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LE GOUVERNEMENT
DU GRAND-DUCHÉ DE LUXEMBOURG
Ministère de l'Énergie et de
l'Aménagement du territoire



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

DRAFT INTEGRATED NATIONAL ENERGY AND CLIMATE PLAN FOR LUXEMBOURG

In accordance with REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the Governance of the Energy Union and Climate Action, amending Directive 94/22/EC, Directive 98/70/EC, Directive 2009/31/EC, Regulation (EC) No 663/2009, Regulation (EC) No 715/2009, Directive 2009/73/EC, Council Directive 2009/119/EC, Directive 2010/31/EU, Directive 2012/27/EU, Directive 2013/30/EU and Council Directive (EU) 2015/652 and repealing Regulation (EU) No 525/2013

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1. Overview and process for establishing the plan

1.1. Summary

Regulation (EU) 2018/1999 of 11 December 2018 on the Governance of the Energy Union and Climate Action requires the Member States of the European Union to submit an integrated national energy and climate plan.

This draft integrated national energy and climate plan defines the scope of Luxembourg's energy and climate policies up 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 recently published IPCC report¹ highlights the extent of the challenge and the urgent need to take action: it will only be possible to limit global warming to 1.5 degrees Celsius if global greenhouse gas emissions are halved by 2030 (compared to current levels), followed by climate neutrality by 2050.

Against this background, the current government has decided, in the context of the new Coalition Agreement 2018-2023: '... to make every possible effort to meet this [Paris] Agreement and to take into account the findings of the special report of the Intergovernmental Panel on Climate Change (IPCC) on 1.5 degrees Celsius.'

At European level, Luxembourg intends to set ambitious climate action targets in keeping with the five-year cycles of the Paris Agreement. Luxembourg will continue to encourage the European Commission to introduce a credible and comprehensive strategy for a 'net zero emissions' Europe by 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 IPCC special report on the impacts of global warming of 1.5 °C above pre-industrial levels

The major challenge faced by energy policy will be adapting to the climate and environmental challenges and guaranteeing the security and competitiveness of the national supply. When implementing the policies, the area of energy efficiency must be seen as the priority, in accordance with the principle of 'energy efficiency first', followed by the increased and systematic expansion of renewable energy and the introduction of sustainable mobility.

The long-term challenge of the energy transition has already been intensively dealt with in recent years in Luxembourg, and is part of the Third Industrial Revolution process, which was initiated in 2015 and the cornerstones of which involve developing renewable energy on a large scale and incorporating it into the energy network, developing decentralised energy storage, digitising the energy networks, using sustainable means of transport and improving the energy efficiency of existing buildings. The current government of Luxembourg intends to further speed up the energy transition that has already been set in motion. Luxembourg's 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 play a proactive role in the European energy transition, with the aim of a sustainable, secure and competitive supply of energy in the context of decarbonisation.

The present draft 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 digitisation. Against this background, it is also important to intensify research and development (R&D) in the areas mentioned, in order to bring about and develop modern, industrial activity in Luxembourg. The draft national integrated energy and climate plan will therefore also have the potential to attract investment into innovative business start-ups in the relevant areas. The draft plan will also help to create the credibility needed to make Luxembourg into a global 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 the national energy and climate plan of Luxembourg. It should be noted here that fluctuation margins were established in order to determine the three objectives, in particular due to the fact that it was not possible to carry out a

detailed analysis of the impact of implementing the plan during the preparatory phase of the draft plan. The modelling activities presented in the present draft plan refer to the upper fluctuation margin values mentioned in each case.

Dimension
GHG emissions
Renewable energy
Energy efficiency
Energy security
Internal energy market
Research, innovation and competitiveness

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Dimension	Central policies and measures
Decarbonisation	<ul style="list-style-type: none"> ▪ Introducing a climate framework law ▪ Further developing the climate pact with the municipalities ▪ Strengthening financing measures, including the climate and energy fund, environmental fund, the PRIME House climate loan support scheme, the PRIME Car-e support scheme ▪ Adjusting the taxation of mineral oil products ▪ Implementing and further developing the strategy for sustainable mobility
Renewable energy	<ul style="list-style-type: none"> ▪ Streamlining further incentive effects in the field of heat from renewable energy ▪ Pursuing calls for tenders for large photovoltaic systems ▪ Strengthening regional cooperation ▪ Cooperating with other EU Member States ▪ Adapting and expanding the support schemes ▪ Creating a solar and thermal land register ▪ Cross-border joint projects ▪ Strengthening internal consumption in the electricity sector ▪ Joint calls for tenders with neighbouring countries in relation to photovoltaic capacities
Energy efficiency	<ul style="list-style-type: none"> ▪ High-quality and efficient renovations of existing buildings ▪ Adjusting the taxation of mineral oil products ▪ Implementing and further developing the strategy for sustainable and active mobility
Energy security	<ul style="list-style-type: none"> ▪ Strengthening regional cooperation ▪ Measures for expanding the network at transmission system level ▪ Implementing and further developing the strategy for sustainable and active mobility ▪ National strategic framework for market development in relation to alternative fuels in the transport sector and for extending the corresponding infrastructure
Internal energy market	<ul style="list-style-type: none"> ▪ Implementing the network expansion projects that are already planned ▪ No further measures for extending gas infrastructure: the existing gas infrastructure is of a sufficient size
Research, innovation and competitiveness	<ul style="list-style-type: none"> ▪ Intensifying innovation and research in the fields of renewable energy, energy efficiency, smart cities and neighbourhoods, and buildings ▪ Increasing existing efforts and skills at the national research institutes

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. For instance, the population has increased from 483 799 to 602 005 residents in the last ten years. 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 different price level for fuels compared to the neighbouring countries. 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 also atypical. For instance, the electricity consumed by the steel industry alone accounts for approximately 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, owing to a lack of geology, and only limited storage capacity for oil products.

Luxembourg thus only has limited possibilities to influence the overarching energy security using national measures. In the past, Luxembourg has focused on diversifying the sources and supply routes in order to guarantee its energy security.

In addition, 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 integrated into the principles of the European Energy Union.

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

Energy efficiency

Between 2008 and 2014, Luxembourg adopted three national action plans for energy efficiency and implemented the measures contained therein. The current, fourth, national action plan for energy efficiency 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 the requirements regarding energy efficiency over the last ten years and is playing a leading role in this regard in Europe. The AAA standard applicable in the field of energy classes has been compulsory for every newly constructed residential building since the start of 2017, and approximately corresponds to the internationally recognised *Passivhaus Standard* [passive-house standard].

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. With regard to the significant potential for energy saving 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 (*PRIME House* support scheme) and municipalities (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 improving energy efficiency and promoting renewable energy that apply to businesses were 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 of 11 % renewable energy in the final energy consumption by 2020 for Luxembourg. The target of 10 % renewable fuels in energy consumption in the transport sector for 2020 must also be observed.

Luxembourg is well on track to meet its targets for 2020. In 2016, the share of renewable energy in the final energy consumption reached 5.44 %, compared with 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 for 2017 and 2018.

In the field of new residential buildings, the Regulation on the energy efficiency of residential buildings was used to introduce an implicit requirement for the use of renewable energy. The regulations on the feed-in tariffs have been systematically amended in recent years, in order to create interesting incentives for investment, particularly in the fields of biomass, wind and photovoltaics, and for photovoltaics cooperatives. In addition, a first national competitive procedure for photovoltaic systems on buildings or industrial or landfill sites was organised in 2018.

Finally, it should also be mentioned that the biofuel rate in the fuel admixture was set at 5.5 % for 2017. In 2017, the minimum rate for biofuels from waste, residues and cellulose materials that are not from foodstuffs and fall under the principle of 'double counting' was set at 15 %. It should also be mentioned that the new government programme stipulates limiting the use of first-generation biofuels to no more than 5 % in order to promote the use of second-generation biofuels that are thought to be more sustainable.

Sustainable mobility

In parallel to the increased support for public transport and active mobility, 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. This should mean a total of 800 stationary chargers being installed in public areas and in park & ride car parks by 2020. Just under 280 stationary chargers had already been

installed by the end of 2018. This means Luxembourg is already in third place in the field of public charging infrastructure in Europe in terms of population.

Digitisation

As part of efforts to digitise the energy transition, Luxembourg legally requires the 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 was recently expanded to include the topics of air quality and 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 was well received and has now been signed by all municipalities in Luxembourg, 86 % of which had already achieved one of the three certification stages 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 draft 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

The recitals of Regulation (EU) 2018/1999 of 11 December 2018 on the Governance of the Energy Union and Climate Action provide for public consultations to be carried out. This refers to the establishment of a permanent multi-level energy and climate dialogue, in order to bring together local authorities, civil society organisations, the business community, investors and other relevant stakeholders to discuss the different options envisaged for energy and climate policies.

In this context, Luxembourg, at the initiative of the Ministry of the Economy and in cooperation with the Chamber of Commerce and IMS Luxembourg, in 2015 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 strategic 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 elaboration of the strategic study was linked to an open, participatory and sustainable process with the aim of identifying the megatrends, drawing the necessary conclusions therefrom and introducing these in a suitable form into democratic institutions. The TIR process also attempted to make use of the 'collective intelligence' approach, which is an important part of the concept of open social innovation.

As well as the areas of food, industry, finance, smart economy, circular economy and prosumers & social model, the TIR strategic study also dealt, in particular, with the areas of energy, mobility and buildings, and with the associated climate action challenges. The work was organised in open, thematic platforms in which more than 300 participants from the business community, politics and civil society took part during the preparation of the study.

As part of the strategic study, the topic of energy was analysed, structured and discussed in detail during numerous working group meetings, and a vision for a sustainable, climate-friendly and resource-conserving energy policy for Luxembourg was defined, which was also included in the final report of the strategic study.² Energy efficiency, particularly in the buildings sector, is given a key role here. In addition, the necessity of a rapid and intensive switch to renewable energy is set out.

After the study, the government resolved to allow the participatory approach via existing platforms to continue. In this context, the 'Energy Future of Luxembourg' platform was set up for the energy sector, in which important and specific topics relating to the energy transition have been dealt with at several events in recent months. On 12 March 2018, an open workshop on the energy transition was held in the context of current developments in the European Energy Union, with presentations and discussions on the main pillars of the Energy Union, the current National Action Plan for energy efficiency, the modelling for the development of the 2030 energy and climate strategy, the renovation potential in

² http://www.troisiemerevolutionindustrielle.lu/wp-content/uploads/2016/11/TIR-Strategy-Study_Short.pdf

Luxembourg looking ahead to 2070, the potential of renewable energy in Luxembourg looking ahead to 2030, energy security issues and competitiveness in the areas of electricity, natural gas and oil. The results of this workshop have, where possible, been taken into account in the present draft national energy and climate plan.

With regard to developing a long-term climate strategy, the Ministry of Sustainable Development and Infrastructure organised several rounds of consultations with civil society, business, science and public administration representatives during 2018. At a first co-creation workshop on the weekend of 3 and 4 February 2018, around 100 participants identified social innovations for curbing 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 most significant results of the workshops mentioned above have, where possible, been taken into account in the present draft national energy and climate plan.

The present draft national energy and climate plan was prepared as part of intensive consultations involving the two responsible ministries, the Ministry of Energy and Spatial Planning and the Ministry of the Environment, Climate and Sustainable Development.

In order to enable further-reaching and more comprehensive analysis in connection with the preparation of the final national energy and climate plan, further national consultations are planned as part of a joint process of the two responsible ministries. Luxembourg's long-term strategy will also be discussed as part of this process.

1.4. Regional cooperation in preparing the plan

The framework for regional cooperation is specified by Regulation (EU) 2018/1999 of 11 December 2018 on the Governance of the Energy Union and Climate Action and is of central importance for the most cost-effective and concrete achievement of the objectives of the Energy Union. It is indispensable in improving the efficacy and efficiency of the measures retained in the plans and in promoting market integration and energy security.

The recitals of the regulation require the Member States to cooperate, taking into consideration the existing regional forums of cooperation. Here, in particular, Luxembourg must take into account the Pentalateral Energy Forum and the North Seas Countries' Offshore Grid Initiative (NSCOGI), in the work of which Luxembourg has been actively involved since the foundation of these initiatives. As part of this, Luxembourg uses the Committee of Ministers of the Benelux cooperation and the Benelux Talanoa Dialogue as a platform to promote cross-border cooperation on climate action issues. Ultimately, however, other cooperation bodies such as the 'Gas Platform' or the 'Green Growth Group' will also need to be used for regional cooperation when preparing the integrated national energy and climate plans (NECP).

