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Energy Union Factsheet Luxembourg

Accompanying the document

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PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL
COMMITTEE, THE COMMITTEE OF THE REGIONS AND THE EUROPEAN
INVESTMENT BANK**

Third Report on the State of the Energy Union

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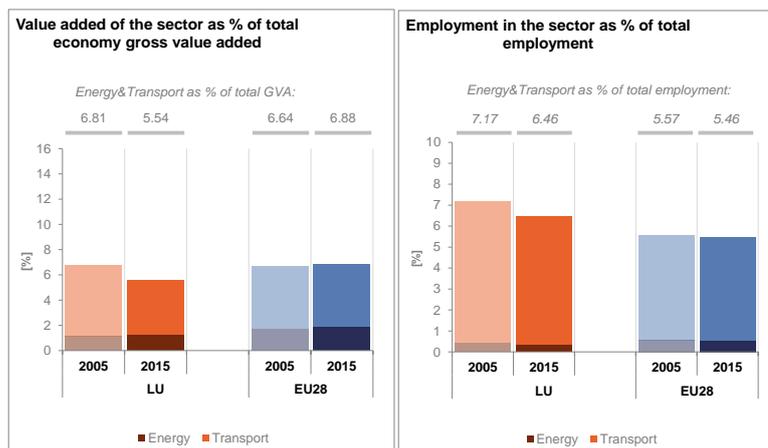
Luxembourg

Energy Union factsheet¹

1. Macro-economic implications of energy activities

Energy and transport are key sectors for the overall functioning of the economy as they provide an important input and service to the other sectors of the economy. Together the activity in these two sectors² accounted for 5.5 % of the total value added of Luxembourg in 2015. Their share in total employment³ was 6.5 % in 2015, of which 6.1 % in the transport sector and 0.4 % in the energy sector.

The decarbonisation of the energy and transport sectors will require significant investments and economic activity beyond the remit of these sectors themselves. The energy transition implies a structural shift in economic activity. Energy-related investment and jobs will in part migrate from traditional fossil fuel based activities towards construction, equipment manufacturing and other services related to the deployment of low carbon and clean energy technologies. At the moment, the efforts related to the low-carbon and clean energy transition in sectors beyond energy can only be partially quantified and are therefore not included in this analysis.



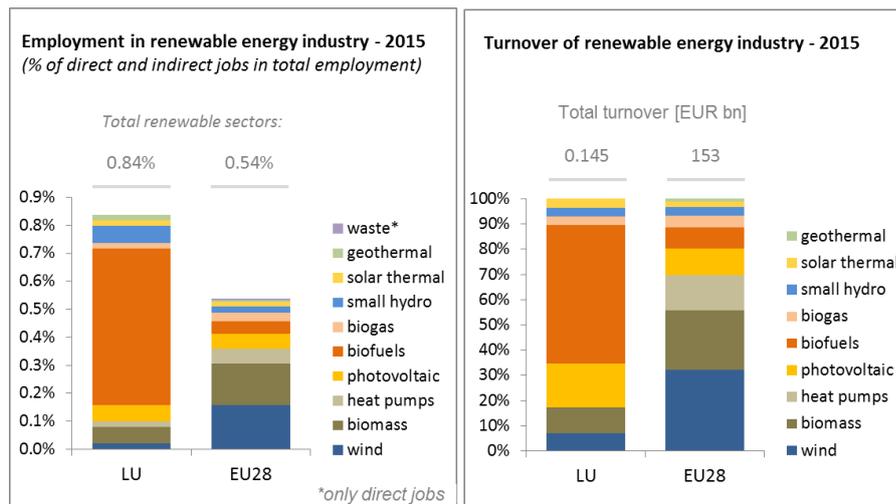
(source: Eurostat)

¹ The indicators used in this country factsheet largely build on indicators developed for the Commission Staff Working Document "Monitoring progress towards the Energy Union objectives – key indicators" (SWD(2017) 32 final) https://ec.europa.eu/commission/sites/beta-political/files/swd-energy-union-key-indicators_en.pdf

² Gross value added and employment in NACE sectors D-Electricity, gas, steam and air conditioning supply and H-Transportation and storage.

³ National accounts, Eurostat

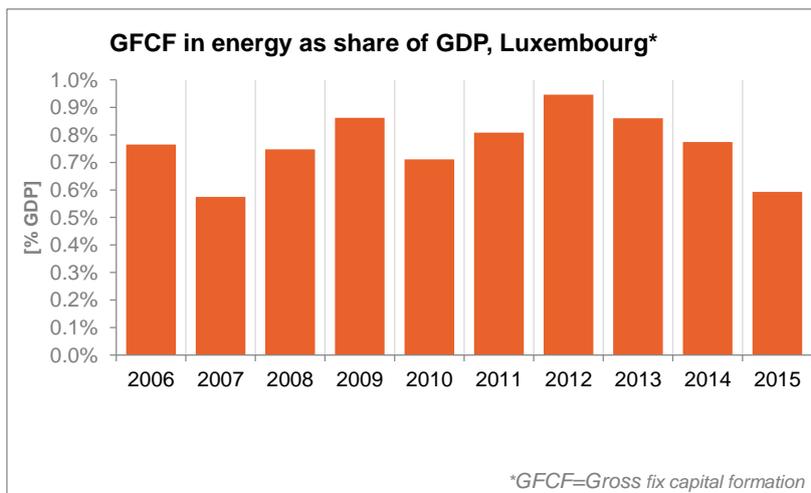
In the case of renewable energy sector, both the direct as well as the indirect effects on employment are being estimated. According to EurObserv'ER, in 2015, the share of renewable energy related employment in total employment of the economy in Luxembourg was at about 0.84 %, above the EU average of 0.54 %. The turnover of the renewable energy industry in the same year was estimated at around EUR 145 million, the biggest part being attributed to biofuels (EUR 80 million), followed by photovoltaic (EUR 25 million), biomass (EUR 15 million) and wind (EUR 10 million) industries.



(source: EC based on EurObserv'Er and Eurostat)

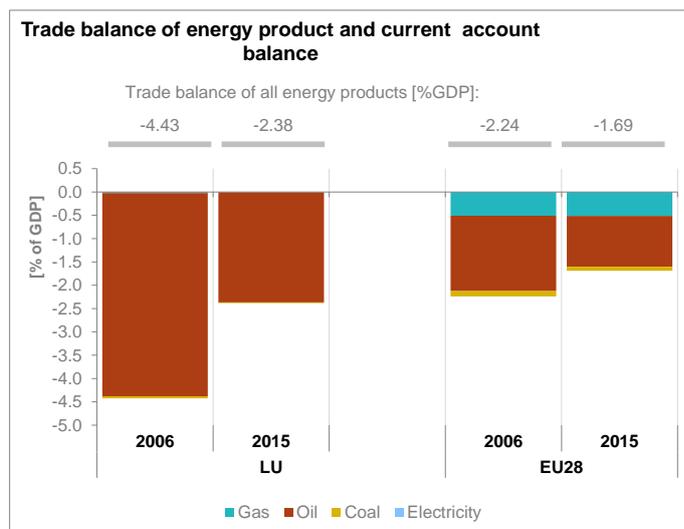
An indication of the level of efforts and challenges encountered by Luxembourg in the energy sector is given by the Gross fixed capital formation (GFCF)⁴. Investments in the electricity and gas sectors, which are taken as reference sectors, have been on a decreasing trend since 2012. They represented around 0.6 % of the country's GDP in 2015, the lowest level since 2007.

⁴ Gross fixed capital formation consists of resident producers' acquisitions, less disposals, of fixed tangible or intangible assets. This covers, in particular, machinery and equipment, vehicles, dwellings and other buildings. It also includes foreign direct investment (FDI). Steam and air conditioning supply are also included in the figures mentioned above, as Eurostat reports electricity, gas, steam and air conditioning supply together.



(source: Eurostat)

In terms of trade, Luxembourg is a net importer of fossil fuels. No data are available for electricity, where Luxembourg is also a net importer. The trade deficit in fossil fuels products has fallen from about 4.4% of GDP in 2006 to 2.4% in 2015. The decrease is almost fully accounted for by a decrease in the trade deficit of petroleum products.

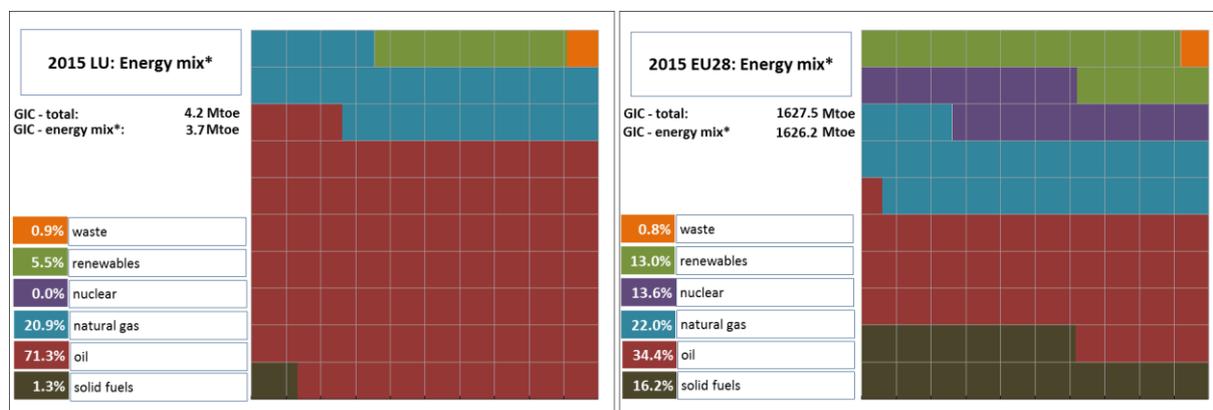


(source: Eurostat. No available data for electricity)

2. Energy security, solidarity and trust

2.1. Energy Mix

Luxembourg's energy mix differs from the average energy mix in the EU in one important respect: more than two-thirds (71.3 %) of the country's energy mix are made up by oil (petroleum products). In comparison, the EU's oil share is close to one third (34.4 %). The predominance of oil can be explained by different factors: first, there is an important number of inbound commuters. Moreover, the taxation of transport fuels is relatively advantageous, which incentivises motorists from neighbouring countries to purchase fuel in Luxembourg. In addition, Luxembourg's energy mix is notable for the absence of nuclear energy and for a lower than average share of renewable energy sources (5.5 %). The EU's average share of renewable energy sources is 13.0 % (unless specified otherwise, all figures are for 2015).



