHG inventory taking the different period (ARD areas starting with 1990) as well as the permanence of ARD areas into account.

Furthermore, the methods used to estimate emissions/removals from ARD activities are of the same Tier method as those used for the UNFCCC reporting.

III.2.4. Key Category Analysis for submission 2017v1.2

The identification of key categories is described in Chapter 4 of the 2006 IPCC Guidelines. It stipulates that a key category is one that is prioritised within the National System because its estimate has a considerable influence on a country's total inventory of GHG in terms of the absolute level of emissions or removals, the trend in emissions or removals, or both. Any category meeting the 95% threshold in any year of the Level Assessment (LA) or in the Trend Assessment (TA) is considered a key category. Then, whenever a method used for the estimation of emissions/removals of a key category is not consistent with the requirements of the 2006 IPCC Guidelines, the method will have to be improved to reduce uncertainty, which is considered in the emission inventory improvement programme.

All notations, descriptions of identification and results for key categories included in this section are based on the 2006 IPCC Guidelines. The identification includes all reported GHG, i.e. CO_2, CH_4, N_2O, HFC and SF_6,[102] and all IPCC categories.

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101 https://www.eea.europa.eu/publications/emep-eea-guidebook-2016.

102 There are no emissions stemming from perfluorocarbons (PFCs) and nitrogen trifluoride (NF_3) in Luxembourg.

The key category analysis was performed **using the Tier 1 approach** based on submission 2017v1.2. It comprises a level assessment for all years between 1990 and 2015, as well as a trend assessment for the trend of the year 2015 with respect to base year emissions, i.e. 1990 (1995 for F-gases). Key categories have been identified excluding LULUCF categories and for the full inventory including LULUCF categories.

III.2.4.1. Key categories for Luxembourg – GHG inventory (including and excluding LULUCF)

This sub-section presents the results of Luxembourg's key category analysis, once excluding LULUCF categories, once including them.

Key categories analysis – excluding LULUCF

The key source categories comprise 9810.37 Gg CO_2e in the year 2015, which is a share of 95.52% of Luxembourg's total GHG emissions in 2015, excluding LULUCF ***[→ Table III.2-6]***.

Table III.2-7 indicates which source categories have been identified as key categories for every reported year from 1990 to 2015.

Key categories analysis – including LULUCF

The key categories comprise 9385.48 Gg CO_2e in the year 2015, which is a share of 95.15% of Luxembourg's total GHG emissions in 2015, including LULUCF ***[→ Table III.2-8]***.

Table III.2-9 indicates which source categories have been identified as key categories for every reported year from 1990 to 2015.

TABLE III.2-6 – KEY CATEGORIES (TIER 1, LA), EXCLUDING LULUCF, BASED ON EMISSION DATA RECORDED IN SUBMISSION 2017V1.2

IPCC category	Category name	Fuel	Gas	2015 emissions in Gg CO_2e	Share in 2015 national total GHG emissions (excl. LULUCF)
1A1	**Fuel combustion - Energy industries**	*gaseous*	*CO_2*	368.54	3.59%
1A1	**Fuel combustion - Energy industries**	*other*	*CO_2*	82.88	0.81%
1A2	**Fuel combustion - Manufacturing Industries and Construction**	*liquid*	*CO_2*	198.49	1.93%
1A2	**Fuel combustion - Manufacturing Industries and Construction**	*solid*	*CO_2*	162.90	1.59%
1A2	**Fuel combustion - Manufacturing Industries and Construction**	*gaseous*	*CO_2*	697.52	6.79%
1A3b	**Road Transportation**	*gasoline*	*CO_2*	883.90	8.61%
1A3b	**Road Transportation**	*Diesel oil*	*CO_2*	4748.46	46.23%
1A4	**Fuel combustion – Other sectors**	*Liquid*	*CO_2*	787.76	7.67%
1A4	**Fuel combustion – Other sectors**	*gaseous*	*CO_2*	762.04	7.42%
1A5	**Fuel combustion – Other**	*liquid*	*CO_2*	0.12	0.00%
2A1	**Cement production**		*CO_2*	329.47	3.21%
2A3	**Glass production**		*CO_2*	65.06	0.63%
2C1	**Iron & steel production**		*CO_2*	122.80	1.20%
2F1	**Refrigeration and air conditioning**		*F-gases*	63.27	0.62%
3A	**Enteric fermentation**		*CH_4*	429.60	4.18%
3B	**Manure management**		*CH_4*	64.19	0.63%
3D1	**Direct N_2O emissions from managed soils**		*N_2O*	106.75	1.04%
5A	**Solid waste disposal**		*CH_4*	53.17	0.52%
All	**Sum of all key categories**	***all***	***all***	**9810.37**	**95.52%**

Source: Environment Agency – Submission 2017v1.2.

TABLE III.2-8 – KEY CATEGORIES (TIER 1, LA), INCLUDING LULUCF, BASED ON EMISSION DATA RECORDED IN SUBMISSION 2017V1.2

IPCC	IPCC source category	Fuel	Gas	2015 emissions in Gg CO_2e	Share in 2015 national total GHG emissions (incl. LULUCF)
1A1	**Fuel combustion - Energy industries**	*gaseous*	*CO_2*	368.54	3.74%
1A2	**Fuel combustion – Manufacturing industries and construction**	*gaseous*	*CO_2*	697.52	7.07%
1A2	**Fuel combustion – Manufacturing industries and construction**	*liquid*	*CO_2*	198.49	2.01%
1A2	**Fuel combustion – Manufacturing industries and construction**	*solid*	*CO_2*	162.90	1.65%
1A3b	**Fuel combustion – Transport - Road transportation**	*diesel oil*	*CO_2*	4748.46	48.14%
1A3b	**Fuel combustion – Transport - Road transportation**	*gasoline*	*CO_2*	883.90	8.96%
1A4	**Fuel combustion – Other sectors**	*gaseous*	*CO_2*	762.04	7.73%
1A4	**Fuel combustion – Other sectors**	*liquid*	*CO_2*	787.76	7.99%
2A1	**Cement production**		*CO_2*	329.47	3.34%
2C1	**Iron and steel production**		*CO_2*	122.80	1.24%
3A	**Enteric fermentation**		*CH_4*	429.60	4.36%
4A1	**Forest Land remaining Forest Land**		*CO_2*	378.19	3.83%
4A2	**Land converted to Forest Land**		*CO_2*	101.48	1.03%
all	Sum of all key categories	*all*	*all*	9385.48	95.15%

Source: Environment Agency – Submission 2017v1.2.

Table III.2-7 – Key categories (qualitative), excluding LULUCF, of submission 2017v1.2: 1990-2015

IPCC source category	gas	fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2015
			LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	TA
1A1 - Energy Industries	CO_2	gaseous									X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
1A1 - Energy Industries	CO_2	other									X													X	X	X	X	X	
1A2 - Manuf. Ind. and Construction	CO_2	liquid	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
1A2 - Manuf. Ind. and Construction	CO_2	solid	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1A2 - Manuf. Ind. and Construction	CO_2	gaseous	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1A3b - Road transportation	CO_2	gasoline	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1A3b - Road transportation	CO_2	diesel oil	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1A4 - Other sectors	CO_2	liquid	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
1A4 - Other sectors	CO_2	gaseous	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1A5 - Other	CO_2	liquid										X																	
2A1 - Cement production	CO_2		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2A3 - Glass production	CO_2												X										X				X	X	
2C1 - Iron & steel production	CO_2		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2F1 - Refrig. & air cond.	F-gases																										X		
3A - Enteric fermentation	CH_4		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
3B - Manure management	CH_4							X	X	X	X	X	X	X	X										X	X		X	
3D1 - Direct emissions from man. soils	N_2O		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
5A - solid waste disp.	CH_4							X	X	X	X	X	X	X	X	X	X			X	X	X							

Source: Environment Agency – Submission 2017v1.2.

TABLE III.2-9 – KEY CATEGORIES (QUALITATIVE), INCLUDING LULUCF, OF SUBMISSION 2017V1.2: 1990-2015

IPCC source category	gas	fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2015
			LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	TA
1A1 - Energy Industries	*CO_2*	*gaseous*													X	X	X	X	X	X	X	X	X	X	X	X	X	X	
1A1 - Energy Industries	*CO_2*	*other*																											X
1A1 - Energy Industries	*CH_4*	*other*																											X
1A1 - Energy Industries	*N_2O*	*other*																											X
1A1 - Energy Industries	*CH_4*	*biomass*																											X
1A1 - Energy Industries	*N_2O*	*biomass*																											X
1A2 - Manuf. Ind. and Construction	*CO_2*	*liquid*	X	X																			X	X					
1A2 - Manuf. Ind. and Construction	*CH_4*	*liquid*																											X
1A2 - Manuf. Ind. and Construction	*CO_2*	*solid*	X	X	X	X	X	X	X	X													X	X					X
1A2 - Manuf. Ind. and Construction	*CH_4*	*solid*																											X
1A2 - Manuf. Ind. and Construction	*CO_2*	*gaseous*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
1A3a - Aviation	*CO_2*	*gasoline*																											X
1A3b - Road transportation	*CO_2*	*gasoline*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
1A3b - Road transportation	*CH_4*	*gasoline*																											X
1A3b - Road transportation	*N_2O*	*gasoline*																											X
1A3b - Road transportation	*CO_2*	*diesel oil*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	

1A3b - Road transportation	*CH_4*	*LPG*																											X
1A3b - Road transportation	*N_2O*	*LPG*																											X
1A3c - Navigation	*CH_4*	*liquid*																											X
1A3c - Navigation	*N_2O*	*liquid*																											X
1A4 - Other sectors	*CO_2*	*liquid*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
1A4 - Other sectors	*CO_2*	*gaseous*	X	X				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
1A5 - Other	*CO_2*	*liquid*																											X
2A1 - Cement production	*CO_2*		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
2C1 - Iron & steel production	*CO_2*		X	X	X	X	X	X																					
3A - Enteric fermentation	*CH_4*		X	X	X		X		X		X	X	X	X					X	X	X	X	X	X	X	X	X	X	
4A1 - FL remaining FL	*CO_2*				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	
4A2 - Land converted to FL	*CO_2*		X																				X						

Source: Environment Agency – Submission 2017v1.2.

III.2.4.2. Key categories for Luxembourg – KP-LULUCF inventory

According to the IPCC GPG for LULUCF, the key categories for Kyoto Protocol activities can be derived from the identified key categories in the UNFCCC inventory as follows: whenever a category is identified as key in the UNFCCC inventory, the associated activity under the Kyoto-Protocol can be considered as key in reporting under the Kyoto Protocol[103].

The key category analysis was performed **using the Tier 1 approach** based on submission 2017v1.2. It comprises a level assessment for all years between 1990 and 2015, as well as a trend assessment for the trend of the year 2015 with respect to base year emissions, i.e. 1990. As stipulated in the IPCC-GPG-LULUCF, key categories have been identified, for the full inventory, including LULUCF categories.

Afforestation and Reforestation, Deforestation, and Forest Management are considered key categories according to the quantitative analysis.

III.2.5. Recalculation of data

Compiling an emission inventory includes data collection, data transfer and data processing. For Luxembourg's GHG inventory, data are collected from different sources, for instance national statistics, plant operators, studies, personal information or other publications. The provided data must be transferred from different data formats and units into a unique electronic format to be processed further. The calculation of emissions, by applying methodologies on the collected data, and the final computing of time series into a predefined format (CRF) are further steps in the preparation of the final submission. Finally, the submission must be delivered in due time. Even though the implemented QA/QC system should prevent or at least minimize potential errors *[→ Section III.2.6]*, it will remain necessary to make some revisions (called "recalculations") under the following circumstances:

- an emission source was not considered in the previous inventory;
- a source/data supplier has delivered new data. The causes might be that previous data were preliminary data or that methodology has been improved/modified;
- occurrence of errors in data transfer or processing: wrong data, unit-conversion, software errors, etc.;
- methodological changes: a new methodology must be applied to fulfil the reporting obligations because of one of the following reasons:
  - to decrease uncertainties;
  - an emission source becomes a key source;

[103] IPCC Good Practice Guidance for LULUCF, Section 5.4.2. and Table 5.4.1.

- consistent input data needed for applying the methodology is no longer accessible;
- input data for more detailed methodology is now available;
- the methodology is no longer appropriate.

In Luxembourg, recalculations of previously submitted inventory data are performed following the 2006 IPCC-GL, Chapter 5 ("Time Series Consistency") with, as the list above shows, the **unique purpose to improve the GHG inventory**. They are made **on an ad-hoc basis** by each sector experts and should be documented so that the NIC can cross-check and assess the rationale for any recalculation.[104] The procedures put in place for the QA/QC – such as checklists, e.g. – provides also a mean to present, justify and validate recalculations.

III.2.6. Quality Assurance and Quality Control (QA/QC)[105]

The overall responsibility for the establishment and existence of a Quality Management System (QMS), in order to prepare the national inventory of GHG and air pollutants, lies with the Inventory Focal Point – i.e. the Environment Agency as designated by the national Regulation for the setting-up of a National Inventory System *[→ Section III.2.1.2]*. Within the Agency, the *Unité surveillance et évaluation de l'environnement* supervises the inventory preparation process for various obligations as outlined in *Section III.2.1.1* and acts as both the NIC and the national Inventory Focal Point *[→ Section III.2.1.2]*. The political responsibility lies with the Department of the Environment of the Ministry of Sustainable Development and Infrastructure (MDDI-DEV).

More precisely, the *Unité surveillance et évaluation de l'environnement* is responsible for the following tasks:

The National Inventory Compiler (NIC):

- supervises the inventory preparation process for various obligations as outlined below;
- is the national inventory focal point to the Ministry (MDDI-DEV).

The national, European and international obligations are:

- UNECE Convention on Long Range Transboundary Air Pollution and its Protocols;
- UNFCCC & Kyoto Protocol;
- European Union:
  - EU GHG Monitoring Mechanism (Regulation (EU) No 525/2013);
  - NEC Directive (Directive (EU) 2016/2284);
  - Ambient Air Quality Directive (2008/50/EC).

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104 The NIC is the only person who will populate, i.e. insert, delete, and document data in the "compiler" version of CRF Reporter, i.e. the version used for preparing an official submission (see Section III.2.2.2 on the submission preparation process).

105 This section has been prepared by the Environment Agency and *SEG Umwelt-Service GmbH*.

III.2.6.1. Quality Policy

The quality policy is the central aspect of a Quality Management System. It defines the understanding of quality in relation to all topics of inventory preparation and specifies its basic principles.

The single national entity has:

- to establish and maintain the quality policy and quality objectives regarding GHG Inventories;
- to promote the quality policy and quality objectives regarding GHG Inventories throughout the organisation to increase awareness, motivation and involvement;
- to ensure focus on the fulfilment of the Kyoto Protocol and the requirements of the IPCC GPG Chapter 8 QA/QC;
- to ensure that appropriate processes are implemented to enable requirements of the IPCC GPG Chapter 8 QA/QC (and other interested parties) to be fulfilled and quality objectives to be achieved;
- to ensure that an effective and efficient QMS is established, implemented and maintained in order to achieve these quality objectives;
- to ensure the availability of necessary resources;
- to review the Quality Management System periodically;
- to decide on actions regarding the quality policy and quality objectives regarding GHG Inventories;
- to decide on actions for the improvement of the Quality Management System;
- to decide on actions for the improvement of national GHG inventories.

III.2.6.2. QMS build-up

The build-up of the QMS of the GHG emission reporting is currently outsourced and supervised by *SEG Umwelt-Service GmbH*.[106]

Luxembourg's QMS follows a Plan-Do-Check-Act-Cycle (PDCA-cycle), which is an accepted model for pursuing a continual improvement of performance according to international standards and is in line with procedures described in decision 19/CMP.1 and in the IPCC Good Practice Guidance.

Due to Luxembourg's clear extent, its QMS deals with a manageable quantity of documents. Following are the specifications of Luxembourg's Quality Management System:

- firm build-up with a quality manual consisting of a chart with all relevant documents, handling instructions and deadlines for check *[→ Figure III.2-4]*;

[106] SEG Umwelt-Service GmbH, Auf der Haardt 2, D – 66693 Mettlach, http://www.seg-online.de.

- good manageability (instead of a complex system);
- usable and effective quality control procedures (user-friendly, clearly arranged).

Since the QMS has been implemented in the year 2008, it has evolved continuously and many improvements have already been realised.

The QMS shall ensure and continuously improve the quality (measured by transparency, accuracy consistency, comparability, completeness (TACCC) and timeliness) of Luxembourg's GHG Inventory in order to fulfil the party's obligations according to articles 3, 5 and 7 of the Kyoto Protocol. The QMS therefore supplies procedures to:

- check integrity, correctness and completeness of data;
- identify errors and omissions;
- reduce uncertainties of emission estimates;
- document and archive inventory calculation sheets and background data.

III.2.6.3. QMS Structure

Luxembourg's QMS of the GHG inventory is organised in three layers *[→ Figure III.2-4]*:

Performance processes

Performance processes directly concern the compilation of the GHG inventory. They comprise input data, data acquisition, calculations, and generation of CRF tables and NIR as well as quality control checks and the outcomes of the NIR and CRF tables.

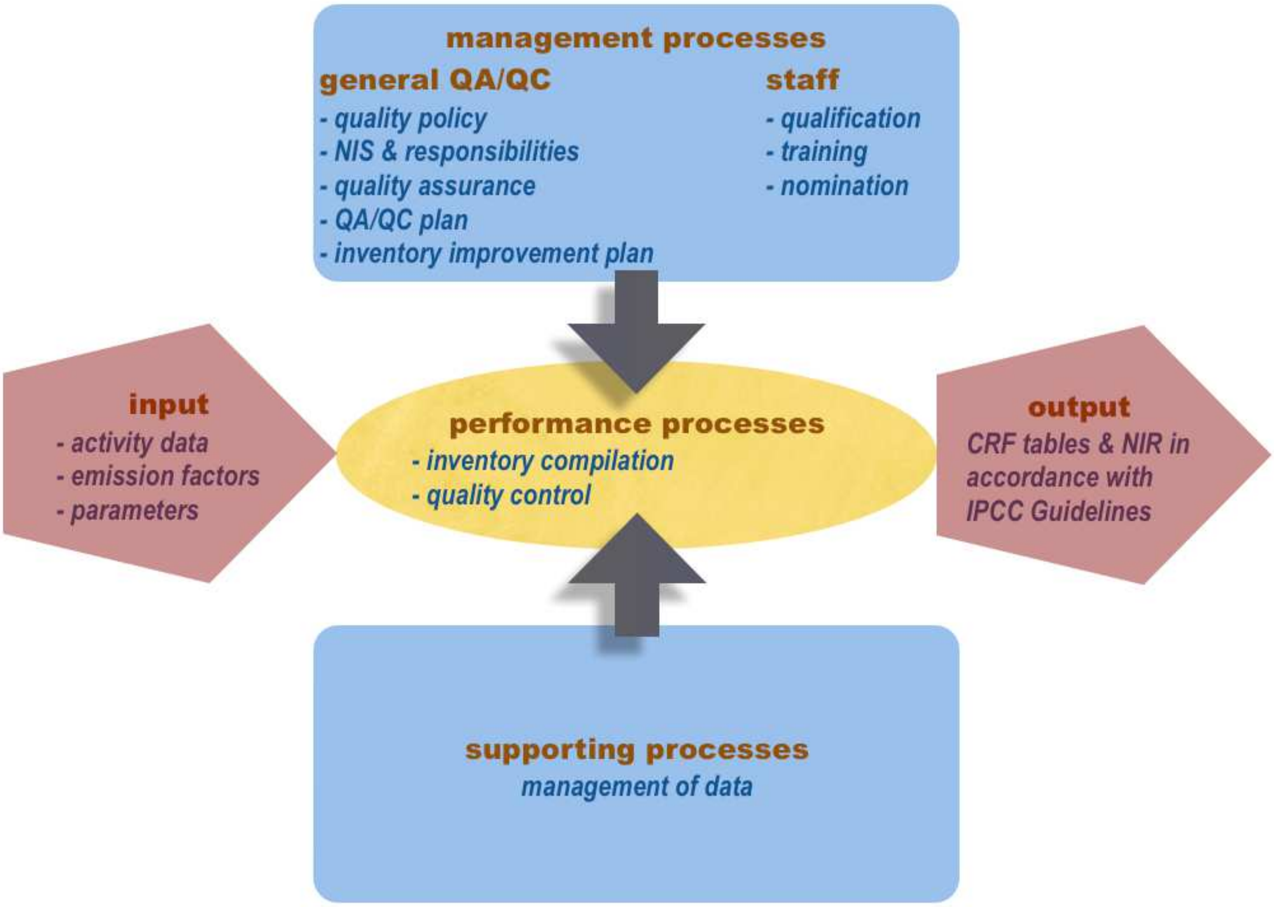
Management processes

Management processes control the system's performance by defining quality objectives, responsibilities, quality assurance procedures, improvement plans and the personnel's qualifications and obligations.

Supporting processes

Supporting processes assist the system's performance by providing technical requirements and standards.

FIGURE III.2-4 – QMS STRUCTURE



III.2.6.4. Quality Manual

The applied quality manual adopts the structure of the QMS and is divided in management, performance and supporting processes.

For each process, a list of related documents exists with information on content, handling, interval of document check and planned improvement. An extract of the quality manual is given below *[→ Figure III.2-5]*.

FIGURE III.2-5 – EXTRACT OF THE QA/QC MANUAL

	QA/QC procedure	purpose	document	content	handling	interval of document check
management processes	**quality policy**	basis of the implemented quality management system	quality policy	obligation to prepare and improve a GHG inventory according the demands resulting from UNFCCC, Kyoto protocol and other obligations	the head of administration, NIC and quality manager check validity of quality policy -> adjustment if necessary -> announcement	yearly before kick-off meeting
	general QA/QC	organisation of inventory work	definitions and list of abbreviations	explanation of important terms and abbreviations that are used	NIC and quality manager check validity -> adjustment if necessary	yearly before kick-off meeting
			Luxembourg's National Inventory System	organisation of Luxembourg's National System, organigram, position of QA/QC within the organisation, handling of submission	"Règlement grand-ducal du 1er août 2007 relatif à la mise en place d'un Système d'Inventaire national des émissions de gaz à effet de serre dans le cadre de la Convention-cadre des Nations Unies sur le Changement Climatique" (RGD) dictates handling of submission (AEV -> EIONET, MEV -> UNFCCC); NIC and quality manager check validity -> adjustment if necessary -> announcement	yearly before kick-off meeting
			responsibilities	personnel involved in inventory work (collection of activity data, selection of emission factors and methods, calculation of emissions, data compilation, uncertainties, recalculations, identification of key categories, etc.)	nomination of sector experts and data suppliers according RGD; NIC and quality manager check validity -> adjustment if necessary -> announcement	yearly before kick-off meeting
	personnel		nominations	nominations of sector experts and data suppliers according RGD	nomination by minister of environment; NIC and quality manager check validity -> information of ministry if necessary	yearly before kick-off meeting
			personal file	proof of sector expert's qualification	sector experts complete their personal file	current
	quality assurance	to support and complete quality control measures	internal audit programm	checklist for performance of internal reviews (conformity with IPCCC Guidelines, target-performance comparison)	internal audit of general aspects by quality manager, of sector specific aspects by NIC -> internal audit report -> QA/QC plan	yearly before kick-off meeting
		check of formal aspects	internal audit report	audited sectors, observations, proposed improvements	report prepared by quality manager and NIC -> generation of QA/QC plan	current
		check of applicability & comparisons	external audit report	audited sectors, observations, proposed improvements	report prepared by external persons or organisations -> generation of QA/QC plan	current
			audit list	date, audit character, audited sectors, auditors, hence prepared audit reports and QA/QC plans	auditlist completed by NIC and quality manager	current
			inconsistencies	procedure for handling of inconsistencies (that are detected during compilation of inventory, in internal or external audits)	documenting and archiving of indication of inconsistency (audit report, annotation) -> informing of NIC and quality manager -> entry of proposals for improvement in QA/QC plan	yearly before kick-off meeting
	improvement plan	list of objectives and proposed actions in order to improve inventory's quality	improvement plan	QAQC plan, inventory improvement plan, priority list	result of internal and external audits; documenting of detected inconsistencies or possibilities for improvement in QA/QC plan by NIC and quality manager -> definition of deadlines -> check if objectives have been achieved during the following audits	current
performance processes	**inventory**		inventory timetable	timetable for inventory planning and preparation, sector specific timetable for inventory planning and preparation, QAQC timetable, submission deadlines	NIC, quality manager and sector experts check validity -> adjustment if necessary -> announcement per mail	yearly before kick-off meeting
			calculation sheets	calculated emissions; information on activity data, data suppliers (QA/QC), emission factors, calculation methods and special events; information on completeness, revisions and planned improvements of emission data	sector experts complete their calculation sheets -> transfer to NIC before deadline; check of document by NIC and quality manager; check of data content by sector expert	yearly before kick-off meeting
			NIR and crf-tables	national greenhouse gas inventory	sector experts submit calculation sheets to NIC before deadline -> NIC generates crf-tables and compiles NIR -> submission of crf-tables and NIR to EU and UNFCCC	current according the deadlines
	quality control	activities to assess and maintain the quality of the inventory being compiled	sector specific checklists validation and verification	Accuracy checks on data acquisition and calculations, verification of activity data, emission factors and methods	performance by sector experts before submission; completion of checklists; archiving of checks; transmission of completed checklists in common with NIR data to NIC	yearly before kick-off meeting
			checklist data supplier	validation of data that are submitted by plant operators and other organisations	performance by data supporter before submission; check and archiving by sector expert	yearly before kick-off meeting
supporting processes	**data management**	definition of data naming and archiving	data flow	cooperation between the competent authorities and organisations; exchange and archiving of data and information	sector experts calculate emissions and perform data validation checks -> submission of calculations to NIC -> NIC validates methods, activity data and emission factors, generates crf-tables and compiles NIR; NIC and quality manager perform internal audit on NIR compilation -> generation of a QA/QC plan including proposed improvements -> information of sector experts and implementation of improvements	yearly before kick-off meeting
			data management on CIRCA	instruction for data naming and archiving	NIC designates access authorisation	yearly before kick-off meeting

Sources: SEG Umwelt-Service GmbH and Environment Agency.

III.2.6.5. Inventory Timetable

The inventory timetable gives several schedules to control the performance of inventory compilation, quality control and quality assurance procedures, implementation of inventory improvements and inventory publication *[→ Table III.2-2]*.

In addition, there are summaries of deadlines regarding EU and UNFCCC submissions.

Timetable for inventory planning and preparation

This schedule refers to general inventory work:

- yearly meetings of the inventory work group and the decision making body;
- key category analysis;
- uncertainty analysis;
- generation of CRF tables;
- NIR preparation and finalisation;
- NIR and CRF submission;
- publication and archiving of NIR;
- consideration and implementation of EU review recommendations;
- consideration and implementation of UNFCCC review recommendations;
- internal and external training;
- documentation and archiving.

Sector specific timetable for inventory planning and preparation

This schedule refers to sector specific compilation work and quality control checks:

- collection of activity data, emission factors and other parameters;
- calculation of emissions and removals;
- quality check of data, comparison with previous years, documentation of calculations and assumptions;
- uncertainty analysis;
- completion of checklists and other QC activities;
- documentation and archiving.

QA/QC timetable

This schedule especially refers to QA procedures:

- internal audit;
- implementation of internal review recommendations;
- yearly meetings of the inventory work group and the decision making body;

- QA/QC training for the NIC and the sector experts.

III.2.6.6. Quality Control and Quality Assurance procedures

The first steps to implement quality control and quality assurance procedures *[→ Figure III.2-6]* have already been undertaken but need further improvement. The current status and planned improvements are described in the following sub-sections.

FIGURE III.2-6 – QA/QC PROCEDURES

<table>
<tr><th>does NOT require knowledge of the emission source category</th><th>requires knowledge of the emission source category</th></tr>
<tr><th>general</th><th>source specific</th></tr>
<tr><td colspan="2">QC procedures
sector experts (1^{st} party)
performed throughout preparation of inventory</td></tr>
<tr><td>TIER 1</td><td>TIER 2</td></tr>
<tr><td>data validation, calculation sheet (check of formal aspects)</td><td>preparation of NIR, comparison with Guidelines (check of applicability, comparisons)</td></tr>
<tr><td colspan="2">QA procedures
quality manager (2^{nd} or 3^{rd} party; staff not directly involved, preferably independent)
performed after inventory work has finished</td></tr>
<tr><td colspan="2">TIER 1
basic, before submission</td></tr>
<tr><td></td><td>Internal audit / EU 'Initial check'
(Expert Peer Review)</td></tr>
<tr><td></td><td>evaluate if TIER2 QC is effectively performed (check if methodologies are applicable)</td></tr>
<tr><td colspan="2">TIER 2
extensive</td></tr>
<tr><td>System audit by Umweltbundesamt (Audit)</td><td>ICR by UNFCCC (Expert Peer Review)</td></tr>
<tr><td>evaluate if TIER 2 QC is effectively performed</td><td>evaluate if TIER 2 QC is effectively performed (Check if methodologies are applicable)</td></tr>
</table>

Sources: *Umweltbundesamt* Austria, *SEG Umwelt-Service GmbH* and Environment Agency.

Quality Control procedures

The following Quality Control procedures are conducted:

- yearly meeting of the "Decision Making Body" *[→ Section III.2.2.1]* in order to appoint responsibilities, priorities and schedules for inventory work;
- checklists for data supplier that have to be completed by external suppliers of input data in order to assure the reliability of the reported data;
- checklists for validation of data that have to be completed by sector experts until data are transmitted to the NIC. An example of a data validation checklist for a sector expert is given in *Figure III.2-7*. checks for validation of data include:
  - checks of activity data (trend checks, time series consistency, completeness, check of assumptions and criteria for activity data, check for transcription errors in data input and reference);
  - checks of EFs (trend checks, time series consistency, completeness, check of correct recording of units and the use of appropriate conversion factors, check of documentation of assumptions and criteria for the selection of emission factors, check for transcription errors in data input and reference);

- checks of emissions (trend checks, time series consistency, completeness, check of documentation of assumptions and criteria for emissions, check for transcription errors in data input and reference, check of correct recording of units and the use of appropriate conversion factors);
- check of uncertainties (check of correct calculation and estimation of uncertainties in emissions and removals).

- checklists for verification of methods, activity data and emission factors that have to be completed by sector experts.
- checklist for the monitoring of internal and external reviews that has to be completed by the quality manager.

Quality Assurance procedures

The following Quality Assurance procedures are conducted:

- internal audit during NIR preparation time performed by the quality manager, the NIC and a consultant from *Umweltbundesamt Wien*. The internal review analyses every sector as well as the QMS system and checks:
    - whether inventory work and the inventory comply with Revised 1996 IPCC Guidelines, Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories and Good Practice Guidance for Land Use, Land Use Change and Forestry;
    - whether data acquisition, calculation, referencing and archiving is handled according to the defined methods;
    - whether there are enough resources for inventory work;
    - whether relevant data are available and if the reliability of external data is guaranteed;
    - whether the QMS system needs improvement;
    - whether recommendations of EU reviews, UNFCCC reviews and previous internal audits have been considered and implemented.
- QA/QC training for the sector experts and the NIC during execution of the internal audit;
- support by inventory experts from *Umweltbundesamt Wien*;
- external audits conducted by experts who provide support for inventory work, EU or UNFCCC.

FIGURE III.2-7 – DATA VALIDATION CHECKLIST

Data:	1990 - 2xxx																	
Source:	CRF	XXX		Snap	XX XX													
	Activity data			check done			Emission factor			check done			Emissions			check done		
Greenhouse gas	CO2	CH4	N2O	Remarks	Date	Person	CO2	CH4	N2O	Remarks	Date	Person	CO2	CH4	N2O	Remarks	Date	Person
Content check																		
Trend checks																		
For each category, current inventory estimates should be compared to previous estimates, if available. If there are significant changes or departures from expected trends, re-check estimates and explain any differences																		
Data plausible in comparison to other references																		
Check time series consistency																		
For each category check input data for temporal consistency in time series																		
Check methodological and data changes resulting in recalculations																		
Check that the effects of mitigation activities have been appropriately reflected in time series calculations																		
Check completeness																		
Confirm that estimates are reported for all categories and for all years from the appropriate base year to the period of the current inventory																		
For subcategories, confirm that entire category is being covered																		
Provide clear definition of "Other" type categories																		
Check that known data gaps that result in incomplete estimates are documented, including a qualitative evaluation of the importance of the estimate in relation to total emissions																		
Uncertainty estimation of data existent																		
data relying on a legal reporting commitment																		
Formal check																		
Collection of data is understandable																		
Check that assumptions and criteria for the selection of data are documented																		
Assumptions and criteria for the selection of data are documented																		
Cross-check descriptions of activity data, emission factors and other estimation parameters with information on categories and ensure that these are properly recorded and archived																		
Check for transcription errors in data input and reference																		
data correctly entered and transcribed																		
Confirm that bibliographical data references are properly cited in the internal documentation																		
Cross-check a sample of data from each source category (either measurements or parameters used in calculations) for transcription errors																		
Accurate data aggregation and correctness of calculations																		
Parameters and units are correctly recorded																		
Data fields are properly labelled																		
Data transmission of intermediate result is correct																		
Check that parameters and units are correctly recordedand that appropriate conversion factors are used																		
Units are properly labelled and correctly carried through from beginning to end of calculations																		
Conversion factors respectively temporal and spatial adjustment factors are correct																		
Data path and data coherence are understandable																		
Consistency given for the multiple use of data																		
Archiving of data and records ensured																		
Emissions complete																		
Uncertainty estimation of emissions existent																		
emission measurements in compliance with international accredited standards																		

	Uncertainties			check done		
Greenhouse gas	CO2	CH4	N2O	Remarks	Date	Person
Content check						
Check that uncertainties in emissions and removals are estimated and calculated correctly						
Check that qualifications of individuals providing expert judgement for uncertainty estimates are appropriate						
Check that qualifications, assumptions and expert judgements are recorded						
Formal check						
Designation of uncertainties is understandable						
Uncertainties complete						
documentation of fundamental assumption concerning expert judgement						
Archiving of data and records ensured						

Sources: *Umweltbundesamt* Austria, *SEG Umwelt-Service GmbH* and Environment Agency.

Improvement plan

The results from internal and external audits are merged in the improvement plan. This plan lists the relevant sector, recommendations for improvement, responsibilities, deadlines and gives opportunity for attest.

The improvement plan is segmented in a QA/QC plan, that contains recommendations for the improvement of the QMS, and an inventory improvement plan, that contains recommendations for inventory improvement.

The "Decision Making Body" prioritises the recommended improvements and cares for associated resources.

Planned improvements

The following QMS improvements shall be implemented in 2018 and the following years:

- strengthening the implementation of the QMS in general;
- improvement of QC procedures in the LULUCF sector;
- strengthening the implementation of QA/QC procedures in KP-LULUCF;
- development of the four-eyes principle in inventory work;
- continuance in QA/QC training of NIC and sector experts.

III.2.6.7. Archiving and documentation

Within the inventory system, a system for transparent documentation of inventory data and related information (special circumstances, assumptions etc.) is implemented. Archiving takes place on the CIRCALUX server within the folder "*Inventaires gaz à effet de serre*".[107] The data is secure for at least fifteen years.

As a principle, every file shall be named clearly, shall be write/delete protected and supply relevant information concerning validity in the footer.

III.2.7. Procedures for official consideration and approval of the inventory

The process for the official consideration of the GHG inventory has been presented in ***Section III.2.1.2*** and ***Figure III.2-1*** where it is explained that the Environment Agency has the "technical" knowledge and responsibility for the GHG inventories, and that the Department of the Environment acting as UNFCCC National Focal Point (NFP) has the "political" responsibility. Thus, it is the Department that officially submits the inventories and their related reports to the UNFCCC

107 https://circalux.etat.lu/Members/irc/public/invges/home (only for members). See section III.2.2.2.

Secretariat and to the EC (see Article 11 of the Grand-Ducal Regulation[108] setting-up a National Inventory System in Luxembourg).

III.2.8. Additional information

According to Article 10, paragraph (f), of the Kyoto Protocol, Annex I Parties should include in their national communications information on programmes and activities undertaken pursuant to this Article. It is suggested, in the framework of the National System, to report on paragraph a of Article 10 dealing with "(…) **cost-effective** national and, where appropriate, regional **programmes to improve the quality of local EFs, activity data and/or models** which reflect the socio-economic conditions of each Party for the preparation and periodic updating of national GHG inventories (…)".

In this context, on-going activities one activity is worth to be briefly described. It touches upon "road fuel sales to non-residents".

As discussed in ***Section II.8***, an unequivocal imbalance exists in Luxembourg between road fuel consumption by the resident population and the total road fuel sales. Due to its location, the usually cheaper prices as compared to the neighbouring countries and the fact that the Luxembourg economy nearly doubles its workforce during the day through the effect of commuters coming from Belgium, France and Germany, a large part of road fuel sold in Luxembourg is also consumed beyond its borders. This is the concept of "road fuel sales to non-residents".

In line with relevant commitments taken internationally, it is necessary to determine **precisely** the domestic and foreign consumptions, respectively the emissions resulting from these consumptions. This is particularly important while, as underlined in ***Section III.1.2.1***, and according to the NEMO model approach, "road fuel sales to non-residents" are estimated amounting to 37.3% of the total GHG emissions in 2015.

That is why the Department of the Environment commissioned a study on the ecological, economic and fiscal aspects of road fuel sales and mobility in Luxembourg that was presented end 2016.[109] Following this study, an inter-ministerial working group was set up with the aim to inform the Government on possible venues to reduce the weight of road fuel sales in the GHG balance of Luxembourg, as well as making public finances less dependent from that source of revenue. In parallel, STATEC is working on evaluating price-elasticities of road fuel sales.

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108 *Règlement grand-ducal du 24 avril 2017 relatif à la mise en place d'un système national pour la surveillance, l'évaluation et la déclaration des émissions de gaz à effet de serre et des polluants atmosphériques et la déclaration d'autres informations ayant trait au changement climatique et à la pollution atmosphérique* (http://data.legilux.public.lu/eli/etat/leg/rgd/2017/04/24/a446/jo).

109 *Ermittlung und Bewertung der positiven und negativen Wirkungen des Treibstoffverkaufs unter besonderer Berücksichtigung negativer externer Umwelt-und Gesundheitseffekte – Status quo 2012 und maßnahmeninduzierte Veränderungen, Bericht für das Ministerium für Nachhaltige Entwicklung und Infrastrukturen des Großherzogtums Luxemburg*, Königswinter, 2016. (http://environnement.public.lu/fr/actualites/20161/11/etude_tt.html)

III.3. NATIONAL REGISTRY[110]

III.3.1. The Registry administrator

The **Environment Agency** acts as **Registry administrator** designated to maintain Luxembourg's National Registry.[111]

Contact information
Administration de l'Environnement (Environment Agency)
Registre des quotas d'émission de gaz à effet de serre
Martine Kemmer & Tiffany Wilsius – authorised representatives of the Registry administrator
1, avenue du Rock'n'Roll
L-4361 Esch-sur-Alzette
e-mail: martine.kemmer@aev.etat.lu
tiffany.wilsius@aev.etat.lu

III.3.2. A consolidated system

Directive 2009/29/EC adopted in 2009, provides for the centralization of the EU ETS operations into a single European Union registry operated by the European Commission as well as for the inclusion of the aviation sector. At the same time, and with a view to increasing efficiency in the operations of their respective national registries, the EU Member States who are also Parties to the Kyoto Protocol (26) plus Iceland, Liechtenstein and Norway decided to operate their registries in a consolidated manner in accordance with all relevant decisions applicable to the establishment of Party registries - in particular Decision 13/CMP.1 and Decision 24/CP.8.

The consolidated platform, which implements the national registries in a consolidated manner (including the Registry of the EU), is called the **Union Registry** and was developed together with the new EU Registry on the basis the following modalities:

- each Party retains its organization designated as its registry administrator to maintain the national registry of that Party and remains responsible for all the obligations of Parties that are to be fulfilled through registries;
- each Kyoto unit issued by the Parties in such a consolidated system is issued by one of the constituent Parties and continues to carry the Party of origin identifier in its unique serial number;
- each Party retains its own set of national accounts as required by paragraph 21 of the Annex to Decision 15/CMP.1. Each account within a national registry keeps a unique account number

110 This section has been prepared by Martine Kemmer from the Environment Agency.

111 *Loi du 23 décembre 2004 1) établissant un système d'échange de quotas d'émission de gaz à effet de serre; 2) créant un fonds de financement des mécanismes de Kyoto; 3) modifiant l'article 13bis de la loi modifiée du 10 juin 1999 relative aux établissements classes*, Article 18 (http://www.legilux.public.lu/leg/a/archives/2004/0210/a210.pdf, p. 3792-3799)

comprising the identifier of the Party and a unique number within the Party where the account is maintained;

- Kyoto transactions continue to be forwarded to and checked by the UNFCCC Independent Transaction Log (ITL), which remains responsible for verifying the accuracy and validity of those transactions;
- the Transaction Log and national registries continue to reconcile their data with each other in order to ensure data consistency and facilitate the automated checks of the ITL;
- the requirements of paragraphs 44 to 48 of the Annex to Decision 13/CMP.1 concerning making non-confidential information accessible to the public is fulfilled by each Party through a publically available web page hosted by the Union Registry;
- all registries reside on a consolidated IT platform sharing the same infrastructure technologies. The chosen architecture implements modalities to ensure that the consolidated national registries are uniquely identifiable, protected and distinguishable from each other, notably:
    (a) with regards to the data exchange, each national registry connects to the ITL directly and establishes a secure communication link through a consolidated communication channel (VPN tunnel);
    (b) the ITL remains responsible for authenticating the national registries and takes the full and final record of all transactions involving Kyoto units and other administrative processes such that those actions cannot be disputed or repudiated;
    (c) with regards to the data storage, the consolidated platform continues to guarantee that data is kept confidential and protected against unauthorized manipulation;
    (d) the data storage architecture also ensures that the data pertaining to a national registry are distinguishable and uniquely identifiable from the data pertaining to other consolidated national registries;
    (e) in addition, each consolidated national registry keeps a distinct user access entry point (URL) and a distinct set of authorisation and configuration rules.

Following the successful implementation of the Union Registry, the 28 national registries concerned were re-certified in June 2012 and switched over to their new national registry on 20 June 2012. Croatia was migrated and consolidated as of 1 March 2013. During the go-live process, all relevant transaction and holdings data were migrated to the Union Registry platform and the individual connections to and from the ITL were re-established for each Party.

III.3.3. Changes in the Registry since the last National Communication

The following changes to the national registry have occurred since the last National Communication report [Ministry of Sustainable Development and Infrastructure, Department of the Environment (2014a)] *[→ Table III.3-1].*

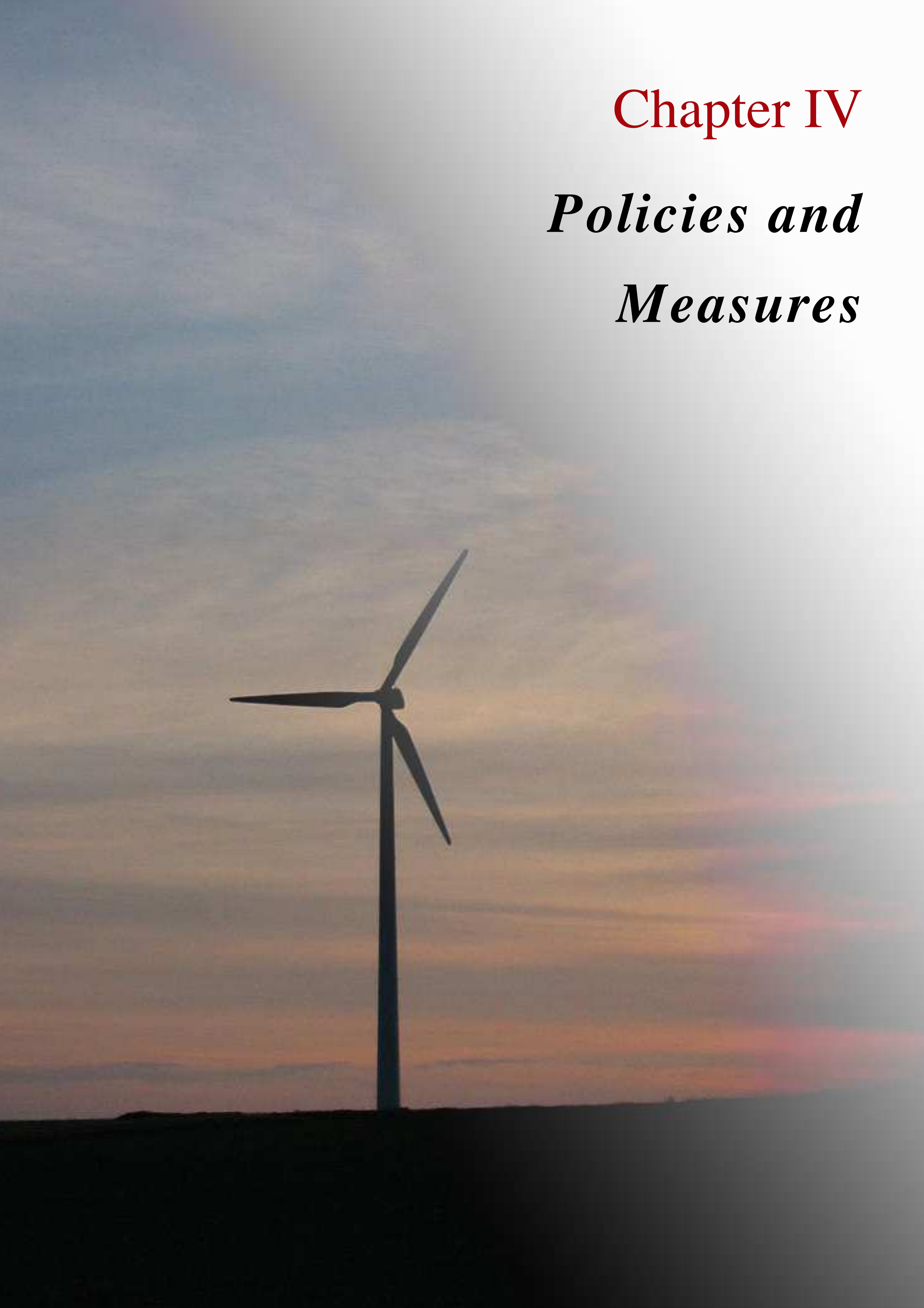
TABLE III.3-1 – CHANGES TO THE EU NATIONAL REGISTRY

Reporting Item	Description
15/CMP.1 Annex II.E paragraph 32.(a) Change of name or contact	None
15/CMP.1 Annex II.E paragraph 32.(b) Change regarding cooperation arrangement	No change of cooperation arrangement occurred during the reported period.
15/CMP.1 Annex II.E paragraph 32.(c) Change to database structure or the capacity of national registry	In 2016, new tables were added to the database for the implementation of the CP2 functionality. Versions of the Union registry released after 6.1.6 (the production version at the time of the last NC submission) introduced other minor changes in the structure of the database. These changes were limited and only affected EU ETS functionality. No change was required to the database and application backup plan or to the disaster recovery plan. No change to the capacity of the national registry occurred during the reported period.
15/CMP.1 Annex II.E paragraph 32.(d) Change regarding conformance to technical standards	Each release of the registry is subject to both regression testing and tests related to new functionality. These tests also include thorough testing against the DES and were successfully carried out prior to each release of a new version in production. Annex H testing is carried out every year. No other change in the registry's conformance to the technical standards occurred for the reported period.
15/CMP.1 Annex II.E paragraph 32.(e) Change to discrepancies procedures	No change of discrepancies procedures occurred during the reported period.
15/CMP.1 Annex II.E paragraph 32.(f) Change regarding security	The mandatory use of hardware tokens for authentication and signature was introduced for registry administrators.
15/CMP.1 Annex II.E paragraph 32.(g) Change to list of publicly available information	Publicly available information is provided via the Union registry homepage for each registry e.g. https://ets-registry.webgate.ec.europa.eu/euregistry/XX/public/reports/publicReports.xhtml
15/CMP.1 Annex II.E paragraph 32.(h) Change of Internet address	No change of the registry internet address occurred during the reporting period.
15/CMP.1 Annex II.E paragraph 32.(i) Change regarding data integrity measures	No change of data integrity measures occurred during the reporting period.
15/CMP.1 Annex II.E paragraph 32.(j) Change regarding test results	Both regression testing and tests on the new functionality are carried out prior to release of the new versions in Production. The site acceptance tests are carried out by quality assurance consultants on behalf of and assisted by the European Commission. Annex H testing is carried out on an annual basis.

Source: Environment Agency.

Chapter IV

Policies and Measures



Chapter IV deals with policies and measures (PaMs). It starts with the description of the overall policy context and of the policy-making process according to paragraphs 20 and 21 of the UNFCCC reporting guidelines *[→ Section IV.1]*. The domestic programmes pursuant to the implementation of the Kyoto Protocol, as required by paragraph 37 of the Kyoto Protocol reporting guidelines, are presented in the subsequent section *[→ Section IV.2]*, where information on Article 3.3 and 3.4 of the Kyoto Protocol and their relation with the conservation of biodiversity and the sustainable use of resources could be found (paragraph 38). Finally, PaMs and their effects, as well as those which have expired or have been repealed, are discussed in the last section, which responds to UNFCCC reporting guidelines, paragraphs 13 to 17 and 23 to 26, as well as to Kyoto Protocol reporting guidelines, paragraphs 34 to 36 *[→ Section IV.3]*.

IV.1. POLICY-MAKING PROCESS

IV.1.1. International context

IV.1.1.1. The Convention, the Kyoto Protocol and the Paris Agreement

Luxembourg signed the **UNFCCC** on June 9, 1992 and ratified it on May 9, 1994 so that the Convention **entered into force on August 7, 1994**. As for the **Kyoto Protocol**, it has been signed by Luxembourg on April 29, 1998, ratified on May 31, 2002 and **entered into force**, concomitantly with other EU Annex I Member States, **on February 16, 2005**.[112] Pursuant to that Protocol and the terms of the European agreement distributing the burden among the, at the time, 15 Member States of the EU, Luxembourg undertook **to reduce its GHG emissions by 28% below their 1990 levels over the period 2008-2012**. This was the deepest cut of any agreed by the 15 Member States. In 2004, the Government made a commitment that the bulk of its emission reductions under the Kyoto agreement would be achieved in Luxembourg itself, with limited resort to the Protocol's "flexible mechanisms". However, this commitment had to cope with very peculiar national circumstances – amongst which size and "road fuel sales to non-residents" are the main driving forces – and the limited GHG reduction potentials within the country *[→ Section II.12]*.

With regard to the **"Doha Amendment" to the Kyoto Protocol** that establishes the second commitment period of this Protocol – which began on 1 January 2013 and will end on 31 December 2020 – Luxembourg submitted its **instrument of acceptance** to the United Nations Framework Convention on Climate Change **on September 21, 2017**.[113] As it was the case for the first commitment period, an European agreement distributing the burden among the Member States of the EU, but this time also among the sectors, has been put in place: a **target compliance architecture** was set up within the EU in order to meet the 2010 EU's pledge under the Convention, and indirectly

[112] Source: http://unfccc.int/kyoto_protocol/status_of_ratification/items/2613.php.

[113] Source: https://treaties.un.org/Pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-7-c&chapter=27&clang=_en.

under the Kyoto Protocol (*[→ Section IV.1.1.4]* for the differences); i.e. **to reduce, by 2020, its GHG emissions by 20% compared to 1990 levels**.[114]

The **Paris Agreement** was adopted on December 12, 2015 at the twenty-first session of the Conference of the Parties to the United Nations Framework Convention on Climate Change and entered into force on November 4, 2016.[115] The EU ratified the Agreement on October 5, 2016, whereas Luxembourg's ratification was completed in **November 4, 2016**.[116]

IV.1.1.2. The EU "2020 Climate & Energy package"

In 2009, the EU established internal rules under the target compliance architecture – the "**2020 Climate & Energy package**" – that distributes the mitigation burden among the Member States and the sectors. The package is intended **to combat climate change**, as well as **to contribute to a common energy policy after 2012**. Besides reducing GHG emissions by 2020 by 20% compared to 1990 levels, it therefore also defines headline targets in the energy field for 2020: reach 20% of clean, renewable energy sources in the final energy consumption, increase energy efficiency by 20% and, as part of the renewable energy effort, reach, in each Member State, a 10% share for sustainable produced biofuels and other renewable fuels in final energy consumption of the transport sector.[117] Following controversial discussions on agricultural production dedicated to biofuels – fear of shortages and of increasing prices for food-related crops – the European Commission published, in October 2012, a proposal to limit global land conversion for biofuel production, and raise the climate benefits of biofuels used in the EU. The use of food-based biofuels to meet the 10% renewable energy target will be limited to 5%.

The three objectives of the "2020 Climate & Energy package" are included in the "**Europe 2020 Strategy**", i.e. the EU's growth strategy for the 2010-2020 decade that aims the EU to become a smart, sustainable and inclusive economy.[118]

Climate component target compliance architecture

The package introduced a clear approach to **collectively deliver, under the Convention and by 2020, a 20% reduction of total GHG emissions from 1990 levels**, which is equivalent to a 14% reduction compared to 2005 levels – 2005 is the key year for the 2020 commitment at EU level. This 14% reduction objective is **divided between sectors' emissions covered by or outside the EU Emissions Trading System** (EU ETS). These two sub-targets are:

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114 The -20% target was proposed to be raised up to -30%, provided that other developed countries also commit to achieving comparable emission reductions, and that developing countries contribute adequately, according to their responsibilities and respective capabilities. Nevertheless, these conditions having not yet been met, the target remains at -20%.

115 http://unfccc.int/paris_agreement/items/9485.php

116 http://unfccc.int/paris_agreement/items/9444.php

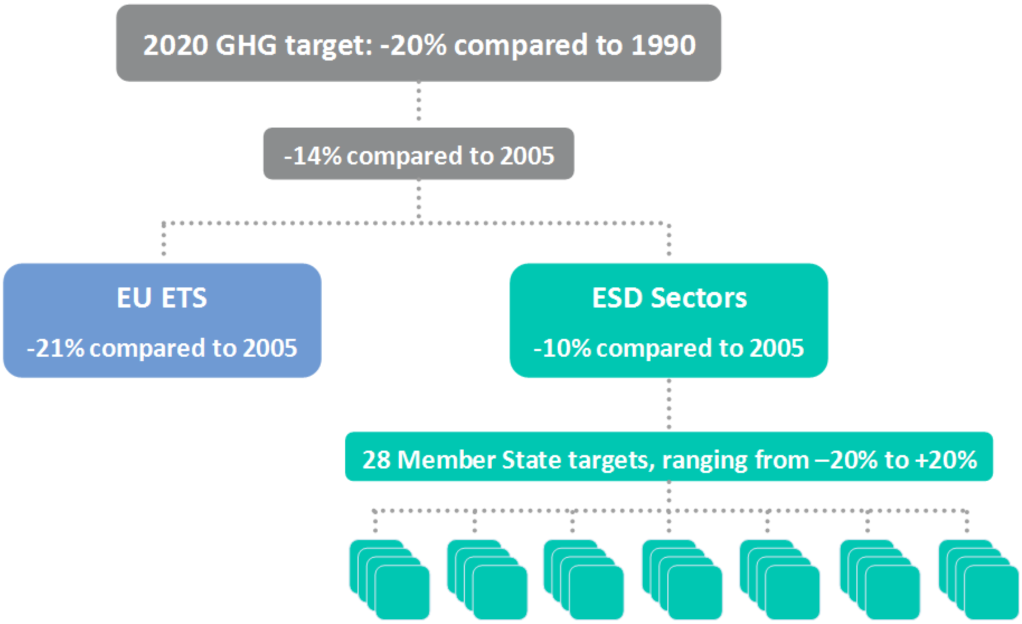
117 For more details on the "2020 Climate & Energy package", see https://ec.europa.eu/clima/policies/strategies/2020_en.

118 https://ec.europa.eu/info/business-economy-euro/economic-and-fiscal-policy-coordination/eu-economic-governance-monitoring-prevention-correction/european-semester/framework/europe-2020-strategy_en.

- **a 21 % reduction target compared to 2005** for emissions covered by the EU ETS (including domestic and international aviation);
- **a 10 % reduction target compared to 2005** for emissions outside the EU ETS, shared between the 28 Member States through individual national GHG targets.

Figure IV.1-1 illustrates how the objective of the "2020 Climate & Energy package" is shared between Member States and the ETS sectors (also referred to as "Effort Sharing Decision (ESD) sectors").

FIGURE IV.1-1 – "2020 CLIMATE & ENERGY PACKAGE" – A SHARED EFFORT BETWEEN THE SECTORS AND THE MEMBER STATES



Source: European Commission, DG CLIMA.

As the "2020 Climate & Energy package" defines differentiated commitments and targets by 2020 for each EU countries, for **Luxembourg**, it calls to:

- **reduce GHG emissions by 20% below their 2005 level** for sectors outside the EU ETS – "ESD target";[119]
- **achieve an 11% share of energy from renewable sources in all forms** in final energy consumption; and
- **achieve a 10% share of energy from renewable sources in all forms** in total transport.[120]

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119 The targets regarding emissions are set in Decision 406/2009/EC of the European Parliament and of the Council of 23 April 2009 on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020 (http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0136:0148:EN:PDF).

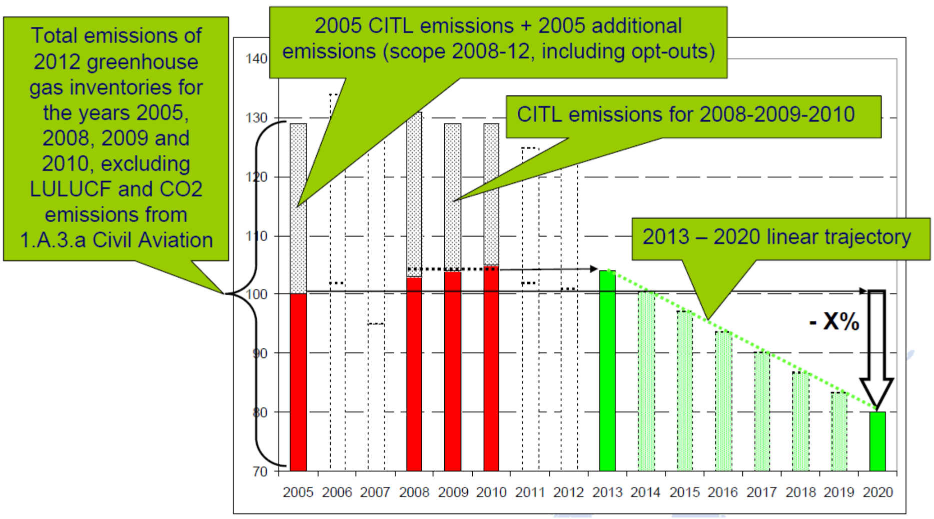
120 The targets regarding renewable energy are set in Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC (http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02009L0028-20151005&from=EN).

Non-ETS/ESD emissions

The Effort Sharing Decision No 406/2009/EC[121] (ESD) establishes the **binding annual GHG targets for Member States for the period 2013–2020**. These targets concern emissions from most **sectors not included in the EU ETS** and are expressed in percentage changes from 2005 levels. They range from a 20% emissions reduction by 2020 (from 2005 levels) for the richest Member States to a 20% increase for the least wealthy one.[122] Luxembourg being the richest Member State if GDP per capita is used as a benchmark, it inherited the highest reduction target, together with Denmark and Ireland. The non-ETS or ESD sectors include transport (road and rail, but not aviation or international maritime shipping), buildings (in particular heating), services, small industrial installations, agriculture and waste. Since the non EU ETS emissions represented 83.5% of Luxembourg's total GHG emissions (excl. LULUCF) in 2013, the "ESD target" set for Luxembourg is very challenging and has been driving the revision of the first national "Action Plan for reducing CO_2 emissions" *[→ Section IV.1.2]*.

Concretely, each Member State has been assigned "**Annual Emissions Allocations**" (AEAs) for the years 2013 to 2020. These allocations actually constitute a linear trajectory between these two years with the 2020 level being the "ESD target" and the 2013 level corresponding to the average non-ETS emissions from the years 2008 to 2010 *[→ Figure IV.1-2]*. The national AEAs have been set in a Commission Decision published on 26 March 2013.[123]

FIGURE IV.1-2 – AEAS DEFINITION, INCL. THE "ESD TARGET"



Source: European Commission, DG CLIMA.
Note: the Community Independent Transaction Log (CITL) is a central transaction log, run by the EC, which checks and records all transactions taking place within the trading scheme. CITL emissions equals verified emissions, allowances and surrendered units under the EU ETS.

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121 Decision No 406/2009/EC of the European Parliament and of the Council of 23 April 2009 on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020 (http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0136:0148:EN:PDF).

122 See this graphic for individual Member States' "ESD targets": http://climatepolicyinfohub.eu/sites/default/files/member_state_esd_targets2.png.

123 Commission Decision No 2013/162/EU of 26 March 2013 on determining Member States' annual emission allocations for the period from 2013 to 2020 pursuant to Decision No 406/2009/EC of the European Parliament and of the Council (notified under document C(2013) 1708) (http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:090:0106:0110:EN:PDF).

According to Article 10 of the ESD, the **AEAs have subsequently been adjusted** to take into account **changes in the EU ETS scope** between the periods 2008-2012 and 2013 onwards. This exercise was concluded during autumn 2013 and is set in a Commission Implementing Decision of 31 October 2013.[124]

Finally, it was also considered a possible **revision of AEAs** following the **move to the 2006 IPCC Guidelines for reporting on GHG inventories** that occurred during the ESD period. The European Commission examined the impact of the use of the 2006 IPCC Guidelines, and of changes to UNFCCC methodologies used, on Member State's GHG inventories. Noticing that the difference in the total GHG emissions relevant for the ESD exceeded 1 % for most Member States, all Member States' AEAs for the years 2017 to 2020 contained in the Commission Decision of 26 March 2013 have been revised in order to take into account the updated inventory data reported.[125]

This process and its adjustments require that Luxembourg's **non-ETS emissions should reach 8 117 Gg CO2e in 2020** in order to comply with the "ESD target" of minus 20% ***[→ Figure IV.1-3]***. Moreover, from 2013 onwards, non-ETS emissions should remain below a linear trajectory, the turquoise line in ***Figure IV.1-3***. If this is not the case, according to provisions in the ESD and in order to be compliant with the requirements of the ESD, Luxembourg:[126]

- may buy "unused" AEAs from other Member States. Two cases are foreseen by the ESD:
  - Member States with overachievement of AEAs in a year of the period 2013–2019 – i.e. with non-ETS emissions below their linear trajectory – may transfer their "surplus"[127] to other Member States, which may use this emission allocation until 2020. This is done after the ESD compliance of the "selling" Member State has been confirmed for a given year: ex-post transfer *(→ Art. 3(5) of the ESD)*;
  - Member States anticipating "surpluses" – i.e. overachievement of AEAs - in a year of or for the period 2013–2019 may transfer up to 5% of their AEAs to other Member States. The "buying" Member State may use these transferred emission allocation until 2020: ex-ante transfer *(→ Art. 3(4) of the ESD)*.[128]

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[124] Commission Implementing Decision No 2013/634/EU of 31 October 2013 on the adjustments to Member States' annual emission allocations for the period from 2013 to 2020 pursuant to Decision No 406/2009/EC of the European Parliament and of the Council (http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:292:0019:0022:EN:PDF).

[125] Commission Decision No 2017/1471/EU of 10 August 2017 amending Decision 2013/162/EU to revise Member States' annual emission allocations for the period from 2017 to 2020 (http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32017D1471&qid=1513963782923&from=en).
The revision of AEAs is limited to those that were allocated for the years 2017 to 2020, since for GHG emissions for the years 2013 to 2016 Member States can no longer change their policies and measures.

[126] The three cases below are derived from European Environment Agency (2013), p. 102-103.

[127] "Surplus" = AEAs minus verified non-ETS emissions for a given year.

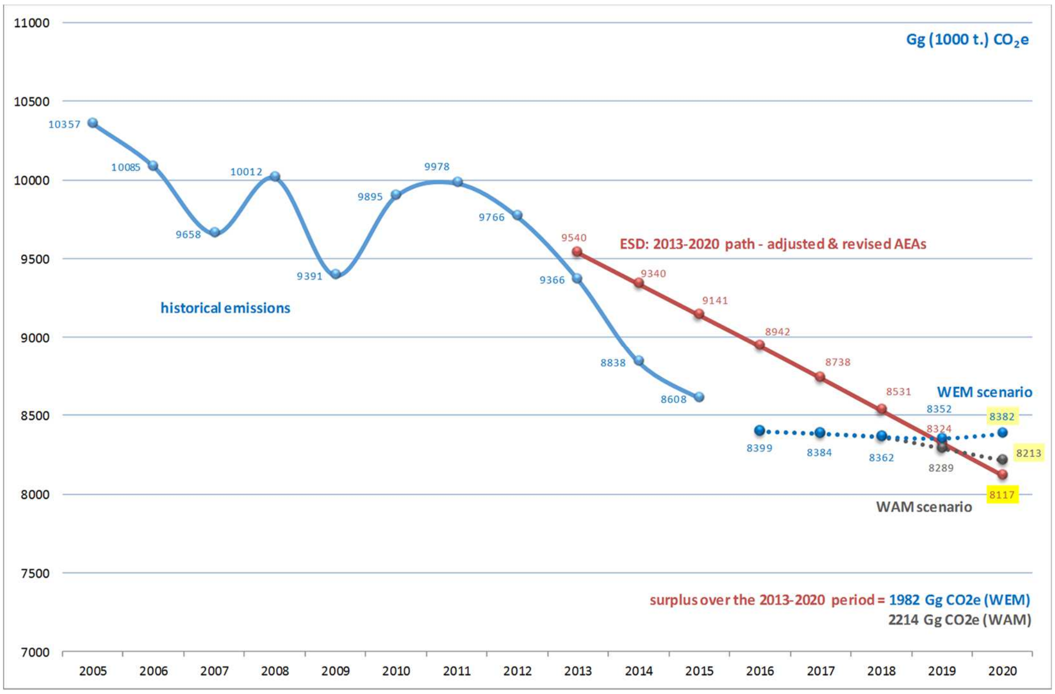
[128] Consequently, a "selling" Member State anticipates that it will not use all its AEAs for a given year, or over the period 2013-2019, and therefore decides to sell its AEAs in excess – with a limit of 5%of its total AEAs – to other Member States. Once these AEAs are transferred to the "buying" Member States, they cannot be reclaimed back by the "selling" Member State if it is finally missing its "ESD target".

- may use JI/CDM credits according to the following provisions:
  - the use of project-based emission credits[129] is capped on a yearly basis up to 3% of 2005 non-ETS emissions *(→ Art. 5(4) of the ESD)*;
  - may benefit from transfers from other Member States that do not use their 3% limit for the use of project-based credits or bank unused part of its project-based credits for own use until 2020. The "buying" Member State acquires rights, but not project-based emission credits per se that it will have to obtain subsequently *(→ Art. 5(6) of the ESD)*;
  - may use credits from projects in Least Developed Countries and Small Island Developing States (LDCs and SIDS) up to an additional 1% of its verified emissions in 2005 if it fulfils additional criteria considered in the ESD – which is the case of Luxembourg *(→ Art. 5(5)(c) of the ESD & Annex III)*. These credits are not bankable and transferable.

- could carry over any overachievement in a year of the period 2013–2019 to subsequent years, up to 2020. More precisely, an emission allocation of up to 5% during 2013–2019 may be carried forward from the following year *(→ Art. 3(3)§1 of the ESD)*.

Actual GHG projections ***[→ Section V.3]*** anticipate Luxembourg's non-ETS emissions to be below the linear trajectory for most of the 2013-2020 period ***[→ Figure IV.1-3]***. Since Luxembourg uses the ESD carry-over provision, it is anticipated that, despite an overachievement in 2020, **it would not be necessary to buy AEAs and/or project-based credits to comply with the "ESD target"**.

FIGURE IV.1-3 – ESD IMPLICATION FOR LUXEMBOURG – 2013-2020 TRAJECTORY FOR NON-ETS EMISSIONS



Sources: Environment Agency and MDDI-DEV – Submission 2017v7
MDDI-DEV – 2017 projections submission

129 CERs, ERUs, tCERs, lCERs and other units as defined in Art. 5(1), 5(2) and 5(3) of the ESD.

EU ETS emissions

The EU ETS is a cornerstone of the EU policy for reducing GHG emissions. The system works by putting a limit on overall emissions from covered installations – power stations and manufacturing plants – which is reduced each year. Within this limit, companies can buy and sell emission allowances as needed. This "**cap-and-trade**" approach is supposed to offer companies the flexibility they need to cut their emissions in the most cost-effective way.

Set up by Directive 2003/87/EC,[130] the system is now in its **3rd phase covering the period 2013-2020**. For this latest phase, major reform took effect (Directive 2009/29/EC[131]). The biggest changes have been the introduction of an EU-wide cap on emissions – reduced by 1.74% each year so that in 2020, GHG emissions from the EU ETS sector will be 21% lower than in 2005 – and a progressive shift towards auctioning of allowances in place of cost-free allocation that was the rule for the two previous phases. Concretely, a cap is set on the total amount of certain GHG that can be emitted by installations covered by the system. The cap is reduced over time so that total emissions fall. Within the cap, companies receive or buy emission allowances that they can trade with one another as needed. They can also buy limited amounts of international credits from emission-saving projects around the world. The limit on the total number of allowances available ensures that they have a value. After each year a company must surrender enough allowances to cover all its emissions, otherwise heavy fines are imposed. If a company reduces its emissions, it can keep the spare allowances to cover its future needs or else sell them to another company that is short of allowances.[132]

Renewable energy

The Renewable Energy Directive No 2009/28/EC [133] (RED) establishes a common framework for the production and promotion of energy from renewable sources**.** Each Member State has a **target calculated according to the share of energy from renewable sources in its gross final consumption for 2020**. The RED states that Member States are to **establish national action plans** that set the share of energy from renewable sources consumed in transport, as well as in the production of electricity and heating, for 2020 – the National Renewable Energy Action Plans (NREAPs). These action plans must take into account the effects of other energy efficiency measures on final energy consumption and will establish procedures for the reform of planning and pricing schemes and access to electricity networks, promoting energy from renewable sources. Latest estimates of the share of renewable

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130 Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC (http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32003L0087&qid=1514287861312&from=EN).

131 Directive 2009/29/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading scheme of the Community (http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32009L0029&qid=1514288132673&from=EN).

132 For more information, see [European Commission (2016a)] as well as https://ec.europa.eu/clima/policies/ets_en.

133 Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC (http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02009L0028-20151005&from=EN).

energy sources in the total final energy consumption of Luxembourg amounted to 5% in 2015, i.e. far short below the 11% goal to be reached by 2020.[134]

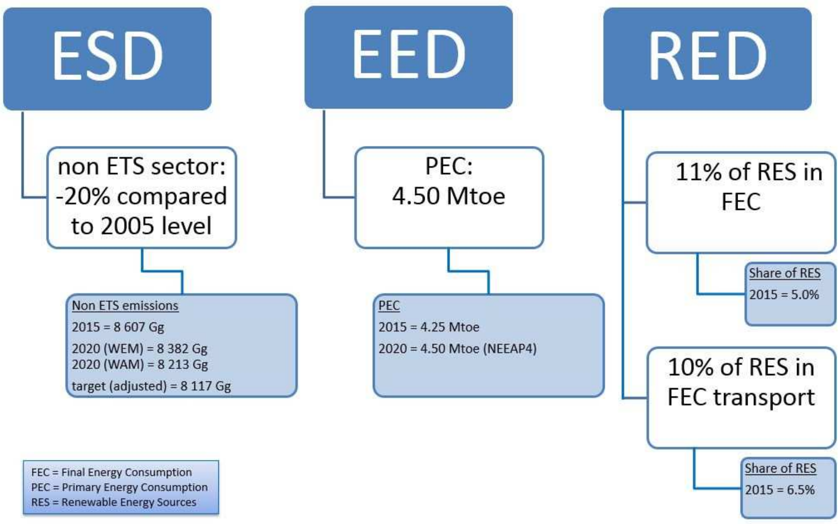
Energy efficiency

The Energy Efficiency Directive No 2012/27/EU[135] (EED) establishes a common framework of measures for the promotion of energy efficiency within the EU in order to ensure the achievement of the associated headline target. The EED also covers the obligation on each Member State **to set an indicative national energy efficiency target in the form they prefer** (e.g. primary/final savings, intensity, consumption) and to regularly report National Energy Efficiency Action Plans (NEEAPs) to the European Commission. Luxembourg's primary energy consumption target for 2020 under Article 3(1) of the EED is 4.5 Mtoe.[136]

Here too, the goals set for and by Luxembourg in the framework of the RED and the EED will be particularly challenging, for the same reasons as those for the Kyoto Protocol.

Figure IV.1-4 summarizes the "Climate & Energy package" related objectives for Luxembourg.

FIGURE IV.1-4 – "2020 CLIMATE & ENERGY PACKAGE" – OVERVIEW OF LUXEMBOURG'S OBJECTIVES



Source: MDDI-DEV.

[134] Source: Eurostat, energy statistics under Directive 2009/28/EC produced using the SHARES tool (updated 14.03.2017) (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_ind_335a&lang=en).

[135] Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC (http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02012L0027-20130701&from=EN).