The Pentalateral Energy Forum (PLEF) was founded in 2005, with the active participation of Luxembourg, and initially brought together the Benelux states with Germany and France. Austria and Switzerland joined the forum in 2011. The Energy Forum pursues the aim of improving regional cooperation between Belgium, Germany, France, Luxembourg, the Netherlands, Austria and Switzerland. In various working groups, the regulatory authorities, network operators, electricity exchanges and representatives of regional market participants work together to improve regional ties between their markets and seek out synergies together. The areas of focus dealt with in recent years have been market coupling, energy security and issues regarding the potential for flexibility in the energy transition. The forum has collectively launched initiatives to achieve an internal energy market, for example the successful market coupling in 2010, and the introduction of the regional analysis of energy security in 2013. For many years, the PLEF has thus been creating the framework for regional cooperation in Central Western Europe and is a proponent of a better integrated and more secure energy market.

In the run-up to the Energy Council meeting of 11 June 2018, Luxembourg, the Netherlands and Belgium signed the 'Declaration on regional cooperation regarding the development of NECPs'. In the same month, the Directors-General for Energy and Climate met for the first 'Regional Energy and Climate Dialogue 2030' to discuss and flesh out the practical steps in coordinating the plans. As part of the dialogue, it was specifically decided to maintain the existing regional energy cooperation and expand it to include cooperation in the areas of climate and the environment. Furthermore, the issue of decarbonisation, with a focus on renewable energy, the internal energy market and energy security, was identified as being particularly relevant to cross-border cooperation.

The PLEF countries intend to draw up jointly coordinated sections of the report for the regional cooperation in the various NECPs, and to develop topics of cross-border relevance and a joint vision by 2030. The scope of the regional cooperation that will take place in the PLEF will concentrate on the following key areas in order to achieve the highest possible specific added value:

- medium- and long-term infrastructure development and increased market coupling;
- exchange and analysis of assumptions as to the use of various energy sources;
- integration of renewable energy into the electricity and gas networks and the impact thereof on the functioning of the internal market and energy security;
- possible impact of national energy efficiency measures on the internal market;
- impact and regulatory incentives of sector coupling;
- flexibility options, including energy storage and the potential prospects of hydrogen;
- other incentives for reducing CO₂ emissions.

The Luxembourg chair of the Pentalateral Forum will focus on the integration of renewable energy into the electricity networks at a regional level and on issues relating to an effectively functioning cross-border charging infrastructure in the area of electromobility.

Apart from the work of the PLEF, information and experience on certain aspects should also be exchanged in the framework of the NSCOGI when developing the NECPs, and incorporated into the NECPs in the most coordinated way possible. This may relate, for example, to the joint development of concepts for a coordinated electricity infrastructure, including the transmission infrastructure, or the specific cooperation in the field of renewable energy.

As part of the Benelux cooperation, Luxembourg will take the chair of the Benelux Committee of Ministers for the third time since the entry into force of the new Benelux Treaty in 2012. Under the Luxembourg chairmanship, the Benelux states will concentrate on the energy transition, the fight against climate change, strengthening the internal market and promoting digitisation. In this regard, the topics of energy transition, renewable energy and cross-border energy security will be further developed.

As part of its Benelux chairmanship, Luxembourg has succeeded Belgium in assuming the presidency of the Pentalateral Energy Forum for 2019. In cooperation with the Benelux secretariat, Luxembourg will

concentrate on the regional cooperation in the development of the NECPs and thus build on the intensive groundwork carried out by the Belgian presidency.

The North Seas Countries' Offshore Grid Initiative (NSCOGI) is a regional initiative in which Belgium, Germany, Denmark, France, Great Britain, Ireland, Luxembourg, the Netherlands, Norway and Sweden have been cooperating, with the involvement of the European Commission, since 2010. This initiative prioritises discussions on issues of network infrastructure of offshore facilities, with the aim of achieving better coordination of the expansion of the offshore wind potential in the North Sea. Offshore wind power stations and network infrastructure projects may in fact have a cross-border impact on energy prices, energy security and the environment, including on the availability of maritime space and on the speed of innovation. The main objective of the initiative remains the coordination and facilitation of the cost-effective use of renewable offshore energy, in particular wind energy, and the safeguarding of a sustainable, secure and accessible energy supply in the North Sea countries through enhanced and more effectively coordinated offshore wind power stations and potential joint projects.

The Benelux Talanoa Dialogue³ is used as a further platform for promoting cross-border cooperation. As part of this inclusive and participatory process that took place on 24 September 2018 in Brussels, regional project proposals were developed with stakeholders from the Benelux Member States on the focus areas of 'sustainable mobility', 'energy and resource efficiency', 'green finances' and a 'just transition'. In this context, Belgium, the Netherlands and Luxembourg signed a joint declaration on strengthening interregional cooperation, in order to achieve the targets of the Paris Climate Agreement. One of the main focus areas of the declaration is the optimum implementation of the 'Regional Energy and Climate Dialogue 2030', which aims to promote ongoing synergies in developing the national energy and climate plans and in implementing a long-term national strategy for reducing greenhouse gas emissions.

³ The Talanoa Dialogue is a method for allowing countries to improve their contributions to the climate targets before 2020 as part of a participatory process. The contracting states to the Climate Agreement of the United Nations initiated this dialogue to examine whether the joint efforts to reduce greenhouse gas emissions are in accordance with the target of the Paris Climate Agreement of limiting the worldwide increase in temperatures to well below 2 °C and making every effort to keep it below 1.5 °C.

2. National objectives and targets

The new regulatory framework for the EU energy and climate change package for 2030 encompasses the revision of the Energy Efficiency (EFF) Directive, the Renewable Energy (RE) Directive and the Governance Directive. As part of this, the EU Member States, the European Parliament and the European Commission reached a political agreement on the target system for 2030 as part of the trilogue in June 2018. This involves binding EU targets of a 40 % reduction in greenhouse gases (GHG), a share of 32 % renewable energy in the final energy demand and 32.5 % for energy efficiency, and a review clause providing for an increase in 2023. The Member States are obliged to submit the draft national energy and climate plan to the European Commission by the end of 2018, comprising a detailed presentation of the national targets for reducing greenhouse gases, the targets for renewable energy and energy efficiency and the measures planned in this regard. The present draft plan depicts Luxembourg's preferred route to the target system mentioned. 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 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. For renewable energy, the new directive provides for a benchmark formula, resulting in an increase in the RE target of around 12 % points for Luxembourg, 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.

Below, Luxembourg's preferred route to achieve the energy and climate objectives for 2030 is presented on the basis of the dimensions to be considered. It should initially be mentioned here that this clearly meets all of the minimum requirements outlined above, whether in the area of GHG reduction or regarding the contribution of renewable energy or energy efficiency. Luxembourg considers it of central importance to tread an ambitious path here together with its European partners.

⁴ European Commission DG for Energy and Transport (2008). European energy and transport -TRENDS TO 2030 — UPDATE 2007. <https://ec.europa.eu/energy/en/data-analysis/energy-modelling>

2.1. Decarbonisation dimension

2.1.1. Emissions and removals of greenhouse gases

Regarding compatibility with the objective enshrined in Article 2.1.a of the Paris Climate Agreement, Luxembourg is already aiming at a national level **to reduce GHG emissions for the sectors outside the emissions trading scheme by between 50 % and 55 % by 2030 compared to the base year of 2005**. In fact, the recently published IPCC special report⁵ states that it will only be possible to limit global warming to 1.5 degrees Celsius if global greenhouse gas emissions are halved by 2030 (compared to current levels), followed by climate neutrality by 2050. Luxembourg is pursuing this national goal independently, but within the framework of the Paris Climate Agreement and in accordance with its contribution to the EU target.

Luxembourg's binding contribution to the EU target arises from 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 sector⁶. Taken together, the debits from the land use categories included in the accounting (pursuant to 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 between 23 % and **25 % by 2030**.

According to the currently determined scenarios, the national expansion of renewable energy by 2030 would be in a range from 18.6 % to 19.8 %, in each case on the basis of the gross final energy demand, in

⁵ IPCC special report on the impacts of global warming of 1.5 °C above pre-industrial levels

⁶ LULUCF: Land Use, Land Use Change and Forestry

other words the total of the sectoral energy demands for electricity, heat and fuels in the transport sector. However, in line with the EU target (increasing the RE share to 32 % at EU level by 2030), a national contribution of between 23 % and 25 % would appear to be reasonable 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 in 2020. The cooperation with other Member States and the statistical transfers should be further developed and involve specific projects.

Target quantities at sectoral level and technology 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 upper fluctuation margin value of a target of 25 %.

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 biomass, wind energy and photovoltaics – 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 3.2 % in 2005 to 6.7 % in 2016) but also in terms of heat production (from 3.6 % in 2005 to 7.3 % in 2016). In the transport sector, which is dominated by the use of first- and second-generation biofuels and the transition to electrically operated drive systems, this change was even more dramatic: although the RE share was marginal in 2005 (0.14 %), Luxembourg today (2016) has an RE share of 5.9 %.

The coming decade, specifically the years up to 2030, will be assessed in the context of an underlying study (see Resch et al. 2019), on the basis of a number of possible development trajectories and corresponding energy scenarios. The target scenario presented in the current draft plan corresponds to the upper fluctuation margin value of 25 % for 2030. If the status quo (2016) 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 RE 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 accordingly increase from 5.4 % in 2016 to 12.9 % in the case of merely continuing with the existing policies (reference development) – as is shown by corresponding data in Section 4 of this report.

If additional interventions are made, in both renewable energy and energy efficiency, an increase to 19.8 % 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). In second place in terms of the speed of the 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 or modern biomass heating systems. Furthermore, a massive increase in the use of renewable energy is also expected in the transport sector. In this case, specifically, it is assumed that there will be an increase in the admixture of biofuels, as shown in Table 1 and Table 2. In addition, a massive expansion of e-mobility is envisaged, 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, a considerable increase of the RE share in the transport sector, to 21.9 %, will be achieved by 2030.

Table 1. Sectoral shares of renewable energy in Luxembourg by 2030 according to the target scenario with the upper fluctuation margin value of 25 %. (Source: own illustrations, 2019)

RE shares		<u>2016</u>	<u>2020</u>	<u>2025</u>	<u>2030</u>
sectoral					
RE share electricity sector	%	6.7 %	11.9 %	23.5 %	33.6 %
RE share heat sector	%	7.3 %	13.6 %	20.0 %	30.3 %
RE share biofuels	%	4.6 %	6.0 %	9.1 %	10.0 %
RE share transport sector	%	5.9 %	-	-	21.9 %
RE share, total (national)					
- national generation/consumption	%	5.4 %	8.7 %	14.7 %	19.8 %
RE share, total					
- incl. RE cooperation	%	5.4 %	11.1 %	18.7 %	25.0 %

Table 2. Technology-specific energy generation from renewable energy in Luxembourg by 2030 according to the target scenario with the upper fluctuation margin value of 25 %. (Source: own illustrations, 2019)

Energy generation, technology details		<u>2016</u>	<u>2020</u>	<u>2025</u>	<u>2030</u>
Electricity sector					
Biogas	GWh	74	56	70	93
Biomass	GWh	67	192	228	271
Hydroelectric power	GWh	104	93	97	100
Photovoltaics	GWh	100	247	786	1 112
Wind energy	GWh	127	161	382	674
RE electricity, total	GWh	473	748	1 563	2 251
Heat sector					
Biomass & biogas, grid-connected	GWh	155	589	625	676
Biomass, decentralised	GWh	706	883	1 145	1 383
Solar thermal energy	GWh	23	58	116	192
Heat pumps	GWh	48	95	208	427
RE heat, total	GWh	932	1 626	2 093	2 679
Transport sector					
Biofuels, total (without multipliers)	GWh	1 012	1 234	1 315	1 434
RE use in transport sector (incl. multipliers)	GWh	1 341	-	-	4 877
RE energy use, total	GWh	2 416	3 608	4 971	6 363

2.2. Energy efficiency dimension

Regarding compatibility with Article 2.1.a of the Paris Climate Agreement, Luxembourg is already striving for a reduction in the final energy demand of between 40 % and 44 % for 2030 compared to the EU PRIMES baseline development (2007).

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

- the ambitiousness of the energy building renovations – rate and intensity of the renovations that are carried out;
- the extent to which transit and cross-border commuter traffic are addressed;
- the development of electromobility in existing vehicles.