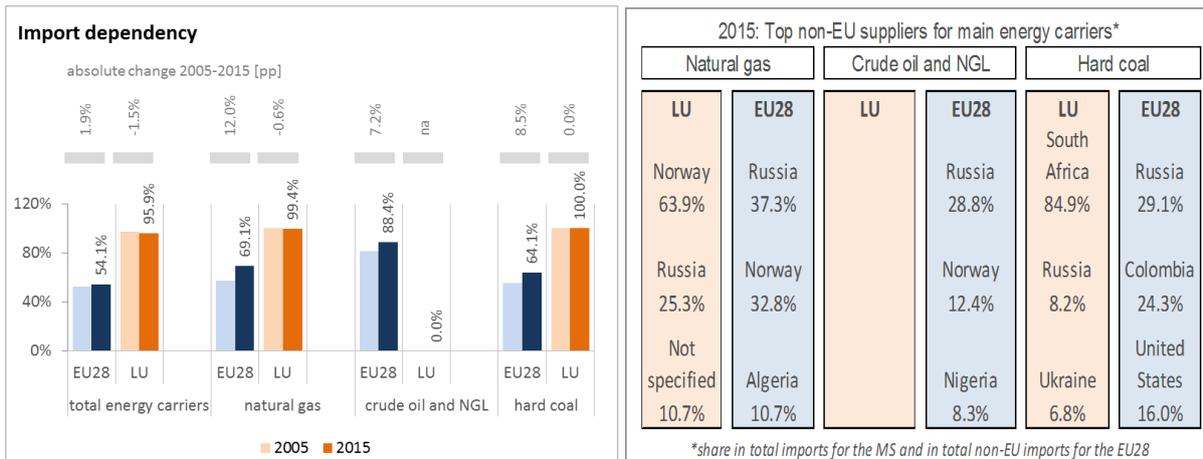
*energy mix as share share in GIC-excluding electricity and derived heat exchanges, GIC=gross inland consumption

(source: Eurostat)

2.2. Import dependency and security of supply

Luxembourg is one of the Member States with the highest energy import dependency. In 2015, the EU covered on average 54.1 % of its gross inland consumption with imported energy carriers, but for Luxembourg, the figure was nearly double (95.9 %), with only a slight improvement as compared to twelve years earlier (-1.5 percentage points). Luxembourg's import dependency can be attributed to the absence of domestic natural resources (a situation no different for many other Member States). Also, the number of adequate sites for wind and solar energy installations may be limited, given the country's relatively small size.

In 2015, Luxembourg's biggest non-EU suppliers for gas imports were Norway (63.9 %) and Russia (25.3 %). For hard coal, they were South Africa (84.9 %) and Russia (8.2 %). Luxembourg improved the diversification of hard coal imports; and presumably also for gas. However, in 2005, gas imports were reported as "not specified", so the extent of supply diversification is difficult to verify. There are no imports of crude oil, but only of refined petroleum products.



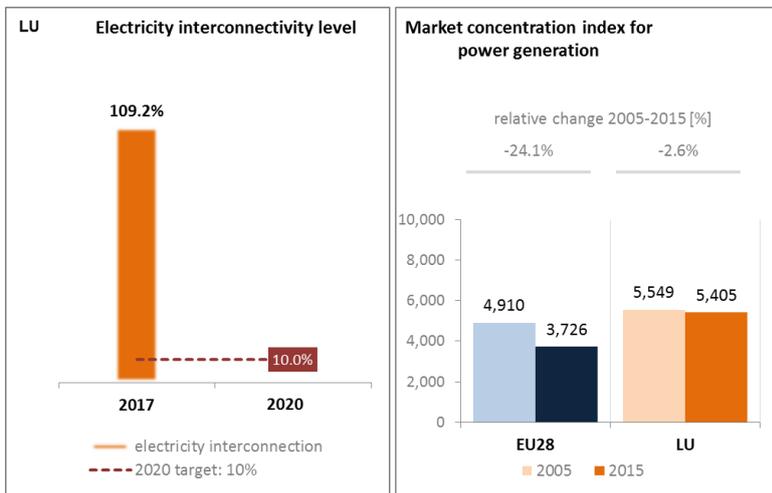
(source: Eurostat)

The EU Regulation on the security of gas supply sets the so-called "N-1 rule for gas": if the single largest gas infrastructure fails in one Member State, the capacity of the remaining infrastructure needs to be able to satisfy total gas demand during a day of exceptionally high gas demand. This condition is met if the value of the N-1 indicator is equal to or above 100 %. Luxembourg does not meet the N-1 requirement, but in fact, the country has a derogation from complying with the rule.

3. Internal market

3.1. Interconnections and wholesale market functioning

3.1.1. Electricity



(source: EC services based on ENTSOE) (source: EC services based on Eurostat)

Luxembourg's electricity grid is interconnected with Belgium, France and Germany. In fact, it is the EU Member State with the highest electricity interconnection rate. The interconnection target set at

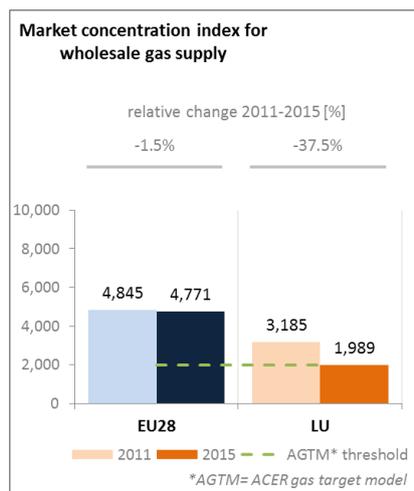
EU level is 10 %, which means that, by 2020, the electrical interconnection capacity with neighbouring Member States should equal at least 10 % of the Member State's installed production capacity. In 2017, Luxembourg's interconnection level⁵ was 109.2 %.

Luxembourg is currently involved in one electricity interconnection project with Belgium, between Aubange (in Belgium) and Bascharage / Schiffflange (in Luxembourg). This project has an expected commissioning date of 2020.

The concentration of the power generation market is above EU average; only slightly lower than ten years ago.

3.1.2. Gas

In contrast, the concentration of wholesale gas supply is below EU average and was reduced significantly in comparison with 2011 (the drop in the Luxembourg's gas market concentration index in 2011-2015 was -37.5 %, whereas for the EU, it was -1.5 %). In 2015, Luxembourg was one of only five Member States that had a concentration index below ACER's gas target model threshold indicating a well-functioning market.



(source: ACER)

3.2. Retail electricity and gas markets

3.2.1. Electricity

In 2015, according to the national regulatory authority, the leading supplier totalled almost 75 % of market shares on the retail market for household customers, as well as 58 % on the market for business customers.

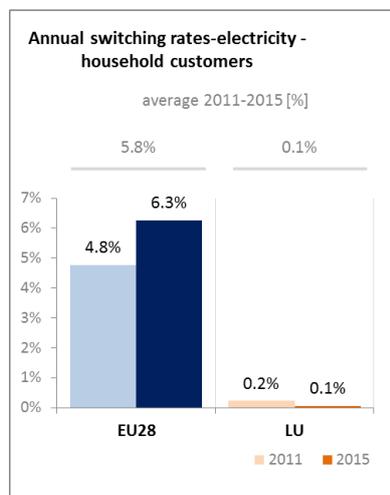
⁵ The interconnectivity level is calculated as a ratio between import interconnection and net generation capacities of the country (i.e. the 2017 value is the ratio between simultaneous import interconnection capacity [GW] and net generating capacity [GW] in the country at 11 January 2017, 19:00 pm as resulted from ENTSO-E Winter Outlook 2016/2017)

In 2016, households' electricity prices in Luxembourg were below the EU average. Between 2013 and 2016, average band retail electricity prices for households increased by 3.2 %. The energy component of electricity prices decreased between 2013 and 2015, but to a lesser extent than the wholesale prices.⁶ Retail prices in Luxembourg are non-regulated. Annual switching rates by household customers in electricity retail markets are very low.

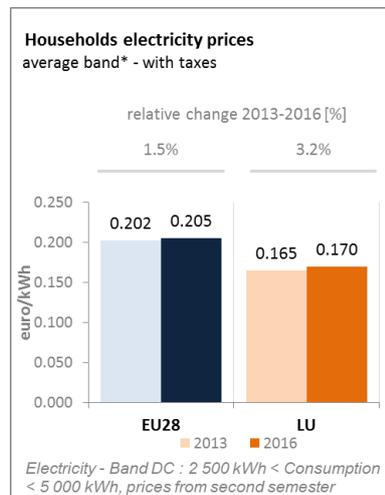
The share of taxes and levies in household electricity prices is below the EU average, but it increased substantially between 2013 and 2016. The national regulatory authority reported an increase in levies for the financing of renewable energy sources and cogeneration (*mécanisme de compensation*) and an increase in VAT.⁷

According to an analysis of electricity supplies in European capitals, the network charges in Luxembourg City constitute 39 % share of the total offer price for electricity (one of the highest in Europe). Thanks to a lower share of the energy component in the retail price, increased network charges were partially off-set.⁸

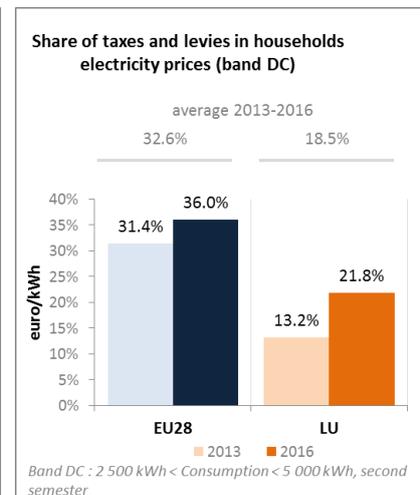
Following a positive cost-benefit analysis, Luxembourg opted for a large-scale roll-out of smart electricity metering by the end of 2019. The expected diffusion rate is set at 95 %. The roll-out is to be financed through network tariffs.⁹



(source: ACER)



(source: Eurostat)



(source: Eurostat)

3.2.2. Gas

⁶ ACER Market Monitoring Report of November 2016, p. 70, Figure 44.