[136] See https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive. Latest energy statistics report a volume of 4.25 Mtoe for the primary energy consumption in 2015 *[→ Table II.6-1 – TJ converted in Mtoe]*. Consequently, Luxembourg's target under the EED is higher than the consumption reported for 2015 and should remain slightly above the projected 2020 consumption as estimated in the latest National Energy Efficiency Action Plan (NEEAP) submitted to the European Commission. Analysing the forecasts up to 2020, one can see increasing estimates for buildings – whether residential, commercial or institutional – as well as for agriculture. Industries and road transportation related consumption are expected to stabilise to their 2015 level according to the latest NEEAP.

IV.1.1.3. The EU "2030 Climate & Energy framework" and the Paris Agreement

Looking beyond 2020, a "**2030 Climate & Energy framework**" was adopted by EU leaders in 2014 [European Commission (2014)]. This builds upon the "2020 Climate & Energy package", and is in line with the EU long-term goal of reducing Europe's GHG emissions by 80% by 2050, compared with 1990 levels, as outlined in the EU long-term low-carbon economy and energy roadmaps [European Commission (2011a) & (2011b)].[137] The "2030 Climate & Energy framework" endorses a binding EU target of an **at least 40% domestic reduction in GHG by 2030 compared to 1990**. Across the EU, compared to 2005 levels, this correlates to, at least, a collective 43% reduction in EU ETS sectors and a 30% reduction of non-ETS/ESD sectors. For the latter, the methodology for setting the national reduction targets is still based on Member States relative GDP per capita, as for the 2020 targets, but for Member States with a GDP per capita above the EU average the targets will be adjusted relatively, to reflect cost-effectiveness in a fair and balanced manner. All Member States will contribute to the overall EU reduction in 2030, with the targets ranging from 0% to - 40%, compared with 2005 levels. According to these criteria, **Luxembourg**, together with Sweden, will have again the highest reduction target amongst Member States, i.e. **- 40%**.[138]

The "2030 Climate & Energy framework" also includes binding 2030 energy targets at EU level: (i) to increase the **share of renewables to at least 27% of EU energy consumption** and (ii) **to improve energy efficiency to at least 27%**.[139] However, neither the renewable energy target nor the energy efficiency target will be translated into nationally binding targets. Individual Member States are free to set their own higher national targets.

These 2030 targets were submitted to the UNFCCC on March 6, 2015 as **EU's joint intended nationally determined contribution** (INDC) for the **Paris Agreement**.

IV.1.1.4. The EU 2020 reduction targets under the Convention and under the Kyoto Protocol

As the EU system in place aims at meeting the pledge under the Convention as well as the legally binding quantified emission limitation and reduction commitment for the second commitment period of the Kyoto Protocol (CP2), it is worth underlining the slight discrepancies between these two international commitments. ***Table IV.1-1*** depicts all relevant GHG reduction targets for the EU, and further its Member States, as well as their key facts.

137 For more details see https://ec.europa.eu/clima/policies/strategies/2050_en and https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/2050-energy-strategy. An overall framework covers the climate and energy initiatives: the "Clean Energy for All Europeans Package" adopted on 30 November 2016: https://ec.europa.eu/energy/en/news/commission-proposes-new-rules-consumer-centred-clean-energy-transition.

138 For more details see https://ec.europa.eu/clima/policies/effort/proposal_en.

139 This target will be reviewed in 2020, to evaluate whether it should be increased to 30%.

TABLE IV.1-1 – OVERVIEW OF THE EU 2020 TARGETS UNDER THE CONVENTION AND UNDER THE KYOTO PROTOCOL (CP2) (Source: European Commission)

	International commitments			EU domestic legislation	
	Kyoto Protocol		UNFCCC	"2020 Climate & Energy Package"	
				EU ETS	ESD
Target year of period	First commitment period – CP1 (2008-2012)	Second commitment period – CP2 (2013-2020)	2020	2013-2020	2013-2020
Emission reduction target	- 8%	- 20%	- 20%	- 21% compared to 2005 for ETS emissions	Annual targets by MS 2020: - 10% compared to 2005 for non-ETS/ESD emissions
Further targets	-	-	Conditional target of - 30% if other Parties take on adequate commitments	RED: 20% share of renewable energy of gross final energy consumption EED: increase energy efficiency by 20%	
Base year	1990 and KP flexibility rules (Art 3(5)) regarding F-gases and economies in transition	1990, but subject to flexibility rules 1995 or 2000 may be used as the base year forNF_3	1990	1990 for overall emission reduction target; 2005 for renewable energy and energy efficiency target; as well as for targets broken down into ETS and non-ETS emissions	
LULUCF	Includes ARD and other activities if elected	Includes ARD and forest management, other activities if elected (new accounting rules)	Excluded	Excluded	
Aviation	Domestic aviation included International aviation excluded	Domestic aviation included International aviation excluded	Aviation in the scope of the EU ETS included. In practice total aviation emissions considered	Domestic and international aviation included, as in the scope of EU ETS	Aviation generally excluded, some domestic aviation included (operators below ETS *de minimis* thresholds)
Use of international credits	Use of KP flexible mechanisms subject to KP rules	Use of KP flexible mechanisms subject to KP rules	Subject to quantitative and qualitative limits	Subject to quantitative and qualitative limits *[→ Section IV.1.2]*	Subject to quantitative and qualitative limits*[→ Section IV.1.2]*
Carry-over of units from preceding periods	Not applicable	Subject to KP rules including those agreed in the Doha Amendment	Not applicable	EU ETS allowances can be banked into subsequent ETS trading periods since the second trading period	No carry-over from previous period
Gases covered	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, NF_3	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6[140]	
Sectors included	Annex A of KP (Energy, IPPU, agriculture, waste), LULUCF according to KP accounting rules for CP1	Annex A of KP (Energy, IPPU, agriculture, waste), LULUCF according to KP accounting rules for CP2	Energy, IPPU, agriculture, waste, aviation in the scope of the EU ETS	Power & heat generation, energy-intensive industry sectors, aviation (Annex 1 of ETS directive)	Transport (except aviation), buildings, non-ETS industry, agriculture (except forestry) and waste
GWPs used	IPCC SAR	IPCC AR4	IPCC AR4	IPCC AR4	

140 In its third trading period, the EU ETS however only covers the gases CO_2, N_2O, CH_4 and C_2F_6.

IV.1.2. National approach to climate change mitigation and adaptation: an historical overview since 1990 …

Climate change has been a policy issue of the highest importance in Luxembourg for many years.

Mitigating GHG emissions

The **first climate policy objectives for Luxembourg** were adopted in **1990** when the Government decided on a stabilization target for CO_2 emissions by 2000 at their level in 1990, and a 20% reduction target for CO_2 emissions by 2005.[141] The climate strategy has been gradually developed since then, primarily within the framework of policy decisions on the environment, energy and transport.

Many of the policy instruments in Luxembourg's climate policy have been introduced and gradually tightened up since the 1990's. A "**National Strategy for reducing GHG emissions**" was adopted in **May 2000** and outlined how Luxembourg intends to meet its reduction potentials. The strategy identified six areas for action: renewable energies, energy production efficiency, energy savings, "green taxation", transportation, and co-operation with developing countries and countries in transition. This was followed by regulations instituting subsidies for the rational use of energy and the promotion of renewable energy sources. A ministerial working group, headed by the Ministry of the Environment, was set up to evaluate progress of measures implemented at national and Community level.

The Ministry/Department of the Environment engaged, and still engages, consultants with expert skills to conduct some of the GHG inventory related tasks, reporting and other requirements in the area of climate change. During autumn 2005 until spring 2006, with the help of these consultants, workshops were organized by the Ministry of the Environment, with stakeholders' involvement, in order to evaluate Luxembourg's national GHG emissions reduction potentials and with the view to develop a new Action Plan.

This first national "**Action Plan for reducing CO_2 emissions**" was adopted by the Government in **April 2006**, and presented to the public in May 2006 [Ministry of the Environment (2006b)]. It outlines how Luxembourg intends to meet its emission reduction commitments under the Kyoto Protocol and identifies two major goals: (i) limiting dependence on fossil fuels, especially by accelerating their replacement through renewable energy sources (in particular, for thermal energy generation), and (ii) seeking energy savings by enhancing the energy efficiency of transportation, industry and buildings. It called for regulatory measures and also voluntary economic instruments, public awareness campaigns, training and counselling, as well as the use of the "flexible

141 If the intermediary target for 2000 was encountered and even exceeded, the 2005 goal was not reached, mainly because of road fuel sales and power generation (see Section III.1.1 for instance).

mechanisms".[142] This first Plan stressed that resorting to "flexible mechanisms" cannot be avoided in Luxembourg – even at a rather large scale – since preparatory workshops concluded on the fact that the country presents limited national GHG reduction potentials: no power plants running old technologies or using carbon-intensive fuels that could be replaced, "road fuel sales to non-residents", etc. *[→ Section II.12]*.

Alongside the first "Action Plan for reducing CO_2 emissions", and in the wake of an initial "**National Allocation Plan for GHG emission allowances**" (NAP) covering the years **2005-07**, i.e. the 1st trading period under the EU ETS scheme **2005-07** [Ministry of the Environment (2004)], a second NAP was adopted for the period **2008-12**, pursuant to Directive 2003/87/EC, and was notified to the European Commission in 2006 – 2nd trading period [Ministry of the Environment (2006a)]. For the 3rd trading period under the EU ETS, i.e. the period **2013-2020**, Luxembourg notified to the European Commission the amount of free allowances to be distributed amongst the selected installations *[→ Section IV.1.1.2 – EU ETS emissions]*.[143]

The Government that came out from the general elections in **June 2009** clearly indicated that climate change mitigation and adaptation remains a central issue. Under its term in office, two main activities were lead:

- as for other EU Member States, and further to the EC white paper on adaptation to climate change [European Commission (2009)], Luxembourg prepared a **national adaptation strategy on climate change** that has been adopted by the Government in **June 2011** *[→ Section VI.3]*;
- to cope with the ambitious 2020 targets and commitments decided for Luxembourg in the EU context *[→ Section IV.1.1.2]*, a **second** "**Action Plan for reducing CO_2 emissions**" has been presented in **May 2013** [Ministry of Sustainable Development and Infrastructure, Department of the Environment (2013b)].

These two main actions have been co-ordinated by the Department of the Environment in conjunction with a **governmental task-force** gathering the competent Ministries and Administrations.

At that time, the Government also reiterated its intention to reduce the post-2012 GHG emissions by using national PaMs but, due to its national circumstances, also "flexible mechanisms" and the exchange of emission permits between countries. However, it was stressed that the projects under CDM and JI had to comply with the ecological and social criteria established in the framework of the approval procedures of the UNFCCC and to the specific criteria defined by the national

142 For more information on the first Action Plan, see Ministry of Sustainable Development and Infrastructure, Department of the Environment (2010), Box VI.1-1, p. 148.

143 For more information on the 3rd period, see http://www.environnement.public.lu/air_bruit/dossiers/CC-systeme_d_echange_de_quotas_ETS/index.html.

committee in charge of managing the Kyoto Mechanisms Fund – the "Climate & Energy Fund" *[→ Section V.6.3]*.

On the basis of the consensus and dialogue approach favoured in Luxembourg *[→ Section II.1]*, the Minister for Sustainable Development and Infrastructure announced, end 2009, that it was foreseen to consult a vast number of stakeholders – Ministries, Administrations, local authorities, workers and businesses associations, NGOs – for discussing climate change and sustainable development in Luxembourg. Consequently, in **February 2010**, the Government Council gave its approval for the launch of the "***Partenariat pour l'Environnement et le Climat***" ("Environment and Climate Partnership"), bringing together several stakeholder representatives to discuss climate change and sustainable development issues. The objective of the "Environment and Climate Partnership" consisted in the elaboration of:

- a first "**National Adaptation Strategy on Climate Change**" *[→ Section VI.3]*;
- a "***Pacte Climat***" (Climate Agreement), ensuring the collaboration with municipalities on climate matters *[→ Section IV.3.1.1]*; and
- a second "**Action Plan for reducing CO_2 emissions**" (see Box IV.1-2).

In order to cover the whole scope of intervention, five thematic working groups were created under the Partnership with the aim of building a "Climate Change & Sustainable Development" package of PaMs that could be accepted, hence implemented, by all stakeholders and citizens. The five themes were:

1. urban planning, housing & construction;
2. mobility;
3. energy & eco-technologies;
4. biodiversity, forest, water & agriculture; and
5. international aspects and impacts of climate change.

In **May 2011**, the "***Paquet Climat***" (Climate Package), consisting in a synthesis document summarising the work of the Partnership and a **catalogue of 35 priority measures**, was adopted by the Government Council. The catalogue has been compiled by the Department of the Environment following a request from the Steering Group ("*Groupe de Pilotage*") of the "Environment and Climate Partnership". The Steering Group asked the Department of the Environment to compile proposals from the five working groups into one document in order to facilitate the objectives and content of the second national "Action Plan for reducing CO_2 emissions".

The selection of these 35 priority measures (details in Box IV.1-1.) rested upon two selection criteria. Firstly, measures that could affect the 2012 state budget and secondly, measures that would request some legal texts and arrangements and that, therefore, had to be initiated as soon as possible due to a legislative process that might be quite long.

Box IV.1-1 – 35-priority measures catalogue – *Paquet Climat*

Measures - urban planning, housing & construction

sub-theme construction

1. (1) combining & streamlining the financial subsidies for functional buildings; (2) adapting energy efficiency criteria; monitoring & checking of the financial subsidies efficiency; (3) increasing the means, both human & financial, for the improvement of the energy efficiency of public buildings.
2. promoting evaluation systems with regard to sustainable construction of functional buildings.
3. monitoring & disseminating the energy consumption of public & private buildings.

sub-theme housing **(1)**

4. in close cooperation with the construction sector, progressive strengthening of energy efficiency requirements for new residential buildings. The targets are C/B energy norm in 2012, then reinforcement every two years to reach an “almost zero” energy consumption for new residential buildings by 2018. For the energy still needed, offering incentives to use renewable energy sources.
5. for both private and public developers, adapting financial subsidies & supports for high-energy efficient buildings construction, as well as for existing buildings energy efficiency improvement works (some of this measures are part of the “Housing Package”): (1) reinforcing links between subsidies schemes & the “energy efficiency certificate” (http://www.guichet.public.lu/fr/citoyens/logement/construction/performances-energie/demande-passeport-energetique/index.html); (2) introducing an ecological certification on top of the “energy efficiency certificate”; (3) revising the social criteria for those households which are the most financially vulnerable and that therefore could benefit from zero-rate loans e.g. for improving the energy efficiency of their accommodation.
6. taxes: (1) linking the existing notarial deeds reductions – offered in case of a first purchase or construction of an accommodation by an individual – with the energy efficiency of the new or existing construction; (2) develop “green taxation” schemes.
7. defining & implementing a legal framework for the “Housing Sector Plan” (http://amenagement-territoire.public.lu/fr/plans-caractere-reglementaire/plans-sectoriels/logement.html).

sub-theme urban development

8. streamlining municipal buildings regulations and links those with sustainable development criteria.
9. raising awareness on the objectives of a sustainable urban development at all levels.
10. creating a database grounded on the information collected via the PAP (“*Plans d’Aménagement Particuliers*” – local land-use planning) and linking this information with the existing overarching land-use planning instruments (sector plans: http://amenagement-territoire.public.lu/fr/plans-caractere-reglementaire/plans-sectoriels.html & IVL: http://www.mt.public.lu/planification/concept_dev_spatial/index.html).

Measures – mobility **(2)**

11. streamlining land-use planning and mobility developments approaches.
12. increasing public transport infrastructure: tramway in Luxembourg-city, connection train-tramways in new suburban train stations to be constructed, increasing Park & Ride capacities, etc.).
13. implementing as soon as possible the concept of “parking places offer management” in urban areas: adapting parking places offered in new residential condominiums with the existing public transport offer.
14. continuing to promote non-motorized mobility (“*mobilité douce*” – “*MoDu”*), notably by subsidies to buy electrical bicycles e.g.
15. promoting electro-mobility (electrical cars): (1) subsidies for both households & enterprises; (2) starting pilot projects; (3) setting up a global concept for the electro-mobility.
16. promoting & setting-up car-sharing systems through pilot projects using low-emission vehicles, etc.
17. analysing whether carpooling could be further developed and promoted, especially through reserved parking places in Park & Ride.

18. going on with the offered subsidies for the acquisition of low-emission passenger cars – "CAR-e": http://www.car-e.lu/ **(3)**.

19. re-examining vehicle annual tax for high emitting passenger cars.

20. re-examining fiscal arrangements for company cars provided to the employees & workers (adaptation of the fiscal deductions to the CO_2 emissions of the vehicles).

21. gradually increasing road fuels excise rates following a cautious approach based on a better knowledge of the factors determining road fuel sales in Luxembourg that also takes into account the impacts on the public finances of the country.

Measures – energy & eco-technologies

sub-theme energy

22. examining and, if necessary, adapting the various subsidies & feed-in tariffs schemes in place with the view of a further development of energy savings & renewable energy use (households, enterprises, public sector, and agriculture).

23. increasing the use of biomass as an energy source (wood, green waste & leftovers, sewage sludge, agricultural waste & leftovers).

24. examining further developments of tools such as eco-discount & eco-loans at a zero rate that are foreseen by the "Housing Package" (see also measure n° 5).

25. fighting against energy precariousness (landlords & tenants): (1) specific financial supports for people with a very low revenue; (2) accelerated fiscal depreciation opportunities for investments aiming at increasing energy efficiency of rented accommodations; (3) adaptation of the rental law (see also measure n° 5).

26. setting up pilot projects for "*Energieinsparcontracting*" and, if conclusive, promoting this tool.

27. enterprises: (1) increasing energy efficiency in the enterprises; (2) reflecting on the possibility to use part of the emission rights (EU ETS) auctioning revenues for that objective.

sub-theme eco-technologies

28. (1) increasing public subsidies for promoting eco-technologies & sustainable development in enterprises; (2) linking energy policy measures with industry policy measures with the aim of reinforcing the role of Luxembourg in the eco-technologies field; (3) helping & pushing enterprises towards international markets, and in participating to international projects oriented towards renewable energy production & GHG emissions reduction; (4) increasing & implementing sustainable development criteria in public procurements.

Measures - biodiversity, forests, water & agriculture

29. promoting & implementing a legal framework for agro-forestry.

30. optimising carbon sinks in forests & in derived products, notably by promoting forestry plantations, which increase both carbon storage and the production of goods with a long-term time span (woodwork, construction).

31. increasing soil quality for reducing soil erosion risks and, at the same time, increasing biogenic carbon storage.

Cross-cutting measures

32. information, awareness raising, advices & assistance, training (non-exhaustive):

    ► WG1 – (1) increasing information, awareness raising, advices & training with regard to energy efficiency & renewable energy sources; (2) reinforcing *myenergy* activities **(4)**; (3) setting up an assistance network at national level in collaboration with the municipalities; (4) increasing the communication to the citizens on the state subsidies offer; (5) developing pilot projects using "best-practices" guidelines; (6) creating an exchange platform to be used by the construction stakeholders; (7) extending the energy efficiency, renewable energy sources & ecological construction training offer, and adapting this offer to the targeted audience; (8) awareness raising programs on indirect effects (comfort, increased value of the good, etc.) of higher energy efficient buildings (new construction & renewal projects) targeted to supervisors & landlords.

► WG2 – (1) promoting public transport via targeted campaigns; (2) extending telematics systems for public transports (real time route information, setting up of an intermodal platform); (3) promoting car-sharing & carpooling; (4) proposing a mobility policy ecological label to enterprises; (5) including the theme "ecological transport modes" in the national Strategy on Education for Sustainable Development.

► WG3 – (1) extending information, awareness raising, advices & assistance on energy efficiency & renewable energy sources (see also suggested measures from WG1); (2) reinforcing the support to enterprises; (3) promoting pilot projects; (4) using further "green electricity" via awareness raising campaigns & a forerunner role played by the public sector.

33. to better evaluate the impacts of our PaMs, increasing & systemizing monitoring activities on energy consumption & GHG emissions from the various economic sectors & from the households.

34. following-up the implementation of the national "Action Plan for reducing CO_2 emissions", in association with the Steering Group.

Climate Agreement ("Pacte Climat") with the municipalities **(5)**

35. implementing this Agreement with the municipalities so to offer a legal, technical & financial reference framework which should help these municipalities to act against climate change: (1) carrying on the financial support scheme from the State to the municipalities for the achievement of projects relating to the environment, notably by adapting the criteria of the financial tool used by the State, i.e. the "*Fonds pour la Protection de l'Environnement*" ("Environment Protection Fund") and by increasing its resources (both will require a revision of the Law that created this tool); (2) applying a certification system – based on the "European Energy Award" – to evaluate & acknowledge the municipalities performances that will be used as a basis for offering extra financial resources (the latter requiring to precisely define, via a Regulation, the conditions under which the extra resources will be granted to the municipalities): http://www.pacteclimat.lu/.

(1) measures 11 to 17: see also Box IV.1-5 for the "MoDu" strategy.
(2) see Section IV.3.1.1 for the "PRIMe House" scheme.
(3) "CAR-e" scheme: see [Ministry of Sustainable Development and Infrastructure, Department of the Environment (2014a), Box IV.3-2].
(4) *myenergy*: see Box IV.1-9.
(5) *Pacte Climat*: see Section IV.3.1.1.

The above catalogue was the result of a close consultation between the Ministry of Sustainable Development and Infrastructure as well as the Ministries of Finance and Economy in order to simplify the set up of the second "Action Plan for reducing CO_2 emissions". After publication of this catalogue, the Government Council tasked the Minister and the delegated Minister for Sustainable Development and Infrastructure with:

- the organisation, together with the Commission of Sustainable Development of the Parliament, of a consultation debate in the Parliament (this debate took place in **June 2011**);
- the elaboration of the second Action Plan in reference to the synthesis document and the priority measures catalogue, further to the above mentioned debate;
- the immediate launch of the implementation of the priority measures in cooperation with the other concerned ministerial departments in consideration of the budget calendar constraints.

A first draft of the second Action Plan was discussed by the Steering Committee of the Partnership in **October 2011**. Observations of other parties were mostly incorporated in the document. The announcement of the Secretariat of the UNFCCC end of 2011, that Luxembourg's 5th National Communication would undergo an in-depth review by a group of experts, led the Department of the Environment to postpone the finalisation of the Action Plan in order to incorporate the recommendations of the review. The final version of **May 2013** [Ministry of Sustainable

Development and Infrastructure, Department of the Environment (2013b)], is therefore the result of a close consultation with other concerned ministerial departments. As details provided in Box IV.1-2 show, the second "Action Plan for reducing CO_2 emissions" focuses on the continuation of the PaMs already put into place or planned in the context of the Kyoto commitment and is the **main tool Luxembourg has at its disposal to comply with the EU "2020 Climate & Energy package" commitment** that was assigned to the country, the "ESD target" *[→ Section IV.1.1.2]*. In this second Plan, actions are mainly driven by increasing energy efficiency in all sectors as well as by promoting the use of renewable energy sources – in Luxembourg: biomass, solar energy, windmills, hydro-electricity, geothermic installations. These actions also take their place in the context of "green economy" and "green growth" that the Government advocated in its 2009 Programme.

Box IV.1-2 – the second "Action Plan for reducing CO2 emissions" – main measures & actions

1.1 – Reinforce production and implementation of renewable energies

01 Review and adaptation of existing financial support systems (new financial support "PRIMe House" **(1)**, achieving better visibility for subsidies directed to SMEs and industries).

02 Adaptation of compensation mechanisms for electricity supply from renewable energy sources through regulation, tariff adjustment and promotion of heat recovery.

03 Financial compensation for the supply of biogas in the natural gas grid through regulation.

04 Conception of a targeted promotion for the use of biomass.

1.2 – Increase energy efficiency and decrease energy consumption

05 Specification and implementation of a legal frame for the "Housing Sector Plan".

06 Redevelopment and simplification of the financial support system in case of old-building renovation and new constructions in the residential area, through fundamental assessment of measures for renovation and adjustment of financial support for new constructions **(1)**.

07 Encourage energy efficient renovation of public buildings by increasing financial means and transposing of the Energy Efficiency Directive No 2012/27/EU.

08 Monitoring energy consumption of public buildings through a measuring concept and data analysis.

09 Reinforce "construction standards" for new commercial and services buildings.

10 Implementing incentives to cover residual households' energy needs by renewable energy sources.

11 Standardisation of the provisions for deploying energy efficiency and the use of renewable energy sources in municipal buildings

12 Linking building construction and renovation to sustainable development criteria **(1)**.

13 Faster depreciation of the investments concerning energy efficient renovation through regulation.

14 Promoting and fostering electro-mobility through regulations, including financial support.

15 Promoting and fostering natural gas mobility.

16 Adjustment of "CAR-e" bonus for electro-cars **(2)**.

17 Increase energy efficiency in private companies through voluntary agreements, awareness rising, information and guidance, pilot projects.

18 Increase energy efficiency in companies under the EU ETS through a voluntary agreement scheme (FEDIL), and energy efficiency measures financed by EU ETS public revenues.

19 Application of sustainability criteria for public procurement and during the whole planning process through fixed guidelines and continuous monitoring.

2.1 – Focus on eco-technologies and R&D	
20	Promoting eco-technologies in the fields of invention and innovation.
2.2 – Shape the mobility of tomorrow **(3)**	
21	Integrative und structured spatial development through regulation, mobility strategy, sector roadmaps, Government-municipalities conventions.
22	Promotion of cycling and walking ("*mobilité douce*") through regulation and integration in regional planning.
23	Reorganisation of the public transport as part of the national mobility strategy.
24	Development and improvement of the public transport infrastructure.
25	Management of parking space in urban regions.
26	Promotion of intermodal transport (private-public transport).
27	Improvement of transboundary mobility.
28	Promotion of alternatives to passenger cars.
2-3 – Reform the tax system in a sustainable way	
29	Analysis for a revision of car taxation.
30	Analysis for a revision of company car taxation.
31	Increase in excise duties taking into account impact on public finances.
2.4 – Development of efficient and socially equitable financial devices	
32	New forms of promotion/appeal devices (e.g. by implementing a "zero rate eco-loan").
33	Improve renovation opportunities for rented apartments through regulation **(1)**.
34	Analysis of environmentally harmful subsidies and setting-up of a regulatory framework for those subsidies.
2.5 – Improvement of information, communication and decision-making	
35	Capacity adaptation at *myenergy* **(4)** through higher financial framework and additional communal climate experts.
36	Support of municipal capacities through higher financial framework and secondment of climate experts for implementing the Climate Agreement **(5)**.
37	Extend the "Environment and Climate Partnership" to a "Sustainability Commission" through regulation.
38	Improvement and systematisation of data collection concerning energy consumption and emissions development in diverse sectors.
39	Improvement and systematisation of data collection concerning energy consumption and emissions development in municipalities.
40	Evaluation of the second national "Action Plan for reducing CO_2 emissions".
41	Expansion of the offer for training and education on energy efficiency, renewable energies and ecological construction; in connection with additional specific possibilities for competencies certification (artisans, energy advisors).
42	Programmes on awareness rising and specific information for property owners and properties managers about the indirect advantages of energy efficient constructions and renovations (comfort, etc.) with the support of *myenergy* **(4)** and information campaigns.
43	Awareness rising for more energy efficient construction and renovation with support of *myenergy* **(4)**.
44	Pilot project targeting energy advisors who are supporting low-income households in order to reduce their energy and water bills.
45	Use of new communication tools to increase attractiveness for public transport.

46 Installation and development of a traffic telematics system for public transport.

47 Introduction of an "ecological mobility label for companies.

48 Development of advices and support to industry and SMEs concerning energy efficiency and the usage of renewable energies.

2.6 – Reach an arrangement with municipalities with regard to the Climate Agreement

49 Reach an arrangement with municipalities with regard to the Climate Agreement **(5)**.

2.7 – Develop a "National Adaptation Strategy on Climate Change"

50 (amongst other things) Development and application of a legal frame for the promotion of agro-forestry.

51 (amongst other things) Optimisation of forest carbon storage and optimisation of carbon storage in cultivated (grown) land, increase of organic carbon resulting in a structural improvement of soil stability and a reduction of the risk of erosion

The whole document can be found under the following link, where measures and actions presented in this Box are listed on page 21 to 35: http://www.environnement.public.lu/actualites/2013/05/plan_action_climat/index.html.

(1) see Section IV.3.1.1 for the "PRIMe House" scheme.
(2) "CAR-e" scheme: see [Ministry of Sustainable Development and Infrastructure, Department of the Environment (2014a), Box IV.3-2].
(3) measures 21 to 27: see also Box IV.1-5 for the "MoDu" strategy.
(4) *myenergy*: see Box IV.1-9.
(5) *Pacte Climat*: see Section IV.3.1.1.

Adaptation to climate change

Whereas climate change is an inescapable truth, it is first a question of limiting the extent of these changes. "Action Plans for reducing CO_2 emissions" constitute the red wire of the national climate change policy. However, adaptation to climate change is an essential complement to prepare our societies for a changing climatic environment.

For that reason, besides the second "Action Plan for reducing CO_2 emission", the elaboration of a national "Climate Change Adaptation Plan" was planned since 2009. But before a concrete action plan could be put in place, it was necessary to develop a strategy with the objective to enable the country to face under the best possible conditions the consequences of climate change, to limit the vulnerability of the society and nature towards these changes and to benefit, if necessary, of opportunities which would rise from a changing environment. It is in this context that the first **national adaptation strategy on climate change** has been implemented by the "Environment and Climate Partnership" in May 2011 and adopted by the Council of Ministers in **June 2011** *[→ Section VI.3]*.

IV.1.3. … and plans ahead

Mitigating GHG emissions

In the **first half of 2018**, the Government plans to adopt its **third national "Climate Plan",** which will be the **main policy instrument with regard to the 2030 GHG related targets** that have been assigned to Luxembourg *[→ Section IV.1.1.3]*. This Plan will be a **strategic document** rather than a detailed listing of individual PaMs. What is expected by the **coming summer** is (i) an overall strategy presenting a general guidance and orientation for Luxembourg's climate change policy up to 2030 but also beyond, i.e. up to 2050 and, (ii) a proposal on how to structure and organize this policy – "governance". Obviously, this Climate Plan will also serve as a long-term policy strategy in accordance with the relevant provisions of the Paris Agreement.

The strategic document will define the objectives of Luxembourg's GHG mitigation policy as well as identify the (economic) opportunities of such a policy, at both horizons, i.e. 2030 and 2050, when major decarbonisation of the national economy is anticipated. It will cover the following sectors:

- housing/buildings (residential and non-residential);
- transport;
- economy (non-ETS industry, craft industries, retail, services);
- energy supply;
- agriculture and nutrition.

and the following cross-cutting issues:

- public finance;
- land planning;
- the Climate Agreement with municipalities *[→ Section IV.3.1.1]*.

In this context, **stakeholder consultations** are planned during the first quarter of 2018. The format of the consultations will however differ from the "Environment and Climate Partnership" held in view of the preparation of the second plan. Firstly, a **two-day "co-creation" process called "Climate Innovation Lab"** aims to come up with innovative ideas with regard to climate change mitigation and management policies in Luxembourg. For this event, along citizens and representatives from the youth, a large number of selected stakeholders were invited according to their professional involvement in the different key sectors identified for the preparation of the strategic document. It will be followed by a further co-creation event called **"Climate Policy Lab"** dedicated specifically to climate policy governance.[144] Both events are scheduled for early 2018 and their respective outcomes will contribute to the draft climate plan that will be presented to and discussed with other Ministries and Administrations, NGOs and professional chambers as well as other stakeholders. It

[144] http://wakeupweekend.lu/fr/fr.html.

is foreseen that, upon conclusion of these consultations, the final version of the strategic document will be **adopted by the Government before the 2018 summer break**.

The third "Climate Plan" will feed into comprehensive integrated "**National Energy and Climate Plan**" (NECP) as required by the future EU regulation on the Governance of the Energy Union and Climate Action.[145]

Adaptation to climate change

A revision and extension of the first **national adaptation strategy on climate change** is expected to be finalized during the year 2018 *[→ Section VI.4]*.

General context

Both the mitigation strategy/plan and the adaptation strategy are being **developed in the wider context of international, European and national strategies**:

- international – the **Paris Agreement**;[146]
- international – the **United Nations 2030 Agenda for Sustainable Development** and its **17 Sustainable Development Goals** (SDGs);[147]
- EU – the "**2030 Climate & Energy framework**" [European Commission (2014)] and associated longer term perspectives set out in the Roadmap for moving to a competitive low carbon economy in 2050 [European Commission (2011a)], the Energy Roadmap 2050 [European Commission (2011b)] and the Transport White Paper European Commission (2011c)];
- EU – the European Commission proposal of a **Regulation on the Governance of the Energy Union and Climate Action** (including NECPs);
- EU – the European Commission proposals (i) for an **Effort Sharing Regulation 2021-2030** (ESR)[148] and (ii) on the **inclusion of GHG emissions and removals from land use, land use change and forestry** (LULUCF) into the "2030 Climate & Energy framework";[149]
- EU – the **Energy Efficiency Directive** (EED) and its associated National Energy Efficiency Action Plans (NEEAPs). Luxembourg's 4th NEEAP has been submitted to the European Commission in June 2017 [Ministry of the Economy (2017)][150] *[→ Section IV.1.1.2]*;
- national – the "**Third Industrial Revolution Strategy Study**" [The Third Industrial Revolution Consulting Group LLC, 2016] that takes a cross-disciplinary approach to the future development of Luxembourg, combining social, cultural, and environmental narratives with

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145 For more details on this process, see https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/governance-energy-union.

146 http://unfccc.int/paris_agreement/items/9485.php.

147 http://www.un.org/sustainabledevelopment/.

148 https://ec.europa.eu/clima/policies/effort/proposal_en.

149 Both texts are in "trilogue" discussions.

150 English version will be available here: https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive/national-energy-efficiency-action-plans.

economic theory and business practices, with the goal of reconceiving economic development within a larger frame of "quality of life." (see Box IV.1.3);

- national – the second "**National Sustainable Development Plan**" [Ministry of Sustainable Development and Infrastructure, Department of the Environment (2010b)] and the on-going work on the **implementation of the Agenda 2030** in Luxembourg [Ministry of Sustainable Development and Infrastructure, Department of the Environment (2017)]. The actual Government puts sustainable development in the frontline of its Programme [Government of the Grand Duchy of Luxembourg (2013), p. 4]. Political decisions at a sector level have to be in line with the principles of sustainability and comply with the priorities and objectives decreed in the plan, as well as with those presented in the report on the implementation of the Agenda 2030 (see Box IV.1-4);
- national – the on-going **scientific advice on the 2030 energy and climate strategy** of Luxembourg, i.e. a study aiming at identifying and defining the best energy options to comply with the proposed energy targets under the "2030 Climate & Energy framework", as well as with other implemented requirements under the Energy Union. For the latter, this study will also offer assistance on drafting the NECP for the period 2021 to 2030. Conclusions and proposals coming out from this work are expected during the first semester of 2018.

Box IV.1-3 – The Third Industrial Revolution Lëtzebuerg– TIR

The "Third Industrial Revolution Strategy Study" – in brief TIR – is a joint project, launched in September 2015 by the Ministry of the Economy, the Chamber of Commerce of the Grand Duchy of Luxembourg and IMS Luxembourg **(1)** and realized in close collaboration with the American economist-prospectivist Jeremy Rifkin and his team of international experts (the Third Industrial Revolution Consulting Group LLC). The TIR is a process characterized by the transition to a new economic model defined in particular by the coupling of information technologies, renewable energies and intelligent transport networks. Luxembourg has evolved at all these levels in recent years, notably through its policy of economic diversification, its investments in digital infrastructure and its various action plans for energy efficiency or the promotion of renewable energies.

Taking into account the socio-economic specificities of the country, this major strategic study was thus intended to foster this momentum and to make the existing economic model more sustainable and interconnected for future generations. The main goal of the joint project was to provide ideas and tools to help Luxembourg, its society and its economy to integrate the "Third Industrial Revolution", which, within an intelligent network of information and communication technologies (ICT), is based on the convergence of opportunities related to digitization, energy transition and alternative mobility. It is essential to be prepared to face these new technologies and disruptive models, to adapt to them, and to assimilate them into business models in order to turn perceived threats into real opportunities.

Spanning a year, the development of the strategic study constituted a real transverse work that was achieved through a "bottom-up" co-creation approach which was implemented in nine working groups operating in the framework of the nine thematic pillars of the TIR project, namely: "Energy", "Mobility", "Building", "Food", "Industry", "Finance", "Smart Economy", "Circular Economy" and "Prosumers and social model". This approach has enabled the various socio-economic actors' part of the TIR process to get involved in the development of the strategic study and in the drafting of its conclusions.

Thus, through a constructive and participatory approach, the strategic study identified the opportunities, priorities and challenges as well as the operational aspects that accompany the transition to a more sustainable and interconnected economy. Its main outcomes were presented in November 2016. They consist of:

1. a comprehensive and detailed 475 pages study considering the socio-economic characteristics of the country and proposing concrete actions and tools, including a range of strategic measures and projects, to prepare the country, its society and its economy to start the TIR process;
2. a 140 pages summary-synthesis of the study consisting of an introduction presenting the main challenges of the TIR and their economic implications for the country and society, as well as summaries for the nine thematic sections which are containing the quintessence of the identified strategic measures, in particular those that are seen as priorities (5 per theme).

Both reports are available here: http://www.troisiemerevolutionindustrielle.lu/etude-strategique/.

As a follow-up of the TIR, the Government put in place a mode of governance aiming at, on the one hand, discuss and further study possible strategic measures to be taken following the proposals made in the strategic study and, on the other hand, support projects already under way and transpose other recommendations presented in the final report.

The governance model provides thematic platforms, already existing or to be created, in which the study recommendations and projects corresponding to the nine thematic pillars, are analysed and discussed. These platforms allow an exchange and a common understanding of the measures and visions presented in the study. The regulatory, operational and technical aspects related to the transposition of these measures, as well as projects to be carried out, are discussed. Platforms' composition varies according to the themes addressed, the general orientation being public-private partnership, without prejudice to particular cases that might require a different specific approach.

The nine thematic platforms are as follows: the National Council for Sustainable Construction, Energiezukunft Lëtzebuerg, the High Committee for Industry, Circular Economy, Intelligent Mobility, Luxembourg Sustainable Development Finance Platform, as well as Labour, Employment and Social Issues. The platforms are opened to actors from different sectors concerned, the social partners and experts (functional diagram available here: http://www.troisiemerevolutionindustrielle.lu/gouvernance/).

At the level of overall coordination of the process, a Strategic Monitoring Committee has been set up under the leadership of the Minister of the Economy. This structure centralises the work of the thematic platforms and discusses major orientations and major challenges related to future technological changes. In addition, the Strategic Monitoring Committee draws up regular progress reports submitted to the Government, which decides whether measures developed within the thematic platforms will or will not be undertaken.

Concretely, in these nine thematic platforms the work now concentrates on:

1. deploying a "national energy internet", i.e. smart grids and smart meters;
2. promoting electromobility and launching a program for the use of emission-free personal vehicles;
3. gradually introducing the concept introduction of "mobility as a service" i.e. a sustainable mobility ecosystem where citizens, according to a multimodal approach, choose a combination of modes of transport that best suits their daily needs;
4. implementing of a flagship project to demonstrate the socio-economic contribution of smart, sustainable and circular neighbourhoods/cities;
5. establishing a roadmap for sustainable food production based on transparency and trust;
6. developing co-located technology platforms for industry and the public research sector;
7. establishing a sustainable development financing intermediation platform called "Luxembourg Sustainable Development Finance Platform";
8. implementing an infrastructure offering the required capabilities in the field of "High Performance Computing" (HPC);
9. promoting the circular economy concept for public procurement.

Clearly, a majority of these developments and reflections will affect the drafting of the strategic document that will lead to the third national "Climate Plan".

On 9 November 2017, the Minister of the Economy presented a first interim report of the work done so far within each of the platforms: http://www.troisiemerevolutionindustrielle.lu/wp-content/uploads/2017/11/TIR-Rapport-interm%C3%A9diaire-de-suivi-2017.pdf.

Source: Ministry of the Economy.

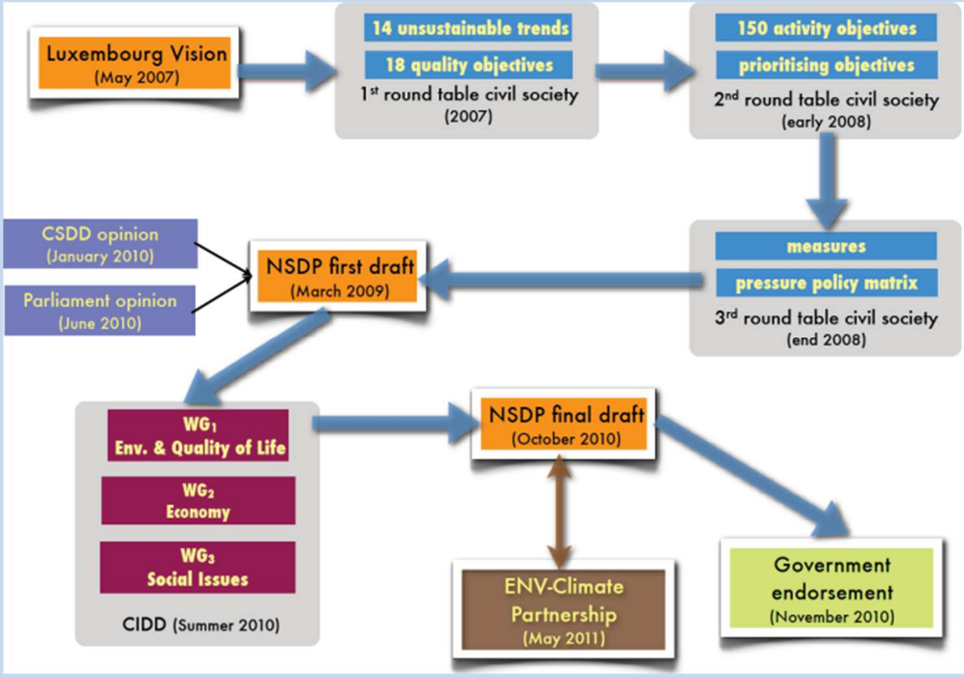
(1) IMS - Inspiring More Sustainability - is the dedicated network that supports organizations in their commitment to Corporate Social Responsibility (CSR) by promoting dialogue with their stakeholders. IMS is an independent non-profit organisation.

Box IV.1-4 – National Sustainable Development Plans – NSDP

NSDP2

Luxembourg's second NSDP (NSDP2) has been adopted by the Government Council on 23 November 2010 and is available here: http://environnement.public.lu/fr/developpement-durable.html. The Plan benefited from comments and inputs from various stakeholders: citizens; NGOs; social, business and environmental organizations; High Council for Sustainable Development (*Conseil Supérieur pour le Développement Durable – CSDD*); Chamber of Deputies): see illustration 1.

Illustration 1 – NSDP2 overall process



The second NSDP has been constructed based on 14 non-sustainable trends identified by an inter-departmental body – the CIDD for *Commission Interdépartementale du Développement Durable* – and on 18 quality objectives to be achieved by 2050. These objectives are intended to be responses to the non-sustainable trends and they come with 148 actions or activity objectives, which are break downed into 415 individual measures: see illustration 2.

Illustration 2 – NSDP2 sequence

Amongst the 14 non-sustainable trends, one relates to climate change – "GHG emissions that does not slow down due to an increasing energy use"**(1)** – and one to transport – "continuous growth of transport flows with adverse consequences on energy consumption, land use and road safety". Another non-sustainable trend that could be linked to climate change related issues is the "important land consumption leading to landscapes fragmentation (...)", which reduces GHG potential sinks. Responses to these trends – the quality objectives – are (i) climate protection by limiting the effects of climate change and its costs through mitigation and adaptation actions; (ii) decoupling between economic growth and transport flows, and (iii) a sustainable land planning.

Turning to actions and measures, NSDP2 makes Luxembourg's post-Kyoto objectives its own – reduce by 2020 GHG emissions by 20% below their 2005 for sectors outside EU ETS; achieve an 11% share of renewable energy in total energy consumption by 2020 – and indicates the first NEEAP objective of improving energy efficiency by 9% by 2016. Most of the NSDP2 measures were actually included in the second national "Action Plan for reducing CO_2 emissions". It also insists on the warning role that the State of Luxembourg could play in the domains of energy efficiency and of renewable energy sources: energetic improvement of state buildings, use of renewable energies in state buildings, new constructions following the "low-energy" and "passive" construction standards (http://www.developpement-durable-infrastructures.public.lu/fr/developpement-durable-infrastructures/plan-national/climat/objectifs-mesures/index.html)

For economy-transport decoupling; NSDP2 lists various measures, some of them being included in the PST. Specific NSDP2 measures are, for instance, the setting-up of a transboundary mobility action plan or the reduction of cross-border commuters flows by encouraging moving in Luxembourg.**(2)** (http://www.developpement-durable-infrastructures.public.lu/fr/developpement-durable-infrastructures/plan-national/transport/objectifs-mesures/index.html)

With regard to communication around the NSDP2, see ***Section IX.1.1***.

NSDP3

Currently, Luxembourg is in the process of elaborating its Third NSDP (NSDP3). This plan will build on Luxembourg's report regarding the implementation of the 2030 Agenda with the 17 Sustainable Development Goals (SDGs) in and by Luxembourg.**(3)** The report, addressing the current state of the existing policies and the global commitments integrating the SDGs, also contributed to the national voluntary review in the margins of the High Level Political Forum of the United Nations in July 2017 in New York. The report was adopted by the Government on 12 May 2017 and is being followed by an in-depth gap analysis based on indicators with recommendations that will be reflected and incorporated into the NSDP3.

Demographic, economic and environmental challenges that occurred during the last decades put pressure on several primary action domains (social inclusion and education for all, diversification and decarbonisation of economy, land use, sustainable mobility, environmental degradation, climate protection) and increase the harmful tendencies, which can affect a sustainable development in Luxembourg. For that matter, several recent flagship initiatives undertaken by the Government addressing these issues have been linked to the SDGs.

Since the implementation of the SDGs is ambitious in itself, Luxembourg plans to strongly implicate youth groups, civil society, private sector, municipalities and schools into the elaboration and implementation process of the NSDP3. The NSDP3 is planned to be finalized for June 2018.

SDG 13 – take urgent action to combat climate change and its impacts – is of course directly linked with GHG mitigation actions. However, when it comes to implement the SDGs, a lot of them may have indirect impacts on GHG emissions. Hence, as for the TIR, developments and reflections on how to implement the SDGs in Luxembourg will influence the drafting of the strategic document that will lead to the third national "Climate Plan".

Source: MDDI-DEV
NSDP2: http://www.luxembourg.public.lu/fr/actualites/2011/06/09-pndd/index.html.
NSDP3: http://www.environnement.public.lu/actualites/2017/05/29_agenda_2030/index.html and http://www.gouvernement.lu/7018389/31-objectifs-millenaire.

(1) nevertheless, GHG emissions recorded in the inventory are declining since 2005 (see Section III.1).
(2) this last measure is part of the "social cohesion" theme under the NSDP2.
(3) *Mise en oeuvre de l'Agenda 2030 au et par le Luxembourg : transformer les vies tout en préservant la planète* (http://www.gouvernement.lu/7018419/rapport_meo_Agenda2030.pdf).

IV.1.4. Other plans and programmes

In addition to the actions and PaMs presented in the two previous sections, other plans and programmes may have co-benefits in terms of climate change mitigation though this is not their first concern. They mostly deal with energy efficiency *[→ Section IV.1.3]* and the use of renewable energy sources, air pollutants emissions and concentrations, road transportation and mobility, agriculture, land planning and preservation of eco-systems. These are listed below (non-exhaustive):

- the "National Renewable Energy Action Plan" (NREAP) [Ministry of the Economy (2010)] that provides detailed roadmaps of how Luxembourg expects to reach its legally binding 2020 target for the share of renewable energy in its final energy consumption. For the 2030 horizon, the above-mentioned scientific advice on the 2030 energy and climate strategy will propose measures and options so to meet the renewable energy objectives enforced on Luxembourg.
  (https://ec.europa.eu/energy/sites/ener/files/documents/dir_2009_0028_action_plan_luxembourg.zip in both German and English)
- the "National Programme aiming at reducing air pollutants" – "*Programme National de Réduction Progressive des Emissions de Polluants Atmosphériques (SO_2, NOx, COV, NH_3)* " – that could have some co-benefits with regard to GHG mitigation. This programme was issued in 2003 to implement the National Emission Ceilings (NEC) Directive (Directive No 2001/81/EC)[151] that has been revised by end 2016 to include more stringent emission reduction objectives for Member States. The new text (Directive No 2016/2284)[152] indicates that, as a minimum, Member States shall limit their annual anthropogenic emissions of sulphur dioxide (SO_2), nitrogen oxides (NOx), non-methane volatile organic compounds (NM-VOC), ammonia (NH_3) and fine particulate matter ($PM_{2.5}$) in accordance with compulsory national emission reduction commitments applicable from 2020 to 2029 and from 2030 onwards. The objectives for Luxembourg might be very difficult to reach for some gases, particularly the NOx. Undoubtedly, reaching the NOx target is linked with fulfilling Luxembourg's commitments under the ESD *[→ Section IV.1.1.2]*.
  (http://www.environnement.public.lu/air_bruit/dossiers/PA-PN_reduction_polluants_atmospheriques/index.html)
- the 2013 "A Clean Air Programme for Europe"[153] and its implementation at national level through the "*Programme National de la Qualité de l'Air*" (PNQA) adopted in 2017. This PNQA focuses mainly on two gases: nitrogen dioxide (NO_2) and fine particulate matter (PM_{10}).

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[151] Directive 2001/81/EC of the European Parliament and of the Council of 23 October 2001 on national emission ceilings for certain atmospheric pollutants.
(http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32001L0081&qid=1514400445347&from=EN).

[152] Directive (EU) 2016/2284 of the European Parliament and of the Council of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC.
(http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016L2284&qid=1514400445347&from=EN).

[153] A Clean Air Programme for Europe (Communication to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions).
(http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52013DC0918&from=EN).

Measures presented in this programme are either EU wide – complying with Euro standards for private vehicles in real driving conditions e.g. – or national/local – lowering individual motorised transport and shifting it to alternative fuels (reducing the number of diesel vehicles), promoting (clean) public transports, facilitating traffic flows, considering air quality in urban planning development plans, information and awareness. Clearly, these measures have some co-benefits with regard to GHG mitigation.
(http://www.environnement.public.lu/air_bruit/dossiers/Programme-national-de-qualite-de-l_air/index.html)

- the "Sustainable Mobility Strategy" – "MoDu" for "*Mobilité Durable*" – that complements the "Transport Sector Plan"; the latter offering the legal framework on which the strategy could be build. More details in Box IV.1-5.
(http://www.mt.public.lu/planification_mobilite/1strategie_modu/index.html)
- the "Transport Sector Plan" – "*Plan Sectoriel Transports – PST*" – which is one of the national "primary sector plans" linked to the general long-term planning concept of integrated spatial development and transports – the IVL for *Integratives Verkehrs-und Landesentwicklungskonzept* – that fixes objectives for the 2020 horizon and which is the regulatory counterpart of the "MoDu". More details in Box IV.1-6.
(http://amenagement-territoire.public.lu/fr/plans-caractere-reglementaire/plans-sectoriels/transports.html)
(http://www.mt.public.lu/planification/concept_dev_spatial/index.html)
- the "National Waste & Resources Management Plan" – "*Plan national de gestion des déchets et des ressources*" (PNGDR) – which should lead to emission reductions from waste management activities by reducing waste generation, increasing waste recovery and reducing the negative impacts of waste disposal. It promotes the concept of "circular economy" and introduces long-term objectives such as ressources preservation, climate protection and effects on future generations ***[→ Section II.11.1]***.
(http://www.environnement.public.lu/dechets/dossiers/pngd/index.html)
- the "National Plan for Nature Preservation" - "*Plan National de Protection de la Nature*" – 2017-2021 and the accompanying "National Biodiversity Strategy" that provides a framework for national and European nature protection areas. By preserving biodiversity and protecting ecosystems, or restoring them, there are co-benefits for climate mitigation – for instance, through restoring wetlands that offer bigger carbon absorption possibilities than other types of land uses.
(http://www.environnement.public.lu/conserv_nature/dossiers/PNPN/index.html and http://www.environnement.public.lu/conserv_nature/Observatoire/).
- the "Landscapes Sector Plan" – "*Plan Sectoriel Paysages – PSP*" – which is one of the national "primary sector plans" and that could contribute to climate change policies by preventing urban sprawling, for instance.
(http://amenagement-territoire.public.lu/fr/plans-caractere-reglementaire/plans-sectoriels/paysage.html)

- the "National Forests Programme" – "*Programme Forestier National*" – which should aim at restoring good quality forests in Luxembourg: nowadays, forests are characterized by high fragmentation, old species and trees and, sometimes, carelessness *[→ Section II.10]*.
(http://www.environnement.public.lu/forets/dossiers/pfn/index.html)
- the "Rural Development Programme" – "*Programme de Développement Rural*" – 2014-2020 whose one of the four strategic axes is the improvement of the environmental conditions and of the rural space. Box IV.1-10 describes some actions led in the field of agricultural activities having possible co-benefits for climate mitigation.
(http://www.ma.public.lu/index.html, right box)
- the "Eco-technology Action Plan" – *Plan d'Action Eco-technologies – PAET* – and its "*EcoInnovation*" cluster. Through synergies with research centres and through logistic and financial support by the authorities, it is aiming at positioning Luxembourg in the "green economy" by stimulating the production of green products and services and to support research and development in the environmental technologies field. These activities could have spillover effects that would be beneficial to both climate change adaptation and mitigation.
(http://www.gouvernement.lu/4253563/ecotechnologies and https://www.luxinnovation.lu/cluster/luxembourg-ecoinnovation-cluster/)

Box IV.1-5 – "MoDu"

"MoDu" is a global strategy for sustainable mobility ("MoDu" for "*mobilité durable*") of residents and cross-border commuters.

The planning approach developed in the framework of the "MoDu" strategy is directed to an optimal co-ordination between spatial development, environmental constraints and the future organisation of transport networks. The approach aims at reducing potential conflicts between transport planning and the environment, and seeks for synergies between a sustainable land planning and the development of transport infrastructures and offer.

The need for a sustainable mobility strategy was stemming from the following observations with regard to Luxembourg's territorial development: (1) demographics have been extremely dynamic compared to other European countries, but it is in rural communities that the largest growths have been noticed (diffuse urbanisation); and (2) domestic employment has grown much stronger than in neighbouring countries and, therefore, the redundancy of workplaces had to be compensated by labour coming from outside ("new" residents and cross-border commuters) *[→ Section II.4]*. Turning to mobility issues, it was observed that (4) in 2009, only 13% of the daily trips were the fact of pedestrians or cyclists although 40 % of the daily trips in Luxembourg are made on a distance of less than 3 km; (5) two thirds of the journeys by private cars and public transports happen during peak hours, which results in an overload of the transport network (train/bus/road); and (6) these bottlenecks, especially the ones on the roads, have a negative impact on the environment and the economy, lead to lower quality of life for residents and to a growing risk of accidents.

To answer to these six findings, four political objectives have been defined:

1. improve the links between regional development and mobility;
2. reach 25% of daily trips by non-motorized traffic ("mobilité douce") by 2020;
3. reach 25% of motorized trips by public transport by 2020;
4. promote an alternative use of the car: Park &Ride stations, car sharing, carpooling and electro-mobility.

It is anticipated that, together with actions on road fuel sales, the implementation of the "MoDu" strategy through the PST (see Box IV.1-6) will grant the biggest GHG reduction potential in the coming years through a likely reduction of cars journeys within the country and from cross-border commuters. Actually, the modal split objective of 25/75 by 2020 – i.e. 25% of the journeys by public transport and 75% by private vehicles – is one of the cornerstones of "MoDu", which proposes substantial investments in national and cross-border public transport infrastructures (the actual modal split is estimated at 17/83 by DG MOVE – 2015 figures **(1)**). More precisely, "MoDu" lists the following measures and actions:

1. promote and favour urban development around the main railways axes;
2. reduce congested roads and bottlenecks that create vehicles lines, hence unnecessary emissions of various pollutants;
3. realisation of large railway projects at national, regional and cross-border levels (new stations; new lines, improving existing lines);
4. develop "multimodal" platforms for both private journeys (park & ride sites next to train stations, e.g.) and for fret (such as the Bettembourg-Perpignan rail speedway for trailers – the "autoroute ferroviaire");
5. create a maximum of bus reserved lanes and putting strong emphasis on the extension of the bus network for cross-border commuters;
6. promote cycling and walking ("mobilité douce").

In the context of "MoDu", it is worth mentioning a project, which is also a very good example of collaboration between partners of the *Grande Région*: the cross-border mobility schemes SMOT – *schémas de mobilité transfrontalière*. Three SMOTs are on the table, one signed with the Lorraine Region of France in 2009 (http://www.mt.public.lu/presse/actualite/2009/01/08_SMOT/index.html?highlight=SMOT), one with the Walloon Region of Belgium for which a Memorandum of Understanding has been signed in 2013 but that has not been materialized yet (http://www.mt.public.lu/presse/communiques/2013/01/22_smot/index.html?highlight=SMOT) and one with the neighbouring German Länder of Saarland Rhineland-Palatinate which is still under preparation. Due to the size of the important workforce that comes from abroad every working day (+-180.000 commuters), these types of cross-border projects are vital for Luxembourg's policies aiming at reducing environmental nuisances and their driving forces.

For more information on this ambitious strategy, see:

a) the complete global strategy (in French):
http://www.mt.public.lu/planification_mobilite/1strategie_modu/Strategie_pour_une_mobilite_durable_Version_integrale_MODU.pdf;
b) the information leaflet (in both French and German):
http://www.mt.public.lu/planification_mobilite/1strategie_modu/Brochure_d_information_MoDu.pdf or
http://www.mt.public.lu/planification_mobilite/1strategie_modu/Informationsbroschuere_MoDu.pdf;
c) the communication strategy ***[→ Section IX.1.2]***.

Source: Ministry of Sustainable Development and Infrastucture, Department of Transport.

(1) European Commission, DG MOVE, EU Transport in Figures – 2017 statistical pocketbook, Table 2.3.3, p. 49 (https://ec.europa.eu/transport/facts-fundings/statistics/pocketbook-2017_en).

Box IV.1-6 – Transport Sector Plan – PST

Whilst the "MoDu" strategy presented in Box IV.1-5 describes the integrated approach for the future organization of transport network, the primary sectoral plan for transport (PST – http://amenagement-territoire.public.lu/fr/plans-caractere-reglementaire/plans-sectoriels/transports.html) describes the different transport policy projects and defines measures that require a regulatory framework. It is in fact the regulatory counterpart of the "MoDu".

The PST aims at optimizing coordination between spatial development, environmental restrictions and the future organization of transport networks. It allows responding to the forecasted increase in mobility needs by focusing on the development of resource-efficient means of transport, i.e. public transport and non-motorized traffic ("mobilité douce"). The PST also contains prescriptions and recommendations with regard to the communes and serves as a basis regulatory framework to integrate different measures of the "MoDu" strategy into communal general development plans.

More concretely, the PST defines legal instruments to introduce a parking management system for all urban areas and for the promotion of cycling and walking. It also reserves land corridors for new transport infrastructures and sets priorities for key infrastructural transport projects, with a special focus on public transport and non-motorized traffic.

For prioritizing the projects, three criteria are used:

1. the potential complementarity between transport means;
2. practical impacts at local, regional, national and transnational levels;
3. potential damaging effects on the environment and contribution to climate change mitigation.

For a summary overview of the PST, see: http://amenagement-territoire.public.lu/content/dam/amenagement_territoire/fr/plans_caractere_reglementaire/plans_sectoriels/transports/PST_Presentation.pdf.

Source: Ministry of Sustainable Development and Infrastucture, Department of Transport.

Next to public national action plans and programmes, there also exist **local projects as well as private/corporate initiatives**. Some of these are presented in Boxes IV.1-7 and IV.1-8.

Box IV.1-7 – Initiatives at local level

The *Climate Alliance of European Cities with the Indigenous Rainforest Peoples / Alianza del Clima e. V.* is Europe's largest city network for climate protection. It aims at reducing GHG emissions in the industrialised countries of the North, and conserving the rainforests in the South of the planet, more precisely in Amazonia. For achieving this goal, local climate strategies are developed and implemented, especially in the energy and transport sectors. Furthermore, there are measures to raise the public's awareness for the protection of the rainforest and to abstain in municipal procurement from tropical timber derived from destructive logging (http://www.climatealliance.org/home.html).

Luxembourg's branch of the Climate Alliance is *Klima-Bündnis Lëtzebuerg* (http://www.klimabuendnis.lu/fr/). It comprises 37 municipalities, out of 106 in Luxembourg (http://www.klimabuendnis.lu/fr/nous-connaitre/communes-membres/). These 37 municipalities represent around 75% of the population of the country.

To reach the mitigation objectives they committed themselves to, municipalities can exchange experiences, as well as submitting projects and leading common actions with other municipalities.

Klima-Bündnis Lëtzebuerg also launched a project for helping its members to monitor their own mitigation actions and to build PaMs scenarios. This project consists of using the ECORegion software tool developed by the Swiss company *Ecospeed*. The tool allows monitoring as well as to simulate the impact of policy measures on regional energy consumption and related CO_2 emissions (http://www.ecospeed.ch/welcome/en/). The tool has been implemented during the 2011 Summer, making Luxembourg the fourth country, after Germany, Italy and Switzerland, to put it in place.

Though the ECORegion tool certainly suffer from its limitation to energy related CO_2 emissions only and from some methodological drawbacks in the eyes of GHG inventory specialists and compilers, it might be a very useful way to further mobilize municipalities in their actions for limiting GHG emissions, as well as for informing and involving their inhabitants and local businesses.

In 2016, the Ministry of Sustainable Development and Infrastructure commissioned *Klima-Bündnis Lëtzebuerg* to draw up a carbon footprint for all municipalities part of the *Pacte Climat* *[→ Section IV.3.1.1]*; a work done in close cooperation with myenergy (see Box IV.1-9). The calculations for all the *Pacte Climat* participating municipalities was finalized during the course of 2017.

Two municipalities of the Grand Duchy of Luxembourg –Beckerich and Naturpark Our – are signatories to the new integrated Covenant of Mayors for Climate & Energy that was launched by the European Commission on 15 October 2015 (http://www.covenantofmayors.eu/index_en.html). The three pillars of the strengthened Covenant – mitigation, adaptation, and secure, sustainable and affordable energy – were symbolically endorsed on this occasion. Signatories endorse a shared vision for 2050: accelerating the decarbonisation of their territories, strengthening their capacity to adapt to unavoidable climate change impact, and allowing their citizens to access secure, sustainable and affordable energy.
For more details, see http://www.klimabuendnis.lu/fr/la-nouvelle-convention-des-maires-integree/.

Box IV.1-8 – Initiatives at corporate and business level

The Voluntary Agreement of the Business Federation of Luxembourg – *FEDIL* addresses energy consumption of the industrial sector, including enterprises participating to the European Union Emissions Trading System (EU ETS) – see PaM EC42 in ***Table IV.3-2*** below. All FEDIL member companies having a significant energy consumption – defined on certain criteria – can participate to the agreement. The common objective is to annually increase energy efficiency by 1%, calculated for all the participating enterprises (global objective, not an individual one). In order to reach this 1% goal, each participating company prepares a technical evaluation – or an energy audit – that will allow it to define and put in practice an action plan. The counterpart for the company is that it can benefit from several advantages, such as the support of *myenergy* **(1)** through a convention between the consultancy agency and the participating company (http://entreprises.myenergy.lu/grandes-entreprises-et-industries/accord-volontaire-fedil/). Nowadays, the majority of the country's large industrial energy consumers participate in this voluntary agreement (i.e. about 60 enterprises).

The first version of the agreement came in force in 1996, when the members of the FEDIL (http://www.fedil.lu/) agreed upon a voluntary agreement promoting the improvement of energy efficiency in the industrial sector. It has been several times extended and amended until 2010. For the 2011-2016 period, the aim of the voluntary agreement was to improve energy efficiency by a general objective of 7% (i.e. 1% per year). The average for 2009 and 2010 was used as a reference. The development of energy efficiency is measured using a general efficiency characteristic value, which corresponds to the arithmetic mean of the company-specific efficiency characteristics. If the general objective is not met and the company-specific improvement is below the 7 % target, the relevant participating enterprises must pay a proportion of the tax on the purchasing of electricity and gas, from which they are otherwise exempt. In addition to improving their energy efficiency, the participating industrial companies undertook to introduce an energy management system, by identifying the potential for improvement and drawing up an action plan for implementing at least some of this potential. Enterprises that fail to meet their obligations – including annual reporting requirements – may be excluded from the agreement.

The Voluntary Agreement has been recently renewed and is running from 1st March 2017 up to 31st December 2020. In this latest agreement, training in energy efficiency management requirements have been included, as well as exchange of good practices between participating companies. The general objective of 7 % over the period is however maintained. The average for 2014 and 2015 is used as a reference. The participating enterprises are required to finance the energy efficiency improvements themselves. In return, they are exempted from a proportion of the tax on electricity and gas.

However, there are also initiatives in other economic domains. For instance, the national railway company *Chemins de Fer Luxembourgeois* – CFL, took a series of environmental commitments (http://www.cfl.lu/espaces/groupecfl/fr/le-groupe/environnement). One of the most important decisions is that now trains are moved by "green electricity" only (all the network is electrified in Luxembourg): http://www.gouvernement.lu/768415/15-lux-cfl?context=519177.

Another example is the energy efficiency and energy reduction actions led by the postal and telephone company *Post Luxembourg*. The enterprise took the commitment to buy only "green electricity", to promote sustainable low-energy buildings, to reduce fossil fuel consumption of the vehicle fleet ("eco-driving" guides for the staff, natural gas driven vehicles, etc.): http://www.postgroup.lu/fr/70.

These two cases covers public owned companies. However, they set an example and are in line with the Government views expressed in its Programme and in the "Action Plans for reducing CO_2 emissions".

Note:
With regard to electricity, all the providers in Luxembourg propose "green electricity" to their clients:
a) the main provider is Enovos with its *Naturstroum* and *Nova Naturstroum* offers:

https://www.enovos.lu/en/Individuals/Electricity;

b) the other (smaller) providers also offer different "green electricity" mixes: EIDA (https://www.eida.lu/en/), Electris (http://www.electris.lu/fr/42/electris/presentation-et-engagements/) and Sudstroum (http://www.sudstroum.lu/fr/Produits-et-tarifs/Sudstroum-TERRA).

Most of the electricity produced from renewable sources is imported, i.e. bought abroad since the capacities – especially in hydro-electricity – are limited in Luxembourg.

A similar scheme is in place for natural gas:

a) the main provider is Enovos with its *Naturgas* and *Nova Naturgas* offers: https://www.enovos.lu/en/Individuals/Natural-gas;

b) the other (smaller) provider is Sudgaz that also offer a "green" alternative with an extra-cost: http://sudgaz.lu/wp-content/uploads/2016/07/Flyer-biogaz.pdf.

(1) *myenergy*: see Box IV.1-9.

In the implementation of energy-related policies and measures, ***myenergy*** is a key player: see Box IV.1-9.

Box IV.1-9 – *myenergy*

In 1991, an Energy Agency was created to promote energy efficiency and the use of renewable energy sources in the commercial, financial and housing areas. During the course of 2008, this Agency was reformed and split into two different structures. The first one named ***energie****agence* continued its commercial activity on the energy advice market as a corporation – http://www.energieagence.lu/ – whereas a second structure, an Economic Interest Group (EIG), named *myenergy* was as created as an Economic Interest Group (EIG) in order to provide a national and neutral contact point for information and advice on energy matters – http://www.myenergy.lu/.

myenergy's missions consist in the information, the support and the education of private persons, municipalities, companies and experts towards the development of sustainable and energy efficient constructions and the use of renewable energy sources.

myenergy's main activity is the free and neutral energy advice offered to private consumers by telephone or by appointment in its various regional infopoints, operated in cooperation with municipalities. The basic energy advice is meant:

1. to offer targeted guidance on the numerous products and services available on the market;
2. to clarify the advantages and disadvantages of measures;
3. to optimize the energy efficiency, the sustainability and the costs of a project;
4. to encourage the house builder to use renewable energies;
5. to offer information on the state subsidy programs.

myenergy has also introduced a voluntary certification programme ("myenergy certified") for the experts working in the area of energy efficiency and renewable energies. The professionals meeting the criteria defined by myenergy and demonstrating consolidated skills obtain a quality label and are added to a list, which is actively distributed by myenergy to guide the consumers searching for an expert.

In addition to general advice and information activities destined to the municipalities and companies, myenergy has assisted the Ministry of Sustainable Development and Infrastructure with the implementation of the *Pacte Climat* and is now in charge of the project management ***[→ Section IV.3.1.1]***.

myenergy also develops and manages national and European projects in the fields of energy efficiency, renewable energy sources and sustainable constructions and supports the Government for the national implementation of European Directives in the area of energy efficiency and renewable energies – for instance, *myenergy* contributed to the third and fourth NEEAP drafting.

myenergy is supported by the Luxembourg Government, represented by the Ministry of Economy, the Ministry of Sustainable Development and Infrastructure and the Ministry of Housing.

As stressed above, there are measures and actions that could have positive effects on GHG emissions reduction, though their primary aim is not GHG mitigation or adaptation. This is the case in **agriculture** for instance: see Box IV.1-10.

Box IV.1-10 – *Agriculture*

Though the agricultural sector represented only 5.5% of the national total GHG emissions, excl. LULUCF (2011), it might contribute to climate change mitigation by putting in place a number of practices, such as, for instance:

1. maintaining and enhancing permanent grassland and promoting reduced or zero tillage practices – mulch-till or direct seeding – which will both favour carbon sequestration;
2. developing several agri-environmental schemes for arable land and pasture in protected areas – extensive farming;
3. promoting organic production measures, as well as measures to reduce livestock density – extensive farming;
4. favouring renewable energy sources production through slurry bonus for biogas production and the combustion of biomass
5. improving agricultural production methods, for instance by encouraging better application techniques for liquid manure.

[→ Section IV.3.1.4].

IV.1.5. Inter-ministerial decision making process/bodies

The overall coordination and implementation of:

- the national climate change strategy;
- the national adaptation strategy on climate change;
- the NAP; as well as
- the first and second "Climate Action Plans for reducing CO_2 emissions";
- the (future) third national "Climate Plan";

was/is under the responsibility of the Department of the Environment.

The implementation of measures at the sector level is, in general, the responsibility of the relevant Government departments and agencies.

IV.1.6. Monitoring and evaluating PaMs

Achieving reduced emissions of GHG requires the implementation of a number of different measures, both technical measures and behavioural changes. Various policy instruments can be used to achieve this. The strategy followed by Luxembourg includes taxes, grants, regulations, information and a market-based system that mainly influence emissions within the energy and transport sectors *[→ Sections IV.1.2 & IV.1.3]*. Policy instruments introduced in the waste and agricultural sectors, as well as to improve and transform mobility, also influence developments *[→ Section IV.1.4]*. There are also linkages between national PaMs and the "Common and

Coordinated Policies and Measures" (CCPM's) of the EU. CCPM's have different kind of impacts in Luxembourg, some reducing emissions beyond what is achieved by or possible with purely national policies (such as the agreement with car manufacturers at EU level and the biofuels Directive), others that do not lead to additional emission reductions beyond those generated by national policies.

Though it remains difficult to distinguish the effects of individual policy instruments from each other and from other driving forces in society, a capacity building work programme was initiated in 2017 to develop Luxembourg's reporting of climate PaMs required under the EU Regulation No 525/2013 (MMR).[154] This programme involved improving the completeness of climate PaMs across economy-wide sectors. A total of **79 PaMs are now listed in the database** *[→ Section IV.3, Table IV.3-1]*. They are structured in **9 categories**, namely:

- AG – agriculture – 10 PaMs;
- EC – energy consumption – 25 PaMs;
- ES – energy supply – 3 PaMs;
- FO – forestry – 6 PaMs;
- GO – good governance – 4 PaMs;
- IP – industrial processes – 1 PaM;
- IR – innovation & research / R&D – 1 PaM;
- TR – transport & mobility – 12 PaMs;
- WM – waste management – 17 PaMs.

Luxembourg's key PaMs are still in the energy and transport sectors as detailed in the 6th National Communication [Ministry of Sustainable Development and Infrastructure, Department of the Environment (2014a), Sections IV.3.3 & IV.3.4], but information on PaMs in additional sectors (agriculture, forestry, waste) are now included in this 7th National Communication.

Through this work, **the mitigation impact potential of 10 PaMs** reported in *Section IV.3* were quantified for the years 2020, 2025, 2030 and 2035, aligned with the MMR requirements. Ex-ante savings of **two additional PaMs** for 2020 are included in *Section IV.3* from work undertaken during the production of Luxembourg's 4th NEEAP.

This work is still on-going, and it is therefore expected that more PaMs reported in *Section IV.3* will be evaluated with regard to their ex-ante potential savings during the course of 2018. However, Luxembourg's third "Climate Plan", which is scheduled to be completed in 2018 *[→ Section IV.1.3]*, may rearrange the structure and content of the PaMs listed in this section.

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[154] Regulation No 525/2013 of the European Parliament and of the Council of 21 May 2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/2004/EC. (http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013R0525&rid=1).

Consequently, in this 7th National Communication, **it is not possible to present mitigation potentials for all of the individual or groups of PaMs** requested by paragraph 17 of the UNFCCC guidelines for the preparation of National Communications by Parties included in Annex I to the Convention, part II [UNFCCC (1999)].

With regard to **GHG projections** ***[→ Chapter V]***, they are therefore **based on a "business as usual" scenario**, i.e. a "with measures" scenario (WEM). Only one "additional measure" (WAM) is considered, but it is rather an alternative than an "additional measure" per se ***[→ Section V.2.2]***.