The central target figures of the target scenario, based on the upper fluctuation margin value of 44 %, are presented in Table 1.

Table 1: Central target figures of the target scenario in the area of energy efficiency based on the upper fluctuation margin value of 44 %

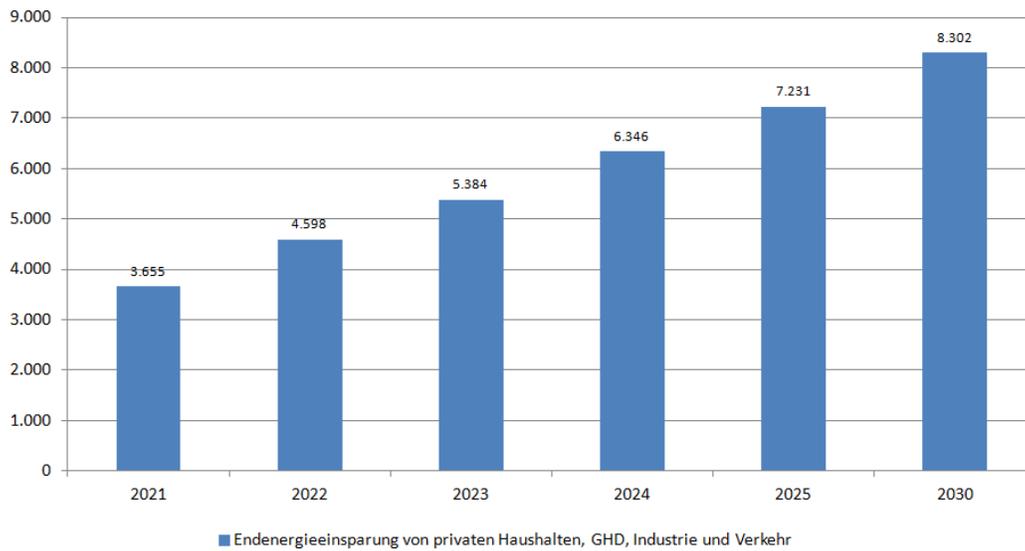
	Target scenario 44 % efficiency (EFF44)
Efficiency target 2030 (versus EU PRIMES in 2030)	-44 %
Final energy demand [GWh]	35 568
Total	-21 %
Households	-37 %
Tertiary	-25 %
Industry	-13 %
Road transport	-33 %
Road fuels (without electricity for e-mobility)	-35 %
Renovation rate 2020-2030 ⁷	2.7 %
Renovation intensity (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 2018

The cumulative final energy savings from all sectors (private households, trade, commerce and services, industry and transport) amount to around 8.3 TWh in the case of the implementation of the planned energy efficiency measures in the period from 2021 to 2030. (See Figure 1).

⁷ Based on the additional renovations compared to the baseline scenario. The renovation rate expresses the share of buildings that are renovated each year compared to the existing old buildings (buildings built before 1991)

GWh



Endenergieeinsparung von privaten Haushalten, GHD, Industrie und Verkehr	Final energy saving of private households, trade, commerce and services, industry and transport
GWh	GWh

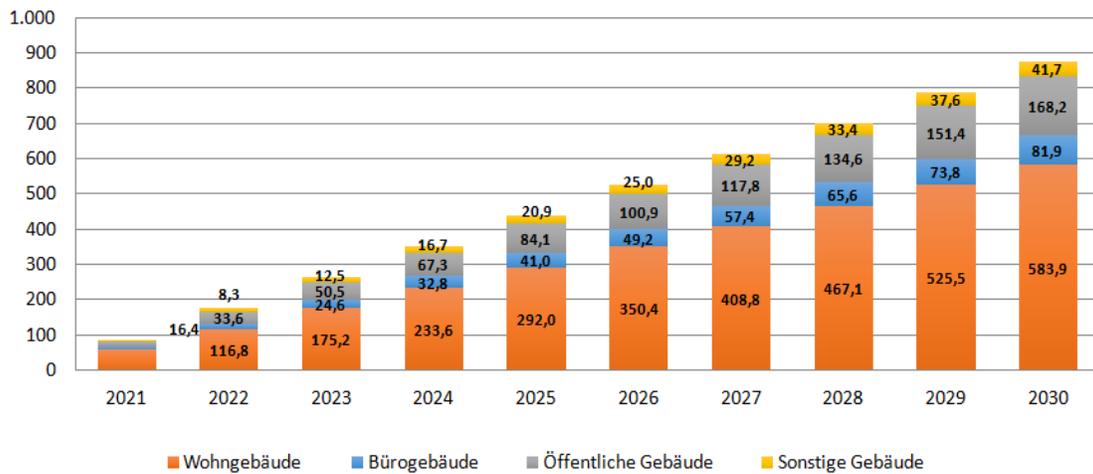
Source: own calculations 2018

Figure 1: Cumulative final energy saving in GWh in private households, the trade, commerce and services sector, industry and the transport sector over the period from 2021 to 2030 (based on the upper fluctuation margin value of a target of 44 % in the area of energy efficiency.)

The cumulative energy efficiency renovation of residential and non-residential buildings in Luxembourg over the period from 2021 to 2030, at just under 876 GWh, contributes to the final energy savings in all sectors (see Figure 2). The biggest final energy savings will be achieved through the renovation of private residential houses, followed by the renovation of public buildings, the renovation of office buildings and the renovation of other buildings.

In Figure 3, the development of the final energy saving 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 final energy saving will grow gradually from just under 17 GWh (2021) to 168 GWh (2030), corresponding to an increase of around 150 GWh. This will involve the renovation of on average more than 110 000 square metres of building space in public buildings each year. As a result, the renovation of public buildings will contribute more than 19 % towards the overall final energy saving through energy efficiency renovations of buildings.

GWh

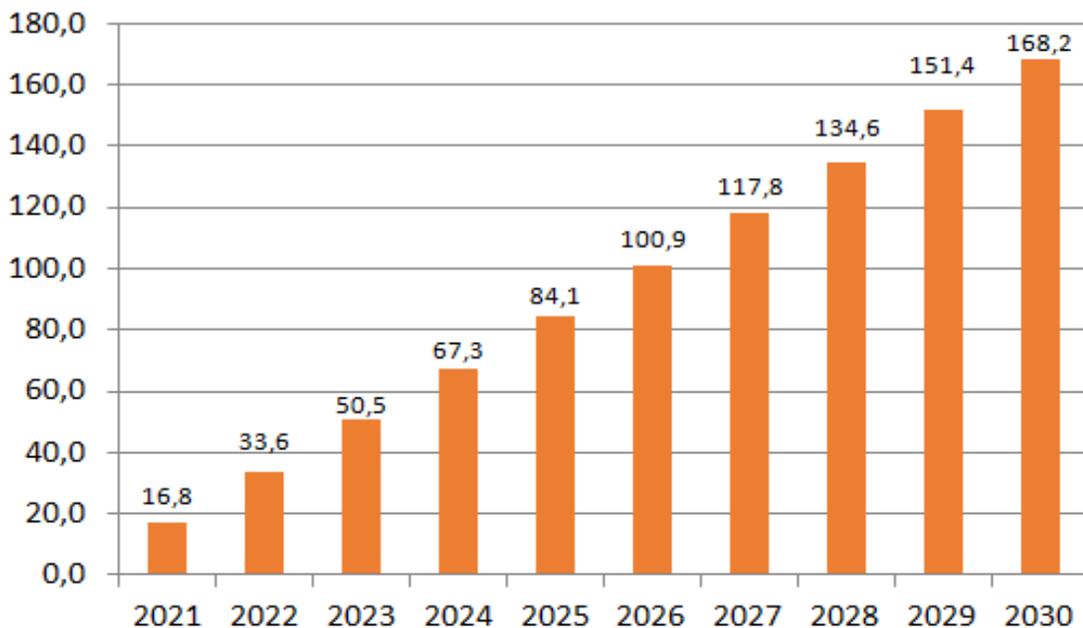


Wohngebäude	Residential buildings
GWh	GWh
Öffentliche Gebäude	Public buildings
Sonstige Gebäude	Other buildings
Bürogebäude	Office buildings

Source: own calculations 2018

Figure 2: Cumulative final energy saving in GWh through renovation of combined residential and non-residential buildings in Luxembourg over the period from 2021 to 2030 (based on the upper fluctuation margin value of a target of 44 % in the area of energy efficiency.)

GWh



Source: own calculations 2018

Figure 3: Cumulative final energy saving in GWh through renovation of public buildings in Luxembourg over the period from 2021 to 2030 (based on the upper fluctuation margin value of a target of 44 % in the area of energy efficiency.)

There is a strategy in place for the further development of the existing building renovation strategy in Luxembourg. This gives particular priority to highly efficient and high-quality renovations. Such highly efficient building renovations make a greater contribution to climate action than merely stipulating the building renovation rates that have been established (Government of the Grand Duchy of Luxembourg, Ministry of the Economy, 2017). Since 2017, therefore, the statutory energy standard for new buildings in Luxembourg roughly corresponds to the level required by the *Passivhaus Standard*. At the same time, the energy renovation of existing buildings is seen as a key element in achieving the efficiency targets.

As part of the national building renovation strategy, the implementation of a national initiative for energy renovation was announced. Since then, a new analysis has been drawn up by Energieinstitut Vorarlberg and the architects Vallentin + Reichmann, who dealt with the further development of the building renovation strategy (Energieinstitut Vorarlberg & Vallentin + Reichmann 2017). The success of the building renovation strategy will be ensured by the interplay between the efficiency strategy (including high quality in terms of energy in new buildings and the renovation of existing buildings) and the phasing out of fossil heating systems by no later than 2050/2070. The national building renovation strategy was submitted in December 2014 pursuant to Article 4 EED (Third National Energy Efficiency Action Plan Luxembourg, 2012).

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

2.3. Energy security dimension

Luxembourg has neither large power stations for generating electricity, nor installations for generating and storing gas. It is therefore largely dependent on energy imports and thus on a functioning European internal market for electricity and gas. Luxembourg is therefore aiming to rapidly achieve an internal

electricity market with intensive cross-border competition between suppliers and tap in to the flexibility potential of consumers. In addition, Luxembourg advocates the further intensification of regional cooperation in the field of energy security in the case of electricity and gas. Further-reaching national measures for guaranteeing energy security in terms of electricity and gas are currently not considered necessary or expedient.

The expansion of renewable energy that is needed to achieve the targets in the areas of renewable energy and decarbonisation will noticeably reduce Luxembourg's dependence on electricity imports. Due to the limited potential for expansion of renewable energy that can be realised, however, domestic energy sources will also be able to make only a limited contribution to Luxembourg's energy security in future. In the field of load flexibility, Luxembourg is aiming to significantly increase the share of consumers actively participating in the electricity market.

2.4. Internal energy market dimension

2.4.1. Electricity interconnectivity

Luxembourg is almost completely reliant on imports to cover its demand for electricity. This is why, even today, it has interconnection capacities that far exceed the 2030 targets in accordance with the Council decision of October 2014. In terms of figures, the interconnection level in relation to the annual peak load is currently approximately 270 %. With the network development projects that are currently planned, this will increase to approximately 400 % in 2030 and should therefore offer sufficient reserves to be able to flexibly manage future increases in consumption in all areas.

2.4.2. Energy transmission infrastructure

In the gas sector, the currently existing transmission network infrastructure is considered sufficient from a long-term perspective, particularly because the decommissioning of the TwinErg power station has considerably reduced peak demand. Further expansion of the cross-border connections is not needed at present. At the same time, the joint gas market with Belgium will be further enhanced.

In the electricity sector, Luxembourg's integration in the European grid interconnection has markedly improved through the commissioning of a phase-shifting transformer and the establishment of a permanent cable connection between the Luxembourg and Belgian transmission networks. This

connection is currently being operated in test mode. As soon as the organisational requirements for inclusion in the capacity calculation in the CWE region have been met, the connection will shift to commercial operation. Luxembourg is endeavouring 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, it is necessary to expand the existing interconnections. The transmission network operator Creos is therefore planning to convert an existing 220 kV interconnection towards Germany to high-temperature conductors by 2020, and to equip/strengthen the 220 kV line towards Germany in the medium to long term. Furthermore, there are also no plans to connect the public Luxembourg electricity grid to the French electricity 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, ignore the impact on other Member States and, at worst, jeopardise energy security.

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 network operator Creos are actively participating in the further development of the internal electricity market in European bodies and institutions.

