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LE GOUVERNEMENT
DU GRAND-DUCHÉ DE LUXEMBOURG
Ministère de l'Environnement, du Climat
et du Développement durable

LUXEMBOURG'S INTEGRATED NATIONAL ENERGY AND CLIMATE PLAN FOR 2021-2030

In accordance with REGULATION (EU) 2018/1999 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2018

on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council

Final version

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1. Overview and process for establishing the plan

1.1. Summary

The integrated national energy and climate plan is a new planning and monitoring tool for the EU and its Member States. It aims to improve the coordination of European energy and climate policies and is the key instrument for achieving the EU 2030 targets on climate action, renewable energy and energy efficiency. It is based on Regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action (Governance Regulation). It requires each EU Member State to draw up an integrated national energy and climate plan for the period from 2021 to 2030.

The Paris Agreement, which was unanimously adopted on 12 December 2015, established a new basis for global climate action. At the centre of the Paris Agreement is the target of limiting global warming to well below 2 degrees Celsius compared to pre-industrial levels and pursuing efforts to limit it to 1.5 degrees Celsius. There is broad scientific and political consensus that current contributions, including those of the European Union, are insufficient and many signs indicate accelerated and irreversible global warming. The IPCC Special Report on the consequences of global warming of 1.5 degrees Celsius shows the scale of the challenge and the urgency to act.

The IPCC Special Report has led the European Commission to upwardly revise the EU's climate target for 2030. The new President of the European Commission, Ursula von der Leyen, has called for a 50-55% reduction target by 2030, and Vice-President Frans Timmermans, Commissioner for Climate Action and European Green Deal, will soon be presenting a climate law with new measures. The European Investment Bank is also currently being transformed into a climate bank. Luxembourg will continue to encourage the European Commission to introduce a credible and comprehensive strategy for a 'net zero emissions' Europe by no later than 2050 and will also continue to advocate a policy of not promoting nuclear power, coal, fracking, or the capture and storage of carbon dioxide[1]. The government's target of a 55% reduction in greenhouse gases by 2030 is in line with the high ambitions of Luxembourg.

The Luxembourg Government considers that nuclear power is not one of the possible solutions for reducing greenhouse gas emissions due to its multiple risks, and it therefore strongly advocates a policy of not promoting nuclear power. There is support at European level for efforts to phase out nuclear power and for a fundamental reform of the Euratom Treaty, in particular with a view to abolishing public subsidies for nuclear power once and for all and making nuclear power operators liable for the full risk. In all relevant international forums, initiatives will be supported to ensure that extending the life of nuclear power plants

[1] This policy of non-promotion does not cover carbon sequestration in forest and agricultural sinks.

is subject to the same safety and environmental impact assessments as new projects. The Luxembourg Government will also work at both European and national level to ensure that nuclear energy is excluded from future investments that are classified as sustainable, and welcomes the decision at EU level to exclude nuclear power from 'green finance' (the Directive on financial taxonomy).

It is clear that facing and overcoming the challenges identified in the Paris Climate Agreement will require a huge amount of investment. In order to achieve the goals of the Paris Agreement, Europe needs additional investment of around €260 billion per year over the next decade alone[2].

These investments can be financed by green bonds, inter alia. In 2007, the Luxembourg Stock Exchange listed the first green bond ever issued. Since then, it has been a leader in this class of investment. Now, more than 160 green bonds are listed. The issuers range from states, development agencies and banks to financial institutions and companies.

The major challenge for energy policy will be to phase out fossil fuels such as coal, oil and gas much faster than has so far been the case. Energy efficiency is a priority for policy implementation, based on the 'energy efficiency first' principle, followed by increased and consistent development of renewable energy and mobility that reduces dependence on cars and trucks and converts the remaining cars and trucks to electric or hydrogen propulsion.

Against this background, as part of the 2018-2023 coalition agreement, the current government has decided '… to do its utmost to comply with this [Paris] agreement and to take into account the findings of the Intergovernmental Panel on Climate Change (IPCC) Special Report on global warming of 1.5 degrees Celsius.' The integrated national energy and climate plan defines the framework for Luxembourg's energy and climate policy up to 2030.

The energy transition has already been addressed in Luxembourg in recent years and is part of the Third Industrial Revolution process, which was initiated in 2015 and the cornerstones of which involve energy efficiency in new buildings, developing renewable energy on a large scale and incorporating it into the energy network, developing decentralised energy storage, digitalising the energy networks and using more sustainable means of transport. The Luxembourg Government intends to further speed up the energy transition that has already been set in motion. Its climate and energy policies are essentially based on improving energy efficiency, promoting renewable energy and promoting more sustainable public and individual mobility. Luxembourg wants to be actively involved in the European energy transition and to become a country of climate solutions.

[2] Information provided by the European Commission.

The present plan offers new chances to strengthen the connection between energy and climate policies, on the one hand, and the scientific development of Luxembourg, on the other. The aim will in fact be to ensure the intelligent and sustainable development of the country in line with the conclusions of the strategic study on the Third Industrial Revolution, in particular in the areas of environmental technologies, mobility, climate action and digitalisation. Against this background, it is also important to intensify research and development in the areas mentioned, in order to bring about and develop modern, industrial activity in Luxembourg. The integrated national energy and climate plan will thus also have the potential to establish Luxembourg as a hub for climate-friendly start-ups and businesses. In addition to new instruments, the plan will also help to create the credibility needed to make Luxembourg a world leader in offering investment funds in the fields of energy efficiency and renewable energy and in climate financing.

The two tables below present the central objectives, policies and measures of Luxembourg's national energy and climate plan. The IPCC's recent reports point to the need to halve global greenhouse gases by 2030 in order to achieve the goals of the Paris Climate Agreement. The Paris Agreement also states that, due to historically high emissions of greenhouse gases, developed countries have a particular responsibility in this respect. This also applies to the EU and Luxembourg. With regard to compatibility with the goals of the Paris Climate Agreement, the Luxembourg government has decided at national level to reduce greenhouse gas emissions for sectors outside the EU emissions trading scheme by 55% by 2030 compared to the reference year 2005. The government has also decided to set an energy efficiency target of 40-44% by 2030 and to increase the share of renewable energy to 25% by 2030.

Dimension	Central objectives
GHG emissions	▪ National climate target: **-55%** by 2030, compared to 2005
Renewable energy	▪ **25%** share of renewable energy in the gross final energy consumption in 2030 by consistently developing wind and solar energy and heat pumps in Luxembourg ▪ Cooperating with other EU Member States
Energy efficiency	▪ Energy efficiency target of **40-44%** by 2030 (compared to the EU PRIMES model (2007)) ▪ New fossil-free single-purpose and residential buildings ▪ High rate of renovation and highly efficient building renovations ▪ Developing renewable heating networks

	▪ Preventing traffic through massive expansion of public transport and 49% share of electromobility by 2030 ▪ Developing a large energy efficiency market for industry, SMEs and office buildings
Energy security	▪ Reducing dependence on electricity imports by expanding renewable energy ▪ Exploiting the potential for flexibility by developing an energy data hub ▪ Further intensifying regional cooperation in the field of security of electricity and gas supply
Internal energy market	Gas sector: ▪ No further development of national gas infrastructure, either at transmission or distribution level ▪ Further expansion of the cross-border connections is not needed at present ▪ Consolidating the common gas market with Belgium Electricity sector: ▪ Upgrading grids to meet the needs of existing routes ▪ Combining the sectors of electricity, heat and transport by means of sector coupling
Research, innovation and competitiveness	▪ Luxembourg to become a pioneer in the successful implementation of a nationwide energy transition with the main pillars 'zero carbon', 'circularity', 'renewable energy' and 'energy efficient buildings' with flexibility options/storage capacity as well as sustainable mobility components and a grid and information flow enabling this ▪ Luxembourg to promote resilient urban and spatial development, transition processes and social innovation, in conjunction with urban/spatial planning and positive lifestyle changes ▪ Luxembourg to become an attractive location for climate solutions providers and start-ups, with an attractive testing and experimentation environment for the (further) development of their products ▪ Luxembourg's financial centre to switch 20% of all cash flows to green finance by 2025 and become a globally recognised financial centre for investments in energy efficiency, renewable energy, electro- and hydrogen mobility

Dimension	Central policies and measures
Decarbonisation	▪ Introducing a climate framework law ▪ Further developing the climate pact with the municipalities ▪ Introducing a minimum price for CO_2 and adjusting the taxation of mineral oil products ▪ Strengthening financing measures, targeted climate incentive programmes, including the climate and energy fund, environmental fund, the PRIMe House climate loan support scheme, climate loans, the 'clever fueren [drive smart]' support scheme ▪ Implementing and further developing the strategy for sustainable mobility ▪ Reforming car tax and company car taxation ▪ Fuel oil phasing-out programme
Renewable energy	▪ Solar offensive: • pursuing calls for tenders for large photovoltaic systems • adapting and expanding the support schemes • strengthening internal consumption in the electricity sector ▪ Wind energy development with a small number of large wind installations ▪ Creating a solar and thermal land register ▪ Biomass in the context of sustainable wood availability in the wider region ▪ Targeted expansion of renewable heat (heat pumps, deep geothermal energy, renewable heating networks from waste heat) ▪ Electromobility, second-generation biofuels, green hydrogen ▪ Transnational joint projects, for example through joint tenders for photovoltaic and wind capacity with neighbouring countries, and active participation in the new EU Renewable Finance Platform ▪ Cooperating with other EU Member States
Energy efficiency	▪ Low-energy and energy-plus buildings by law for residential and single-purpose buildings ▪ Ambitious renovation of existing housing stock (3% renovation rate at 72% renovation depth on average)

	▪ Developing a large energy efficiency investment market for industry, SMEs and large office buildings (by combining audits including an audit transparency platform, a specific energy efficiency financing fund (de-risking), strengthening the voluntary agreement with industry and expanding it to SMEs, continuing and extending the energy efficiency obligation (EEO) for all sellers of energy) ▪ Increasing energy efficiency in transport through traffic avoidance, massive expansion of public transport and the rapid development of electromobility in cars and vans (premiums, establishing a nationwide fast charging network) ▪ Reducing the sale of diesel to transiting HGVs ▪ State and municipalities to play an exemplary role, including in their buildings and lighting (Luxembourg LED 2025 programme) ▪ Large-scale training programme for tradespeople and engineers/architects
Energy security	▪ Strengthening regional cooperation ▪ Network expansion measures at transmission level on existing routes ▪ Reducing dependence on imported oil by preventing traffic and expanding public transport and electromobility ▪ National strategic framework for market development in the transport sector and for developing the corresponding infrastructure (e.g. nationwide fast charging network)
Internal energy market	▪ Expanding electricity transmission capacity on existing routes ▪ Smart management at all voltage levels by building an energy data hub ▪ No further measures for extending gas infrastructure: the existing gas infrastructure is of a sufficient size ▪ Active support for gas distribution companies in setting up green gas infrastructure (collection of biogas from decentralised biogas plants, biogas and sewage sludge washing plants)
Research, innovation and competitiveness	▪ Establishing a new research infrastructure involving all relevant research and innovation stakeholders ▪ Continuously increasing investment in research and development in the energy sector

	▪ Increasing existing efforts and skills at the national research institutes ▪ Luxembourg as an international hub for climate solutions

The success of this plan depends fundamentally on its acceptance by large parts of the population. The social justice of the various measures of the plan is therefore one of the government's central concerns. This plan contains far-reaching measures to tackle the energy poverty of today and prevent it from occurring in the future. Through targeted and socially differentiated support and compensation, this plan will make it possible to become a tool for both climate and social progress.

1.2. Overview of current policy situation

When devising the energy and climate policies, a few specific details of Luxembourg's situation and the energy consumption pattern need to be taken into account. First of all, Luxembourg is characterised by a highly dynamic demographic development of the population. In the last ten years, for instance, the population has increased from 493,500 residents in 2009 to 613,900 residents in 2019. In addition, the very open Luxembourg economy is characterised by dynamic development, reflected in an average annual growth rate of more than 2.5% in the last five years. A further atypical situation compared to its neighbouring countries is the high fuel consumption, which constitutes approximately two-thirds of the entire national final energy consumption. This is largely due to Luxembourg's central position in Europe and to the low price level of fuel compared to the neighbouring countries. Moreover, Luxembourg does not have any large power plants, meaning that, in addition to its own electricity production, it relies mainly on imports (85%), which are not accounted for on the CO_2 balance sheet. This pattern is also reflected in a relatively low consumption of electricity in Luxembourg, at just under 15%. It should also be taken into account that the pattern of industrial energy consumption is likewise considered atypical. For example, the share of electricity consumption in the steel industry alone amounts to about 40% of national electricity consumption. Some of the factors mentioned above have thus become significant drivers of energy consumption in recent years, and will remain so in the future.

It is also important to consider that Luxembourg is characterised by a high level of energy dependency. In fact, Luxembourg is one of the few countries in the European Union that does not have any naturally occurring fossil resources and therefore has to import all of the energy it needs, whether oil or natural gas. Luxembourg also does not have any sea ports, any refining capacity, any gas reservoirs due to the lack of suitable geology, and limited storage capacity for oil products.

Luxembourg thus has only limited opportunities to influence the overarching security of supply using national measures. In order to ensure its security of supply, Luxembourg, in close cooperation with neighbouring countries, has in the past relied on the diversification of sources and routes of supply in the framework of the Pentalateral Energy Forum (DE, FR, BE, NL, LU, AT, CH).

Luxembourg has always been a proponent of a well-functioning and competitive internal energy market and advocates European approaches to energy infrastructure. These approaches are fully in line with the principles of the European Energy Union.

In recent years, Luxembourg has made considerable progress in energy efficiency, renewable energy and climate action, and the digitalisation of the energy transition. These areas will be addressed briefly below.

Energy efficiency

Between 2008 and 2014, Luxembourg adopted three national energy efficiency action plans and implemented the measures contained therein. The current, fourth, National Energy Efficiency Action Plan was adopted by the government in 2017. It contains a large number of measures that are currently being implemented.

In the field of new buildings, Luxembourg has continually tightened its energy efficiency requirements over the last ten years and is playing a leading role in Europe. The nearly zero-energy building standard applicable in the field of energy classes has been compulsory for every newly constructed residential building since the start of 2017, and corresponds approximately to the internationally recognised Passivhaus Standard [passive-house standard]. These nearly zero-energy buildings are generally identified as AAA buildings in the national certification of energy performance certificates.

In 2014, Luxembourg presented its national building renovation strategy, which was praised by the European Commission in particular for its detailed overview of the building stock and for the national information and training programmes. In view of the significant potential for energy savings in existing buildings, the implementation of a national initiative for energy renovation was announced as part of the building renovation strategy. An extension of the building renovation strategy was developed in cooperation with the relevant players in the construction sector. This extension outlined guidelines for further-reaching strategic approaches and contains an action plan based on the currently existing obstacles. The strategic approaches and measures are currently being put into practice.

A series of instruments has also been developed and introduced to support the energy renovation of buildings. These instruments include investment aid for private households (via the *PRIMe House* support scheme) and municipalities (via the environmental fund) and the launch of a climate bank that offers reduced-interest loans for energy renovation. In order to lend fresh impetus to energy efficiency, in 2015 Luxembourg introduced a mechanism obliging natural gas and electricity suppliers to make concrete energy savings each year by implementing energy efficiency measures in sectors of their choosing.

In the industrial sector, the voluntary agreement between the government and industry was reformed in order to focus on increasing energy efficiency by means of binding targets. The investment aid schemes for companies in order to improve energy efficiency and promote renewable energy have also been reformed.

Renewable energy

In the field of renewable energy, Directive 2009/28/EC of 23 April 2009 on the promotion of the use of energy from renewable sources sets a target for Luxembourg of 11% renewable energy in the final energy consumption in 2020. Each Member State will also ensure that the share of energy from renewable sources in all forms of transport in 2020 is at least 10% of its final consumption of energy in transport.

Luxembourg is well on track to meet its targets for 2020. The share of renewable energy in the final energy consumption reached 6.38% in 2017, compared with 5.44% in 2016, 5.04% in 2015 and 4.51% in 2014. In order to be able to respect the indicative trajectory set out in Directive 2009/28/EC, Luxembourg must achieve an average share of 7.47% renewable energy in 2017 and 2018.

In the field of new residential buildings, an implicit requirement for the use of renewable energy was introduced by the Regulation on the energy efficiency of residential buildings. The regulations on feed-in tariffs have been systematically adjusted in recent years to create interesting investment incentives, particularly in the areas of biomass, wind and photovoltaics, as well as for photovoltaics cooperatives. In addition, the feed-in tariffs for photovoltaics were increased in 2019 and a first national competitive procedure for photovoltaic systems on buildings or industrial or landfill sites was organised in 2018. A second invitation to tender was issued in autumn 2019. These measures have triggered a huge wave of investment and could swiftly increase solar production from the current 130 MW to over 200 MW.

Finally, it should also be mentioned that the biofuel blending rate has been set at 5.85% for 2019 and 7.7% for 2020. In 2019, the minimum rate for biofuels made from non-food waste, residues and cellulosic materials covered by the ‘double counting’ principle was set at 35% and in 2020 was even increased to 50% (after double counting). In addition, the government programme stipulated that the use of first-generation biofuels should be limited to no more than 5% in order to promote the use of second-generation biofuels, which are considered more sustainable.

Sustainable mobility

In parallel to the increased support for public transport and active mobility (Luxembourg has the largest investment programme in the EU for trains, trams and buses), recent years have seen the promotion of electromobility. Luxembourg has decided to set up a joint national infrastructure of public charging stations for electric vehicles. A total of 800 charging stations are to be installed in public areas and in park & ride car parks by 2020. Just under 280 charging stations had already been installed by the end of 2018. Relative

to population, Luxembourg is thus already in third place in the field of public charging infrastructure in Europe.

Digitalisation

As part of efforts to digitalise the energy transition, Luxembourg legally requires electricity and gas network operators to replace current electricity and gas meters with smart meters by 2020 and 2021, respectively, and to manage the corresponding data using a joint central system.

Climate Pact

In 2012, the Luxembourg Government concluded a Climate Pact with the municipalities, offering technical advice and financial support for climate action measures. The Climate Pact is a wide-ranging instrument for orienting and shaping communal climate and energy policies, which has been expanded to include the topics of air quality and the circular economy. It supports the municipalities in introducing an integrated climate action and energy management system and achieving certification with the 'European Energy Award'. The Pact has been well received and has now been signed by all municipalities in Luxembourg, of which more than 86% had already achieved one of the three certification levels by the end of 2018. The 2018-2023 coalition agreement envisages the further development of the Climate Pact beyond 2020.

As the above examples show, Luxembourg has managed to make significant progress in recent years in the field of energy and climate policies, thus laying the groundwork for a sustainable energy transition. The present national energy and climate plan picks up on this trend and sets out an ambitious route for Luxembourg to drastically reduce energy consumption in all sectors and rapidly develop renewable energy and electromobility.

1.3. Consultations and involvement of national and Union entities and their outcome

Regulation (EU) 2018/1999 of 11 December 2018 on the Governance of the Energy Union and Climate Action provides for public consultations to be carried out. In addition, a multilevel climate and energy dialogue should be established, in which local authorities, civil society organisations, social partners and other relevant stakeholders come together to discuss the different scenarios envisaged for energy and climate policies.

Luxembourg's present national energy and climate plan for the period 2021-2030 was prepared in the course of intensive consultations under the leadership of the two responsible ministries (Ministry of Energy and Spatial Planning and Ministry of Environment, Climate and Sustainable Development).

Involvement and consultation of the national Parliament

Following the adoption of the draft national energy and climate plan by the Government Council, the draft was presented to Parliament's Committee on Environment, Climate, Energy and Spatial Development on 27 February 2019.

Following the adoption by the Government Council of the draft composition of the final energy and climate plan, an exchange of views took place on 6 and 17 December 2019 in Parliament's Committee on Environment, Climate, Energy and Spatial Development. This exchange between members of Parliament, the Minister for the Environment and the Minister for Energy also served as preparation for a consultation debate in Parliament.

During the consultation debate on 19 December 2019, the spokespersons of the political groups expressed their views on the objectives, policies and measures envisaged under the national energy and climate plan. Further information can be found on the Parliament's website[3].

Involvement and consultation of stakeholders and the public

Stakeholders and the public were given the opportunity to participate in the preparation of the present national energy and climate plan at an early stage. As early as 2018, participatory processes took place during the preparation of the draft national energy and climate plan, the results of which were included in

[3] https://www.chd.lu/wps/portal/public/Accueil/Actualite/ALaUne/?current=true&urile=wcm%3Apath%3Aactualite.public.chd.lu/ST-www.chd.lu/sa-actualites/c96b8d5e-613c-42a7-bb1a-7f4fee350509

the draft plan where useful and possible. Further details on the above processes (strategy study on the Third Industrial Revolution and long-term climate strategy) are provided below.

Following the adoption of the draft plan in early 2019, it was presented in a one-day workshop on 21 May 2019 (Journée 'Generatioun Klima – zesumme fir eise Planéit') and discussed with representatives of civil society, social partners, business, academia, Parliament and other stakeholders, with the involvement of the relevant ministries and administrations as well as local authorities. Almost 200 participants took part in the discussions. The preparation of the final energy and climate plan involved developing, prioritising and specifying measures on the basis of approaches that have already been identified, which should make it possible to achieve the 2030 targets. The participatory process was led by experts and was divided into seven thematic areas:

- housing and sustainable buildings
- mobility
- industry and entrepreneurship
- agriculture
- energy
- changing lifestyles
- governance, sustainable finance and taxation.

In addition, the Ministry of Energy and Spatial Development and the Ministry of Environment, Climate and Sustainable Development held a series of bilateral discussions with civil society organisations and social partners in autumn 2019. The aim of the discussions was to reach the broadest possible consensus among the various stakeholders on the planned policies and measures of the energy and climate plan.

In response to the mobilisation of students for climate action, the government has also actively involved students in the consultations. In order to better understand their expectations, ideas and proposals, four regional workshops were held in lyceums (ClimateXchange) in May 2019, in collaboration with the CNEL National Conference of Schoolchildren. A total of around 500 students participated in the workshops, which were also attended by the Minister for Education, the Minister for the Environment and the Minister for Agriculture. The workshops addressed in particular sustainable schools, mobility, waste, energy and agriculture (sustainable consumption and production).

Process – strategy study on the Third Industrial Revolution

In 2015, at the initiative of the Ministry of the Economy and in cooperation with the Chamber of Commerce and IMS Luxembourg, Luxembourg commissioned the American social theorist, sociologist, economist and public speaker Jeremy Rifkin, who developed the concept of the Third Industrial Revolution and has presented it in a number of his publications and books, to conduct a strategy study on the Third Industrial Revolution (TIR process). The study pursued the aim of making the existing economic model more sustainable and interconnected for future generations. The preparation of the strategy study was linked to an open, participatory and long-term process, with the aim of identifying the megatrends, drawing the necessary conclusions and introducing these in a suitable form into democratic institutions. The TIR process also sought to make use of the 'collective intelligence' approach, which is considered an important part of the concept of open social innovation. In the follow-up to the study, the government stated that the participatory approach should be continued via existing platforms. In this context, the 'Energy Future of Luxembourg' platform was set up for the energy sector, which has dealt with important and specific topics relating to the energy transition at several events. On 12 March 2018, an open workshop on the energy transition was held in the context of the developments in the European Energy Union, with presentations and discussions on the main pillars of the Energy Union, the National Energy Efficiency Action Plan, the modelling for the development of the 2030 energy and climate strategy, the renovation potential in Luxembourg looking ahead to 2070, the potential of renewable energy in Luxembourg looking ahead to 2030, and security of supply issues and competitiveness in the areas of electricity, natural gas and oil.

Process – long-term climate strategy

With a view to developing a long-term climate strategy, the Ministry of Sustainable Development and Infrastructure organised several consultations with civil society, business, science and public administration representatives during 2018. These consultations were also attended by Prof. Reinhard Loske. At a first *co-creation workshop* on the weekend of 3 and 4 February 2018, around 100 participants identified social innovations for mitigating climate change. A second workshop took place on 15 March 2018. There, above all the main principles of governance of the national climate policy were developed with the interest groups. On 5 June 2018, the preliminary draft strategy was presented and discussed with the stakeholders. This is intended to serve as the basis for developing the long-term strategy that must be prepared pursuant to the Paris Climate Agreement and Article 15 of Regulation (EU) 2018/1999 of 11 December 2018 on the Governance of the Energy Union and Climate Action. In addition, the main findings of the above workshops have, where possible, been taken into account in the present national energy and climate plan.

Public consultation

Following the adoption of the draft final national energy and climate plan for the period 2021-2030 by the Government Council on 7 February 2020, the draft was submitted to the public and all stakeholders in a final public consultation. Neighbouring countries were also included in this process.

From 12 February to 29 March 2020, the aforementioned draft and the draft of the associated environmental impact report were available on the Environment Portal (www.emwelt.lu) of the Ministry of the Environment, Climate and Sustainable Development. During this period, interested citizens and stakeholders were able to submit their opinions, suggestions and comments by email or by post.

A total of 328 citizens took advantage of this opportunity. Some 30 stakeholders from civil society and business, including social partners, as well as public institutions, submitted comments.

All contributions and comments, including those received after the deadline of 29 March 2020, were evaluated and duly considered. A lot of the feedback relates to the implementation of measures contained in the plan and will therefore be taken into account in the implementation process. At the same time, a functioning dialogue between all national stakeholders is an important prerequisite for the successful implementation of the energy and climate plan. The bodies provided for in the draft framework law on climate change make it possible to structure this dialogue.

Iterative process with the European Commission

Luxembourg submitted its draft integrated national energy and climate plan 2021-2030 to the European Commission on 18 February 2019. The draft was assessed by the Commission in accordance with Regulation (EU) 2018/1999. On 18 June 2019, the Commission sent nine recommendations to Luxembourg based on the above assessment. In drawing up the final national energy and climate plan, Luxembourg has taken these recommendations into account and acted on them where possible.

1.4. Regional cooperation in preparing the plan

Pentalateral Energy Forum

Luxembourg is an integral part of the energy markets for electricity and gas in Western Europe. As part of these markets, it benefits – as do the other Member States – from significantly better conditions in terms of economic efficiency, security of supply and sustainability of energy supply.

A key element of regional cooperation in the context of energy and climate policy is the Pentalateral Energy Forum. Under the Luxembourg presidency, the following joint chapter was adopted at a conference in June 2019:

Introduction

Within the framework of the Pentalateral Energy Forum for regional cooperation, which has been in existence since 2005, Belgium, Germany, France, Luxembourg, the Netherlands and, since 2011, Austria have been working together on a voluntary basis – countries which together are home to more than one third of the EU population and which account for more than 40% of electricity generation in the EU. Switzerland joined as a permanent observer in 2011 and actively contributes to technical and decision-making work. In close cooperation (upon invitation) with the European Commission, the Pentalateral Energy Forum strengthens cooperation between all relevant stakeholders and thus pursues the objective of creating a regional electricity market as an intermediate step towards establishing a single European electricity market.

The cooperation is steered by the energy ministers, who meet regularly. The continuous monitoring of the activities is ensured by the Penta Coordinators and the Penta NECP Committee, under the leadership of the relevant directors-general for energy in the participating countries. The work programme is implemented by the transmission system operators (TSOs), ministries, regulatory authorities, the European Commission and market players, who meet regularly in three working groups (support groups).

The great success of the past 15 years has been that the perspective of the participating countries in terms of energy policy has evolved from a purely national focus to a regional approach. The participating countries have set concrete regional milestones in various areas that are still relevant today:

Internal electricity market/market integration:

Penta Support Group 1 (SG 1) focuses on the coupling of the electricity markets in the region. SG 1 set itself the goal of the flow-based market coupling (FBMC) of day-ahead markets, which was achieved when the Penta region became the first region in the European Union to introduce this in May 2015. Since then, flow-based market coupling has been continuously optimised to achieve higher welfare gains and now serves as the basis for a fully EU-based market coupling for day-ahead markets.

In order to increase the transmission capacity available for cross-border trading on the intraday market, SG 1 promoted a coordinated process for calculating intraday capacities, which was implemented in March 2016 after the flow-based market coupling of day-ahead markets for all borders in the region as a first step towards coupling the European intraday markets.

The Support Group was able to gain a privileged insight into the drastic changes in the electricity landscape and the governance of the electricity markets. While in 2005 electricity operators were still operating mainly independently of each other, over the years the working group has promoted cooperation between stakeholders, leading, inter alia, to the formation of regional groupings of TSOs within their associations, the merging of power exchanges and TSOs and the emergence of new regional players (TSCNet, Coreso, formerly CASC-CWE, SSC).

In view of the new implementation plans to be presented under the 'Clean energy for all Europeans' package, the countries involved will coordinate closely and explore possibilities for joint action.

Internal electricity market/flexibility:

Support Group 3 (SG 3) focuses on flexibility issues in the region. So far, the work of SG 3 has focused on balancing energy, intraday and the role of demand-side management – three key areas for regional cooperation to improve the flexibility of our electricity markets. A number of technical background papers have been prepared, identifying the main obstacles to greater use of flexibility in the Penta region. SG 3 is open to traditional participants (regulatory authorities, TSOs) as well as other stakeholders such as distribution system operators (DSOs), major consumer associations and renewable energy producers.

In the area of balancing energy, the Pentaforum evaluated existing approaches and exchanged best practices. The Pentaforum also plays an important role in the implementation of the European Union guidelines on balancing energy. In terms of demand-side management, a separate group of

experts has prepared a report outlining the current situation in the Penta region, focusing in particular on the rules and responsibilities of new market players in each country of the region. With regard to further cooperation between the participating countries in the field of hydrogen, a workshop was held to identify possible topics for cooperation in this field.

Security of supply:

Support Group 2 (SG 2) deals with issues surrounding security of supply in the region. In June 2017, the countries involved signed a memorandum of understanding (MoU) on cooperation with regard to security of supply. On this basis, and in light of the new EU Regulation on cooperation in the field of risk preparedness, an emergency exercise was organised in 2018 with 'PENTEX 2018' in order to achieve a better common understanding of national concerns, to identify potentially relevant (cross-border) crisis situations in the region and to assess various measures to reduce the impact of possible crises.

The first regional Generation Adequacy Assessment (GAA), carried out by the TSOs of the participating countries and published in March 2015, was an important milestone. The methodology of the assessment was based on a probabilistic and chronological approach with hourly resolution for the years 2015/2016 and 2020/2021 and thus represented a significant improvement over the existing deterministic approaches. Furthermore, the TSOs of the participating countries used a common regional data set based on the same scenarios and assumptions, such as a temperature-dependent load model for the whole region and harmonised probabilistic hydrological data.

The governments of the Pentaforum countries are convinced that these parameters will remain relevant in the future. In addition to continuing work on the above areas, the countries participating in the Pentalateral Energy Forum will focus in the coming years on:

Decarbonisation of the electricity sector

Shared vision of a decarbonised electricity supply in the participating countries by 2050:

The participating countries will discuss their ideas on how to achieve a decarbonised electricity supply by 2050 (and intermediate targets for 2030 and 2040) based on a highly efficient energy system strongly influenced by renewable energy, a gradual phase-out of fossil power generation and efficient end-use of electricity. The first step is to compare national scenarios on a possible design of the electricity system in 2050 and to identify commonalities and differences between

these scenarios and how security of supply is ensured in the scenarios. This will serve as a basis for developing a common understanding of the expectations and challenges in the development of the future electricity system.

North Seas Energy Cooperation

Luxembourg is part of the North Seas Energy Cooperation and thus belongs to the wider North Sea region, which has great potential in the field of renewable energy. According to the European Commission, offshore wind energy in the North Sea is estimated to be able to cover up to 12% of the EU's electricity consumption by 2030.

Offshore power generation and transmission infrastructure projects can have cross-border implications for energy prices, security of supply and the environment, including the availability of marine space and the speed of innovation. As a result, Luxembourg and the countries bordering the North Sea can greatly benefit from cooperating with one another.

The North Seas Energy Cooperation (NSEC) was established in 2016. It is an initiative of voluntary, bottom-up and market-oriented regional cooperation. The aim is to create synergies and avoid incompatibilities between national policies, exchange knowledge on best practices and promote common strategies where possible and useful. It also aims to coordinate and promote the further cost-effective use of offshore renewable energy, in particular wind energy, in order to ensure a sustainable, secure and affordable energy supply for Luxembourg and the countries bordering the North Sea through an increased and better coordinated use of offshore wind energy and through potential joint or cluster projects. The NSEC primarily follows a step-by-step approach, with the longer-term prospect of further integration and increasing the efficiency of wholesale electricity markets, while contributing to reducing greenhouse gas emissions and average wholesale price ranges and improving security of supply in the region.

The North Seas Energy Cooperation comprises 10 countries, with the participation of the European Commission: Belgium, the Netherlands, Luxembourg, France, Germany, the United Kingdom, Ireland, Norway, Sweden and Denmark.

Regional cooperation

With regard to the development of this plan, the NSEC countries took full advantage of the NSEC, where experts in the working groups shared knowledge and experience on specific aspects, such as obstacles and best practices in the area of national offshore wind energy use, and in particular

the coordination of national renewable energy plans for offshore wind energy by 2030 and market integration.

The working groups (WGs) that are part of the Cooperation focus on the following topics:

WG 1: maritime spatial planning and environmental impact,

WG 2: development and regulation of offshore pipelines and other offshore infrastructure,

WG 3: support framework and financing of offshore wind energy projects,

WG 4: standards, technical requirements and regulation in the field of offshore wind energy.

Maritime spatial planning and environmental impact

Within the framework of the North Seas Energy Cooperation, the NSEC countries contribute to the development of a joint environmental impact procedure. In order to achieve our energy and climate objectives within the EU, we need to better understand the potential environmental limitations of large-scale wind energy use in the North Sea. Further work on maritime spatial planning and environmental impact is needed to realise the potential of the North Sea. In order to increase their knowledge and support the use of offshore wind energy in the North Sea, Luxembourg and the countries bordering the North Sea will continue to work closely together on maritime spatial planning, environmental research and cumulative environmental impact assessment of wind farms by energy, maritime spatial planning and environmental authorities.

Offshore pipelines and other offshore infrastructure

The NSEC serves as a platform to work together on concepts for potential joint offshore wind energy projects and for coordinated electricity infrastructure, including transmission infrastructure.

Luxembourg is working with the other North Seas Energy Cooperation countries to explore the possibilities of specific cooperation projects. In addition to joint offshore wind energy projects connecting and supported by several Member States, this includes work on possible hybrid solutions that would exploit cross-border solutions to connect offshore wind farms to the grid and seek synergies with country interconnection capacities, and on appropriate market rules.

The NSEC countries therefore contribute to the development of opportunities for cooperation in the field of hybrid projects, identifying and addressing legal, regulatory and commercial barriers. Coordinating increased interconnection in the NSEC countries would also allow more surplus

energy to flow to other countries where it could meet the demand in a well-functioning internal energy market.

The NSEC has drawn up a list of possible areas and projects in the region where joint projects could be particularly useful. These include: (1) IJmuiden Ver – offshore wind farm to UK, (2) CGS IJmuiden Ver – Norfolk, (3) COBRA Cable, (4) the DE-NL offshore wind farm and (5) the North Sea Wind Power Hub. NSEC is working to develop concrete approaches for the implementation of selected projects from the above list.

The NSEC will continue to work on the action plans for the specific hybrid projects, which can also be further developed at national and regional level. In addition, the Cooperation will continue to serve as a forum for reflection on how to deal with uncertainties regarding the regulatory treatment of hybrid projects at EU and national level, and as a forum for discussing options to address these issues.

Support framework and financing of offshore wind energy projects

In terms of measures, Luxembourg benefits from the NSEC in several ways: the work of the NSEC provides a platform for the exchange of best practices in designing support programmes and developing and refining new concepts to meet new challenges in the field of promoting offshore wind energy and developing possible options for future joint wind energy projects.

The work of the NSEC countries within the NSEC includes coordinating the timing of calls for tenders, exchanging best practices in designing support programmes for offshore wind energy and, where possible, establishing common principles and possible options for aligning support.

As regards the coordination of tenders, the NSEC countries regularly exchange information on their national tendering schedules. The aim is to identify potential time overlaps and to ensure that the North Sea region is as even as possible in terms of the tendering process in order to optimise competition and achieve the best value for money for consumers. The NSEC countries are prepared to take into account, among other criteria and where possible, the tendering schedules in their future tender planning in order to avoid unnecessary bottlenecks and to ensure a steady flow of capacity without interruption cycles for the parties involved.

Within the NSEC, the NSEC countries exchange information on and discuss their prospective national policy in respect of offshore wind energy, their national offshore utilisation plans and best practices regarding the design of tenders for offshore wind energy.

At the ministerial meeting in Esbjerg on 20 June 2019, the North Sea states and Luxembourg agreed to cooperate to achieve total installed capacity in the NSEC member states of at least 70 GW by 2030 on the basis of national planning.

In order to reflect the dynamics of offshore wind energy use in the region, the long-term planned aggregate capacity of at least 70 GW by 2030 can be achieved with indicative milestones for the region of around 25 GW in 2020 and 54 GW in 2025.

Within the NSEC, Luxembourg also contributes to analysing and developing options for mobilising investments in joint projects, for example through EU funds such as the European Fund for Strategic Investments (EFSI) and the Connecting Europe Facility (CEF) infrastructure fund, as well as through institutional investors. Such future joint projects could be cross-border renewable energy projects in line with the CEF proposal.

Harmonising rules, regulations and technical standards

The North Seas Energy Cooperation is working to harmonise standards and technical requirements that could contribute to further reducing the costs of using offshore wind energy. The harmonisation of rules, regulations and technical standards focuses on five areas. These include: (1) aeronautics, labelling and lighting, (2) health and safety, (3) certification of regulatory requirements, (4) design of wind farms and site exploration, and (5) research approaches. The NSEC works to develop proposals and recommendations for implementation in close cooperation with industry. The aim of these recommendations is to reduce costs while maintaining feasibility. The Cooperation will continue to work to harmonise standards and technical requirements and exchange best practices to reduce unnecessary regulation and cut costs for industry.

European Union

Luxembourg will also continue to support ambitious goals and their implementation at European level. In particular, the following objectives are being pursued.

1) In the European Climate Law, the EU commits to 'zero net greenhouse gases' by 2050 at the latest and presents a concrete roadmap on how this will be implemented.

2) As an important first intermediate step, the EU has committed to a binding target of a 55% reduction of greenhouse gases in the EU by 2030.

3) The European Commission is expected to present by summer 2020 a concrete plan on how to adapt the relevant EU targets for greenhouse gas reductions and energy, as well as existing EU measures (EU emissions trading scheme for CO_2 allowances for industry and power plants, EU effort sharing (ESR), land use, land-use change and forestry (LULUCF), EU Energy Efficiency Directive, EU Renewable Energy Directive, or regulation of CO_2 emissions from passenger cars and light- and heavy-duty vehicles).
The Commission is also proposing the following additional measures:

- in order to prevent unfair competition from imports that are not made in a way that protects the climate, the EU should introduce a 'border tax adjustment' (CO_2 border adjustment);
- in order to accelerate the phasing-out of fossil fuel drives/engines from new cars and vans, all vehicles should be fossil-free (electrical, hydrogen) from 2031 onwards;
- the EU should also introduce standards for new trucks, ships and aircraft.

4) The EU presents a financial framework on how the EU budget will proactively support the climate and energy transition (GHG emissions in the industrial sector: zero carbon steel, cement or glass, major EU housing renovation programme, support to build 400 GW offshore wind farms in the North Sea, infrastructure development for zero- or low-emission transport, and conversion to climate-friendly agriculture and land use). Progress will be measured by a credible and transparent system and a methodology for verification, traceability and monitoring of expenditure and its impact on climate action and the energy transition.
The European Investment Bank will be transformed into a climate bank that will no longer lend for fossil fuel projects. It is also important that no common funds are wasted on the further development or maintenance of nuclear energy in Europe.

5) Before summer 2020, the EU is expected to present a new law to ensure that all batteries sold in the EU (in cars, buses, but also in other electronic devices) are 100% recycled and produced from materials that meet high environmental and human-rights standards.

6) The EU should not only tax the big internet companies, but also commit them to high energy efficiency standards (immersion cooling) and 100% renewable energy.

7) The EU should establish the industrial basis for a radical energy transition through large-scale research projects (zero carbon steel, cement, glass, green batteries programme, hybrid electric aircraft/ships) and prevent dumping by imports through binding climate clauses in trade agreements.

2. National objectives and targets

As part of the trialogue in June 2018, the EU Member States, the European Parliament and the European Commission reached a political agreement on the target system for 2030, with binding EU targets of a 40% reduction in greenhouse gases (GHG), a 32% share of renewable energy in the final energy demand and 32.5% for energy efficiency, and a revision clause providing for an increase in 2023. According to Regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action, the Member States are obliged to submit to the European Commission a national energy and climate plan, comprising a detailed presentation of the national objectives for reducing greenhouse gases, the objectives for renewable energy and energy efficiency and the measures planned in this regard. This plan sets out Luxembourg's objectives under the target system referred to above. There is also the requirement that the combined trajectories submitted by the Member States achieve the European minimum targets.

For Luxembourg, there is already a minimum binding GHG reduction target that arises from Regulation (EU) 2018/842 on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030. The GHG reduction set down in this regulation is 40% by 2030, based on Luxembourg's GHG emissions in 2005. In terms of renewable energy, Directive (EU) 2018/2001 on the promotion of the use of energy from renewable sources provides for a benchmark formula, resulting in an increase in the target for Luxembourg of around 12 percentage points, which corresponds to a 2030 target of around 23%. This target can be met by using domestic resources, importing biofuels or promoting electromobility in the transport sector as well as by using cooperation mechanisms. For the area of energy efficiency, EU effort sharing and the EU target for energy efficiency result in a target corridor of 35 to 40%, which is determined in comparison with the EU reference development for Luxembourg for 2030, which was published in 2007 (EU PRIMES 2007)[4].

Luxembourg's objectives in the dimensions to be considered are presented below. It should be mentioned at the outset that all of the minimum requirements outlined above, whether in the area of GHG reduction or regarding the contribution of renewable energy or energy efficiency, are clearly met. Luxembourg considers it essential to embark on an ambitious path together with its European partners.

[4] European Commission DG for Energy and Transport (2008). European energy and transport -TRENDS TO 2030 — UPDATE 2007.

2.1. Decarbonisation dimension

2.1.1. Greenhouse gas emissions and removals

In terms of consistency with the objective set out in Article 2.1.a of the Paris Climate Agreement, Luxembourg is aiming at a national level **to reduce GHG emissions for the sectors outside the emissions trading scheme by 55% by 2030 compared to the base year 2005**. In fact, the IPCC special report on the impacts of global warming of 1.5 °C above pre-industrial levels states that it will only be possible to limit global warming to 1.5 °C if global greenhouse gas emissions are halved by 2030 (compared to current levels), followed by climate neutrality by 2050.