Finally, other research projects might also help to produce better projections and evaluations of PaMs, such as the use of an economic general equilibrium model (CGE) ***[→ Section V.4]***.

IV.2. DOMESTIC PROGRAMMES PURSUANT TO THE IMPLEMENTATION OF THE KYOTO PROTOCOL[155]

In previous chapters and sections, the various institutions playing a role in climate change reporting and management in the context of the UNFCCC and the Kyoto Protocol have been pointed out. ***Table IV.2-1*** recapitulates the situation.

The description of any institutional arrangements and decision-making procedures that are in place in Luxembourg to coordinate activities relating to participation in the mechanisms under Articles 6, 12 and 17 of the Kyoto Protocol, including the participation of legal entities, are provided in ***Section V.6***, where the "Climate & Energy Fund" is presented in detail ***[→ Section V.6.3]***.

With regard to **Article 3.3 of the Kyoto Protocol,** actual calculations – submission 2017v7 – show that related activities could be carbon sinks. With regard to **Article 3.4 of the Kyoto Protocol**, Luxembourg has decided, during the first commitment period, not to elect any of the activities. Hence, according to this Article 3.4, Luxembourg has to carry out accounting for its forestry activities (forest management) in the second commitment period. Due to a lack of reliable data, emissions from harvested wood products are reported as instantaneous oxidation. Furthermore, Luxembourg has elected the option "natural disturbances" but not the "provision for carbon equivalent forests" [Ministry of Sustainable Development and Infrastructure, Environment Agency (2017), Chapter 11].

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[155] Due to its size, there are no regional programmes or legislative arrangements and enforcement in Luxembourg.

TABLE IV.2-1 – UNFCCC AND KYOTO PROTOCOL – RESPONSIBLE AUTHORITIES

Topic	Responsible or co-ordinating authority(ies)	Corresponding legal act or decision
UNFCCC National Focal Point	MDDI-DEV (responsibility)	Officially notified to the Convention Secretariat Not defined as such in a national act, only mentioned in Art. 5, Regulation of 24 April 2017 *[→ Section III.2.1.2]*.
National Registry	AEV (responsibility)	Law of 23 December 2004 *[→ Section III.3]*
National Strategy and Action Plans, incl. NAP and Adaptation Strategy	MDDI-DEV (responsibility + co-ordination)	Government Programme & declaration.
Kyoto Protocol "flexible mechanisms"	MDDI-DEV (responsibility + co-ordination)	Law of 23 December 2004 *[→ Section V.6.3]*
"Climate & Energy Fund"	MDDI-DEV (responsibility + authority)	Law of 23 December 2004 *[→ Section V.6.3]*
GHG inventories		Regulation of 24 April 2017 *[→ Section III.2.1.2]*.
Single National Entity (SNE)	The Minister having environment in his or her attributions – for the moment it is the AEV that has been designated (co-ordination)	
National GHG Inventory Focal Point	Nominated by the SNE – for the moment it is the AEV (responsibility + co-ordination)	
National Inventory Compiler	AEV (responsibility + co-ordination)	
official submission	The Minister having environment in his or her attributions – for the moment it is the MDDI-DEV ("political" responsibility)	
GHG projections and definition of PaMs		Regulation of 24 April 2017 *[→ Section III.2.1.2]*.
Single National Entity (SNE)	The Minister having environment in his or her attributions – for the moment it is the MDDI-DEV (responsibility + co-ordination)	
National GHG Projections Focal Point	Nominated by the SNE – for the moment it is the MDDI-DEV (responsibility + co-ordination)	
official submission	The Minister having environment in his or her attributions – for the moment it is the MDDI-DEV ("political" responsibility)	
Kyoto Protocol, Art. 3.3 (& 3.4)	ANF ("technical" responsibility)	Government internal decision.
Awareness raising, information	MDDI-DEV (responsibility)	Government internal decision.

Abbreviations used in Table IV.2-1:
MDDI-DEV – Ministry of Sustainable Development and Infrastructure – Department of the Environment (*Ministère du Développement durable et des Infrastructures – Département de l'environnement*): http://www.emwelt.lu/:
AEV = Environment Agency (*Administration de l'Environnement*): http://www.gouvernement.lu/972044
ANF = Nature & Forests Agency (*Administration de la Nature et des Forêts*): http://www.environnement.public.lu/functions/apropos_du_site/anf/index.html

IV.3. SECTORAL AND CROSS-SECTORAL PAMS[156]

This section describes PaMs with the primary aim is GHG mitigation, i.e. which might have a significant impact on GHG emissions and removals as emphasized in section IV.C of the Outline and General Structure of the NC5 [UNFCCC (2009)]. Paragraph 16 of the UNFCCC guidelines for the preparation of National Communications by Parties included in Annex I to the Convention, part II [UNFCCC (1999)] also indicates that Parties should report on action taken to implement commitments under Article 4.2(e)(ii) of the Convention, which requires that Parties identify and periodically update their own policies and practices which encourage activities that lead to greater levels of anthropogenic GHG emissions than would otherwise occur.

156 This section of the NC7 covers sections IV.C and IV.D of the Outline and General Structure of the NC5 according to IPCC reporting guidelines (para. 5).

As explained in *Section IV.1.6* above, **it is not yet possible to present complete mitigation potentials for those individual or groups of PaMs presented here as** requested by paragraph 17 of the UNFCCC guidelines for the preparation of National Communications by Parties included in Annex I to the Convention, part II [UNFCCC (1999)].

In *Sections IV.3.1 & IV.3.2* **descriptions of the key policies and measures** in each sector, as well as cross-sectoral measures, are presented, along with **summary tables**. These tables are a work in progress *[→ Section IV.1.6]* and contain the data that is requested to be presented in a summary table by the Outline and General Structure of the NC5 [UNFCCC (2009)]. Defining which gases are affected – column (3) "GHG affected" – is not a straightforward task since many measures, though addressing primarily CO_2, can also reduce emissions of other GHG such as CH_4 and N_2O. In the table, the column provides the main gas targeted, which is in most of the case CO_2.

Those **PaMs that expired or were repealed** during the reporting period between the 6th and the 7th National Communications are discussed in *Section IV.3.4*.

Some plans and policies, which could have the effect to increase GHG emissions, are indicated in *Section IV.3.5*.

Actions undertaken to **minimize adverse effects of PaMs** – both national and according to Articles 6, 12 and 17 of the Kyoto Protocol – are briefly described in *Section IV.3.6*. It is also in this Section that Luxembourg would like to share its commitment and actions with regard to **Gender Equality and Human Rights in the context of climate change**.

Steps taken to promote and/or implement any decisions by the **International Civil Aviation Organization** and the **International Maritime Organization** in order to limit or reduce emissions of GHG not controlled by the Montreal Protocol from aviation and marine bunker fuels are presented in *Section IV.3.7*.

Table IV.3-1 lists the 79 PaMs presented and discussed in *Sections IV.3.1 to IV.3.4* and indicated whether they could be estimated or not with regard to their respective mitigation impact potential, as well as their implementation status.

Table IV.3-1 – List of PaMs in the current database

PaM number	Name of the PaM	Status of implementation	Mitigation potential estimated?
AG01	Agriculture - Rural Development Programme - livestock management	Implemented	NE
AG02	Agriculture - Rural Development Programme - livestock management - climate-smart agriculture investments	Implemented	IE
AG03	Agriculture - Rural Development Programme - livestock management - promoting research and knowledge transfer for climate-smart agriculture	Implemented	IE
AG04	Agriculture - Rural Development Programme - livestock management - practices to reduce GHG emissions and ammonia	Implemented	IE
AG09	Agriculture - Rural Development Programme - development and application of a legal frame for the promotion of agro-forestry	Expired	NA
AG11	Agriculture - Common Agricultural Policy - greening - crop diversification	Implemented	NE
AG12	Agriculture - Common Agricultural Policy - greening - permanent grassland	Implemented	NE
AG13	Agriculture - Common Agricultural Policy - greening - ecological focus area	Implemented	NE
AG21	Agriculture - practices - organic farming	Implemented	NE
AG22	Agriculture - practices - conservation tillage or zero-tillage	Adopted	NE
EC01	Energy consumption - residential buildings - new constructions - intensification of energy efficiency requirements - heating and hot water	Implemented	Yes
EC02	Energy consumption - residential buildings - new constructions - promotion of low-energy and passive houses	Expired	NA
EC03	Energy consumption - residential buildings - new and existing constructions - increasing energy efficiency - heating and hot water	Implemented	NE
EC04	Energy consumption - residential buildings - existing constructions - increasing energy efficiency - insulation and ventilation	Expired	NA
EC05	Energy consumption - residential buildings - new constructions - increasing energy efficiency - heating and hot water	Implemented	NE
EC06	Energy consumption - residential buildings - existing constructions - increasing energy efficiency - heating and hot water	Implemented	NE
EC07	Energy consumption - residential buildings - existing constructions - increasing energy efficiency - heating and hot water - "climate bank"	Implemented	Yes
EC08	Energy consumption - residential buildings - existing constructions - increasing energy efficiency - insulation and ventilation - VAT rate	Implemented	NE
EC09	Energy consumption - residential buildings - existing constructions - increasing energy efficiency - insulation and ventilation - rented houses and apartments	Planned	NE
EC10	Energy consumption - residential buildings - new and existing constructions - increasing energy efficiency - training and education	Adopted	NA

EC11	Energy consumption - residential buildings - new and existing constructions - increasing energy efficiency - information and awareness	Implemented	NA
EC21	Energy consumption - non-residential buildings - new constructions - intensification of energy efficiency requirements - heating and hot water	Implemented	Yes
EC22	Energy consumption - non-residential buildings - existing constructions - increasing energy efficiency - heating and hot water	Implemented	Yes
EC23	Energy consumption - non-residential buildings - new constructions - increasing energy efficiency - electricity consumption for lighting	Implemented	NE
EC24	Energy consumption - non-residential buildings - public buildings - new and existing constructions - increasing energy efficiency - 'Pacte Climat'	Implemented	NE
EC25	Energy consumption - non-residential buildings - public buildings - new and existing constructions - increasing energy efficiency - 'Pacte Climat' - support	Implemented	NA
EC26	Energy consumption - non-residential buildings - public buildings - new and existing constructions - increasing energy efficiency - 'Pacte Climat' - monitoring	Implemented	NA
EC27	Energy consumption - non-residential buildings - public buildings - new and existing constructions - increasing energy efficiency - public procurement	Adopted	NA
EC28	Energy consumption - non-residential buildings - public buildings - new and existing constructions - increasing energy efficiency - monitoring	Adopted	NA
EC41	Energy consumption - industries - increasing energy efficiency - EU ETS	Implemented	NE
EC42	Energy consumption - industries - increasing energy efficiency - FEDIL Voluntary Agreement	Implemented	NE
EC43	Energy consumption - industries - increasing energy efficiency - training and education	Adopted	NA
EC51	Energy consumption - residential and non-residential buildings - increasing energy efficiency - training and education	Implemented	NA
EC52	Energy consumption - all sectors - increasing energy efficiency - training and education ; information and awareness	Implemented	NA
EC53	Energy consumption - all sectors - increasing energy efficiency - monitoring	Implemented	NA
ES01	Energy supply - renewable energy and cogeneration - electricity and heat supply - feed-in tariffs	Implemented	Yes
ES02	Energy supply - renewable energy and cogeneration - biogas supply - feed-in tariffs	Implemented	Yes
ES11	Energy supply - renewable energy and cogeneration - electricity and heat supply - promotion for the use of biomass	Planned	NE
FO01	Forestry - forest management - establishment of forest management plans in public forests	Implemented	NE
FO02	Forestry - forest management - protection of existing forests	Implemented	NE
FO03	Forestry - forest management - increase of the size of forest nature reserves	Implemented	NE
FO04	Forestry - forest management - increase of the amount of dead wood in forests	Implemented	NE
FO11	Forestry - logging - Wood Cluster	Adopted	NE
FO12	Forestry - forest management - private forest nature reserve subsidy	Implemented	NE

GO01	Good governance - Environment and Climate Partnership	Planned	NA
GO02	Good governance - evaluation of the second national "Action Plan for reducing CO_2 emissions"	Expired	NA
GO11	Good governance - environmentally harmful subsidies	Planned	NA
GO12	Good governance - Housing Sector Plan	Expired	NA
IP01	Industrial processes - F-gas related emissions regulation	Implemented	Yes
IR01	R and D - promoting eco-technologies in the fields of invention and innovation - EcoInnovation Cluster	Implemented	NE
TR01	Transport - alternative fuels - framework and infrastructure	Implemented	Yes (2020)
TR02	Transport - alternative fuels - public transportation	Adopted	NE
TR03	Transport - alternative fuels - biofuels	Implemented	NE
TR04	Transport - alternative fuels - tax incentives	Adopted	NE
TR11	Transport - taxation - excise duties on fuel for transport purposes	Implemented	Yes (2020)
TR12	Transport - taxation - vehicle tax reform - private cars	Implemented	NE
TR13	Transport - taxation - vehicle tax reform - company cars	Implemented	NE
TR21	Transport - mobility - integrated strategy for a sustainable mobility (MoDu)	Implemented	NA
TR22	Transport - mobility - promotion of car-pooling and car-sharing	Adopted	NE
TR23	Transport - mobility - information - new communication tools	Adopted	NA
TR24	Transport - mobility - information - traffic telematics systems for public transport	Implemented	NA
TR25	Transport - mobility - enterprises mobility plans	Adopted	NE
WM01	Waste - overall management - National Waste & Ressources Management Plan	Implemented	NA
WM02	Waste - overall management - Environmental Protection Fund	Implemented	NA
WM03	Waste - overall management - polluter pays principle	Implemented	NE
WM04	Waste - overall management - waste transfer fees	Implemented	NA
WM05	Waste - overall management - reduced consumption of plastic bags	Implemented	NA
WM11	Waste - energy - incineration and burning - energy recovery from waste incineration	Implemented	NO
WM12	Waste - energy - anaerobic digestion at biogas facilities	Implemented	IE
WM13	Waste - incineration and burning - prohibition of open air burning of waste	Implemented	NA
WM21	Waste - landfills - overall management - advanced waste collection system	Implemented	NA
WM22	Waste - landfills - overall management - reduced landfilling of municipal solid waste	Implemented	Yes

WM23	Waste - landfills - overall management - biological pre-treatment of solid waste	Implemented	IE
WM24	Waste - landfills - methane recovery systems	Implemented	Yes
WM25	Waste - landfills - verification of closed unmanaged landfills	Implemented	NA
WM31	Waste - recycling - SuperDrecksKescht	Implemented	NE
WM32	Waste - recycling - packaging waste	Implemented	NO
WM33	Waste - overall management - biowaste	Implemented	Yes
WM35	Waste - recycling - valorisation of sewage sludge	Implemented	NE
Summary			
AG - 10 EC - 25 ES - 3 FO - 6 GO - 4 IP - 1 IR - 1 TR - 12 WM - 17 **Total - 79**	-	adopted -11 implemented - 59 planned - 4 expired - 5 **Total - 79**	estimated - 12 NA - 27 NE -33 NO -2 IE -5 **Total - 79**

Notes: AG01, TR21 & WM01 are groups of PaMs.
AG01 = AG02 + AG03 + AG04
TR21 = TR01 + TR02 + TR22 + TR23 + TR24 + TR25
WM01 = WM03 + WM21 + WM25

NA = not applicable
NE = not estimated
NO = not occurring
IE = indicated elsewhere

IV.3.1. Sectoral policies and measures

IV.3.1.1. Energy consumption and production (excluding transport)

PaMs within the energy sector (excluding transport) under the WEM and WAM scenarios are outlined in *Table IV.3-2* at the end of this section. 23 PaMs concerning energy consumption are presented, as well as 3 PaMs related to energy supply. This split reflects the special circumstances of Luxembourg's energy supply sector and high import dependency (see below).

Energy: the keyword in Luxembourg's set of policies and measures

National PaMs implemented or planned cover a rather large number of domains, from the overall policy regarding mobility to very specific grant schemes. However, actions are **mainly driven by increasing energy efficiency in all sectors as well as by promoting the use of renewable energy sources**. They take the form of **direct allowances and payments** for the installation of devices that offer the possibility to use renewable energy sources – such as solar energy equipment – or for the renovation or the construction of low-energy ("passive") houses. The direct subsidies also cover cash-back schemes, or financial incentives, such as refunding partially the purchase of a low-energy electrical appliance. Actions also correspond to **subsidy schemes** for the production of "green" energy, such as a bonus – feed-in tariffs – offered for electricity production from windmills, hydraulic installations, biomass or biogas.

Promoting electricity generation from renewable energy source is not a PaM

Only a relatively small fraction of overall electricity consumption in Luxembourg is generated by installations in Luxembourg – especially since the generation from blast furnace gas was stopped. The natural gas fired TWINerg power plant, which was set into service in 2002 but which shut down in 2016, led to an increase of the share of domestically produced electricity, as did the numerous small CHP installations. Despite the increase in generation capacity, since 2002 the import dependency –measured as net imports divided by national consumption – remains on a high level of about 50 to 70%, compared to 94.3% in 1990. With the subsequent slowdown and shut down of the TWINerg, this ratio is again close to 90% *[→ Section II.6]*. The import dependency – mainly from the German network – has one major impact on the quantitative assessment of effects of PaMs in the field of electricity generation from renewable energy sources: while most EU Member States – and by extension, most countries – own a "double dividend" from the encouragement of electricity generation from renewable ("carbon neutral") sources – by increasing the share of renewable energy in accordance with Directive No 2009/28/EC[157] (RED) and, in addition, by lowering GHG emissions from electricity generation – Luxembourg only benefits from the increase in the share of renewable energy. As stressed in *Section II.12.3*, electricity generated in Luxembourg from renewable sources does not substitute generation from fossil fuels, as it is the case in most other Member States, but replaces electricity imports, which are "carbon neutral" according to IPCC allocation rule of GHG emissions based on the territorial principle. Therefore the **promotion of electricity generation from renewable energy sources or from CHP does not have an impact on the GHG emissions** and are consequently **not considered as measures in this report** and are, **de facto**, **included in the baseline – or BAU - scenario**.

Other renewable energy sources, which **substitute fossil fuel consumption** within Luxembourg (e.g. biomass or biogas for heating purposes or solar thermal installations), **do have**, instead, **a lowering effect on the GHG balance and are, therefore, considered as PaMs** – e.g. ES01 and ES02 – as described later in this section.

The legislative package, "Climate Bank and subsidies for sustainable housing" ("*KlimaBank a Prime fir nohaltegt Wunnen*") took effect on 1st January 2017. It aims at promoting the sustainable construction of residential buildings, sustainable and energetic renovations/sanitations and a stronger reliance on renewable energy sources.

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[157] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC (http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02009L0028-20151005&from=EN).

The package comes with several novel elements but also a revision of existing grants and subsidies such as the "PRIMe House" regime. The key elements of the package are:

- **Climate Bank**, offering either a reduced-rate loan or a zero-rate loan (depending on socio-economic factors) for energy efficient and ecologic sanitation or renovation of residential buildings. This new financing mechanism targets the promotion of sustainable and energy efficient residential building renovation/sanitation and the prevention of energy insecurity (EC07);
- **LENOZ** ("*Lëtzebuerger Nohaltegkeets-Zertifikat fir Wunngebaier*"), a certification system for new and sustainable residential buildings. The system relies on three sustainability-oriented pillars: protection of the environment, economic efficiency and social justice (EC05).
- **PRIMe House**, (a revision of the existing grant regime) will focus on the sustainable construction of residential buildings, energy-efficient and sustainable renovations/sanitations and the promotion of renewable energy sources (repealed EC02 & EC04 PaMs).

Climate Agreement with the municipalities: an innovative tool to engage stakeholders at local level

One of the main outcomes of the "Environment and Energy Partnership" ***[→ Section IV.1.2]*** is the Climate Agreement with the municipalities – the *Pacte Climat* that was presented in October 2012 and entered into operation on the 1st January 2013.[158]

This Agreement reinforces the role of municipalities in the fight against climate change through a legislative, technical and financial framework set up in order to promote action against climate change by the municipalities. The *Pacte Climat* is basically an agreement (contract) between the State and the municipalities. As of 31 December 2017, the whole 105 municipalities of the country are engaged in the Agreement: see ***Figure IV.3-1***.

Under the Agreement, a municipality commits itself to implement a quality management system relating to its energy and climate policy. The State provides financial and technical assistance, which increases according to the certification level reached by the municipalities. This certification level is defined under the "European Energy Award" (EEA) which consists of a catalogue of measures with currently around 79 measures from 6 areas: (i) development planning and regional planning, (ii) municipal buildings and facilities, (iii) supply and disposal, (iv) mobility, (v) internal organization, and (vi) communication and cooperation.

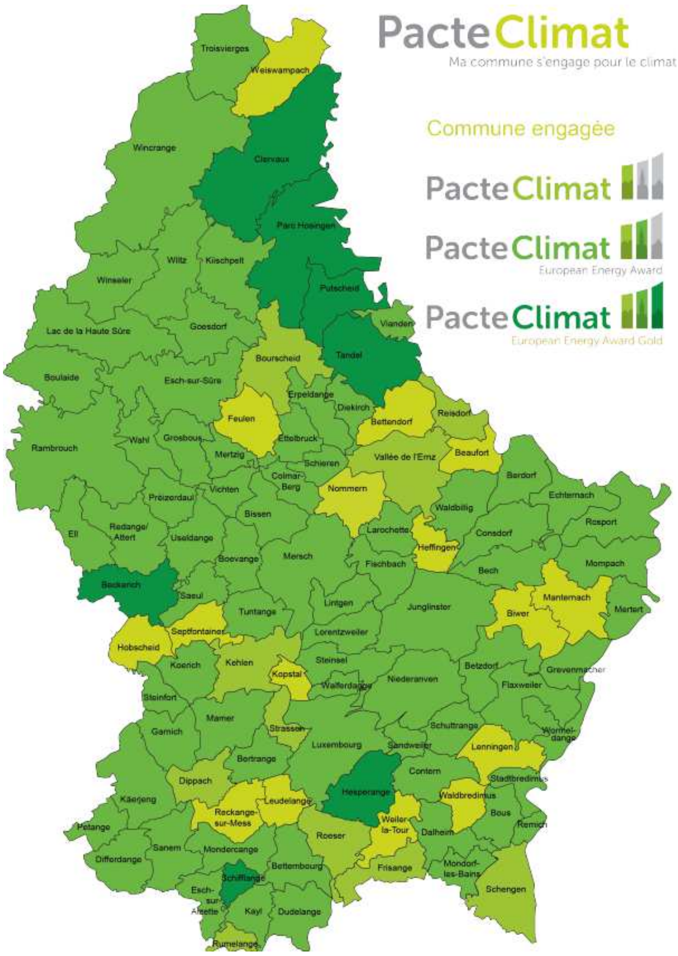
[158] http://www.pacteclimat.lu/.

More precisely, the “European Energy Award” is the main tool of the *Pacte Climat*. It:

1. supports communities that want to contribute to a sustainable energy policy and urban development through the rational use of energy and an increased use of renewable energies;
2. is a qualified instrument for steering and controlling communal energy policy in order to review systematically all energy-related activities;
3. allows municipalities to identify strengths, weaknesses and potential for improvement and implement effectively energy efficient measures. The success of a municipality's efforts is made visible by an award;
4. allows municipalities to share their experiences and expertise.

In 2016, air quality criteria have been included in the *Pacte Climat*. In 2017, it was the turn of the “circular economy” to be included.

FIGURE IV.3-1 – *PACTE CLIMAT* – CERTIFICATION LEVEL REACHED BY THE MUNICIPALITIES



Source: Pacte Climat website: http://www.pacteclimat.lu/.
Note: The darker the colour, the highest the level reached: engaged (yellow), certified up to 40%, 50% and 75%.

Quantified mitigation potentials

The mitigation potential of EC01, EC07, EC21, EC22, ES01 and ES02 have been quantified for the years 2020, 2025, 2030 and 2035.

The mitigation potential of **EC01** is derived from new residential buildings complying with higher energy efficiency standards. Emission reductions increase across the projected timeline as the number of houses functioning at the improved energy efficiency standards increase.

The mitigation potential of **EC07** is derived from the renovation of existing residential buildings implementing energy efficiency measures, decreasing energy consumption. Emission reductions stay constant after the policy expires, as renovations will be unlikely to continue unless there is a commitment or update of the policy.

The mitigation potential of **EC21** is derived from new non-residential buildings complying with higher energy efficiency standards. Since 1 January 2011 (date of building application), non-residential buildings have been obliged to meet efficiency class D. Compared to buildings before the introduction of this regulation, savings of around 30 % were expected. Then, with effect from 1 July 2015 (date of building application), non-residential buildings have had to meet efficiency class C. Compared to the previous standards, this intensification corresponds to extra savings of 15 %. Emission reductions increase across the projected timeline as the number of buildings functioning at the improved energy efficiency standards increase.

The mitigation potential of **EC22** is derived from the renovation of existing non-residential buildings to meet minimum energy efficiency requirements. This assumes an average renovation rate of 0.5% per year, resulting in final energy savings of 26 GWh in 2020. Emission reductions stay constant after 2020 as after the policy expires renovations will be unlikely to continue unless there is a commitment or update of the policy post 2020.

The mitigation potential of **ES01** is derived from the feed-in tariff (FIT) increasing electricity production from renewable energy sources and heat cogeneration. Quantities of waste wood and sewage gas consumed for energy generation increase due to the FIT, and the heat produced by sewage gas, pellets and waste wood replaces heat produced by natural gas plants. Electricity produced from sewage gas, pellets and waste wood replaces imported electricity with an emission factor of zero, whereas heat produced by sewage gas, pellets and waste wood replaces heat produced by natural gas plants. Emission saving allocated to heat production was calculated dividing the fuel use for cogeneration according to production of heat and electricity. The main assumptions are that (i) energy efficiency of electricity and heat production from sewage gas is estimated to be the same as for natural gas and therefore the input of natural gas in energy units is estimated to be equal to the input of sewage gas, (ii) production rates for sewage gas plants for years 2016-2035 have been estimated to stay at the level reported for year 2015, and (iii) the need for wastewater treatment remains, and thus the plants to be decommissioned would either be renewed or replaced so that the production in future years would be the same as in 2015. Consequently, emission reductions remain stable across the projected timeline as the inputs from the alternative sources of sewage gas, pellets and waste wood remain constant post 2020.

The mitigation potential of **ES02** is derived from the feed-in tariff increasing the supply of biogas in the natural gas grid. Electricity produced from biogas replaces imported electricity with an emission factor of zero. Heat produced with biogas is assumed to replace heat produced with natural gas. Emission reductions remain stable across the projected timeline as the biogas input remains constant post 2020.

For detailed assumptions and methodology, see [Aether / Benviroc (2017)].

TABLE IV.3-2 – PAMS ACCORDING TO THE WEM AND *WAM* (*ITALIC*) SCENARIO IN THE ENERGY SECTOR (EXCLUDING TRANSPORT)

Number & name of the PaM	Objective and/or activity affected	GHG(s) affected	Type of instrument	Status of implementation	Brief description	Start year of implementa-tion	Implemen-ting entity or entities	Estimate of mitigation impact, by gas (for a particular year, not cumulative, in CO_2e)			
								2020	2025	2030	2035
EC01 - Energy consumption - residential buildings - new constructions - intensification of energy efficiency requirements - heating and hot water	Efficiency improvements of buildings.	CO_2 CH_4 N_2O	Regulatory	Implemented	Increase energy efficiency standards for new residential buildings wrt. heating and hot water. Suggest a timetable for energy efficiency requirements for thermal insulation class as well as overall energy performance class moving from class D before 1st July 2012 to class A from 1st January 2017 onwards for both criteria (where classes A/A corresponds to a passive house). Corresponds to measure HH_1 in NEEAP4.	2012	MECO-DEN	78.89	108.62	142.36	176.10
EC03 - Energy consumption - residential buildings - new and existing constructions - increasing energy efficiency - heating and hot water	Efficiency improvements of buildings.	CO_2 CH_4 N_2O	Economic	Implemented	Increase energy efficiency standards for new and existing residential buildings wrt. heating and hot water using renewable energy sources based on a support mechanism consisting of financial incentives. Subsidies were granted up to end 2016 for the use of solar thermal systems and heat pumps. Corresponds to measure HH_5 in NEEAP4.	2013	MECO-DEN MDDI-DEV	NE	NE	NE	NE
EC05 - Energy consumption - residential buildings - new constructions - increasing energy efficiency - heating and hot water	Efficiency improvements of buildings; Ensuring more sustainable housing through the delivery of a certificate: LENOZ - *Letzebuerger Nohaltegkeets-Zertifikat fir Wunngebaier*.	CO_2 CH_4 N_2O	Economic	Implemented	Increase energy efficiency standards for new residential buildings wrt. heating and hot water through better insulation, ventilation and the use of renewable energy sources. A durability demand is added that comes on top of energy efficiency and use of renewable energy sources requirements: LENOZ. This certificate combines 3 criteria for defining a sustainable construction: (i) environment protection, (ii) economic efficiency, and (iii) a fair social organization. A new construction should at least reach 60% for the 3 LENOZ criteria to be eligible for subsidies.	2017	MDDI-DEV MFIN MLOG	NE	NE	NE	NE

EC06 - Energy consumption - residential buildings - existing constructions - increasing energy efficiency - heating and hot water	Efficiency improvements of buildings; Ensuring more sustainable housing using sustainable materials during energy renovation.	CO_2 CH_4 N_2O	Economic	Implemented	Increase energy efficiency standards for existing residential buildings wrt. heating and hot water through better insulation, ventilation and the use of renewable energy sources. Subsidies are increased if sustainable materials are used.	2017	MDDI-DEV MFIN	NE	NE	NE	NE
EC07 - Energy consumption - residential buildings - existing constructions - increasing energy efficiency - heating and hot water - "climate bank"	Efficiency improvements of buildings. The objective of the "Climate bank" is to increase the number of energy efficient and sustainable renovations of residential buildings through the pre-financing of energy-efficient renovation projects.	CO_2 CH_4 N_2O	Economic	Implemented	The so-called "Climate bank" ("Klimabank"/"banque climatique") for private persons and legal entities came in to force in January 2017. The applicants are offered financial support in form of a low-interest loan, or for low-income households an interest-free loan. Measures supported by the "Climate bank" include renovation projects, replacement of technical installations and, in the case of interest-free loans prior energy consultation on residential buildings. Corresponds to measure HOR_2 in NEEAP4.	2017	MDDI-DEV MFIN MLOG	10.62	10.62	10.62	10.62
EC08 - Energy consumption - residential buildings - existing constructions - increasing energy efficiency - insulation and ventilation - VAT rate	Efficiency improvements of buildings; Support housing construction and renovation in Luxembourg (high population growth pushing housing prices upwards) through the application of a reduced VAT rate of 3%..	CO_2	Fiscal Regulatory	Implemented	The reduced VAT rate of 3% instead of 17% applies to new constructions but also to existing buildings being renovated, that will or are used as a primary residence. That would ensure a quicker depreciation of energy efficient investments when renovating residential buildings.	2002	MLOG MFIN-ADA	NE	NE	NE	NE
EC09 - Energy consumption - residential buildings - existing constructions - increasing energy efficiency - insulation and ventilation - rented houses and apartments	*Efficiency improvements of buildings*	*CO_2*	*Economic*	*Planned*	*Improve renovation opportunities for rented houses and apartments through different scales for subsidies offered to property owners and tenants, according to their revenues.*	*Mid-term*	*MDDI-DEV MFIN MLOG*	*NE*	*NE*	*NE*	*NE*

EC10 - Energy consumption - residential buildings - new and existing constructions - increasing energy efficiency - training and education	Efficiency improvements of buildings.	CO_2	Education	Adopted	Educating advisors for giving energy consumption advices primarily to families with low revenues so that they can reduce their expenses with regard to energy and water consumption.	2013	MDDI-DEV MECO-DEN MFIGR MTEES myenergy	NA	NA	NA	NA
EC11 - Energy consumption - residential buildings - new and existing constructions - increasing energy efficiency - information and awareness	Efficiency improvements of buildings.	CO_2	Information	Implemented	Strengthening awareness campaigns at regional or local level aiming at promoting and diffusing information on energy efficient construction and renovation and their advantages. This is realised through the myenergy "infopoints" and other myenergy information activities such as participation at fairs, organising special events and publishing various documents on energy savings and the use of renewable energy sources.	nd	MDDI-DEV MECO-DEN MLOG myenergy	NA	NA	NA	NA
EC21 - Energy consumption - non-residential buildings - new constructions - intensification of energy efficiency requirements - heating and hot water	Efficiency improvement in services/ tertiary sector.	CO_2 CH_4 N_2O	Regulatory	Implemented	Increase energy efficiency standards for new non-residential buildings wrt. heating and hot water. Since 1 January 2011 (date of building application), non-residential buildings have been obliged to meet efficiency class D. Compared to buildings before the introduction of this regulation, savings of around 30 % was expected. Then, with effect from 1 July 2015 (date of building application), non-residential buildings have to meet efficiency class C. Corresponds to measure GHD_1 & GHD3 in NEEAP4.	2011	MECO-DEN / MDDI-DEV	20.06	32.67	44.55	55.63
EC22 - Energy consumption - non-residential buildings - existing constructions - increasing energy efficiency - heating and hot water	Efficiency improvement in services/ tertiary sector.	CO_2 CH_4 N_2O	Regulatory	Implemented	Increase energy efficiency standards for existing non-residential buildings wrt. heating and hot water. Since 1st January 2011, non-residential buildings have been obliged to meet minimum requirements for selected parameters such as U-values, thermal insulation of distribution pipes, control systems etc. Corresponds to measure GHD_2 in NEEAP4.	2011	MECO-DEN MDDI-DEV	4.61	4.61	4.61	4.61
EC23 - Energy consumption - non-residential buildings - new constructions - increasing energy efficiency - electricity consumption for lighting	Efficiency improvement in services/ tertiary sector.	CO_2	Regulatory	Implemented	Increase energy efficiency standards for new non-residential buildings wrt. lightning related electricity consumption. Since 1st January 2011 (date of building application), non-residential buildings have been obliged to meet efficiency class D (see EC21). Corresponds to measure GHD_4 in NEEAP4.	2011	MECO-DEN MDDI-DEV	NE	NE	NE	NE

EC24 - Energy consumption - non-residential buildings - public buildings - new and existing constructions - increasing energy efficiency - *Pacte Climat*	Efficiency improvement in services/ tertiary sector.	CO_2	Regulatory	Implemented	The Climate Agreement with the municipalities (*Pacte Climat*) was presented in October 2012 and entered into force on the 1st January 2013. It reinforces, inter alia, the role of municipalities in the fight against climate change through a legislative, technical and financial framework set up in order to promote action against climate change. The *Pacte Climat* means that municipalities commit to implement a quality management system relating to their energy and climate policy as well as an energy management tool for their infrastructures and their equipment. In return, and according to their 'certification level' under the European Energy Award scheme, they benefit from technical and financial support given by the Government *[→ more details supra]*.	2013	MDDI-DEV MINT MFIN	NE	NE	NE	NE
EC25 - Energy consumption - non-residential buildings - public buildings - new and existing constructions - increasing energy efficiency - *Pacte Climat* - support	Efficiency improvement in services/ tertiary sector.	CO_2	Regulatory	Implemented	Support of municipal capacities through higher financial framework and the secondment of climate experts for implementing the Climate Agreement (*Pacte Climat*). This PaM aims at ensuring that the municipalities have the human means and expertise to implement the Climate Agreement.	2013	MDDI-DEV MINT MFIN myenergy	NA	NA	NA	NA
EC26 - Energy consumption - non-residential buildings - public buildings - new and existing constructions - increasing energy efficiency - *Pacte Climat* - monitoring	Efficiency improvement in services/ tertiary sector; Making data collection compulsory with regard to energy consumption and related emissions covered by the Climate Agreement (*Pacte Climat*).	CO_2	Regulatory	Implemented	The Climate Agreement (*Pacte Climat*) requires municipalities to monitor the effects of energy efficiency and other energy related measures taken. For helping them, a software called 'EnerCoach' is provided to the municipalities.	2013	MDDI-DEV MINT MFIN myenergy	NA	NA	NA	NA

EC27 - Energy consumption - non-residential buildings - public buildings - new and existing constructions - increasing energy efficiency - public procurement	Efficiency improvement in services/ tertiary sector; Efficiency improvement of appliance; Promoting sustainable and environment-friendly public purchases and procurements, as well as in public planning.	CO_2	Information Education Planning	Adopted	Application of sustainability criteria for public procurement and during the whole planning process through fixed guidelines and continuous monitoring. This should lead to the acquisition of less energy intensive appliances.	nd	MDDI-DEV MECO-DEN	NA	NA	NA	NA
EC28 - Energy consumption - non-residential buildings - public buildings - new and existing constructions - increasing energy efficiency - monitoring	Efficiency improvement in services/ tertiary sector.	CO_2	Other	Adopted	Reducing final energy consumption of public buildings through the monitoring of energy consumption of public buildings using a measuring concept and data analysis, notably based on smart meters.	nd	MDDI-DEV ABP	NA	NA	NA	NA
EC41 - Energy consumption - industries - increasing energy efficiency - EU ETS	Efficiency improvement in industrial end-use sectors.	CO_2 CH_4	Regulatory	Implemented	Application of the EU ETS Regulation *[→ Section IV.1.1.2]*.	2005	MDDI-DEV	NE	NE	NE	NE
EC42 - Energy consumption - industries - increasing energy efficiency - FEDIL Voluntary Agreement	Efficiency improvement in industrial end-use sectors.	CO_2	Voluntary/ negotiated agreements	Implemented	Voluntary agreement between the Luxembourg Government and FEDIL: see Box IV.1-8. Corresponds to measure IND1_1 in NEEAP4.	1996	MECO myenergy	NE	NE	NE	NE
EC43 - Energy consumption - industries - increasing energy efficiency - training and education	Efficiency improvement in industrial end-use sectors.	CO_2	Education	Adopted	This PaM covers various projects aiming at a better deployment of energy efficiency and renewable energy projects in industries and SMEs through training and education. It covers the "learning factory" initiative, which is a national structure of lifelong training.	nd	MECO-DEN MDDI-DEV	NA	NA	NA	NA

EC51 - Energy consumption - residential and non-residential buildings - increasing energy efficiency - training and education	Efficiency improvements of buildings; Efficiency improvement in services/ tertiary sector.	CO_2	Education	Implemented	Offering training schemes and certificates of competence to various actors potentially involved in energy efficiency, the use of renewable energy sources and ecological reconstruction in buildings (residential, commercial, institutions). One of the programmes is "build-up skills Luxembourg" that is initiated in the context of the EU project "Build up skills, energy training for builders" that is coordinated in Luxembourg by myenergy.	2014	MDDI-DEV MECO-DCM myenergy Chamber of Trade FDA IFSB	NA	NA	NA	NA
EC52 - Energy consumption - all sectors - increasing energy efficiency - training and education ; information and awareness	Efficiency improvements of buildings. Efficiency improvement in services/ tertiary sector; Efficiency improvement in industrial end-use sectors.	CO_2	Regulatory Information Education	Implemented	This PaM aims at guaranteeing sufficient human and financial means to myenergy so that it can fulfil all its missions, notably with regard to the Climate Agreement (*Pacte Climat*) with municipalities.	nd	MECO-DEN MDDI-DEV	NA	NA	NA	NA
EC53 - Energy consumption - all sectors - increasing energy efficiency - monitoring	Efficiency improvements in energy consumption sector.	CO_2 CH_4 N_2O	Information Other	Implemented	Improvement and systematisation of data collection on energy consumption and related emissions in various sectors: buildings, industries, transportation, etc. This PaM covers the development of statistical and econometric work on energy consumption and related emissions: projections, ex ante and ex post evaluations of PaMs (emissions, abatement costs), etc. This is a "good governance" action.	2015	MDDI-DEV MECO-DEN STATEC	NA	NA	NA	NA

ES01 - Energy supply - renewable energy and cogeneration - electricity and heat supply - feed-in tariffs	Increase in renewable energy.	CO_2	Fiscal	Implemented	This PaM aims at increasing the share of renewable energy sources (RES) in the electricity networks; whether it is produced by households or enterprises. It aims also at developing heat generation (cogeneration) alongside electricity production from RES. This PaM is linked to a 2014 Regulation that outlines method of calculating feed-in tariff (FIT) levels for renewable energy electricity. FIT levels vary depending on the renewable energy source and generation capacity of the plant. FITs are being guaranteed for a period of 15 years for all types of renewable plants (except geothermal installations) counting from the year when the plant was connected to the national grid. Additional bonus for commercialized heat generated by combined heat and power based on biomass and wood waste is introduced by the Regulation. Bonus is paid on top of the feed-in tariff. In order to benefit from this additional premium certain conditions must be met.	2014	MECO-DEN	23.18	23.18	23.18	23.18
ES02 - Energy supply - renewable energy and cogeneration - biogas supply - feed-in tariffs	Increase in renewable energy.	CO_2	Fiscal	Implemented	This PaM aims at developing the production of biogas and its addition in distribution networks. This PaM is linked to a 2014 Regulation that outlines method of calculating feed-in tariff (FIT) levels for the supply of biogas in the natural gas grid. Biogas plants are eligible for the tariff if they were commissioned on or after 1st of January 2007 and that they were renewed or extended from then in order to increase their capacity. Additional bonus for commercialized heat generated by combined heat and power based on biogas is also introduced by the Regulation. Bonus is paid on top of the feed-in tariff. In order to benefit from this additional premium certain conditions must be met.	2014	MECO-DEN	9.50	9.50	9.50	9.50
ES11 - Energy supply - renewable energy and cogeneration - electricity and heat supply - promotion for the use of biomass	*Increase in renewable energy.*	CO_2	*Information Planning*	*Planned*	*This PaM aims at increasing the use of biomass as energy source through the elaboration of new concepts for an increased use of biomass (wood, green waste, agricultural waste and sewage sludge), as well as through a better adequacy between planning tools, decision and public information.*	*Short-term*	*MDDI-DEV MDDI-AEV MDDI-AGE MAVPC-SER*	*NE*	*NE*	*NE*	*NE*

Abbreviations used in Table IV.3-2:

MAVPC – Ministry of Agriculture, Viticulture and Consumer Protection (*Ministère de l'Agriculture, de la Viticulture et de la Protection des consommateurs*): http://www.ma.public.lu/
SER = Department for Rural Economy (*Service d'Economie Rurale*): http://www.ser.public.lu/
MECO – Ministry of the Economy (*Ministère de l'Economie*): http://www.eco.public.lu/
DCM = Medium and Small Businesses Directorate (*Direction des Classes Moyennes*): http://www.mcm.public.lu/fr/index.html
DEN = Energy Directorate (*Direction de l'Energie*): http://www.eco.public.lu/index.html
STATEC = National Statistical Institute: http://www.statistiques.public.lu/fr/acteurs/statec/index.html

MDDI-DEV – Ministry of Sustainable Development and Infrastructure – Department of the Environment (*Ministère du Développement durable et des Infrastructures – Département de l'environnement*): http://www.emwelt.lu/:
AEV = Environment Agency (*Administration de l'Environnement*): http://www.gouvernement.lu/972044
AGE = Water Agency (*Administration de la Gestion de l'Eau*): http://www.eau.public.lu/
MDDI-TP – Ministry of Sustainable Development and Infrastructure – Department of Public Works (*Ministère du Développement durable et des Infrastructures – Département des travaux publics*): http://www.mtp.public.lu/
ABP = Public Buildings Administration (*Administration des Bâtiments Publics*): http://www.abp.public.lu/
MFIGR – Ministry of Family Affairs, Integration and the Greater Region (*Ministère de la Famille, de l'Intégration et à la Grande Région*): http://www.mfi.public.lu/
MFIN – Ministry of Finance (*Ministère des Finances*): http://www.mf.public.lu/
ADA: Customs & Excises Administration (*Administration des Douanes et Accises*): http://www.do.etat.lu/
MINT – Ministry of Home Affairs (Ministère de l'Intérieur): http://www.mi.public.lu/
MLOG – Ministry of Housing (*Ministère du Logement*): http://www.ml.public.lu/fr/index.html
MTEES – Ministry of Labour, Employment and the Social and Solidarity Economy (*Ministère du Travail, de l'Emploi et de l'Économie sociale et solidaire*): http://www.mte.public.lu/

FDA – Federation of Craftsmen (Fédération des Artisans): https://www.fda.lu/
IFSB – Training Institute for the building sector (*Institut de Formation Sectoriel du Bâtiment*): https://www.ifsb.lu/
myenergy – see Box IV.1-9: http://www.myenergy.lu/

Note: NA = not applicable
NE = not estimated

IV.3.1.2. Transport and mobility

PaMs within the transport sector under the WEM scenario are outlined in ***Table IV.3-3*** at the end of this section. Twelve transport PaMs are presented, with a mix of fiscal tax incentives, regulatory obligations, and information/awareness policies. One PaM (TR21) is a group of PaMs that cannot currently be estimated with regard to its mitigation impact potential. No WAM scenario PaMs for transport have been identified.

As underlined in ***Section II.12.1***, the impact from "road fuel sales to non-residents" can hardly be controlled by unilateral adaptations in national tax-policy: as fuel sales attributed to "road fuel sales to non-residents" are mainly triggered by fuel price differentials (which are determined by differentials in excise rates ***[→ Section II.4.3]***), Luxembourg would need to permanently coordinate its tax policy with the policy of all neighbouring states (Belgium, France and Germany). This would mean to accept a limitation of the scope of national tax design options. However, the current Government intends to assign additional revenues from road fuel sales to measures aiming at an energetic transition to a more sustainable economic model (instead of using them to cover current expenses), in order to step away from the "road fuel sales to non-residents" dependency. In its work programme, it indicated that "an economic feasibility study will be undertaken with the aim of determining the impacts of getting out of road fuel sales to non-residents" [Gouvernement du Grand-Duché de Luxembourg (2013), p. 84]. This study was presented in November 2016.[159] Following this presentation, the Government decided to set up an **inter-ministerial working group** composed of representatives of the Ministry of Finance, the Ministry of Sustainable Development and Infrastructure, the Ministry of the Economy, the Customs and Excise Administration and the National Statistical Institute (STATEC). This group, chaired by the Ministry of Finance, is responsible for:

- carrying out a detailed and regular monitoring of the evolution of road fuel sales, analysing the factors underlying the evolutions observed, monitoring the impacts of the new measures proposed by the Government within the framework of an overall tax reform in Luxembourg, and comparing the results of the feasibility study with STATEC's ongoing work on road fuel sales forecasts and their price elasticities;
- analysing the desirability of introducing a tax segmentation between professional use and private use of diesel – similar to the systems put in place in Belgium and France – coupled with an increase in the ""Kyoto cent" (see below);
- thinking about alternative models, including the possibilities of introducing an excise duty on electromobility, knowing that long-term planning is imperative to anticipate the gradual reduction of budget revenues from fossil road fuel sales.

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[159] For details, see http://www.environnement.public.lu/actualites/2016/11/etude_tt/index.html.

This inter-ministerial working group produced a first report that was submitted to the Government end November 2017 for its consideration.

The "Kyoto-cent"

Increasing excise rates on road fuels lead to increases of the retail price of these fuels. Higher prices set an incentive for consumers to lower demand. By the 1st of January 2007, the excise rate on gasoline was increased by 2 ct€/litre. For diesel, the excise rate was increased in two stages: 1.25 ct€/litre on the 1st of January 2007 and another 1.25 ct€/litre on the 1st of January 2008. The last tax increase on diesel took place in 2012-2013. Actually, this autonomous addition to the existing excise rates was introduced to finance the "Kyoto Fund" – renamed "Climate & Energy Fund" since January 2011 – set up in Luxembourg to deal with the Kyoto "flexible mechanisms" *[→ Section V.6.3]* and it is labelled "climate change contribution" or "Kyoto-cent".

Quantified mitigation potentials

The mitigation potentials for TR01 and TR11 for 2020 are included in ***Table IV.3-3*** below. These were quantified in the preparation of the 4th NEEAP.

The mitigation potential of **TR01** is derived from the increase in vehicle tax based on their CO_2 emissions. An annual fuel consumption reduction rate of 2% is applied annually until 2020 for new diesel and petrol vehicles, based on STATEC modelled consumption of new diesel and gasoline road vehicles. This leads to a saving of 17kt CO_2 in 2020.

The mitigation potential of **TR11** is derived from an increase in tax on diesel vehicles. A price elasticity rate of 0.6% for the years 2013, 2014, 2015 and 2016 and 1.6% for the years 2017, 2018, 2019 and 2020 is applied. From the final energy consumption of road transport for diesel modelled by STATEC, this leads to a saving of 74.8 GWh and 19.7 ktCO_2 in 2020.

For detailed assumptions and methodology, see [Aether / Benviroc (2017)].

TABLE IV.3-3 – PAMS ACCORDING TO THE WEM SCENARIO IN THE TRANSPORT SECTOR

Number & name of the PaM	Objective and/or activity affected	GHG(s) affected	Type of instrument	Status of implementation	Brief description	Start year of implementa-tion	Implemen-ting entity or entities	Estimate of mitigation impact, by gas (for a particular year, not cumulative, in CO_2e)			
								2020	2025	2030	2035
TR01 – Transport – alternative fuels – framework and infrastructure	Low carbon fuels & electric cars.	CO_2	Fiscal Regulatory	Implemented	This PaM aims at promoting and fostering the transition to alternative fuels: electro-mobility (battery electric vehicles (BEV) and plug-in hybrid electric vehicles (PHEV)) and natural gas mobility (CNG and LNG). All member states of the EU established a national policy frameworks outlining their national targets and objectives, and supporting actions for the development of the market as regards alternative fuels, including the deployment of the necessary infrastructure to be put into place, in close cooperation with regional and local authorities and with the industry concerned, while taking into account the needs of small and medium-sized enterprises. Besides infrastructure developments, tax cuts (on annual private person's tax declaration) are offered for the purchase of an electric vehicle (BEV).	2016	MDDI-TRA	17.05	NE	NE	NE
TR02 – Transport – alternative fuels – public transportation	Efficiency improvements of vehicles; Low carbon fuels/electric cars.	CO_2	Voluntary/ negotiated agreements	Adopted	Use of plugin hybrid and full electric buses, which are being charged by opportunity charging stations.	2017	MDDI-TRA Municipalities	NE	NE	NE	NE
TR03 – Transport – alternative fuels – biofuels	Low carbon fuels & electric cars.	CO_2	Regulatory	Implemented	Obligation to blend biofuels in transport related fuels. The budget law 2007 sets the mandatory part of biofuel to be blended in diesel and gasoline in transport to 2%. The law of 17 December 2010 defining the excises taxes takes over this percentage and additionally sets sustainable criteria for the blended biofuels. The budget laws 2013, 2014, 2015, 2016 and 2017 set the level of incorporated biofuels to 3.75%, 4.75%, 5.40%, 5.15% (adjusted for avoiding a previous double counting) and 5.50% respectively. These percentages are calculated in relation to the energy content of the fuels.	2007	MECO-DEN MFIN-ADA	NE	NE	NE	NE

TR04 – Transport – alternative fuels – tax incentives	Efficiency improvements of vehicles; Low carbon fuels & electric cars.	CO_2	Fiscal	Adopted	New fiscal incentives for zero and low emission vehicle were introduced in 2017. A return of tax of 5,000 euro for zero-emissions vehicles; - battery electric vehicles (BEV) and fuel cell-electric vehicles (FCEV) – on the annual tax declaration for private car owners has been created. For company cars the deductibility from corporate income of expenses related to the use of company cars will be calculated based on CO_2 emissions. Zero emission vehicles benefit to the highest degree.	2017	MDDI-TRA MFIN	NE	NE	NE	NE
TR11 – Transport – taxation – excise duties on fuel for transport purposes	Low carbon fuels & electric cars; Improved behaviour.	CO_2	Fiscal	Implemented	Taxes on fuel (petrol and diesel) are raised on a regular basis. By the 1st of January 2007, the excise rate on gasoline was increased by 2 cents/litre. For diesel, the excise rate was increased in two stages: 1.25 cents/litre on the 1st of January 2007 and another 1.25 cents/litre on the 1st of January 2008. These increased were known as "Kyoto-cents". The last tax increase on diesel took place in 2012-2013. In the short term, this will encourage driving behaviour that aims to achieve lower fuel consumption, and in the longer term, this will influence motorists to purchase vehicles that are more economical. Corresponds to measure TRA_1 in NEEAP4. *[→ also presented supra]*.	2007	MFIN-ADA MDDI-DEV	19.75	NE	NE	NE
TR12 – Transport – taxation – vehicle tax reform – private cars	Low carbon fuels & electric cars.	CO_2	Fiscal	Implemented	In December 2006, a Regulation introduced a vehicle tax reform based on CO_2 emissions. It entered into force on the 1st of January 2007. On average, this change in approach led to an increase in tax. In the longer term, this will influence purchasing decisions in favour of more economical vehicles. Corresponds to measure TRA_2 in NEEAP4.	2007	MFIN-ADA	NE	NE	NE	NE
TR13 – Transport – taxation – vehicle tax reform – company cars	Low carbon fuels & electric cars; Improved behaviour.	CO_2	Fiscal	Implemented	Fiscal benefits in kind for company car is no longer a flat rate but is now determined according to CO2 emissions per km and propulsion means (gasoline, diesel, hybrid, natural gas, etc.).	2017	MDDI-DEV MFIN-ACD	NE	NE	NE	NE

TR21 – Transport – mobility – integrated strategy for a sustainable mobility (MoDu)	Improved behaviour; Improved transport infrastructure; Modal shift to public transport or non-motorized transport; Reducing conflicts between land planning and transport; Promotion of alternatives to cars (P and R stations, car sharing, carpooling and electro-mobility).	CO_2	Regulatory; Planning	Implemented	The "MoDu" (Sustainable Mobility "Mobilité Durable") is presented in Box IV.1-5. This PaM is a group of PaMs. It covers PaMs TR01 + TR02 + TR22 + TR23 + TR24 + TR25.	2012	MDDI-TRA MDDI-DAT MINT CdT CFL Municipalities Foreign neighbouring regions	NA	NA	NA	NA
TR22 – Transport – mobility – promotion of car-pooling and car-sharing	Demand management/ reduction. Improved behaviour.	CO_2	Information Education Planning	Adopted	Setting up of a national car-pooling portal in order to promote this alternative form of transportation and to increase the car occupancy rate, which is as of now at 1.2 passengers per car. Setting up of car-sharing facilities in order to reduce the number of cars per household. It is evaluated that one shared car through a car-sharing scheme and infrastructure could replace 7 to 10 private cars. Car-sharing would also allow promoting the use of public transport by offering flexibility when reaching a journey destination.	2017	MDDI-TRA	NE	NE	NE	NE
TR23 – Transport – mobility – information – new communication tools	Improved behaviour; Modal shift to public transport or non-motorized transport; Realising information and awareness campaigns for promoting an environment-friendly transport.	CO_2	Information Education	Adopted	This PaM aims at promoting environment-friendly transportation related behaviours through information and awareness campaigns at national and regional level using new communication tools such as social networks, etc.	2012	MDDI-TRA CdT	NA	NA	NA	NA
TR24 – Transport – mobility – information – traffic telematics systems for public transport	Improved behaviour; Modal shift to public transport or non-motorized transport.	CO_2	Information	Implemented	This PaM aims at developing near-real time information on the situation on the roads, in the public transport, on the parking availabilities, etc. so that users can optimize their choices through an on-line service.	2012	MDDI-TRA / CdT	NA	NA	NA	NA

TR25 – Transport – mobility – enterprises mobility plans	Low carbon fuels & electric cars; Launching an “ecological mobility” label for enterprises using low consumption and emissions vehicles.	CO_2	Voluntary/ negotiated agreements	Adopted	This PaM aims at modifying behaviours of employees and paid workers in administrations and private companies. It consists in a mobility management tool provided by the Verkeiersverbond: “mConcept”. mConcept is offering solutions to promote the use of sustainable transport means and to reduce the use of individual cars. These mobility management solutions are mostly based on awareness raising through information and communication on alternative transport means. They also integrate “soft” measures, which are essentially based on a reorganisation of the activities and on partnerships. As an example, enterprises and administrations could finance a “mPass” for their workers so that they can use the public transportation network free of charge.	2009	CdT	NE	NE	NE	NE

Abbreviations used in Table IV.3-3:

MECO – Ministry of the Economy (*Ministère de l'Economie*): http://www.eco.public.lu/
DEN = Energy Directorate (*Direction de l'Energie*): http://www.eco.public.lu/index.html
MDDI-DAT – Ministry of Sustainable Development and Infrastructure – Department of Land Planning (*Ministère du Développement durable et des Infrastructures – Département de l'aménagement du territoire*): http://amenagement-territoire.public.lu/fr.html
MDDI-DEV – Ministry of Sustainable Development and Infrastructure – Department of the Environment (*Ministère du Développement durable et des Infrastructures – Département de l'environnement*): http://www.emwelt.lu/;
MDDI-TRA – Ministry of Sustainable Development and Infrastructure – Department of Transport (*Ministère du Développement durable et des Infrastructures – Département des transports*): http://www.mt.public.lu/
MFIN – Ministry of Finance (*Ministère des Finances*): http://www.mf.public.lu/
ACD: Direct Tax Administration (*Administration des Contributions Directes*) http://www.impotsdirects.public.lu/
ADA: Customs & Excises Administration (*Administration des Douanes et Accises*): http://www.do.etat.lu/
MINT – Ministry of Home Affairs (Ministère de l'Intérieur): http://www.mi.public.lu/

CdT – Transport Community (*Communauté des Transports – Verkéiersverbond*): http://www.mobiliteit.lu/verkeiersverbond/role-missions/
CFL – Luxembourg Railways (*Société Nationale des Chemins de Fer Luxembourgeois*): http://www.cfl.lu/fr

Note: NA = not applicable
NE = not estimated

IV.3.1.3. Industry

The policy within the industrial sector under the WEM scenario is outlined in ***Table IV.3-4***. The most significant CO_2 emissions from the industry sector are covered in the EU ETS, which is under EC41 presented in ***Section IV.1.1.2***. No specific policies or measures have been identified that target any remaining small levels of CO_2 sources. Thus, the only policy included in the industry sector (IP01) concerns the implementation of the F-gas Regulation (2014/517/EC)[160] to limit emissions from F-gases (HFC, PFC, SF_6). This phases down HFCs on the EU market and bans HFCs in certain applications, which will lead to a replacement of HFCs with lower global warming potentials (GWP) in some applications. No WAM scenario PaMs for industry have been identified.

Quantified mitigation potentials

The mitigation potential of **IP01** was quantified for the years 2020, 2025, 2030 and 2035. This was derived from the quantity of F-gas releases avoided, and the difference in global warming potentials of the replaced F-gases. There were three parts to the calculation:

- 2F excluding mobile air conditioning (MAC) in passenger vehicles;
- 2F mobile air conditioning (MAC) in passenger vehicles;
- 2G electrical switchgear.

2F excluding MAC in passenger vehicles includes fridge production, commercial and industrial refrigeration, stationary air-conditioning, refrigerated transport, and MAC in non-passenger vehicles. In the business as usual (BAU) scenario, projections are extrapolated based on data from 1990-2016. To estimate the effects of the policies emerging from the F-gas Regulation, the projections from the BAU scenario were coupled with the HFC reduction plan of the aforementioned regulation. In this case, placements on the EU market of HFC are directly impacted by the phase down that is planned in the F-gas Regulation. As such, the following reductions, as given by the F-gas Regulation, have been directly applied to the emissions of the category F. A 7% reduction for the year 2017, a 37% for the years 2018-2020, a 55% for the years 2021-2023, a 69% reduction for the years 2024-2026, a 76% reduction for the years 2027-2029, a 79%reduction for the years 2030-2035. Except for emission from mobile air conditions systems of passenger vehicles, which are regulated by another directive and therefore estimated separately, all subsectors were assumed to be equally affected the progressive phasedown.

Calculating savings from **MAC in passenger vehicles** used the main assumption based on the Directive 2006/40/EC[161] relating to emissions from air-conditioning systems in motor. This

[160] Regulation (EU) No 517/2014 of the European Parliament and of the Council of 16 April 2014 on fluorinated greenhouse gases and repealing Regulation (EC) No 842/2006 (http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0517&qid=1515177938709&from=EN).

[161] Directive 2006/40/EC of the European Parliament and of the Council of 17 May 2006 relating to emissions from air conditioning systems in motor vehicles and amending Council Directive 70/156/EEC (http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32006L0040&qid=1515178219452&from=EN).

directive dictates that starting the year 2017, the use of cooling refrigerants possessing a GWP of 150 in new passengers is forbidden. Previously, R134a, which has a GWP of 1430, was mainly used in this type of vehicles. Two alternatives are currently used, R1234yf (GWP=4) and CO_2 (GWP=1), in which case the coolant R1234yf is used by the majority of car manufactures. To determine the proportions of R1234yf and CO_2 usage on the Luxembourgish market, data corresponding to the share of the each car brand on the Luxembourgish market was obtained from STATEC. The corresponding usage of R1234yf or CO_2 by each car manufacture was obtained from manufacture databases. This led to the estimation that newly registered cars in Luxembourg are using R1234yf in 85% of the cases and CO_2 in 15% of the cases. Due to a lack of information on future developments, this distribution was kept constant for the years 2017-2035. The average amount of coolant contained in passenger vehicles was determined using technical data sheets from various car models.

The F-gas Regulation does not directly affect **SF_6 in switchgears** as none of the restrictions is directly aimed at these components. Instead, the general reduction over the years of the SF_6 quantities, which are placed on the EU market via the quota system, has been considered to affect the emissions of SF_6 containing switchgears. This was estimated to be a 7% reduction for the year 2017, a 37% for the years 2018-2020, a 55% for the years 2021-2023, a 69% reduction for the years 2024-2026, a 76% reduction for the years 2027-2029, and a 79% reduction for the years 2030-2035.

See also [Aether / Benviroc (2017)].

IV.3.1.4. Agriculture

PaMs within the agriculture sector under the WEM scenario are outlined in ***Table IV.3-5***. Eight agricultural PaMs have been identified, as well as a 9th grouped PaM (AG01) that groups AG02, AG03 and AG04 together.[162] The main agriculture PaMs in Luxembourg focus on the implementation of the EU Common Agricultural Policy (CAP) and the Rural Development Programme (RDP). AG21 and AG22 are economic national PaMs on the farming practices that increase carbon stocks in soils. No WAM scenario PaMs for agriculture have been identified.

As of today, no mitigation potentials have been quantified for agriculture PaMs.

[162] Estimation of the mitigation potential may be performed for the grouped PaM AG01, hence IE for the PaMs covered by AG01.

TABLE IV.3-4 – PAM ACCORDING TO THE WEM SCENARIO IN THE INDUSTRIAL SECTOR

Number & name of the PaM	Objective and/or activity affected	GHG(s) affected	Type of instrument	Status of implementation	Brief description	Start year of implementa-tion	Implemen-ting entity or entities	Estimate of mitigation impact, by gas (for a particular year, not cumulative, in CO_2e)			
								2020	2025	2030	2035
IP01 - Industrial processes - F-gas related emissions regulation	Reduction of emissions of fluorinated gases.	HFCs SF_6	Regulatory	Implemented	Maximum annual rate for F-gas emissions from refrigeration and air-conditioning equipment.	2015	MDDI-AEV	9.87	59.64	87.86	115.53

Abbreviations used in Table IV.3-4:

MDDI-AEV – Ministry of Sustainable Development and Infrastructure – Environment Agency (*Ministère du Développement durable et des Infrastructures – Administration de l'Environnement*): http://www.gouvernement.lu/972044

TABLE IV.3-5 – PAMS ACCORDING TO THE WEM SCENARIO IN THE AGRICULTURE SECTOR

Number & name of the PaM	Objective and/or activity affected	GHG(s) affected	Type of instrument	Status of implementation	Brief description	Start year of implementa-tion	Implemen-ting entity or entities	Estimate of mitigation impact, by gas (for a particular year, not cumulative, in CO_2e)			
								2020	2025	2030	2035
AG01 - Agriculture - Rural Development Programme - livestock management	Improved animal waste management systems; Improved livestock management.	CO_2 CH_4 N_2O	Regulatory	Implemented	This PaM covers priority 5 of the Rural Development Programme, i.e. promoting resource efficiency and supporting the shift towards a low CO_2 emission and climate resilient economy.	2014	MAVPC-SER	NE	NE	NE	NE
AG02 - Agriculture - Rural Development Programme - livestock management - climate-smart agriculture investments	Improved animal waste management systems.	CO_2 CH_4 N_2O	Fiscal	Implemented	This PaM covers priority 5.D.1 of the Rural Development Programme, i.e. climate-friendly investment. Agricultural investments can contribute significantly to the reduction of GHG emissions. By taking into account the energy aspects during construction but also, in the case of heated stables, by adequate insulation. When storing and processing livestock waste, precautions may be taken to avoid ammonia losses (e.g. covering tanks). These considerations should be taken into account when developing new agriculture areas.	2014	MAVPC-SER	IE	IE	IE	IE

AG03 - Agriculture - Rural Development Programme - livestock management - promoting research and knowledge transfer for climate-smart agriculture	Improved animal waste management systems; Further identification of needs at the practical agricultural sector; Coordinating activities at the research level with the needs of the field; Ensuring an effective transfer of research results to practice.	CO_2 CH_4 N_2O	Information Education Research	Implemented	This PaM covers priority 5.D.2 of the Rural Development Programme (RDP), i.e. promoting research and knowledge transfer for climate-smart agriculture. The current transfer of knowledge between the research and practice is insufficient and too slow. The exchange of information at these levels needs to be improved. The achievement of these objectives requires a reorganization of agricultural research and advisory structures, as well as communication between the different actors. The RDP management authority will ensure the implementation of these objectives at national level.	2014	MAVPC-SER	IE	IE	IE	IE
AG04 - Agriculture - Rural Development Programme - livestock management - practices to reduce GHG emissions and ammonia	Improved animal waste management systems; Improved livestock management.	CO_2 CH_4 N_2O	Economic Voluntary/ negotiated agreements Regulatory Education	Implemented	This PaM covers priority 5.D.3. of the Rural Development Programme, i.e. livestock management practices to reduce GHG emissions and ammonia. Reduced tillage reduces overall fuel consumption and thus reduces CO_2 emissions. Modern slurry spreading techniques can significantly reduce ammonia losses. Reduction of nitrogen fertilization helps to reduce NO_2 emissions. It is therefore a question of promoting methods that help limiting the emission of GHG.	2014	MAVPC-SER	IE	IE	IE	IE
AG11 - Agriculture - Common Agricultural Policy - greening - crop diversification	Other activities improving cropland management.	CO_2	Economic	Implemented	This PaM pushes towards a more careful choice of crop rotation, which should lead to increase in soil carbon stock. It is based on green direct payments, which are linked to certain crop diversification conditions.	2013	MAVPC-SER	NE	NE	NE	NE
AG12 - Agriculture - Common Agricultural Policy - greening - permanent grassland	Activities improving grazing land or grassland management.	CO_2 N_2O	Economic	Implemented	The aim of this PaM is to conserve soil carbon and grassland habitats associated with permanent grassland. It is based on green direct payments linked to the conditions that permanent grasslands are protected. Hence, they cannot be ploughed or converted.	2013	MAVPC-SER	NE	NE	NE	NE
AG13 - Agriculture - Common Agricultural Policy - greening - ecological focus area	Other activities improving cropland management; Activities improving grazing land or grassland management.	CO_2 N_2O	Regulatory	Implemented	This PaM aims at protecting existing hedges and trees and at encouraging the plantation of new ones if they are not yet present. Farmers with arable areas exceeding 15 ha must ensure that at least 5% of such areas is an 'ecological focus area' dedicated to ecologically beneficial elements. Ecological focus areas cover a broad range of features, including ones that affect biodiversity: directly, such as fallow land, field margins, hedges and trees, buffer strips.	2013	MAVPC-SER	NE	NE	NE	NE

AG21 - Agriculture - practices - organic farming	Other activities improving cropland management.	CO_2 N_2O	Economic	Implemented	The conversion of conventional agriculture to organic agriculture is supported financially by the government. This measure is believed to increase carbon stocks in soils due to reduced tillage and improved organic fertilisation techniques.	2009	MAVPC-SER	NE	NE	NE	NE
AG22 - Agriculture - practices - conservation tillage or zero-tillage	Other activities improving cropland management.	CO_2 N_2O	Economic	Adopted	This PaM is believed to increase carbon stock in soils. In order to be eligible for a government grant for reduced tillage (or conservation tillage) farmers have to guarantee, over a 5-year period, that a certain amount of their fields will not undergo full tillage.	2013	MAVPC-SER	NE	NE	NE	NE

Abbreviations used in Table IV.3-5:

MAVPC – Ministry of Agriculture, Viticulture and Consumer Protection (*Ministère de l'Agriculture, de la Viticulture et de la Protection des consommateurs*): http://www.ma.public.lu/
SER = Department for Rural Economy (*Service d'Economie Rurale*): http://www.ser.public.lu/

Note: IE = indicated elsewhere
NE = not estimated

TABLE IV.3-6 – PAMS ACCORDING TO THE WEM SCENARIO IN THE FORESTRY SECTOR

Number & name of the PaM	Objective and/or activity affected	GHG(s) affected	Type of instrument	Status of implementation	Brief description	Start year of implementa-tion	Implemen-ting entity or entities	Estimate of mitigation impact, by gas (for a particular year, not cumulative, in CO_2e)			
								2020	2025	2030	2035
FO01 - Forestry - forest management - establishment of forest management plans in public forests	Conservation of carbon in existing forests; Enhanced forest management.	CO_2	Regulatory	Implemented	Forest officials have to establish forest management plans for all public forest. Those plans have establish harvest rates for the next 10 years. The harvest strategy is predefined and aims to smooth out age class structure. Clear-cut felling is prohibited and instead forests having reached their maturity are harvested over a period of 30 years for deciduous and 10 years for coniferous forests. Those long harvest times stabilise the existing carbon stocks in forests. The forest management plans also include the choice of tree species for future planting. Overall, those measures also aim to make forests more resilient towards extreme weather events.	2000	MDDI-ANF	NE	NE	NE	NE
FO02 - Forestry - forest management - protection of existing forests	Afforestation and reforestation; Conservation of carbon in existing forests.	CO_2	Regulatory	Implemented	This PaM aims to protect existing carbon stocks in forests. Current legislation (Article 13 of 19 January 2004 law on nature and natural resources protection) prohibits deforestation without previous authorisation and without compensation through afforestation of new forest areas.	2004	MDDI-ANF	NE	NE	NE	NE

FO03 - Forestry - forest management - increase of the size of forest nature reserves	Afforestation and reforestation; Conservation of carbon in existing forests; Enhancing production in existing forests.	CO_2	Voluntary/ negotiated agreements	Implemented	This PaM aims at increasing forest areas, which are left undisturbed with no harvesting taking place. In the short term, this will lead to an increase in dead wood and hence an increase in carbon stock in the forest sector. On the other hand, this measure lessens the total wood harvest potential and the potential for substitution effect for building materials or energy sources.	nd	MDDI-ANF	NE	NE	NE	NE
FO04 - Forestry - forest management - increase of the amount of dead wood in forests	Conservation of carbon in existing forests.	CO_2	Regulatory	Implemented	Harvest of wood in public forests is limited to tree trunks with a diameter greater than 10 cm. All other wood remains as dead wood in forests. This has already lead to an increase of carbon in the dead wood pool over the last years.	2005	MDDI-ANF	NE	NE	NE	NE
FO11 - Forestry - logging - Wood Cluster	Increasing the harvested wood products pool.	CO_2	Voluntary/ negotiated agreements	Adopted	The aim of the Wood Cluster is to assemble all actors of the wood sector in order to improve the utilisation of wood from forests. The aim is to use wood in cascade from high value product to lower value product and finally as energy source. This is in line with the objectives of the circular economy and will lead to maximise the use of this primary resource. It also means that new outlet markets have to be found for beech wood that, now, is primarily used as energy source or exported. In the long term, this should lead to an increase in the HWP pool and reduce the use of higher energy consuming cement-based building products.	2017	MDDI-ANF Luxinnovation	NE	NE	NE	NE
FO12 - Forestry - forest management - private forest nature reserve subsidy	Conservation of carbon in existing forests; Enhanced forest management; Prevention of deforestation; Strengthening protection against natural disturbances.	CO_2	Economic	Implemented	Subsidies paid to private forest owners and forests owned by communes to leave forests in their natural state.	2017	MDDI-ANF	NE	NE	NE	NE

Abbreviations used in Table IV.3-6:

MDDI-DEV – Ministry of Sustainable Development and Infrastructure – Department of the Environment (*Ministère du Développement durable et des Infrastructures – Département de l'environnement*): http://www.emwelt.lu/:
ANF = Nature & Forests Agency (Administration de la Nature et des Forêts): http://www.environnement.public.lu/functions/apropos_du_site/anf/index.html

Luxinnovation: https://www.luxinnovation.lu/

Note: NE = not estimated

IV.3.1.5. Forestry

Policies and measures within the forestry sector under the WEM scenario are outlined in *Table IV.3-6* above. Six forestry PaMs have been identified, which are a mix of regulatory, economic and voluntary agreements instruments. These include subsidies to private and commune forest owners to leave forests in their natural state (FO12), limiting the minimum diameter of wood being harvested to increase carbon stocks in dead wood pool (FO04), and the creation of the "Wood Cluster" to bring all actors of the forestry sector together to move to a circular economy approach (FO11). No WAM scenario PaMs for the forestry sector have been identified.

As of today, no mitigation potentials have been quantified for forestry PaMs.