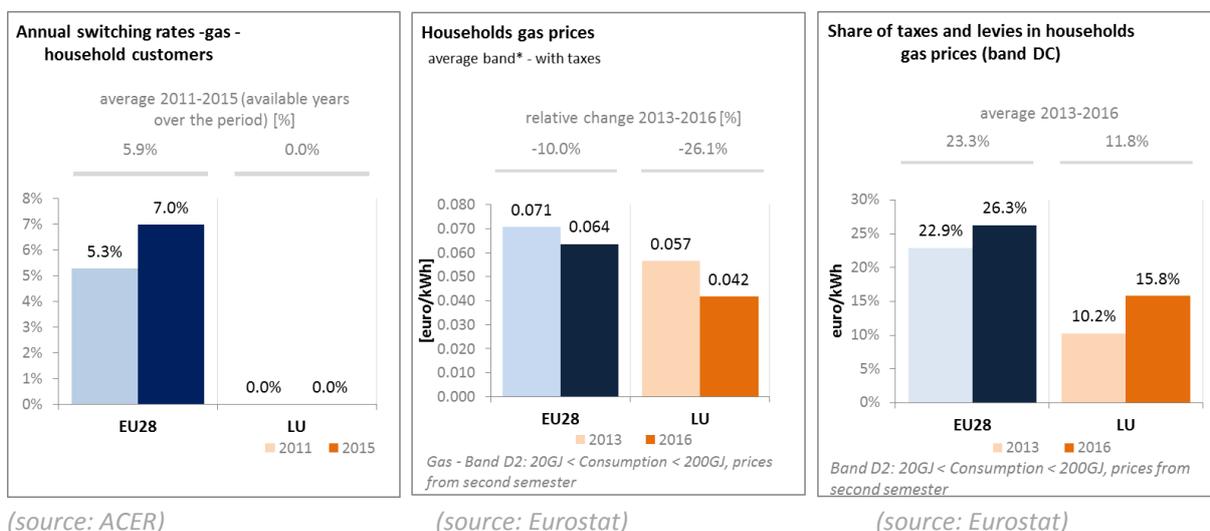
⁷ <https://assets.ilr.lu/energie/Documents/ILRLU-1685561960-288.pdf>, p. 9.

⁸ ACER Market Monitoring Report of November 2016, p.32.

⁹ Commission Staff Working Document of 17.6.2014, "Cost-benefit analyses & state of play of smart metering deployment in the EU-27", SWD(2014) 189 final.

The average band household gas prices in Luxembourg are below the EU average, and they have decreased by 26.1 % between 2016 and 2013. As in electricity markets, the annual switching rates in gas retail markets are very low. While the share of taxes and levies in household gas prices increased between 2013 and 2016, the share remains considerably below EU average.

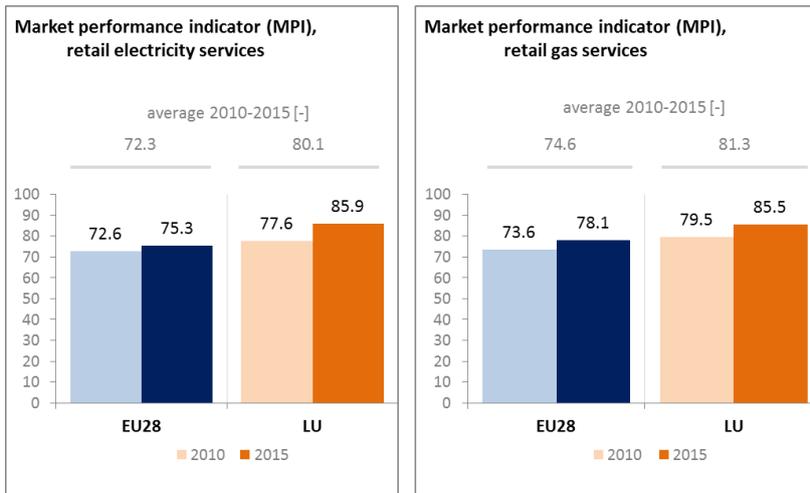
The energy component of the retail gas price decreased between 2013 and 2015 to the greater extent than wholesale gas price.¹⁰ Gas retail prices are non-regulated. As mentioned above, Luxembourg has opted for a large-scale roll-out of smart meters; this also covers smart gas meters. The expected diffusion rate is set at 90 % by the end of 2020. As for electricity, the roll-out will be financed through network tariffs.



3.2.3. Market performance indicators

According to the periodical survey of the Commission, consumers in Luxembourg are slightly more satisfied than the EU average with the services received on energy retail markets. With regard to retail services in both electricity and gas, consumer satisfaction has increased between 2010 and 2015. For both electricity and gas, Luxembourg's consumer satisfaction appears among the highest across the EU.

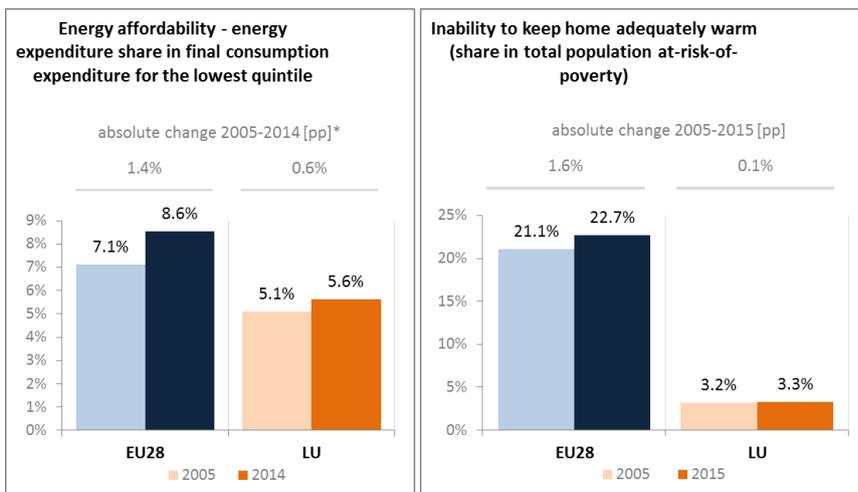
¹⁰ ACER Market Monitoring Report of November 2016, p. 74, Figure 46.



(source: DG JUST survey)

3.3. Energy affordability

Energy affordability is understood as consumers' ability to pay for their energy needs without this negatively impacting their comfort and livelihood. Affordability can be measured by looking at how much people in the lowest income bracket have to pay for their energy needs (or, in other words, by calculating the share of energy expenditure in total household expenditure for the quintile of population with the lowest income). In Luxembourg, in 2014, the most modest households spent on average 5.6 % of their total expenses on their energy needs. For the EU-28, that share stood at 8.6 %. Another indicator for energy affordability is to calculate the share of the population that is unable to keep their homes adequately warm. In Luxembourg, 3.3 % of the people that are already below the at-risk-of-poverty threshold are also unable to keep their homes adequately heated. The EU's share is much higher (22.7 %). While some degree of energy poverty seems to persist, the situation in Luxembourg is less problematic than in other Member States.

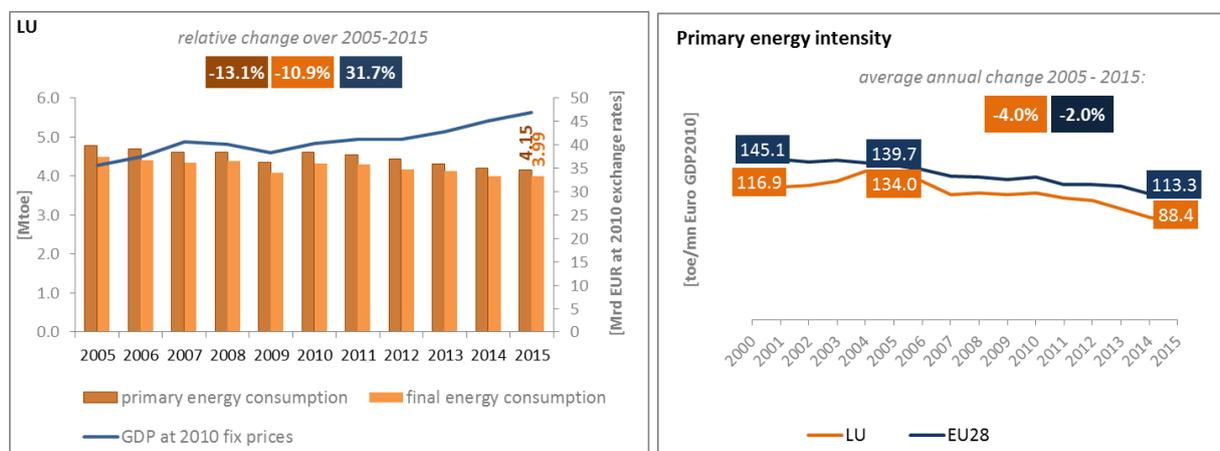


(source: ad-hoc data collection of DG ENER based on HBS with the support of Eurostat and national statistics)

4. Energy efficiency and moderation of demand

Between 2005 and 2015, Luxembourg reduced its primary energy consumption by 13.1 % to 4.15 Mtoe. Over the same period, final energy consumption fell by 10.9 % to 3.99 Mtoe. At the same time, GDP increased by a total of 31.7 % from 2005 to 2015, showing that economic growth has decoupled from energy consumption.

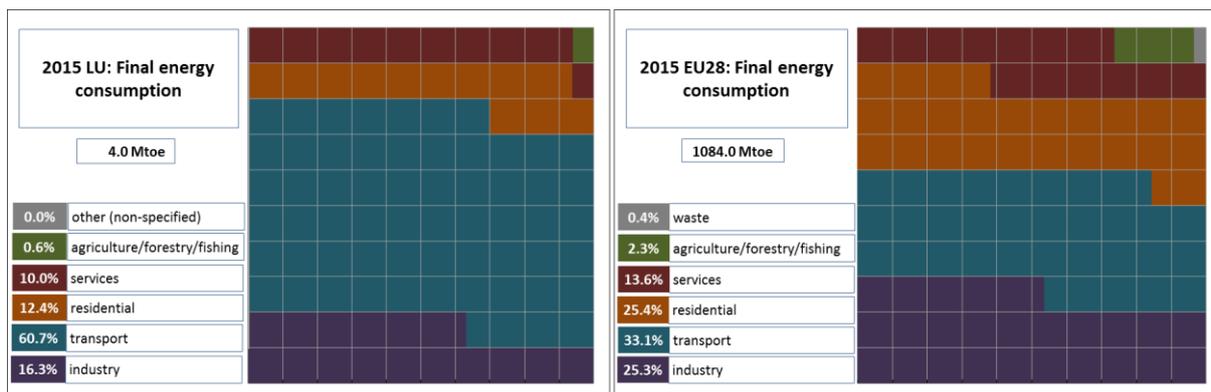
Luxembourg has set itself national indicative targets of reaching a primary energy consumption of 4.5 and a final energy consumption of 4.2 Mtoe in 2020. In other words, Luxembourg is on track to achieve its 2020 targets. However, in the years up to 2020, Luxembourg is also expected to step up the national energy efficiency actions and programs which are necessary to meet the cumulative saving requirements stemming from Article 7 of the Energy Efficiency Directive.