The national GHG reduction target is therefore more ambitious than Luxembourg's binding contribution to the EU target in accordance with Regulation (EU) 2018/842 on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030. The GHG reduction target enshrined in this regulation for the sectors outside the emissions trading scheme is 40% by 2030 compared to 2005. The annual emissions budgets are calculated on the basis of a linear reduction trajectory between the real average GHG emissions in 2016 to 2018 and the points target for 2030.

According to Regulation (EU) 2018/841 on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework, each EU Member State is given a target for the LULUCF sector[5]. Taken together, the debits from the land use categories included in the accounting (in accordance with Article 2 of Regulation (EU) 2018/841) may not exceed the credits at the end of the two five-year periods 2021 to 2025 and 2026 to 2030 ('no net debit rule').

2.1.2. Renewable energy

Luxembourg is aiming to increase the **share of renewable energy** from 11% in 2020 to **25% by 2030**.

According to current scenarios, the national expansion of renewable energy by 2030 would amount to 19.6%, in each case on the basis of the gross final energy demand, in other words the sum of the sectoral energy demands for electricity, heat and fuels in the transport sector. In addition to ambitious renewable energy policies, what these scenarios have in common is a significant increase in energy efficiency (see Section 2.2) and thus a reduction in energy demand, which in turn implies an additional increase in the share of renewable energy in relation to consumption. However, in line with the EU target (increasing the renewable share to 32% at EU level by 2030), a national contribution of 25% would appear to be reasonable

[5] LULUCF: Land Use, Land Use Change and Forestry

and appropriate. To cover the corresponding shortfall, it is advisable to cooperate with other EU Member States, which would involve the use of the cooperation mechanisms that had already proved themselves by 2020. Cooperation with other Member States as well as statistical transfers will be further developed and will include concrete projects (e.g. large solar installations in southern Europe or offshore wind installations).

Target volumes at sectoral and technological level will be presented below, while the following chapters contain a discussion of the measures and an impact assessment. The results and values presented relate to the target of 25%.

Table 1 : Sectoral shares of renewable energy in Luxembourg up to 2040 according to the target scenario with the upper range value of 25% (in 2030).

Renewable energy shares, sectoral		2017	2020	2025	2030	2035	2040
Renewable energy share, electricity sector	%	8.1%	11.9%	23.5%	33.6%	38.8%	45.4%
Renewable energy share, heat sector	%	8.1%	13.7%	19.9%	30.5%	35.8%	47.1%
Renewable energy share, transport sector	%	6.4%	11.3%	18.4%	25.6%	40.4%	54.3%
Admixture rate for biofuels	%	5.6%	7.7%	8.8%	10.0%	14.4%	18.7%
Renewable energy share, total - national production/consumption	**%**	**6.4%**	**9.4%**	**13.9%**	**19.6%**	**24.8%**	**31.9%**
Renewable energy share, total - incl. renewable energy cooperation	%	**6.4%**	**11.8%**	**17.6%**	**25.0%**	**31.0%**	**39.3%**

Source: Own illustrations, 2019

Renewable energy currently plays a significant but comparatively limited part in energy generation in Luxembourg. However, this can and should change significantly in the coming years, thus making it a consistent continuation of the trend that has been set in the recent past. Renewable energy such as wind energy and photovoltaics, but also biomass – the core technologies in the field of electricity generation for Luxembourg – have also seen considerable growth in recent years. In the space of a decade, their contribution has doubled – both in the electricity sector (from 3.3% in 2007 to 8.1% in 2017) but also in

terms of heat production (from 4.4% in 2007 to 8.1% in 2017). In the transport sector, this change has been even more pronounced. The renewable energy share was 2.2% in 2007 and increased to 6.4% in 2017.

Table 2 : Technology-specific energy generation from renewable energy in Luxembourg up to 2040 according to the target scenario with the upper range value of 25% (in 2030).

Energy production, technological details		2017	2020	2025	2030	2035	2040
Electricity sector							
Biogas*	GWh	72	56	70	93	96	97
Biomass**	GWh	101	192	228	271	268	338
Hydroelectric power	GWh	104	93	97	100	104	107
Photovoltaics	GWh	108	197	786	1,112	1,257	1,442
Wind energy	GWh	185	211	382	674	956	1,166
Renewable energy electricity, total	**GWh**	**570**	**748**	**1,563**	**2,251**	**2,680**	**3,150**
Heat sector							
Biomass & biogas, grid-connected	GWh	302	589	625	676	669	728
Biomass, decentralised	GWh	672	883	1,084	1,263	1,083	1,083
Solar thermal energy	GWh	25	58	115	190	236	290
Heat pumps	GWh	52	95	207	422	507	507
Renewable energy heat, total	**GWh**	**1,052**	**1,626**	**2,030**	**2,551**	**2,495**	**2,609**
Transport sector							
Biofuels, total	**GWh**	**1,282**	**1,632**	**1,563**	**1,485**	**1,738**	**1,749**
Renewable energy use, total (national)	**GWh**	**2,904**	**4,006**	**5,156**	**6,287**	**6,914**	**7,508**
Renewable energy cooperation							
Renewable energy cooperation energy	**GWh**	**0**	**1,000**	**1,374**	**1,748**	**1,748**	**1,748**

** Central plants (fed into a heating network)*

*** Decentralised plants (not fed into a heating network, all sectors)*

Source: Own illustrations, 2019

The coming decade was looked at in the context of an underlying study (cf. Resch et al. 2019), using a variety of possible development trajectories and corresponding energy scenarios. The target scenario presented in this plan corresponds to 25% in 2030. If the status quo (2017) and the reference development, which corresponds to a continuation of the existing policies, are additionally taken into account, the increase is even more noticeable. The share of renewable energy in gross final energy demand, in other words the sum of the sectoral energy demands for electricity, heat and fuels in the transport sector, would accordingly increase from 6.4% in 2017 to 12.9% in the case of merely continuing with the existing policies (reference development) – as illustrated by corresponding data in Section 4 of this report. If additional interventions are made, in both renewable energy and energy efficiency, an increase to 19.6% in 2030 would be possible in accordance with the target scenario presented here.

Table 1 provides information on the sectoral decomposition of the overall balance and Table 2 provides supplementary details on the potential underlying technology split. Accordingly, the highest growth is expected for renewable energy in the electricity sector. Here, a share of around 33.6% appears possible for 2030 – including on the basis of projects that are already in progress (for example in the field of wind turbines, solar installations and biomass cogeneration). By 2040, the share of renewable energy in gross electricity consumption would then increase further to a remarkable 45.4%. In second place in terms of the speed of change is the heat sector. Considerable growth compared to the current situation is expected here, partly in line with electricity generation (biomass cogeneration), but also at a decentralised level, for instance in the case of heat pumps, solar thermal collectors for water heating or modern biomass heating systems. Accordingly, the share of renewable energy in the heating sector would rise from the current 8.1% (2017) to 30.5% by 2030 and to 47.1% by 2040. The considerable increase in the share of renewable energy in the years after 2030 is mainly a consequence of the significant increase in energy efficiency, and thus the reduction of energy demand in the heating sector. Furthermore, a massive increase in the use of renewable energy is also expected in the transport sector. This assumes an increase in biofuel blending (second generation). It is also assumed that the biofuel mix up to and including 2030 will consist of a maximum of 5% of first-generation fuels[6], measured by total road transport fuel demand. The aim is also to massively increase e-mobility. Overall, this will result in a significant increase in the share of renewable energy in the transport sector, to 25.6% by 2030 and 54.3% in 2040 (using the calculation logic established

[6] More specifically, both the target and the reference scenarios assumed that by 2030 the share of first-generation biofuels could be reduced to 2.5% of road transport fuel demand.

under EU Directive 2018/2001). The required renewable energy volumes, which are to be covered in future by renewable energy cooperation with other countries, as they are necessary to achieve the envisaged renewable energy targets of 11%[7] in 2020 and 25% in 2030, are also listed in Table 2. In the target scenario considered here, these amount to 1 TWh in 2020 and 1.75 TWh in 2030 (and beyond).

[7] In the target scenario, the assumed renewable energy cooperation volumes (1 TWh) mean that the national minimum target (11%) will be exceeded in 2020 – thus, taking into account renewable energy cooperation, a renewable energy share of 12% of gross final energy demand is achieved.

2.2. Energy efficiency dimension

Regarding compatibility with the GHG reduction target mentioned in Section 2.1.1, Luxembourg is aiming for a reduction of final energy demand of between 40% and 44% by 2030 compared to the EU PRIMES baseline (2007).

With regard to achieving the goal, which in the illustration below is 44%, a distinction is made in particular between the following areas, based on the assumed intensification of existing policy instruments and the introduction of new ones:

- level of ambition in the building stock, both for new construction and energy renovation – renovation rate and depth of renovations implemented,
- efficiency in industry and SMEs,
- the extent to which transit and cross-border commuting are addressed,
- the development of electromobility in existing vehicles.

The key target figures of the target scenario, based on the upper range value of 44%, are presented in Table 3.

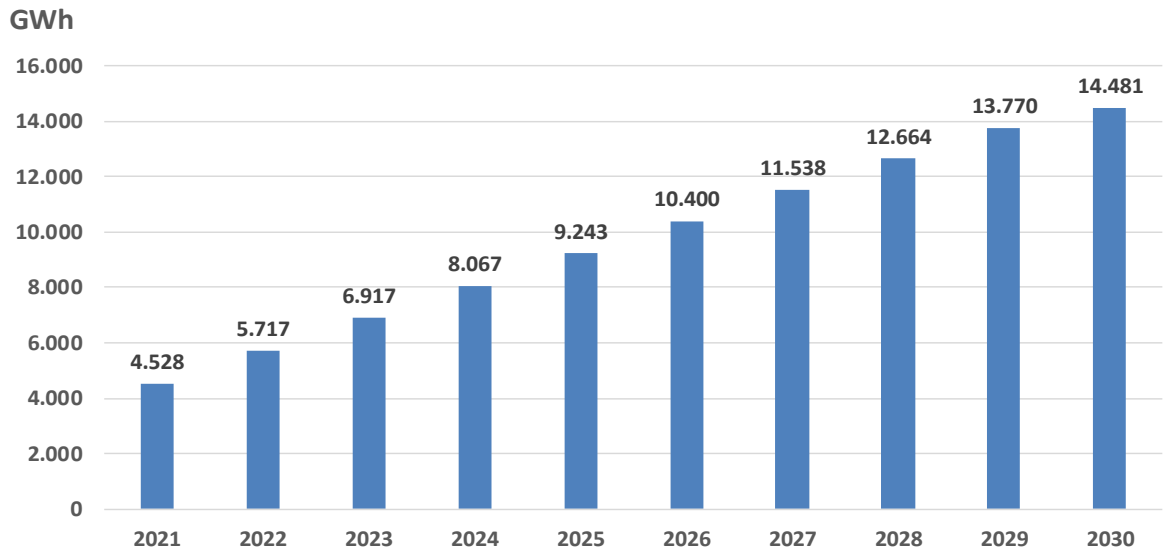
The sum of the annual final energy savings of all sectors (private households, trade, commerce and services, industry and transport) compared to the corresponding final energy demand in the reference scenario in the period 2021 to 2030 is shown in Figure 1. In 2030, the final energy savings achieved by all sectors through the implemented measures amount to approximately 14.5 TWh, resulting in a final energy consumption of 35,568 GWh compared to the final energy consumption of 50.5 TWh in the reference scenario. The final energy demand of 35,568 GWh in 2030 (see Table 3), corresponds to a 44% reduction in final energy demand according to EU PRIMES 2007.

Table 3 : Key target figures of the target scenario in the area of energy efficiency based on the upper range value of 44%

Target scenario	44% efficiency (EFF44)
Efficiency target 2030 (versus EU PRIMES in 2030)	-44%
Final energy demand [GWh]	35,568
Total	-30%
Households	-40%
Tertiary	-24%
Industry	-17%
Road transport	-38%
Road fuels (excluding electricity for e-mobility)	-41%
Renovation rate 2020-2030[8]	2.7%
Depth of renovation (average reduction in heat requirement after full renovation)	72%
E-mobility: Share of electric cars/plug-in hybrids in existing vehicles 2030 (residents)	49%

Source: own calculations 2019

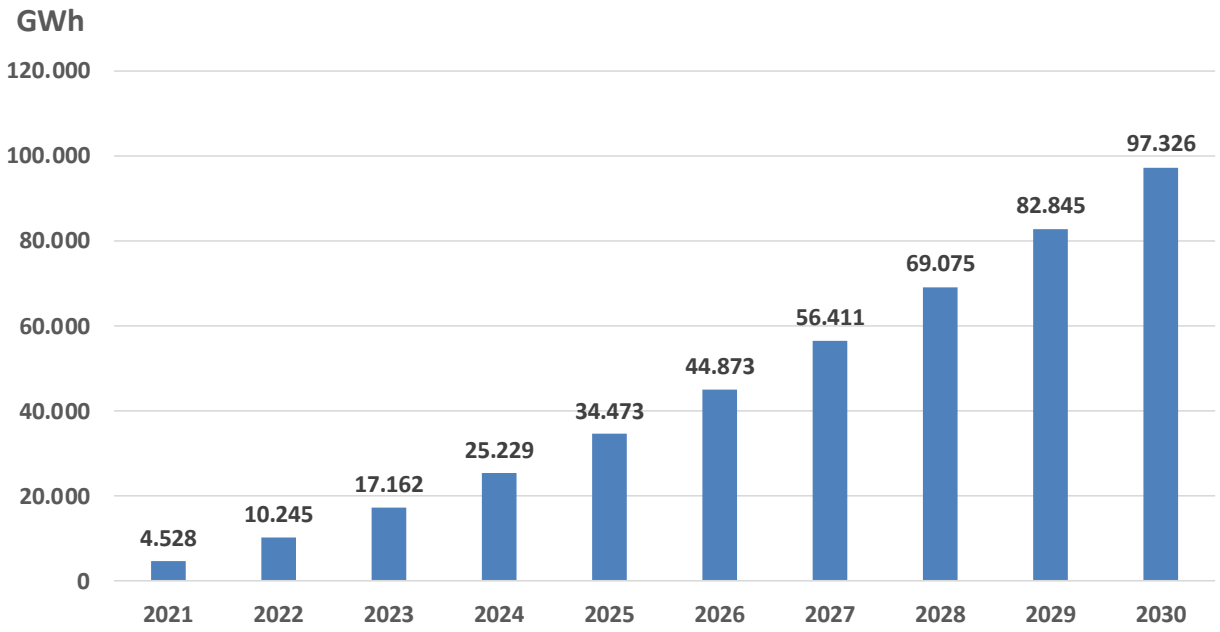
[8] Based on the additional renovations compared to the baseline scenario. The renovation rate expresses the proportion of buildings renovated per year in relation to the old building stock (buildings built before 1991).



Source: own calculations 2019

Figure 1: Annual final energy savings in GWh in private households, the trade, commerce and services sector, industry and the transport sector in Luxembourg (based on an energy efficiency target of 44%)

The cumulative final energy savings of all sectors (private households, trade, commerce and services, industry and transport) in the period 2021 to 2030 amount to a good 97.3 TWh if the planned energy efficiency measures are implemented (see Figure 2).

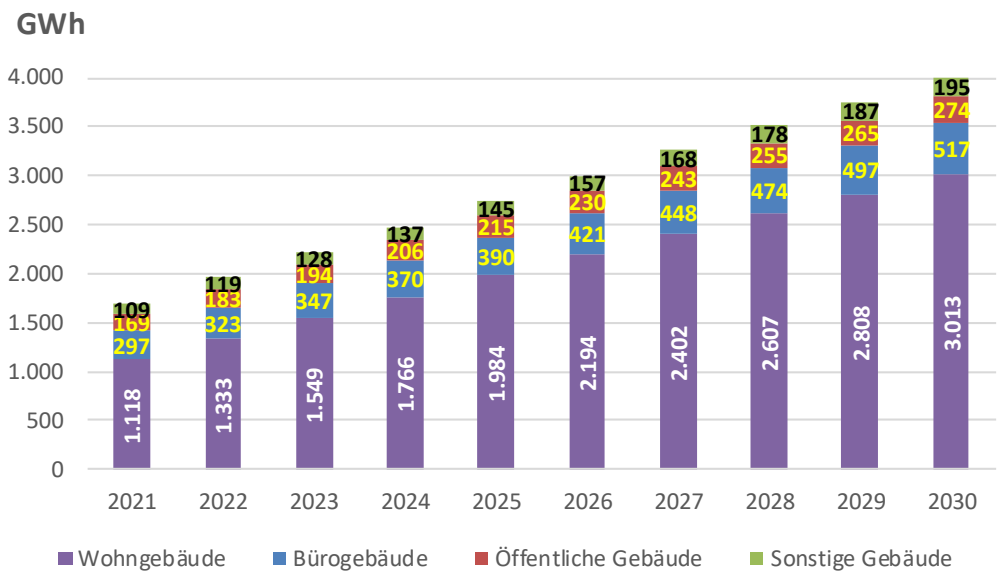


Source: own calculations 2019

Figure 2 : Cumulative final energy savings over the period 2021 to 2030 in GWh in private households, the trade, commerce and services sector, industry and the transport sector in Luxembourg (based on an energy efficiency target of 44%)

The sum of the annual final energy savings of residential and non-residential buildings in Luxembourg compared to the corresponding final energy demand in the reference scenario in the period 2021 to 2030 is shown in Figure 3. In 2030, the final energy savings achieved by the planned measures in residential and non-residential buildings amount to approximately 4 TWh (see Figure 3).

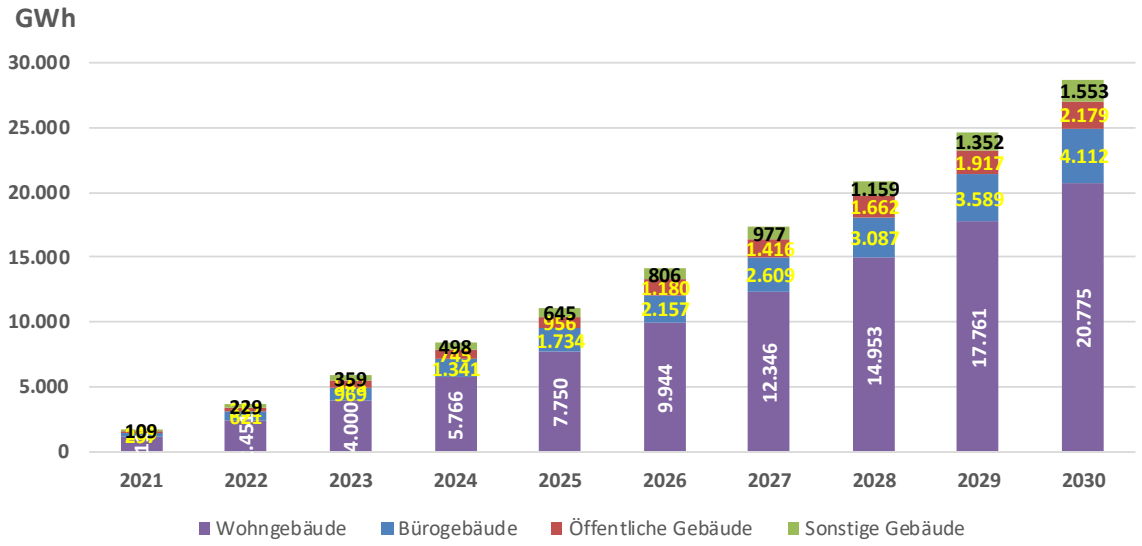
The cumulative energy efficiency renovation of residential and non-residential buildings in Luxembourg over the period from 2021 to 2030, at just under 28.6 TWh, contributes to the final energy savings in all sectors (see Figure 4**)**. The biggest final energy savings are achieved by the renovation of private dwellings, followed by the renovation of office and public buildings and the renovation of other buildings (see Figure 4). This is explained by the fact that even in Luxembourg, despite the importance of the financial centre, there are considerably more square metres of residential than office buildings.



GWh	GWh
Wohngebäude	Residential buildings
Bürogebäude	Office buildings
Öffentliche Gebäude	Public buildings
Sonstige Gebäude	Other buildings

Source: own calculations 2019

Figure 3 : Annual final energy savings in GWh from the renovation of all residential and non-residential buildings in Luxembourg (based on an energy efficiency target of 44%)

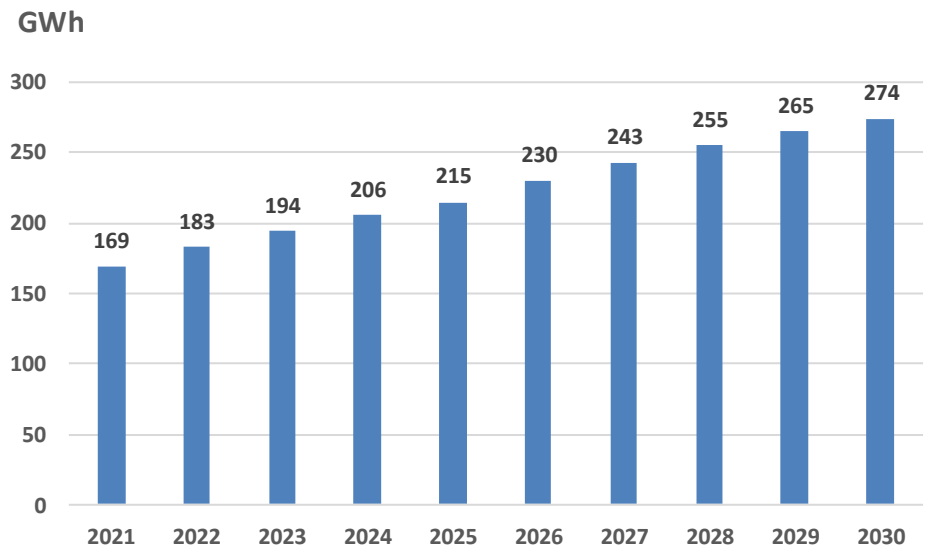


GWh	GWh
Wohngebäude	Residential buildings
Bürogebäude	Office buildings
Öffentliche Gebäude	Public buildings
Sonstige Gebäude	Other buildings

Source: own calculations 2019

Figure 4 : Cumulative final energy savings over the period 2021 to 2030 in GWh from the renovation of all residential and non-residential buildings in Luxembourg (based on an energy efficiency target of 44%)

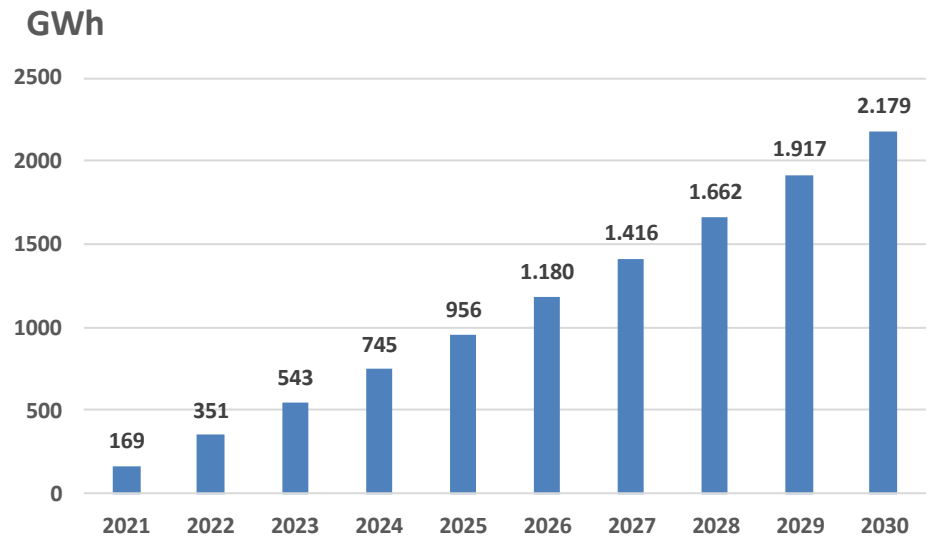
In Figure 5, the development of the final energy savings that will be achieved through the renovation of public buildings in Luxembourg by 2030 is once more presented separately by way of example. The public sector will serve as an example and will be the starting point for the development of a large energy efficiency market in Luxembourg. Over this period, the annual final energy savings will grow gradually from 169 GWh (2021) to 274 GWh (2030), corresponding to a total increase in annual final energy savings of 105 GWh. The renovation of public buildings accounts for approximately 8% of the total final energy savings through energy efficiency renovations of buildings.



Source: own calculations 2019

Figure 5 : Annual final energy savings in GWh from the renovation of public buildings in Luxembourg (based on an energy efficiency target of 44%)

In Figure 6, the development of the cumulative final energy savings that will be achieved through the renovation of public buildings in Luxembourg by 2030 is once more presented separately by way of example. Over this period, the cumulative final energy savings from the renovation of public buildings will grow gradually from just under 169 GWh (2021) to just under 2.2 TWh (2030), corresponding to an increase in cumulative final energy savings of around 2 TWh.



Source: own calculations 2019

Figure 6 : Cumulative final energy savings over the period 2021 to 2030 in GWh from the renovation of public buildings in Luxembourg (based on an energy efficiency target of 44%)

As a result of the dynamic economy and population growth, new construction is more important than in other EU countries, in terms of both residential and purpose-built buildings. Therefore, in 2017, Luxembourg introduced a statutory energy standard for new buildings, roughly corresponding to the level required by the Passivhaus Standard.

The interplay between building efficiency (roof, walls, windows, basement) and the phasing-out of fossil-fuel heating systems should help to make the building renovation strategy a success. This will be complemented by a fuel oil substitution programme and the establishment of low-temperature heating networks fed by waste heat from industry and renewable energy sources (deep geothermal energy, heat pumps, sustainable wood). The national building renovation strategy will be developed in cooperation with all stakeholders. In particular, social aspects, heritage protection aspects, and 'multi-apartment buildings' will be discussed in detail and specific measures implemented.

Due to the dynamic development of the housing market that is characteristic of Luxembourg, driven by high demographic growth and strong price increases, it should be mentioned at this point that the proportion of new buildings resulting from the demolition of existing buildings is not insignificant, as this

also makes it possible to steadily reduce the number of unrenovated existing buildings and achieve significant efficiency improvements.

Further national long-term targets regarding the further development of energy efficiency in Luxembourg are presented in Luxembourg's 4th National Energy Efficiency Action Plan (NEEAP 2017). In accordance with Article 3(1) of the Energy Efficiency Directive, Luxembourg has set an energy efficiency target of 49,292 GWh for 2020 (NEEAP 2017). In order to achieve this energy efficiency target, measures will inevitably be needed in all sectors.

2.3. Energy security dimension

Luxembourg has neither its own large power plants for electricity generation nor gas production and storage facilities and is therefore highly dependent on imported energy. Security of supply is the responsibility of the undertakings operating on the market and those regulated by the regulatory authority (*Institut Luxembourgeois de Régulation*, ILR), as provided for in the revised Law of 1 August 2007 on the organisation of the electricity market and the revised Law of 1 August 2007 on the organisation of the gas market. The government is responsible for monitoring security of supply.

Luxembourg's dependence on energy imports calls for a well-functioning European internal market for electricity and gas. It is therefore aiming to rapidly achieve an internal electricity and gas market with intensive cross-border competition between suppliers and tap in to the flexibility potential of consumers. Luxembourg is also in favour of further intensifying regional cooperation on security of supply in the electricity and gas sectors. On the basis of their legal obligations, electricity and gas network operators attach great importance to ensuring that their infrastructure is in good condition and in line with the state of the art. The available capacity of the networks must meet the growing demands caused by the country's economic and demographic development. The widespread installation of smart meters for all consumers will allow network operators to manage their networks even more intelligently and securely.

The expansion of renewable energy that is needed to achieve the targets will allow Luxembourg to noticeably reduce its dependence on electricity imports. Nevertheless, due to the enormous demand for electricity by industry, domestic energy sources will still only be able to make a certain contribution to Luxembourg's energy supply in future. In the field of load flexibility, Luxembourg is aiming to significantly increase the share of consumers actively participating in the electricity market (including by setting up an energy data platform).

The increased thermal insulation requirements for new buildings and the planned renovation strategy for the building stock will lead to a downward revision of the demand for natural gas.

Luxembourg has no oil reserves of its own and must therefore import 100% of the oil it consumes. Moreover, Luxembourg does not have any refineries on its national territory. Therefore, only mineral oil products, and not crude oil, are imported. The vast majority of these come from Belgium, followed by Germany, France and the Netherlands. In the interests of security of supply, it is important to maintain the diversification of countries of origin in the future and to diversify supply routes. Since the airport in Luxembourg is supplied with fuel directly via an underground pipeline (CEPS), the diversification of supply routes relates primarily to the mineral oil products diesel, petrol and fuel oil. The majority of imports are

via road, with only about a fifth being handled by rail. The remainder is imported by inland waterway via the Moselle to Mertert, the only port in Luxembourg.

As a member of the European Union and the International Energy Agency (IEA), Luxembourg is obliged to maintain stocks of mineral oil equivalent to, on average, 90 days of the previous year's imports. The importers of mineral oil products have a national legal obligation to hold compulsory stocks of 8 days on national territory, 37 days on regional territory outside Luxembourg, and the remainder elsewhere in the EU.

2.4. Internal energy market dimension

2.4.1. Electricity interconnectivity

Luxembourg is almost completely reliant on imports to cover its demand for electricity. A high level of interconnection is therefore essential for Luxembourg and can only be compared to a limited extent with the interconnection levels of other EU Member States. Luxembourg already has interconnection capacities that far exceed the 2030 targets set in the Council Decision of October 2014. In mathematical terms, the (N-0) interconnection level in relation to the annual peak load is currently approximately 270%. With the network expansion projects that are currently planned, this will increase to approximately 400% in 2030 and should therefore offer sufficient reserves to be able to adequately manage future increases in consumption in all areas.

2.4.2. Energy transmission infrastructure

In the gas sector, the currently existing transmission system infrastructure is considered sufficient, particularly because peak demand has fallen significantly due to the decommissioning of the TwinErg CCGT power plant. There is no need to further expand cross-border connections. At the same time, the gas market with Belgium, which has been shared since 2015, is to be further enhanced.

In the electricity sector, apart from the fact that the Creos public grid is located in the same bidding zone as the German Amprion grid, the integration of Luxembourg into the European electricity grid has been significantly improved by the commissioning of a phase-shifting transformer and the establishment of a permanent line connection between the Luxembourg and Belgian transmission systems. Testing of the phase-shifting transformer has now been completed. Currently, the phase-shifting transformer is used to optimise the load flows in Luxembourg and the surrounding regions. Luxembourg aims to further strengthen this meshed integration over the medium term. Since an increase in the demand for electricity and peak load is expected in Luxembourg, in part due to the expected population increase, diversification of economic activities and general economic growth, it is necessary to expand the existing interconnections. The transmission system operator Creos is therefore planning to convert an existing 220 kV interconnection towards Germany to high-temperature conductors by 2020 and, in the medium to long term, to upgrade/reinforce the 220 kV line towards Germany. There are still no plans to connect the Luxembourg public grid to the French grid.

2.4.3. Market integration

From Luxembourg's perspective, bringing about an internal energy market is of central importance, particularly for the electricity sector. Luxembourg is supporting the European Commission's efforts to develop a new European market design for the electricity markets. The consistency of electricity market design in the Member States will be of paramount importance here. Separate national routes will only burden the electricity consumers, disregard the impact on other Member States and, at worst, jeopardise security of supply.

In a complete internal electricity market, national borders should no longer pose a challenge to market players. The Luxembourg Government, the regulatory authority ILR and the transmission system operator Creos are actively participating in the further development of the internal electricity market in European bodies and institutions.

Particular importance is attached to cooperation within the framework of the Pentalateral Energy Forum (PLEF), which, in addition to Luxembourg, comprises Belgium, the Netherlands, France, Germany, Austria and Switzerland. This region, which is closely linked from a technical and economic perspective, has been playing a leading role in bringing together the European electricity markets for years. Within the PLEF, the close integration of the electricity markets of Germany and Luxembourg with the cross-border market area once again stands out. Luxembourg aims to maintain this joint market area and further enhance the cooperation.

Luxembourg will investigate whether the conclusion of bilateral agreements with other Member States on mutual solidarity in the event of energy crises could improve security of supply in Luxembourg.

Compared with the rest of Europe, electricity and gas prices for final consumers in Luxembourg are well below the European average. However, the proportion of consumers who change suppliers is relatively low. In this context, it is important to create comparability and transparency. By actively comparing the tariffs of their supplier with those of competitors and changing suppliers if necessary, energy consumers can considerably reduce their energy costs. It is therefore an aim to ensure that the prices are readily comparable and transparent.

To improve the involvement of active consumers in the market, whether by decentralised production or by participation in flexibility markets yet to be defined, Luxembourg will convert 95% of its electricity meters to smart meters by 2020.

To improve the market integration of renewable energy, Luxembourg has converted parts of its support system to a sliding market premium. Joint, cross-border calls for tenders for renewable energy with other European countries are also in the planning stage.

In order to minimise the risk of supply bottlenecks in the natural gas sector, as well as to increase security of supply in general and to integrate the markets, Creos merged the two national gas markets to form a single, country-wide market in 2015 in cooperation with the Belgian network operator Fluxys. As part of this consolidation of the market areas, the guaranteed, uninterruptible capacities at the Belgian border were also considerably increased to their maximum technical availability. This significantly increases uninterruptible capacities even without line upgrades and ensures long-term security of supply for Luxembourg.

2.4.4. Energy poverty

Luxembourg has a comprehensive strategy for tackling poverty in general (minimum wage, social inclusion income (REVIS), etc.). In addition, there is a series of measures in Luxembourg offering targeted help to people affected by energy poverty.

The amended laws of 1 August 2007 on the organisation of the electricity market and on the organisation of the natural gas market stipulate that household customers who are unable to pay their electricity or gas bills can receive social assistance from the responsible social welfare office.

For its part, the Law of 18 December 2009 on the organisation of social assistance stipulates that, when applying the procedures established in the above-mentioned laws on the organisation of the electricity and natural gas markets, the responsible social welfare office must investigate whether the household customer is able to pay his or her energy bills and is thus entitled to social assistance.

Particular attention must be paid to housing in the fight against energy poverty, as rising housing prices have become a major social challenge in Luxembourg. Low-income population groups can often only have access to poorly maintained rented housing in old buildings with low energy standards. The government is

therefore targeting the creation of affordable housing. Energy efficiency measures in the housing sector will be designed in a way that simultaneously improves the national energy balance and the living conditions of low-income groups.

The government will also work with all relevant stakeholders to develop innovative programmes, as part of the national long-term renovation strategy, which will create incentives to renovate old housing while providing housing for low-income households.

It should also be mentioned that there is already a programme in place through the cost-of-living allowance ('Allocation de vie chère'), which also counteracts energy poverty. At the same time, the state rent subsidy can help those in need to face a possible increase in the cost of housing. It should also be pointed out that the current social assistance legislation stipulates that any person who satisfies the conditions for entitlement to social assistance is entitled, under defined conditions, to a minimum provision for domestic energy if he or she is unable to cover the costs of domestic energy.

The enormous amount of investment in infrastructure development and the introduction of free public transport from 1 March 2020 are certainly not only transport policy measures, but also clearly social measures.

2.5. Research, innovation and competitiveness dimension

Luxembourg is a dynamic country in terms of industrial research, development and technology. In order to make the transition to a low-carbon economy and society, considerable efforts are needed to support technological development, research and development of new technologies and social innovation. The development of research and innovation activities is crucial for the competitiveness of a country, and the Luxembourg Government is therefore investing considerable financial and organisational resources in these activities.

The consistent energy and climate policies, combined with the transformation of Luxembourg's financial centre towards green finance and the emerging university and research landscape, make Luxembourg an ideal location for green tech and climate solutions. The Luxembourg Government will develop a concrete strategy in the coming months, bringing together all relevant stakeholders and embedding this in the 'Let's make it happen' strategy.

In June 2010, the European Council adopted the development of the *Europe 2020* strategy and thus confirmed the five joint EU targets: promoting the employment of those able to work, improving the conditions for accessing innovation, research and development, achieving the climate change and energy targets, improving the level of education and promoting social integration, in particular by reducing poverty. Each Member State has aligned its national 2020 targets with the core targets of the EU and set out a number of actions in its National Reform Programme (NRP). The NRP is a key contribution of the Member States to the Europe 2020 strategy. Luxembourg's latest NRP[9] of April 2019 explains how the objectives are to be achieved. Implementing an effective research policy for both the public and private sectors is a priority for the Luxembourg Government. For 2020, Luxembourg has set itself a national research intensity target of between 2.3% and 2.6% of GDP. The associated key measures for achieving the national target are set out in the NRP. In Luxembourg, the trend in state resources spent on research and innovation has grown steadily, both in the public and the private sector, from €23.6 million in 2000 (0.13% of GDP) to €368.5 million in 2018 (0.65% of GDP).

Public support for research and development is focused on innovation in all businesses. Research and development has traditionally focused on the steel, aviation and automotive sectors. In recent years, however, the government has made considerable efforts to develop further priorities in the areas of information and communication technologies, logistics, health technologies, materials, energy and

[9] https://odc.gouvernement.lu/fr/publications/rapport-etude-analyse/programme-national-de-reforme/2019-pnr-luxembourg-2020.html

environmental technologies (cleantech). Environmental technologies are among the priorities of the national economic diversification strategy. In recent years, Luxembourg has made concrete progress in the areas of sustainable construction, sustainable mobility and the circular economy. Initiatives in these areas are in line with EU policy and the various directives on issues such as the energy efficiency of buildings, smart transport systems or ecodesign requirements.

Thanks to its steel industry, Luxembourg has a long-standing tradition of materials-based research. Today it is working, among other things, on the development of sustainable building materials. In addition, Luxembourg now has three research teams in the field of materials research for solar photovoltaics, which are working on the further development of resource-optimised thin-film PV.

Furthermore, Luxembourg also has innovation clusters that are dedicated to the issues mentioned above. Public research stakeholders, including the University of Luxembourg, play a key role in this. The same applies to Luxinnovation, the national agency for promoting innovation and research, which offers personalised consultancy and support for the stakeholders and the government in the areas of research and innovation (access to funding opportunities, finding partners, business creation, etc.) and thus plays an important role in terms of the European networks in this area.

To strengthen the competitiveness of the country, Luxembourg has in recent years created the liberal, modern, flexible, attractive and innovative legal framework needed to develop new activities, by means of an active economic policy.

Regarding competitiveness, compound index values that combine several pieces of information to form a single numerical value and therefore only give a rough overall picture of territorial competitiveness are increasingly being used for international comparisons. In Luxembourg, the Observatoire de la Compétitivité (ODC) analyses and monitors a number of international reference values and rankings in its annual competitiveness report[10]. The ODC monitors the annual reports, including those of the World Economic Forum, the Institute for Management Development, the Heritage Foundation and the European Commission. According to the results, Luxembourg is within the top 10 at EU level for the vast majority of the benchmarks analysed.

[10] https://odc.gouvernement.lu/fr/actualites.gouvernement%2Bfr%2Bactualites%2Btoutes_actualites%2Bcommuniques%2B2018%2B11-novembre%2B13-bilan-competivite-2018.html

In addition to the international reference values, the ODC has also kept a national 'scoreboard' for competitiveness since 2004, in order to measure and assess Luxembourg's competitive position, the results of which are published in the competitiveness report and discussed with social partners and experts. Since 2017, the ODC has developed a new national 'scorecard'[11], which is a flexible instrument that can be further developed over time and adapted if necessary. It covers the dimensions of competitiveness, welfare and sustainability and at the same time ensures that there is a balance between economic, social and ecological aspects. This Luxembourg reference value analyses 68 different indicators. This instrument makes it possible to summarise the performance of the countries in the indicators of the three aspects of economy, society and environment and the associated advantages and disadvantages. In the overall ranking, Luxembourg is in ninth place at EU level, thus securing its position among the 'high performance' countries. The result of the national 'scoreboard' confirms the results of the analysed international reference values at EU level.

In terms of innovation, reference can be made to an annual comparative evaluation analysis by the European Commission, which measures the innovation performance of the EU Member States by comparing the innovation performance with the international competition. This 'European Innovation Scoreboard' assesses the relative strengths and weaknesses of national research and innovation systems and helps countries to identify areas that they need to address. The 2018 edition of the EIC emphasises that the innovation performance of the EU Member States is continuing to improve, progress is accelerating and the outlook is very positive. Since 2010, the average innovation performance of the European Union has risen by 5.8 percentage points and is expected to improve by a further 6 percentage points in the next two years. The 2018 evaluation is led by Sweden (average evaluation: 0.710 out of 1), followed by Denmark (0.668) and Finland (0.649). Luxembourg is also among the group of innovation leaders, in sixth place (0.611).

[11] https://odc.gouvernement.lu/fr/statistiques/tableau-bord-competitivite.html

3. Policies and measures

3.1. Decarbonisation dimension

3.1.1. Greenhouse gas emissions and removals

3.1.1.i. Policies and measures to achieve the target set under Regulation (EU) 2018/842 as referred to in point 2.1.1 and policies and measures to comply with Regulation (EU) 2018/841, covering all key emitting sectors and sectors for the enhancement of removals, with an outlook to the long-term vision and goal to become a low-emission economy and achieving a balance between emissions and removals in accordance with the Paris Agreement

Introducing a climate framework law

With the aim of climate policy to provide a legal basis in line with the Paris Climate Agreement, the government presented a draft climate law in autumn 2019, in line with the coalition agreement. This draft law is designed to strengthen the framework of national climate policy, in particular to allow for a coordinated and integrated approach between all relevant stakeholders, levels and sectors, and to improve consistency during the implementation. The draft consists of three main parts.

The first part establishes an **institutional framework** for climate policy and sets out the principles and objectives as well as the governance structure of Luxembourg's climate policy.

The draft law sets out the following four **principles**: the principle of climate justice, the principle of progression, according to which only continual improvements to climate policy are possible, the principle of integrated pollution control, according to which climate policy must not be pursued at the expense of biodiversity, air quality, water or other elements of the environment, and the principle of integrity, according to which climate policy genuinely pursues the objective of ensuring a safe and healthy climate.

In addition to national climate targets consistent with the Paris Climate Agreement, the draft introduces **sectoral climate targets**. This will ensure that there is a shared responsibility. If the annual amount of emissions available in a sector is exceeded, the matter will be referred to the Government Council with a view to establishing an emergency programme to ensure compliance with the climate objectives. A Grand Ducal Regulation sets the respective emission allowances for the sectors for an initial period up to 2030. The target scenario presented in Section 5 provides a template for this. The inter-ministerial committee for the coordination of climate policy provided for in the draft climate framework law will participate in the drafting of the said regulation.