IV.3.1.6. Waste management

Policies and measures within the waste sector under the WEM scenario are outlined in *Table IV.3-7* at the end of this section. 16 waste PaMs are presented, as well as a 17th grouped PaM - WM01, the "National Waste & Ressources Management Plan", which groups WM03, WM21 and WM25 together and that is not estimated at that level. The majority of the waste PaMs are regulatory instruments, some of which relate to the implementation of EU legislation such as the Waste Framework Directive 2008/98/EC [163] and the Waste Incineration Directive 2000/76/EC [164] (WM11), the Landfill Directive 1999/31/EC[165] (WM22 and WM23), the Waste Packaging Directive 2015/720/EU[166] (WM32). Luxembourg has several national regulatory policies concerning waste, for example, the *SuperDrecksKescht* (SDK),[167] which manages problematic waste from households and improves waste management systems in the private and public sectors. No WAM scenario PaMs for the waste sector have been identified.

Quantified mitigation potentials

The mitigation potential of three waste PaMs (WM22, WM24 and WM33) have been quantified.

WM22 – since 2014, no direct landfilling of waste has occurred in Luxembourg. Due to agreements between the syndicates, only one controlled landfill site in Muertendall, managed by SIGRE, is used since 1st January 2015. To further reduce CH_4 emissions, pre-treatment of all residual waste prior to

163 Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives (http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008L0098&qid=1515365261195&from=EN).

164 Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the incineration of waste (http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32000L0076&qid=1515365470109&from=EN).

165 Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste (http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31999L0031&qid=1515365555982&from=EN).

166 Directive (EU) 2015/720 of the European Parliament and of the Council of 29 April 2015 amending Directive 94/62/EC as regards reducing the consumption of lightweight plastic carrier bags (http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32015L0720&qid=1515365638612&from=EN).

167 https://www.sdk.lu/index.php/en/.

its disposal has been reinforced (since 1993 at SIGRE, since 2007 at SIDEC) so that only composted waste is landfilled (see also WM23). This is estimated to save 65.6 ktCO_2e in 2020.

WM24 covers the methane recovery systems that have been installed at the individual landfills Muertendall (managed by SIGRE) and Fridhaff (managed by SIDEC) in the years 2000 and 2002, respectively. While the recovered CH_4 is used for the production of electricity at the SIGRE landfill Muertendall, recovered gas is flared at the SIDEC landfill Fridhaff. The underlying assumption for quantifying PaM WM24 is that if methane recovery systems would not have been installed at landfills (Muertendall and Fridhaff) methane would escape directly to the atmosphere. This is estimated to save 6.66 ktCO_2e in 2020.

WM33 – a study by IGLUX[168] included an estimate of the potential of wood waste energy use due to this PaM and how much CO_2 its use would save in comparison to the use of natural gas or oil. In this ex-ante estimate, it was assumed that 70% of the wood waste potential replaces natural gas while 30% is consumed in existing biomass plants thus replacing other wood fuels. This is estimated to save 3.78 ktCO_2e in 2020.

The quantification of several other waste PaMs has been considered:

WM03 – notation key "NE. By 2017, 25 communes had implemented the waste tax, but no clear trend of municipal solid waste (MSW) generation since implementation of the PaM was observed. As the implementation timeframe by the rest of the municipalities is also unknown, it was concluded that the quantification of the PaM is not feasible at this stage.

WM11 – notation key "NO". The effect of this PaM would be the energy production related emissions avoided by incinerating waste, as well as avoided emissions from alternative treatment of waste (e.g. landfilling). The plant was built in 1976 and no energy efficiency improvements were identified because of the implementation of 2000/76/EC or 2008/98/EC. Thus decided not to quantify the impact of this PaM as any impact does not seem to be a result of a recent PaM.

WM12 – notation key "IE". Impact overlaps with WM22, WM33 and ES02 and the remaining emission reduction impact (on manure management) is minor.

WM23 – notation key "IE". This PaM is to be considered together with WM22.

WM31 – notation key “NE”. It might be possible to estimate avoided emissions thanks to the *SuperDrecksKescht* (SDK) programme.

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168 *Landesweite Potentialstudie Zur Energetischen Nutzung Holziger Biomasse* (http://www.environnement.public.lu/dechets/dossiers/Gestion-des-dechets-de-verdure/Etude-de-potentiel/Potentialstudie-Biomasse-IGLux.pdf).

WM32 – notation key “NO”. All recycling targets were reached already before 2005 (with one exception year for wood in 2009 being below target), thus it has been decided not to calculate the mitigation impact.

WM35 – notation key "NE". The effect of this PaM would be the production related emissions avoided by using sewage sludge instead of other fuels. However, the use of sewage sludge was smaller in 2014-2016 than in the earlier years, and therefore the available data did not allow estimation of the impact of the PaM. In the future years, if sewage sludge use starts to increase again, the impact could be estimated by assuming that sewage sludge replaces other fuels.

For detailed assumptions and methodology, see [Aether / Benviroc (2017)].

IV.3.2. Cross-sectoral policies and measures

Cross-sectoral policies and measures under the WEM and WAM scenarios are outlined in ***Table IV.3-8*** below. Three cross-cutting PaMs have been identified. Two are related to the good governance framework, concerning the function and extension of the “Environment and Climate Partnership” and the evaluation of environmentally harmful subsidies. The third concerns the diversification of Luxembourg’s economy and the use of public funds for the promotion of eco-technologies in the context of the development of an EcoInnovation Cluster in Luxembourg. It has been considered that a quantified mitigation potential estimate is not feasible for these PaMs.

TABLE IV.3-7 – PAMS ACCORDING TO THE WEM SCENARIO IN THE WASTE SECTOR

Number & name of the PaM	Objective and/or activity affected	GHG(s) affected	Type of instrument	Status of implementation	Brief description	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact, by gas (for a particular year, not cumulative, in CO_2e)			
								2020	2025	2030	2035
WM01 - Waste - overall management - National Waste & Ressources Management Plan	Demand management / reduction; Enhanced recycling; Enhanced CH_4 collection and use; Improved treatment technologies; Improved landfill management; Waste incineration with energy use; Improved wastewater management systems; Reduced landfilling.	CO_2 CH_4 N_2O	Planning	Implemented	According to Article 36 of the law of 21 March 2012 concerning the management of waste, the next national waste management plan is currently being elaborated. Luxembourg's national waste plan is a fundamental instrument that drives the waste management policy. Except for radioactive waste and waste from extractive operations, it covers all waste types (municipal solid waste, food and organic waste, packaging waste, electrical and electronic equipment/batteries) and has the goal to promote measures related to prevention and management of waste. The national waste plan does not include any quantitative targets.	2012	MDDI-AEV	NA	NA	NA	NA
WM02 - Waste - overall management - Environmental Protection Fund	Demand management / reduction; Enhanced recycling; Improved treatment technologies.	CO_2 CH_4 N_2O	Economic	Implemented	The modified law of 31 May 1999 on the establishment of a fund for the protection of the environment defines the manner in which, through the funds of the Environmental Protection Fund, the State may contribute financially to certain projects, including (A) water protection and sanitation;(B) prevention and control of air pollution, noise and climate change:(C) waste prevention and management;(D) the protection of nature and natural resources;(E) the remediation and rehabilitation of waste disposal sites and contaminated sites.	1999	MDDI-AEV MDDI-DEV	NA	NA	NA	NA

WM03 - Waste - overall management - polluter pays principle	Demand management / reduction.	CH_4	Regulatory	Implemented	In application of Art. 17(3) of the law of 21 March 2012, municipal charges must cover all costs incurred by municipalities in relation with waste management. The taxes charged to the various households and, where applicable, of establishments, must take into account the quantities of waste actually produced. For these purposes, the taxes must include at least one variable component calculated as a function of the weight and / or the volume of the residual household waste in a mixture actually produced as well as a variable component calculated according to the weight and / or volume of bulky waste actually produced.	2012	MDDI-AEV	NE	NE	NE	NE
WM04 - Waste - overall management - waste transfer fees	Waste management.	CO_2 CH_4	Regulatory	Implemented	Fees are to be collected on national waste transfer notification documents according to the law of 31 August 2016.	2016	MDDI-AEV	NA	NA	NA	NA
WM05 - Waste - overall management - reduced consumption of plastic bags	Demand management / reduction.	CO_2	Regulatory	Implemented	According to Art. 5 of the law of 21 March 2017 on the reduced consumption of plastic bags on a long-term basis, (1) the level of annual consumption shall not exceed ninety light plastic bags per person in December 31, 2019 and forty light plastic bags per person on December 31, 2025.	2017	MDDI-AEV	NA	NA	NA	NA
WM11 - Waste - energy - incineration and burning - energy recovery from waste incineration	Waste incineration with energy use.	CO_2 CH_4	Regulatory	Implemented	The aim of the Directive 2000/76/EC is to prevent or to reduce emissions caused by the incineration of waste. This is to be achieved through the application of operational conditions, technical requirements, and emission limit values for incineration plants within the EU. With regard to the incineration of mixed municipal waste, the Waste Framework Directive 2008/98/EC defines the minimum energy efficiency to be met by an incineration plant so that this operation can be considered as a recovery operation. Luxembourg has a single waste incineration plant (SIDOR), in operation since 1976. It deals with municipal solid waste generated in the communes of the cantons of Luxembourg, Esch and Capellen.	1976	MDDI-AEV	NO	NO	NO	NO

WM12 - Waste - energy - anaerobic digestion at biogas facilities	Enhanced CH4 collection and use.	CH_4	Economic Regulatory	Implemented	In the interest of maximizing the renewable energy source constituted by organic waste, organic waste is used for the production of biogas. CH_4 generation is used to produce heat and/or electricity. The network of biogas plants has increased to 21 installations during the period 2010-2015. In addition, several facilities, including Minett-Kompost, have been connected to the natural gas distribution network according to the regulation of 15 December 2011. Further, the Grand-Ducal Regulation of 3 August 2005 introduces an environmental incentive payment for electricity production from wind, hydro, solar, biomass and biogas.	2005	MECO-DEN ILR	IE	IE	IE	IE
WM13 - Waste - incineration and burning - prohibition of open air burning of waste	Demand management / reduction.	CO_2	Regulatory	Implemented	Article 42 of the modified law of 21 March 2012 states that the abandonment, dumping or uncontrolled management of waste is prohibited. This statement includes the prohibition of open burning of waste, which is considered as an uncontrolled management of waste. This includes the ban on cremation of green waste, household and non-domestic waste in the open air. Waste fines imposed for non-compliance with this provision are fixed in the Grand-Ducal Regulation of 18 December 2015. Indeed, a fine of 145 euros is imposed for open burning of waste and even 250 euros for open burning of non-domestic waste. Many municipalities have also implemented this prohibition in their respective municipal regulations.	1994	MDDI-AEV	NA	NA	NA	NA
WM21 - Waste - landfills - overall management - advanced waste collection system	Demand management / reduction; Improved landfill management; Reduced landfilling.	CO_2 CH_4 N_2O	Regulatory	Implemented	According to the Grand-Ducal Regulation of 1 December 1993 concerning the collective management of waste, it is mandatory to collect separately waste categories for which different treatment is required. Hence, an advanced waste collection system has been implemented, often with waste collection charges, allowing the evaluation of annual quantities of municipal waste.	1993	MDDI-AEV	NA	NA	NA	NA

WM22 - Waste - landfills - overall management - reduced landfilling of municipal solid waste	Reduced landfilling.	CH_4	Regulatory	Implemented	The modern requirements for disposal sites of the Landfill Directive 1999/31/EC aiming at preventing or reducing environmental damage by landfilling waste have been transposed into national legislation through the Grand-Ducal Regulation of 24 February 2003, subsequently amended and rectified by the Grand-Ducal Regulation of 17 February 2006. In order to reduce methane generation, Luxembourg has decided to minimise quantities of waste dumped into landfills as much as possible.	1993	MDDI-AEV	65.50	78.75	89.75	90.50
WM23 - Waste - landfills - overall management - biological pre-treatment of solid waste	Improved treatment technologies; Improved landfill management; Reduced landfilling.	CH_4 N_2O	Regulatory	Implemented	According to the national implementation of the Landfill Directive 1999/31/EC, large streams of waste undergo aerobic treatment procedures prior landfilling. Biological pre-treatment of solid waste prior landfilling, during which air is forcedly blown through the bulk waste to speed up its decomposition, has been systematically performed since SIGRE has first introduced aerobic treatment processes for the managed waste in 1993. At SIDEC, a mechanical-biological treatment plant has been installed treating mixed waste since 2007. According to Art. 7(a) of the modified Grand-Ducal Regulation of 24 February 2003 on landfilling waste, only pre-treated waste is landfilled.	1993	MDDI-AEV	IE	IE	IE	IE
WM24 - Waste - landfills - methane recovery systems	Enhanced CH_4 collection and use.	CH_4	Regulatory	Implemented	Methane recovery systems have been installed at the individual landfills Muertendall (managed by SIGRE) and Fridhaff (managed by SIDEC) in the years 2000 and 2002, respectively.	2000	MDDI-AEV	6.66	6.66	6.66	6.66
WM25 - Waste - landfills - verification of closed unmanaged landfills	Improved landfill management.	CH_4	Regulatory	Implemented	When the national waste legislation came into force in 1994, all private and municipal unmanaged landfills had to be closed. These areas were cleaned, planted and designed to fit into the landscape. A cadastre was set up, with all landfill sites that could be contaminated. Since 1994, inspections were systematically performed by the Environment Agency at a total of 616 former landfills, according to the procedure under Art. 14 of the modified Grand-Ducal Regulation of 24 February 2003. The environmental management oversaw the work that lasted until 2005. No abnormal behaviour of these closed sites has been detected and no corrective actions have been required.	1994	MDDI-AEV	NA	NA	NA	NA

WM31 - Waste - recycling - SuperDrecksKescht	Demand management / reduction; Enhanced recycling; Improved landfill management.	CH_4	Regulatory	Implemented	The 'SuperDrecksKescht' (SDK) is a programme for managing problematic waste from households and for implementing waste management in the business sector based on the principles of prevention, reduction and recovery of waste and promotes a new commercial model based on the 'consumption-reconsumption' philosophy. It covers: the management of problematic waste from households;- the assistance and advice of companies and establishments in the public and private sectors with a view to the certification of an ecological management of waste by these enterprises and establishments; promoting the ecological management of waste through publicity and awareness-raising activities; organization of the collection of small quantities of waste from enterprises and establishments in the public and private sectors; the proper storage, treatment and packaging of problem waste and the management of the warehouse in question. Different initiatives, such as "clever akafen" (buy smart) for residents and consulting for companies serve to prevent waste.	1985	MDDI-AEV	NE	NE	NE	NE
WM32 - Waste - recycling - packaging waste	Enhanced recycling.	CO_2 CH_4	Regulatory	Implemented	Pursuant to Directive 2015/720/UE, Art. 6. of the law of 21 March 2017 on packaging waste defines that, (1) Packaging managers are required to achieve, on an individual or collective basis, the following minimum targets for recovery and recycling: 1) 65% by weight of packaging waste shall be recovered or incinerated in incineration plants of waste with energy recovery; (2) 60% by weight of packaging waste shall be recycled with the following minimum recycling for the materials contained in the packaging waste: 60 per cent by weight for glass, 60 per cent by weight for paper and cardboard, 50 per cent by weight for metals, 22.5 per cent by weight for plastics, considering exclusively materials that are recycled as plastics and 15 percent by weight for wood.	2006	MDDI-AEV	NO	NO	NO	NO

WM33 - Waste - overall management - biowaste	Demand management / reduction; Reduced landfilling.	CH_4 N_2O	Regulatory Planning	Implemented	According to Art. 25 of the modified law of 21 March 2012, (1) Bio-waste must be separately collected in order to subject it to a composting operation or digestion or, if due to the nature of the material this is not possible, to any other recovery operation. (2) The treatment of bio-waste must be carried out in a manner compatible with a high level of environmental protection. The use of materials produced from bio-waste must be carried out without risk to the environment and human health.	2017	MDDI-AEV	3.18	3.18	3.18	3.18
WM35 - Waste - recycling - valorisation of sewage sludge	Improved treatment technologies.	CH_4 N_2O	Regulatory	Implemented	The Grand-Ducal Regulation of 23 December 2014 on sewage sludge outlines: - long-term reduction of valorisation in agriculture;- definition of additional prohibition zones for agricultural valorisation; reduction of the concentration limits for heavy metals;- widening of analytical parameters on certain organic pollutants (PAHs, PCBs, PCDDs / PCDFs). Valorisation of sewage sludge by energy recovery exists in Luxembourg at a clinker production facility in Rumelange. This facility has the necessary authorizations to accept maximum quantities of 15,000 Mg of dried sewage sludge.	2014	MDDI-AEV	NE	NE	NE	NE

Abbreviations used in Table IV.3-7:

MECO – Ministry of the Economy (*Ministère de l'Economie*): http://www.eco.public.lu/
DEN = Energy Directorate (*Direction de l'Energie*): http://www.eco.public.lu/index.html
MDDI-DEV – Ministry of Sustainable Development and Infrastructure – Department of the Environment (*Ministère du Développement durable et des Infrastructures – Département de l'environnement*): http://www.emwelt.lu/:
AEV = Environment Agency (*Administration de l'Environnement*): http://www.gouvernement.lu/972044

ILR – Luxembourg Institute of Regulation (Institut Luxembourgeois de Régulation): https://web.ilr.lu/FR/ILR

Note: NA = not applicable
NE = not estimated
NO = not occurring
IE = indicated elsewhere

TABLE IV.3-8 – CROSS-SECTORAL PAMS ACCORDING TO THE WEM AND *WAM* (*ITALIC*) SCENARIO

Number & name of the PaM	Objective and/or activity affected	GHG(s) affected	Type of instrument	Status of implementation	Brief description	Start year of implementa-tion	Implemen-ting entity or entities	Estimate of mitigation impact, by gas (for a particular year, not cumulative, in CO_2e) 2020	2025	2030	2035
GO01 - Good governance - Environment and Climate Partnership	*Framework policy*	*CO_2 CH_4 N_2O HFCs PFCs SF_6*	*Regulatory*	*Planned*	*This PaM should perpetuate the functioning and the synergies built up through the "Environment and Climate Partnership" by giving a future, clear perspectives and a legal framework to the work and functioning of this Partnership. It aims at extending the "Environment and Climate Partnership" to a "Sustainability Commission".*	*Mid-term*	*MDDI-DEV*	*NA*	*NA*	*NA*	*NA*
GO11 - Good governance - environmentally harmful subsidies	*Framework policy*	*CO_2 CH_4 N_2O HFCs PFCs SF_6*	*Regulatory*	*Planned*	*This PaM suggests the analysis of the different subsidies in conjunction with their possible harmful impacts on the environment as well as the setting-up of a regulatory framework for those subsidies.*	*Mid-term*	*MDDI-DEV MFIN*	*NA*	*NA*	*NA*	*NA*
IR01 - R and D - promoting eco-technologies in the fields of invention and innovation - EcoInnovation Cluster	Efficiency improvement in industrial end-use sectors; Measure that is part of the general policy aiming at diversifying Luxembourg's economy though the development of several clusters: Luxembourg Cluster Initiative.	CO_2 CH_4 N_2O HFCs PFCs SF_6	Research Other	Implemented	This PaM aims at a better use of public financial supports for the promotion and the use of eco-technologies, as well as supporting sectors and businesses operating in eco-technologies (fostering research projects and international developments) in the context of the development of an EcoInnovation Cluster in Luxembourg.	2012	MDDI-DEV MECO-DEN MESR LIST Luxinnovation	NA	NA	NA	NA

Abbreviations used in Table IV.3-8:

MECO – Ministry of the Economy (*Ministère de l'Economie*): http://www.eco.public.lu/
DEN = Energy Directorate (*Direction de l'Energie*): http://www.eco.public.lu/index.html
MDDI-DEV – Ministry of Sustainable Development and Infrastructure – Department of the Environment (*Ministère du Développement durable et des Infrastructures – Département de l'environnement*): http://www.emwelt.lu/
MESR – Ministry of Higher Education and Research (*Ministère de l'Enseignement Supérieur et de la Recherche*): http://www.mesr.public.lu/
MFIN – Ministry of Finance (*Ministère des Finances*): http://www.mf.public.lu/

LIST – Luxembourg Institute of Science and Technology: https://www.list.lu/fr/
Luxinnovation: https://www.luxinnovation.lu/

Note: NA = not applicable

IV.3.3. Assessment of aggregate effects of policies and measures

This assessment is presented in *Section V.5*.

IV.3.4. Policies and measures no longer in place

Since the submission of the sixth National Communication and second Biennial Report of Luxembourg, the following PaMs are no longer in place:

- **AG09** – Rural Development Programme - development and application of a legal frame for the promotion of agro-forestry. This PaM was in place in 2013-2015 and it aimed at developing a legal framework for agro-forestry activities and to consider it in the national "Rural Development Programme".
- **GO02** – evaluation of the 2nd national "Action Plan for reducing CO_2 emissions". This PaM was in place in 2013-2017, and the monitoring of the Plan was carried out on ad hoc basis. The 3rd national "Climate Plan" will be established during the year 2018 *[→ Section IV.1.3]* and therefore this specific PaM relevant for the second action plan is now expired.
- **GO12** – Housing Sector Plan. This PaM was in place 2013-2015 and it called for specifying and implementing a legal frame for the "Housing Sector Plan" with the aim to avoid urban sprawling and, therefore, reducing travelling distances as well as to promote a more sustainable development and use of land. As the national "Housing Sector Plan" is now in place in Luxembourg,[169] this PaM has expired.
- **PRIMe CAR-e**. As explained in [Ministry of Sustainable Development and Infrastructure, Department of the Environment (2014a), Section IV.3.3], this PaM concerned premiums for the buying of new energy efficient cars by companies and was ended in 2014.
- **EC02** – energy consumption – new constructions – promotion of low-energy and passive houses. This PaM that was part of the previous "PRIMe House" scheme was in place over the period 2013-2016 [Ministry of Sustainable Development and Infrastructure, Department of the Environment (2016b), Box 3-2]. It accelerated the introduction of energy standards in new residential buildings.
- **EC04** – energy consumption - residential buildings - existing constructions - increasing energy efficiency - insulation and ventilation. This PaM that was part of the previous "PRIMe House" scheme was in place over the period 2013-2016 [Ministry of Sustainable Development and Infrastructure, Department of the Environment (2016b), Box 3-2] and provided subsidies for improving the thermal insulation or the use of mechanical ventilation systems to increase energy efficiency.

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169 For an overview of this Plan: http://amenagement-territoire.public.lu/fr/plans-caractere-reglementaire/plans-sectoriels/logement.html.

In addition to the above-mentioned ones, other PaMs have also been adapted over time, in order to better achieve their goals. This is especially the case for the PaMs dealing with energy use in buildings.

Furthermore, some PaMs are renewed in an annual basis, such as the one dealing with excise duties on fuels for road transport. These PaMs are repealed and replaced by new ones every year fixing the various rates for the next period. However, strictly speaking, one cannot consider these revisions as a repeal of the PaMs.

IV.3.5. Plans and policies that could lead to increasing GHG emissions

Luxembourg has identified policies that may result in increasing GHG emissions, as explained below. However, further work would be needed to record the main programmes and plans, as well as fiscal and tax arrangements, not directly connected to climate change or energy issues but that could lead to increasing GHG or other air pollutants emissions.

For instance, the overall strategy for Luxembourg's economic development calls for the diversification of the economy. One of the diversification "clusters" pushed forward is on logistics, and more precisely for contract, air and rail freight-based logistics activities with a focus on value-added logistics. This might lead to some extra road or air transportation activities that might increase GHG emissions.

The development of cogeneration plants in Luxembourg, presented in *Section II.12.3*, though increasing energy security and offering a less polluting electricity than the one imported, led to increasing GHG emissions in Luxembourg. The response to this is now the development of cogeneration plants using biogenic fuels (biomass) that is considered as neutral with regard to CO_2 emissions (but not for the other GHG).

Various harmful subsidies act as incentives for GHG emitting activities. This is the case of a tax abatement in the income tax return offered for home-work journeys exceeding a given threshold. However, Luxembourg has now put in place several measures – such as TR25 – which aim at promoting the use of alternative modes of propulsion for cars (such as electric vehicles) as well as increasing the use of public transport for the commuting journeys.

IV.3.6. Minimizing the adverse effects of policies and measures in other countries

A small economy such as Luxembourg is unlikely to generate significant negative impacts abroad via its policy choices. As already shown in the chapters before, Luxembourg has identified a broad diversification of measures to reduce national GHG emissions via its second national "Action Plan for reducing CO_2 emissions". Most of the identified measures have no direct or indirect negative effects on developing countries (DCs).

However, where potential adverse impacts are identified, Luxembourg strives to implement its PaMs in such a way as to minimize adverse impacts on other Parties, especially developing country Parties (DCs) *[→ Section IV.3.6.2]*.

Furthermore, in order to minimize adverse impacts of the use of flexible mechanisms, Luxembourg ensures that the choice of project-based mechanisms is in line with sustainability criteria *[→ Section IV.3.6.1]*. Luxembourg also supports developing countries in addressing adverse impacts of climate change: Luxembourg's cooperation aid is focused on least developed countries (LDC's) and climate finance is additional to Official Development Aid (ODA). The country's cooperation is focused on several programmes of international financial institutions.

Luxembourg has identified some of the potentially harmful subsidies and adverse incentives in tax system *[→ Section IV.3.6.3]*, but these adverse impacts occur within Luxembourg. Potential carbon leakage to DCs has been addressed in emissions trading *[→ Section IV.3.6.4]*.

Finally, Luxembourg now engages on key topics such as human rights and gender equality in the context of climate change *[→ Section IV.3.6.5]*.

IV.3.6.1. Flexible mechanisms

The projects under Clean Development Mechanism (CDM) and the Joint Implementation (JI) should comply with **the ecological and social criteria established in the framework of the approval procedures of the UNFCCC**. In this context, Luxembourg has established procedures in order to evaluate the environmental, social and economic matters on the one hand, as well as the sustainability and cost-effectiveness of the projects on the other hand. In addition, projects must not involve nuclear and LULUCF activities, large hydro projects have to demonstrate compliance with the recommendations of the World Commission on Dams and projects shall not be located in a prohibited host country. The list of prohibited host countries is provided by the Ministry of Finance or the Ministry of Foreign and European Affairs. **Funding does not come from development-cooperation aid**.

The 2013-2018 governmental programme states that: "*The Government intends to review the governance of the climate & energy fund as well as the foreign emission rights acquisition policy in order to avoid bad quality certificates ("hot air") or the finance of environmentally harmful practices (e.g. coal extraction and production of HFCF-22)*" [Government of the Grand Duchy of Luxembourg (2013), p. 84].

In this context, the Government decides that, from 2014 onwards, only "high quality credits" will be considered for the conclusion of any new emission reduction purchase agreement (ERPA). Therefore, since 2014, every newly established ERPA only consists in "**Gold Standard certified CERs**", except for one carried out with the Adaptation Fund.

The Adaptation Fund portfolio is merely composed of **high quality CDM projects** – renewable energy (solar, geothermal, biomass, wind [mainly <60 MW], small hydro [<15 MW]), transport, landfill gas and methane avoidance – located in some 34 host countries and includes a share of 9% of Gold Standard CERs.

Since July 2016, no new ERPA has been concluded.

Funding for the purchase of carbon credits comes from the "Climate & Energy Fund" *[→ Section V.6.3]* and is additional to ODA funding.

IV.3.6.2. Biofuels

The promotion of biofuels is one policy having potential negative indirect effects on DCs as it could lead to the destruction of (or adverse shifts in) resources. EU legislation ensures that biofuels imported from such countries are **produced in accordance with the principles of sustainable development.** The conditions are set out in such a way that biofuels do not compete with food production and are not causing degradation of valuable ecosystems. Luxembourg supports relevant EU activities, such as the Directive on the Promotion of the Use of Energy from Renewable Sources & the Directive on Fuel Quality.

The 2013-2018 governmental programme states that: "*As 1st generation biofuels have shown not to fulfil the requirements of sustainable development, the Government is determined to condition the promotion of biofuel through social and ecological criteria and to introduce a limitation (cap) on the use of 1st generation biofuels. In the Community framework, the Government consequently will commit to the promotion of 2nd generation biofuels*" [Government of the Grand Duchy of Luxembourg (2013), p. 63].

IV.3.6.3. Harmful subsidies and adverse incentives in tax system

Environmentally harmful subsidies and adverse incentives in the tax system are partially identified. The objective is a **gradual elimination of such negative incentives**. Fiscal deductions for commuting to work and the fiscal arrangements for company cars are two of such negative incentives. Tax exemptions for some "occupational" fuels, such as in agriculture, are another example of potential field of action.

The 2013-2018 governmental programme foresees the progressive decoupling of budgetary revenues from road fuel sales and ordinary expenses of the State [Government of the Grand Duchy of Luxembourg (2013), p. 62]. To the extent that the budget permits it, revenues will progressively be assigned to the financing of measures aiming at an energetic transition to a more sustainable model. To do so, an economic feasibility study has been realised *[→ Section IV.3.1.2]*.

IV.3.6.4. Emission Trading

Companies under the EU ETS Directive are faced with legal requirements that can bear additional costs (e.g. reduction of GHG emissions through investments, purchase of CO_2 quotas). In order to prevent industries from "carbon leakage" and to avoid the associated negative effects on countries underlying a less constraining regulation, free allocations have been delivered to companies falling under EU ETS regulation (e.g. cement, glass, steel and chemical industries). During the first Kyoto Commitment Period (2008-2012) about 14 installations were concerned (total of 12.44 million tonnes CO_2e of free allocations), whereas in the second period (2013-2020), 21 installations are beneficiating from approx. 10.06 million tonnes CO_2e.

IV.3.6.5. Gender equality and Human Rights in the context of Climate Change

The European Convention on Human Rights is an international treaty under which the 47 Member States of the Council of Europe ensure fundamental, civil and political rights not only to their nationals, but also to all the people under their jurisdiction. Signed in Rome on November 1, 1950, this text came into force on 3 September 1953. In accordance with article 66 of the Convention, it is the deposit, in Strasbourg, of the 10th instrument of ratification by the Grand Duchy of Luxembourg that triggered the entry into force of the Convention. From 2012 to 2015, the Luxembourg judge Dean Spielmann, held the Presidency of the European Court of Human Rights.

Since 2015, Luxembourg is a proud signatory of the "Geneva Pledge for Human Rights in Climate Action". **The protection and the promotion of human rights, gender equality and the fight against climate change figure among the top policy priorities of the Luxembourg government**. Luxembourg is firmly of the view that it is important to take the stance to defend the universal agendas in the international fight against climate change in the context of human rights and gender equality.

Luxembourg is in various ways actively involved in the promotion and protection of human rights and gender equality, e.g.:

- focus on gender equality in the programming cycles of international cooperation activities;
- during the selection process of projects applying for international climate finance support a sustainable development assessment is performed, which includes social criteria (e.g. health and safety, quality of employment, access to clean drinking water) and gender criteria looking at aspects of women empowerment and equality and gender sensitive development impacts;
- financial support to the Gold Standard Foundation for the development of "Gender Equality Guidelines and Requirements" and application of the guidelines and requirements in a pilot climate project;

- financial support to the "Energy Sector Management Assistance Program" (ESMAP) of the World Bank with focus on project preparation activities related to the creation of a climate, health and gender results-based finance structure for distributing high efficient and clean cook stoves and helping women adopt new technologies;
- in May 2015, establishment of an Inter-ministerial Committee for Human Rights (CIDH) in order to improve the national coordination as well as the close cooperation with civil society, which forms an integral part of the work of the committee;
- support of the United Nations Office of the High Commissioner for Human Rights.

Today, clear political statements and commitments are necessary in order to move to a fair and sustainable climate framework for the years to come. However, political commitment on its own is not enough. Acutely aware that complex challenges, like climate change and human rights, cannot be taken up effectively by one actor alone, but call for coordinated, multidisciplinary and multistakeholder responses, Luxembourg has associated itself with partners from like-minded countries, international organizations and civil society to carry on the ongoing works in this regard. In order to stress its engagement in this cause, Luxembourg, together with its partners, hosted a side event dedicated to human rights and climate during COP23 in Bonn in 2017.

IV.3.7. Steps relating to aviation and marine bunker fuels

Each Party included in Annex I shall, in pursuit of Article 2, paragraph 2, of the Kyoto Protocol, identify the steps it has taken to promote and/or implement any decisions by the International Civil Aviation Organization (ICAO) and the International Maritime Organization (IMO) in order to limit or reduce emissions of GHG not controlled by the Montreal Protocol from aviation and marine bunker fuels.

Luxembourg is of the view that there is an urgent need to agree on global emission reduction targets for both international aviation and maritime transport, consistent with the 2°C objective, and believes that work should be continued through the ICAO and the IMO to implement a global policy framework ensuring a level playing field.

Luxembourg is actively participating in the ICAO work, mainly through the Abis group, representing the civil aviation authorities of eight European States (Austria, Belgium, Croatia, the Netherlands, Luxembourg, Ireland, Portugal and Switzerland) to the ICAO.

Luxembourg is of the view that the resolution for a global market-based measure to address CO_2 emissions from international aviation as of 2021, agreed upon by the ICAO Assembly in October 2016, is a significant step forward.

All aircraft operators administered by Luxembourg under the EU ETS are obliged to monitor their annual emissions and to submit a verified annual emission reports. Revenues regenerated through the auctioning of the allowances (15% will be auctioned) will be added to the "Climate & Energy Fund" *[→ Section V.6.3]*.

Furthermore, Cargolux, one of the leading cargo airlines worldwide based in Luxembourg, was the launch customer for the latest-generation of Boeing 747-8F, which is even more fuel-efficient and produces lower noise disturbances than the widely used Boeing 747-400F, one of the most fuel-efficient and quietest long-range wide-body aircraft available. The airline, in 2016, concluded its fleet rollover program with the delivery of its 14th and final 747-8 freighter. In June 2016, the company's environmental efforts were validated, as Cargolux became the first airline worldwide to be honoured with the Lean & Green award. The airline was recognized for its commitment to improve its carbon efficiency by 10% within five years.

Luxembourg is also participating in the work undertaken by the IMO, and in particular the work of the Marine Environment Protection Committee. Luxembourg shares the general concern within the EU that the IMO needs to further accelerate its efforts to reduce GHG emissions from the maritime sector and to adopt in April 2018 an ambitious initial IMO Strategy on reduction of greenhouse gas emissions from ships.

IV.3.8. Modification of longer-term trends in GHG emissions

Luxembourg's climate and sustainable development policies aim at modifying longer-term trends in anthropogenic GHG emissions and removals consistent with the objective of the Convention. The NSDP2 identified 14 non-sustainable trends, including "GHG emissions that do not slow down due to an increasing energy use" and "continuous growth of transport flows with adverse consequences on energy consumption, land use and road safety". The identified non-sustainable trends are tackled with 18 long-term objectives in NSDP2 to be reached by 2050. Nowadays, as discussed in Boxes IV.3-3 & IV.3-4, longer-term national objectives will be framed through the "Third Industrial Revolution Strategy Study" as well as through the future implementation of the Agenda 2030 and the associated NSDP3 that will be elaborated during the course of 2018. **Synergies between these two projects and the 3rd national "Climate Plan" will be clearly sought**.

A large share of the current PaMs of Luxembourg contribute to reducing GHG emissions in the longer-term. This is in particular the case for PaMs that have an impact on investments with long lifetimes such as construction of low-energy and passive houses and investments in energy supply by renewable fuels. In addition, promotion of electric vehicles is expected to have a long-term impact as it contributes to the long-term infrastructure development.

Chapter V

National Projections of GHG Emissions

Chapter V discusses GHG projections up to 2035 for two scenarios: "with existing measures" (WEM scenario), and "with additional measures" (WAM scenario). After short preliminary comments *[→ Section V.1]*, this chapter touches on the methodology underpinning the projections *[→ Section V.2]*, as requested by paragraphs 42, 43 and 48 of the UNFCCC reporting guidelines. Then, results of the projection exercise are presented for a collection of sectors *[→ Section V.3]*. The projections are in line with most of the recommendations of the UNFCCC reporting guidelines, paragraphs 27 to 32 and 34 to 41. Finally, after a brief discussion of possible improvements in the GHG projections methodology *[→ Section V.4]*, the **estimated and expected effects of individual policies and measures are presented in this chapter** *[→ Section V.5]*. To close this chapter, supplementarity relating to "flexible mechanisms" under Article 6, 12 and 17 of the Kyoto Protocol is discussed *[→ Section V.6]*.

V.1. PRELIMINARY REMARKS: PROJECTIONS ASSOCIATED TO HIGH UNCERTAINTY

This Communication has already emphasized specific national circumstances of Luxembourg on several occasions, which are setting the limits of a GHG projections exercise for Luxembourg.

V.1.1. Economy size increases uncertainty of GHG projections

Luxembourg's and its economy sizes yield uncertainties since single decisions at company level – being the opening, the closure or the breakdown of an industrial installation – could have a major impact on the overall national emissions development *[→ Section II.12.2]*. The power generation sector – with the TWINerg power plant that started its operation in 2002, faced long maintenance operations in 2008 and 2011 and finally shut down in 2016 - and the iron & steel sector – with the move from blast furnaces to electric arc furnaces between 1994 and 1998 – both give good examples of the difficulty to provide reliable long-run projections. **As decisions at company level can hardly be anticipated appropriately**, **emissions projections** for both the power generation and the industrial sectors **need to be evaluated with care**.

V.1.2. Road transportation: "road fuel sales to non-residents" share complicates the projection exercise

With more than 55% of total GHG emissions (excl. LULUCF), stemming from road transport, and around 40% allocated to "road fuel sales to non-residents" *[→ Table III.1-3]*, emissions structure is dominated by one sub-category – namely CRF 1A3b – for which the future evolution will not only depend on national PaMs, but also (i) on the international context, such as road fuel prices and taxation in the neighbouring countries, (ii) on options chosen with regard to mobility at EU level and, especially, in the neighbouring countries or regions (limitation of trucks circulation, introduction of road use fees or changes in the toll policy, etc.) or (iii) on technological developments (electric or hybrid cars, fuel cells vehicles, higher energy efficient engines, etc.). There is, therefore, a **high uncertainty** for the projected emissions due to road transport. Nevertheless, projections **take into account national PaMs implemented, adopted or planned and, to the extent possible, overall transport and traffic developments as appraised in European models**.

More precisely, the dominant influence of tax policy, but also other factors such as the expansion of road networks in neighbouring countries, which would allow a by-pass of the territory of Luxembourg, or the institution or increase of road use taxes in these same countries,[170] make projection of fuel sales – and corresponding GHG emissions – a hard task. As stressed under ***Section IV.3.1.2***, the impact from "road fuel sales to non-residents" can hardly be controlled by unilateral adaptations in national **tax policy**: as fuel sales attributed to "road fuel sales to non-residents" are mainly triggered by fuel price differentials (which are determined by differentials in excise rates), Luxembourg would need to permanently coordinate its tax policy with the policy of all neighbouring states (Belgium, France and Germany). This would mean to accept a limitation of the scope of national tax design options. **Technological developments** also complicate the exercise: for instance, what would be the impact of higher energy efficient engines in 5 to 10 years? – though EU regulations and planned EURO norms could help in this respect. Sometimes it is even impossible to predict here and now the influence of technological changes on road fuel sales since it depends on numerous indeterminate parameters such as the launch date of new types of vehicles driven by electricity, fuel cells or compressed air or the speed at which new concepts will be deployed, and adopted by the public.

V.2. MODEL AND METHODOLOGY[171]

V.2.1. Overall approach

GHG projections **for the years 2020, 2025, 2030 and 2035** have been prepared end April 2017 in the context of EU Regulation No 525/2013 (MMR),[172] which requires Member States to report on projections, as well as on PaMs, every odd years. This exercise should cover a sequence of four future years ending with 0 or 5 immediately following the reporting year.

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170 Road use taxes could be tolls to be paid on certain sections of motorways or other infrastructures, such as it is the case in France or specific taxes levied on specific vehicles categories, such as the "Eurovignette".
Like Belgium up to recently, and as well as the Netherlands, Denmark and Sweden, Luxembourg has, since 2001, been charging the "Eurovignette" on trucks using its highways following the so-called "Eurovignette Directive": http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32011L0076&from=EN. In Luxembourg, this tax (or user fee) is based on pollutant emissions (EURO standards) and the truck's number of axles. It can be paid on a yearly, monthly, weekly or daily basis: see http://www.do.etat.lu/vehaut/eurovignette.htm.

171 This section of the NC7 covers section V.D of the Outline and General Structure of the NC5 according to IPCC reporting guidelines (para. 5).

172 Regulation No 525/2013 of the European Parliament and of the Council of 21 May 2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/2004/EC.
(http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013R0525&rid=1).

GHG projections are estimated for all gases except PFCs and NF_3, for which no emissions are reported by Luxembourg *[→ Section III.1.2]*. They have been performed at CRF category or sub-category levels, the only sectors that were not estimated being CRF 3.H – urea application – and some memo items. Projected emissions are reported for both the "with existing measures" (WEM) and the "with additional measures" (WAM) scenarios. They are also distributed between ETS and non-ETS (ESD) when relevant, since this is of high significance for EU member countries *[→ Section IV.1.1.2]*. Most of the time, in-between years (2016 to 2019, 2021 to 2024, etc.) are the result of a linear interpolation.

The latest inventory submitted to the UNFCCC has been used for the reported (or "historical") years 1990 to 2015, i.e. **submission 2017v7**.[173] Some of the former projections – based on past submissions – have been adjusted applying a "rule of three", i.e. the projected trend has been kept but the level revised.

Consequently, the projections are the result of **a "bottom up" or "case-by-case" approach**. ***Table V.2-1*** summarizes the various methods, hypothesis and data sources that have been used.

V.2.2. WEM vs WAM scenario

The **WEM scenario** consists of a "Business as Usual" (BAU) or "reference" projection that includes the effects of the adopted and implemented PaMs **up to 31 December 2016** *[→ Section IV.3]*.

The **WAM scenario** does not include the planned measures described in *Section IV.3*. Indeed, the capacity building work programme that was initiated in 2017 to develop Luxembourg's reporting of climate PaMs required under the EU Regulation No 525/2013 (MMR) **has been started after** GHG projections have been submitted to the European Commission under this Regulation. Consequently, one of the main tasks to be performed in 2018 will be to align GHG projections and the effect of the PaMs. For those PaMs for which the ex-ante mitigation potential has been estimated, emission anticipated savings are summarized in ***Table IV.3-9***.

Thus, the WAM projections presented in this chapter **are not strictly speaking a "real" WAM scenario**. It is actually rather a **sensitivity analysis** since what differentiates the WEM and WAM scenarios is a hypothesis on future "road fuel sales to non-residents". For the WAM scenario, it is anticipated that these sales will reduce by 2% yearly from 2019 onwards due to anticipated policies in neighbouring countries, such as the Belgian and French announced policies aiming at balancing the prices of gasoline and diesel within a few years.

Finally, **there are no optional "without measures" (WOM) projections** produced yet for Luxembourg.

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173 http://unfccc.int/files/national_reports/annex_i_ghg_inventories/national_inventories_submissions/application/zip/lux-2017-crf-06apr17.zip.

TABLE V.2-1 – MAIN ASSUMPTIONS FOR GHG PROJECTIONS FOR BOTH SCENARIOS (WEM & WAM)

Sector (aggregated)	Projection method A	Projection method B	Other hypothesi(e)s	non-ETS (ESD) vs. ETS emissions	GHG evaluation
Total excluding LULUCF					
Total including LULUCF					
1 Energy					
1.A Fuel combustion					
1.A.1 Energy industries					
1.A.1.a Public electricity and heat production	2016: - STATEC/NEAM CO_2 estimate; - projections at CO_2 level.	2020/25/30/35: - adjusted 2015 Econotec projections (base year = 2016); - projections at CO_2 level.	a) the TWINerg is not re-activated; b) no new CHP plant similar to the TWINerg is starting operations; c) new power plants are using biomass only (wood, biogas, etc.) and the associated CH_4 & N_2O emissions are not estimated.	Projections calculated for total GHG since the STATEC/NEAM data provided does not split ETS & ESD emissions: a) ETS: ETS verified CO_2 emissions in 2016, excl. TWINerg, extended to 2035 (➔ CO_2 = total GHG); b) ESD: difference between total GHG estimates & ETS constant estimates.	a) CO_2: 2016: STATEC/NEAM CO_2 estimate; 2020/25/30/35: adjusted 2015 Econotec projection (base year = 2016); b) CH_4: 2015 ratio (CH_4/CO_2) applied to CO_2 estimates 2016-2035; c) N_2O: 2015 ratio (N_2O/CO_2) applied to CO_2 estimates 2016-2035. PS: for CH_4 & N_2O, the 2015 ratio has been used - not an average or a trend - since the sector experienced dramatic changes with the slowdown of the TWINerg leading to its closing.
1.A.1.b Petroleum refining	NO	NO	NO	NO	NO
1.A.1.c Manufacture of solid fuels and other energy industries	NO	NO	NO	NO	NO

1.A.2 Manufacturing industries and construction	All years: - STATEC/NEAM CO_2 annual growth rates for industry (base year = 2015); - projections at CO_2 level.	-	No closings of or new operating plants are considered.	Projections calculated for total GHG since the STATEC/NEAM data provided does not split ETS & ESD emissions: a) ETS 2016: ETS estimate by MDDI-DEV (difference between total verified ETS emissions minus ETS verified emissions and minus MDDI-DEV estimated process ETS emissions). b) ETS 2020/25/30/35: average ETS phase III (2013-2015) share in total GHG emissions applied to total GHG projections (average value ETS/total GHG = 0.7725); c) ETS: in-between years are linear interpolations; d) ESD: difference between total GHG estimates & ETS estimates.	a) CO_2: STATEC/NEAM CO_2 annual growth rates for industry (base year = 2015); b) CH_4: average 2010-2015 ratio (CH_4/CO_2) applied to CO_2 estimates 2016-2035; c) N_2O: average 2010-2015 ratio (N_2O/CO_2) applied to CO_2 estimates 2016-2035.
1.A.3 Transport					
1.A.3.a Domestic aviation	All years: MDDI-DEV hypothesis: 2016-2035 = 2015 emissions.	-	-	NA, however 1A3a CO_2 related emissions are not part of the non-ETS/ESD emissions.	All gases: MDDI-DEV hypothesis: 2016-2035 = 2015 emissions.
1.A.3.b Road transportation	**WEM** All years: adjusted Komobile projections; i.e. S4 E-mobility scenario.	**WAM** All years: - adjusted Komobile projections; i.e. S4 E-mobility scenario, for vehicles registered in Luxembourg; - MDDI-DEV hypothesis of a 2% annual decrease in emissions from “road fuel sales to non-residents” from 2019 onwards.	See [Komobile & FVT (2017a) & (2017b)].	NA	All gases: adjusted Komobile projections; i.e. S4 E-mobility scenario.
1.A.3.c Railways	All years: unadjusted Komobile projections.	-	See [Komobile & FVT (2017a)].	NA	All gases: unadjusted Komobile projections.
1.A.3.d Domestic navigation	All years: adjusted Komobile projections.	-	See [Komobile & FVT (2017a)].	NA	All gases: adjusted Komobile projections.
1.A.3.e Other transportation	NO	NO	NO	NO	NO

1.A.4 Other sectors					
1.A.4.a Commercial/Institutional	All years: - STATEC/NEAM CO_2 annual growth rates for the commercial/institutional sector (base year = 2015); - projections at CO_2 level.	-	See STATEC hypotheses (unpublished yet).	NA	a) CO_2: STATEC/NEAM CO_2 annual growth rates for the commercial/institutional sector (base year = 2015); b) CH_4: average 2010-2015 ratio (CH_4/CO_2) applied to CO_2 estimates 2016-2035; c) N_2O: average 2010-2015 ratio (N_2O/CO_2) applied to CO_2 estimates 2016-2035.
1.A.4.b Residential	All years: replication of 2015 Econotec projections, adjusted for submission 2017v7.	-	See [ECONOTEC Consultants (2015)].	NA	All gases: replication of 2015 Econotec projections, adjusted for submission 2017v7.
1.A.4.c Agriculture/Forestry/Fishing	All years: adjusted Komobile projections.	-	Projections based on the developments estimated by Komobile for mobile machinery used in forestry and agriculture only. See [Komobile & FVT (2017a)]	NA	All gases: adjusted Komobile projections.
1.A.5 Other	All years: adjusted Komobile projections.	-	Projections based on the developments estimated by Komobile for military vehicles only. See [Komobile & FVT (2017a)]	NA	All gases: adjusted Komobile projections.
1.B Fugitive emissions from fuels					
1.B.1 Solid fuels	NO	NO	NO	NO	NO
1.B.2 Oil and natural gas and other emissions from energy production	All years: adjusted PRIMES 2016 Reference Scenario projections for natural gas gross inland consumption.	-	Based on PRIMES projected gross inland consumption of natural gas [European Commission (2016c)].	NA	CO_2 & CH_4: adjusted PRIMES 2016 Reference Scenario projections for natural gas gross inland consumption.
1.C CO_2 transport and storage	NO	NO	NO	NO	NO
2 Industrial processes					
2.A Mineral Industry					
2.A of which cement production	2020/25/30/35: MDDI-AEV projections.	2016: process ETS emissions are estimated by MDDI-DEV from total ETS emissions for that category by using the 2011-2015 average ratio (verified ETS process emissions/total verified ETS emissions).	See MDDI-AEV hypotheses (unpublished yet).	All CO_2 projected emissions are supposed to be ETS emissions, hence projections realised at CO_2 level except for 2016 (at ETS level).	CO_2: 2016: ETS estimate by MDDI-DEV; 2020/25/30/35: MDDI-AEV projections.

2.A of which other non-cement production	2020/25/30/35: MDDI-AEV projections.	2016: process ETS emissions are estimated by MDDI-DEV from total ETS emissions for that category by using the 2015 ratio (verified ETS process emissions/total verified ETS emissions), since there is a clear trend for this ratio.	See MDDI-AEV hypotheses (unpublished yet).	All CO_2 projected emissions are supposed to be ETS emissions, hence projections realised at CO_2 level except for 2016 (at ETS level).	CO_2: 2016: ETS estimate by MDDI-DEV; 2020/25/30/35: MDDI-AEV projections.
2.B Chemical industry	NO	NO	NO	NO	NO
2.C Metal industry					
2.C of which Iron and steel production	2020/25/30/35: MDDI-AEV projections.	2016: process ETS emissions are estimated by MDDI-DEV from total ETS emissions for that category by using the 2015 ratio (verified ETS process emissions/total verified ETS emissions), since there is a clear trend for this ratio.	See MDDI-AEV hypotheses (unpublished yet).	All CO_2 projected emissions are supposed to be ETS emissions, hence projections realised at CO_2 level except for 2016 (at ETS level).	CO_2: 2016: ETS estimate by MDDI-DEV; 2020/25/30/35 MDDI-AEV projections.
2.C of which other non-iron and steel production	NO	NO	NO	NO	NO
2.D Non-energy products from fuels and solvent use	All years: MDDI-AEV projections.	-	See MDDI-AEV hypotheses (unpublished yet).	NA	CO_2: MDDI-AEV projections.
2.E Electronics industry	NO	NO	NO	NO	NO
2.F Product uses as substitutes for ODS	All years: MDDI-AEV projections.	-	See MDDI-AEV hypotheses (unpublished yet).	NA	N_2O, HFC & SF_6: MDDI-AEV projections.
2.G Other product manufacture and use	All years: MDDI-AEV projections.	-	See MDDI-AEV hypotheses (unpublished yet).	NA	HFC: MDDI-AEV projections.
2.H Other	NO	NO	NO	NO	NO
3 Agriculture					
3.A Enteric fermentation	All years: adjusted GAINS 2016 Reference Scenario projections for livestock.	-	Quantities derived in GAINS based on Eurostat & CAPRI model data.	NA	CH_4: adjusted GAINS 2016 Reference Scenario projections for livestock.
3.B Manure management	All years: adjusted GAINS 2016 Reference Scenario projections for manure management.	-	Quantities derived in GAINS based on Eurostat & CAPRI model data. For CH_4 the N_2O GAINS developments have been used since the ratio CH_4/N_2O for 3.B. is rather stable through the historical years.	NA	CH_4 & N_2O: adjusted GAINS 2016 Reference Scenario projections for manure management.
3.C Rice cultivation	NO	NO	NO	NO	NO
3.D Agricultural soils	All years: adjusted GAINS 2016 Reference Scenario projections for soils.	-	Quantities derived in GAINS based on Eurostat & CAPRI model data.	NA	N_2O: adjusted GAINS 2016 Reference Scenario projections for soils.

3.E Prescribed burning of savannahs	NO	NO	NO	NO	NO
3.F Field burning of agricultural residues	NO	NO	NO	NO	NO
3.G Liming	All years: MDDI-DEV hypothesis: 2016-2035 = 2015 emissions.	-	2015 value (=2013 & 2014 values) replicated up to 2035: this is a strong hypothesis because the time series since 1990 is not homogenous and is very volatile.	NA	CO_2: MDDI-DEV hypothesis: 2016-2035 = 2015 emissions.
3.H Urea application	NE	NE	NE	NE	NE
3.I Other carbon-containing fertilizers	NO	NO	NO	NO	NO
3.J Other	NO	NO	NO	NO	NO
4 Land Use, Land-Use Change and Forestry					
4.A Forest land	All years: MDDI-AEV projections	-	Land use changes from and to forestland are assumed to be zero. Future harvest rates are assumed similar to harvest rates calculated according to the hypothesis used to determine the Forest Management Reference Level: see MDDI-AEV report (unpublished yet).	NA	CO_2 & N_2O: MDDI-AEV projections.
4.B Cropland	All years: MDDI-AEV projections	-	Agricultural practices remain unchanged and hence the carbon stock change within the category cropland remaining cropland is zero. The land use changes from grassland to cropland are assumed to be zero: see MDDI-AEV report (unpublished yet).	NA	CO_2 & N_2O: MDDI-AEV projections. For 2035, MDDI-AEV provided a zero value for N_2O: a value has been estimated by the MDDI-DEV.
4.C Grassland	All years: MDDI-AEV projections	-	Agricultural practices remain unchanged and hence the carbon stock change within the category grassland remaining grassland is zero. The land use changes from cropland to grassland are assumed to be zero: see MDDI-AEV report (unpublished yet).	NA	CO_2 & N_2O: MDDI-AEV projections. For 2035, MDDI-AEV provided a zero value for CO_2 & N_2O: a value has been estimated by the MDDI-DEV.
4.D Wetlands	All years: MDDI-AEV projections	-	See MDDI-AEV report (unpublished yet).	NA	CO_2 & N_2O: MDDI-AEV projections. For 2035, MDDI-AEV provided a zero value for CO_2 & N_2O: a value has been estimated by the MDDI-DEV.

4.E Settlements	All years: MDDI-AEV projections	-	Land use is based on the business as usual scenario of population growth provided by STATEC: see MDDI-AEV report (unpublished yet).	NA	CO_2 & N_2O: MDDI-AEV projections.
4.F Other Land	All years: MDDI-AEV projections	-	See MDDI-AEV report (unpublished yet).	NA	a) CO_2: MDDI-AEV projections. For 2035, MDDI-AEV provided a zero value: a value has been estimated by the MDDI-DEV.; b) N_2O: MDDI-DEV hypothesis: 2015 value replicated up to 2035 since no projected emissions were provided by MDDI-AEV for this sub-category.
4.G Harvested wood products	NO	NO	NO	NO	NO
4.H Other	NO	NO	NO	NO	NO
5 Waste					
5.A Solid Waste Disposal	All years: MDDI-AEV projections	-	See MDDI-AEV report (unpublished yet).	NA	CH_4: MDDI-AEV projections.
5.B Biological treatment of solid waste	All years: adjusted GAINS 2016 Reference Scenario projections for solid waste composting quantities.	-	Quantities derived in GAINS based on Eurostat data.	NA	CH_4 & N_2O: adjusted GAINS 2016 Reference Scenario projections for solid waste composting quantities.
5.C Incineration and open burning of waste	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE
5.D Wastewater treatment and discharge	All years: MDDI-AGE projections	-	See MDDI-AGE hypotheses (unpublished yet).	NA	a) CH_4: MDDI-AGE projections. From 2030 onwards, MDDI-AGE reports NO. Between 2025 & 2030, the interpolation is a decreasing trend towards 0 suggested by MDDI-DEV; b) N_2O: MDDI-AGE projections.
5.E Other	NO	NO	NO	NO	NO
Memo items					
International bunkers					

Aviation	All years: - adjusted PRIMES 2016 Reference Scenario projections for CO_2 emissions for aviation; - projections at total GHG level.	-	-	NA	Projections calculated at total GHG level: a) CO_2: average 2010-2015 ratio (CO_2/total GHG) applied to total GHG estimates 2016-2035 ; b) CH_4: average 2010-2015 ratio (CH_4/total GHG) applied to total GHG estimates 2016-2035 ; c) N_2O: average 2010-2015 ratio (N_2O/total GHG) applied to total GHG estimates 2016-2035.
Navigation	NE	NE	NE	NE	NE
CO_2 emissions from biomass	NE	NE	NE	NE	NE
CO_2 captured	NO	NO	NO	NO	NO
Long-term storage of C in waste disposal sites	NE	NE	NE	NE	NE
Indirect N_2O	All years: MDDI-DEV projections based on the constant value (0.225) for the ratio (Indirect N_2O/total LULUCF N_2O emissions).	-	-	NA	N_2O: MDDI-DEV projections based on the constant value (0.225) for the ratio (Indirect N_2O/total LULUCF N_2O emissions).
International aviation in the EU ETS	All years: MDDI-DEV projections based on the 2014-2015 average for the ratio (intl. aviation ETS CO_2 emissions/intl. aviation total GHG emissions).	-	-	ETS: MDDI-DEV projections based on the 2014-2015 average for the ratio (intl. aviation ETS CO_2 emissions/intl. aviation total GHG emissions).	NA
1.A.3.a Domestic aviation (CO_2 only - for ESD calculation)	All years: MDDI-DEV hypothesis: 2016-2035 = 2015 emissions.	-	-	NA, however 1A3a CO_2 related emissions are not part of the non-ETS/ESD emissions.	CO_2: MDDI-DEV hypothesis: 2016-2035 = 2015 emissions.

Abbreviations used in Table V.2-1:
MDDI-DEV – Ministry of Sustainable Development and Infrastructure – Department of the Environment (*Ministère du Développement durable et des Infrastructures – Département de l'environnement*): http://www.emwelt.lu/:
AEV = Environment Agency (*Administration de l'Environnement*): http://www.gouvernement.lu/972044
AGE = Water Agency (*Administration de la Gestion de l'Eau*): http://www.eau.public.lu/
MECO – Ministry of the Economy (*Ministère de l'Economie*): http://www.eco.public.lu/
STATEC = National Statistical Institute: http://www.statistiques.public.lu/fr/acteurs/statec/index.html

CHP – Combined Heat and Power.
EC PRIMES & GAINS 2016 Reference Scenarios – see Section V.2.4.

Notes:
1. inventory data up to 2015; ETS data up to 2016 (2016 distribution between combustion & processes not available ➔ MDDI-DEV estimate).
2. when projections are only calculated for the "0" or "5" years, in-between years are linear interpolations.
3. adjusted & unadjusted: "adjusted" means that the emission trend reported by the data source used for the calculation of the projected emissions has been kept (annual growth rates) but adjusted to take into account the latest inventory data ("rule of three"). This option is chosen if the historical data from the data are too different from the latest GHG inventory data (i.e. submission 2017v7).

NA = not applicable NE = not estimated NO = not occurring IE = indicated elsewhere

V.2.3. Detailed assumptions for emissions projections

Since Luxembourg's projections mostly rely on a "bottom-up" approach, only a few key parameters have been used for detailed assumptions for emissions projections, namely population anticipated growth and projections of energy demand by main sectors, including the housing and transport sectors. Assumptions on future physical production in the various energy and industrial sectors are another input. **GDP growth has not been taken into account while preparing the projections**. There are obvious reasons for not considering GDP implicitly in the projections exercise: firstly, the GDP of Luxembourg is mainly driven by service activities and, more precisely, finance related activities. Moreover, a great share of the industrial production in Luxembourg is exported (small internal market, most of the big industrial installations are subsidiaries of foreign business concerns) and finally, road freight transport, that is definitively correlated to GDP, is actually more correlated to an aggregated GDP for various EU Member States than to the GDP of Luxembourg since its emissions are principally due to traffic in transit. **With regard to international carbon and energy prices, no specific hypotheses have been made**. Nevertheless, these prices are implicitly taken into account where results of the PRIMES & GAINS 2016 Reference Scenario *[→ Section V.2.4.4]* exercise have been used [European Commission (2016c) and *Table V.2-1]*. Consequently, without explicit use of either GDP or energy and carbon prices, **no sensitivity analysis stricto sensu could have been performed so far on the projections** *[→ Section V.3.10]*.

Table V.2-2 below lists the main relevant information on factors and activities – parameters – used for projecting GHG emissions up to 2035. This table is constructed based on a template to be filled in by EU member countries under Article 14 of EU Regulation No 525/2013 (MMR).

If some parameters are not available in Luxembourg ("not estimated" – NE), others are reported as "not applicable" (NA) because they are not used for projecting GHG emissions up to 2035.

TABLE V.2-2 – PARAMETERS USED FOR GHG PROJECTIONS FOR THE WEM SCENARIO

Parameter used - WEM scenario	Default unit	Base/ Reference year (year)	Base/ Reference year (value)	2015	2020	2025	2030	2035	Data source	Year of publication of data source	Sectoral projections for which the parameter is used	Comment
Population 1	count	2015	576 249	576 249	644 975	700 500	750 000	797 600	Data prepared by the NSI (STATEC) in the framework of DG ECFIN Ageing Working Group	2017	1.A.1 1.A.4a 4.E	Latest official submission to DG ECFIN Ageing Working Group.
Population 2	count	2012	537 039	560 649	600 000	637 500	675 000	705 000	Data prepared by the NSI (STATEC) in the framework of DG ECFIN Ageing Working Group	2014	5.A	Projected emisions for 5.A where produced using a previous submission to DG ECFIN Ageing Working Group.
Population 3	count	2015	569 558	569 558	639 921	715 466	792 882	868 741	PRIMES & GAINS 2016 updated Reference Scenarios	2016	Intl. aviation in the EU ETS	Population projections as reported for the PRIMES 2016 exercice.
Working population	count	2015	405 600	405 600	471 934	511 968	549 243	587 277	STATEC - NEAM	2017	1.A.4.a	-
Gross domestic product (GDP):-Real growth rate	% (EUR 2010)	-	NA	NA	NA	NA	NA	NA	-	-	-	-
Gross domestic product (GDP):-Constant prices	Mio. EUR 2010	-	NA	NA	NA	NA	NA	NA	-	-	-	-
Gross value added (GVA) total industry	Mio. EUR 2010	-	NA	NA	NA	NA	NA	NA	-	-	-	-
Exchange rates EURO (for non-EURO countries), if applicable	EUR 2010/currency	-	NA	NA	NA	NA	NA	NA	-	-	-	-
Exchange rates US DOLLAR, if applicable	USD 2010/ currency	-	NA	NA	NA	NA	NA	NA	-	-	-	-
EU ETS carbon price	EUR 2010/EUA	-	NE	NE	NE	NE	NE	NE	-	-	-	Implicitly taken into account where results of the PRIMES and GAINS 2016 exercise have been used.
International (wholesale) fuel import prices:-Electricity Coal	EUR 2010/GJ	-	NE	NE	NE	NE	NE	NE	-	-	-	
International (wholesale) fuel import prices:-Crude Oil	EUR 2010/GJ	-	NE	NE	NE	NE	NE	NE	-	-	-	
International (wholesale) fuel import prices:-Natural gas	EUR 2010/GJ	-	NE	NE	NE	NE	NE	NE	-	-	-	
Energy parameters												
National retail fuel prices (with taxes included):-Coal, industry	EUR 2010/GJ	-	NE	NE	NE	NE	NE	NE	-	-	-	-
National retail fuel prices (with taxes included):-Coal, households	EUR 2010/GJ	-	NE	NE	NE	NE	NE	NE	-	-	-	-
National retail fuel prices (with taxes included):-Heating oil, industry	EUR 2010/GJ	-	NE	NE	NE	NE	NE	NE	-	-	-	-
National retail fuel prices (with taxes included):-Heating oil, households	EUR 2010/GJ	-	NE	NE	NE	NE	NE	NE	-	-	-	-
National retail fuel prices (with taxes included):-Transport, gasoline	EUR 2010/GJ	-	NE	NE	NE	NE	NE	NE	-	-	-	-
National retail fuel prices (with taxes included):-Transport, diesel	EUR 2010/GJ	-	NE	NE	NE	NE	NE	NE	-	-	-	-
National retail fuel prices (with taxes included):-Natural gas, industry	EUR 2010/GJ	-	NE	NE	NE	NE	NE	NE	-	-	-	-
National retail fuel prices (with taxes included):-Natural gas, households	EUR 2010/GJ	-	NE	NE	NE	NE	NE	NE	-	-	-	-
National retail electricity prices (with taxes included):-Industry	EUR 2010/kWh	-	NE	NE	NE	NE	NE	NE	-	-	-	-
National retail electricity prices (with taxes included):-Households	EUR 2010/kWh	-	NE	NE	NE	NE	NE	NE	-	-	-	-
Gross inland consumption: solid fuels	GJ	-	NE	NE	NE	NE	NE	NE	-	-	-	-
Gross inland consumption: total petroleum products	GJ	-	NE	NE	NE	NE	NE	NE	-	-	-	-
Gross inland consumption: gas	ktoe	2015	1 030.58	1 030.58	1 025.80	1 139.23	1 157.79	1 350.63	PRIMES & GAINS 2016 updated Reference Scenarios	2016	1B	-
Gross inland consumption:-Renewables	GJ	-	NE	NE	NE	NE	NE	NE	-	-	-	-
Gross inland consumption:-Nuclear	GJ	-	NE	NE	NE	NE	NE	NE	-	-	-	-
Gross inland consumption:-Other	GJ	-	NE	NE	NE	NE	NE	NE	-	-	-	-
Gross inland consumption:-Total	GJ	-	NE	NE	NE	NE	NE	NE	-	-	-	-
Gross electricity production:-Coal	TWh	-	NO	NO	NO	NO	NO	NO	STATEC - NEAM	2017	-	-
Gross electricity production:-Oil	TWh	-	NO	NO	NO	NO	NO	NO	STATEC - NEAM	2017	-	-
Gross electricity production:-Natural gas	TWh	2015	0.83	0.83	0.26	0.26	0.26	0.26	STATEC - NEAM	2017	1.A.1 1.A.2	-
Gross electricity production:-Renewables	TWh	2015	0.19	0.19	0.83	0.83	0.83	0.83	STATEC - NEAM	2017	1.A.1 1.A.2 1.A.4.a 1.A.4.b	Incl. organic waste residues incinerated with energy recovery.
Gross electricity production:-Nuclear	TWh	-	NO	NO	NO	NO	NO	NO	STATEC - NEAM	2017	-	-
Gross electricity production:-Other	TWh	-	NO	NO	NO	NO	NO	NO	STATEC - NEAM	2017	-	-
Gross electricity production:-Total 1	TWh	2015	1.03	1.03	1.09	1.09	1.09	1.09	STATEC - NEAM	2017	NA	Econotec EPM projections used instead.
Gross electricity production:-Total 2	TJ	2012	32 636.56	26 924.44	25 515.47	28 373.87	29 092.02	29 225.98	Econotec EPM	2015	1.A.1	Projected values from the Econotec EPM model of 2015.
Total net electricity imports	TWh	2015	4.97	4.97	5.17	5.39	5.57	5.71	STATEC - NEAM	2017	NA	Econotec EPM projections used instead.
Gross final energy consumption	GJ	2015	173 005 497	173 005 497	176 555 850	177 980 109	180 892 987	183 452 553	STATEC - NEAM	2017	NA	Projections calculated for each combustion category sources.
Final energy consumption:-Industry	GJ	2015	28 054 924	28 054 924	28 299 468	28 951 471	29 601 285	30 216 123	STATEC - NEAM	2017	1.A.2	-
Final energy consumption:-Transport	GJ	2015	103 873 172	103 873 172	104 428 254	104 380 189	106 306 383	108 616 243	STATEC - NEAM	2017	NA	Komobile & FVT projections used instead.
Final energy consumption:-Residential 1	GJ	2015	24 043 783	24 043 783	26 318 739	27 685 889	28 812 021	29 281 343	STATEC - NEAM	2017	NA	Econotec EPM projections used instead.
Final energy consumption:-Residential 2	TJ	2012	16 108.49	15 660.05	14 456.01	13 047.37	11 763.88	11 194.74	Econotec EPM	2015	1.A.4.b	-
Final energy consumption:-Agriculture/Forestry	GJ	2015	237 689	237 689	294 144	294 144	294 144	294 144	STATEC - NEAM	2017	NA	Komobile & FVT projections used instead.
Final energy consumption:-Services	GJ	2015	16 795 929	16 795 929	17 215 245	16 668 415	15 879 153	15 044 699	STATEC - NEAM	2017	1.A.4.a	-
Final energy consumption:-Other	GJ	-	NO	NO	NO	NO	NO	NO	STATEC - NEAM	2017	-	-
Final energy consumption:-Total	GJ	2015	173 005 497	173 005 497	176 555 850	177 980 109	180 892 987	183 452 553	STATEC - NEAM	2017	NA	Projections calculated for each combustion category sources.

Number of heating degree days (HDD)	count	2015	3 342.03	3 342.03	3 542.91	3 542.91	3 542.91	3 542.91	STATEC - NEAM	2017	1.A.4.a	-
Number of cooling degree days (CDD)	count	-	NE	NE	NE	NE	NE	NE	STATEC - NEAM	2017	-	-
Transport parameters												
Number of passenger-kilometres (all modes) 1	million pkm	2015	9 574.76	9 574.76	13 366.01	13 859.86	14 354.76	14 897.43	Komobile & FVT	2017	1.A.3	Inland journeys only. Covers private cars, buses, motorbikes, trains, bicycles and walking: details by transport mode available on request.
Number of passenger-kilometres (all modes) 2	million pkm	2015	7 068.47	7 068.47	5 835.18	5 245.65	5 326.38	5 660.19	Komobile & FVT	2017	1.A.3	Covers only private cars that fuelled up in Luxembourg but are not registered in Luxembourg.
Freight transport tonnes-kilometres (all modes) 1	million tkm	2015	3 861.26	3 861.26	4 850.54	5 606.65	6 415.67	7 183.63	Komobile & FVT	2017	1.A.3	Inland journeys only. Covers light & heavy duty vehicles and trains: details by transport mode available on request.
Freight transport tonnes-kilometres (all modes) 2	million tkm	2015	45 639.72	45 639.72	46 917.56	52 960.81	59 019.73	65 188.68	Komobile & FVT	2017	1.A.3	Covers only light & heavy duty vehicles that fuelled up in Luxembourg but are not registered in Luxembourg.
Final energy demand for road transport	GJ	2015	103 873 172	103 873 172	104 428 254	104 380 189	106 306 383	108 616 243	STATEC - NEAM	2017	NA	Komobile & FVT projections used instead.
CO_2 emissions aviation	kt CO_2	2015	1 308.96	1 308.96	1 338.53	1 435.98	1 548.56	1 669.71	PRIMES & GAINS 2016 updated Reference Scenarios	2016	1.A.3.a Intl. aviation in the EU ETS	-
Buildings parameters												
Number of households	count	2015	240 081	240 081	280 235	309 801	339 367	360 905	STATEC - NEAM	2017	NA	Econotec EPM projections used instead.
Household size	inhabitants/household	2015	2.40	2.40	2.30	2.26	2.21	2.21	STATEC - NEAM	2017	NA	Econotec EPM projections used instead.
Agriculture parameters												
Livestock:-Dairy cattle	1000 heads	2015	48.46	48.46	44.36	42.68	43.72	44.29	PRIMES & GAINS 2016 updated Reference Scenarios	2016	3.A 3.B	-
Livestock:-Non-dairy cattle	1000 heads	2015	134.40	134.40	128.81	127.58	124.66	120.80	PRIMES & GAINS 2016 updated Reference Scenarios	2016	3.A 3.B	-
Livestock:-Sheep	1000 heads	2015	14.80	14.80	16.14	17.47	18.93	20.50	PRIMES & GAINS 2016 updated Reference Scenarios	2016	3.A 3.B	-
Livestock:-Pig	1000 heads	2015	82.37	82.37	83.31	83.02	85.10	84.92	PRIMES & GAINS 2016 updated Reference Scenarios	2016	3.A 3.B	-
Livestock:-Horses	1000 heads	2015	4.60	4.60	4.60	4.60	4.60	4.60	PRIMES & GAINS 2016 updated Reference Scenarios	2016	3.A 3.B	-
Livestock:-Poultry	1000 heads	-	NE	NE	NE	NE	NE	NE	-	-	-	-
Milk yield	kg/head	2015	7 906.11	7 906.11	9 210.36	10 005.93	9 992.32	9 980.14	PRIMES & GAINS 2016 updated Reference Scenarios	2016	3.A 3.B	-
Nitrogen input from application of synthetic fertilizers	kt nitrogen	2015	12.18	12.18	11.36	11.51	11.12	11.01	PRIMES & GAINS 2016 updated Reference Scenarios	2016	3.D	-
Nitrogen input from application of manure	kt nitrogen	-	NE	NE	NE	NE	NE	NE	-	-	-	-
Nitrogen fixed by N-fixing crops	kt nitrogen	-	NE	NE	NE	NE	NE	NE	-	-	-	-
Nitrogen in crop residues returned to soils	kt nitrogen	2015	0.01	0.01	0.01	0.01	0.01	0.01	PRIMES & GAINS 2016 updated Reference Scenarios	2016	3.D	-
Area of cultivated organic soils	Ha (hectares)	2015	0.00	0.00	0.00	0.00	0.00	0.00	PRIMES & GAINS 2016 updated Reference Scenarios	2016	3.D	-
Waste parameters												
Municipal solid waste (MSW) generation	kt MSW	2015	278.10	278.10	315.00	356.60	401.30	451.70	PRIMES & GAINS 2016 updated Reference Scenarios	2016	NA	MDDI-AEV projections used instead.
Municipal solid waste (MSW) going to landfills	kt MSW	2015	190.80	190.80	214.90	221.90	228.20	230.30	MDDI-AEV	2017	5.A	Dynamic scenario.
Share of CH4 recovery in total CH4 generation from landfills	%	-	NE	NE	NE	NE	NE	NE	-	-	-	-
Solid waste composting	kt	2015	23.83	23.83	26.94	30.45	34.23	38.47	PRIMES & GAINS 2016 updated Reference Scenarios	2016	5.B	-

Abbreviations used in Table V.2-2:

MDDI-DEV – Ministry of Sustainable Development and Infrastructure – Department of the Environment (*Ministère du Développement durable et des Infrastructures – Département de l'environnement*): http://www.emwelt.lu/:

AEV = Environment Agency (*Administration de l'Environnement*): http://www.gouvernement.lu/972044

MECO – Ministry of the Economy (*Ministère de l'Economie*): http://www.eco.public.lu/

STATEC = National Statistical Institute: http://www.statistiques.public.lu/fr/acteurs/statec/index.html

DG ECFIN – Directorate-General Economic and Financial Affairs.