This places particular importance on the cooperation in the context of the Pentalateral Energy Forum (PLEF), which comprises Belgium, the Netherlands, France, Germany, Austria and Switzerland in addition to Luxembourg. This region, which is closely linked from a technical and economic perspective, has for years been playing a leading role in bringing together the European electricity markets. 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 is striving 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 energy security in Luxembourg.

Compared to Europe, the electricity and gas prices for final consumers in Luxembourg are considerably lower than the European average. However, the share of consumers who change suppliers is relatively low. The aim is to increase this share. 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 switch 95 % of electricity meters to Smart Meters by 2019.

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.

2.4.4. Energy poverty

Luxembourg does not yet have an established definition of energy poverty. Currently, the terminology coined by the Luxembourg Institute of Socio-Economic Research (referred to below as 'LISER') is being used. According to LISER, household customers are affected by energy insecurity when they do not have sufficient means to heat their homes or when they have not been able to pay their electricity, gas, water or heating costs over the past 12 months due to a lack of financial resources.

Luxembourg has a comprehensive policy for tackling poverty in general (minimum wage, social inclusion income (REVIS), etc.). In addition, there is a series of measures in Luxembourg for 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. In this case, the network

operators are obliged to install pre-payment meters in the homes of the affected customers at the request of the supplier(s).

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. In this case, it informs the suppliers in question and deals with processing the payment obligations of the affected customer.

In this regard, and in order to acquire experience of dealing with such precarious situations, My Energy GIE (hereinafter 'myenergy') has launched a support project for low-income households in cooperation with the Ministry of Sustainable Development and Infrastructure, the Ministry of Family Affairs, Integration and the Greater Region and the social welfare offices. The main aim of this project is to better identify the problems faced by these households that are associated with the energy situation and to offer more effective support to these households through the provision of basic information and advice (behavioural advice, investment proposals for energy saving and energy efficiency, etc.). A further aim is not only to offer financial support to the affected households but to combat energy poverty and change or reduce energy consumption over the long term. Based on a checklist drawn up by myenergy, the social welfare offices can assess the situation of the affected households during the first phase. myenergy can then use this checklist to verify the situation together with an energy adviser. In the event that energy-intensive appliances (freezer, washing machine, dishwasher or refrigerator) are identified, the affected household can apply to the responsible social welfare office to receive a public subsidy of 75 % of the price, including value added tax, up to a maximum of EUR 750 per appliance. The social welfare offices can draw up a finance plan with the affected household (for the part that is not subsidised) and help the household to buy a new electrical appliance.

2.5. Research, innovation and competitiveness dimension

Luxembourg is a dynamic country in terms of industrial research, development and technology. In order to be able to make the transition to a low-emission economy, considerable efforts are needed to support technological developments and the research and development of new technologies. The development of research and innovation activities is of decisive importance to the competitiveness of a

country, and the Luxembourg Government is therefore investing considerable financial and organisational resources into these activities.

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 coordinated its national 2020 targets to the core targets of the EU and established a series of measures in its national reform programme (NRP). The NRP is the central contribution of the Member States to the Europe 2020 strategy. Luxembourg's last NRP⁸ of April 2018 explains how Luxembourg will achieve the targets. Implementing an effective research policy for both the public and the private sector is a priority of the Luxembourg Government. For 2020, Luxembourg has set itself an interval of from 2.3 % to 2.6 % of GDP (from 0.7 % to 0.9 % for the public sector) as a national target for research intensity. 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 EUR 23.6 million in 2000 (0.13 % of GDP) to EUR 345.5 million in 2017 (0.67 % 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, energy and environmental technologies. The environmental technologies are among the priorities of Luxembourg's economic diversification strategy. In recent years, 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, intelligent transport systems or ecodesign requirements.

In addition, 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

⁸ <https://odc.gouvernement.lu/fr/publications/rapport-etude-analyse/programme-national-de-reforme/2018-pnr-luxembourg-2020.html>

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 this area in terms of the European networks.

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 report⁹. The ODC monitors the annual reports, including of the World Economic Forum, the Institute for Management Development, the Heritage Foundation and the European Commission. According to the results, Luxembourg is in the top 10 at EU level for the vast majority of the benchmarks analysed.

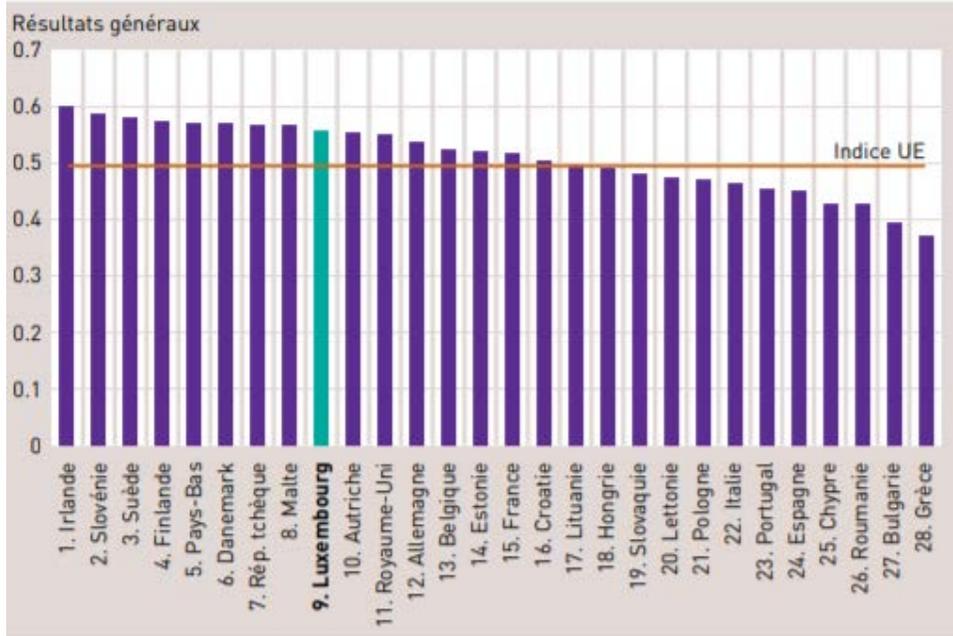
In addition to the international reference values, the ODC has also kept a national 'scoreboard' for competitiveness since 2004, in order to measure and assess Luxembourg's competitive position, the results of which are published in the competitiveness report and discussed with social partners and experts. Since 2017, the ODC has developed a new national 'scorecard'¹⁰, which is a flexible instrument that can be further developed and adapted over time, 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

⁹ https://odc.gouvernement.lu/fr/actualites.gouvernement%2Bfr%2Bactualites%2Btoutes_actualites%2Bcommuniqués%2B2018%2B11-novembre%2B13-bilan-compétitivite-2018.html

¹⁰ <https://odc.gouvernement.lu/fr/statistiques/tableau-bord-compétitivite.html>

among the 'high performance' countries. The result of the national 'scoreboard' confirms the results of the analysed international reference values at EU level.

COURTESY TRANSLATION



Résultats généraux	Overall results
Indice UE	EU index value
1. Irlande	1. Ireland
2. Slovénie	2. Slovenia
3. Suède	3. Sweden
4. Finlande	4. Finland
5. Pays-Bas	5. The Netherlands
6. Danemark	6. Denmark
7. Rép. Tchèque	7. Czech Republic
8. Malte	8. Malta
9. Luxembourg	9. Luxembourg
10. Autriche	10. Austria
11. Royaume-Uni	11. United Kingdom
12. Allemagne	12. Germany
13. Belgique	13. Belgium
14. Estonie	14. Estonia
15. France	15. France
16. Croatie	16. Croatia
17. Lituanie	17. Lithuania
18. Hongrie	18. Hungary
19. Slovaquie	19. Slovakia
20. Lettonie	20. Latvia
21. Pologne	21. Poland
22. Italie	22. Italy
23. Portugal	23. Portugal
24. Espagne	24. Spain
25. Chypre	25. Cyprus

26. Roumanie	26. Romania
27. Bulgarie	27. Bulgaria
28. Grèce	28. Greece

In terms of innovation, it is possible to refer 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 speeding up 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 among the group of innovation leaders, in sixth place (0.611).

3. Policies and measures

3.1. Decarbonisation dimension

3.1.1. Emissions and removals of greenhouse gases

Central, cross-sector policies and measures for achieving the GHG reduction targets by 2030 include introducing a climate framework law, further developing the climate pact with the municipalities, adjusting the taxation of mineral oil products and introducing a package of financing instruments.

Introducing a climate framework law

The 2018-2023 coalition agreement signed in December 2018 provides for the introduction of a climate framework law to strengthen the governance of the national climate policy. Within the context of European governance, this law will make it possible for all relevant stakeholders, levels and sectors to act in a coordinated and integrated manner and allow improved consistency during the implementation.

Further developing the climate pact with the municipalities

Together with the climate pact (see description in Chapter 1.2), Luxembourg has an effective legislative instrument (*Loi modifiée du 13 septembre 2012 portant création d'un pacte climat avec les communes*) to orient and shape communal climate and energy policies. With regard to the further development of the climate pact beyond 2020, as set down in the 2018-2023 coalition agreement, the following approaches have already been identified in cooperation with the stakeholders participating in the implementation: development of a project-related approach, increased participation of citizens and companies, strengthening regional cooperation, adjusting the catalogue of measures, expanding the monitoring, etc.

Environmental legislation

European and national environmental legislation, particularly in the areas of air quality, industrial immission control, waste management and the circular economy, leads to inherent emission reductions of all relevant greenhouse gases.

Adjusting the taxation of mineral oil products (fuels and fuel oil)

In accordance with the 2018-2023 coalition agreement, Luxembourg is planning to adjust the taxation of mineral oil products (fuels and fuel oil) in line with the targets of the Paris Climate Agreement. The first

adjustment will already be taking place in 2019. An interministerial committee (finance, environment, energy, economy) will be tasked with monitoring the sale of fuels, analysing the factors underlying the observed development and monitoring the impact of the new measures proposed by the government. With regard to achieving the climate action targets, the committee should also identify measures for steadily reducing the impact of the sale of fuels on Luxembourg's greenhouse gas balance.

Financing instruments

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 two sources: a proportion of the fuel tax (2.5 euro cents per litre of diesel and 2 euro cents per litre of petrol) and 40 % of the income from the fuel tax.

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, including in the areas of climate action, energy efficiency and renewable energy.

PRIME House climate loan 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 energy renovation of residential buildings, for the construction of sustainable nearly zero-energy buildings and for the use of renewable energy. The support scheme has been extended and amended a number of times since 2001.

In addition to this support scheme, the 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*).

Regarding the reduction in GHG emissions due to energy, which represented a share of around 89 % of GHG emissions outside the emissions trading scheme in Luxembourg in 2016, policies and measures, in

particular to reduce the energy consumption and develop renewable energies, are also necessary. A broad spectrum of corresponding policies and measures is described in further detail in 3.1.2. Renewable energy, 3.1.3. Other elements of the dimension and 3.2. Energy efficiency dimension.

In addition to the 89 % of GHG emissions that are due to energy, agriculture is a further emissions sector, with a share of around 9 % in GHG emissions outside the emissions trading scheme in 2016. The explanations regarding the future policies and measures in the area of agriculture will need to be submitted later, after the decisions, to be prepared together with the Ministry of Agriculture, Viticulture and Rural Development, on the concrete form these will take are in place. The agricultural sector must make its contribution to the fulfilment of the requirements. The size of this contribution will be determined in consideration of the opportunities of an agricultural sector dominated by animal husbandry and will depend on any compensation through the decrease in GHG emissions due to energy.

3.1.2. Renewable energy

Detailed preparation of the package of policies and measures is currently under way. In the area of renewable energy, however, the envisaged package of measures essentially comprises a continuation of the existing framework, partly in connection with streamlining the incentive effect – for instance in the field of RE heat – and making it more ambitious, for example in the field of biofuels, where it is expected that the rate of admixture will be higher in the target scenario than the reference case.

A first pilot call for tenders for large photovoltaic systems in 2018 will be followed by others. Announcements of multiannual calls for tenders are planned from 2020 onwards, and the quantities put out to tender will gradually be significantly increased (20 MW in the pilot). It is also envisaged that additional areas will be admitted. Due to the shortage of land in Luxembourg, this will require a precise analysis. The competent bodies are currently checking the potential along traffic routes (motorways, railways). These analyses must cover various aspects such as environmental protection and landscape protection, existing network infrastructure and commercially viable development by 2030.

