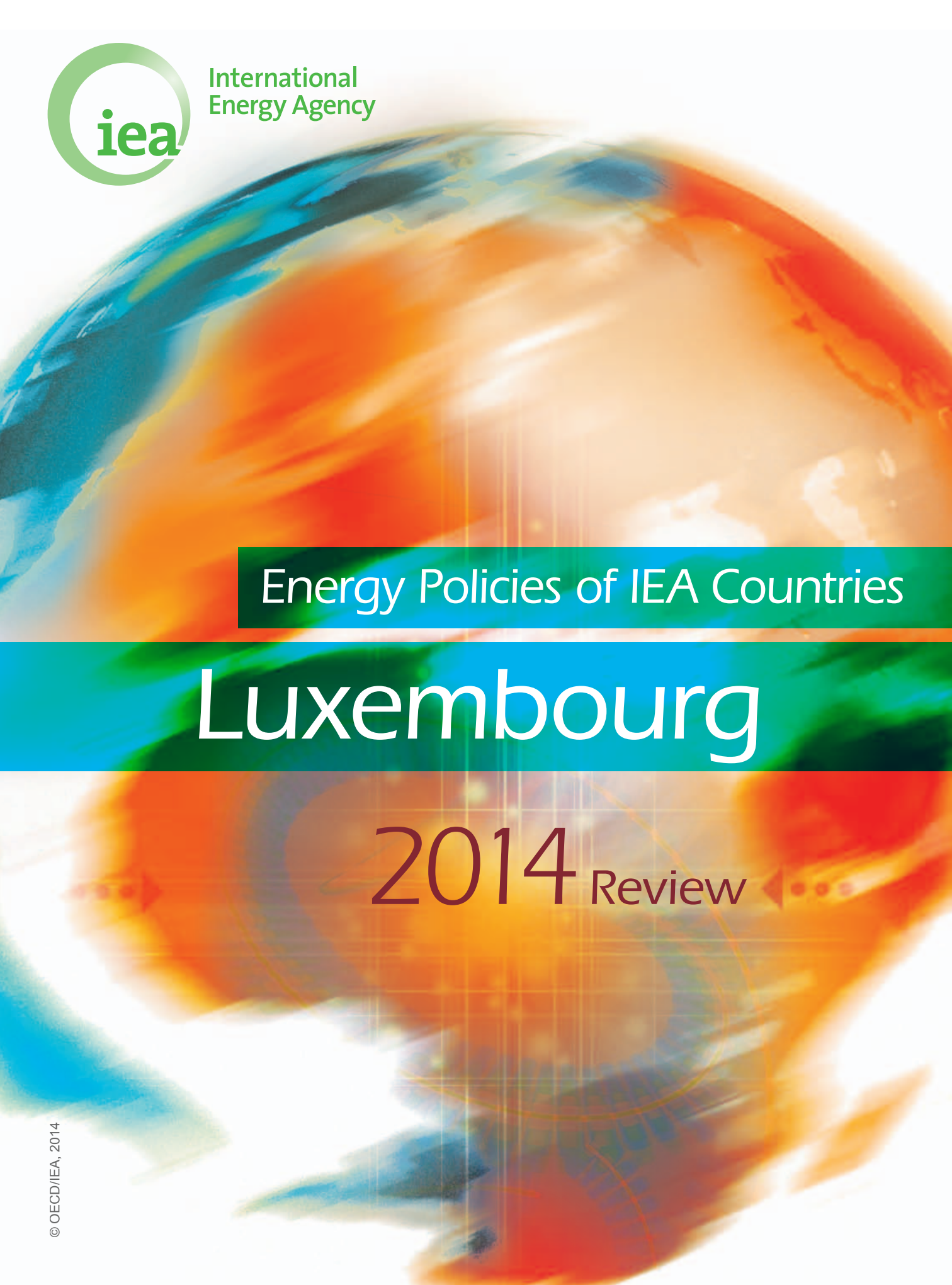

International Energy Agency

Energy Policies of IEA Countries

Luxembourg

2014 Review

INTERNATIONAL ENERGY AGENCY

The International Energy Agency (IEA), an autonomous agency, was established in November 1974. Its primary mandate was – and is – two-fold: to promote energy security amongst its member countries through collective response to physical disruptions in oil supply, and provide authoritative research and analysis on ways to ensure reliable, affordable and clean energy for its 29 member countries and beyond. The IEA carries out a comprehensive programme of energy co-operation among its member countries, each of which is obliged to hold oil stocks equivalent to 90 days of its net imports. The Agency's aims include the following objectives:

- Secure member countries' access to reliable and ample supplies of all forms of energy; in particular, through maintaining effective emergency response capabilities in case of oil supply disruptions.
- Promote sustainable energy policies that spur economic growth and environmental protection in a global context – particularly in terms of reducing greenhouse-gas emissions that contribute to climate change.
- Improve transparency of international markets through collection and analysis of energy data.
- Support global collaboration on energy technology to secure future energy supplies and mitigate their environmental impact, including through improved energy efficiency and development and deployment of low-carbon technologies.
- Find solutions to global energy challenges through engagement and dialogue with non-member countries, industry, international organisations and other stakeholders.

IEA member countries:

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The European Commission also participates in the work of the IEA.

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1. EXECUTIVE SUMMARY AND KEY RECOMMENDATIONS

EXECUTIVE SUMMARY

Since the 2008 in-depth review, Luxembourg has made progress towards strengthening its energy supply security, developing sustainable energy supplies and integrating its markets into the Central-West European (CWE) region. Luxembourg promotes a resource-efficient energy supply and made eco-innovation and clean energy technologies priorities for research and development. As the smallest International Energy Agency (IEA) member country with the highest income per capita in the Organisation for Economic Co-operation and Development (OECD), Luxembourg is well placed to continue its development towards a sustainable and innovative economy at the heart of the European energy market.

In line with the IEA recommendations, in 2009 the government launched a white paper process to develop a new national energy strategy which was discussed with stakeholders. In addition, new initiatives, such as the *Climate Pact* with municipalities and the *Second Action Plan on CO_2 Reduction,* which includes 51 measures based on the *Environment and Climate Partnership,* were launched. Efforts are being made to diversify fuel use in the domestic transport sector and promote public transport; and deployment of alternative fuels and fuel infrastructure, notably electric vehicles, are among the measures set out in the *Global Mobility Strategy* and the *Transport Sector Plan.*

Luxembourg has challenging targets to reduce greenhouse gases (GHG) by 28% below 1990 levels during the period 2008-12 under the Kyoto Protocol, in line with historic emissions reductions in industry. This is the highest target of a European Union (EU) member state and is complemented by the aim to reduce carbon dioxide (CO_2) emissions outside the European Union Emissions Trading Scheme (EU-ETS) sectors by 20% by 2020, compared to 2005 levels. Overall GHG emissions decreased by 8.2% since 1990 and energy-related CO_2 emissions remain stable since 2008. Luxembourg is committed to increase the share of renewable energy to 11% of final consumption and to 10% in the transport sector. With regard to energy efficiency, the country works towards energy savings of 14.06% by 2016 and 20% by 2020 compared to 2007 levels. The country envisages meeting its Kyoto target through flexible mechanisms and has already set aside the needed financial reserve, the *Climate and Energy Fund,* which is mainly formed by the *Kyoto cent*, an environmental tax on road fuel sales.

Commendably, the government makes security of oil, gas and electricity supply a priority. Progress on shaping energy security policies is under way: the national oil stockholding regime has been revised, an electricity interconnector to France came online and the regional integration of the gas market with Belgium is progressing thanks to the planned merger of the Belgian and Luxembourg balancing zones. Market integration has been strong since 2008. Luxembourg actively supports regional market integration and now benefits from the wider price coupling in the North-West Europe (NWE) region, which was extended to South-West Europe (SWE).

Since 2008, the government has reinforced the institutional framework governing its energy and climate policies, notably through the creation in 2009 of a dedicated national energy agency, *Myenergy,* and the reform of its energy statistics to consolidate the energy sector data collection at the national statistical office STATEC. In the area of energy efficiency, the government is to be commended for the strong progress, notably in the buildings sector. Energy efficiency ambitions are set for 2016 and up to 2020 under the EU Energy Efficiency Directive. Energy performance standards were strengthened over time for both residential and non-residential buildings; investment aid for renovation of residential buildings is depending on conformity with these standards. A voluntary agreement with industry was reached to save 7% of energy during 2011-16, which is monitored by *Myenergy*. These are major achievements.

Considerable challenges remain to be addressed by 2020 if the government wants to succeed towards the objective of secure, sustainable, competitive and affordable energy.

Emissions in the transport sector are on the rise and their reduction remains most challenging. The increase in emissions is linked to the growing number of cross-border commuters and to the significant volumes of fuel sold to non-residents, encouraged by the differences between taxation in neighbouring countries. These duties account for around 10% of the State budget.

The share of renewable energies in final energy consumption increased at a slow pace, rising from 1.4% in 2006 to 2.9% in 2011. Luxembourg is on track to meet the EU intermediary target set out in the national action plan. Among IEA member countries, Luxembourg has the third-lowest share of renewable energy in total primary energy supply with 4.5% and expects its domestic contribution to remain small. Efforts to engage with EU member states on the use of co-operation mechanisms under the EU Renewables Directive 2009/28/EC have so far not materialised.

Energy security is of crucial importance to Luxembourg's energy policy, as the country has little domestic energy production and imports nearly all its needs in oil, gas and electricity. Luxembourg is dependent on single fuel types to meet its transport and heating needs, oil products and gas respectively, which exposes the country to energy security risks as well as environmental challenges. The next decade is likely to bring new challenges. The price coupling of the CWE and NWE market areas in 2014 contributes to the further integration of Luxembourg in the wider market area and provides an opportunity to strengthen its energy market.

The Grand Duchy intends to meet its renewable energy and climate targets mainly through efforts at EU and international levels. Beyond 2020, the government needs to set out ambitions and contribution to a secure and sustainable energy system in the European Union for 2030. Given the regional integration of its gas and electricity markets, Luxembourg is likely to be impacted by the decarbonisation policies of neighbouring countries, as it imports most of its energy needs. Notably the German *Energiewende* and capacity constraints in southern Germany may point to the need to strengthen Luxembourg's security of supply by fostering indigenous resources, including renewable energies, and align its climate and energy policies with regional neighbours.

Looking ahead, the country should seize opportunities for promoting a smart and green economy, competitive retail markets, smart transport and mobility solutions, and regional integration of the short- and longer-term electricity markets, with a view to maximising energy security benefits while minimising costs to consumers.

SHAPING PROGRESS

TOWARDS A SMART AND GREEN ECONOMY

Luxembourg has seen strong economic growth and reports the highest income per capita in the OECD, factors which attract workers from other European countries and contribute to growing population, energy consumption and construction of new buildings. With its purchasing power, Luxembourg has a good potential to develop into an innovative and smart green economy up to 2020, going well beyond its small size.

A sustainable economy is an essential objective for the economic and social benefit of Luxembourg. During the first Kyoto commitment period (2008-12), emission mitigation focused on international efforts. Up to 2020, substantial emissions reductions will need to be achieved outside the EU-ETS sector, notably in transport, while the future use of Kyoto flexible mechanisms is likely to be limited. The *Kyoto cent* and the *Energy and Climate Fund* have proven to be successful instruments. While maintaining the oil industry as an important sector for the economy, Luxembourg should rebalance the economic benefits against the environmental cost of fuel sales to non-residents and consider increasing the *Kyoto cent* on road fuel. The government should prioritise the actions set out in the *Second Action Plan on CO_2 Reduction* with a view to scale up renewable energy, energy efficiency and other decarbonisation solutions to come forward in meeting its 2020 targets. As the seat of several EU and international institutions, Luxembourg City has a large amount of public buildings and cross-border commuters. Energy efficiency in public buildings, emissions reduction in the transport sector and eco-innovation should be key priorities.

Since the last in-depth review, the government has demonstrated its commitment to attain these objectives. Research and innovation programmes are now available in the energy field to support eco-innovation and ambitions are set on clean energy technologies. In 2011, the government had allocated 31% of its total research, development and demonstration (RD&D) budget of EUR 79.67 million to energy. Moreover, Luxembourg was able to triple its energy RD&D spending from EUR 24.65 million in 2011 to EUR 71.4 million in 2012, ranking the highest among IEA member countries in terms of government spending on energy research and development (R&D) as a ratio of gross domestic product. This marks strong progress.

The government can foster its ambitions on clean energy technologies by reinforcing its institutional capacities for international outreach and co-operation. Engaging within the IEA Technology Co-operation networks on priority matters, like transport and smart energy systems, can add value to the energy RD&D policy. The plan of setting up a green investment bank in Luxembourg can be successful if project sizes are enlarged, for instance through international co-operation within EU programmes, such as the ELENA programme (European Local ENergy Assistance) of the European Investment Bank, which focuses on the financing of local initiatives for sustainable development, with priority on energy efficiency in buildings.

TOWARDS SECURE ENERGY SUPPLIES

Luxembourg's energy security is strongly linked to the market dynamics in the Benelux and wider CWE region. Open and competitive energy markets are the best guarantee to

ensure security of supply, supported by well-designed emergency responses and security policies for oil, gas and electricity, co-ordinated at regional level in a more and more integrated EU energy market. In 2014, the IEA completed the emergency response review of Luxembourg on oil, gas and electricity, and its findings have been reflected in this in-depth review.

Oil consumption in the transport sector has been on the rise to account for 88% of oil products, all of which are imported via a diverse range of routes and modes, including road, rail and ship. Luxembourg ensures its oil supply security by holding national oil stocks, but given the limited storage capacity, the majority of its IEA oil stockholding obligation is met through holdings abroad. Increasing fuel sales entails rising imports and stockholding needs. However, permits for two-thirds of the domestic oil storage capacity in Luxembourg are to expire by 2019. The government has presented the draft law on the organisation of the oil product markets, including the creation of a national stockholding agency, transposing EU Directive 2009/119/EC, which is expected to be adopted in 2014. Looking ahead, it is important to swiftly approve and implement the new stockholding regime, to help secure the renewal of oil storage capacity in the country or within geographic proximity.

Equally, dependence on gas imports is on the rise as natural gas plays a larger role in the heating (and power) sectors; and thus the natural gas grid has been expanded. Imports are predominantly sourced from Germany and Belgium. There is no domestic storage. Luxembourg is unable to meet peak demand if the largest gas infrastructure, the entry point from Germany, is not available to the system. Despite the fact that Luxembourg has an exception from this N-1 rule of EU regulation 994/2010, co-operation with neighbouring grid operators and the diversification of heating fuels and supply routes remains important. The planned merger of the gas balancing zones of Belgium and Luxembourg secures diverse gas supplies.

Luxembourg imports most of its electricity needs, has small electricity market and two separate balancing zones (Sotel, Creos). It has two major power generation sites, located on its territory: the pumped-storage hydro plant in Vianden and the combined-cycle gas turbine (CCGT) Twinerg. However, these sites are directly connected to the German and Belgium grid, respectively, and only Twinerg could partly supply physical electricity to Luxembourg if need be. The domestic electricity grid is balanced by the German transmission system operator Amprion. National reserve margins are tight and transmission capacity may approach its limits, as power demand is set to increase in the coming years. Luxembourg can enhance its security of supply by reinforcing its domestic grid and regional interconnectivity and/or investing in new generating capacity at home. However, the outlook for new conventional plants is currently weak. A new interconnection to Belgium is in the planning as a project of common interest in the region and renewable energy capacities are to be added by 2020.

In light of this dependence and the new interconnection, Luxembourg is increasingly exposed to developments in the neighbouring Belgium, France and Germany including: rising shares of renewable flows in the grids; the phase-out of nuclear energy; and the increasing mothballing of fossil fuel capacities in the CWE region. With possible new interconnections, this exposure is likely to grow and will require timely and effective implementing policies for a new market design. In an enhanced regional market integration scenario, the management of the two electricity balancing zones of Creos and Sotel, and the role of the pumped-storage plant and Twinerg CCGT should be clarified.

BUIDLING COMPETITIVE AND SMART RETAIL MARKETS

Since the last review, the competitive picture in Luxembourg's electricity and gas markets significantly changed following the creation of a national, vertically integrated utility. Enovos International was created by merging Soteg and Cegedel, the two important historic players in the energy sector, and Saar Ferngas. Following up on the previous IEA recommendation, a single transmission system operator for gas and electricity, Creos Luxembourg, was created, which is now legally unbundled from Enovos Luxembourg.

At an electricity wholesale level, integration with the German price zone and the existence of 28 suppliers of electricity in Luxembourg all contribute to the diversity of the offer. However, major players from neighbouring countries (GDF Suez, E.ON and RWE), together with AXA Private Equity, are engaged in the mother company, Enovos International, along with the state of Luxembourg. Enovos International holds 100% of Enovos Luxembourg and 75.43% of Creos Luxembourg. A national champion can have advantages but also risks for efficient market development. For example, Enovos can extract economies of scale and scope as a result of its size. However, its dominant position in the national and regional markets could raise concerns about the development of efficient, competitive and innovative markets.

At the retail level, energy consumers have been free to choose their suppliers since 2007; the regulatory authority now has more competences and provides information on markets and price comparison. Both gas and electricity markets are small – with a demand of 1.2 billion cubic metres of natural gas and 6.3 terawatt hours of electricity in 2012. Both retail markets are dominated by Enovos Luxembourg and its subsidiary suppliers. Enovos supplied 88% of the gas to the power sector, 100% to industry and 36.7% to household customers, and around 90% of the electricity residential market in 2012.

In 2012, the supplier switching rate of residential consumers in the electricity and gas retail markets was very low – below 0.1% – compared to rates of around 10% in more competitive markets of the European Union. For large consumers, there is more diversity in Luxembourg, as 15.4% of industrial customers switched. With the high purchasing power and nominal electricity prices around the IEA average, consumers' interest in looking for an alternative supplier might be limited. However, Luxembourg's energy-intensive industry (metallurgic, cement and glass producers) and households seek competitively priced electricity.

More competitive retail markets and consumer empowerment can be achieved with smarter technologies, access to timely and transparent information, and strong regulatory supervision. This includes the strengthening of network regulation, monitoring of transparency, and unbundling requirements, notably of distribution and supply. Regulatory oversight should be stringent to avoid incentives to allocate costs to the network company within legally unbundled firms and possible windfall gains from setting revenue cap incentives that encourage such behaviour. The regulator and Myenergy, in line with their mandate, should raise awareness and information for consumers on energy markets and promote supplier switching, the availability of dynamic tariffs, and harmonised switching and billing.

Given the importance of cross-border transport and transit, working with the neighbouring countries in fostering green transport, smart mobility and the related energy infrastructure roll-out can reduce the costs, avoid technology lock-in and increase interoperability in a larger market. As a major milestone, Luxembourg is set to develop a smart energy system through the country-wide roll-out of smart meters, smart

grids and a public charging infrastructure for electric vehicles as well as smart mobility solutions. The IEA encourages the government to proceed with these important actions and extend them to a sustainable regional and smart city approach.

Last but not least, market integration can help to increase competition. Strengthening the regional integration of market areas, notably for electricity and gas balancing and intraday markets, should therefore remain key pillars, in light of the rising share of renewable energies in these markets.

A LONG-TERM ENERGY AND CLIMATE STRATEGY

A special report on *Redrawing the Energy-Climate Map* presented as part of the *2013 IEA World Energy Outlook* highlighted that targeted energy efficiency measures in buildings, industry and transport and the phase-out of fossil fuel subsidies are the key measures that could halt the growth in energy-related emissions by the end of this decade at no net economic cost.

Up to 2020 and beyond, it is timely for the government to prioritise measures among the 51 set out in the *Second Action Plan on CO_2 Reduction,* to implement these actions and to reassess the potential for renewable energies as well as to adopt cost-effective plans for their deployment. In consultation with all stakeholders, Luxembourg will need to define its ambitions beyond 2020 and set a long-term vision for its energy system up to 2030-50 as neighbouring countries follow ambitious decarbonisation policies. Luxembourg's national white paper process opens a window of opportunity to finalise its energy and climate strategy for 2030. Such a strategy would enable the country to more effectively engage in EU discussions and mitigate potential risks from its regional dependence on fuel imports.

Such an energy and climate strategy needs to ensure consistency of instruments and use synergies between efforts to increase energy efficiency, the share of renewable energies and the development of a more flexible demand side with smart meters and electric vehicles. The strategy should be underpinned by robust scenarios, taking account of the context of Luxembourg, changing technologies, energy consumption and CO_2 emission trends.

Electricity supply security within Luxembourg cannot be considered outside of the CWE market context. Price coupling and system integration within the CWE and NWE market areas will advance, and Luxembourg should assess the implications and opportunities for strengthening security of supply policies in this context.

KEY RECOMMENDATIONS

The government of Luxembourg should:

- ☐ *Raise the profile of the country as a smart and green economy.*
- ☐ *To meet climate targets up to 2020, consider increasing the* Kyoto cent *on road fuel sales to strengthen the revenue base of the Climate and Energy Fund to support domestic renewable energy, energy efficiency and other decarbonisation solutions.*
- ☐ *Proactively engage in international co-operation on energy policy, including technology and innovation, with a view to leverage the full potential from public energy R&D investment, notably in smart mobility and energy efficiency.*

- *Develop efficient, competitive and innovative electricity and gas markets by integrating markets at regional and EU levels. This includes enhancing system operation and co-ordination, strengthening the integration of market areas in gas and electricity, notably in intraday market and balancing markets, to support more efficient and cost-effective integration of renewable energies.*
- *Develop an integrated energy and climate strategy for the 2030-50 horizon based on robust demand and supply scenarios; a shared vision for the development of the energy system and new technology needs; and actions to be taken towards regional integration to reinforce the country's energy security.*

PART I
POLICY ANALYSIS

Figure 2.1 Map of Luxembourg

This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

2. GENERAL ENERGY POLICY

Key data (2013 estimated)

TPES: 4 Mtoe (oil 61.2%, natural gas 22.3%, net electricity imports 10.7%, biofuels and waste 3.9%, coal 1.2%, hydro 0.3%, wind 0.2%, solar 0.2%), +3.6% since 2003

TPES per capita: 7.3 toe (IEA average: 4.5 toe)

TPES per GDP: 0.11 toe/USD 1 000 PPP (IEA average: 0.13 toe/USD 1 000 PPP)

Electricity generation: 1.8 TWh (natural gas 86.7%, biofuels and waste 5.6%, hydro 3.5%, wind 2.7%, solar 1.4%), -2% since 2002

Electricity and heat generation per capita: 4.7 MWh (IEA average: 10 MWh)

COUNTRY OVERVIEW

The Grand Duchy of Luxembourg is Europe's smallest member state (after Malta) with a territory of 2 586 square kilometres (the distance from north to south is 82 kilometres [km]; from east to west, 57 km). The capital and government seat is the city of Luxembourg. Luxembourg's geographic location as a landlocked energy economy, bordering Belgium, France and Germany, makes it a European transit crossroad for rail, road and air transportation, notably for freight. The country has three main districts, Diekirch, Grevenmacher and Luxembourg, which are further divided into 12 cantons and 106 communes, and is organised as a unitary state.

Luxembourg is a parliamentary democracy under the form of a constitutional monarchy. The Head of State is the Grand Duke, Henri Albert Gabriel Félix Marie Guillaume de Luxembourg. The Grand Duke appoints the Prime minister on the basis of election results. Luxembourg holds elections every five years; the last general elections were held on 20 October 2013 which resulted in the formation of a coalition government with liberal, green and socialist parties. On 4 December 2013 Prime Minister Xavier Bettel was appointed. Mr Etienne Schneider continues to be Minister of the Economy.

The energy policy of Luxembourg, a founding member state of the European Union, is framed by European Union (EU) requirements on policies such as those shaping the electricity and gas markets and those on energy efficiency, renewable energy, state aid, environment and greenhouse gas (GHG) emissions. Given the limited size of its energy market and lack of interconnectivity, Luxembourg has obtained derogations for the application of EU internal gas and electricity market rules.

Luxembourg closely co-operates with neighbouring countries, notably through the Benelux, the Pentalateral Energy Forum and North Sea region on energy policy challenges, be it oil, gas and electricity security or the transition to a low-carbon economy.

Reflecting its international and EU focus, the city of Luxembourg is the seat of several European institutions and agencies, including the European Investment Bank, the European

Court of Justice, the European Court of Auditors, the Statistical Office of the European Union (Eurostat), the Secretariat of the European Parliament, and others.

Luxembourg has seen strong economic performance over the past 30 years. It has the highest income per capita in the Organisation for Economic Co-operation and Development (OECD) (USD 88 276 in purchasing power parity per capita in 2013) and the second-highest in the world after Qatar. Consumers have a strong purchasing power which is a guaranteeing factor for stable investment conditions and the affordability of energy policy initiatives. Thanks to high incomes and favourable tax regimes, the country attracts work migrants from other European countries. Besides its manufacturing (metallurgical) industry, the financial services sector (private and investment banking) contributes more than one-third of gross domestic product (GDP). In the past, the steel industry strongly shaped the country's profile and electricity generation, but the decline of activities meant a reduced industry energy use by 16.7% over the past decade, leading to a decline in energy supply in general. A shift to the tertiary sector is in the making, Luxembourg is the seat of global media and information and communications multinationals (Amazon, AOL, Apple iTunes, eBay, PayPal, Skype).

Unlike other OECD members, Luxembourg has experienced continuous growth of its GDP and population, which stood at 525 000 inhabitants in 2013, a trend which impacts energy consumption, urbanisation and city development. After the Nordic countries and the United States, Luxembourg had the sixth-highest electricity consumption per capita in the OECD (see Chapter 4 on Energy Efficiency) and almost twice as much energy supply per capita (7.7 tonnes of oil-equivalent [toe]) as the International Energy Agency (IEA) average (4.5 toe) in 2012.

The economy withstood the global financial and economic crisis. During a double recession in 2008/09 and 2012, GDP growth was negative without major impact on unemployment trends (still at 5.1% in 2012) (STATEC, 2014; OECD, 2013). In 2012, the total GDP amounted to EUR 42.6 billion in current market prices (OECD, 2012). At times of low domestic demand and slowdown in world trade amid the global financial turmoil, the financial sector remains exposed to high volatility while the country's privileges in taxation level and bank secrecy have been reduced over time.

Luxembourg experienced a decline of competitiveness since 2003 and saw a lower ranking (13th position) in the World Competitiveness Index, compared to its best ranking in 2003, putting at evidence the strong impact of increasing globalisation and competitiveness. In 2013, the most competitive nations in Europe included Switzerland (second), Sweden (fourth) and Germany (ninth). Their success relied upon an export-oriented manufacturing, diversification of the economies, strong small and medium-sized enterprises (SMEs) and fiscal discipline (IMD, 2013).

Luxembourg's future performance will depend on the country's ability to fully exploit its economic potential and ensure sustainability over time. Applying and expanding the expertise acquired in the services industry and eco-innovation to the area of sustainable development, e.g. in energy-efficient services, urban planning, or in transport and mobility, can foster the country's competitiveness and secure its attractiveness and quality of life to a growing population and business sector. The government has made green investment and green growth a priority of its economic programme. With regard to the future outlook, the Ministry of the Economy and STATEC expect a flat GDP growth around 2.7% up to 2015.

SUPPLY AND DEMAND

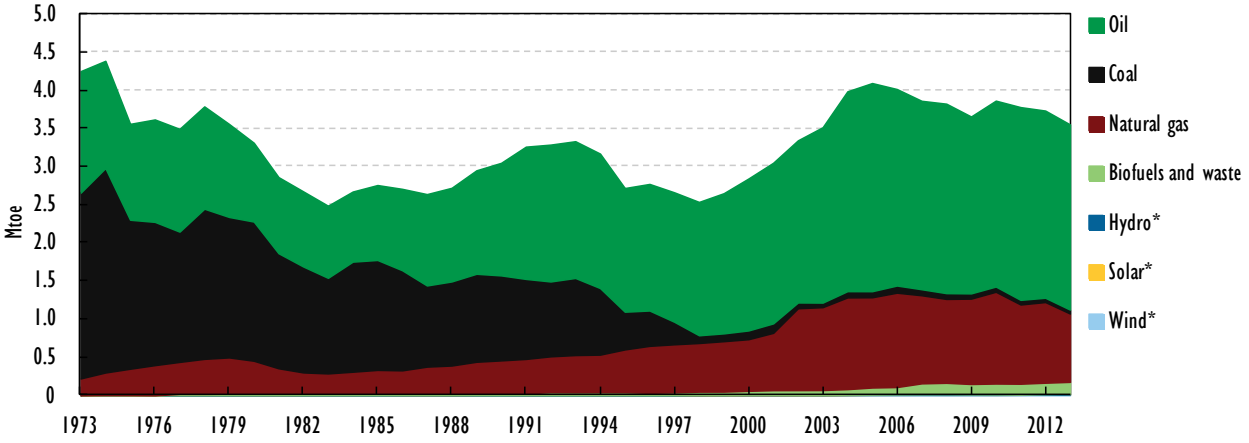
SUPPLY

Luxembourg's total primary energy supply (TPES) was 4 million tonnes of oil-equivalent (Mtoe) in 2013, declining for a third consecutive year from 4.2 Mtoe in 2010. Energy supply reached a peak of 4.4 Mtoe in 2004 and has followed a downward trend since. In the nine years since 2004, TPES contracted by a total of 7%. However, it was 3.6% higher in 2013 compared to 2003, mainly thanks to the commissioning of the Twinerg combined-cycle gas turbine (CCGT) power plant.

Luxembourg relies on imports for its energy needs. Oil is the major imported fuel, accounting for 61.2% of TPES in 2013. Natural gas represents a further 22.3% share, while 10.7% of its energy needs is covered by net imports of electricity. While most IEA members participate in electricity trade, the energy value of the level of trade is usually insignificant in TPES.

Biofuels and waste[1] account for 3.9% of TPES, followed by coal (1.2%), hydro (0.3%), wind (0.2%) and solar (0.2%). While coal is imported, the renewable energy sources in Luxembourg are produced within the country, except biofuels used in transport. Over the decade since 2003, production of biofuels and waste has increased by 142.1%, while wind power production grew by 218.2%. Hydro power production increased by 48.5% over the same period, essentially because of climate conditions, as the installed capacity slightly increased during the period.

Figure 2.2 TPES, 1973-2013



Note: estimated for 2013.

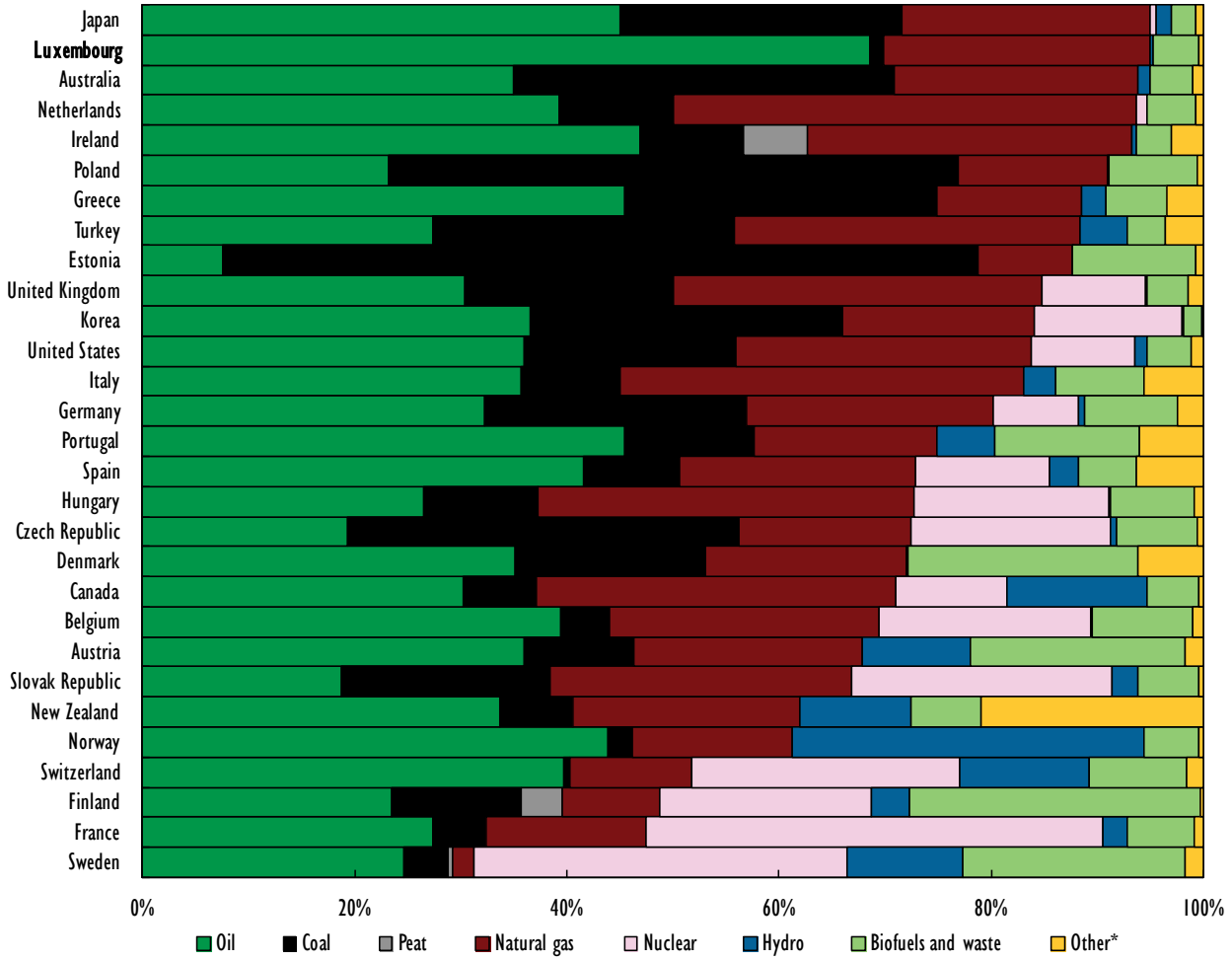
* Negligible.

Source: IEA (2013), *Energy Balances of OECD Countries 2013*, OECD/IEA, Paris.

Fossil fuels represent 84.8% of TPES in Luxembourg. This share ranks the country second-highest among IEA members after Japan, followed by Australia and Ireland. Luxembourg also has the highest share of oil in its energy mix compared to other IEA members. This is explained by the fact that the country has high shares of fuel sales to non-residents which are counted towards its oil supply.

1. Biofuels and waste comprise solid and liquid biofuels, biogases, industrial waste and municipal waste.

Figure 2.3 Breakdown of TPES in IEA member countries, 2013



Note: estimated data.

* *Other* includes geothermal, solar, wind, and ambient heat production.

Source: IEA (2013), *Energy Balances of OECD Countries 2013*, OECD/IEA, Paris.

DEMAND

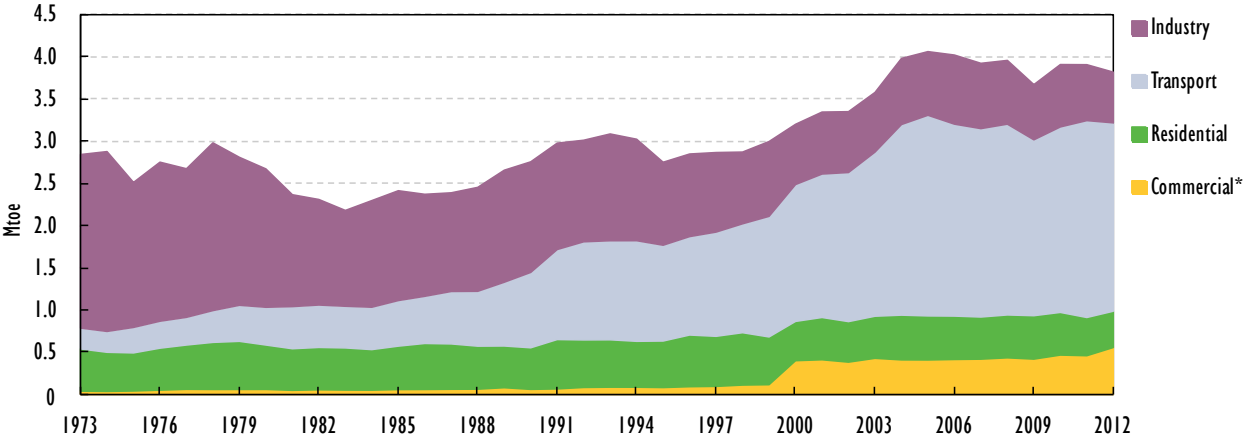
Total final consumption (TFC) of energy was 3.9 Mtoe in 2012. This is 14% higher than in 2002; however, it has decreased by 5.8% from a peak of 4.1 Mtoe in 2005.

Transport is the largest energy-consuming sector in Luxembourg, accounting for 57.6% of TFC. The share of transport in TFC has been growing steadily over time, increasing from 8.1% of TFC in 1973. Total energy consumed in this sector grew by 26.6% from 1.8 Mtoe in 2002 to 2.2 Mtoe in 2012. This is a much larger increase in consumption compared to other sectors of the economy.

Industry is the second-largest energy-consuming sector with a share of 15.6% of TFC. This sector has reduced its energy use by 16.7% over the ten years to 2012. Conversely, demand from the commercial sector has grown, with energy consumption increasing by 44.7% over the same period. In 2012, the commercial sector accounted for 14.7% of TFC.

The residential sector represents 11.2% of TFC. Demand from households has experienced the largest decline over the past decade, with total consumption decreasing by 10.8% from 2002 to 2012.

Figure 2.4 TFC by sector, 1973-2012

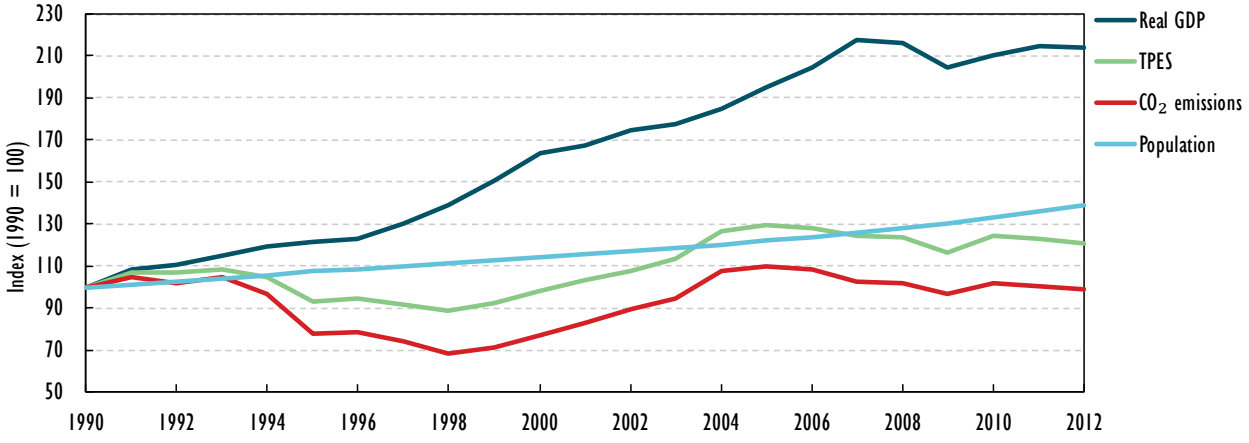


Notes: reporting methodology on *Commercial* changed in 2000. Data are preliminary for 2012.

* *Commercial* includes commercial and public services.

Source: IEA (2013), *Energy Balances of OECD Countries 2013*, OECD/IEA, Paris.

Figure 2.5 CO_2 emissions and main drivers in Luxembourg, 1990-2012



Note: preliminary data for 2012.

Sources: IEA (2013), *Energy Balances of OECD Countries 2013*, OECD/IEA, Paris; OECD (2013), *National Accounts of OECD Countries 2013*, OECD Publishing, Paris.

Economic growth was 4% at average during the period 1990-2008, fostered by the switch from an industrial to a service economy. This shift resulted in the development of a strong financial intermediation and business services sector, driving employment, population growth and attracting an ever-increasing number of cross-border commuters. This economy driven by banking and financial services is now exposed to higher volatility, following the ups and downs of the global economic and financial crisis, as it did notably in 2008/09, which also strongly impacted the manufacturing industry. In general, given the shrinking industrial activity and the switch to services, Luxembourg saw a relative decoupling of emissions from strong GDP and population growth.

INSTITUTIONS

Luxembourg has a relatively small and lean government administration, so that many portfolios are integrated in one multi-portfolio ministry and several ministers and state secretaries deal with several policy areas.

The **Ministry of the Economy** is in charge of business, technology and competitiveness, regional economic development, research and development (R&D), technology transfer and innovation, industrial property and intellectual rights. In the area of energy, the **General Directorate for Energy** deals with the overall energy policy, including renewables, efficiency and energy security. It supports the minister with a small team of ten staff which increased from six in 2004 and eight in 2008.

For the implementation of the energy policy programmes, the Ministry of the Economy is supported by **Myenergy**. In 2009, the government founded this national energy agency which currently has a staff of 15 people. The agency supports the government in the implementation of sustainable energy policies and promotes the rational use of energy and renewable energy sources. It is financed by the government and has the status of an economic interest group (EIG).

Taxation of energy products falls within the competence of the **Ministry of Finance**.

In 2009, the government decided to create the **Ministry of Sustainable Development and Infrastructure (MDDI)** by merging the former Ministry of the Environment, the Ministry of Transport, the Ministry of Public Works and the Land Planning Administration. MDDI also hosts the Environment Agency which is in charge of monitoring GHGs through the GHG inventory and of reporting to the United Nations Framework Convention on Climate Change (UNFCCC) and the national Kyoto Fund. MDDI deals with overall climate change policy, environment protection, transport and mobility. It co-ordinates the national plan for sustainable development and promotes energy efficiency and renewable energies for the household sector.

The **Institut Luxembourgeois de Régulation (ILR)** is Luxembourg's regulatory authority (for gas, electricity, telecom, postal services, and rail). The **Conseil de la Concurrence** is the general competition authority which also oversees energy.

In 2008, the responsibility for energy statistics was transferred from the former Ministry of the Economy and Foreign Trade to the national statistical office, STATEC, with a view to improve, notably, the detail of statistics about energy end use. **STATEC** is the government's statistical office which started close co-operation with the Ministry of the Economy and MDDI to develop energy scenarios and statistics, notably on energy demand and GHG projections.

Within the Ministry of the Economy, the Directorate-General for Research, Intellectual Property and Innovation, and the Directorate for Research and Innovation, lead on research, development and innovation, and work in collaboration with the **Higher Committee for Research and Innovation** under the **Ministry of Higher Education and Research**.