EC PRIMES & GAINS 2016 Reference Scenarios – see Section V.2.4.

Note: NA = not applicable
NE = not estimated
NO = not occurring

V.2.4. Models used for emissions projections

As *Tables V.2- & V.2-2* show, four main models or tools have been used for performing the projections up to 2035:

- the EPM model from ECONOTEC;
- the NEAM model developed by STATEC and used in conjunction with a macro-economic “computable general equilibrium” (CGE) model;
- the GEORG and NEMO models used by Komobile and FVT (*Forschungsgesellschaft für Verbrennungskraft-maschinen und Thermodynamik*) and developed in collaboration with the *Technische Universität Graz* (TU Graz);
- the 2016 PRIMES and GAINS “reference” scenarios.

V.2.4.1. ECONOTEC EPM model – a “bottom-up” simulation model

CRF (sub-)categories covered by this model	1.A.1.a (except 2016) & 1.A.4.b
GHG covered	CO_2, CH_4 & N_2O for the GHG; NOx & $PM_{2.5}$ for the CLRTAP gases
Reference/base year	2012
Projected years	2015, 2020, 2025, 2030 & 2035
Interface with other models	none
Input from other models	some trends are identical to the 2013 PRIMES Baseline Scenario
Reference document for the calculations	ECONOTEC Consultants (2015)

EPM (Energy/Emissions Projection Model) is a projection model for energy demand and atmospheric emissions that covers all relevant emission sectors (energy sector, industry, residential, commercial, transport). It is a **techno-economic simulation model**, of the “**bottom-up**” type, i.e. explaining energy consumptions and related GHG emissions from activity variables expressed as far as possible in physical units. For each identified source of emissions, quantitative and qualitative assumptions are made for the projections: possibility to integrate structural anticipated changes at a very detailed level, to use "field/on the spot information" (opening/closing of units, new investments, etc.) and to take into account specific emission reduction measures for each source of emissions. EPM also allows for determining emission mitigation policies (economic potential for emission reduction, marginal abatement cost [MAC] curves) as well as for building emission reduction scenarios.

Sector related desegregation is realised at sub-sector level (e.g. cogeneration & thermal power plants) and for each energy type (liquid fuel, solid fuel, gaseous fuel, etc.). For each couple {sub-sector ; energy type}, the model requires a specific consumption as well as an activity variable for the reference year. These data are coming from available energy balances, from sector-related detailed information (incl. ETS declarations), etc.

For the **residential sector**, EPM usually considers existing and new houses, existing and new apartments (electric and non-electric heated), domestic water heating and 10 specific uses of electricity (cooking, refrigerators, washing machines, dryers, etc.). The heat load is estimated using a separate module made of 14 type-dwellings. In this module, energy consumptions are calculated taking into account the respective performances of 15 heat production, distribution or emission systems. For this sector, ECONOTEC also used **a specific "Residential-Tertiary Tool"** [ECONOTEC Consultants (2013c)].

For more details on the EPM model in general and on results it can provide as well as on analytic possibilities it offers, refer to ECONOTEC Consultants (2000), ECONOTEC Consultants (2002) and ECONOTEC Consultants & VITO (2005) as well as to the former National Communication [Ministry of Sustainable Development and Infrastructure, Department of the Environment (2014a), sections V.2.4 & V.2.5, p. 204-208].

V.2.4.2. STATEC – NEAM model – a "bottom-up" empirical model interacting with a CGE model

CRF (sub-)categories covered by this model	1.A.1.a (2016), 1.A.2 & 1.A.4.a
GHG covered	CO_2
Reference/base year	2015
Projected years	2015, 2020, 2025, 2030 & 2035
Interface with other models	LuxGEM, STATEC's general equilibrium model for Luxembourg
Input from other models	LuxGEM and Modux, STATEC's macro-econometric annual model used for forecasting and for policy simulation
Reference document for the calculations	none (spreadsheets and various internal notes: work in progress)

NEAM is a "**bottom-up**" model developed by STATEC, which is based on the establishment of stocks and their evolution up to 2030. It is an **empirical model**, at annual time interval. The latest version has been calibrated using data from energy balances for the period 2001-2015. It allows simulating energy scenarios for the mid (2020) and long (2050) terms.

NEAM is structured based on a hybrid "actor-use" typology:

- the residential sector;
- the tertiary sector;
- the industrial sector;
- transport use.

Main outputs are the final and primary energy demand on the national territory, broken down by production means, energy types and use, as well as the associated CO_2 emissions.

The model is made of three parts:

- energy balances derived from NAMEA-Energy;[174]
- data and information for developing a reference or BAU scenario;
- data, information and hypotheses for developing an "energy trajectory" scenario.

Energy demand is modelled for the following sectors: (i) industry (anticipated production level, anticipated energy efficiency gains); (ii) transport - road, rail, maritime, air (anticipated vehicles stocks and mileage, anticipated activity development for road and maritime transport), anticipated energy efficiency gains); (iii) institutional and commercial sectors - electricity and heat (anticipated employment developments, anticipated shares of the various energy types); and (iv) residential sector - electricity and heat (anticipated development of the housing stock, anticipated population growth, anticipated energy efficiency gains of buildings and appliances). Sector related desegregation is realised at sub-sector level (e.g. cogeneration & thermal power plants), and for each energy type (liquid fuel, solid fuel, gaseous fuel, etc.).

Energy supply is modelled for four energy types: coal, natural gas, petroleum products, electricity & heat.

In practice, STATEC interacts NEAM with LuxGEM, a macro-economic "**computable general equilibrium**" (CGE) model. CGE models are widely employed for economic policy analysis and are built upon economic general equilibrium theory. The abstract modelling structure is combined with detailed micro-data on, e.g. relevant production processes, assumptions on supply and demand behaviour or the market structure. Hence, CGE models allow analysing the impact of structural changes, e.g. in input prices, taxes or other framework conditions on several markets of an economy.

The coupling of the two models is accomplished through the application of a single exchange cycle between them:

- as a first step, LuxGEM, which contains the demographic and econometric hypotheses, is launched to forecast five "interacting" variables, i.e. (i) population; (ii) domestic employment; (iii) cross-border commuters employment; (iv) manufacturing industries value added; and (v) fuel imports;
- then, these LuxGEM forecasts are introduced into the NEAM model, as exogenous variables. Coupled with NEAM's own hypotheses, six variables are estimated: (i) renewable electricity generation; (ii) energy consumption; (iii) biofuels consumption; (iv) number of buildings and electric vehicles (stock variables); (v) energy efficiency rates; and (vi) CO_2 emission factors;

[174] NAMEA = National Accounting Matrix with Environmental Accounts, a tool to analyse relationships between the economy and the environment. For details on Air Emissions Accounts (AEA), see http://ec.europa.eu/eurostat/web/environment/emissions-of-greenhouse-gases-and-air-pollutants/air-emissions-accounts.

- as a third step, the six variables are introduced in LuxGEM, which will be launched a second time in order to generate output files, such as energy demand and CO_2 emissions by economic branches.

In both the NEAM and the LuxGEM models, many hypotheses support estimates of potential scenarios. Therefore, in order to assess the magnitude generated by the macroeconomic assumptions taken into account, three combinations of strong, intermediate and weak hypotheses were tested to ultimately provide a high, a low and a middle scenario. These hypotheses are: (i) the evolution of the population and its impact on disposable income; (ii) the share of cross-border workers in total employment; (iii) GDP growth; and (iv) the employment rate. Hypotheses concerning the technological aspects – namely the rates of renovation and demolition of buildings, the unit consumption per type of building, efficiency of the industrial processes, the vehicle fleet use and the unit efficiency by vehicle type – have been kept identical.

An analysis of the results of these simulations (high, low and intermediate) was then performed by sector and type of energy or. From this analysis, it appears that the main factors determining energy demand are the evolution of the population and the prices of petroleum products (both wholesale & retail).

For the actual GHG projections, the **middle scenario** outputs and results have been used.

V.2.4.3. Komobile & FVT – GEORG & NEMO – "bottom-up" models for the transportation sector

CRF (sub-)categories covered by this model	1.A.3.b, 1.A.3.c, 1.A.3.d, 1.A.4.c & 1.A.5
GHG covered	CO_2, NOx, $PM_{2.5}$ & PM_{10}
Reference/base year	2015
Projected years	all years from 2016 up to 2050
Interface with other models	none
Input from other models	adapted 2016 PRIMES baseline scenario trends have been used as input for the possible development of road fuel exports related emissions
Reference document for the calculations	[Komobile & FVT (2017a) & (2017b)]

GEORG & NEMO allow computing energy demand and related air pollutants emissions projections for the **road and off-road transportation sector**. Both models are "**bottom-up**".

The **GEORG model** ("*Grazer Emissionsmodell für Off-Road Geräte*") was developed at the Graz University of Technology (TU Graz). It has a fleet model part which simulates the actual age and size distribution of **non-road mobile machinery** (NRMM) stock via age- and size-dependent dropout rates (i.e. the probability that a vehicle will have been scrapped by the following year). With this approach the number of vehicles in each mobile source category is calculated according to the year of the vehicles' first registration and propulsion systems (gasoline 4-stroke, gasoline 2-stroke, diesel > 80 kW, diesel < 80 kW). For the projections, assumptions on emission factors and fleet are included in the model that can then derives air pollutants emissions.[175]

The **NEMO model** ("Network Emission Model") was developed at the Institute for Internal Combustion Engines and Thermodynamics (IVT) at the Graz University of Technology (TU Graz) as a tool for the simulation of **traffic related emissions in road networks**. It combines a detailed calculation of the fleet composition with a simulation of energy consumption and emission output on a vehicle level. It is fully capable of depicting the upcoming variety of possible combinations of propulsion systems (internal combustion engine, hybrid, plug-in hybrid, electric propulsion, fuel cell, …) and alternative fuels (CNG, biogas, FAME, ethanol, GTL, BTL, H2, …). In addition, NEMO has been designed in such a way as to be suitable for all the main application fields for the simulation of energy consumption and emission output using a road-section based model approach. For the projections, assumptions on emission factors and fleet are included in the model that can then derives air pollutants emissions.[176]

Projections have been realised by the expert bureau Komobile and FVT (Forschungsgesellschaft für Verbrennungskraft-maschinen und Thermodynamik) from the TU Graz using various datasets and information. For road transportation, **three specific traffic flows** have been characterized: **inland journeys**, **cross-borders commuting journeys** and **transit traffic**. For each of the three specific flows, various data sources and anticipated socio-economic developments – in Luxembourg and in Europe in general – have been used.

V.2.4.4. European Commission – PRIMES & GAINS – modelling suite for the whole range of source categories

CRF (sub-)categories covered by this model	1.B.2 & international aviation (PRIMES) / 3.A, 3.B, 3.D & 5.B (GAINS)
GHG covered	CO_2, CH_4 & N_2O
Reference/base year	2014
Projected years	2015, 2020, 2025, 2030, 2035, 2040, 2045 & 2050
Interface with other models	none
Input from other models	none
Reference document for the calculations	[European Commission (2016c)]

The **PRIMES modelling suite** is the core element of the modelling framework **for transport, energy and CO_2 emission projections**, whereas the **GAINS model** is used for **non-CO_2 emission projections**.

175 Source: Umweltbundesamt (2017), *GHG Projections and Assessment of Policies and Measures in Austria, reporting under Regulation (EU) 525/2013*, Wien, p. 35.

176 ibid., p. 34. See also Ministry of Sustainable Development and Infrastructure, Environment Agency (2017), section 3.2.8.3.2.2, p. 226-234.

The energy system model **PRIMES** is a modelling system that simulates a market equilibrium solution for energy supply and demand in the EU28 and its Member States. It is central to a suite of framework or sectoral interlinked models, some being "computable general equilibrium" (CGE) model. It works by determining an equilibrium by finding the prices of each energy form such that the quantity produced matches the quantity consumers wish to use. The market equilibrium is achieved for each period and the simulation is dynamic over time. The model is behavioural but also represents, in an explicit and detailed way, the available energy demand and supply technologies and pollution abatement technologies. The system reflects considerations about market economics, industry structure, energy/ environmental policies and regulation, which are conceived to influence market behaviour of energy system agents. The modular structure of PRIMES reflects a distribution of decision making among agents that act individually about their supply, demand, combined supply and demand, and prices. The market integrating part of PRIMES subsequently simulates market clearing.

As a general-purpose energy model, PRIMES is conceived for designing production and consumption projections, scenario building and policy impact analysis. It covers a medium to long-term horizon. Its modular structure allows either for integrated model use or for partial use. More details are available in [European Commission (2016c), Introduction Chapter].

For the projections, the PRIMES 2016 results for the "**reference**" scenario have been used. This scenario supposes that Member States will meet legally binding EU "2020 Climate & Energy package" targets but it does not incorporate the "2030 Climate & Energy framework" targets since these were not yet decided at the time the exercise was led ***[→ Sections IV.1.1.2 & IV.1.1.3]***.

The **GAINS model**, operated by the International Institute for Applied Systems Analysis (IIASA), covers projections of air pollution and non-CO_2 GHG, including costs of emission reductions and projections of atmospheric emissions. GAINS allows exploring trade-offs and synergies between GHG emission reductions and air pollution. The model also evaluates and projects atmospheric dispersion, air quality impacts, health impacts, impacts on ecosystems, and climate impacts. Moreover, it assesses costs of abatement strategies. As a part of the modelling suite, GAINS takes inputs from PRIMES (among others) and produces outputs for use by other models, e.g. PRIMES.[177]

[177] For more information on GAINS, see http://gains.iiasa.ac.at/gains/index.html.

V.3. PROJECTIONS[178]

Detailed projections results are available from the reporting tool used by Member States to report to the European Commission (*Table 1* file).[179] Consequently, this chapter presents the projections in an aggregated way and in CO_2e. Nevertheless, where relevant, non-ETS/ESD and ETS projections are presented.

For this Communication, the following CRF sectors, categories and sub-categories are distinguished:

- public electricity & heat production (1.A.1.a) – includes waste incineration;
- industries & construction (incl. product uses) (1.A.2 & 2);
- road transportation (1.A.3.b) – includes lubricants to be reported under 1.A.3.b;
- commercial & institutional buildings (1.A.4.a);
- residential buildings (1.A.4.b);
- agriculture (incl. combustion) (1.A.4.c & 3);
- LULUCF (4);
- other source categories (1.A.3.a/c/d, 1.A.5, 1.B.2 & 5).

Historical data in the following tables and graphs (2005 to 2015) are extracted from the GHG inventory, submission 2017v7 of 6 April 2017 to both the EC and the UNFCCC.[180] Data prior to 2005 are not shown for readability reasons, but also because 2005 is the key year for the 2020 and 2030 commitments at EU level ***[→ Section IV.1.1]***.

In ***Tables V.3-1 to V.3-9***, data are presented both in 1000 tonnes of CO_2e (Gg) and in indices (with 2005 being equal to 100), whereas ***Figures V.3-1 to V.3-9*** are limited to emissions in Gg. The two scenarios – **WEM** & **WAM** – are presented when relevant, i.e. for the moment for road transportation (1.A.3.b) only. In the short to medium term, once the on going work on the identification and evaluation of PaMs will be terminated ***[→ Section IV.1.6]***, it is expected to be able to develop effective WEM and WAM scenarios.

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[178] This section of the NC7 covers sections V.A, V.B and parts of V.D not discussed in Section V.2 of the Outline and General Structure of the NC5 according to IPCC reporting guidelines (para. 5). International aviation projections are not presented in this NC.

[179] http://cdr.eionet.europa.eu/lu/eu/mmr/art04-13-14_lcds_pams_projections/colvb_fog/envwqqltq/.

[180] http://unfccc.int/files/national_reports/annex_i_ghg_inventories/national_inventories_submissions/application/zip/lux-2017-crf-06apr17.zip.

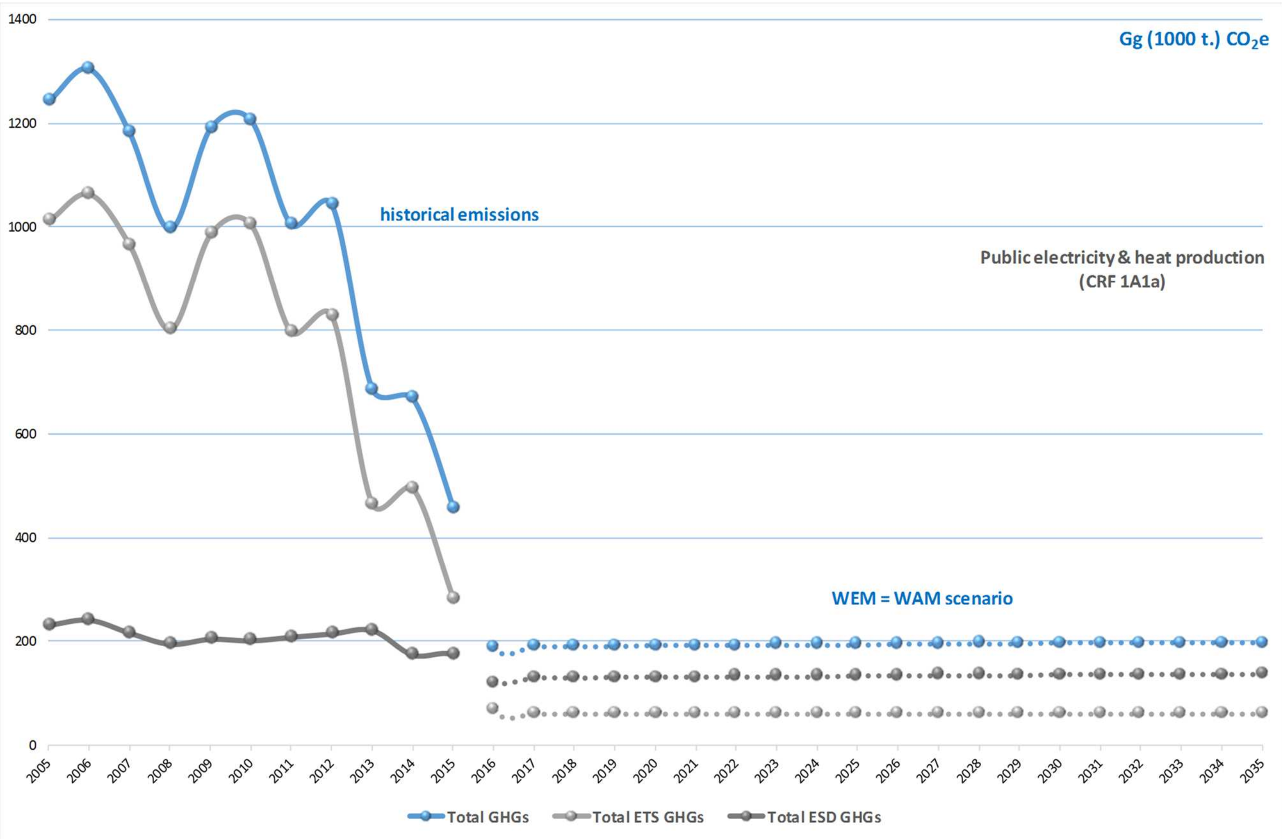
V.3.1. Public electricity & heat production (1.A.1.a)

TABLE V.3-1 – HISTORICAL AND PROJECTED EMISSIONS FOR PUBLIC ELECTRICITY & HEAT PRODUCTION

Sector	CRF	GHG	2005	2010	2015	2020	2025	2030	2035	
Public electricity and heat production	1.A.1.a	Total GHGs	1 243.19	1 205.97	457.22	191.34	193.39	196.27	197.10	WEM
		Total ETS GHGs	1 011.63	1 004.50	282.43	60.59	60.59	60.59	60.59	
		Total ESD GHGs	231.56	201.48	174.79	130.75	132.80	135.68	136.51	
		Total GHGs	1 243.19	1 205.97	457.22	191.34	193.39	196.27	197.10	WAM
		Total ETS GHGs	1 011.63	1 004.50	282.43	60.59	60.59	60.59	60.59	
		Total ESD GHGs	231.56	201.48	174.79	130.75	132.80	135.68	136.51	
		Total GHGs	100.00	97.01	36.78	15.39	15.56	15.79	15.85	WEM
		Total ETS GHGs	100.00	99.29	27.92	5.99	5.99	5.99	5.99	
		Total ESD GHGs	100.00	87.01	75.48	56.47	57.35	58.59	58.95	
		Total GHGs	100.00	97.01	36.78	15.39	15.56	15.79	15.85	WAM
		Total ETS GHGs	100.00	99.29	27.92	5.99	5.99	5.99	5.99	
		Total ESD GHGs	100.00	87.01	75.48	56.47	57.35	58.59	58.95	

Sources: Environment Agency and MDDI-DEV – Submission 2017v7
MDDI-DEV – 2017 projections submission

FIGURE V.3-1 – HISTORICAL AND PROJECTED EMISSIONS FOR PUBLIC ELECTRICITY & HEAT PRODUCTION



Sources: Environment Agency and MDDI-DEV – Submission 2017v7
MDDI-DEV – 2017 projections submission

The projections do not take into account any possible start-up of new fossil-fuelled power plants in Luxembourg – the rationale being that the development of further CHP installations using fossil fuels or natural gas is not favourable to Luxembourg with regard to the accounting of GHG emissions in inventories *[→ Sections II.12.3, II.12.4 & IV.3.1.1]*. The fall in ETS emissions is explained by the slowdown of the TWINerg power plant leading to its closing in 2016. Finally, the diversion by 2020, of waste from landfills to the incinerator is accounted for.

Since these projections have been calculated for CO_2, they have been completed by simplistic assumptions made by the Department of the Environment for CH_4 and N_2O *[→ Table V.2-1]*.

For the split between non-ETS/ESD & ETS emissions, it has been assumed that ETS verified CO_2 emissions in 2016, excluding TWINerg, would remain constant up to 2035. Then ESD emissions are simply the difference between total GHG estimates & ETS constant estimates *[→ Table V.2-1]*.

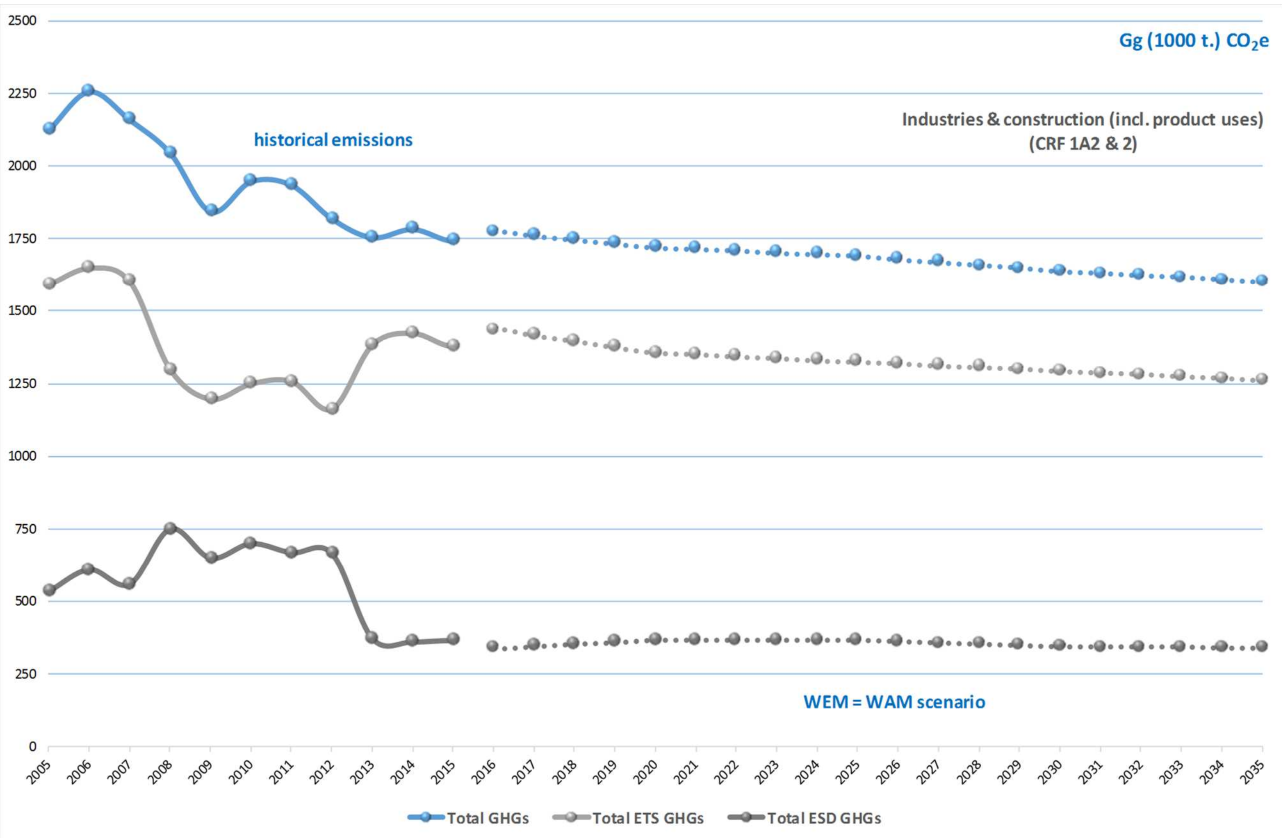
V.3.2. Industries & construction (incl. product uses) (1.A.2.a & 2)

TABLE V.3-2 – HISTORICAL AND PROJECTED EMISSIONS FOR INDUSTRIES & CONSTRUCTION

Sector	CRF	GHG	2005	2010	2015	2020	2025	2030	2035	
Industries & construction	1.A.2	Total GHGs	2 125.46	1 947.51	1 742.43	1 719.19	1 688.90	1 636.75	1 600.51	WEM
(incl. product uses)	2	Total ETS GHGs	1 591.72	1 248.17	1 378.42	1 354.22	1 323.29	1 292.60	1 261.01	
		Total ESD GHGs	533.74	697.96	364.05	364.97	365.61	344.15	339.50	
		Total GHGs	2 125.46	1 947.51	1 742.43	1 719.19	1 688.90	1 636.75	1 600.51	WAM
		Total ETS GHGs	1 591.72	1 248.17	1 378.42	1 354.22	1 323.29	1 292.60	1 261.01	
		Total ESD GHGs	533.74	697.96	364.05	364.97	365.61	344.15	339.50	
		Total GHGs	100.00	91.63	81.98	80.89	79.46	77.01	75.30	WEM
		Total ETS GHGs	100.00	78.42	86.60	85.08	83.14	81.21	79.22	
		Total ESD GHGs	100.00	130.77	68.21	68.38	68.50	64.48	63.61	
		Total GHGs	100.00	91.63	81.98	80.89	79.46	77.01	75.30	WAM
		Total ETS GHGs	100.00	78.42	86.60	85.08	83.14	81.21	79.22	
		Total ESD GHGs	100.00	130.77	68.21	68.38	68.50	64.48	63.61	

Sources: Environment Agency and MDDI-DEV – Submission 2017v7
MDDI-DEV – 2017 projections submission

FIGURE V.3-2 – HISTORICAL AND PROJECTED EMISSIONS FOR INDUSTRIES & CONSTRUCTION



Sources: Environment Agency and MDDI-DEV – Submission 2017v7
MDDI-DEV – 2017 projections submission

The main existing measures in this sector are the EU ETS and the voluntary agreement under the aegis of FEDIL (see Box IV.1-8).

Projected CO_2 emissions for CRF sector 1.A.2 obtained from STATEC's NEAM model central scenario are based on various hypotheses: (i) the secondary sector/manufacturing industry gross value added growth rate is assumed to be 1.44% in 2020 and 1.26% in 2030; (ii) autonomous reduction rates for electricity and for heat are invariable over the period at minus 0.5%/year and (iii) activity growth rate at 0.5%/year for the cement industry and at 0%/year for the iron and steel industry, both invariable over the period. These are conservative hypotheses, in particular when looking at the FEDIL voluntary agreement seeking a 1% or more yearly gain in energy efficiency. These CO_2 projections have been completed by simplistic assumptions made by the Department of the Environment for CH_4 and N_2O ***[→ Table V.2-1]***.

Projected CO_2-equivalent emissions for industrial processes and product uses (CRF 2) are the result of ad-hoc methods developed by the Environment Agency ***[→ Table V.2-1]***.

For the split between non-ETS/ESD & ETS emissions under CRF sector 1.A.2, it has been assumed that the average EU ETS phase III (2013-2015) share in total GHG emissions is applied to total GHG projections for the years 2020/25/30/35 and that in-between years are simple linear interpolations. Then ESD emissions are simply the difference between total GHG estimates & ETS estimates ***[→ Table V.2-1]***.

For industrial processes and product uses, the hypothesis was made that all CO_2 projected emissions are supposed to be ETS emissions (CRF sectors 2.A & 2.C, no ETS emissions for 2.D to 2.G) ***[→ Table V.2-1]***.

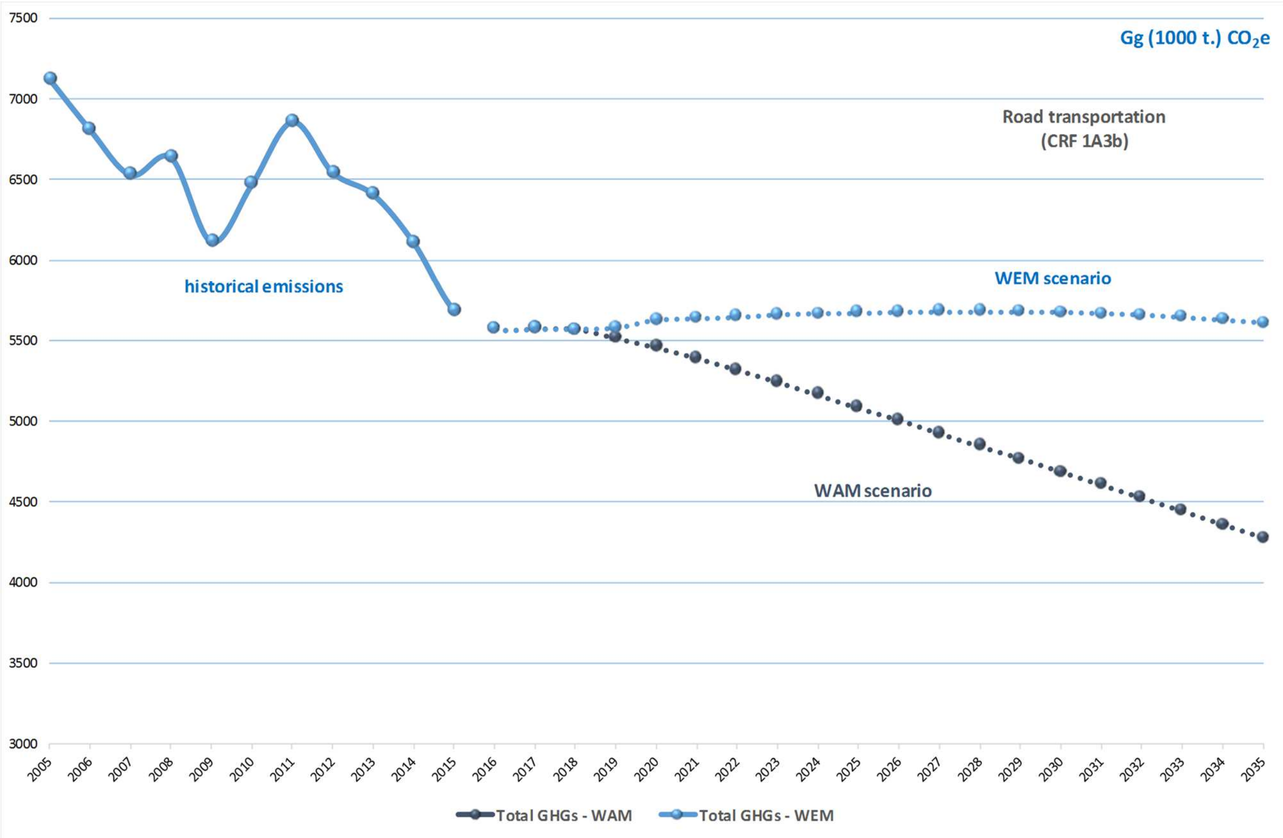
V.3.3. Road transportation (1.A.3.b)

TABLE V.3-3 – HISTORICAL AND PROJECTED EMISSIONS FOR THE ROAD TRANSPORTATION SECTOR

Sector	CRF	GHG	2005	2010	2015	2020	2025	2030	2035	
Road transportation	1.A.3.b	Total GHGs	7 122.06	6 471.75	5 684.11	5 624.67	5 669.29	5 673.72	5 607.60	WEM
		Total GHGs	7 122.06	6 471.75	5 684.11	5 455.67	5 082.98	4 686.92	4 275.74	WAM
		Total GHGs	100.00	90.87	79.81	78.98	79.60	79.66	78.74	WEM
		Total GHGs	100.00	90.87	79.81	76.60	71.37	65.81	60.04	WAM

Sources: Environment Agency and MDDI-DEV – Submission 2017v7
MDDI-DEV – 2017 projections submission

FIGURE V.3-3 – HISTORICAL AND PROJECTED EMISSIONS FOR THE ROAD TRANSPORTATION SECTOR



Sources: Environment Agency and MDDI-DEV – Submission 2017v7
MDDI-DEV – 2017 projections submission

For the road transportation sector, projected GHG emissions have been obtained using a rather complex set of data combined with elaborated simulations performed by the NEMO model [Komobile & FVT (2017a) & (2017b)]. More precisely, the reference scenario is the one considering a rather ambitious penetration rate for electro-mobility [Komobile & FVT (2017b), p. 9].

Since WEM projections do not take into account a possible narrowing of road fuel price differentials between Luxembourg and its neighbouring countries, projected emissions are rather flat up to 2030. Indeed, technological developments benefits in terms of emission, which lead to always more energy efficient and less carbon emitting vehicles, would be offset by increasing traffic flows anticipated by European and other traffic model.

The difference between the WEM and WAM projections is the result of the following hypothesis: from 2019 onwards, "road fuel sales to non-residents "will be decreasing linearly by 2% per year reflecting a possible narrowing of road fuel price differentials between Luxembourg and its neighbouring countries.

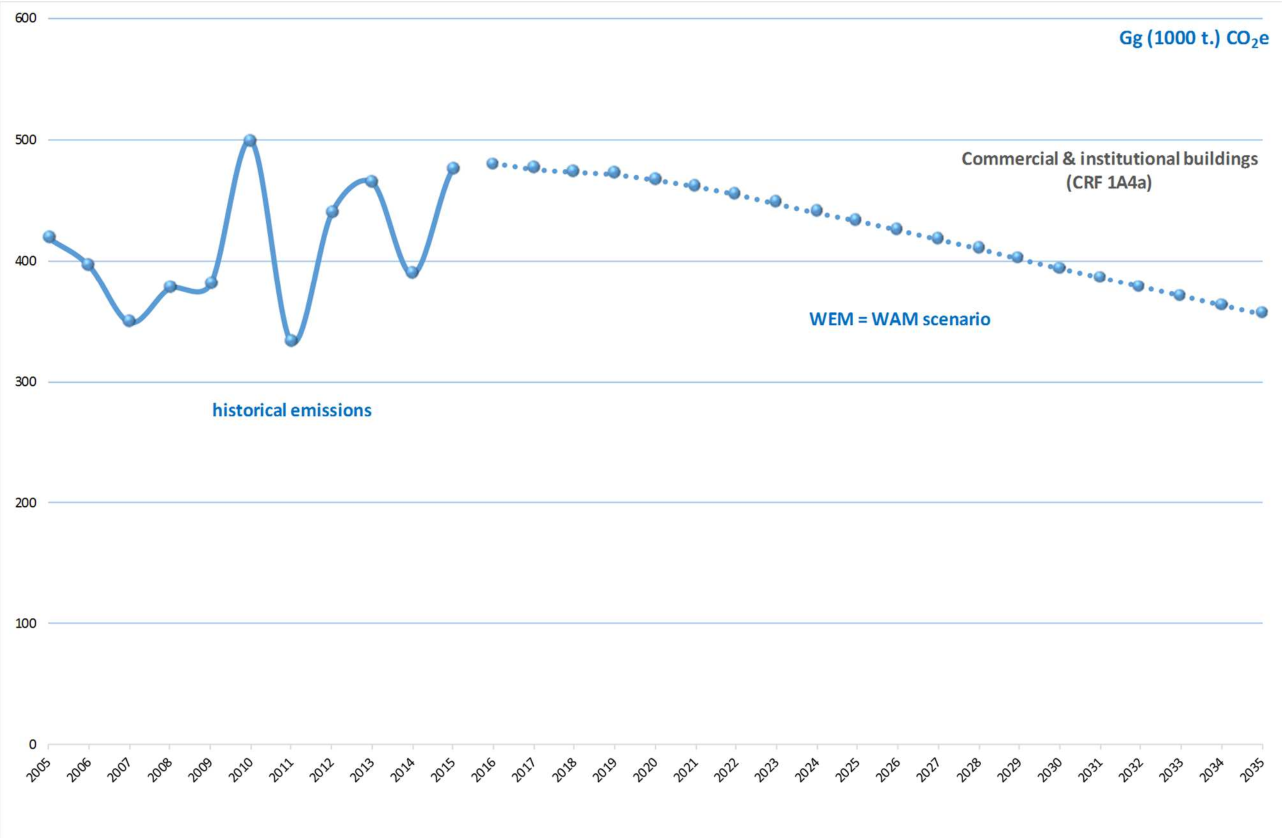
V.3.4. Commercial & institutional buildings (1.A.4.a)

TABLE V.3-4 – HISTORICAL AND PROJECTED EMISSIONS FOR COMMERCIAL & INSTITUTIONAL BUILDINGS

Sector	CRF	GHG	2005	2010	2015	2020	2025	2030	2035	
Commercial & institutional buildings	1.A.4.a	Total GHGs	418.25	498.51	475.67	466.46	432.35	393.57	355.66	WEM
		Total GHGs	418.25	498.51	475.67	466.46	432.35	393.57	355.66	WAM
		Total GHGs	100.00	119.19	113.73	111.53	103.37	94.10	85.04	WEM
		Total GHGs	100.00	119.19	113.73	111.53	103.37	94.10	85.04	WAM

Sources: Environment Agency and MDDI-DEV – Submission 2017v7
MDDI-DEV – 2017 projections submission

FIGURE V.3-4 – HISTORICAL AND PROJECTED EMISSIONS FOR COMMERCIAL & INSTITUTIONAL BUILDINGS



Sources: Environment Agency and MDDI-DEV – Submission 2017v7
MDDI-DEV – 2017 projections submission

Projected CO_2 emissions obtained from STATEC's NEAM model central scenario are based on various hypotheses: (i) a tertiary sector employment growth of almost 20% between 2020 and 2030, (ii) an autonomous reduction rate for electricity which is invariable at minus 1.6%/year and (ii) autonomous reduction rate for heat which is invariable at minus 3.3%/year. These projections have been completed by simplistic assumptions made by the Department of the Environment for CH_4 and N_2O *[→ Table V.2-1]*.

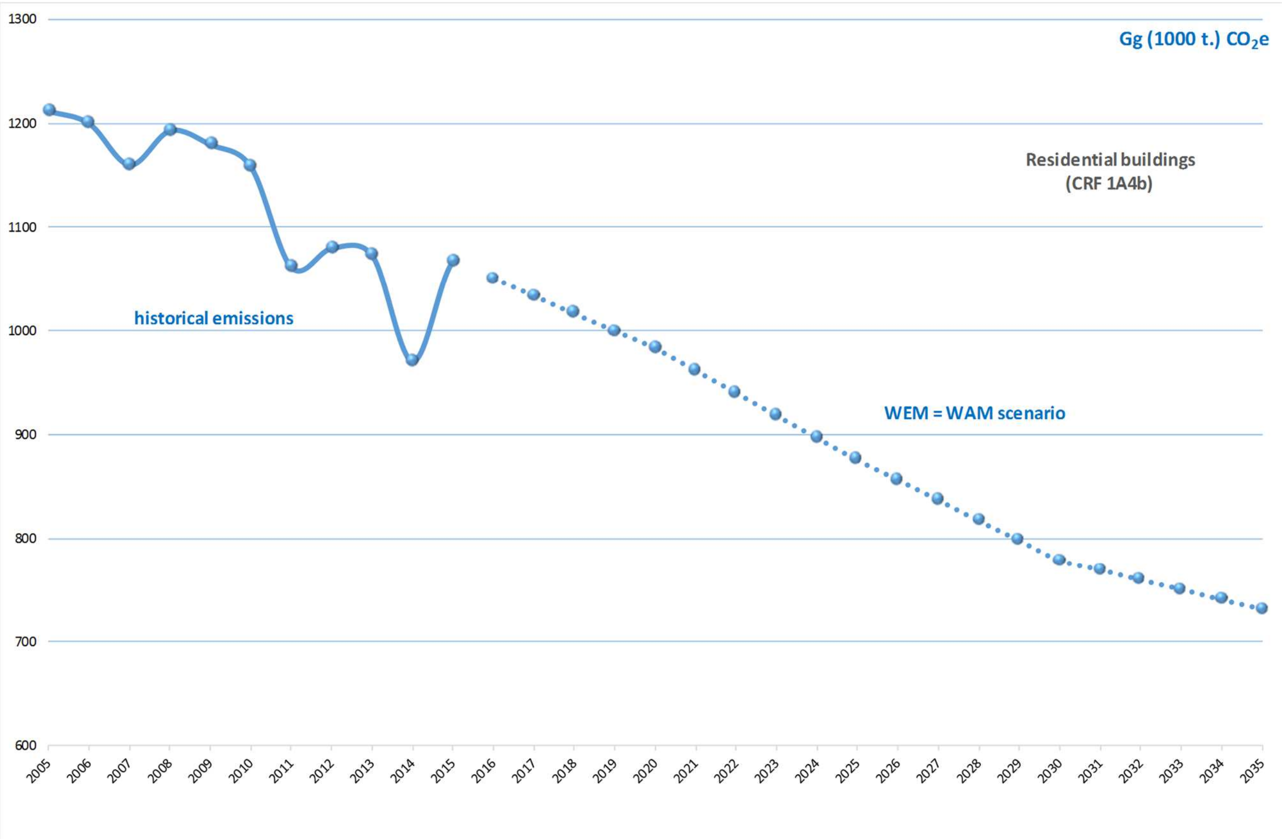
V.3.5. *Residential buildings (1.A.4.b)*

Table V.3-5 – Historical and projected emissions for residential buildings

Sector	CRF	GHG	2005	2010	2015	2020	2025	2030	2035	
Residential buildings	1.A.4.b	Total GHGs	1 211.99	1 158.09	1 067.06	982.53	875.24	778.61	731.43	WEM
		Total GHGs	1 211.99	1 158.09	1 067.06	982.53	875.24	778.61	731.43	WAM
		Total GHGs	100.00	95.55	88.04	81.07	72.21	64.24	60.35	WEM
		Total GHGs	100.00	95.55	88.04	81.07	72.21	64.24	60.35	WAM

Sources: Environment Agency and MDDI-DEV – Submission 2017v7
MDDI-DEV – 2017 projections submission

Figure V.3-5 – Historical and projected emissions for residential buildings



Sources: Environment Agency and MDDI-DEV – Submission 2017v7
MDDI-DEV – 2017 projections submission

For the residential sector, projected CO_2 emissions have been obtained using a rather complex set of data combined with elaborated simulations within the EPM model [ECONOTEC Consultants (2015)] and its associated "Residential-Tertiary Tool" developed by ECONOTEC [ECONOTEC Consultants (2013c)]. These projections have been completed by simplistic assumptions made by the Department of the Environment for CH_4 and N_2O *[→ Table V.2-1]*.

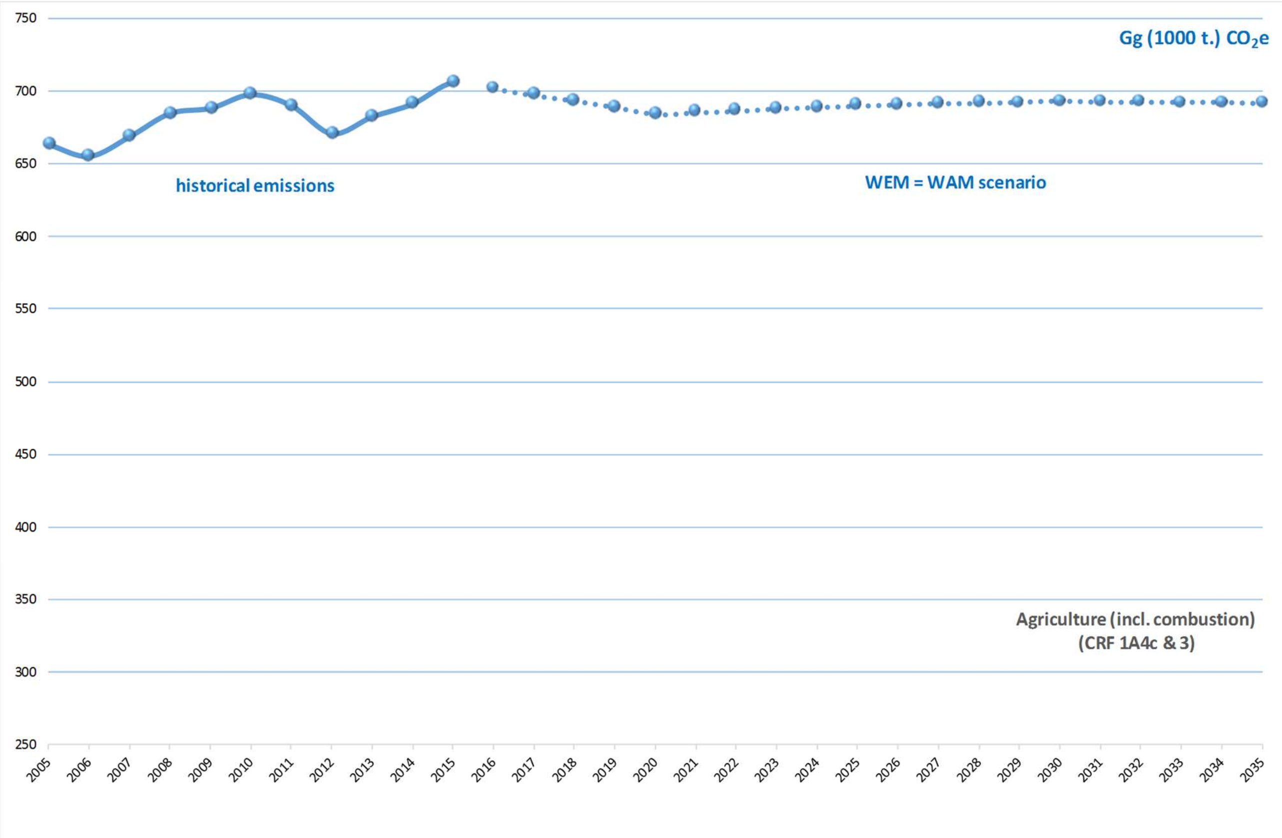
V.3.6. Agriculture (incl. combustion) (1.A.4c & 3)

Table V.3-6 – Historical and projected emissions for agriculture

Sector	CRF	GHG	2005	2010	2015	2020	2025	2030	2035	
Agriculture (incl. combustion)	1.A.4.c	Total GHGs	662.83	697.49	706.03	683.90	689.68	692.85	691.68	WEM
	3	Total GHGs	662.83	697.49	706.03	683.90	689.68	692.85	691.68	WAM
		Total GHGs	100.00	105.23	106.52	103.18	104.05	104.53	104.35	WEM
		Total GHGs	100.00	105.23	106.52	103.18	104.05	104.53	104.35	WAM

Sources: Environment Agency and MDDI-DEV – Submission 2017v7
MDDI-DEV – 2017 projections submission

Figure V.3-6 – Historical and projected emissions for agriculture



Sources: Environment Agency and MDDI-DEV – Submission 2017v7
MDDI-DEV – 2017 projections submission

Expected future emissions for agriculture related activities (combustion, animal husbandry, cultivation, and soils related emissions) have been estimated by the Department of the Environment using basic assumptions based on the 2016 GAINS exercise *[→ Table V.2-1]*. In the absence of national projections on agricultural practices and activities, it is not possible to cross-check GAINS assumptions and therefore, to explain the decreasing trends that is projected up to 2030.

For liming (CRF sector 3.G), there are no specific projections for that activity in GAINS. Consequently, the 2015 value has been replicated up to 2035, which is a rather strong hypothesis because the time series since 1990 is not homogenous and is very volatile.

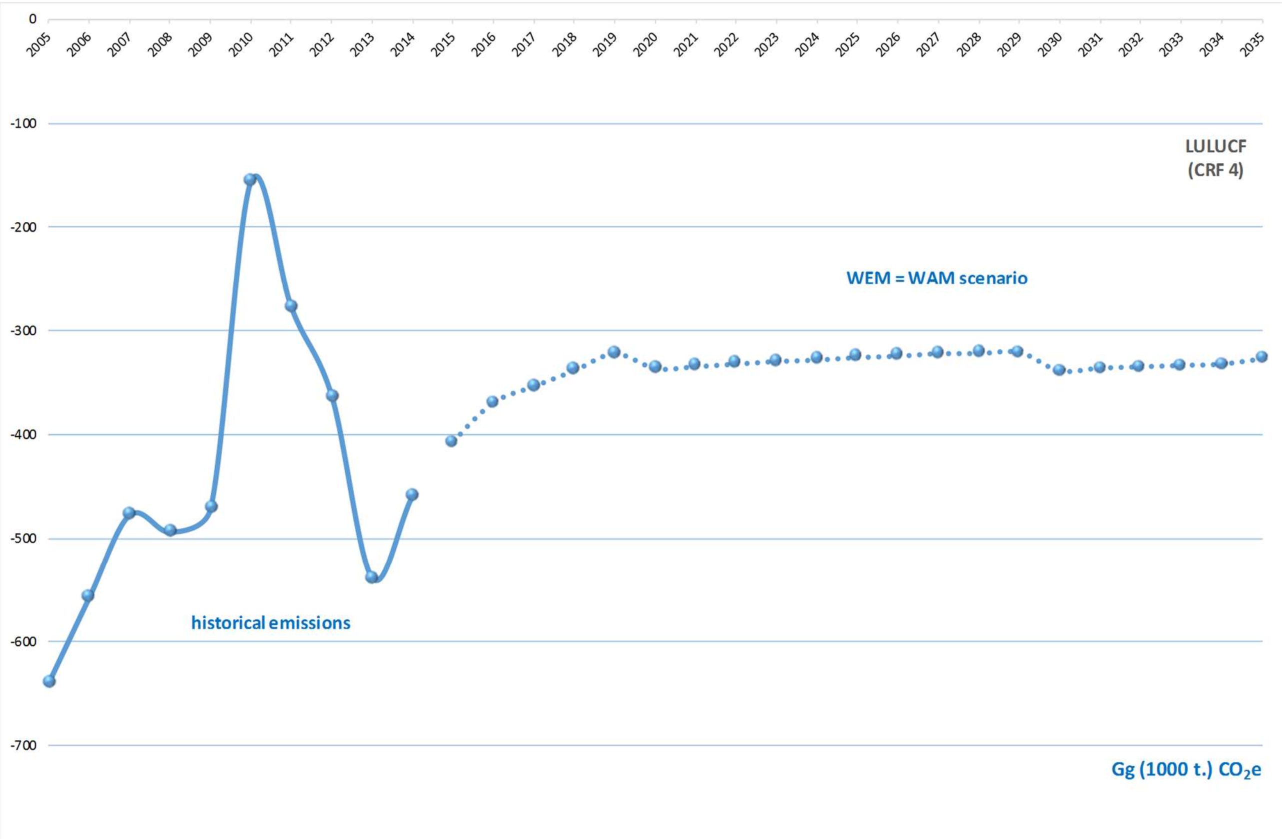
V.3.7. LULUCF (4)

TABLE V.3-7 – HISTORICAL AND PROJECTED EMISSIONS FOR LULUCF

Sector	CRF	GHG	2005	2010	2015	2020	2025	2030	2035	
LULUCF	4	Total GHGs	-639.48	-155.93	-407.41	-336.06	-325.76	-338.91	-326.91	WEM
		Total GHGs	-639.48	-155.93	-407.41	-336.06	-325.76	-338.91	-326.91	WAM
		Total GHGs	100.00	24.38	63.71	52.55	50.94	53.00	51.12	WEM
		Total GHGs	100.00	24.38	63.71	52.55	50.94	53.00	51.12	WAM

Sources: Environment Agency and MDDI-DEV – Submission 2017v7
MDDI-DEV – 2017 projections submission

FIGURE V.3-7 – HISTORICAL AND PROJECTED EMISSIONS FOR LULUCF



Sources: Environment Agency and MDDI-DEV – Submission 2017v7
MDDI-DEV – 2017 projections submission

Projections for the LULUCF sector are the result of ad-hoc methods developed by the Environment Agency, which are making use of information on demographic and housing developments in Luxembourg.

The two main variables on which the projections are based are, on the one hand, the conversion of grass- and cropland into settlements and, on the other hand, the evolution of harvest rates in forestland, with land use for the development of settlements being the biggest driver of land use change in Luxembourg.

The projected decrease in carbon removals can mainly be attributed to an increase in harvest rates with a high proportion of forest stands reaching their maturity age over the evaluated period. In public forest, these rates are determined by the age class structure of forests and are therefore quite predictable. Harvest rates in private forests, on the other hand, are driven by policy and the price of wood. The latter one has been very depressed over the last decade and consequently harvest rates have been quite low. No assumption have however been made on the evolution of prices for wood. Instead, the age class structure as well as past harvest rates have been used to determine future harvest rate. The method employed is identical to the one used to calculate the "Forest Management Reference Level" and is described in detail in the latest National Inventory Report [Ministry of Sustainable Development and Infrastructure, Environment Agency (2017)]. It is however important to highlight that harvest rates always show very strong inter-annual variation and that projections can only provide long-term trends; hence, they will never be capable to reproduce those annual changes. Furthermore, extreme weather events followed by windfall and subsequent salvage logging can produce very high annual harvest rate that will strongly affect the balance.

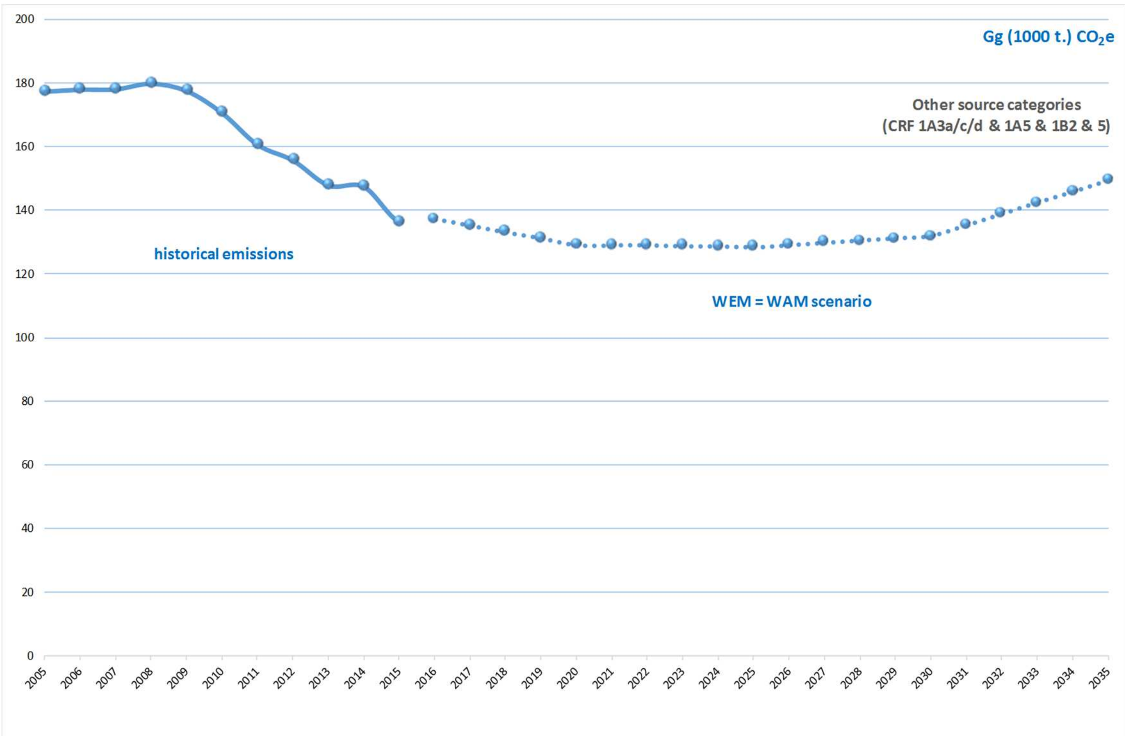
V.3.8. Other source categories (1.A.3a/c/d, 1.A.5, 1.B.2 & 5)

TABLE V.3-8 – HISTORICAL AND PROJECTED EMISSIONS FOR OTHER SOURCE CATEGORIES

Sector	CRF	GHG	2005	2010	2015	2020	2025	2030	2035	
Other source categories	1.A.3.a/c/d	Total GHGs	177.39	170.65	136.42	129.17	128.44	131.85	149.36	WEM
	1.A.5	Total GHGs	177.39	170.65	136.42	129.17	128.44	131.85	149.36	WAM
	1.B.2	Total GHGs	100.00	96.20	76.91	72.82	72.41	74.33	84.20	WEM
	5	Total GHGs	100.00	96.20	76.91	72.82	72.41	74.33	84.20	WAM

Sources: Environment Agency and MDDI-DEV – Submission 2017v7
MDDI-DEV – 2017 projections submission

FIGURE V.3-8 – HISTORICAL AND PROJECTED EMISSIONS FOR OTHER SOURCE CATEGORIES



Sources: Environment Agency and MDDI-DEV – Submission 2017v7
MDDI-DEV – 2017 projections submission

Most projections have been calculated based on simple assumptions by the Department of the Environment, the Environment Agency or the Water Agency. They were sometimes based on the 2016 PRIMES and GAINS projections *[→ Table V.2-1]*. For the off-road transportation and the non-road mobile machinery, projected GHG emissions have been obtained through simulations performed by the GEORG model [Komobile & FVT (2017a)] *[→ Table V.2-1]*.

Out of the various emission source categories grouped under this heading, increasing emissions are reported for fugitive emissions from natural gas transmission and distribution (CRF sector 1.B.2). This is the result of an anticipated extension of the national gas network, as well a more widespread use from 2020 onwards.

Turning to waste emissions (CRF sector 5), solid waste disposal related emissions (5.A) decreases from 2015 on [→ *PaM WM22 in Table IV.3-7*], whereas composting emissions (5.B) increase. Wastewater handling emissions (5.D) are decreasing over the period.

Finally, railways related emissions (CRF sector 1.A.3.c) tend to slightly increase (other transportation source categories – 1.A.3.a & b are negligible).

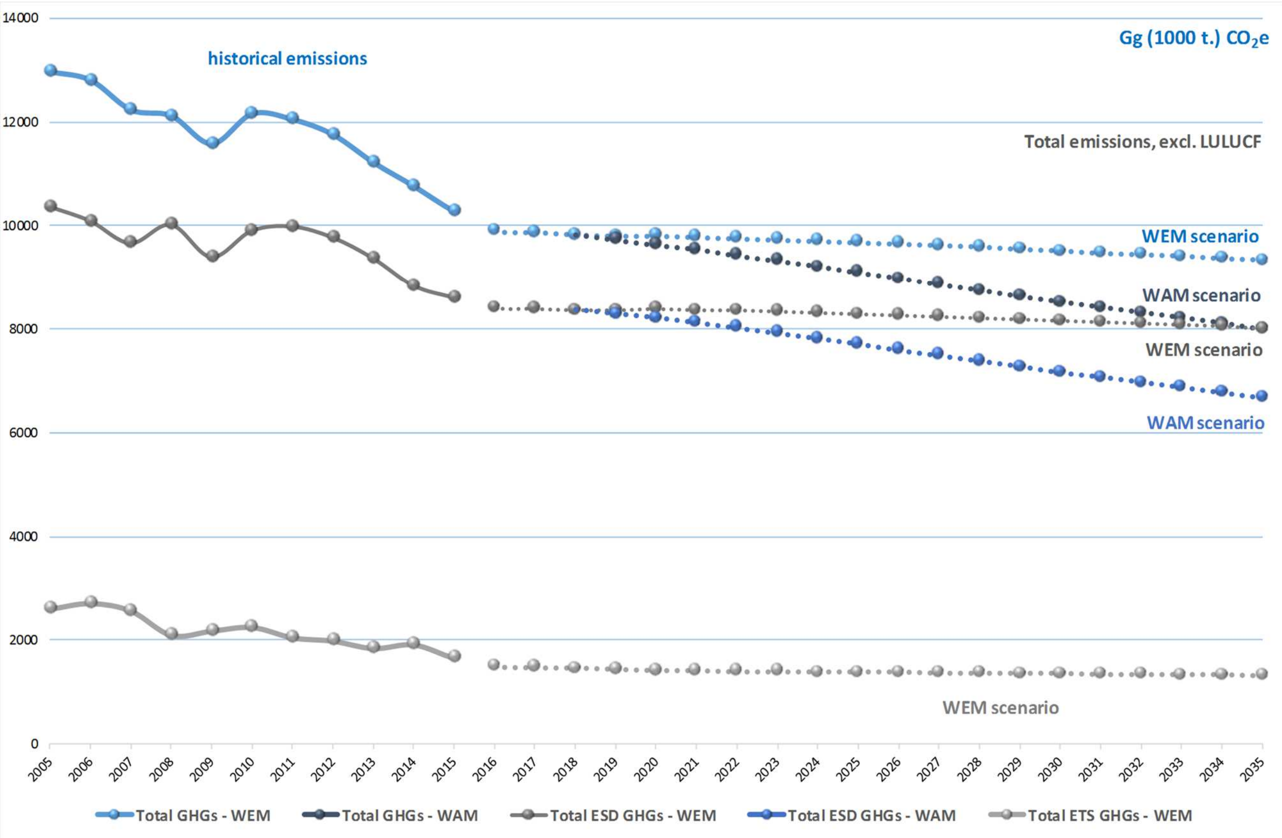
V.3.9. Total GHG, excl. LULUCF

TABLE V.3-9 – HISTORICAL AND PROJECTED EMISSIONS FOR TOTAL, ETS AND NON-ETS GHG, EXCL. LULUCF

Sector	CRF	GHG	2005	2010	2015	2020	2025	2030	2035	
Total emissions excl. LULUCF	-	Total GHGs	12 961.17	12 149.97	10 268.93	9 797.28	9 677.28	9 503.61	9 333.34	WEM
		Total ETS GHGs	2 603.35	2 252.66	1 660.85	1 414.81	1 383.87	1 353.19	1 321.60	
		Total ESD GHGs	10 357.21	9 895.39	8 607.53	8 381.86	8 292.80	8 149.82	8 011.13	
		Total GHGs	12 961.17	12 149.97	10 268.93	9 628.27	9 090.98	8 516.81	8 001.48	WAM
		Total ETS GHGs	2 603.35	2 252.66	1 660.85	1 414.81	1 383.87	1 353.19	1 321.60	
		Total ESD GHGs	10 357.21	9 896.77	8 607.48	8 212.86	7 706.50	7 163.02	6 679.28	
		Total GHGs	100.00	93.74	79.23	75.59	74.66	73.32	72.01	WEM
		Total ETS GHGs	100.00	86.53	63.80	54.35	53.16	51.98	50.77	
		Total ESD GHGs	100.00	95.54	83.11	80.93	80.07	78.69	77.35	
		Total GHGs	100.00	93.74	79.23	74.29	70.14	65.71	61.73	WAM
		Total ETS GHGs	100.00	86.53	63.80	54.35	53.16	51.98	50.77	
		Total ESD GHGs	100.00	95.55	83.11	79.30	74.41	69.16	64.49	

Sources: Environment Agency and MDDI-DEV – Submission 2017v7
MDDI-DEV – 2017 projections submission

Figure V.3-9 – Historical and projected emissions for total, ETS and non-ETS GHG, excl. LULUCF



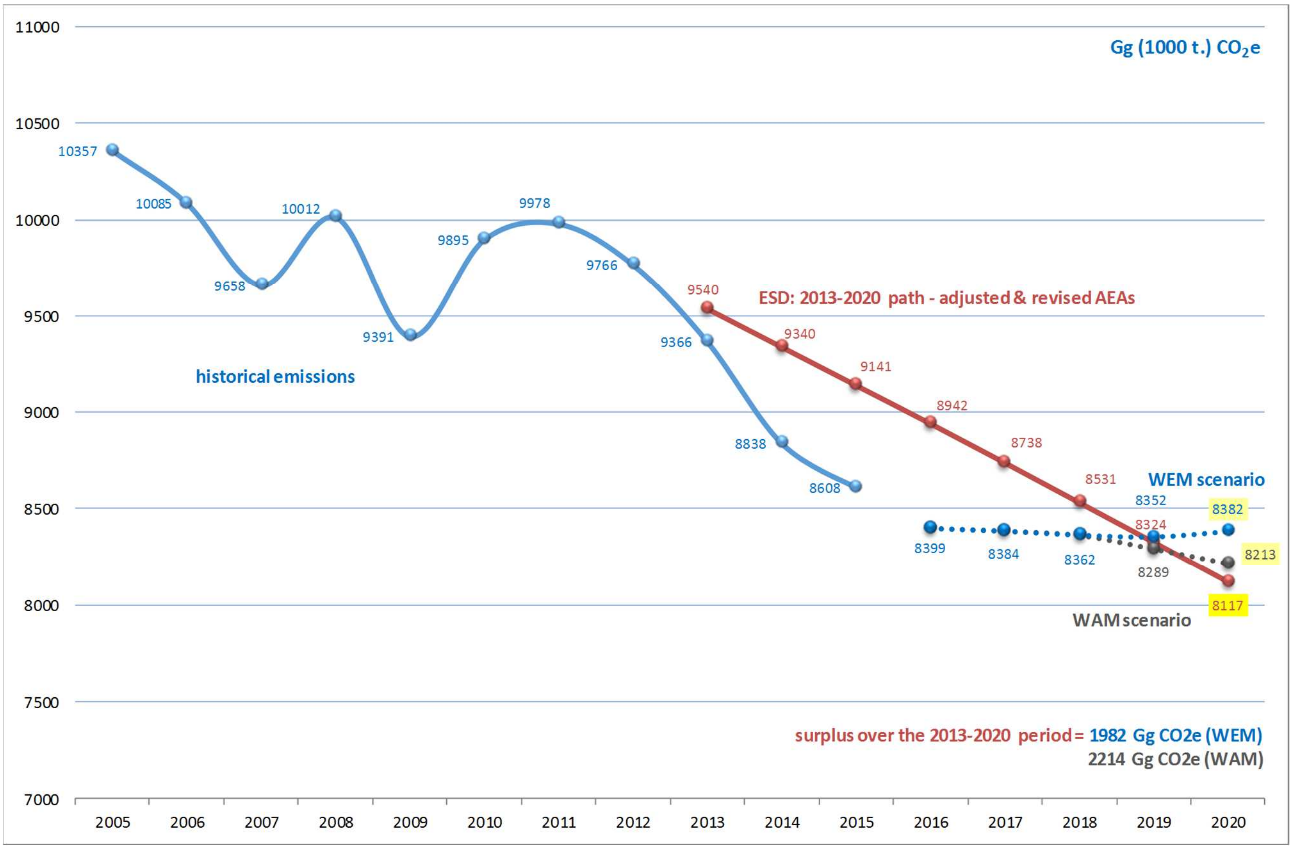
Sources: Environment Agency and MDDI-DEV – Submission 2017v7
MDDI-DEV – 2017 projections submission

Results of the projections exercise show that, in 2035, total GHG emissions, excluding LULUCF, would be 28% below their 2005 level for the WEM scenario, and 38% below their 2005 level for the WAM scenario. Turning to the non-ETS/ESD emissions, these diminutions are -23% and -36% respectively. ETS emissions, on their side, would be divided by almost two between 2005 and 2035. Nevertheless, when taking the last historical year as a starting year – i.e. 2015 – emission reductions are less prominent, with ETS emissions decreasing by 20% up to 2035. For the WEM scenario, over that same period, total emissions would reduce by almost 9%, whereas non-ETS/ESD emissions would only lessen by around 7%. It is only when considering the WAM scenario that important reductions of about 22% would be recorded (for both total & non-ETS emissions). These differences are easily explained. 2005 was a peak year for GHG emissions reported by Luxembourg and, since then, they have regularly decreased. In addition, projections – at least for the WEM scenario – are somewhat conservative as they do not prolong the diminishing trend but remain rather flat.

Nevertheless, what is crucial for Luxembourg is that it respects its **binding annual GHG targets for the period 2013-2020 as set under the ESD** *[→ Section IV.1.1.2]*. *Figure V.3-10* shows that actual GHG emissions and projections of Luxembourg's non-ETS/ESD emissions are below the linear trajectory for most of the 2013-2020 period. For the time being, it is anticipated that, despite an overachievement in 2020, **it will not be necessary to buy AEAs and/or project-based credits to**

comply with the "ESD target". The 2020 overachievement would reach 3.3% for the WEM scenario (0.3 Mio. t CO_2e) and 1.2% for the WAM scenario (0.1 Mio. t CO_2e).

FIGURE V.3-10 – ESD IMPLICATION FOR LUXEMBOURG – 2013-2020 TRAJECTORY FOR NON-ETS EMISSIONS AND 2016 TO 2020 PROJECTED EMISSIONS



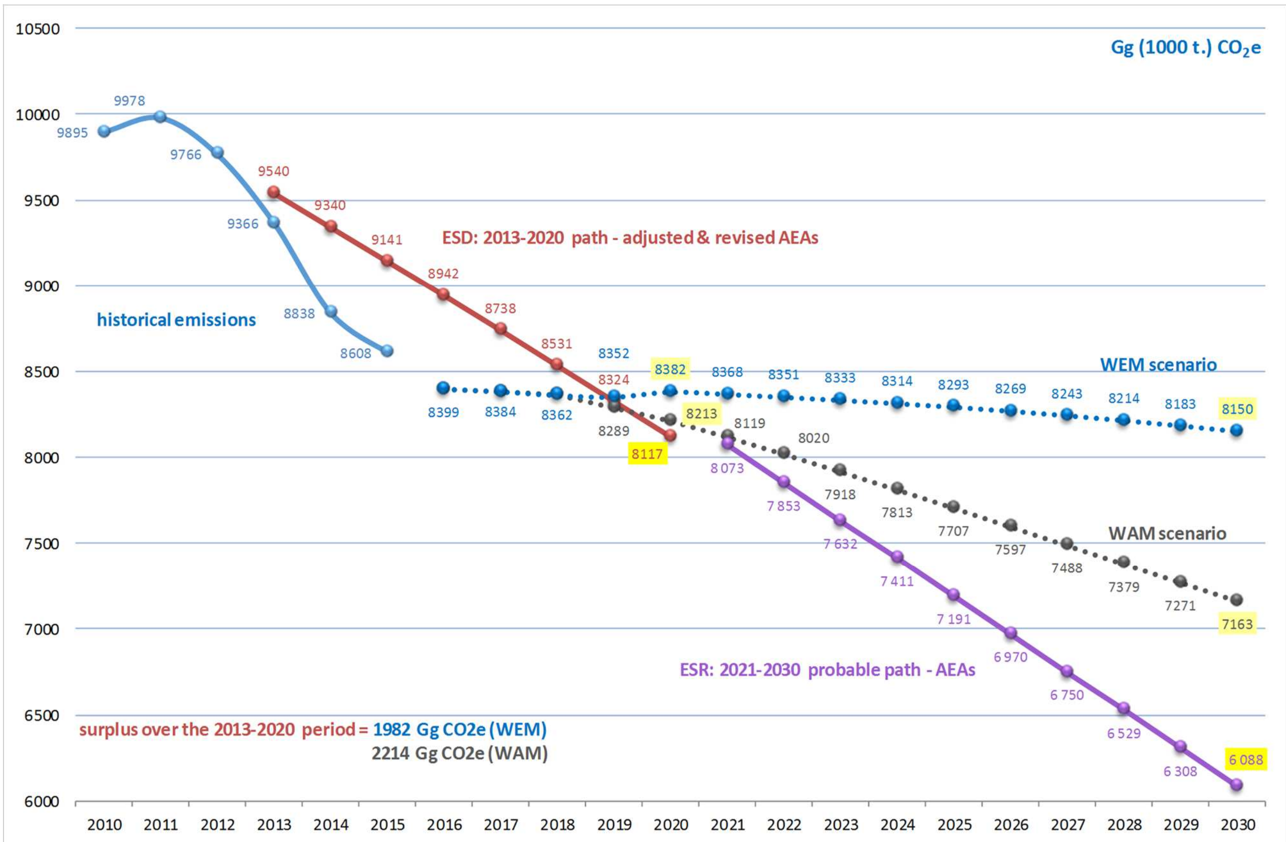
<u>Sources</u>: Environment Agency and MDDI-DEV – Submission 2017v7
MDDI-DEV – 2017 projections submission

EU joint intended nationally determined contribution (INDC) for the Paris Agreement is reflected in the "**2030 Climate & Energy framework**" *[→ Section IV.1.1.3]*. Anticipated emissions up to 2030 reveal that with actual PaMs in place, but also when considering the additional measure scenario, Luxembourg would not reach its non-ETS target *[→ Figure V.3-11]*.[181] There might be an overachievement of the 2030 target by 34% for the WEM scenario (2.1 Mio. t CO_2e) and almost 18% for the WAM scenario (1.1 Mio. t CO_2e).