In order to achieve the highest possible utilisation of roofs with photovoltaic systems, these should also be supported by means of attractive feed-in tariffs for small-scale systems as well as for cooperative systems. The involvement of concepts of self-sufficiency and energy communities will play a particular role here.

In 2017, Luxembourg became the first EU Member State to conclude cooperation agreements with other Member States: detailed analyses are used to determine the extent to which Luxembourg is reliant on cooperation mechanisms in order to be able to meet the targets regarding RE share in 2020 and continue to adhere to these beyond 2020.

It will not be possible to reach the target achievement corridor of 23 % to 25 % in 2030 with national expansion alone. According to currently determined calculations, the national RE expansion by 2030 would be in the region of 20 %. The shortfall is to be met by cooperation mechanisms. Statistical transfers will continue to play a role. The cooperation should, however, also be further developed and involve specific projects. The specific framework for this transnationally will be Benelux and/or the North Seas Energy Cooperation, but also the Pentalateral Energy Forum (Germany, France, Benelux, Austria, Switzerland).

The possibility of joint calls for tenders with neighbouring countries in relation to photovoltaic capacities will continue to be assessed.

3.1.3. Other elements of the dimension

With regard to low-emission mobility, Luxembourg's policy is based on three main pillars: expanding active mobility, shifting from individual transport to public transport and promoting electromobility. The newly constructed tram in the capital city, the public transport that can be freely used as of 2020, the expansion of the cycle path network, the nationwide expansion of charging infrastructure for electromobility and the financial accompanying measures for supporting electromobility (including the PRIME Car-e support scheme) can be mentioned here by way of example. In this context, the strategy paper 'Modu 2.0 – Strategy for sustainable mobility' was adopted last year.

The future European legal framework for establishing CO₂ 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 to lower-emission mobility.

3.2. Energy efficiency dimension

Future building measures to support energy efficiency in the field of private households and the trade, commerce and services sector

In Luxembourg, the energy saving regulation for residential and non-residential buildings, the support scheme for efficient new buildings and renovation measures and the support scheme for decentralised heating systems, in particular, encourage energy efficiency measures and the transition to RE heating systems.

There will be a continuation or further intensification of existing policy instruments that tighten the requirements or minimum standards for building renovation of existing buildings in the period from 2020 to 2030. This will also be accompanied by a shift in financial support towards higher efficiency standards, thus addressing the depth of the renovations. By contrast, this amendment does not envisage any further policy measures dealing with the renovation rate, since the priority will be on high-quality renovations of existing buildings.

Future measures to support energy efficiency and framework conditions in industry by 2030

Additional energy efficiency measures compared to the baseline development are expected in the form of the increased application of ISO 50001 and obligatory audits for non-SMEs (in the context of the EU Directive on energy end-use efficiency and energy services) and the introduction of energy efficiency networks in Luxembourg (either according to the Swiss model or the more competitive, voluntary German model). There will also be improved advice services through high-quality training of the energy advisers, and increasing offers or acceptance of energy services of the energy suppliers and other suppliers (e.g. contracting companies and financing offers from machine and equipment manufacturers). On account of the depth of knowledge in the matter of energy efficiency among all stakeholders in the economy, in future there will be higher and earlier investments in new, more energy efficiency machines and equipment, even where re-investments are due.

By 2020, the production of the three most energy-intensive product groups (steel, cement, glass) and the rest of the industrial sector will increase considerably in its tonnage on account of the rapid population development and the increasing space for living and services, stagnate in the next five years and then decline slightly between 2025 and 2030 due to saturation effects and high material efficiency.

The growth rates in gross value creation of the three most energy-intensive sectors are still increasing slightly, at 1 % per year, due to the trend for higher material quality (e.g. special cement, steel and glass) and product-related services. The inter-industrial structural change – and thus the structurally determined decrease in the energy intensity of Luxembourg’s industrial sector – will take place in particular after 2020, when the gross value creation of the rest of the industrial sector will increase twice as fast, at over 2 % per year, as that of the three most energy-intensive raw materials.

The rest of Luxembourg’s industrial sector will be affected in particular by the voluntary agreement to make additional energy savings of around 1 000 GWh from 2020 onwards; in other words, an approximate 12 % reduction within 12 years.

Future measures to support energy efficiency in the transport sector

By increasing fuel tax in Luxembourg, savings in the various energy sources of the corresponding vehicles are expected in domestic transport. The level of price elasticity of the corresponding energy sources will determine the saving in demand for the individual energy sources.

Presently, the consumer prices for petrol and diesel are still affordable compared to neighbouring countries (France, Belgium, Germany), which means that a large number of commuters from other countries purchase low-cost fuel in Luxembourg. This effect will diminish when the fuel prices in Luxembourg are increased and the price difference from the neighbouring countries is accordingly reduced. The level of the decrease in fuel exports depends on the assumed price increase.

Depending on the age of the registered vehicles, the existing vehicles in Luxembourg have specific energy consumption and corresponding specific CO₂ emissions (g/km). Continual developments in the field of drives and, for example, in the field of lightweight construction or aerodynamics increase the energy efficiency of corresponding new vehicles.

3.3. Energy security dimension

In the gas sector, the Member States are 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, initial talks were held with the gas transmission system operator Creos, which is involved in initiating the appropriate steps and analyses.

Pursuant to Article 7 of Regulation (EU) 2017/1938 of 25 October 2017, Luxembourg is currently also carrying out risk assessments to ensure the security of gas supply. Current analyses indicate that although Luxembourg's energy security 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, thus 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.

In the electricity sector, the regional cooperation within the PLEF is the most important mechanism for the early recognition of energy security problems, from the perspective of Luxembourg. Luxembourg and the Luxembourg transmission network operator Creos are actively supporting 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, no critical energy security risks can be identified for Luxembourg at present.

At national level, Luxembourg also prepares reports on the status of energy security in terms of electricity and gas supply every two years. These reports not only consider the resource situation, but also investigate whether the network operators in Luxembourg are making sufficient investments in expanding and maintaining their networks.

Relevant network expansion measures are planned at transmission network level, in particular, in the next few years. The financing of projects to safeguard Luxembourg's energy security via grid fees has been secured.

Around 60 % of the final energy used in Luxembourg will be consumed in the transport sector (all figures: Statec 2016). In the transport sector, Luxembourg aims to introduce sustainable mobility in all areas. On the one hand, this includes maximising the shift from individual transport to public transport and, on the other, working towards emission-free mobility. The measures for increasing efficiency and reducing CO₂ emissions that were discussed in Chapter 3.1.3 will also help to improve energy security by

reducing fossil fuels. In the European bodies, Luxembourg also advocates stricter limit values for passenger and heavy goods vehicles, which continue to rely on fossil fuels.

Despite the large number of planned and realised initiatives that aim to make mobility sustainable and free of carbon dioxide in the future, at the moment it is also necessary to ensure in parallel to this that the 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 for this reason 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 came from Belgium, followed by Germany, France and the Netherlands. In terms of energy security, it is important that the diversification of the countries of origin is also maintained in the future.

It is also important for energy security, 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 close to one fifth being handled by rail. The remainder of imports are by ship. 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 corresponding to on average 90 days of 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 are kept either in the regional territory outside Luxembourg or in the rest of 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 need to be modified.

In order to reduce the dependency on oil as far as possible and limit the impact on the environment due to transport, Luxembourg will establish a national strategic framework for market development in relation to alternative fuels in the transport sector and for extending the corresponding infrastructure. The basic idea of this strategy will be that all potential alternative fuels will need to be based on renewable energy.

3.4. Internal energy market dimension

3.4.1. Electricity infrastructure

On account of Luxembourg's high dependency on imports, it already has electricity interconnection capacities that are able to sustainably safeguard energy security. This is particularly apparent from the high load interconnection level, which is significantly above the 2030 targets of the Council decision and is set to further increase by 2030 in line with the planned network expansion projects. Provided that the network expansion and enhancement measures that are currently foreseen are implemented, the network expansion projects that are already planned are thus sufficient for no further measures to be needed to extend the electricity infrastructure.

3.4.2. Energy transmission infrastructure

The decommissioning of the TwinErg gas power plant has considerably reduced the peak demand for gas. In the medium term, it is also not expected that new gas power plants will be commissioned in Luxembourg. The existing gas infrastructure, which has provided for a gas demand for generating electricity, is therefore adequately dimensioned for the current and foreseeable supply needs. 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.

3.4.3. Market integration

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 energy security 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 Schiffflange 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. Luxembourg is aiming to switch the connection, which is currently being operated in test mode, to commercial operation soon and make its transmission capacity available in the CWE region for flow-based market coupling.

As part of the joint market area with Germany, Luxembourg is actively supporting the coalescence of the intraday and balancing markets in Europe and in particular in the CWE and core regions. The transmission network operator Creos is currently conducting a study to investigate how to open up the German and European electricity balancing markets to Luxembourg grid customers. A particular challenge here is the fact that Creos's transmission network is not a separate control area, but is operated in a joint control area with the control area manager Amprion (D). Access to the German and European electricity balancing markets for Luxembourg grid customers offers the potential to stimulate the decentralised production of electricity in Luxembourg and to open up new marketing opportunities for both household and business customers and the industrial sector.

Luxembourg strives to cooperate closely with Germany when designing market rules for scheduled and balancing energy markets. The transmission network operator Creos is currently investigating whether there should be further contractual regulation of cooperation in the joint wholesale price zone, including in terms of the procedure in crisis situations, for example by means of contracts between the network operators or intergovernmental agreements.

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 2019. This would create the conditions, in particular, for the introduction of time-variable tariffs. The decision on the introduction of flexible tariffs must be made by the electricity supply companies and approved by the regulator ILR.

The Luxembourg regulator ILR is currently carrying out a study into the appropriateness of the grid fee system. 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*).

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.

3.4.4. Energy poverty

It should be noted here that there is currently no definition for 'energy poverty' at European level. Luxembourg would welcome a Europe-wide definition and wonders whether the EU Energy Poverty Observatory could tackle this issue and make a concrete suggestion.

The government's planned measure regarding the introduction of free public transport as of 2020 will certainly be helpful to household customers. It should also be stated that the disconnection of household customers who are unable to pay their electricity or gas bills is prohibited under current legislation. Observations on the planned measures in the field of new buildings and energy renovation of buildings will also be examined.

3.5. Research, innovation and competitiveness dimension

In recent years, the Luxembourg Government has made considerable efforts to support technological developments and the research and innovation of new technologies. The 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, smart cities, neighbourhoods and buildings. Existing efforts and skills at the national research institutes should be increased. In addition, the connection between energy policies and the economic development of the country in general should be strengthened.

COURTESY TRANSLATION

4. Current situation and projections with existing policies and measures

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

Further details on this part will be provided when drawing up the final energy and climate plan.

4.2. Decarbonisation dimension

4.2.1. GHG emissions and removals

Table 3 presents the annual greenhouse gas emissions in the period from 2005 to 2016. The values and the definition of the sectors have been taken from the GHG inventory of 2018.¹¹ In accordance with international conventions, the total sum of the LULUCF emissions is not included. In 2016, a total of 10 million t CO₂eq was emitted. This is a 22.9 per cent reduction compared to 2005.

Table 3. Greenhouse gas emissions by sector for 2005 to 2016, in kt CO₂eq

	2005	2010	2011	2012	2013	2014	2015	2016
Energy-related emissions	11 491	10 673	10 550	10 351	9 808	9 320	8 823	8 539
Energy industry	1 243	1 206	1 004	1 043	686	670	458	252
Industry	1 405	1 263	1 240	1 183	1 132	1 143	1 097	1 126
Transport	7 133	6 464	6 838	6 530	6 392	6 086	5 651	5 480
Private households	1 212	1 158	1 061	1 080	1 073	971	1 083	1 051
Trade, commerce and services	418	499	333	440	461	389	476	574
Others*	27	29	27	27	23	24	24	24
Diffuse emissions	53	54	47	48	41	38	35	32
Non-energy-related emissions	1 518	1 494	1 500	1 417	1 419	1 446	1 451	1 490
Industrial processes	725	676	692	633	618	634	628	652
Agriculture	684	720	713	692	709	719	736	752
Waste	109	99	95	92	92	93	88	86
Total	13 009	12 167	12 050	11 768	11 227	10 766	10 275	10 029
For information: LULUCF	-636	-153	-275	-361	-536	-457	-407	-491

* Other emissions relate to combustion in construction and agriculture

Source: GHG Inventory 2018 v1 (March 2018)

For the period 2005 to 2016, the annual greenhouse gas emissions can be broken down by emissions in the sectors subject to the ETS and those in other, non-ETS sectors (illustrated in Table 4).