(source: Eurostat)

Between 2005 and 2015, the primary energy intensity of the economy (expressed by the ratio of energy consumption over GDP) has decreased annually by -4.0 %. The magnitude of the change is bigger than the EU average of -2.0 % annual change. In 2015, Luxembourg's primary energy intensity stood at 88.4 tons of energy (toe) per million euros of GDP. This figure is also below the EU average of 113.3 toe per million euros of GDP. This could reflect the strong focus of Luxembourg's economy on services, notably in the financial sector.

The profile of Luxembourg's final energy consumption differs from the EU-28 average, mostly because of the larger share of the transport sector: the share of transport (60.7 %) is almost double the EU average (33.1 %), which is largely due to a large number of commuters and transit traffic.



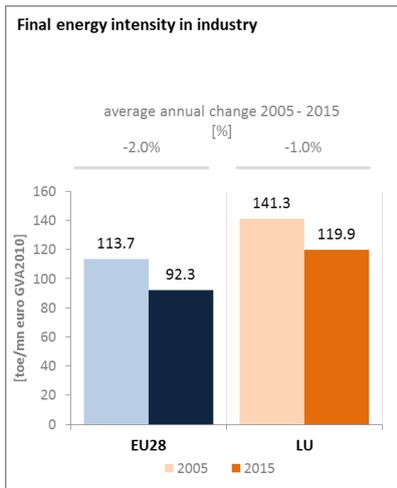
(source: Eurostat)

A variety of energy efficiency policy measures are in place in order to reach the efficiency target. The following are identified as the most important measures:

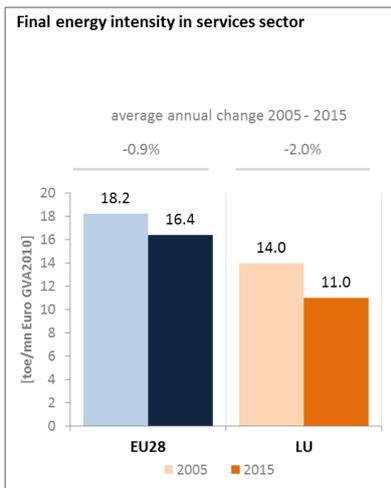
- High energy efficiency standards in all newly constructed buildings: this measure will be implemented in approx. 8000 new constructed residential units per year. It corresponds to more than 10 % of the total energy savings planned for 2020.
- "Climate pact" initiative (*Klimapakt*): municipalities are obliged to introduce energy management system in order to receive financial and technical support from the state. 106 out of 106 Luxembourg's municipalities participate.
- Energy efficiency obligation scheme: all electricity and gas suppliers of the households, service and industrial sectors are obliged to realise energy savings.
- Increase of fuel and CO₂ taxes for motor vehicles.

For the industrial sector, the most important measure, implemented since 1996, is the voluntary agreement between the Government and the Fedil-Business federation Luxembourg with the aim of improving energy efficiency in the industrial sector. Mandatory energy audits and energy management systems are implemented.

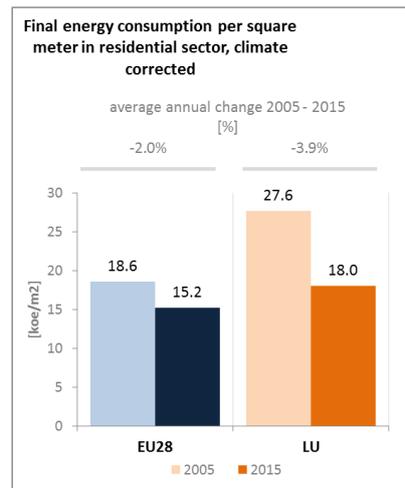
Between 2005 and 2015, the final energy intensity in industry has decreased on average by 1.0 % each year. It remains higher than the EU average. Over the same period, the final energy intensity in the services sector has fallen by an average of 2.0 % per annum and is well below the EU average. The final energy consumption per square meter in the residential sector, albeit still slightly higher than the EU average, was significantly reduced between 2005 and 2015 (by an average of 3.9 % per year).



(source: Eurostat)



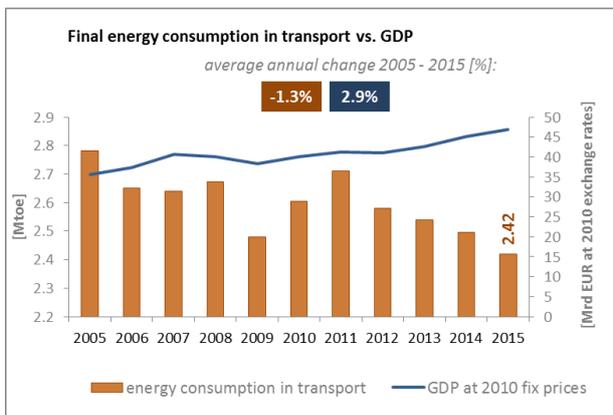
(source: Eurostat)



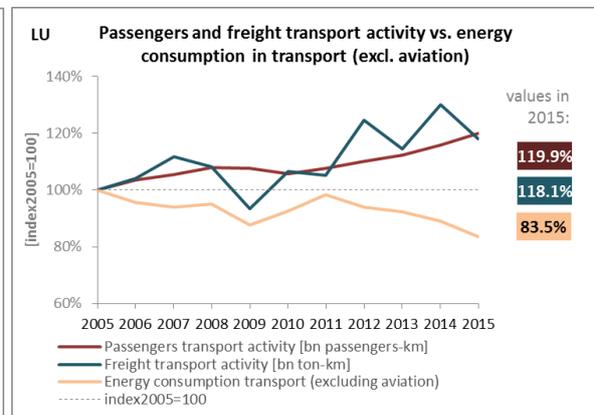
(source: Odyssee database)

Between 2005 and 2015, the final energy consumption in transport in Luxembourg recorded an average annual reduction of 1.3 %, while GDP increased annually by 2.9 %. This occurred in a context of steady increases in passengers transport activity (+19.9 %) and freight transport activity (+ 18.1 %) over a decade (2005–2015). It is worth mentioning that Luxembourg is a transit country for road transport; this may influence transport activity.

The share of collective passengers land transport into total passengers' transport increased slightly between 2005 and 2015; it is now very close to EU average. The efforts in this respect are best exemplified by the works on a new tramway in the city of Luxembourg.

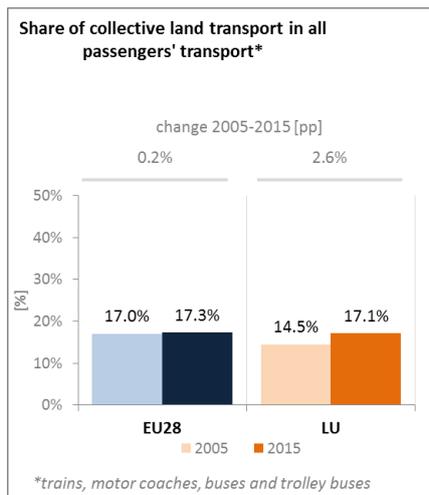


(source: Eurostat)



passengers transport activity=Private cars + bus + rail + tram & metro
 freight transport activity=road+rail+inland waterways+pipeline

(source: Eurostat and DG MOVE pocketbook)



(source: Eurostat)

With the launch of the flagship Sustainable Mobility Strategy of 2012 (*Mobilité durable*, "MoDu"), the Government of Luxembourg set the objective to reduce the share of individual motorised traffic (from 72.5 % in 2009 to 56 % in 2020) and to increase the share of collective modes of transport on one hand (from 14.5 % in 2009 to 19 % in 2020) and of active modes (walking and cycling) on the other (from 13 % in 2009 to 25 % in 2020).

Luxembourg is facing a large challenge from the road traffic that regularly congests the main traffic arteries in and around the capital city. Every day, the country with its 576,000 inhabitants welcomes approximately 176,000 commuters from Germany (43,000 commuters), Belgium (43,000 commuters), and France (90,000 commuters). Jobs continue to be predominantly situated in the capital (163,000 jobs) which only has 45,000 working residents. Economic growth and the concentration of jobs in the capital have resulted in increased traffic congestion and in longer commutes for residents and foreign commuters alike. As a result, traffic jams often extend across the borders of the Grand Duchy into neighbouring countries.

In order to remedy this situation, Luxembourg is investing heavily in a more multimodal and sustainable transport network. Throughout the country, about twenty multimodal hubs are currently being built to enable commuters to easily switch between different modes of transportation. Nine of these multimodal hubs are located along the 16 kilometre track of the future tramline that will cross the entire urban agglomeration of the capital and thereby serve as the backbone of the public transportation network.

In addition, new railway stations are being built on the outskirts of the city centre and regional bus lines are being reorganised to directly connect to the tram. In order to facilitate the transfer from cars to public transport, the capacity of park & ride parking lots is being doubled throughout the country (construction of an additional 13,100 spaces). A part of these will be equipped with charging stations for electric vehicles to promote low and zero-emission cars. Concerning active mobility, new cycle lanes, parking racks and bike sharing stations will further enhance multimodality.

The majority of these projects are being implemented at the moment; in particular the tram with its nine multimodal hubs. The first section of the track will be completed by the end of 2017. Concerning

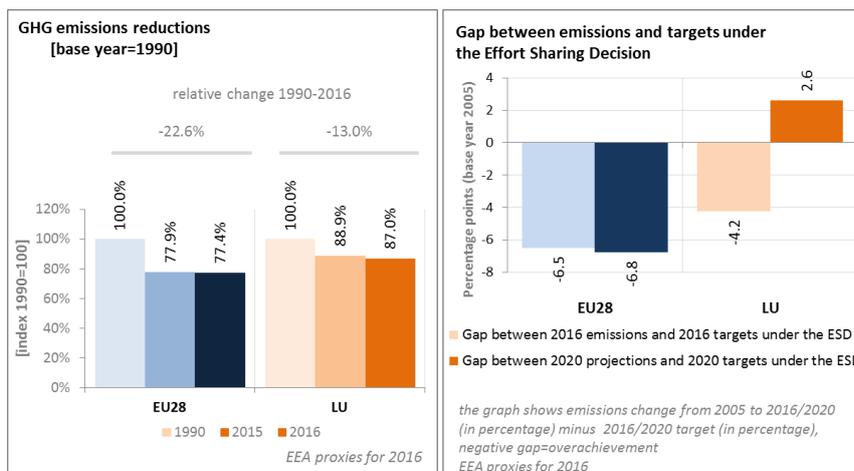
private car ownership, Luxembourg carried out a tax reform which entered into force in 2017 and applies, *inter alia*, to energy products in transportation.