The draft law also establishes **three bodies** with regard to the governance structure. Firstly, an inter-ministerial committee will be set up to coordinate climate policy. A climate action platform will be established in accordance with Article 11 of Regulation (EU) 2018/1999, which requires Member States to establish a multi-level dialogue on climate and energy issues. There are also plans for an independent body to deal with the scientific, ethical and societal aspects of climate policy and the associated challenges.

In accordance with Regulation (EU) 2018/1999, it also sets out the **procedure** for adopting and updating the integrated national energy and climate plan, the long-term strategy for reducing greenhouse gas emissions and the strategy for adapting to climate change.

The second part of the draft law re-enshrines the existing Climate and Energy Fund and adapts it to the current challenges[12].

The third part transposes Directive (EU) 2018/410 of the European Parliament and of the Council of 14 March 2018 amending Directive 2003/87/EC to enhance cost-effective emission reductions and low-carbon investments, and Decision (EU) 2015/1814.

Climate action, budgetary and social policy

The budgeting of the measures included in the integrated national energy and climate plan will be in line with the fiscal path and the rules of the Stability and Growth Pact. National measures are given priority because of their co-benefits (air quality, jobs). Climate action is one of the most pressing tasks facing humanity. Accordingly, our national and international climate commitments are also a high priority in terms of budgetary and fiscal policies. They are important investments for the benefit of future generations.

Measures with a direct impact on public finances will, like all capital expenditure, be subject to multi-annual budgeting. The Climate Framework Law establishes an inter-ministerial committee to assess the effectiveness of the measures on a regular basis. This will take into account the ministerial powers (*compétences ministérielles*). To this end, the measures shall be subject to a qualitative assessment of their impact on the national budget in terms of revenue and expenditure and their effectiveness in relation to national targets for reducing greenhouse gas emissions, improving energy efficiency and developing renewable energy. This will also take into account the co-benefits (air quality, jobs). It is therefore quite

[12] See the section on financing measures below for further details on this point.

possible that the prioritisation of measures will be adjusted according to their efficiency and that the respective measures will be replaced or supplemented by more efficient measures, if necessary.

The climate crisis is also a social crisis: vulnerable people are far more affected by the climate crisis than those in a better position. There is a gap between richer and poorer people, both geographically (North-South divide) and within societies.

The government is aware that it is taking people with it in the fight against climate change. The climate and energy plan will only be accepted if there is fair compensation for the more vulnerable groups in our society. For this reason, the measures of the climate plan will be assessed in terms of social justice and, if necessary, compensation will be provided for affected citizens. This important principle is also in line with the Climate Bill and is guiding the government's climate policy.

The measures in the integrated national energy and climate plan that have already been adopted and are set down in a law or Grand Ducal regulation are taken into account in the draft budget for 2020 and in the multi-annual plan.

It goes without saying that the new measures in the integrated national energy and climate plan have not yet been reflected in the draft budget for 2020, as this law was already deposited in Parliament on 14 October 2019.

Knowing that the implementation of this plan entails expenditure, it is important not to overlook any revenue that could result from carbon pricing.

The tax measures outlined in the plan will be analysed in detail before their final adoption as part of the tax reform negotiations.

Minimum price for CO_2 – introduction of the 'polluter pays' principle

In addition to the emissions trading scheme for industry introduced more than 10 years ago at EU level, carbon pricing – a cost-effective tool for reducing greenhouse gas emissions – already plays an important role in many EU Member States.

Following this model, Luxembourg will introduce a minimum CO_2 price as part of the forthcoming tax reform and continuously adapt it in line with the objectives of the Paris Climate Agreement. The target starting price will be the average CO_2 price in our neighbouring countries. For 2021, this means a CO_2 price of approximately €20 per tonne of CO_2. This amounts, for example, to approximately 5 cents per litre of

diesel fuel. An increase of €5 per tonne is planned in both 2022 and 2023. This corresponds to approximately 1.5 cents per litre of diesel fuel. The further implementing provisions for a dynamic CO_2 price will be drawn up as part of the preparations for the planned tax reform. This will involve looking into whether a scaling of the CO_2 price should be introduced.

The socially fair implementation of the CO_2 price will be ensured by using the revenues in a targeted way. Based on the currently available data, revenues of approximately €150 million can be expected for 2021. These are used in a balanced way (*d'une manière équilibrée*) for concrete climate action and targeted social relief via fiscal (e.g. tax credit) and social justice (*équité sociale*) measures for low-income households.

Climate support measures

A successful climate policy requires effective measures to reduce emissions. Although everyone has individual responsibility, climate policy can only be successful if it indicates the direction, creates the necessary framework conditions and thus offers concrete alternatives to all stakeholders. Therefore, enhanced incentive mechanisms will be put in place through improved **support schemes**, which are explained in more detail in Section 3.1.1.iii.

- The **PRIMe House** support scheme provides investment aid for the energy and sustainable renovation of residential buildings and related, qualified energy advice, for the construction of sustainable residential buildings and for the use of renewable energy (PV installations, solar thermal installations, heat pumps, wood pellet and wood chip heating systems).
- In addition to the PRIMe House support scheme, the energy and sustainable renovation of residential buildings is supported by **low-interest or** – to help low-income households – **interest-free loans** (climate bank).
- The '**Clever fueren**' scheme supports the purchase of electric vehicles, electric motorcycles and bicycles through direct grants.
- The support schemes for improving the protection and **sustainable management of forest ecosystems** ensure sustainable timber production, improve the condition of forests and help our forests adapt to climate change. In this way, the state, society and forest owners together ensure that we will continue to have stable, healthy, climate-tolerant and species-rich forests in Luxembourg in the future.

- In industry and small and medium-sized enterprises, the existing instruments will continue to be used and expanded by the relevant ministries. The **voluntary agreement** (*accord volontaire*) and the **energy saving obligation** (ESO) will be further developed and continue to serve as important cornerstones for future efficiency efforts.
- With regard to the efficiency efforts of small and medium-sized enterprises, new instruments such as a **de-risking instrument** and a **transparency platform for audits** will be created in order both to overcome the financing hurdles and to improve the overview and identification of energy efficiency measures.
- In terms of agriculture, **climate action schemes** (methane strategy, climate check, etc.) are being drawn up by the relevant ministries.

Social measures

Climate change and the health impact of fossil energy supply affect low-income population groups in particular. Climate action therefore also provides a tangible contribution to social justice. However, climate action must also be socially embedded in order to prevent energy poverty.

Luxembourg has a comprehensive strategy for tackling poverty in general (minimum wage, social inclusion income (REVIS), etc.). In addition, there is a series of measures in Luxembourg offering targeted help to people affected by energy poverty. The amended laws of 1 August 2007 on the organisation of the electricity market and on the organisation of the natural gas market stipulate that household customers who are unable to pay their electricity or gas bills can receive social assistance from the responsible social welfare office.

For its part, the Law of 18 December 2009 on the organisation of social assistance stipulates that, when applying the procedures established in the above-mentioned laws on the organisation of the electricity and natural gas markets, the responsible social welfare office must investigate whether the household customer is able to pay his or her energy bills and is thus entitled to social assistance.

Particular attention must be paid to housing in the fight against energy poverty, as rising housing prices have become a major social challenge in Luxembourg. Low-income population groups can often only access poorly maintained rented accommodation in old buildings with low energy standards. The government is therefore targeting the creation of affordable housing. Energy efficiency measures in the housing sector will be designed in a way that simultaneously improves the national energy balance and the living

conditions of low-income groups. In particular, climate support measures in the housing sector will be improved with the aim of increasing support for low-income households.

The Luxembourg Government will also work with all relevant stakeholders to develop innovative programmes, as part of the national long-term renovation strategy to be developed in the coming year, which will create incentives to renovate old housing while providing housing for low-income households.

It should also be mentioned that there is already a programme in place through the cost-of-living allowance ('Allocation de vie chère'), which also counteracts energy poverty. At the same time, the state rent subsidy can help those in need to face a possible increase in the cost of housing. It should also be pointed out that the current social assistance legislation stipulates that any person who satisfies the conditions for entitlement to social assistance is entitled, under defined conditions, to a minimum provision for domestic energy if he or she is unable to cover the costs of domestic energy.

The enormous amount of investment in infrastructure development and the introduction of free public transport from 1 March 2020 are certainly not only transport policy measures, but also clearly social measures.

Strengthening EU law and standards

Improved EU standards and regulations facilitate the achievement of Luxembourg's climate and energy targets. This is why the government will promote an ambitious climate and energy policy framework at EU level. In addition to the EU emissions trading scheme, other important climate action instruments originate at EU level, such as the Regulation on the effort sharing of emission reduction targets among the individual EU Member States, the Regulation on emissions from land use, land use change and forestry, as well as the Directive on the promotion of the use of energy from renewable sources, the Energy Efficiency Directive and the Energy Performance of Buildings Directive. Other instruments include ecodesign requirements for appliances and the regulation of CO_2 emissions from cars, vans and trucks. Luxembourg will advocate a ban on the sale of internal combustion engine vehicles at EU level as of 2030.

Government to lead by example

The government will increasingly play a leading role in the use of renewable energy and the improvement of energy efficiency. It will build on existing programmes and their results, but will also take or develop new initiatives.

Ultra-efficient public buildings

The government is developing a strategy for 'sustainable and energy-efficient public buildings' in new and existing buildings to improve sustainability, energy efficiency and the use of renewable energy in public buildings. It will incorporate the principles of the circular economy and the relevant health aspects. This includes the introduction of an obligation to install photovoltaic systems on state-owned buildings, both for new buildings and renovations. This will also be reflected in a ramping up of the existing photovoltaics programme of the Public Buildings Administration. The aim is for all suitable public buildings to be equipped with photovoltaic installations by 2025.

The state-owned buildings should become the most efficient in all of the EU Member States. In order to better assess and improve the environmental performance of existing public buildings, the mandatory use of the Environment Management and Audit Scheme (EMAS) will be introduced for the management of buildings in order to minimise the environmental impact of buildings and continuously improve their performance. EU institutions based in Luxembourg can serve as a model here.

In addition, the Luxembourg Government is currently developing major housing projects with the respective state and municipal players (SNHBM, Fonds du logement, Fonds Kirchberg, Fonds Belval, Agora, Entwicklungsgesellschaft Nordstad). The planning is in the direction of 'zero CO_2', 'zero waste', 'car free' and 'socially inclusive'. These projects provide the basis for a significant part of the expected population growth in these areas to be climate neutral.

Luxembourg LED 2025 initiative

The government, through its administrations, will completely convert all lighting sources in streets, public places, buildings, stations and monuments from the existing energy-wasting luminaires to energy-efficient LED lighting.

Car fleets

In addition to public buildings, the state's car fleet policy is to be revised with regard to the purchase and use of official cars, and more efficient fleet management is to be introduced. By the same token, the share of electric vehicles in the fleet is to be steadily increased.

Sustainable purchasing

Public administrations will make greater use of sustainability criteria when purchasing. The framework established by the revision of the legislation on public procurement (*Loi du 8 avril 2018*

sur les marchés publics) makes it easier to use other criteria than the price component for the award of contracts. This means that both environmental (life cycle) and social criteria can play a greater role in procurement. Standardisation of tender criteria for different product groups will help to leverage public procurement on the markets. In this context, digitalisation will also be further promoted in order to minimise the use of paper in the long term.

Climate-friendly schools

It is particularly important to focus more on schools and their infrastructures, as young people want to experience and learn about climate action in practice. The 'ClimateXchange' organised with pupils in spring 2019 gathered together many ideas to reduce the ecological footprint of schools. In addition to increasing the use of renewable energy sources (both electricity and heat), sustainable mobility and transport concepts, as well as elements that reduce water consumption, will be taken into account in planning and in major refurbishment works. It is often possible and useful to involve the students themselves in the implementation of their ideas. For example, pupils have already helped to install solar panels on school roofs. In order to make future generations more aware of sustainability issues, the themes of energy efficiency, renewable energy, climate change and sustainability will be integrated into the curriculum.

Further developing the climate pact with the municipalities – Climate Pact 2.0

In order to guide and shape municipal climate and energy policy, Luxembourg has an effective and legally enshrined instrument for climate action in the municipalities (*Loi modifiée du 13 septembre 2012 portant création d'un pacte climat avec les communes*) – the Climate Pact (see Section 1.2 – Overview of current policy situation). In view of an agreement in the coalition agreement 2018-2023, and based on a broad acceptance by the municipalities, the current climate pact, which will expire in 2020, will be continued and further developed under the name 'Climate Pact 2.0'. In order to meet the climate objectives, the climate pact will evolve over the period 2021-2030 in a targeted way in three areas: strengthening the quantification approach, improving framework conditions for the municipalities and providing greater support for the municipalities in their civic work. On the one hand, based on the measures of the climate pact and in view of the objectives of the integrated national energy and climate plan, more locally relevant quantitative indicators will be integrated into the climate pact and given greater weight in the overall assessment. The development of monitoring and communication tools also plays a role in improving the working framework for municipalities, as does the increased support for municipalities in their civic work.

The overall aim is to anchor Climate Pact 2.0 even more firmly as a key implementation tool for national energy and climate policy at local level.

Mobility

Almost two-thirds of Luxembourg's non-ETS climate emissions come from fuel sales, with two figures concisely reflecting the atypical situation. Around 70% of the climate emissions from fuel sales come from motor vehicles registered abroad and the share of lorries is close to 60% of the climate emissions from fuel sales. Increasing fossil-fuelled truck traffic is not only a climate and health issue, but also a transport problem for transit countries such as Luxembourg. Tax and excise policies have a significant impact on the volumes of diesel and petrol sold. This is described in the 'Tax measures' section.

Luxembourg will continue to support schemes at national and European level that reduce lorry traffic (e.g. Eurovignette) and facilitate shifting freight transport to alternative propulsion systems and to rail. In this context, Luxembourg will also promote the development of a sustainable logistics location and support the sector's efforts in this regard. Among other things, existing initiatives to optimise the logistics sector (Lean+Green) will be further developed in the future. Integrated spatial planning, traffic avoidance and the consistent development of soft mobility and public transport will reduce the need for individualised car transport. The remaining cars will be consistently switched from the current 'fossil' age (diesel and petrol) to climate-friendly alternatives (electromobility, hydrogen). This rapid changeover is an essential contribution to achieving the Luxembourg and European climate and energy targets. The measures for electromobility are described in detail in Section 3.1.3.iii.

The transport sector therefore plays a particular role in decarbonising Luxembourg's society and economy. However, the improvement or optimisation of mobility can only be achieved by introducing many different measures.

As part of a long-term **national mobility plan**, the government adopted the sustainable mobility strategy '**MoDu 2.0**' on 23 May 2018. The basic principles of the 2012 'MoDu' strategy, namely multimodality and the strengthening of public transport and active mobility, were retained. The strategic objective for 2025 is to improve the flow of traffic at peak times, with 20% more passengers to be transported than in 2017. The desired modal split on commuting routes should be 46% drivers, 19% passengers, 22% public transport users, 9% pedestrians and 4% cyclists. In addition, the government will set new targets up to 2035 in its MoDu 2.0 development programme during this legislative period.

In addition, 'MoDu 2.0':

- highlights the progress made since 2017;
- contains up-to-date key figures;
- sets fixed targets for Horizon 2025;
- integrates recent technological advances;
- ensures the coherence of new global and national strategies (e.g. Paris Climate Agreement, Third Industrial Revolution, etc.);
- develops a strategy for the creation of a mobility toolbox;
- is explicitly addressed to four stakeholders:
    - citizens
    - the municipalities
    - employers and educational establishments
    - the state.

As part of the planning of mobility projects, a long-term cost-benefit analysis will be used, which will take greater account of climate considerations. The MOBIMPACT tool will be used for project planning. A more multimodal approach will also be put in place for the planning of road-building projects. This includes, for example, preference being given to public transport and carpooling in new road-building projects.

At company level, a mobility plan or strategy for relocations will be established. It will also raise awareness about increasing the use of public transport and creating car pools in existing establishments and activity zones. In addition, the reorganisation of the RGTR network will also improve the coordination of connections to activity zones.

Technical and financial assistance programmes will be made available to municipalities in order to implement concrete measures that reduce the carbon footprint. New mobility plans for activity zones and new municipal mobility concepts will meet predefined criteria in future and will receive technical and financial support. The new procedures and criteria are intended to promote initiatives that reduce the carbon footprint in the transport sector (following the Austrian model 'Klimaaktiv Mobil'). For example, the following criteria could be integrated into the mobility plans and concepts:

- removing P&R from urban centres (transnational cooperation),
- improving the combination of public transport and passenger cars,

- providing electric company cars.

As a tool for traffic management (reducing peak hourly traffic and avoiding traffic caused by people looking for parking spaces) and behavioural management through the availability of parking spaces, a national parking space strategy is being developed, based on the meaningful design, pricing and use of parking spaces.

A regulatory framework and new incentives will be created for the development of 'Mobility-as-a-service' services. The aim is to provide more support for innovative transport solutions through ongoing digitalisation. In addition, existing offers (such as the carpooling project CoPilote) will be reinforced or reinvigorated. The development of a comprehensive mobility app will also be pursued.
In order to promote carpooling, the 'CoPilote' portal will be further promoted and targeted cooperation with employers will continue. In addition, carpooling will be granted further benefits, notably on motorways, in order to increase the number of passengers per vehicle.

At company level, employees who choose a means of transport other than a car should not be further disadvantaged. A 'mobility budget' tax benefit will be introduced which is equivalent to that for company cars and thus offers an alternative to the company car. Alternatively, the following measures may form part of or complement the mobility budget:

- car sharing of electric vehicles,
- financial or administrative support for the creation of car pools within companies or activity zones,
- support for the construction of secure bicycle storage facilities within activity zones,
- financial aid to companies for the installation of charging points,
- offering zero-emission lease cars.

The creation of such a mobility budget will also involve adapting the regulatory framework to encourage a transformation in transport within companies. For example, the use of low-emission and zero-emission vehicles is to be given priority by adjusting the taxation of company vehicles.

Traffic avoidance

In order to avoid traffic, a regulatory framework will be established, in consultation with the social partners, to promote teleworking and thus also to create modern and flexible working conditions. To this end, the tax treatment for the use of teleworking by commuters will be adapted and the current labour and health laws will be amended. Following the example of the current discussions

with Belgium, negotiations will be launched with France and Germany in order to find an appropriate tax treatment that favours teleworking by frontier workers. In addition to promoting teleworking, coworking spaces will also be established in the border area in order to reduce cross-border commuting. Work on the first such structure is due to start at the beginning of 2019 in Esch-Belval, with additional structures to be provided preferably along the A1, A3 and A6 motorway axes and the N31 national road in Rodange.

Consistent development of local public transport

In order to promote public transport, its free use will be introduced on the territory of the Grand Duchy of Luxembourg on 1 March 2020. However, important infrastructure work and projects will also continue to be pursued and implemented. The government sees consistent and continuous investment as an essential precondition for promoting the attractiveness of public transport. Supply, punctuality and quality of service are crucial in encouraging people to change their habits and switch from private cars to public transport. The investments in the railway planned between 2018 and 2023 amount to €2,212,000,000. In 2019, the national railway company, CFL, concluded the largest contract for the procurement of materials in the history of the railway, amounting to €400 million. The material will be delivered between 2020 and 2023. Tram investments between 2018 and 2023 amount to €390,000,000.

As part of the upgrading of the tramway, the existing tram line will be further extended as planned and new tram lines will be created taking into account cost-benefit, coherence with multimodal transport networks, feasibility, etc. In addition, the express tramway project between Luxembourg City and Esch-sur-Alzette will be further developed and integrated into any further road-building project on this line.

In order to improve train services, the extension of double or quadruple tracks on existing lines and the extension or modernisation of existing stations (in particular Luxembourg City and Ettelbruck) will continue. In addition, comfort on the trains will be enhanced by providing quiet compartments in 1st class as well as free Wifi, and by increasing capacity on the train routes. In addition to these infrastructural works, the overall aim is to improve communication and the flow of information to customers regarding disruptions on the railway network and train delays or cancellations. Communication and coordination will be improved for customers, especially in the case of cancellations. To further increase comfort for customers, the coordination between the train and bus networks is to be continuously improved and adapted to ensure that bus connections run smoothly even in the event of delays.

In addition to the rail network, further investment is to be made in the **bus network**, which will be constantly expanded and improved. The current reorganisation of the RGTR network will be systematically continued with the aim of prioritising and optimising the regional bus routes. This includes optimising the bus network on weekends and public holidays and increasing the frequency of bus services in the evening hours. In addition, the reorganisation of the RGTR network will also improve the coordination of connections to activity zones. In addition to organisational adjustments, however, infrastructural improvements, such as the creation of specific bus lanes on motorways or express bus lanes on the main axes, are to be continued. In order to increase comfort for customers, the aim is also to harmonise bus stops and other bus or train lines in terms of connections, as well as providing a minimum level of equipment (bench seat, display boards, etc.). In rural areas in particular, the use of dial-a-bus systems with minibuses will increase, avoiding empty runs outside peak hours and weekends without weakening peak hours capacity.

In addition to the respective projects on the rail and bus networks, the number and capacity of P&R will be increased, especially in the border area. To this end, an appropriate connection to public transport should also be ensured, in particular through the measures mentioned above.

As part of the decarbonisation of the bus sector, a gradual replacement of the traditional RGTR buses by electric buses is also planned. The aim is to analyse the feasibility of the bus routes and build on the experience of the urban bus operator.

A significant part of the reduction in CO_2 emissions will also be achieved through the broad promotion of **electromobility** and the increased use of **biofuels**. The detailed measures to be taken in this context are set out in 3.1.3.iii.

Taking responsibility for aviation and shipping

In order to reduce GHG emissions from **aviation**, the Luxembourg Government supports carbon pricing at European level. In this regard, Luxembourg, together with Belgium and the Netherlands, has put forward a proposal to introduce a **Europe-wide kerosene tax**. Luxembourg will also increase its support for carbon offsetting measures, for example through the tax deductibility of payments to government-accredited organisations (e.g. myclimate.org).

The infrastructure of Luxembourg's international airport is to be made free of GHG emissions. The airport operator has signed a declaration of the Airports Council International Europe (ACI Europe) in which it commits itself to reducing CO_2 emissions to net zero by 2050. In addition, hybrid electric aircraft are to be tested and a new tax regime introduced. Approach charges with a strong

environmental component will be introduced and the 'passenger' charge will be raised to a level comparable to that at neighbouring airports.

The Luxembourg Government is also committed to a Europe-wide solution to improve the climate and environmental compatibility of shipping and has submitted or supported a corresponding proposal at EU level. Improving the energy efficiency and reducing the CO_2 intensity of shipping would not only protect the climate but also reduce air pollution from ships, including nitrogen and sulphur oxides (NO_x and SO_x) and particulate matter (PM), with positive effects on public health and the quality of life of European citizens.

The Luxembourg Government is working towards the adoption, as soon as possible, of binding and effective measures to implement the IMO target – adopted as part of the International Maritime Organisation's (IMO) first strategy to reduce greenhouse gas emissions from ships in 2018 – of a 40% reduction in the carbon intensity of shipping by 2030 compared to 2008 in the EU. To this end, greenhouse gas emissions from international shipping must now also be included in the EU's emission reduction commitment under the Paris Agreement and the Commission must assess and report on the progress made towards reducing them, in relation to European climate and environmental objectives and the related international commitments, on an annual basis. The government is open and optimistic about the measures to be announced for the sector by the next Commission.

The taxation of Luxembourg-flagged vessels (registration fee) will be revised along the lines of the 'green shipping' concept.

The building sector

Measures for sustainable construction and building renovation

The building sector (residential and functional buildings) is currently responsible for around 12% of national climate emissions. This important sector needs a mix of standards and norms, in particular for new construction, but also targeted support schemes for energy upgrading of existing buildings. Luxembourg is a global leader in energy standards for new residential buildings, as in 2017 (rather than waiting until 2021 as permitted by the EU Directive) it became the first country to introduce the new 'nearly zero energy standards' established in 2012. This courageous policy also explains

why, despite the increase in population and new buildings, the energy requirement for residential buildings has decreased. This success story now needs to be extended to cover new functional buildings. Like all other EU countries, Luxembourg still has much to do in terms of energy renovation. There has been a lot of renovation in Luxembourg, but not enough energy renovation.

Strategy and measures relating to the use of renewable energy and energy efficiency in the building sector are set out in Chapters 3.1.2. and 3.2. An overview of the financing measures can be found in Chapter 3.1.1 iii. In the building sector, the PRIMe House support scheme for residential buildings merits particular mention.

Alternative forms of housing

The government wants to pursue a conscious policy to promote innovative housing concepts, such as housing for the elderly (intergenerational housing), housing without cars, housing cooperatives or modular housing. Associated information campaigns, support schemes and pilot projects will be carried out. The legal framework must be reviewed and adapted to allow this kind of housing to become established in order to create affordable and high-quality living space:

- building and housing cooperatives must be legalised by making the Law on Cooperatives [*Loi modifiée du 25 février 1979 concernant l'aide au logement*] more flexible and adapting the legal framework, so that citizens can be provided with cheaper housing.
- In addition, Luxembourg needs a legal definition of the terms *logements sociaux* [social housing] and *logements à loyer modéré* [affordable housing].

Pacte logement 2.0

The *Pacte Logement* [housing pact] of 2008 (*Loi du 22 octobre 2018 portant sur la promotion de l'habitat et la création d'un pacte logement avec les communes*), which provides municipalities with, among other things, additional financial resources to create new housing and public infrastructure, will come to an end in December 2020. Considering the high demand for affordable housing in Luxembourg, the government has decided to extend and refocus the *Pacte Logement*. This pact between the government and the municipalities is to be relaunched under the name ***Pacte logement 2.0*** and, on the basis of a wide range of measures, will help the municipalities to achieve important objectives in relation to housing construction and to improve the quality of

housing available to inhabitants. The focus here is on increasing the supply of housing and the mobilisation of building land, and improving the quality of housing and energy performance in both new housing projects and existing ones. The new *Pacte Logement* will be in force until around 2030 and its structure will be more diverse. Possible elements include improved advice to municipalities from the Ministry of Housing, providing a housing consultant and promoting various measures focusing on both the quantity and quality of housing. The range of measures for achieving these objectives was drawn up in cooperation with the municipalities. The advice provided to municipalities on implementing larger housing projects is to be improved under *Pacte Logement 2.0.* to help them strengthen their position as participants in the housing market. This advisory support covers, in particular, the acquisition and development of land, housing construction (independently or in collaboration with the private sector), the sale or letting of land and residential properties, and the management of an inventory of rented buildings. For this purpose, the municipalities will be provided with a professional consultant on housing construction (housing consultant). As a general rule, synergies with the Climate Pact and the Nature Pact will be identified and valorised. Furthermore, the Ministry of Housing will be provided with increased capacity in order to support the municipalities in creating housing developments.

Spatial planning is becoming more important, including in relation to climate change

Heat map and solar map

Energy investment planning will play a more important role in the climate age. For this reason, the Energy and Spatial Planning Departments within the Ministry for Energy and Spatial Planning are working hand in hand to produce two important maps; a heat map to show where our country can, as a priority, replace housing blocks and entire districts which today run on natural gas or fuel oil with heating networks which use renewable energies or waste heat from industrial plants or data centres. A national solar map will also facilitate the planning of large and smaller solar plants.

Eco-district made in Luxembourg

The Luxembourg government is in the process of developing major housing projects with the respective national and municipal bodies (SNHBM, Fonds du logement, Fonds Kirchberg, Fonds Belval, Agora, Entwicklungsgesellschafft Nordstad). Planning is moving in the direction of 'zero CO_2', 'zero waste', 'car free' and 'socially inclusive'. These projects provide the basis for a significant part of the expected population growth in these areas to be climate neutral.

Bringing together housing, work and leisure

The best energy is energy that is saved, i.e. that never has to be produced at all. The best mobility is mobility which never takes place. In order to improve planning for the country and its urban areas in a dynamic economic environment, the government, led by the Ministry for Energy and Spatial Planning, is working on a new planning strategy for 2035 (*programme directeur*). This strategy sets out proposals for where an increased number of residential properties should be built in Luxembourg in the future (e.g. close to existing or new railway stations), what new transport infrastructure is needed and which areas must be off-limits as they are key to maintaining biodiversity. The 2035 Planning Strategy will also include concrete proposals for improving cooperation with our border regions. In order to allow discussion surrounding the drafting of the 2035 Planning Strategy to take account of fundamental issues, an ideas workshop will be organised for Luxembourg in 2050, based on the model of the Grand Genève's 'competition for ideas' [*concours d'idées*].

Economy

The 22 largest industrial CO_2 consumers are subject to the EU Emissions Trading Scheme. In total, industry was responsible for 50% of electricity consumption and 44% of natural gas consumption in 2018. When combined with the services sector, these figures rise to around 62% and 83%. Consequently, in addition to the EU Emissions Trading Scheme, further efforts are needed in relation to the best available technologies, energy efficiency and renewable energies. This will reduce energy costs and thus make a significant contribution to competitiveness.

The industrial sector will play an important role in achieving the energy efficiency targets pursued because, due to its high share of overall electricity consumption in Luxembourg (50%), this sector still has a lot of savings potential. Therefore, the government will introduce additional measures (e.g. de-risking, transparency platform for audits, continuing the EEO) to make it easier for those in industry to invest in energy efficiency themselves or via third parties. The government will also proactively participate in EU research projects on zero-carbon steel, zero-carbon cement, zero-carbon glass etc.

In Luxembourg, the 2018-2023 coalition agreement provides for the creation of an integrated support instrument for SMEs, which functions supplementary to the *Accord volontaire* [voluntary agreement] and the de-risking instruments (described under 3.2.1.i) and aims to provide the relevant companies with a support framework for their implementation of energy and climate policies.

Green Jobs and Climate Solutions made in Luxembourg

Many studies show that climate protection also leads to net creation of jobs. This applies in particular to countries in which there are now few jobs in coal mines, natural gas fields and on oil rigs.

Investment is needed in Luxembourg in solar plants, wind farms, electric charging columns, energy efficiency measures in industry and SMEs, developing heating networks, the circular economy and in particular energy renovation of existing buildings. The government is aware of this, and has introduced initiatives both in basic training and in further training (*formation continue*).

Luxembourg should however also be entitled to become a 'start-up nation' in the field of climate change. The pioneering role in key technologies (zero-energy buildings, electromobility, photovoltaics), the development of energy research and innovation in Luxembourg, and particularly the high level of expertise in 'green finance' create an environment which facilitates assisting existing companies in Luxembourg with climate protection, and attracting new companies from Europe and around the world.

Important role of the circular economy as a climate protection measure

The circular economy can also help to reduce GHG emissions, beyond the measures described elsewhere. A 2018 study shows that if a circular economy were to be consistently implemented, European emissions from heavy industry could be reduced by up to 50% by 2050.

On the basis of the Circular Economy Study (2014) and the Rifkin process, it is important to define the circular economy in Luxembourg, in order to ensure that all parties from different sectors have the same understanding. This definition is equally important in order to determine and best support the social aspects of a transition to a circular economy. A change to a circular economy can only take place accompanied by a societal shift. Economic concepts which meet this challenge are, for example, the development of 'sharing initiatives' and cooperatives or the upgrading of service offers. Another important issue in relation to developing a circular economy is promoting a regional focus.

A key aspect of the circular economy is resource management, which is strongly defined by waste legislation. Only through continued promotion of cascading use can transition from a linear economy to circular value creation be achieved. It is only possible to establish cascading use if the necessary steps are taken in the design stage to arrange for the further use or the reuse of resources. The current Waste and Resources Management Plan (2018) already

sets out targets for, among other things, prevention, recycling and different waste categories. Thus, recycling rates for packaging are already set at 70% for the year 2022. A review of the legal basis for waste management will provide the necessary impetus. Other strategic aspects are set out in a 'Null Offall Lëtzebuerg' [zero waste Luxembourg] strategy and a circular economy strategy. Work on the 'Null Offall Lëtzebuerg' strategy has already begun and has been accompanied by public consultations. This strategy aims to transform the current waste management system into an economy with a stronger focus on resource management.

In addition to these structural measures, companies in particular require support during the transition. In this context, a material flow analysis will be carried out to identify the flows for which circular and regional value creation appears possible. In addition, continuous adjustments will be made to the business environment to promote circular business models.

In addition, the construction sector will be assisted and supported in order to further promote sustainable construction and the circular economy. In this regard, national criteria will be defined and developed for sustainable and circular construction in cooperation with the various operators in the sector, with the aim of creating a database that is also compatible with the BIM working method. In addition, legal and regulatory measures to ensure implementation of sustainable construction in Luxembourg will also be analysed. There will be continued efforts to increase timber construction. Due to its potential for cascading use, the possible regional nature and the reduced climate impact, this building material in particular has potential which should be further exploited.

Furthermore, sustainable living and ecology and circular economy ideas within urban neighbourhoods will be supported, for example, by the promotion of sharing economy and urban farming projects.

Lastly, circular value creation will be further promoted in commercial and industrial areas. Important aspects in this context, which also have a direct impact on greenhouse gas emissions, are the efficient use of energy, e.g. the use of waste heat, the use of roof surfaces for solar energy or reducing the need for mobility.

Waste and household water management

In the **waste sector** all measures are listed in the national waste management plan. Additional measures will be introduced with the new waste regulation. In relation to greenhouse gas emissions, the most relevant measures here are those which aim to reduce waste production. In particular, the aim is to reduce food waste by 50% by 2022.

In the **household water management** sector, Luxembourg will increasingly find itself confronted with the problem of sewage sludge. The size of treatment plants and the amount of sewage sludge produced are increasing with population and economic growth. The government programme anticipates the implementation of a national strategy to propose sustainable solutions for recovery (energy recovery, phosphorus recovery, etc.) or removal of sludge. A study is expected to deliver initial results by the end of 2020. The Strategy for Adapting to Climate Change in Luxembourg (2018-2023) also sets out recommendations for integrating aspects related to climate change into the design of sewerage systems. The recycling of wastewater will be further promoted and the effective use of grey water (e.g. thermal use) will be further developed.

Industrial processes and fluorinated gases

Mitigation measures in the field of **industrial processes** are subject to the EU ETS standards. However, mitigation measures established as part of the national air pollution control programme under European Directive 2284/2016 may lead to an additional reduction in greenhouse gas emissions, in particular in the use of various products such as solvents. Measures in the energy efficiency sector can also lead to additional reductions in industrial processes.

Reduction measures for **fluorinated gases** are set out in European Regulation No 517/2014 on fluorinated greenhouse gases. These include both placing on the market and monitoring the use of various fluorinated gases, and reducing the quantity of hydrofluorocarbons placed on the market through allocation of quotas and creation of a register.

Agriculture and forestry

Agriculture and forestry are both actors in and affected by climate change. On the one hand, they directly influence the development of greenhouse gas concentrations in the atmosphere through release of greenhouse gases and carbon storage. On the other hand, climate change affects agricultural and forestry production conditions.

Anticipatory adaptation to climate change should help Luxembourg's agriculture and forestry sector to maintain and increase its production and public services in the long term.

The IPCC Special Report on Climate Change and Land highlights the impacts of climate change observed across the globe on natural terrestrial ecosystems, land degradation and food security. The frequency and intensity of some extreme climate and weather events affecting the land surface has increased. The report illustrates the vulnerability of terrestrial ecosystems and resources and food security to climate change. Climate change is expected to exacerbate the existing challenges facing land systems, posing serious risks to livelihoods and the well-being of the population.

All of the reduction trajectories evaluated in the report, which limit warming to 1.5 °C or to clearly below 2 °C, require land-based mitigation measures and changes in land use which remove CO_2 from the atmosphere. The report also shows that there are many land-based mitigation measures which do not compete with land use (such as sustainable agricultural practices and agroforestry) and have potential added benefits. A change in eating habits and reduction of food waste and loss could also reduce pressure on the land, while contributing to the eradication of poverty and improving health and hygiene. However, the report also emphasises that the use of large-scale land-based solutions (such as bioenergy with carbon capture and storage, and reforestation), if applied on a large scale and in a non-sustainable manner, can increase pressure on the land and food security.

Agriculture

In line with the aforementioned IPCC Special Report, a first set of measures has been identified for reducing GHG emissions in agriculture by reducing the use of nitrogen-containing fertilisers, and in some regions even promoting the elimination of nitrogen-containing fertilisers altogether. These measures include agri-environmental measures defined under the EU's Common Agricultural Policy (CAP) and incorporate programmes to **reduce nitrogen fertilisation on arable land and grassland**, but also the non-fertilisation of, for example, flower borders and field margins.

A second set of measures concerns the use of organic manure and mineral nitrogen fertilisers. These are implemented as part of the agri-environmental measures and the NEC Directive and include **promoting environmentally friendly techniques for spreading manure, the ban on splash plates from 2025** and the **ban on open new slurry or biogas slurry containers**, with **support available for covering existing open containers**. These measures also all lead to a reduction in GHG emissions.

There will be further promotion of **biogas** as an **energy source** in the interests of the circular economy. As explained in more detail under 3.1.2.i., organic manure of animal origin should be

used as a priority in biogas plants, in order to concurrently reduce methane emissions. The coalition agreement provides for the drafting of a **strategy to reduce methane emissions**.

A number of interventions under the agri-environmental measures, the Agricultural Biodiversity Action Plan and the Water Protection Act will lead to extensification of agricultural land use, in particular in sensitive areas, but also by promoting the grazing of dairy cows. Furthermore, the coalition agreement anticipates that **at least 20% of agricultural land will be subject to organic cultivation by 2025** (and 100% by 2050), which will contribute to extensification of agricultural use. In addition, greening measures and the landscape conservation premium will also help to reduce GHG emissions. Overall, **agriculture** should remain **land-dependent**.

Further development of advice and diversification of the consultancy modules on offer, which promote climate-friendly, climate-resilient, environmentally friendly and economical crop and animal production, is another measure which will help to reduce GHG emissions. In this sense, any major agricultural investment project financially supported by the State will in future be subject to an economic, social, ecological and energy-related analysis. Furthermore, sustainability checks will be introduced for agricultural holdings. There is also a need to increase knowledge about climate change and agriculture and to promote innovation through relevant research projects relating to Luxembourgian agriculture.

Preventing food waste makes a key contribution to reducing emissions. The 'Antigaspi' [anti-food waste] campaign must be continued and intensified in order to prevent waste along the entire food chain.

In addition to forestry, the agricultural sector also provides a carbon sink which absorbs CO_2 from the atmosphere and is therefore vital to achieving the objectives of the Paris Agreement. A research project will draw up the necessary guidelines to specifically encourage the development of humus as a carbon sink. In this area, the existing ban on ploughing permanent grassland in sensitive areas and the promotion of reduced tillage and cover crops should be pointed out. The crop diversification obligation under the agri-environmental measures and greening are other measures which increase carbon sinks. Agroforestry would have a positive impact here.

Forestry

All relevant forestry measures have been listed in the national forestry accounting plan (Regulation (EU) 2018/841). These include, in particular, the protection of existing woodland, sustainable forest management and the designation of semi-natural forests. Based on these already existing measures, a reference value has been established for forests which serves as a basis for accounting rules in the forestry sector. These existing measures will be maintained in order to record zero emissions in the forestry sector.

New subsidies will be introduced in relation to increasing semi-natural and climate-resilient forest management. Reforestation measures and steps to increase the volume of wood in forests will be taken to increase CO_2 sinks. Furthermore, increased use of wood products in the construction sector and improved cascading use of wood will prolong the CO_2 storage effect.

Taxation measures

Energy and environmental taxes in Luxembourg are low in comparison to Europe and its neighbours. This poses various challenges in relation to climate and energy policies. The government is aware of this, and the coalition agreement accordingly states that the government will develop and implement a predictable and coherent tax policy which will provide adequate responses to the realities and challenges of family, social, economic and environmental policy.

As part of the tax reform planned in this regard, energy and resource taxation, including the described minimum CO_2 price, will be revised to incorporate the treatment of non-sustainable tax privileges detrimental to the climate. This will also take into account the findings and recommendations of the ongoing study 'Effects of subsidies and tax incentives on sustainable development – environmentally harmful subsidies in Luxembourg'.[13]

The social fairness of an energy and resource taxation reform is a prerequisite for its success. The coalition agreement states in this regard that revenue from an increase in energy taxes is to be used to finance the social efforts necessary to create ecological change, which should at the same time be socially just.

[13] The study 'Effects of subsidies and tax incentives on sustainable development – environmentally harmful subsidies in Luxembourg' is explained in more detail in Chapter 3.1.3.iv.

Fuel taxation

The government is aware that Luxembourg can only meet its climate and energy targets if enhanced measures are taken in relation to fuel sales in general and in particular in relation to fuel exports to HGVs. This is because, according to the Paris Agreement and the detailed EU framework legislation, CO_2 emissions are recorded where the fuel is sold. The fuel prices for diesel and petrol in Luxembourg are cheap in comparison with neighbouring countries. Price differences with neighbouring countries must thus be gradually reduced in order to reduce fuel exports. In this connection, it will also be necessary to reduce the dependency of public finances on fuel sales and to avoid supporting false price signals which lead to an increase in fossil-fuelled HGV traffic. Revenue that is incompatible with the objectives of the Paris Climate Agreement will be relinquished.

It was decided in the coalition agreement to adjust taxation of mineral oil products, in particular fuels, to bring it into line with the objectives of the Paris Climate Agreement. An initial increase in excise duties on diesel (+2 euro cents per litre) and petrol (+1 euro cent per litre) was introduced on 1 May 2019.

An inter-ministerial committee (finance, environment, energy, economy) monitors and analyses trends in the sale of fuels and the impact of the new measures proposed by the government. With regard to achieving climate targets, under the coalition agreement the committee will also identify measures for steadily reducing the impact of the sale of fuels on Luxembourg's greenhouse gas balance and will regularly propose adjustment measures to the government. Care will be taken to reduce the unjustified preference for diesel over petrol in the event of any future increases.

In addition to the taxation measures, there are also instruments that could contribute to reducing fuel exports. For example, aspects relevant to climate change must be enshrined in motorway service station licences and, at the same time, police checks on HGVs at motorway exits must be increased, and carried out with greater cooperation from the municipalities, in order to prevent transit fuel traffic placing an increasing burden on our towns and villages.

Vehicle taxation

Although the vehicle tax for vehicles in category M1 registered after 1 January 2001 is calculated according to CO_2 emissions (according to the EU Conformity Certificate) and fuel type, their current steering effect is low.

Therefore, the vehicle tax will be revised to take account of the polluter pays principle. The revised vehicle tax will exclusively apply to vehicles which are registered after a date yet to be determined.

The current tax regime for company cars (40% of all new cars sold in Luxembourg) provides an incentive for both employers and employees to purchase and use these cars. Since 1 January 2017, the financial benefits to the employee have been calculated on the basis of CO_2 emissions per kilometre and are thus intended to encourage selection of lower-emission vehicles.

The coalition agreement also provides for further revision of the financial benefits of company cars, with the aim of promoting electromobility through this route. In addition, employees who choose a means of transport other than the car should not be further disadvantaged. The introduction of a 'mobility budget' tax benefit will be considered, equivalent to that for company cars. This will facilitate workers' access to LPT mobility, active mobility or car-sharing services.