The **third national "Climate Plan"** under preparation will be one of the main tool to address the gap predicted for 2030 *[→ Section IV.1.3]*.

[181] The target for Luxembourg (- 40%, compared with 2005 level) is not yet firmly set. The same is true for the 2021-2030 trajectory. Nevertheless, what is shown in this figure will be very close to the final decision under the Effort Sharing Regulation – ESR – that will replace the Effort Sharing Decision No 406/2009/EC (ESD) presented in Section IV.1.1.2.

FIGURE V.3-11 – ESR IMPLICATION FOR LUXEMBOURG – 2021-2030 PROBABLE TRAJECTORY FOR NON-ETS EMISSIONS AND 2016 TO 2030 PROJECTED EMISSIONS



Sources: Environment Agency and MDDI-DEV – Submission 2017v7
MDDI-DEV – 2017 projections submission

V.3.10. Sensitivity analyses

It is not straightforward to produce sensitivity analyses for the projections. Indeed, such an exercise is made **complex by the extremely high sensitivity of the projections to internal and external parameters**. Luxembourg is a small country and economy where, for instance, a single industrial project – internal parameter – or changes in relative road fuels pricing or VAT differences compared to neighbouring countries – external parameters – could strongly influences the projected emissions.

Thus, if a large company discontinues its activities or a new one settles in Luxembourg, this could have significant impacts on the GHG emissions, hence on their projections. The same holds if the Government would decide to revive the now standing idle gas and steam turbine power plant TWINerg *[→ Section II.6.1]* or if it chooses to reject any project of combined heat-power plant running on either fossil fuels or natural gas. In industry, changes in processes in existing units could also lead to noticeable changes in the emissions *[→ Sections II.12.2, III.1.1 & V.1.1]*.

For external parameters, changes in the policy of a neighbouring country might have a strong impact on national GHG emissions since "road fuel sales to non-residents" is responsible of about 38.8% of the total GHG emissions (excl. LULUCF) in Luxembourg *[→ Sections II.8.2, III.1.1 & IV.3.1.2]*.

However, we have tried to evaluate uncertainties of the projections for each of the GHG source categories analysed in the WEM and WAM scenarios *[→ Table V.3-10]*. It is not, strictly speaking, a sensitivity analysis but it gives, at least, an indication of the level of confidence for these projections.

TABLE V.3-10 – LEVEL OF UNCERTAINTY OF THE PROJECTIONS

Source category	WEM	WAM
Public electricity & heat production	fair (if no new fossil fuel based units start to operate, otherwise high)	NA
Manufacturing industry	high	NA
Road Transportation	high	very high (the WAM hypothesis could actually be seen as a sensitivity analysis)
Residential, commercial & institutional combustion	fair	NA
Agriculture	fair	NA
Other miscellaneous sources	high	NA

Source: MDDI-DEV own appraisal.

As planned improvements, options could be to analyse the impacts on the emissions of new industrial projects or of cessation of activities. Various scenarios for the road transportation sector should also be regarded as an option for a sound sensitivity analysis of Luxembourg's emissions projections (e.g. various penetration rates for electro-mobility). Finally, it should be investigated whether or not it would be possible to play with various hypotheses on population growth, the number of inhabitants per dwelling, prices of fuels, taxes and other fiscal instruments. For testing these hypotheses, the use of an equilibrium model could be a plus *[→ Section V.4]*.

However, a few alternative scenarios have been calculated when reporting on GHG projections in 2015 [Ministry of Sustainable Development and Infrastructure, Department of the Environment (2015) and ECONOTEC Consultants (2015), p. 27-34]. They could be considered as sensitivity analyses but since these alternative scenarios are mostly outdated nowadays, they are not described in this Communication.

V.4. IMPROVEMENT OF METHODOLOGIES[182]

The first well-thought-out projection exercise goes back to the years 2007-2008, when projections were based on an ad-hoc energy balance set up by the Ministry of the Economy, the FiFo-Köln and the Ministry of the Environment. Projected emissions were obtained using the MS™ Windows based TRAMO-SEATS software for time series analysis and used 2005 as the base year [Ministry of the Environment (2008a)].

Later in 2008, data from the GHG inventory submission of January 2008 could be used and that helped to significantly increase the quality of the projections. Moreover, for the quantitative

[182] This section of the NC7 covers part of section V.D of the Outline and General Structure of the NC5 according to IPCC reporting guidelines (para. 5).

assessment of impacts of measures on GHG emissions projections, the results from the NEEAP submissions of February 2008 could be applied as well as results from a study by Thöne (2008) analysing the specific feature of "road fuel sales to non-residents". Baseline projected emissions were obtained using the PRIMES baseline from July 2007 as basis. However, PRIMES projections were modified if necessary, and for the transport sector two framing scenarios were introduced [Ministry of the Environment (2009)].

The **2009** exercise relies on detailed data from the GHG inventory submission of May 2009. As for the 2008 exercise, most of the impacts of the various PaMs identified were coming from the NEEAP and from the study by Thöne (2008). Baseline projected emissions for the main gas (CO_2) and sectors (CRF 1A, CRF 2A-C) were obtained using ECONOTEC's EPM tool [Ministry of Sustainable Development and Infrastructure, Department of the Environment (2009)].

The projections performed in **2011** were mostly updating the results obtained in 2008, but using the GHG inventory submission of April 2011 as a basis for the reference year. The effects of the PaMs were identical to those reported for the 2009 exercise [Ministry of Sustainable Development and Infrastructure, Department of the Environment (2011)].

In **2013**, projections were realised in two stages. A "quick" update of the 2011 projections was performed early 2013 to allow Luxembourg to be compliant with regard to reporting at EU level [Ministry of Sustainable Development and Infrastructure, Department of the Environment (2013a) and ECONOTEC Consultants (2013a)]. Then, during the fall, this first update has been revised and completed in view of the writing of Luxembourg's NC6 and BR1 [ECONOTEC Consultants (2013b) and Ministry of Sustainable Development and Infrastructure, Department of the Environment (2014a)]. These late 2013 projections were based on the GHG inventory submission of March 2013 and on ECONOTEC's EPM tool ***[→ Section V.2.4.1]***. Detailed assumptions and methodology regarding the 2013 exercises are presented in Luxembourg's NC6 [Ministry of Sustainable Development and Infrastructure, Department of the Environment (2014a), sections V.2.4 & V.2.5, p. 196-208].

Firstly in **2014 and** then in **2015**, projections have been refined again. Based on the GHG inventory submission of April 2015 for the latter, they combined outcomes from various sources and approaches: (i) ECONOTEC's updated results [ECONOTEC Consultants (2015)], notably through its specific "Residential-Tertiary Tool" [ECONOTEC Consultants (2013c)]; (ii) Komobile's "bottom-up" models for the transportation sector [Komobile & FVT (2014)]; and (iii) several national sources (STATEC, Customs & Excises Administration) – for detailed assumptions and methodology, see [Ministry of Sustainable Development and Infrastructure, Department of the Environment (2014b) & (2015)]. These 2015 projections have been slightly revised in **2016** to reflect the latest historical developments – GHG inventory submission of March 2016 – as well as updated figures and forecasts for road fuel sales that were communicated to the Department of the Environment [Ministry of Sustainable Development and Infrastructure, Department of the Environment (2016a)].

Finally, a very similar approach has been used for the projections which were performed in **April 2017** and which are presented in this Communication. They are basically updates of the 2015 and 2016 exercises taking into account (i) outcomes from the revised 2015 Komobile's study [Komobile & FVT (2017a) & (2017b)]; (ii) the latest results from STATEC models; as well as (iii) the PRIMES reference scenario from July 2016 [European Commission (2016c)] ***[→ Sections V.2 & V.3]***.

The above summary on GHG projections through time testifies of their continuous improvement. Nevertheless, **future major progresses are still expected**. **Firstly**, via the **work done and still to be done on the PaMs** ***[→ Section IV.1.6]***. Indeed, simply listing (and not necessarily quantifying) mitigation actions allows to identify those that are going to have a material impact on projections and it helps prioritizing them for quantification and integration into projections. Then, understanding and quantifying these actions helps to build realistic projections.

Secondly, the macro-economic "computable general equilibrium" (CGE) model **LuxGEM** that is developed by STATEC ***[→ Section V.2.4.2]***. LuxGEM is still being improved, especially with regard to one specific addition, the "energy & environment module". This module will allow the assessment of certain PaMs in the Luxembourg energy market and, therefore, their corresponding impact on GHG development. Nevertheless, CGE models alone could not lead to appropriate GHG projections since their predictive power lies more in the interaction between economic parameters – "general equilibrium" – than in an accurate technological representation – CGE models are "top-down" models. Consequently, it is recommended to use the CGE approach as a framework model that will look at cross-sectoral effects of measures that would be estimated better using "bottom-up" technology driven models, though the latter do not encompass the impacts of measures in one sector on all the other sectors. So far, no technology driven model is coupled with LuxGEM, only the "empirical" model NEAM ***[→ Section V.2.4.2]***.

Luxembourg still believes that the **"bottom-up" and "top-down" approaches are complementary**. The move to a more elaborated system for GHG projections would also offer better opportunities to realize relevant projections sensitivity analyses.

V.5. ASSESSMENT OF AGGREGATE EFFECTS OF POLICIES AND MEASURES

The aggregated effects of implemented and adopted PaMs is calculated as the sum of estimated impacts of individual PaMs presented in ***Sections IV.3.1 and IV.3.2*** above. Either the impact estimates use 1990 or the starting year of the PaM as the reference, i.e. calculating the impact of the PaM compared to a situation where the PaM would not have been implemented in a given year. This approach facilitates avoiding double counting of emissions savings.

In preparation of ex-post and ex-ante estimates, priority has been given to those PaMs that are expected to have the most significant impact on GHG emissions in the stationary energy, transport, waste and IPPU sectors. The estimates for agriculture and many transport sector PaMs are not yet available, which is expected to underestimate the total impact of PaMs presented in ***Table V.5-1***.

Total impact of PaMs in 2020, in accordance with the **with measures** definition is **269 kt CO_2e**, which means that in the absence of the PaMs, Luxembourg's GHG emissions would be at least 269 kt CO_2e higher than in the with measures projection. Over the **period relevant for the second commitment period of the Kyoto Protocol**, i.e. 2013-2020, total savings due to PaMs in place reach **1.4 Mio. t CO_2e.**

TABLE V.5-1 – TOTAL IMPACT OF IMPLEMENTED AND ADOPTED PAMS, BY SECTOR AND GAS, 2013-2035 AND CUMULATIVE IMPACTS RELEVANT FOR THE SECOND COMMITMENT PERIOD OF THE KYOTO PROTOCOL

Sector & number of the PaM	GHG affected	kt CO_2e/year											kt CO_2e, cumulative	
		2013	2014	2015	2016	2017	2018	2019	2020	2025	2030	2035	2013-2016	2013-2020
Stationary Energy		**12.15**	**45.25**	**62.68**	**76.66**	**91.72**	**109.92**	**128.26**	**146.86**	**189.20**	**234.82**	**279.64**	**196.74**	**673.51**
ES01	CO2	2.36	21.47	24.51	23.18	23.18	23.18	23.18	23.18	23.18	23.18	23.18	71.52	164.25
ES02	CO2	7.19	8.19	9.50	9.50	9.50	9.50	9.50	9.50	9.50	9.50	9.50	34.37	72.35
EC01	CO2	NO	9.67	18.27	29.18	39.61	52.89	65.96	78.89	107.85	141.36	174.86	57.11	294.47
EC01	CH4	NO	NE	NE	NE	NE	NE	NE	NE	0.61	0.79	0.98	NE	NE
EC01	N2O	NO	NE	NE	NE	NE	NE	NE	NE	0.16	0.21	0.26	NE	NE
EC07	CO2	NO	0.63	1.58	2.74	4.12	5.77	7.75	10.12	10.12	10.12	10.12	4.95	32.71
EC07	CH4	NO	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.06	0.06	0.06	0.03	0.20
EC07	N2O	NO	0.02	0.06	0.11	0.17	0.24	0.32	0.43	0.43	0.43	0.43	0.19	1.35
EC21	CO2	2.11	4.26	7.09	9.67	12.24	14.82	17.40	19.98	32.52	44.36	55.38	23.13	87.57
EC21	CH4	0.01	0.01	0.02	0.03	0.04	0.05	0.05	0.06	0.10	0.14	0.17	0.07	0.27
EC21	N2O	0.00	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.04	0.06	0.07	0.03	0.11
EC22	CO2	0.48	0.98	1.63	2.22	2.81	3.41	4.00	4.59	4.59	4.59	4.59	5.32	20.13
EC22	CH4	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.06
EC22	N2O	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.03
Transport		**9.92**	**12.34**	**14.38**	**16.46**	**31.36**	**33.24**	**35.05**	**36.80**	**NE**	**NE**	**NE**	**53.10**	**189.54**
TR01	CO2	2.20	4.66	6.77	8.94	11.06	13.12	15.11	17.05	NE	NE	NE	22.56	78.90
TR11	CO2	7.72	7.68	7.61	7.52	20.30	20.12	19.94	19.75	NE	NE	NE	30.54	110.64
IPPU		**NO**	**NO**	**NO**	**NO**	**1.94**	**10.09**	**9.68**	**9.87**	**59.64**	**87.86**	**115.53**	**NO**	**31.57**
IP01	HFCs	NO	NO	NO	NO	1.85	9.63	9.20	9.37	58.61	86.54	114.07	NO	30.05
IP01	SF6	NO	NO	NO	NO	0.09	0.47	0.48	0.49	1.03	1.32	1.45	NO	1.52
Agriculture		**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
Forestry		**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
Waste		**53.08**	**53.91**	**57.05**	**59.16**	**65.84**	**69.09**	**72.34**	**75.34**	**88.59**	**99.59**	**100.34**	**223.20**	**505.81**
WM22	CH4	46.25	47.25	48.25	52.50	56.00	59.25	62.50	65.50	78.75	89.75	90.50	194.25	437.50
WM24	CH4	6.83	6.66	8.80	6.66	6.66	6.66	6.66	6.66	6.66	6.66	6.66	28.95	55.58
WM33	CO2	NO	NO	NO	NO	3.18	3.18	3.18	3.18	3.18	3.18	3.18	NO	12.73
Total		**75.15**	**111.50**	**134.12**	**152.27**	**190.86**	**222.34**	**245.33**	**268.87**	**337.43**	**422.27**	**495.50**	**473.04**	**1400.43**
Total	CO2	22.06	57.54	76.96	92.94	126.01	145.99	166.03	186.24	190.95	236.29	280.81	249.50	873.76
Total	CH4	53.09	53.93	57.09	59.21	62.73	66.00	69.27	72.30	86.19	97.42	98.39	223.32	493.62
Total	N2O	0.00	0.03	0.07	0.12	0.19	0.26	0.35	0.46	0.64	0.71	0.77	0.23	1.49
Total	HFCs	NO	NO	NO	NO	1.85	9.63	9.20	9.37	58.61	86.54	114.07	NO	30.05
Total	SF6	NO	NO	NO	NO	0.09	0.47	0.48	0.49	1.03	1.32	1.45	NO	1.52

Source: Aether / Benviroc (2017).

V.6. Supplementarity relating to Mechanisms under Article 6, 12 and 17 of the Kyoto Protocol

V.6.1. Bridging the gap – target assessment 2008-2012

Luxembourg has ratified the Kyoto Protocol on May 31st, 2002. Pursuant to that Protocol and the terms of the European agreement distributing the burden among, at that time, the EU-15 Member States, Luxembourg undertook **to reduce its GHG emissions by 28% below their 1990 level over the period 2008-12** – the so-called "burden sharing" EU target. This is the deepest cut of any agreed by the 15 Member States for the first Kyoto commitment period. This corresponds to a disposable volume of 9.48 Mio. t CO_2e per year for the period between 2008 and 2012.[183]

As shown in ***Table V.6-1***, emissions for 2008-2012 were above the assigned amount of 9.48 Mio. t CO_2e, which could be disposed of annually in the first commitment period of the Kyoto Protocol (CP1).

This can be explained by Luxembourg's limited mitigation potentials and considerations linked to the size and the location of the country, as well as by the anticipated economic and demographic growths that set off part of the energy-efficiency gains. As a result, national policies and measures showed not to be sufficient to bridge the gap between allocated emissions under the Kyoto Protocol and real emissions for CP1.

According to the inventory submission 2014v3.1 of 17 November 2014 – which is the one to be considered for the final calculation of the first commitment period under the Kyoto Protocol since it matches recommendations and adjustments requested by the UNFCCC experts review team on the 2014 submission historical emission estimates for CP1 – usage of Kyoto mechanisms reached 2.84 Mio. t CO_2e on average per year (line 10 of the table, column Average 2008-2012). Over the whole period, the gap **reached 14.2 Mio. t CO_2e** (line 10 of the table, column Sum 2008-2012).

Table V.6-1, also shows that Luxembourg could only count to a minimum extend on carbon sinks over the period 2008-2012 (Article 3.3 activities under the Kyoto Protocol).[184] The annual reduction as a result of carbon sinks in the period 2008-2012 was yielding only 0.075 Mio. t CO_2e. Therefore, Luxembourg could only issue a total amount of 0.373 Mio. t CO_2e of Removal Units (RMUs – line 8 of the table) over the CP1 period that reduced the gap from 14.6 Mio. t CO_2e (line 7 of the table) to 14.2 Mio. t CO_2e. These calculations take into account the "losses" induced by EU ETS related

[183] Burden sharing exact value is 9 480 599 tonnes.

[184] Luxembourg did not plan to account for net emissions and removals from activities under Article 3.4 of the Kyoto Protocol. For more details on Article 3.3 and 3.4, see [Ministry of Sustainable Development and Infrastructure, Environment Agency (2017), Chapter 11].

allowances finally not used by the beneficiaries,[185] which represent 14.7% of the difference between the recorded total GHG emissions and the total AAUs for the CP1 period.

Consequently, closing the gap between the volume of AAUs (line 4 of the table) and the volume of emissions according to IPCC rules required Luxembourg **to use Kyoto mechanisms in addition to its domestic PaMs**. The acquisition of additional emission permits was fulfilled either by making use of project based mechanisms (Clean Development Mechanisms – CDM and Joint Implementation – JI) or by purchasing permits on the International Emissions Trading market (IET), pursuant to Articles 6, 12 and 17 of the Kyoto Protocol. The **CDM provided about 37% of the emission reductions**, **JI and IET the remaining part**.

For Luxembourg, the projects under CDM and JI had to comply with the ecological and social criteria established in the framework of the approval procedures of the UNFCCC and to the specific criteria defined by the committee in charge of managing the Kyoto Fund – the "Climate & Energy Fund" *[→ Section V.6.3]*. In order to facilitate emission rights transfers, Luxembourg also concluded deals with other EU countries ready to sell a part of their assigned amount units (AAUs), as well as with host-countries of CDM and JI projects.

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185 These "losses" equal 1.87 Mio. t CO_2e (line 5 minus line 2 of the table, column Sum 2008-2012).

TABLE V.6-1 – KYOTO COMPLIANCE OVERVIEW FOR LUXEMBOURG – CP1

Line	Category	Operation	2008	2009	2010	2011	2012	Average 2008-2012	Sum 2008-2012	Source/Notes
0	Base-year emissions		13.167	13.167	13.167	13.167	13.167	13.167	-	*UNFCCC review report of initial report under KP*
1	Total GHG emissions		12.199	11.690	12.260	12.128	11.838	12.023	60.116	*2008-2012: 2014v3.1 inventory submission to the EC and the UNFCCC (http://cdr.eionet.europa.eu/lu/eu/ghgmm/envvgoyvw/)*
2	Verified emissions under the EU ETS		2.099	2.182	2.253	2.052	1.990	2.115	10.575	*CITL / EEA viewer (https://www.eea.europa.eu/data-and-maps/dashboards/emissions-trading-viewer-1)*
3	Non-ETS GHG emissions	(1) – (2)	10.101	9.508	10.008	10.076	9.849	9.908	49.541	
4	Initial assigned amount (AAUs)		9.481	9.481	9.481	9.481	9.481	9.481	47.403	
5	Allowances issued under the EU ETS		2.488	2.488	2.488	2.488	2.488	2.488	12.441	*CITL / EEA viewer & MDDI (http://www.environnement.public.lu/air_bruit/dossiers/CC-systeme_d_echange_de_quotas_ETS/ETS_etat_conformite.pdf) 2012: the figure takes into account the fact that the Luxlait allowances not used after the closure of the Belair plant (0.003883 Mt) have been sold, and therefore cannot be counted as surrendered by the installation.*
6	Non-ETS target	(4) – (5)	6.992	6.992	6.992	6.992	6.992	6.992	34.962	
7	**Difference between target and GHG emissions (non-ETS, domestic)**	**(6) – (3)**	**-3.108**	**-2.516**	**-3.016**	**-3.084**	**-2.856**	**-2.916**	**-14.579**	*These differences take into account the fact that not all allowances have been used by the ETS installations. These allowances that have not been used are "lost" for the Government, hence for the calculation of the differences.*
8	Expected net carbon sequestration from LULUCF activities (RMUs)		0.075	0.075	0.075	0.075	0.075	0.075	0.373	*See KP_LULUCF file KP-LUX-2014-2012-v3.1.xls, sheet "Accounting" (http://cdr.eionet.europa.eu/lu/eu/ghgmm/envvgoyvw/)*
9	**Difference between target and GHG emissions (non-ETS, domestic), including effect of carbon sequestration**	**(7) + (8)**	**-3.034**	**-2.441**	**-2.941**	**-3.009**	**-2.782**	**-2.841**	**-14.206**	*These differences take into account the fact that not all allowances have been used by the ETS installations. These allowances that have not been used are "lost" for the Government, hence for the calculation of the differences.*
10	Planned use of Kyoto mechanisms by government (net transfer of AAUs + purchase of CERs + ERUs)	[(4) - (1)] + (8) + [(2) - (5)]	3.034	2.441	2.941	3.009	2.782	2.841	14.206	*Under the hypothesis that Luxembourg will cover its "Kyoto CP1 deficit" by using FlexMex, the expected uses of Kyoto mechanisms for each year are reported here.*
11	Emission reduction units (ERUs) issued under JI projects		0.000	0.000	0.000	0.000	0.000	0.000	0.000	*Luxembourg did not issue ERUs.*
12	**Difference between target and GHG emissions (non-ETS, including plans on Kyoto mechanisms and carbon sinks)**	**(7) + (8) + (10) – (11)**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	
12'	***Percentage gap***	***(11) / (0)***	***0.00%***	***0.00%***	***0.00%***	***0.00%***	***0.00%***	***0.00%***	**-**	

Source: MDDI-DEV based on a revised and updated table published by the EEA in Chapter 9 of the *Greenhouse gas emission trends and projections in Europe 2012 report*, page 77 (http://www.eea.europa.eu/publications/ghg-trends-and-projections-2012).

Notes: 2 = also "allowances surrendered under the EU ETS" since ETS operators are legally bound to surrender to their Government an amount of allowances equivalent to their emissions.
2 = the 2008-2012 sum is divided as such: surrendered allowances (EUAs) - 9.77771 Mt; surrendered CERs - 0.789223 Mt & surrendered ERUs - 0.008066 Mt (source: https://www.eea.europa.eu/data-and-maps/dashboards/emissions-trading-viewer-1).
8 = estimates of annual RMUs based on 5 historical reporting years (2008-2012). In the file KP-LUX-2014-2012-v3.1.xls, sheet "Accounting", take the sum of A1 & A2, column "Accounting quantity" and divide it by 5: (-606.41+233.13)/5 = -74.6559 Gg or 0.0746559 Mt CO_2e.

V.6.2. Bridging the gap – target assessment 2013-2020

To reach its target under the second commitment period (CP2) of the Kyoto Protocol, Luxembourg is considering the use of Kyoto mechanisms in addition to its domestic PaMs, even though actual tendencies show that the recourse to such mechanisms may not be necessary.

As explained in the above chapters and sections *[e.g. Section V.1.2]*, transport sector emissions are variable and have a significant impact on the total GHG emission trends of Luxembourg. At the end of CP1, the transport sector projections predicted high GHG emissions for the coming years and Luxembourg decided to enlarge its credit acquisition program to CP2 credits, focusing mainly on Gold Standard credits.

However, the emission development in the transport sector was more moderate than expected, and from 2013 to 2016, Luxembourg's GHG emissions did not exceed its national targets. As of today, Luxembourg did not use any of the purchased CP2 credits. Similarly, based on the most recent WEM projections, it is expected that Luxembourg **will not need to use Kyoto mechanisms in addition to its domestic PaMs to reach its CP2 target** *[→ Section V.3.9]*, in which case they may be cancelled if carry-over to post-2020 period will not be possible *[→ Tables V.6-2 & V.6-3]*.

Table V.6-2 – Annual and cumulative gaps – CP2

-20% target in 2020	2013	2014	2015	2016	2017	2018	2019	2020
Non-ETS emissions ***WEM projections***	9.37	8.86	8.61	*8.40*	*8.38*	*8.36*	*8.35*	*8.38*
Annual emission budget	9.54	9.34	9.14	8.94	8.74	8.53	8.32	8.12
Gap – annual	-0,17	-0,48	-0,53	*-0,54*	*-0,35*	*-0,17*	*0,03*	*0,26*
Gap – cumulative	-0.17	-0.66	-1.19	*-1.73*	*-2.09*	*-2.26*	*-2.23*	*-1.96*

Source: MDDI-DEV.

Notes: for the years 2013, 2014 & 2015 non-ETS emissions are those already set at EU level for the compliance period under the ESD.
a negative sign indicates that the actual non-ETS/ESD emissions are below the annual emission allocation (AEA) determined under the ESD.

Table V.6-3 – Available credits from Kyoto Mechanisms and their expected use – CP2

	Kyoto Mechanisms (Mio. t. CO_2e)
Carry-over from CP1 to CP2	0.49
Purchase of CP2 CDM credits by end of 2017	0.92
On-going purchase projects, estimate	0.10
Total available credits at the end of CP2 (estimate)	1.51
Use of credits by end of 2017	0.00
Total use of credits in CP2 (estimate)	0.00

Sources: MDDI-DEV and Aether / Benviroc (2017).

Table V.6-4 compares the use of Kyoto mechanisms *[→ Table V.6-3]* to the impact of domestic PaMs *[→ Table V.5-1]* in 2013-2016 and for the entire duration of the CP2, 2013-2020. In both periods, the impact of domestic measures is higher than the use of Kyoto mechanisms. Based on this information it is concluded that, unless a sudden increase in transport emissions occurs, **the use of the Kyoto mechanisms by Luxembourg is supplemental to domestic action**, and domestic action thus constitutes a significant element of the effort made to meet Luxembourg's quantified limitation and reduction commitments under Article 3, paragraph 1, of the Kyoto Protocol.

TABLE V.6-4 – REALIZED (2013-2016) AND EXPECTED USE OF KYOTO MECHANISMS COMPARED WITH THE IMPACTS OF DOMESTIC PAMS – CP2

Years	Use of Kyoto Mechanisms (Mio. t. CO_2e)	Cumulative impact of domestic PaMs (Mio. t. CO_2e)
2013-2016	0.0	0.5
CP2 (2013-2020)	0.0	1.4

Sources: MDDI-DEV and Aether / Benviroc (2017).

V.6.3. How financing the use of "Kyoto flexible mechanisms"? – the "Climate & Energy Fund"

By a law of 23rd December 2004, Luxembourg has set up a fund to finance the Kyoto mechanisms (the "Kyoto Fund") [186]. In January 2011, this Fund has been renamed "Climate & Energy Fund" to reflect the fact that from that year onward it is also used to finance projects in the domains of energy efficiency and renewable energy sources following the objectives set out for Luxembourg in the context of the EU "2020 Climate & Energy package". The Department of the Environment remains in charge of the "Kyoto" side of the "Climate & Energy Fund" and decision-making responsibility for CDM and JI rests with the same Department. According to the Law, the Minister in charge of the environment is advised by an inter-ministerial committee made up of representatives of the Directorate for Development Cooperation and Humanitarian Affairs of the Ministry of Foreign and European Affairs, of the Ministry of the Economy, of the Department of the Environment of the Ministry of Sustainable Development and Infrastructure and of the Ministry of Finance.

Various types of instruments have been deployed by the Government in order to acquire Certified Emission Reductions units (CERs) and Emission Reduction Units (ERUs). Firstly, voluntary and non-binding Memoranda of Understanding with some potential host countries. Secondly, for the selection of projects and the purchase of CERs and ERUs, various intermediary organizations have been contracted along the following tracks:

- participation in carbon funds of multilateral and regional financial institutions;
- facilities with private international banks;
- bilateral purchase agreements.

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[186] Loi du 23 décembre 2004 1) établissant un système d'échange de quotas d'émission de gaz à effet de serre; 2) créant un fonds de financement des mécanismes de Kyoto; 3) modifiant l'article 13bis de la loi modifiée du 10 juin 1999 relative aux établissements classés (http://www.legilux.public.lu/leg/a/archives/2004/0210/a210.pdf, p. 3792-3799).

The annual current budget of the "Kyoto Fund" (2005-2010) / "Climate & Energy Fund" (from 2011) is as follows *[→ Table V.6-5]*.

TABLE V.6-5 – CURRENT ANNUAL BUDGET OF THE "KYOTO FUND" / "CLIMATE AND ENERGY FUND IN MIO. EUR

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013 to 2017*
Budget	5.00	10.00	10.00	10.50	11.00	11.00	11.00	5.00	0.00

Source: MDDI-DEV.

Note: the exact amount is 100 EUR, i.e. it has been decided that the Fund will be financed only by taxation revenues.

Additionally to this budgetary grant, 40% of the CO_2-based vehicle tax and 100% of the "Kyoto-cent" represent extra sources of revenues for the Fund. The "Kyoto-cent" is an additional tax on every gasoline and diesel litre sold in Luxembourg (2 & 2.5 euro-cents per litre respectively) *[→ Section IV.3.1.2]*. In 2016, the CO_2-based vehicle tax contributed an amount of 27 Mio. EUR to the "Climate & Energy Fund", whereas the "Kyoto-cent" generated an income of 56 Mio. EUR. These two PaMs are notably described in the Second Biennial Report of Luxembourg under the UNFCCC [Ministry of Sustainable Development and Infrastructure, Department of the Environment (2016b), Table 3-1, P&M ID 29 and 31, p.82)].

As of today (since 2005), Luxembourg committed about 124 Mio. EUR to the use of project based mechanisms, through the Fund:

- International Emission Trading (IET), permitting countries to transfer parts of their "assigned amount units" (AAUs);
- Clean Development Mechanism (CDM), allowing emission-reduction projects that assist in creating sustainable development in developing countries to generate "certified emission reductions" (CERs) for use by the investor;
- Joint Implementation (JI), allowing countries to claim credit for emission reductions that arise from investment in other industrialized countries, which result in a transfer of equivalent "emission reduction units" (ERUs) between the countries.

A share of 30.5 Mio. EUR has been committed to the participation in multilateral funds: Luxembourg participates in various carbon funds of international financial institutions covering ERPAs pertaining to CDM and JI projects. Committed expenditures presented in the above include these contributions to the:

- "Biocarbon Fund" of the World Bank;
- "Community Development Carbon Fund" of the World Bank;
- "Carbon Fund for Europe" of the European Investment Bank and the World Bank (terminated);
- "Multilateral Carbon Credit Fund" of the European Bank for Reconstruction and Development (terminated);
- "Asian Pacific Carbon Fund" of the Asian Development Bank (terminated).

At the end of 2016, some 117 Mio EUR have been disbursed for the use of project based mechanisms (AAUs, CERs and ERUs). Around 21% of these expenses are allocated to multilateral purchases and 79% to bilateral purchase agreements. The counterpart of these payments represents approx. 16 Mio. t CO_2e. This volume enabled Luxembourg to comply with its CP1 engagements, as Luxembourg faced a CP1 gap of 14.2 Mio. t CO_2e, and to report and buy a certain amount of credits to CP2 (0.49 Mio. t CO_2e) *[→ Table V.6-3]*.

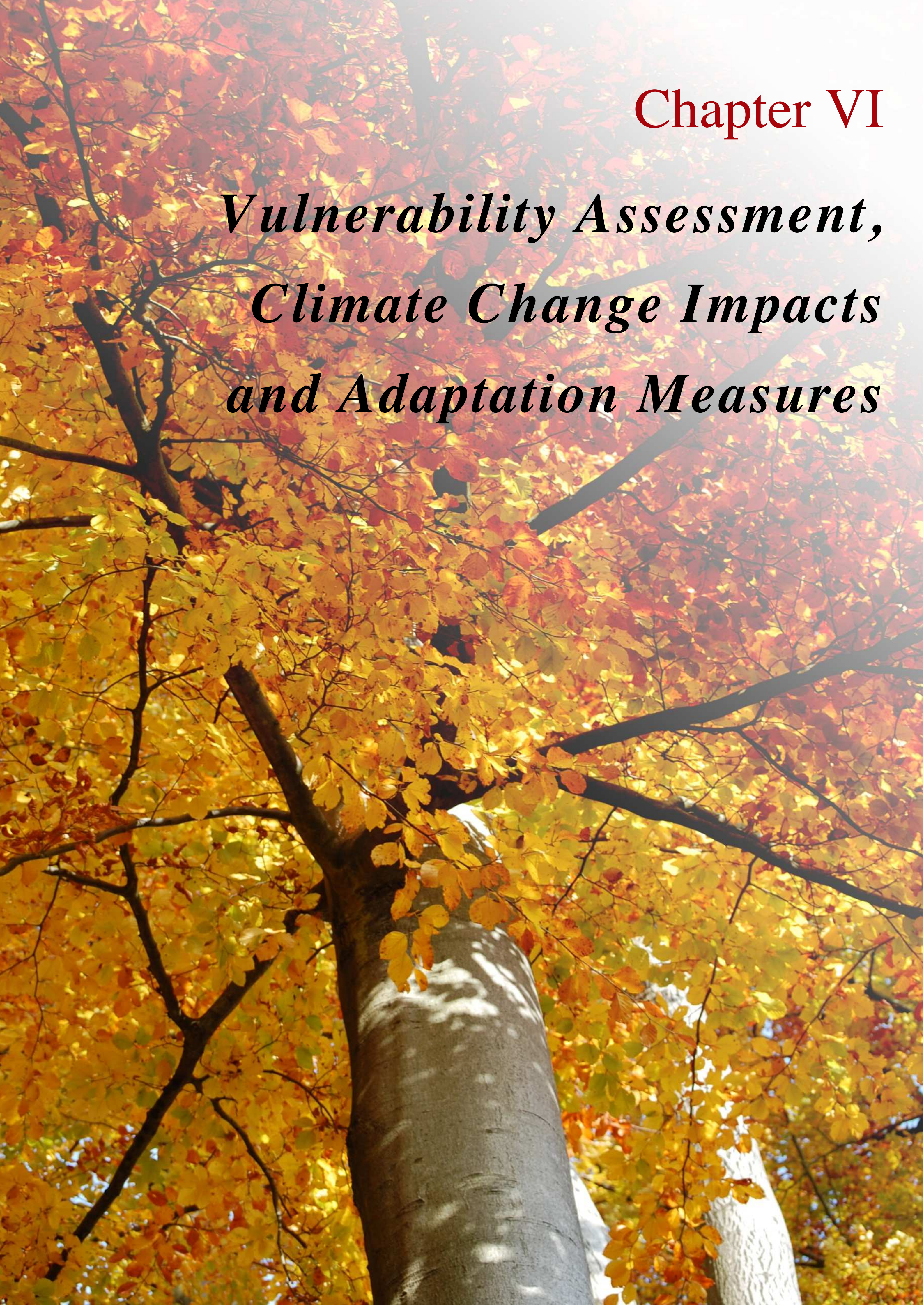
For the years 2014 to 2017, disbursements for the acquisition of emission rights (mainly CERs) in the framework of the "Climate & Energy Fund" amount to a total of 10.32 Mio. EUR *[→ Table V.6-6]*.

TABLE V.6-6 – LUXEMBOURG'S 2014-2017 DISBURSEMENTS AND 2018-2020 BUDGETARY PROVISIONS FOR THE PURCHASE OF EMISSION RIGHTS (IN MIO. EUR)

Year	2014	2015	2016	2017	2018	2019	2020
Projects abroad	4.25	4.35	0.94	0.78	6.00	6.00	6.00

Although budgetary provisions are foreseen for the years 2018-2020, there is currently no need to plan the purchase of further credits for CP2.

This distribution of funds is likely to be revised and adapted, depending on the development of emission projections, notably with regard to possible changes in the transport sector, for which emissions could suddenly shift and have a significant impact on the total GHG emission trends of Luxembourg.



Chapter VI

Vulnerability Assessment, Climate Change Impacts and Adaptation Measures

In line with the recommendations of the UNFCCC reporting guidelines, paragraph 49, Chapter VI presents the expected impacts of climate change in Luxembourg *[→ Section VI.1]*, whereas vulnerability assessment is analysed through the prism of water *[→ Section VI.2]*. This chapter concludes with a presentation of strategies **on adaptation to climate change** *[→ Section VI.3]*.

This chapter is usefully supplemented by the description of the climatic circumstances in Luxembourg *[→ Section II.3]*.

VI.1. EXPECTED IMPACTS OF CLIMATE CHANGE IN LUXEMBOURG: VEGETATION AND WATER IN THE FOREFRONT[187]

VI.1.1. Vegetation

According to a report published in 2016 by the EEA [European Environment Agency (2016)], Luxembourg is part of the biogeographical "Continental Region" area as defined under the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) – see Map ES.1, p. 25 of the aforementioned report. The threats identified for this peculiar region are:

- increase in heat extremes;
- decrease in summer precipitation;
- increasing risks of river floods;
- increasing risk of forest fire;
- decrease in economic value of forests;
- increase in energy demand for cooling.

Two of these threats are of main concern for Luxembourg, **those relating to forests**. **Temperature extremes** and **summer precipitation** reduction are also causes for concern due to their impacts on human health, especially of the most fragile persons and the elderly (heat, air quality), and impacts on water quality in summer when rivers flows are usually at their lowest.

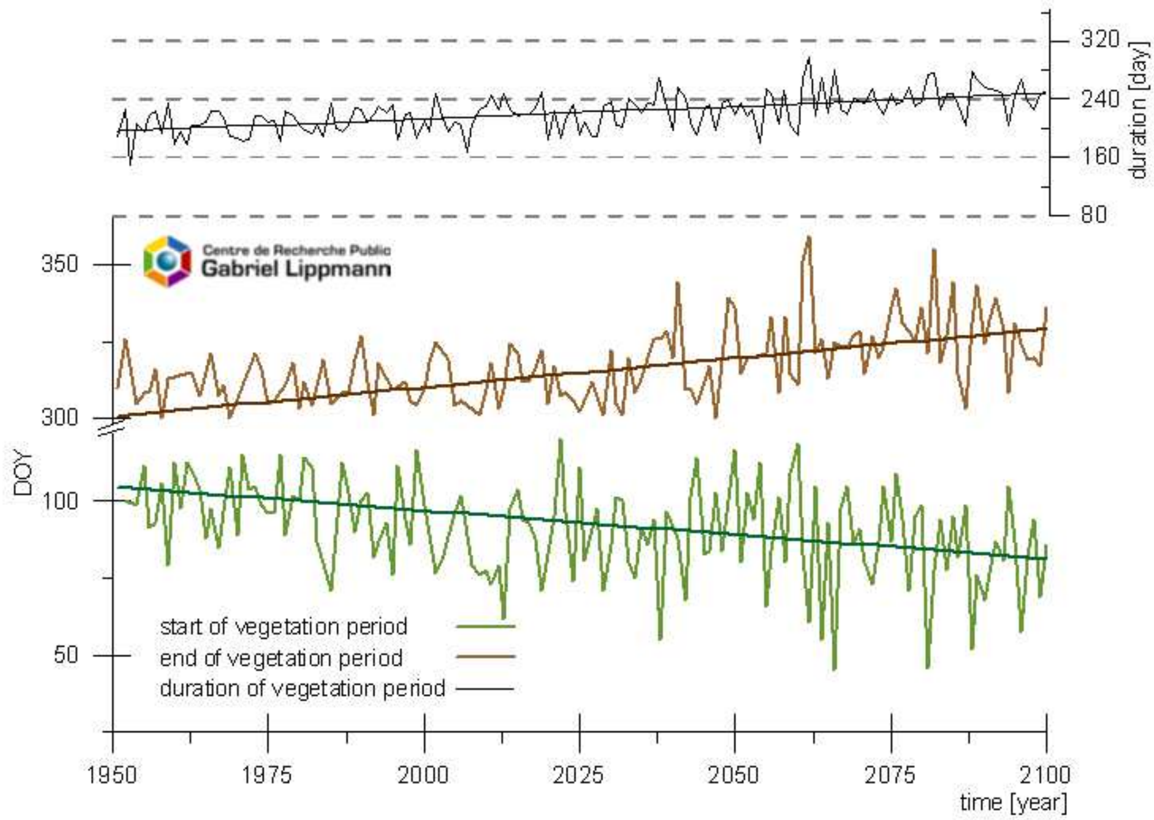
According to the researchers of the *Luxembourg Institute of Science and Technology* (LIST), the projected changes in air temperature *[→ Section II.3.2]* are likely to induce a modification of the vegetation period in Luxembourg. The start of the vegetation period is defined as the exceedance of the 5°C daily mean temperature threshold in spring for at least 5 successive days; the end of the vegetation period corresponds to the undershooting of this threshold until the end of the year [Chmielewski & Rötzer (2001)].

187 The texts of Sections VI.1.1 to VI.1.3, and VI.1.4 first paragraph, have been prepared by Junk, J., Trebs, I., Hoffmann, L. of the *Luxembourg Institute of Science and Technology* (LIST). The text of the other paragraphs under Section VI.1.4 has been prepared by the Water Agency (AGE).

In Luxembourg, the **vegetation period** is expected to be initiated earlier in spring and to last longer into autumn *[→ Figure VI.1-1]*. During the early stages of the vegetation period this might cause an increased risk of frost damages to vegetation [Goergen et al. (2013)].

The increase of temperatures, especially during the winter period *[→ Section II.3.1]*, already has significant impacts on the **phenology of plants** (earlier flowering dates) and animals (e.g. earlier breeding dates of birds, advancement of life cycle of insects [Junk et al. (2012); Eickermann et al. (2014)], three instead of two yearly cycles), but also on the **migratory behaviour of birds and insects** (i.e. species now winter in Luxembourg that in former times migrated to Spain or northern Africa). Furthermore, the temperature changes have an impact on the **bio-geography of plants and animals**, with new species with a Mediterranean distribution, formerly unknown in Luxembourg, which recently appeared in the country fauna (e.g. *Nomophila noctuella*, *Udea ferrugalis*, *Brenthis daphne*) and flora (some moss species). Bio-climatic approaches also indicate that some relict species of the last glaciation period (e.g. *Lycaena helle*) will disappear from Luxembourg with the expected temperature increase.

FIGURE VI.1-1 – START, END AND DURATION OF THE VEGETATION PERIOD



Source: Georgen et al. 2013; *Centre de Recherche Public-Gabriel Lippmann* (now integrated into the LIST)
Notes: (1) based on selected ENSEMBLES data sets. A1B emission scenario.
(2) end and duration of the vegetation period as defined by Chmielewski & Rötzer (2001).
(3) DOY = day(s) of year.

Box VI.1-1: The ENSEMBLES model

The data used in most of the presented impact studies in this NC were taken from the 6th Framework Programme Priority of the EC (FP6) ENSEMBLES project.**(1)** Within this project, only a dynamical downscaling approach was used. Data from different Global Climate Models (GCMs) were used as input data for different Regional Climate Models (RCMs). An overview of the GCM-RCM combination as well as the institution that run the projections is given in table 1; a more detailed description is given by Junk et al. (2014). Local references were only used for the bias correction of the RCM output. Therefore, single stations within the country were not used but rather the E-OBS (www.ecad.eu) data set, which includes gridded data of air, temperature, precipitation, relative humidity, and pressure.

Table 1 – Regional climate change projection datasets from the ENSEMBLES project

Model ID used as abbreviations	GCM	Institution running the GCM	RCM	Institution running the RCM
E01	HadCM3Q16	METO-HC	RCA3	C4I
E03	ARPEGE_RM5.1	CNRM	ALADIN	CNRM
E04	ECHAM5r3	MPI-MET	DMI-HIRHAM5	DMI
E05	ARPEGE	CNRM	HIRHAM5	DMI
E06	BCM	UIB	HIRHAM5	DMI
E07	HadCM3Q0	METO-HC	CLM	ETHZ
E08	IPSL	IPSL	CLM	GKSS
E09	HadCM3Q0	METO-HC	HadRM3Q0	METO-HC
E10	HadCM3Q3	METO-HC	HadRM3Q3	METO-HC
E11	HadCM3Q16	METO-HC	HadRM3Q16	METO-HC
E12	ECHAM5r3	MPI-MET	RegCM	ICTP
E13	ECHAM5r3	MPI-MET	RACMO	KNMI
E16	ECHAM5r3	MPI-MET	REMO	MPI-M
E18	BCM	UIB	RCA3	SMHI
E19	ECHAM5r3	MPI-MET	RCA3	SMHI
E20	HadCM3Q3	METO-HC	RCA3	SMHI

During the upcoming years, the *Luxembourg Institute of Science and Technology* (LIST) will focus on the detailed analyses of the high resolution COSMO-CLM projections for Luxembourg and apply a bias correction to this data set.

Additionally, data provided by the CORDEX project (the successor of the ENSEMBLES project, spatial resolution 25 km and 7 km) will be used for further impact studies. The exact timeline and extend of these tasks are dependent of the acquired funding by the research institute.

(1) http://ensembles-eu.metoffice.com/.

VI.1.2. Human health

The climate projections for the second half of this century will also have significant impacts on public health conditions in Luxembourg. The thermal environment is a relevant parameter for human health because of the close interaction between the thermoregulatory mechanism of the human body and the circulatory system.

The danger of **increasing heat exposure** for the population in Luxembourg is most severe in urban areas with high building densities due to the increased thermal storage capacity and night time thermal emissions. The higher air temperatures, especially during night times (important recreation time for humans) also increase the likelihood of extreme heat events such as the one that struck Europe in August 2003 [Matzarakis et al. (2013)]. Even relatively moderate levels of heat stress could be associated with adverse health impacts, and characteristically temperature-mortality relationships could be established for air temperatures below 30°C. The greatest health threat to humans will be the projected increase in extreme events especially in the frequency and intensity of heat waves. Based on climate change projections the impact of climate change on human thermal comfort over the next century using two common human-biometeorological indices, the "Physiological Equivalent Temperature" and the "Universal Thermal Climate Index" was assessed. For the future, trends in air temperature, vapour pressure, and both human-biometeorological indices could be determined.

Cold stress levels will decrease significantly in the near future up to 2050, while the increase in heat stress turns statistically significant in the far future up to 2100. This results in a temporarily reduced **overall thermal stress** level but further increasing air temperatures will shift the thermal comfort towards heat stress [Lokys et al. (2015)]. Climate indices developed by the *World Climate Research Programme's Expert Team on Climate Change Detection and Indices* were used to analyse data from (i) a long-term measurements site (Findel-Airport station) and (ii) different regional climate models to assess potential health effects for Luxembourg.

The four air temperature based climate indices: frost days, summer days, warm days and tropical nights were calculated for the observational data of the Findel-Airport site for the period from 1971 until 2000, as well as for the results of the multi-model ENSEMBLE (MME) *[→ Figure VI.1-2]*.[188]

In general, the climate indices reflect the trend of increasing air temperature. The observed decreasing trend in the absolute number of frost days based on the measurements on the Findel-Airport site is sustained in the projections. Until the end of this century the general frost risk will almost disappear except for single events in areas with higher frost potential, e.g. due to cold drainage air flows. Higher air temperature during the cold season decreases the future cold stress and would potentially reduce the short-term increases in mortality, mainly from thrombotic and respiratory disease during the winter season.

The **number of summer days** increased considerably up to the year 2000 based on the observed air temperatures. This trend is also visible in the future projections. For the direct health effect, the number of tropical nights is even more important, because the lack of regeneration due to heat-stress conditions at night has been identified to be particularly dangerous to human health. According to the observational data set, these events were rare events in the past. On average, less than one **tropical night** is observed per year in the last century. The transient multi model projections revealed an average increase to 4.3 days in the near (2041 - 2050) and 12.9 days in the far future (2089 - 2098) [Junk et al. (2014)].

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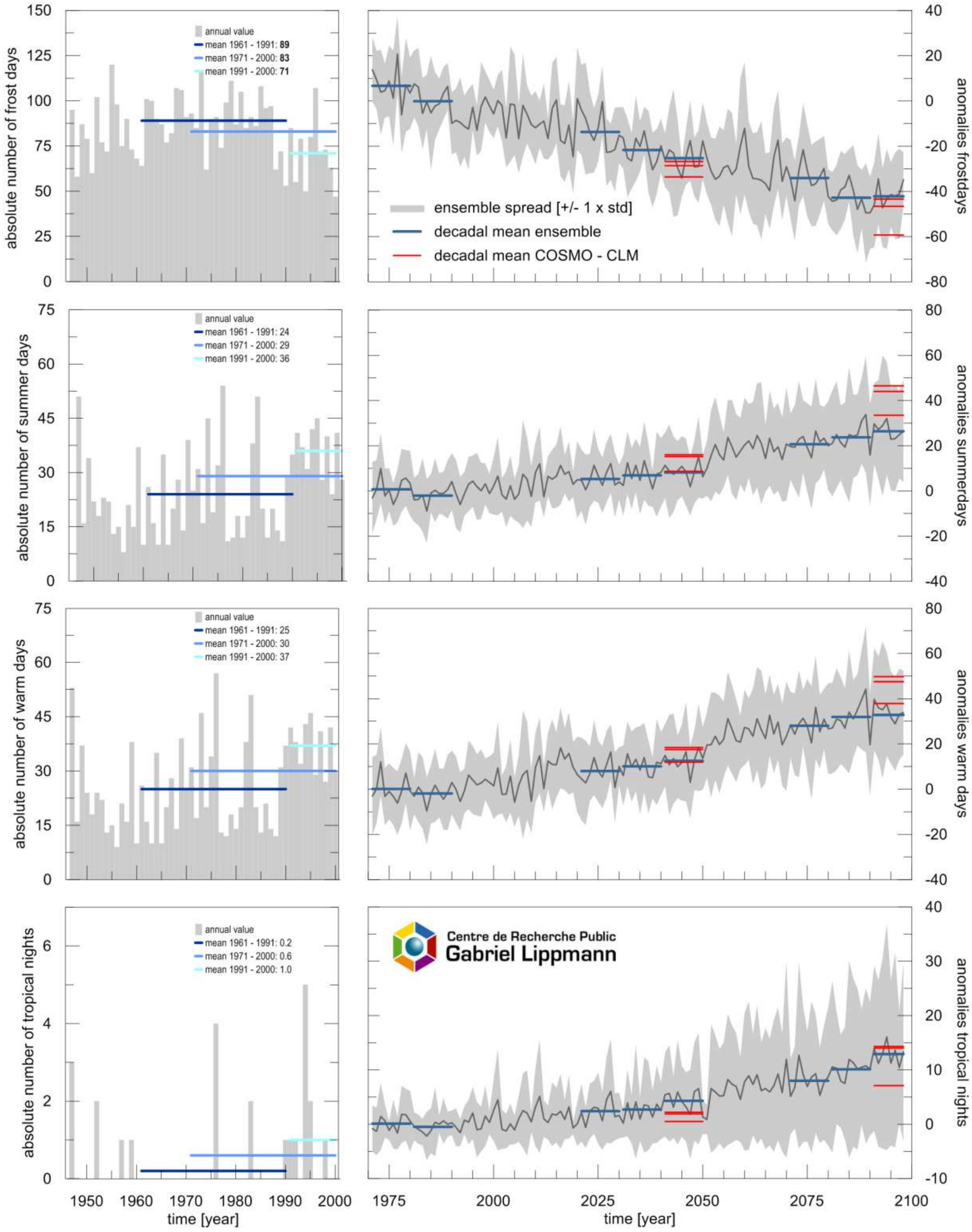
188 https://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch10s10-5-4-1.html.

FIGURE VI.1-2 – ABSOLUTE NUMBER OF EVENTS FROM DIFFERENT CLIMATE INDICES BASED ON OBSERVATIONAL DATA AND ON THE MULTI MODEL ENSEMBLE DATA SET



Source: Junk et al. (2014).

Notes: Absolute number of events from different climate indices based on observational data from the Findel-Airport station for the period from 1947 until 2000 (left side of the panel). Blue lines indicate mean values for different timespans. Anomalies of the same indices based on the multi model ENSEMBLE (MME) data set for the period from 1971 until 2098 with respect to 1991 until 2000 are shown on the right side of the panel. Lines: decadal mean values of the anomalies of the ensemble data set (blue) and for the three selected artificial sites of the COSMO – CLM data set (red).

VI.1.3. Agriculture and forestry

Besides impact on the human health, the trends observed with regard to summer days and tropical nights will lead to more frequent and more stringent stress conditions for **agricultural plants and forestry**, most severely impacting perennial forest trees. Observations on the phytosanitary state of Luxembourg forests – rather "old" forests – show a sharp degradation – which seems to have stabilised nowadays – resulting, among other factors, from climate change ***[→ Section II.10.1]***. The ageing of the forest also increases the risk of disease outbreaks and of infestation by insects and other parasites that could proliferate if milder winters and overall higher air temperatures are recorded in Luxembourg.

With regard to **crops**, a higher yield variability is noticed for the last years with "extreme" events repeating themselves more frequently (dry year, late springtime, longer raining periods, etc.). Consequently, harvests are more irregular. However, even if Luxembourg is small, the above findings are an average and disparities occur between the regions of the country.[189]

Projected climate changes will affect wheat crop production both in the main processes of plant growth and development but also in the occurrences and severities of plant diseases. El Jarroudi et al. (2016) assessed the potential infection periods of wheat leaf rust (WLR) at two climatologically different sites in Luxembourg. A threshold-based model, taking hourly values of air temperatures, relative humidity and precipitation during night-time into account, was used for calculating favourable WLR infection days during three periods throughout the cropping season. The highest proportions of favourable days of WLR infection were simulated during spring and summer at both sites. Regional climate projections showed an increase in temperatures by 1.6 K for 2041–2050 and by 3.7 K for 2091–2100 compared to the reference period 1991–2000. Positive trends in favourable WLR infection conditions occur at both sites more conducive than in the reference period due to projected climatic conditions.

For the Luxembourgish **grape and associated wine production**, late frost represents a significant hazard. Increasing air temperatures due to climate change might advance grape budburst and later frost events in spring. So far, it is unclear if both trends will have the same magnitude, or if one will be more pronounced than the other, thus resulting in an increase/decrease of the risk of late frost damages. In order to assess the future frost risk in the Luxembourgish winegrowing region, the combined impact of simulated future climate conditions on budburst and last frost dates were considered.

Due to increasing spring temperatures budburst and the date of last frosts will advance ***[→ Figure VI.1-3]*** [Molitor et al. (2013)]. This trend will be more pronounced for last frost events than for budburst. Projections based on an ensemble of regional climate models coupled to a phenological

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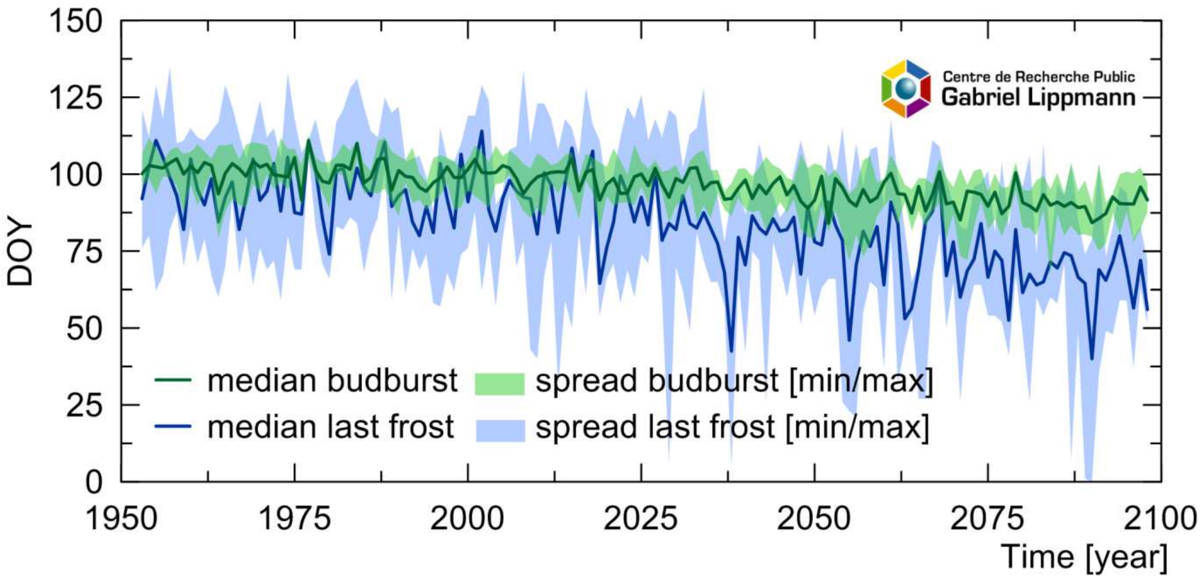
189 Expert judgement from the ASTA (Agriculture Technical Services Administration of the Ministry of Agriculture, Viticulture and Consumer Protection).

model for budburst of grapevine showed that the frequency of spring frost damages in the Luxembourgish winegrowing region would decrease, without completely excluding them for the near (2021 to 2050) or the far future (2069 to 2098).

FIGURE VI.1-3 – MEDIAN OF ANNUAL BUDBURST DATES OF THE VARIETY MÜLLER-THURGAU AND DATES OF THE LAST FROST EVENTS



Source: Molitor et al. (2013).
Notes: (1) based on selected ENSEMBLES data sets. A1B emission scenario.
(2) median of annual budburst dates of the variety Müller-Thurgau (green line) and dates of the last frost events (blue line). both in day of year (DOY) for Remich/Luxembourg for the period 1961 to 2098.

VI.1.4. Water

With regard to water, the most analysed phenomena so far are **floods**. It is known that, due to major redistributions of, essentially, winter rainfalls *[→ Section II.3.1]*, a higher inundation frequency has been documented. The river systems have indeed reacted to these shifts in winter precipitation by a statistically significant increase of maximum daily runoff during winter [Pfister et al. (2005a)]. Consequently, a hydro-climatic monitoring network (*réseau d'observation hydro-climatologique*) has been implemented in the mid-1990s.[190] Its main purpose consists in continuously (24/7) monitoring Luxembourg's river network. All recorded data are freely available and published yearly via the "*Atlas hydro-climatologique du Grand-Duché de Luxembourg*". The monitoring network also serves for the design of flood protection measures and river restoration projects.[191]

The Water Agency (*Administration de la Gestion de l'Eau* – AGE) runs a website on flood risk[192] where measured water levels and forecasts, as well as additional information during flood warning times (e.g. a flood report containing information on weather conditions, the current situation and the

190 http://www.hydroclimato.lu/.

191 For an example, look at http://www.luxnatur.lu/alzrena1.htm.

192 www.inondations.lu.

forecast of water levels of the alert stations), are permanently provided. Water levels are updated up to every 15 minutes. The predictions are calculated and published three times a day, depending on the situation an hourly update is possible. For approximately 15 stations, predictions of water level are presented with a forecast time of up to 24 hours.

According to a scenarios study on the discharge regime of the Rhine,[193] published by the "International Commission for the Protection of the Rhine" (ICPR)[194] in July 2011, by the middle of the century, up to 20% higher discharges are to be expected during winters in the Rhine catchment and up to 10% lower discharges are expected during summers, while regional variations may occur. The study presents discharge projections at representative gauging stations on the Rhine and the Moselle for the near future (up to 2050) as well for the remote future (up to 2100).

According to these projections, the development until 2050 is characterized by a continuous rise in temperature which, for the period 2021 to 2050 compared to the present (1961-1990) will amount to an average of +1 to +2°C for the entire Rhine catchment. As far as precipitation is concerned, no considerable changes are to be noted in summer. For the winter, moderate increases are projected which, for the entire Rhine, will vary between 0% and +15%. These developments are accompanied by mostly moderate changes of the discharge pattern. Compared to the present, the mean and lower discharges (MQ and NM7Q) in summer remain almost unchanged. Increased precipitation in winter that, due to rising temperatures increasingly occurs as rainfall, will lead to a rise of the mean discharges and low flow in winter by about 10% of the median of spreads. Partly, the evaluations result in slightly differing findings for the tributaries under consideration. Along the Moselle, a trend towards less precipitation in summer is recorded.

Under the assumption of continued increasing atmospheric greenhouse concentrations until the end of the 21st century, changes compared to the present (1961-1990) will be obvious. A rise in temperature of +2°C to +4°C (until 2100) is projected. The regionally differing tendencies – stronger rise in temperature in the south than in the north – will remain unchanged compared to the "near" future. In addition, the rise in temperature is stronger in summer than in winter. Unlike the changes in precipitation stated until 2050, precipitation in the Rhine catchment will considerably fall during the summer months, mostly by -10% and -30%. On this basis, falling mean runoff and low flow in summer is simulated in comparable orders of magnitude. The increase in precipitation during the winter months projected until 2100 for the entire Rhine mostly ranges between +5% to +20%. It lies above the values pointed out for the near future (0% to 15%). The increase of the mean runoff and of low flow in winter largely corresponds to that of area precipitation.

193 http://www.iksr.org/index.php?id=342&L=3.

194 http://www.iksr.org/index.php?id=58&L=3&cHash=455fdab52ce6eafbf6f72632159564bf.

With regard to its work on climate change, the ICPR has recently assessed the future development of Rhine water temperatures from Basel to the Rhine delta based on climate scenarios[195] [196]. The basis for the assessment are the existing water balance and hydraulic wave activity models for the Rhine, which can also simulate water temperatures with a corresponding temperature model. In 2015, the ICPR adopted a strategy for the international river basin district of the Rhine for adapting to climate change.[197] The report summarizes the information available for the Rhine catchment on possible impacts of climate change on the discharge of the Rhine and on water temperature. The additional impacts on water quality and the ecosystem are also described as well as the impact on today's water uses and possible fields of action and measures to adapt to the expected impact of climate change.

Under the overall control of the "International Commissions for the Protection of the Moselle and the Saar" (ICPMS)[198] and with the participation of Rhineland-Palatinate, the Saarland, Luxembourg and France, the Interreg VI-A Project Flow MS (Flood and Low Water Management in the Moselle-Saar basin)[199] was conducted in the Moselle and Saar catchment during a 5-year period from 2009 to 2013. Among others, the aim of the project was to investigate eventual impacts of climate change on flooding and low flows on a transboundary basis and to develop adjustment strategies.[200] The results of existing climate scenarios served as the basis for analysis using available hydrological balance models (such as LARSIM).

According to a study[201] carried out within the Flow MS project, the projected precipitations for the Moselle-Saar catchment area for the period 2021 to 2050 will change in the following way compared to the period 1971 to 2000: the average precipitations during the winter period will increase in-between +4 % and +20%, which results in an average increase of about +12.5% over the whole region. While the precipitations will rise during the winter period, the average precipitations during the summer period will decrease in-between -13% and +2% resulting in an average decrease over the whole region by -7.5%.

Based on the above projected calculations of the precipitations, different runoff values for the projected period 2021 to 2050 have been calculated. During the winter period, which is the period with the highest runoff values, the average value of the MoMHQ will rise in the projected period for all runoff-measuring points taken into account. The increase will vary between +5% and +24%. Compared to the winter period, the same runoff value will change in the summer period from

195 https://www.iksr.org/fileadmin/user_upload/Dokumente_en/Reports/213en.pdf.

196 https://www.iksr.org/fileadmin/user_upload/Dokumente_de/Taetigkeitsberichte/214_en.pdf.

197 https://www.iksr.org/fileadmin/user_upload/Dokumente_en/Reports/219_en.pdf.

198 http://www.iksms-cipms.org/servlet/is/392/.

199 http://www.iksms-cipms.org/servlet/is/60262/.

200 http://www.iksms-cipms.org/servlet/is/3183/.

201 http://www.iksms-cipms.org/servlet/is/3183/Brochure_Changement-Climatique.pdf?command=downloadContent&filename=Brochure_Changement-Climatique.pdf.

-13% to +8%. The projected values of the MoMQ show a similar evolution as the MoMHQ values. The values for the MoMNQ show a slight increase in-between +5% and +15%. In the summer period, which is the period with the lowest runoff values, the change will be towards slightly lower values in the future. The changes for this period will vary from -13% to +5% depending on the runoff measuring point.

The study shows that for the period from 2021 to 2050, the values for the HQ10 will remain either unchanged or will slightly increase for the Moselle region. The simulation shows a more mixed situation for the HQ100 values. For some of the runoff-measuring points that show increasing HQ10 values, the values for the HQ100 will decrease but overall the HQ100 values show a trend to higher values for the 2021 to 2050 period throughout the Moselle-Saar region.

As periods of low flows will presumably become more frequent due to climate change, this topic has been integrated into the work programmes (period 2016-2021) of the ICPR and the ICPMS. In both river basin Commissions, expert groups have been established in order to assembly the available knowledge on past events of low water as well as the existing national surveillance/monitoring, prevention and management activities concerning the issue of low water.

VI.2. VULNERABILITY ASSESSMENT: THE CASE OF WATER[202]

Vulnerability refers to the risk of adverse impacts from climate change, such as extreme weather events, droughts or floods, on both natural and human systems. In Luxembourg, **a thorough vulnerability assessment has not been done yet**. The following text focuses on water related aspects of vulnerability to climate change and a more holistic view on vulnerability is provided in ***Table VI.3-1*** below.

VI.2.1. Drought and drinking water supply

A lack of precipitations over an extended period may lead to a hydrological drought which results in a decrease of available water reserves in aquifers, lakes and groundwater sheets. A projected increase in the number of dry periods and the number of days within a dry period may result in an increased risk of drought for Luxembourg. In addition, droughts can endanger aquatic ecosystems.

If a drought period coincides with a period of increased demands for drinking water, it is possible that the needs of the population can no longer be satisfied and restrictions or prohibitions regarding drinking water use have to be declared (e.g. watering gardens, washing vehicles, and filling swimming pools). Adaptation measures to ensure security of drinking water supply are in that case necessary, especially with regard to the fact that the drinking water consumption in Luxembourg is likely to increase up to +141% in 2040 due to the demographic development.

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202 The text of this section has been prepared by the Water Agency (AGE).

VI.2.2. Infrastructure and economy

The high soil sealing due to the demographic pressure is causing a reduction of the water infiltration potential of the soil, which increases the discharges and the risk of floods. Besides, the increase in winter precipitations is likely to generate a swelling of the average flow in winter as well as to increase the risk of floods. An increased flood frequency and intensity may affect human safety and human health and cause environmental damages, damages to property and infrastructures and a still standing of economic activities.

On the other side, the decrease in summer precipitations increases the risk of pronounced low flows during the summer. The hydrological regime of watercourses in Luxembourg changes and tends towards a Mediterranean regime with more pronounced seasons. Even during dry periods, navigability of navigation routes must be ensured and the natural water purification system present in rivers and the survival of aquatic biotopes be guaranteed.

Hydropower production will be affected by the time shift of precipitations, especially during summer or due to the multiplication of heat waves during which energy consumption increases. Consumers have to be encouraged to not increase their demand for energy during periods of high heat, and the use of alternatives should be considered.

VI.2.3. Preservation of aquatic ecosystems

Increased rainfall may lead to a deterioration of the groundwater and surface water quality due to reinforced soil erosion and faster water infiltration into the soil. The risk of deteriorating surface water quality is intensified by increasing water temperatures, which are a consequence of the projected increasing air temperatures. A rise in stream water temperatures and the decrease in their flow rate risk to lead to quality problems as the available water can no longer sufficiently dilute pollutants and the low oxygen levels threaten the survival of fish.

In the framework of its work on climate change, the "International Commission for the Protection of the Rhine" (ICPR) has elaborated a report describing the present state of knowledge on possible consequences of changes of the discharge pattern and water temperature on the Rhine ecosystem and possible perspectives for action[203]. The report describes the general correlations and particularly the impact to be expected on the four biological quality elements: *phytoplankton*, *macrophytes/phytobenthos*, *marcrozoobenthos* and fish fauna that are used, as described by the Water Framework Directive,[204] for the classification of ecological status.

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[203] https://www.iksr.org/fileadmin/user_upload/Dokumente_en/Reports/204_e.pdf.

[204] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy (http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32000L0060&qid=1517219395714&from=EN).

Even though groundwater resources are less affected by drought periods in summer as the groundwater recharge is essentially taking place between end of autumn and beginning of spring (October to March), a shift in the precipitations during the winter months can affect the recharge regime of groundwater systems. If the groundwater recharge is reduced this may also affect the quality of groundwater.

VI.2.4. Human health

Health risks associated with drinking water insecurity and shortages, which may result from the increased number of dry periods and of days within a dry period, just as the degradation of its quality are undeniable. Changes in the water cycle could therefore increase public health risks related to water quality and water scarcity.

It should also be noted that a few waters are used in Luxembourg as freshwater bathing waters.[205] As reduced flow rates and increased water temperatures can promote the growth of algae in lakes and rivers, the bathing water quality will also be impacted and deteriorated if these are used for bathing purposes.

The increased flood probability and their expected increased intensity are likely to affect human health. The preparation of flood hazard maps and flood risk maps,[206] flood evacuation plans and early warning systems,[207] as well as maintaining a "risk aware culture" are essential to build and raise public awareness.[208]

VI.3. STRATEGIES ON ADAPTATION TO CLIMATE CHANGE

VI.3.1. Overview: past and new strategies

In April 2013, the European Commission adopted an **EU strategy on adaptation to climate change** [European Commission (2013)]. This strategy focuses on three goals: (i) the promotion of adaptation activities by Member States, (ii) the integration of climate change aspects in key sectors at EU level and, (iii) a decision-making support for the implementation of measures.[209]

The Paris Agreement of December 2015 also addresses adaptation to climate change in order to enhance adaptive capacities, strengthen resilience and diminish vulnerabilities. According to Article 7(10) of the Agreement [Decision 1/CP.21, document FCCC /CP/2015/10/Add.1], Parties are

205 https://eau.public.lu/cours_eau/eau_baignade/index.html.

206 http://www.eau.public.lu/publications/brochures/hochwasser/hochwasser.pdf.

207 http://www.inondations.lu/.

208 http://www.eau.public.lu/publications/brochures/hochwasserfibel/brochure_hochwasserfibel.pdf.

209 For more information, see https://ec.europa.eu/clima/policies/adaptation_en.

obligated to start an adaptation process and, as appropriate, submit and update periodically an adaptation communication.

In Luxembourg, initial reflections on adaptation to climate change go back to **June 2011**, when Luxembourg's Council of Ministers adopted a "**National Adaptation Strategy to Climate Change**".[210] This strategy prioritized (i) biodiversity, (ii) water, (iii) agriculture and (iv) forestry and provided a framework for adaptation to the impacts of climate change in Luxembourg. In **2012**, a report linked adaptation and spatial planning – "Adaptation to Climate Change – Strategies for Spatial Planning".[211]

At this time, **a revised and more comprehensive adaptation strategy to climate change**, building on the above-mentioned documents, **is being developed**. It combines and updates the available information with the aim to allow Luxembourg to cope with climate change challenges and to take appropriate precautionary measures. The adaptation strategy itself will outline changes in temperature, precipitation and extreme events, as well as the expected outcomes with respect to the bio-, pedo- and hydrospheres.

The strategy looks at 13 sectors or cross-cutting topics, namely:

1. construction & housing;
2. energy;
3. forestry;
4. infrastructure;
5. disaster management;
6. land planning;
7. agriculture, incl. plants & cattle condition;
8. human health;
9. ecosystems & biodiversity;
10. tourism;
11. urban space;
12. water use & water resources management;
13. economic activities.

86 expected climate impacts are identified based on their potential threats for the next decades. Out of them, 40 prioritized climate impacts are identified based on a specific methodology combining those impacts having the highest relevance for Luxembourg and the domains with the highest expected climate change related variation by 2050. A catalogue of measures that builds on existing

210 For more information, see http://climate-adapt.eea.europa.eu/countries-regions/countries/luxembourg.

211 http://amenagement-territoire.public.lu/content/dam/amenagement_territoire/fr/publications/documents/C-Change/CChange_conclusions.pdf.

measures, as well as on 40 new measures for the prioritized climate impacts, is being elaborated. These measures are allocated to the 13 different sectors or cross-cutting topics. As an example, for the energy sector, six expected climate impacts are identified:

1. higher/lower potentials for the use of solar energy;
2. changes in electricity consumptions;
3. increase in biomass development;
4. changes in water availabilities;
5. increase of stormy days;
6. increased impacts of extreme events.