5. Decarbonisation of the economy

5.1. GHG emissions

Luxembourg's greenhouse gas (GHG) emissions declined by 13 % between 1990 and 2016, which is significantly less than the reduction achieved at the level of the 28 EU Member States (-22.6 %).

Under the Effort Sharing Decision¹¹ (ESD), Luxembourg's target is to reduce by 20% its emissions by 2020 (compared to 2005). Between 2005 and 2016, Luxembourg's GHG emissions declined by 16 %, which is a bigger reduction than its 12 % interim reduction target for 2016. Luxembourg will comply with its emission reduction obligations as it will bank a surplus of AEAs over the period 2013-2020. However, according to the latest national projections, Luxembourg's existing domestic measures will not be sufficient to meet its ESD targets in the year 2020. Overall, GHG emission reductions are projected to be limited to 17.4% against the country's binding target of 20% (i.e. a gap of 2.6 pps). In contrast, the 28 Member States will, taken together, is expected to over-achieve their overall GHG emission reduction target in 2020 by 6.8 pps.



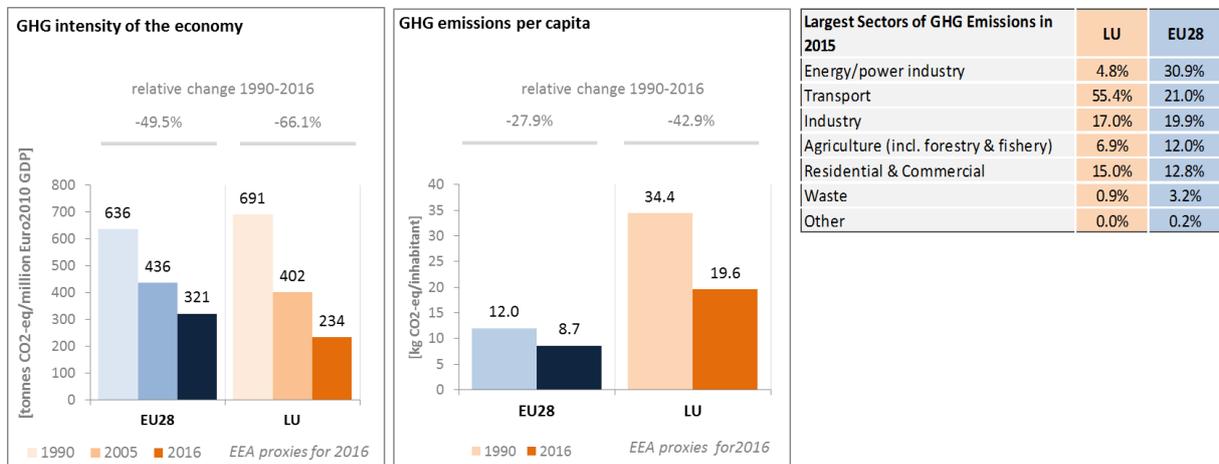
(source: EC and EEA)

Luxembourg continues to decouple its economic growth from its GHG emissions. During the 1990–2016 period, Luxembourg's GHG emissions intensity of the economy, defined as the ratio between emissions and GDP, decreased by 66.1 %. This is a faster pace of reduction than the rate observed at the EU level over the same period (-49.5 %).

In 2015, more than half (55.4 %) of Luxembourg's GHG emissions came from the transport sector, of which 70 % are linked to fuel exports. This is a much higher proportion than the EU's average (21 %).

11 Decision No 406/2009/EC of the European Parliament and of the Council of 23 April 2009 on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020

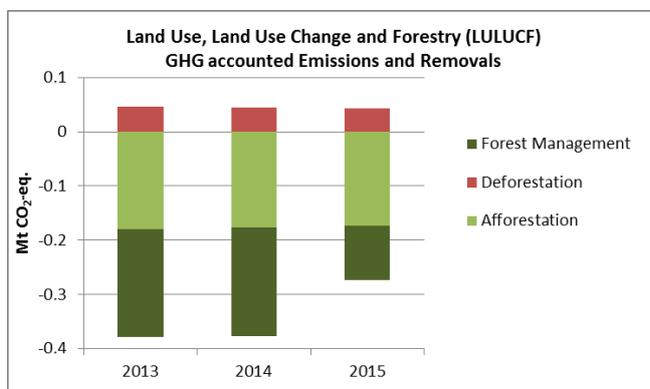
The main reasons for this phenomenon are Luxembourg's geographical situation as a transit country and, more importantly, the taxation of transport fuels at tax rates well below those of neighbouring Member States.



(source: EC and EEA)

Preliminary accounts under the Kyoto Protocol for Luxembourg show overall removals of 0.3 Mt CO₂eq. as an annual average in the period 2013-2015. For comparison, the annual average of the EU-28 accounted for removals of 119.0 Mt CO₂eq. It should be noted that in this preliminary simulated accounting exercise, removals from Forest Management did by far not exceed the accounting cap.

Removals by Afforestation are notably higher than emissions by Deforestation. The removals by Forest Management were similarly high than Afforestation, but their relative importance decreased notably in 2015. Overall, there is a decreasing trend in removals, due to previously noted declining removals by Forest Management in 2015. Emissions by Deforestation and removals by Afforestation show no change over the course of the three-year period.



Note: Forest Management credits are capped and presented as yearly averages when the total Forest Management credits of the considered period exceed the simulated cap over the same period.

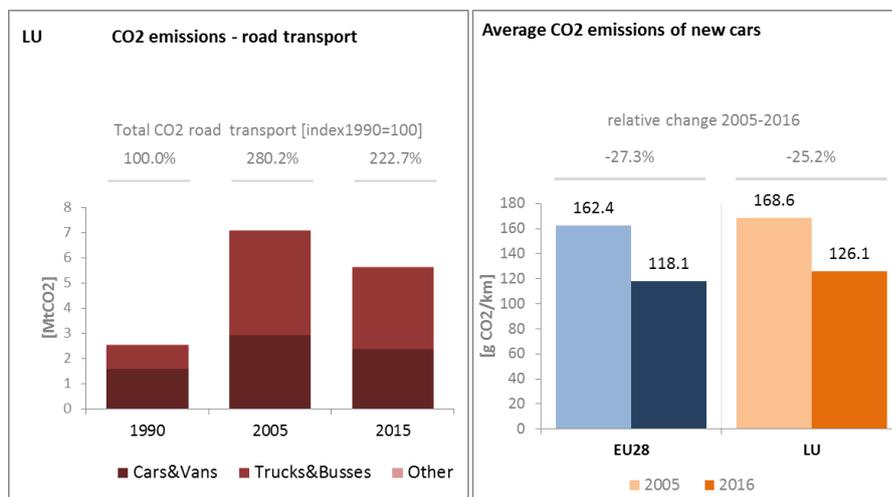
(source: EC and EEA)

CO₂ emissions in transport and alternative fuelled vehicles

In Luxembourg, the CO₂ emissions from road transport were, in 2015, 123 % higher than the 1990 levels, but they had decreased from 2005 onwards by about 21 %.

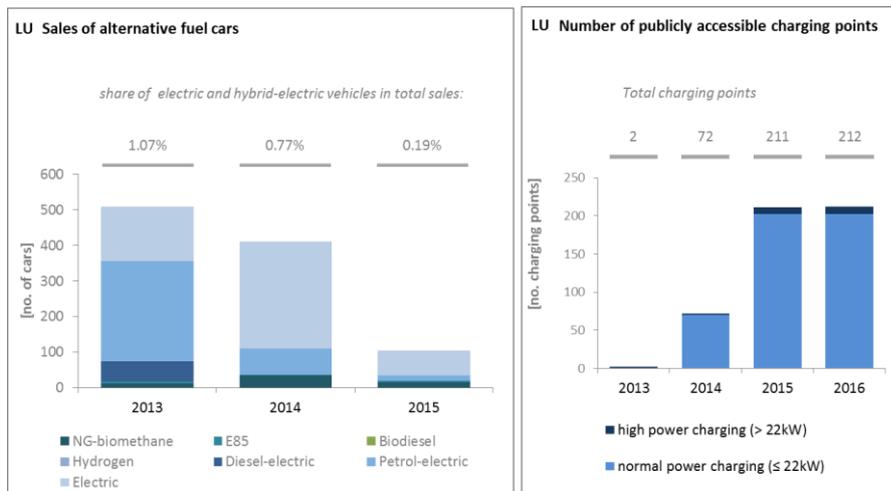
Between 2005 and 2016, the average CO₂ emissions of new cars in Luxembourg also fell by about a quarter; a similar reduction occurred at EU level. In 2016, it reached an average level of CO₂ emissions of 126.1 g CO₂ per kilometre, which is slightly above the EU average (118.1 g CO₂ emissions per kilometre).

Since 1 January 2017, zero emission vehicles (battery electric and fuel cell electric vehicles) as well as bikes and pedelec²⁵ bikes benefit from a tax allowance of 5,000 EUR and 300 EUR, respectively. The use of less polluting vehicles is also encouraged with a re-evaluation system that lowers the costs of less polluting cars for employers, incentivising employers to opt for those vehicles as a benefit in kind. Although the exact impact of this measure on greenhouse gas emissions is not known, it is meant to curb greenhouse gas emissions from road transportation.



(source: European Environment Agency)

The share of alternative fuel cars in total sales fell sharply between 2013 and 2015 and now is at a very low level (0.19 %). Over the three years between 2014 and 2016, the number of charging points in Luxembourg has been almost stable, reaching the amount of 212 points in 2016.



(European Environment Agency)

(European Alternative Fuels Observatory)

National Policy Frameworks under Directive 2014/94/EU on alternative fuels infrastructure have to establish targets, objective and measures for the development of the market of alternative fuels in the transport sector and the deployment of the relevant infrastructure. Luxembourg has submitted its National Policy Framework as requested under article 3 of the Directive 2014/94/EU.

A detailed assessment of Luxembourg's National Policy Framework in terms of its compliance with the requirements of Directive 2014/94/EU, its contribution to achievement of long-term energy and climate objectives of the Union and coherence of its targets and objectives in terms of cross-border continuity has been published as part of the Communication on Alternative Fuels Action Plans (COM(2017)652) and the related staff working document SWD(2017)365.