The **National Research Fund** (Fonds National de la Recherche [**FNR**]) is a public body with scientific, financial and administrative autonomy. It works together with **Luxinnovation,** the national agency for innovation and research (since 1984), which has the status of an EIG.

KEY POLICIES

Since 2008, the government has continued building a social consensus with the municipalities and all energy stakeholders on climate and energy policy objectives. In 2011, the Minister of the Economy launched the process for the formulation of a national energy strategy on the basis of the so-called *White Paper* prepared by research institutes from Germany (Ziesing and Eichhammer, 2009). The national energy strategy has been discussed with public and private stakeholders and the consultation results have been taken up in a new version of the *White Paper on the Energy Strategy*.

Luxembourg has agreed to strong energy and climate targets for 2020. It is committed to reduce GHGs by 28% below 1990 levels between 2008-12 under the Kyoto Protocol, to cut CO_2 emissions by 20% by 2020 compared to 2005 levels in the non-European Union Emissions Trading Scheme sectors (which account for 83% of total GHG emissions), and to increase the share of renewable energy to 11% of total final energy and 10% in the transport sector. Additionally, Luxembourg has announced a goal of energy savings of 14.06% by 2016 and of 49 292 gigawatt hours, or 4 239.2 thousand tonnes of oil-equivalent of final energy by 2020, which equals a 20% reduction from 2007 levels.

As GHG emissions declined by 8.2% since 1990, below the 28% reduction of strategic objectives, Luxembourg relies on flexible mechanisms under the Kyoto Protocol.

During 2010/11, the Ministry of the Economy initiated the *Environment Protection and Climate Partnership* and consulted with stakeholders, including business associations, non-governmental organisations, trade unions, and citizens, with the aim to agree on a longer-term strategy for sustainable development, building on the results of the White Paper of 2009. The partnership led to the adoption of the *Climate Package* in 2011.

Box 2.1 The Climate Pact (*Pacte de collaboration climat avec les communes*)

In Luxembourg, the responsibility for climate measures lies with the central government which aims to align all interests of the municipalities and cities in the fight against climate change. The Climate Pact sets out the legislative, technical and financial framework to be set up in order to promote climate change mitigation by the municipalities. An agreement (contract) between the State and the municipality foresees that the municipality commits itself to implement a quality management system and the State provides financial and technical assistance to the municipality.

The Climate Pact is an agreement with municipalities on the introduction of a European Energy Award (EEA) certification system. The EEA supports communities that wish to contribute to a sustainable energy policy and urban development through the rational use of energy and an increased use of renewable sources of energy. The EEA is a qualified instrument for steering and controlling communal energy policy in order to review systematically all energy-related activities. It also allows municipalities to identify strengths, weaknesses and potential for improvement and to implement effectively energy-efficient measures. The success of a municipality's efforts is made visible through the award which allows municipalities to share their experiences and expertise.

The Climate Pact, adopted by the government, entered into force in January 2013. In total, 86 municipalities were invited to participate and by 16 May 2013, 50 agreements had been signed.

In 2013, the *Second Action Plan on CO_2 Reduction* was adopted laying down 51 measures needed to mitigate GHG emissions across the economy. In 2013, the government adopted a *Climate Pact* with municipalities, which allows Luxembourg to foster the implementation of climate policies across the country (see Box 2.1).

The government programme under newly appointed Prime Minister Bettel makes the energy transition a key priority, notably the promotion of renewable energy sources and energy efficiency (Government of Luxembourg, 2013). Several other priorities are outlined.

In the area of renewable energies, the government aims to revise the 2010 Renewable Energy Action Plan, with an updated assessment of the potential of renewable energies and a review of the cost-effectiveness of different support schemes. Besides the promotion of buildings refurbishment and stronger requirements in the buildings sector, the implementation of the EU Energy Efficiency Directive 2012/27/EU encourages Luxembourg to review its current policies, take a lead in energy efficiency in the public sector and design a coherent policy framework for energy efficiency. The promotion of energy efficiency in the services sector is seen as an instrument to spur efficiency gains in industry, SMEs and the tertiary sector.

With a view to finance these measures, the government announced its intention to increase the financing of Myenergy's activities, the creation of a Green Bank, support of R&D activities in Luxembourg and international financing partnerships. At the same time, the possibility to phase out fuel tourism in favour of raising revenues from electric mobility will be studied.

Improvements in Luxembourg's integration and physical interconnectivity with neighbouring countries, in securing oil storage locally or through bilateral arrangements in geographic proximity, as well as the completion of the reform of the oil market regime are listed among the measures likely to strengthen the security of supply.

In addition, the government envisages a cap for the consumption of first-generation biofuels and rules out any support to shale gas or nuclear energy. These plans follow the measures included in the Second National Action Plan on CO_2 Emissions Reductions.

ASSESSMENT

Over the past decades, Luxembourg has seen strong economic growth and today has the highest income per capita in the OECD, despite being the smallest IEA member country in terms of territory. The country has been attractive for a growing number of migrant workers from other European countries. Population growth and employment in Luxembourg have translated into rising energy consumption in the commercial and residential area, led to an increasing number of commuters which is around 40% of the workforce and created a boom in the construction of new buildings. At the same time, energy use in industry declined sharply, by 16.7% over the past decade, mainly due to the financial and economic crisis and the decline of the activity in the steel industry.

Since the 2008 in-depth review, Luxembourg has made progress towards consolidating its energy policies and institutional framework, notably in the area of energy efficiency and climate mitigation measures.

In line with IEA's recommendations, in 2009 the government launched a white paper process to prepare a new national energy strategy and discussed the future perspectives with stakeholders, notably through the *Environment and Climate Partnership* which led

to the adoption of a *White Paper on the Energy Strategy*. In May 2013, the government presented a comprehensive climate action plan, *the Second Action Plan on CO_2 Reduction* with 51 priority measures.

Since 2009, the country transferred its energy statistics to STATEC with a view to foster energy data collection and the preparation of joint energy and climate scenarios. At the same time, the government created a dedicated energy agency, Myenergy, and formalised the *Climate Pact* with municipalities in 2013 to foster the implementation, awareness and commitment for its new climate priorities at local level. The efforts to diversify the domestic transport sector through alternative fuels and infrastructure, measures set out in the *Global Mobility Strategy* and in the *Transport Sector Plan*, are commendable.

Luxembourg adopted challenging energy and climate targets for 2020 within the EU framework for 2020. The country is unlikely to meet its 2020 energy and climate targets without efforts at national and EU/international levels, notably for the purchase of international carbon credits or renewable energy projects. Reinforced national action and regional market integration are the two factors likely to reach these targets cost-effectively, notably in the transport and electricity sectors.

In the context of the EU objectives to achieve a reduction of 80% to 95% of GHG emissions by 2050 and the discussion on the 2030 climate and energy framework, Luxembourg will need to adopt its position and consider its contribution. The national white paper process opens a window of opportunity to further work on a new integrated energy and climate strategy. In this context, Luxembourg can benefit from developing a shared vision on how its energy system is to evolve in the medium to long term up to 2030-50, with a view to maximise its energy security benefits while minimising environmental impacts and costs to the consumer.

Such a new energy and climate strategy needs to be underpinned by robust scenarios that take account of the specific context of Luxembourg: changing trends in energy consumption and CO_2 emissions, harmonising efforts to increase energy efficiency, the share of renewables in energy supply, and the development of a more flexible demand side with a large-scale roll-out of smart meters and electric vehicles fleet of 40 000 by 2020 with around 800 public charging stations.

Developing a long-term vision for the energy system up to 2030-50 in consultation with all key institutions, would provide Luxembourg with the opportunity to play an active and valuable role in enhancing energy security and meeting the decarbonisation challenges faced not only in Luxembourg but in the region. The regional element is vital, as it will encourage resource efficiency, interoperability of technologies and infrastructure, including in the transport sector.

The institutional capacity of the General Directorate for Energy of the Ministry of the Economy and of government agencies has increased over the past years. However, staffing seems to be still inadequate to the need for reinforced action in energy efficiency and renewable energies or energy RD&D policy. Taking a proactive stance in the co-ordination of energy and climate policies and engaging at international level are essential. This requires reinforced staffing at the ministries, at the regulatory and competition authorities, including at Myenergy, and enhanced co-ordination at government level.

RECOMMENDATION

The government of Luxembourg should:

- ☐ *Develop an integrated energy and climate strategy for the horizon 2030-50 based on:*
  - *robust scenarios in order to understand possible future trends and constraints in energy and electricity consumption, including the potential of energy efficiency and demand-side responses as well as opportunities from further market integration and greater interconnectivity*
  - *enhanced co-ordination between the energy and climate policies and international co-operation underpinned by adequate staffing at the level of the ministries, the regulator and the competition authority, as well as at Myenergy*
  - *close co-operation with neighbouring countries and at EU level with a view to maximise Luxembourg's energy security and to address common challenges linked to policy decisions regarding the energy transition, electricity security as well as transport in the region*
  - *a shared vision on technology needs for the national energy system.*

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3. CLIMATE CHANGE

Key data (2012 preliminary)

GHG emissions (excluding LULUCF):* 11.8 $MtCO_2$-eq, -8.2% since 1990, -10% compared to the base-year value considered for the Kyoto Protocol

GHG emissions (including LULUCF):* 11.4 $MtCO_2$-eq, -13.9% since 1990

2008-12 target: -28% from 1990

CO_2 emissions from fuel combustion: 10.2 Mt, -1.3% since 1990

Emissions by fuel: oil 72.4%, natural gas 24.1%, coal 2.1%, other 1.4%

Emissions by sector: transport 64.2%, power generation 11%, industry 9.1%, residential 9%, commercial 6.7%

Carbon intensity: 0.29 tCO_2/USD 1 000 PPP (IEA average: 0.33 tCO_2/USD 1 000 PPP), -10.4% since 2002

* Source: Ministry of Sustainable Development and Infrastructure, 2014a.

OVERVIEW

A party to the Kyoto Protocol, Luxembourg adopted the highest greenhouse gas (GHG) emissions reduction target among the EU member states. The country is committed to reduce GHG emissions[1] by 28% during 2008-12 (from 1990 levels). GHG emissions reached a peak in 2005 at around 13.09 million tonnes (Mt) and by 2012 had fallen by 8.2% below 1990 levels. CO_2 emissions saw a sharp decline in industry at the end of the 1990s, which was offset by an increase in the transport and power generation sectors. Thus, overall CO_2 emission levels remain largely unchanged.

There are several structural reasons which largely influence Luxembourg's climate and energy policy choices. Given the country's size, slight changes in the activities in the transformation or industry sectors (cement, clinker, iron and steel) have a strong impact on the GHG balance. The country has a low share of renewable energies and imports all of its oil, gas and electricity needs. During the 1990s, the steel industry introduced electric furnaces which phased out coal use. Fuel changes impacted the GHG emission profile, notably the increasing use of natural gas in power and heat generation with increasing CO_2 emissions, following the start of the Twinerg combined-cycle gas turbine (CCGT) in 2002 and the increase in co-generation facilities. In recent years, the financial and economic crisis led to the reduction of manufacturing activities.

1. GHG emissions data used in this chapter stem from the national inventory prepared for the United Nations Framework Convention on Climate Change (UNFCCC) and refer to emissions excluding land use, land-use change and forestry (LULUCF) and international bunkers. Unless otherwise indicated, CO_2 data presented here are only on energy-related CO_2 and stem from IEA databases. They may differ from the official submission of emissions inventories to the UNFCCC Secretariat. This is the case for historic trends, as, in line with the Intergovernmental Panel on Climate Change (IPCC) Guidelines, the national inventory re-allocated part of the energy production to the manufacturing industry since this production was/is mainly for own use (autoproducers).

Luxembourg's growing economy and population (a 39.7% increase during 1990-2012) are directly correlated to its emission trends. In addition, the number of cross-border commuters rose by 350.7% during 1990-2012 and urban development increased. Luxembourg is located at the heart of main traffic axes in Western Europe, and attracts an increasing number of cross-border workers and commuters.

In 2012, almost two-thirds of non-ETS emissions came from the transport sector. Fuel sales, notably diesel sales, to non-residents increased significantly for both private and freight transport, leading to the country's emission and fuel consumption records. During 1990 and 2012, road fuel sales to residents increased by 97% and to non-residents by 168%, which was stimulated by one of the lowest excise and value-added tax levels on gasoline and diesel within the European Union. As under international IPCC reporting, fuel sales at stations in Luxembourg are counted in the GHG emissions of the country, while the lion's share is emitted outside Luxembourg (Ministry of Sustainable Development and Infrastructure, 2014b).

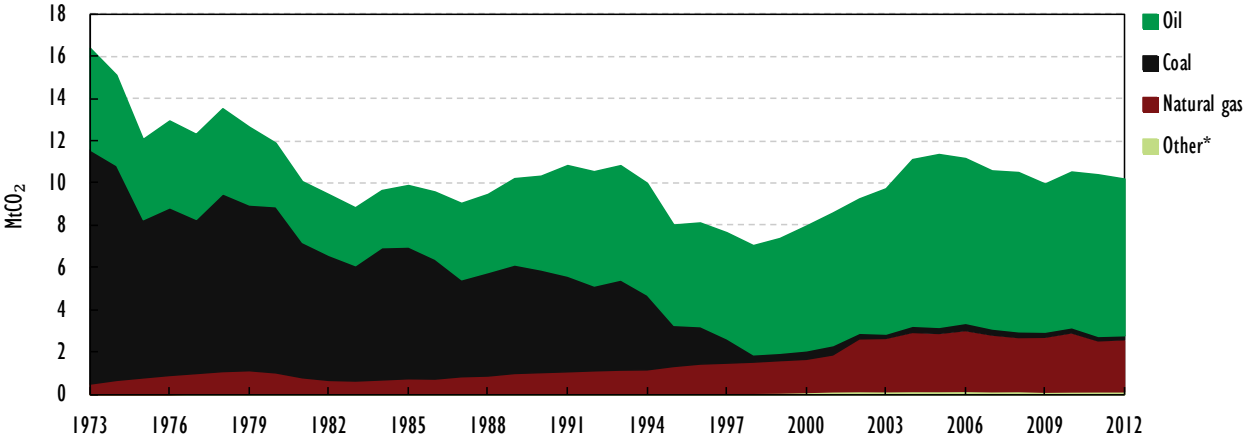
ENERGY-RELATED CO_2 EMISSIONS

SOURCES OF CO_2 EMISSIONS

Energy-related CO_2 emissions from fuel combustion were 10.2 Mt in 2012. They accounted for 87% of total GHG emissions in 2012, up from 80% in 1990. During 1990 to 2011, they have remained almost unchanged, while total GHG emissions have fallen by 8.2%.

In 2012, the largest share of energy-related CO_2 emissions was emitted by the transport sector, namely 64.2%. The power generation sector accounted for 11%, the industry sector for 9.1%, the residential sector for 9% and the commercial sector for 6.7%.

Figure 3.1 CO_2 emissions by fuel, 1973-2012



Note: preliminary data for 2012.

* *Other* includes industrial waste and non-renewable municipal waste (negligible).

Source: IEA (2013), *CO_2 Emissions from Fuel Combustion 2013*, OECD/IEA, Paris.

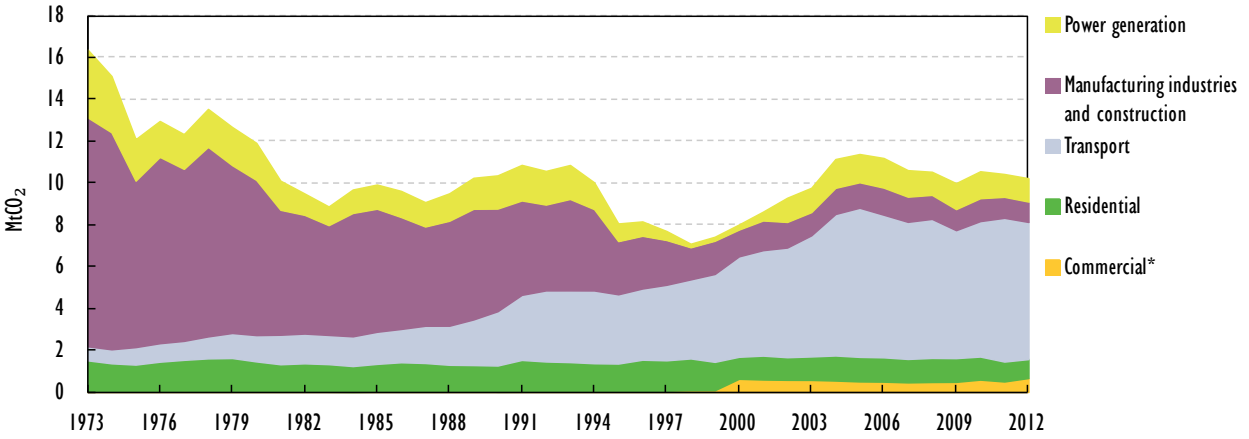
The share of CO_2 emissions by sector has changed considerably since 1990. Industry was the largest emitter two decades ago, followed by transport, power generation and the

residential and commercial sectors. CO_2 emissions in industry have contracted by 80.8% from 1990 to 2012 following the switch of steel production to electric arc furnaces. Conversely, emissions in the transport sector have increased by 152.3%, and in the power generation sector by 3 000% and in the residential sector over the same period (MDDI, 2014b).

CO_2 emissions from oil use accounted for 72.4% of total energy-related emissions in 2012. Natural gas accounted for 24.1%, which is largely the effect of the gas-fired power plant Twinerg in Luxembourg since 2002 and the increase in co-generation facilities run on natural gas. Important maintenance work at Twinerg during 2007/08 and 2010/11 led to a significant dip in CO_2 emissions. Coal and other fuels represented 2.1% and 1.4%, respectively.

Since 1990, emissions from oil, natural gas and other fuels (mostly from waste) have increased substantially, growing by 67.1%, 145.6% and 202%, respectively. On the other hand, emissions from coal have declined by 95.7% over the same period due to the change in the industrial production, as described above.

Figure 3.2 CO_2 emissions by sector, 1973-2012



Note: preliminary data for 2012.

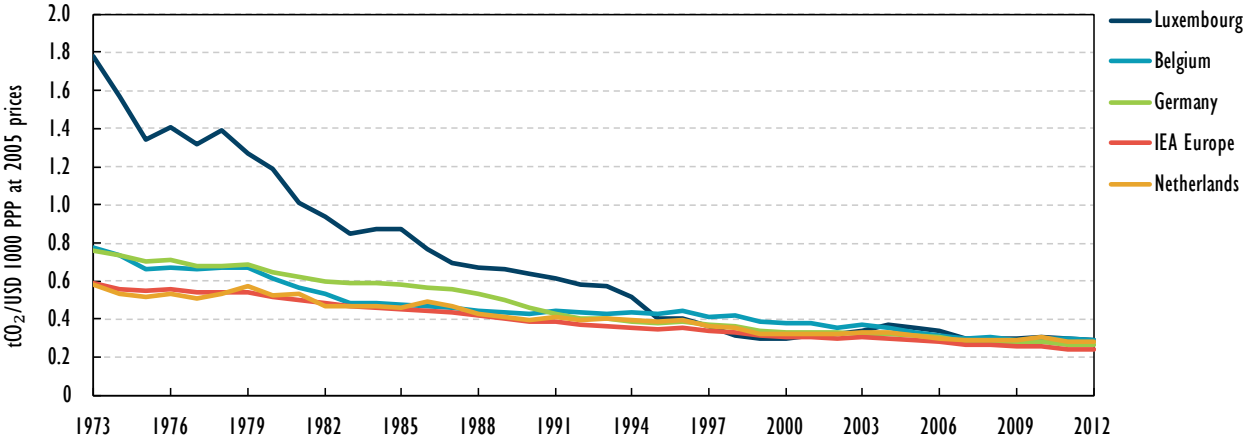
* *Commercial* includes commercial and public services, agriculture/fishing and forestry.

Source: IEA (2013), *CO_2 Emissions from Fuel Combustion 2013*, OECD/IEA, Paris.

CARBON INTENSITY

Luxembourg emitted 0.29 tonnes of CO_2 per USD 1 000 at purchasing power parity (PPP) of real GDP (tCO_2/USD 1 000 PPP) in 2012. This is a similar level as in 2011 but lower than the 2011 IEA member country average of 0.33 tCO_2/USD 1 000 PPP. The Grand Duchy ranked 12th-highest with regard to carbon intensity among IEA members in the same year, where the median was 0.28 tCO_2/USD 1 000 PPP. Carbon intensity in Luxembourg has decreased by 10.4% over the ten years since 2002. The IEA average intensity has decreased by 16.3% from 2002 to 2011. In a historic perspective, the country was able to achieve a sharp reduction in carbon intensity following the switch from an industry-based to a service-based economy, reaching a level comparable to the IEA Europe average and neighbouring countries.

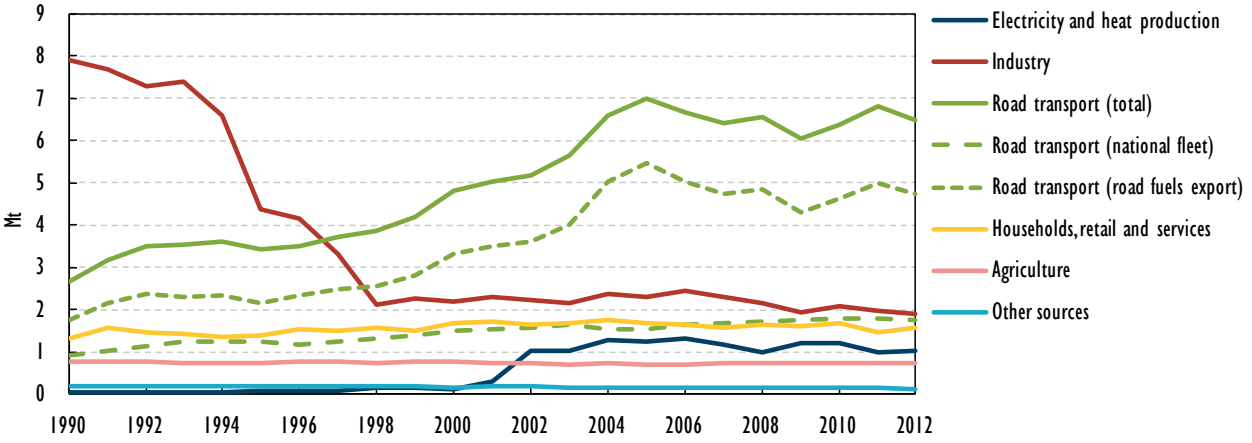
Figure 3.3 Carbon intensity in Luxembourg and in other selected IEA member countries, 1973-2012



Note: preliminary data for 2012.

Sources: IEA (2013), *CO_2 Emissions from Fuel Combustion 2013*, OECD/IEA, Paris; OECD (2013), *National Accounts of OECD Countries 2013*, OECD, Paris.

Figure 3.4 GHG emissions by sector, 1990-2012



Note: As indicated in footnote 1 some developments differ from the CO_2 emissions due to the re-allocation of part of the energy production to the manufacturing industry.

Source: MDDI-DEV (2014).

INSTITUTIONS

The overall responsibility for climate policies lies with the **Ministry of Sustainable Development and Infrastructure** (*Ministère du Développement durable et des Infrastructures* [***MDDI***]), which leads environmental policies (air, water and soil quality, environmental impacts, climate change and adaptation) through its *Département de l'Environnement (MDDI-DEV*), environmental and spatial planning (*MDDI-Land Planning Department*) as well as transport and mobility (including public services, subsidies for hybrid or electric cars). The Ministry of the Environment remains integrated in MDDI. In 2009 the government had decided to create the MDDI by merging the Ministry of the Environment, the Ministry of Transport, the Ministry of Public Works and the Land Planning Administration. MDDI also hosts the **Environment Agency** which is in charge of the GHG inventory and of reporting to the UNFCCC. GHG projections and the evaluation of policies and measures are carried out in close collaboration with MDDI-DEV, the Ministry of the Economy and STATEC.

The Energy Directorate within the **Ministry of the Economy (***Ministère de l'Economie*) deals with the overall energy policy, including renewables, energy efficiency and energy security, on top of its overall portfolio of business, technology and competitiveness, regional economic development, research and technological development (R&D), technology transfer and innovation, industrial property and intellectual rights. For the implementation of the energy policy programmes, the ministry is supported by **Myenergy**, which is financed by the government and has the status of an economic interest group (EIG).

There is no division of competences between the central government and the regions. Municipalities are involved in climate and environment policies through the *Climate Pact* and/or via the support of the *Climate Alliance*.

The **Ministry of Finance** is in charge of energy taxation.

POLICIES AND MEASURES

As a member state of the European Union, Luxembourg's climate policies are largely determined by its international commitments under the Kyoto Protocol and the EU 2020 Energy and Climate Package.

Luxembourg has been implementing a broad range of climate policy measures under the First National Action Plan on the reduction of CO_2 emissions (2006) and significantly strengthened efforts to address climate change under the new Second National Action Plan of 2013. An overview on the existing policies and measures is provided in Table 3.2.

The legal framework for climate and energy efficiency policies includes the measures to meet the Kyoto target and the objectives of the European Union Emissions Trading Scheme (EU-ETS). Luxembourg has not set specific emission targets for different sectors, but developed sectoral action plans, notably for the transport and mobility sector. The government relies on the following instruments, among others:

- EU-ETS
- international measures (flexible mechanisms under the Kyoto Protocol)
- energy taxation and green tax incentives
- support of renewable energies
- transport and mobility action
- a broad range of energy efficiency measures, including voluntary agreements with industry.

Under the Second National Action Plan, the government announced the presentation of a climate change adaptation plan.

GHG EMISSIONS, TARGETS AND PROJECTIONS

Luxembourg is a party to the Kyoto Protocol since ratification on 31 May 2002 and has a national commitment to reduce total GHG emissions by 28% from the base-year level (13.17 $MtCO_2$-eq.) during 2008-12.[2] The country thus shares the burden of the collective

2. The base year for reductions of CO_2 (carbon dioxide), CH_4 (methane), N_2O (nitrous oxide) is 1990, while it is 1995 for F-gases (hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride).

EU-15 target to reduce GHG emissions by 8%. Among EU member states, 28% is the largest emissions reduction target under the EU Burden-Sharing Decision (2010/778/EU) which for Luxembourg equals an emission level of 47.4 $MtCO_2$-eq and leaves a disposable volume of 9.48 $MtCO_2$-eq per year. In 2001, when the Kyoto Protocol was implemented, such an ambitious target was considered feasible, as Luxembourg had already experienced a steep decline of GHG emissions between 1990 and 2000.

The latest historical GHG emissions (2012) stood at 11.8 $MtCO_2$-eq, 20% above the disposable volume, which translates into a reduction of 10% compared to the base-year value considered for the Kyoto Protocol or 8.2% less than in 1990. The country cannot meet its Kyoto target of 28% through domestic measures alone, but needs to make use of international measures, including the emissions trading schemes. Luxembourg decided to make extensive use of the so-called flexible mechanisms under the Kyoto Protocol (see section below on International Measures) and set aside a financial reserve under the dedicated Climate and Energy Fund (see Box. 3.1). The government has already set out its intentions to use flexible mechanisms which, if successful, should enable Luxembourg to meet its Kyoto target by 2015 (European Environment Agency, 2013).

Box 3.1 Luxembourg's Climate and Energy Fund

Luxembourg created the Climate and Energy Fund in 2011 building on an earlier Kyoto Fund. The new Fund supports the implementation of national climate change policies and measures, notably the purchase of flexible mechanisms, particularly in developing countries, feed-in tariffs for renewable electricity production and the cost of engaging in co-operation mechanism under the EU Renewable Energy Directive. In practice, the funds are not primarily directed to the greening of transport but will mainly serve the purchase of Kyoto credits. The Fund is to finance several national measures relating to energy use (efficiency, renewable sources, etc.) over the coming years.

Revenues are raised through various fiscal instruments, notably the "*Kyoto cents*" – i.e. a special tax on road fuel sales (EUR 0.02 for gasoline and EUR 0.025 for diesel) and a 40% annual vehicle tax which is CO_2-based. An annual budgetary allocation completes these revenues, but only for a small part (around 10% of the annual revenues of the Fund).

Luxembourg contributes to the overall efforts of the European Union to reduce GHG emissions by 20% by 2020 under the Energy and Climate Package. On the one side, the EU effort is set at a 21 % reduction target below the level in 2005 for the emissions covered by the EU-ETS, the cap-and-trade system which was set up in 2003 and started in 2005 for the implementation of the Kyoto Protocol by Directive 2003/87/EC. On the other side, a 10% reduction target is set (below the 2005 level) for the remaining non-ETS emissions, which was translated into national emission targets for the period 2013-20. Luxembourg is committed to reduce its GHG emissions in the non-trading sectors under the EU Effort Sharing Decision (Decision 406/2009/EC) by 20% by 2020, compared to their levels in 2005.

Around 17% of GHG emissions in Luxembourg are covered under the EU-ETS. The lion's share (83%), however, stems from sectors outside the ETS.

Up to 2020, national projections show that with existing measures, Luxembourg is able to stabilise emissions in non-ETS sectors. Additional measures would allow the country to reduce its GHG emissions by 7.5%, compared to 2005.

In 2014, however, Luxembourg has not yet completed the evaluation of the possible contribution of policies and measures and their CO_2 mitigation potential nor set out 2030-50 projections of GHG trends.

EU-ETS

Luxembourg joins the overall European efforts to achieve the Union-wide target of reducing CO_2 emissions by 21% relative to 2005 over the period 2013-20. Each EU member state set out the total CO_2 emission allowances and the quantity allocated for each installation covered by the EU-ETS in the first (2005-07) and the second (2008-12) trading periods in a national allocation plan. For the third trading period 2013-20, national allocation plans are being progressively replaced with harmonised allocation rules across the European Union, with auctioning as the main allocation principle. Full auctioning is the rule for the power sector, and a transitional system for free allocation based on benchmarks of best performers has been put in place for other sectors. On 5 September 2013, the European Commission adopted a decision on the national implementation measures for 2013-20.

ETS sectors include power stations and other combustion plants, oil refineries, coke ovens, iron and steel plants and cement, glass, lime, bricks, ceramics, pulp and paper factories. As of 1 January 2012, ETS extends to aviation, including all airlines operating on EU territory whether European or not.[3] In 2013, the following sectors were also added: the production of petrochemicals, aluminium and ammonia, and capture, transport and geological storage of all GHG emissions and emissions of nitrous oxide in certain industries.

Box 3.2 Reforming the EU-ETS

As a short-term measure, the European Commission will postpone the auctioning of 900 million allowances from the years 2013-15 to 2019-20, through an amendment to the EU-ETS Auctioning Regulation. It is expected that this "back loading" of auctions will adjust the CO_2 price. Back loading does not reduce the overall number of allowances to be auctioned during phase three, but only the distribution of auctions over the period. The proportionate impact assessment demonstrates that back loading can rebalance supply and demand in the transition to phase three and reduce price volatility without any significant impacts on competitiveness. It can also strengthen government revenues in phase three. In early 2014, the back-loading proposal was adopted by Parliament and Council. In 2014, about a 400 million allowance quota will be withdrawn from the system.

As a longer-term measure to strengthen the EU-ETS in the period after 2020, the European Commission proposed on 22 January 2014 to establish a market stability reserve at the beginning of the next ETS trading period in 2021. The reserve should both address the surplus of emission allowances that has built up and improve the system's resilience to major shocks by automatically adjusting the supply of allowances to be auctioned. The ETS cap, determined by a linear annual reduction factor, is to be increased to 2.2% per year from 2021 (compared with 1.74% currently), an increase needed to achieve the target of a 40% reduction in EU GHG emissions by 2030 below 1990 levels.

3. On 22 January 2014, the European Commission proposed a *domestic* GHG reduction target of 40% from 1990 to 2030 and an EU-wide target of at least 27% of renewables by 2030 as the pillars of the 2030 Energy and Climate Package, together with a proposal for the reform of the ETS post-2020 (stability reserve). The sectors covered by the ETS are to cut emissions by 43% in 2030 (versus 2005). The emissions reductions in the non-ETS sectors are set at -30% in 2030 (versus 2005). The burden sharing of the EU-wide target is expected to be discussed in 2014/15.

Process industries may receive part, or, if subject to carbon leakage, all of their allowances for free at the level of harmonised industrial best practice benchmarks. These benchmarks and the allocation rules were adopted by the European Commission for the whole third trading period. The so-called "carbon leakage list" was adopted for five years. The existing list was adopted in 2009. A new list is currently being prepared for the period 2015-19. European Union member states can compensate companies at risk of carbon leakage for up to 85% of the cost increase of electricity due to the ETS incurred by the most efficient installations in 2013-15, falling gradually to 75% by 2019-20.

During the second trading period 2008-12, Luxembourg allocated emission allowances of 2.49 $MtCO_2$-eq per year to 14 existing installations, according to the Second National Allocation Plan.

In the third period (2013-20) about 18 industries will benefit from free allocations, and, Luxembourg has foreseen the allocation of 10.25 $MtCO_2$-eq allowances. New installations joined the ETS: steel industry plants, an aluminium factory (recycling used aluminium) and two asphalt manufacturers. These additional installations in 2009 represented 12% of the verified emissions of the second ETS period. For the third period, Luxembourg has foreseen one new entrant.

DOMESTIC MEASURES OUTSIDE THE EU-ETS

Under the Effort Sharing Decision (ESD), Luxembourg has been allocated a binding target of 20% reduction from 2005 levels during 2013-20 for those sectors outside the ETS (or 83% of total GHG emissions).

Given the high importance of non-trading sectors in the country's emission profile, as outlined above, notably transport and road fuel sales to non-residents, Luxembourg has to focus measures on the non-ETS sectors, where mitigation is more difficult and costly.

Luxembourg was not on track at the end of the first Kyoto commitment period, but had a gap of about 20%. During 2008-12, non-ETS emissions accounted for about 10 $MtCO_2$-eq, going beyond the emission budgets set at 7.0 $MtCO_2$-eq.

The non-ETS sector is particularly challenging for Luxembourg, given the relatively large emissions from energy-intensive industries and transport, in comparison to the size of the economy. GHG emissions in non-ETS sectors are mainly driven by the transport, residential and industry sectors. In 2012, road fuel sales to the residents accounted for 15%, non-residents (commuters, transit, and fuel tourism) for 40%, and the residential, commercial and institutional sectors for 13%.

FOCUS ON THE TRANSPORT SECTOR

The government has been increasing efforts to improve the emission performance of the transport sector, including through financial incentives for low-emission cars under *Prime CAR-e*, as outlined in Chapter 4 on Energy Efficiency.

In 2012, the *Global Strategy for Sustainable Mobility* (*mobilité durable, [MoDU]*) and a *Transport Sector Plan* (*plan sectoriel transports, PST*) were adopted, the aim being an increase in public transport and a fleet of 40 000 electric vehicles by 2020 with around 800 public charging stations. This plan addresses cross-border commuting in 22 major infrastructure projects involving EUR 2.4 billion investments by 2020. The government

envisages switching some 25% of motorised trips to public transport in 2020 and is stepping up country-wide cross-modal public transport solutions, including a national park-and-ride network and a parking management system.

The *Second Action Plan on CO_2 Reduction* reinforces the commitment of existing measures, notably with regard to mobility and infrastructure planning, including electric vehicles, and the strengthening of taxation measures. The action plan announces the continuation of the tax incentives for the purchase of low-emission vehicles, the review of the CO_2-based vehicle tax, to re-examine road vehicle tax for high-emission passenger cars, the reform of the taxation of company cars, notably by linking tax breaks to the CO_2 emissions of the vehicle, and a continuous increase of excise duties and/or taxes on road fuels. Non-financial measures include the promotion of car-pooling, non-motorised mobility, an integrated approach to land use, spatial and transport planning and improvements in the public transport network.

The current biofuel blending obligation has increased the share of alternative renewable fuels. Luxembourg supports strict sustainability criteria set at EU level and will raise its contribution to 10% in line with the obligation set in the European Directive on Renewables.

INTERNATIONAL MEASURES

Luxembourg has to make significant use of the so-called flexible mechanisms under the Kyoto Protocol, namely the clean development mechanism (CDM), joint implementation (JI) projects and international emissions trading (IET), so as to meet its emission targets under the Kyoto first commitment period (2008-12).

According to the latest historical data, over the whole Kyoto commitment period 2008-12, domestic emissions were 12.6 $MtCO_2$-eq. above the Kyoto target, which is obtained by subtracting Luxembourg's total assigned amount for the period 2008-12 – i.e. 47.40 $MtCO_2$-eq – from total GHG emissions, excluding land use, land-use change and forestry (LULUCF), for the same period. The country plans to purchase carbon credits for about 14.2 $MtCO_2$-eq.

To secure the budget for these international credits, Luxembourg created the Climate and Energy Fund. CDM is expected to provide about 33% of the emissions reductions, JI about 4% and IET the remainder (see Table 3.2). However, the actual distribution could change, depending on the development of prices and schemes, notably for Luxembourg's contribution to the carbon funds of international financial institutions.

Table 3.1 International GHG emission credits, Luxembourg

Flexible Kyoto mechanisms	Total projected quantities for the first commitment period ($MtCO_2$-eq)
IET	8.95
All project-based activities	5.25
JI	*0.55*
CDM	*4.70*
Total	**14.2**

Source: country submission.

Table 3.2 Expenditures under the Climate and Energy Fund

Expenses incurred in:	2005-13 (EUR million)
CDM in developing countries	36.6
Participations in carbon funds of international financial institutions (CDM, JI and IET)	30.5
Financing energy efficiency activities in Estonia and Lithuania (IET/AAUPA)	48.5
Financing activities in developing countries (GFDRR , REDD, IUCN SIDS and others)	4.7
Projects, programmes, activities, reports and other measures to reduce GHG emissions at national level	55.6
Total energy part of the Fund: compensation mechanism	**32.5**

Source: country submission.

Luxembourg estimates it would need to purchase around 11 $MtCO_2$-eq between 2013 and 2020, corresponding to EUR 110 million at current 2013 carbon prices to meet its emission targets during 2013-20.

Amid pending international climate change negotiations, there is no certainty about the availability of flexible mechanisms for the Kyoto second commitment period. Luxembourg will also need to prove that the use of these mechanisms complements the domestic mitigation efforts.

ENERGY TAXATION

Luxembourg has been maintaining low taxation levels, notably for gasoline and diesel fuel sales (see Chapter 6 on Oil), in comparison to its European neighbours and this leads to large quantities of fuel being sold to non-residents. Taxation rates applicable to energy products and the value-added tax (VAT) rates in Luxembourg are set at the minimum levels established under European regulations. Given the high share of fuel sales to non-residents and related CO_2 abatement cost, in the past the government has chosen to include an environmental component, the so-called *Kyoto cent,* in the tax.

Since the last review, Luxembourg increased efforts to reduce the dependence of the state budget on road fuel sales in favour of directing tax revenues of EUR 55.6 million to environmental purposes (projects, programmes, activities, reports and other measures to reduce GHG emissions at national level). Luxembourg has been successful in using parts of the environmental taxation to finance GHG mitigation measures at national level under the Climate and Energy Fund (see Box 3.1), beyond the purchase of Kyoto emission units.

As outlined in the Chapter 6, Luxembourg had the lowest light fuel oil prices (with a share of 12% taxes in the first quarter 2013) among all IEA member countries and maintains the lowest diesel (41% tax in Q1 2013) and lowest petrol taxes (49% tax in Q1 2013) in the European Union. There has been no change in energy taxation policy since the last in-depth review in 2008, except an increase of gasoil excise taxes from EUR 302 to EUR 335 per 1 000 litres between 2008 and 2013. In 2011, other environmental transport taxes (excluding fuel taxation, but including taxes related to the ownership and use of motor vehicles) only played a minor role in the revenue base, 0.2% of the GDP. Vehicle taxes and the annual circulation tax are below EU average and only partly based on CO_2 emissions. No registration tax applies. Given the high share of transport in the country's CO_2 profile, fuel taxes alone contributed 2.2% to Luxembourg GDP (European Commission, 2013a). In total, fuel sales make up 10% of the state budget.

Table 3.3 Overview of main existing measures to reduce GHG emissions

Sector	Activity	Description of the measure(s)	Objectives
Energy	Supply	CO_2 ETS	Cost optimisation of CO_2 reduction
		Support scheme for renewable electricity (feed-in tariff for hydro, wind, biomass, biogas and for some solar PV installations) and efficient co-generation	Stimulate the production of energy with renewable energy sources
		Four investment grant schemes for renewable energies and tax incentives for solar photovoltaics (PV)	
Industry		CO_2 ETS	Cost optimisation of CO_2 reduction
		Voluntary agreement on energy efficiency in industry with Union of Luxembourg's Enterprises (FEDIL, 56 medium or large manufacturing enterprises)	Improving energy efficiency and use of renewable energy technologies during 2011-16
Transport	Road fuels	Environmental excise duty on gasoline and diesel (*Kyoto cent*)	Raising funds to finance climate mitigation measures
		Increasing excise duties on gasoline and diesel	Reducing the price differential between Luxembourg and its neighbouring countries with regard to road fuels while taking into consideration the impacts on the public finance and the economy
	Road biofuels	Obligation for oil companies to meet a specific quota of biofuels in annual sales	Increasing the share of renewable fuels in transport
	Vehicles taxation	Vehicle taxation based on the CO_2 emissions and 40% of its revenues contribute to the Climate and Energy Fund	Raising funds to finance climate mitigation measures
	Low-emission cars	EU CO_2 emission standards for cars and fiscal policy on car efficiency (*Prime CAR-e* for vehicles with emissions less than 60 g/km CO_2)	To curb CO_2 emissions in transport by setting CO_2 standards for cars within the European Union and stimulating the purchase of passenger cars with low CO_2 emissions (electric vehicles, hybrid plug-in cars) through fiscal incentives
	Public transport	Construction of the tramway in the city of Luxembourg	Contributing to modal shift of 25/75 between public and private transport
Waste		Law regulating waste	Reduction in landfilled waste, reduction of CH_4 emissions from landfill sites
Buildings		More restrictive energy efficiency standards (energy passport/*passeport énergétique*) for new or renovated residential buildings	To stimulate energy savings in new or renovated buildings
		Stringent energy efficiency standards for new or renovated non-residential buildings	
		Financial incentives for the renovation of existing residential buildings older than ten years including support to modernisation of heating systems (heat bonus)	To stimulate energy savings in old and new residential buildings according to the energy passport and the level of heat expenditure of the building
		Financial support for investment in passive and low-energy residential buildings	
		Financial incentives for energy efficiency and use of renewable energy sources in the new residential buildings sector	Facilitating investments in improving the energy quality of homes and speeding up the application of renewable energy concepts in buildings

* 2008-12.