Taxation of fuel oil and natural gas

Taxation of fuel oil will be gradually increased as part of the aforementioned tax reform, taking into account the described minimum CO_2 price, in order to encourage the shift towards renewable, comparatively climate-friendly heating. In order to ensure that this measure is socially just, an attractive support scheme for oil heating exchange will be introduced. In this connection, the competent ministries will analyse the impact of increasing the cost of fuel oil with the public subsidy from the *Allocation de vie chère* [cost of living allowance] and, if necessary, adjust the effectiveness of this premium, as well as respecting the technical feasibility.

Further taxation measures

To promote the circular economy and tackle excessive consumption of resources, the government will consider applying the super-reduced VAT rate of **3% to eligible repair work under European law.**

The government will also explore opportunities to introduce tax incentives for natural persons **investing in sustainable development, climate protection and energy transition.** The benefits of such investments will be proportionate to the taxable income and the risks taken by the taxpayer concerned.

3.1.1.ii. Any regional cooperation in this area

Within the framework of the Pentalateral Energy Forum (DE, FR, BE, NE, LU, AU, CH), Luxembourg will prioritise action in the following areas:

- A shared vision for a decarbonised electricity system in western Europe by 2050
- initiating cross-border cooperation in the field of renewable energy
- integrating electromobility options and services without regional constraints
- Exploring options for CO_2 pricing and its cross-border impact on electricity prices.

These issues have already been further discussed in Chapter 1.4.

3.1.1.iii. Without prejudice to the applicability of State aid rules, financing measures, including Union support and the use of Union funds, in this area at national level, where applicable

Climate and Energy Fund

The Climate and Energy Fund (*Loi modifiée 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*) on the one hand finances governmental and semi-governmental projects in the areas of climate action and renewable energy at national level and on the other hand is used for international climate financing. The Fund is fed from three sources:

- a proportion of the fuel tax (3.5 euro cents per litre of diesel and 2.5 euro cents per litre of petrol, since the increase in excise duties of 1 May 2019 (see Chapter 3.1.1.i.))
- 40 % of the vehicle tax revenue; and
- national auction proceeds from EU emissions trading.

The future climate law (see Chapter 3.1.1.i – introduction of a climate law) will again enshrine the Climate and Energy Fund in law and adapt it to current challenges in line with the Paris Climate Agreement. This will lead to adjustments in terms of both expenditure and revenue. The Climate Pact for municipalities is to be funded by the Climate and Energy Fund.

Environmental fund

The environmental fund (*Loi modifiée du 31 mai 1999 portant institution d'un fonds pour la protection de l'environnement*) is used to support communal projects in the areas of climate action, energy efficiency and renewable energy, as well as the waste sector and nature conservation. It subsidises energy concepts, energy renovations, communal buildings, energy-efficient new construction, renewable heat and power generation (photovoltaic installations, solar thermal installations, heat pumps, biomass heating plants and combined heat and power plants), communal heating networks based on renewable energy and waste heat and converting street lighting to LED technology, among other things. The kinds of project eligible and the associated eligibility criteria are regularly updated and adapted to technical and economic development as well as climate and energy objectives.

PRIMe House housing support scheme

The PRIMe House support scheme (*Loi du 23 décembre 2016 instituant un régime d'aides pour la promotion de la durabilité, de l'utilisation rationnelle de l'énergie et des énergies renouvelables dans le domaine du logement*) offers investment aid for the sustainable energy renovation of residential buildings and corresponding qualified energy consultancy, for the construction of sustainable residential buildings and for the use of renewable energy (photovoltaic installations, solar thermal installations, heat pumps, wood pellet and wood chip heating systems). The support scheme has been extended and reviewed a number of times since 2001. The current programme runs until the end of 2020.

Regarding the continuation and further reinforcement of the programme, the following aspects will be the focus of further development:

- Checking and, if necessary, adjusting the amounts of support
- Integrating additional sustainability criteria, in particular to promote the circular economy
- Including criteria to reduce health risks in residential buildings
- Developing eligibility criteria for energy efficiency in listed buildings, in coordination with existing support schemes run by the National Sites and Monuments Service.
- Further administrative simplification, for example by increasing the digitalisation of the application procedure and optimising quality control (relationship between quality improvement and intensity of controls)

An inter-ministerial working group is responsible for monitoring and further developing the support scheme.

In addition to the further development of PRIMe House, the criteria for the Luxembourg sustainability certification for residential buildings (*Lëtzebuerger Nohaltegkeets Zertifizéierung* – LENOZ) will also be reviewed:

- The certification is to be generalised.
- A selection of LENOZ criteria is to be progressively introduced as compulsory and promoted, and then gradually phased out from PRIMe House support.

Climate loans for residential buildings

In addition to the PRIMe House support scheme, the sustainable energy renovation of residential buildings is supported via low-interest or (for low-income households) interest-free loans (*Loi du 23 décembre 2016 relative à un régime d'aides à des prêts climatiques*), with the technical requirements being the same as the PRIMe House criteria.

There are plans to review and simplify the terms and conditions and application procedure, so that more homeowners can benefit from a climate loan in the future.

'Clever fueren' [drive smart] support scheme for electric vehicles

As regards increased promotion of electromobility, the tax incentives for electric vehicles in effect until the end of 2018 were replaced by direct subsidies on 1 January 2019 (*Règlement grand-ducal du 7 mars 2019 portant introduction d'une aide financière pour la promotion des véhicules routiers à zéro ou à faibles émissions de CO_2*). Passenger cars, vans, motorcycles and bicycles are subsidised via the 'Clever fueren' scheme. All-electric vehicles, plug-in hybrid vehicles (≤ 50 g CO_2/km) and hydrogen-powered fuel cell vehicles are eligible.

The support scheme was continued in 2020. The subsidy for plug-in hybrid vehicles is due to end in 2021.

Subsidy schemes and financial incentives for businesses

Under Commission Regulation (EU) No 651/2014 of 17 June 2014 declaring certain categories of aid compatible with the internal market in application of Articles 107 and 108 of the Treaty, the Luxembourg government can provide direct investment aid in the fields of environmental technologies and innovation for businesses (both SMEs and also larger companies). The Ministry of the Economy is responsible for granting the aid, supported by the innovation and research agency Luxinnovation (*Loi du 15 décembre 2017 relative à un régime d'aides à la protection de l'environnement*; *Loi du 17 mai 2017 ayant pour objet 1) le*

renouvellement des régimes d'aides à la recherche, au développement et à l'innovation; 2) les missions de l'Agence nationale pour la promotion de l'innovation et de la recherche; et modifiant la loi modifiée du 5 juin 2009 relative à la promotion de la recherche, du développement et de l'innovation).

In addition, SMEs can also apply for funding through a special government support scheme.

To support companies' efforts and to accelerate the energy transition, the following aspects will be the focus of further development:

- Increased promotion of aid schemes by providing companies with better information
- Simple and transparent communication of the measurable benefits of support schemes
- Simplifying the eligibility conditions, in coordination with national and European law
- Accelerating administrative simplification, in particular through increased digitalisation
- More resources for the support scheme directed at SMEs
- Enhanced efficiency through a combination of support schemes for SMEs and larger companies

The existing support schemes will be reviewed.

3.1.2. Renewable energy

The Luxembourg government would like to accelerate the push for renewable energy with a target of 25% by 2030, and supports further development through investment aid and subsidies for private individuals and businesses. Wind power, as one of three key technologies for Luxembourg (wind, solar, biomass), surpassed the expectations of the NREAP in 2009 and continues to be financed accordingly. There will be a fresh attempt to instigate widespread use of photovoltaics (recently, development has almost stagnated). For biomass, priority will be given to improving cascading or multiple use (round timber for sawmills for use in furniture and construction, used and residual wood for particleboard plants, waste and scrap wood for cogeneration installations) and sustainability criteria (including procuring wood from the Greater Region in principle or within a radius corresponding to the Greater Region). In addition, new options, such as geothermal energy, will be further explored and promoted. Luxembourg's aim is to become a proactive player in the energy transition, involving its whole population. In addition to the expansion in Luxembourg, the government will also actively participate in renewable energy development in Europe, through the instruments provided for in the new Directive 2018/2001 on the promotion of the use of energy from renewable sources. The following points will be implemented:

- In order to increase investment in renewable energy, **new incentives** will be introduced, such as increasing feed-in tariffs for photovoltaic installations, regular calls for tender for large installations and the **removal of current barriers**.

- In general, Luxembourg will promote the expansion of renewable energy production at **European level** and will not support new projects based on fossil fuels or the development of fossil fuel power plants. By 2050, 100% of the energy supply in the EU should come from renewable energy sources.

3.1.2.i. Policies and measures to achieve the national contribution to the binding 2030 Union target for renewable energy and trajectories as referred to in Point (a)(2) of Article 4, and, where applicable or available, the elements referred to in Point 2.1.2 of this Annex, including sector- and technology-specific measures.

Wind energy

A large proportion of renewable energy production in Luxembourg already comes from wind power (installed capacity in 2018: 123 MW from 69 installations). At present, around 10 wind farm projects, some of which have already undergone the strategic environmental assessment and other required impact studies, are in the development and finalisation phase for 2020 and are expected to produce electricity for around 50,000 additional households per year.

The existing feed-in payment/market premium will be continued and existing barriers will be removed where possible. The possibility for municipalities and citizens to make a financial contribution will also remain a key development factor. In the past, this has ensured a very high level of acceptance for wind power plants among the population and will continue to do so.

Solar energy

Due to its strong potential and multiple direct uses, solar power plays a key role in the country's energy mix and will be developed even further in the coming years. As regards photovoltaics, Luxembourg is currently in 6th place in the European Union in terms of installation capacity per inhabitant, with a total of 6990 photovoltaic installations (2018). The government's aim is to reach the top of this ranking by 2030.

Feed-in tariffs

The increase in feed-in tariffs in 2019 aims to maximise the use of building roofs (and other sealed/non-agricultural areas) in Luxembourg to fit photovoltaic installations. Attractive feed-in tariffs for small installations up to 10 kW should allow all households to fit their own installation,

including with a view to later self-consumption. As previously, co-operative installations will be supported separately. Every citizen will have the opportunity to take part in the energy transition. After the introduction of a new category, collective installations in the range of 30 to 500 kW can now benefit from a feed-in tariff. Municipalities will be encouraged to make their roof areas available to cooperatives. More than 100 of these large 'solar power plants for the people' are currently in the pipeline.

Calls for tender

In order to speed up the expansion of photovoltaics in Luxembourg, a call for tender for large photovoltaic installations (≥ 500 kW) was launched for the first time in 2018. The contract was awarded to 15 MW capacity on buildings and industrial areas/landfills. The second call for tender over 40 MW took place in autumn 2019 and now provides a specific category for carports, among other things. It also permits installations between 200 and 500 kW.

On the basis of the results and analyses of both these calls for tender, a multiannual plan for calls for tender will subsequently be published in 2020, in which the volumes offered for tender will be successively increased each year in order to achieve the targets in the photovoltaics sector.

Self-consumption

The inclusion of self-consumption concepts (in conjunction with energy storage) and energy communities will play a new, specific role in the PV sector. Both concepts, as provided for in Directive 2018/2001, have already been enshrined in a legislative amendment (on the electricity market), allowing accompanying measures and support measures to be implemented quickly.

The '30-200 kW' category for self-consumption will be specifically targeted in the overall photovoltaics approach – attractive tariffs for small installations, special categories for cooperatives for citizen participation, calls for tender for larger and major installations from 200/500 kW – in order to create incentives for SMEs and office buildings.

Solar map

The coalition agreement (2018-2023) provides for the creation of a national solar map for Luxembourg. Up to now, such a tool has only been available at municipal level in some cases, for example in the capital city. The development of a solar map provides a decision-making tool in

relation to solar energy and helps to recognise and exploit existing potential in terms of private photovoltaic installations, energy cooperatives and public calls for tender. Furthermore, the map can be used by network operators and administrations to help them optimise the integration of solar installations into the network.

The map, which should be complete by the end of 2020, should facilitate more efficient planning. This tool will take account of the type of roof (flat roof, etc.) and the heights of buildings, so that citizens/company only need to click on their roof in order to obtain an initial assessment of whether it would make sense to install photovoltaics. The map is intended to serve as a planning and management tool for administrations in relation to larger areas (along roads, old industrial or landfill sites, possibly later free agricultural space).

Heat pumps

Heat pumps are stated as the reference technology for new buildings in the improved thermal insulation regulations for residential and service buildings. It is estimated that the use of geothermal energy in connection with **heat pumps** has an achievable potential of around 180 GWh/a. Heat pumps are a highly versatile technology for using renewable energy and energy efficiency technologies and have proved to be particularly effective heating systems in well-insulated buildings. The government intends to continue to promote and develop this technology by means of financial aid (see Chapter 3.1.1.iii) and an improved information policy (e.g. updated restriction map via Geoportal).

Medium-depth geothermal energy

Potential for exploiting **medium-depth geothermal energy** will be more systematically identified and more consistently taken into account in relevant project areas. The aim is to reduce the existing uncertainties and risks and to promote increased use of geothermal energy in suitable locations. The main focus here is on the area around Düdelingen and Esch-sur-Alzette.

Biomass

In recent years, use of biomass has predominantly been promoted in cogeneration plants. The new Directive 2018/2001 provides sustainability criteria for the use of biomass in large plants (> 20MW). On this

basis, the Luxembourg Government intends to set stricter requirements in relation to sustainability criteria for new plants in future, and therefore plans to extend the European sustainability criteria for biomass use in cogeneration plants to smaller installations. Plants with a rated electrical output over 10 MW which use biomass or used and residual wood as an energy source must comply with these sustainability criteria in order to receive a feed-in tariff/market premium. In addition, it will also be ensured that the objectives of Directive 2016/2284 on the reduction of national emissions of certain atmospheric pollutants remain achievable, through the use of suitable technology.

The stated objective is for biomass for energy production to be sourced from the Greater Region or within a radius corresponding to the Greater Region. More detailed provisions will be set out when the sustainability criteria are developed. In general, the cascading use principle should become more firmly entrenched in relation to the use of wood. The Luxembourg Government is considering creating its own sustainability label, which could be linked to the 'Holz vun hei' [locally sourced wood] label. In addition, the draft *code forestier* [forestry code] law also sets out better sustainability criteria for national forestry.

Biogas

Biogas continues to be a pioneering energy source (electricity, heat, supply). The framework conditions need to be revised in order to better promote biogas and to better take account of the not insignificant environmental and water protection issues (methane, NH_3 emissions, nitrate, phosphorus). Part of the reform will involve adjustments to state aid to better recognise the non-energy related benefits of the sector. The government is setting very clear priorities, including in relation to the circular economy, the recovery of slurry, manure, biowaste and other residues. The biogas strategy is therefore also part of the methane reduction strategy. Currently, only slightly more than 10% of the theoretically available slurry is used for energy purposes (13.6% in 2018). The use of renewable raw materials is restricted. Biogas produced will be fed into the gas network as a priority.

To this end, a technical and economic analysis was commissioned to determine the potential of biogas and the implementation of all of the above factors. In view of the scarcity of land in Luxembourg, the 2030 renewable energy targets and the results of the study, the Ministries concerned (energy, environment and agriculture) will work closely together to define the future role of agriculture in energy production and specifically in relation to biogas and photovoltaics.

Government to lead by example

As already mentioned under 3.1.1, Luxembourg has adopted a strategy for 'sustainable and energy-efficient public buildings' in relation to new construction and existing structures, in order to improve energy efficiency and the use of renewable energy in government and government-related buildings. This includes the introduction of an obligation to **fit photovoltaic installations** on government and government-related buildings, for both new and renovated structures. This should also be reflected in an improvement to the existing **photovoltaics scheme** run by the *Administration des bâtiments publics* [Administration for Public Buildings]. The aim is for all suitable public buildings to be equipped with photovoltaic installations by 2025. In addition, better integration of photovoltaic installations and increased use of renewable heat, in particular based on medium-depth geothermal energy, will be promoted in **schools and their infrastructures**.

> *Army barracks to go green*
>
> It has already been decided that the infrastructure on the Herrenberg will be extensively renovated into an 'energy autonomous zero CO_2' area. The houses will be renovated, solar energy will be installed on many rooftops and the heating network will be switched to renewable energy. Many army vehicles will also be examined to see if they can run on electricity or hydrogen. Through smart energy management, the entire area will then be largely self-sufficient in terms of energy.

Hydrogen

The production of hydrogen, which is mainly used in industry, is today largely based on fossil fuels, primarily gas and what is known as gas reformation. In order for hydrogen to play its part in decarbonisation, renewable hydrogen or 'green hydrogen' must be produced by electrolysis of demineralised water using renewable electricity (photovoltaics or wind power). This low-emission or zero-emission hydrogen can be used in many fields, including in industry, in transport or even in energy storage (it is primarily suitable for seasonal storage of renewable energy).

There are plans to construct a hydrogen refuelling station. A key factor is the certification and supply of 'green hydrogen' which is an essential condition for commissioning.

Committees such as the Pentalateral Energy Forum or Hydrogen Europe also take this position. Luxembourg will contribute to a Europe-wide network of hydrogen refuelling stations. To enable longer

journeys within Europe, in particular in the trucking and logistics industry, locations along or on the motorways are the most logical. Studies in this regard are currently being prepared.

Hydrogen can also play an important role in reducing CO_2 emissions, in particular in the steel and cement industries. Companies in Luxembourg specialising in steelworks construction are already active in this field.

Looking ahead to 2030, hydrogen can play a crucial role in energy supply and in sector coupling for the electricity, heat and transport sectors, in particular if energy losses in production and conversion through electrolysis are improved and the effectiveness of fuel cells developed for use in transport is increased. Luxembourg intends to work closely with other EU Member States in this area.

A hydrogen strategy for Luxembourg is currently being prepared as part of the European Green Deal and a future European hydrogen strategy. The H_2 strategy for Luxembourg will analyse potential in the following areas:

- How substantial is the current and future demand for hydrogen?
- Is it possible to produce renewable hydrogen in Luxembourg, and if so, how much? Alternatively, how can the importation of hydrogen be arranged?

This analysis will examine, in particular, potential in the transport, industrial and renewable energy sectors (production – flexibility – storage – recovery).

A future hydrogen economy will operate across borders, and it is therefore essential to have discussions at various levels with neighbouring countries and EU Member States. The Ministry of Energy and Spatial Development is currently preparing an initial strategy document for Luxembourg, in close cooperation and frequent discussion with interested parties from the scientific community and from industry.

Innovative funding instruments for renewable energy

Luxembourg's financial centre is already home to a considerable number of investment funds which invest in renewable energy globally. The Luxembourg government is currently considering setting up a 'de-risking fund' for renewable energy. In 2018, Luxembourg's legislation relating to mortgage bonds was extended to cover a form of financial instruments secured by 'renewable energy' projects. It was the first financial centre in the world to do anything of the kind.

Luxembourg intends, together with the EIB, to promote a de-risking instrument for long-term renewables power purchase agreements (PPA) at European level as well. This will make green electricity contracts cheaper for industry and for SMEs. During the last legislative period, the Luxembourg Finance Centre became a pioneer in matters of sustainable finance. Luxembourg will continue to be very active in this area, for example by supporting the Luxembourg-EIB Climate Finance Platform and the International Climate Finance Accelerator-Luxembourg (ICFA). On an international level, Luxembourg participates in the UN's GCF (Green Climate Fund) and the Network of Financial Centers for Sustainability. Luxembourg also promotes renewable energy through development cooperation. Luxembourg is a member of the International Renewable Energy Agency (IRENA) and has applied to join the International Solar Alliance (ISA).

Monitoring tool and financial measures for businesses

In order to increase companies' investment in renewable energy and energy efficiency measures, financial incentives will be reviewed and further developed. The associated strategy and measures for creating a monitoring tool and reviewing financial incentives for companies in relation to renewable energy can be found in Chapters 3.1.1.i. Economy and 3.1.1.iii. Funding measures.

PRIMe House support scheme

Strategies and measures relating to the national support scheme PRIMe House and the associated implicitly required use of renewables are set out in Chapter 3.1.1.iii.

3.1.2.ii. Any specific measures for regional cooperation, as well as, optionally, the estimated excess production of energy from renewable sources which could be transferred to other Member States in order to achieve the national contribution and trajectories referred to in point 2.1.2

Cooperation mechanisms (statistical transfers, joint projects, etc.)

Luxembourg also wants to contribute to the development of renewable energy abroad. As stated in Directive 2009/28/EC and in the NREAP, Luxembourg needs to use cooperation mechanisms in order to achieve its 2020 targets. Luxembourg has made various efforts in the past to explore and promote possible methods of cooperating with different countries. In 2017, Luxembourg became the first Member State to enter into two statistical transfer contracts with Lithuania and Estonia. Both agreements include the

mandatory transfer of minimum quantities and the possibility of carrying over quantitative limits for the period 2018-2020, which is a clear indication of enhanced European cooperation in the field of renewable energy.

In this sense, the Luxembourg government intends to continue to rely on cooperation mechanisms in the future. The new Directive 2018/2001/EU continues to build on existing cooperation mechanisms (statistical transfers, joint projects and shared support mechanisms) and also provides for new methods of cooperation: the Union renewable development platform (URDP) and the Union renewable energy financing mechanism.

Statistical transfers will continue to play a certain role. The cooperation should, however, also be further developed and involve specific projects. The specific framework for this is the Benelux and/or the North Seas Energy Cooperation, but also the Pentalateral Energy Forum (Germany, France, Benelux, Austria, Switzerland). Luxembourg intends to participate in the Union renewable development platform (URDP) and also has a strong interest in the establishment and functioning of the Union renewable energy financing mechanism enshrined in Article 33 of the European Regulation 2018/1999/EU.

The European Commission will establish this financing mechanism by 1 January 2021, to tender support for new renewable energy projects in the Union. It is anticipated that this financing mechanism will support countries in implementing the development of renewable energies towards the EU target and will have the potential to improve investment conditions for renewable energy across the EU.

Luxembourg has already made some efforts in the past to launch a joint tender with another country in the renewable energy sector. Due to its complexity, this project did not come to fruition. This is another reason why Luxembourg supports the introduction of this European instrument, which is a move towards a European tendering process, and will actively participate in the first steps towards its implementation.

3.1.2.iii. Specific measures on financial support, where applicable, including Union support and the use of Union funds, for the promotion of the production and use of energy from renewable sources in electricity, heating and cooling, and transport

The main support schemes in this area are already listed under 3.1.1.iii. The most important support schemes are mentioned again here:

- The PRIMe House support scheme offers investment aid for the use of renewable energy (photovoltaic installations, solar thermal installations, heat pumps, wood pellet and wood chip heating systems). The

support scheme has been extended and reviewed a number of times since 2001. The current programme runs until the end of 2020.

- The environmental fund is used to support communal projects in the areas of climate action, energy efficiency and renewable energy, as well as the waste sector and nature conservation.
- Passenger cars, vans, motorcycles and bicycles have been supported through direct subsidies via the 'Clever fueren' scheme since 1 January 2019.

3.1.2.iv. Specific measures to introduce one or more contact points, streamline administrative procedures, provide information and training, and facilitate the uptake of power purchase agreements

The ministries and administrations concerned are currently discussing how to set up this contact point.

3.1.2.v. Assessment of the necessity to build new infrastructure for district heating and cooling produced from renewable sources

Low-temperature heating networks

In order to comply with Article 14 of Directive 2012/27/EU on energy efficiency, a study assessing the potential for use of high-efficiency cogeneration was published in 2016. This study assessed the potential of the heating network supply and revealed that a significant proportion of the co-generation potential is already being exploited in the building sector. However, there is still potential to further develop the current situation in the future. Mainly as a result of the high energy standard for buildings (NZEB for residential buildings since 2017), the Luxembourg government expects a high number of potential heating and cooling uses for low-temperature heating networks. These low-temperature networks will in future be supplied predominantly from environmentally friendly sources (deep geothermal energy, heat pumps, waste heat from industry and data centres, solar thermal installations), insofar as this is economically viable. High potential, particularly in the field of geothermal energy, is expected in the south of the country. The opportunities for using medium-depth geothermal energy for heating networks to supply residential areas, schools and sports complexes are currently being studied more closely. In this context, myenergy, in cooperation with the Luxembourg Geological Service and a research institute, is launching a project to improve the data currently available, to more accurately assess the geothermal potential in Luxembourg and to provide scientific support for construction projects currently planned.

Heat map

The creation of a web-based **heat map** will increase transparency on the heat market by means of an integrated analysis and presentation of the relevant data in this connection. The main focus is on illustrating the heat demand and heat supply in the territory of Luxembourg, which can be used to, inter alia, prepare and further develop heat strategies at regional and national level. However, the tool will also be used by the municipalities as part of the Climate Pact, for example to implement energy planning or general accounting within the Climate Pact. However, existing heating networks will also be represented and an assessment of potential energy recovery (i.e. sewage sludge drying) will also be carried out. There are also plans to map the energy sources used to produce heat and the share of heat they produce.

Additionally, a hot-spot analysis will make it possible to identify larger renovation areas and possible synergies at industrial level. The economic viability of potential projects for planners and companies will be better assessed using relevant indicators. This is expected to increase energy efficiency for companies, SMEs and in residential areas. These hot-spot analyses will also include an assessment of the use of waste heat from efficient 'green' data centres.

3.1.2.vi. Any specific measures to promote the use of energy from biomass, especially for new biomass mobilisation, taking into account:

The key factors in this area are listed under 3.1.2.i. Specific measures are as follows:

- Extending the sustainability criteria to cover installations with a rated electrical output above 10 MW
- Sourcing biomass for energy production in principle from the Greater Region or within a radius corresponding to the Greater Region
- Cascading use of wood
- Creating a sustainability label for Luxembourg.

3.1.3. Other elements of the dimension

3.1.3.i. Any national policies and measures affecting the EU ETS sector and assessment of the complementarity and impacts on the EU ETS

The voluntary agreement with industry (*accord volontaire*) described under 3.2.i. involves companies which are participating in the EU emissions trading scheme.

3.1.3.ii. Policies and measures to achieve other national targets, where applicable

Sustainable funding

International solidarity and climate finance

Regarding climate finance, the Paris Climate Agreement calls on developed nations to provide financial resources to support developing countries for both damage mitigation and adaptation purposes.

In recent decades, Luxembourg has provided substantial financial and technical assistance to support climate action in developing countries, focusing on Least Developed Countries (LDCs), Small Island Developing States (SIDS) and Luxembourg's development cooperation partners.

Luxembourg will continue to support developing countries in the fight against climate change: from 2021 to 2025, it will be able to contribute a total of €200 million and an annual budget at least equivalent to the 2020 contribution of €30 million. This total amount includes a significant financial contribution, currently €10 million annually, to the Green Climate Fund and an annual budget of €5 million for climate projects by Luxembourg Non-Governmental Organisations (NGOs).

These funds are designated as International Climate Finance (ICF) and are new and in addition to Official Development Assistance (ODA). They are made available through the Climate and Energy Fund, which is supervised by the Minister for the Environment. It is guaranteed that the ICF will be continue to be available in addition to the ODA.

In the run-up to the COP21 Paris Climate Conference in 2015, the government had already committed to supporting climate action in developing countries, with a contribution of €120 million from 2014 to 2020.

A strategy for distributing the Luxembourg ICF, including eligibility criteria, was drawn up in 2017. It is aiming towards a provisional distribution of 40% for mitigation, 40% for adaptation and 20% forestry (REDD+).

Furthermore, the Government Council has endorsed the introduction of a comprehensive approach to governance in the primary partner countries for development cooperation, in order to reinforce cohesion and synergies between development measures and other areas, including the fight against climate change and the development of economic, cultural, political and security relations. As Cape Verde is the country with which Luxembourg has the most diverse and developed relations, this new approach will be implemented there first.

Knowing that public investment alone will not be sufficient to reach the target of $100 billion by 2020, it is essential that public investment provide leverage for other sources of funding, including the private sector.

However, investment in new forms of climate financing will be far from sufficient. Trillions of US dollars and euros must be transferred from carbon-intensive investments to low-carbon alternatives in order to 'make finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development', as enshrined in the Paris Climate Agreement.

Luxembourg today acts as an important international platform for sustainable finance, which connects investors around the world. In the coalition agreement, the government clearly made sustainable finances a priority for developing the financial centre. The aim is to develop Luxembourg as a centre of expertise in sustainable finance, and to promote and support public-private partnerships in the field of sustainable finance.

The underlying principle of Luxembourg's success has always been its capacity for change and constant innovation. Building on Luxembourg's financial infrastructure, Luxembourg's financial centre has found a new direction and diversified. It has adopted green, sustainable finance and is now the European market leader in this field.

In recent years, the government has launched several important climate finance initiatives together with partners from the financial sector:

- the LU-EIB Climate Finance Platform, a joint initiative with the European Investment Bank (EIB), has been developed to mobilise investments for climate action projects with the

combination of a first loss guarantee. It is the first time that the EIB has entered into such a project with a Member State. This kind of initiative is key to reducing the risks (de-risking) of climate investment and to attracting private investors who would otherwise be reluctant to invest.

- The International Climate Finance Accelerator, a public-private partnership, provides fund managers with financial and operative support to launch new and innovative climate funds.
- The Forestry and Climate Change Fund is a ground-breaking impact fund which aims to demonstrate that sustainable forest management in secondary and degraded tropical forests generates economic, environmental and social value.

Thanks to its important financial centre, Luxembourg can create a substantial leverage effect and play an important role in sustainable finance, far out of proportion to its geographical size. This means that Luxembourg acts as a catalyst driving sustainable investment, in particular by matching investors with sustainable investments.

The roadmap towards sustainable finance

Luxembourg already has a long and successful history in relation to sustainable finance, from microfinance to green bonds. LuxFLAG, a dedicated finance labelling agency, was set up back in 2006. In 2007, the world's first green bond (EIB) was listed on the Luxembourg Stock Exchange and the Luxembourg Green Exchange (LGX) was established in 2016. The LGX is the first platform in the world to deal exclusively with green securities. Currently, almost half of the world's green bonds are listed in Luxembourg.

Boosted by recent successes in this field, the relevant ministers presented the Luxembourg Sustainable Finance Roadmap (LSFR) in October 2018, together with the United Nations Environment Programme-Finance Initiative. This will further consolidate the leading role played by Luxembourg's financial sector in sustainable finance. In fact, Luxembourg ranks 4th on the Global Green Finance Index.

The aim of the roadmap is to take stock of existing sustainable finance initiatives in Luxembourg, to lay the foundations for a sustainable finance strategy in order to contribute to the 2030 agenda and to achieve the targets set out in the Paris Climate Agreement, and to consolidate the leading role played by Luxembourg's financial centre in relation to sustainable finance.

The roadmap is ambitious in terms of Luxembourg's contributions to sustainable development and to European and international climate initiatives. It is leading the way towards future opportunities and challenges.

The recommendations cover several aspects of the financial centre, such as developing financial products for sustainable finance, developing education and training programmes to meet the needs of the financial sector, or promoting innovation to facilitate financing of sustainable development.

In this connection, the government will support the creation of conditions which encourage a further increase in the market share held by sustainable financial products, in order to give Luxembourg's financial centre a leading role in sustainable finance.

The LSFR recommendations will be supplemented by further analyses in the coming years, in order to produce a customised and feasible action plan. To achieve this, the Luxembourg Sustainable Finance Initiative, a public-private body, will be set up to bring together the relevant parties in the field of sustainable finance and will be led by the relevant ministers.

This body will provide the ideal forum for drawing up Luxembourg's national sustainable finance strategy, based on the key elements of the LSFR. It will also serve as a discussion platform for examining the feasibility and impact of the measures resulting from the LSFR recommendations.

Equal opportunities and human rights

Luxembourg is committed to implementing climate change policies which help to promote equal opportunities, empower women and girls, and show respect for human rights.

Luxembourg recognises that climate change has gender-specific effects, and that increasing the participation and leading roles played by women and girls will boost the effectiveness of the fight against climate change and the level of ambition in all areas.

The National Plan for Sustainable Development is the main tool for implementing the 2030 Agenda in Luxembourg. Pursuant to SDG 5: 'Achieve gender equality and empower all women and girls', Luxembourg has identified the following objectives as a priority: 5.1. 'End all forms of discrimination against women', 5.2 'Eliminate all forms of violence against women' and 5.5 'Equality of the sexes'.

As regards climate finance, in May 2017 Luxembourg presented its strategy for providing resources for international financing to fight climate change. Luxembourg's strategy is based on a number of guiding

principles, including that funding should meet stringent requirements of environmental integrity, social benefits and gender equality.

At international level, aspects of climate change relating to human rights and to protecting local communities and indigenous peoples will also be taken into account. Luxembourg is actively engaged in promoting and protecting human rights in relation to climate change in various ways:

- Establishing (May 2015) an inter-ministerial committee on human rights to improve national coordination and close cooperation with civil society, which is an integral component of the committee's work
- Supporting the Local Communities and Indigenous Peoples Platform (UNFCCC)
- Organising round tables and events, as well as encouraging the preparation of reports on human rights in the context of climate change in collaboration with the Center for International Environmental Law (CIEL) and the Office of the United Nations High Commissioner for Human Rights (OHCHR).

In addition, over the past few years Luxembourg has signed all declarations and initiatives specifically focusing on human rights and gender equality in relation to climate change:

- Geneva Pledge for Human Rights in Climate Action, COP21
- Declaration on Gender Equality and Climate Change, COP24
- For all Coalition, UNEA4
- Climate Actions that advance Gender equality and Women Empowerment, UNCAS 2019

3.1.3.iii. Policies and measures to achieve low emission mobility (including electrification of transport)

E-mobility

As explained in Chapter 3.1.1.i, **electromobility** plays a particularly important role in decarbonising the transport sector in Luxembourg. The government has laid the foundations for supporting this by way of regulatory adjustments, such as supporting the inclusion of empty conduits in new buildings for subsequent

installation of a charging infrastructure, the regulated construction of a public charging network, and introducing financial support for purchasing electric vehicles.

Luxembourg will prepare a detailed route map in order to boost development of electromobility, and in view of the objective of the corresponding scenario of 49% of cars being electric by 2030 (see Chapter 2.2).

The cross-border element is particularly important in terms of promoting electromobility in Luxembourg, in order to make the switch an attractive prospect for over 200,000 commuters and Luxembourg residents who travel long distances abroad. The government will implement associated initiatives at the level of the Pentalateral Forum (DE, FR, B, NL, LU, AU, CH) and the Greater Region.

Active mobility will also make a significant contribution to low-emission mobility. The detailed measures under MoDu 2.0 are described in 3.1.1.i.

Green batteries

The government is proactively committed to new legislation on green batteries at EU level. The EU Commission will table a new directive at the start of 2020, which will enshrine in law a future 100% recycling rate for lithium and other materials used in batteries for all batteries used in cars, buses or elsewhere. The standards for the industrial processes which are necessary for producing batteries will also be subject to strict criteria. The EU Commission is also working with Canada, Japan and South Korea on an agreement to develop a sustainable mining initiative, to ensure that raw materials used in the EU come from mining areas with good health and safety conditions.

The EU budget also supports the development of European green battery production. With EU funding, Northvolt has already created the first 'major green battery factory' in northern Sweden, where electricity comes from 100% renewable energy sources and the sourcing of minerals meets high environmental standards.

Biofuels

A comprehensive strategy for the use of sustainable biofuels will be developed to help reduce emissions for conventional transport users. The blending of first-generation biofuels with fossil fuels plays a limited role here due to their less positive CO_2-balance. The Luxembourg government will promote the use of second-generation biofuels through mandated blending and cooperation particularly with Benelux partners. The

government programme stipulated that use of first-generation biofuels is to be limited to no more than 5%, in order to promote the use of second-generation biofuels which are thought to be more sustainable.

EU standards for cars, vans and HGVs

Alongside the national initiatives and programmes, the revision of the European legal framework establishing CO_2 limit values for passenger vehicles and light commercial vehicles (final compromise with reductions of 37.5% and 31%, respectively, by 2030 compared to 2021) and for heavy goods vehicles (general approach with a reduction of 30% by 2030 compared to 2020) will also contribute significantly to lower-emission mobility. Luxembourg will strive to ensure that this revision stipulates that as of 2030, only fossil-free drive systems will be approved in the EU, for cars and vans at least.

3.1.3.iv. Any national policies, timelines and measures planned to gradually phase out energy subsidies, in particular for fossil fuels

The study 'Effects of subsidies and tax incentives on sustainable development – environmentally harmful subsidies in Luxembourg'

The 2018 government programme indicated the intention to analyse the numerous direct and indirect subsidies and tax incentives relating to sustainable development and to finalise the test results of the ongoing study and use them for possible adjustment.

Luxembourg has set itself standards in its own plans (e.g. the National Plan for Sustainable Development) and targets that trigger a review of the existing subsidy policy. Launching such reforms of the framework conditions is necessitated not only by climate change objectives, but also other environmental and social targets.

The study focuses on three specific sectors in particular (transport, energy and agriculture) where economic activities play a particular role that can lead to environmental pressures.

3.2. 'Energy efficiency' dimension

Energy efficiency is considered a top priority (implementation of the 'energy efficiency first' principle enshrined in EU legislation) and is of particular importance for Luxembourg in achieving its energy and climate objectives, given its extremely dynamic economy. In the area of new buildings, Luxembourg is already at the forefront of the implementation of the energy efficiency requirements for residential buildings with virtually zero energy consumption and has successfully decoupled population growth from CO_2 emissions. In line with the European 'energy efficiency first' principle, Luxembourg intends to continue to pay particular attention to improving energy efficiency in the building sector. By increasing the renovation rate of buildings and using all available smart technologies, this sector has much to offer a climate neutral and competitive economy. As 50% of electricity consumption is in industry, this will also be a focus of energy efficiency policy. There is also a need to increase the efficiency of mobility (from internal combustion engines to electric motors, which are far more efficient). In general, all energy efficiency measures should pay particular attention to social impacts and measures should be taken to embed the new regulations in social terms.

3.2.i. Energy efficiency obligation schemes and alternative policy measures under Articles 7a and 7b and Article 20(6) of Directive 2012/27/EU and to be prepared in accordance with Annex II to this Regulation

Continuation of the energy efficiency obligation scheme;

In order to transpose Article 7 of Directive 2012/27/EU into national law for the period up to 2020, Luxembourg introduced a national system of energy efficiency obligations in 2015. The instrument should lead to the achievement of the energy efficiency target under Article 7(1), subject to the possibility of using other alternative measures in the future.

A guide was published in August 2019 to facilitate the accounting of transport measures under the 'Lean and Green' programme. The new programme will target 1.2 to 1.5% of final energy and will cover all sectors.

There were a few teething problems, but some of the parties bound by the programme have now improved their resources, invested in structures and developed concepts to improve the effectiveness of the mechanism.

For these reasons, the Luxembourg government is determined to continue with and optimise the Energy Efficiency Obligation Scheme for the period 2021 to 2030 in order to comply with the obligation set out in Article 7 of the amended Energy Efficiency Directive.

The creation of new instruments in the field of energy saving for industry, small and medium-sized enterprises and large office buildings (de-risking financial instrument, transparency platform for audits, exemplary role of public buildings) will also increase the scope for energy efficiency investments for the 'parties obligées'. The final energy savings target for the period 2021-2030 will be set at 1.2 to 1.5% per year and will cover all sectors. In addition, the further development of the commitment system will include an adjustment to the penalties for failure to comply, making non-compliance with the savings commitment more costly than the investment required to meet the targets. To ensure that the framework is in force in time for the start of the new period (1 January 2021), details for the 2021-2030 period will be provided in the early implementation of EED II (Revised Energy Efficiency Directive) or via the current version of the Electricity Act [Stromgesetz].

Industrial sector

Strategies and measures aimed at creating a **monitoring tool for businesses** and future measures and framework conditions **to support energy efficiency** in industry by 2030 are set out in Section 3.1.1.

Accord volontaire

The 'Accord volontaire' between the industrial sector, represented by FEDIL, the Luxembourg government and My Energy G.I.E., which has been in existence since 1990, is a voluntary agreement to improve energy efficiency in the industrial sector in Luxembourg. The current agreement is valid from 2017 to the end of 2020 and includes 54 companies from the industrial and tertiary sectors. In return for fulfilling several requirements and achieving a 7% improvement target for a joint energy efficiency indicator for the reference periods 2014-2015 and 2020, participating companies will receive a tax credit on electricity and natural gas allowed under Council Directive 2003/96/EC of 27 October 2003 restructuring the Community framework for the taxation of energy products and electricity. This voluntary agreement is to be continued, deepened and extended after 2020 in order to reach out to more companies, especially SMEs. Improved communication and cooperation between participating companies should help to identify and make use of possible synergies in the field of energy efficiency. A detailed analysis of the current 'Accord volontaire' will serve as a basis for this. In addition, the continuation of the voluntary agreement should lead to more ambitious energy efficiency improvement targets by encouraging and adequately supporting companies in

the implementation of identified savings measures and providing additional opportunities for action in the financing and implementation of projects.

Energy audits transparency platform

An important prerequisite for investing in energy efficiency is detailed knowledge of potential savings in an industrial process or a building. This is ensured by means of audits. As these audits are currently only mandatory for very large consumers, a simplified version will be extended to medium-sized industrial processes and office buildings. In addition, a transparency platform will be set up for the results of energy audits, following the example set by France. This will improve the contact between the 'parties obligées' under the Energy Savings Regulation and industrial, SME and office buildings.

New financial instrument for energy efficiency in industry and large office buildings

Experience in recent years has shown that there is a large discrepancy between the savings potential identified in the audits and the savings actually achieved by industry and owners of large office buildings. Many potential investments identified as useful by engineers are blocked by companies' strict financial requirements. In order to remedy this discrepancy, consideration is being given to making the implementation of the results of the 'Accord volontaire' audits mandatory and to establishing an additional financial instrument in close cooperation with the EIB (European Investment Bank).

De-risking

Although the financial aid described in point 3.1.1.iii. helps to improve the economic viability of projects in the field of climate and environmental protection, it does not make it possible to remove all barriers and obstacles to the use of environmental technologies in order to achieve national climate and energy objectives more quickly. In this context, the Luxembourg government is looking into creating an additional financial instrument that will allow a number of obstacles to the implementation of energy efficiency measures to be addressed in a systemic manner at national level. A **pre-financing and risk management ('de-risking') tool** is to be developed and promoted for energy transition projects at industry and SME level. The aim is to increase investment in energy efficiency measures through improved use and a more transparent analysis of data from existing building and industrial projects. Pre-financing will be provided through a state fund or bank guarantee to cover part of the investment risk, and a 'risk' climate fund (private/public), or part of the climate and energy fund, will be used to assess and mitigate existing risks. In addition, a pooling of invoices ('securisation of receivables') is to be made possible in order to spread the risk and an instrument is to be created that can be used to quantify legal, financial and ecological aspects (possibly as

a research project). Within the scope of de-risking projects, it is also important to create a mechanism between 'risk takers' and 'risk providers' in order to promote a standardised process and ensure hedging.