5.2. Adaptation to climate change

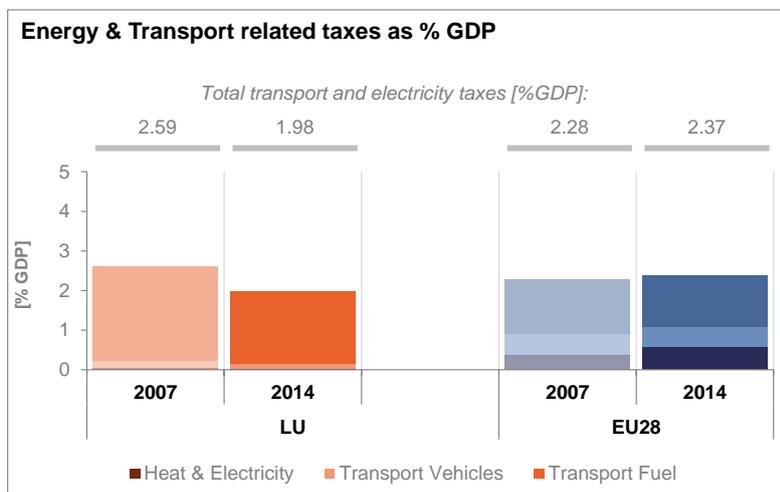
Luxembourg's Council of Ministers adopted a National Adaptation Strategy on Climate Change in 2011, prioritising four sectors: biodiversity, water, agriculture and forestry. Currently a new, more comprehensive adaptation strategy is being elaborated. It will list concrete measures mostly in those areas that are the most impacted by higher and erratic rainfalls as well as by river flow regimes: drinking water, agriculture, viticulture, biodiversity, energy, buildings and infrastructure, navigation, health, tourism and other domains. No National Adaptation Plan has been adopted, nor has a Monitoring and Reporting Framework been developed.

5.3. Taxes on energy and transport and fossil fuel subsidies

The overall tax burden on energy and transport in Luxembourg amounts to 2.0 % of GDP, nearly 0.4 percentage points (p.p.) lower than the EU average. It is particularly the tax burden on transport

vehicles and on heat and electricity that is low. Revenues from fuel taxation in Luxembourg are still much higher than the EU-average, despite a decrease by 1.0 p.p. since 2005. The high level is primarily driven by "border shopping" of fuels as excise duties on petrol and diesel are lower in Luxembourg than in the neighbouring countries. In terms of vehicle taxation Luxembourg applies a circulation tax based on CO₂ emissions, but there is no CO₂ component in the tax framework for energy products.

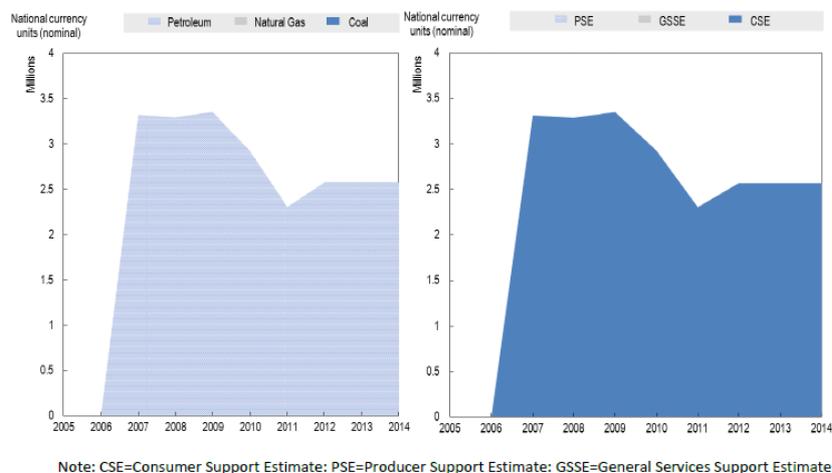
A key policy to increase efficiency in the transport sector is increasing fuel and CO₂-taxes for motor vehicles. The increase of the fuel taxes is expected to result in energy savings in Luxembourg of 86 GWh in 2020. The CO₂ tax increase for motor vehicles is in force since 2007 and aims to save 66 GWh of final energy by 2020.



(source: Eurostat)

Since 2007, the Luxembourg has set preferential VAT rates and excise duties on mineral fuels and for certain sectors and users, leading to a sharp increase in fossil fuel subsidies. However, also in 2007, the excise rate on gasoline increased while those for diesel were adjusted in two stages: a first hike in 2007 and subsequently in 2008.

Total support for fossil fuels in Luxembourg by fuel type (left) and support indicator (right)



(source: OECD Inventory of Support Measures for Fossil Fuels 2015)

5.4. Renewable energy

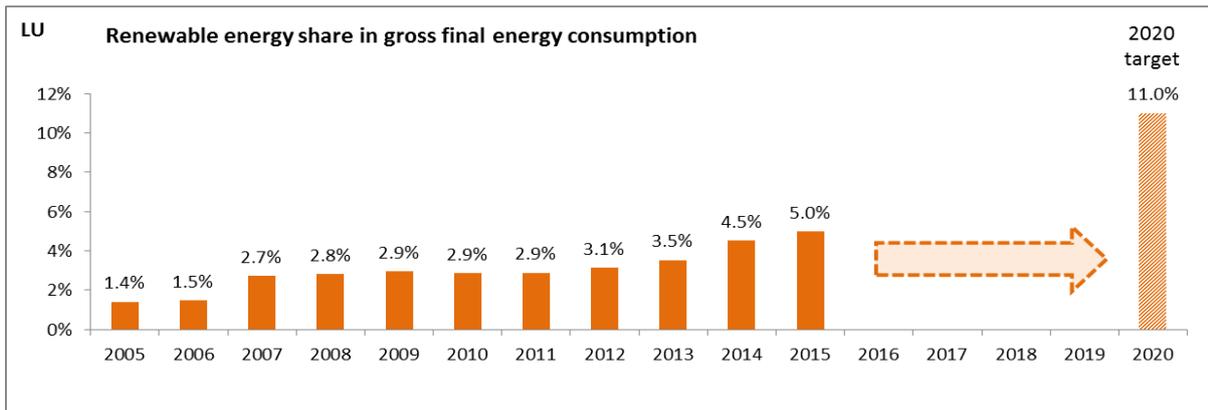
On renewable energy in general, Luxembourg had so far been on track with renewable energy shares set above the indicative trajectory defined in the Renewable Energy Directive. In 2015, wind power and solar PV capacity grew by 6 MW each, and there was some growth in heat pumps, solar thermal and biofuels. However, in 2015, for the first time, Luxembourg's share fell below the indicative trajectory (5.4 %), albeit by a small margin (the actual renewable share being 5 %). The share of renewables in electricity production continued to grow (from 5.9 % in 2014 to 6.2 % in 2015), but the share of renewables in heating and cooling declined (from 7.2 % in 2014 to 6.9 % in 2015).

Luxembourg has different measures in place to promote the use of renewable energy. In 2016, the support scheme for renewable electricity production was reformed, with a view to integrate renewable electricity better in the market. The scheme consists of premium payments for operators of wind, solar, biogas, hydropower and biomass installations, to spur further investment in renewable electricity generation. The total budget of the measure will be approximately EUR 150 million, allocated between 2016 and 2020.

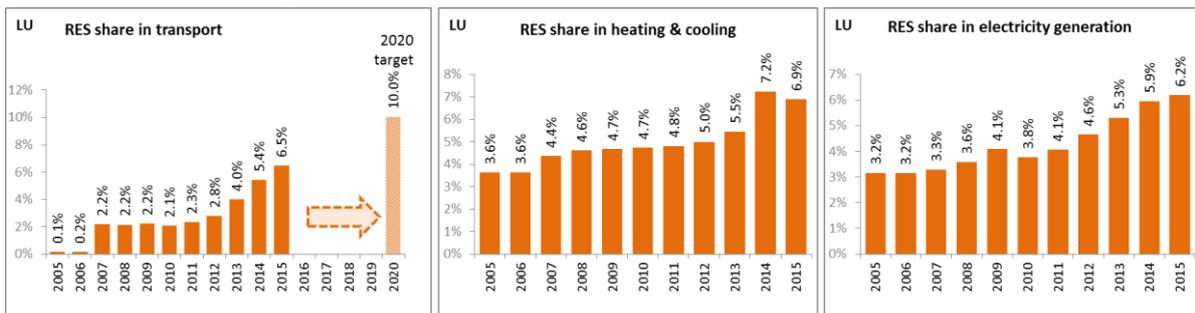
Luxembourg is also one of the few Member States to already have a so-called "one-stop-shop", online application facilities, and a maximum time limit for procedures for renewable developers in order to facilitate the installation of renewable energy plants. Also, in April 2016, the government announced three new projects in public-private partnership (wind, biomass, and cogeneration partly converted to wood-pellet use), totalling EUR 131 million of investment and covering nearly a quarter of the country's renewable energy needs. In 2016, a set of measures was implemented in order to increase the share of renewable energies. Modifications in respect to the feed-in and the market premium scheme entered into force in order to promote renewable electricity production as well as the injection of biogas in the natural gas grid. Moreover, a reform of the subsidy scheme for private

households continues to provide financial incentives for various renewable energy technologies (such as PV, thermal solar, heat pumps).

But the indicative trajectory will become steeper (the 2020 target is more than double the indicative trajectory value for 2015). The government is considering statistical transfers of renewable energy from other Member States that are expected to achieve their target, but no final decision has been made yet.



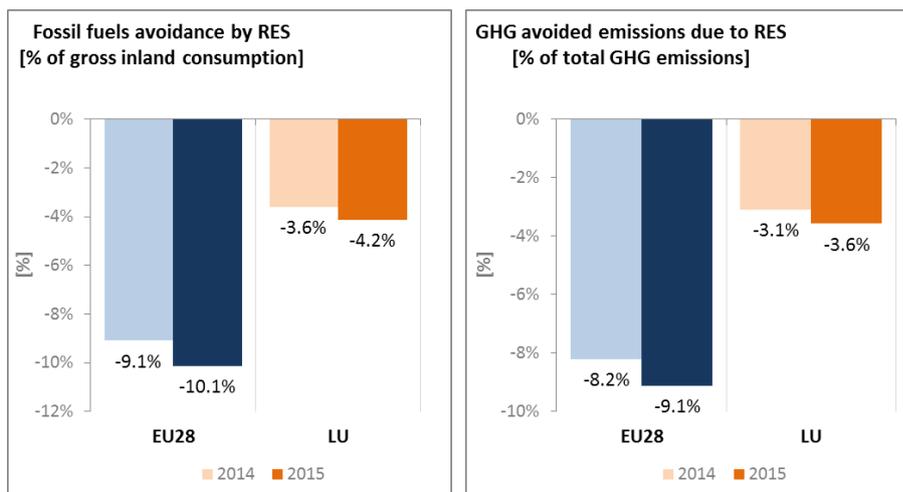
(source: Eurostat-SHARES)



(source: Eurostat-SHARES)

It is estimated that in 2015, Luxembourg avoided 4.2 % of fossil fuel in gross inland consumption and about 3.6 % of GHG emissions at national level by its renewable energy systems.¹² This is considerably lower than the EU average, which for fossil fuel and GHG emission avoidance stood at 10.1 % and 9.1 % respectively.