Source: MDDI (2014b), *Sixth National Communication of Luxembourg under the United Nations Framework Convention on Climate Change, including Luxembourg's Biennial Report No 1*, MDDI, Luxembourg.

The amount of energy taxation on gas and electricity consumption is split into two categories, depending on the consumption. Electricity consumption under 25 megawatt hours (MWh) per year is subject to a tax of EUR 1 per MWh whereas consumption of more than 25 MWh per year in the industrial and transformation sectors is charged with EUR 0.50 per MWh. Gas consumption over 550 MWh per year is taxed EUR 0.54 per MWh and gas consumption less than 550 MWh is taxed EUR 1.08 per MWh. This taxation promotes the consumption of gas and electricity in industry rather than energy efficiency measures.

ASSESSMENT

Since the last in-depth review in 2008, CO_2 emissions have remained stable. In 2012, they amounted to around 11.8 $MtCO_2$-eq, failing to meet the 28% Kyoto target (2008-12) through domestic efforts and also making it difficult to achieve the 20% target for the non-trading sectors.

In particular, CO_2 emissions from the transport sector have increased since 2009, with a steady rise of emissions from domestic road transport and from fuel sales to non-residents. Current climate policy measures, such as energy efficiency, energy taxation or emissions trading, have not been able to mitigate and reverse these emission trends.

Luxembourg has been focusing on meeting the lion's share of its reduction needs outside the country, by investing in cost-effective emission abatement via the Kyoto flexible mechanisms CDM/JI projects. Between 2005 and 2013, Luxembourg spent EUR 36.6 million on CDMs in developing countries and EUR 30.5 million through participations in carbon funds of international financial institutions (CDM, JI and IET).

Luxembourg expects to purchase about 11 $MtCO_2$-eq between 2013 and 2020 which would equal EUR 110 million at current 2013 carbon prices. Given that the future use of such mechanisms in the post-Kyoto period is not guaranteed, the government should seek to re-evaluate and rebalance domestic and international abatement potentials. Investing in domestic solutions would help Luxembourg achieve its 2020 energy and climate targets.

Emissions from the energy-intensive steel and glass industry; fell sharply over time and remained stable at their historic levels. In the third trading period the EU-ETS provides for EU-wide allocation of trading certificates according to EU-wide production benchmarks. New installations in Luxembourg joined the ETS as of 2013, including steel industry plants, an aluminium factory and two asphalt manufacturers. However, the ETS sectors only cover around 17% of GHG emissions.

In the non-trading sectors, representing 83% of total GHG emissions, emissions reduction was 6% between 2005 and 2012. High emissions from road transport (with fuel sales to residents making up 15% and to non-residents 40%) and the residential and commercial sectors (13%), mainly linked to the use of heating oil, remain the biggest challenge. Luxembourg is most likely to miss its reduction target of 20% in the non-EU-ETS sector. Current policies will not lead to any significant decrease in GHG emissions by 2020 since it is expected that GHG emissions will be in fact almost the same in 2020 as in 2005.

Commendably, Luxembourg has continuously supported the purchase of low-emission cars (*Prime CAR-e*), and since 2013, the purchase of electric vehicles, and continued its environmental tax, the *Kyoto cent* on road fuel sales. Additionally, 40% of the CO_2-based vehicle tax is directed to the Climate and Energy Fund. The government put forward a *Global Strategy on Sustainable Transport* and aims to have 40 000 e-vehicles by 2020

with around 800 public charging stations. However, there has been no new energy taxation measure decided under the *Second Action Plan on CO_2 Reduction*. The new government coalition programme however has ambitions to rebalance and is to consider new measures.

Low-energy taxation sends a distorted signal to consumers about the full cost of their energy consumption. The government should carry out a cost-benefit analysis, taking into account the benefits associated with tax revenues and other economic activities from commerce at filling stations and weighing them with the cost related to CO_2 emissions and security of oil supply. Phasing out low taxes and excise rates on fossil fuel consumption, could eventually increase the tax base of the state with revenues available to finance the "greening of transport".

The government should take the lead by switching the public car fleet to electric vehicles to complement the e-mobility initiative, and increasing *Prime CAR-e,* or should require motorway station contract holders to provide low-emission fuels at the pump where there is demand. In order to turn its ambitions in the transport sector into reality, the government is encouraged to integrate e-mobility and smart meter roll-out in an energy system approach.

On the one hand, the government should consider raising the *Kyoto cent* and on the other hand, direct revenues from emission auctions to strengthen the budget of the Climate and Energy Fund with a view to support domestic measures on energy efficiency and renewable energies, notably in the transport sector and the refurbishment of buildings.

As pointed out in the 2013 IEA/*WEO* special report *Redrawing the Energy-Climate Map* (IEA, 2013), targeted energy efficiency measures in buildings, industry and transport and the phase-out of fossil fuel subsidies are the key measures that could stop the growth in global energy-related emissions by the end of this decade at no net economic cost. The government should prioritise measures among the 51 set out in the *Second Action Plan on CO_2 Reduction* and the Second and the forthcoming Third National Energy Efficiency Action Plan.

RECOMMENDATIONS

The government of Luxembourg should:

- *Prioritise actions under the* Second Action Plan on CO_2 Reduction *to spur the implementation of cost-effective measures, in particular in the transport sector, and implement the Second (and Third) National Energy Efficiency Action Plans.*
- *Consider an increase of the* Kyoto cent *on road fuel sales to strengthen the revenue base of the Climate and Energy Fund in support of national renewable energy, energy efficiency and other decarbonisation solutions, notably in transport by promoting smart mobility in the country and across its borders. Also consider switching the vehicle fleet into low-emission cars and encourage further modal shift for freight transport.*
- *Review energy taxation on the basis of a comprehensive cost-benefit analysis taking into consideration changing freight, fuel consumption and mobility patterns.*

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4. ENERGY EFFICIENCY

Key data (2013 estimated)

Energy supply per capita: 7.3 toe (IEA average: 4.5 toe), -14% since 2003

Energy intensity: 0.11 toe/USD 1 000 PPP (IEA average: 0.13 toe/USD 1 000 PPP), -16% since 2003

TFC (2012): 3.9 Mtoe (oil 64%, natural gas 15.9%, electricity 14%, biofuels and waste 2.8%, heat 1.9%, coal 1.4%), +14% since 2002

TFC by sector (2012): transport 57.6%, industry 15.6%, commercial 14.7%, residential 11.2%

TOTAL FINAL CONSUMPTION

Total final consumption (TFC) was 3.9 million tonnes of oil-equivalent (Mtoe) in 2012. Consumption has contracted by 5.8% since 2005. With the transition from an industrial to a service economy, TFC fell by 7.1% during the 2009 recession without a full recovery in 2010. Energy supply decreased accordingly by 14% since 2003 and the country's energy intensity declined in line with IEA member countries' average trends.

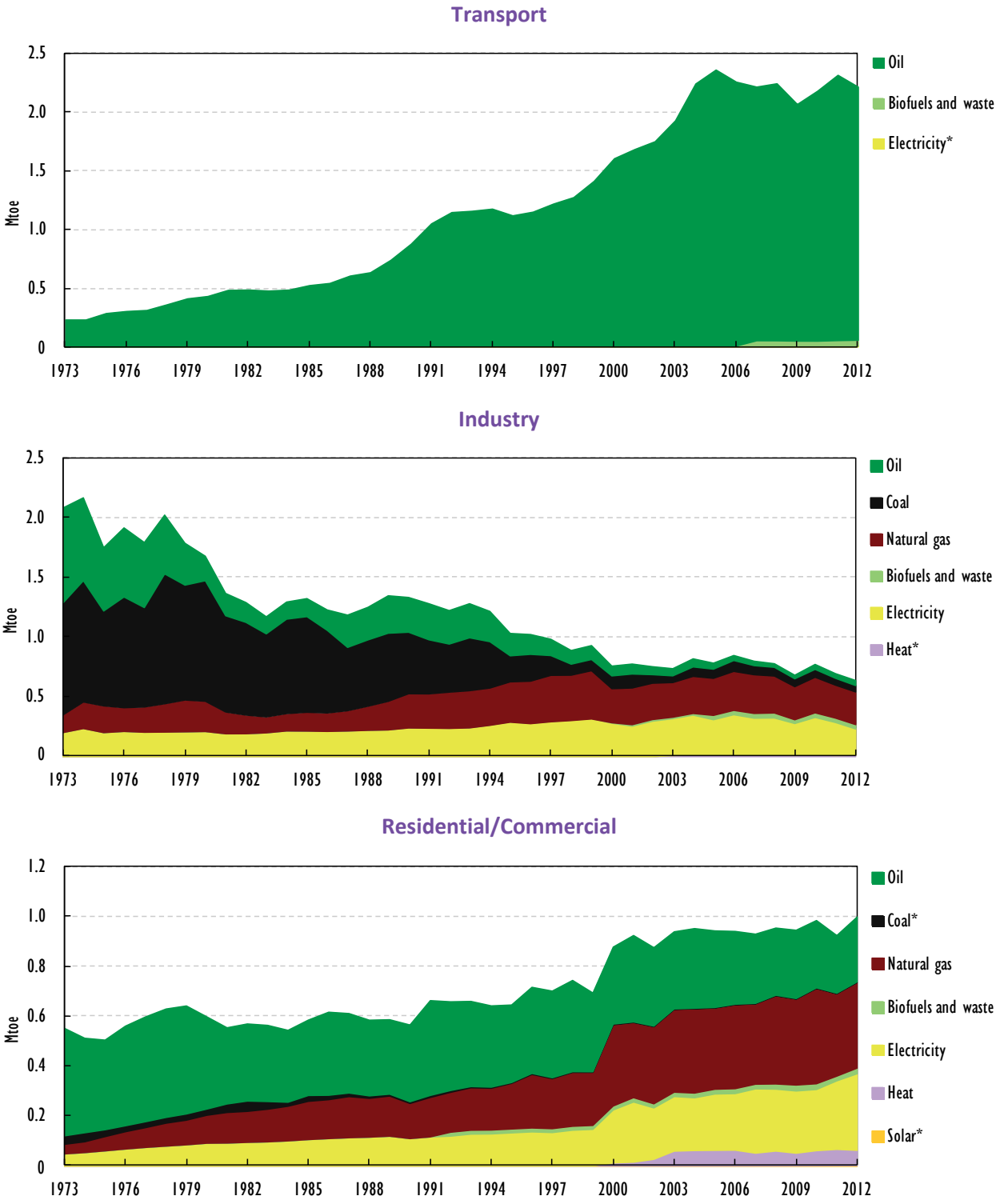
Oil, gas and coal account for 81.2% of TFC. Oil represents 64%, natural gas 15.9% and coal 1.4%. Demand for oil has increased over the past decade while demand for natural gas and coal has fallen. As a share of TFC, coal and natural gas have contracted from 2.2% and 18% in 2002, respectively, while oil is up from 63.1% in 2002. Electricity represents 14% of TFC, a share which has contracted slightly from 15% in 2002. Biofuels and waste and solar energy account for 2.8% and 0.04% of TFC, respectively. Solar energy consumption started in 2008 and is still being developed, while the use of biofuels and waste has increased by 228.5% since 2002, when it stood at 1% of TFC.

Transport is the largest energy-consuming sector, with 57.6% of TFC in 2012. Energy consumption in transport has increased by 26.6% since 2002, coinciding with an increase in the consumption of oil. The use of biofuels in transport began in 2004 and has risen to 2.2% in seven years.

The industry sector accounts for 15.6% of TFC. Consumption has declined by 16.7% since 2002. Natural gas is the main source of energy in the power sector, accounting for 42.1%, followed by electricity (34.9%), coal (8.4%) and oil (6.8%). Biofuels and waste also play a role and provide 5.9% of energy consumption in industry. The most notable change in this sector over the past decade has been a contraction in demand for coal and oil, and growth in demand for electricity and natural gas.

The commercial and residential sectors are mainly fuelled by electricity, natural gas and oil. Demand from commercial services has increased since 2002 while household demand has fallen. Heat consumption in Luxembourg is negligible.

Figure 4.1 TFC by sector and by source, 1973-2012



Note: Reporting methodology on *Commercial* changed in 2000. Data are preliminary for 2012.

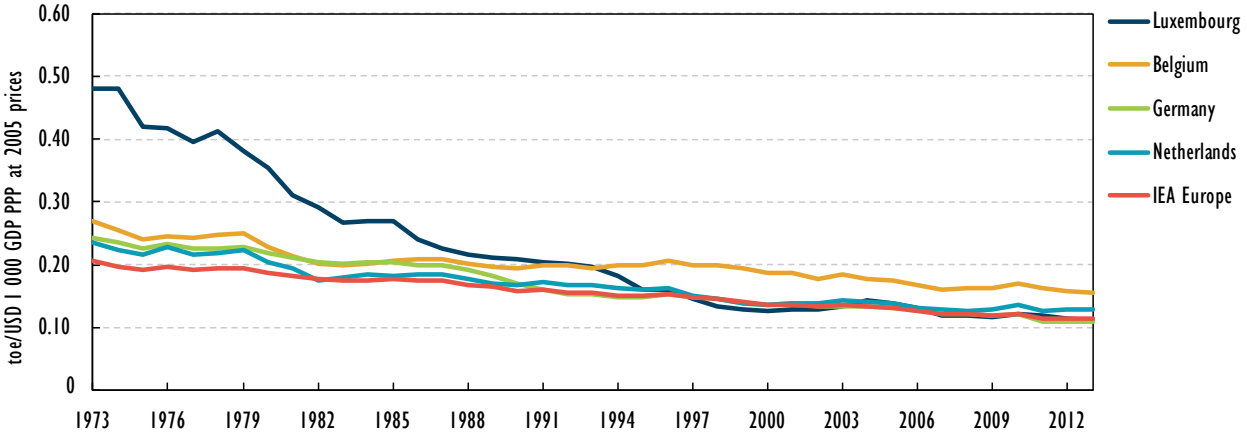
* Negligible.

Source: IEA (2013), *Energy Balance of OECD Countries 2013*, OECD/IEA, Paris.

ENERGY INTENSITY

Energy intensity, measured as the ratio of energy supply by GDP, was 0.11 tonnes of oil-equivalent (toe) per USD 1 000 with purchasing power parity (toe/USD 1 000 PPP) in Luxembourg in 2013. This is lower than the IEA average of 0.13 toe/USD 1 000 PPP. The country is ranked 13th-lowest among IEA member countries with regard to energy intensity. Energy intensity has decreased by 16% since 2003, which is similar to the decline in the IEA average. The most significant decline in energy intensity in Luxembourg had occurred in the last three decades of the 20th century, decreasing by 73.9% from 1973 to 2000. Despite an energy intensity around the IEA average, Luxembourg ranks sixth-highest among IEA member countries in terms of electricity consumption per capita, given the small size of its economy and the high share of services.

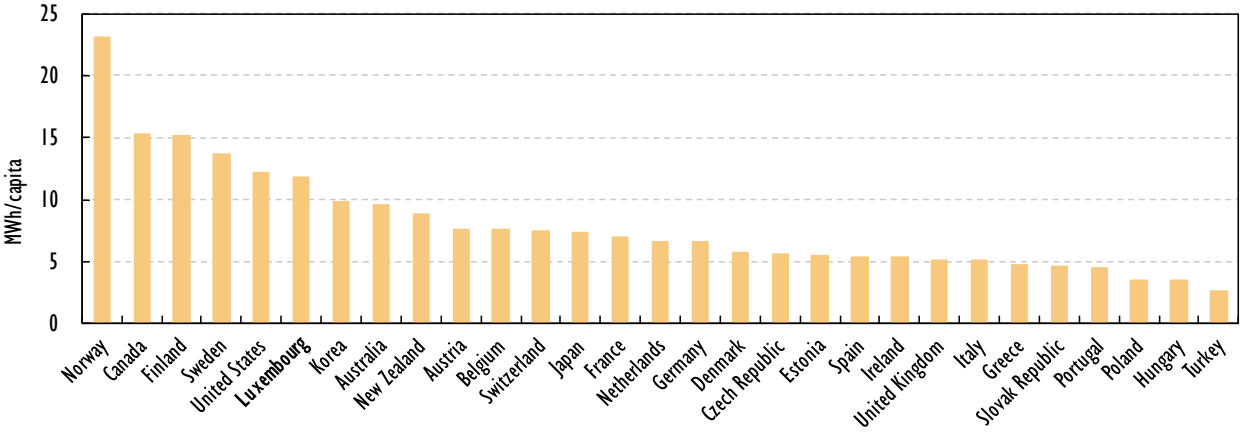
Figure 4.2 Energy intensity in Luxembourg and in other selected IEA member countries, 1973-2013



Note: estimated for 2013.

Sources: IEA (2013), *Energy Balances of OECD Countries 2013*, OECD/IEA, Paris; OECD (2013), *National Accounts of OECD Countries 2013*, OECD, Paris.

Figure 4.3 Electricity consumption per capita in Luxembourg and other IEA member countries, 2012



Note: preliminary data.

Source: IEA (2013), *Energy Balances of OECD Countries 2013*, OECD/IEA, Paris.

INSTITUTIONS

Responsibility for energy efficiency lies with the **Ministry of the Economy** which is in charge of the overall energy policy, except the subsidy scheme for households for energy-efficient residential buildings, a programme which falls within the competence of the Ministry of Sustainable Development and Infrastructures which is also in charge of mobility and transport policies.

Created in 2009, the national energy agency **Myenergy** supports the government in the implementation of sustainable energy policies and promotes the rational use of energy and renewable energy sources. Myenergy provides common neutral information and advice in the field of energy efficiency and renewable energy.

POLICIES AND MEASURES

EU POLICIES

As in other EU member states, Luxembourg's energy efficiency policies are determined by several EU regulations and directives.

The European Union has a primary energy reduction target of 20% below the 2007 projected energy demand target by 2020. Several EU directives relating to energy efficiency guide the policy of Luxembourg.

Directive on Energy Efficiency (2012/27/EU), repealing Directives 2006/32/EC and 2004/8/EC, establishes a common framework of measures for the promotion of energy efficiency within the Union in order to ensure the achievement of the Union's 2020 headline target of 20% on energy efficiency and to pave the way for further energy efficiency improvements beyond that date. The legal definition and quantification of the EU 2020 energy efficiency target have been revised − after the accession of Croatia − to 1 483 Mtoe primary energy or no more than 1 086 Mtoe of final energy. The directive lays down rules designed to remove barriers in the energy market and overcome market failures that impede efficiency in the supply and use of energy. It provides for the establishment of indicative national energy efficiency targets for 2020 (see Box 4.1).

Up to 2012, the framework was based on the Directive on Energy End-Use Efficiency and Energy Services (2006/32/EC) which required member states to develop national energy efficiency action plans and to meet an indicative target to reduce final energy use in the sectors not covered by the EU Emissions Trading Scheme (EU-ETS) by 9% by 2016. The directive obliged member states to establish National Energy Efficiency Action Plans (NEEAP) in 2007, 2011 and 2014 about the implementation of the directive.

The Directive on the Energy Performance of Buildings (EPBD, 2002/91/EC) and its 2010 successor (EPBD, 2010/31/EU) established requirements for building codes. These codes have to include minimum energy performance standards (MEPS) and energy certificates. The 2010 recast requires new buildings to be at "near-zero energy" performance by the end of 2020.

The Ecodesign Directive (2009/125/EC) sets MEPS for energy-related products with the objective to reduce the environmental impact, including from energy consumption, throughout the entire life cycle. There is no mandatory requirement but energy-related products are chosen by implementing measures and voluntary agreements. Fifteen product groups have been regulated so far by product-specific implementing regulations.

Energy labelling of energy-related products encourages consumers to choose, and industry to develop, energy-efficient products. EU-wide requirements are set under the Energy Labelling Directive (2010/30/EU). Product-specific labelling standards are set up in delegated acts under this directive.

Since May 2009, new passenger cars manufactured in the European Union fall under the CO_2 emissions regulation (Regulation 443/2009), which effectively controls the fuel efficiency of vehicles. By 2015, CO_2 emissions of new passenger cars must be at, or below, 130 grammes CO_2 per kilometre (gCO_2/km). Complementary measures are being introduced to reduce the CO_2 emissions of other than engine components by a further 10 g CO_2/km through efficiency improvements in those components, such as tyres and transmission technology. The CO_2 emission limit is expected to be reduced to 95 g CO_2/km by 2020. A similar regulation for new vans was introduced (Regulation 253/2014) with limits of 175 gCO_2/km by 2017 and 147 g by 2020. The CO_2 emissions of heavy-duty vehicles are not regulated at present; however, the introduction of regulations is planned.

Box 4.1 EU energy efficiency regulations

On 25 October 2012, the EU-adopted Directive 2012/27/EU on Energy Efficiency (EU EED), which establishes a common framework of measures for the promotion of energy efficiency within the European Union in order to achieve the Union's 20% target on energy efficiency by 2020 and to pave the way for further energy efficiency improvements beyond that date. It lays down rules designed to remove barriers in the energy market and overcome market failures that impede efficiency in the supply and use of energy, and provides for the establishment of indicative national energy efficiency targets for 2020.

Overall, the directive is considered an important milestone for EU-wide co-operation on energy efficiency. It calls for binding measures rather than binding targets. Each member state should set its own target and present a national energy efficiency action plan every three years, beginning in 2014. The new directive requires each member state to:

- Set an indicative national energy savings target for the period 01 January 2014 through 31 December 2020 in line with the EU-wide 20-20-20 target.
- Establish a long-term strategy for renovating the building stock, including a renovation rate of 3% for buildings occupied and used by central government.
- Develop public procurement rules ensuring that central governments purchase only highly efficient products.
- Oblige energy providers to achieve cumulative end-use energy savings by 2020 equivalent to 1.5% of annual energy sales over the period 2014-20. Member states can pursue alternative ways to achieve equivalent energy savings.
- Require all large enterprises to undergo quadrennial energy audits.
- Facilitate the development of national financing institutions for the implementation of energy efficiency measures.
- Ensure that individual meters of energy consumption are installed at the end user's premises, if technically possible and economically feasible.

The directive may fall short (by 3% to 5%) of the 2020 target. It requires a review in mid-2014; a shortfall in energy savings may result in a shift from binding measures to binding targets.

Luxembourg has implemented the EU legislation at national level through the following framework:

- amended Law of 5 August 1993 concerning the efficient use of energy *(Loi modifiée du 5 août 1993 concernant l'utilisation rationnelle de l'énergie)*
- amended Grand-Ducal Regulation of 30 November 2007 concerning the performance of energy in residential buildings *(Règlement grand-ducal modifié du 30 novembre 2007 concernant la performance énergétique des bâtiments d'habitation)*
- amended Grand-Ducal Regulation of 31 August 2010 concerning the performance of energy in non-residential buildings *(Règlement grand-ducal modifié du 31 août 2010 concernant la performance énergétique des bâtiments fonctionnels)*
- Grand-Ducal Regulation of 26 December 2012 concerning the electricity production from highly efficient co-generation (*Règlement grand-ducal du 26 décembre 2012 relatif á la production d'électricité basée sur la cogénération à haut rendement*)
- Grand-Ducal Regulation of 27 February 2010 concerning gas-fired installations *(Règlement grand-ducal du 27 février 2010 concernant les installations à gaz)*
- Grand-Ducal Regulation of 15 December 2011 concerning the production, remuneration and the commercialisation of biogas *(Règlement grand-ducal du 15 décembre 2011 relatif à la production, la rémunération et la commercialisation de biogaz)*

  The government is completing the full transposition of directive 2012/27/EU and is analysing the different mandatory mechanisms for energy efficiency (defining the obligated parties and the renovation obligation in the public sector), including the meter requirements and energy audits. In 2013, the Ministry of Sustainable Development and Infrastructure presented the report on the implementation of the near-zero energy buildings standards.

DOMESTIC STRATEGIES AND PLANS

The government acknowledges the importance of energy efficiency in driving the competitiveness of the economy and in reaping economic benefits and improving the quality of life for businesses and citizens alike. The national energy efficiency policies are set out in the First and Second NEEAPs, based on the requirements of Directive 2006/32/CE mentioned above.

In March 2008, Luxembourg prepared a first NEEAP which outlined the measures needed to achieve an indicative energy-saving target of 9% or 1.582 GWh out of the total average energy consumption 2001-05 of 17.576 GWh (without petrol exports and emissions trading), as set under the ESD.

In September 2011, Luxembourg presented the second NEEAP which analysed and evaluated the progress made on the measures contained in the first NEEAP, updated the final energy consumption to 19 654 GWh and thus the target to 1 769 GWh. In this framework, Luxembourg has set out measures that should allow it to achieve the indicative target of energy savings of 2 764 GWh by 2016 (or 14.06% against a reference consumption average of 2001-05). In 2010, Luxembourg had achieved 7.59% or 1 493 GWh. The second NEEAP also includes sectoral targets along the following split of contributions:

- households: 5.5%
- business and services: 2.85%

- combined heat and power: 1.05%
- renewable energies: 1.28%
- traffic: 1.51%
- industry: 2.33%.

In July 2013, the government notified a preliminary target value for 2020 of 49 292 GWh or 4 239.2 thousand tonnes of oil-equivalent (ktoe) of final energy in the light of the EU EED of 2012. The European Union's overall final energy target under the EED is based on a projection from 2007: the EU Primes 2007 projections. The target proposed for Luxembourg is derived from the same source and based on the same driver developments as the EU target. The reported target for 2020, under Article 3 EU EED, represents a reduction of 20% of the Primes 2007 provision for the Grand Duchy. The reported target is "preliminary" because Luxembourg reserves the right to adjust these targets under the 2014 Third NEEAP once the effects of the measures have been calculated more precisely. The Third NEEAP is being prepared.

The top five measures with the highest potential included in the NEEAPs are the building sector regulation of 1996, the voluntary agreement with industry and introduction of monitoring by Myenergy (2011), the promotion of decentralised co-generation production, the introduction of an energy performance certificate in the building code of 2008 (for residential buildings) and of 2011 (for non-residential buildings) with a timetable until 2017 with enforcement for residential buildings.

The European Commission evaluated the second NEEAP in 2013 and concluded that Luxembourg has a realistic forecast of the 2016 savings based on the measures set out, which go beyond the requirements under the Directive on Energy End-Use Efficiency and Energy Services (European Commission, 2013b). There is however still large untapped potential for further energy efficiency improvements, notably in the existing building stock, or in the public sector's lead and the promotion of energy efficiency services and performance contracting.

The section below offers a more detailed analysis of the measures put in place in the transport, buildings and industry sectors.

TRANSPORT

Luxembourg adopted EU regulations which foster energy efficiency in public and private transport, including the labelling of tyres, the setting of emissions standards for new passenger vehicles, vans and light-duty vehicles and others. The country introduced in 2007 a vehicle taxation based on CO_2 emissions and, since 2011, 40% of the vehicle tax revenues (or EUR 24 to EUR 28 million) contributed to the Climate and Energy Fund during 2008-12 (see Box 4.1).

Luxembourg uses fiscal incentives for the purchase of efficient and low-emission cars.

Several financial incentives were introduced in 2007 by the government for the purchase of very low-emission cars (≤ 100 g/km before 31 July 2011 and ≤ 90 g/km from 1 August 2011 to 31 December 2012), notably the *Prime CAR-e* financial incentive of EUR 750 (1 June 2007 to 31 December 2012), which was raised to EUR 1 500 (1 January 2010 to 31 December 2012). For electric cars, the incentive was raised to EUR 3 000 (2011) and EUR 5 000 (2012 and 2013). During the period 1 January 2009 to 31 July 2010, there was an additional incentive of EUR 1 500 or 1 750, the *Prime CAR-e plus,* which depends on the CO_2 emissions of the new car, when scrapping a car older than ten years.

The support mechanism for energy-efficient cars and information campaigns supported an increase in the number of efficient cars in Luxembourg. In total, EUR 22.5 million were paid for 24 300 cars under the *Prime CAR-e* and EUR 15.3 million for 7 000 cars under the *Prime CAR-e plus* scheme – 13.9 % of newly registered cars in 2012 were below 100 gCO_2/km (17 times more than in 2009) and 37.2 % below 120 gCO_2/km, with average emissions of newly registered cars registered at 138.4 gCO_2/km in 2012 (minus 16.6% compared to 2007) and average emissions of all registered cars on 1 January 2013 of 156.6 gCO_2/km (or -13.6% compared to 1 January 2005). These levels are above the EU average and the efforts to support clean cars are mixed. Since 2013, the incentives were restricted: the government decided to continue the support (EUR 5 000) only for electric cars and cars emitting below 60 gCO_2/km, i.e. electric cars and hybrid plug-in cars, for one more year.

The government is decided to promote electrical mobility and commissioned a study for a national electro-mobility concept (Schwartz and Co, 2011). In 2012, the *Global Strategy for Sustainable Mobility (mobilité durable, MoDU)*[1] and a *Transport Sector Plan (plan sectoriel transports, PST)* were adopted. The latter addresses cross-border commuting in 22 major infrastructure projects with planned investments of EUR 2.4 billion by 2020. The government envisages switching some 25% of motorised trips to public transport by 2020 and is stepping up country-wide cross-modal public transport solutions, including a national park-and-ride network and a parking management system. The current efforts by the government to increase the offer of public transport has led to an increase in the number of cross-border workers using public transport from 9% in 2007 to 14% in 2010. The number of passengers using the regional buses has increased by 37%.

Table 4.1 Modal split of passenger transport on land, 2011

Type of transport	Share
Car	83.1%
Bus	12.5%
Train	4.4%

Source: European Commission (2013), "EU Transport in Figures", *Statistical Pocketbook*, Publications Office of the European Union, Luxembourg.

Table 4.2 Modal share of freight transport (% in total inland freight), 1996-2011

Type of transport	Share in 1996	Share in 2011
Road	80.4%	93.7%
Rail	12.2%	3.1%
Inland waterways	7.4%	3.2%

Source: EEA, TERM 2013.

Luxembourg co-operates with neighbouring countries on climate change, notably on electro-mobility. The Ministry of Sustainable Development and Infrastructure is co-financing different projects related to electro-mobility in the trans-boundary context, through the Public Research Centre Henri Tudor, including via INTERREG IV A-Projects and Trans-

1. Details of the strategy are available under the following link: www.dat.public.lu/actualites/2012/04/1904_MODU/index.html.

European Transport Network (TEN-Tea) Project "Greening European transportation infrastructure for electric vehicles", which is conducted by "Better Place at the European Level" (the project has been finalised in 2012), pilot projects "Nordstad-Emovin", targeting the use of electro-mobility and "Zac-Emovin", focusing on the use of electro-mobility in the business sector.

Luxembourg has no tram or metro network so far and largely relies on public bus transportation in its cities (see Table 4.1). Many commuters travel by car. Inland road transport increased over the past decade in line with population growth. This is also illustrated by the fact that Luxembourg saw the highest increase in new passenger cars in the European Union, rising from 477 to 658 passenger cars per 1 000 inhabitants between 1990 and 2011 (European Commission, 2013a). A tramway in the city of Luxembourg (Luxtram) is planned.

The increase of freight transport is more significant, in particular the increasing shift from rail to road since 1996 (see Table 4.2). This has not been reversed by the introduction of a time-based road toll for heavy-duty-vehicles above 12 t (*Eurovignette*) of EUR 1 250 per year. Instead, the government has set out ambitions to become a major European logistics hub and supports multimodal freight transport with access to cargo railways, fluvial freight (Port of Mertert), air freight and highways connecting the country with all markets in Europe. A new Eurohub South logistics platform is to become operational in 2015. It is expected that three times more CO_2 emissions can be avoided between 2015 and 2025.[2]

BUILDINGS (INCLUDING APPLIANCES, LIGHTING AND EQUIPMENT)

Since 2008, Luxembourg has made the implementation of energy efficiency requirements in buildings a priority and was able to increase energy performance standards in residential buildings in 2008 and in non-residential buildings in 2011.

In July 2013, the government presented the national plan for raising the level of near-zero energy buildings, which sets out the measures to reach the ambitious targets and requirements of the Energy Efficiency Directive, under which all new buildings have to meet this new standard by 31 December 2020: public buildings by 31 December 2018.

With regard to energy efficiency in buildings, Luxembourg has strengthened its building codes, effective compliance systems and is committed to foster the implementation of energy performance certificates (EPC). The legal framework was set out in the 2008 regulation about energy efficiency of residential buildings and the 1 January 2011 regulation concerning energy efficiency of non-residential buildings. Since 2012, with the *Règlement grand-ducal modifié du 30 novembre 2007 concernant la performance énergétique des bâtiments d'habitation* (modified in May 2012), Luxembourg raised the energy performance (annual primary energy consumption) and thermal insulation (annual heat consumption) requirements for residential buildings with a timetable for enforcement until 2017. For non-residential buildings, a regulation is to be presented to Parliament which will enforce their energy performance. The government intends to implement near-zero-energy performance for buildings by 2019 and also an obligation to deliver an energy passport indicating the energy efficiency performance of the building in the event of rental or sale.

2. The European Gateway project contains detailed information on Luxembourg as an international logistics hub. See www.cc.lu/uploads/media/Brochure_Cluster-_Luxembourg_The_European_Gateway.pdf.

For new and existing residential buildings, the calculation of the energy performance is based on energy needs and includes heating, hot water, ventilation and other needs. It is expressed in terms of absolute levels of primary energy need, final energy need and CO_2 emissions.

For non-residential buildings, the calculation of the energy performance is based on the energy needs of new buildings and the energy consumption of existing buildings. The methodology for both new and existing buildings includes, in addition to the calculation of needs for residential buildings (heating, hot water, ventilation and other needs), the calculation of energy needs (consumption) for refrigeration, lighting, humidification and dehumidification. The results are expressed as a ratio to a reference building of the same type. The 100% mark represents the requirement for new non-residential buildings. This means that no building permit is granted for new buildings situated above this mark. For existing non-residential buildings, the scale of classification ranges from 0% to 400%; 100% represents a typical existing building of the same type.

Since 1996, the energy performance requirements have been raised over time, in principle for all components of all types of buildings (with a few exceptions). Table 4.3 illustrates the minimum required U-values applicable from 1996 to 2008 and those currently in force. The new minimum performance standards for residential (2008) and non-residential buildings (2011) are shown in Table 4.4. The government expects the new rules to reduce the energy consumption in the buildings sector by between 30% and 50% compared to the previous regulation. Table 4.4 shows the different stages and requirements for residential and non-residential buildings from 1 January 2008 up to now.

Table 4.3 Minimum requirements for buildings U-values* in 1996 and 2008

1996 building component	**To outdoor air**	**To soil or unheated spaces**
Outdoor walls	0.4	0.4
Windows and doors	2	0.3
Ridget/flat roof and attic	0.3	2
Foundation, cellar	0.4	2.5

2008 building component	**To outdoor air**	**To weakly heated spaces**	**To soil or unheated spaces**
Wall and floor	0.32	0.5	0.4
Roof and ceiling	0.25	0.35	0.3
Domes	2.7	2.7	2.7
Window or balcony door including frame	1.5	2	2
Door including frame	2	2.5	2.5

*The U-value represents the rate of heat loss, i.e. how much energy passes through one metre of a material by a difference of one degree in temperature. It is measured in watts (W) per degree Kelvin (K) per square metre.

Source: country submission, 2013.

The government has implemented several important measures to improve existing buildings and to promote the construction of low-energy and passive buildings. In December 2012, a new regulation was adopted for the period 2013-16 which links the level of subsidies granted for energy efficiency improvements and for the use of renewable energies in the

residential sector. Depending on the refurbishment impact, support can range from EUR 10 to EUR 52 per square metre. Wood-fuelled boilers and geothermal heat pumps are also eligible for support.

To improve skills in energy audits and in finding the best economic and technological solutions to improve buildings, special courses have been offered, by the Chamber of Trade, to train qualified experts.

The Ministry of Sustainable Development offers technical and financial support to municipalities under the Climate Pact. In addition, the government tightened the bilateral co-operation, networking and sharing of best practices on energy policy, notably on energy efficiency, with Switzerland (co-operation between Myenergy and Swiss Energie-Agentur der Wirtschaft).

An additional tool to implement the energy performance standards is the coupling of these standards with investment aid for energy efficiency in residential buildings.

In 1989, Luxembourg established a mandatory acceptance procedure in new buildings and regular inspections of oil- and gas-fired boilers in existing buildings. For gas-fired boilers, this system became mandatory in 2000. The acceptance procedure and the regular inspection of air-conditioning systems are mandatory since 2009, in residential and non-residential buildings. The installers have the obligation to make the application for the acceptance procedure to the Chamber of Handcrafts, which acts for parts of this procedure under the mandate of the government, on the basis of a special agreement. Each new oil- or gas-fired heating system in new and existing buildings is submitted to an acceptance procedure. After the acceptance procedure, a periodic control of the heating system is mandatory. Gas-fired heating systems are subject to an inspection every four years, whereas the inspection interval is two years for oil-fired boilers. The results of these certifications and inspections are centralised in a database. The certificate of oil-fired heating systems includes, besides information on the user of the heating system and on the controller, the following information: location of the boiler; fuel type; nominal power of the installation; black carbon index and residual fuel in the exhaust gas; CO_2 emissions; temperature of exhaust gas; combustion efficiency and the inspection result.

In the case of gas-fired boilers, the certificate contains, in addition to the information mentioned above, a safety check of the installation, including the whole exhaust system and the location of the system inside the building. Since 2010, each heating system with a boiler older than 15 years is subject to a unique inspection comprising an analysis concerning the power of the boiler in relation to the heating needs of the building. On the basis of an agreement between the Chamber of Handicrafts and the government, the inspections are carried out by qualified installers.

A new regulation is going through the legal procedure which will introduce similar acceptance and inspection procedures for wood-fired heating systems.

As Luxembourg imports nearly all appliances and equipment, European standards and standards of the import countries are applicable in the country. A tax incentive to promote the purchase of low-energy electric appliances (*PRIMe Cool* for fridges and freezers) was discontinued at the end of 2011. The government promotes low-energy housing and appliances through the so-called Oekotopten. The online tool provides an overview of appliances benchmarked on the contribution to the environment.[3]

3. www.oekotopten.lu.

Table 4.4 Building requirements 2008-11

The principles of legislation: requirements		
Before 1 January 2008	**After 1 January 2008**	**After 1 January 2011**
	Residential buildings	
RGD 22 November 1995	RGD 30 November 2007	RGD mod. 30 November 2007
U-values*	1. Minimal values: • U-values • tightness • pipes • ventilation 2. Heating energy index 3. Primary energy index	
	Non-residential buildings	
RGD 22 November 1995	RGD 30 November 2007	RGD 2010
U-values*	U-values	1. Minimal values: • U-values • sun protection • tightness • thermal bridges • pipes and storage • ventilation • regulating and measurement devices 2. Heating energy index 3. Primary energy index

RGD = Règlement grand-ducal.

* The U-value represents the rate of heat loss, i.e. how much energy passes through one metre of a material by a difference of one degree in temperature. It is measured in watts (W) per degree Kelvin (K) per square metre.

Source: country submission, 2013.

INDUSTRY, SERVICES AND CO-GENERATION

The EU EED requires mandatory audits for large enterprises and supports audits for small and medium-sized enterprises.

Luxembourg has been making use of voluntary long-term agreements to stimulate energy efficiency in industry and to increase the use of renewable energy sources (the most recent is the *Accord volontaire avec le secteur industriel 2011-2016*).[4] The voluntary agreement is set between the government and the Business Federation Luxembourg. Participating members agreed to set up an energy management manual to identify the increasing potential for energy efficiency and to submit an action plan to bring out this potential. It is expected that 1% of energy efficiency improvements can be achieved per year.

Expectations that the EU-ETS would deliver considerable energy savings in the industry have not been achieved on account of the low CO_2 price. Myenergy has been designated as the co-ordinator of these industrial action plans and its mission is to advise participants and to ensure the follow-up of the results. In this agreement the sector has taken the engagement to improve energy efficiency by 7% of the average energy consumption in 2009-10.

4. "Accord volontaire entre le gouvernement luxembourgeois, Myenergy GIE et la Fedil – Business Federation Luxembourg relatif à l'amélioration de l'efficacité énergétique dans l'industrie luxembourgeoise".

At the end of 2012, a new regulation was adopted for the promotion of highly efficient co-generation through feed-in tariffs for electricity produced as well as the conditions of connection to the distributions network and the guarantee of origin (Schwartz and Co, 2011). The government intends to increase support to co-generation based on renewable energy sources, continues to support existing fossil fuel-based co-generation and, as from mid-2014, abolishes support for new fossil fuel-based co-generation.

In 2011 a study was carried out on the introduction of smart meters in Luxembourg. An economic interest group was formed, bringing together the grid operators, the regulatory authority and the Ministry of the Economy. The 2007 law on the electricity and gas markets was amended in 2012 by defining a timeframe for the introduction of a common smart metering platform for natural gas and electricity. The deployment of smart meters should start in 2015 and equip at least 95% of all final consumers by 2020. Seven grid operators (Creos, Sudgaz, Sudstroum, Electris, Ville de Diekirch, Ville d'Ettelbruck and Ville de Dudelange) are to carry out the implementation of smart meters.

ASSESSMENT

Luxembourg's energy consumption is determined by oil, gas and coal which account for 81.2% of TFC, with transport being the largest energy-consuming sector (57.6% of TFC in 2012) followed by industry (15.6% of TFC) and the commercial and residential sectors. Energy consumption in transport has increased by 26.6% since 2002, coinciding with an increase in the consumption of oil. This growth is strongly driven by non-residential energy consumption, i.e. road fuel sales to foreign passenger cars and lorries, crossing Luxembourg, and some 150 000 daily commuters from across the country's border, who account for some 36% of the energy consumption on its own.

Electricity consumption is growing rapidly, as the country is facing an unprecedented population growth (512 400 in 2011 against 483 800 in 2008), substantially above the IEA average; combined with a projected increase in commuters, expected to reach some 200 000 by 2020, this will most likely result in growing energy consumption trends. Given that the Luxembourg price levels for electricity and gas depicted in purchasing power parity (PPP) are among the lowest in the European Union, with low-energy taxes encouraging large-scale electricity and gas consumers, this underlines the need for a stringent and ambitious stance on energy efficiency.

The national energy efficiency policy is framed by EU provisions, notably the policies and measures put in place under the Energy Service Directive (Directive 32/2006/EC) and listed in the Second National Energy Efficiency Action Plan. In this framework, Luxembourg has set the indicative target to save 2 764 GWh (14.06% against the reference consumption average of 2001-05) by 2016. The First and Second NEEAPs laid down the measures already undertaken and planned to reach this target. A third Energy Efficiency Action Plan is under preparation.