¹¹ https://cdr.eionet.europa.eu/lu/eu/mmr/art07_inventory/ghg_inventory/envwuz9a/

Table 4. Greenhouse gas emissions by ETS and non-ETS for 2005 to 2016, in kt CO₂eq

	2005	2010	2011	2012	2013	2014	2015	2016
ETS emissions without international air transport	2 603	2 253	2 052	1 990	1 847	1 931	1 661	1 503
Energy-related non-ETS emissions	9 546	9 006	9 082	8 901	8 472	7 928	7 680	7 574
Energy industry	232	201	208	215	221	175	175	184
Industry	472	601	567	561	260	246	236	230
Transport	7 133	6 464	6 838	6 530	6 392	6 086	5 651	5 480
Private households	1 212	1 158	1 061	1 080	1 073	971	1 083	1 051
Trade, commerce and services	418	499	333	440	461	389	476	574
Others*	27	29	27	27	23	24	24	24
Diffuse emissions	53	54	47	48	41	38	35	32
Non-energy-related non-ETS emissions	860	909	916	878	908	920	934	954
Industrial processes	67	90	108	94	107	108	110	116
Agriculture	684	720	713	692	709	719	736	752
Waste	109	99	95	92	92	93	88	86
Total non-ETS emissions	10 406**	9 915	9 998	9 778	9 380	8 848	8 614	8 528
For information: LULUCF	-636	-153	-275	-361	-536	-457	-407	-491

* Other emissions relate to combustion in construction and agriculture

** The total emissions differ from those used to establish Luxembourg's targets for 2020 and 2030 in respect of emissions outside the ETS. This is due to the fact that the inventory is being constantly improved and checked.

Source: GHG Inventory 2018 v1 (March 2018) and EUA EU Emissions Trading System (ETS) data viewer.¹²

Table 4 shows that the non-energy-related GHG emissions represent only about 11 % of all GHG emissions outside the EU emissions trading system.

Table 5 contains projections of the sector-specific developments by ETS and non-ETS for the reference scenario. The results of the projections to the reference development are provisional.

Table 5. Greenhouse gas emissions by ETS and non-ETS for 2020 to 2040, in the event of the reference scenario, in kt CO₂eq

	2020	2025	2030	2035	2040
ETS emissions without international air transport	1 091	1 078	1 025	1 006	985
Energy-related non-ETS emissions	7 754	7 612	7 821	8 047	8 199
Energy industry	178	181	184	186	188
Industry	224	216	207	202	208
Transport	5 611	5 549	5 845	6 168	6 353
Private households	1 167	1 153	1 122	1 059	1 042
Trade, commerce and services	513	449	393	349	321
Others*	26	26	27	27	27
Diffuse emissions	34	38	43	56	60
Non-energy-related non-ETS emissions	926	922	897	889	882
Industrial processes	110	105	79	68	63
Agriculture	730	736	739	738	738
Waste	86	81	79	83	81
Total non-ETS emissions	8 680	8 534	8 718	8 936	9 081
For information: LULUCF	-447	-433	-450	-434	-439

* Other emissions relate to combustion in construction and agriculture

Source: own illustrations, 2019

¹² <https://www.eea.europa.eu/data-and-maps/dashboards/emissions-trading-viewer-1>

4.2.2. Renewable energy

Renewable energy currently plays a significant but comparatively limited part in energy generation in Luxembourg. However, as shown by the reference scenario in the context of Section 2 of this report, this can and should change significantly in the coming years, making it a consistent continuation of the trend that has been set in the recent past. 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 generation and demand.

Status quo of renewable energy use in Luxembourg

Recent years have seen considerable growth in renewable energy such as biomass, wind energy and photovoltaics, being the core technologies in the field of electricity generation for Luxembourg. In the space of a decade, their contribution has doubled – both in the electricity sector (from 3.2 % in 2005 to 6.7 % in 2016) but also in terms of heat production (from 3.6 % in 2005 to 7.3 % in 2016). 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: although the RE share was marginal in 2005 (0.14 %), Luxembourg today (2016) has an RE share of 5.9 %.

Reference development in the event of a continuation of existing measures

A reference development for the period up to 2040 is presented below, specifically the expected development in the event of a continuation of existing measures, both in terms of supply and demand.

The RE 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 accordingly increase from 5.4 % in 2016 to 12.9 % by 2030, and finally to 13.5 % in 2040.

Table 6 provides information on the sectoral decomposition of the overall balance and Table 7 provides supplementary details on the potential underlying technology split. Compared to the target scenario with the upper fluctuation margin value 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 RE technologies. Accordingly, a massive 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 a share of 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 additionally 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 RE share in the reference scenario will increase from 6.7 % in 2016 to 18.6 % by 2030 and finally 21.9 % in 2040. Both grid-connected (in line with electricity generation in biomass cogeneration plants) and decentralised biomass use play a considerable part here. At decentralised level, heat pumps and solar thermal collectors will also be increasingly used to supply hot water.

Table 6. Sectoral shares of renewable energy in Luxembourg by 2030 according to the reference scenario (source: own illustrations, 2019)

RE shares, sectoral		<u>2016</u>	<u>2020</u>	<u>2025</u>	<u>2030</u>	<u>2035</u>	<u>2040</u>
RE share electricity sector	%	6.7 %	11.9 %	19.4 %	26.5 %	31.3 %	34.7 %
RE share heat sector	%	7.3 %	12.1 %	15.4 %	18.6 %	20.4 %	21.9 %
RE share biofuels	%	4.6 %	5.4 %	8.1 %	8.2 %	5.8 %	5.6 %
RE share transport sector	%	5.9 %	-	-	14.9 %	-	-
RE share, total (of gross final energy demand)	%	5.4 %	7.8 %	11.2 %	12.9 %	12.8 %	13.5 %

Table 7. *Technology-specific energy generation from renewable energy in Luxembourg by 2030 according to the reference scenario (source: own illustrations, 2019)*

Energy generation, technology details		<u>2016</u>	<u>2020</u>	<u>2025</u>	<u>2030</u>	<u>2035</u>	<u>2040</u>
Electricity sector							
Biogas	GWh	74	56	65	68	63	62
Biomass	GWh	67	192	228	271	260	267
Hydroelectric power	GWh	104	93	97	100	104	107
Photovoltaics	GWh	100	251	476	616	687	729
Wind energy	GWh	127	161	383	676	958	1 167
RE electricity, total	GWh	473	752	1 249	1 731	2 071	2 332
Heat sector							
Biomass & biogas, grid-connected	GWh	155	589	623	667	649	656
Biomass, decentralised	GWh	706	883	1 145	1 383	1 522	1 560
Solar thermal energy	GWh	23	58	113	188	302	453
Heat pumps	GWh	48	95	190	224	226	227
RE heat, total	GWh	932	1 626	2 070	2 462	2 699	2 896
Transport sector							
Biofuels, total	GWh	1 012	1 237	1 892	1 993	1 450	1 450
RE energy use, total	GWh	2 416	3 614	5 211	6 187	6 221	6 679

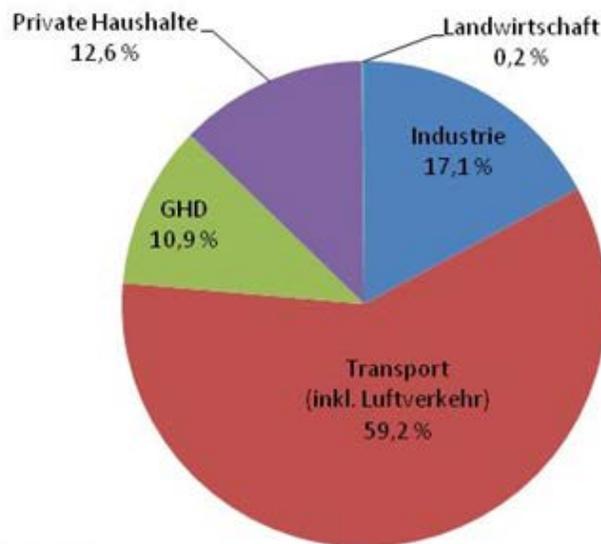
In unison with electricity and heat, a massive increase in the use of renewable energy is also expected in the transport sector in the reference case. In this case, specifically, it is assumed that there will be an increase in the admixture of biofuels (at an admixture rate of around 8 % in 2030). In 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, a increase of the RE share in the transport sector, to 14.9 %, will be achieved by 2030 in the reference case.

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, at 59 %, is accounted for by the transport sector (Figure 4). The majority of this amount, at 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, around 12 % of the total final energy demand is accounted for by air transport. In other words, domestic road transport accounts for a share of around 13 % in Luxembourg’s final energy demand. While the agricultural sector has the lowest share in the final energy demand, at around 0.2 %, the industrial sector requires the greatest share of energy in Luxembourg, at over 17 %.



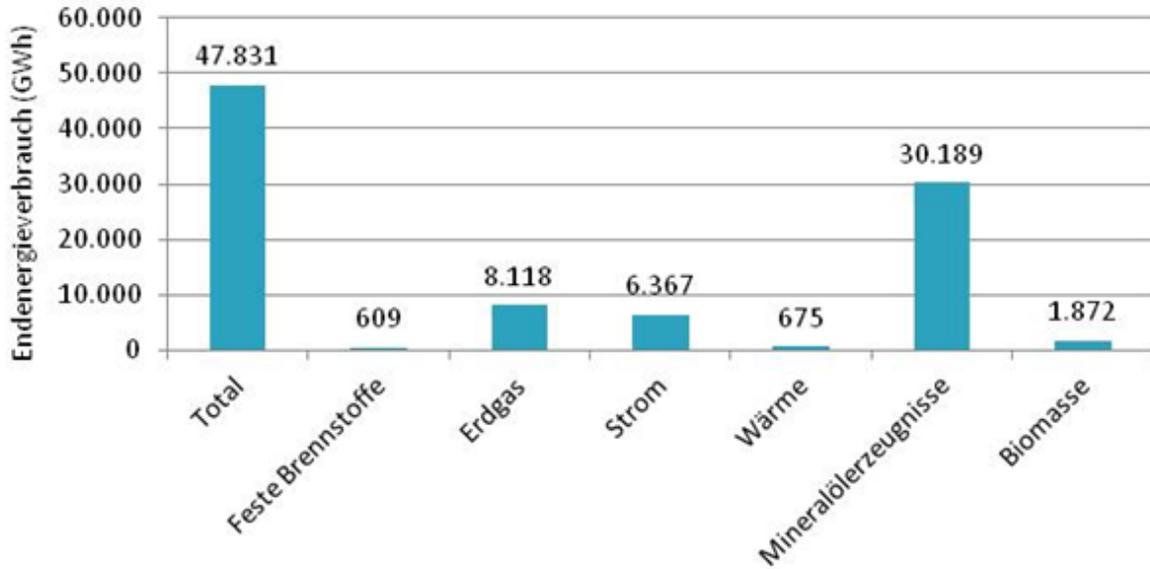
Endenergiebedarf gesamt
in 2016: 47.831 GWh

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 4: Luxembourg’s final energy demand in 2016, broken down by industrial, private household, trade, commerce and services, transport and agricultural sector

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 %). Added to this were solid fuels at 1 % and heat (2 %) (cf. Figure 5).



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

Existing potential for using highly efficient cogeneration and efficient district heating and cooling

In 2015, just under 326 GWh of electricity and 527 GWh of heat were generated 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)

There is further potential for the highly efficient use of cogeneration in the areas 1) decentralised cogeneration plants in buildings, 2) use of cogeneration in industry and 3) heating network supply and central cogeneration plants.