Based on the previously mentioned methodology, the expected climate impacts 2, 3 & 6 are prioritized. For these impacts, the newly derived measures are:

2. taking awareness-raising measures in the field of energy savings and expansion of decentralized solar energy infrastructures;
3. expansion of biomass plants capacities taking into account sustainable characteristics;
6. scrutiny and adaptation of existing energy infrastructures with regard to vulnerability towards extreme events.

This new adaptation strategy is expected **to be finalized in 2018**.

VI.3.2. Vulnerability and adaptation – overview

Though the latest adaptation strategy is being finalized, Luxembourg has already generated an extensive amount of information on the expected national impacts of climate change, as well as on the country's vulnerability to climate change, as the two previous sections illustrate *[→ Sections VI.1 & VI.2]*. Detailed information on national projections of future climatic conditions, such as temperature, precipitation, extreme climate events and the evolution of event days have been assembled. Luxembourg has also carried out analyses of national climate change impacts, including the expected impacts on vegetation, agriculture, viticulture, forests, biodiversity and the water cycle (e.g. via the 2011 "**National Adaptation Strategy on Climate Change).**

Whilst *Section VI.3.3* will focus more precisely on water related adaptation measures, ***Table VI.3-1*** summarizes the information on **vulnerability** and **adaptation** to climate change by sector as it has been used to define the 2011 national strategy. It is derived from UNFCCC (2012), p. 23-24, as not many changes happened since the review of the 5th National Communication.

TABLE VI.3-1 – VULNERABILITY AND ADAPTATION – A SECTOR-BASED APPROACH

Vulnerable area	Sector-based information on vulnerability and adaptation to climate change
Biodiversity (and natural ecosystems)	*Vulnerability*: changing climatic conditions are expected to lead to species range shifts, in particular a south to north migration of species. Projected temperature changes could also have an impact on the biogeography of flora ***[→ Section VI.1.1]***. *Adaptation*: the "National Adaptation Strategy on Climate Change" includes the following measures: o vulnerability analysis; o the establishment of protected areas and green corridors; o agro-forestry; o regional implementation and the planning of measures, conservation and restoration of wetlands and permanent grassland; o green infrastructure and architecture; o the monitoring of biodiversity; combating invasive alien species; o a study on the economics of ecosystem services and biodiversity; o additionally, the "River Basin Management Plan" (2009–2015) includes measures to re-establish river morphology and a natural river dynamic that should help to preserve and re-establish biological continuity ***[→ Section VI.3.3.3]***.
Water	*Vulnerability*: projections indicate future changes in the water cycle, such as an increase in rainfall with increasing discharges in winter and a decrease in rainfall with reduced runoff in summer by 2050 ***[→ Section VI.1.4]***. *Adaptation*: the "National Adaptation Strategy on Climate Change" includes measures in the water resources sector, such as ***[→ Section VI.3.3]***: o a monitoring network; o riverbank restoration, water retention, water loss reduction, production water recycling, rainwater use and anti-erosion measures, among others.
Agriculture (and food security)	*Vulnerability*: projected changes in air temperatures are likely to induce a modification of the vegetation period in Luxembourg and could cause an increased risk of frost damage to vegetation. The projected increase in temperature is also expected to have an impact on the life cycle of insects. Projections also show that the number of dry periods, as well as the days within a dry period, could increase, causing drier conditions. These factors, as well as the fact that Luxembourg has very little agricultural surface area using irrigation, could lead to significant impacts on the agriculture sector ***[→ Section VI.1.3]***. Nevertheless, Luxembourg does not identify climate change as an imminent threat to national food security, as it is already a net importer of food. *Adaptation*: the "National Adaptation Strategy on Climate Change" includes the agriculture sector and identifies four specific objectives and measures in this area: o to protect against soil degradation and the maintenance of its production potential; o to protect animals against heat and potential new diseases; o to adapt plant production to climate change; and o to manage risks through multirisk insurance and the existing rural development policy.
Forestry	*Vulnerability*: projected overall yearly temperature increases could lead to a decline in Luxembourg's forest health, owing to the increased risk of the outbreak of diseases and insect or parasite infestation ***[→ Section VI.1.3]***. *Adaptation*: the "National Adaptation Strategy on Climate Change" specifically targets forests and proposes adaptation measures for forests that include certification, conservation and the use of wood as a renewable energy resource, among others. Luxembourg also monitors the health of forests and is planning to institutionalize this monitoring with legislation. These measures will be integrated into the country's 10-year forest management plans.
Drought	*Vulnerability*: a projected increase in the number of dry periods and the number of days within a dry period demonstrates an increased risk of drought for Luxembourg ***[→ Section VI.2.1]***. *Adaptation*: the Water Agency has identified potential adaptation measures, including the prohibition of certain water uses to guarantee the water supply ***[→ Section VI.3.3.1]***.
Human health	*Vulnerability*: a projected increase in temperature in all seasons and an increase in the number of dry periods and the number of days within a dry period could increase the risk of heat waves and have an effect on air quality ***[→ Section VI.1.2]***. Changes in the water cycle could increase public health risks related to water quality and water scarcity ***[→ Section VI.2.4]***. *Adaptation*: at this time, the "National Adaptation Strategy on Climate Change" does not address the area of human health, although it is planned to include additional sectors, such as health, to the strategy within the next two years. Plans are under way for additional water intake points in emergency cases (by 2024) and the resizing of the drinking water infrastructure ***[→ Section VI.3.3.1]***.
Infrastructure and economy	*Vulnerability*: projections for an increase in rainfall with increasing discharges in winter show that there could an increase in the frequency of inundations ***[→ Section VI.2.4]***. Luxembourg is currently participating in a regional study to assess the eventual consequences of climate change for floods and low water flow in the Moselle and Saar catchments and to develop adjustment strategies ***[→ Section VI.1.4]***. *Adaptation*: Luxembourg has carried out a preliminary flood risk assessment and has prepared flood hazard maps and flood risk maps, and is planning to establish flood risk management plans by 2015 ***[→ Section VI.2.4]***. Luxembourg also has a flood warning service (http://www.hydroclimato.lu/) operated by the Water Agency, the Agriculture Technical Services Administration of the Ministry of Agriculture, Viticulture and Consumer Protection and the *Centre de Recherche Public-Gabriel Lippmann* ***[→ Section VI.1.4]***.

VI.3.3. Vulnerability and adaptation – the water sector[212]

VI.3.3.1. Drought and drinking water supply

In order to guarantee a water quality suitable for human consumption and secure the drinking water supply, water preservation measures (water quantity and quality) had to be adopted. In 2008 the "*Plan de Sensibilisation et de Restriction*" aiming at ensuring drinking water supply during periods of scorching heat has been put in place (warning plan regarding the use of water intended for human consumption). This plan is divided into three phases namely the yellow phase ("*phase jaune*") meant to raise consumer awareness, the orange phase ("*phase orange*") meant to put in place first restrictive measures in order to avoid the red phase, and the red phase ("*phase rouge*") meant to put in place restrictive measures in order to avoid the breaking off of water supply.

In case of drinking water shortage during warm and dry summer seasons, the municipal authorities are informed by the responsible Minister that the orange phase or the red phase of the warning plan has been launched at national level. This information is also made available for the public on the official national platform for governmental "geodata" and services – the "*Geoportail*".[213] Then the municipal authorities, through an emergency municipal regulation, decide on the measures to be taken immediately in order to temporarily reduce the drinking water consumption to guarantee that enough water resources for the drinking water supply of the population remain available. Such measures may include temporary tap water use restrictions such as the filling of private swimming pools, cleaning of cars, watering of gardens or spraying of sidewalks. For example, due to the prolonged drought and the warm and sunny weather in the beginning of 2017, all citizens have been encouraged to reserve the use of drinking water, as far as possible, to essential uses such as food preparation and hygiene and to keep activities that consume water in large quantities to a minimum.[214]

Soil erosion and rapid water infiltration may cause a change in the pollution load (nutrients, organic matter, micro pollutants, and drug residues) towards surface water and groundwater used for drinking water supply. These phenomena therefore require the adaptation of preventive measures (e.g. prohibitions, regulations, permits within drinking water safeguard zones[215]) and curative measures (e.g. drinking water treatment plants).

Flow rate fluctuations as well as fluctuations in peak water demands may lead to variations of the time the water remains in the drinking water distribution system. Consequences of this are deteriorations in securing the drinking water supply and in the quality of the distributed water.

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212 The text of this section has been prepared by the Water Agency (AGE).

213 http://map.geoportail.lu/theme/eau?version=3&zoom=10&X=679734&Y=6421054&lang=en&layers=797-617-481&opacities=1-1 1&bgLayer=topogr_global&crosshair.

214 https://eau.public.lu/actualites/2017/05---Mai/Phase-vigilance/index.html.

215 http://www.eau.public.lu/publications/brochures/ba_ZP_eau_potable/ZP_eau_potable_fr.pdf.

Therefore, the resizing of drinking water infrastructures (e.g. increase storage capacities) has to be considered as an adaptation measure to climate change.

VI.3.3.2. Infrastructure and economy

In order to maintain or improve water infiltration into soil, measures limiting soil sealing and soil compaction should be promoted.[216] It is also important to reactivate the natural flood retention capacity of rivers and restore them where possible.[217]

According to article 4 of the EU Floods Directive,[218] Member States had to proceed with a preliminary flood risk assessment by the end of 2011 and according to Article 5, Member States were required to identify, on the basis of the preliminary flood risk assessment, those areas for which a potential significant flood risk exist or might be considered likely to occur. As the flood risk[219] had already been assessed within the Interreg IIIB project TIMIS Flood (Transnational Internet Map Information System on Flooding),[220][221] Luxembourg made use, by the end of 2010, of Article 13, para. 1a and Article 13, para. 2 of the floods Directive and has thus not proceeded with any preliminary assessment.[222][223]

For the areas for which a potential significant flood risk exist, Member States had to prepare by the end of 2013 flood hazard maps and flood risk maps.[224] On the basis of these maps, by the end of 2015 Member States had to establish flood risk management plans which address all aspects of flood risk management focusing on prevention, protection, preparedness, including flood forecasts and early warning systems and taking into account the characteristics of the particular river basin or sub-basin. Flood risk management plans may also include the promotion of sustainable land use practices, improvement of water retention as well as the controlled flooding of certain areas in the case of a flood event. The first flood risk management plan for Luxembourg has been published on December 22, 2015.[225]

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216 http://www.eau.public.lu/publications/brochures/Regenwasserleitfaden2/Leitfaden_2013_pdf.pdf.

217 http://www.eau.public.lu/publications/brochures/Renaturation/Brochure_Bunusevac.pdf.

218 Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks.
(http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32007L0060&rid=1)

219 http://eau.geoportail.lu/?lang=fr.

220 http://www.europaforum.public.lu/fr/temoignages-reportages/2008/11/reportage-timis-flood/index.html.

221 http://www.eau.public.lu/publications/brochures/hochwasser/hochwasser.pdf.

222 http://www.iksr.org/fileadmin/user_upload/Dokumente_en/Reports/FD-1st_report_01.pdf.

223 http://www.iksms-cipms.org/servlet/is/392/Rapport%20application%20articles%204%20et%205%20DI.pdf?command=downloadContent&filename=Rapport%20application%20articles%204%20et%205%20DI.pdf.

224 http://eau.geoportail.lu/?lang=fr.

225 https://eau.public.lu/directive_cadre_eau/directive_inondation/1er-cycle/HWRML-PL_final/index.html.

Navigation could be affected by prolonged and recurrent periods of low water but also by floods, which are likely to occur more frequently. In order to keep its capacity and competitiveness, navigation must be guaranteed throughout the year on the main waterways. The adaptation strategy includes several points, such as advanced boat technologies, logistics and infrastructural facilities.

VI.3.3.3. Preservation of aquatic ecosystems

In order to maintain the biodiversity of aquatic environments, it is advisable to restore the natural morphological conditions of the river systems and a natural river dynamic. Variations in the depth of the water, the flow rate as well as the water temperature support the development of a rich aquatic flora and fauna.

The report elaborated by the "International Commission for the Protection of the Rhine" (ICPR) on the present state of knowledge on possible consequences of changes of the discharge pattern and water temperature on the Rhine ecosystem and possible perspectives for action[226] shows that, as a matter of principle, strengthening the functionality of ecosystems by protecting, interconnecting and extending habitats, and thus enhancing biodiversity, should be approved and improved when considering the impacts of climate change.

The estimated changes in the seasonal distribution of precipitations and discharges of river flows as mentioned in *Section II.3.* and *Section VI.1.4.* have consequences on the effects of wastewater treatment plants on water quality. While river flows in the summer months might be lowered, the discharge of wastewater treatment plants will remain the same or even rise for example due to an increased water consumption and subsequent discharge to sewage system for e.g. cooling purposes, swimming pools, etc. The ratio of treated wastewater discharge to residual river flow increases and sufficient dilution of nutrients and other chemical substances cannot be guaranteed, especially taking into account local small scale changes in precipitations and rivers flows. It is thus a possibility that water bodies that were in a good ecological status according to the Water Framework Directive will not be able to meet the ever more stringent environmental quality standards and that water bodies that are not in a good ecological status may not achieve the supposed status.

In order to achieve good ecological status, significant, expensive and lengthy modernisations to wastewater treatment plants may be necessary (this is without taking into account measures on diffuse sources). These renovations might thus have to be implemented at a much faster rate than initially planned (generally 30 years). However, the water preservation measures mentioned in *Section VI.3.3.1* might indirectly remediate these consequences by limiting water consumption in times of dry periods; periods that are usually accompanied by low river flows. Increased heavy rainfall will also affect the discharge frequencies of the sewerage system, which are mostly combined sewerage system in Luxembourg. The construction of more separate sewer systems, rainwater

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226 https://www.iksr.org/fileadmin/user_upload/Dokumente_en/Reports/204_e.pdf.

management measures, as well as the construction of more retention volume in the sewer systems, could potentially attenuate these effects.

The development of sustainable land and soil uses, such as the conversion from arable land to permanent grassland which leads to an increased storage of CO_2 would contribute, on the one hand, to climate change mitigation measures, and on the other hand, to the protection of water resources (soil protection against erosion, reduced inputs of fertilizers and pesticides).

VI.3.3.4. Human health

In order to guarantee a fast containment of pollution in drinking water and to inform citizens, a crisis management group composed of all concerned actors in case of drinking water pollution has been set up.

VI.3.3.5. Monitoring

Considerable uncertainties remain with regard to climate monitoring and climate simulations. As gaps in the monitoring networks and measurement errors affect observation data as well as the models based on them, it is important to further extend existing monitoring networks (e.g. enhanced monitoring of low flows) in order to better track changes taking place and to improve their interpretation.

VI.3.3.6. Adapting consumer behaviour

It is only through raising public awareness and setting good examples that consumer behaviour can change. It is therefore advisable to promote research and development in the field of saving water, in terms of both infrastructures and devices as well as constructions. However, it is important to note that inappropriate tap water savings may, in some cases, induce negative effects such as the degradation of the quality of the water used for human consumption. In this context campaigns promoting the consumption of tap water as well as awareness raising campaigns to inform the public about the risks associated with the use of pesticides, particularly in urban areas[227] (e.g. use of pesticides in gardens, public areas) are to be planned.

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227 http://www.ounipestiziden.lu/.

Chapter VII

Financial Resources and Transfer of Technology

After introductory notes on Luxembourg's International Climate Finance *[→ Section VII.1]* and Luxembourg's development cooperation, partly in line with paragraph 50 of the UNFCCC reporting guidelines *[→ Section VII.2]*, some information will be given on the provision of "new and additional" resources: GEF and LDC's Trust Fund accordingly to paragraph 51 of the UNFCCC reporting guidelines *[→ Section VII.3]*. With regard to paragraph 52 of these guidelines, Luxembourg reports on its cooperation policy paper on environment and climate change *[→ Section VII.4]*. Provision of financial resources – paragraph 53 – is somehow provided, including for Article 11 of the Kyoto Protocol – paragraph 43 of the Kyoto Protocol reporting guidelines *[→ Section VII.5]*. Activities related to transfer of technology – paragraphs 54 to 56 of the UNFCCC reporting guidelines – are briefly discussed too *[→ Section VII.6]*. Finally, as recommended by paragraph 39 of the Kyoto Protocol reporting guidelines, a table is indicating where information on the implementation of Article 10 is presented throughout the Communication *[→ Section VII.7]*.

This Chapter has been written by the Department for the Environment and the Directorate for Development Cooperation and Humanitarian Affairs of the Ministry of Foreign and European Affairs[228] and edited by the Department of the Environment to be in line with the UNFCCC reporting guidelines.

VII.1. LUXEMBOURG'S INTERNATIONAL CLIMATE FINANCE

During the United Nations Sustainable Development Summit, that took place in New York in **September 2015**, Luxembourg's Prime Minister announced that Luxembourg would provide a total amount of **120 Mio. EUR for International Climate Finance** (ICF)[229] from 2014 to 2020.

These **funds are new and additional** to Luxembourg's Official Development Assistance (ODA). The disbursements related to ICF are being carried out via the "Climate & Energy Fund" *[→ Section V.6.3]*. In **2016**, a large part of the work of the inter-ministerial committee of the fund was to discuss and develop a **strategy for the allocation of Luxembourg's ICF pledge**. The strategy called "*Attribution of international climate finance funds in the fight against climate change*" was finalized and published throughout the first half of **2017**.[230]

VII.1.1. Strategy for the allocation of Luxembourg's ICF pledge

The main characteristics of the strategy are presented below.

Themes and preferential sectors

Luxembourg's ICF pledge concentrates on three main areas: (i) GHG emissions mitigation, (ii) adaptation to a changing climate, and (iii) actions for reducing emissions resulting from

[228] http://www.gouvernement.lu/cooperation.

[229] Table VII.3-2 - Luxembourg's financial contribution to the ICF for the years 2014-2020.

[230] http://environnement.public.lu/content/dam/environnement/fr/actualites/2017/05/22_financement_climatique/fci_strategie.pdf.

deforestation and forest degradation, for the conservation of carbon stocks, and for a sustainable forest management and a consolidation of forest carbon stocks (REDD+).

Preferential sectors benefiting from the Luxembourg's ICF are:

- mitigation (renewable energy, energy efficiency, transport, waste management, agriculture);
- adaptation (especially in the least developed countries (LDCs) and Small Island developing States (SIDS): resilience to climate change, reducing vulnerability to climate variability, early warning, adaptation in the agricultural sector);
- REDD+ (fight against deforestation and forest degradation, activities that are integrated into national REDD + activities).

Activities in the eligible areas for the Luxembourg ICF are described in detail in the strategy document. A "*negative list*" summarizes projects that cannot benefit from Luxembourg funding.

Balanced allocation

A balanced distribution is the main criteria for distributing ICF funds and it is adapted to the needs of the target countries. The Paris Agreement reiterated the objective to increase substantially funding for adaptation. The Luxembourg strategy foresees the following distribution key: (i) 40% for adaptation measures, (ii) 40% for mitigation measures, and (iii) 20% for the REDD+ – knowing that this distribution is only an indication, and that account will be taken of the needs of the host and partner countries.

Geographical distribution

The ICF program seeks a balanced distribution of the host countries, with, to the extent possible, a minimum amount of 50% of the ICF for projects in cooperation (current and former) partner countries, the LDCs and SIDS.

Eligibility criteria

The strategy proposes criteria for the eligibility of activities as well as of beneficiaries and managers of ICF Funds (experience, implementation at the field level, registration and/or license by the regulator or financial sector surveillance authority of the country, administrative and financial capacity). Regarding NGOs and associations in particular, their selection will be based on simple and easily verifiable criteria (proof of prior activities, experience in the field, financial health, bilateral consultation between the Department of the Environment and the Directorate for Development Cooperation and Humanitarian Affairs of the Ministry of Foreign and European Affairs to avoid double funding).

Five main selection criteria are being proposed:

- impact and efficiency;
- compliance with sustainable development;

- transforming potential;
- creation of an enabling environment for investments;
- national priority, political will, needs of the beneficiaries.

Forms of support offered by the ICF

The ICF will be provided, on the one hand, through donations, and on the other, by own funds, special capital (at risk, initial, patient) and guarantees (e.g. first loss). The Department of the Environment will make an analysis of the support required by funding applicants and, if it is considered useful, can steer applications, depending on the type of funding requested, to different evaluation platforms or specialized entities that can support the Department of the Environment in its analyses and monitoring.

Eligibility criteria for funding applicants

The application process is open to all types of candidates, subject to such eligibility as defined in the strategy paper. In this context, the Department of the Environment also had contacts with representatives of NGOs and the "*Cercle de Coopération des ONG de développement*"[231], for the conception of procedures applying to their funding demands.

VII.1.2. Public – private interface

International climate finance is one of the priorities of the Government policy. Ambitious targets have been set at COP21 in Paris. It turns out that **public investment will not be sufficient** and that it is necessary that the latter constitutes a lever for the mobilization of other sources of financing, including financing from the **private sector**.

To this end, the "***Climate Finance Task Force***" (CFTF) has been convened early 2015, in an informal, interdisciplinary and multistakeholder format, bringing together representatives of the public sector and the private finance sector with the double aim to make a meaningful contribution to the international fight against climate change and advising the Government on ways to establish Luxembourg as an international centre for climate finance. The initial work of the CFTF was aiming at sensitizing the private sector partners to both the challenge of climate finance and the economic opportunities that come with serious investment mainly in economically viable infrastructure for the production of renewable energy around the world.

The following initiatives of the CFTF, which will be supported financially by the "**Climate & Energy Fund**", can already be mentioned:

- the "***LuxFlag Climate Finance Label***"[232] was officially launched on **September 23, 2016**. The goal is to grant an official label to funds investing in climate action while respecting well-

[231] http://cercle.lu/.

[232] https://www.luxflag.org/labels/climate-finance/.

defined criteria. The Government has been actively involved in the development of these criteria. In **2017**, the "***Luxflag Green Bond Label***"[233] was launched. The primary objective of the Green Bond Label is to reassure investors that the Green Bond follows internationally recognised standards and uses its proceeds to finance green projects. This label is additional to the ones already launched by "*LuxFlag*" since 2006; the microfinance label, the environment label and the ESG label issued to funds that meet criteria complying with environmental and social objectives and governance;

- the Luxembourg Stock Exchange launched on **September 27, 2016** the first platform in the world entirely dedicated to green financial instruments ("***Luxembourg Green Exchange***"). It can be considered as a precursory project to promote the role of Luxembourg in green finance;
- in **September 2017**, a Contribution Agreement between the Government and the European Investment Bank (EIB) has been signed, with the aim to implement a platform dedicated to climate finance, the "***LU-EIB Climate Finance Platform***". The objective of this joint initiative is, on the one hand, to finance innovative investment projects with high impact in the fight against climate change, in and outside of the European Union, and on the other, to increase the leverage effect on investments from the private sector by reducing the financial risk of private partners investing in innovative climate action. A participation of 30 Mio. EUR over 3 years, that is divided between the "Climate & Energy Fund" and funds from the Ministry of Finance, has been secured;
- on **October 20, 2017**, the Government, together with the banks *BCEE* and *BIL* and the insurance company *Foyer*, and in collaboration with "*Luxembourg Microfinance and Development Fund SICAV*", have launched the "***Forestry and Climate Change Fund***" (FCCF). This public-private partnership will provide financing for companies, communities and small farmers to manage secondary and degraded forests in the tropics. By creating the enabling environment for business models that allow the generation of revenues, deforestation can be stopped so to yield a substantial positive climate impact;
- the idea for an accelerator for climate finance was a demand from the private sector and was developed in a working group within the CFTF. The working group was led by "*Innpact*", a Fund manager working in impact finance and the "*Luxembourg Microfinance and Development Fund SICAV*". The main objective of the "***International Climate Finance Accelerator Luxembourg***" (ICFA Luxembourg) is to allow for small and innovative climate-related funds and asset managers to set up successfully in Luxembourg and attract private investment. It is directly complementary to the "*LU-EIB Climate Finance platform*" and the "*LuxFlag Climate Finance Label*". The Accelerator will take the form of a public-private partnership and be composed of interested stakeholders (Government, law firms, Big4) who will make up the governance structure and finance the project (which is also estimated to be profitable).

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233 https://www.luxflag.org/labels/green-bond/.

Besides its contributions to the CFTF, the "Climate & Energy Fund" participates in a wide range of ICF projects *[→ Table VII.5-3]*, including:

- **multilateral programs** such as the Green Climate Fund (GCF), the United Nations Convention to Combat Desertification (UNCCD), the United Nations Environment Program (UNEP), the Global Green Growth Institute (GGGI), the Sahara and Sahel Observatory (OSS);
- **initiatives** such as "CREWS" (Climate Risk and Early Warning Systems), "BNCFF" (Blue Natural Capital Financing Facility and Fund - IUCN), "Gold Standard Gender Equality guidelines and Requirements" (Gold Standard), "Energy Sector Management Assistance Program" (ESMAP – World Bank);
- **bilateral climate related projects** with hosts counties (e. g. Vietnam, Senegal, Cabo Verde and Fiji);
- several **NGO projects**.

VII.2. LUXEMBOURG'S DEVELOPMENT COOPERATION

The primary objective of the "Luxembourg's Development Cooperation" is the **eradication of poverty**, notably in least developed countries. Its activities are conceived in the light of the 2030 Agenda and the Sustainable Development Goals (SDGs) for 2020-2030. The actions carried out by Luxembourg's development cooperation aim to be inclusive and to leave no one behind.

In the section discussing Luxembourg's development cooperation, the 2014-2018 Government Programme states that "*the Government will continue its quantitative effort in percentage of gross national income – 1% of GNI – especially in difficult times where tensions and crises, and the misery they generate, touch a growing number of individuals, including those living to the gateways to Europe*". It stresses too that "*additional actions put in place by the Government jointly with partner countries to prevent climate change will not affect the budgetary means reserved for the eradication of poverty or humanitarian aid*" and that "*Luxembourg will assert its leading role at international level to continue providing untied aid*" [Government of the Grand Duchy of Luxembourg (2013), p. 197]. In 2016, Luxembourg's Official Development Assistance (ODA) amounted to 353 143 813 EUR and represented 1.02% of the GNI [Ministry of Foreign and European Affairs, Directorate for Development Cooperation and Humanitarian Affairs (2016), p. 16]. Luxembourg thus confirms **its position among the top five donors** who meet the commitment made in 1970 at the UN General Assembly to allocate at least 0.7% of their GNI to development cooperation. As in the past, this ODA consists of grants only (no loans) and is implemented through bilateral and multilateral cooperation instruments, technical cooperation and cooperation with development NGOs.

From a geographic point of view, and in order to maximise its effectiveness and impact, Luxembourg's development cooperation follows a policy of targeted intervention in a limited number of **partner countries,** which are chosen primarily by taking into account the composite human development index (HDI) of the UNDP. Nowadays, the partner countries are among the

Least Developed Countries (LDCs) and Small Island Developing States (SIDS). Five of the partner countries are in West Africa; these are Burkina Faso, Cabo Verde, Mali, Niger and Senegal. The other countries are Lao People's Democratic Republic and Nicaragua. Luxembourg also supports projects in seven countries, which are El Salvador, Vietnam, Kosovo, Afghanistan, Mongolia, Myanmar and the Occupied Palestinian Territories. El Salvador and Vietnam's Indicative Cooperation Programmes ended in 2015 as they both had attained the status of middle-income countries. Development cooperation activities with these countries are distinguished by a heightened sense of partnership with both public authorities and civil society. This spirit of partnership, which is achieved through actual ownership of the programmes and projects by the beneficiaries themselves, is the cornerstone of the multi-annual cooperation programmes, the "**Indicative Cooperation Programmes**" (ICPs).

Luxembourg's general strategy for development cooperation sees **climate change as one of the global and interdependent challenges** and identifies sustainable development as a common global cause. Luxembourg's approach concerning the protection of the environment in development cooperation is essentially focused on the SDGs, which replaced the Millennium Development Goals (MDGs) in September 2015. The inclusion of the principles of sustainable development into country policies and programmes and reversing the loss of environmental resources and reducing biodiversity loss are cross-cutting issues in ICPs. In this regard, particular attention is attached to the necessity to protect natural resources from the negative effects of climate change. Moreover, each project document includes a "climate change checklist".

In order to improve reporting of ODA statistics to the OECD's Development Assistance Committee (DAC), Luxembourg has **mainstreamed the DAC policy marker system in all projects and programmes**. This system includes an "Aid to Environment" marker, as well as the four so-called "Rio markers", covering biodiversity, combat against desertification, mitigation and adaptation.

VII.3. PROVISION OF "NEW AND ADDITIONAL" RESOURCES

Luxembourg upholds the **principle of "additionality" between ODA and climate finance**. Indeed, the poverty eradication challenge is made more complex due to climate change impacts, especially in developing countries, and therefore calls for additional financial means on top of existing ODA commitments. Consequently, "new and additional" means that the resources that Luxembourg commits to deliver are not taken over from earlier commitments and are thus "new". "Additional" means that they come "on top of" Luxembourg's ODA commitments and thus are not "double counted" or draining on other resources dedicated to poverty eradication: as stated in the 2014-2018 Governmental Programme "*additional actions put in place by the Government jointly with partner countries to prevent climate change will not affect the budgetary means reserved for the eradication of poverty or humanitarian aid*" [Government of the Grand Duchy of Luxembourg (2013), p. 197].

As regards **Fast Start Finance 2010-2012**, Luxembourg pledged a contribution of 9 Mio EUR on the top of the country's ODA commitment, to be provided by the "Climate & Energy Fund" *[→ Section V.5.3]*. At the end of 2015, a total amount of 8.86 Mio. EUR had been disbursed *[→ Table VII.3-1]*.

TABLE VII.3-1 – LUXEMBOURG'S FAST START CONTRIBUTIONS 2010, 2011 & 2012 IN EUR

Projects	Fast Start Finance 2010-2012	Thematic area	Commitment
GFDRR	Support of integrated climate risk management and adaptation	Adaptation	2 000 000
UN-REDD	Core contribution	REDD+	2 000 000
Adaptation Fund	Core contribution	Adaptation	2 000 000
IUCN – SIDS	Pacific SIDS EESLI (Energy, Ecosystems and Sustainable Livelihoods Initiative) - Managing the Ecosystem and Livelihood Implications of Energy Policies	Renewable Energies / Mitigation	1 000 000
Yasuni National Park	*Saving Yasuni National Park in Ecuador**	*Adaptation / Mitigation*	*1 000 000*
Bilateral programmes in partner countries	LuxDev / Solartec – Cabo Verde Project: Electric installation at the professional training centre for renewable energy and industrial maintenance	Renewable Energies / Mitigation	681 000
	ASTM/ARFA – Burkina Faso Project: Promotion and construction of adaptation and mitigation devices against the effects of climate change and creation of village risk prevention mechanisms In the North and East of Burkina	Renewable Energies / Mitigation	67 196
	Scoping Study for the elaboration and implementation of a NAMA	Mitigation	112 262
Total			**8 860 458**

Source: Ministry of Sustainable Development and Infrastructure, Department of the Environment.
Note: Yasuni: restitution of the funds due to the stop of the project in 2013.

Furthermore, during the United Nations Sustainable Development Summit, that took place in New York in September 2015, Luxembourg's Prime Minister announced that Luxembourg would provide a total amount of 120 Mio. EUR for **International Climate Finance** (ICF) from 2014 to 2020. This amount includes an annual contribution of 5 Mio. EUR to the **Green Climate Fund** (GCF), representing a total of 35 Mio. EUR. Since this engagement, Luxembourg has disbursed a total of 22.04 Mio. EUR of its **ICF** pledge for mitigation and adaptation relevant actions, including REDD+ *[→ Table VII.3-2]*.

TABLE VII.3-2 – LUXEMBOURG'S FINANCIAL CONTRIBUTIONS TO ICF FOR THE YEARS 2014-2020 IN EUR

	2014	2015	2016	2017	2018	2019	2020
Pledged	1 000 000	17 000 000	12 000 000	15 000 000	20 000 000	25 000 000	30 000 000
Pledged (revised)				17 000 000	22 000 000	25 000 000	30 000 000
Disbursed	0	13 268 421	11 774 979	-	-	-	-

Source: Ministry of Sustainable Development and Infrastructure, Department of the Environment.
Notes: this table represents a disbursement forecast, i.e. pledges. Part of the pledges that have not been disbursed a certain year have been reported to the forthcoming years: it is the case for the years 2017 and 2018 that compensate for the "deficit" for the years 2014, 2015 and 2016.
Disbursed amounts have been financed by the "Climate & Energy Fund" except 100 000 EUR coming from the Directorate for Development Cooperation and Humanitarian Affairs of the Ministry of Foreign and European Affairs and the Ministry of Finance.
2015 disbursed amount contains 3 Mio. EUR used to pay off Fast Start Finance engagements (double counting avoided in Table VII.5-3).

Luxembourg is furthermore represented in the **Global Environment Facility** (GEF) by its Ministry of Finance and has been a member of the GEF since 1997. For the last three years, Luxembourg's contributions are depicted below *[→ Table VII.3-3]*.

TABLE VII.3-3 – LUXEMBOURG'S FINANCIAL CONTRIBUTIONS TO THE GEF FOR THE YEARS 2014, 2015 & 2016 IN EUR

	2014	2015	2016
Global Environment Facility	872 700	1 030 500	952 400

Source: Ministry of Finance.

Through the Directorate for Development Cooperation and Humanitarian Affairs of the Ministry of Foreign and European Affairs, Luxembourg made a contribution of 4.12 Mio. USD to the **Least Developed Countries Trust Fund** (LDCF) for the years 2005 to 2008. An additional contribution of 1 Mio. EUR came in 2007. Since 2010, however, no contributions were made to the LDCF.

VII.4. ASSISTANCE TO DEVELOPING COUNTRY PARTIES THAT ARE PARTICULARLY VULNERABLE TO CLIMATE CHANGE

In 2009, the Directorate for Development Cooperation and Humanitarian Affairs of the Ministry of Foreign and European Affairs elaborated **a** policy paper on environment and climate change**.** This paper is part of a set of 11 thematic position papers steering Luxembourg's development cooperation policy and has been discussed with civil society organisations. An update was completed in 2014 and led to a "**strategy for environment and climate change action**" [Ministry of Foreign and European Affairs, Directorate for Development Cooperation and Humanitarian Affairs (2014)].[234] This "strategy for environment and climate change action" states the following:

"Luxembourg's Development Cooperation aims to generate environmental and climatic benefits in developing countries, by mainstreaming environment and climate change in its interventions, by backing national sustainable development goals and the preservation of natural resources of these countries, by supporting specific activities in the field of natural resources management, sustainable agriculture, energy and the fight against climate change.

More precisely, as regards technology transfer, it specifies that:

Cooperation can work with the private sector in Luxembourg and in developing countries, in areas where the sector has adapted environmental expertise. Such cooperation with the private sector should be framed so as to provide a real benefit to the population, by ensuring that companies respect environmental and social standards and that their activities take into account the needs of the economy of the recipient country and of local

[234] The themes are (i) agriculture and food safety, (ii) humanitarian relief, (iii) local development, (iv) water and sewing, (v) education, (vi) environment and climate change, (vii) gender issue, (viii) governance, (ix) micro-finance, (x) health, and (xi) fragile states. The "strategy for environment and climate change action" (in French) is available here: http://www.gouvernement.lu/4555736/environnement-changement-climatique-2014.pdf.

communities, in accordance with the Council conclusions of the European Union of 23 June 2014 on the role of the private sector in development.".

Furthermore, the following environmental and climate change related clause is to be inserted in all 3rd and 4th generation ICPs:

"With reference to the Kyoto Protocol (1997), the seventh Millennium Development Goal (2000) and the Cancun Agreement (2010), both parties agree to promote policies for the conservation of natural resources, sustainable development, environmental taxation and the regulation of pollution.

To this end, Luxembourg's "strategy for environment and climate change action" will be considered at all levels of the project / program cycle management; that is to say at the levels of identification, formulation, instruction and implementation of projects / programs.

Luxembourg's Development Cooperation will assist the (partner countries) to identify interventions that preserve natural resources and are part of efforts to adapt to climate change. It may also support the (partner countries) in terms of capacity building, particularly at institutions responsible for Clean Development Mechanisms (CDMs).

Pooling resources and sharing of environmental information will be given priority to promote interventions that generate the highest environmental and social benefits in terms of local and global public goods. Depending on the respective national laws, it may be useful to conduct a specific strategic environmental assessment or environmental impact studies.

Luxembourg's Development Cooperation will work to integrate environmental concerns and climate policy acquisition and promote sustainable energy, clean technology and technology transfer and access to environmental information. Collaboration with research centres may be considered for this purpose.

In synergy with Luxembourg's Directorate for Development Cooperation and Humanitarian Affairs, its Ministry for Sustainable Development and Infrastructures, in charge of the management of the Climate and Energy Fund, may make available to the partner country additional funds to public development aid, to implement projects against climate change in the areas of adaptation and mitigation, including emissions reductions through the use of market mechanisms."

VII.5. PROVISION OF FINANCIAL RESOURCES

VII.5.1. Overall multilateral financial flows

Cooperation with multilateral partners is an important component of Luxembourg's development cooperation policy, notably in the context of achieving the SDGs. In order to achieve a high degree of predictability, multilateral aid is delivered through multi-annual framework agreements.

The interventions of Luxembourg's development cooperation are firmly based on the **four principles of effective development cooperation,** i.e. ownership by the partner countries, focus on results, inclusive partnerships as well as transparency and mutual accountability. The principles of 100% untied aid, predictability of funds through multi-annual indicative programmes, concentration in sectors where Luxembourg has a real added value and full alignment on the priorities and development strategies of our partner countries remain at the heart of Luxembourg's development cooperation. Over the past years, Luxembourg has made considerable progress in terms of aid transparency, in the use of country-led results frameworks and has developed innovative means of implementation that fully respect and strengthen national public finance systems.

Following the summits in Rome, Paris and Accra, Luxembourg participated in 2016 at the second high-level meeting of the Global Partnership for Effective Development Cooperation in Nairobi. The conference enabled to take stock of the implementation of commitments in terms of development effectiveness and Luxembourg's development cooperation has in fact been used as an example in the brochure "Effective Development Cooperation: Has the European Union delivered?" [European Commission (2016d)]. In the light of the commitments made in Nairobi and the new development paradigms agreed both at the international level – through Agenda 2030 and the Addis Ababa action programme on financing development – and at the European level – through the new European consensus on development – Luxembourg reviewed its "**Action plan for effective development cooperation**" and covers the years 2017 to 2019.

In 2016, the share of **multilateral cooperation in the total ODA** – i.e.353 Mio. EUR – was 28.43% ***[→ Table VII.5-1]***.

TABLE VII.5-1 – OVERALL MULTILATERAL COOPERATION FOR THE YEAR 2016

Institution	Total in Mio. EUR	% of multilateral ODA	% of total ODA
United Nations (Agencies, Programmes, etc.)	34 802 055,61 €	34,57%	9,83%
European Union	32 650 558,77 €	32,44%	9,22%
World Bank & IMF	22 236 454,00 €	22,09%	6,28%
Regional Development Banks	7 947 596,00 €	7,90%	2,24%
Other	3 021 349,45 €	3,00%	0,85%
Total	100 658 013,83	100.00 %	28,43%

Source: Ministry of Foreign and European Affairs, Directorate for Development Cooperation and Humanitarian Affairs.

The table below ***[→ Table VII.5-2]*** synthesises **Luxembourg's overall financial contributions to multilateral institutions and programmes**. This table is produced according to the format suggested for Table 4 of the guidelines for the preparation of National Communications by Parties in Annex I to the Convention [UNFCCC (1999)].

TABLE VII.5-2 – OVERALL MULTILATERAL COOPERATION: FINANCIAL CONTRIBUTIONS ACCORDING TO "TABLE 4" FORMAT FOR THE YEARS 2014, 2015 AND 2016 IN EUR

Institution or Programme	2014	2015	2016 prov.
European Union			
EC Budget	16 140 598	15 847 761	22 811 079
European Development Fund (EDF)	8 509 199	8 640 000	9 034 480
European investment Bank (EIB)	1 406 998	1 940 000	1 805 000
United Nations			
FAO	1 102 570	1 174 768	1 603 537
UNCCD	5 826	206 103	6 049
UNDP incl. thematic contribution to the Environment Trust Fund (500k)	15 790 444	14 231 472	12 398 494
UNEP	250 000	260.306	250 000
UNICEF	7 334 767	9 497 890	9 084 567
International Financial Institutions			
World Bank	2 300 000	657 000	not available
International Development Association (IDA)	11 365 000	8 280 000	16 686 454
International Bank for Reconstruction and Development (IRBD)	2 522 700	6 780 236	3 945 000
European Bank for Reconstruction and Development (EBRD)	2 000 000	not available	not available
Asian Development Bank (ADB)	2 834 546	2 599 502	2 469 712
Other Multilateral Institutions			
OECD	460 000	510 000	560 000

Source: Ministry of Foreign and European Affairs, Directorate for Development Cooperation and Humanitarian Affairs.

VII.5.2. Climate change related financial flows to developing country Parties to the UNFCCC

As indicated above *[→ Section VII.2]*, five out of Luxembourg's seven partner countries are among the LDCs and are located in West Africa. The negative effects of climate change affect them all.

The following tables *[→ Table VII.5-3]* are derived from the "Provision of public financial support" tables 7, 7(a) and 7(b) as defined in Decision 19/CP.18 on a Common Tabular Format (CTF) for "UNFCCC biennial reporting guidelines for developed country Parties". Only the year 2016 is reproduced in this report but similar tables are available on a web repository for the years 2013, 2014 and 2015 too.[235]

[235] The file also covers the years 2010, 2011 and 2012. However, information is incomplete for these years. (http://cdr.eionet.europa.eu/lu/eu/mmr/art16_finance/envwc2hig/)

This table reports **ODA's financial flows and contributions** managed by the Directorate for Development Cooperation and Humanitarian Affairs of the Ministry of Foreign and European Affairs, **contributions to the Global Environment Facility** (GEF) which are under the responsibility of the Ministry of Finance, and **other official flows (OOF)** coming from the **EU Fast Start Finance scheme** and from **Luxembourg's International Climate Finance** (ICF) commitment ***[→ Section VII.3]*** managed mostly through the "Climate & Energy Fund" ***[→ Section V.5.3]***.

As it can be seen from the table, in 2016, Luxembourg's climate specific **disbursed** provision of public financial support is **primarily made of bilateral contributions as well as of co-financing and framework agreements with NGOs**. The bilateral contributions are chiefly managed by Luxembourg's executing agency for development cooperation, LuxDev.[236]

With regard to recipient countries, it is worth mentioning that Least Developed Countries receive a high share of total climate related ODA - Burkina Faso, Niger, Mali, Senegal and Lao People's Democratic Republic being among Luxembourg's privileged partner countries. Cabo Verde – as a SIDS, member of AOSIS – is another privileged partner country of Luxembourg's Development Cooperation. The priority sectors – water & sanitation, renewable energies – align very well with the country's mitigation ambitions and adaptation needs.

Luxembourg reserves 5% of its humanitarian aid to **disaster risk reduction and prevention activities**. Among these funds, regular contributions to the UNISDR and GFDRR have to be mentioned.

Resilience building activities are playing an increasingly important role in Luxembourg's ODA. Acknowledging that preventing catastrophes and addressing the causes of recurrent crises rather than responding only to disasters are not only investments in the best interest of the beneficiaries but also more cost-efficient, Luxembourg tries to facilitate the transition between humanitarian aid and development aid, with resilience building activities at its intersection. Contributions to the GFDRR, UN-Women and various NGO projects reflect Luxembourg's commitment in this regard. Contributions to these activities are partly reported in ***Table VII.5-3***.

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236 http://luxdev.lu/en/home.

TABLE VII.5-3 – PROVISION OF CLIMATE CHANGE RELATED PUBLIC FINANCIAL SUPPORT: SUMMARY INFORMATION FOR THE YEAR 2016 IN EUR

Note: an Excel file containing these tables for the years 2010 to 2016 is available following this link: http://cdr.eionet.europa.eu/lu/eu/mmr/art16_finance/envwc2hig/ . However, tables for the years 2010, 2011 and 2012 are incomplete.

Table 7

Provision of public financial support: summary information in 2016

Allocation channels	*Year*									
	European euro - EUR					*National currency[a]*				
	Core/ general[b] 1	*Climate-specific [2]*				*Core/ general*	*Climate-specific [2]*			
		Mitigation[c]	*Adaptation[c]*	*Cross-cutting[c]*	*Other[cd]*		*Mitigation*	*Adaptation*	*Cross-cutting*	*Other*
Total contributions through multilateral channels:	952.400,00	257.500,00	19.028.459,87	67.900.000,00	-					
Multilateral climate change funds[e]	952.400,00	-	-	35.000.000,00	-					
Other multilateral climate change funds[f]	-	-	-	-	-					
Multilateral financial institutions, including regional development banks	-	257.500,00	12.570.000,00	32.000.000,00	-					
Specialized United Nations bodies	-	-	6.458.459,87	900.000,00	-					
Total contributions through bilateral, regional and other channels		10.494.267,87	9.141.080,72	22.707.257,53	-					
Total climate specific by funding type (total for mitigation, adaptation, crosscutting, other)		10.751.767,87	28.169.540,59	90.607.257,53	-					
Total climate specific finance		129.528.565,99								

Total climate specific by funding source (EUR)		**Total climate specific by financial instrument (EUR)**	
ODA	45.879.266,05	Grant	92.028.565,99
OOF	83.649.299,94	Concessional loan	-
Other	-	Non-concessional loan	-
Total	**129.528.565,99**	Equity	-
		Other	37.500.000,00
		of which committed	*78.524.321,04*
		of which disbursed	*51.004.244,95*

1-7 Please provide information on definitions or methodologies used for reporting in the Documentation box

[a] Please provide exchange rate

[b] This refers to support to multilateral institutions that Parties cannot specify as climate-specific.

[c] These categories should be mutually exclusive

[d] Please specify

[e] Multilateral climate change funds: Global Environment Facility, Least Developed Countries Fund, Special Climate Change Fund, Adaptation Fund, Green Climate Fund and the Trust Fund for Supplementary Activities (paragraph 17(a) of the "UNFCCC biennial reporting guidelines for developed country Parties" in 2/CP.17).

[f] Not listed under e)

Luxembourg's notes

Committed amounts are only reported for programs/actions/projects which are still on-going or for which the whole committed amount has not yet been disbursed at the end of 2016.

Table 7(a)

Provision of public financial support: contribution through multilateral channels in 2016

Donor funding	*Total amount*				*Status: disbursed, committed*[a, 3]	*Funding source: ODA, OOF, Other*[4]	*Financial instrument: grant, concessional loan, non-concessional loan, equity, other*[5]	*Type of support: Mitigation, adaptation, crosscutting, other*[c,6]	*Sector*[d, 7]
	Core/general[a, 1]		*Climate-specific* [2]						
	European euro - EUR	*National currency*	*European euro - EUR*	*National currrency*					
Multilateral climate change funds									
1. Global Environment Facility	952.400,00		-		disbursed	ODA	Equity	Cross-cutting	Other (multisectoral)
2. Least Developed Countries Fund			-		-	-	-	-	-
3. Special Climate Change Fund			-		-	-	-	-	-
4. Adaptation Fund			-		-	-	-	-	-
5. Green Climate Fund			25.000.000,00		committed	OOF[(1)(2)]	Grant	Cross-cutting	Cross-cutting
5. Green Climate Fund			10.000.000,00		disbursed	OOF[(1)(3)]	Grant	Cross-cutting	Cross-cutting
6. UNFCCC Trust Fund for Supplementary Activities			-		-	-	-	-	-
7. Other multilateral climate change funds			-		-	-	-	-	-
Multilateral financial institutions, including regional development banks									
1. World Bank - Global Facility for Disaster Reduction and Recovery (GFDRR)	-		300.000,00		disbursed	ODA	Grant	Adaptation	Other (resilience and disaster risk reduction)
2. International Finance Corporation	-		-		-	-	-	-	-
3. African Development Bank	-		-		-	-	-	-	-
4. Asian Development Bank	-		-		-	-	-	-	-
5. European Bank for Reconstruction and Development	-		-		-	-	-	-	-
6. Inter-American Development Bank	-		-		-	-	-	-	-
7. Other									
Mekong River Commission (MRC)	-		*1.000.000,00*		*committed*[(6)]	*ODA*	*Grant*	*Adaptation*	*Cross-cutting*
Mekong River Commission (MRC)	-		*400.000,00*		*disbursed*	*ODA*	*Grant*	*Adaptation*	*Cross-cutting*
United Nations Office for Disaster Risk Reduction (UNISDR), Global Facility for Disaster Reduction and Recovery (GFDRR) & World Meteorological Organization (WMO) - Climate Risk and Early Warning Systems (CREWS)	-		*1.000.000,00*		*disbursed*	*OOF*[(1)]	*Grant*	*Adaptation*	*Other (resilience and disaster risk reduction)*
International Union for Conservation of Nature - Blue Natural Capital Financing Facility and Fund (IUCN - BNCFF)	-		*2.220.000,00*		*committed*[(5)]	*OOF*[(1)]	*Grant*	*Adaptation*	*Energy* *Other (ecosystems protection & restoration)*
International Union for Conservation of Nature - Blue Natural Capital Financing Facility and Fund (IUCN - BNCFF)	-		*110.000,00*		*disbursed*	*OOF*[(1)]	*Grant*	*Adaptation*	*Energy* *Other (ecosystems protection & restoration)*
Gold Standard Foundation - gender methodology	-		*150.000,00*		*committed*[(5)]	*OOF*[(1)]	*Grant*	*Mitigation*	*Other (gender equality)*
Gold Standard Foundation - gender methodology	-		*107.500,00*		*disbursed*	*OOF*[(1)]	*Grant*	*Mitigation*	*Other (gender equality)*
Luxembourg - European Investment Bank (EIB) Climate Finance Platform	-		*30.000.000,00*		*committed*[(7)]	*OOF*[(1)]	*Other (first loss guarantee)*	*Cross-cutting*	*Cross-cutting*
Luxembourg - Climate Finance Accelerator	-		*2.000.000,00*		*committed*[(8)]	*OOF*[(1)]	*Grant*	*Cross-cutting*	*Cross-cutting*
Investing for Development SICAV (formerly Luxembourg - Microfinance and Development Fund SICAV - LMDF)	-		*7.500.000,00*		*committed*[(9)]	*OOF*[(1)]	*Other (first loss guarantee)*	*Adaptation*	*Forestry*
Observatoire du Sahara et du Sahel (OSS)	-		*40.000,00*		*committed*[(10)]	*OOF*[(1)]	*Grant*	*Adaptation*	*Cross-cutting*

Specialized United Nations bodies									
1. United Nations Development Programme									
United Nations World Food Programme (UN-WFP)	-		800.000,00		*committed(11)*	*ODA*	*Grant*	*Adaptation*	*Agriculture Other (food safety)*
United Nations World Food Programme (UN-WFP)	-		500.000,00		*disbursed*	*ODA*	*Grant*	*Adaptation*	*Agriculture Other (food safety)*
United Nations Entity for Gender Equality and the Empowerment of Women (UN-Women)	-		3.950.000,00		*committed(12)*	*ODA*	*Grant*	*Adaptation*	*Agriculture*
United Nations Entity for Gender Equality and the Empowerment of Women (UN-Women)	-		1.000.000,00		*disbursed*	*ODA*	*Grant*	*Adaptation*	*Agriculture*
United Nations Entity for Gender Equality and the Empowerment of Women (UN-Women)	-		108.459,87		*disbursed*	*ODA*	*Grant*	*Adaptation*	*Cross-cutting*
2. United Nations Environment Programme	-		-		-	-	-	-	-
3. Other									
Food and Agriculture Organization of the United Nations (FAO)	-		900.000,00		*committed(13)*	*ODA*	*Grant*	*Cross-cutting*	*Agriculture*
United Nations Convention to Combat Desertification (UNCCD)	-		100.000,00		*disbursed*	*OOF(1)*	*Grant*	*Adaptation*	*Other (land)*
Total contributions through multilateral channels	**952.400,00**		**75.068.459,87**						
disbursed - ODA	***952.400,00***		***2.308.459,87***						
disbursed - OOF	***0,00***		***11.317.500,00***						
net committed - ODA (committed minus already disbursed amounts)	***0,00***		***4.750.000,00***						
net committed - OOF (committed minus already disbursed amounts)	***0,00***		***56.692.500,00***						

Abbreviations: ODA = official development assistance, OOF = other official flows.

[a] This refers to support to multilateral institutions that Parties cannot specify as climate-specific.

[b] In the context of the MMR, the term "provided" equals "disbursed".

[c] These categories should be mutually exclusive

[d] See the OECD purpose codes at http://www.oecd.org/investment/stats/dacandcrscodelists.htm. Codes include energy, transport, industry, agriculture, forestry, water and sanitation etc.

Luxembourg's notes

Committed amounts are only reported for programs/actions/projects which are still on-going or for which the whole committed amount has not yet been disbursed at the end of 2016. Net committed amounts = committed amounts for year T minus what has been disbursed that same year T.

(1) International Climate Finance

(2) committed for the period 2014-2020; 10 000 000 EUR disbursed already in both 2015 & 2016

(3) corresponds to 2016-17 annual contributions

(4) committed for the period 2016-2020; 400 000 EUR disbursed already in 2016

(5) committed for the year 2016; only 110 000 EUR disbursed in 2016

(6) committed for the year 2016; only 107 500 EUR disbursed in 2016

(7) committed initially for the period 2017-2019; 10 000 000 EUR disbursed already in 2016

(8) committed for the period 2017-2019

(9) committed for the period 2016-2020; 7 500 000 EUR disbursed already in 2016

(10) committed for the period 2016-2018

(11) committed for the period 2015-2019; 700 000 EUR disbursed already in 2015 & 500 000 EUR disbursed already in 2016

(12) committed for the period 2016-2020; 1 000 000 EUR disbursed already in 2016

(13) committed for the period 2015-2018; no disbursement in 2016 but 600 000 EUR already disbursed in 2015

Table 7(b)

Provision of public financial support: contribution through bilateral, regional and other channels in 2016

Recipient country/region/project/programme	*Total amount*		*Status: disbursed, committed*	*Funding source: ODA, OOF, Other*	*Financial instrument: grant, concessional loan, non-concessional loan, equity, other*	*Type of support: Mitigation, adaptation, crosscutting, other*[a]	*Sector*[b]	*Additional information*[c]
	Climate-specific							
	European euro - EUR	*national currency*						
Africa / AOSIS-SIDS / bilateral	208.913,50		disbursed	ODA	Grant	Cross-cutting	Other (technical and vocational training)	Project in Cabo Verde (CVE/071 - training & access to employment [12.07-03.16]; CVE/081 -training & access to employment [06.16-11.20]).
Africa / AOSIS-SIDS / bilateral	2.056.137,19		disbursed	ODA	Grant	Mitigation	Water and sanitation	Project in Cabo Verde (CVE/078 - integrated management of water resources [05.12-05.16]; CVE/082 - water and sanitation [06.16-11.20]).
Africa / AOSIS-SIDS / bilateral	398.088,04		committed[2]	OOF[1]	Grant	Mitigation	Energy Waste	Implementing entity: Lee Sàrl. Project in Cabo Verde: setting up of a resource centre on the Santiago Island for recovering waste and extracting energy from it through methanization.
Africa / AOSIS-SIDS / bilateral	227.478,90		disbursed	OOF[1]	Grant	Mitigation	Energy Waste	Implementing entity: Lee Sàrl. Project in Cabo Verde: setting up of a resource centre on the Santiago Island for recovering waste and extracting energy from it through methanization.
Africa / DEs / NGOs	16.514,00		disbursed	ODA	Grant	Adaptation	Other (technical and vocational training)	Projects in west African countries (training).
Africa / DEs / NGOs	168.442,80		disbursed	ODA	Grant	Cross-cutting	Agriculture Other (ecosystems protection and restoration, financial support)	Projects in Cameroon (agriculture information, eco-systems & micro-finance).
Africa / DEs / NGOs	24.014,57		disbursed	ODA	Grant	Mitigation	Other (technical and vocational training)	Project in South Africa (training & education).
Africa / LDCs / bilateral	5.544.148,72		disbursed	ODA	Grant	Adaptation	Agriculture Forestry Other (food safety, technical and vocational training)	Projects in Burkina Faso (BKF/017 - rural development [09.10-06.16] & BKF/019 - forestry [07.12-07.17]), Mali (MLI/021 - food safety and rural development [04.16-12.19]), Niger (NIG/018 - rural development [11.11-10.16]) and Senegal (SEN/029 - training [07.13-06.18]).
Africa / LDCs / bilateral	12.769.384,88		disbursed	ODA	Grant	Cross-cutting	Agriculture Forestry Other (technical and vocational training)	Projects in Burkina Faso (BKF/017 - rural development [09.10-06.16] & BKF/019 - forestry [07.12-07.17]) and Niger (NIG/017 - training & education [06.11-09.16], NIG/018 - rural development [11.11-10.16] & NIG/019 - training & education [07.11-09.16]).
Africa / LDCs / bilateral	7.635.371,70		disbursed	ODA	Grant	Mitigation	Other (health, technical and vocational training)	Projects in Burkina Faso (BKF/018 - training [07.12-07.17]) and Senegal (SEN/027 - health [07.13-06.18] & SEN/028 - training [07.13-06.18]).
Africa / LDCs / bilateral	201.233,00		committed[3]	OOF[1]	Grant	Cross-cutting	Cross-cutting	Implementing entity: Centre de Suivi Ecologique de la République du Sénégal. Project in Senegal: capacity-building convention for both adaptation and mitigation - better knowledge of the impacts of anthropogenic activities on climate and eco-systems, identifying the best endogenous policies and measures, communication and awareness.
Africa / LDCs / bilateral	80.000,00		disbursed	OOF[1]	Grant	Cross-cutting	Cross-cutting	Project in Senegal: capacity-building convention for both adaptation and mitigation - better knowledge of the impacts of anthropogenic activities on climate and eco-systems, identifying the best endogenous policies and measures, communication and awareness.
Africa / LDCs / NGOs	82.790,19		disbursed	ODA	Grant	Adaptation	Other (financial techniques, food safety, technical and vocational training)	Project in Burkina Faso (food safety, micro-finance & training).
Africa / LDCs / NGOs	1.931.527,10		disbursed	ODA	Grant	Cross-cutting	Agriculture Forestry Water and sanitation Other (living conditions, financial support)	Projects in Burkina Faso (agriculture, forestry, water & integrated development), Dem. Rep. of the Congo (agriculture), Niger (integrated development, micro-finance), Senegal (rural development) and Togo (agriculture, integrated development).
Africa / LDCs / NGOs	87.524,20		disbursed	ODA	Grant	Mitigation	Agriculture	Project in Ethiopia (agriculture).
Asia-Pacific / DEs / bilateral	1.574.228,25		disbursed	ODA	Grant	Adaptation	Agriculture Other (living conditions)	Projects in Vietnam (VIE/033 - local development [07.13-12.17], VIE/035 - increase the efficiency and effectiveness of the IFAD loan [02.14-09.17] & VIE/036 - water irrigation for agriculture [08.15-07.20]).
Asia-Pacific / DEs / bilateral	1.522.280,54		disbursed	ODA	Grant	Cross-cutting	Other (living conditions)	Project in Vietnam (VIE/033 - integrated local development [07.13-12.17]).
Asia-Pacific / DEs / bilateral	65.000,00		committed[4]	OOF[1]	Grant	Adaptation	Cross-cutting	Project in Vietnam: contribution for climate adapted green growth in Thua Thien Huê Province (ref. LuxDev project VIE/401).
Asia-Pacific / DEs / bilateral	4.000.000,00		committed[5]	OOF[1]	Grant	Cross-cutting	Cross-cutting	Projects in Vietnam: contributions for bilareral climate cooperation to finance two climate pilot interventions - one on mitigation (2 mio.), one on adaptation (2 mio.) - in Thua Thien Huê Province (ref. LuxDev projects VIE/433ext & VIE/401).

Asia-Pacific / DEs / NGOs	150.663,73		disbursed	ODA	Grant	Cross-cutting	Agriculture Other (food safety, living conditions)	Projects in India (living conditions) and Philippines (organic & sustainable farming, food safety).
Asia-Pacific / DEs / NGOs	28.552,60		disbursed	ODA	Grant	Mitigation	Other (waste management)	Project in India (waste recycling).
Asia-Pacific / LDCs / bilateral	1.411.736,71		disbursed	ODA	Grant	Adaptation	Other (living conditions, tourism)	Projects in Laos (LAO/021 - integrated development [10.09-06.16] & LAO/029 - human resources development in the tourism sector [08.16-08.21]).
Asia-Pacific / LDCs / NGOs	310.637,84		disbursed	ODA	Grant	Cross-cutting	Other (health)	Project in Laos (health).
LAC / DEs / NGOs	446.662,85		disbursed	ODA	Grant	Adaptation	Agriculture Forestry Other (resilience and disaster risk reduction, technical and vocational training)	Projects in Bolivia (agriculture, forestry, training & risk management), Ecuador (training) and Peru (agriculture & training).
LAC / DEs / NGOs	626.529,87		disbursed	ODA	Grant	Cross-cutting	Agriculture Other (food safety, living conditions, technical and vocational training)	Projects in Bolivia (organic & sustainable farming, integrated development, natural resources management), Guatemala (training in agriculture) and Peru (food safety and training).
LAC / DEs / NGOs	37.100,67		disbursed	ODA	Grant	Mitigation	Other (technical and vocational training)	Project in Nicaragua (training).
LAC / LDCs / NGOs	5.521,91		disbursed	ODA	Grant	Cross-cutting	Other (technical and vocational training)	Project in Haiti (training).
Various / bilateral	282.122,36		disbursed	ODA	Grant	Cross-cutting	Other (financial techniques & support)	Financial support through the Forestry and Climate Change sub-fund of the LMDF.
Various / bilateral	300.000,00		committed(6)	OOF(1)	Grant	Cross-cutting	Other (investment funds)	Implementing entity: Luxembourg Fund Labelling Agency LuxFLAG. Convention - awarding a climate finance label to investment funds according to agreed and published criteria.
Various / bilateral	150.000,00		disbursed	OOF(1)	Grant	Cross-cutting	Other (investment funds)	Implementing entity: Luxembourg Fund Labelling Agency LuxFLAG. Convention - awarding a climate finance label to investment funds according to agreed and published criteria.
Total contributions through bilateral, regional and other channels	**41.885.127,22**						**42.342.606,12**	
disbursed - ODA	***36.920.806,18***					***Adaptation***	***9.141.080,72***	
disbursed - OOF	***457.478,90***					***Cross-cutting***	***22.707.257,53***	
net committed - ODA	***0,00***					***Mitigation***	***10.494.267,87***	
net committed - OOF	***4.506.842,14***							

Abbreviations: ODA = official development assistance, OOF = other official flows; USD = United States dollars.

[a] These categories should be mutually exclusive.

[b] See the OECD purpose codes at http://www.oecd.org/investment/stats/dacandcrscodelists.htm. Codes include energy, transport, industry, agriculture, forestry, water and sanitation etc.

[c] Parties should report, as appropriate, on project details and the implementing agency.

Luxembourg's notes

Committed amounts are only reported for programs/actions/projects which are still on-going or for which the whole committed amount has not yet been disbursed at the end of 2016. Net committed amounts = committed amounts for year T minus what has been disbursed that same year T.

Except when indicated, bilateral projects or programmes are implemented by Lux-Development SA.

(1) International Climate Finance

(2) committed in 2015; 170 609.18 EUR disbursed already in 2015 & 224 478.90 EUR disbursed already in 2016

(3) committed for the period 2016-2018; 80 000 EUR disbursed already in 2016

(4) committed in 2016

(5) committed in 2016 for an estimated project duration of 2-3 years.

(6) committed for the period 2016-2017; 150 000 EUR disbursed already in 2016

VII.6. ACTIVITIES RELATED TO TRANSFER OF TECHNOLOGY

The following projects and programmes illustrate the efforts of Luxembourg's Development Cooperation capacity building and technology transfer to developing countries. It should be noted that capacity building is one of the cornerstones to Luxembourg's programmes in developing countries. The list below is not exhaustive:

Cabo Verde: programme CVE/083 – 2016-2020 – 4.5 Mio. EUR

Renewable energy is one of the three key sectors of the IV ICP in Cabo Verde, and the aim of the programme is to ensure access to clean, reliable modern and affordable energy for all, while increasing energy independence. It also seeks to reinforce governance, regulation and business climate of the renewable energy sector in Cabo Verde. The activities will also aim to increase the fundraising capacity for renewable energies.

Vietnam: programme VIE/033 – 2013-2017 – 10 Mio. EUR

The cooperation with Vietnam is being diversified on a political level to include climate change and energy as one of the focus areas. This specific project aims to adapt, strengthen and diversify the livelihoods of people in 29 costal and lagoon communes and protect those livelihoods and the fragile environment from the increasing impacts of climate change.

Burkina Faso: programmes BKF/023 and BKF/024 – 2017-2021 – 22 Mio. EUR

In Burkina Faso, Luxembourg's development cooperation projects include interventions in the forestry sector and climate mitigation activities. Currently two new programmes, building on previous projects, are being finalised. BKF/023 focuses on the implementation of the national "environment, green economy and climate change" policy by providing capacity building to national and regional level actors and supporting the protection and promotion of the sector's assets. The second project (BKF/024) targets climate mitigation efforts through rehabilitation of degraded land measures and capacity building for institutional actors involved in climate finance and fundraising ventures.

All activities described above are publicly financed (respectively co-financed to at least 66% as far as regards NGO projects). As a public administration, primarily concerned with development policies and ODA management, the Ministry of Foreign and European Affairs, Directorate for Development Cooperation, does not report on private sector's investments.

This said, for publicly funded (bilateral or NGO) projects in the field of technology transfer, the Ministry does rely on the private sector as a skilled and specialised technical partner. In this context, the following examples illustrate how Luxembourg encouraged private sector activities:

- capacity building activities in Cabo Verde's Energies Training Centres will create an incentive for private sector investment in clean technologies in these countries;

- collaboration with companies that provide solar panels or more complex solar container systems: either LuxDev chooses these companies through a tendering process or NGOs choose these companies for collaboration and the Ministry co-finances such projects.

TABLE VII.6-1 – DESCRIPTION OF SELECTED PROJECTS OR PROGRAMMES THAT PROMOTED PRACTICABLE STEPS TO FACILITATE AND/OR FINANCE THE TRANSFER OF, OR ACCESS TO, ENVIRONMENTALLY-SOUND TECHNOLOGIES

<table>
<tr><td colspan="4">Project / programme title: Renewable energy, Programme CVE/083 Cabo Verde</td></tr>
<tr><td colspan="4">Purpose:
• Access to clean and affordable energy;
• Capacity building and set up of legal framework.</td></tr>
<tr><td>Recipient country</td><td>Sector</td><td>Total funding</td><td>Years in operation</td></tr>
<tr><td>Cabo Verde</td><td>• Renewable energy production</td><td>4.5 Mio. EUR</td><td>2016-2020</td></tr>
<tr><td colspan="4">Description: renewable energy is one of the three key sectors of the IV ICP in Cabo Verde, and the aim of the programme is to ensure access to clean, reliable modern and affordable energy for all, while increasing energy independence. It also seeks to reinforce governance, regulation and business climate of the renewable energy sector in Cabo Verde. The activities will also aim to increase the fundraising capacity for renewable energies.</td></tr>
<tr><td colspan="4">Indicate factors that led to project's success: holistic and integrated approach to the energy sector. The programme was developed with full involvement of the Cabo Verde authorities and entities working in the sector, to ensure appropriation. The programme has been developed to be coordinated with the other programmes financed by Luxembourg's Development Cooperation, and includes capacity building and training, as well as the financing of studies and pilot projects.</td></tr>
<tr><td colspan="4">Technology transferred:
• Sector reform and legal framework;
• Capacity-building.</td></tr>
<tr><td colspan="4">Impact on greenhouse gas emissions/sinks (optional): not applicable.</td></tr>
</table>

<table>
<tr><td colspan="4">Project / programme title: Adapted local development and innovation project, Programme VIE/033 Vietnam</td></tr>
<tr><td colspan="4">Purpose:
• Assist sustainable, equitable and efficient trends of poverty reduction and adaptation to environmental and climate change in socioeconomic development in 29 lagoon and coastal communes.</td></tr>
<tr><td>Recipient country</td><td>Sector</td><td>Total funding</td><td>Years in operation</td></tr>
<tr><td>Vietnam</td><td>• Climate change</td><td>10 Mio. EUR</td><td>2013-2017</td></tr>
<tr><td colspan="4">Description: the cooperation with Vietnam is being diversified on a political level to include climate change and energy as one of the focus areas. This specific project aims to adapt, strengthen and diversify the livelihoods of people in 29 costal and lagoon communes and protect those livelihoods and the fragile environment from the increasing impacts of climate change.</td></tr>
<tr><td colspan="4">Indicate factors that led to project's success: holistic and integrated approach to the climate change sector. The programme was developed with full involvement of the authorities in Vietnam and local and national level as well as entities working in the sector, to ensure appropriation. Two other programmes in the renewable energy and climate change sectors will follow up this programme.</td></tr>
<tr><td colspan="4">Technology transferred:
• Capacity building.</td></tr>
<tr><td colspan="4">Impact on greenhouse gas emissions/sinks (optional): not applicable.</td></tr>
</table>

Project / programme title: *Support to the implementation of the sectoral policy on environment, green economy and climate change (PSEEVCC), Programme BKF/023 Burkina Faso*			
Purpose: • Protect and preserve natural resources; • Capacity building and strengthening of the legal and regulatory framework.			
Recipient country	**Sector**	**Total funding**	**Years in operation**
Burkina Faso	• Environment • Capacity-building	17 Mio. EUR	2017-2021
Description: Luxembourg cooperation has been active for a long time in the environment sector of Burkina Faso. Building on previous interventions, notably in the forestry sector, this project aims to offer continuous support to the government's efforts in implementing its new sectoral policy.			
Indicate factors that led to project's success: holistic and integrated approach to the targeted sectors and a high degree of alignment on the priorities identified by the line ministries as well as local actors contribute to ensuring appropriation. This project is closely related to the previous interventions of Luxembourg to strengthen the sustainability of the results as well as to another new project to promote synergies within the sector.			
Technology transferred: • Capacity building.			
Impact on greenhouse gas emissions/sinks (optional): One specific objective of the project aims to strengthen the reduction of greenhouse gas emissions.			

Project / programme title: *Reclamation of degraded lands in a pastoral environment, Programme BKF/024 Burkina Faso*			
Purpose: • Environmental capacity building and awareness raising.			
Recipient country	**Sector**	**Total funding**	**Years in operation**
Burkina Faso	Environment	5 Mio. EUR	2017-2021
Description: building on previous interventions in this sector and in particular those activities targeting the recuperation of degraded lands this project aims to strengthen the results already obtained and to expand the areas covered. Beyond the recuperation efforts, the project also provided capacity building to the line ministry, local actors and village-level coordination bodies.			
Indicate factors which led to project's success: • Close alignment on national priorities strengthen appropriation; • Capacity building affects the governance of the sector and promotes transparency.			
Technology transferred: • Capacity building.			
Impact on greenhouse gas emissions/sinks (optional): The recovery of degraded lands contributes to the fight against greenhouse gas emissions.			

In 2013, the Ministry of Sustainable Development and Infrastructure engaged in a scoping study on the potential for a **Nationally Appropriate Mitigation Action** (NAMA) in six of the Luxembourg's development cooperation partner countries: El Salvador, Nicaragua, Tunisia, Montenegro, Lao People's Democratic Republic and Viet Nam. The study was supported by Luxembourg's contribution to the EU Fast Start Finance scheme. LuxDev was in charge of mobilising the local expertise for the study entrusted to an international climate experts' consortium. In July 2013, Phase 1 of the assignment concluded that Lao People's Democratic Republic, Montenegro and Vietnam would be the most promising candidates. Throughout 2013, subsequent phases deepened analysis on capacity and readiness, set priorities, and evaluated costs, before recommending, by the end of 2013, a single country ready for Luxembourg NAMA support, i.e. **Vietnam**. In close cooperation with the selected NAMA host country Government and Luxembourg's officials, the overall aim was to prepare a "Project Idea Note" (PIN) that may qualify for further support from Luxembourg with "fast start" or other funds.

In 2012, Luxembourg financed a study to explore the **potential of renewable energy sources** (RES) **in Cabo Verde**, in view of the fulfilment of the country's policy to switch to 50% of RES until 2020 and to 100% of RES in the longer term. As a follow-up to the study, a mission to explore opportunities for economic cooperation by attracting potential investors or technical partners (companies active in the field of RES) from Luxembourg and Germany took place in 2013. Further workshops and conferences were planned in order to clarify the legal environment necessary for a transition from fossil to RES, as well as to set up a financing model. The study's final report was presented in October 2013 and was meant to feed into the Government's Master Plan for its planned energy transition. A change of Government in 2016 led to a revision of the countries targets for renewable energy.