Implementation of the measures under the European Energy Efficiency Directive (2012/27/EU) requires a series of stringent energy efficiency measures across all sectors, i.e. the national indicative target for 2020, put in place energy audits for industry, demonstrate the leading role of the public sector for energy efficiency by refurbishing central government buildings and public procurement as well as achieving 1.5% annual energy savings among final energy customers through installing energy efficiency obligations or alternative mechanisms. In addition, the Directive requests for several measures to assess and develop the existing potential for the deployment of combined heat and power production and district heating and cooling.

Luxembourg has taken the lead by setting a preliminary target value for 2020 of 49 292 GWh or 4 239.2 ktoe of final energy. The implementation of the comprehensive actions of the EED could strongly foster Luxembourg's energy efficiency policy and act as a support for its future national energy strategy.

The creation of a national agency, Myenergy, in 2009 is a commendable development. Energy efficiency in the industry sector is tackled by voluntary agreements. Myenergy is monitoring the achievements under these voluntary agreements. However, energy audits are not implemented in a systematic manner.

In the buildings sector, the framework is set by the European Energy Performance of Buildings Directive (Directive 2010/31/EU), covering new buildings and major refurbishments. Luxembourg has opted for an ambitious implementation of the Directive, introducing EPCs in 2008 and adopting a timetable for enforcement in residential buildings with law enforcement until 2017. Non-residential buildings have received EPCs since 2011 and an implementation table until 2017 is currently under consideration. The government has also defined steps towards a near-zero-energy house standard. It is also completing the full transposition of the EPBD (Directive 2010/31/EU) by submitting the required reports on cost optimisation and near-zero energy buildings. The swift move to passive-house standards for new buildings by 2017 is to be commended.

Regarding the transport sector, the government has set the objective to improve the links between regional development and mobility, notably in *Global Strategy for Sustainable Mobility (mobilité durable, MoDU)* and a *Transport Sector Plan (plan sectoriel transports, PST)*. The ambitions and measures set out in the MoDU and the Transport Plan are commendable and should be implemented swiftly, notably by switching 25% of motorised transport to public transportation mode. The phasing-in of e-mobility will be a complementary pillar to this structure and replace polluting and noise-intensive modes of public and private transport.

While the transport policy is comprehensive with a number of schemes, its benefits are largely offset by the quantity of road fuel sold to non-residents and its related emissions. The policy is not adequately responding to the growing urbanisation, the ambitions to become a logistics hub and the overall population development of the country. The actions set out in the Second Action Plan should be swiftly implemented, notably with regard to the public sector, the taxation of company cars and the review of the costs and benefits of increasing energy and fuel taxation. Energy efficiency improvements in the transport and mobility sectors can contribute to emission mitigation and will contribute to the quality of life in a more and more urbanised Luxembourg.

RECOMMENDATIONS

The government of Luxembourg should:

- *Strive to achieve the national energy efficiency objectives set for 2016 and 2020 and use the implementation of the European Energy Efficiency Directive as a trigger to implement cost-effective energy efficiency programmes and measures.*
- *Strive to increase the energy efficiency of the country-wide public transport system and develop a strategy with neighbouring countries and regions on ways to implement multimodal transport solutions for cross-border commuters. In this respect, the national MoDU strategy should be put in place swiftly, notably by switching some 25% of motorised trips to public transport in 2020.*

- *Implement the strategy on energy efficiency in buildings and take appropriate steps to train and qualify the building workforce. A key focus should be the refurbishment of existing buildings.*
- *Develop energy service markets, notably energy performance contracting, in support of enhancing the efficiency of industrial installations, office buildings, data centres and the public sector.*

References

European Commission (2013a), "EU Transport in Figures", *Statistical Pocketbook*, Publications Office of the European Union, Luxembourg.

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PART II
SECTOR ANALYSIS

5. ELECTRICITY

Key data (2013 estimated)

Installed capacity:* 1.8 GW

Peak demand: 1 GW (Creos peak demand of 778 MW; Sotel peak demand of 279 MW)

Total electricity generation: 1.8 TWh, -34.9% since 2003

Electricity net imports: 5 TWh, +31.4% since 2003

Electricity generation mix: natural gas 78%, biofuels and waste 8.3%, hydro 6.4%, wind 4.5%, solar 2.8%

Electricity consumption (2012): 6.3 TWh (commercial 43.5%, industry 41%, residential 13.5%, transport 2.1%)

*Source: ILR (2013).

OVERVIEW

Luxembourg's electricity system is relatively small and its electric transmission system is interconnected with Germany, Belgium and France. The electricity sector in Luxembourg has a number of unique aspects. Despite being located in Luxembourg, the two largest power generation facilities almost entirely service electricity industry needs in the neighbouring systems in Germany and Belgium. For that reason, Luxembourg has two separate electricity networks, Sotel and Creos.

Electricity generation in Luxembourg fluctuates depending on the production cycles in energy-intensive industries. Recently, the generation of the gas-fired power plant which supplies the steel industry decreased significantly as a result of the global economic and financial crisis. At the same time, the importance of electricity imports is growing due to increased domestic consumption and the generation needs of the pumped-storage hydro power plant.

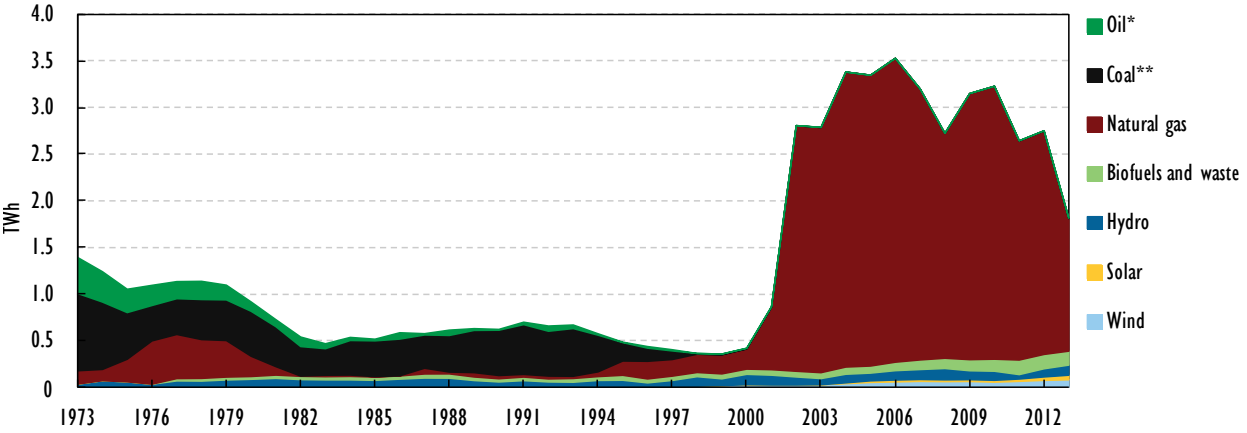
These unique features mean that the government has to ensure effective domestic and regional policies for electricity market integration and security of electricity supply.

SUPPLY AND DEMAND

ELECTRICITY GENERATION

Installed generating capacity in Luxembourg was around 1.8 gigawatts (GW) in 2012, with a large share represented by pumped-storage hydro (see Table 5.1). Total pumped-storage hydro capacity was 1.1 GW, or 61% of the total. The remainder is made up of 395 megawatts (MW) of gas-fired generation (22.3%), 116.5 MW combined heat and power with biomass and waste (5.8%), 75 MW of solar (4.2%), 58 MW of wind (3.2%), 34 MW of other hydro (1.9%) and 19.8 MW of steam (1.1%). Solar photovoltaic (PV) installed capacity has almost doubled from 40 MW in 2011 to around 75 MW in 2013.

Figure 5.1 Electricity generation by source, 1973-2013



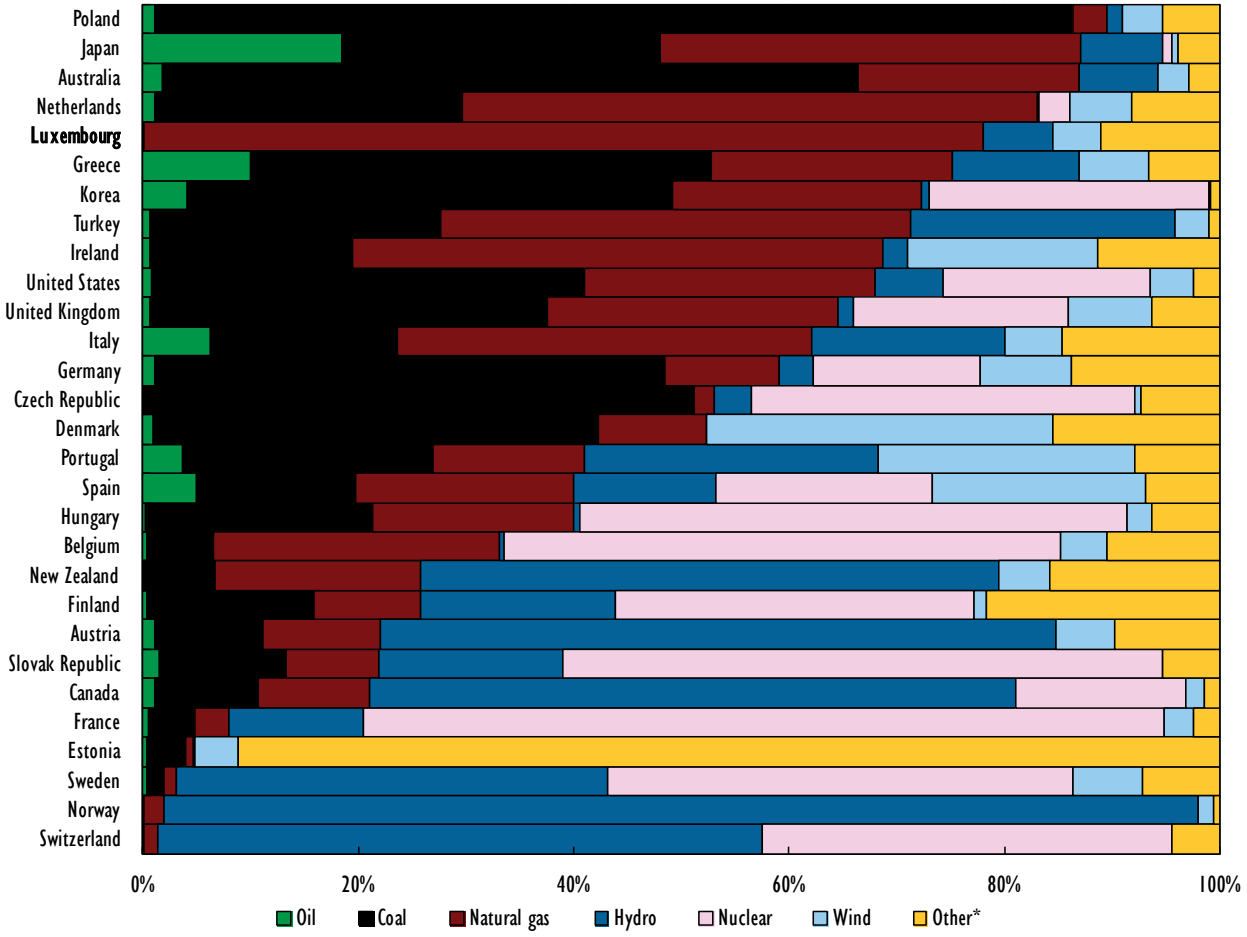
Note: estimated for 2013.

* Negligible.

** Coal use in electricity generation ceased in 1997.

Source: IEA (2013), *Energy Balances of OECD Countries*, OECD/IEA, Paris.

Figure 5.2 Electricity generation by source in IEA member countries, 2013



Note: estimated data.

* *Other* includes geothermal, solar, biofuels and waste and ambient heat production.

Source: IEA (2013), *Energy Balances of OECD Countries 2013*, OECD/IEA, Paris.

Box 5.1 Vianden pumped-storage hydro plant

Luxembourg hosts one of Europe's largest pumped-storage hydro power plants, which is located in Vianden. Brought into operation in 1964 at the Our River, this pumped-storage plant is operated by the Société Electrique de l'Our s.a. (SEO). On 10 July 1958, the Grand Duchy of Luxembourg and the Land Rhineland Palatinate (Germany) had concluded a bilateral governmental agreement with regard to the operation of Vianden. Today, RWE and the Grand Duchy of Luxembourg own equal shares of 40.3% next to the Luxembourg investment bank Luxempart (5.44%) and the country's largest utility Enovos Luxembourg (4.46%), Electrabel Invest Luxembourg (3.44%) and others 6.6%. In 2013, Vianden pumped-storage plant had an installed capacity of 1.1 GW and generated an average of 1 650 GWh per year. Construction of an eleventh pump-generator began in 2010 and it is expected to be commissioned in 2014, which will increase the plant's installed capacity to 1 296 MW. Bordering Germany, the pumped-storage hydropower plant is physically located in Luxembourg, but dispatched in the control zone of the German electricity transmission system operator Amprion. This is a unique feature of regional integration of system operation and resources. The plant is connected to Germany (at Bauler station) from where a direct connection brings electricity to Luxembourg.

Originally, the main function of the pumped-storage hydro plant was to cover the demand peaks during the day (turbine mode) and store the reserves at off-peak hours (pump mode) at night. Today, Vianden continues to serve as a peaking power plant and as a critical provider of balancing and reserve services. However, the traditional load levelling function during peaks and off-peaks changed to a larger flexibility to manage frequent steep gradients, compensate forecast deviations for wind power and increase the performance factor of wind turbines (energy storage). The pumped-storage plant has a wide range of applications, as it is flexible to adapt to different market conditions and to the technical requirements of the system operation. The plant provides large-scale and fast backup capacity for thermal plants (shortfall reserve), notably the German coal-fired power plants in the Rhine area and positive and negative control power as a grid standing reserve.

In a scenario of further market integration, the energy system should take account of an adapted market design of the balancing zones and the further integration of the pumped-storage hydropower plant in the domestic and regional power system to maintain a secure and reliable electricity supply.

Electricity generation was 1.8 terawatt hours (TWh) in 2013 excluding pumped-storage hydro at Vianden which is directly connected to the German electricity grid. This total generation represents a decrease of 34% compared to 2012, due to a 40% drop in natural gas-fired generation. Generation output in Luxembourg is moderately volatile, averaging 3 TWh over the ten years since 2003.

Luxembourg's electricity generation landscape changed in 2002 with the introduction of the 376 MW Twinerg combined-cycle gas turbine (CCGT) plant. Generation output increased from 0.9 TWh in 2001 to 2.8 TWh in 2002. Gas-fired generation has represented approximately 90% of total output on average over the past decade. However, electricity generation from gas turbines has been volatile, ranging from a high of 3.2 TWh in 2006 to a low of 1.4 TWh in 2013. This illustrates the substantial decrease of peak load in the Sotel grid, the declining energy consumption for the steel production by Arcelor Mittal amid the crisis and plant idlings, which led to the decrease in the load factor and shift of Twinerg

from base load to a peak unit. Owned by Electrabel/GDF Suez, Arcelor Mittal and Enovos, Twinerg's electricity generation is directly fed into the industrial grid of Sotel with power being exported to Belgium, not transiting through Luxembourg's transmission network (but it can be coupled with the Luxembourg system).

Electricity used for pumped-storage hydro alone (not included in total generation output) amounted to 1.5 GWh in 2013, a 28.3% increase from 2003 levels. Total output has risen steadily over the past decade, owing to an increase in demand for electricity storage from neighbouring countries. In the current power market with larger amounts of renewable energies and the German nuclear phase-out decision under the *Energiewende,* demand for peak and balancing capacity has been growing.

Other hydropower generation (excluding pumped-storage hydro) represented 6.4% of total generation in 2013.

Biofuels and waste represented 8.3% of electricity generation in 2013, while wind power and solar power amounted to 4.5% and 2.8%, respectively. Electricity from these renewable sources has experienced a boom, thanks to investments in new installed capacity (see Table 5.1). Wind farm capacity has tripled since 2002 to 58 MW in 2012, while solar panel capacity has increased five times to 75 MW in 2012, since it was first introduced in 2003. Capacity improvements in biofuels and waste (internal combustion) were more subdued, increasing by 48.6% compared to 2002.

Table 5.1 Installed generating capacity in Luxembourg, 2012

Type of power generation facility		Installed capacity (MW)	Number of installations
Combined heat and power (CHP)	Industry CHP	29.2	3
	Small CHP	83.82	86
	Micro-CHP	0.92	43
	Autoproduction	2.56	1
	Total	116.5	133
Thermal (gas-fired)		395.2	2
Hydro	Pumped-storage hydro	1 096	1
	Run-on-the river (Moselle, Sûres)	32.3	4
	Micro	2	29
	Total	1 130.3	34
Wind		58.33	51
Biogas		8.01	26
Steam		1.98	5
Waste		0.08	1
Photovoltaic		74.65	3 644
Total without pumped-storage hydro		**689.05**	**3 895**
Total		**1 785**	**3 896**

Source: ILR (2013).

In comparison to other IEA member countries, Luxembourg's share of fossil fuels in electricity generation was ranked fifth-highest with 78% in 2013, behind Poland, Japan, Australia and the Netherlands (see Figure 5.2). However, unlike most IEA member countries, Luxembourg is highly dependent on electricity imports, which reduces the effective share of domestic fossil fuel generation to just over 26% of total consumption.

IMPORT AND EXPORT

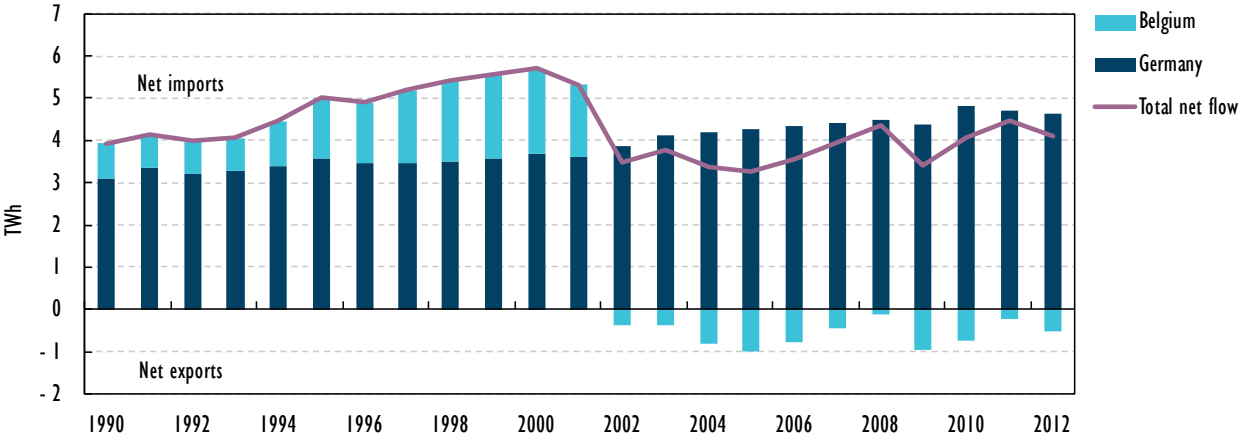
Luxembourg has electricity interconnections with Germany and Belgium. The country remains a substantial net importer of electricity, as it relies on imports for most of its electricity needs, because of its size and lack of domestic generating capacity. The two main generation facilities, Twinerg gas-fired power plant and the pumped-storage hydro plant in Vianden, export power to the Belgian and German grids. (Twinerg is considered as an export flow.) Luxembourg meets its domestic electricity demand with imports from Germany and is almost 100% dependent on electricity imports.

During 2013, net imports amounted to 5 TWh, which was around 31% more than ten years ago. Total imports were 6.9 TWh with 1.9 TWh of exports. During 2012, the lion's share of 84.6% was imported from Germany and the remainder from Belgium. In the same year, 59% of exports were destined for Belgium and the remainder to Germany. As Luxembourg has large pumped-storage capacity, import and export flows are dominated by the need for its neighbouring countries to balance their system operations (see Box 5.1).

The level of net power imports to Luxembourg has averaged 4 TWh per year over the past decade, without significant volatility. Net imports were higher before the additional gas-fired generation capacity came online in 2002. Since then, imports have declined and exports to Belgium have boomed. As such, Luxembourg became a net exporter of electricity to Belgium in 2002. The level of net imports from Germany has experienced a steady increase over time.

Net imports represent approximately 74% of demand, while wind, co-generation and photovoltaics deliver indigenous production.

Figure 5.3 Net electricity between Luxembourg, Belgium and Germany, 1990-2012



Note: preliminary data for 2012.

Source: IEA (2013), *Electricity Information 2013*, OECD/IEA, Paris.

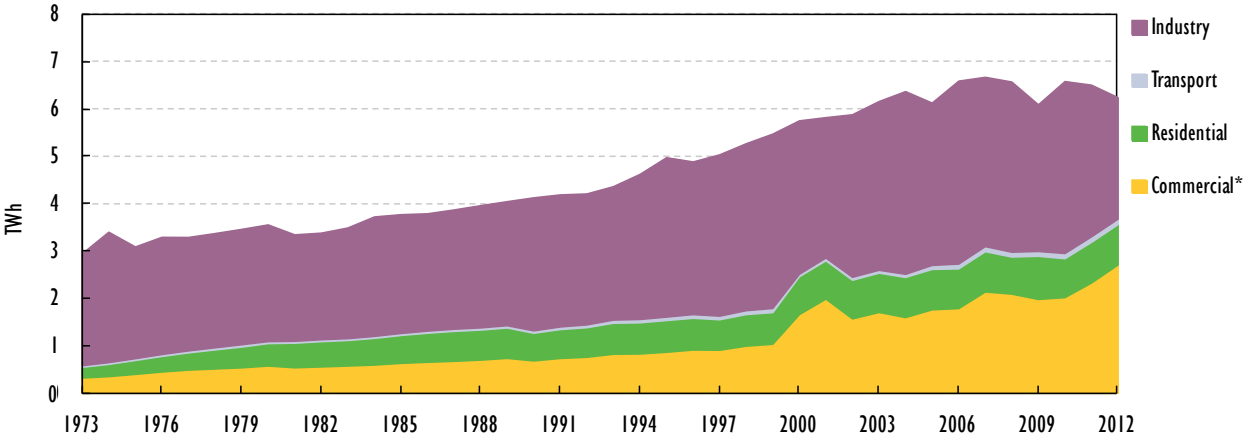
ELECTRICITY CONSUMPTION

Luxembourg consumed 6.3 TWh of electricity during 2012. This represents a decrease of 4% compared to the previous year, albeit 2.5% higher than in the 2009 recession. Over the ten years since 2002, electricity consumption has moderately increased by 6.1%, less than 1% per year.

Electricity consumption is dominated by the commercial sector which accounted for 43.5% of total consumption in 2012, followed by industry with 41%, the residential sector with 13.5% and the transport sector with 2.1%. Over the past decade, demand from industry has fallen owing to declining activity, while consumption by the commercial, residential and transport sectors has increased. The transport sector, though a relatively small consumer of electricity, has seen consumption double since 2002, increasing its share in total consumption from 1.2% in 2002 to 2.1% in 2012. The commercial sector has also exhibited significant growth in demand, while demand growth in the residential sector has been more subdued.

The Ministry of the Economy expects electricity demand to increase in the coming years, mainly driven by the increase in population. The transmission system operator (TSO), Creos, forecasts that the peak load would slightly increase to over 800 MW in its transmission grid in 2015 as new connections come online and imports are on the rise. In 2020, total demand is expected to reach up to 8 000 GWh/year.

Figure 5.4 Electricity consumption by sector, 1973-2012



Note: preliminary data for 2012.

* *Commercial* includes commercial and public service, agriculture/fishing and forestry.

Source: IEA (2013), *Electricity Information*, OECD/IEA, Paris.

REGULATION

Luxembourg's regulatory authority for energy, the Institut Luxembourgeois de Régulation (ILR), is an independent public authority with a total budget of EUR 9.6 million in 2012, out of which EUR 1.7 million is allocated to the energy department. Since the last in-depth review, ILR doubled its staff to seven employees.

ILR is one of the public authorities in charge of market transparency under Regulation No 1227/2011 of 25 October 2011 on wholesale energy market integrity and transparency (REMIT). Besides its core competences of ensuring network access and tariffs and

cross-border co-operation, it regulates the monitoring of the network investment plan and the market functioning. ILR also manages the compensation scheme for renewable energies and co-generation, supervises the universal service provision and monitors residential retail tariffs, and has a consumer contact point (*guichet unique*).

The electricity market regulation of Luxembourg is based on the Law on the Organisation of the Electricity Market of 1 August 2007, transposing EU Directive 2003/54/EC concerning common rules for the internal market in electricity. This law was modified by Law of 7 August 2012, transposing the Directive 2009/72/EC concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC (hereinafter the Electricity Market Law).

The reform of the electricity market of 2012 introduced the following key aspects:

- strengthening of consumer rights
- redefinition of the missions and competences of the regulatory authority
- legal unbundling of the vertically integrated electricity utility to form a separate generation and retail company (Enovos) and transmission and distribution company (Creos)
- introduction of incentive-based economic regulation of transmission and distribution networks
- introduction of full retail contestability
- preparations for the roll-out of "smart" meters as of 2015 to most customers by 2018 (for electricity) and 2020 (for gas) and for the public charging infrastructure for electric vehicles.

NETWORKS

TRANSMISSION AND DISTRIBUTION NETWORKS

The high-voltage transmission network of Luxembourg, which has a combined length of 537.4 km, is owned and operated by the TSO Creos Luxembourg s.a., which forms part of the vertically integrated utility Enovos International, but is legally unbundled from the production and supply activities.

Luxembourg's domestic grid is fully integrated with the German network and balanced by the German TSO Amprion. Creos is responsible for implementing, in co-ordination with Amprion, the dispatching throughout Luxembourg.

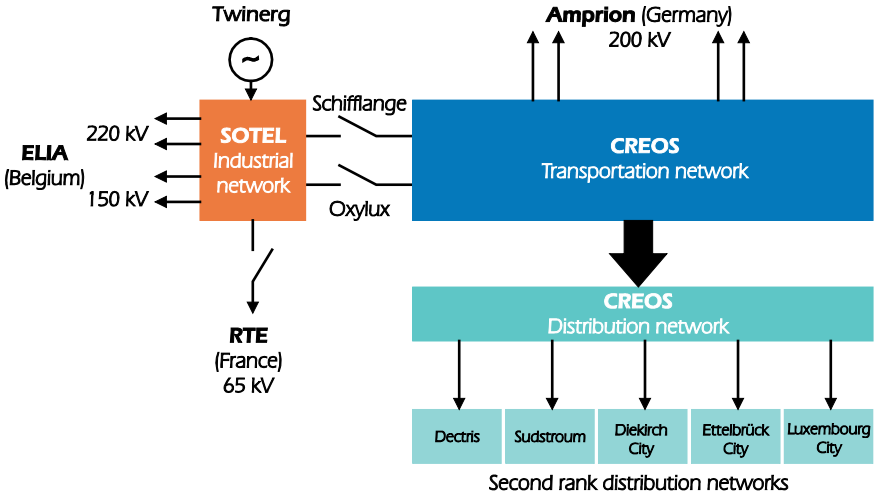
Transmission networks are all lines above 35 kilovolts (kV) while distribution is defined as electricity lines with voltage levels below 35 kV. Creos network has two interconnections with Germany (and indirectly with French and Belgian grids via the industrial grid Sotel).

Creos operates the 8 635 km-long distribution system that includes the municipality of Steinfort, the city of Echternach and the city of Vianden. There are four other distribution system operators (DSOs), Hoffmann Frères (Electris), Ville de Diekirch, Sudstroum and Ville d'Ettelbruck (see Table 5.2).

Created in 1927 by the Luxembourg metallurgic industry, Sotel Réseau et Cie s.e.c.s operates a separate industrial distribution grid. The 113 km-long industrial network is owned by Sotel Réseau et Cie s.e.c.s, Arcelor Mittal Belval & Differdange s.a., Arcelor

Mittal Rodange & Schifflange s.a., ELIA Asset s.a., Paul Wurth s.a. Arcelor Mittal is the largest shareholder of the industry grid operator with 75% of the shares. Sotel is directly connected to the Belgian transmission network operated by TSO Elia and French RTE grid (see Figure 5.5 for an overview of the networks in Luxembourg).

Figure 5.5 Electricity network structure in Luxembourg, 2013



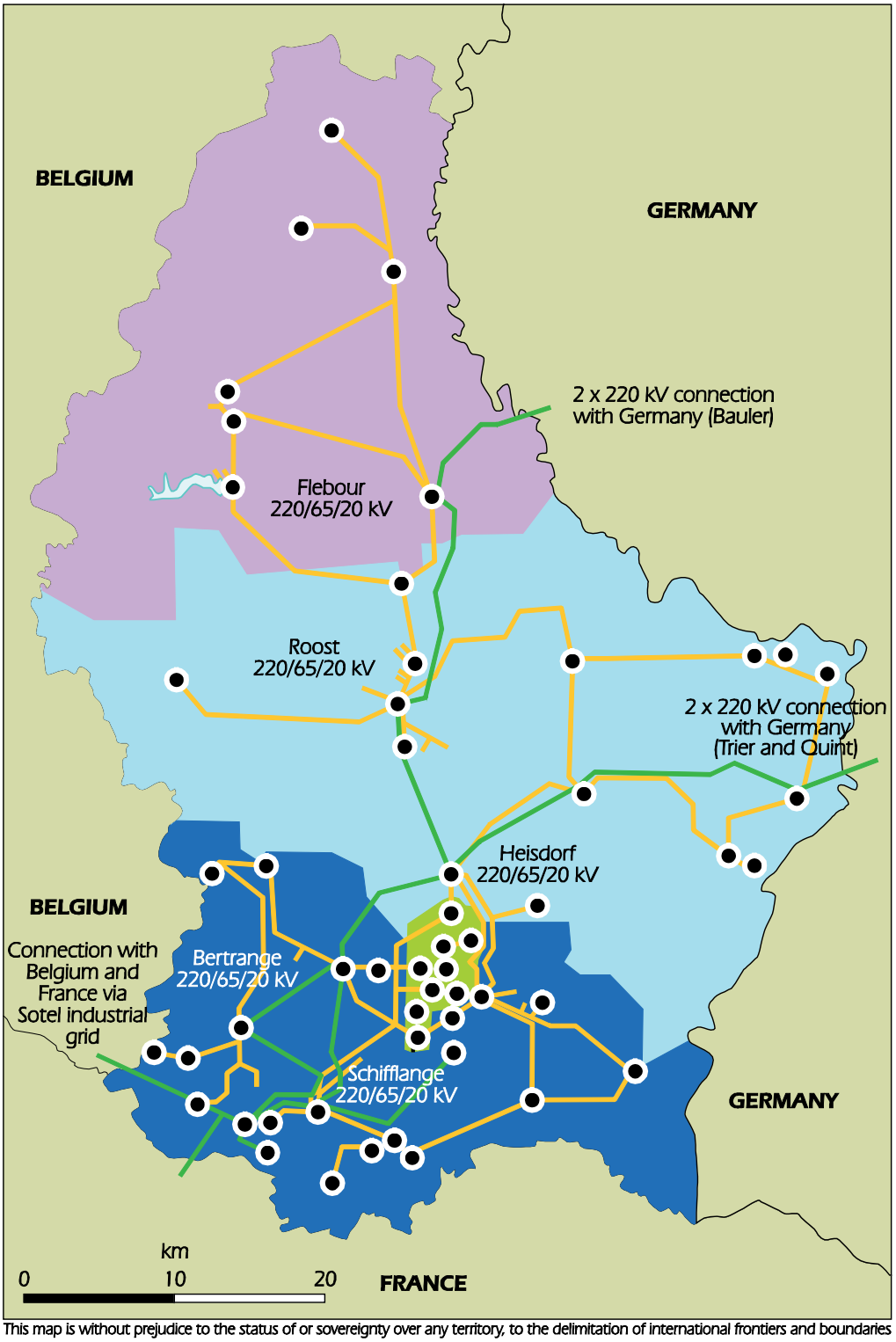
Source: country submission, 2013.

According to Article 44.2 of Directive 2009/72/EC of 13 July 2009 concerning common rules for the internal electricity market and repealing Directive 2003/54/EC, Luxembourg has a derogation from ownership unbundling requirements and has implemented legal unbundling of network and generation/supply activities. Luxembourg has set out in the Electricity Market Law the requirement of an adequate unbundling of transmission activities from production and supply. The TSO Creos and the industrial grid operator Sotel are each part of a vertically integrated company. In line with special provisions under Article 26 of Directive 2009/72/EC, if the grid operator is part of a vertically integrated undertaking, the operator shall be independent at least in terms of its legal form, organisation (including separate branding) and decision making from other activities not relating to distribution, except for DSOs with less than 100 000 connected customers.

Creos forms part of the vertically integrated undertaking Enovos International and has to comply with legal and account unbundling. Creos has no derogation as a DSO, as it has more than 100 000 customers. The city networks of Luxembourg, Vianden and Steinfort, were merged with Creos. Next to Creos, there are several independent DSOs in public and private ownership, serving less than 100 000 users.

In 2012, Luxembourg introduced incentive-based regulation for transmission and distribution networks with a rate of return on the invested capital of 7.6% before tax (a higher rate of return is set for interconnectors), according to E12/05/ILR of 22 March 2012 for the regulatory period of 2013-16. For the operational expenditures (OPEX), an efficiency factor (X-factor) is set at 1.5% for all networks. There is no benchmarking behind this productivity factor because of methodological problems. The value of X is set as a result of negotiations.

Figure 5.6 The electricity grid of Luxembourg, 2014



This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Source: IEA, 2014.

Table 5.2 Grid operators in Luxembourg, 2013

Grid operator	Name	Connected users	Length of the network (above 35 kV) in km	Length of the network (below 35 kV) in km	Owners
TSO	Creos Luxembourg s.a.	250 112	537.4		Creos Luxembourg s.a.
DSO	Creos Luxembourg s.a.			8 635	Creos Luxembourg s.a., Commune de Steinfort, Ville de Vianden
DSO	Hoffmann Frères s.a.r.l. et Cie s.e.c.s.	3 762	0	210.2	Hoffmann Frères s.a.r.l. et Cie s.e.c.s.
DSO	Ville de Diekirch	3 364	0	153.7	Ville de Diekirch
DSO	Sudstroum s.a.r.l. et Cie s.e.c.s.	19 104	0	463	Ville d'Esch-sur-Alzette
DSO	Ville d'Ettelbruck	4 573	0	95.2	Ville d'Ettelbruck
Industrial grid operator	Sotel Réseau et Cie s.e.c.s	19	113.3	0	Sotel Réseau et Cie s.e.c.s, ArcelorMittal Belval & Differdange s.a., ArcelorMittal Rodange & Schifflange s.a., ELIA Asset s.a., Paul Wurth s.a.

Source: ILR (2013).

COMBINED HEAT AND POWER

Luxembourg has 133 CHP plants. Luxenergie s.a. runs several CHP plants for a total of 161 MW heat capacity and 35 MW electricity capacity, among which is the Kirchberg CHP, with thermal capacity of 54 MW and electricity capacity of 12 MW. Findel CHP, with thermal capacity of 5 MW, is run by Airport Energy s.a., and Esch-sur-Alzette CHP, with a thermal capacity of 18 MW, is run by Sudcal s.a. The city of Luxembourg operates several CHP plants, with a total thermal capacity of about 63 MW and a total electricity capacity of 39 MW.

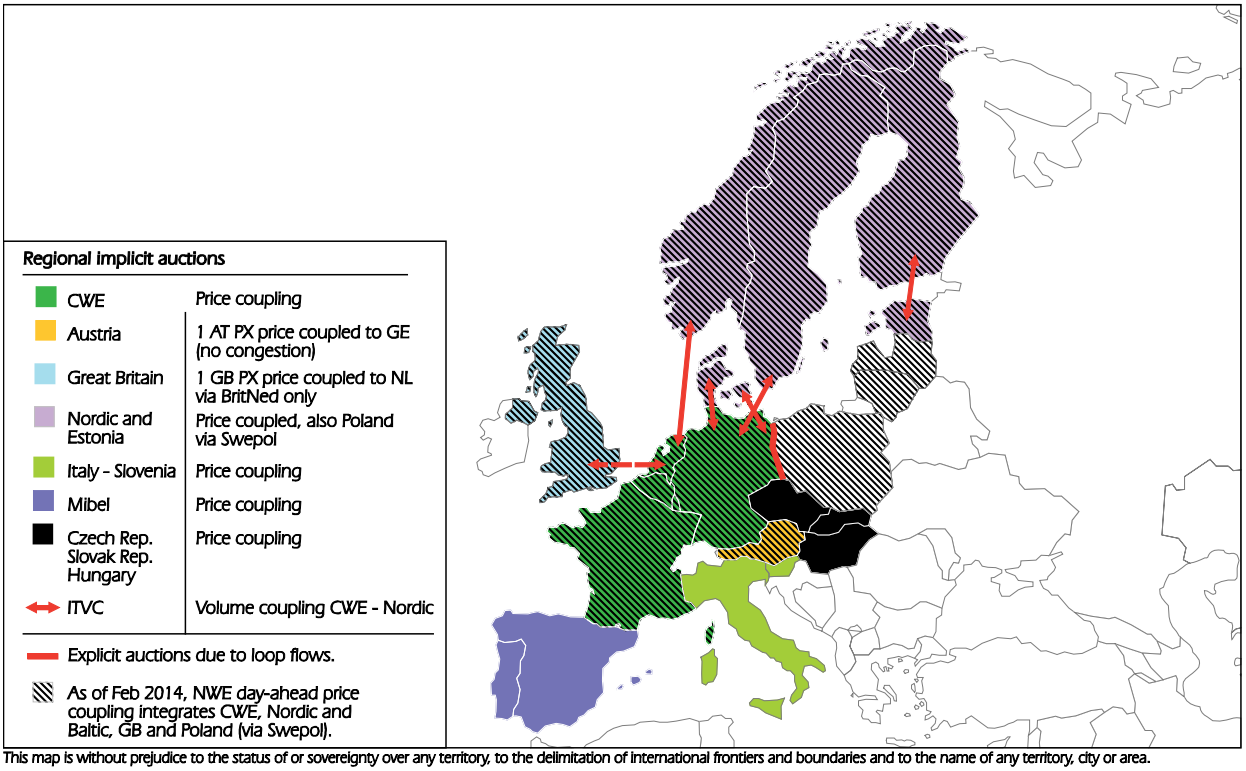
Regulation of 26 December 2012 on the promotion of highly efficient co-generation (*Règlement grand-ducal du 26 décembre 2012 relatif à la production d'électricité basée sur la cogénération à haut rendement*) defines feed-in tariffs for electricity based on high-efficient co-generation as well as the conditions for the connection to the distribution network and the guarantee of origin according to Directive 2004/8/EC. The CHP charge is paid together with the renewable energy charge by the final electricity consumer.

MARKET STRUCTURE

Luxembourg is fully integrated into the German price zone. As a result, there is no domestic electricity exchange or wholesale market as such in Luxembourg. Because of the absence of congestion on cross-border interconnections, there are no restrictions for market players in Luxembourg to participate in the regional electricity market which extends from Central-West Europe (CWE) to South-West Europe (SWE) in 2014 (see Figure 5.7). The reference price for the wholesale market in Luxembourg is the day-ahead price realised on the Epex Spot for the German and Austrian region (Phelix).

At the wholesale level, there were 12 suppliers active on the Grand-Ducal electricity market in 2012 (IRL, 2013). The level of competition on the wholesale market thus also depends on the access of foreign suppliers to Luxembourg. The Ministry of the Economy is in charge of authorising the suppliers for Luxembourg, and in 2013, 28 suppliers were authorised.[1] Despite the number of suppliers at wholesale level, there is no effective entry to Luxembourg electricity market, and retail market competition is very low (ACER, 2013). Out of 28, fewer suppliers are active at supply level, while four of them are part of one supplier.

Figure 5.7 Overview of market coupling in the European internal electricity market



This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Source: IEA, 2013.

According to ILR, market concentration in Luxembourg remains high, with a Herfindahl-Hirschman index (HHI)[2] of 2 311 points in 2012 (ILR, 2013), which is considered to be a highly concentrated market.

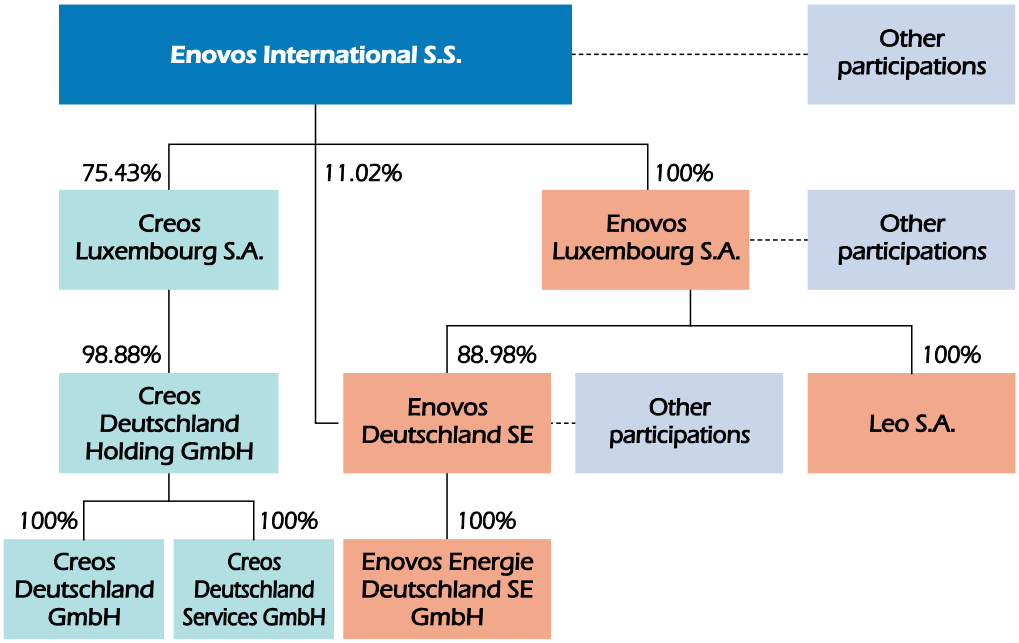
The supply and distribution of electricity (and gas) is largely dominated by one player, Enovos International (see Figure 5.8). Luxembourg's single largest vertically integrated utility, Enovos Luxembourg, also owns several retailers, the transmission and distribution grid company for

1. See the list at: www.ilr.public.lu/electricite/fournisseurs/index.html.

2. The Herfindahl-Hirschman Index (HHI) is a measure for competition taking into account the size of firms in relation to the industry. According to the European Commission use of the index, an HHI with scores of 750 to 1 800 is considered indicative of moderate concentration, scores of 1 800 to 5 000 indicative of high levels of concentration, and scores above 5 000 indicative of very high concentration consistent with the presence of substantial potential market power. The HHI is a conventional indicator of ownership concentration in product markets. It is calculated by adding the sum of the squares of the percentage market shares of each market participant. For example, a market consisting of five competing firms, each with a 20% share of the market, would have an HHI score of 2 000 (i.e. 20^2 x 5). HHI analysis is typically used to help assess the degree of market dominance and potential for market power abuse.

gas and electricity, Creos Luxembourg s.a., which includes local distribution networks of the cities of Luxembourg, Vianden, Steinfort, as well as various shareholdings in renewable energy producers. Together with Enovos Luxembourg s.a., SEO owns and operates (50%-50%) the company Soler with three hydropower plants in Luxembourg (Esch-Sûre, Rosport and Ettelbrück) and several wind installations. Most of the supply licences are owned by the Enovos Group (see Figure 5.8), including Steinergy, Nordenergie, Leo s.a., which is 100% owned by Enovos Luxembourg both for the supply and the distribution grids, and Luxenergie in which Enovos Luxembourg owns 60.35% of energy contracting in the heat segment operation of CHP plants. Enovos International has also a 4.46% shareholding in the Vianden plant of SEO.