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 thus 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 unused 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 tapped 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 8). 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 necessary. (Klobasa, Steinbach & Pudlik 2016)

Table 8: Additional potential for the cogeneration of heat in industry by 2030 based on final energy use in industry

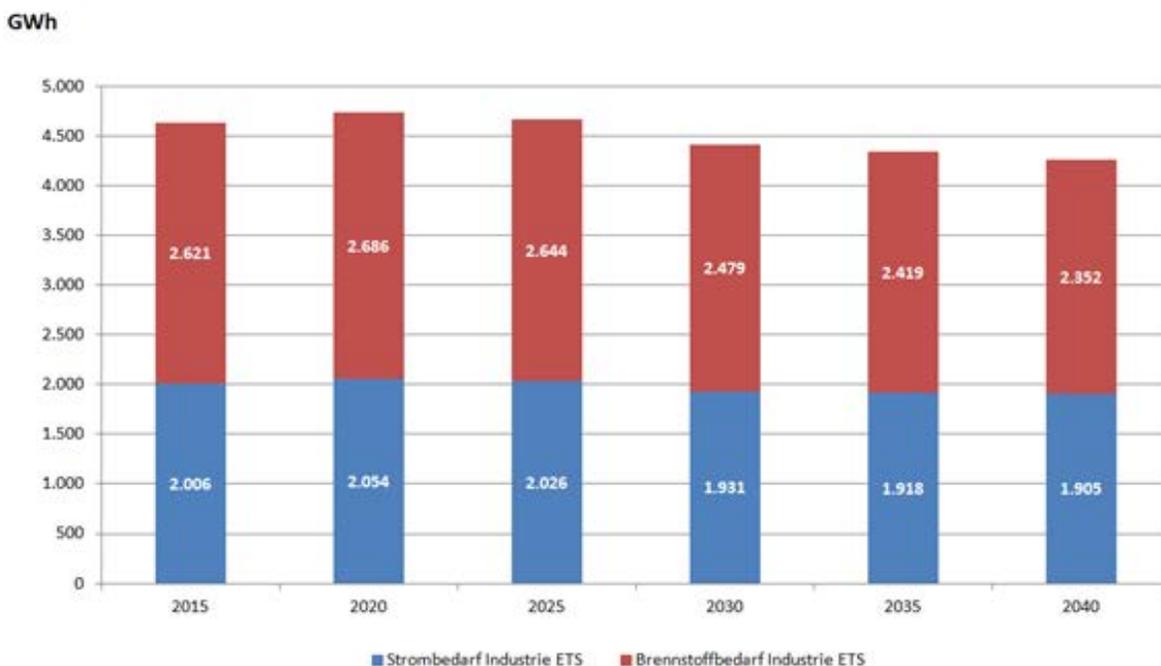
Sector	Fuel demand in GWh		Cogeneration suitable (<500 °C) in GWh		Cogeneration existing in GWh	Expansion potential in GWh
	2014	2030	2014	2030		
Steel	1 670	1 422	67	57		
Stone/earth	1 094	589	164	88		
Chemistry	319	295	316	292		210
Textiles	226	208	226	208		
Timber	274	253	274	253	65	150
Food	61	57	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 private household, trade, commerce and services, industrial and transport sectors contribute to Luxembourg's total final energy demand. 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 (business as usual), the final energy demand of Luxembourg's non-ETS sector will rise by 13.2 % in the period from 2015 to 2040; from just under 39 TWh per year to around 44 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 13.2 % 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 around 10.9 TWh).

In parallel to this, the electricity demand of the non-ETS sector of industry will sink to around 1.9 TWh in 2040 following a slight increase of 100 GWh (- 5 %). At the same time, the fuel required by non-ETS industry will likewise decrease by over 10 % to approximately 2.4 TWh following a slight increase of 2.6 TWh.



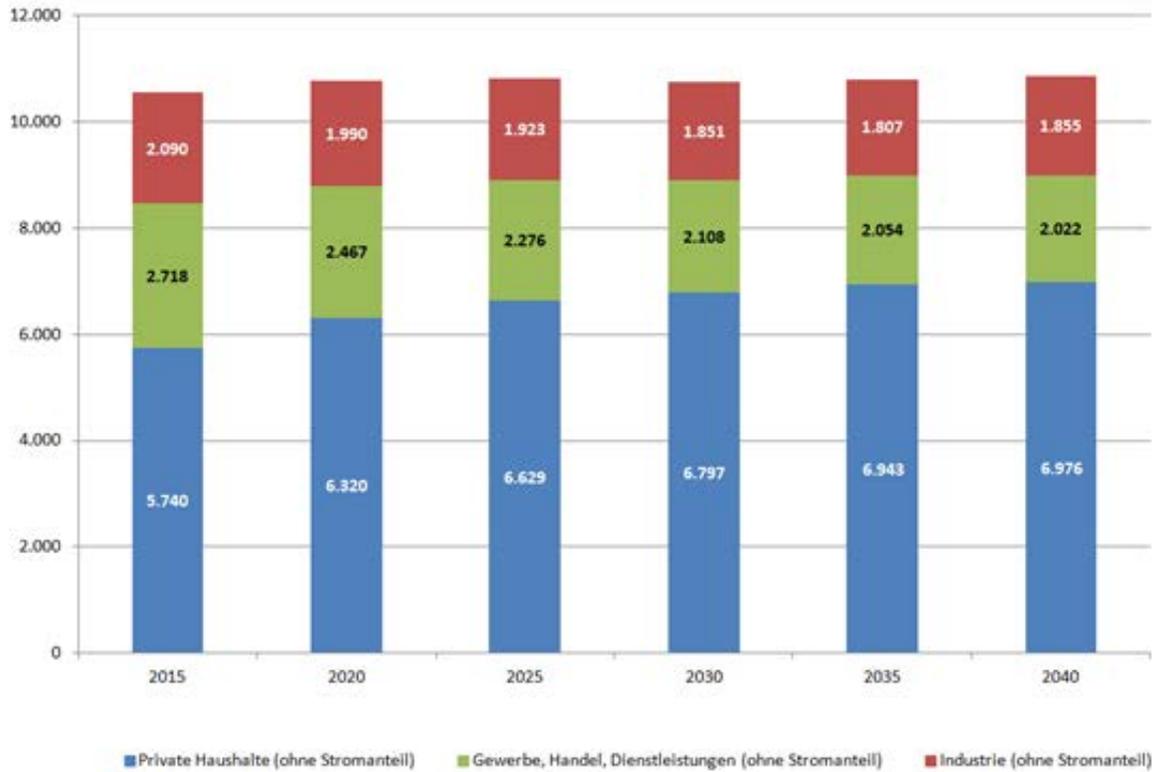
GWh	GWh
Strombedarf Industrie ETS	Electricity demand industry ETS
Brennstoffbedarf Industrie ETS	Fuel demand industry ETS

Source: own illustration 2018

Figure 6: 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 (without an electricity part) in the non-ETS sector shows a slight increase of 2.9 % overall over the entire study period (+ 0.9 % compared to 2030). This is based on the increased use of wood and other fuels, while there is a significant drop in the use of the fossil energy sources natural gas, fuel oil and coal. This increase in the final energy demand for heat generation is due exclusively to the 'private 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 3 % in the period from 2030 to 2040 (see Figure 7). In contrast to private households, the sectors 'trade, commerce and services' and 'industry' show a greater or lesser decline, of just under 26 % and over 11 %, respectively, in the use of final energy for heat generation in 2040 compared to 2015 (see Figure 7). The final energy demand in the transport sector, which will see strong growth by 2040 and 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 compared to 2015) and diesel (+ 1.8 TWh compared to 2015) (see Figure 8). In the same period, biofuels will see an absolute increase of just under 0.5 TWh.

GWh

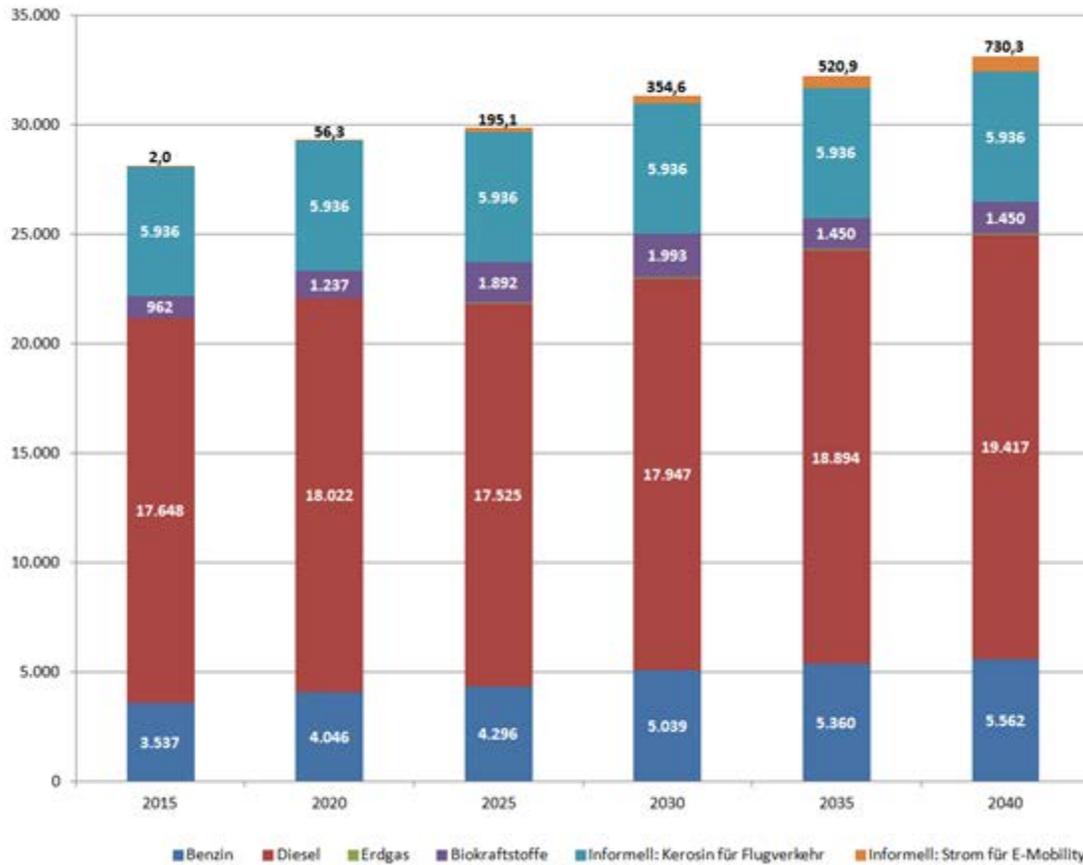


GWh	GWh
Private Haushalte (ohne Stromanteil)	Private households (without electricity part)
Gewerbe, Handel, Dienstleistungen (ohne Stromanteil)	Trade, commerce, services (without electricity part)
Industrie (ohne Stromanteil)	Industry (without electricity part)

Source: own calculations 2018

Figure 7: Sectoral development of the fuel required for heat generation by private households, trade, commerce, services and industry (without ETS part) in the period from 2015 to 2040 in the event of the reference scenario

GWh



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 2018

Figure 8: 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

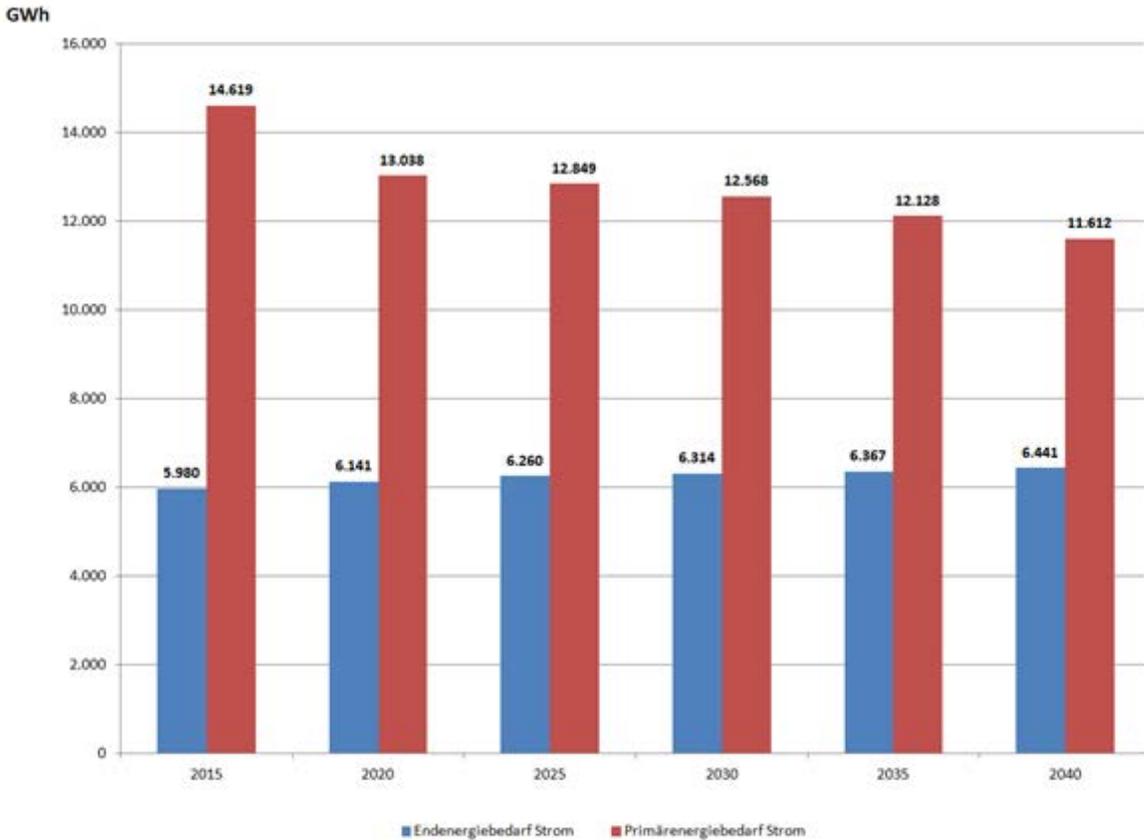
Table 9 below gives a brief overview of common primary energy factors. With the exception of electricity, the primary energy demand and the final energy demand are identical, due to a primary energy factor of 1.0. Therefore, separate designation of the primary energy demand is dispensed with here. Figure 9 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 generation 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 digitisation, more applications of electricity, etc.). At the same time, the primary energy demand for electricity generation will sink by well over 20 % (see Figure 9).