With regard to the **types of technologies to be transferred by companies from Luxembourg to developing countries**, there are companies specialised in photovoltaic slabs and containers, others specialised in biogas installations and yet others constructing thermo-solar boilers. It is worth mentioning that the majority of those companies operating in the field of energy, environment and sustainable development are regrouped within the "EcoInnovation Cluster" of Luxinnovation, an agency linked to the Ministry of Economy. This Cluster focuses on the following three topics: Circular Economy, Mobility, Sustainable Cities and Smart Technologies.[237] From 2013 on, the contacts between the EcoInnovation Cluster and Luxembourg's Directorate for Development Cooperation have intensified in order to encourage Luxembourg's companies to engage in developing countries and, more specifically in the case of RES, in Cabo Verde, where concrete opportunities and needs have been identified. It is important however to note that given the untied nature of Luxembourg's ODA, no public tender advantages can be given to Luxembourg companies through ODA grants.

The following examples illustrate how Luxembourg encourages private sector activities:

- The Business Partnership Facility (BPF) is a financing facility aimed at encouraging the private sector to engage with partners in developing countries to implement sustainable business projects. The facility has an annual budget of 1 Mio. EUR to co-finance private sector initiatives that contribute to development and job creation in developing countries and/or transfers of technology. The BPF addresses the sectors of Bio-health, Information and Communication Technologies (ICT), Fintech, and Eco-innovation in developing countries.
- capacity-building activities in Cabo Verde's or Tunisia's RES Training Centres will create an incentive for private sector investment in clean technologies in these countries;
- collaboration with companies that provide solar panels or more complex solar container systems. These collaborations are organized as follows: either LuxDev chooses the companies through a tendering process (see Box VI.6.1) or NGOs choose the companies and

[237] For more information, please consult: http://www.ecoinnovationcluster.lu.

the Development Cooperation Directorate of the Ministry of Foreign and European Affairs co-finances such projects (up to 66% or 75% depending on the supported country).

In the field of agriculture and through bilateral programmes as well as through NGO projects, Luxembourg supports farmer organisations that promote **endogenous capacities**, try to divulge these technologies and organise trainings and awareness raising seminars on this purpose (e.g., ASTM's[238] collaboration with ARFA[239] and *Jonggbaueren a Jongwënzer*[240] - field labour with donkeys).

BOX VII.6-1 – INTEGRATION OF ENVIRONMENT AND CLIMATE CHANGE INTO LUXDEV PROCUREMENTS

General Regulations of LuxDev's acquisition process

The award of contracts of goods, services and works financed (…) by the Government (…) of Luxembourg and for which LuxDev is the Awarding Authority translates the development policy of the Government, according to which the environment must imperatively be taken into account for any development that aims to be sustainable.

(…) LuxDev acting as Awarding Authority can require that particular conditions related to environmental protection and climate change are included in the tender dossiers.

These clauses will aim at promoting sustainable energies and clean technologies as well as the transfer of these technologies and the access to environmental information in the partner countries.

Consequently, the award of contracts might be refused if a given contract is likely to have a negative impact on the environment and the ecosystems of the partner country; this in order to contribute avoiding all interventions that could prove harmful to the environment.

With regard to Biennial Report's Tables 8 (Provision of technology development and transfer support), and 9 (Provision of capacity building support), as Luxembourg's does not have an OECD marker for technology development, this information is difficult to disaggregate from the existing statistics. As regards capacity building, however, the information can be retrieved following the capacity building marker.

238 ASTM stands for *Action Solidarité Tiers-Monde* – http://astm.lu/.

239 ARFA stands for *Association de Recherche et de Formation Agro-écologique* – http://astm.lu/projets-de-solidarite/afrique/association-de-recherche-et-de-formation-agro-ecologique-arfa/.

240 http://jongbaueren.lu/.

VII.7. Information under Article 10 of the Kyoto Protocol

Information on activities, actions and programmes undertaken in fulfilment of the commitments under Article 10 of the Kyoto Protocol are given in various parts of the 7th National Communication. *Table VII.7-1* below provides an overview, where this information is located.

Table VII.7-1 - Information under Article 10 of the Kyoto Protocol – correspondence table

Art. 10.a	National system for the development and continuous improvement of the national inventory	*Section III.2*
Art. 10.b	Domestic (and regional) programmes aimed at mitigating climate change	*Section IV.2*
	Domestic adaptation strategies and measures	*Section VI.3*
Art. 10.c	Activities related to transfer of technology transfer	*Section VII.6*
Art. 10.d	Research and systematic observation	*Chapter VIII*
Art. 10.e	Education, training and public awareness	*Chapter IX*

Other requested information is presented below.

VII.7.1. Elements of success of Luxembourg's bilateral adaptation and mitigation programmes

The following "success stories" are worth mentioning:

- in general, capacity building provided in the framework of, for example, BKF/017 (Improvement of Livestock and Sustainable Pastoral Resources Management, Azawak Zebu, 2010-2015) could be highlighted as having been particularly successful components of these projects. In the same line of thoughts, the awareness raising that took place within the projects BKF/017 and its predecessor BKF/012 (both of them following Burkina Faso's concept of "*eco-citoyenneté*") should be highlighted;
- within project BKF/019, (Support to the national Forestry Program) further capacity building was provided to relevant actors in Burkina Faso and in light of the successes achieved, it was decided to continue this support with a new project (BKF/023);
- a separate, parallel program (BKF/024) aims to consolidate the achievements obtained regarding the rehabilitation of degraded land component of project BKF/017. Particularly worth mentioning here is the successful integration of villagers' (via land charters/"*chartes foncières*" for example) organizations into the program implementation, thereby strengthening the impact and width of awareness raising campaigns;

- Luxembourg is currently working on supporting Cabo Verde with the revision of its energy sector strategy. Luxembourg support focusses on the renewable energy component for ICP 2016-2020.

VII.7.2. Lessons learnt from these programmes

As a “failure story”, Luxembourg has so far to register poor results on helping its partner countries identify, formulate, register or implement CDM projects. This component was for instance foreseen in YUG/012, but was eventually dropped, due also to a lack of commitment from the Montenegrin side. For BKF/017, it is worth mentioning that the high degree of mobility of human resources within public bodies and the lack of resources of the beneficiaries (breeders and local organisations) hamper the long-term impact of the project.

ANNEX – LUXEMBOURG'S ODA PER SECTOR (2016)

Ventilation sectorielle de l'APD bilatérale & multilatérale brute	APD bilatérale	%	APD multilatérale	%	Total par secteur	%
Infrastructure et services sociaux	**114 221 128,37 €**	**45,08 %**	**22 807 516,05 €**	**22,66 %**	**137 028 644,42 €**	**38,71 %**
Éducation	**46 090 510,13 €**	**18,19 %**	**1 100 000,00 €**	**1,09 %**	**47 190 510,13 €**	**13,33 %**
dont éducation, niveau non spécifié	2 020 865,13 €	0,80 %	300 000,00 €	0,30 %	2 320 865,13 €	0,66 %
dont éducation de base	10 995 815,26 €	4,34 %	800 000,00 €	0,79 %	11 795 815,26 €	3,33 %
dont éducation secondaire	31 947 399,02 €	12,61 %	-	0,00 %	31 947 399,02 €	9,02 %
dont éducation post-secondaire	1 126 430,72 €	0,44 %	-	0,00 %	1 126 430,72 €	0,32 %
Santé	**23 745 530,51 €**	**9,37 %**	**5 190 000,00 €**	**5,16 %**	**28 935 530,51 €**	**8,17 %**
dont santé, général	19 677 972,12 €	7,77 %	2 470 000,00 €	2,45 %	22 147 972,12 €	6,26 %
dont santé de base	4 067 558,39 €	1,61 %	2 720 000,00 €	2,70 %	6 787 558,39 €	1,92 %
Politique en matière de population/santé et fertilité	**9 586 848,85 €**	**3,78 %**	**12 400 000,00 €**	**12,32 %**	**21 986 848,85 €**	**6,21 %**
Distribution d'eau et assainissement	**4 703 763,71 €**	**1,86 %**	**-**	**0,00 %**	**4 703 763,71 €**	**1,33 %**
Gouvernement et société civile	**22 735 678,13 €**	**8,97 %**	**3 617 516,05 €**	**3,59 %**	**26 353 194,18 €**	**7,44 %**
dont gouvernement et société civile - général	20 711 834,64 €	8,17 %	3 000 000,00 €	2,98 %	23 711 834,64 €	6,70 %
dont politique fiscale et soutien à l'administration fiscale	250 000,00 €	0,10 %	500 000,00 €	0,50 %	750 000,00 €	0,21 %
dont participation démocratique et société civile	4 522 410,14 €	1,78 %	-	0,00 %	4 522 410,14 €	1,28 %
dont conflits, paix et sécurité	2 023 843,49 €	0,80 %	1 117 516,05 €	1,11 %	3 141 359,54 €	0,89 %
Ventilation sectorielle de l'APD bilatérale & multilatérale brute	APD bilatérale	%	APD multilatérale	%	Total par secteur	%
Infrastructure et services sociaux divers	**7 358 797,05 €**	**2,90 %**	**-**	**0,00 %**	**7 358 797,05 €**	**2,08 %**
Infrastructure et services économiques	**18 478 566,97 €**	**7,29 %**	**650 000,00 €**	**0,65 %**	**19 128 566,97 €**	**5,40 %**
Communications	381 217,08 €	0,15 %	-	0,00 %	381 217,08 €	0,11 %
Énergie : production, distribution et efficacité - général	18 509,69 €	0,01 %	-	0,00 %	18 509,69 €	0,01 %
Production d'énergie, sources renouvelables	267 729,98 €	0,11 %	-	0,00 %	267 729,98 €	0,08 %
Banques et services financiers	17 102 465,34 €	6,75 %	650 000,00 €	0,65 %	17 752 465,34 €	5,01 %
Entreprises et autres services	708 644,88 €	0,28 %	-	0,00 %	708 644,88 €	0,20 %
Production	**15 078 497,41 €**	**5,95 %**	**600 000,00 €**	**0,60 %**	**15 678 497,41 €**	**4,43 %**
Agriculture, sylviculture et pêche	12 585 264,08 €	4,97 %	600 000,00 €	0,60 %	13 185 264,08 €	3,72 %
Industries manufacturières, industries extractives, construction	294 027,62 €	0,12 %	-	0,00 %	294 027,62 €	0,08 %
Politique commerciale et réglementations	2 000 000,00 €	0,79 %	-	0,00 %	2 000 000,00 €	0,56 %
Tourisme	199 205,70 €	0,08 %	-	0,00 %	199 205,70 €	0,06 %
Destination plurisectorielle ou transversale	**15 512 611,47 €**	**6,12 %**	**-**	**0,00 %**	**15 512 611,47 €**	**4,38 %**
Protection de l'environnement	890 478,71 €	0,35 %	-	0,00 %	890 478,71 €	0,25 %
Autres multisecteurs	14 622 132,76 €	5,77 %	-	0,00 %	14 622 132,76 €	4,13 %
dont aide plurisectorielle	5 285 474,33 €	2,09 %	-	0,00 %	5 285 474,33 €	1,49 %
dont développement et gestion urbaine	72 732,28 €	0,03 %	-	0,00 %	72 732,28 €	0,02 %
dont développement rural	9 088 767,70 €	3,59 %	-	0,00 %	9 088 767,70 €	2,57 %
dont éducation et formation plurisectorielles	75 158,46 €	0,03 %	-	0,00 %	75 158,46 €	0,02 %
dont institutions scientifiques et de recherche	100 000,00 €	0,04 %	-	0,00 %	100 000,00 €	0,03 %
Aide alimentaire développementale/sécurité alimentaire	**3 349 176,64 €**	**1,32 %**	**-**	**0,00 %**	**3 349 176,64 €**	**0,95 %**
Aide humanitaire	**48 813 653,37 €**	**19,27 %**	**-**	**0,00 %**	**48 813 653,37 €**	**13,79 %**
Intervention d'urgence	43 198 132,22 €	17,05 %	-	0,00 %	43 198 132,22 €	12,20 %
dont assistance matérielle et services d'urgence	33 593 545,68 €	13,26 %	-	0,00 %	33 593 545,68 €	9,49 %
dont coordination des secours et services de soutien et de protection	9 604 586,54 €	3,79 %	-	0,00 %	9 604 586,54 €	2,71 %
Reconstruction et réhabilitation	3 607 379,97 €	1,42 %	-	0,00 %	3 607 379,97 €	1,02 %
Prévention des catastrophes et préparation à leur survenue	2 008 141,18 €	0,79 %	-	0,00 %	2 008 141,18 €	0,57 %
Frais administratifs des donneurs	**16 348 707,71 €**	**6,45 %**	**-**	**0,00 %**	**16 348 707,71 €**	**4,62 %**
Sensibilisation	**2 566 227,89 €**	**1,01 %**	**-**	**0,00 %**	**2 566 227,89 €**	**0,72 %**
Non affecté / non spécifié	**18 998 712,48 €**	**7,50 %**	**76 600 497,78 €**	**76,10 %**	**95 599 210,26 €**	**27,00 %**
Total aide bilatérale et multilatérale ventilable par secteur	**253 367 282,33 €**	**100,00 %**	**100 658 013,83 €**	**100,00 %**	**354 025 296,15 €**	**100,00 %**

Source: Ministry of Foreign and European Affairs, Directorate for Development Cooperation and Humanitarian Affairs.

Chapter VIII

Research and Systematic Observation

Chapter VIII describes actions undertaken in Luxembourg in the fields of research and systematic observation and tries to stick with UNFCCC reporting guidelines, paragraphs 57 to 64. It is, however, not yet possible for Luxembourg to provide relevant and complete information related to Articles 10d and 10f of the Kyoto Protocol.

VIII.1. GENERAL POLICY ON RESEARCH AND SYSTEMATIC OBSERVATION[241]

MeteoLux, the national weather service in Luxembourg, a department of the Aviation Administration (*Administration de la navigation aérienne* - ANA) of the Ministry of Sustainable Development and Infrastructure,[242] operates one meteorological synoptic station and one aeronautical meteorological station, both located at Luxembourg Airport. These stations are monitoring key climate and aviation weather parameters with a high quality and their number will not change in the near future. The synoptic station is part of the WMO **Global Observing System** (GOS), and is reporting under WMO station identifier 06590 under the World Weather Watch (WWW) program. Further to this, the station is an integral part of the **Global Climate Observing System** (GCOS) and the GCOS Surface Network (GSN). MeteoLux is currently taking the responsibilities for the GCOS and as such, is **the official contact point in Luxembourg**. The synoptic data, and especially Essential Climate Variables (ECV-data) like temperature and precipitation, are available in electronic form for data going back up to the 1st January 1947. CLIMAT-codes are distributed on a monthly basis via the WMO GTS. The quality of the codes for precipitation is monitored by the GSN Monitoring Centre at the *Deutscher Wetterdienst* (DWD) in Germany, which is the lead centre for GCOS data in WMO region VI, and air temperature at the JMA in Japan. This data is used to support climate-monitoring applications and are used in the analyses of the Intergovernmental Panel on Climate Change (IPCC). The final quality flagged data is **available at the GSN Monitoring Centre** (GSNMC) and is **forwarded**, on a monthly basis, **to the World Data Centre** (WDC) **for Meteorology** in Asheville, NC, USA. This transfer is only realised once a quality control of the CLIMAT temperature and precipitation data has been completed. From December 2013 on, MeteoLux satisfies to the standards of the WMO WIS (WMO Information System) and EU INSPIRE Directive for metadata and data.[243]

All meteorological services to be provided for international aviation are determined in accordance with the **standards of ICAO Annex 3**. The aeronautical station (ELLX) provides information at intervals required for operational planning, flight operations, the protection of aeronautical equipment on the ground, and for various other aeronautical uses. At the airport, there is a statutory requirement for manual observations, which are made by means of instruments and visual

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241 The text of this section has been prepared by Freyermuth, A., Bareiss, J. and Reckwerth, M. of MeteoLux.

242 http://www.meteolux.lu/ et http://www.ana.public.lu/fr/index.html.

243 Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE). (http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32007L0002&from=EN).

estimation. In addition to the standard meteorological instrumentation, automatic sensors for base of cloud height, runway visual range, visibility, present weather are in operation. To meet the safety needs for aviation a second back-up station – with identical instrumentation as the one installed at the meteorological synoptic station – is located at the airport.

Luxembourg is a member of the **European National Meteorological Services Network** (EUMETNET). Meteorological data from the synoptic station are provided to the EUMETNET Composite Observing System (EUCOS) surface land station network, satisfying the main user requirements for general forecasting and NWP, and improving data quality within Europe.

Luxembourg contributes to space-based observations through membership of the **European Space Agency** ESA (2005) as well as to the **European meteorological satellite agency** for monitoring weather, climate and the environment EUMETSAT. The Meteorological Service at the airport has facilities for receiving real-time satellite data as well as historical satellite products of ECVs via the EUMETSAT Satellite Application Facility (SAF) on climate monitoring.

VIII.2. RESEARCH[244]

Concerning research, activities are led by the *Luxembourg Institute of Science and Technology* (LIST), for which some examples and findings have been presented in ***Section II.3*** and ***Section VI.1***. The LIST also centralizes data covering the complete Luxembourgish territory from its **own hydro-climatic monitoring network** ***[→ Section VI.1]*** as well as from **observation stations** operated and maintained by the Water Agency (*Administration de la gestion de l'eau* – AGE), the Civil Defence Service (*Administration des services de secours* from the Ministry of Home Affairs), the Agriculture Technical Services Administration (*Administration des Services Techniques de l'Agriculture* – ASTA), and MeteoLux. A complete list of observational sites, variables and measurement time-steps, can be found in the "*Atlas hydro-climatologique du Grand-Duché de Luxembourg*".

The validated data are freely available and published yearly via the "*Atlas hydro-climatologique du Grand-Duché de Luxembourg*". This serves as a basis for different research activities but also for operational measures, among other for the design of flood protection measures and river restoration projects.

Concerning the future climate change research activities of LIST, it is foreseen to analyse new emissions scenarios taken from the CORDEX (Coordinated Regional climate Downscaling Experiment). Three different emission scenarios – RCP2.6, RCP4.5 and RCP8.5 (RCP = representative concentration pathway) – will be analysed. These data sets are also included in different research proposals submitted to national or international research funding agencies. As examples, at national level, the project BEWARE (Implications of Bioenergy crop performance for sustainable water

[244] The text of this section has been prepared by Junk, J., Trebs, I. and Hoffmann, L. of the Luxembourg Institute of Science and Technology (LIST).

resources under climate change conditions) and at international level, the H2020 project SustainBFF (StrawBerry Feeds Forever: Utilizing beneficial microbes as an innovation in plant protection to promote sustainable strawberry and horticultural production under present and future climate conditions).

VIII.3. SYSTEMATIC OBSERVATION[245]

MeteoLux is operating a meteorological station network at the Luxembourg Airport. First measurements and visual observations started in October 1946; systematic observations began on January 1, 1947. The station is manned and operated 24/7 throughout the year.

As per a law of 21 December 2007 on the ANA, missions of Luxembourg's Meteorological Service (MeteoLux) are defined as follows: *the core task is to provide meteorological assistance for safeguarding of aviation. Additional main tasks are the archiving and dissemination of climatological data as well as providing meteorological service and warnings of meteorological hazards for the general public and national authorities. This includes the provision of high temporal resolution hydro-meteorological/climatic data like precipitation, temperature etc.*

The **meteorological station is a synoptic station** (WMO ID 06590) under the WMO World Weather Watch (WWW) program ***[→ Section VIII.1]***. SYNOP-messages (FM-94) are issued on an hourly-basis via Belgium into the GTS. The key climate parameters reported in SYNOP messages are:

- the hourly air temperature;
- the 6-hourly amount of precipitation;
- the hourly 10-minute mean wind speed and direction;
- the maximum wind speed gust;
- the maximum 10-minute wind speed.

Further to this, **hydro-climatic data is disseminated** on a daily and monthly basis to national research institutes (e.g. LIST) and other national administrative authorities. The meteorological station is also part of the GCOS-GSN and CLIMAT-reports are distributed on a monthly basis via the WMO GTS ***[→ Section VIII.1]***. For aviation matters, key climate and aviation weather parameters are reported in the form of the METAR message (FM-15):

- the prevailing horizontal visibility;
- the 10-minute mean wind speed and direction;
- significant weather conditions;

245 The text of this Section has been prepared by Freyermuth, A., Bareiss, J., Reckwerth, M. of MeteoLux.

- cloud coverage and base height;
- air temperature and dew point temperature;
- atmospheric pressure.

Observations of meteorological conditions (instruments and visual estimation) are used for landing and take-off, en-route navigation and flight performance, and as a basis for forecasting. Those observations used primarily for aircraft operations are called "OPMET information" while those used primarily for forecasting purposes are considered to be "basic meteorological data". Basic meteorological data include synoptic surface observations. MeteoLux is also responsible for aeronautical climatology and provides monthly statistics of low visibilities and ceiling.

Since October 1 2015, MeteoLux operated new Automatic Weather and Observation Station (AWOS) software. The system follows the ICAO Annex 3 recommendations.

Since 2011, a **Climate Data Management System** is implemented at MeteoLux, called CLiSys. CliSys has been developed by *Météo-France International* in compliance with WMO and GCOS guidelines, and in the frame of a tight collaboration with *Météo-France*. The system benefits from regular upgrades and permits e.g. historical data import, quality controls, customized production of reports, summaries, and time series. The latest upgrade of the software was done in May 2017, together with the replacement of the operational server in order to enhance the performance of the system. In addition, a second backup server was installed, ensuring the continuity of the data flow. To further improve the data quality, several quality controls specified by MeteoLux were implemented in CliSys by MFIand a Data Rescue Program started in 2013/2014 in order to digitize additional historical meteorological data that is available on an hourly basis since 1946.

The Water Agency is the competent authority for the provision of flood forecasts for all watercourses in Luxembourg. In case of an alert, the website on flood risk[246] is updated with additional information on flooding and by a flood report. These reports contain information on weather conditions, the current situation and the forecast of water levels of the alert stations. Outside flood warning times, the current water levels and forecasts can be viewed. Water levels are updated up to every 15 minutes. The predictions are calculated and published three times a day, depending on the situation an hourly update is possible. For approximately 15 stations, predictions of water level are presented with a forecast time of up to 24 hours.

246 www.inondations.lu.

The Water Agency is responsible for the hydrometric stations in the catchment of the Sauer, Chiers and Syre. It operates hydrometric monitoring stations at more than 50 locations in Luxembourg:[247]

- 40 gauging stations;
- 14 precipitation stations (rain gauges);
- 10 air temperature stations;
- 4 meteorological stations (including rainfall);
- 3 groundwater-monitoring stations (in the alluvium).

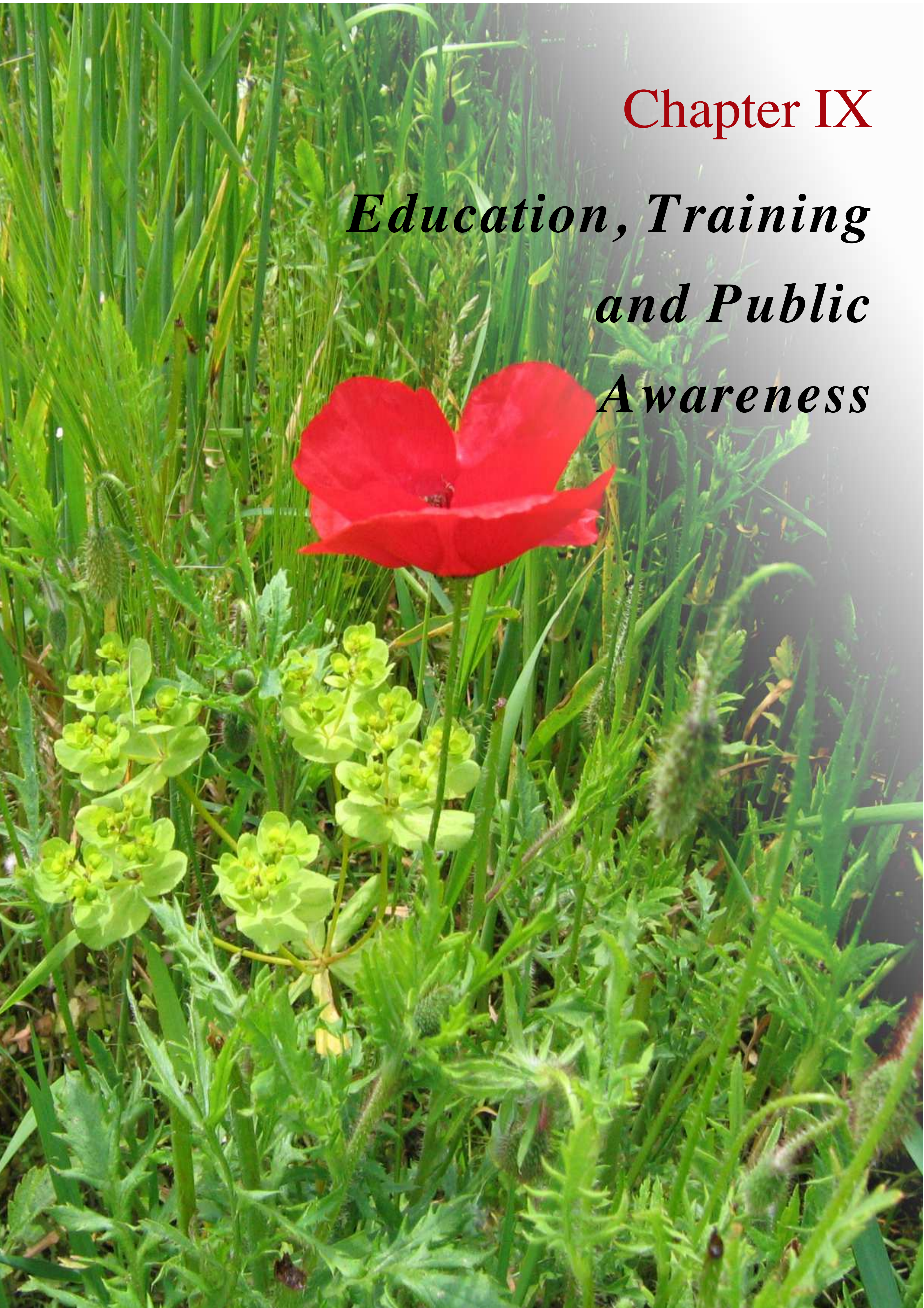
All measurement data can be provided upon request.

The *Service de la navigation*, under the authority of the Minister of Transport, is responsible for the hydrometric stations in the Mosel catchment.

247 https://inondations.lu/information/about.

Chapter IX

Education, Training and Public Awareness



Chapter IX describes actions undertaken in Luxembourg in the fields of education, training and public awareness in line with UNFCCC reporting guidelines, paragraphs 65 and 66. This chapter is divided in four sections: public information and awareness *[→ Section IX.1]*, education *[→ Section IX.2]*, training programmes *[→ Section IX.3]*, and involvement of the "civil society" *[→ Section IX.4]*.[248]

IX.1. PUBLIC INFORMATION AND AWARENESS

IX.1.1. Operations led by or involving the Department of the Environment

The Department of the Environment conducts regular awareness and information campaigns on environmental issues, with biodiversity, waste, climate change and energy savings being the most recurrent themes. Campaigns are increasingly supported by the online media.

Different actions and/or campaigns are linked to the issue of climate change – they are presented thematically and chronologically from 2010 onwards.[249]

In the context of the Luxembourg ecological fair "Oekofoire", that was organized annually up to 2016 by the NGOs *Mouvement Ecologique* and *Oekozenter Pafendall* *[→ Section IX.4]*, the Department of the Environment launches every year an awareness campaign based on a specific theme.
(http://www.oekofoire.lu/)

In particular, the fair stands in the years **2010** and **2011** were related to the climate change issue. During these two years, the Department of the Environment presented the "***Partenariat pour l'Environnement et le Climat***" ("Environment and Climate Partnership") initiative *[→ Section IV.1.2]* with the aim of promoting civil society involvement in the climate change issue.
(http://www.environnement.public.lu/actualites/2010/09/Oekofoire/index.html)
(http://www.developpement-durable-infrastructures.public.lu/fr/actualites/communiques/2011/09/16_Oekofoire2011/index.html)

The ecological fair stand hosted in **2016** in collaboration with the Ministry of Housing, the Ministry of the Economy and the partners *myenergy* and *oekotopten.lu* was held under the motto "**Together for Climate Change**" ("*Zesummen fir de Klimaschutz*"). The main goal was to promote information on the revised public subsidies that are being granted for housing (for more information, see paragraph on the new legislative package in this section), for investments in renewable energies, for the purchase of energy-saving household appliances and for green mobility, i.e. e-bikes and e-cars.
(http://www.environnement.public.lu/actualites/2016/09/20_oekofoire/index.html?highlight=oekofoire)

248 This chapter has benefited from extensive contributions from Karin Riemer and Jérôme Faé from the Department of the Environment.

249 For older operations and campaigns, refer to [Ministry of Sustainable Development and Infrastructure, Department of the Environment (2010), p. 244-247].

The illustration below shows the main exhibition pane that was displayed at the 2016 fair:

Adopted by the Government Council on 23 November 2010, the **Second National Sustainable Development Plan** (NSDP2) (see Box IV.1-4) has been presented to the public in **May 2011**. A printed brochure (available on request) and its web-based version were issued – the brochure is an abstract of the full NSDP2. The climate issue is presented alongside topics such as biological diversity, social cohesion, mobility and others.

(http://environnement.public.lu/fr/developpement-durable.html)

Currently, Luxembourg is in the process of elaborating its **Third National Sustainable Development Plan** (NSDP3). This plan will build on Luxembourg's report regarding the implementation of the 2030 Agenda with the 17 Sustainable Development Goals (SDGs) in and by Luxembourg. [250] The report, addressing the current state of the existing policies and the global commitments integrating the SDGs, also contributed to the national voluntary review in the margins of the High Level Political Forum of the United Nations in July 2017 in New York. The report was

250 *Mise en oeuvre de l'Agenda 2030 au et par le Luxembourg : transformer les vies tout en préservant la planète* (http://www.gouvernement.lu/7018419/rapport_meo_Agenda2030.pdf).

adopted by the Government Council on 12 May 2017 and is being followed by an in-depth gap analysis based on indicators with recommendations that will be reflected and incorporated into the NSDP3.

Demographic, economic and environmental challenges that occurred during the last decades put pressure on several primary action domains (social inclusion and education for all, diversification and decarbonisation of economy, land use, sustainable mobility, environmental degradation, climate protection) and increase the harmful tendencies that can affect a sustainable development in Luxembourg. For that matter, several recent flagship initiatives undertaken by the Government addressing these issues have been linked to the SDGs.

Since the implementation of the SDGs is ambitious in itself, Luxembourg plans to strongly implicate youth groups, civil society, private sector, municipalities and schools into the elaboration and implementation process of the NSDP3. The NSDP3 is planned to be finalized for June 2018.

(http://environnement.public.lu/fr/actualites/2017/05/29_agenda_2030.html)

(http://www.gouvernement.lu/7018389/31-objectifs-millenaire)

In **October 2012** the Department of Environment, in cooperation with *Emweltberodung asbl* *[→ Section IX.4]*, produced a short video clip (1 min.) and a documentary (16 min.) in relation to **energy savings in everyday life**. These videos were presented on the website of the Department of Environment, as well as on vimeo and Facebook.

Oekotopten.lu is a consumer-oriented online search tool set up and jointly developed by the Ministry of Sustainable Development and Infrastructure and the two NGOs *Mouvement Ecologique* and *Oekozenter Pafendall*. It displays "best products" from various categories (i.e. larger household appliances like washing machines and refrigerators, TVs, lamps, cars etc.). The key criteria for differentiating such products are energy efficiency, impact on the environment, health and quality. In January 2013, on the occasion of its 5-year anniversary, an updated presentation of the website was introduced, as well as its mobile version. In order to facilitate the search for and purchase of the various appliances listed in the "best products" categories, the website introduced an interactive map that can be used by consumers to locate the more than 80 ***oekotopten.lu*** partner stores in Luxembourg. In these partner stores, the website-listed topten items are marked with the respective ***oekotopten.lu*** label and customers are guaranteed a best possible information/consultation on the corresponding energy efficiencies. *Oekotopten.lu* is co-funded by the *Intelligent Energy Europe* programme of the European Union[251] and a member of the European project "Topten Act" and the network "Topten International Group (TIG)".

(http://www.oekotopten.lu/)

[251] http://ec.europa.eu/energy/intelligent/.

From **October to November 2013**, the Government, represented by the Department of Environment, the Ministry of Housing, the Ministry of the Economy and *myenergy*, launched a multimedia campaign (print ads, web banner, TV & cinema video clip, radio spots) to promote **energy efficiency and the use of renewable energy sources**. The focus was set on the advantages for households of energy modernisation (more comfort and fewer costs) and on the various subsidies and grants offered by the Government for the renovation of existing buildings aiming at energy efficiency gains. In order to recall print and online ads made in the last years, as well as the role of *myenergy* as the main counselling reference regarding energy efficiency and renewable energy sources, the "**PRIMe House**"[252] visual was re-used and put in a new and broader context.

In **2016**, a new legislative package was presented by the Department of Environment, the Ministry of Housing, the Ministry of Finance and the Ministry of the Economy. This legislative package, named "**Climate Bank and subsidies for sustainable housing**" ("*KlimaBank a Prime fir nohaltegt Wunnen*") and which took effect on 1st January 2017, aims at promoting sustainable construction, energetic renovations and a stronger reliance on renewable energy sources. The package comes with several novel elements but also a revision of existing grants and subsidies such as the "PRIMe House" regime. The key elements of the package are:

- implementation of a new financing mechanism referred to as "**Climate Bank**" offering either a reduced-rate loan or a zero-rate loan, depending on socio-economic factors. This new mechanism targets the promotion of sustainable and energy-efficient residential building renovation/sanitation and the prevention of energy insecurity;[253]
- revision of the existing grant regime "**PRIMe House**" with focus on sustainable construction of residential buildings, energy-efficient and sustainable renovation/sanitation and renewable energy sources;
- introduction of a certification system for new and sustainable residential buildings, termed **LENOZ** (as derived from the native expression: "*Lëtzebuerger Nohaltegkeets-Zertifikat fir Wunngebaier*"). The system relies on three sustainability-oriented pillars: protection of the environment, economic efficiency and social justice.[254]

In light of these changes, and in order to **facilitate administrative procedures**, a single desk within the Ministry of Housing and the Ministry of Sustainable Development and Infrastructure was established.

252 See section IV.3.1.1.

253 See also PaM EC07 – Table IV.3-2.

254 See also PaM EC05 – Table IV.3-2.

This so-called "**One Stop Shop**" significantly simplifies the required application procedures and allows a centralized processing for all grant-related applications in the housing construction domain.

(http://www.guichet.public.lu/citoyens/fr/logement/index.html)

(https://www.myenergy.lu/fr/mediatheque/telechargements/telecharger/962)

The two illustrations below (as used in the printed brochures) show the visuals under the 2017 legislative package promotion campaign:

In **2014**, ***Emweltberodung asbl [→ Section IX.4]***, the ***Institut de Formation sectorial du Bâtiment*** (IFSB) and the Department of the Environment launched the project "**ecoquartier**". This project was developed as a planning support for Luxembourg's municipalities that are oriented towards various energy- and sustainability-relevant domains, such as agriculture, energy, waste, water, land-use and mobility. The project clarifies existing responsibilities and constitutes a source of ideas to encourage sustainable development by providing best practice examples.

(http://ecoquartier-miroir.eu/index.php/home)

In **2015**, the Department of the Environment signed conventions with ***IMS* (*Inspiring More Sustainability*) *and CELL*** (Centre for Ecological Learning Luxembourg) ***[→ Section IX.2] in order to support companies in the implementation of sustainable policies in the areas of climate change, energy and mobility, on one hand, and to implement the project "Development of the citizen and energy transition in Luxembourg", on the other.***

As explained in Box IV.1-9, ***myenergy*** was created to promote renewable energy projects and to inform citizens, the economic sector as well as municipalities on a better use of energy, renewable energy sources and financial public support. Therefore, *myenergy*, whose public partners are the

Department of the Environment, the Ministry of the Economy and the Ministry of Housing, is the national focal point put in place to inform and raise awareness in all energy matters. With its team of advisers, *myenergy* provides services in the following domains:

- how to reduce energy consumption in existing buildings and how to refurbish them consequently?
- how to ensure low energy and/or energy efficient new constructions?
- how to develop the use of renewable energy sources?
- how to save energy in everyday life?
- what are the financial incentives offered by the Government?
- what is the regulation with regard to the energy balance of housing?

Thus, *myenergy* may be defined as the **national energy advice structure**, supported by the Luxembourg Government. As such, the web site of *myenergy* also acts as an information gateway to all these issues.
(http://www.myenergy.lu)

Since it started operating back in 2008, *myenergy* has developed one of its main activities, which is free energy advices offered to households or businesses by telephone or by appointment. In order to improve this service, *myenergy*, in cooperation with either municipalities or municipality associations, has started developing regional advice centres: ***myenergy infopoints***. Nowadays, 100 municipalities share energy advices with the support of *myenergy* in 21 offices disseminated throughout the country. Approximately 90% of the population has an access to *infopoints*, the other 10% having always the possibility to go to the main premise of *myenergy* in Luxembourg-City.
(https://www.myenergy.lu/fr/communes/nos-prestations-pour-vous/myenergy-infopoint-de-quoi-s-agit-il)[255]

In addition to advices, *myenergy* has developed numerous **informative tools** for different target groups:

- thematic leaflets for households and businesses;
- a website for private consumers, municipalities, companies and experts providing complete and targeted information;
  (http://www.myenergy.lu)
- an exhibition stand with general technical information and theme exhibitions on passive houses and energy renovation intended for municipalities;
- specific material addressing the children;
- an electricity measurement device that may be borrowed for free in the *myenergy infopoints*;

[255] See also PaM EC11 – Table IV.3-2.

- "*EnerCoach*" program – an energy bookkeeping software for municipal infrastructures and for equipment that monitors consumptions of heat, water, electricity and CO_2 emissions;[256]
- *smart home* - online animation tool with visualization of "smart" neighbourhoods, allows the discovery of energy-related topics such as sustainable constructions, advantages of smart technologies and introduces the concept of the circular economy; (https://www.myenergy.lu/fr/mediatheque/actualites/smart-home)
- increased use of social media: introduction and maintenance of Facebook/LinkedIn accounts with regular updates;
  (https://www.facebook.com/myenergy.lu)
  (https://www.linkedin.com/company/myenergy-gie)
- development of mobile app "*my AAA*": interactive 3D tool which provides information on high energy performance homes;
- introduction of a toolkit "*building inspections for more energy efficiency*" – a checklist package to support municipal staff when performing building inspections or when issuing building permits. The checklist package gives an overview of the minimum energy requirements that have to be met.

Finally, myenergy is behind the **launch of numerous actions and events**:

- *Passive House Week*: since 2010, with an exhibition on passive housing, conferences aiming at a private and professional public, guided tours of passive houses in Luxembourg;
- *myenergy days*: annual event, first edition of this national fair specialized on energy renovation in May 2011 with the aim of creating a new and until then non-existing exchange platform for professionals and private persons to increase the energy efficiency of the national housing sector; the number of exhibitors (from 45 in 2011 to around 100 in 2016) and visitors is steadily growing;
- general and theme cross-media advertising campaigns, the campaigns being either general image promotion campaigns for *myenergy* itself or the *myenergy infopoints* network, or focusing on specific themes such as energy renovation or public subsidies ("Climate Bank", "PRIMe House", etc.);
- editorial contribution to the national and regional press on a regular basis, either to present or promote projects and events, but also to deliver technical and practical information on energy efficiency, renewable energy sources and public subsidies;
- thematic conferences and evenings on the same topics as those covered by the thematic leaflets presented above. These presentation packages are held by *myenergy* advisors and are meant for private persons. Companies, municipalities and other associations nevertheless may book them too;

[256] See also PaM EC26 – Table IV.3-2.

- awareness raising amongst children, *myenergy* having participated in 2010, 2011 and 2013 in the organization of an awareness raising action ("*Galileo Science Bus*") with the "*Musée national d'histoire naturelle*". This action took place in the "*Energiepark Remerschen*" and offered a daily program of activities and presentations for school classes. In 2012, *myenergy* also developed a package of presentations and demonstrations for children that can be booked by school classes and other associations;
- *Renov'action:* annual event, with didactic lectures, live demonstrations and guided visits in renovated houses. The first edition of this concept took place in 2015 with lectures organized regionally in five different locations throughout the country. Altogether, 260 participants took part with a total of 10 guided visits;
- *myenergy at home:* weeklong event with first edition in 2016. Upon request, a *myenergy* consultant makes domestic visits and offers advices free of charge;
- management/mentoring/development/execution of the climate agreement with the municipalities – *Pacte Climat* *[→ Section IV.3.1.1]*: organization of the "climate agreement day" and participation in the "European Energy Award" (EEA) ceremonies.[257]

During **mid-2017**, the Department of the Environment together with the national television channel RTL aired a new **television cooking show titled "More with less"** ("*Méi mat Manner*"). In multiple episodes of this show, a number of contestants compete about buying food items and preparing meals as sustainably as possible. Special consideration is given if products are bought locally, seasonally, unwrapped and environmental-friendly. After broadcasting, the main conclusions were drawn from the show and concrete suggestions formulated within the framework of the **National Waste & Resources Management Plan**.[258]

(http://environnement.public.lu/fr/actualites/2017/06/mei_mat_manner.html)

[257] See also PaM EC25 – Table IV.3-2.

[258] See also PaM WM01 – Table IV.3-7.

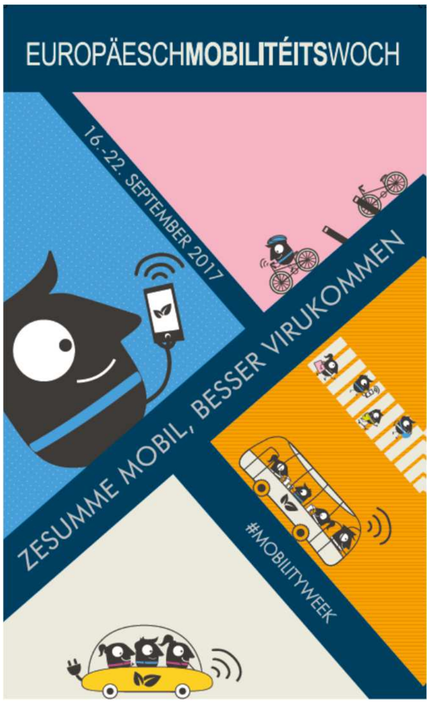
In **September 2017**, the Ministry of the Economy, the Department of the Environment and the Ministry of Housing in collaboration with *myenergy* launched a **photovoltaic energy promotion campaign**. The aim was to put forward the efforts and contributions by the civil society in favour of the energy transition and to highlight the financial profitability of investing in solar energy. Within its multiple promotion measures including advertisements at bus stops and bus rears (see visuals below), internet and press, the main highlights include eligibility extensions of the financial aids to include private persons, companies, civil society, cooperatives and municipalities. Furthermore, injection rates for installed capacities higher than 30 kW were introduced.

(https://www.myenergy.lu/fr/cleversolar)

IX.1.2. Other operations[259]

Some initiatives aiming at a more environmental friendly behaviour can also be associated to the climate change thematic.

The Ministry of Sustainable Development and Infrastructure, with the cooperation of the Transport Community (CdT – "*Verkéiersverbond*"), a public institution under the Ministry, regularly participates in the **European Week of Mobility** (**"*Europäesch Mobilitéitswoch*"**).
(http://www.mobiliteitswoch.lu/)



The yearly sensitization and **awareness-raising campaign "*bike to work or school*"** ("mam velo op d'Schaff oder an d'Schoul") organized by the Transport Community in cooperation with the Department of Transport of the Ministry of Sustainable Development and Infrastructure (10th edition in 2017) aims at promoting bike culture in Luxembourg.

259 For operations and campaigns prior to 2010, refer to [Ministry of Sustainable Development and Infrastructure, Department of the Environment (2010), p. 247-249].

For that matter, teams of up to 4 people need to ride their bikes to work or school at least 15 times during a given time period (usually 15 May – 31 July). The company or school with the most successful participation is awarded a trophy. The campaign encourages multimodal mobility by allowing participants to combine their bike rides arbitrarily with the use of public transportation (bus, train etc.). Statistical data including the total number of teams and participants, distances covered and indications of CO_2 savings are provided and regularly updated on the internet site. The opportunity of this campaign is also seized to inform participants on rules of conduct that need to be adopted on the road, security-related matters and they also receive advice for the right choices on technical and personal bike equipment.
(http://www.mvos.lu/)

In **June** 2012, the Department of Transport of the Ministry of Sustainable Development and Infrastructure initiated "**MoDu**", Luxembourg's global strategy for a sustainable mobility.[260] "MoDu" is an integrative approach favouring public transport, in particular cycling and walking ("*mobilité douce*"), and defining the infrastructure priorities of Luxembourg for the next years. The "MoDu" concept was presented at the Springtime Fair 2012. A brochure in German and French was sent to all secondary schools in Luxembourg.
(http://www.mt.public.lu/planification_mobilite/1strategie_modu/Strategie_pour_une_mobilite_durable_Version_integrale_MODU.pdf)

260 See Box IV.1-5 as well as PaM TR21 which covers PaMs TR01 + TR02 + TR22 + TR23 + TR24 + TR25 – Table IV.3-3.

The first edition of the "***Tour of the village***" ("*Tour du Duerf*"), organized by the Transport Community **and Climate Alliance Luxembourg** – *Klima-Bündnis Lëtzebuerg*[261], took place in **2014** and is since then repeated on a yearly base. The competition is carried out between local politicans and citizens. The aim of the campaign is to sensitize the general population and local politicians to use their bike in everyday life and to further integrate the topics of bicycle-use and bicycle-traffic planning into local council discussions. In fact, local politicians should experience what it means to use the bike within their own municipality in order to start thinking about measures to improve traffic situations and initiate their implementation. Furthermore, their commitment should function as an exemplary role to encourage other people to use the bike. The travelled distances are gathered over a period of three weeks and the winning municipality and teams are awarded ceremonially.

TOUR DU DUERF
Responsabel fir meng Gemeng

In **2014**, the "***heater check***" ("*Heizungscheck*") was implemented by the Environment Agency to facilitate the heater inspection procedures as required by national law. Heater installations are inspected following an established protocol to identify saving potentials and elaborate optimization measures. The heater check only covers energy-relevant aspects such as energy efficiency, energy consumption and energy-related costs.

In **2017** and in light of the tax reform, the Ministry of Sustainable Development and Infrastructure started an initiative called "***drive cleverly, save taxes***" ("*Clever fueren, Steiere spueren*"; see visual below) and introduced a new set of measures to promote sustainable mobility with the following main features:

- tax relief for the purchase of zero emission vehicles (5,000 €), bikes and pedelecs25 (300 €) for private persons valid from January 1st, 2017 (depending on certain conditions);
- reassessment of the lump-sum advantages for service cars depending on their environmental impact relative to their contribution to the greenhouse effect (CO_2 emissions) and air pollution (NOx emissions).

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261 See BoxIV.1-7.

CLEVER FUEREN Steiere spueren

The general aim of this approach lies in making the purchase of diesel cars less attractive and thereby contributing significantly to the improvement of public health and to the protection of the environment.

(http://www.developpement-durable-infrastructures.public.lu/fr/developpement-durable-infrastructures/mobilite-durable/index.html)

In a parallel process, larger investments in Luxembourg's infrastructure are being undertaken in order to enable the expansion of the network of **charging stations for electric and plug-in hybrid cars**. By 2020, the network is expected to comprise around 800 charging terminals distributed strategically, in proximity to points of interest, and equally, between public parking lots of municipalities and Park & Ride facilities. A mobile application also provides an overview on the existing charging station grid as well as various technical information.

(https://chargy.lu/fr/)

Even more, Luxembourg promotes and expands its **carsharing infrastructure** by offering several car sharing services in and around Luxembourg city:

- *Carloh Car Sharing* is the first provider of professional carsharing in Luxembourg and gives access to a fleet of cars in the city of Luxembourg. The cars put at disposal by Carloh are allocated in the heart of the main city districts, near the central station and in the city centre.
  (https://www.carloh.lu/en/)
- *City Mov'* is a service provided by several municipalities which offers car and e-bike sharing and intends to complement the offer in public transportation.
  (http://www.citymov.lu/particuliers)
- *Flex* is a new car-sharing provider that will be available early 2018 and which is part of an initiative undertaken by the Luxembourg National Railway Company. The service aims to offer great flexibility to Flex car users by placing a total of 86 electric cars strategically around 20 of the most used train stations in Luxembourg. People can also use their Luxembourg public transportation travel card, the so called "*M-Kaart*" ("mobility-card") to get access to the Flex service.
  (http://www.cfl.lu/espaces/voyageurs/fr/actualites/actus/flex-carsharing-by-cfl)
  (http://flex.lu/)

In **2017**, the Ministry of Sustainable Development and Infrastructure – Department of Transports launched an **online survey** to assess the mobility habits/situation of Luxembourg's citizens as well as commuters. The survey aims to help public authorities in better organizing and planning public transportation. The same Department also announced the development of a carsharing app that will most likely be available early 2018.

IX.2. EDUCATION[262]

A range of actions and initiatives exist in Luxembourg to make children and students aware of various environmental issues as well as familiar to the concept of sustainable development. Examples of such activities can be read in a distinct section of the environmental web portal. (http://www.environnement.public.lu/kanner/index.html)

With regard to climate change in particular, the following actions of **Climate Alliance Luxembourg (see Box IV.1-7)**, a network grouping almost half of the municipalities in Luxembourg, may be noteworthy to mention:

- in the years **2010-2013**, many children from primary school have visited the interactive exhibition "*Klima, Kanu, Quetschekraut*". It has given over 5000 kids an insight of how our climate system works and what the impacts of climate change are, especially with regard to the rain forest regions;
  (http://www.klimabuendnis.lu/klima-kanu-quetschekraut-2/)
- through the promotion of the German project "*Geoscopia Klimaexpedition*", Luxembourg's schoolchildren aged 11-12 years old could discover live satellite pictures of different parts of the world like the pole caps or tropical forests and compare them to historical pictures of the same areas;
  (http://germanwatch.org/klima/ke.htm)
- public exhibition in **2014** "*Nous sommes tous témoins – destins humains dans la tourmente climatique*" ;
- the "*Op Kannerféiss duerch d'Welt*" operation led in **2011, 2013, 2015 and 2017**, invited children and their parents to leave the family car in the garage and to walk, cycle or take the bus/train to go to school for at least one week;
  (http://www.klimabuendnis.lu/fr/op-kannerfeiss-duerch-dwelt-2017/)
  (http://www.klimabuendnis.lu/wp-content/uploads/2017/03/Kannerfeis-depliant-2017.pdf)

[262] For initiatives prior to 2010, refer to [Ministry of Sustainable Development and Infrastructure, Department of the Environment (2010), p. 253].

- a new and free catalogue is being offered to member municipalities, local associations, schools and organizations with modules and materials to be used for educational and sensitization purposes; (http://www.klimabuendnis.lu/fr/un-nouveau-catalogue-des-cours-de-formation-nordsud)
- exhibition and workshops on climate change issues in light of the environment weeks in 2016.

"***Action Solidarité Tiers Monde***" (ASTM)[263] – in its role as responsible NGO for imparting knowledge on "North-South" issues – and **Climate Alliance Luxembourg** both support – amongst others – grass-roots organisations in the Global South, whose local projects are closely linked to climate impacts so to make the public aware of the fact that climate change is a global concern. In this context, ASTM constantly develops educational material such as exhibitions, booklets or workshop concepts. The municipality members of Climate Alliance Luxembourg use such educational material to organize regularly awareness raising projects.

Several collaborations with partner organizations exist:

- CHINTAN (India): linked to waste management; (http://www.chintan-india.org/) (http://astm.lu/wp-content/uploads/2011/01/Brochure-Chintan-aou%CC%82t-2012.pdf)
- ARFA (Burkina Faso): adaptation to climate change impacts in the agricultural sector by improving agro-ecological techniques to enhance soil fertility and humidity levels; (http://www.ongarfa.org)
- MASIPAG (Philippines): facing climate change in agriculture; (http://www.masipag.org)
- FDA (Ecuador): defending human and environmental rights.

Besides, awareness-raising initiatives, especially among children and students, aim at giving ideas on how to (re)act or at presenting possible alternatives that can be taken. Motivating this target group to take action in climate protection is the central objective.

In this context **Climate Alliance Luxembourg** launched the project "***GO(al) for fair development!***" intended for football youth clubs as it focused on the first international football tournament which was held in South Africa in 2010. Youngsters from eight different youth clubs in Luxembourg were asked to choose one of the 32 world cup teams/countries they would represent in their own tournament at the end of the three-month project. First, they had to develop specific presentations on these respective countries. The presentations had to deal with racism, culture, climate change, migration, among others, all these themes being linked to the issue "development". For most youngsters this was the first active confrontation with this thematic. (http://astm.lu/goal-for-fair-development/)

263 http://astm.lu/.

The ***Centre for Ecological Learning Luxembourg*** (*CELL*), launched in **2011**, is a non-profit organization and volunteer network that provides an experimental space for thinking, researching, disseminating and practicing post-carbon lifestyles and regenerative culture. *CELL* co-ordinates and supports local initiatives of the *Transition movement* in Luxembourg and provides expertise and education services on permaculture, low-carbon projects and resilient living research. *CELL* enables and supports regional and thematic action groups within the Luxembourg Transition Platform on the energy transition, the food transition as well as the citizen-led transition.

(https://cell.lu/)

move. is a project founded by the *Mouvement Ecologique* in **2015** in view of Luxembourg's Presidency of the Council of the European Union at the COP21 in Paris. The project supports younger generations (up to 27 years old) in their engagements for a future-oriented and environmental-friendly society. Meetings/activities/workshops take place on a regular basis in the *Oekozenter Pafendall* and address current topics/issues such as climate change, mobility, housing, environmental education, globalization and consumption. *move.* also organizes workshops for schools and youth clubs and offers internships for students in specific fields.

(http://move.meco.lu/)

Recent events/activities (2017) of the *move.* project include:

- *move.approved*: creation of a city map/city guide to locate shops/restaurants that fulfil a defined set of sustainability criteria developed by *move.* members; (http://move.meco.lu/wp-content/uploads/2017/04/move.approved-online-LU.pdf)
- *move.Gaart 1*: rural excursion with debates and critical reflections on the development of the agricultural sector and policies;
- *move.Summercamp*: a 3-day get-together-event with focus on various topics;
- several discussion rounds in view of the local elections in October 2017.

The *Oekozenter Pafendall* media library *oekobib* has become publicly available in April 2017 and offers a broad and well-sorted range of literature, magazines and didactic material on sustainability-, nature-, health- and policy-related themes.
(http://www.oekobib.lu/)

IX.3. TRAINING PROGRAMMES

Training programmes in Luxembourg in connection with the climate change problematic are **mostly vocational training initiatives in the field of energy efficiency in buildings**. Several bodies, mainly professional associations or Orders, organize such trainings. For example:

- the OAI with its "*Energy & Construction* "cycle (current cycle 2017-2018) offering training sessions in sustainable construction methods;[264]
- the *House of Training* with training courses in planning of high energy performance homes to acquire the label "internationally certified high energy performance home planer";
- the *Energie fir d'Zukunft-plus* label of the *Chambre des Métiers* (Chamber of trades) that requires vocational trainings for enterprises (it replaces the former *Energie fir d'Zukunft* label from 2017 on); the label is valid for a duration of 5 years and label holder (+ company) names are published.[265]

- the "*build-up skills Luxembourg*" programme that is initiated in the context of the EU project "Build up skills, energy training for builders" and that is co-funded by the Horizon2020 Programme of the European Union and coordinated in Luxembourg by *myenergy*, the Chamber of Trade, the Federation of Craftsmen (FDA) and the Training Institute for the Building Sector (IFSB).[266] In the context of this initiative, the LuxBuild2020 consortium was created in 2014. The main goal is to prepare builders for the 2017 challenge, which consists of constructing residential buildings solely under the high-energy performance standard (AAA) as required by law. In order to guarantee the availability of a highly qualified working force and enhance their access to and the offer of training courses, the following projects were initiated by the lead partners:
  - development of training courses for multipliers to spread know-how within companies;

264 http://www.oai.lu/fr/162/oai/accueil/formations-continues/oai/.

265 http://www.cdm.lu/formation-continue/energie-fir-d-zukunft-plus & http://www.passivhaus-handwerk.de/.

266 See also PaM EC51 – Table IV.3-2 – and https://www.luxbuild.lu/fr.

- development of company coaching regarding energy efficiency;
- development of an educational tool (AAA BOX);
- personalized support for the preparation of grant request dossiers;
- development of technical competence centres.

- the *myenergy certified* label to emphasize particular qualities of builders. In order to acquire the label, professionals need to demonstrate their knowledge/qualifications and have to engage in a quality insurance programme implemented by *myenergy*.

- *SuperDrecksKëscht* training and further education addressing companies in the production and waste domain. Training sessions, through the *SuperDrecksKëscht* competence centre, include information on waste prevention (ecological waste management, reverse production, protection of ozone layer, ISO14024) and teaching of economic practices and circular economy;
- the *Learning Factory* provides experiential learning on energy efficiency improvements in production cycles and optimization of production processes (identification and reduction of energy losses, increase of resource productivity…).

In **2011**, **Climate Alliance Luxembourg** together with the **National Institute of Public Administration** (INAP) conducted a **training programme for municipality staff on sustainable procurement** ("*Formation pour agents communaux sur l´approvisionnement durable*"). Since then, the training programme has been offered regularly and gives information about the principles of sustainable procurement but also recommendations on the implementation within the municipality structures.

An important online tool set up by **Climate Alliance Luxembourg** in **2011** is the so-called **ECORegion**, which allows the member municipalities to establish their CO_2-balance, thus giving them better understanding of how much energy is spent where and by whom.

In **2012**, **Climate Alliance Luxembourg** launched training programmes related to the climate change issue (e.g. to guide visitors round an exhibition). To optimise the access to its target groups in Climate Alliance Luxembourg, ASTM developed and conducted trainings for community staff and volunteers (committees), i.e. members of the target groups within the municipalities themselves. These participants afterwards not only organise activities for their own municipalities but they also strengthen the networking between the members of Climate Alliance Luxembourg by operating in other municipalities.

The initiative "***Klima-Bündnis Betriebe***", launched in **2013** by **Climate Alliance Luxembourg** aims to help small and medium sized businesses in energy efficiency and mobility issues.

Finally, **Climate Alliance Luxembourg** organized many other conferences and workshops on issues such as local energy concepts, energy cooperatives, mobility concepts, etc.

In **2016**, new training sessions were introduced for teaching staff on topics related to **land grabbing and climate change**. The courses and workshops were offered by the ASTM and intended to give teachers background material to include these topics into their educational curricula and familiarize children with terms like climate change, greenhouse effect, impacts etc.

(http://www.klimabuendnis.lu/fr/nouvelles-formations-continues-offertes-par-lastm-pour-enseignants-et-educateurs-sur-les-sujets-climat-et-landgrabbing/)

Neobuild is a technological innovation pole for sustainable construction in Luxembourg. This private body assumes several roles: (i) a market observer promoting the transfer of technology, (ii) a skill aggregator providing expertise and partnership through an expert network, (iii) a provider for expertise in development and innovation, and (iv) a facilitator for the promotion and dissemination of innovation projects. *Neobuild* members are guaranteed access to various services including the *Neobuild* Innovation Living Lab, which allows testing, monitoring and analysing the behaviour of innovations in a zero-energy building under real life conditions. Other services include coaching innovations, urban farming, event planning, information distribution through the Neomag magazine and maintenance of the information portal and collaborative platform Construction21.

(http://www.neobuild.lu/)

(https://www.construction21.org/luxembourg/)

Luxinnovation is an organisation that contributes to the economic development of Luxembourg by strengthening national business through innovation and by promoting Luxembourg business abroad. A service that is noteworthy to mention are the Luxembourg Cluster Initiatives that focus on reinforcing the links between business and research by targeting key technologies and boosting existing economic fields in Luxembourg but also by developing new business sectors. For instance, the EcoInnovation Cluster focuses on sustainable living and eco-technologies and seeks to diversify the activities of Luxembourg-based companies, to contribute to the development of new environmental solutions and to raise public awareness for the uptake of green technologies. *Luxinnovation* provides expert and personalized support for innovative start-ups and innovation activities.
(https://www.luxinnovation.lu/)

The *Luxinnovation* Fit 4 Circularity performance programme has been designed to facilitate and accelerate a company's transition to the circular economy. The programme helps to explore the possibilities of extending the life cycle of products and highlights potential gains linked to circular supply chains. It also studies the benefits of collaborative platforms and analyses new business models based on selling – not products themselves – but the services provided by the products. Finally, Fit 4 Circularity underlines the importance of recycling and using recyclable materials for a more responsible production.
(http://www.innovation.public.lu/en/innover/pme-artisanat/fit-for-circularity/index.html)

IX.4. "CIVIL SOCIETY" INVOLVEMENT

As emphasized in ***Section IV.1.2***, "civil society" – i.e. stakeholders such as NGOs, professional associations, etc. – have been involved in the setting up of the second national "Action Plan for reducing CO_2 emissions" [Ministry of Sustainable Development and Infrastructure, Department of the Environment (2013b)] via the "***Partenariat pour l'Environnement et le Climat***" ("Environment and Climate Partnership") for which participation of the "civil society" was the prime aspect *[→ Sections IV.1.2 & IX.1.1]*. That was also the case in 2007, when the first Action Plan has been evaluated *[→ Section IV.1.2]*[267] and will be the case early 2018 for the third national "Climate Plan" ***[→ Section IV.1.3].***

267 A one day forum was organized (*Klimaschutz schaaft Chancen*) opened to contributions from various stakeholders.

Among the Luxembourg NGOs acting in favour of climate change protection, **Climate Alliance Luxembourg** and **ASTM** may be mentioned in the first place. The other important NGOs are the ***Mouvement Ecologique***,[268] the main Luxembourg nonprofit organization for the protection of the environment, and ***Oekozenter Pafendall***,[269] which acts more specifically for a sustainable development. Both NGOs have already been mentioned in *Section IX.1.1*. Finally, **EBL** ("*Emweltberodung Lëtzebuerg*")[270] is an advisory structure on all ecological issues mainly, but not exclusively, for municipalities.

Among the specific climate change campaigns initiated by Luxembourg NGOs, several are worth some explanations.

"**Energy-light**", was the name of a campaign led during the years **2010–2012** under the aegis of **EBL** to reduce energy spending of the municipal administrations through information and motivation of the employees. The campaign was relaunched in **2017** under the name "Energy-light reloaded". (http://ebl.lu/project/energie-light-reloaded/)

The EBL initiative "**akaf-plus**" intends to raise awareness among municipalities when purchasing supplies from different product categories, e.g. paper- and cleaning products, office supplies and food items. The custom-made practical guides primarily target municipalities, but their use can be extended to NGO's, public administrations, companies and educational institutions. Similarly, the campaign "**ech-kafe-clever**" is dedicated to the purchase of sustainable school and office supplies.
(http://ebl.lu/project/projekt-test-1/)
(http://www.ech-kafe-clever.lu/)

268 http://www.meco.lu/.
269 http://mouvement.oeko.lu/oekozenter.
270 http://www.ebl.lu/.

"**EnergyBridges**" – **a campaign for energy justice (2008-2010)** was a EuropeAid co-financed project that has built public awareness for the energy inequality between North and South. Since 2008, the partners in the Climate Alliance – European cities and municipalities and Indigenous Peoples in the Amazon rainforests – have been lobbying for a fair use of energy through public education campaigns, lobbying and concrete project support. They focused on the following goals:

- contributing to widen access to eco-friendly and renewable energies to reduce poverty;
- contributing to the sustainable use of the natural resources in the Amazon region;
- working towards achieving the Millennium Development Goals (MDGs);
- helping to initiate responsible energy production and use in industrialized countries.

Project partners of "EnergyBridges" were the Climate Alliance European Secretariat (lead), **ASTM**, **Climate Alliance Luxembourg**, Protect the Future Hungary, the Czech Environmental Partnership Foundation and, as southern partners, *Frente de Defensa de la Amazonía* (Ecuador), *Programa de Formación de Maestros Bilingües de la Amazonía Peruana and Centro de documentacion e informacion* (Bolivia).

(http://www.energybridges.eu/)

"**Local Authorities acting for the MDGs: Europe for more development**" (**2013-2015**) is an EU project which intended to contribute to the achievement of the Millennium Development Goals (MDGs). It helped to better integrate development issues into the work of local authorities. Together with the cities of Munich (Germany), Nuremberg (Germany), Tirgu Mures (Romania), Ostopovice (Czech Republic), Nagykanizsa (Hungary) and the long-term partners **ASTM** and **Climate Alliance Luxembourg**; Climate Alliance Austria, Reflex Hungary and other partner organizations from Romania and the Czech Republic Climate Alliance (European Secretariat) developed a wide range of materials and activities both for decision makers and citizens.

(http://action-for-mdgs.eu/)

"**From Overconsumption to Solidarity**" (**2013-2015**) was another project financed by EuropeAid. Three exhibitions were central to the project, "People in a changing climate" being the most important. In this exhibition, people from around the world reported on their current and future challenges and appeal to the responsibility of each individual. In addition to the show, the member municipalities have been offered a package of activities, such as trainings for decision makers and administration, seminars, films, art actions, theatre, etc. **ASTM was the lead organization** and the European project partners were Climate Alliance (European Secretariat), Climate Alliance Austria, Védegylet Egyesület (Hungary), Nadace Partnerstvi (Czech Republic), Priatelia Zeme-CEPA (Slovakia) and crossing borders (Denmark).
(http://www.overconsumption.eu/)

Another example for aware raising activities around climate change issues took place in **March 2012** at the "*Festival des migrations*" where **ASTM** arranged a viewing of Yann-Arthus Bertrand´s film "**7 billion others**", followed by a discussion with the attendees.
(http://astm.lu/29e-edition-du-festival-des-migrations/)

On their side, the ***Mouvement Ecologique*** and ***Oekozenter Pafendall*** are responsible for the following campaigns and initiatives:

- "***Energiewochen – Semaine de l'Energie***" – energy weeks are organized every year during three weeks to show house owners concrete examples for energy efficient construction and/or renovation. Environmental friendly materials are also a topic of these energy weeks. During the visits, participants may ask questions to architects, engineers and owners and can exchange experiences;
- "***Gréng Hausnummer***" – the green number for green buildings – is a distinction awarded by the two NGOs in collaboration with the Ministry of Housing. In this way, house owners ensuring a reduction of their CO_2 emissions by the choice of the right materials and the respect of energy criteria are publicly rewarded.
(http://mouvement.oeko.lu/hausnummer_oekozenter.301-2.html)
- "***Green meetings – green festivities***" – a project from *Oekozenter Pafendall* with partners with a mainly cultural background, intends to reduce CO_2 emissions during festivities and meetings.

- "*Mecoskop*" – a tool to keep track on the development of national policies and to monitor the state and quality of implementation of the 114 governmental measures regarding sustainable development.
  (http://www.mecoskop.lu/)
- "*DingDong – share your tools*" – a 2015 initiative by the *Mouvement Ecologique* that comes with a sharing platform for everyday objects with the goal of waste reduction, resource saving, environment preservation and promotion of social contacts.
  (https://www.dingdong.lu/)

Oekozenter Pafendall advises hotels, camping grounds, youth hostels in how to respect ecological criteria, with a strong focus on energy saving. The project "**Ecolabel**" is organized together with the Ministry of Sustainable Development and Infrastructure and the (former) Ministry of Tourism. (http://mouvement.oeko.lu/ecolabel_oekozenter.286-2.html)

Oekozenter Pafendall together with the organization of young farmers "*Jongbaueren a Jongwenzer*" also gives recommendations to farmers and carries through pilot projects like growing soya beans in Luxembourg instead of importing them from far away. The aim is to give new opportunities to farmers and to reduce the ecological and climate impact of food imports to Luxembourg. (http://www.oekozenter.lu/de/dienstleistungen/landwirtschaftsberatung/)

For the local elections in **2011** and the national elections in **2013**, *Mouvement Ecologique* developed concrete suggestions concerning climate and energy policies and transmitted them to a broad public and political parties, published articles in newspapers and organized round tables. In preparation of the local elections, a seminar was held to help new candidates to get a certain basic knowledge in key themes like energy and mobility.

ASTM, besides its cooperation with Climate Alliance Luxembourg, conducts every two years information campaigns on its own that are closely linked to the issue of climate change. Since 2010, the following campaigns have been undertaken:

- **November 2011**: "*Leurs minerais, notre richesse*" was a campaign about the excessive exploitation of natural resources in development countries for consumer electronics, harming at the same time indigenous people, the environment and the climate, and thus evoking a public discussion on consumerism, climate change and climate justice. A web page, bulk mailings, artist's workshops, leaflets, school workshops, a photo exhibition and public conferences formed part of the campaign. All national newspapers, television and radio reported in full. The video clip produced for this campaign is still available online;[271]
- **November 2013**: "*La grande braderie des terres*" was a campaign that tried to make the public aware of the impacts of transnational land deals for agriculture in the Global South. A

271 http://www.youtube.com/watch?v=u42CFp4Egn8.

significant number of multinationals – as well as financial institutions across Europe appear to be involved in financing land grabs and food speculation directly or indirectly. This purchasing or leasing land, and securing water rights for agricultural production has devastating impacts on the local population in the respective countries (human rights/working conditions/food sovereignty) as well as on the environment and the climate (e.g. monocultures for energy plants). A detailed program of the campaign activities, a web documentary on three case studies as well as background information and scientific studies can be found on the web page.[272]

As part of a consortium of Luxembourg-based NGOs named "*Cerealkiller*" ASTM campaigns for sustainable societies and for the protection of climate and environment in the context of the industrial production of agrofuels.
(http://cerealkiller.lu/)

Votum Klima, a platform of 26 NGOs with the common goal to increase peace, solidarity and climate justice, organized the *Luxembourg Climate March* in view of COP21 and to which over 800 people participated.

"*Eis Gemeng beSONNeg gutt*" is another campaign initiated by the *Votum Klima* platform. Its goal is to promote and support the use of renewable (e.g. solar) energies on a national level. So far, 13 municipalities are participating.
(http://astm.lu/eis-gemeng-besonneg-gutt/)

272 http://www.solidarite.lu/.

Finally, municipalities as well as professional associations such as **FEDIL** – the Business Federation of Luxembourg – also regularly organize seminars and information sessions that touch upon climate change, renewable energy sources, energy efficiency, mobility, etc.

IX.5. EFFORTS AND ACTIONS FOR SUPPORTING DEVELOPING COUNTRIES

Four NGOs under a framework agreement have a cross-cutting "sustainable development" thematic which is of course more broad than the one on climate change, but which is difficult to differentiate in these projects.

TABLE IX.5-1 – OVERVIEW OF THE NGOS ACTIVITIES RELATING TO AWARENESS RAISING, FORMATION AND EDUCATION IN DEVELOPING COUNTRIES

NGO	Framework Agreement	Objective of the Framework Agreement	Indicative envelope 2015-2017	Particular remarks
Frère des Hommes	Framework Agreement	The Framework Agreement was focused on the challenges of rural development to maintain coherence in actions in the North and the South.	194 000.00 €	
SOS Faim	Framework Agreement	One of the objectives of this Agreement was to promote a sustainable rural development relying on a priority support for family agriculture.	420 284.64 €	The responsible rural development theme is cross-cutting to the Framework Agreement (in this case, the envelope is for the whole Framework Agreement).
Caritas	Framework Agreement	The objective of the Framework Agreement "*Plaidons responsable*" was the promotion of the participation of the Luxemburgish population in the elaboration of a post-2015 agenda for a socially fair and ecologically responsible future.	757 729.00 €	
Action Solidarité Tiers Monde	Framework Agreement	The objective of the Framework Agreement was to contribute to a global sustainable development by promoting the environmental, economic, social and cultural rights and their realisation in the South.	810 000.00 €	ASTM is one partner of "Klimabündnisgemeng" (Climate Alliance): envelope for actions related to climate change.
		Total	**2 182 013.64 €**	

Source: Ministry of Foreign and European Affairs, Directorate for Development Cooperation and Humanitarian Affairs.

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Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC.

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Commission Decision (EU) 2017/1471 of 10 August 2017 amending Decision 2013/162/EU to revise Member States' annual emission allocations for the period from 2017 to 2020.

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Annex A.I – Summary tables on emission trends

Luxembourg's 2017v1.2 GHG inventory submission to the UNFCCC secretariat is available on the UNFCCC website:

http://unfccc.int/files/national_reports/annex_i_ghg_inventories/national_inventories_submissions/application/zip/lux-2017-crf-06apr17.zip.

For GHG emissions trends by gases and CRF categories, see table **Summary 2** and **Tables 10** of the CRF. See Also tables III.1-2, III.1-3 & III.1-4 and the associated figures for details ***[→ Section III.1]***.

For methodologies, data sources and emission factors used by Luxembourg for submission 2017v1.2, see table **Summary 3** of the CRF.

Annex A.II– Summary of reporting of the Supplementary Information under Article 7, paragraph 2, of the Kyoto Protocol

SUPPLEMENTARY INFORMATION UNDER THE KYOTO PROTOCOL – CORRESPONDENCE TABLE

Information reported under Article 7, paragraph 2	NC5 Section
National systems in accordance with Article 5, paragraph 1	*Section III.2*
National registries	*Section III.3*
Supplementarity relating to the mechanisms pursuant to Articles 6, 12 and 17	*Section V.6*
Policies and measures in accordance with Article 2	*Section IV.3*
Domestic and regional programmes and/or legislative arrangements and enforcement and administrative procedures	*Chapter IV.2*
Information under Article 10 Art. 10a Art. 10b Art. 10c Art. 10d Art. 10e	 *Section III.2* *Section IV.2* *Section VII.7* *Chapter VIII* *Chapter IX*