Figure 5.8 The structure of the Enovos Group



Source: Enovos, 2014.

Major players from neighbouring countries (GDF Suez, E.ON and RWE) are, together with AXA Private Equity, engaged in the mother company Enovos International along with the state of Luxembourg. Enovos International holds 100% of Enovos Luxembourg and 75.43% of Creos Luxembourg.

The dominance of Enovos International in Luxembourg's retail gas and electricity markets is the result of the merger created by Soteg and Cegedel, the two historic important players in the country's energy sector and Saar Ferngas. It was and still is the aim of the government to create an important player which could compete with the large utilities in the regional market. The merger, possibly strengthening the former dominant positions of the players in the retail markets for electricity and gas, was not controlled under national merger control rules, as in Luxembourg there is no national merger control competence on cross-border mergers. The merger was controlled under the European rules, as there is no merger control for these types of mergers in Luxembourg.

A national champion can have advantages as well as risks for competitive and efficient market development in Luxembourg. The dominant position of Enovos in the national market raises several concerns but, on a more positive note, the merger benefits of economies of scale and scope.

Early performance suggests some success with Enovos integration. The benefits from economies of scale and scope in gas and electricity retail markets helped strengthen its profitability. However, the market dominance has also created a range of concerns, notably about transparency, competitive neutrality and other competition issues.

The dominant position of Enovos in the national market could raise concern, especially if more DSOs would join the Creos network. This could have a negative impact on competition if suppliers were to compete on prices with Enovos. In general, vertical integration of supply, production and network activities has the potential to magnify the risk of cost shifting between regulated and competitive functions, with the potential to substantially reduce competitive pressure for more efficient commercial behaviour.

The legal unbundling of Creos Luxembourg is a step in the direction towards transparency. However, the ILR will need to carefully monitor performance and be ready to intervene whenever outcomes are not efficient, innovative or cost-effective.

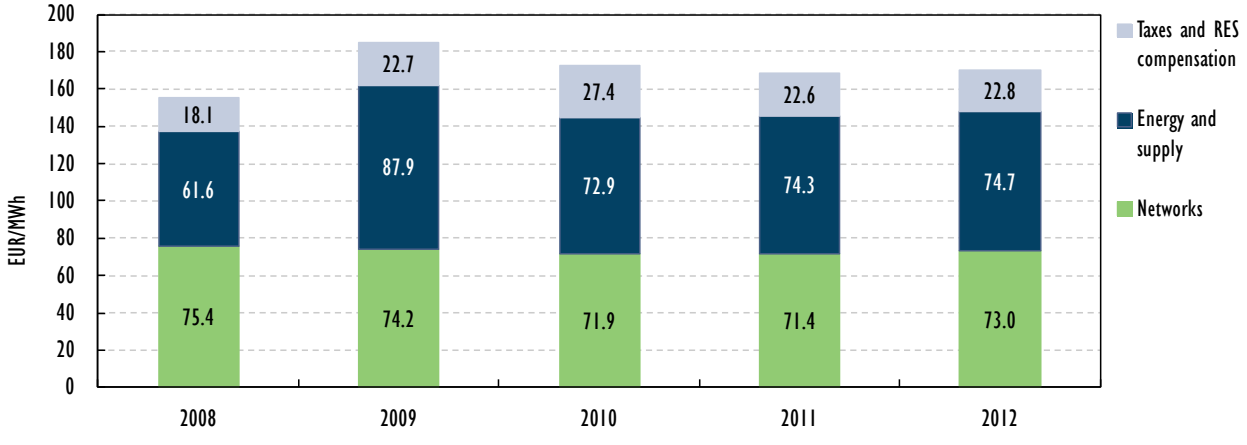
The ILR and the government need to continuously ensure transparency and the strengthening of network regulation, so as to avoid incentives to allocate costs to the network company within legally unbundled firms and possible windfall gains from setting equal incentives within a revenue cap.

RETAIL MARKET AND PRICES

There is no retail price regulation in Luxembourg and the retail market is fully open to competition since 1 July 2007.

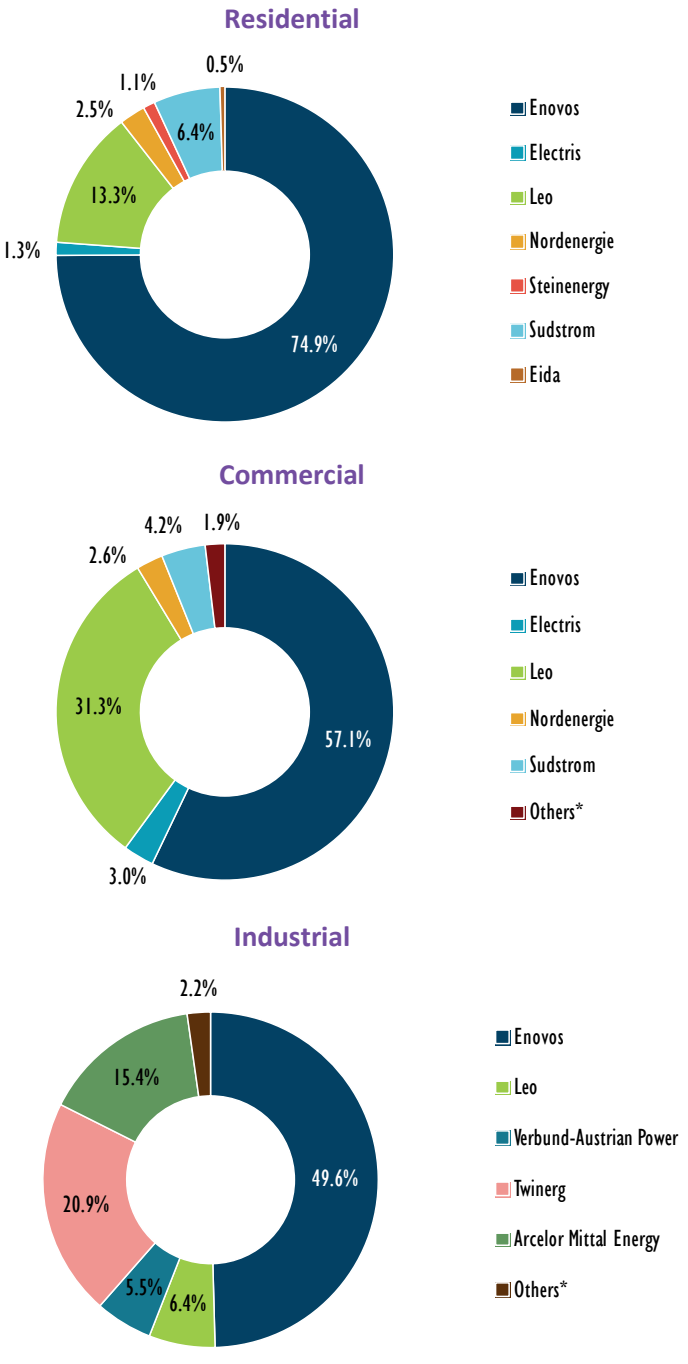
By the end of 2012, there were 216 657 households, 61 628 commercial and 211 industrial users. However, in terms of electricity consumption, industrial users make up the lion's share with around 62.6% of the retail market. With a total of 278 496 customers, the retail market in Luxembourg is small. The market was served by 11 suppliers in 2012 with seven companies serving households alone: Eida s.a., Electris (through Hoffmann Frères), Enovos Luxembourg s.a., Leo s.a., Nordenergie s.a., Steinergy s.a. and Sudstroum. Despite this variety of the market structure (illustrated by Figures 5.10) around 90% of all households are supplied by Enovos Luxembourg and its subsidiaries, Leo, Steinergy and Nordenergie.

Figure 5.9 The electricity retail bill for households, 2008-12



Source: ILR (2013).

Figure 5.10 Market structure in the electricity retail market segments, 2012



Note: Leo, Nordenergie and Steinergy are part of Enovos Luxembourg.

* *Others* includes Eida, Electris, Steinergy, Nordenergie, Sudstroum, Pfalzwerke.

Source: ILR, 2013.

In 2011, a study by WIK-Consult, commissioned by regulator ILR, analysed the reasons for limited competition at retail level (Schweinsberg and Müller, 2011). WIK found that the market potential in Luxembourg is limited. Also, supplier switching and billing procedures

differ between Germany and Luxembourg, which can be an essential barrier for competition. Since Luxembourg is fully integrated into the German grid zone of Amprion and the German price zone, customers should ideally benefit from similar retail market regulations as in the neighbouring countries.

Despite the integration with the German price zone and the existence of 28 suppliers of electricity in Luxembourg, major players from neighbouring countries (GDF Suez, E.ON and RWE, and several *Stadtwerke* in Germany) are, together with AXA Private Equity, engaged in the mother company Enovos International along with the state of Luxembourg. Enovos International holds 100% of Enovos Luxembourg and 75.43 % of Creos Luxembourg. According to WIK, this structure seems to limit the interest of other players to challenge Enovos's position in Luxembourg (Schweinsberg and Müller, 2011).

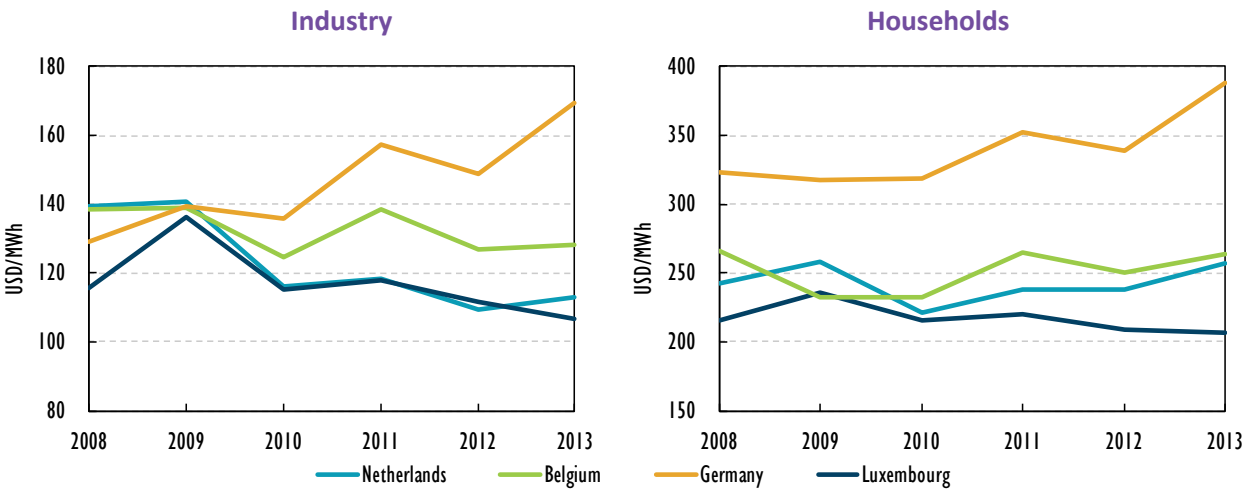
The IEA believes it could be beneficial to work towards common retail market structures with neighbouring Germany, Belgium or France, for instance through harmonised billing and switching systems. In other IEA jurisdictions, notably in the Nordic market, such integrated common retail market provisions are being studied and could present valuable experience for the Luxembourg market.

It is not surprising that the supplier switching rate was the lowest among households, with 0.07% in 2012, and the highest, at 15.4%, in 2012, among industrial customers, where more diversified suppliers are available at the wholesale level (Verbund Austria Power, Arcelor Mittal). The total average switching rate was 9.7% in 2012. This is rather low in comparison with active supplier switching rates in other European countries, such as 11.6% in Spain, 12.1% in Great Britain, 10.6% in Ireland or 12.6% in the Netherlands.[3]

Since the last in-depth in 2008, the composition of the retail electricity bill has remained stable.

In comparison to the IEA member countries, Luxembourg has relatively low industry prices for electricity, thanks to a low tax rate of 5%. Only Sweden and Norway had lower industry prices in 2013.

Figure 5.11 Electricity prices in Luxembourg and in other selected IEA member countries, 2008-13



Source: IEA (2013), *Energy Prices and Taxes 2013*, OECD/IEA, Paris.

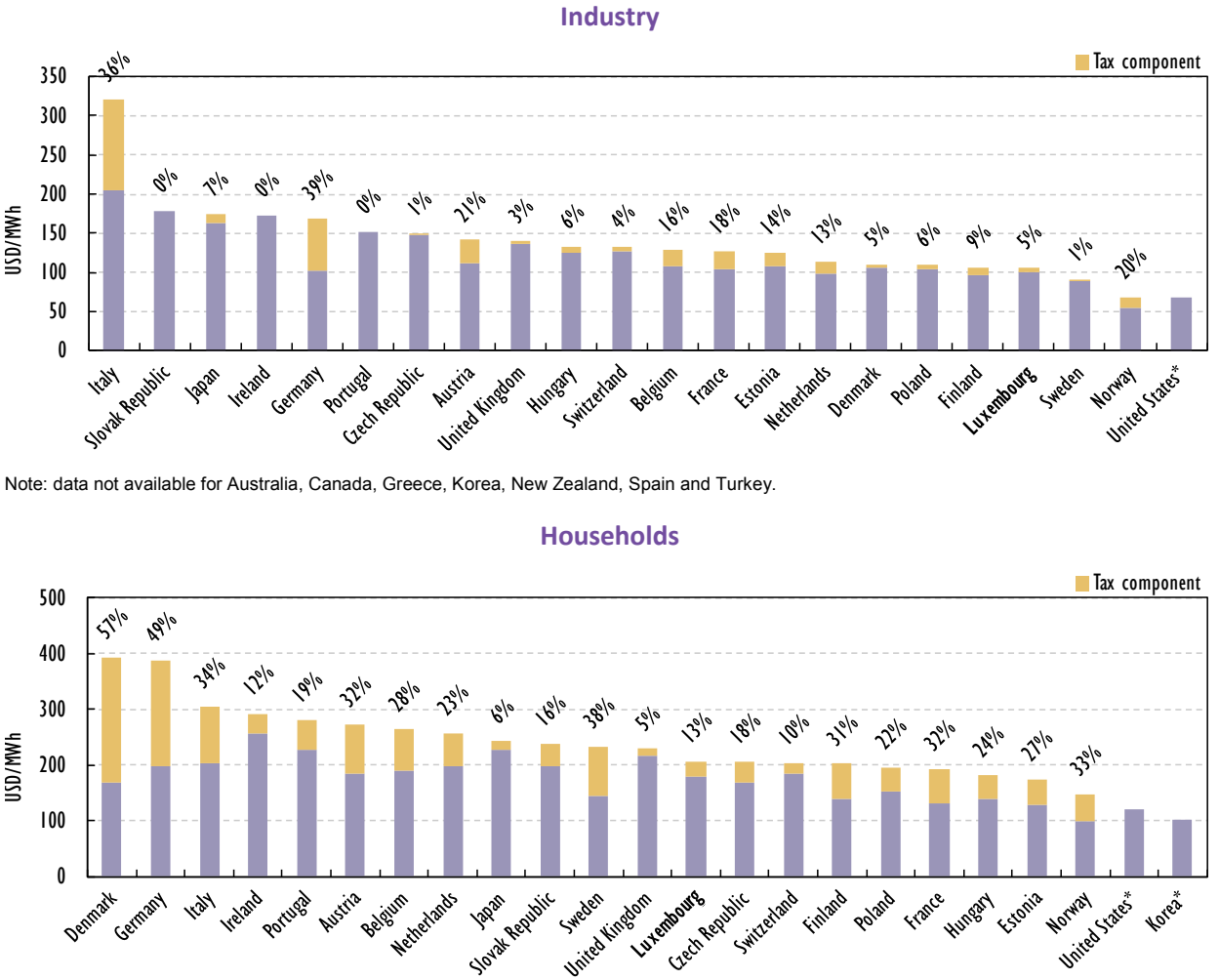
3. The switching rate for the Netherlands refers to all segments of the retail market.

Household electricity prices are at the IEA average (see Figure 5.11). The electricity bill for households (see Figure 5.9) is composed of supply costs, taxes which include the energy tax and network charges, which are almost as high as the supply cost.

Given the high purchasing power of consumers in Luxembourg and electricity prices around the IEA average, household consumers' interest in looking for an alternative supplier seems to be limited and hindered by the effective market dominance of Enovos and the related suppliers (Leo, Steinergy and Nordenergie), which amounts to around 90% in the residential segment (ILR, 2013).

Well-informed and active consumers are critical for the development of well-functioning electricity markets. Therefore, it would be beneficial for the government and especially the regulator and other government agencies to support consumers with more information and transparency on the functioning of the energy market and the possibilities to change suppliers, including the regional market integration of Luxembourg.

Figure 5.12 Electricity prices and taxes, 2013



Note: data not available for Australia, Canada, Greece, Korea, New Zealand, Spain and Turkey.

Note: data not available for Australia, Canada, Greece, New Zealand, Spain and Turkey.

* Tax information not available.

Source: IEA (2013), *Energy Prices and Taxes 2013*, OECD/IEA, Paris.

The ILR provides information on Luxembourg's energy market on its website (STROUMaGAS.lu) and a price comparison tool, Calculix,[4] which was launched in 2013 to improve transparency. The ILR website informs the retail market participants about the network regulation, the electricity market rules and also differences between the suppliers and the DSOs with a view to improve consumer information and empowerment.

In addition, Myenergy organises a range of events, including information days, publications and awareness-raising campaigns, to inform all energy consumers, households and companies. A strong partnership between Myenergy and ILR could create synergies and reinforce consumer empowerment.

SMART METERS AND SMART MARKETS

In line with EU third internal energy market rules, every member state has to set out a timetable for the introduction of smart meters. After a positive cost-benefit analysis, at least 80% of consumers shall be equipped with such meters by 2020. The Energy Performance of Buildings Directive (EBPD) also requires national action plans to programme the installation of smart meters. The government envisages starting the deployment of smart meters in 2015 so as to equip at least 95% of all final consumers by 2020. Seven grid operators (Creos, Sudgaz, Sudstroum, Electris, Ville de Diekirch, Ville d'Ettelbruck and Ville de Dudelange) are ready to carry out the implementation.

The development of smart markets and energy-saving services requires innovative regulatory and technology methods, tools for independent data management and privacy. Providing businesses with a framework for innovative products, while securing consumers' privacy and security, will be a key task for policy makers in the coming years (see Box 5.2). Experience in New Zealand and European markets, notably Ireland, shows that the deployment of smart meters can be facilitated by establishing an independent data management system, effective switching procedures, strong regulatory oversight and more dynamic pricing for innovative retail product development. The unbundling of distribution and supply and campaigns for supplier switching can serve as experience for an effective basis to develop a smart and competitive retail market.

Box 5.2 Empowering consumer choice in electricity markets

International experience among IEA jurisdictions suggests that the key elements of an effective and integrated approach for competitive retail markets would include:

- increasing customer exposure to real-time pricing, with protection of vulnerable consumers addressed through targeted transfers that do not unduly distort efficient price formation
- a competitive, dynamic retail market to encourage the development of innovative products and services that can harness demand response effectively and at least cost
- ready access to detailed, real-time customer information, while ensuring privacy, to help stimulate competition, facilitate competitive entry, support the emergence of innovative business responses, and improve the quality of customer choice

4. www.calculix.lu/web/tk/tk.

Box 5.2 Empowering consumer choice in electricity markets (continued)

- a knowledgeable and well-informed customer base that has the capability and opportunity to take full advantage of available choices
- marked processes for contracting, switching and billing that are as simple and seamless as possible to keep transaction costs to a minimum
- legal and regulatory governance frameworks that reduce uncertainty, establish clearly specified rights, responsibilities and obligations on contracting parties, promote greater harmonisation of standards and functionality specifications, and maximise scope for participation among potential service providers and customers
- enabling technologies that provide cost-effective, real-time metering information, verification and control capability to support the introduction of real-time pricing, the development of a wider range of innovative demand response products, and more effective customer choice.

Source: IEA (2011), *Empowering Customer Choice in Electricity Markets*, OECD/IEA, Paris; see www.iea.org/publications/freepublications/publication/Empower.pdf.

ELECTRICITY SECURITY

In-depth country reviews focus on the adequacy dimension of electricity security. Adequacy in this context refers to a power system's capability to meet current and future changes in aggregate power requirements in the present and over time, through timely and flexible investment, operational and end-use responses. This analysis complements the IEA emergency response review of Luxembourg in 2014.

The country has set out the governance structure for the security of electricity supply.

Under the Law of 1 August 2007 on the Organisation of the Electricity Market, TSO Creos and DSOs are responsible for ensuring electricity security, reliability, efficiency of transmission/distribution and quality of electricity supply. In its annual company report Creos includes an analysis of the security of electricity (and gas) supply and an overview of the planned investment in the expansion of the network for the regulatory period. A long-term (ten-year) investment plan is to be produced by Creos every two years, the next one in 2015, in line with Article 17 of the Electricity Market Law.

The Government Commissioner for Energy is the competent authority for monitoring security of supply and every two years reports to the European Commission and the ILR on the security of supply situation in Luxembourg. The report evaluates generation and network adequacy, grid maintenance, modernisation and expansion needs in the electricity grids. The latest available report by the Ministry of the Economy on security of electricity supply dates back to July 2012.[5]

ILR is the competent authority for monitoring the quality of supply in Luxembourg under Regulation E11/26/ILR of 20 May 2011. Since 2011, ILR measures the quality of supply on the basis of harmonised indicators, the SAIDI and SAIFI indices.[6]

5. Ministry of the Economy and Foreign Trade, *Bericht über die Versorgungssicherheit*, July 2012 (www.eco.public.lu/documentation/rapports/index.html).

6. SAIDI (System Average Interruption Duration Index) measures the duration of interruptions. SAIFI (System Average Interruption Frequency Index) measures the average number of interruptions per customer.

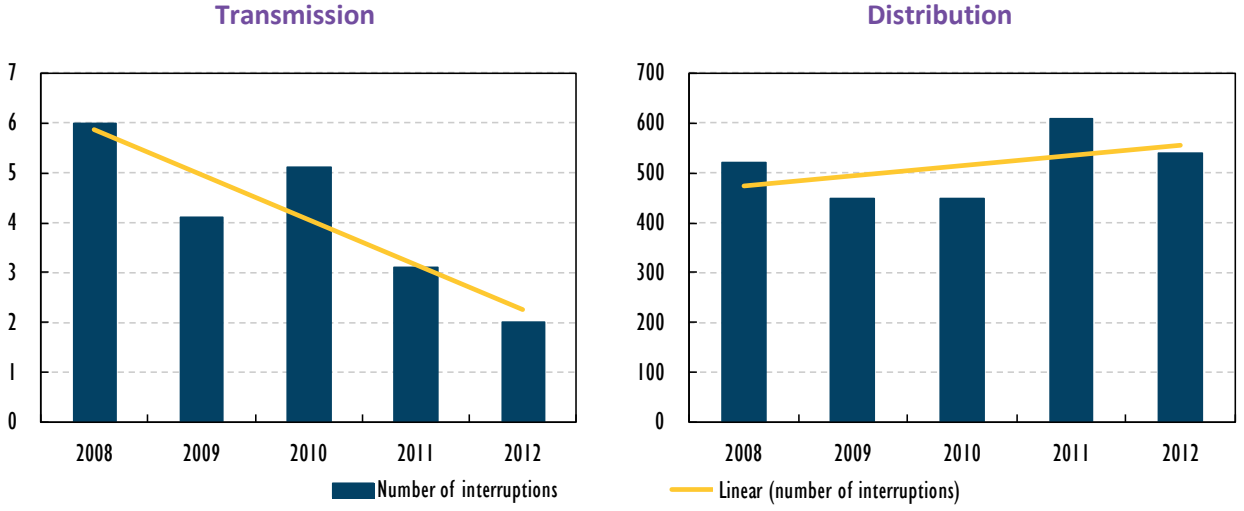
POWER SYSTEM ADEQUACY

Luxembourg's electricity system has a large share of distribution grids. There were about 600 km of high-voltage lines (35 kV to 110 kV), 3 500 km of medium-voltage (1 kV to 35 kV) and more than 6 000 km of low-voltage lines.

A comparison between 2011 and 2012 illustrates the reduction in the number of interruptions on the distribution system (from 172 in 2011 to 115 in 2012). The SAIDI index fell from 12 to 10 minutes interruption and the SAIFI frequency from 0.27 to 0.18 per year. Given their recent introduction, it is too early to draw conclusions on the quality of supply trends over time from the ILR data. In general, recent data from network operator Creos indicate that total interruptions at the distribution level fell from 600 to around 540 between 2011 and 2012. Looking at the evolution since the last in-depth review in 2008, the number of total interruptions at the distribution level has remained stable and has even slightly increased.

The number of total interruptions at transmission level has considerably decreased from six in 2008 to two in 2012, by over one-third (see Figure 5.13), which illustrates the investment in transmission grid upgrades in recent years.

Figure 5.13 Continuity of supply indicators for Luxembourg, 2008-12



Notes: Interruptions above 3 min are taken into account. Transmission includes lines with voltage levels of 220 kV and 65 kV, while distribution comprises medium- and low-voltage levels of 20 kV and 0.4 kV. On the distribution chart, it is important to note that in 2011 the distribution grid of the city of Luxembourg was incorporated into the Creos grid.

Source: Creos Annual Report, 2012.

GENERATION ADEQUACY

Up to 2020, the overall generation adequacy is considered to remain positive, as confirmed by the Ministry, data from Creos and the analysis of the European network of TSOs for electricity (ENTSO-E) in 2012. This is thanks to *i)* generating capacity additions from the expansion of the Vianden power plant from 1 100 to 1 300 MW, additional wind capacity of 105 MW and solar PV of 88 MW, *ii)* energy efficiency gains over time and *iii)* an expected reduction of peak load during 2013/14 due to a decrease in the Sotel network,

with a moderate increase of the load in the Creos network in the coming five years. However, this overstates the actual level of generation adequacy in practice.

Out of the total domestic installed generating capacity of 689 MW in 2013, a capacity of 313 MW was available in the Creos zone, which is an increase (264 MW) since 2011 thanks to additions from wind power and photovoltaic installations. Actual availability of capacity is limited, given that renewable energy installations provide only variable supply of electricity. The availability of the run-on-the-river plants on the Moselle and Sûres (32 MW) rivers is largely determined by the water flows and basin levels; the CHP plants are run mostly for heat production purposes.

In a limited national perspective, the generation reserve margin in the electricity system of Luxembourg seems to be very tight, with a reserve margin of 6% to 9% for 2013. It is no surprise, as there are no major generation facilities connected to the Creos zone, and Twinerg is located in the industrial grid of Sotel and exports to Belgium. The Vianden plant is directly linked to the German Amprion grid and can only provide peak capacity for a limited period of time, as there is no continuous water availability. The operation of Vianden requires electricity imports which are much larger than the total domestic generation of Luxembourg.

According to IEA calculations, the national concentration of fuels and technology, measured as an HHI index, reached up to 5 800 points in 2013, taking into account the generation diversity by technology and fuel.

Given its strong grid integration into the German and Belgium electricity markets, the country relies on the generation adequacy in the region. These reserve and fuel concentration risks can be largely offset in a small-sized electricity system thanks to regional integration. The diversity and security of supply are mainly ensured by imports. Luxembourg depends on the generation adequacy of neighbouring countries and the availability of interconnectors. Network adequacy and system integration with the neighbouring energy systems are of key importance for the security of electricity supply of Luxembourg.

NETWORK ADEQUACY

Luxembourg meets its domestic electricity demand with imports from Germany and is thus almost 100% dependent on electricity imports. In 2012, the total contractual interconnection capacity stood at 1 700 MW. The Creos network has one permanent double 220 kV interconnection to the German Amprion network. In an emergency situation, the available transfer capacity is still 980 MW, when the maximum transmission flow capacity in the Creos grid is 770 MW. There is no congestion on the interconnector to Germany. In 2012, Creos network capacity was at the maximum levels when it had to cover a peak demand of 778.4 MW. The TSO Creos forecasts the peak load to slightly increase to reach over 800 MW in its transmission grid in 2015. Current transmission capacity would be at its limit. The Ministry of the Economy expects the load to further increase to 1 100 MW by 2027, a level which requires an increase in import capacity through new interconnections, network expansion or additional investment in new generation in Luxembourg.

The Ministry of the Economy concludes that the current age of the existing transmission and distribution networks and their components requires continuous investment in their maintenance. Given the high share of underground distribution lines, Luxembourg exhibits more cost-intensive modernisation and operation of its grids, which is reflected in the level of network charges.

The government and the TSO are strengthening regional integration through various projects, including the upgrading of system operation contracts, the installation of a phase-shifting transformer, network reinforcement, and increasing interconnector transfer capacity.

Creos is a member of the European Network of Transmission System Operators for Electricity (ENTSO-E) and participates in the North Sea regional grid planning group.[7] Here network expansion is planned together with all regional neighbouring TSOs. Alone in Luxembourg, Creos plans an investment of EUR 709.2 million for the electricity grid expansion and smart metering technologies during the five-year period 2012-17. A national ten-year network investment plan for the transmission system is foreseen, in line with Article 17 of the Electricity Market Law.

Box 5.3 Key projects for regional network integration

Luxembourg is at the heart of the regional electricity market in the CWE region, but has only one permanent interconnection to Germany (apart from the connection of the industrial Sotel grid to the Belgian Elia network). Today, there is no permanent interconnection to France or Belgium. The strategic objective of improving regional market integration includes new interconnections and the need to permit transit power flows between Germany and Belgium through Luxembourg.

Under the trans-European networks for electricity, Luxembourg has several projects which are considered of common interest under EU Regulation 347/2013 on guidelines for trans-European energy infrastructure and repealing Decision No 1364/2006/EC and amending Regulations (EC) No 713/2009, (EC) No 714/2009 and (EC) No 715/2009.

The Cluster Belgium-Luxembourg includes a capacity increase at the Belgium-Luxembourg border with three sub-projects, including the co-ordinated installation and operation of a phase-shift transformer in Schifflange (Luxembourg) which would be placed in the existing 225 kV line between the two countries.

In a second stage, one new interconnection is planned to be constructed between Creos grid and Elia grid via a 16 km alternating current double circuit interconnection between Aubange (Belgium) and Bascharage/Schifflange (Luxembourg) of a 225 kV underground cable with a capacity of 1 000 MVA.

A strong focus on integration and international collaboration on regional network and system adequacy planning is of clear benefit for Luxembourg. Creos co-operates at regional level with Amprion, Elia and RTE to improve the security of supply. The increasing importance of effective regional co-operation among TSOs in CWE is illustrated by the emergence of new TSO co-operation network, like TSC or CORESO. Luxembourg's TSO Creos can benefit from such regional co-operation.

Luxembourg has several projects to reinforce the capacity with its neighbours Belgium and Germany (see Box 5.3). Luxembourg plans to strengthen its electricity security by fully integrating its power system with the CWE network by 2017. Any new interconnection to Belgium will alter import/export flows with Luxembourg and create transit flows through Luxembourg and this requires stronger transmission capabilities in the domestic grids.

7. A Regional Investment Plan 2012-22 has been elaborated by TSOs of the Regional Group North Sea within ENTSO-E. The North Sea Region includes Belgium, Denmark, France, Germany, Ireland, Luxembourg, the Netherlands, Norway and United the Kingdom.

Box 5.4 Market coupling in Western Europe

Following the start of the trilateral market coupling between the Netherlands, Belgium and France in 2007, market coupling was extended in 2010 to Luxembourg, Germany/Austria (market splitting) and to Norway and the United Kingdom. The primary aim of the mechanism is to improve market liquidity and competition and, consequently, to induce lower and more stable electricity prices by integrating a number of energy markets into one single area for energy exchanges.

This overall integration process was supported at political level by the Pentalateral Energy Forum, together with Austria, Belgium, France, Germany, Luxembourg, the Netherlands and Switzerland (observer since 2011). Further liquidity and depth was added to the CWE market by so-called interim tight volume market coupling (ITVC) with the Nordic region via four direct-current cables, including NorNed, and the day-ahead coupling with the British market via the BritNed cable.

The day-ahead market coupling applied in CWE allows hourly physical spot transactions between buyers and sellers on the exchanges, independent of their physical location. Cross-border capacity is used to eliminate price spreads between the markets, as long as capacity remains available. The cross-border capacity is allocated together with the financial energy settlement in one single operation, which renders prior reservation of cross-border capacity unnecessary. In cases of sufficient cross-border capacity, this so-called implicit auctioning process delivers one single market price across borders. In cases of cross-border capacity constraints, optimal trades become restricted and lead to price separation.

Along with market coupling, there has been a trend to merge national power exchanges across several price zones in the CWE region. Market coupling has also led to a more efficient use of cross-border interconnector capacity, as transmission capacity use supported least-cost dispatch across the regional power system. However, it fails to reflect the cost of transmission network use (e.g. losses) which would encourage even more cost-efficient trades across regions.

Market coupling was first operational in the day-ahead market of the CWE and has been rolled out across the European Union through the price coupling of NWE (CWE, Nordic, Baltic, Great Britain and Poland) as of 14 February 2014 and to SWE in mid-2014. This so-called NWE day-ahead market coupling now links Nordpool (including the Baltic States, Poland and Sweden), Great Britain and CWE.

In autumn 2014, the introduction of flow-based market coupling (for implicit auctions) is foreseen to add greater accuracy to the market coupling method. This accuracy comes from a more detailed description and modelling of the underlying physical network and thus allows for a more precise measurement of the impact of congestion on price formation. However, its efficiency is limited by national boundaries which can mask critical points of congestion that fundamentally affect power flows and inhibit efficient regional price formation. Flow-based market coupling is meant to further enhance network integrity and price convergence. It is planned to be introduced across the EU internal energy market, and will include Central Eastern and Southern regions in the medium term. The flow-based allocation is expected to deliver welfare benefits from increased price convergence (58% to 90%), trade and reliability in the range of EUR 136 000 per day across all regions.

Box 5.4 Market coupling in Western Europe (continued)

The introduction of smaller price zones across the European Union, which would be defined by congestion and not by national borders, is under consideration to better deal with congestion in the networks, both at national and cross-border levels, with a view to improving transparency and delivering more efficient price formation.

Market coupling and flow-based market coupling are largely focused on the day-ahead markets, while intraday and balancing markets largely remain national or bilateral, as organised by TSOs.

However, to ensure efficient grid integration of renewable energies, the flow-based algorithm is only one element; it will also require renewable sources to be fully integrated in the wholesale markets and merit-order dispatch in the region. With the rising shares of variable renewables and more dynamic power flows in the NWE market, integrated intraday markets will play a strong role in providing flexibility and strengthening cross-border trade. The creation of a harmonised platform for continuous implicit cross-border intraday trading in the CWE region is currently under development.

In co-operation with RWTH Aachen, Creos also analyses the possibilities to expand the network for the horizon 2030.

At the end of 2013, in the Sotel network, a new interconnection came online between Moulaine (France, RTE) and Belval (Luxembourg, Sotel) to expand the transfer capacity by 350 MW.

Within Luxembourg, network investment by Creos in the Luxembourg-Ring is planned to lift internal congestions. A new transmission line will link the central dispatch centre of Heisdorf with the centre and south of the country.

Luxembourg is active at regional level with regard to enhancing its market integration, notably in the CWE region since 2010, which was enlarged to North-West European (NWE) market coupling in 2014 (see Box 5.4).

Given its strong integration with neighbouring networks, Luxembourg's electricity supply security is challenged by the latest developments in the region. The decommissioning of power plants in the CWE region, notably in the Elia and TenneT control zones, means that in the coming years regional peak capacities will be lower than previously planned. In the Elia zone, 900 MW were decommissioned in 2013 and another 1 400 GW are planned to be mothballed in 2014 (two CCGTs, Verbrande Bug & Seraing, Dorgenbos, Herdersbrug). Capacity mechanisms are considered in Belgium, Germany and France. The utilisation of Luxembourg's peak capacity plants (Vianden and Twinerg) is likely to be impacted by these new market conditions. Luxembourg's Twinerg facility is also expected to lose 70 MW of peak load in 2013-14.

Luxembourg largely depends on the German electricity grid of Amprion for the system stability and imports. Given the nuclear phase-out decision in Germany in the context of the *Energiewende* and the adequacy and reliability shortages in southern Germany, it is important for Luxembourg to closely co-operate with Germany on these matters in the coming years.

Luxembourg may wish to re-evaluate costs and benefits of investment in new generation facilities within its territory, including renewable energies. The foreseen expansion of renewable electricity facilities is rather small and would only marginally contribute to the resource and generation adequacy, given its variable nature of availability. The renewable energy target is expected to be largely met by additions from biofuels.

A quantified assessment of the costs and benefits of raising the share of renewables with regard to cost-effective system integration would be useful to underpin the revision. Latest IEA analysis shows that existing resources in the energy system can easily deal with a share of 5% to 10% of variable renewable energies in annual generation in the electricity grid (IEA, 2014). But costs and benefits differ for each country. In any event, higher shares of renewable energies installed in Luxembourg would require a smarter grid and more flexible backup loads, even more so as the domestic system does not have any substantial domestic peak or base-load backup capacities at this point in time. In the coming years, Luxembourg would be expected to act as a transit country to balance renewable energies via import/export flows and this means also system operations will need to be more co-ordinated at regional levels and higher transmission capacity is required.

Investment in new conventional power plants has not come forward, also given the limited market size and integration into the German price zone. The plan to build a new gas-fired power plant did not materialise. An open season was carried out in 2013 to build a new gas-fired power plant and a new gas interconnector with France but there was no market interest at the time.

Concluding on the above, Luxembourg is advised to facilitate the timely development of new interconnectors and related grid reinforcement in Luxembourg to support market integration. An essential prerequisite to ensure security of supply under an increased level of market integration is the implementation of all elements of the proposed integration plan before transit flows commence. In support of this, Luxembourg may want to consider the review of contractual and other technical arrangements governing the operation of the pumped-storage hydro plant and of the Twinerg facility in light of the changing power market dynamics in the region and of the new market design.

ASSESSMENT

Since the previous in-depth review, Luxembourg has successfully implemented electricity sector reforms consistent with the European Union Third Electricity Directive 2009/72/EC. Key achievements have included legal unbundling of generation, supply and networks, the introduction of incentive-based economic regulation and full retail contestability as well as preparing to roll out smart meters by 2020.

Luxembourg is right to promote a policy of regional market integration in light of its high dependence on electricity imports, the electricity-intensive nature of its steel and service industries and the competition and security benefits which an effective regional market can bring. In particular, the country has participated in the development of the CWE and NWE wholesale electricity market and related processes to support the development of harmonised regulation, network codes and other operational standards needed to co-ordinate regional power system management. The integration into a wider regional price coupling, as launched in 2014 with NWE and SWE, is an important milestone.

Importantly, TSO Creos Luxembourg is analysing a major transmission investment that will more effectively link Luxembourg into this regional market. This involves a new interconnector linking Luxembourg with Belgium and grid reinforcement within Luxembourg that is to permit transit power flows between Germany and Belgium for the first time. The government should ensure that there are no undue administrative or regulatory barriers that would delay the development of this project.

However, increasing integration can be expected to bring new challenges. Pressures are building among other jurisdictions within the CWE to adopt a range of regulatory interventions to address merit-order effects, such as capacity payments, which have the potential to further distort efficient regional market operation and development. Continued piecemeal policy development on a national basis could lead to fractured regional markets, with the potential to distort coherent operation of the NWE market and discourage the efficient, timely investment needed to ensure reliable electricity supplies into the future. Such developments could pose a serious threat to Luxembourg's electricity security.

Opportunities exist to enhance energy-only markets including more effective harnessing of demand response and incorporation of large-scale remotely located renewable generation into balancing and market-based dispatch. Opportunities also exist to improve the co-ordination of system operation to more effectively manage unscheduled power flows associated with variable renewable generation and to improve harmonisation of network regulation to facilitate efficient operation and timely investment. The government is encouraged to continue its engagement with NWE jurisdictions, with a view to building greater harmonisation of policies and programmes to support more efficient NWE market operation and development.

EU market integration is fundamentally transforming wholesale power markets, offering new opportunities for more effective and productive deployment of flexible generation assets. For instance, highly flexible generators, such as the pumped-storage hydro facility in Vianden, will become increasingly important for maintaining power system security as increasing volumes of variable renewable generation are deployed within the CWE region.

The current technical and contractual arrangements governing this facility's operation were negotiated decades before these reforms were contemplated and may unduly restrict its deployment in this new operating environment. The shareholders, including the government, could identify the impact of the changing electricity markets in the region and the necessary technical arrangements governing the Vianden pumped-storage facility, with a view to ensuring that it can make an effective contribution to delivering more secure and affordable electricity supplies consistent with Luxembourg's interests as an electricity importer reliant on the effective operation of the regional electricity market. In a scenario of further market integration, the government should assess an adapted market design of the balancing zones and a further integration of the pumped-storage hydropower plant in the domestic and regional power system to maintain a secure and reliable electricity supply.

Dynamic retail electricity markets are needed to encourage the development of innovative products and services that will capitalise on the roll-out of smart meters, empower customer choice and promote demand response. However, retail electricity markets have been slow to develop in Luxembourg, especially at the residential customer level with little supplier switching and little new entry evident to date.