Lean & Green programme

The '**Lean & Green**' programme will continue to be implemented with stakeholders from the transport and logistics sector in order to further reduce the sector's CO_2 emissions. The programme was set up by Connekt, an independent network of Dutch companies and public authorities, with the aim of encouraging companies to reduce their environmental impact. Any company that can demonstrate, on the basis of a detailed action plan, that it will achieve a 20% reduction in CO_2 emissions over the next 5 years can apply for the 'Lean and Green' label.

As a number of the measures can be booked through the Energy Efficiency Obligation Scheme, this 'Lean and Green' label was more strongly integrated into the scheme in 2019.

The optimisation of the logistics sector will also support the conversion of supply fleets to small electric trucks and cargo bikes.

3.2.ii. Long-term renovation strategy to support the renovation of the national stock of residential and non-residential buildings, both public and private, including strategies, measures and actions to stimulate cost-effective deep renovation and strategies and actions to target the worst performing segments of the national building stock, in accordance with Article 2a of Directive 2010/31/EU

Implementation of the national renovation strategy

Within the framework of Directive 2012/27/EU 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, in November 2016, the Luxembourg government published the further development of the **national building renovation strategy** drawn up within the framework of the third NEEAP, which is based on four guiding principles:

- Priority to high-efficiency renovations
- Affordability of energy renovation measures
- Alignment of energy policy and heritage protection objectives
- Inclusion of elements of sustainable construction and the circular economy

These guiding principles are consistently taken into account in the development of projects, in awareness-raising and information policy and in legal or regulatory amendments in the area of building renovation.
In addition to the guiding principles, some 35 measures have been identified to reduce legal and financial barriers, among others, that have been reviewed and implemented within the scope of the work carried out by the '*Conseil national de la construction durable*' (CNCD). The following measures were identified as priorities:

- To remove obstacles faced by building managers
- To introduce an obligation to establish renovation reserves for owners' associations
- To adjust the decision-making quorums for the implementation of renovation measures (introduction of a simple majority for decisions by owners' associations)
- Municipalities should become pioneers in building renovation (climate pact, financial aid, logistical aid, competitions, etc.)
- To examine the possibility of applying the reduced VAT rate of 3% to buildings constructed 10 years ago (instead of 20 years)
- To promote energy-efficient renovation in the building stock by simplifying the administrative stages of the 'climate loan'.
- Oil replacement programme in old buildings

An **ambitious long-term building renovation strategy is being presented** with a view to increasing the renovation rate (to 3% per year) and the depth of renovation ('deep renovation'), with the aim of rehabilitating all existing houses to 'net zero' by 2050. In addition to the requirements for a long-term building renovation strategy as described in the EU Directive 2012/27/EU EED, the existing building renovation strategy is to be extended to include the following:

- Monitoring of the existing renovation strategy
- Creation of an interministerial working group
- Workshops with stakeholders to define how the objectives will be achieved
- Updated potential analysis or assessment of the baseline situation
- Stronger social embedding of the measures

The measures defined as part of the building renovation strategy drawn up in 2016 will be further developed, but may be extended by newly identified measures. For this purpose, workshops or a comprehensive survey to identify new measures can be implemented as in the existing building renovation strategy. The following measures, among others, have already been identified and are being implemented:

- Improved and faster advice from independent energy consultants and a new digital 'app' that is also made available to tradesmen
- Targeted advice, financial measures and a reform of the 'Syndic' law for larger apartment buildings
- Systematic urban district or entire street rehabilitation
- In addition, densification of the existing building stock, following the example of the City of Vienna, is being researched in pilot projects

Renovation of functional buildings

In order to support building renovation in the non-residential sector, there are plans to extend the **mandatory energy audits** for large energy consumers in the commercial sector to SMEs, taking account of the specificities and possible simplifications for SMEs. This means that SMEs would also be obliged to have their energy consumption regularly checked in order to better assess the renovation potential of their buildings.

In order to increase the energy performance and renovation rate of non-residential buildings, consideration is also being given to introducing a **renovation obligation** along the lines of the Dutch model.

In November 2018, a measure was introduced in the Netherlands setting the energy standard of office buildings at energy class C from 2023 onwards. Owners of existing properties are therefore obliged to renovate their buildings to energy standard C by 2023 or to prove that the necessary measures have been taken to this end.

Introduction of an energy passport 'plus' in the building stock (housing and functional buildings)

In order to improve and generalise the information base in the building stock, there are plans to introduce an **energy passport 'plus'** specifically for existing residential buildings, which should provide a better picture of the real renovation potential. The purpose of this energy passport is to provide the owner with a transparent and individualised ex-ante assessment of the renovation potential and the associated savings. There are also plans to introduce a similar energy passport 'plus' for existing functional buildings.

Post-densification

At district level, the aim is to support the **densification of the existing stock** by simplifying the municipal framework conditions and promoting self-contained flats. To some extent, corresponding adjustments

have already been made as part of the revision of the existing development plans. However, they will be pursued further, especially for the municipalities that still need to implement this revision. In particular, the revision of the specific urban development plans for existing neighbourhoods can show an important tax effect in the case of densification. To raise the awareness of citizens in the participatory processes, there are also plans to make sample plans and regulations available in order to better inform the affected citizens about the possibilities of post-densification.

There are also plans to make the cadastral register more flexible or to revise it in general, so as to allow for a sharper division of ownership within the buildings, particularly in the case of apartment blocks and terraced houses. The public social housing agencies SNHBM and Fonds du Logement will launch the first pilot projects in this area.

Financing measures – climate bonus programme

The main support schemes have already been listed under 3.1.1.i. The following funding programmes are relevant in the field of building renovation:

- The PRIMe House support programme offers investment grants for the energy-efficient and sustainable renovation of residential buildings. The support scheme has been extended and reviewed a number of times since 2001. The current programme runs until the end of 2020.
- In addition, the sustainable energy renovation of residential buildings is supported via low-interest or (for low-income households) interest-free loans, with the technical requirements being the same as the PRIMe House criteria. There are plans to review and simplify the terms and conditions and application procedure, so that more homeowners can benefit from a climate loan in the future

Reduced VAT rate of 3%

The conditions for obtaining the reduced **VAT rate of 3%** for renovation work will be adapted and harmonised with the requirements of the PRIMe House programme. The aim is to examine whether owners of buildings constructed 10 years ago can benefit from the reduced VAT rate instead of the current 20 years.

3.2.iii. Description of policy and measures to promote energy services in the public sector and measures to remove regulatory and non-regulatory barriers that impede the uptake of energy performance contracting and other energy efficiency service models

The ministries and administrations concerned are currently discussing how these barriers can be removed.

3.2.iv. Other planned strategies, measures and programmes to achieve the indicative national energy efficiency contributions for 2030 as well as other objectives referred to in point 2.2 (for example measures to promote the exemplary role of public buildings and energy-efficient public procurement, measures to promote energy audits and energy management systems, consumer information and training measures, and other measures to promote energy efficiency)

New construction

In addition to the comprehensive energy-related renovation of buildings to increase energy efficiency, measures must also be implemented in the new build sector. The following measures are to be developed or expanded within the scope of the improvement of energy efficiency in new buildings:

Raising the building standard for non-residential buildings

Following the introduction of the 'Nearly zero energy building (nZEB)' energy standard for new residential buildings in 2017, this standard will also apply to non-residential buildings from 2020/2021. This standard is to be further increased by 2030 and the 'near zero' standard is to be redefined by improving energy efficiency requirements for new non-residential buildings.

Introduction of an A+ energy class for residential buildings

As mentioned in the section above, the 'nZEB' construction standard for new residential buildings has been in force since 2017. This is to be extended in the short term (A+ energy class) to ensure 100% renewable energy coverage.

Sustainability and health in construction

New residential and non-residential buildings will also integrate aspects such as health and well-being, alongside a stronger anchoring of sustainability. This will be implemented through the integration of elements in the national energy passport, the 'LENOZ' sustainability certification or

the creation of a new label. Toxic and harmful building materials are to be banned and a positive list of building materials is to be drawn up which includes natural and ecological options.

Circular economy

The concept of the circular economy will be further promoted in the construction sector in order to improve the quality of future buildings. This should be achieved through support programmes within the scope of 'progressive requirements'. Specific strategies and measures with regard to the circular economy in the construction sector can be found in Section 3.1.1.i.

Sustainable neighbourhoods – Made in Luxembourg ecodistricts

Luxembourg will ensure that neighbourhoods built in the future allow for improved urban quality and quality of life while also being CO_2-free. To this end, a definition of sustainable neighbourhoods, with uniform criteria, a clear methodology and new subsidies will be drawn up under the guidance of the Minister for Spatial Development. In addition, the existing system of building inspections is to be analysed and, if necessary, revised in order to guarantee compliance with building and energy standards through increased and harmonised building inspections by the municipalities.

Green data centres

As digitalisation progresses steadily, data centres are essential. However, in the future these will need to be built in a far more energy efficient manner and operators will have to make greater efforts to operate more efficiently. It is important to apply the best technical solutions, such as immersion cooling, and to use the waste heat produced by data centres for heating or cooling buildings or whole neighbourhoods. The reduction of energy consumption and the preference for renewable energies should also be implemented at the level of computer infrastructures, such as data centres, which is why the Luxembourg government is committed to creating appropriate framework conditions for green data centres, including at EU level.

Government to lead by example

As already mentioned under 3.1.1, Luxembourg has adopted a strategy for 'sustainable and energy-efficient public buildings' in relation to new construction and existing structures, in order to improve energy efficiency and the use of renewable energy in government and government-related buildings.

In the 'Fourth National Energy Efficiency Action Plan Luxembourg (2017)', drawn up within the framework of Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy

efficiency, Luxembourg has identified energy efficiency measures in public institutions that will be partially adopted and further developed for 2030. For example, the government has taken the lead as a state and has stepped up efforts in recent years and implemented an ambitious renovation programme. In order to calculate the renovations, Luxembourg drew up an inventory of the public buildings concerned. According to Article 5(7) of the EED, public facilities that are not part of the central government (e.g. schools) should also be encouraged to act as role models in the energy efficiency of buildings. For example, the public social housing agencies, the *Société Nationale des Habitations à Bon Marché (SNHBM)* and the *Fonds du Logement* are working to gradually renovate and improve the energy efficiency of the rental housing stock.

The airport in the capital city is to be transformed to become the ***Findel Green Airport*** within this framework. In particular, this involves the implementation of energy-saving measures and the use of renewable energy, primarily to convert the existing terminal into an energy-plus building. Another aspect of the state's pioneering role is the replacement of all light bulbs in public buildings and street lighting with LEDs by 2025 in order to improve efficiency and contribute to the fight against light pollution. In addition, the introduction of a state Top Runner programme will encourage the purchase of energy-efficient equipment from the state and municipalities.

Businesses

Strategies and measures with regard to financing measures for new construction can be found in Section 3.1.1.

Pacte logement 2.0

Strategies and measures with regard to the 'Pacte logement 2.0' can be found in Section 3.1.1.

3.2.v. Description of measures to exploit energy efficiency potentials in gas and electricity infrastructure

Electricity and gas network operators are continuously pursuing programmes with a view to ensuring security of supply in the future. These programmes include investment measures for the conversion, expansion, maintenance and replacement of the respective infrastructures. In addition to ensuring security of supply, these measures also help ensure that networks are constantly up-to-date, thereby contributing to improving energy efficiency.

Other specific measures to exploit energy efficiency potentials in gas and electricity infrastructure are sometimes not foreseen.

3.2.vi. Any regional cooperation in this area

Specific measures for regional cooperation aimed at exploiting energy efficiency potentials in gas and electricity infrastructure are sometimes not foreseen.

3.2.vii. Financing measures, including Union support and the use of Union funds, in this area at national level

Strategies and measures with regard to financing measures for the energy efficiency sector can be found in Section 3.1.1.

3.3. 'Energy security' dimension

3.3.i. Strategies and measures related to the elements set out in point 2.3

In order to analyse and ensure the security of supply in the **electricity and gas sector**, the Luxembourg government draws up reports on this subject every two years. These reports not only consider the balance between supply and demand, but also investigate the extent to which network operators in Luxembourg are making sufficient investments in the maintenance and expansion of their networks. The most recent reports, dating from 2018, clearly show that national electricity and gas infrastructures are in good condition and are as close as possible to the state of the art. The existing gas infrastructure is large enough for the current and foreseeable supply task and, accordingly, no further expansion measures are planned, except for possible densification within the connected municipalities. In the electricity sector, on the other hand, various investment measures are foreseen (see Section 3.4.1). In the context of security of supply in the Greater Region of Luxembourg, the Vianden Pumped Storage Power Plant has an important role to play.

Pursuant to Article 7 of Regulation (EU) 2017/1938 of 25 October 2017 concerning measures to safeguard the security of gas supply, Luxembourg is currently also carrying out risk assessments to ensure the security of gas supply. Current analyses indicate that although the security of supply in Luxembourg is highly dependent on neighbouring countries, having neither its own mining operations nor extensive storage capacities, it will be possible to manage disruptions in the majority of the gas infrastructure through demand-side measures. These demand-side measures may be limited to industrial customers, thereby guaranteeing the supply of protected customers. At the same time, it is not possible to rule out negative economic implications in the event of disruptions to network connection points over the longer term.

The widespread installation of **smart meters** will also make a useful contribution to security of supply. The switching relays of the new smart electricity meters enable grid operators to switch off loads in a targeted manner for system security purposes. National law provides for a smart meter rollout of 95% in the electricity sector and 90% in the gas sector by the end of 2020. Regular stocktaking indicates that implementation is on schedule, which is also backed up by current statements from the distribution network operators. There is currently a debate about the extent to which these technical possibilities should be flanked by an expanded regulatory framework. Work is also under way to establish how further use can be made of these technical possibilities through an energy data platform.

In addition to the above, it should also be noted that the **implementation of the Clean Energy Package** in the revised Electricity Market Organisation Act of 1 August 2007 will further increase cross-border competition between suppliers, which in turn has a positive impact on security of supply.

With regard to the **oil sector**, the measures set out in Section 3.1.3 aimed at increasing efficiency and reducing CO_2 emissions will contribute to reducing the consumption of fossil fuels and therefore to improving security of supply. Despite the large number of initiatives planned and implemented with a view to making mobility sustainable and free of CO_2 in the future, it is also necessary to ensure in parallel to this that the current and future supply of fossil fuels, which are currently still necessary, is secure, whether by diversifying the sources or supply routes or by providing sufficient stocks of mineral oil products to overcome potential supply bottlenecks.

Since Luxembourg does not have any refineries in its national territory and therefore imports no crude oil but only mineral oil products, the scope for diversifying the countries of origin is very limited. Regarding the imports of mineral oil products by country of origin, it must be taken into account that the majority by far comes from Belgium, followed by Germany, France and the Netherlands. In terms of the security of supply, it is important that the diversification of the countries of origin is also maintained in the future.

It is also important for the security of supply, particularly in Luxembourg's situation, to diversify the supply routes. Since the airport in Luxembourg is supplied with fuel directly via an underground pipeline (CEPS), the diversification of supply routes relates primarily to the mineral oil products diesel, petrol and fuel oil. The majority of imports are via road, with only around one fifth being handled by rail. The remainder of the imports are carried out by inland waterway via the Moselle. Owing to the limited opportunities to influence the transport routes, it is necessary for Luxembourg to keep sufficient stocks of mineral oil products in its national territory to be able to compensate for any disruptions to the supply routes.

As a member of the European Union (EU) and the International Energy Agency (IEA), Luxembourg is obliged to keep stocks of mineral oil equivalent to, on average, 90 days of the previous year's imports. In practice, Luxembourg has consistently fulfilled its international obligations regarding the stockpiling of mineral oil in recent years. The importers of mineral oil products have fulfilled the national legal obligation of the compulsory storage of eight days in the national territory, while the other amounts must be kept either in the regional territory outside Luxembourg (37 days) or elsewhere in the EU.

Although access to the stocks accounted for in Luxembourg is guaranteed in the event of a crisis, it can also be assumed, given Luxembourg's limited size, that the stocks kept in neighbouring countries can be transported to

Luxembourg in the event of a local crisis. In the case of stocks kept further away from Luxembourg, the prompt transport of these stocks to Luxembourg in the event of a crisis is likely to be associated with relatively large logistics expenses (transport capacities, expenditure of time, etc.). If, in future, there is a clear and consistent downward trend in the consumption of the transport sector, the need to construct new tank farms would have to be modified.

In order to reduce the dependency on oil as far as possible and limit the environmental impact of transport, Luxembourg is pursuing a multidimensional strategic plan. The primary focus is on traffic avoidance and public transport. In addition, Luxembourg is promoting the introduction of e-mobility and alternative fuels, each of which must be based on renewable energy sources.

3.3.ii. Regional cooperation in this area

In the electricity sector, the regional cooperation within the **'Security of Supply' working group of the Pentalateral Energy Forum (PLEF)** is the most important mechanism for the early recognition of problems with the security of supply from the perspective of Luxembourg. The Luxembourg government is working together with the Luxembourg transmission network operator, Creos, to actively support the drafting of the PLEF Adequacy Assessment, which was last updated in February 2018. The inclusion of the flow-based capacity calculation method for the first time, in particular, has further increased the validity of the monitoring. Based on this monitoring, which is based on a probabilistic approach, no critical energy security risks can be identified for Luxembourg at present. Further development of the methodology, analyses and reports is planned or already under way.

Joint exercises will also be organised in this same working group to improve emergency procedures and cooperation in a regional crisis. In this context, the active participation and cooperation with the **Regional Security Center**, TSCNet, should also be mentioned in order to prepare and coordinate activities relevant to the security of supply ('Coordinated Security Analysis', 'Outage Planning Coordination', 'Short and Medium Term Adequacy forecasts' and 'Consistency check of TSOs' system defence and restoration plans') at regional level. As provided for in Article 37 of Regulation (EU) 2019/943 on the internal market for electricity, regional cooperation in the field of security of supply will be further deepened by means of 'Regional Coordination Centres'. In this regard, mention should be made of all of the activities defined and implemented under **Regulation (EU) 2019/941 on risk-preparedness in the electricity sector**, in particular:

- Monitoring the security of electricity supply in the Union through the Electricity Coordination Group
- Defining an electricity crisis and developing a common methodology for risk identification

- Regional approach to identifying risk scenarios and to developing preventive, preparatory and mitigating measures
- Drawing up and regularly updating risk-preparedness plans, including national, regional and, where applicable, bilateral measures
- Agreeing on coordinated measures and technical, legal and financial arrangements
- Complying with transparency requirements

At European level, the Luxembourg transmission system operator Creos is a member of ENTSO-E and is actively involved in the annual Mid-Term Adequacy Forecast. In addition to the reports mentioned above, this is used to assess and ensure security of supply in the electricity sector.

In the gas sector, regional cooperation takes place in the Gas Forum of the Pentalateral Energy Forum. This forum brings together the Benelux countries with Germany and France. The Gas Forum consults national and regional risk assessments and ensures consistency between national preventive action plans and emergency plans established in accordance with Regulation (EU) 2017/1938 of 25 October 2017 concerning measures to safeguard the security of gas supply.

The Gas Forum sets out a common approach to ensuring security of supply in the event of an emergency and reduces the risk of adverse effects that purely national measures could have.

In the gas sector, the Member States are also obliged to conclude bilateral agreements on terms and conditions in order to be able to provide solidarity in accordance with Article 13 of Regulation (EU) 2017/1938 in the case of demand from neighbouring Member States. To this end, preliminary discussions have been held with neighbouring countries with a view to launching the relevant steps and agreements.

In the oil sector, the Member States coordinate their supply and stockholding activities in the Oil Coordination Group, of which Luxembourg is a member.

3.3.iii. Any financing measures in this field at national level, including Union support and the use of Union funds

In the electricity sector, relevant network expansion measures are planned over the next few years, particularly at transmission grid level, to ensure energy security in Luxembourg. The financing of projects will be ensured through network charges.

In the oil sector, since importers of mineral oil products have a national legal obligation to hold mandatory stocks, they are also responsible for financing these obligations in accordance with market conditions.

3.4. 'Internal energy market' dimension

A key building block for the overall strengthening of the European Single Market will be the swift implementation of the entire 'Clean Energy Package'. Individual elements that are of relevance are discussed below, but a full recap is not required.

3.4.1. Electricity infrastructure

3.4.1.i. Strategies and measures to achieve the targeted level of interconnectivity as set out in point (d) of Article 4

On account of its high dependency on imports, Luxembourg already has electricity interconnection capacities that are able to sustainably safeguard the security of supply. This can be seen in particular from the high load interconnection rate, which is well above the 2030 objectives set out in the European Council Decision, but is also indispensable for Luxembourg and only comparable to a limited extent with interconnection levels in other EU Member States. While the target size for Member States has recently been increased from 10% to 15%, Luxembourg is already exceeding this many times over with a load interconnection rate of 270% (see also 4.5.1). The level of interconnection will continue to increase until 2030 in line with the planned network expansion projects. Among other things, the transmission system operator, Creos, is actively promoting the reinforcement and upgrading of the high and medium voltage levels to enable and support the transition from fossil fuels to renewable energies. In particular, the aim is to enable the production of electricity (especially wind and photovoltaics) to be continually increased in the north of the country and to allow for high consumption in the centre and south of the country. Due to its dependence on imports, a further expansion of the existing interconnectors is also planned in order to continue to guarantee the security of supply for Luxembourg. For example, the upgrade/reinforcement of the existing 220 kV line towards Germany is already part of the network development plans of both Luxembourg and Germany.

The planned network development projects on existing corridors are being implemented in line with the existing procedures and are intended to improve the situation for the population as a whole. In order to ensure the necessary public acceptance, the public will be involved through a broad consultation process.

3.4.1.ii. Regional cooperation in this area

There will be close cooperation with neighbouring countries for the implementation of cross-border electricity infrastructure projects. In addition to the respective bilateral cooperation, coordination shall also take place at regional level (in particular in the framework of the Pentalateral Forum) and at European level (within the respective ENTSO-E working groups, in particular the Ten Year Network Development Plan).

As has already been described in more detail in Section 1.4, the Pentalateral Energy Forum has adopted the common plan to further develop the internal energy market through coordinated activities in the following areas:

- Market integration
    - Electricity market coupling
    - Implementation of the Clean Energy Package
    - Redispatching
- Flexibility
    - Demand-side management
    - Sector coupling and Power-to-X
    - Role of hydrogen
    - Role of storage technologies
    - E-mobility

3.4.1.iii. Any financing measures in this field at national level, including Union support and the use of Union funds

The electricity infrastructure is financed by corresponding network charges, which are set and monitored by the regulatory authority (*Institut Luxembourgeois de Regulation*, ILR). Separate funds are available at European level, which can be distributed within the framework of the *Projects of Common Interest*. However, there are no projects currently planned for Luxembourg that depend on this financing measure.

The Pentalateral Energy Forum will discuss possible regional approaches to increasing energy efficiency and expanding renewable energies. For example, common approaches could be sought with financial institutions, such as the European Investment Bank, in order to reduce financing risks.

3.4.2. Energy transmission infrastructure

3.4.2.i. Strategies and measures related to the elements set out in point 2.4.2, including any specific measures to enable the delivery of Projects of Common Interest (PCIs) and other key infrastructure projects

The decommissioning of the TwinErg GuD power plant has considerably reduced the peak demand for gas. Therefore, even in the case of further expansion of biogas plants (see Section 4.4.2), it can be expected that the current and foreseeable supply task can be adequately met by the existing gas infrastructure. Accordingly, no further measures are envisaged for extending the gas infrastructure. The import capacity will be increased by other measures, such as improving the use of these capacities through cross-border cooperation.

3.4.2.ii. Regional cooperation in this area

Although no further development activities are foreseen, close cooperation will be pursued with neighbouring countries in order to optimise the use of existing gas infrastructure, particularly in crisis situations. This coordination will take place bilaterally, regionally (especially in the gas platform within the Pentalateral Energy Forum) and at European level (ENTSO-G).

3.4.2.iii. Any financing measures in this field at national level, including Union support and the use of Union funds

The gas infrastructure is financed by corresponding network charges, which are set and monitored by the regulatory authority (*Institut Luxembourgeois de Regulation*, ILR). There are no plans at present to use European funds.

3.4.3. Market integration

A key building block for the overall strengthening of market integration will be the swift implementation of the entire 'Clean Energy Package'. Individual elements that are of relevance are discussed below, but a full recap is not required.

3.4.3.i. Strategies and measures related to the elements set out in point 2.4.3

The introduction of the 'BeLux' joint gas market with Belgium in 2015 was an essential measure for improving Luxembourg's market integration in the gas sector. Through this joint gas market, it is easier for suppliers active in Luxembourg to access the liquid trading hub at Zeebrugge as well as LNG terminals and gas reservoirs. This promotes competition in the whole of the joint market and offers gas customers high security of supply at more affordable prices.

In the electricity sector, Luxembourg's market integration has already significantly improved from a technical perspective due to the construction of a phase-shifting transformer in Schifflange and the integration of the Luxembourg grid interconnection into the European transmission network that this has made technically possible, with permanent connections to Germany and Belgium. Commercialisation of this interconnector is not planned in the short term. However, the issue will be closely monitored in the course of the further development of congestion management (especially in the context of the Capacity Calculation Region 'Core', see below).

Within the Pentalateral Energy Forum, the close integration of electricity markets in the region will be further developed in the 'Market Integration' working group. In this respect, this Forum is a European pioneer that fully exploits the potential of transmission capacity by calculating capacity allocation methods using a flow-based approach. This will further improve market liquidity and ensure efficient congestion management and an overall efficient market on a regional basis. Possibilities for cross-border participation in the capacity markets in France and Belgium are also being discussed.

As part of the joint market area with Germany, Luxembourg is actively supporting the coalescence of the electricity markets. For the day-ahead market, the further development of capacity calculation and congestion management in the core region is a top priority. As regards the intraday market, both the active participation in the integrated XBID platform and the harmonisation of the conditions for Luxembourg network users with the German framework conditions (in particular Gate Closure Times) should be mentioned. The same applies to balancing markets: the transmission system operator CREOS is currently investigating ways of opening up access to the German and European balancing market for network customers in Luxembourg. A particular challenge here is posed by the fact that the Creos transmission network is a separate 'scheduling area', while load-frequency control is handled by the German Amprion for the joint 'load-frequency control' (LFC) area. At the same time, access to the German and European electricity balancing markets for Luxembourg network customers offers the potential to stimulate the

decentralised production of electricity in Luxembourg and to open up new marketing opportunities in the area of demand-side management for household and business customers, as well as the industrial sector. Consequently, Luxembourg is also actively participating in the relevant European balancing reserve platforms (MARI, PICASSO). In this context, reference should also be made to the pumped storage power plant in Vianden, which is directly connected to the German transmission system and provides a significant contribution to the stability of the system and security of supply in the Greater Region (see Section 4.4.1.).

Due to the specific configurations of the transmission network operators Creos and Amprion, the extent to which cooperation in the common wholesale price zone should be further regulated by contract, inter alia with a view to dealing with crisis situations, e.g. through contracts between network operators or intergovernmental agreements under Regulation (EU) 2019/941 on risk-preparedness in the electricity sector, is currently being examined.

3.4.3.ii. Measures to increase the flexibility of the energy system with regard to renewable energy production such as smart grids, aggregation, demand response, storage, distributed generation, mechanisms for dispatching, re-dispatching and curtailment, real-time price signals, including the rollout of intraday market coupling and cross-border balancing markets

To enable electricity consumers to actively participate in the market, Luxembourg has legally obliged the network operators to convert at least 95% of all electricity meters to smart meters by the end of 2020. This would create the conditions, in particular, for the introduction of time-variable tariffs.

Smart meters also provide a technical basis for improving transparency, service quality and efficiency, as well as opportunities for innovative energy services. Examples include transparent access to own consumption data, improved market communication processes, activation of flexibility on the consumer side, or more efficient network operation. However, further development of the data infrastructure is necessary in order to take full advantage of these opportunities. A current legislative proposal therefore provides for the development of an energy data platform, in particular to enable access to relevant electricity consumption data for authorised users (i.e. in particular the end consumers themselves), taking into account all aspects of data protection, which must be given high priority at all times. The design phase is scheduled for completion by the end of 2020. Depending on the cost-benefit ratio of the proposed options, the implementation phase will then follow.

The design of network charges is closely linked to the issue of additional flexibilities and fair allocation of costs in the electricity sector. This is currently being investigated by the Luxembourg regulatory authority, ILR, as part of a study. In this regard, it is also being checked that the applicable rules do not constitute any obstacles to consumers actively participating in the market and that the possibility is open for self-sufficiency with appropriate sharing of the network costs of all consumers.

The regulatory authority, ILR, prepares annual reports on the electricity and gas markets. These reports deal, in particular, with the competitive situation on the markets, for example based on the number of suppliers active in Luxembourg and the rates of switching for customers in different segments. ILR also prepares an annual report on whether the prices for supplying electricity and gas are in conformity with the public service obligations (*'obligations de service public'*).

The implementation of the 'Clean Energy Package' in the revised Electricity Market Organisation Act of 1 August 2007 reinforces the potential for flexibility of consumers. An amendment to this law, which was introduced in 2018 and, with some adjustments, in 2019, will regulate and also promote own consumption based on renewable energies. Renewable electricity consumed individually or in a community shall be exempted from electricity taxation and network use in terms of consumption volume. Network charges for connection services shall be levied on a cause-related and non-discriminatory basis. These measures create an important condition for easing the burden on the electricity networks and enabling them to operate in a smarter and safer manner.

3.4.3.iii. Measures to ensure priority access and dispatch of electricity from renewable sources or high efficiency cogeneration and avoidance

The revised Law of 1 August 2007 on the organisation of the electricity market guarantees a feed-in priority for renewable energy. It also obliges network operators to minimise security of supply measures restricting the supply of electricity from renewable energy sources.

However, the aim is to further integrate renewable energy into the market. In the case of larger plants, the support was changed to a market premium model, which stimulates a more efficient optimisation of use on the basis of efficient price signals.

3.4.3.iv. Strategies and measures to protect consumers, especially vulnerable and, where applicable, energy-poor consumers, and to improve the competitiveness and contestability of the retail energy market

To provide consumers with a clearer overview of electricity and gas tariffs and to evaluate the potential savings of switching suppliers, the regulatory authority runs the comparison portal *www.calculix.lu*. In its report, the authority also gives recommendations on how to improve the competitive situation on the electricity and gas markets, for example through transparency measures.

3.4.3.v. Description of measures to enable and develop demand response, including those addressing tariffs to support dynamic pricing

Corresponding measures have already been described in Section 3.4.3.ii. and are therefore not listed again here.

3.4.4. Energy poverty

3.4.4.i. Any strategies and measures to achieve the objectives set out in point 2.4.4

Low-income sections of the population are being hit particularly hard by climate change and the health impact of fossil energy sources. Climate action therefore also provides a tangible contribution to social justice. However, climate action must also be socially embedded in order to prevent energy poverty.

Luxembourg has a comprehensive strategy for tackling poverty in general (minimum wage, social inclusion income (REVIS), etc.). In addition, there is a series of measures in Luxembourg offering targeted help to people affected by energy poverty. The acts of 1 August 2007 on the organisation of the electricity market and on the organisation of the natural gas market stipulate that household customers who are unable to pay their electricity or gas bills can receive social assistance from the responsible social welfare office.

For its part, the act of 18 December 2009 on the organisation of social assistance stipulates that, when applying the procedures established in the above-mentioned acts on the organisation of the electricity and natural gas markets, the responsible social welfare office must investigate whether the household customer is able to pay his or her energy bills and is entitled to social assistance.

Particular attention must be paid to tackling energy poverty in the housing sector: in Luxembourg, rising house prices have become a major social challenge. Low-income population groups can often only have access to poorly maintained rented housing in old buildings with low energy standards. The government is

therefore targeting the creation of affordable housing. Energy efficiency measures in the housing sector will be designed in a way that simultaneously improves the national energy balance and the living conditions of low-income groups.

At the same time, targeted programmes will also be put in place which, in the face of rising CO_2 prices, will provide significant financial incentives for homeowners to switch from fossil to renewable energy sources. This change should also be affordable for people on low incomes. Among other things, a 'heating oil replacement programme' aims to simplify the changeover both technically and financially.

The government will also work with all relevant stakeholders to develop innovative programmes to provide incentives for the renovation of old housing while providing housing for low-income groups as part of the national long-term renovation strategy to be prepared next year.

It should also be mentioned that there is already a programme in place through the cost-of-living allowance ('Allocation de vie chère'), which also counteracts energy poverty. At the same time, the state rent subsidy can help those in need to face a possible increase in the cost of housing. It should also be pointed out that the current social assistance legislation stipulates that any person who satisfies the conditions for entitlement to social assistance is entitled, under defined conditions, to a minimum provision for domestic energy if he or she is unable to cover the costs of domestic energy.

The huge volume of investment in infrastructure development and the introduction of free public transport from 2020 are certainly not just transport policy measures, but also clearly social measures.

3.5. 'Research, innovation and competitiveness' dimension

3.5.i. Strategies and measures related to the elements set out in point 2.5

In 2015, the Chamber of Commerce of Luxembourg, IMS Luxembourg and the Ministry of Economic Affairs commissioned the sociologist, economist and journalist Jeremy Rifkin to study the development of a new vision for the Luxembourg economy, taking account of his reflections on the 'Third Industrial Revolution (TIR)'. The study was carried out as part of a collective process using the concept of 'Open Societal Innovation'. This approach aims to identify solutions to the challenges faced by the state and society, and seeks to exploit the collective intelligence of the stakeholders involved, in the form of group intelligence.

The TIR process was therefore conceived as an open, inclusive, collective intelligence-based and future-shaping process, targeting a common ambition to understand an increasingly complex world, to identify megatrends, to draw the necessary conclusions and to bring them into the democratic institutions in an appropriate manner. Last but not least, the TIR process should also break up the traditional silo thinking, which is widespread in both the private and the public sector.

The TIR strategy study, which covers the areas of *energy, mobility, buildings, food, industry, finance, smart economy, circular economy* and *prosumers & social model*, was organised in thematic platforms covering the individual areas and involving over 300 participants from business, politics and civil society.

Based on the conclusions of the study, the Government Council decided to use the results as a general guide for the design of national future policy. In the energy and climate field, the Government Council identified as priorities the development of a national energy internet, the promotion of e-mobility, the introduction of the concept of 'Mobility as a Service' and the implementation of a flagship project to demonstrate the socio-economic contribution of sustainable neighbourhoods/cities with sustainably constructed healthy buildings that take account of the principle of 'circularity'.

The above-mentioned priority projects and the approaches outlined in the TIR strategic study, which are based on the significant development of renewable energies and their integration into the energy network, the development of decentralised energy storage, the digitalisation of energy networks, the use of more sustainable means of transport and the energy efficiency of the building stock, are therefore the cornerstones and an appropriate basis for greater prioritisation of research and innovation policy in the field of energy.

It should be noted in this regard that Luxembourg, as a small country, can of course only make a correspondingly small contribution to the necessary global energy turnaround. On the other hand, the very fact that it is a small country means that Luxembourg has the potential to become a pioneer at country level to illustrate how certain key technologies and innovations associated with the energy transition can be scaled up at country level and how they affect a country's energy balance. In this way, Luxembourg could become a pioneer in key technologies and innovation in the energy transition, thereby achieving a transfer value that would be extremely valuable from an international perspective and that would be disproportionately higher than the direct contribution of a small country to the global energy balance. In this sense, and as a consequence of the developments outlined above, Luxembourg will focus on a number of key areas of research and innovation, selected on the basis of the following criteria: (1) they build on existing skills developed in recent years in the Luxembourg research landscape (2) they build on existing infrastructures that Luxembourg has built up in recent years and has already scaled up at country level, and (3) they are suited to ensuring that research competencies combine with infrastructures to form the basis for a workshop for key technologies and innovations for the energy transition. (4) In addition to these more technical innovations, research is also being conducted into spatial planning and socio-political processes of climate-friendly transformation.

As far as existing research competencies are concerned, Luxembourg can build on an internationally highly successful and visible research landscape in the field of computer science, in which energy-related topics such as 'smart grid', 'smart mobility', 'smart buildings' and the 'Internet of Things' have also developed very well. Following on from these themes, Luxembourg has also increased its investment in the fields of 'data science' and 'data modelling' and has recently acquired the necessary IT infrastructure with an internationally visible HPC infrastructure, which can also handle larger data processing and data modelling projects. Appropriate and successful research stakeholders are also available to shed light on the social aspects of an energy transition.

As far as national, energy-related infrastructure is concerned, the Luxembourg government has launched a whole series of highly relevant initiatives in recent years. For example, electricity and gas system operators were required by law to replace current metering systems with smart meters and to manage the relevant data through a national central system by 2020 and 2021 respectively. Luxembourg is therefore one of the first countries in the world to have comprehensive and integrated smart meters for electricity and gas, with the possibility of extending them to other media such as water and district heating. In

addition, electricity distribution network operators have also been required by law to set up a common national infrastructure of public recharging points for electric vehicles, which by 2020 foresees a total of 800 recharging points in public spaces and in park & ride parking areas. Luxembourg's guidelines on energy efficiency for buildings, which are highly progressive when compared with those of other countries, are also worthy of note as are its extensive approaches in the areas of 'indoor pollution', 'sustainable building materials' and even '*circularity* of buildings and whole districts' (*éco-quartiers made in Luxembourg*).

The above considerations lead to the conclusion and aspiration that Luxembourg intends to become a pioneer for the successful implementation of a large-scale nationwide energy transition. Sustainable and energy efficient buildings with local flexibility options and/or energy storage capacity, as well as sustainable mobility components (smart grids) will form the main pillars of this system. Sensor technology and data interoperability open up possibilities for overall monitoring and modelling, which in turn can be used to optimise the system components.

Luxembourg will therefore also become a highly attractive location for suppliers and start-ups in the field of smart energy management, which will find an attractive testing and experimentation environment in Luxembourg for the (further) development of their products.

The cross-border dimension of spatial and mobility planning is also particularly important for Luxembourg. More than in other cross-border metropolitan areas (Copenhagen, Basel, Geneva), Luxembourg is a magnet for a border area with three different countries (France, Germany, Belgium) and commuter flows, as well as the cross-border housing and labour market, which is unique in Europe on this scale. For Luxembourg, it is essential to promote research and innovation in this area.

Luxembourg therefore intends, among other things, to continuously increase the volume of investment in research and development in the energy sector and hopes to focus in particular on the following thematic priorities:

1. Sustainable buildings and building materials – energy efficiency and circular economy, decentralised renewable energy, 'indoor pollution'
2. Éco-quartiers made in Luxembourg – plus energy systems, car-free mobility, socially inclusive urban planning
3. Integration of renewable energies and e-mobility in digital power networks, energy-internet and sector coupling

4. Territorial and cross-border transformation processes in the areas of mobility and spatial planning
5. Social transition processes and social innovation aimed at 'climate positive lifestyles'

In order to address the above-mentioned issues in a structured, clustered and targeted way, the above-mentioned thematic areas will be grouped together in a new research infrastructure that is to be established, involving all relevant stakeholders: the University of Luxembourg, the Luxembourg Institute of Science and Technology (LIST) and the Luxembourg Institute for Socio-Economic Research (LISER), in order to take a mission-based approach to research that will shed light on the social and societal aspects of the targeted pioneer. The national research fund, 'Fonds National de la Recherche' (FNR), will be able to take over the necessary financing aspect and the indispensable quality control.

As regards innovation, Luxembourg is a strong supporter of sustainable development in economic, environmental and also social terms. Luxembourg is also developing a growing community of clean technology start-ups and SMEs, addressing issues such as energy transition, smart cities, smart mobility and also recycling. It is also important to highlight that Luxinnovation's vision is to be a trustworthy partner for entrepreneurs and to find pragmatic solutions for their innovative business development projects that are in line with the government's objectives and that develop the Luxembourg economy in a sustainable way through innovation and research.

Luxembourg's national innovation agency, Luxinnovation, currently plays a crucial role in supporting the above-mentioned enterprises. It encourages and supports companies to innovate and grow, while facilitating collaboration with public research stakeholders. This applies in particular to the area of clean technologies and the transition to a circular economy.

Luxinnovation's portfolio of services for companies and public research institutions will be expanded and streamlined around the topics of energy system transformation and the associated digitalisation of this sector. It will also seek to improve the attractiveness of international investors, companies and professionals to ensure that companies and activities attracted from outside are compatible with the government's objective of developing the economy in a sustainable manner.

Financing the energy transition and 'green finance'

Luxembourg is one of the world's leading financial centres, particularly in the area of investment funds. Luxembourg is also home to the world's largest investment bank, the European Investment Bank (EIB),

which is currently being transformed into a climate bank. In its current legislative programme, the government has committed to transforming Luxembourg's financial centre into a 'green finance' centre.

Research priorities currently include the creation of a research team for 'green finance' and 'impact finance'. Luxembourg will also develop a research priority on 'Financing the Energy Transition', notably due to its geographical proximity to the EIB, where new financial instruments such as 'de-risking instruments' for energy efficiency, renewable energy and energy infrastructure will be explored and taught, as well as the interfaces with the insurance industry based in Luxembourg. Further strategies and measures are outlined in Section 3.1.3.ii.

Stimulating behavioural changes in lifestyles

In addition to the regulatory and financial framework of the state, there is also a need to change lifestyles within society. Climate and energy policies require the **participation and acceptance** of citizens. In order to achieve a sustainable stimulation of behavioural changes in lifestyles, an attractive environment should be created that motivates permanent changes in everyday routines:

- Enhancing public transport and accessibility for all citizens
- Promoting the concept of the sharing economy
- Encouraging responsible travel and nutrition
- Setting an example of climate protection through public institutions
- Increasing the supply of alternative means of transport, such as bike sharing, *cargobikes, car sharing* or *carpooling*
- *Cross-border integrative urban (neighbourhood) and spatial planning*

An additional measure to raise citizens' awareness and encourage behavioural change is the appointment and promotion of a '**neighbourhood administrator**' within the municipalities. The intention is to provide a decentralised approach to sustainable living and the ecology and circular economy within the neighbourhood through, for example, the promotion of the sharing economy and urban farming projects, the organisation of an exchange platform or a repair café.

3.5.ii. Any regional cooperation with other Member States in this area; this includes any information on how the objectives and policies of the SET-Plan are applied to national situations.

The steps and institutional developments mentioned in the previous sections will be further developed in cooperation with other European research and innovation institutions. European programmes are particularly appropriate here, as well as doctoral students, etc.

3.5.iii. Any financing measures in this area at national level, including Union support and the use of Union funds

In recent years, the Luxembourg Government has made considerable efforts to support technological developments and the research and innovation of new technologies. Environmental technologies are among the priorities of Luxembourg's economic diversification strategy.