¹² Avoided GHG emissions mentioned here have a theoretical character as these contributions do not necessarily represent 'net GHG savings per se'. Nor are they based on a life-cycle assessment or full carbon accounting.



(source: EEA)

5.5. Contribution of the Energy Union to better air quality

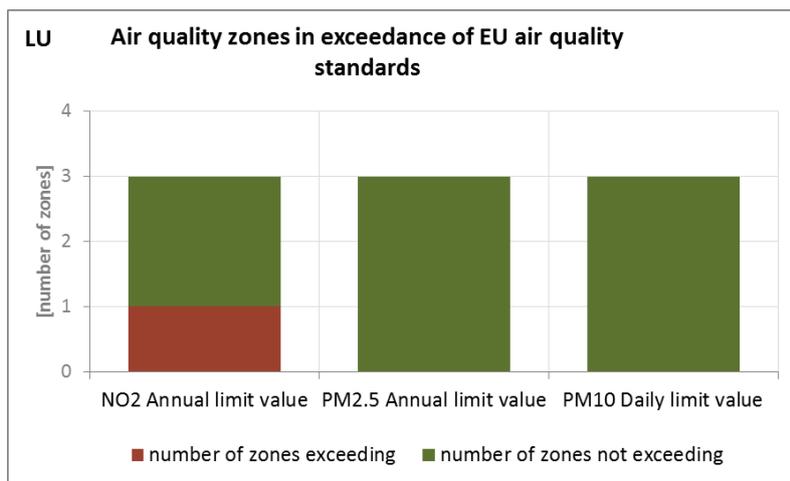
Air quality in Luxembourg continues to give cause for concern. For the year 2013, the EEA estimated that about 280 premature deaths were attributable to fine particulate matter (PM_{2.5}) concentrations and 80 to nitrogen dioxide (NO₂) concentrations¹³.

For NO₂, Luxembourg reported exceedances of the binding EU air quality standard¹⁴. For 2015, Luxembourg reported exceedances of the limit value for NO₂ in 1 out of the 3 air quality zones in Luxembourg as shown in the figure below¹⁵.

¹³ European Environment Agency, 2016, [Air Quality in Europe – 2016 Report](#), table 10.2. The report also includes details as regards the underpinning methodology for calculating premature deaths.

¹⁴ Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe, OJ L 152, 11.6.2008, p.1-44

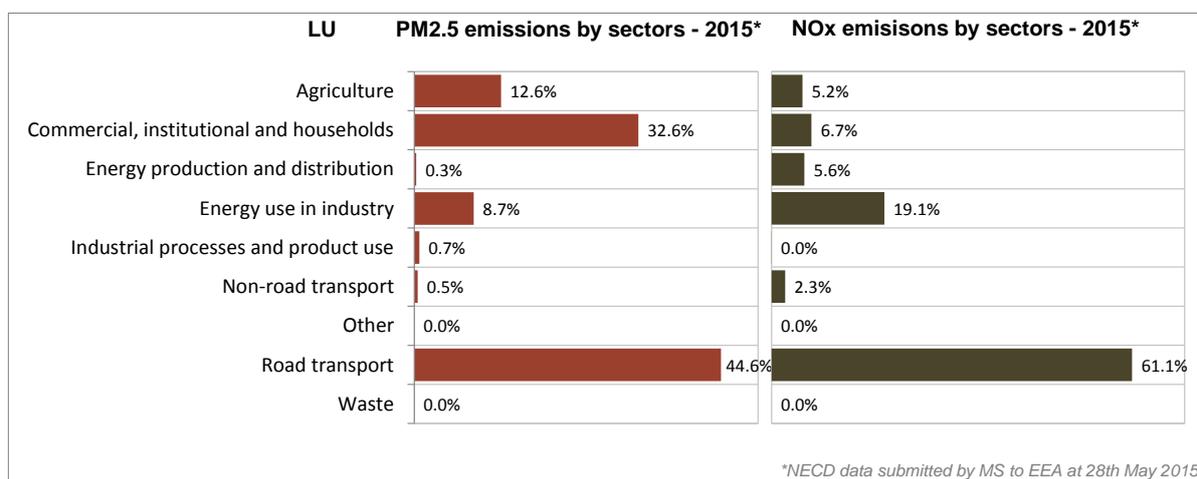
¹⁵ Compliance data as reported by the Member States as part of their official annual air quality report for the calendar year 2015 (available on the European Environment Agency's (EEA) Eionet/Central Data Repository), <http://cdr.eionet.europa.eu/lu/eu/aqd>



(source: EEA)

The health-related external costs from air pollution in Luxembourg have been estimated to be more than EUR 859 million/year (income adjusted, 2010), which includes the intrinsic value of living a healthy life without premature death as well as the direct costs to the economy such as healthcare costs and lost working days due to sickness caused by air pollution¹⁶.

The Energy Union can substantially contribute to addressing these air quality problems through measures reducing emissions of both GHG and air pollutants such as PM and nitrogen oxides (NO_x) from major contributing sectors such as (road) transport, energy production, industry and residential heating (e.g. stoves and boilers) as shown in the figure below¹⁷.



(Source: EEA. This table reflects only sources of primary PM_{2,5} emissions.)

¹⁶ See also the EU Environmental Implementation Review Country Report for Luxembourg, SWD(2017)49 final of 3.2.2017

¹⁷ National emission data as reported by the Member States to the EEA (available on the EEA's Eionet/Central Data Repository), http://cdr.eionet.europa.eu/lu/eu/nec_revised

6. Research, innovation and competitiveness

6.1. Research and innovation policy

The Luxembourg National Research Fund (FNR) is the funding agency for public research in Luxembourg. Luxinnovation (the national agency for innovation and research) has a supporting role by providing advice on R&I to all actors in the sector, including the government. Luxinnovation also drives the Luxembourg Cluster Initiative, which brings together several clusters and innovation networks. One of the networks established under this initiative is the EcoInnovation Cluster, which supports green technologies and renewable energy.

Energy R&I has traditionally been a low priority in Luxembourg, with the exception of participation in specific programmes such as the European fusion research programme. Among renewable energy sources, wind has received the largest share of support, with some funding also going to solar thermal and bioenergy.

Luxembourg is not an active contributor to the ongoing work of the Strategic Energy Technology (SET) Plan. It does not participate in any of the fourteen temporary working groups, which have been set up to implement the integrated SET Plan.

Regarding the Horizon 2020 programme (for which Luxinnovation is the National Contact Point), Luxembourg has received so far 0.1 % of the EU contribution devoted to the 'secure, clean and efficient energy' part of the programme. As of September 2017, 17 participations from national organisations have been awarded EUR 2.6 million in Horizon 2020 energy projects. This includes a grant of almost EUR 0.5 million to the University of Luxembourg for its participation in project Sharc25 (thin-film solar cells).

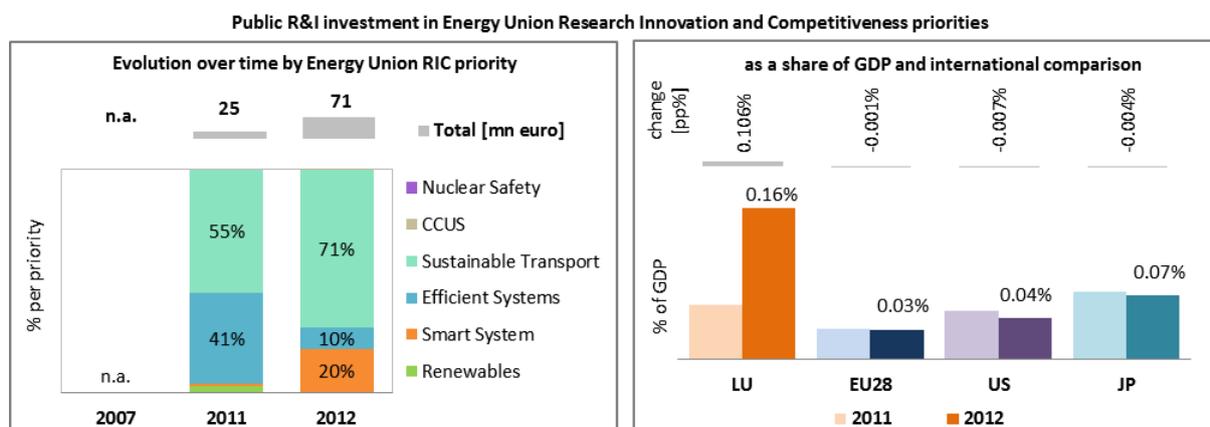
6.2. Investments and patents in the Energy Union R&I priorities

In 2012, public (national) investments in the Energy Union R&I priorities reached EUR 71 million, almost three times the amount reported in 2011. The largest share of these investments (71%) was attracted by the Sustainable Transport R&I priority of the Energy Union, followed by the Smart System (20%). For the same year, 2012, public investment per GDP was over five times the EU average.

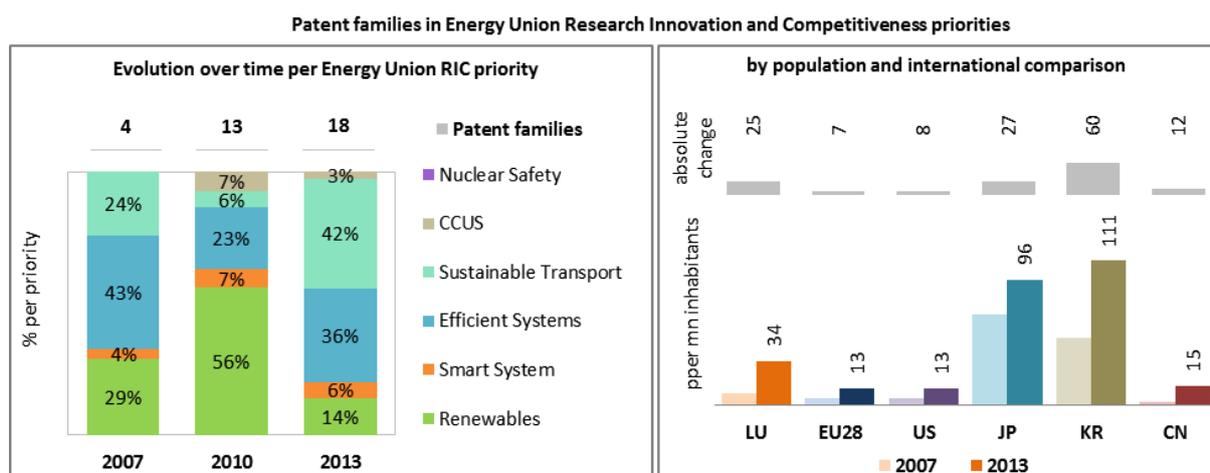
Private investment in the Energy Union R&I priorities in 2013 was estimated at EUR 46 million (0.3% of the private R&I investment in Energy Union R&I priorities in the EU). The focus was on Sustainable Transport, which received 42% of these investments, followed by the Efficient Systems priority with a share of 36%.