The regulatory authority ILR launched an online price comparison tool to help educate consumers about electricity markets and to inform them on choice. This is a welcome development but more may be needed. For instance, opportunities exist to leverage the knowledge, experience, credibility and reach of Myenergy. Myenergy has developed a range of resources, including shop fronts, a call centre and mobile units, which could be harnessed to more effectively communicate and disseminate information about retail electricity markets to households. It would also allow for synergies between customer choice, energy efficiency and renewable energy to be more effectively developed. The government should encourage Myenergy to co-operate on ILR's information programme, with a view to accelerating the process of actively engaging consumers in retail electricity markets as smart meters are introduced.

Another critical requirement for effective retail market development is access to accurate time-of-use information to help empower choice, facilitate new entry and support the development of innovative products and services. Data access and management has proven to be a contentious issue in other reform processes with incumbents often advocating approaches that can unduly restrict access to data, undermining new entry and effective exercise of choice. Processes for data management and access are currently being developed. The government should ensure that the data management arrangements ultimately adopted provide ready access to the data needed to support the development of dynamic retail markets while addressing legitimate consumer protection concerns.

Creos Luxembourg and the other DSOs have been subject to incentive regulation since 2012. The regulator applies a hybrid revenue cap. The uniform benchmarking efficiency factor provides an equal incentive for all networks to use networks efficiently, but fails to take account of different levels of efficiency/inefficiency because of the lack of comparability with similar grid operators in the same or even other jurisdictions.

Further, concerning network regulation, it should be noted that legal unbundling maintains incentives to allocate costs to the network company, as vertical structures remain active. Thus, the regulator should put a strong focus on assessing the cost allocations between the regulated and the competitive activities.

The network charges are a substantial share of the electricity bill, as the country's grid has a regional distribution characteristic and maintenance and security at distribution level entail high costs. Luxembourg could substantially improve the management of the network and mitigate the operational cost by managing it in a smart way. The roll-out of smart meters is crucial in this context and will allow the integration of regional power flows and renewable energies, notably solar PV, in the distribution system.

Next to ensuring imports, the generation adequacy of Luxembourg can also be increased by planned additions from new renewable generation capacities in the country. Given the mothballing and closure of generating capacities in the Benelux region and the nuclear phase-out decision in Germany in the context of the *Energiewende,* the adequacy and reliability shortages in Southern Germany are expected to remain for the coming years. It is important for Luxembourg to closely co-operate with Germany on these matters, at a regional level, to mitigate possible reserve shortages in the German price zone. As neighbouring countries consider the adoption of capacity mechanisms in their jurisdiction, Luxembourg will need to be actively engaged in the discussion and is well placed to further foster market integration, notably within the Pentalateral Forum.

RECOMMENDATIONS

The government of Luxembourg should:

- ☐ *Continue to actively engage with relevant jurisdictions in the development of an efficient, competitive and innovative CWE wholesale power market, including:*
  - *building support for market coupling based on effective wholesale energy-only markets that can deliver adequacy, harness demand response and more effectively incorporate large-scale remotely located renewable generation into balancing and market-based dispatch*

- *supporting efforts to strengthen co-ordination of system operation and network regulation, and to harmonise renewable and other support programmes to promote efficient regional market development and security of electricity supplies*
- *facilitating timely development of the new interconnector into Belgium and related grid reinforcement in the Grand Duchy*
- *assessing the arrangements governing the operation of the Vianden pumped-storage hydro plant in an enhanced market integration scenario and considering adapting the market design of the balancing zones, with a view to ensuring that the plant can make an effective contribution to the adapted market design and to security of supply within Luxembourg and within the CWE electricity market.*

☐ *Promote the development of a more dynamic and innovative retail electricity market that can increase choice, empower customers and facilitate demand response, including:*

- *strengthening consumer education and information dissemination, including using Myenergy to help disseminate information and raise awareness about electricity choices among households*
- *ensuring that market participants and potential new entrants have access to accurate time-of-use data on a customer basis, while respecting legitimate privacy and confidentiality issues.*

☐ *Focus on controlling the strong position of Enovos Luxembourg and developing network regulation further for a more cost-efficient access regime, especially to discourage from allocating costs to the network within legally unbundled firms and setting adequate incentives within a revenue cap.*

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6. OIL

Key data (2013 estimated)

Share of oil: 61.2% of TPES and negligible share of electricity generation

Crude oil production and imports: nil

Oil products imports: 2.8 Mt, +6.4% since 2003

Oil supply by sector (2012): transport 87.7%, residential 6.9%, commercial 3.6%, industry 1.8%

SUPPLY AND DEMAND

SUPPLY

Oil is the most significant fuel in Luxembourg's energy mix, as it accounts for 61.2% of total primary energy supply (TPES). Luxembourg relies on imports of all its oil supply needs. It neither produces nor refines crude oil domestically.

All oil products imports come from neighbouring countries – namely from Belgium (77.2% of total imports in 2013), Germany (16.8%), the Netherlands (4.5%) and France (1.5%).

In 2013, oil products imports totalled 2.8 million tonnes (Mt) or 59 thousand barrels per day (kb/d), and were made up of gas and diesel oil (73.4%), kerosene-type jet fuel oil (12.9%), gasoline (12%) and others. With demand for oil having grown over the past decade, imports have increased by 6.4% from 2003 to 2013. Notably, demand for diesel increased from 62% of total consumption in 2003 to 73% in 2013. During the period 2000-13, the share of gasoline declined from 21.6% to 12%.

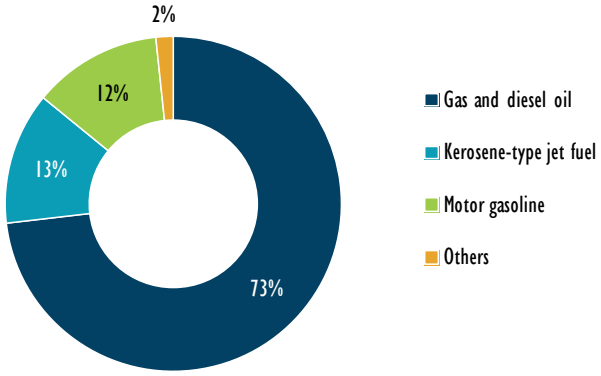
Luxembourg does not export oil products.

DEMAND

The transport sector is the main consumer of oil products, and the largest consumer of energy in the country. During 2012, oil consumption in transport was 2.2 Mt, or 87.7% of total oil consumption. The residential and commercial sectors represented 6.9% and 3.6% of oil use, respectively, while industry accounted for only 1.8% of the total. Oil is also consumed in power generation, however at negligible levels.

Over the ten years since 2002, demand for oil has increased in the transport and commercial sectors, while it has contracted in other sectors of the economy. Total consumption of oil in transport grew by 12.1% from 2002 to 2012, while it declined by 29.1% in industry and by 24.7% in households. Commercial sector use increased by 8.2%.

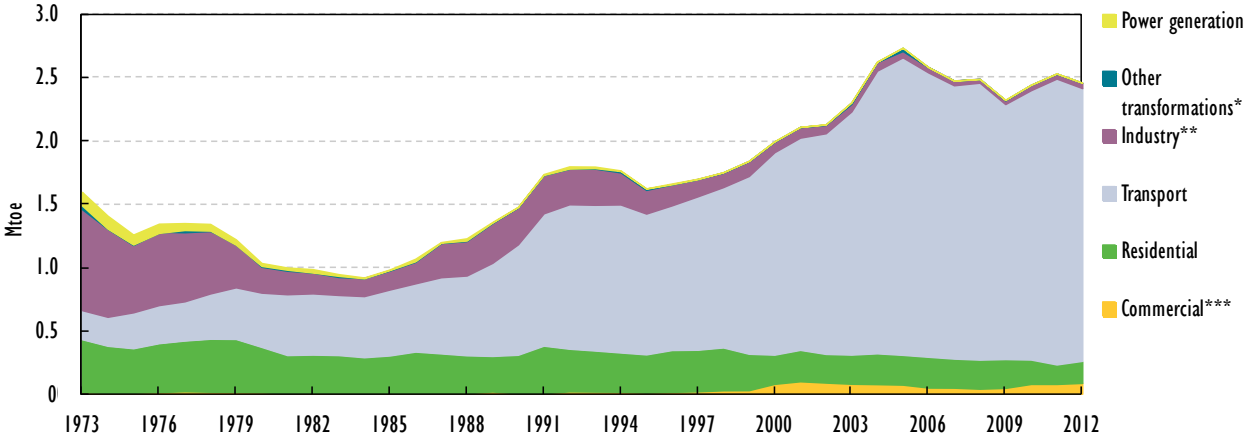
Figure 6.1 Oil demand by product, 2013



Note: estimated data.

Source: IEA (2013), *Oil Information 2013*, OECD/IEA, Paris.

Figure 6.2 Oil supply by sector, 1973-2012



Notes: represents TPES by consuming sector. Data are preliminary for 2012.

* *Other transformations* include refining and energy sector consumption.

** *Industry* includes non-energy use.

*** *Commercial* includes commercial, public services, agriculture/forestry, fishing and other final consumption.

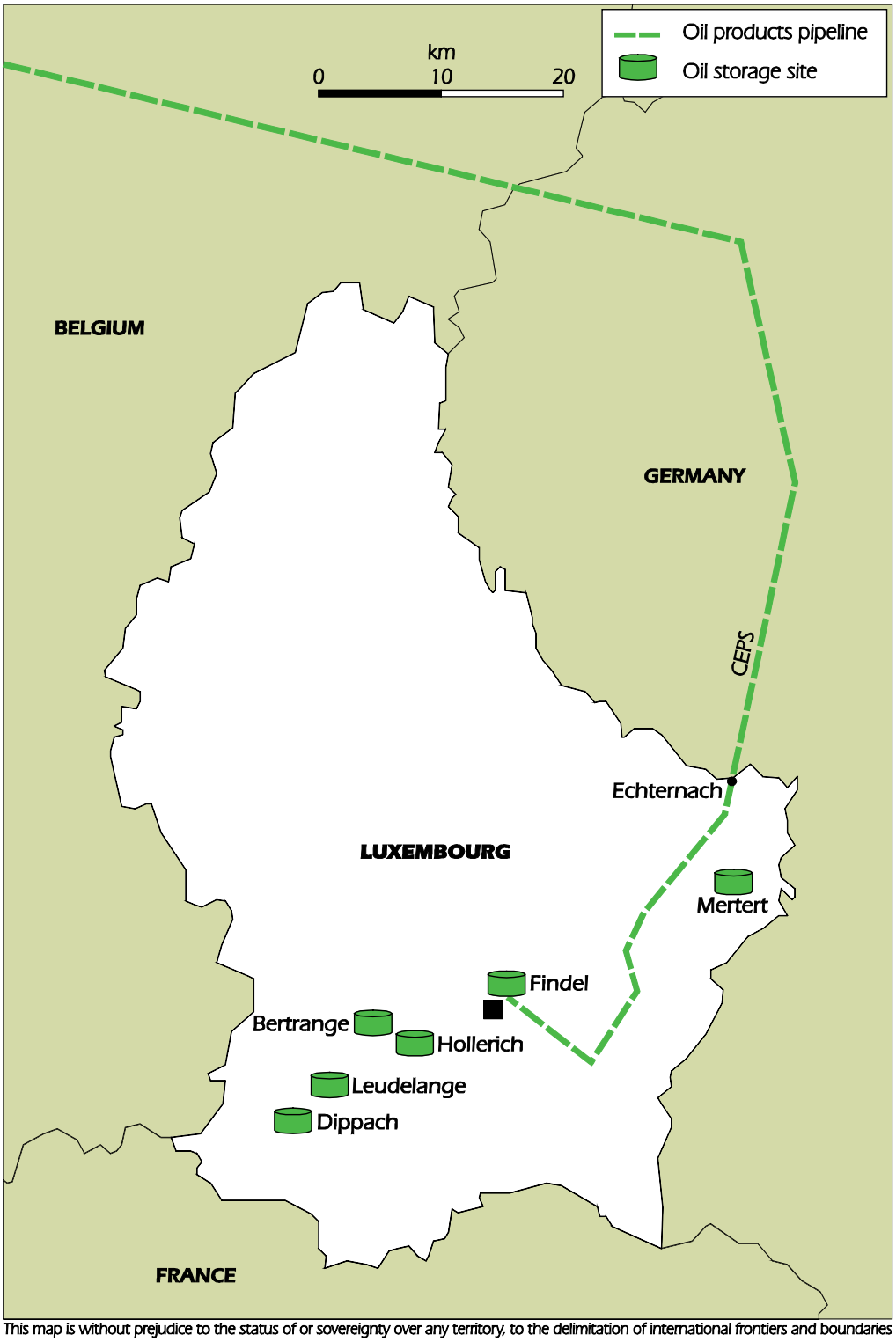
Source: IEA (2013), *Energy Balances of OECD Countries 2013*, OECD/IEA, Paris.

OIL MARKET AND INFRASTRUCTURE

Luxembourg has no oil production or refinery for petroleum products. The country covers its entire demand of finished oil products by imports from neighbouring countries. Refined products are mostly imported by road (50% in 2010), followed by rail (23%), barge (16%) and pipeline (11%). Luxembourg is connected to one pipeline branch of the Central European Pipeline System (CEPS) which only supplies aviation kerosene to the airport at Findel.

Luxembourg has six main storage facilities, with a total capacity of 196 000 $m,^3$ which are used by oil companies to supply the domestic market. The storage sites are located at Bertrange, Findel, Mertert, Hollerich, Dippach and Leudelange.

Figure 6.3 The oil infrastructure of Luxembourg, 2014



This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Source: IEA, 2014.

The government has publicly announced its intention to increase the domestic storage capacity by 480 000 m^3 in the coming years, by extending the storage site of Mertert with another 90 000 m^3 and by building two new storage sites in Bascharage (90 000 m^3) and in Luxembourg-Ouest (300 000 m^3).

The new sector plan for economic zones (*plan sectoriel zone d'activités économiques,* PSZAE) is to be presented during 2014 and is to indicate reserved land zones dedicated for petroleum storage sites. The storage expansion is also linked to the fact that the operation permits of two-thirds of all storage capacity are expiring by 2019.

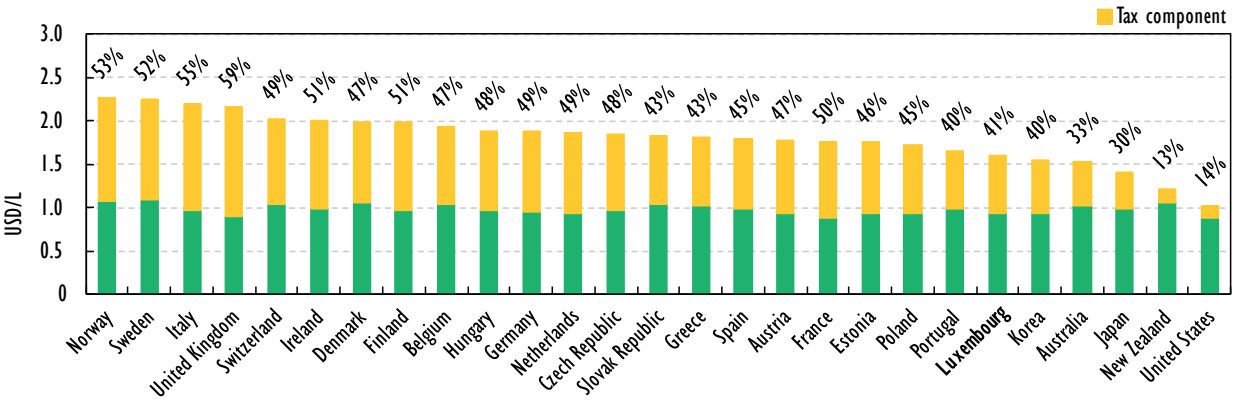
In 2013, there were 12 retail oil market players active in Luxembourg, eight large international players (Aral, BP, Q8, Delek, Esso, Shell, Lukoil and Total) and four distributors (Argos, Q8-Calpam, Petro-Center and Gulf). In 2013, Luxembourg had in total 239 service stations, with average annual throughput of about 6.4 million litres (located outside motorways) and 107.8 million litres (on motorways in eight service stations). The interests of the industry are represented by the *Groupement Pétrolier Luxembourgeois*, the national oil company association.

In 2013, oil industry provided employment for 2 100 people and revenues of EUR 1.15 billion to the state budget (excise tax, VAT, concession rights), corresponding to around 10% of the state budget.

OIL PRICES AND TAXES

Among IEA member countries, Luxembourg had the lowest light fuel oil prices (with 12% tax in third quarter 2013) and also the lowest diesel and petrol taxes compared to its European neighbours (41% tax for diesel and 49% for unleaded petrol), with low VAT and excise duties. In 2014, diesel excise duties in Luxembourg were at EUR 0.335 to EUR 0.338 per litre of diesel (depending on the sulphur content), while neighbouring countries had EUR 0.43 per litre (Belgium), EUR 0.47 per litre (Germany) and EUR 0.43 per litre (France). As of February 2014, leaded gasoline excise duty was at EUR 0.516 per litre and between EUR 0.462 and EUR 0.464 per litre for unleaded gasoline, depending on the sulphur content (ADA, 2014; EC 2014).

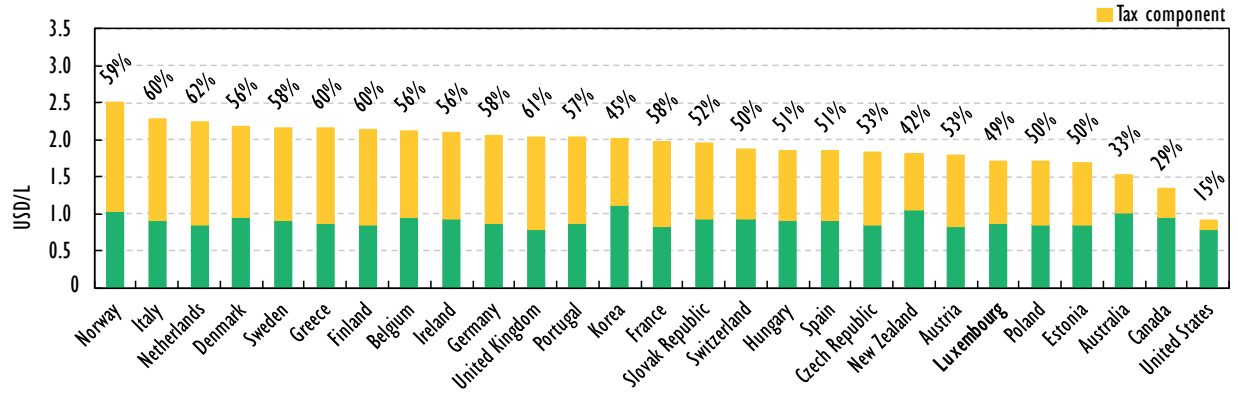
Figure 6.4 Automotive diesel prices and taxes in IEA countries, fourth quarter 2013



Note: data not available for Canada and Turkey.

Source: IEA (2013), *Energy Prices and Taxes 2013*, OECD/IEA, Paris.

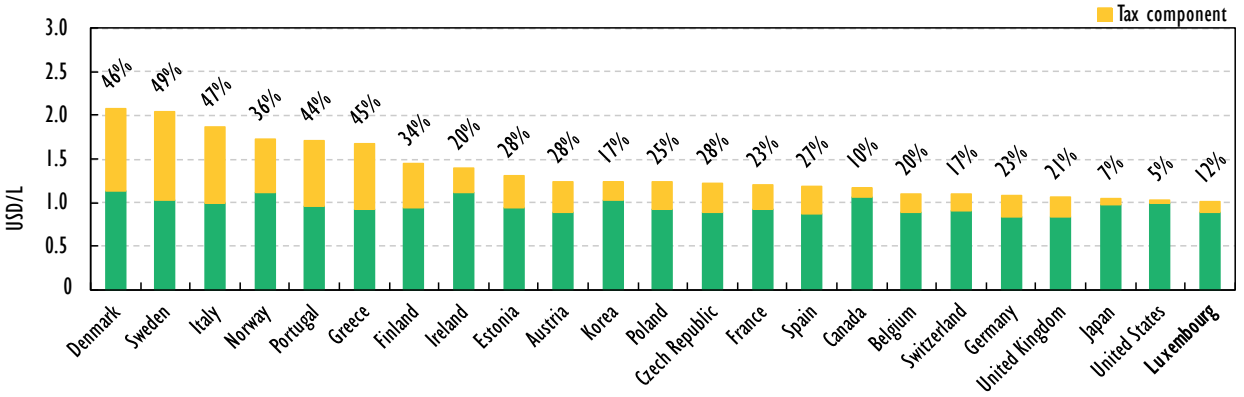
Figure 6.5 Premium unleaded petrol prices and taxes in IEA countries, fourth quarter 2013



Note: data not available for Japan and Turkey.

Source: IEA (2013), *Energy Prices and Taxes 2013*, OECD/IEA, Paris.

Figure 6.6 Light fuel oil prices and taxes in IEA countries, fourth quarter 2013



Note: data not available for Australia, Hungary, the Netherlands, New Zealand, the Slovak Republic and Turkey.

Source: IEA (2013), *Energy Prices and Taxes 2013*, OECD/IEA, Paris.

Luxembourg maintains a maximum price-setting mechanism for oil products. In compliance with an agreement between the Luxembourg State and the oil-importing companies, a maximum price is set for oil products sold to end-consumers, including gasoline, automotive diesel, heating oil and liquefied petroleum gas (LPG). The formula is calculated on the price of oil products (CIF included), to which are added a standard cost of transport from Antwerp to Luxembourg, a standard distribution margin for the market actors, and the cost of compulsory storage. Companies are free to set prices below the maximum daily levels set by the Ministry of the Economy, which are communicated via emails to market players only in case of changes. The mechanism foresees a four-day delay between the time prices are quoted and the time retailers are able to adjust to a new maximum rate. As the formula is available to operators, they can calculate the price change on their own. Transportation costs, margin and storage costs are negotiated with the industry representation *Groupement Pétrolier Luxembourgeois*.

SECURITY OF OIL SUPPLY

STOCKHOLDING REGIME

Luxembourg meets its IEA stockholding obligations with industry stocks. Under the Grand-Ducal Regulation of 31 October 1973, the industry (oil-importing companies) is obliged to hold petroleum products equivalent to at least 90 days of imports during the previous calendar year. Current legislation provides for 45 days of category I, 55 days of category II stocks to be kept within the country. Given limited oil storage capacities in Luxembourg, the lion's share of compulsory stocks is held in neighbouring countries under bilateral agreements, despite the requirement in the legislation. Since March 2006, Luxembourg has consistently held stocks that meet IEA and EU requirements.

In 2012, Luxembourg started transposing and implementing the new EU Oil Stocks Directive 2009/119/EU and is amending its stockpiling regime in 2014. The new law, which is in the approval procedure in Parliament, is creating the legal framework for the establishment of a national stockholding agency.

The IEA and EU emergency response policy is co-ordinated by the Directorate-General for Energy within the Ministry of the Economy. The Directorate-General for Energy is the contact point in case of an oil supply disruption. Its activities include collecting data, monitoring the domestic oil market and following up on the industry's compulsory oil stockholding obligations.

According to the Emergency Law of 22 September 1982 "*relative à l'approvisionnement du pays en cas de nécessité",* the Minister of the Economy has the legal authority to take decisions on emergency measures "if oil products supply is endangered". These measures can be taken either by means of decrees or by notification to individual companies, which could regulate imports, trade and consumption of oil products.

Luxembourg closely works with neighbouring countries on security of oil supply.

ASSESSMENT

Oil represents a very large share of total final energy consumption (TFC) with 64% in 2012, up from 63.1% in 2002. The share of oil in TFC, notably in the transport sector remains high. And oil consumption in transport saw a constant increase (by 12.1% from 2002 to 2012).

All oil products are imported, mostly by trucks and rail, mainly from Belgium. Lower quantities also come from France, Germany and the Netherlands. Over the past years, diesel has increased its role in domestic consumption and imports, while the role of heating oil is decreasing.

Given Luxembourg's low taxation policy, about 40% of all fuel purchased locally is sold to non-residents, as it is consumed by trucks, commuters and fuel tourists. This leaves Luxembourg with the highest CO_2 footprint per capita in OECD Europe but on the other hand secures important state revenues and employment.

Luxembourg's price-setting mechanism for oil products sets a maximum daily price for oil products at the service station for gasoline, diesel oil, heating oil and LPG. While in theory the government expects companies to set prices below the maximum levels,

competition is rather limited and most prices tend to converge around the maximum level. The maximum price is likely to reduce the choice for consumers and margins for producers, and should be reconsidered from a public interest point of view. A more market-based scheme could allow the development of a more competitive oil market in Luxembourg.[1]

Luxembourg is subject to stockholding obligations under the EU and IEA obligations. At present, a 90-day stockholding obligation is imposed on the industry. Luxembourg has only 196 000 m^3 storage capacity, spread on six storage sites, some being used for operating purposes (commercial stocks). Today, industry meets its obligations by keeping stocks in Belgium and the Netherlands on the basis of bilateral agreements. Amid rising and fluctuating shares of road fuel sales, the country needs to adjust its stockholding obligations. However, Luxembourg has constraints in modernising and expanding its oil storage capacity because of environmental impacts. And two-thirds of current operation permits for total storage capacity is expiring by 2019. The lack of storage leaves Luxembourg exposed to serious price and volume risks of possible disruptions of or unavailability of fuel supplies delivered on the road or rail. Against this background, there are plans to expand the storage capacity by 480 000 m^3. Domestic storage capacity, physically within geographic reach, is essential.

In January 2013, the government presented a new draft law on the organisation of the oil products market with a view to transpose EU Oil Stocks Directive 2009/119/EC, including the creation of a national stockholding agency. The law is currently being reviewed by Parliament and should be adopted by mid-2014. But the details concerning the structure of the new agency and the setting up and testing of new emergency arrangements will require time. The IEA encourages the government to ensure swift implementation and early consultations with stakeholders. A cost-benefit analysis of the different options and shares for stockholding arrangements, including bilateral tickets and oil storage in and outside Luxembourg, can help identify the optimal security choice between domestic and foreign stocks.

RECOMMENDATIONS

The government of Luxembourg should:

- *Take steps towards eliminating the maximum price-setting mechanism with the aim of supporting an open and competitive oil market in the country.*
- *Support swift adoption and implementation of the national legislation transposing the EU Oil Stocks Directive, and notably the creation of a national stockholding agency, in consultation with all stakeholders.*
- *Carry out a cost-benefit analysis of various options for meeting the country's stockholding obligation, in line with the new EU directive, to identify the costs and benefits of meeting the requirements in co-operation with regional markets and by opening new oil storage sites inland.*

1. For further information see also the comparative analysis of gasoline price regulation in Austria, Australia and Canada. Haucap, Justus/Müller, Hans-Christian: The Effects of Gasoline Price Regulations: Experimental Evidence, Düsseldorf Institute for Competition Economics, Discussion Paper No 47, April 2012.

References

Administration des Douanes et Accises (ADA) (2014), www.do.etat.lu/acc/Taux_droits_accise/Luxembourg.htm, accessed in 2014.

European Commission (EC) *Energy Observatory Oil Bulletin*, Duties and Taxes, accessed on 26 May 2014.

7. NATURAL GAS

Key data (2013 estimated)

Production: nil

Imports: 1 bcm, -15.8% since 2003

Share of gas: 22.3% of TPES and 78% of electricity generation

Consumption by sector (2012): power generation 42.2%, industry 25.3%, commercial 16.9%, residential 16%

SUPPLY AND DEMAND

SUPPLY

Natural gas accounts for more than one-fifth of total primary energy supply (TPES), namely 22.3% in 2013 or 0.9 million tonnes of oil-equivalent (Mtoe). Gas supply has been moderately volatile over the past decade, after a surge in 2002. During 2002, additional 376 megawatts (MW) of gas-fired generation capacity came online with the installation of the Twinerg plant, which boosted the demand and supply of gas in the country. Total supply of gas grew by 43% year on year from 2001 to 2002 and peaked in 2006 with 1.4 billion cubic metres (bcm).

Luxembourg imports all of its natural gas needs through pipelines from Belgium and Germany and a very minor part from France. In 2013, gas imports totalled 1 bcm of which 51.8% from Norway, 24% from the Russian Federation, 12.4% from Belgium, 1.2% from, the Netherlands, and 10.7% from other countries. No gas is exported.

DEMAND

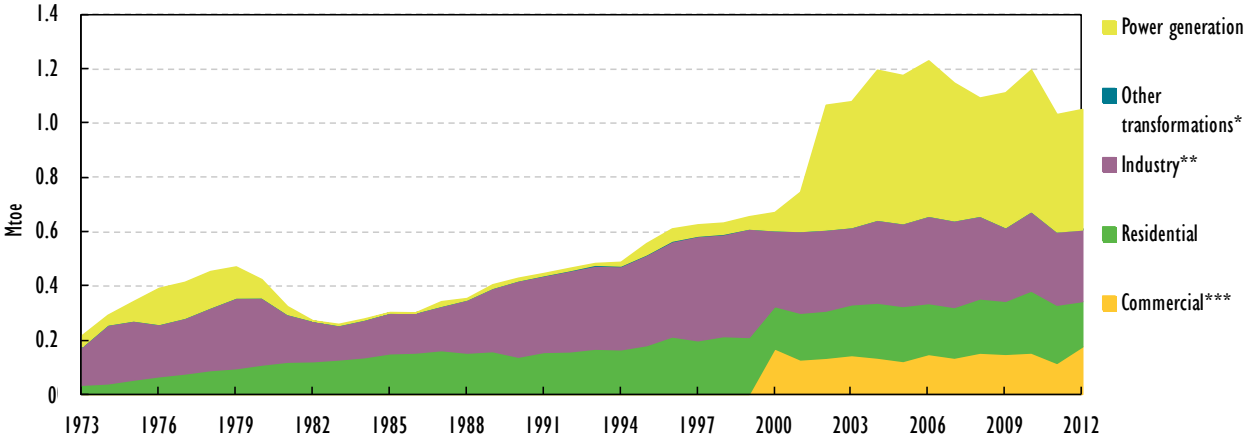
The power generation sector is the main consumer of natural gas. It accounted for 42.2% of inland consumption in 2012. This sector has been a significant consumer of gas since 2002 when the gas-fired generation capacity came online with the construction of the combined-cycle gas turbine (CCGT) Twinerg. Since 2002, gas use has been volatile, mainly because of maintenance works in the plant but also because of the evolution of demand in the iron and steel production. Overall demand by the power generation sector was 5.7% lower in 2011 than in 2002.

The industry sector consumed 25.3% of gas in 2012, mainly in iron and steel manufacturing. The commercial and residential sectors represented 16.9% and 16% of domestic gas consumption. The largest change in the sectoral split of gas consumption has seen an increase in demand by the commercial sector over the past decade, while demand from industry and the residential sector has contracted.

For the future outlook, the residential sector is expected to be the source of growing demand for natural gas. However, supply/demand projections for 2020, 2030 or 2050 are not available for Luxembourg. The gas distribution network in municipalities will need to be fully developed, in case more gas will be consumed.

Natural gas is also used in the transport sector, but marginally, with only six filling stations supplying compressed natural gas (CNG) and 250 cars running on natural gas in the country. Luxembourg brought three biogas plants into operation in 2011 which delivered 49 gigawatt hours (GWh) of biogas into the distribution network.

Figure 7.1 Natural gas supply by sector, 1973-2012



Notes: represents TPES by consuming sector. Data are preliminary for 2012.

* *Other transformations* includes refining and energy sector consumption.

** *Industry* includes non-energy use.

*** *Commercial* includes commercial, public services, agriculture/forestry, fishing and other final consumption.

Source: IEA (2013), *Energy Balances of OECD Countries 2013*, OECD/IEA, Paris.

NATURAL GAS INFRASTRUCTURE

Natural gas is supplied to Luxembourg via four entry points: at Pétange and Bras with Belgium, both of which form one virtual point, at Esch with France and at Remich with Germany. Luxembourg has no exit point or exit capacity, as it does not export gas.

Only about 50% of the country's territory is covered with a natural gas grid of 1 917 km, of which a transmission network of 412 km linked up to three distribution networks that ensure access to natural gas for an estimated share of 76% of households (see Figure 7.2). The country has neither natural gas storage nor compressor stations. There are three distribution systems operators (DSOs): Creos Luxembourg (both transmission and distribution operator), Sudgaz (an integrated company owned by 14 municipalities with a 13% share in the natural gas market) and the municipal DSO (Ville de Dudelange). The Luxembourg gas transmission system is operated by Creos Luxembourg s.a. which is also the largest DSO. The city of Dudelange and Sudgaz s.a. are the other DSOs. Creos Luxembourg plans to expand the natural gas distribution grid. According to the EU-wide ten-year network development plan prepared by the European Network of Transmission System Operators for Gas (ENTSO-G) for the period 2013-22, Creos is analysing opportunities to expand its natural gas entry capacity with France and Belgium.

Figure 7.2 The natural gas network of Luxembourg, 2014

This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Source: IEA, 2013.

GRTgaz and Creos had the plan to increase capacity up to 40 gigawatt hours per day (GWh/d), equivalent to 3.6 million cubic metres per day (mcm/d) by 2018. An open-season process run in 2013 by French TSO GRTgaz and Creos failed because of lack of market interest. Another option is to strengthen the existing interconnection with Belgium by either increasing the entry pressure or reinforcing the interconnection capacity to 6.4 mcm/d. Between 2009 and 2010, Fluxys carried out an open season for exit capacities to the Grand Duchy and received capacity bookings for the period 2015-25 that justify the construction of a pipeline between Ben-Ahin and Bras on the transmission axis to Luxembourg. This would result in a capacity increase of 10.85 GWh/d in the Creos network thanks to higher delivery pressure from the Fluxys network.

Box 7.1 Gas projects of common interest

Under the trans-European networks, Luxembourg has a cluster of gas projects considered of common interest in line with the EU Regulation 347/2013 on guidelines for trans-European energy infrastructure and repealing Decision No 1364/2006/EC and amending Regulations (EC) No 713/2009, (EC) No 714/2009 and (EC) No 715/2009.

In October 2013, a cluster of gas projects between Luxembourg, France and Belgium was added to the EU-wide list of common projects. In the gas sector, this concerns two main projects.

The first project relates to the integration with France. Two options for an interconnection between France and Luxembourg are possible: a new pipeline of 15 km or 56 km in France and 2 km in Luxembourg and a daily capacity of 0.8 or 3.5 mcm/d.

The second project relates to the reinforcement of the interconnection between Belgium and Luxembourg through the upgrade of the existing entry point at Pétange and the construction of a 50 km pipeline in Belgium.

NATURAL GAS MARKET STRUCTURE AND REGULATION

MARKET STRUCTURE

In 2009, the state of Luxembourg, Société Nationale de Crédit et d'Investissement (SNCI), Arcelor Mittal, RWE Energy, E.ON Ruhrgas, Electrabel and Soteg had signed a memorandum regarding the merger of the historic players Cegedel and Soteg, and Saar Ferngas. Today, a major player on the gas market is Enovos Luxembourg s.a. The state of Luxembourg holds, directly and indirectly, 35% of the shares in Enovos International s.a., the holding company of Enovos Luxembourg s.a.

In 2012, there were eight suppliers active on the national gas market, in addition to Enovos Luxembourg, three serving the residential sector (Dudelange, Leo, Sudgaz) and five the commercial sector (Distrigas, GNEurope, GDF Suez, Sudgaz, Leo) (ILR, 2013). Three players supply gas to the power generation sector (Leo, GDF Suez, Sudgaz), while the industry sector is solely supplied by Enovos Luxembourg (see Figure 7.5). Enovos supplied 100% of industry and 88% of the power generation sector. At the household level, Enovos has a market share of 5.4%, together with its subsidiary Leo, 36.7%.

REGULATION

Unbundling of the activities of gas supply and production from network operations was enshrined in the Law on electricity and gas markets of 1 August 2007. Transparent and non-discriminatory procedures were also put in place to grant supply authorisation to gas suppliers. In total 11 authorisations have been granted since 2008.

Luxembourg adapted its gas market regulation with a view to transpose Directive 2009/73/EC on common rules for the internal natural gas market and repealing Directive 2003/55/EC of 7 August 2012.

Changes included notably the responsibilities of the regulatory authority ILR, the strengthening of consumer rights, such as facilitating the switch of suppliers and the roll-out of smart meters, the supervision of the unbundling of supply and transmission/ distribution activities. Easier and faster procedures for customers to change supplier were introduced by the Law of 7 August 2012.

As a fully owned subsidiary of Luxembourg's utility Enovos International s.a., the TSO Creos Luxembourg s.a. is legally and functionally unbundled from gas supply activities of Enovos International s.a., but shares some horizontal departments. Operators are also owners of the grid but ILR ensures that third-party access rules are applicable as well as the freedom to change gas supplier.

Since 2012, Creos Luxembourg s.a. has been regulated by a revenue cap for a period of four years 2013-16.

At the distribution level, the two other DSOs (Ville de Dudelange and Sudgaz) do not serve more than 100 000 customers and are not subject to legal unbundling under the third internal energy market rules.

The harmonisation of the cross-border arrangements will be an important milestone for the gas market integration. The future EU code on congestion management will bring about new congestion management rules at the entry points with Germany and Belgium. Until September 2013, there was a lack of firm capacities at the borders with Belgium and Germany and capacity calculations are not yet harmonised. In addition, in Luxembourg gas is odourised for safety reasons. Discussions between Creos and Fluxys are ongoing on market coupling to the Belgium zone, offering direct access to the Belgian wholesale market and harmonisation of the capacity calculations on the borders to Belgium and Germany.

SECURITY OF GAS SUPPLY

As an importer of natural gas, Luxembourg is vulnerable to disruptions of supplies and to events in gas-producing or gas-importing countries. Amid the phase-out of heating oil in favour of an increasing role of gas and the dependence of the commercial and power generation sectors on imported natural gas, security of gas supply has gained importance over time.

Flexibility of the gas system is very limited, as the country has no storage, limited line pack and no exit points. The natural gas emergency response relies on the load-shedding plans established by the system operators. The country's daily peak demand over the past was 7.1 mcm/d on 7 February 2012.

Luxembourg's emergency policy for natural gas is set by EU Regulation 994/2010 concerning measures to safeguard security of gas supply and repealing Council Directive 2004/67/EC. The Government Commissioner for Energy is responsible for monitoring the general state of the networks and interconnections as well as the security of supply as required by Law of 1 August 2007 on Natural Gas Market (last amended on 7 August 2012). The system operators, generators, suppliers and wholesalers are responsible for the security of supply to final consumers in normal time, while the TSO (Creos) and DSOs (Creos, Sudgaz and Ville de Dudelange) are expected to take the necessary measures to safeguard the natural gas system.

The system operators (TSO and DSOs) have established a load-shedding plan (*plan de délestage)* in case of an emergency so as to safeguard the supply to protected domestic customers.

On the basis of EU Regulation 994/2010, Luxembourg carried out a risk analysis of the natural gas sector and subsequently prepared preventive actions and an emergency plan (Ministry of the Economy, 2012) in December 2012. The main conclusion is that the gas infrastructure cannot deal with a disruption of the largest infrastructure, the entry point to Germany, which supplies half of the country's natural gas. The resilience of the gas system to a disruption of the largest infrastructure is also referred to as N-1 rule, which has been established for the gas sector under the EU Regulation 994/2010. Luxembourg has an exception to this N-1 rule and does not have to comply with it in the current gas grid structure.

As outlined above, the increase of gas entry capacity is an objective for the country. An open-season process was carried out in 2013 by GRTgaz in France and Creos which, however, has not resulted in interest by the market on neither side by 1 July 2013. Another option could be to consider security of supply considerations for the construction of a new pipeline, however, there would be no commercial case for the operation of the pipeline.

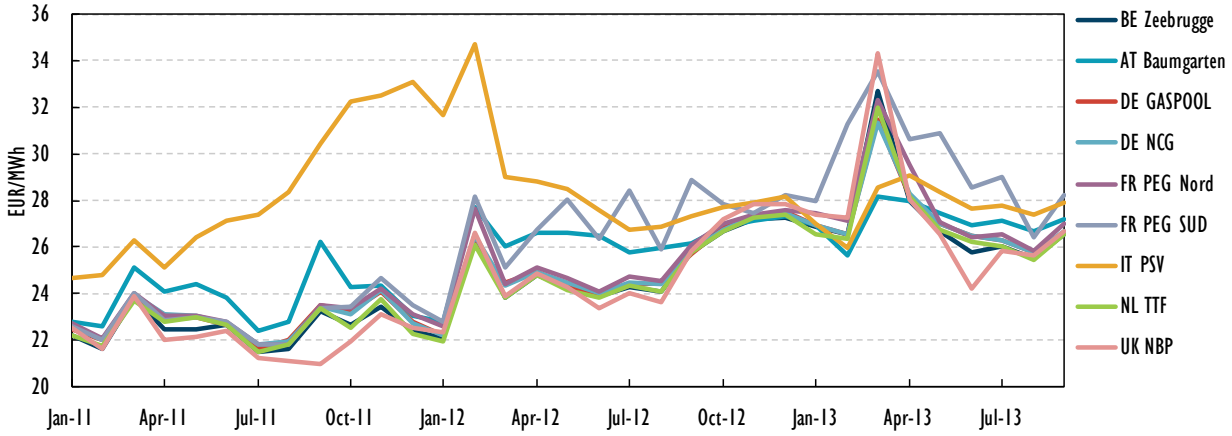
Since 2013, the increase in capacities by upgrading an existing entry point with the Belgian network was studied, and the integration of market areas across the borders, either through integrated balancing markets or through a common entry-exit zone, were examined. After several years, in May 2014, Belgian TSO Fluxys and Creos Luxembourg successfully signed a Memorandum of Understanding on the integration of the Belgium-Luxembourg gas market through a common gas balancing zone. This cross-border regional market zone is the first of its kind.

NATURAL GAS PRICES

Luxembourg does not have a wholesale market for natural gas and no virtual trading point, but is a price taker for its gas supplies from adjacent markets in Belgium (Zeebrugge), the Netherlands (TTF) and Germany (NetConnect Germany).