Table 9: 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



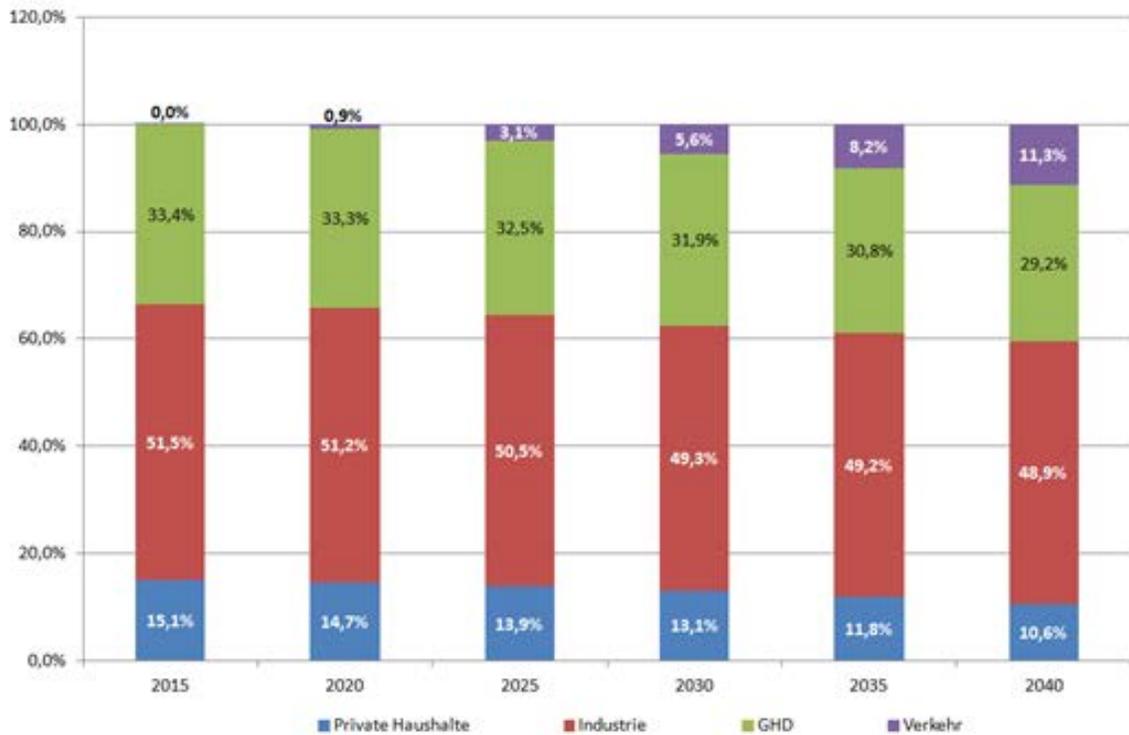
GWh	GWh
Endenergiebedarf Strom	Final energy demand electricity
Primärenergiebedarf Strom	Primary energy demand electricity

Source: own calculations 2018

Figure 9: 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, private households, industry or the transport sector. While the share of the transport sector in the total electricity demand will considerably increase by 2040 compared to 2015 (share of transport 2040: approximately 12 %), the shares of the remaining sectors (trade, commerce and services, private households, industry) will decrease to a greater or lesser extent (see Figure 10). 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 private 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 electromobility (+ 0.7 TWh).

GWh



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

Source: own calculations 2018

Figure 10: 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, including when compared to Europe. The average outage duration per point of use and per year was 21.8 minutes in 2017¹³.

¹³ ILR, *Chiffres Clés du Marché de l'Électricité, Année 2017 - Partie I*

Gross electricity production

The data on gross electricity production based on gas-powered, small-scale cogeneration plants in the past were gathered from the monitoring conducted by ILR¹⁴. The expected electricity production from gas was updated to 220 GWh/year in accordance with the status quo. Other data are from the baseline scenario.

[GWh]	2016	2020	2030	2040
Biogas	74	56	68	62
Gas	220	220	220	220
Biomass/biowaste	67	192	271	267
Water (without pumped-storage power plants)	104	93	100	107
Wind	127	161	676	1 167
PV	100	251	616	729
Total	692	973	1 951	2 552

Table 10: Gross energy production in Luxemburg by 2040

Source: Baseline 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 baseline scenario.

¹⁴ ILR, *Chiffres Clés du Marché de l'Électricité, Année 2017 - Partie I*

Import dependency

The import dependency is the result of gross electricity consumption minus domestic production. Table 11 shows the projections regarding gross electricity consumption, both in ktoe and TWh¹⁵. Since it is expected that there will be a considerable increase in RE production in Luxembourg by 2040, with only a minor increase in gross electricity production, the import dependency would accordingly reduce from just under 90 % in 2015 to 60 % in 2040. Luxembourg mainly imports electricity from Germany, at over 75 %.

	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 generation [TWh]	0.69	0.97	1.95	2.55
Import dependency [%]	89 %	84 %	69 %	60 %

*Table 11: Electricity import dependency of Luxembourg
Source: Own calculations based on ILR and baseline scenario*

Relevant risks

Provided that the projections on domestic electricity generation are correct, Luxembourg's dependence on energy imports over the long term will be lower than it is today, although still high. The energy security in Luxembourg therefore also depends on the energy security in the rest of Europe. There are currently various studies that draw conclusions on the energy security not only of specific countries but of the entire model region. Since Luxembourg's energy security depends in particular on the available generating capacities of neighbouring countries, this approach can also be used to directly predict Luxembourg's energy security. This involves mapping probabilities, including the availability of renewable energy generating plants, 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. For France and Belgium, in particular, the situation continues to appear highly critical. When comparing the results of these studies, no considerable energy security risks are expected for Luxembourg over the short term up to around 2020. In the long term,

¹⁵ In principle, the EU Commission templates stipulate ktoe as the unit.

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 energy security situation in the region as a whole could become more critical during this time than it is at the moment. 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 energy security, such as 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 (the first auctions in Belgium are due to begin in 2021 in preparation for the decommissioning of nuclear energy power plants at the end of 2025). 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, but rather 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 level of the import 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 market¹⁶.

¹⁶ ; ILR, *Chiffres Clés du Marché du gaz naturel, Année 2017 - Partie I*

	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 %

Table 12: Gas import dependency of Luxembourg
Source: Creos; Creos's projection as of 2030 updated to 2040.

Relevant risks

The high import dependency means that Luxembourg's energy security 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 sufficient gas storage capacities in principle 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, uninterrupted capacities. According to Creos, however, it is possible that these capacities may need to be booked again in the event of changes to gas demand in order to safeguard energy security.

In order to additionally minimise the risk of supply bottlenecks, 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, uninterrupted capacities at the Belgian border were also considerably increased to their maximum technical availability. As a result, the uninterrupted capacities will considerably increase and Luxembourg's energy security will be safeguarded on a sustainable basis without needing to expand the grid.

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 energy security 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 energy security as part of 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 grid 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 grid, 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. Test operation is currently under way. At the same time, unanswered questions on the commercial use of the phase-shifting transformer are being clarified, however it is planned to start commercial operation soon in close consultation with the neighbouring transmission network operators and regulatory authorities. In isolation from the issue of marketing, the stronger connection to the Belgian supply network is already contributing to increased energy security.

Creos envisages the following network expansion and enhancement measures:

- Continuously replacing existing lines with high-temperature conductors (HTC).
- Equipping/strengthening the 220-kV line towards Germany in the medium to long term, with a prospective maximum increase of around 2 600 MW in nominal transmission capacity.

Interconnection level

- Three different calculations are used to determine the interconnection level. This involves relating the (n-0) interconnector capacity to the
 - peak load
 - total installed generating capacity
 - total installed generating capacity from RE

The relationship to the total installed generating capacity corresponds to the definition of interconnection level on which the EU's 10 % interconnection target for 2020 is based. The Governance Regulation, by contrast, provides for several criteria for measuring the interconnection level, including the relationship to peak load and installed generating capacity from RE.

Regardless of the specific definition of the interconnection level, however, Luxembourg exceeds both the 2020 and 2030 targets many times over.

	2016	2020	2030	2040
Interconnector capacity [MW]	3 130	3 130	6 546	6 546
Peak load [MW]	1 150	1 220	1 620	2 020
Generating capacity Total [MW]	390	565	1 225	1 600
Generating capacity RE [MW]	290	465	1 125	1 500
Interconnection level load [%]	270	255	405	325
Interconnection level gen. [%]	805	555	535	410
Interconnection level RE [%]	1 080	675	580	435

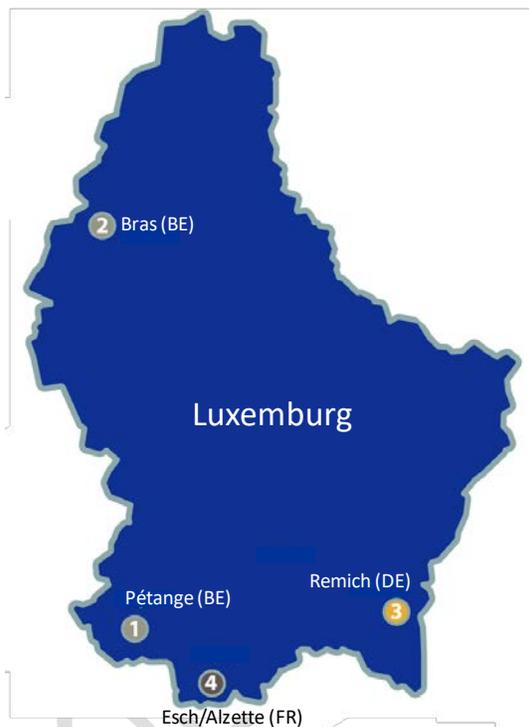
Table 13: Luxembourg's interconnection level.

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

4.5.2. Energy transmission infrastructure

Analysis – gas

Luxembourg currently has network interconnection points to all three of its neighbouring countries, which are shown in Image 4.5.2.1. 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 minor extensions of the secondary lines are planned presently and in the future. Therefore, no considerable changes to the aggregated pipeline lengths are expected in the coming years.



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

Image 4.5.2.1: Cartographic representation of Luxembourg's supply situation

Source: Creos

Table 14 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.

[Nm ³ /h]	2017	2020	2030	2040
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

Table 14: Existing and future capacities of the network interconnection points.

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 active¹⁷.

¹⁷ ILR, *Chiffres Clés du Marché de l'Électricité, Année 2017 - Partie I*; ILR, *Chiffres Clés du Marché du gaz naturel, Année 2017 - Partie I*

The current electricity and gas prices for end customers 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 customers, such as annual consumption, voltage level, etc.
- The gas price in Luxembourg for an average-sized household was €13.77/GJ (or 13.3 (€₁₃/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.

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

Table 15: *Development of electricity and gas prices for end customers.*
Source: Primes Reference Scenario, own calculations.

4.6. Research, innovation and competitiveness dimension

Further details on this part will be provided when drawing up the final energy and climate plan.

5. IMPACT ASSESSMENT OF THE PLANNED POLICIES AND MEASURES

This chapter will be finalised in 2019 when drawing up the final energy and climate plan.

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