As provided for in the 2018-2023 government programme, Luxembourg will focus even more in the coming years on innovation and research in the fields of 'renewable energy', 'energy efficiency', 'sustainable cities' and 'neighbourhoods and buildings'. Existing efforts and skills at the national research institutes should be increased. In addition, the connection between energy and climate policies and the economic development of the country in general should be strengthened.

By bringing the national legal framework for the promotion of research, innovation, energy and the environment into line with European State aid guidelines, Luxembourg has already equipped itself with the necessary tools to best assist the private sector in implementing forward-looking innovations. In the future, it will be important to use these instruments in the most targeted way possible in order to ensure the competitiveness of national companies on the one hand and to achieve national climate, energy and environmental goals on the other.

4. Current situation and projections with existing policies and measures

In order to analyse the current situation with regard to energy and climate policy in Luxembourg and to prepare projections based on the current policies and measures, the Luxembourg government commissioned a consortium of consultants from the Fraunhofer Institute for System and Innovation Research (Fh-ISI), Consentec GmbH, the Institute for Resource Efficiency and Energy Strategies (IREES) and TU Wien – Energy Economics Group. The consortium supplemented and adapted the models already applied in previous projects concerning energy demand and energy supply to the given requirements in order to establish an analytical basis that is as robust as possible.

Two scenarios have emerged from the model-based assessment of policies and measures. The reference scenario includes the projections based on current policies and measures and is described in Section 4. The impact assessment of the planned policies and measures described in Section 3 resulted in the target scenario presented in Section 5.

In general, it should be noted that such modelling and the resulting projections do indeed serve as guidance, but are always subject to uncertainty. This is especially true in the case of small open economies, such as that of Luxembourg. As a result, individual decisions or decisions taken abroad or at European level can bring about significant changes when compared with the scenarios presented in this plan.

4.1. Projected evolution of main exogenous factors influencing energy system and GHG emission developments

For both scenarios (reference and target) a very similar set of assumptions was applied in terms of key exogenous factors. On the one hand, these parameters stem from national and European sources and, on the other hand, they are based on the expertise of the consortium of consultants. They are presented in brief below.

Macroeconomic forecasts and sectoral changes

According to projections by the national statistical institute, Statec[14], the population of Luxembourg is expected to increase from around 626,000 inhabitants in 2020 to around 752,000 inhabitants in 2030 and to around 869,000 inhabitants in 2040. This corresponds to average growth of 1.85% per year until 2030, decreasing to around 1.45% per year between 2030 and 2040. Overall, the population of Luxembourg will increase by about 20% by 2030 when compared with 2020.

Table 4: Population growth and gross domestic product

	Unit	2020	2025	2030	2035	2040
Population	Thousand inhabitants	626	690	752	812	869
Gross domestic product	Annual growth rate in %	3.8	3.0	3.0	3.0	3.0

Source: Statec (2019)

The above-mentioned projections by Statec show that the annual growth rate for gross domestic product will be 3.8% in 2020, falling to 2.5% by 2023, before finally settling at around 3%.

Global/Europe-wide energy trends

As regards the assumptions on price trends on the global and European energy markets, the Commission's recommendation was followed. Accordingly, the model-based analysis of the Luxembourg energy system

[14] Long-term macroeconomic and demographic projections 2017-2060 (November 2017) updated with medium-term projections 2019-2023 (March 2019). The population figures correspond to the situation on 1 January of the respective year.

was based on assumptions and results of the impact assessment of the EU climate and energy targets for 2030[15]. Table 5 allows a comparison to be made of the specific energy prices of fossil fuels.

Table 5: Assumptions on energy price trends

Key price trends for fossil fuels

	Unit	2020	2025	2030	2035	2040
Oil	€/toe	502.3	589.8	649.8	677.8	717.7
Natural gas (net calorific value)		323.1	361.6	393.3	420.0	434.2
Hard coal		95.8	118.4	142.1	150.5	156.8

Source: European Commission (2016)

Assumptions on cost developments for renewable energy technologies

Table 6 shows the assumptions on cost developments for renewable energy technologies that were used for modelling. As can be seen, previous trend developments are expected to continue for all technologies, which will trigger a steady decrease in specific costs. This assessment and the assumptions made specifically for technologies such as photovoltaics can nevertheless be classified as conservative.

[15] European Commission, 2016, SWD(2016) 410 final: Impact Assessment. Supplementary to the following documents: COM(2016) 861 final, SWD(2016) 411 final, SWD(2016) 412 final, SWD(2016) 413 final. Brussels, 30 November 2016

Table 6: Assumptions on cost developments for renewable energy technologies

	Unit	2020	2025	2030	2035	2040
Electricity sector		-	-	-	-	-
Biogas	€/kW	3,830	3,558	3,359	3,181	3,005
Biomass		4,900	4,530	4,336	4,194	4,134
Hydroelectric power		3,754	3,697	3,668	3,642	3,618
Photovoltaic		1,045	906	817	716	688
Wind energy		1,459	1,405	1,344	1,298	1,241
Heat sector		-	-	-	-	-
Biomass, decentralised	€/kW	699	651	640	611	604
Solar thermal energy		670	642	677	700	743
Heat pumps		786	762	743	627	719

Source: Green-X Model, Vienna University of Technology (Resch et al, 2019)

4.2. 'Decarbonisation' dimension

4.2.1. GHG emissions and removals

Table 7 shows the development of the annual greenhouse gas emissions in the period from 2005 to 2017. The values and the definition of the sectors have been taken from the GHG inventory of 2019.[16] In accordance with international conventions, the total sum of the LULUCF emissions is not included. In 2017, a total of 10.2 million t CO_2eq was emitted. This is a 21.4 per cent reduction when compared with 2005.

Table 7: Greenhouse gas emissions by sector for 2005 to 2017, in kt CO2eq

	2005	2010	2011	2012	2013	2014	2015	2016	2017
Total emissions	**13,025**	**12,180**	**12,062**	**11,781**	**11,239**	**10,787**	**10,295**	**10,052**	**10,236**
Energy-related emissions	**11,552**	**10,737**	**10,613**	**10,410**	**9,872**	**9,388**	**8,896**	**8,614**	**8,778**
Energy sector	1,243	1,206	1,004	1,043	686	669	458	252	244
Industry	1,407	1,268	1,242	1,185	1,146	1,147	1,106	1,142	1,141
Transport	7,188	6,517	6,893	6,585	6,439	6,139	5,706	5,533	5,639
Private households	1,216	1,161	1,064	1,083	1,075	973	1,086	1,119	1,116
Trade, commerce and services	419	502	336	439	463	398	483	512	583
Others*	27	29	28	28	24	24	24	24	24
Diffuse emissions	53	54	47	48	41	38	35	32	31
Non-energy-related emissions	**1,472**	**1,443**	**1,449**	**1,371**	**1,366**	**1,399**	**1,399**	**1,438**	**1,458**
Industrial processes	726	676	692	633	617	633	625	650	662
Agriculture	641	672	666	649	660	675	688	704	712
Waste	105	95	91	89	90	91	85	83	84
LULUCF	***-601***	***-88***	***-220***	***-313***	***-500***	***-416***	***-362***	***-452***	***-344***

** Other emissions relate to combustion in construction and agriculture*

Source: GHG Inventory 2019v1 (March 2019)

For the period 2005 to 2017, the annual GHG emissions can be broken down by emissions in the sectors subject to the ETS and those in other, non-ETS sectors (see Table 8). Due to the change to the scope of the ETS from 2013 onwards, additional activities and installations have been included in the ETS. The corresponding GHG emissions are therefore no longer accounted for in the non-ETS sector (non-ETS emissions for industry in 2012: 563 kt CO_2eq and non-ETS emissions for industry in 2013: 274 kt CO_2eq). The GHG emissions from the non-ETS sectors amounted to 8.7 million t CO_2eq in 2017, of which only about 10% were non-energy-related GHG emissions.

[16] https://cdr.eionet.europa.eu/lu/eu/mmr/art07_inventory/ghg_inventory/envxitkwg/

Table 8: Greenhouse gas emissions by ETS and non-ETS for 2005 to 2017, in kt CO_2eq

	2005	2010	2011	2012	2013	2014	2015	2016	2017
ETS emissions excl. internat. air transport	**2,603**	**2,253**	**2,052**	**1,990**	**1,847**	**1,931**	**1,661**	**1,503**	**1,492**
Total non-ETS emissions	**10,421**	**9,926**	**9,998**	**9,798**	**9,391**	**8,855**	**8,634**	**8,549**	**8,744**
Energy-related non-ETS emissions	**9,608**	**9,070**	**9,144**	**8,960**	**8,536**	**7,982**	**7,753**	**7,653**	**7,832**
Energy sector	232	201	208	215	221	174	175	184	184
Industry	474	605	570	563	274	236	245	249	255
Transport	7,188	6,517	6,893	6,585	6,439	6,139	5,706	5,533	5,639
Private households	1,216	1,161	1,064	1,083	1,075	973	1,086	1,119	1,116
Trade, commerce and services	419	502	336	439	463	398	483	512	583
Others*	27	29	28	28	24	24	24	24	24
Diffuse emissions	53	54	47	48	41	38	35	32	31
Non-energy-related non-ETS emissions	**814**	**856**	**854**	**838**	**855**	**873**	**882**	**896**	**912**
Industrial processes	68	89	97	100	106	108	108	109	116
Agriculture	641	672	666	649	660	675	688	704	712
Waste	105	95	91	89	90	91	85	83	84
LULUCF	***-601***	***-88***	***-220***	***-313***	***-500***	***-416***	***-362***	***-452***	***-344***

** Other emissions relate to combustion in construction and agriculture*

Source: GHG Inventory 2019v1 (March 2019) and EUA EU Emissions Trading System (ETS) data viewer.[17]

The projections for the sector-specific developments by ETS and non-ETS for the reference scenario based on current policies and measures are shown in Table 9 .

Table 9: Greenhouse gas emissions by ETS and non-ETS for 2020 to 2040, in the event of the reference scenario (without additional measures), in kt CO_2eq

	2020	2025	2030	2035	2040
ETS emissions excl. internat. air transport	**1,393**	**1,308**	**1,202**	**1,138**	**1,068**
Total non-ETS emissions	**8,394**	**8,379**	**8,554**	**8,822**	**8,967**
Energy-related non-ETS emissions	**7,502**	**7,530**	**7,736**	**8,016**	**8,168**
Energy sector	163	163	163	163	163
Industry	196	206	205	223	236
Transport	5,453	5,549	5,844	6,167	6,352
Private households	1,144	1,131	1,099	1,058	1,042
Trade, commerce and services	489	426	370	349	321
Others*	25	25	25	26	26
Diffuse emissions	31	31	30	29	29
Non-energy-related non-ETS emissions	**892**	**849**	**817**	**806**	**799**
Industrial processes	112	106	80	70	64
Agriculture and forestry	701	671	669	668	667
Waste	79	72	68	68	67
LULUCF	***-390***	***-393***	***-401***	***-399***	***-397***

** Other emissions relate to combustion in construction and agriculture*

Source: Own illustrations, 2019

[17] https://www.eea.europa.eu/data-and-maps/dashboards/emissions-trading-viewer-1

4.2.2. Renewable energy

The contribution made by renewable energy to energy production in Luxembourg is steadily increasing. As can be seen from the target scenario in Section 2 of this report, a consistent continuation of the trend established in the recent past is being sought. The following section explains the starting position in respect of the use of renewable energy, followed by a consideration of the future development – in this case purely in the event of a continuation of existing measures, both in terms of production and demand.

Status quo of renewable energy use in Luxembourg

In recent years, considerable growth has been achieved in renewable energies such as wind energy, photovoltaics and biomass, i.e. the core technologies in the field of electricity production for Luxembourg. Over the course of a decade, their contribution has increased significantly – both in the electricity sector (from 3.3% in 2007 to 8.1% in 2017), but also in connection with heat generation (from 4.4% in 2007 to 8.1% in 2017). In the transport sector, which is dominated by the use of biofuels and the transition to electrically operated drive systems, this change was even more dramatic: In 2007, the renewable energy share was around 2.2%; in 2017, Luxembourg achieved a renewable energy share of 6.4%.

Reference development in the event of a continuation of existing measures

In the following, a reference development or the expected development with continuation of existing measures, both on the supply and the demand side, is presented for the period up to 2040.

The renewable energy share in the gross final energy demand, in other words the total of the sectoral energy demands for electricity, heat and fuels in the transport sector would increase accordingly from 6.4% in 2017 to 12.9% by 2030, and finally to 13.5% in 2040.

Table 10 provides information on the sectoral decomposition of the overall balance and Table 11 provides supplementary details on the potential underlying technology split. Compared to the target scenario of 25%, as depicted in Section 2 of this report, the underlying volumes only show comparatively minor differences in terms of the energy-related contribution of specific renewable energy technologies. Accordingly, a significant increase in renewable energy in the electricity sector is also expected in the reference scenario. This results in a share of approximately 26.5% for 2030 and around 34.7% for 2040. Substantial contributions in terms of volume are expected here from wind energy and photovoltaics – the latter, however, being considerably slower than in the case of the development compatible with the target

scenario (according to Section 2). Projects that are already in the implementation stage, for instance in the field of biomass cogeneration, will also make substantial contributions.

Similarly to electricity, a significant expansion of renewable energy is also expected in the heat sector in the event of a continuation of existing measures. In this case, the renewable energy share in the reference scenario will increase from 8.1% in 2017 to 18.6% by 2030 and finally 21.9% in 2040.

In unison with electricity and heat, a huge increase in the use of renewable energy is also expected in the transport sector in the reference case. In this specific case, it is assumed that there will be an increase in the admixture of biofuels (with an admixture rate of around 8% in 2030). In addition, an expansion of e-mobility is expected, and it is also assumed that by the end of 2030 the biofuel mix will consist of no more than 5% first-generation fuels. In total, an increase of the renewable energy share in the transport sector to 15.1% will therefore be achieved by 2030 in the reference case.

Table 10: Sectoral shares of renewable energy in Luxembourg by 2040 according to the reference scenario

Renewable energy shares, sectoral		2017	2020	2025	2030	2035	2040
Renewable energy share, electricity sector	%	8.1%	11.9%	19.4%	26.5%	31.3%	34.7%
Renewable energy share, heat sector	%	8.1%	12.1%	15.4%	18.6%	20.4%	21.9%
Renewable energy share, transport sector	%	6.4%	11.1%	13.5%	16.1%	15.1%	17.6%
Admixture rate for biofuels	%	5.4%	7.7%	8.0%	8.0%	5.6%	5.5%
Renewable energy share, total - national production/consumption	**%**	6.4%	**9.2%**	**11.2%**	**12.9%**	**12.8%**	**13.5%**
Renewable energy share, total - incl. renewable energy cooperation	%	6.4%	**11.3%**	**17.4%**	**23.0%**	**22.7%**	**23.2%**

Source: Own illustrations, 2019

In addition to national renewable energy production Table 11 also shows the volumes of renewable energy that are to be covered in the future through renewable energy cooperation with other countries. These are

used in the reference scenario to achieve an overall renewable energy target of 23% in 2030 and amount to (already contractually agreed) 1 TWh in 2020 and 4.83 TWh in 2030 (and thereafter).

Table 11: Technology-specific energy production from renewable energy in Luxembourg by 2040 according to the reference scenario

Energy production, technological details		2017	2020	2025	2030	2035	2040
Electricity sector							
Biogas	GWh	72	56	65	68	63	62
Biomass	GWh	101	192	228	271	260	267
Hydroelectric power	GWh	104	93	97	100	104	107
Photovoltaics	GWh	108	201	476	616	687	729
Wind energy	GWh	185	211	383	676	958	1,167
Renewable energy electricity, total	**GWh**	570	**752**	**1,249**	**1,731**	**2,071**	**2,332**
Heat sector							
Biomass & biogas, grid-connected*	GWh	302	589	623	667	649	656
Biomass, decentralised**	GWh	672	883	1,145	1,383	1,522	1,560
Solar thermal energy	GWh	25	58	113	188	302	453
Heat pumps	GWh	52	95	190	224	226	227
Renewable energy heat, total	**GWh**	1,052	**1,626**	**2,070**	**2,462**	**2,699**	**2,896**
Transport sector							
Biofuels, total	**GWh**	1,282	**1,855**	**1,892**	**1,993**	**1,450**	**1,450**
Renewable energy use, total (national)	**GWh**	2,904	**4,232**	**5,211**	**6,187**	**6,221**	**6,679**
Renewable energy cooperation							
Renewable energy cooperation energy	**GWh**	0	**1,000**	**2,917**	**4,833**	**4,833**	**4,833**

** Central plants (fed into a heating network)*

*** Decentralised plants (not fed into a heating network, all sectors)*

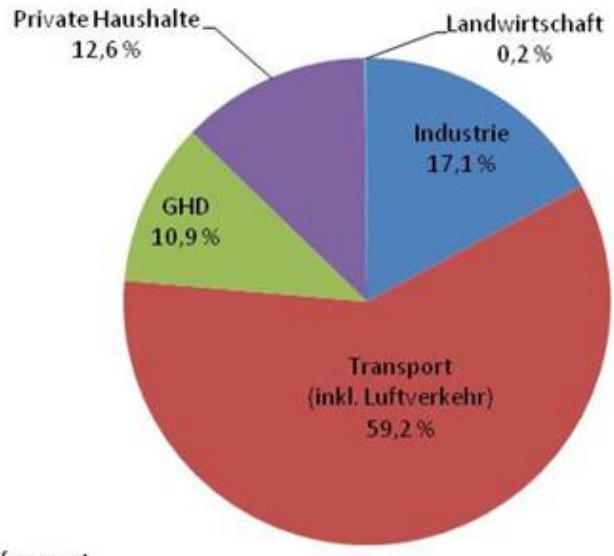
Source: Own illustrations, 2019

4.3. 'Energy efficiency' dimension

Various aspects need to be considered in the 'energy efficiency' dimension in order to paint the most realistic picture possible.

Starting situation in terms of energy demand in Luxembourg

In 2016, Luxembourg's final energy demand was just under 48 TWh (Statec 2018). The majority of the final energy demand in Luxembourg, 59%, is accounted for by the transport sector (Figure 7). Of this, a majority of around 34% is accounted for by foreign road transport. According to energy statistics, this includes the refuelling caused by all non-domestic vehicle owners. This includes through traffic of heavy goods and passenger vehicles, as well as cross-border commuters with passenger vehicles not registered in Luxembourg. At the same time, air transport accounts for about 12% of total final energy demand, which means that domestic road transport accounts for about 13% of Luxembourg's final energy demand. While the agricultural sector accounts for the lowest share in the final energy demand at around 0.2%, the industrial sector requires the greatest share of energy in Luxembourg at just over 17%.

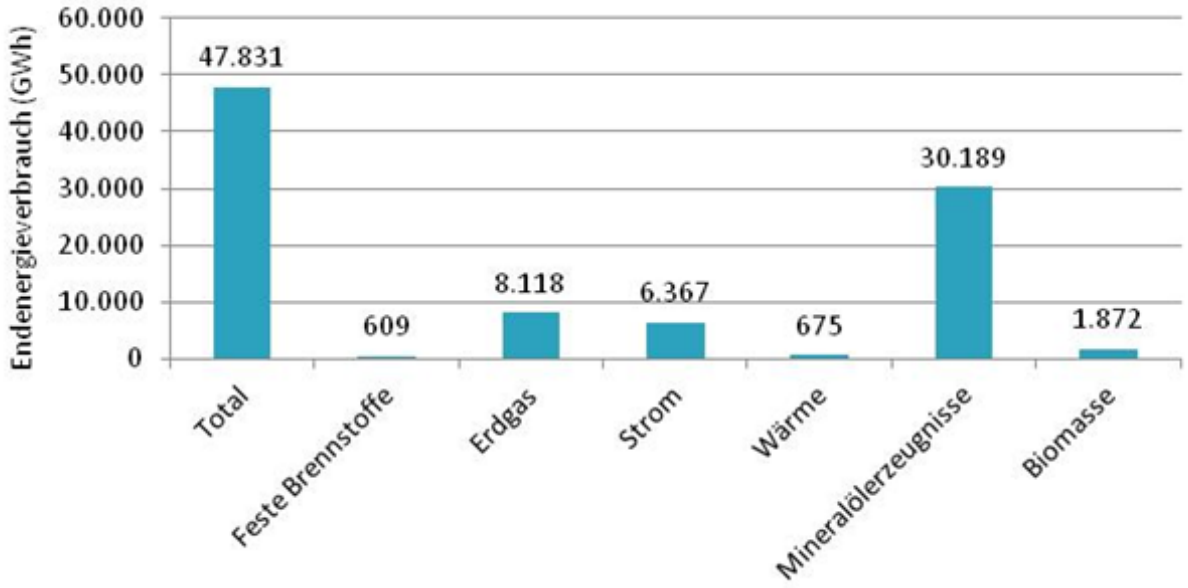


Private Haushalte	Private households
Landwirtschaft 0,2 %	Agriculture 0.2%
GHD	Trade, commerce and services
Industrie	Industry
Transport (inkl. Luftverkehr)	Transport (including air transport)
Endenergiebedarf gesamt in 2016: 47.831 GWh	Total final energy demand in 2016: 47,831 GWh

Source: IREES according to Statec 2018

Figure 7: Luxembourg's final energy demand in 2016, broken down by industrial; household; trade, commerce and services; transport and agricultural sectors

Luxembourg's energy demand in 2016 is dominated by the need for mineral oil products (63%). The energy demand was also covered by natural gas (17%), electricity (13%) and biomass (4%) (see Figure 8).



Endenergieverbrauch (GWh)	Final energy consumption (GWh)
Total	Total
Feste Brennstoffe	Solid fuels
Erdgas	Natural gas
Strom	Electricity
Wärme	Heat
Mineralölerzeugnisse	Mineral oil products
Biomasse	Biomass

Source: IREES according to Statec 2018

Figure 8: Final energy demand in Luxembourg in 2016, broken down by energy source

Note: In terms of electricity consumption, this presentation does not take account of the fact that larger electricity consumers could settle in Luxembourg in the near to medium term.

Existing potential for using high-efficiency cogeneration and efficient district heating and cooling

In 2015, just under 326 GWh of electricity and 527 GWh of heat were produced in Luxembourg using cogeneration technology. It should be noted here that cogeneration plants are able to provide heat at temperatures up to 500 °C. (Klobasa, Steinbach & Pudlik 2016).

Further potential for the use of high-efficiency cogeneration can be found in the following areas:

- Decentralised cogeneration plants in buildings
- Use of cogeneration in industry
- Heating network supply and centralised cogeneration

The economic potential of the use of cogeneration plants and supply based on heating networks depends largely on the development of renovation activities in the building sector and therefore on the development of the heat demand of buildings as a whole. In the field of the decentralised supply of buildings, the use of cogeneration in the power range below 500 kW of electric power is well-established. On account of the building-specific heating or cooling demand values, there is still untapped economic potential for highly efficient cogeneration or district heating, mainly in the area of multi-family buildings.

The economic potential of cogeneration in the building sector is currently being realised at about 50% through existing local heating concepts. Therefore, in Luxembourg, there is currently an economic cogeneration potential of around 1,170 GWh of useful energy in the building sector alone (Klobasa, Steinbach & Pudlik 2016).

At the same time, a limited economic potential of around 500 GWh of final energy or 425 GWh of useful energy is seen in industry by 2030 (see Table 12). Relevant sectors here are the chemical industry, the timber industry and the food industry. However, to realise this industrial potential, good site conditions with long plant running times are absolutely essential (Klobasa, Steinbach & Pudlik 2016).

Table 12: Additional potential for the cogeneration of heat in industry by 2030 based on final energy use in industry

Sector	Fuel demand in GWh 2014	Fuel demand in GWh 2030	Cogeneration suitable (<500 °C) in GWh 2014	Cogeneration suitable (<500 °C) in GWh 2030	Cogeneration existing in GWh 2014	Expansion potential in GWh 2030
Steel	1 670	1 422	67	57		
Stone/earth	1 094	589	164	88		
Chemistry	319	295	316	292		210
Textiles	226	208	226	208		
Timber	274	253	274	253	65	150
Food	61	57	60	56		
Construction	77	71	0	0		
Mechanical engineering	13	12	13	12		
Paper	51	47	50	46		
Other	157	154	145	134	122	115
Total	**3 952**	**3 107**	**1 315**	**1 146**	**187**	**500**
	Cogeneration heat*					425
	Cogeneration electricity**					255

Source: Klobasa, Steinbach & Pudlik 2016

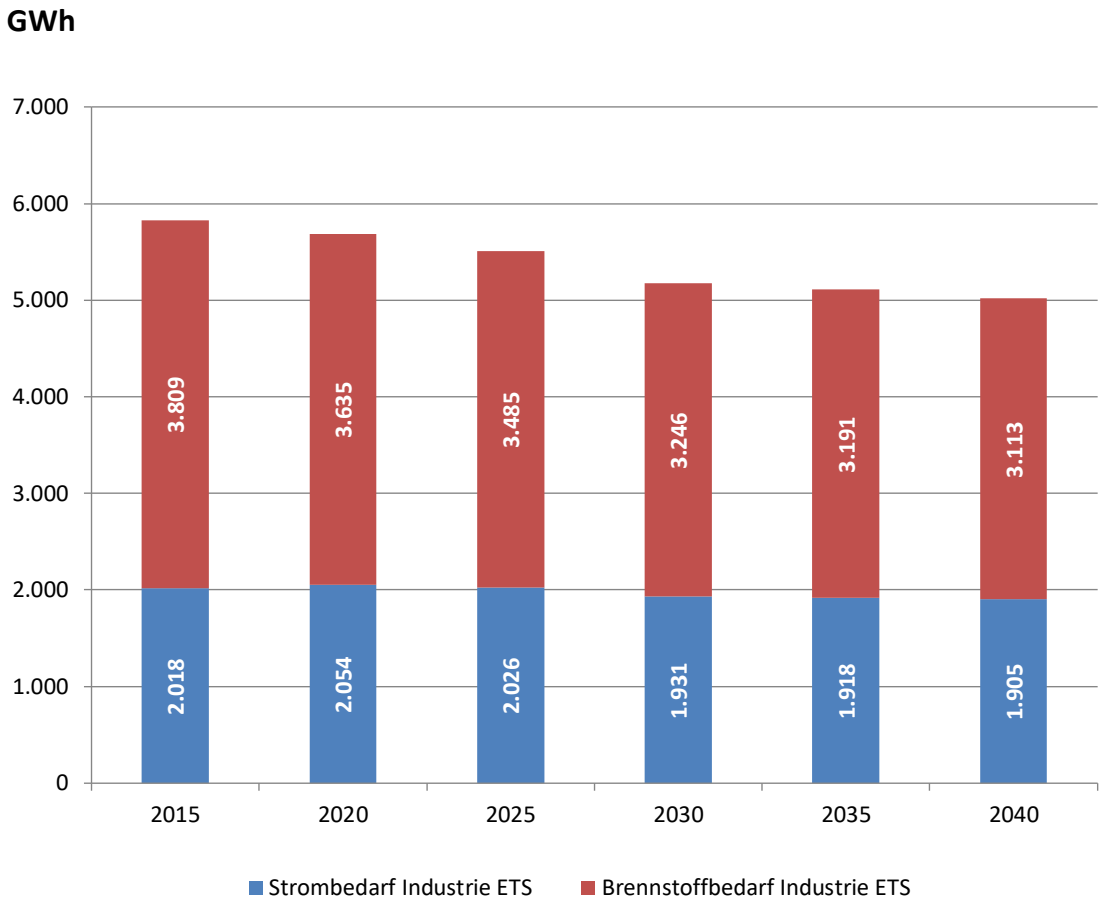
Energy demand development in Luxembourg by 2040

The energy demand developments of the reference scenario and the target scenario from 2015 to 2040 are modelled using a bottom-up model. This model takes account of a number of very different drivers depending on the sector under consideration (private households; trade, commerce and services sector; industry and transport). In the model, these drivers are linked to corresponding specific energy demand parameters in both the reference and target scenarios. The annual energy demand development is then calculated by mathematically linking drivers with the associated energy demand characteristics and other influencing factors. As a basis for the data and a source of information, wherever possible, the model draws on existing accessible data sets or other sources of information (inventory, reports from research projects, previous projects, etc.) for the relevant factors and influencing variables. These come, for example, from Statec or other institutions. If no relevant data are available, assumptions and expert estimates must be used. However, as a result of this, the project is unable to reflect the real situation in Luxembourg in all sectors and sub-sectors in such a way that the modelled results can always be reflected in exactly the same way as the results of other projects or data sets. The large number of influencing factors taken into account demands a certain degree of abstraction or generalisation for the individual control variables. As a result, all project results may differ to some extent from data or data sets that are already available. Understandably, this applies not only to the demand side, but also to the supply side calculations.

The following sectors contribute to Luxembourg's total final energy demand: private households; trade, commerce and services; industry and transport It is possible to draw a distinction here between non-ETS (private households; trade, commerce and services; industry) and ETS (industry, aviation). In the case of the reference development, the final energy demand of Luxembourg's non-ETS sector will rise by 15% in the period from 2015 to 2040; from just under 36 TWh per year to around 42 TWh. The final energy demand of the transport sector will show the largest percentage increase here, growing to around 26.5 TWh in 2040 (+ 19.5%). At the same time, the electricity demand will increase by around 8% to reach 6.4 TWh and the final energy demand for heat generation will show minor growth of 2.9% (from approximately 10.5 TWh to just under 10.9 TWh).

During that same period, the electricity demand of the non-ETS sector of industry will increase by approx. 180 GWh to just over 1.2 TWh in 2040 (+ 17%). At the same time, the fuel required by non-ETS industry will also increase by just over 21% from 0.9 TWh in 2015 to approximately 1.1 TWh. By contrast, after a slight increase in 2020, the electricity demand of ETS industry will decrease by almost 6% to 1.9 TWh in 2040. (see Figure 9).

It should also be noted here that a further increase in electricity consumption seems possible, as this information does not take account of the fact that larger electricity consumers could settle in Luxembourg in the near to medium term.



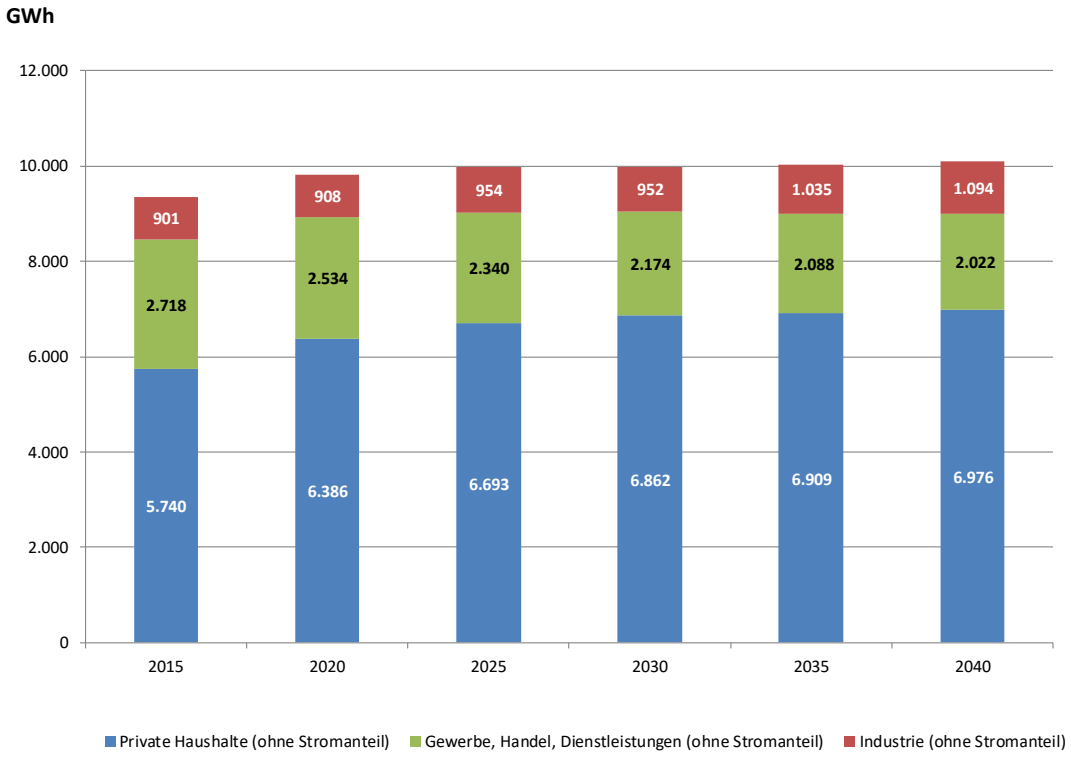
GWh	GWh
Strombedarf Industrie ETS	Electricity demand industry ETS
Brennstoffbedarf Industrie ETS	Fuel demand industry ETS

Source: Own illustration 2019

Figure 9: Electricity and fuel required by industry (ETS sector only) in the period from 2015 to 2040 in the event of the reference scenario

The final energy demand for heat generation (excluding electricity) in the non-ETS sector shows a slight increase of 8% overall over the entire study period (+ 1.0% compared to 2030), i.e. the final energy demand for heating (excluding electricity) will increase from around 9.4 TWh to just under 10.1 TWh. This increase is based on the increased use of wood and other renewable energies (+ 263% in 2040 when compared with 2015) and other fuels (+ 18% in 2040 when compared with 2015), while the use of the fossil energy sources, natural gas, fuel oil and coal, will see a significant drop. This increase in the final energy demand for heat generation is due, on the one hand, to the 'households' sector, which will be 21.5% larger in 2040 than in 2015; most of the increase will be seen in the period up to 2030, while the final energy demand of the sector will only grow by just under 2% in the period from 2030 to 2040 (see Figure 10). On the other hand, the final energy demand of non-ETS industry will also increase at a near-identical rate (+ 21.3%) from

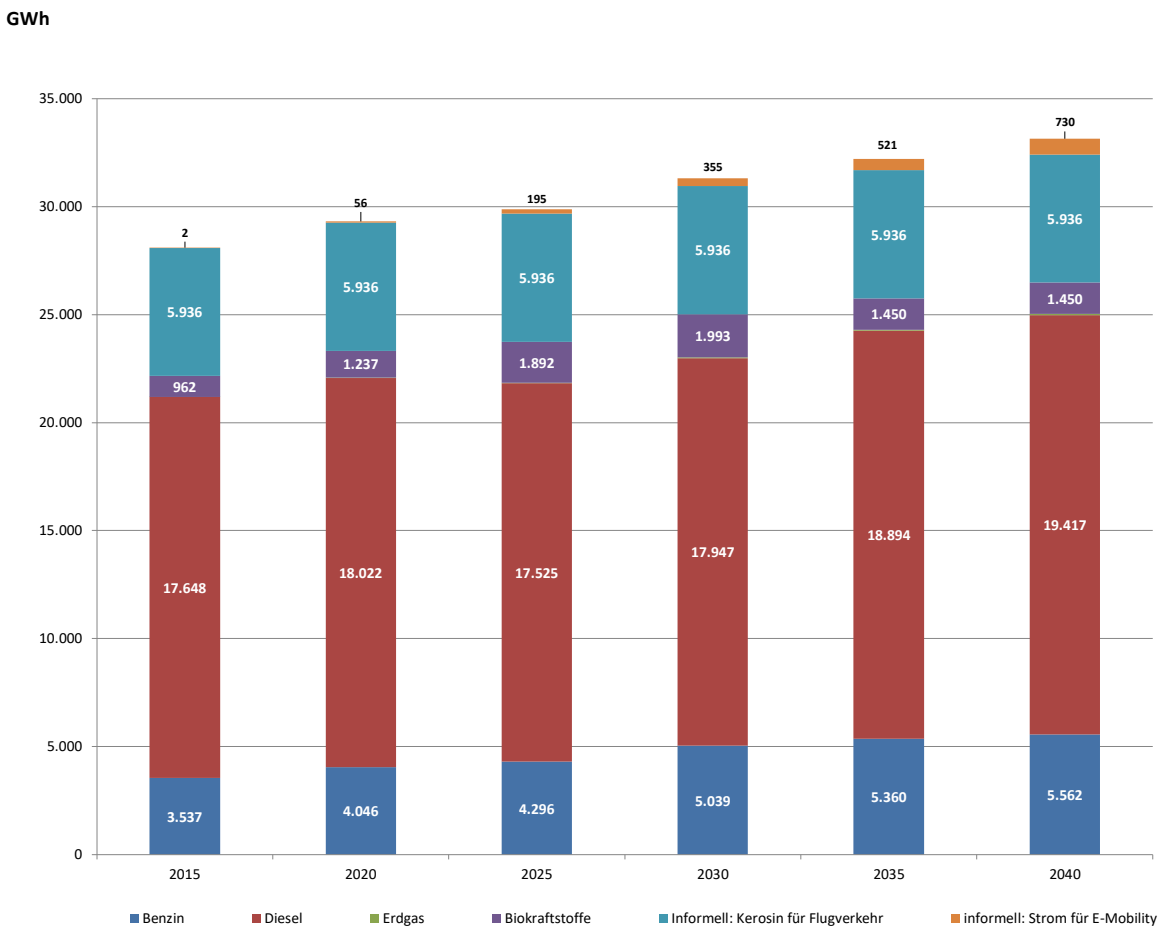
0.9 TWh to approximately 1.1 TWh. In contrast to private households and non-ETS industry, the 'trade, commerce and services' sector shows a decline of just under 26% in the use of final energy for heat generation in 2040 when compared with 2015 (see Figure 10). The final energy demand in the transport sector, which will see strong growth by 2040 (+ 19.5%) and which is based on a growing number of vehicles and ever increasing distances driven, is covered almost exclusively by the conventional fossil energy sources, petrol (+ 2.0 TWh when compared with 2015) and diesel (+ 1.8 TWh when compared with 2015) (see Figure 11). In the same period, biofuels will see an absolute increase of just under 0.5 TWh.



GWh	GWh
Private Haushalte (ohne Stromanteil)	Private households (excluding electricity share)
Gewerbe, Handel, Dienstleistungen (ohne Stromanteil)	Trade, commerce, services (excluding electricity share)
Industrie (ohne Stromanteil)	Industry (excluding electricity share)

Source: Own calculations 2019

Figure 10: Sectoral development of the fuel required for heat generation by households; trade, commerce and services, and industry (without ETS share) in the period from 2015 to 2040 in the event of the reference scenario



GWh	GWh
Benzin	Petrol
Diesel	Diesel
Erdgas	Natural gas
Biokraftstoffe	Biofuels
Informell: Kerosin für Flugverkehr	Informal: Jet fuel for air transport
Informell: Strom für E-Mobility	Informal: Electricity for e-mobility

Source: Own calculations 2019

Figure 11: Development of the final energy demand (broken down by energy source) of the transport sector in the period from 2015 to 2040 in the event of the reference scenario

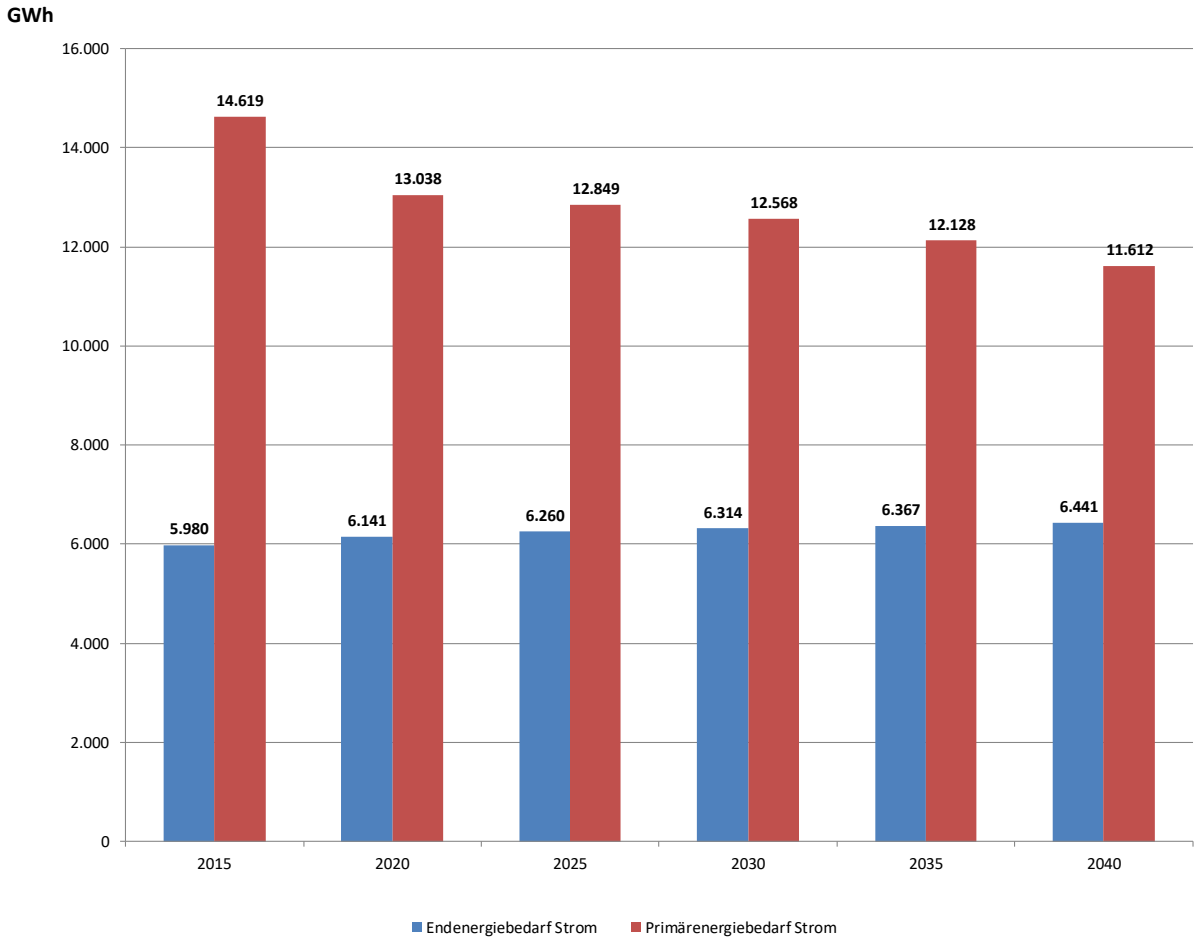
Table 13 below gives a brief overview of common primary energy factors. With the exception of electricity, the primary energy demand and the final energy demand are identical, due to a primary energy factor of 1.0. Therefore, separate designation of the primary energy demand is dispensed with here. Figure 12 provides an overview of the ratio of primary energy demand to final energy demand only in the case of electricity. Due to improved efficiency in the production of electricity, the primary energy factor will decrease by 26% between 2015 and 2040. In absolute terms, Luxembourg's electricity demand (final

energy) will increase by just under 8% between 2015 and 2040 despite improved efficiency (on average around 1% per year), partly because of economic developments, the increasing resident population and technical developments (increasing digitalisation, more applications of electricity, etc.). At the same time, the primary energy demand for electricity production will sink by just under 21% (see Figure 12).