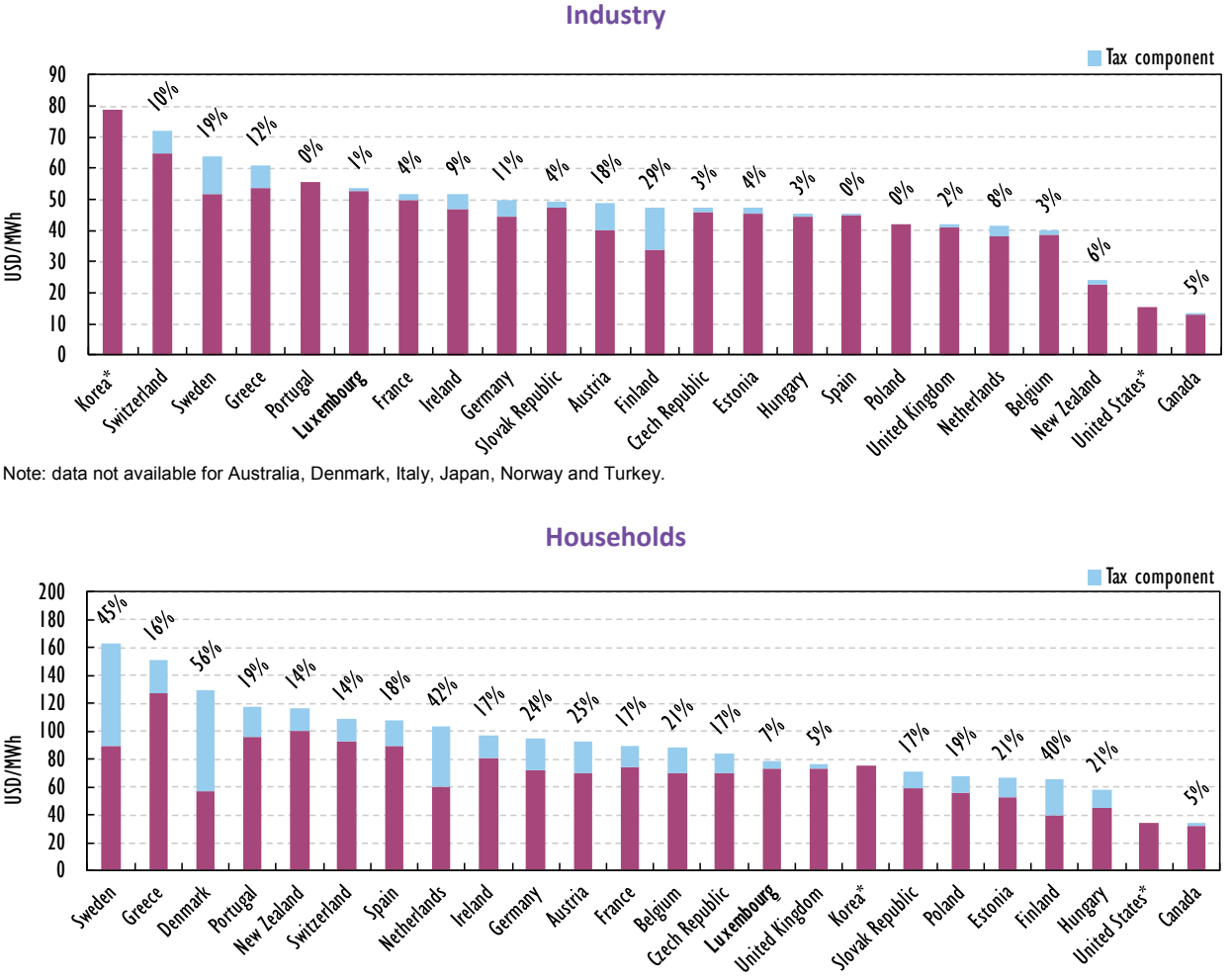
Gas prices for industry and households are in line with IEA average and neighbouring countries, despite low taxation levels in Luxembourg. According to ILR data, natural gas supply cost increased while network charges decreased in the past three years. In 2012, household prices of around EUR 61 per MWh and industry prices of EUR 50 per MWh reflected the price levels of neighbouring countries. The natural gas bill for households was composed of 7% tax, 10% local network charges and 83% supply cost, which also included network charges incurred in the country of import. No effective competition or new entry occurred in the retail market and switching rates remained very low (ACER, 2013). According to ILR, the switching rate was below 0.1% in 2012 with 29 switches recorded in total, 16 among residential households and 13 in the commercial and industry segment.

Figure 7.3 Converging monthly EU gas hub prices, January 2011 to September 2013



Source: Platts, September 2013.

Figure 7.4 Gas prices in IEA member countries, 2013



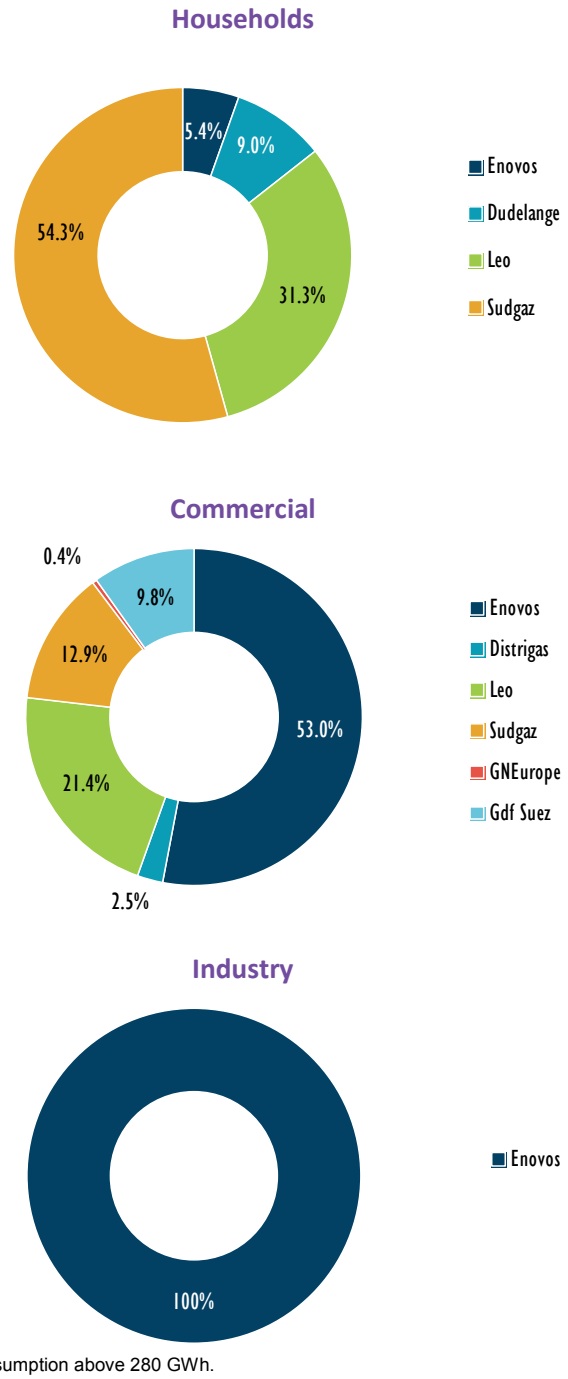
Note: data not available for Australia, Denmark, Italy, Japan, Norway and Turkey.

Note: data not available for Australia, Italy, Japan, Norway and Turkey.

* Tax information not available.

Source: IEA (2013), *Energy Prices and Taxes 2013*, OECD/IEA, Paris.

Figure 7.5 Market structure in the gas sector, 2013



Note: *Industry* refers to customers with a consumption above 280 GWh.

Source: ILR, 2013.

ASSESSMENT

Luxembourg has no natural gas production and covers all its domestic consumption by imports from Belgium, France and Germany.

Since 2008, the use of natural gas has been decreasing in power generation and industry but has been expanding in the commercial sector. In 2012, around 25% was consumed by the industrial sector, 42% in power generation, and the remaining 33% in the residential (16%) and commercial (16.9%) sectors for heating purposes.

As an end-of-pipeline gas consumer in continental Europe 100% reliant on imports, and with no storage capacity, being largely dependent on gas may not be in the best interest of Luxembourg from an energy security point of view. Further expansion of the gas distribution grid has the potential to lock the country further into higher import dependence. The government should analyse scenarios and the benefits and costs of expanding the role of gas and the gas grid over the long term, and options for promoting renewable heat as an alternative.

The gas network and supply activities in Luxembourg are legally unbundled subject to provisions of the third internal energy market package. Legal unbundling requires regulatory supervision by ILR to guarantee the separation of the gas network from gas supply interests within Enovos International. Since the last in-depth review in 2008, there has been a significant change in the gas market structure with the merger of several suppliers into Enovos Luxembourg, which is the only supplier to industry and dominates 88% of gas supplies to the power sector. At household level, Enovos and subsidiaries have a market share of 36.7%.

Luxembourg is to be commended for undertaking efforts to adapt its rules to EU Regulation 994/2010 on security of gas supply by carrying out a risk assessment of gas supplies, preventive action and emergency plans. Today, the gas system does not provide compensation for a disruption of the single largest entry point to Germany (N-1). However, regional market integration has progressed strongly.

Luxembourg examined several options to improve the security of gas supply, including the construction of a new pipeline to France (open season with GRTgaz) or the increase of entry capacities at the Belgian border either with a new pipeline connection to the Fluxys network or by increasing the entry pressure on the Belgian side. A milestone marks the agreement between Belgian Fluxys and Creos Luxembourg on the merger of the market zones which will help to strengthen availability of gas flow capacity at the entry points and could foster competitive entry to the Luxembourg gas market. However, physical flows are essential prerequisites for any market merger and the N-1 situation does not change with a merger. The projects of common interest remain important in this context. Physical capacities will foster entry capacities in Luxembourg that can enhance both security of supply and competition. The government can build on these opportunities to reinforce natural gas security of supply at regional level.

The harmonisation of capacity allocation and congestion management should be a priority for a country which is consuming gas from all neighbouring countries. The implementation of new EU-wide gas network codes and related guidelines are therefore crucial.

RECOMMENDATIONS

The government of Luxembourg should:

- ☐ *Clarify the role of natural gas as a transition fuel in the transport, industry, co-generation and shipping sectors in line with long-term decarbonisation goals, in particular with a view to the need for the expansion of the distribution networks.*

- *Focus on resolving the lack of firm capacities and on harmonising the capacity calculations on the borders to Belgium and Germany. Strengthen the resilience and security of gas supply by studying various options to increase entry capacity either by building new interconnections or merging the gas market areas with neighbouring markets.*
- *Work closely at regional level to foster market integration and security of gas supply. Ensure the diversification of supply routes and sources, and competitive prices as well as backup supplies to gas customers.*

References

ACER (2013), *Annual Report on the Results of Monitoring the Internal Electricity and Natural Gas Markets in 2012*, *ACER/CEER,* November.

Institut Luxembourgeois de Régulation (ILR) (2013), *National Report 2012*, Luxembourg, September.

Ministry of the Economy (2012), *Preventive Action Plan, Emergency Plan for Security of Supply of Natural Gas*, Luxembourg, 11 December.

8. RENEWABLE ENERGY

Key data (2013 estimated)

Share of renewable energy: 4.5% of TPES and 22% of electricity generation (IEA average: 9% of TPES and 21.7% of electricity generation)

Biofuels and waste: 3.9% of TPES and 8.3% of electricity generation

Hydro: 0.3% of TPES and 6.4% of electricity generation

Wind: 0.2% of TPES and 4.5% of electricity generation

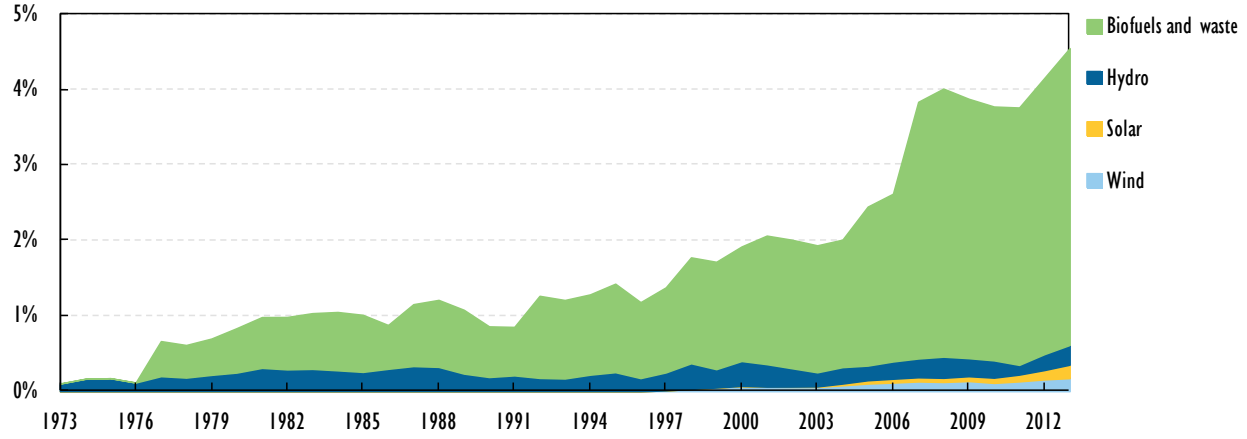
Solar: 0.2% of TPES and 2.8% of electricity generation

RENEWABLE ENERGY SUPPLY

Renewable energy represented 4.5% of total primary energy supply (TPES) in Luxembourg in 2013 and 2.8% in gross final consumption in 2011. This is made up primarily of biofuels and waste (3.9% of TPES). The remainder is from hydro, wind and solar power, all of which play a small role in the country's energy mix. Luxembourg has the third-lowest share of renewable energy in TPES among IEA member countries (Figure 8.2).

Over the past decade since 2003, renewable energy in Luxembourg has experienced a boom, as production of biofuels and waste increased by 142.1% and wind power by 218.2%.

Figure 8.1 Renewable energy as a percentage of TPES, 1973-2013



Note: estimated for 2013.

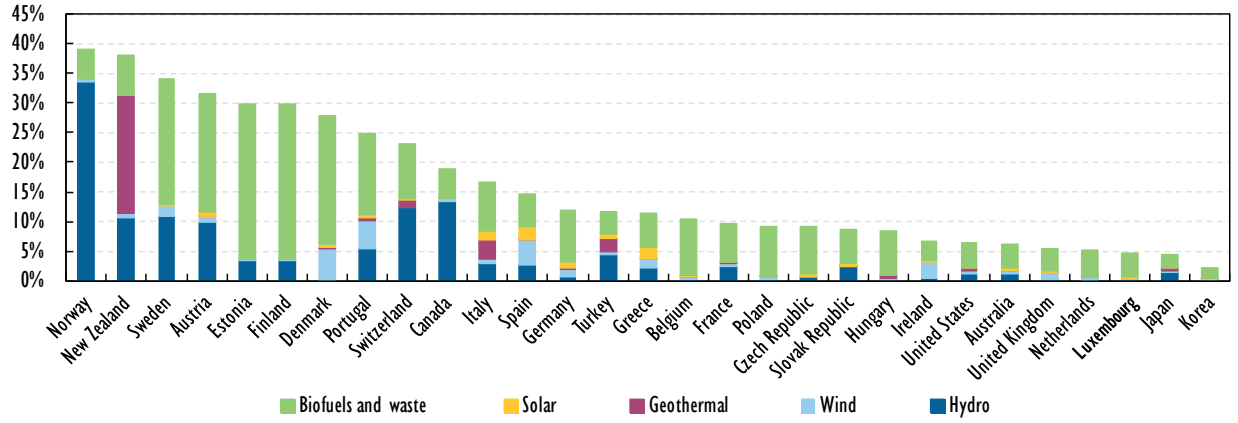
Source: IEA (2013), *Energy Balances of OECD Countries 2013*, OECD/IEA, Paris.

Wind power was first introduced in 1998, while the deployment of solar energy installations began in 2000. Both wind and solar power are still in the early stages of development. Installed capacity of wind power has increased nearly tenfold to 58 megawatts (MW) in

2013, starting from 6 MW in 1997 (EWEA, 2013). In October 2012, a new wind farm of 11.5 MW was inaugurated in Binsfeld, in the north of Luxembourg, which is to make up 10% of the planned wind power generation under the national action plan.

Total hydropower capacity stood at 1.13 gigawatts (GW) in 2012, if to include the 1.1 GW capacity of the Vianden pumped-storage hydro plant and some smaller capacity of other hydropower plants (see Chapter 5 for an overview on installed power generation capacity).

Figure 8.2 Renewable energy as a percentage of TPES in IEA member countries, 2013



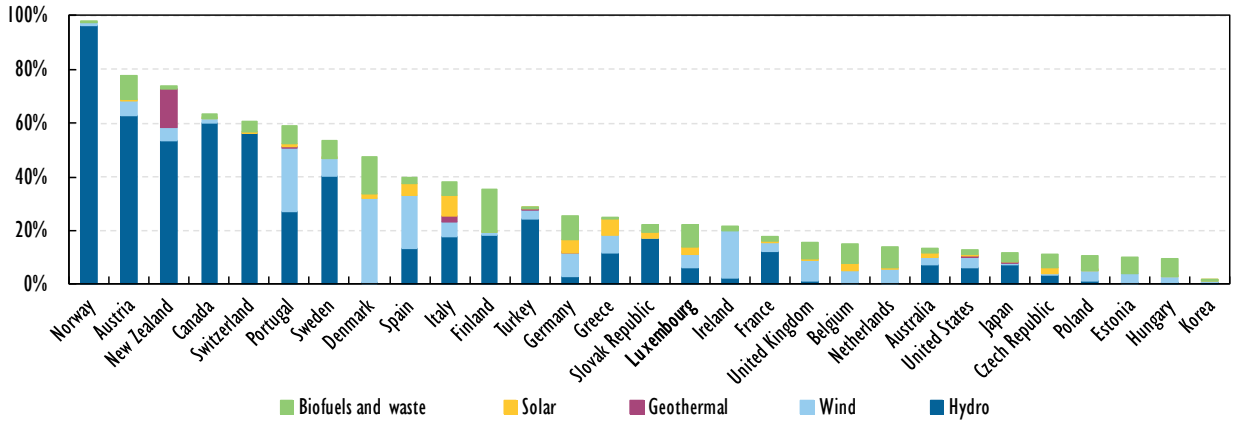
Note: estimated data.

Source: IEA (2013), *Energy Balances of OECD Countries 2013*, OECD/IEA, Paris.

ELECTRICITY GENERATION

Electricity generation from renewable sources was 399 gigawatt hours (GWh) in 2013, or 22% of total generation. This is made up of biofuels and waste (8.3%), hydro (6.4%), wind (4.5%) and solar (2.8%). Hydro power generation excludes pumped storage and therefore output from the Vianden hydro power station excluding pumped storage was 117 MWh.

Figure 8.3 Electricity generation from renewable sources as a percentage of the electricity mix in IEA member countries, 2013



Note: estimated data.

Source: IEA (2013), *Energy Balances of OECD Countries 2013*, OECD/IEA, Paris.

Electricity generation from renewables has boomed over the past decade. Production of electricity from biofuels and waste has increased by 138.1%, and wind by 211.5% since 2003. Electricity from solar power has increased 50 times since its introduction in 2000. Consequently, the share of electricity from renewable sources has increased from 6.1% in 2003 to 22% in 2013.

Luxembourg ranks mid-range among IEA member countries with regard to the 22% share of renewable energy in electricity generation. The IEA average is 21.7%.

INSTITUTIONS

The **Ministry of the Economy** has the overall responsibility for the energy policy, including renewable energy. It supports research policy in the renewable energy sector and the use of renewables in the industrial sector.

The **Ministry of Sustainable Development and Infrastructure** is responsible for climate and environmental policies and for the administration of the investment aid policy concerning renewable energy in the residential and municipal sectors. Independently of the government policy, different municipalities are granting subsidies for the renewable energies.

Myenergy, a common agency of the Ministry of the Economy, the Ministry of Sustainable Development and Infrastructure and the Ministry of Housing, manages the promotion of the use of renewable energy sources. Myenergy is tasked to support the uptake of renewable energies and to identify and remove existing barriers in respect to the development of renewable energies.

The **Luxembourg regulatory authority** (Institut Luxembourgeois de Régulation [ILR]) is in charge of the management of the feed-in tariff compensation mechanism with regard to the distribution of the costs among final electricity customers.

POLICIES AND SUPPORT MEASURES

LEGAL FRAMEWORK AND TARGETS

As a member state of the European Union, Luxembourg's policy on renewable energy is guided by the legal framework for renewable energy under the EU Renewable Energy Directive 2009/28/EC. The directive requires each EU member state to increase the share of renewable energy in its final energy consumption, in order to achieve an EU-wide 20% renewable energy share by 2020. Luxembourg agreed to achieve a share of renewable energies of 11% in its gross final energy consumption as well as reach a target of 10% in final energy consumption in the transport sector.

In the first National Renewable Energy Action Plan (NREAP) of July 2010, the indicative trajectory and 37 measures needed to achieve the national targets are specified (Ministry of the Economy, 2010). Besides the promotion of renewable energy in the production of electricity, heating and cooling and the use of heat pumps, the focus lies on the promotion of biofuels, the development of electro-mobility (public and private) as well as on making use of co-operation mechanisms, notably through joint projects and statistical transfers between EU member states and – if possible – with third countries. While

negotiations are still ongoing with those EU countries which are likely to account for a surplus in 2020, no final results have been achieved so far.

During the period 2010-20, Luxembourg aims to achieve the following interim targets for the overall share of renewable energies in gross final consumption:

- average 2011-12: 2.92%
- average 2013-14: 3.93%
- average 2015-16: 5.45%
- average 2017-18: 7.47%.

Evaluating progress of EU member states towards the 2020 targets, the European Environment Agency (EEA) notes that Luxembourg is in line with its interim renewable energy targets set out under both the NREAP and the Directive for 2011-12 (for EU-wide comparison see Figure 8.4) (European Environment Agency, 2013). The latest available data confirm the constant increase in the share of renewable energies, well beyond expected trajectories. In line with the calculation method of Directive 2009/28/EC, the part of renewable heat in total heat consumption raised from 4.82% in 2008 to 4.94% in 2011 and renewable electricity increased from 3.6% to 4.10% in the same period. In the transport sector, the part of compliant renewable fuels grew from 0.07% in 2008 to 1.96% in 2011. The overall share of renewables in total final consumption stood at 2.84% in 2011 against 1.79% in 2008.

In Luxembourg, the legal framework is set out in the Electricity Market Law of August 2007, which regulates grid connection, access, role of the grid operator and the compensation mechanisms.

There is no priority access to the grid guaranteed, but the grid operator has to consider electricity produced from renewables first. Access to the grid is guided in line with non-discrimination, and no rules are in place for the curtailment or integration of renewable energy. Anyway, producers of renewable electricity are granted a so-called “guaranteed” access to the grid, except in cases of endangering grid security, for example. The grid operator is obliged to purchase electricity produced from renewable energy sources and enters a contract with renewable generators for the defined price, in line with the model contract and the compensation approved by the regulatory authority of Luxembourg. Net costs of supporting renewable energies are borne by final energy consumers and/or by the Climate and Energy Fund.

SUPPORT SCHEMES FOR RENEWABLE ENERGIES

Luxembourg has put forward indicative targets for the use of individual renewable energies. With a large increase projected in wind power and, notably, biogas and solid biomass, Luxembourg aims to meet its target of 11% by a 4% contribution from electricity, heating and cooling, a 5% contribution from biofuels and electro-mobility and with about 2% through co-operation mechanisms. The lion’s share is to come from biofuels, mainly biodiesel, and electro-mobility, which means a 110% increase of the 2005 shares. In terms of targets for renewable energy sources in heating and cooling, the focus on solid biomass and biogas is even more pronounced and complemented by increased use of heat pumps and solar thermal installations.

National law stipulates a mandatory blending of biofuels into fossil fuels used in the transport sector. The minimum share of blending was increased to 3.75% in 2013 against 2% in 2012.

The financial support of renewable energies includes a feed-in tariff scheme, four investment subsidy programmes (aiming private customers, small and medium-sized enterprises, industries and municipalities), tax incentives and a quota system for the transport sector. Investment grants are available for projects in wind, solar and hydropower, biomass, biogas and geothermal energies.[1] Total annual costs of the subsidy scheme amounted to EUR 12.9 million in 2012 and about EUR 19.5 million for 2013. Total annual costs of the feed-in tariffs from the compensation mechanism are shown in Table 8.1.

In 2014, the feed-in regulation is being adapted in order to take into account market evolutions under approval by the European Commission.

Table 8.1 Total cost of the feed-in tariff compensation mechanism (EUR)

Technology	2008	2009	2010	2011
Biogas from sewage stations	220 530	179 250	171 751	129 414
Hydropower	173 168	61 360	149 879	160 650
Wind power	1 261 395	926 104	921 225	1 355 276
Biogas	1 361 443	2 667 291	2 758 316	3 194 033
Solar PV	1 073 933	1 279 605	1 865 327	3 804 439
Co-generation	18 004 282	16 436 144	19 411 950	21 348 960
Heat bonus	0	0	268 261	307 574
Total	**22 094 752**	**21 549 755**	**25 546 709**	**30 300 346**

Source: Ministry of the Economy, Luxembourg, 2013.

ELECTRICITY

Renewable electricity generation is promoted through a technology-specific feed-in tariff scheme based on the framework and tariff levels set out in regulation *"Règlement grand-ducal modifié du 8 février 2008 relatif à la production d'électricité basée sur les sources d'énergie renouvelables".* Feed-in tariffs are granted for a period of 15 years for installations using hydropower, wind, biogas, sewage gas, solar photovoltaic (PV) and biomass. Combined heat and power (CHP) production plants using renewables can obtain a heat bonus in addition. Geothermal electricity production is not supported under the feed-in tariff.

A new regulation is at present in the legal procedure in order to adapt the feed-in tariffs. The new proposal will increase the feed-in tariffs for hydropower, wind, biogas and biomass by a range of 11% to 31%. The feed-in tariff for new PV installations will decrease by 9%. Under the Grand-Ducal Regulation *Régime d'aides pour la promotion de l'utilisation rationnelle de l'énergie et la mise en valeur des énergies renouvelables* (hereinafter: the Aid Scheme), investment subsidies are available for private PV installations with a maximum capacity of up to 30 kilowatt peak (kWp) for investments made between 1 January 2013 and 31 December 2016. Micro-CHP is no longer supported and was abolished on 1 January 2013.

1. Legal sources on renewable energies, online transparency platform, www.res-legal.eu/search-by-country/luxembourg/.

Companies are eligible for investment grants of up to 45% of the additional costs arising from the use of renewable energy sources for electricity generation (wind, solar, geothermal, biomass, hydro, biogas) under the Law of 18 February 2010 on investment aid for companies with regard to environmental protection and the rational use of natural resources. The grant may increase by 20 percentage points for small enterprises and by 10 percentage points for medium-sized enterprises.

There are capital grants (maximum 40% of total investment cost) or reduced interest rates for renewable electricity generation projects under the *Régime d'aide en faveur des classes moyennes*. Since its establishment in 1999, the Luxembourg *Fonds pour la protection de l´environnement* has been supporting solar energy projects of the Luxembourg municipalities. The fund is jointly managed by the Ministry of the Interior, the Ministry of Sustainable Development and Infrastructure and the Ministry of Finance. Private electricity production in small solar installations (with a capacity from 1 kW to 4 kW) can be exempted from income tax.

HEAT

Renewable heat is promoted by the feed-in tariff regulation which defines a heat bonus for plants complying with a number of criteria. Renewable heat-producing plants can also receive investment subsidies under the different schemes presented above. The production of heat or CHP production is supported under the *Régime d'aide en faveur des classes moyennes*. Other companies are also eligible for investment subsidies for the production of heat or CHP under the Law of 18 February 2010 on investment aid for companies with regard to environmental protection and the rational use of natural resources. The fund for municipalities supports biogas, biomass and solar thermal technologies. For private customers, an investment subsidy scheme exists in order to promote renewable heat technologies in households, e.g. for biomass and solar thermal energy.

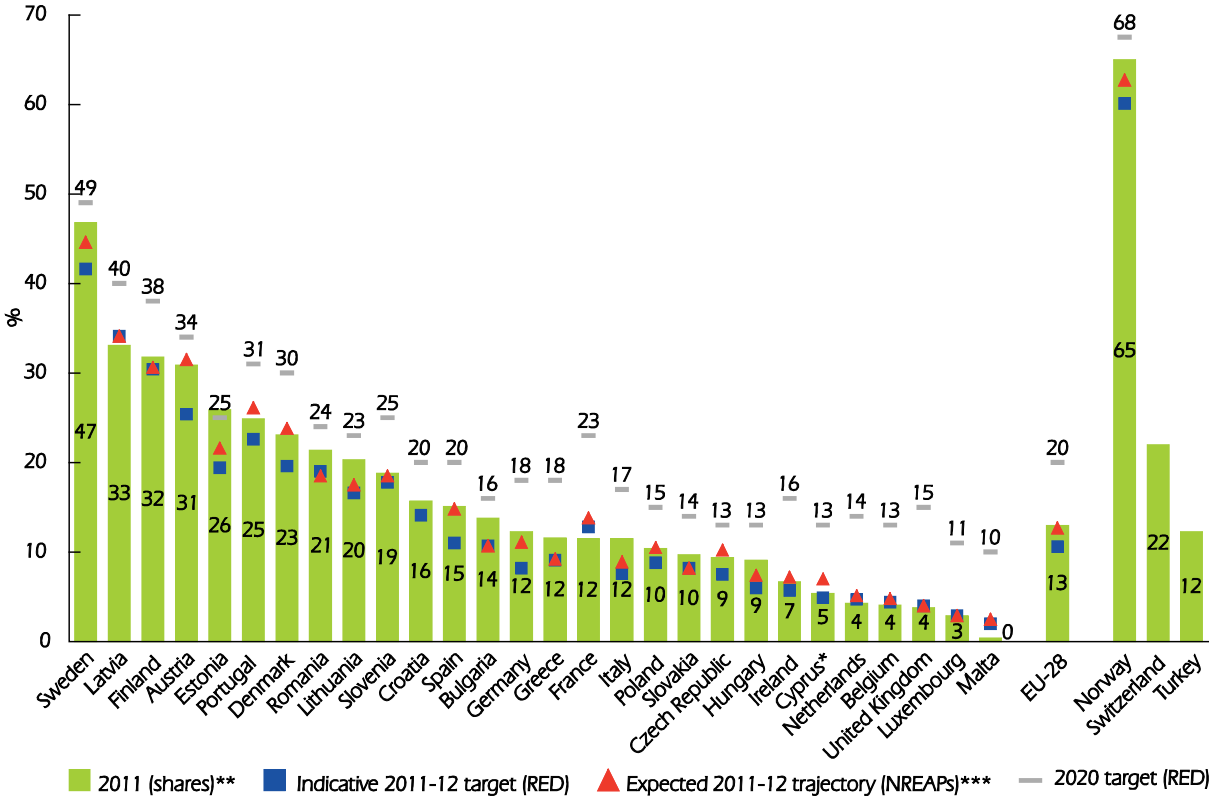
TRANSPORT

Since 2013, Luxembourg sets a blending requirement which obliges companies importing or producing petrol, gas or diesel fuels to ensure that biofuels (bioethanol/biodiesel) make up 3.75% of the company's total annual fuel sales. In Luxembourg, this can only be met with imported biofuels. The percentage will have to be raised further in the coming years in order to fulfil the country's renewable energy target by 2020, which also depends on the possible sustainability criteria under discussion in the European Union.

In order to boost e-mobility in the coming years, Luxembourg plans to reach a total of 40 000 electric vehicles by 2020. Grid operators are currently planning a national public infrastructure of charging points as they have the legal obligation under the Law of August 2012 (*Loi relative à l'organisation du marché de l'électricité en rapport avec l'électromobilité au Luxembourg*).

Luxembourg has been able to increase the feed-in of biogas into the natural gas network under the *Règlement grand-ducal instaurant un mécanisme de soutien aux installations de production de biogaz injectant du biogaz dans les réseaux de gaz naturel à Luxembourg* (December 2011).

Figure 8.4 Progress towards 2020 renewable energy targets in the European Union



* 1. Footnote by Turkey: The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of United Nations, Turkey shall preserve its position concerning the "Cyprus issue".
2. Footnote by all the European Union Member States of the OECD and the European Commission: The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

** Values for Norway and Switzerland are shares for 2010.

*** Value for EU-28 assumed to be identical to that for EU-27.

Source: European Energy Agency, 2013.

There has also been good experience with promoting renewable energies in buildings under the *Règlement grand-ducal concernant la performance énergétique des bâtiments d'habitation* (May 2012). A new law has been proposed to improve the energy performance in buildings by using renewable energies (*Projet de règlement grand-ducal concernant la performance énergétique des bâtiments fonctionnels,* 2013), coupling the use of renewables to the energy performance certificate in buildings, as put in place by the European Energy Performance in Buildings Directive. The directive has been implemented in early 2013 with a progressive reinforcement of the energy performance requirements in new residential buildings.

Table 8.2 Support schemes for electricity generation from renewable sources

Technology	Capacity	Maximum investment subsidy, % of eligible cost	Feed-in tariff* (EUR/MWh)
Wind power	unlimited	20-25	82.7
Solar PV	0-30 kW 31-1 000 kW	30 30	420 370
Hydropower	0-1 MW 1-6 MW	20 20	105 80
Biogas	0-150 kW 151-300 kW 301-500 kW 501-2 500 kW	50 50 50 50	150 140 130 120
Solid biomass	0-1 MW 1-5 MW	20 20	145 125
Waste wood	0-1 MW 1-5 MW	20 20	130 110
Sludge and landfill gas	unlimited	90	65

* Tariffs in 2008.

Source: Ministry of the Economy, Luxembourg, 2008.

ASSESSMENT

Renewable energies are in an early stage of development in Luxembourg with a 4.5% share in TPES, 2.8% in gross final consumption (in 2011) and 22% in electricity generation. Progress is being made thanks to additions from mainly biofuels, waste and wind power based on the feed-in tariff scheme. Biofuels and waste are key sources of electricity generation with 8.3%, followed by wind (4.5%) and solar PV (2.8%).

Luxembourg is developing its potential in line with its projected trajectory and is on track to meet its 2020 target of an 11% share in final consumption. However, population density, the size of the country, nature protection and the topography frame the potential contribution from renewable energy. While the country intends to use co-operation mechanisms with other EU countries, Luxembourg is nonetheless well placed to seize opportunities from developing its potential of renewables to improve air quality, mitigate emissions in the residential sector and pursue integrated industrial applications and R&D activities linked to renewable energy technologies.

In general the Grand Duchy is considered to have good wind, biomass and solar PV potential. The latest assessment of the potential uses of renewable energy sources and strategies towards their more efficient use dates back to the 1990s and 2007 (LUXRES, 2007). On the basis of the NREAP, it would be timely for the government to update the assessment and continuously monitor the development of the potentials with a view to identify possible barriers of individual technologies, notably with regard to wind power.

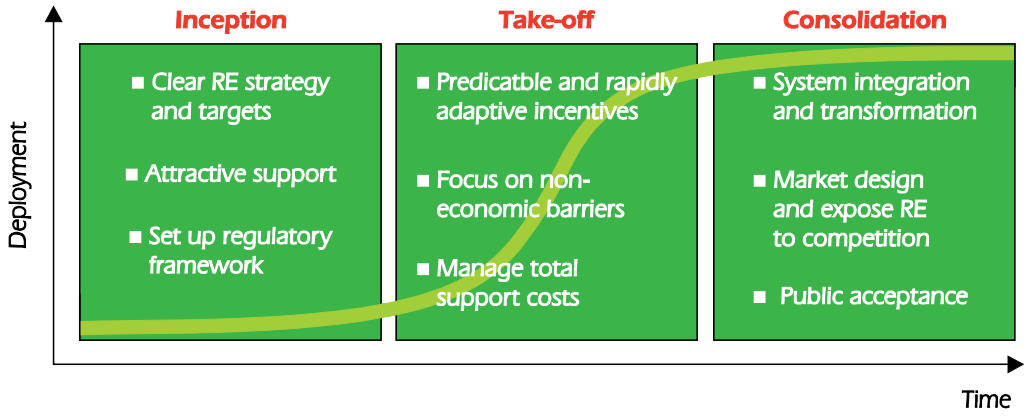
The renewable energy policy of the country is driven by its national target under the EU Directive 2009/28/EC and the indicative trajectory for the development of renewable energies set out in the NREAP. The increase in renewable energies up to 11% by 2020 implies multiplying the current production by 12 compared to 2005. In terms of electro-mobility and biofuels, this target implies multiplying the contribution by 110 by 2020 (2 630 GWh) compared to 2005 (24 GWh).

Luxembourg successfully designed the regulatory framework and support scheme to drive renewable energy investments during the inception period. Luxembourg uses feed-in tariffs for fostering the use of national renewable energy sources. In 2012, the government reduced the support for solar PV electricity to take into account the latest market conditions for this energy source. The integration of renewable energies in the buildings sector has to be commended and should serve as a starting point for further integrating renewable energy and energy efficiency solutions.

Renewables policies should focus on the different needs for different technologies. With the take-off of renewables, the government is advised to focus on identifying and lifting non-economic barriers and managing the total cost of support by continuously adapting the schemes in line with market developments. Luxembourg has yet to address the non-economic barriers. Today, the support regime places the cost of grid connection and grid reinforcement fully on the renewable electricity generator. When integrating higher shares of renewables it can be desirable to develop a transparent and comprehensive grid connection system through transmission and distribution operators on the basis of locational signals to encourage efficient investment in renewable energy sources at adequate locations.

Today, renewables projects can benefit from a large number of investment grants under different schemes. While it is commendable to have technology-specific grants, it is important to assess the interplay of feed-in tariffs and investment grants, notably with a view to reduce grants as technologies become market-ready. The government can improve policy design by reviewing the available schemes, screen their uptake and evaluate their costs and benefits. Beyond the feed-in tariff system and investment grants, Luxembourg should use opportunities to introduce cost-effectiveness and market-based approaches, notably to foster the integration of renewable electricity production, like in Sweden or the Netherlands, and explore opportunities to integrate renewables in market dispatch and balancing as well as in intraday markets, together with its neighbouring markets, Germany or the Netherlands. This will strengthen the efficiency of system integration and mitigate the cost.

Figure 8.5 Evidence-based renewable energy policies



Source: IEA Developing Renewable Energies, Paris, 2011.

In addition to these national efforts, the government should explore all cost-effective options for investment in renewable energy projects across the European Union. The government should continue engaging in finding co-operation partners for possible statistical transfers and joint projects towards 2020, as more member states will have an overview on their target achievement and possible surpluses.

Under the new 2030 energy and climate framework, it will be timely for Luxembourg to assess the impact and opportunities from an EU-wide renewable target, in line with upcoming discussions at the forthcoming October 2014 European Council.

RECOMMENDATIONS

The government of Luxembourg should:

- *Update the assessment of renewable energy potentials and set out a national mapping for wind power installations with a view to support spatial planning, to increase transparency on wind energy potentials and to identify the barriers and associated costs and benefits of local energy production.*
- *Investigate cost-effective ways to develop domestic renewable energy sources, by regularly evaluating the support schemes, feed-in tariffs and investment grants, and by implementing evidence-based policies to stimulate the market and grid integration of renewable energies.*
- *Continue engaging in talks on statistical transfers and joint projects in the framework of the Pentalateral Forum, the North Sea Offshore Grid Initiative and at the wider EU level.*
- *Investigate further ways to combine energy efficiency and the use of renewable energy sources, notably in the domain of sustainable buildings. The criterion of cost effectiveness should be the basis for defining the choice between all available energy solutions.*

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9. ENERGY TECHNOLOGY RESEARCH, DEVELOPMENT, DEMONSTRATION AND DEPLOYMENT

Key data (2012)

Government energy R&D spending: EUR 71.4 million

Share in GDP: 2.1 per 1 000 units of GDP (IEA median:* 0.37)

Share in GDP (2011): 0.8 per 1 000 units of GDP (IEA median: 0.41)

R&D per capita: EUR 134.8

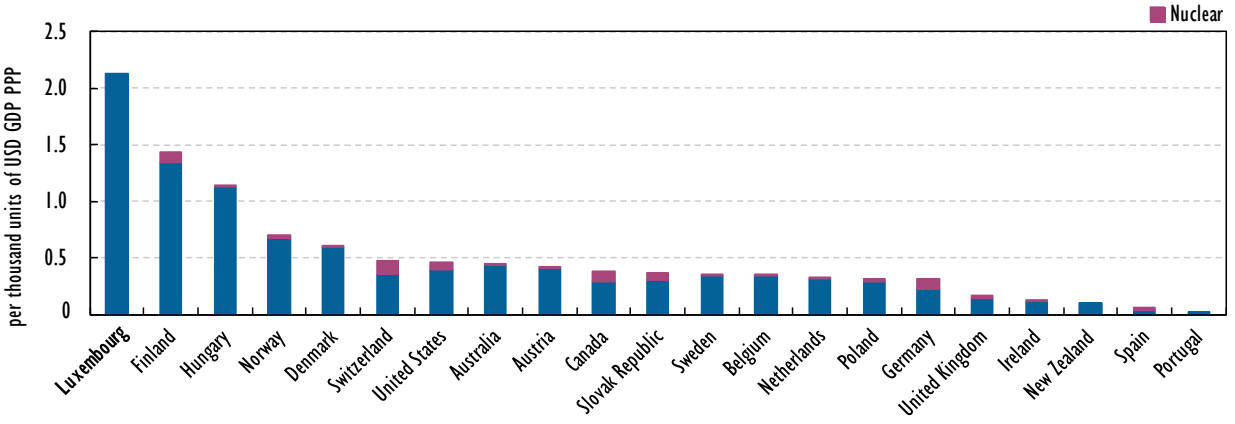
* Median of 21 IEA members

OVERVIEW

Public investment in energy research, development and demonstration (RD&D) has been on the rise in Luxembourg and reached EUR 71.4 million in 2012, accounting for 2.1 per 1 000 units of GDP. This is an increase from 2011 levels of 0.8 per 1 000 units of GDP. The overall R&D intensity per capita in 2012 was at EUR 134.8. Under the 2020 strategy, the government has set its ambition to increase R&D intensity with a target range of 2.3% to 2.6% of R&D spending in total GDP. This is split between an interval of 1.5% – 1.9% for the private sector and an interval of 0.7% – 0.8% for the public sector.

In 2011, the government had allocated EUR 24.65 million out of EUR 79.67 million of RD&D funding to energy, a share of 31%. In 2012, energy spending almost tripled and Luxembourg ranked highest among IEA member countries with regard to the portion of GDP spent on energy RD&D. This is underpinned by the strong GDP.

Figure 9.1 Government spending on energy R&D as a ratio of GDP in IEA member countries, 2012



Notes: data not available for the Czech Republic, Estonia, France, Greece, Italy, Japan, Korea and Turkey.

Sources: country submissions.