Table 13: Primary energy factors used for the various energy sources in the period from 2015 to 2040

	2015	2020	2025	2030	2035	2040
Natural gas	1.0	1.0	1.0	1.0	1.0	1.0
Fuel oil	1.0	1.0	1.0	1.0	1.0	1.0
Timber	1.0	1.0	1.0	1.0	1.0	1.0
Coal	1.0	1.0	1.0	1.0	1.0	1.0
Other fuels	1.0	1.0	1.0	1.0	1.0	1.0
Petrol	1.0	1.0	1.0	1.0	1.0	1.0
Diesel	1.0	1.0	1.0	1.0	1.0	1.0
Biofuels	1.0	1.0	1.0	1.0	1.0	1.0
Jet fuel (air transport)	1.0	1.0	1.0	1.0	1.0	1.0
Electricity	2.4	2.1	2.1	2.0	1.9	1.8

Source: Own illustration 2018



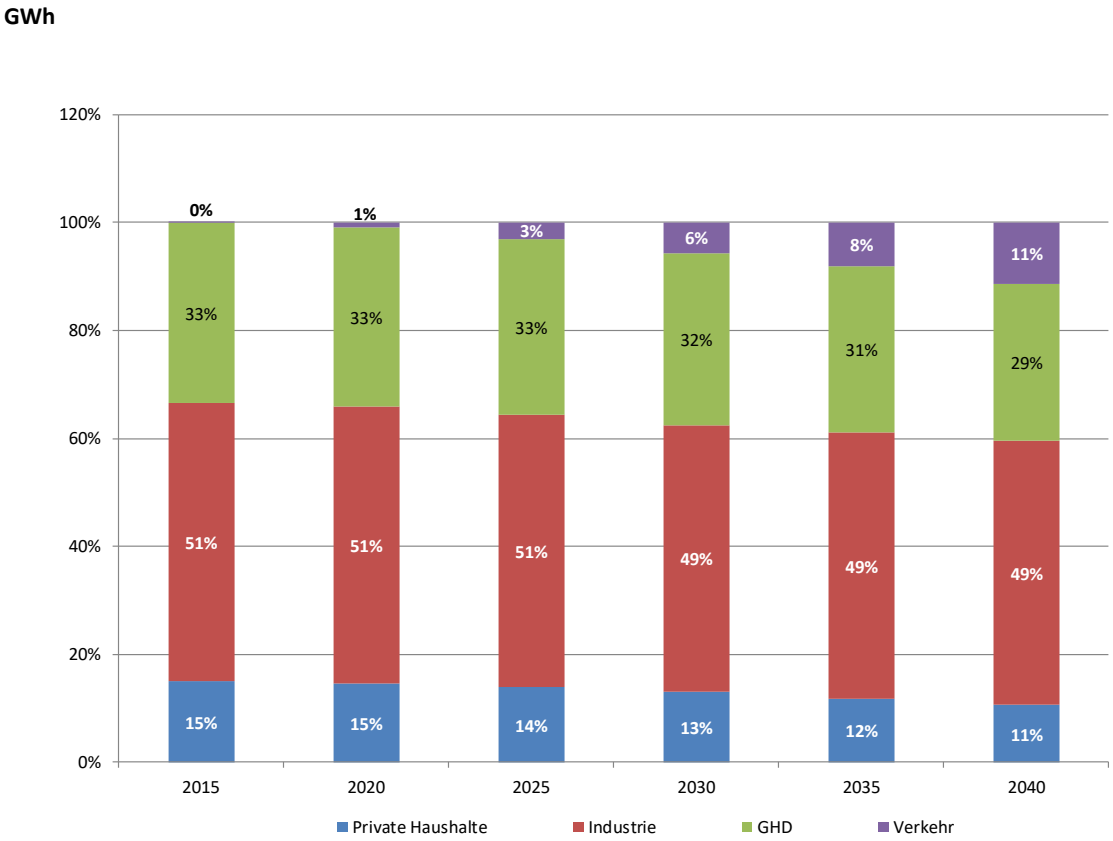
GWh	GWh
Endenergiebedarf Strom	Final energy demand electricity
Primärenergiebedarf Strom	Primary energy demand electricity

Source: Own calculations 2019

Figure 12: Development of electricity demand (final energy demand and primary energy demand) for the period from 2015 to 2040 in the event of the reference scenario

The share of the specific sectors in the electricity demand will vary on account of continuing efforts to improve efficiency and various trends and technological developments in electricity applications and production technologies in trade, households, industry or the transport sector. While the share of the transport sector in the total electricity demand will considerably increase by 2040 when compared with 2015 (share of transport 2040: just over 11%), the shares of the remaining sectors (trade, commerce and services; private households; industry) will decrease to a greater or lesser extent (see Figure 13). When looking at the absolute electricity demand (final energy) of the individual sectors, it is noticeable that, despite the increasing population, the absolute electricity demand of households will decrease by around

220 GWh between 2015 and 2040 due to improved energy efficiency, while that of the transport sector will increase strongly due to the growth in e-mobility (+ 0.7 TWh). Demand in the trade, commerce and services sector will fall by 0.1 TWh, while electricity demand in the industrial sector will see a minimal increase.



GWh	GWh
Private Haushalte	Private households
Industrie	Industry
GHD	Trade, commerce and services
Verkehr	Transport

Source: Own calculations 2019

Figure 13: Sectoral breakdown of the electricity demand for the period from 2015 to 2040 in the event of the reference scenario

4.4. 'Energy security' dimension

4.4.1. Analysis – electricity sector

Reliability of supply

The quality of the electricity supply in Luxembourg is very high, even when compared to Europe. The average outage duration per point of use and per year was 21.8 minutes in 2017[18].

Gross electricity production

The data on gross electricity production based on (small-scale) gas-powered cogeneration plants in the past were gathered from the monitoring conducted by ILR[19]. The expected electricity production from gas was updated to 220 GWh/year in accordance with the status quo. Other data are from the reference scenario.

Table 14: Gross energy production in Luxembourg by 2040

[GWh]	2016	2020	2030	2040
Biogas	74	56	68	62
Gas	220	220	200	180
Biomass/biowaste	67	192	271	267
Water (not including pumped-storage power plants)	104	93	100	107
Wind	127	161	676	1,167
PV	100	251	616	729
Total	692	973	1,931	2,512

Source: Reference scenario, ILR

Domestic energy sources

Electricity production on the basis of renewable energy is a domestic energy source. Together with the domestic electricity production on the basis of decentralised gas-fired power plants, it amounted to around 690 GWh in 2015. In 2020 to 2040, an increase of around 2.55 TWh is expected according to the reference scenario. In addition to the types of production listed in Table 14, the Vianden pumped storage power plant is also worth mentioning. With a production capacity of 1.3 GW and a storage capacity of around

[18] ILR, Chiffres Clés du Marché de l'Électricité, Année 2017 - Partie I
[19] ILR, Chiffres Clés du Marché de l'Électricité, Année 2017 - Partie I

5,000 MWh, it is one of Europe's largest pumped storage power plants and it makes a significant contribution to system flexibility and security of supply in the wider region. It serves, inter alia, as a valuable compensation tool for production ratios and forecasting errors in renewable energy production, as well as for network stabilisation measures.

Import dependency

The import dependency is the result of gross electricity consumption minus domestic production. Table 15 shows the projections regarding gross electricity consumption, both in ktoe and TWh[20]. Since it is expected that there will be a considerable increase in renewable energy production in Luxembourg by 2040, with only a minor increase in gross electricity production, the import dependency is expected to reduce accordingly from just under 90% in 2015 to 60% in 2040. Luxembourg mainly imports electricity from Germany; more than 75% of its electricity is sourced from there.

In terms of electricity consumption, this presentation does not take account of the fact that larger electricity consumers could settle in Luxembourg in the near to medium term.

Table 15: Electricity import dependency of Luxembourg

	2016	2020	2030	2040
Gross electricity consumption [ktoe]	560	528	543	554
Gross electricity consumption [TWh]	6.52	6.14	6.31	6.44
Domestic production [TWh]	0.69	0.97	1.95	2.55
Import dependency [%]	89%	84%	69%	60%

Source: Own calculations based on ILR and reference scenario

Relevant risks

Luxembourg's dependence on energy imports over the long term will be lower than it is today, although it will remain high. The security of supply in Luxembourg therefore also depends on the security of supply in the rest of Europe. Various studies, such as the Generation Adequacy Assessment (GAA) of the Pentalateral

[20] In principle, the EU Commission templates stipulate ktoe as the unit.

Energy Forum or the Mid-Term Adequacy Forecast (MAF) of the ENTSO-E (see Section 3.3.ii.), are currently under way, which draw conclusions about security of supply not only for individual countries but also for the entire model region. Since the security of supply in Luxembourg depends in particular on the available production capacities of neighbouring countries, this approach can also be used to directly predict the security of supply in Luxembourg. This involves mapping probabilities, including the availability of renewable energy production installations, unplanned failures of equipment or lines or the temperature dependency of the demand. One key result is the determination of country-specific LOLE (Loss Of Load Expectation) values. The LOLE values indicate the number of hours in a year that supply cannot be covered by capacities and imports. Depending on the scenario and the model, low, although positive, LOLE values have been calculated for Luxembourg. This positive starting point is linked in particular to the fact that measures are also planned in Germany in the medium to long term to ensure security of supply (e.g. through the development of renewable energy and, if necessary, reserve capacity). In contrast, the recent situation has been rather tense for France and Belgium, but this has had comparatively less impact on Luxembourg. When comparing the results of these studies, no considerable risks are expected for Luxembourg in terms of security of supply over the short term. In the long term, too, the expected LOLE values are below the limit values normally set in Europe, but this situation should be kept under close observation. This is particularly the case since the security of supply situation in the region as a whole could become more critical during this time than it is at present. This is because it is not possible to entirely rule out problems with covering the load for Luxembourg's direct neighbours or for Luxembourg itself. However, it should be noted that state measures for safeguarding the security of supply (in particular the capacity market that has been introduced in France and the recently announced capacity market in Belgium) may have an impact in the period up to 2023 or 2025. It should also be noted that the development of renewable energy will also contribute to security of supply, for example through relatively stable offshore wind injections in the North Sea region. In addition, an actual scarcity of options to cover demand is also likely to be met with market reactions such as the tapping of load flexibility potential. Since the tapping of such potential is possible over the relatively short term, it is not yet or at least not fully included in the studies mentioned above.

4.4.2. Analysis – gas sector

Gas extraction and storage

Luxembourg does not extract any of its own gas. It covers its gas demand via the transport networks of the upstream network operators in Belgium and Germany, which in turn provide access to the production sites in the North Sea, Russia, Qatar, the Netherlands, etc. The supplies are handled via the network operators

and/or via trading and supplying companies. Precise details on the commercial fulfilment of demand are not available.

Luxembourg likewise has no domestic gas reservoirs. Therefore, the required working gas volume and the corresponding injection and withdrawal capacities in other countries are used, in particular in the supply and transit countries from which or via which the gas is also procured.

Import dependency

Since Luxembourg does not extract or store any gas, it is completely reliant on imports. The amount imported depends exclusively on the gas consumption. While in 2014 Luxembourg procured the gas in nearly equal shares from Germany and Belgium, in 2017 the majority, at 81%, was imported from Belgium as a result of the introduction of the joint 'BeLux' market[21].

Table 16: Gas import dependency of Luxembourg

	2017	2020	2030	2040
Gas consumption [ktoe]	770.2	773.5	784.5	795.6
Gas consumption [TWh]	8.96	9.00	9.12	9.25
Import dependency [%]	100%	100%	100%	100%

Source: Creos; Creos's projection as of 2030 updated to 2040

Relevant risks

The high import dependency means that security of supply in Luxembourg is highly dependent on the neighbouring European countries. Supply bottlenecks in neighbouring countries and Europe as a whole therefore also directly affect Luxembourg. In the neighbouring countries of Belgium, Germany, the Netherlands and France, there are, in principle, sufficient gas storage capacities to also cover the storage requirement for supplying the customers in Luxembourg, at least in the event of short-term supply bottlenecks. By contrast, the line capacities are of a sufficient size to maintain the supply of particularly protected customers even in the event of a disruption to the largest network connection point. On account of the currently low demand for natural gas, in particular due to the decommissioning of the GuD power plant, the technical capacities – at least at the German border – are not being fully booked by Creos and are therefore available as guaranteed, uninterruptible capacities. According to Creos, however, it is possible

[21]; ILR, Chiffres Clés du Marché du gaz naturel, Année 2017 - Partie I

that these capacities may need to be booked again in the event of changes to gas demand in order to safeguard security of supply. The reduction in gas consumption by 2040 and beyond will also implicitly improve the security of supply situation.

On the basis of Regulation (EU) 2017/1938 of the European Parliament and of the Council, Luxembourg forms regional partnerships with its direct neighbours in order to safeguard security of supply and draws up risk assessments and prevention and emergency plans on a rolling basis. In addition, the regulation provides for coordination and solidarity measures beyond the mechanisms of the gas market on the basis of bilateral intergovernmental agreements in the event of supply crises. Although Luxembourg is already pursuing close intergovernmental coordination through the joint gas market with Belgium, additional intergovernmental agreements could further increase security of supply by means of coordinated emergency measures.

Since gas, like other fossil fuels in Luxembourg, is also used extensively for heating and cooling, Luxembourg is pushing for an increase in energy efficiency as well as the increased use of renewable energy for heating and cooling. Among other things, this should also reduce the import dependency of third countries.

4.5. 'Internal energy market' dimension

4.5.1. Electricity interconnectivity

Existing and expected interconnections

Luxembourg currently has direct network connections to all three of its neighbouring countries:

- Creos's transmission network is connected to the neighbouring German transmission network (Bauler and Trier switching stations) via two 220-kV double-circuit lines with a nominal total transmission capacity of 1,960 MW.
- Sotel's industrial network is connected to Elia's Belgian transmission network via a 220-kV double-circuit line, which has a nominal total transmission capacity of 720 MW.
- In addition, Sotel operates a further interconnection towards RTE's French extra-high voltage network, with a transmission capacity of 450 MW.

At the end of 2017, the commissioning of the phase-shifting transformer in Schifflange and the possibility for Creos to use a branch of the 220-kV line towards Aubange created the conditions for Luxembourg's integration into the European transmission network, which also enables a permanent connection of the Creos network to the Belgian transmission network from a technical perspective. The control of the phase-shifting transformer in Schifflange by the network operators Elia and Creos makes it possible to coordinate the flow of electricity between Belgium and Germany via the Luxembourg transmission network. The stronger connection to the Belgian supply network is already contributing in particular to greater security of supply. A transition to commercial operations under the European Market Coupling is not foreseen in the short term, but will be re-examined as part of the further development of congestion management.

Creos is currently envisaging the following cross-border network expansion and enhancement measures:

- Targeted replacement of existing lines with high-temperature conductors (HTC) using existing masts
- Equipping/strengthening of the 220-kV line towards Germany, with a prospective maximum increase of around 2,600 MW in nominal transmission capacity in existing corridors.

Interconnection level

Three different calculations are used to determine the interconnection level. This involves relating the (n-0) interconnector capacity to the following:

- peak load
- total installed production capacity

- total installed production capacity from renewable energy

Regardless of the specific definition of the interconnection level, however, Luxembourg exceeds the targets for 2020 and 2030 many times over. As mentioned above, this scenario does not take into account the additional peak load of around 300 MW resulting from the establishment of a large consumer. If such a consumer were to be connected to the network, Luxembourg's level of interconnection would be slightly lower than the values listed below.

Table 17: Luxembourg's interconnection level

	2016	2020	2030	2040
N-0 Interconnector-capacity [MW]	3,130	3,130	6,546	6,546
Peak load [MW]	1,150	1,220	1,320	1,720
Production capacity total [MW]	390	565	1,225	1,600
Production capacity renewable energy [MW]	290	465	1,125	1,500
Interconnection level load [%]	270	255	495	380
Interconnection level gen. [%]	805	555	535	410
Interconnection level renewable energy [%]	1,080	675	580	435

Source: Own calculation in accordance with Creos/Sotel, ILR and reference scenario

4.5.2. Energy transmission infrastructure

Analysis – gas

Luxembourg currently has network interconnection points with all three of its neighbouring countries, which are shown in

Bras (BE)	Bras (BE)
Luxemburg	Luxembourg
Pétange (BE)	Pétange (BE)

Remich (DE)	Remich (DE)
Esch/Alzette (FR)	Esch-sur-Alzette (FR)

Figure 14. The transport network consists of approximately 290 km of high-pressure pipelines and a total of 63 distribution stations (pressure control stations) to downstream networks. In recent years, there have only been minor extensions of the transport network, since the expansion of the main lines is complete and, according to Creos, only occasional densification measures are planned at distribution network level, both now and in the future. Therefore, no considerable changes to the aggregated pipeline lengths are expected in the coming years.

Bras (BE)	Bras (BE)
Luxemburg	Luxembourg
Pétange (BE)	Pétange (BE)
Remich (DE)	Remich (DE)
Esch/Alzette (FR)	Esch-sur-Alzette (FR)

Figure 14: Cartographic representation of Luxembourg's supply situation

Source: Creos

Table 18 contains details of the existing developments of capacities at the network interconnection points and those anticipated by Creos.

Due to a lack of demand for capacity, the cross-border interconnection in Esch-sur-Alzette (FR) was closed in 2013, but could be reactivated if needed. However, this network interconnection point only supplies a small region and is not connected to Creos's transmission system.
The uninterruptible entry capacity at the Remich interconnection point is currently limited to 100,000 Nm³/h.

The (n-1) transmission capacity that is available on a reliable and uninterruptible basis is therefore 170,000 Nm³/h at present. According to Creos, the current peak load of the protected group of customers is around 140,000 Nm³/h. The infrastructure standard applying to Luxembourg in accordance with Regulation (EU) 2017/1938 would therefore have been met. However, due to the low number of interconnection points, Luxembourg is not bound by this obligation, but should attempt to fulfil it, with it still being necessary to safeguard the gas supply of the protected customers.

On account of the decommissioning of the Twinerg power plant and the associated dramatic decrease in gas demand, Creos does not see any need to expand the capacities.
Creos also assumes that no industry will move into the area that will act as a major demander of gas.

Table 18: Existing and future capacities of the network interconnection points.

Esch-sur-Alzette (FR)	20,000	20,000	20,000	20,000
Remich (DE)	150,000	150,000	150,000	150,000
Bras (BE)	110,000	110,000	110,000	110,000
Pétange (BE)	70,000	70,000	70,000	70,000
Total	***350,000***	***350,000***	***350,000***	***350,000***

Source: Creos

4.5.3. Electricity and gas markets, energy prices

Section 4.4 presents the annual electricity and gas consumption.

For the Luxembourg electricity market, 26 suppliers are currently authorised, of which 14 were active on the market last year. On the gas market, the number of authorised distributors is 14 – 9 of which are active[22].

The current electricity and gas prices for end consumers are presented below.

The electricity prices indicated include network costs, but not tax or duties. The projection for 2020 to 2040 is based on the *Primes Reference Scenario*. Primes does not draw any conclusions on the characteristics of the end consumers, such as annual consumption, voltage level, etc.

The gas price in Luxembourg for an average-sized household was €13.77/GJ (or 13.3 ($€_{2013}$/GJ) in 2015, including taxes, duties and network costs. The energy price alone was around 55% of this amount. Luxembourg currently has no precise projections on the future development of the gas price. Assuming the development in the gas wholesale price estimated by the European Commission and a constant exposure to other price components, gas prices will increase by around 62% by 2040.

Table 19: Development of electricity and gas prices for end consumers.

	2015	2020	2030	2040
Average electricity price for end consumers [$€_{13}$/MWh]	116	126	137	148
Average gas price for end consumers [$€_{13}$/ GJ]	13.3	16.6	19.5	21.5

Source: Primes Reference Scenario, own calculations

[22] ILR, Chiffres Clés du Marché de l'Électricité, Année 2017 - Partie I ILR, Chiffres Clés du Marché du gaz naturel, Année 2017 - Partie I

4.6. 'Research, innovation and competitiveness' dimension

4.6.i. Current situation of the low-carbon technology sector

Research and development in Luxembourg has traditionally focused on the steel, aviation and automotive sectors. In recent years, the Government has made significant efforts to develop further priorities in the areas of information and communication technologies, logistics, health technologies, materials, energy and environmental technologies ('*Clean Technology*'). Environmental technologies are among the priorities of the national economic diversification strategy. Luxembourg has made specific advancements in the areas of sustainable building, sustainable mobility and the circular economy. Initiatives in these areas are in line with EU policy and the various directives on issues such as the energy efficiency of buildings, smart transport systems or ecodesign requirements.

Thanks to its steel industry, Luxembourg has a long-standing tradition of materials-based research. Today it is working, among other things, on the development of sustainable building materials. In addition, Luxembourg now has three research teams in the field of solar photovoltaic material research to further develop resource-optimised thin film PV.

In addition, Luxembourg also has innovation clusters that are dedicated to the issues mentioned above. The Luxembourg CleanTech Cluster[23] or even the Wood Cluster[24] deserve special mention. Public research stakeholders, including the University of Luxembourg, play a key role in this context. The same applies to Luxinnovation, the national agency for promoting innovation and research, which offers personalised consultancy and support for the stakeholders and the government in the areas of research and innovation (access to funding opportunities, finding partners, business creation, etc.), thereby playing an important role in this area in terms of the European networks.

[23] https://www.luxinnovation.lu/cluster/luxembourg-cleantech-cluster/

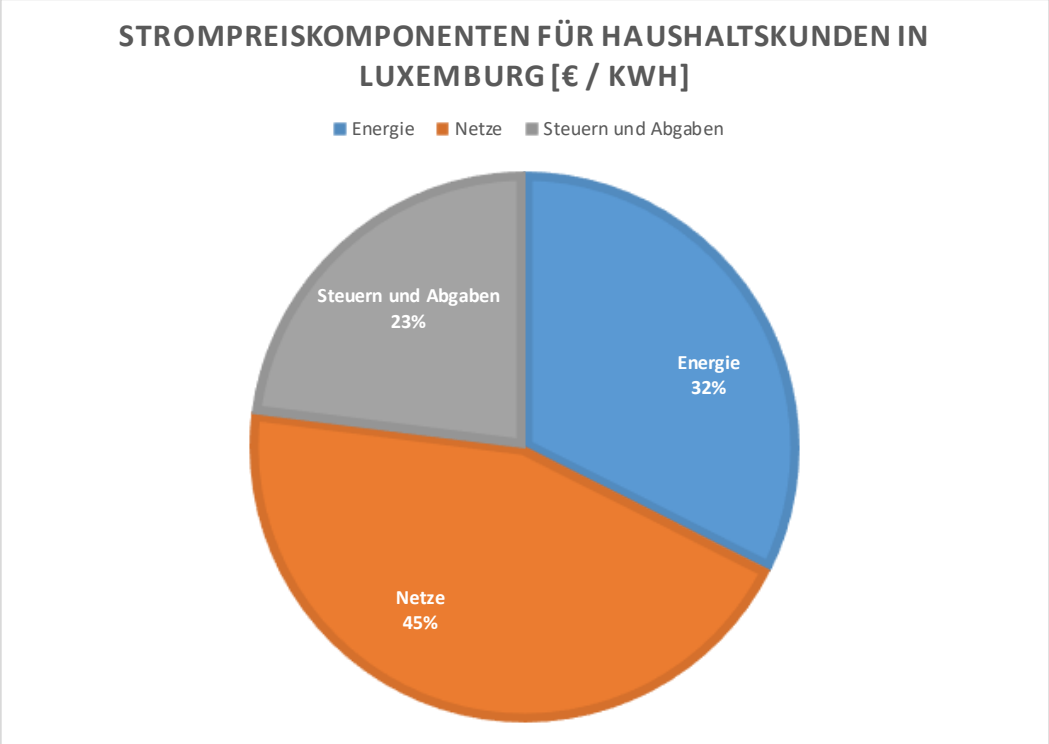
[24] https://www.luxinnovation.lu/cluster/luxembourg-wood-cluster/

4.6.ii. Current level of public and, where available, private research and innovation spending on low-carbon technologies, current number of patents, and current number of researchers

The key public research stakeholders in the field of low-carbon technologies are the Luxembourg Institute of Science and Technology and the University of Luxembourg. Their total expenditure on research and innovation in this field currently amounts to around €20 million. Both institutions currently employ about 160 researchers in this field and together they hold 22 patents or patent families that are assigned to the field.

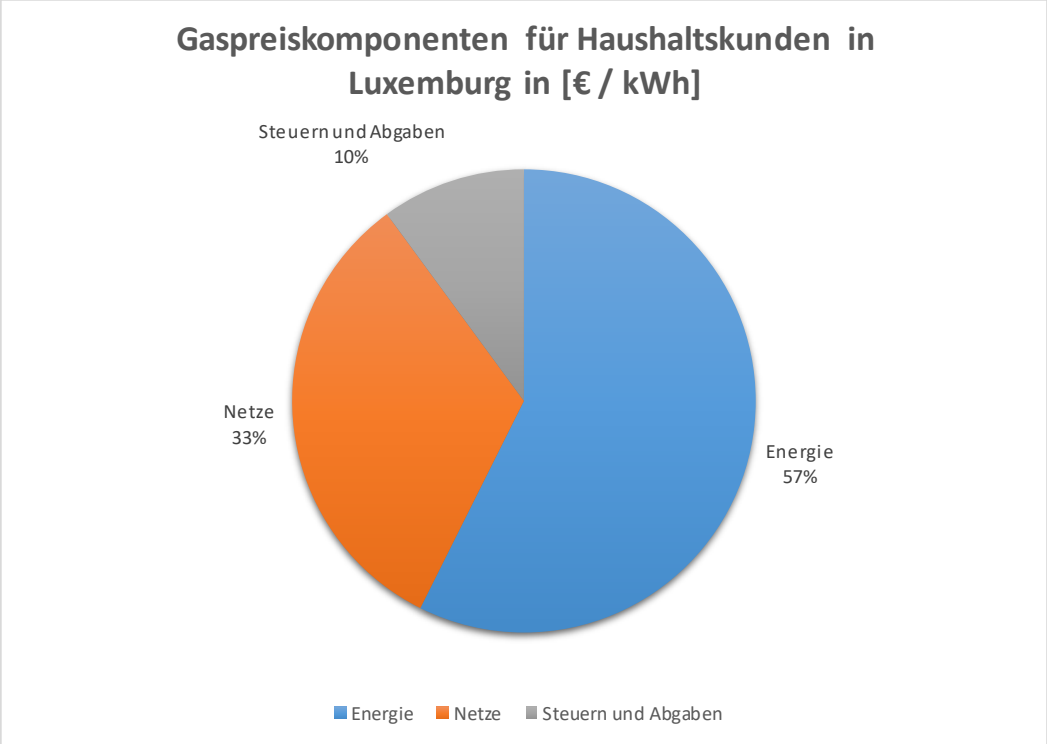
4.6.iii. Breakdown of current price elements that make up the main three price components (energy, network, taxes/levies)

Figure 15 and Figure 16 show the electricity and gas prices for household customers in Luxembourg, broken down into energy, networks and taxes and levies.



STROMPREISKOMPONENTEN FÜR HAUSHALTSKUNDEN IN LUXEMBURG [€ / KWH]	ELECTRICITY PRICE COMPONENTS FOR HOUSEHOLD CUSTOMERS IN LUXEMBOURG [€/KWH]
Energie	Energy
Netze	Networks
Steuern und Abgaben	Taxes and duties

Figure 15: Electricity price components for household customers



Gaspreiskomponenten für Haushaltskunden in Luxemburg in [€ / kWh]	Gas price components for household customers in Luxembourg in [€/kWh]
Energie	Energy
Netze	Networks
Steuern und Abgaben	Taxes and duties

Figure 16: Gas price components for household customers

4.6.iv. Description of energy subsidies, including for fossil fuels

Luxembourg has well-established public funding instruments to promote energy efficiency and renewable energy. These are explained in more detail in Section 3.1.1.iii. This also includes the feed-in tariffs for the production of electricity from renewable sources (see Section 3.1.2.i).

As explained in Section 3.1.3.iv above, the Luxembourg Government has commissioned an analysis of the possible impact of direct and indirect subsidies and tax advantages on sustainable development. The scope of this study also includes tax breaks in the energy and transport sectors. The results of the ongoing study will be used as a basis for any adjustments.

5. Impact assessment of planned policies and measures

In order to provide an impact assessment of the planned policies and measures described in Section 3, the Luxembourg government commissioned a consortium of consultants from the Fraunhofer Institute for System and Innovation Research (Fh-ISI), Consentec GmbH, the Institute for Resource Efficiency and Energy Strategies (IREES) and TU Wien – Energy Economics Group. The consortium supplemented and adapted the models already applied in previous projects concerning energy demand and energy supply to the given requirements in order to establish an analytical basis that is as robust as possible.

The model-based impact assessment of the planned policies and measures resulted in the target scenario presented in this section. In general, it should be noted that such modelling and the resulting projections do indeed serve as guidance, but are always subject to uncertainty. This is especially true in the case of small open economies, such as that of Luxembourg. As a result, individual decisions or decisions taken abroad or at European level can bring about significant changes to the target scenario sought.

This reservation must also be applied to the results of the macroeconomic assessment of the present energy and climate plan presented in Section 5.2.

5.1. Impacts of the planned policies and measures described in Section 3 on the energy system and greenhouse gas emissions and removals

The measures planned in Luxembourg show a very high level of ambition in terms of energy efficiency and therefore lead to a significant reduction in both final energy demand and CO_2 emissions from the relevant sectors or applications, as this is accompanied by a shift away from fossil fuels towards renewable energy sources in addition to energy efficiency progress.

In the following, we look at the target scenario and discuss the resulting impacts on the energy system and greenhouse gas emissions, broken down into changes on the energy demand side, the contribution of renewable energy and greenhouse gas emissions. The focus here is on the package of measures described in Section 3. It should be stressed that it is always the full package of measures that is analysed here in terms of the impacts caused, since an individual assessment would be methodologically inconsistent and would not be considered appropriate. The impact is illustrated by a comparison with developments in the reference case.

Section 5.1.1 looks at the evolution of greenhouse gas emissions, Section 5.1.2 looks at the evolution of energy demand and Section 5.1.3 looks at the evolution of renewable energy.

5.1.1. GHG emissions and removals

Projections of greenhouse gas emissions and removals with the planned policies and measures for the years 2020 to 2040 are summarised in Table 20. Energy-related GHG emissions result from the interaction between the development of energy demand and renewable energy.

Table 20: Greenhouse gas emissions by ETS and non-ETS for 2020 to 2040, in the event of the target scenario (with additional measures), in kt CO2eq

	2020	2025	2030	2035	2040
ETS emissions excl. internat. air transport	**1,376**	**1,238**	**1,074**	**966**	**861**
Total non-ETS emissions	**7,677**	**6,032**	**4,726**	**3,717**	**2,739**
Energy-related non-ETS emissions	**6,787**	**5,262**	**4,095**	**3,098**	**2,130**
Energy sector	145	95	68	62	62
Industry	176	150	119	108	75
Transport	5,077	4,004	3,289	2,548	1,865
Private households	933	685	418	248	46
Trade, commerce and services	403	287	172	108	62
Others*	25	18	12	12	12
Diffuse emissions	29	24	17	13	8
Non-energy-related non-ETS emissions	**890**	**770**	**632**	**619**	**609**
Industrial processes	112	106	80	70	64
Agriculture and forestry	699	607	515	508	503
Waste	79	57	37	40	42
LULUCF	***-390***	***-393***	***-401***	***-399***	***-397***

** Other emissions relate to combustion in construction and agriculture*

Source: Own illustrations, 2019

In 2030, a total of around 4.7 million tonnes of CO_2eq will be emitted by the non-ETS sectors in the target scenario. This corresponds to a reduction of around 55% when compared with the reference year 2005, with emissions that are exclusively energy-related falling even more sharply by just over 57%. Non-energy-related emissions from non-ETS sectors will decrease by about 22% by 2030 when compared with the reference year 2005. By 2040, total non-ETS emissions in the target scenario are expected to fall to 2.7 million tonnes of CO_2eq.

Emissions from ETS installations based in Luxembourg in 2030 are estimated at around 1 million tonnes of CO_2eq, a decrease of almost 60% when compared with 2005.

In the land use, land use change and forestry (LULUCF) sector, removals are expected to stagnate at around 0.4 million tonnes of CO_2eq.

In Table 21, the projections of the target scenario are compared with those of the reference scenario (see Table 9 and Table 20). By 2030, the planned policies and measures therefore lead to a reduction in emissions in the non-ETS sectors of around 45% when compared with the reference scenario. The

difference for the ETS sectors is -11%. It should be reiterated here that in the target scenario, the reduction in emissions by 2030 compared to the reference year 2005 is 55%.

Table 21: Comparison of the greenhouse gas emissions projections of the target scenario (with additional measures) with the reference scenario (without additional measures) for the years 2020 to 2040

	2020	2025	2030	2035	2040
ETS emissions excl. internat. air transport	**-1%**	**-5%**	**-11%**	**-15%**	**-19%**
Total non-ETS emissions	**-9%**	**-28%**	**-45%**	**-58%**	**-69%**
Energy-related non-ETS emissions	**-10%**	**-30%**	**-47%**	**-61%**	**-74%**
Energy sector	-11%	-42%	-58%	-62%	-62%
Industry	-10%	-27%	-42%	-52%	-68%
Transport	-7%	-28%	-44%	-59%	-71%
Private households	-18%	-39%	-62%	-77%	-96%
Trade, commerce and services	-18%	-33%	-54%	-69%	-81%
Others*	0%	-27%	-54%	-54%	-55%
Diffuse emissions	-7%	-23%	-43%	-56%	-71%
Non-energy-related non-ETS emissions	**0%**	**-9%**	**-23%**	**-23%**	**-24%**
Industrial processes	0%	0%	0%	0%	0%
Agriculture and forestry	0%	-10%	-23%	-24%	-25%
Waste	0%	-20%	-46%	-41%	-37%
LULUCF	***0%***	***0%***	***0%***	***0%***	***0%***

** Other emissions relate to combustion in construction and agriculture*

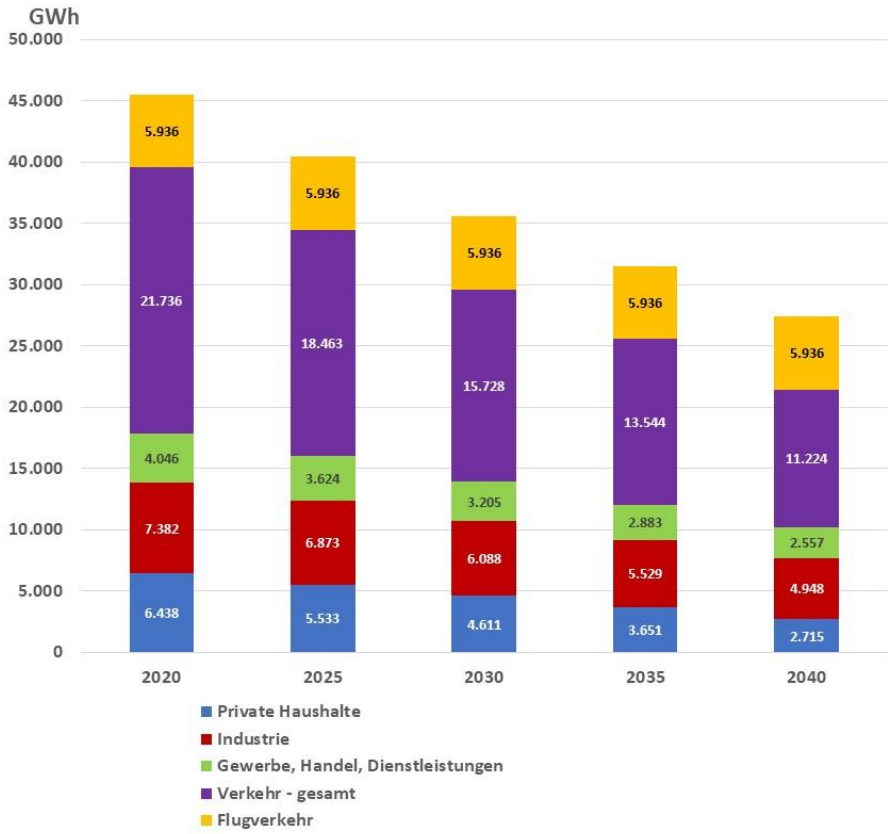
Source: Own illustrations, 2019

5.1.2. Energy demand

The planned energy efficiency measures reduce Luxembourg's total final energy demand between 2020 and 2040 by just under 40% (18.2 TWh) to just under 27.4 TWh (see Table 22). In 2030, the final energy demand of the various sectors in Luxembourg totalled 35,568 TWh (-22% when compared with 2020). The trend in the impact of energy efficiency measures will continue until 2040, meaning that between 2030 and 2040 the total final energy demand for Luxembourg will be reduced by almost 8.2 TWh (-23% when compared with 2030).

Within the target scenario, the reduction in final energy demand achieved in 2040 is accounted for by households with a decrease in final energy demand of almost 58% when compared with 2020 (3.7 TWh), industry with a decrease of 33% (2.4 TWh), the 'trade, commerce and services' sector with a decrease of almost 37% (around 1.5 TWh) and the transport sector with a decrease of around 48% or 10.5 TWh (see Figure 17). In the target scenario, the final energy demand of the transport sector falls to just over 11.2 TWh by 2040; the projected decline in tank tourism also makes a significant contribution to this. The final energy

demand (kerosene) of air transport is maintained at a constant level throughout the period, even in the case of the target scenario, in line with the assumed development in the case of the reference scenario.



Private Haushalte	Private households
Industrie	Industry
Gewerbe, Handel, Dienstleistungen	Trade, commerce and services
Verkehr – gesamt	Transport – total
Flugverkehr	Air transport
GWh	GWh

Source: Own calculations 2019

Figure 17: Development of final energy demand in the period 2020 to 2040 in the case of the target scenario, broken down by sector

The share of the specific sectors in the electricity demand will also vary in the target scenario on account of continuing efforts to improve efficiency and various trends and technological developments in electricity applications and production technologies in trade, households, industry or the transport sector. In contrast to the reference scenario, the share of the transport sector is increasing at a significantly faster pace. In 2040, the transport sector will account for 29% of total electricity demand. Accordingly, the shares of the

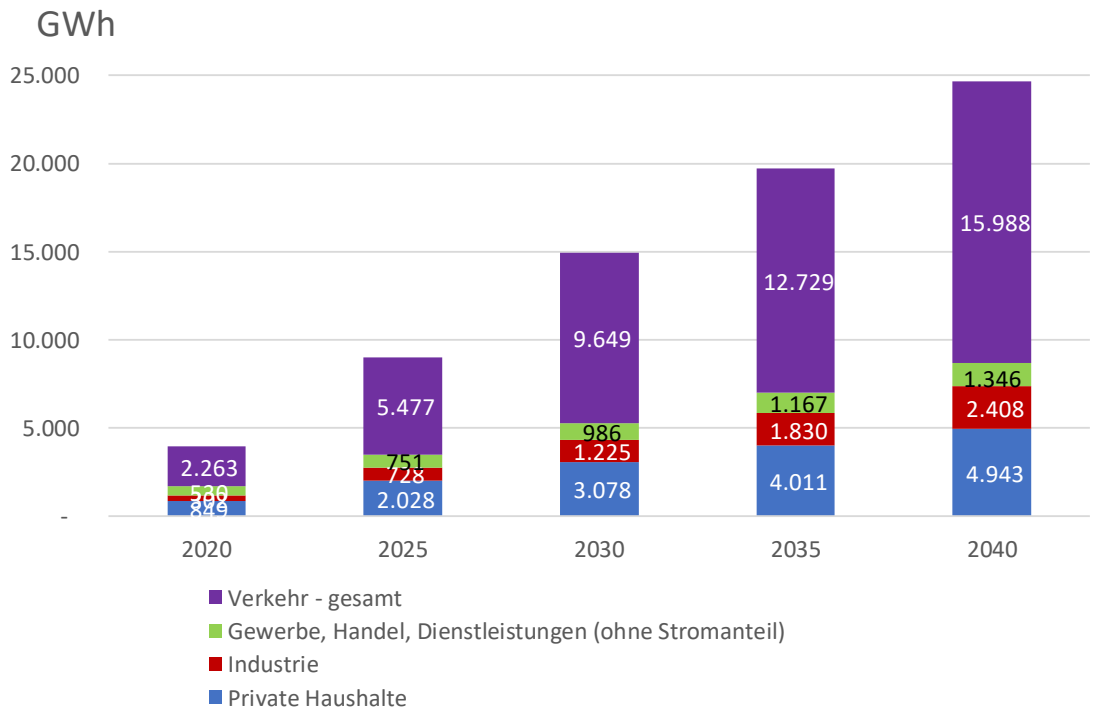
remaining sectors (trade, commerce and services; private households; industry) will decrease to a greater or lesser extent (see Figure 18).

The largest savings in absolute terms (-10.5 TWh when compared with 2020) are achieved by the transport sector throughout the period, followed by household savings, savings in the trade, commerce and services sector and reductions in energy demand in industry (see Figure 19).

GWh	GWh
Private Haushalte	Private households
Industrie	Industry
GHD	Trade, commerce and services
Verkehr	Transport

Source: own calculations 2019

Figure 18: Sectoral breakdown of the electricity demand for the period from 2015 to 2040 according to the target scenario



Verkehr – gesamt	Transport – total
Gewerbe, Handel, Dienstleistungen (ohne Stromanteil)	Trade, commerce and services (excluding electricity share)
Industrie	Industry
Private Haushalte	Private households
GWh	GWh

Source: Own calculations 2019

Figure 19: Reduction in final energy demand (fuels, electricity) within the target scenario broken down by sector for the period 2020 to 2040

Table 22 summarises the impact of the planned strategies and efficiency measures in the field of final energy demand, while allowing for a percentage assessment of the impact of the planned policies and measures in the target scenario (intensification of existing measures, further development of renovation strategies in the building sector, adaptation of fuel taxation, reinforcement of regulatory requirements or minimum standards, commitment, etc.) compared to the reference development, which only takes account of existing policies and measures. The impact of all measures significantly reduces the final energy demand of the target scenario when compared with the reference scenario and, in the case of the target scenario, amounts to a total of 35,568 GWh (see Table 22).

The last part of Table 22 presents the percentage deviations in final energy demand in the target scenario compared to the corresponding development in the reference scenario. This will allow for a clear presentation of the savings made possible by the planned policies and measures.

Finally, it should be noted that the future development of energy demand for both the reference and target scenarios is based on comprehensive modelling and a subsequent discussion and reflection process. National statistics on the energy consumption of households, the 'business, trade, services' sector, industry and the transport sector formed the common basis for both scenarios, which, by their very nature, show differences in future development. Accordingly, the target scenario shows a much stronger decline in demand, which essentially reflects the impact of the additional measures presented in Section 3 (when compared with the reference case). With regard to recent developments in the years up to 2020, the differences indicated reflect the uncertainty inherent in the modelling process. Statistics on different types of motor vehicles or different types of fuels (petrol, diesel, natural gas) were available for the transport sector until 2016. Based on the emerging trend of demand for each type of fuel in the period 2012 to 2016, the transport sector has modelled future demand for fuel up to 2040. Contrary to the weakening demand trend derived from this period, the most recent figures for 2017 (slight increase) and, above all, the market data for 2018 and 2019, which have not yet been statistically verified, indicate that demand for individual types of fuel in the transport sector is now rising strongly. If these trends prove to be correct, this should be seen as a sign that further tightening of the planned additional measures would be necessary to achieve the 2030 energy and climate targets.

Table 22: Comparison of Luxembourg's final energy demand between the reference scenario and the target scenario

Reference scenario

Sector	Unit	2020	2025	2030	2035	2040
Total final energy demand	GWh	**49,483**	**49,412**	**50,506**	**51,279**	**52,065**
Private households		7,287	7,561	7,689	7,662	7,658
Industry		7,684	7,601	7,314	7,359	7,355
Trade, commerce and services		4,576	4,375	4,191	4,050	3,903
Transport – total		**23,999**	**23,940**	**25,377**	**26,273**	**27,213**
Transport – domestic transport		6,745	6,814	7,304	7,870	8,185
Transport – transit traffic		17,254	17,126	18,073	18,404	19,029

Target scenario Paris Article 2.1a

Sector	Unit	2020	2025	2030	2035	2040
Total final energy demand	GWh	**45,538**	**40,429**	**35,568**	**31,543**	**27,381**
Private households		6,438	5,533	4,611	3,651	2,715
Industry		7,382	6,873	6,088	5,529	4,948
Trade, commerce and services		4,046	3,624	3,205	2,883	2,557
Transport – total		**21,736**	**18,463**	**15,728**	**13,544**	**11,225**
Transport – domestic transport		6,115	4,604	3,832	3,305	2,753
Transport – transit traffic		15,621	13,859	11,896	10,239	8,472
Air transport		5,936	5,936	5,936	5,936	5,936

Change from target scenario to reference scenario

Sector	Unit	2020	2025	2030	2035	2040
Total final energy demand[1]	%	-8%	-18%	-30%	-38%	-47%
Private households		-12%	-27%	-40%	-52%	-65%
Industry		-4%	-10%	-17%	-25%	-33%
Trade, commerce and services		-12%	-17%	-24%	-29%	-34%
Transport – total		-9%	-23%	-38%	-48%	-59%
Transport – domestic transport		-9%	-32%	-48%	-58%	-66%
Transport – transit traffic		-9%	-19%	-34%	-44%	-55%

Source: Own illustration 2019

Table 23 summarises, in the same way as Table 22 in the case of final energy demand, the effects of the planned strategies and efficiency measures in the area of Luxembourg's total heat demand and electricity demand, while at the same time allowing for a percentage assessment of the effects of the planned policies and measures in the target scenario over the period 2020 to 2040.

Table 23: Comparison of the development of Luxembourg's heat and electricity demand in the case of the reference and target scenarios

Reference scenario

Sector	Unit	2020	2025	2030	2035	2040
Heat demand (excluding electricity)	GWh	13,463	13,472	13,234	13,251	13,205
Electricity demand		6,141	6,260	6,314	6,367	6,441

Target scenario Paris Article 2.1a

Sector	Unit	2020	2025	2030	2035	2040
Heat demand (excluding electricity)	GWh	11,868	10,223	8,371	6,961	5,544
Electricity demand		6,112	6,457	6,416	6,553	6,568

Change from target scenario to reference scenario

Sector	Unit	2020	2025	2030	2035	2040
Heat demand (excluding electricity)	%	-11.8%	-24.1%	-36.7%	-47.5%	-58.0%
Electricity demand		-0.5%	3.2%	1.6%	2.9%	2.0%

Source: Own illustration 2019

5.1.3. Renewable energy

Renewable energy is making and will continue to make a substantial contribution to the decarbonisation of the energy sector in Luxembourg. The target scenario presented in Section 2 shows a pathway towards achieving a renewable energy share of 25% of gross final energy demand in 2030. This implies a significant increase when comparing the quantities achieved today (6.4% in 2017) and the 2020 target (11%). In addition to the massive expansion of renewable energy, this requires a clear increase in energy efficiency as well as an accompanying reduction in demand, as outlined in the previous section. This section focuses on the impacts on the energy system of the additional measures aimed at further boosting the development of renewable energy and increasing its contribution to meeting demand. More specifically, we look at the energy supply side and look at the contribution of renewable energy sources, which would also result according to the target scenario when compared with the reference case.

Table 24 provides a comprehensive overview of this. For example, this table shows renewable energy production for the years up to 2040, both for the reference and target scenarios, at sectoral level and as a

total balance. The table also allows direct comparison, i.e. consideration of the induced change if the target scenario is sought instead of the reference development. It also sets out the relative share of renewable energy in terms of (sectoral) demand, in addition to absolute energy.

At first glance, it may seem surprising that there is only a slight difference in the total national balance in terms of the amount of energy produced: if, for example, one compares the total national renewable energy production in the focus year 2030 in absolute figures, an increase of only 1.6% (target vs reference scenario) can be observed here. At sectoral level, however, there are significant differences: while renewable energy production shows a significant increase in the electricity sector (+ 30% in 2030) and in the heating sector an increase of + 3.6%, biofuels in the transport sector show a significant decrease (- 25.5%) despite an increase in the admixture rate (10% rather than 8%). This is due to the significant decrease in demand for fuels in the transport sector according to the target scenario (when compared with the reference case). However, if account is taken of the contributions of innovative solutions, such as e-mobility, a significant increase in the contribution of renewable energy can also be observed in the transport sector as a whole (+ 6.9%).[25]

A comparison of the reported relative shares of renewable energy sources for the focus year 2030, i.e. the shares of renewable energy in relation to the respective energy demand (see Table 24), reveals the large differences between the target and reference scenarios. Instead of the marginal increase of 1.6% in the national total balance of absolute energy, when comparing the shares of renewable energy in the gross final energy demand[26], an increase of 51.5% can be observed. The most significant changes are in the heating sector, with an increase of 63.8%. The share of renewable energy in the transport sector, according to the total balance, also rises significantly by 59.3%, while developments in the electricity sector appear somewhat more subdued (+ 26.4%). In general, it illustrates the significant changes on the demand side, as discussed in the previous section. In summary, it can be said that a significant increase in the share of

[25] It is important to note that multiple counting is used here with regard to the contributions of innovative solutions, as per the revised calculation logic for determining the share of renewable energy in the transport sector.

[26] Gross final energy demand is the relevant indicator for determining the renewable energy target. In simplified terms, it is derived from the final energy demand values shown in Table 22, which, in addition to the final demand, which amounts to 35,568 GWh in 2030 across all sectors according to the target scenario, also takes account of transmission losses and the energy sector's own consumption in the case of electricity and grid-connected heat – these amount to 291 GWh in the target scenario.

Furthermore, the EU's regulatory framework imposes a cap on the extent to which the energy demand for air transport can be taken into account to ensure that there is no distortion or penalisation in the case of smaller Member States. According to the target scenario, the energy demand for air transport in 2030 is 5,936 GWh; however, due to the cap, only 2,216 GWh is taken into account for the calculation of the gross final energy demand. In the case of Luxembourg, this therefore entails a noticeable reduction in the gross final energy demand used as a reference value for the total share of renewable energy – without the air transport cap, which would be set at 35,861 GWh. When the cap is taken into account, Table 18 shows 32,141 GWh in 2030 for the target scenario.

renewable energy requires clear intervention on the energy efficiency side in addition to direct measures to increase the expansion of renewable energy.

Table 24: Comparison of the expansion of renewable energy (energy production and shares of (sectoral) demand) between the reference scenario and the target scenario

Reference scenario

	Renewable energy production, absolute energy						Renewable energy share measured by (sectoral) demand					
	Unit	2020	2025	2030	2035	2040	Unit	2020	2025	2030	2035	2040
Renewable energy – electricity		752	1,249	1,731	2,071	2,332		11.9%	19.4%	26.5%	31.3%	34.7%
Renewable energy – heat		1,626	2,070	2,462	2,699	2,896		12.1%	15.4%	18.6%	20.4%	21.9%
Renewable energy – biofuels		1,855	1,892	1,993	1,450	1,450		7.7%	8.0%	8.0%	5.6%	5.5%
Renewable energy – transport, total*		2,784	3,438	4,463	4,355	5,390	%	11.1%	13.5%	16.1%	15.1%	17.6%
Renewable energy – total, national	GWh	**4,232**	**5,211**	**6,187**	**6,221**	**6,679**		**9.2%**	**11.2%**	**12.9%**	**12.8%**	**13.5%**
Renewable energy – cooperation needs		1,000	2,917	4,833	4,833	4,833		2.2%	6.2%	10.1%	9.9%	9.7%
Renewable energy – total incl. cooperation		**5,232**	**8,128**	**11,020**	**11,054**	**11,512**		**11.3%**	**17.4%**	**23.0%**	**22.7%**	**23.2%**
Comparison: Gross final energy demand**		**46,119**	**46,717**	**47,913**	**48,773**	**49,650**						

Target scenario Paris Article 2.1a

	Renewable energy production, absolute energy						Renewable energy share measured by (sectoral) demand					
	Unit	2020	2025	2030	2035	2040	Unit	2020	2025	2030	2035	2040
Renewable energy – electricity		748	1,563	2,251	2,680	3,150		11.9%	23.5%	33.6%	38.8%	45.4%
Renewable energy – heat		1,626	2,030	2,551	2,495	2,609		13.7%	19.9%	30.5%	35.8%	47.1%
Renewable energy – biofuels		1,632	1,563	1,485	1,738	1,749		7.5%	8.8%	10.0%	14.4%	18.7%
Renewable energy – transport, total*		2,581	3,755	4,769	7,391	9,587		11.3%	18.4%	25.6%	40.4%	54.3%
Renewable energy – total, national	GWh	**4,006**	**5,156**	**6,287**	**6,914**	**7,508**	%	**9.4%**	**13.9%**	**19.6%**	**24.8%**	**31.9%**
Renewable energy – cooperation needs		1,000	1,374	1,748	1,748	1,748		2.3%	3.7%	5.4%	6.3%	7.4%
Renewable energy – total incl. cooperation		**5,006**	**6,530**	**8,035**	**8,662**	**9,257**		**11.8%**	**17.6%**	**25.0%**	**31.0%**	**39.3%**
Comparison: Gross final energy demand**		**42,587**	**37,203**	**32,141**	**27,926**	**23,526**						

Change from target scenario to reference scenario

	Renewable energy production, absolute energy						Renewable energy share measured by (sectoral) demand					
	Unit	2020	2025	2030	2035	2040	Unit	2020	2025	2030	2035	2040
Renewable energy – electricity		-0.5%	25.2%	30.0%	29.4%	35.0%		-0.1%	21.1%	26.4%	24.0%	31.0%
Renewable energy – heat		0.0%	-1.9%	3.6%	-7.6%	-9.9%		13.4%	29.2%	63.8%	75.6%	114.6%
Renewable energy – biofuels		-12.0%	-17.4%	-25.5%	19.8%	20.6%		-2.5%	10.1%	25.6%	155.2%	242.3%
Renewable energy – transport, total*	% change based on the reference scenario	-7.3%	9.2%	6.9%	69.7%	77.9%	%, change based on the reference scenario	1.9%	36.2%	59.3%	168.1%	208.9%
Renewable energy – total, national		**-5.3%**	**-1.1%**	**1.6%**	**11.1%**	**12.4%**		**2.5%**	**24.2%**	**51.5%**	**94.1%**	**137.2%**
Renewable energy – cooperation needs		0.0%	-52.9%	-63.8%	-63.8%	-63.8%		8.3%	-40.8%	-46.1%	-36.8%	-23.7%
Renewable energy – total incl. cooperation		**-4.3%**	**-19.7%**	**-27.1%**	**-21.6%**	**-19.6%**		**3.6%**	**0.9%**	**8.7%**	**36.9%**	**69.7%**

*incl. multiplication factors according to the calculation logic regarding the share of renewable energy in the transport sector

**Taking account of the cap on energy demand for air transport: the EU's regulatory framework imposes a cap on the extent to which the energy demand for air transport can be taken into account to ensure that there is no distortion or penalisation in the case of smaller Member States. In both scenarios, the energy demand for air transport in 2030 is 5,936 GWh; however, due to the cap, only 2,216 GWh is taken into account for the calculation of the gross final energy demand. In the case of Luxembourg, this therefore entails a noticeable reduction in the gross final energy demand used as a reference value for the total share of renewable energy – without the air transport cap

Source: Own illustration 2019

5.2. Impacts of the planned policies and measures described in Section 3 on the economy, employment and social conditions, environment and health

5.2.1. Estimation of macroeconomic consequences

The macroeconomic assessment of the present energy and climate plan shows slightly positive effects of the planned package of measures on the key economic indicators up to 2030. The effects are based on the technological and behavioural changes identified in the bottom-up demand and supply models for the target scenario (see Section 5.1.). Only the changes resulting from the planned policies and measures in the target scenario that differed from the reference scenario were included in the assessment. The stimulus in the form of additional, less avoided, energy efficiency and renewable energy investments, changes in energy expenditure, changes in primary energy imports, support programmes and regulatory measures were assessed using the system dynamic ASTRA model[27]. It examined both the direct effects of the stimulus (e.g. direct employment effects of investments in construction measures), the indirect effects (e.g. the effects via the other industries linked to the direct activity via intermediate consumption) and induced effects (the second-round effects of improved economic growth) on the national economy.

According to the model assessments, the planned policies and measures lead to an additional increase in GDP of around €905 million$_{2016}$ or 1.1% by 2030 when compared with the reference scenario. The positive impact on the economy as a whole is mainly due to the kick-starting of investment in energy efficiency and renewable energy, the reduction of household and business energy expenditure, and the avoidance of imports of fossil fuels. There is a positive macroeconomic effect despite the fact that the financing of the measures is taken into account, which is reflected in an increase in employment of 0.3% or 1,470 employees by 2030 when compared with the reference scenario. It should also be borne in mind that the reduction in household and business energy expenditure will of course continue to have a significant positive impact on the economy as a whole after 2030.

The results of the macroeconomic impact assessment indicate that the introduction of a minimum CO_2 price from 2021 could also partly compensate for additional government expenditure through the support programmes and subsidies under the target scenario. Therefore, only marginal new borrowings would have to be accepted until 2030. It should be noted that the revenues generated by the CO_2 minimum price are used in a balanced way (‘d’une manière équilibrée’) for specific climate measures and targeted social relief

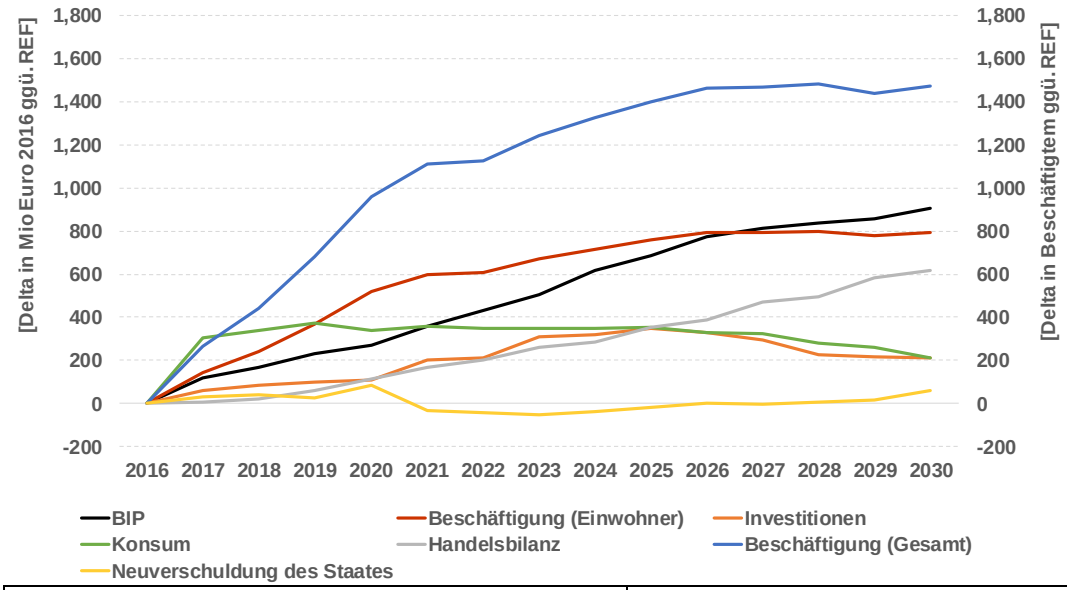
[27] Krail Michael, Sievers Luisa (2019), NECP Luxembourg – macroeconomic impact assessment. The report contains a description of the methodological approach and the ASTRA model, as well as a detailed presentation of the stimulus and results.

through fiscal (e.g. tax credit) and social measures in the sense of social justice ('équité sociale') for low-income households.

In addition to the positive macroeconomic effects, substantial annual external climate costs saved by Luxembourg will amount to as much as €700 million$_{2016}$ in 2030 or cumulatively more than €6 billion$_{2016}$ for the period up to 2030 when compared with the reference value. These external costs are not integrated into the macroeconomic analysis of impacts, but serve as guidance for the negative financial effects of climate change that have been avoided.

Development of key macroeconomic indicators

Figure 20 shows the changes in key macroeconomic indicators as a result of the planned policies and measures when compared with the reference scenario. Table 25 shows, for the years 2025 and 2030, the absolute development of key macroeconomic indicators, both in the reference and target scenarios, and the resulting delta.



[Delta in Mio Euro 2016 ggü. REF]	[Delta in €million 2016 vs REF]
[Delta in Beschäftigtem ggü. REF]	[Delta in employees vs REF]
BIP	GDP
Konsum	Consumption
Beschäftigung (Einwohner)	Employment (inhabitant)
Investitionen	Investments
Handelsbilanz	Trade balance
Beschäftigung (Gesamt)	Employment (all)
Neuverschuldung des Staates	New borrowings by the State

Figure 20: Absolute change in key macroeconomic indicators when compared with the reference in €million$_{2016}$ (source: Fraunhofer ISI)

Table 25: Change of key macroeconomic indicators when compared with the reference (source: Fraunhofer ISI)

Scenario	Indicator	2025	2030	Unit
Reference	Gross domestic product	71,828	82,788	€million 2016
	Employment (inhabitant)	244,966	252,945	Employees
	Employment (all)	453,186	467,949	Employees
	Investments	13,510	15,666	€million 2016
	Household consumption	22,471	26,621	€million 2016
	Disposable income of households	27,873	33,021	€million 2016
	Trade balance	23,353	26,099	€million 2016
	State consumption	11,772	13,568	€million 2016
	Government debt (total)	15,167	17,328	€million 2016
Objective	Gross domestic product	72,513	83,693	€million 2016
	Employment (inhabitant)	245,723	253,741	Employees
	Employment (all)	454,588	469,421	Employees
	Investments	13,858	15,878	€million 2016
	Household consumption	22,824	26,835	€million 2016
	Disposable income of households	28,311	33,285	€million 2016
	Trade balance	23,708	26,719	€million 2016
	State consumption	11,833	13,926	€million 2016
	Government debt	15,166	17,408	€million 2016
Delta	Gross domestic product	684	905	€million 2016
	Employment (inhabitant)	758	795	Employees
	Employment (all)	1,401	1,471	Employees
	Investments	348	212	€million 2016
	Household consumption	353	213	€million 2016
	Disposable income of households	438	264	€million 2016

	Trade balance	355	620	€million 2016
	State consumption	61	358	€million 2016
	Government debt	-1	80	€million 2016
	Annual new borrowings	-17	60	€million 2016
	Annual external costs saved	-412	-719	€million 2016

When compared with the reference scenario, the 2030 ASTRA estimates that Luxembourg's GDP is around €905 million higher$_{2016}$. In terms of annual real GDP growth rates, this means an increase in annual GDP growth of about 0.08 percentage points by 2030. Over the period up to 2030, the NECP already allows for an increase in GDP in 2025 of approximately €684 million$_{2016}$.

GDP growth is driven, on the one hand, by increasing final demand but also by higher potential output in the target scenario when compared with the reference scenario. In terms of final demand, household consumption responds with growth of around €213 million$_{2016}$ in 2030 when compared with the reference level. This increase results from an increase in household income and direct investment stimulus for households. The disposable income of households increases due to the resulting GDP growth and the additional subsidies and support granted in the target scenario (e.g. the premium for the purchase of zero-emission vehicles).

In 2025, the difference in household final consumption when compared with the reference level is slightly higher than in 2030. This slight decline in consumption growth is due to the model's assumption of counter-financing of additional investment by households. This means that, after the investment, part of the income previously available for the consumption of other products and services must be raised for the repayments and interest payments of the loans. As a result of this effect and the investments continually stimulated and initiated by the planned measures until 2030, the annual payments for counter-financing will increase until 2030, thereby reducing the growth in consumption.

Due to the dependence of endogenous investments on consumption, which is anchored in the model logic, a similar effect can be observed for investments. By 2030, the level of investment is €212 million$_{2016}$ higher than in the reference scenario. The increase in investment is therefore a combination of the direct stimulus provided by the investment stimulated in the target scenario and the slight increase in household consumption. The increase in investment of around 0.8% in 2030 is largely influenced by the increase in household consumption.

The results of the macroeconomic impact assessment indicate that carbon pricing could partially compensate for the increased government expenditure due to the support measures in the target scenario

and the decrease in tax revenues. The annual new government debt in the target scenario therefore only increases by around €60 million$_{2016}$ in 2030 when compared with the reference scenario. Meanwhile, revenues from carbon pricing and additional government revenues from the improved economic situation even exceed the increase in government expenditure. This results in a marginally higher cumulative public debt until 2030 of around €80 million$_{2016}$.

A major driver of GDP growth when compared with the reference is the decrease in imports of fossil fuels due to the decrease in fossil fuel consumption. As a result, the trade balance up to 2030 increases by around €620 million$_{2016}$ when compared with the reference value. This already takes account of the fact that the import of technologies, for example in the field of renewable energy, results in an increase in imports in the target scenario when compared with the reference scenario. On the other hand, the slightly higher economic growth also results in a slightly higher export activity.

Employment Effects

The effects on gross value creation are the result of a combination of the changes brought about by the stimulus and the interaction effects caused by the interaction between investment, consumption and intermediate consumption. Since the development of labour productivity for each sector of the economy does not differ between the target scenario and the reference scenario, the effects on employment result directly from the changes in gross value creation. Gross value creation is calculated as the total output of a sector less intermediate consumption purchased. This means, for example, that value creation can also increase if energy or material efficiency measures mean that fewer inputs are needed for production. The effects on employment are positive in line with the value creation effects. In the target scenario, the higher gross value creation when compared with the reference results in an additional labour demand of about 1,400 employees in 2025 or 1,470 employees (total, including cross-border commuters) in 2030. This represents a relative increase of 0.3% in 2030 when compared with the reference.

Analysis of external climate costs saved

External costs saved also play a role in the economic analysis; these are taken into account separately here. A comprehensive cost-benefit analysis of energy and climate protection measures includes information on the level of external costs saved, as these represent a benefit over inaction.

UBA (2018)[28] provides a set of detailed cost rates to quantify external environmental costs. The costs saved are determined here solely in relation to avoided greenhouse gas emissions[29]. Based on a real discount rate of 1%, the Federal Environment Agency recommends cost rates for carbon dioxide emissions ranging from €180_{2016}/t CO_2 for 2016 to €205_{2016}/t CO_2 for the medium term (2030). If the discount rate is set lower, the corresponding cost rates are significantly higher (from €640 to €670_{2016}/t CO_2 without discounting).

As data were only available for avoided CO_2 emissions, the quantification of external costs saved is limited to these. The resulting value should therefore be regarded as a lower limit, as it can be assumed that further external environmental costs saved will be added. The distribution of emissions savings is also reflected accordingly in the distribution of external costs saved. The total cumulative CO_2 savings by 2030 amount to just under 32 Mt, which can be converted into external environmental costs saved (cumulative by 2030) of just over €6 $billion_{2016}$.

5.2.2. Environmental/health impact

A **Strategic Environmental Assessment** (SEA) has been carried out for the integrated national energy and climate plan. The objective of the SEA is to avoid planning that could lead to significant environmental problems. Its purpose is to identify, describe and assess the environmental impacts of the programme of measures as a whole in advance of and in addition to the project-related environmental impact assessments for the individual measures. The SEA considers the impacts (including possible interactions) on the following protected assets:

- People, population and health
- Plants, animals and biodiversity
- Soil
- Water
- Climate and air
- Landscape
- Cultural and material goods

The results of the SEA are compiled in an environmental report.

[28] UBA (2018): Methodological convention 3.0 for the determination of environmental costs. Cost rates. Dessau-Roßlau.

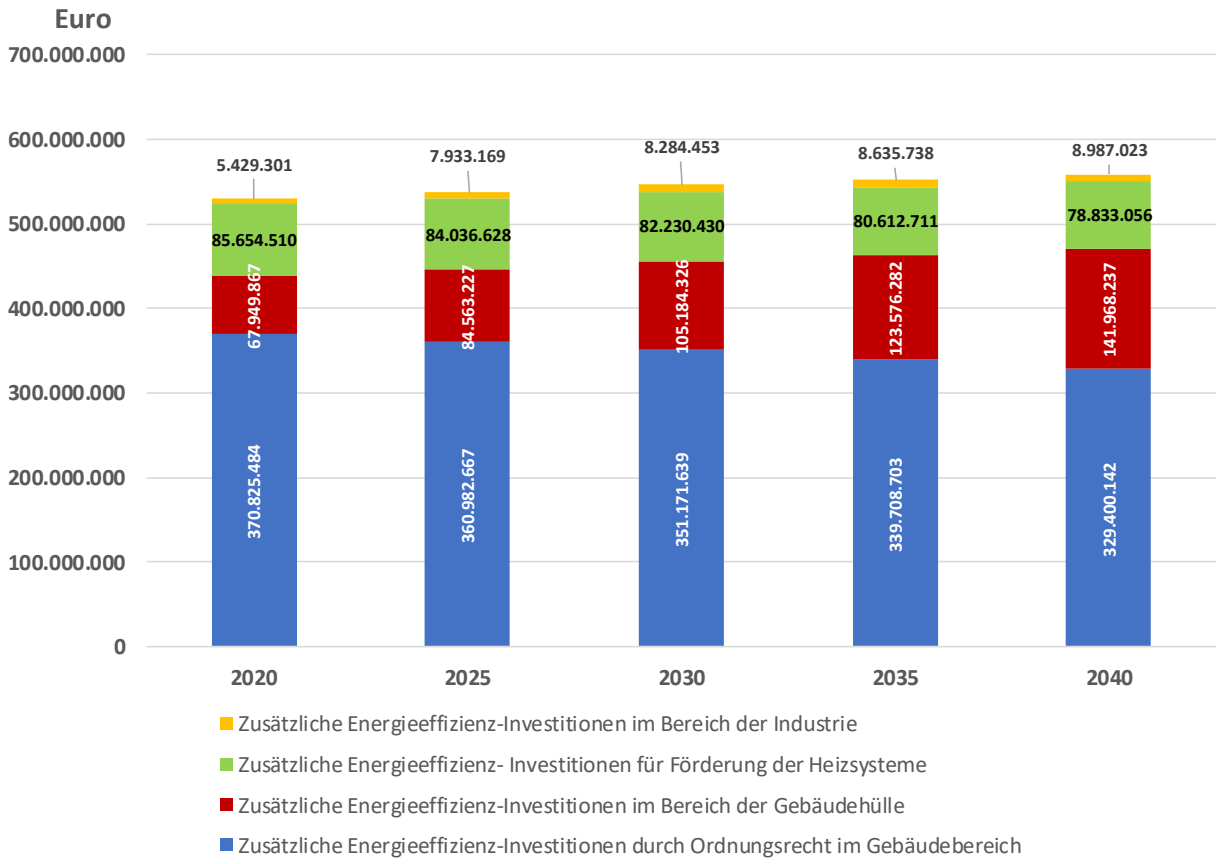
[29] Furthermore, saved costs may also arise in relation to other avoided external effects such as the avoidance of air pollutants, noise pollution or waste, which cannot be taken into account here due to the lack of availability of information on these external effects.

The impact of the planned policies and measures on **emissions of air pollutants** will be quantified in the context of the completion of the future national air pollution control programme under Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants. This will ensure the greatest possible coherence between the integrated national energy and climate plan and the air pollution control programme. Where necessary, the air pollution control programme will lay down specific implementing provisions for the measures set out in this plan (e.g. for the use of biomass for energy).

5.3. Overview of investment needs

5.3.1. Investments in energy efficiency

The additional energy efficiency investments relevant for the implementation of the measures in 2020 amount to almost €530 million and increase by around 6% by 2040 to approx. €560 million (see Figure 21). The total amount results from additional energy efficiency investments in the buildings sector (building envelope, heating systems) and industry.



Euro	Euro
Zusätzliche Energieeffizienz-Investitionen im Bereich der Industrie	Additional energy efficiency investments in the industrial sector
Zusätzliche Energieeffizienz- Investitionen für Förderung der Heizsysteme	Additional energy efficiency investments for the promotion of heating systems
Zusätzliche Energieeffizienz-Investitionen im Bereich der Gebäudehülle	Additional energy efficiency investments in the building envelope
Zusätzliche Energieeffizienz-Investitionen durch Ordnungsrecht im Gebäudebereich	Additional energy efficiency investments via building sector regulations

Source: Own calculations 2019

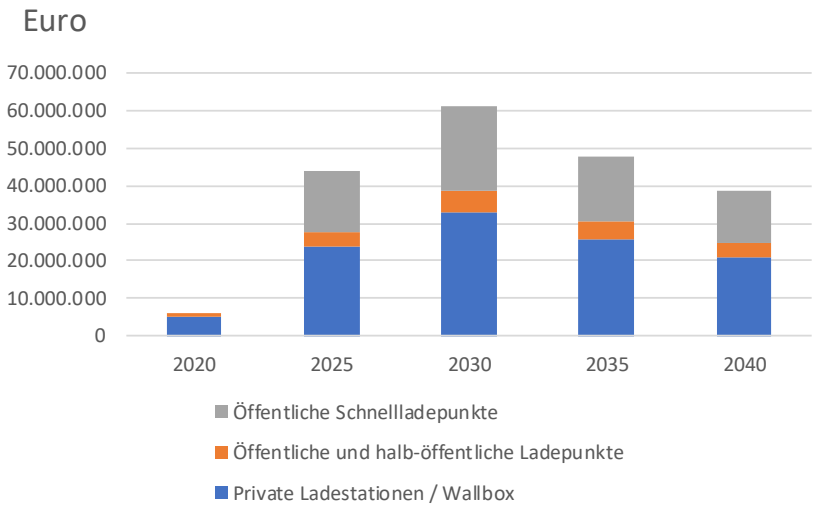
Figure 21: Investments to increase energy efficiency in the period 2020 to 2040, broken down by sector

The transport sector will also see further investment through the construction of charging infrastructure for e-mobility (see Figure 22). A distinction can be made between investments for:

- private charging stations (wallboxes) with average investments per charging station of €1,000
- public and semi-public charging points with an average investment per charging point of €10,000
- public fast charging points with an average investment of €150,000.

The expansion of charging points increases significantly between 2020 and 2040 and peaks in 2030. During that year, just under 34,000 new recharging points will be installed. By 2040, the number of new charging stations added each year will drop again to around 21,200 charging points or charging stations, as a relatively well-developed infrastructure network will by now exist. By way of comparison, the number of new charging stations per year in 2020 will be around 5,200.

In 2020, the total public investment in the area of newly added charging infrastructure facilities for e-mobility will constitute around 6% of the total investment for the charging infrastructure, which amounts to just under €6 million, so around €350,000. By 2030, this total will increase to just over €13.5 million before slowly decreasing to around €7.5 million in 2040. By comparison, total investment will increase by just over €61 million by 2030 before falling to just under €39 million by 2040.



Euro	Euro
Öffentliche Schnellladepunkte	Public high-power recharging points
Öffentliche und halb-öffentliche Ladepunkte	Public and semi-public charging points
Private Ladestationen / Wallbox	Private charging stations/wallbox

Source: Own calculations 2019

Figure 22: Investments in e-mobility charging infrastructure in the period 2020 to 2040 in euro

5.3.2. Investment and support requirements for renewable energy

This analysis focuses on the need for investment in renewable energy technologies and the need for support (where necessary) for the development and operation of renewable energy installations. Both parameters are taken into account in the economic studies carried out since, on the one hand, in the case of investments, a relevant stimulus is created in the complex economic fabric from a macroeconomic perspective and, on the other hand, in view of the support requirements, there are often direct costs associated with the performance of the measures implemented and those planned for the future. Table 26 provides a comprehensive overview of this. The investment and support requirements for energy production based on renewable energy are given for the period up to 2040, broken down by energy sector (electricity, heat, transport (limited to biofuels)). This is presented for both the reference and target scenarios. The table also allows direct comparison, i.e. consideration of the induced change if the target scenario is sought instead of the reference development.

While the total annual investment requirement in new renewable energy plants over the coming decade (2021 to 2030) averages around €153 million according to the reference scenario, in the target scenario it clearly exceeds the €200 million mark and comes to around €214 million – implying an increase of around 40%.[30] In the focus year 2030, the differences are smaller (+ 21.9%), while in 2025 they reach a peak of 93.4%. The electricity sector is dominant in terms of investment: on average, 64% of the total investments are accounted for by the latter over the decade according to the target scenario, while the remainder (36%) is accounted for by renewable energy installations in the heating sector. Biofuel refineries are located in neighbouring countries, so there is no investment in Luxembourg. The same applies to renewable energy cooperation, as this involves renewable energy production abroad.

The annual support requirement for renewable energy, calculated on a net[31] basis, is around €269 million on average over the coming decade according to the target scenario. In the reference case, it would be higher (€297 million), since achieving the target in 2030, although lower (23% share of renewable energy rather than 25%), would result in significant costs for renewable energy cooperation. In the target scenario, expenditure for the electricity sector dominates – approx. 46% of the total renewable energy support

[30] Cumulatively, in the reference case, the total investment requirement in the period 2021 to 2030 is €1,527 million, while cumulative investment of €2,142 million is expected under the target scenario.

[31] The need for funding characterises the necessary direct financial support from the company associated with the expansion or operation of renewable energy plants. Market revenues, e.g. from the marketing of electrical energy on the electricity market, are not included in this figure on a net basis.

requirements for the coming decade (2021 to 2030) are accounted for by electricity from renewable sources, while in the reference scenario, expenditure for renewable energy cooperation would make up the lion's share (31% of the total renewable energy support requirements for the decade).

Table 26: Investment and support requirements for renewable energy – a comparison between the reference and target scenarios

Reference scenario

	Renewable energy investment needs							Renewable energy support needs						
					Cumulative							Cumulative		
	Unit	2020	2025	2030	21-30	2035	2040	Unit	2020	2025	2030	21-30	2035	2040
Renewable energy – electricity	€million	95.5	73.0	73.0	860.4	53.4	57.3	€million	73.7	93.2	66.9	917.7	31.0	16.5
Renewable energy – heat		59.2	57.3	81.2	666.5	69.2	99.4		28.5	21.6	33.8	263.2	32.4	44.6
Renewable energy – biofuels		0.0	0.0	0.0	0.0	0.0	0.0		102.8	75.6	82.8	859.2	55.6	51.3
Renewable energy – total, national		**154.8**	**130.3**	**154.3**	**1,526.9**	**122.6**	**156.6**		**205.0**	**190.4**	**183.5**	**2,040.0**	**119.0**	**112.4**
Renewable energy – cooperation needs		0.0	0.0	0.0	0.0	0.0	0.0		31.7	85.8	153.3	925.1	153.3	153.3
Renewable energy – total incl. cooperation		**154.8**	**130.3**	**154.3**	**1,526.9**	**122.6**	**156.6**		**236.7**	**276.2**	**336.8**	**2,965.1**	**272.3**	**265.7**

Target scenario Paris Article 2.1a

	Renewable energy investment needs							Renewable energy support needs						
					Cumulative							Cumulative		
	Unit	2020	2025	2030	21-30	2035	2040	Unit	2020	2025	2030	21-30	2035	2040
Renewable energy – electricity	€million	89.6	191.9	76.3	1,380.9	64.0	92.1	€million	73.9	146.8	92.0	1,239.8	32.0	22.7
Renewable energy – heat		59.2	60.0	111.7	761.6	38.8	57.6		28.5	28.7	51.5	352.8	15.4	15.2
Renewable energy – biofuels		0.0	0.0	0.0	0.0	0.0	0.0		79.6	62.4	61.7	673.4	66.6	61.9
Renewable energy – total, national		**148.9**	**252.0**	**188.1**	**2,142.5**	**102.7**	**149.7**		**182.0**	**237.9**	**205.2**	**2,266.0**	**114.1**	**99.7**
Renewable energy – cooperation needs		0.0	0.0	0.0	0.0	0.0	0.0		31.7	41.2	53.0	423.8	0.5	0.0
Renewable energy – total incl. cooperation		**148.9**	**252.0**	**188.1**	**2,142.5**	**102.7**	**149.7**		**213.7**	**279.1**	**258.3**	**2,689.8**	**114.6**	**99.7**

Change from target scenario to reference scenario

	Renewable energy investment needs							Renewable energy support needs						
					Cumulative							Cumulative		
	Unit	2020	2025	2030	21-30	2035	2040	Unit	2020	2025	2030	21-30	2035	2040
Renewable energy – electricity	%, change based on the reference scenario	-6.2%	163.0%	4.5%	60.5%	19.9%	60.8%	%, change based on the reference scenario	0.3%	57.5%	37.6%	35.1%	3.4%	37.4%
Renewable energy – heat		0.0%	4.8%	37.5%	14.3%	-44.0%	-42.0%		0.0%	33.0%	52.6%	34.1%	-52.4%	-65.9%
Renewable energy – biofuels									-22.6%	-17.4%	-25.5%	-21.6%	19.8%	20.6%
Renewable energy – total, national		**-3.8%**	**93.4%**	**21.9%**	**40.3%**	**-16.2%**	**-4.4%**		**-11.2%**	**25.0%**	**11.9%**	**11.1%**	**-4.1%**	**-11.3%**
Renewable energy – cooperation needs									0.0%	-52.0%	-65.4%	-54.2%	-99.7%	-100.0%
Renewable energy – total incl. cooperation		**-3.8%**	**93.4%**	**21.9%**	**40.3%**	**-16.2%**	**-4.4%**		**-9.7%**	**1.1%**	**-23.3%**	**-9.3%**	**-57.9%**	**-62.5%**

Source: own calculations 2019

5.3.3. Impact on network costs in the distribution network

The electricity network is of particular importance in the context of the energy transition and the associated shift from fossil to renewable energy sources. Changes in the height and spatial distribution of loads and production installations connected to the distribution networks are the main drivers of the development

needs of distribution networks. In both the reference and target scenarios, there is large-scale expansion of renewable energy installations. At the same time, the load is largely increased by an increase in heat pumps and e-mobility, which can overcompensate for the efficiency-related reduction in load and can therefore lead to some network expansion needs.

In total, renewable energy installations with a capacity of just over 300 MW were installed during the initial year, 2017; PV installations with a capacity of around 185 MW and wind turbines with a capacity of around 75 MW make up the largest share of these. By 2040, the target scenario predicts an increase in renewable energy production to a total of around 2,500 MW, with the contribution from PV installations expected to grow to just over 1,800 MW and wind installations to around 550 MW. This means that the total installed capacity of renewable energy installations is almost eight times higher than today (when compared with a total of just 1,500 MW in the reference scenario due to lower PV plant capacities).

In addition to the installed production capacity, load increases are expected from electric vehicles, connection of electric heat pumps, and also from the construction of new apartments. The biggest driver for the peak load caused by consumers connected to the distribution network is the increase in electric vehicles, which could lead to an almost threefold increase in today's peak load by 2040 in the target scenario and to a doubling of peak load in the baseline or reference scenario. This development is reflected in corresponding annuity distribution network costs, which increase by around 30% in the reference scenario and by around 70% in the target scenario by 2030. At the same time, the total cost burden is spread over a much larger number of end consumers and there is also a slightly higher demand for electricity, which in turn reduces the specific costs accordingly.

In addition, the development of peak load depends crucially on flanking measures in network operation and market design, which could not be taken into account in their entirety in the quantification due to their complexity. For example, the planned further development of flexibility options (see Section 3.4.3.ii), such as smart charging management for electric vehicles or market-based incentives for systemic demand, should significantly reduce peak loads. In principle, network expansion needs arising from an increase in demand can be dampened by a simultaneous increase in distributed production capacity, but only if load and production are in close proximity and correlated over time or integrated via decentralised storage solutions. It should also be noted that the network expansion requirement for PV installations is generally higher than for wind turbines, as the latter are usually connected directly to higher network levels. This also provides a plausibility check for the higher network expansion requirement in the target scenario, in which considerably more PV installations are expected.

5.4. Impacts of the planned policies and measures described in Section 3 on other Member States and regional cooperation

In a small open country like Luxembourg, climate and energy policy objectives also have a cross-border dimension. Ultimately, only the implementation of the measures described in Section 3 will shed light on their exact impact on neighbouring countries and other Member States. However, it should be noted that this impact will remain manageable due to Luxembourg's relatively small size.

Transport infrastructure projects designed to cope with commuter traffic will certainly have a cross-border impact. The agreement between Luxembourg and France, which provides for such investments, amounting to €120 million from Luxembourg and €110 million from France (Lorraine), will contribute to this. Currently, as is well known, fuel exports to the border region have resulted in an increase in the GHG balance in Luxembourg. The planned CO_2 pricing, or the increase in excise duties on diesel and petrol, is expected to lead to a gradual reduction in the differential in fuel prices between Luxembourg and its neighbouring regions.

As regards cooperation mechanisms, Luxembourg has stipulated in existing contracts with Lithuania and Estonia (see Section 3.1.2.ii.) that the financial compensation will be invested in specific new projects in the field of renewable energy and energy efficiency. Luxembourg will continue to focus on the need for cooperation mechanisms to achieve its objectives. The planned future cooperation on specific projects, whether in the framework of the Benelux area or in the existing platforms 'Pentalateral Energy Forum' and 'North Seas Energy Cooperation' (see Section 1.4), will certainly have a positive economic impact in the project areas.