INSTITUTIONAL FRAMEWORK

On the side of policy setting and funding, the **Ministry of the Economy** has primary responsibility for formulating energy RD&D policy through its Directorate-General of Research, Intellectual Property and Innovation. The Ministry of the Economy works closely with the **Ministry of Higher Education and Research** and the **Higher Committee for Research and Innovation**, which is responsible for general R&D policy.

There are two main implementing bodies supporting RD&D funding under the energy research programmes: the **National Research Fund** (*Fonds National de la Recherche*, [FNR]) which is a public body with scientific, financial and administrative autonomy, and Luxinnovation.

Luxinnovation is the national agency for innovation and research (since 1984), which has the status of an economic interest group (EIG). It is tasked to promote R&D and innovation in Luxembourg, inform and support innovative start-ups, companies and public research organisations, and help them at any phase of their projects. It assists and advises the government in the area of R&D and innovation, raises awareness about the various facets of R&D and innovation as widely as possible.

Luxembourg's research landscape is focusing on eco-innovation. Among the research institutes, the **Environment and Agro-biotechnologies Department of CRP Gabriel Lippmann** offers expertise on biogas, waste-water transformation and biopolymer production. The **Resource Centre for Environmental Technologies (CRTE)** conducts research in the areas of life-cycle analysis, eco-design, eco-construction and renewable energies. There are four research centres in Luxembourg active on energy and transport as well as climate change research: CRP Henri Tudor, CRP Gabriel Lippmann, the University of Luxembourg and CEPS.

ENERGY RESEARCH POLICY, PROGRAMMES AND FUNDING

Since 2008, Luxembourg has been increasing its R&D activities in the field of environment, eco-innovation and clean energy technologies. Fostering the development of a green business sector in Luxembourg is key priority of the R&D policy.

In 2009, the government approved a cleantech Action Plan and an intra-ministerial committee was created. It builds on the Logistics Action Plan of 2006 and the Health Sciences and Technologies Action Plan of 2007. In 2010, the priority areas for the cleantech Action Plan were identified on the basis of a study that evaluated possible priorities drawn from the competences existing in industrial activities by Acelor Mittal, Dupont, Delphi or Goodyear and possible synergies with the national energy policy, notably the energy efficiency plan. In 2012, these efforts cumulated in the presentation of the cleantech strategy paper (Ministry of the Economy and Foreign Trade, 2012). The Eco-Technology Action Plan provides entrepreneurs with financial support and networking opportunities. A research axis for sustainable buildings is under consideration.

Leading eco-innovation areas in Luxembourg include eco-construction and eco-materials; eco-transport and eco-logistics; sustainable management of water resources; and green nanotechnologies. Innovative materials for passive and energy-efficient housing, environmental information technology, sustainable smart mobility, and electric mobility are emerging eco-innovation areas.

The cleantech strategy focuses on two key priorities:

Innovative materials focuses on technically and functionally performing materials and materials displaying reduced environmental and sanitary impacts during their entire life cycle (economy of resources, energy, recycling, mastering of environmental and health hazards) as well as new advanced materials, bio-materials, materials in green buildings (insulating materials, steel and glass construction, timber, innovative cements) and intelligent design (cradle to cradle approach, life-cycle analysis, CO_2 footprint reduction).

The **rational use of natural resources** covers biomass (innovative gasification and combustion technologies, biomass to energy, biogas, biofuels, sewage sludge treatment), sustainable mobility, information and communication technologies for sustainable mobility, electro-mobility (vehicles and infrastructures) and energy-efficient propulsion systems, energy storage and smart grid solutions, innovative chemical and/or thermal long-term storage, smart grid solutions improving the rational use of energy as well as innovative control systems for building applications and smart homes.

STATE AID TO INNOVATION AND ENERGY

Public R&D funding has been expanded to cover environmental and energy sectors and eco-innovation. In 2009, Luxembourg introduced a new scheme for general R&D funding, revising the framework that had been in place since 1993. In 2010, a new environmental state aid programme was introduced. Before 2008, no investment project in the environmental field was granted state aid. The government seized the opportunity of the EU Seventh Framework Programme for research and technological development to adapt its R&D aid schemes over time, to broaden the competences of the research centres and improve access of small and medium-sized enterprises (SMEs) to innovation and R&D funding.

In 2009, the new Law of 5 June 2009 relating to the promotion of research, development and innovation (RD&I) enables the government to award aid for RD&I to enterprises and research organisations under the following aid schemes and measures:

- R&D projects or programmes (25% to 80% of R&D costs)
- technical feasibility studies
- protection of technical industrial property
- aid for young innovative enterprises (50% of financial needs, up to EUR 1 million)
- innovation advisory services and innovation support services
- temporary secondment of highly qualified personnel
- process and organisational innovation in services
- investment in innovation clusters and animation of innovation clusters
- *de minimis* measures.

Grants are allocated through co-financing.

Luxembourg allocates funding to promote clean technologies and sustainable development in companies under the new Law of 18 February 2010 on Investment aid for companies with regard to environmental protection and the rational use of natural resources. The state aid scheme supports private sector investment in:

- raising the compliance with environmental protection standards
- anticipatory measures to adapt to planned EU environmental standards

- energy savings
- highly efficient co-generation
- renewable energies production
- environmental studies.

In addition to state aid schemes, Luxembourg promotes the business environment with an 80% exemption of certain types of intellectual property related income.

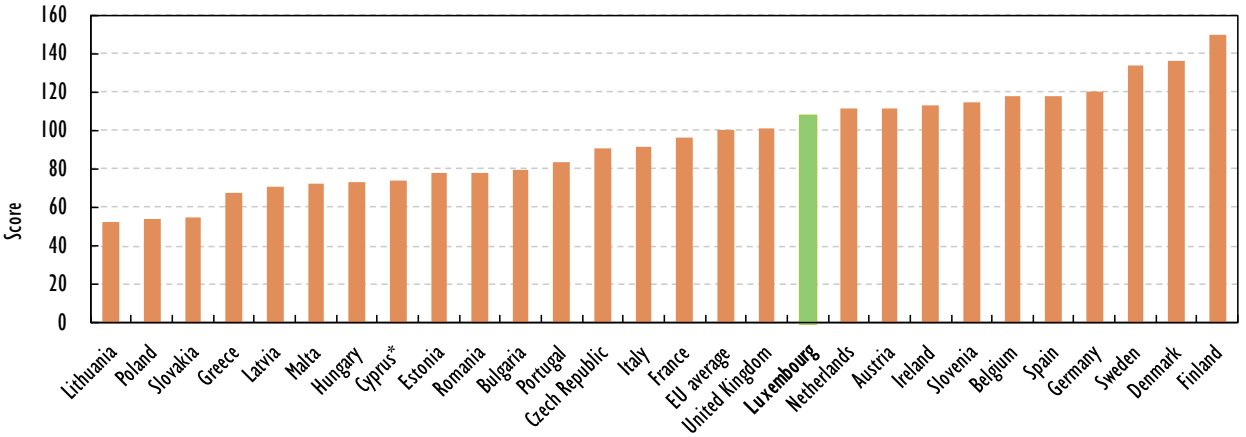
TECHNOLOGY CLUSTERS

The National Research Fund and Luxinnovation promote the development of centres of excellence and technology clusters based on public-private partnerships (BioHealth, EcoInnovation, ICT, Materials and Space) and animate the Luxembourg Cluster Initiative.

Under the Luxembourg Innovation Clusters energy-related R&D activities are focused on resource management, sustainable buildings, bioenergy and spatial/urban planning, and increasingly on clean energy technologies. With regard to energy, the EcoInnovation cluster is noteworthy as it includes eco-construction/eco-materials, renewable and alternative energies (biomass, biogas, photovoltaics), eco-design/eco-conception and the rational use of energy.

In 2011, Luxembourg ranked fourth in Europe in the EU Eco-Innovation Scoreboard (see an updated ranking in Figure 9.2 in 2012, 11th position). The scoreboard benchmarked 27 European member states on the basis of indicators in five areas: eco-innovation inputs, eco-innovation activities, eco-innovation outputs, environmental outcomes and socio-economic outcomes.

Figure 9.2 European Eco-Innovation Scoreboard, 2012



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Source: European Commission, 2012.

Overall, R&D impacts are yet to be fully evaluated and exploited. There has been no monitoring or evaluation of the current state aid programmes and the impact of funding programmes beyond project level.

FUNDING

In total (public and private), cleantech R&D investment amounted to EUR 286 million for the period 2009-11. The private sector is strong, as Luxembourg has a well-established eco-innovation sector with around 200 eco-companies in the country, working mainly in renewable energy, recycling, water management and eco-construction, and a strong export focus.

In 2011, the public RD&I spending related to clean technologies had amounted to around EUR 28 million out of a total of EUR 61 million. In 2012, it stood at EUR 71 million for energy alone. The most important spending increase was recorded for energy efficiency investment, notably for research in advanced combustion engines, including innovative diesel injection systems, in compliance with the anticipated requirements of 2020 with regard to CO_2 emissions and control.

The Delphi Customer Technology Centre based in Luxembourg traditionally develops components, sub-systems related to gasoline and diesel engine management, air-conditioning and engine-cooling systems. Innovative developments relative to vehicle power-train electrification have been added to the portfolio and are actively supported with a newly formed team out of the Luxembourg site.

In 2011, government spending on energy R&D was focused solely on energy efficiency. However, in 2012, the overall public energy R&D spending was broadened to cover a broader range of energy technologies, notably renewable energies, energy storage technologies and hydrogen, while maintaining a strong focus on energy efficiency RD&D.

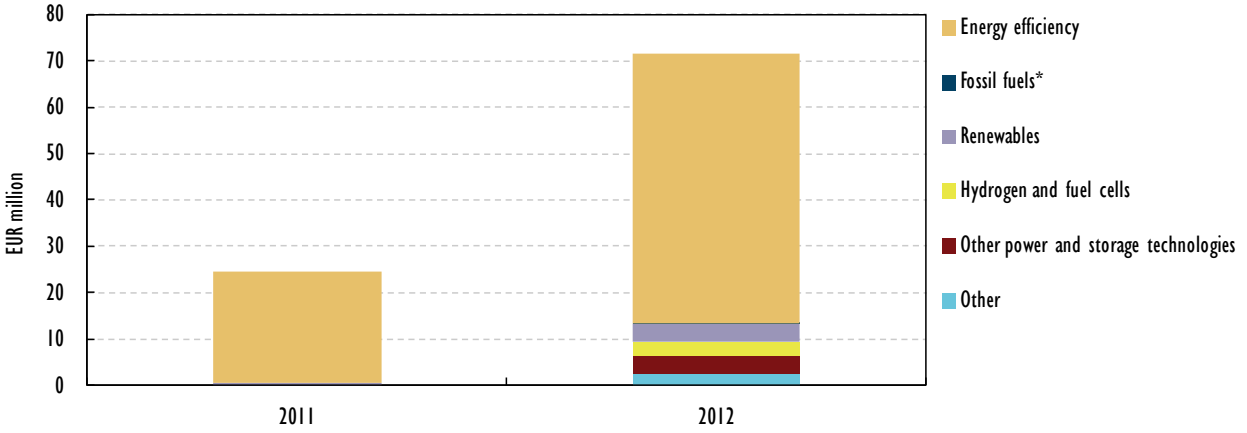
Table 9.1 Overview of total state aid schemes for the period 2008-12

State aid regimes	Number of projects	Investments/ expenditures (EUR million)	New jobs	State aid (EUR million)
State aid to SMEs (article 4 of the Law (modified) of 27 July 1993)	75	187.7	441	17.5
Regional aid (articles 2 and 10 of the Law of 15 July 2008)	25	179.9	388	18.4
R&D support (article 6 of the Law (modified) of 27 July 1993 and chapter ii of the Law of 5 June 2009)	199	446.7	708	159.6
State aid to young innovative enterprises (article 8 of the Law of 5 June 2009)	18	41.9	295.5	12.2
State aid to innovation (under articles 6, 7, 9, 10, 11, 12, 13 and chapter vii of the Law of 5 June 2009)	81	12.7	15	7
State aid to environmental protection (Laws of 22 February 2004 and 18 February 2010): Environmental projects Environmental studies	 28 11	 190.7 0.9	 34 0	 35.9 0.3
Total	**437**	**1 060.5**	**1 881.5**	**250.9**

Source: Ministry of the Economy, 2013.

With the introduction of the environmental state aid scheme, between 2010 and 2012, the number of investment projects has more than doubled (see an overview on the spending in Figure 9.3).

Figure 9.3 Government spending on energy RD&D, 2011 and 2012



* Negligible.

Source: country submission.

INTERNATIONAL COLLABORATION

Given its small size, Luxembourg research landscape does not possess a critical mass of researchers to engage in all areas of energy research. The country does not take part yet in any of the IEA implementing agreements or technology co-operation platforms.

Through Luxinnovation, the country participates in projects funded by the European networks dedicated to R&D, such as the EU Seventh Framework Programme for Research and Technological Development (FP7), the European Space Agency (ESA) and the intergovernmental initiative EUREKA or the INTER programme, and has strong bilateral co-operation with Austria, Belgium, France, Germany, Switzerland and others. The government aims to strengthen the energy research focus of universities and research institutes at national level.

ASSESSMENT

As part of the 2020 strategy, Luxembourg has the objective to allocate 2.3% to 2.6% of its GDP to overall R&D. By international comparison, this is a very high share. In 2011, Luxembourg ranked fourth in the European Eco-Innovation Scoreboard.

Since 2000, Luxembourg has been increasing the R&D intensity of the government budget and public energy R&D funding has gone up from EUR 24.65 million in 2011 to EUR 71.4 million in 2012. The IEA commends these achievements.

The energy RD&D policy developed on the basis of the June 2009 Law on Research, Development and Innovation which introduced a new programme on environmental state aid. Since the last in-depth review, Luxembourg created a framework to support innovative start-ups, SMEs and public research organisations, providing financial assistance, support for technical feasibility studies and organisational innovation, advisory services and the protection of industrial property. Commendably, Luxembourg created favourable conditions for patent registration. Project sizes are small and mainly focus on the services sector.

R&D and innovation activities are developed in close co-operation between the Ministry of the Economy, the National Research Fund, a public body with scientific, financial and administrative autonomy, and Luxinnovation, the national agency for innovation and research, and business associations.

The IEA is pleased to see that Luxembourg's R&D policy is largely consistent with its energy policy objectives. National energy policy priorities have been evolving. Boosting R&D and innovation and promoting eco-innovation technologies are priorities for the government under its clean technology strategy with the priority focus on innovative materials and rational use of natural resources, which include biomass, sustainable mobility, energy storage, smart grids and micro-generation.

With a view to the future energy strategy, the IEA recommends to evaluate the results of the overall R&D policy with regard to energy sector participation, update the priorities of technology and innovation clusters and research institutes so as to scale up activities to increase impacts of R&D outcomes in co-operation with all stakeholders. On the basis of this evaluation, the government is advised to draw up a dedicated energy innovation programme for 2020 and to concentrate and refocus efforts on key clean energy technologies.

Strong public funding needs to be underpinned by strategic planning, prioritisation, evaluation of R&D results, stronger alignment of private and public sector R&D efforts. The IEA believes that advisory boards and technology platforms for each of the priority areas, comprised of experts from industry, academia and others should support the FNR and Luxinnovation, and also Myenergy, in identifying industry needs and developing strategic research plans. This can help boost private business R&D intensity and leverage private sector investment.

Luxembourg participates in projects funded by the European networks dedicated to R&D and should explore opportunities to continue and scale up its engagement under the new Horizon 2020 and other funds. The government also intends to create a green investment bank. Given the usually small size of projects in Luxembourg, the government should also explore potentials to leverage larger projects in the buildings sector and to participate in international networks, such as ELENA (European Local ENergy Assistance), the programme of the European Investment Bank for financing sustainable energy projects at local level.

The IEA encourages the government to raise its profile at international level on targeted energy technologies areas by engaging in activities under the International Energy Agency, for instance the Committee on Energy Research and Technology (CERT) or by joining at least one of the IEA implementing agreements of strategic interest to Luxembourg, e.g. in the energy sector (e-vehicles, smart grid). Accessing EU funds for cross-border co-operation projects on transport mobility and energy efficiency could be a promising field to develop the full chain from research to demonstration and deployment in clean energy technologies.

RECOMMENDATIONS

The government of Luxembourg should:

- *Evaluate research results with a view to scale up activities and develop a dedicated Energy Research Programme in line with the business sector's priorities and strategic energy policy priorities.*

- *Further engage industries, in particular SMEs, in R&D priority setting, planning and scientific/education collaboration to accelerate deployment of new energy technologies.*
- *Increase private contributions to public R&D funding and the access to EU funds under Horizon 2020 or programme of the European Investment Bank ELENA, to ensure that energy technology innovation can drive economic growth and meet future demands for researchers and engineers. Promote cross-border co-operation within neighbouring regions on demonstration projects, in particular to foster sustainable mobility across the borders.*
- *Raise the country's profile through priority engagement on international collaboration in areas of strategic interest to the country, including with the IEA CERT and IEA implementing agreements.*

Reference

Ministry of the Economy and Foreign Trade (2012), *Strategic Background Paper – Clean/Green Technologies*, Version 2.0, Ministry of the Economy and Foreign Trade, Luxembourg, June.

PART III
ANNEXES

ANNEX A: ORGANISATION OF THE REVIEW

REVIEW CRITERIA

The Shared Goals, which were adopted by the IEA Ministers at their 4 June 1993 meeting in Paris, provide the evaluation criteria for the in-depth reviews (IDRs) conducted by the IEA. The Shared Goals are presented in Annex C.

REVIEW TEAM

The in-depth review team visited Luxembourg from 17 to 20 June 2013. The team met with government officials, energy suppliers, interest groups and various other organisations. This report was drafted on the basis of these meetings, the team's preliminary assessment of the country's energy policy, the government response to the IEA energy policy questionnaire and other information. The members of the team were:

IEA member countries

Mr. Lars Georg Jensen, Denmark (team leader)

Mr. Wolfgang Elsenbast, Switzerland

Mr. Milosz Karpinski, Poland

Ms. Rosemary Love, United Kingdom

European Commission

Mr. Marc Ringel, DG Energy

International Energy Agency

Mr. Douglas Cooke

Ms. Sylvia Elisabeth Beyer (desk officer)

The team is grateful for the co-operation and assistance of the many people it met during the visit, their kind hospitality and their willingness to discuss the challenges and opportunities that Luxembourg is currently facing.

The IEA team wishes to express its gratitude to Mr. Tom Eischen, Director-General of the Energy Division at the Ministry of the Economy, for his personal engagement in meeting and briefing the team on current energy policy issues in Luxembourg. The team also wishes to thank Mr. Emil Pantea, Mr. Marco Hoffmann and Mr. Georges Lanners for their tireless efforts and professionalism in planning and organising the review visit and for supporting the team throughout the review process.

Ms. Sylvia Beyer prepared the review and drafted all chapters of this report. Ms. Sonja Lekovic provided the analysis on the statistics and data-related sections of the report. The author is grateful for the fruitful discussions, the comments and input provided by

the review team members and IEA colleagues, including Mr. Steve Heinen, Mr. Paolo Frankl, Mr. Yuichiro Nishida, Mr. Kijune Kim and Ms. Carrie Pottinger.

Equally, the author thanks the IEA Secretariat for the support on data, publication and editing. Ms. Sonja Lekovic and Mr. Bertrand Sadin prepared the new design and supported the report with colourful figures, tables and informative maps. Ms. Roberta Quadrelli and Mr. Klaus Pedersen provided support on the IEA statistics. Ms. Muriel Custodio, Ms. Angela Gosmann and Ms. Astrid Dumond managed the publication process. Ms. Viviane Consoli, Ms. Therese Walsh and Ms. Rebecca Gaghen ensured the editorial finalisation. Ms. Catherine Smith helped in the preparations of the IEA SLT Committee and the logistics of the review visit.

ORGANISATIONS VISITED

During its visit to Luxembourg, the review team met with the following organisations:

- Ministry of the Economy
- Ministry of Sustainable Development and Infrastructure
- Myenergy
- Institut Luxembourgeois de Régulation (ILR)
- Conseil de la Concurrence
- Fonds national de la recherche (FNR)
- Société de l'électrique de l'Or (SEO)
- Soler
- LuxEnergie
- Sudgaz
- Electris
- Eida
- Creos Luxembourg s.a.
- Enovos Luxembourg s.a.
- Twinerg
- Sotel S.C.
- Business Federation Luxembourg (FEDIL)
- Groupement Pétrolier Luxembourgeois a.s.b.l. (GPL)
- Mouvement écologique
- Greenpeace

ANNEX B: ENERGY BALANCES AND KEY STATISTICAL DATA

Unit: Mtoe

SUPPLY		1973	1990	2000	2010	2011	2012	2013E
TOTAL PRODUCTION		**0.00**	**0.03**	**0.06**	**0.12**	**0.12**	**0.13**	**0.13**
Coal		-	-	-	-	-	-	-
Peat		-	-	-	-	-	-	-
Oil		-	-	-	-	-	-	-
Natural gas		-	-	-	-	-	-	-
Biofuels and waste[1]		-	0.02	0.05	0.10	0.10	0.11	0.11
Nuclear		-	-	-	-	-	-	-
Hydro		0.00	0.01	0.01	0.01	0.01	0.01	0.01
Wind		-	-	0.00	0.00	0.01	0.01	0.01
Geothermal		-	-	-	-	-	-	-
Solar		-	-	-	0.00	0.00	0.00	0.01
TOTAL NET IMPORTS[2]		**4.44**	**3.37**	**3.32**	**4.08**	**4.04**	**3.98**	**3.86**
Coal	Exports	-	-	-	-	-	-	-
	Imports	2.44	1.11	0.11	0.07	0.06	0.05	0.05
	Net imports	2.44	1.11	0.11	0.07	0.06	0.05	0.05
Oil	Exports	0.01	0.01	0.02	0.01	0.01	0.01	0.00
	Imports	1.66	1.64	2.39	2.87	2.94	2.85	2.82
	Int'l marine and aviation bunkers	-0.05	-0.13	-0.32	-0.43	-0.40	-0.37	-0.37
	Net imports	1.60	1.49	2.05	2.43	2.53	2.48	2.45
Natural Gas	Exports	-	-	-	-	-	-	-
	Imports	0.22	0.43	0.67	1.20	1.03	1.05	0.89
	Net imports	0.22	0.43	0.67	1.20	1.03	1.05	0.89
Electricity	Exports	0.07	0.06	0.06	0.28	0.22	0.23	0.16
	Imports	0.24	0.40	0.55	0.63	0.61	0.58	0.59
	Net imports	0.18	0.34	0.49	0.35	0.39	0.35	0.43
TOTAL STOCK CHANGES		**-0.01**	**-0.01**	**-0.05**	**0.02**	**0.01**	**-0.01**	**-0.01**
TOTAL SUPPLY (TPES)[3]		**4.43**	**3.39**	**3.33**	**4.22**	**4.17**	**4.09**	**3.98**
Coal		2.44	1.11	0.11	0.07	0.06	0.05	0.05
Peat		-	-	-	-	-	-	-
Oil		1.60	1.48	2.00	2.45	2.54	2.46	2.44
Natural gas		0.22	0.43	0.67	1.20	1.03	1.05	0.89
Biofuels and waste[1]		-	0.02	0.05	0.14	0.14	0.15	0.16
Nuclear		-	-	-	-	-	-	-
Hydro		0.00	0.01	0.01	0.01	0.01	0.01	0.01
Wind		-	-	0.00	0.00	0.01	0.01	0.01
Geothermal		-	-	-	-	-	-	-
Solar		-	-	-	0.00	0.00	0.00	0.01
Electricity trade[4]		0.18	0.34	0.49	0.35	0.39	0.35	0.43
Shares in TPES (%)								
Coal		*54.9*	*32.8*	*3.3*	*1.6*	*1.4*	*1.3*	*1.2*
Peat		-	-	-	-	-	-	-
Oil		*36.1*	*43.7*	*60.0*	*58.0*	*60.9*	*60.2*	*61.2*
Natural gas		*4.9*	*12.7*	*20.1*	*28.4*	*24.8*	*25.7*	*22.3*
Biofuels and waste[1]		-	*0.7*	*1.5*	*3.4*	*3.4*	*3.7*	*3.9*
Nuclear		-	-	-	-	-	-	-
Hydro		*0.1*	*0.2*	*0.3*	*0.2*	*0.1*	*0.2*	*0.3*
Wind		-	-	*0.1*	*0.1*	*0.1*	*0.2*	*0.2*
Geothermal		-	-	-	-	-	-	-
Solar		-	-	-	*0.1*	*0.1*	*0.1*	*0.2*
Electricity trade[4]		*4.0*	*10.0*	*14.7*	*8.3*	*9.2*	*8.6*	*10.7*

0 is negligible, - is nil, .. is not available, x is not applicable, E is estimated. Rounding may cause totals to differ from the sum of the elements.

Unit: Mtoe

DEMAND							
FINAL CONSUMPTION	**1973**	**1990**	**2000**	**2010**	**2011**	**2012**	**2013E**
TFC	**2.87**	**2.78**	**3.24**	**3.94**	**3.94**	**3.85**	**..**
Coal	0.98	0.52	0.11	0.07	0.06	0.05	..
Peat	-	-	-	-	-	-	..
Oil	1.46	1.48	2.00	2.45	2.54	2.46	..
Natural gas	0.18	0.42	0.60	0.68	0.60	0.61	..
Biofuels and waste[1]	-	-	0.02	0.11	0.10	0.11	..
Geothermal	-	-	-	-	-	-	..
Solar	-	-	-	0.00	0.00	0.00	..
Electricity	0.26	0.36	0.50	0.57	0.56	0.54	..
Heat	-	-	0.01	0.07	0.08	0.07	..
Shares in TFC (%)							
Coal	*34.0*	*18.9*	*3.4*	*1.7*	*1.5*	*1.4*	..
Peat	-	-	-	-	-	-	..
Oil	*50.9*	*53.2*	*61.6*	*62.1*	*64.4*	*64.0*	..
Natural gas	*6.2*	*15.1*	*18.6*	*17.1*	*15.3*	*15.9*	..
Biofuels and waste[1]	-	-	*0.7*	*2.7*	*2.6*	*2.8*	..
Geothermal	-	-	-	-	-	-	..
Solar	-	-	-	*0.0*	*0.0*	*0.0*	..
Electricity	*8.9*	*12.8*	*15.3*	*14.4*	*14.3*	*14.0*	..
Heat	-	-	*0.4*	*1.9*	*1.9*	*1.9*	..
TOTAL INDUSTRY[5]	**2.09**	**1.33**	**0.75**	**0.77**	**0.69**	**0.63**	**..**
Coal	0.94	0.52	0.11	0.07	0.06	0.05	..
Peat	-	-	-	-	-	-	..
Oil	0.80	0.29	0.08	0.04	0.04	0.04	..
Natural gas	0.14	0.28	0.28	0.29	0.27	0.27	..
Biofuels and waste[1]	-	-	0.01	0.04	0.04	0.04	..
Geothermal	-	-	-	-	-	-	..
Solar	-	-	-	-	-	-	..
Electricity	0.20	0.24	0.28	0.31	0.28	0.22	..
Heat	-	-	-	0.01	0.01	0.01	..
Shares in total industry (%)							
Coal	*45.2*	*38.9*	*14.2*	*8.6*	*8.4*	*8.4*	..
Peat	-	-	-	-	-	-	..
Oil	*38.4*	*22.0*	*11.1*	*5.5*	*5.8*	*6.8*	..
Natural gas	*6.7*	*20.9*	*36.9*	*38.0*	*39.0*	*42.1*	..
Biofuels and waste[1]	-	-	*0.8*	*5.5*	*5.7*	*5.9*	..
Geothermal	-	-	-	-	-	-	..
Solar	-	-	-	-	-	-	..
Electricity	*9.7*	*18.1*	*37.0*	*40.7*	*39.9*	*34.9*	..
Heat	-	-	-	*1.7*	*1.4*	*1.8*	..
TRANSPORT[3]	**0.23**	**0.88**	**1.61**	**2.19**	**2.32**	**2.22**	**..**
OTHER[6]	**0.55**	**0.57**	**0.88**	**0.98**	**0.92**	**1.00**	**..**
Coal	0.03	0.01	0.00	0.00	0.00	0.00	..
Peat	-	-	-	-	-	-	..
Oil	0.43	0.31	0.31	0.27	0.23	0.26	..
Natural gas	0.04	0.14	0.33	0.38	0.33	0.34	..
Biofuels and waste[1]	-	-	0.02	0.02	0.02	0.02	..
Geothermal	-	-	-	-	-	-	..
Solar	-	-	-	0.00	0.00	0.00	..
Electricity	0.05	0.11	0.21	0.25	0.27	0.31	..
Heat	-	-	0.01	0.06	0.07	0.06	..
Shares in other (%)							
Coal	*6.2*	*1.1*	*0.2*	*0.1*	*0.1*	*0.1*	..
Peat	-	-	-	-	-	-	..
Oil	*78.1*	*54.5*	*35.2*	*27.5*	*25.1*	*26.1*	..
Natural gas	*6.8*	*24.9*	*37.2*	*38.9*	*35.8*	*34.5*	..
Biofuels and waste[1]	-	-	*1.8*	*2.3*	*2.0*	*2.3*	..
Geothermal	-	-	-	-	-	-	..
Solar	-	-	-	*0.1*	*0.2*	*0.2*	..
Electricity	*8.9*	*19.5*	*24.2*	*24.9*	*29.7*	*30.7*	..
Heat	-	-	*1.5*	*6.2*	*7.1*	*6.2*	..

Unit: Mtoe

DEMAND							
ENERGY TRANSFORMATION AND LOSSES	**1973**	**1990**	**2000**	**2010**	**2011**	**2012**	**2013E**
ELECTRICITY GENERATION[7]							
Input (Mtoe)	0.44	0.19	0.11	0.57	0.48	0.50	..
Output (Mtoe)	0.12	0.05	0.04	0.28	0.23	0.24	0.16
Output (TWh)	1.39	0.62	0.42	3.23	2.65	2.75	1.82
Output Shares (%)							
Coal	*58.8*	*76.4*	-	-	-	-	-
Peat	-	-	-	-	-	-	-
Oil	*27.6*	*1.4*	-	-	-	-	*0.1*
Natural gas	*10.2*	*5.4*	*50.9*	*90.3*	*88.5*	*86.7*	*78.0*
Biofuels and waste[1]	-	*5.4*	*13.3*	*4.0*	*5.9*	*5.6*	*8.3*
Nuclear	-	-	-	-	-	-	-
Hydro	*3.4*	*11.2*	*29.4*	*3.3*	*2.2*	*3.5*	*6.4*
Wind	-	-	*6.4*	*1.7*	*2.4*	*2.7*	*4.5*
Geothermal	-	-	-	-	-	-	-
Solar	-	-	-	*0.7*	*1.0*	*1.4*	*2.8*
TOTAL LOSSES	**1.54**	**0.61**	**0.09**	**0.28**	**0.23**	**0.24**	**..**
of which:							
Electricity and heat generation[8]	0.32	0.14	0.06	0.22	0.18	0.19	..
Other transformation	1.08	0.41	-	-	-	-	..
Own use and transmission/distribution losses	0.14	0.06	0.03	0.06	0.05	0.05	..
Statistical Differences	**0.02**	**0.00**	**0.00**	**-0.00**	**0.00**	**-0.00**	**..**
INDICATORS	**1973**	**1990**	**2000**	**2010**	**2011**	**2012**	**2013P**
GDP (billion 2005 USD)	10.94	19.33	31.59	40.70	41.47	41.40	42.28
Population (millions)	0.35	0.38	0.44	0.51	0.52	0.53	0.55
TPES/GDP (toe/1000 USD)[9]	0.41	0.18	0.11	0.10	0.10	0.10	0.09
Energy production/TPES	0.00	0.01	0.02	0.03	0.03	0.03	0.03
Per capita TPES (toe/capita)	12.63	8.87	7.63	8.30	8.03	7.69	7.30
Oil supply/GDP (toe/1000 USD)[9]	0.15	0.08	0.06	0.06	0.06	0.06	0.06
TFC/GDP (toe/1000 USD)[9]	0.26	0.14	0.10	0.10	0.09	0.09	..
Per capita TFC (toe/capita)	8.18	7.27	7.42	7.75	7.58	7.24	..
Energy-related CO_2 emissions ($MtCO_2$)[10]	16.4	10.4	8.0	10.6	10.4	10.2	..
CO_2 emissions from bunkers ($MtCO_2$)[10]	0.2	0.4	1.0	1.3	1.2	1.1	..
GROWTH RATES (% per year)	**73-90**	**90-00**	**00-10**	**10-11**	**11-12**	**12-13**	**90-13**
TPES	-1.6	-0.2	2.4	-1.2	-1.9	-2.7	0.7
Coal	-4.5	-20.7	-4.8	-13.0	-7.4	-11.5	-12.8
Peat	-	-	-	-	-	-	-
Oil	-0.5	3.0	2.0	3.7	-2.9	-1.1	2.2
Natural gas	4.1	4.6	5.9	-13.7	1.8	-15.3	3.2
Biofuels and waste[1]	-	8.3	10.9	0.2	5.3	4.5	8.7
Nuclear	-	-	-	-	-	-	-
Hydro	2.4	6.0	-1.4	-46.2	66.0	21.7	2.3
Wind	-	-	7.4	17.0	18.2	7.7	-
Geothermal	-	-	-	-	-	-	-
Solar	-	-	-	28.6	36.1	40.8	-
TFC	-0.2	1.6	2.0	-0.1	-2.2	..	..
Electricity consumption	2.0	3.4	1.4	-1.1	-4.0	..	..
Energy production	12.3	8.2	6.7	-4.9	8.8	3.8	6.8
Net oil imports	-0.4	3.2	1.7	4.0	-1.9	-1.3	2.2
GDP	3.4	5.0	2.6	1.9	-0.2	2.1	3.5
TPES/GDP	-4.8	-4.9	-0.2	-3.1	-1.7	-4.7	-2.7
TFC/GDP	-3.5	-3.3	-0.6	-2.0	-2.0	..	..

Footnotes to energy balances and key statistical data

1. Biofuels and waste comprises solid biofuels, biogases, industrial waste and municipal waste. Data are often based on partial surveys and may not be comparable between countries.
2. In addition to coal, oil, natural gas and electricity, total net imports also include biofuels and trade of heat.
3. Excludes international marine bunkers and international aviation bunkers.
4. Total supply of electricity represents net trade. A negative number in the share of TPES indicates that exports are greater than imports.
5. Industry includes non-energy use.
6. Other includes residential, commercial and public services, agriculture/forestry, fishing and other non-specified.
7. Inputs to electricity generation include inputs to electricity, CHP and heat plants. Output refers only to electricity generation.
8. Losses arising in the production of electricity and heat at main activity producer utilities and autoproducers. For non-fossil fuel electricity generation, theoretical losses are shown based on plant efficiencies of 100% for hydro, wind and solar photovoltaic.
9. Toe per thousand US dollars at 2005 prices and exchange rates.
10. "Energy-related CO_2 emissions" have been estimated using the IPCC Tier I Sectoral Approach from the *Revised 1996 IPCC Guidelines*. In accordance with the IPCC methodology, emissions from international marine and aviation bunkers are not included in national totals.

ANNEX C: INTERNATIONAL ENERGY AGENCY "SHARED GOALS"

The member countries* of the International Energy Agency (IEA) seek to create conditions in which the energy sectors of their economies can make the fullest possible contribution to sustainable economic development and to the well-being of their people and of the environment. In formulating energy policies, the establishment of free and open markets is a fundamental point of departure, though energy security and environmental protection need to be given particular emphasis by governments. IEA countries recognise the significance of increasing global interdependence in energy. They therefore seek to promote the effective operation of international energy markets and encourage dialogue with all participants. In order to secure their objectives, member countries therefore aim to create a policy framework consistent with the following goals:

1. Diversity, efficiency and flexibility within the energy sector are basic conditions for longer-term energy security: the fuels used within and across sectors and the sources of those fuels should be as diverse as practicable. Non-fossil fuels, particularly nuclear and hydro power, make a substantial contribution to the energy supply diversity of IEA countries as a group.

2. Energy systems should have **the ability to respond promptly and flexibly to energy emergencies.** In some cases this requires collective mechanisms and action: IEA countries co-operate through the Agency in responding jointly to oil supply emergencies.

3. The environmentally sustainable provision and use of energy are central to the achievement of these shared goals. Decision-makers should seek to minimise the adverse environmental impacts of energy activities, just as environmental decisions should take account of the energy consequences. Government interventions should respect the Polluter Pays Principle where practicable.

4. More environmentally acceptable energy sources need to be encouraged and developed. Clean and efficient use of fossil fuels is essential. The development of economic non-fossil sources is also a priority. A number of IEA member countries wish to retain and improve the nuclear option for the future, at the highest available safety standards, because nuclear energy does not emit CO_2. Renewable sources will also have an increasingly important contribution to make.

5. Improved energy efficiency can promote both environmental protection and energy security in a cost-effective manner. There are significant opportunities for greater energy efficiency at all stages of the energy cycle from production to consumption. Strong efforts by governments and all energy users are needed to realise these opportunities.

6. Continued **research, development and market deployment of new and improved energy technologies** make a critical contribution to achieving the objectives outlined above. Energy technology policies should complement broader energy policies. International co-operation in the development and dissemination of energy technologies, including industry participation and co-operation with non-member countries, should be encouraged.

7. Undistorted energy prices enable markets to work efficiently. Energy prices should not be held artificially below the costs of supply to promote social or industrial goals. To the extent necessary and practicable, the environmental costs of energy production and use should be reflected in prices.

8. Free and open trade and a secure framework for investment contribute to efficient energy markets and energy security. Distortions to energy trade and investment should be avoided.

9. Co-operation among all energy market participants helps to improve information and understanding, and encourages the development of efficient, environmentally acceptable and flexible energy systems and markets worldwide. These are needed to help promote the investment, trade and confidence necessary to achieve global energy security and environmental objectives.

(The Shared Goals were adopted by IEA Ministers at the meeting of 4 June 1993 Paris, France.)

* Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Luxembourg, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States.

ANNEX D: GLOSSARY AND LIST OF ABBREVIATIONS

In this report, abbreviations and acronyms are substituted for a number of terms used within the International Energy Agency. While these terms generally have been written out on first mention, this glossary provides a quick and central reference for the abbreviations used.

b/d	barrels per day
bcm	billion cubic metres
CCGT	combined-cycle gas turbine
CDM	clean development mechanism (under the Kyoto Protocol)
CEPS	Central European Pipeline System
CERT	Committee on Energy Research and Technology
CHP	combined production of heat and power
CNG	Compressed natural gas
CWE	Central-West Europe
DSO	distribution system operator
EBPD	Energy Performance of Buildings Directive
EC	European Commission
EEA	European Energy Agency
EED	Energy Efficiency Directive (European Union)
EIB	European Investment Bank
EIG	economic interest group
ENTSO	European Network of Transmission System Operators
EPBD	Energy Performance of Buildings Directive (European Union)
EPC	energy performance certificate
ESA	European Space Agency
ESD	Effort Sharing Decision
EU	European Union
EU-ETS	European Union Emissions Trading Scheme
FNR	National Research Fund (*Fonds national de la Recherche*)
GDP	gross domestic product
GHG	greenhouse gas
GPL	Groupement Pétrolier Luxembourgeois
GW	gigawatt, or 1 watt x 10^9
IEA	International Energy Agency
IET	International emissions trading
ILR	Institut Luxembourgeois de Régulation (the regulator)
IPCC	Intergovernmental Panel on Climate Change
ITVC	Interim tight volume market coupling

JI	joint implementation (projects under the Kyoto Protocol)
kb	thousand barrels
kt	kilotonne
ktoe	thousand tonnes of oil-equivalent
kW	kilowatt, or 1 watt x 10^3
LPG	liquefied petroleum gas
LULUCF	land use, land-use change and forestry
mb/d	million barrels per day
mcm	million cubic metres
MDDI	Ministry of Sustainable Development and Infrastructure (*ministère du Développement durable et des Infrastructures*)
MEPS	minimum energy performance standards
Mt	million tonnes
Mtoe	million tonnes of oil-equivalent
MW	megawatt, or 1 watt x 10^6
N-1	an indicator for the security of electricity or gas supplies describing a situation where the largest infrastructure (1) is down but the system can still work
NAP	National allocation plan
NEEAP	National Energy Efficiency Action Plan
NREAP	National Renewable Energy Action Plan
NWE	North-West Europe
OPEX	Operational expenditures
PPP	purchasing power parity: the rate of currency conversion that equalises the purchasing power of different currencies, *i.e.* estimates the differences in price levels between different countries
PV	photovoltaics
R&D	Research and development
RD&D	research, development and demonstration
RD&I	research, development and innovation
SMEs	small and medium-sized enterprises
SNCI	Société Nationale de Crédit et d'Investissement
SWE	South-West Europe
TFC	total final consumption
toe	tonne of oil-equivalent
TPES	total primary energy supply
TSO	transmission system operator
TW	terawatt, or 1 watt x 10^{12}
UNFCCC	United Nations Framework Convention on Climate Change
VAT	value-added tax

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Energy Policies of IEA Countries

Luxembourg

Since 2008, Luxembourg's energy policy has focused on mitigating CO_2 emissions in transport and industry and on supporting renewable energies and energy efficiency towards 2020. Luxembourg's greenhouse gas emissions have stabilised as energy-intensive industries have scaled back their activities and the government put strong energy efficiency policies in place, notably for buildings. Since 2009, the country's research and development (R&D) policies have promoted eco-innovation and clean energy technologies. In 2012, government spending on energy R&D as a ratio of gross domestic product was the highest among IEA members. Luxembourg is creating a national platform for smart meters and electric vehicles, the first of its kind country-wide roll out.

Nonetheless, Luxembourg faces several energy challenges. Oil consumption in transport is rising because of growing road fuel sales, largely the result of tax differences to neighbouring countries. This increases Luxembourg's emissions and its oil stockholding needs. Because the country imports all of its energy needs, energy security is a priority. Luxembourg has sought to address this through greater regional integration such as merging its gas market with Belgium and increasing its electricity interconnection with France and Belgium. Yet the benefits of regional integration of wholesale energy markets have not yet translated to retail markets. Moreover, as regional electricity trade grows and neighbouring countries introduce ambitious decarbonisation policies and capacity markets, Luxembourg will need to define its priorities for an energy strategy through 2030.

This review analyses the energy policy challenges facing Luxembourg and provides recommendations for each sector. It is intended to help guide the country towards a more secure and sustainable energy future and the development of its 2030 energy strategy.

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