In 2013, the most recent year for which complete patent¹⁸ statistics are available, 13 companies and research organisations based in Luxembourg filed 18 patents in low-carbon energy technologies (0.3% of the EU total). The focus was on Sustainable Transport (42%), followed by Efficient Systems (36%) and Renewables (14%).

In 2013, private R&I investments in Energy Union R&I priorities were lower than the EU average when normalised by GDP. On the contrary, the number of patents in Energy Union R&I priorities normalised by population was much higher than the EU average. In the period 2007–2013, both private R&I investments and the number of patents in Energy Union R&I priorities have increased on average by 16 % and 27 % per year, displaying higher rates of increase than same indicators at EU level (6% and 15% respectively).



Note: Public investment data are only available for the years 2011 and 2012.



¹⁸ In the context of this document, the term 'patent' refers to patent families, rather than applications, as a measure of innovative activity. Patent families include all documents relevant to a distinct invention (e.g. applications to multiple authorities), thus preventing multiple counting. A fraction of the family is allocated to each applicant and relevant technology.

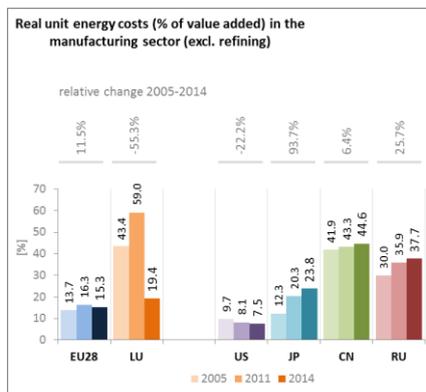
(Data sources: Public investment as available in the International Energy Agency RD&D Statistics database¹⁹ for codes relevant to Energy Union RIC priorities. Patent data based on the European Patent Office PATSTAT database²⁰. Private investment data estimated by JRC SETIS. Detailed methodology available from the JRC²¹.)

6.3. Competitiveness

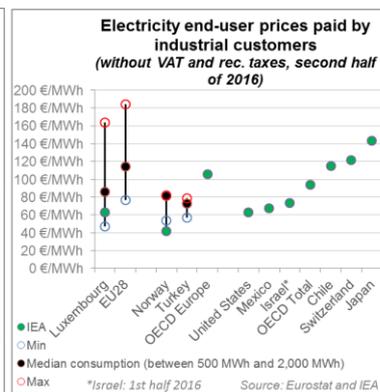
In 2014, the real unit energy costs (RUEC)²² in Luxembourg (19.4 % of value added) were above the EU average (15.3 %), significantly higher than those in the US (7.5 %), but below those in Japan (23.8 %), China (44.6 %) and Russia (37.7 %). In 2011, Luxembourg’s RUEC had been much higher (59.0 %), topping all the countries mentioned.

The average (IEA) electricity prices paid by industrial customers in Luxembourg are below the EU and OECD averages. These prices compare favourably to Switzerland or Japan and are on par with prices in the United States, but higher than average prices in Norway. There is a significant gap between average electricity prices and prices for median consumption in Luxembourg. The latter are still below EU level, but above the price for median consumption in Norway or Turkey.

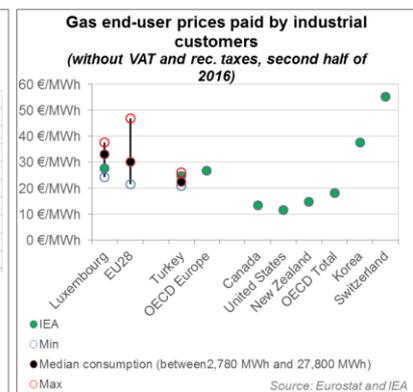
Conversely, average (IEA) gas prices for industrial consumers are above OECD averages. They are lower than prices in Korea and in Switzerland, but higher than in the United States, New Zealand, Canada and Turkey. Gas prices for median consumption are slightly higher than the average prices and top median prices for the EU.



(source: ECFIN)



(source: Eurostat and IEA)



Source: Eurostat and IEA

Regarding the competitiveness in wind and solar energy, Luxembourg is performing quite well in the solar sector notably in the manufacturing of modules and cells, having improved

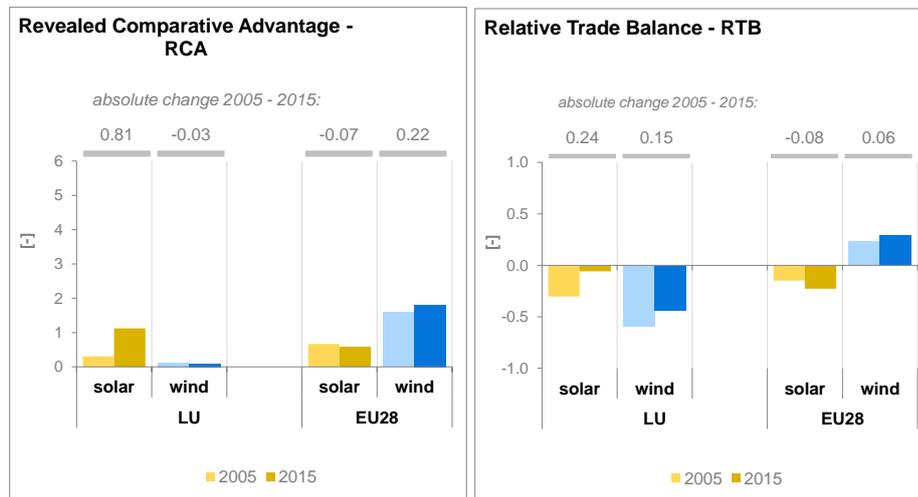
¹⁹ <http://www.iea.org/statistics/RDDonlinedataservice/>

²⁰ <https://www.epo.org/searching-for-patents/business/patstat.html#tab1>

²¹ <https://setis.ec.europa.eu/related-jrc-activities/jrc-setis-reports/monitoring-ri-low-carbon-energy-technologies>

²² This indicator measures the amount of money spent on energy sources needed to obtain one unit of value added.

considerably since 2005. As indicated by the revealed comparative advantage indicator²³ below 1, the Luxembourg economy is not specialised in wind energy. The relative trade balance²⁴ indicates that Luxembourg is a net importer of wind components and, to a lesser degree, of solar energy, although the net imports of the latter have decreased considerably since 2005.



(source: UN comtrade)

7. Regional and local cooperation

Luxembourg is a member of the Pentalateral Energy Forum. It was created in 2005 by Energy Ministers from Benelux, Germany and France, but Austria and Switzerland later also joined. It is an inter-governmental initiative, assisted by an independent secretariat. The countries' energy ministers renewed the mandate of the Pentalateral Energy Forum in 2013 with a political declaration. The focus of the forum is on electricity market integration and security of supply.

Also, together with Belgium, France, Germany and the Netherlands, Luxembourg is part of the Central Western European (CWE) day-ahead market coupling. Since 20 May 2015, it uses the flow-based methodology. The flow-based methodology project has been carried out jointly by CWE transmission system operators, including Amprion, Elia, RTE, Tennet the Netherlands, Creos (the

²³ The RCA index for product "i" is defined as follows: $RCA_i = \frac{X_{j,i}}{\sum_i X_{j,i}} \div \frac{X_{w,i}}{\sum_i X_{w,i}}$ where X is the value of exports, and j is the country and w is the reference group, the World economy. 2005 refers in the text to the indicator average over the 2000-2009 period, while 2015 represents the average over the 2010-2016 period. The same applies for the RTB indicator - see below.

²⁴ The RTB indicator for product "i" is defined as follows: $RTB_i = \frac{X_i - M_i}{X_i + M_i}$ where X_i is the value of product's "i" exports and M_i imports.

Luxembourg TSO) and Transnet BW, and Power Exchanges APX and EPEX SPOT. The flow-based method was approved by national energy regulators on 23 April 2015. The flow-based methodology was successfully run for the first time in the CWE Day-Ahead market coupling process on 20 May 2015 (for delivery day 21 May). This new methodology should lead to further price convergence in the region.

Luxembourg is a member of the High-Level Group on North Seas Energy Cooperation. In June 2016, Luxembourg signed the Political Declaration on energy cooperation between the North seas countries. This Declaration has established a High-Level Group to give the necessary political impetus to a project which is fundamental to facilitate the cost-effective deployment of offshore renewable energy and to promote further interconnection and further integration of wholesale electricity markets around the North Seas. Through a coordinated approach will be achieved market integration and the integration of substantial amounts of indigenous low carbon generation, at lower cost and with an optimal use of maritime space (avoidance of conflicts with other North Seas users). It will boost economic growth and create a significant amount of highly skilled jobs in the region. Luxembourg is also a member of the North Seas Off-shore Grid Regional Group.

European Territorial Cooperation – 'Interreg' – under EU cohesion policy provides further opportunities for cross-border, transnational and interregional cooperation, including in the Energy Union areas.

Cities and urban areas have a key role in the energy and climate challenge. The Urban Agenda for the EU, established by the Pact of Amsterdam in May 2016, better involves cities in the design and implementation of policies, including those related to the Energy Union. It is implemented through Partnerships, in which the Commission, Member States, cities and stakeholders work together on a number of important areas, including on Energy Transition, Urban Mobility, Air Quality, Climate Adaptation and Housing. Luxembourg is participating in the partnership on Housing, as member.

By 2016, under the Covenant of Mayors, one municipality from Luxembourg had submitted a sustainable energy action plan (SEAP) expected to reduce average GHG emissions per capita by 30 % (as compared to 1990 baseline).

	No. of SEAPs submitted	Population covered by SEAPs [million]	Average GHG emissions [t CO ₂ -eq/capita*year]		Relative GHG savings by 2020
 Luxembourg	 1	 0.00	Baseline emissions 10.59	By 2020 7.41	 -30.0%
European Union	5332	160.06	Baseline emissions 5.50	By 2020 4.00	-27.2%

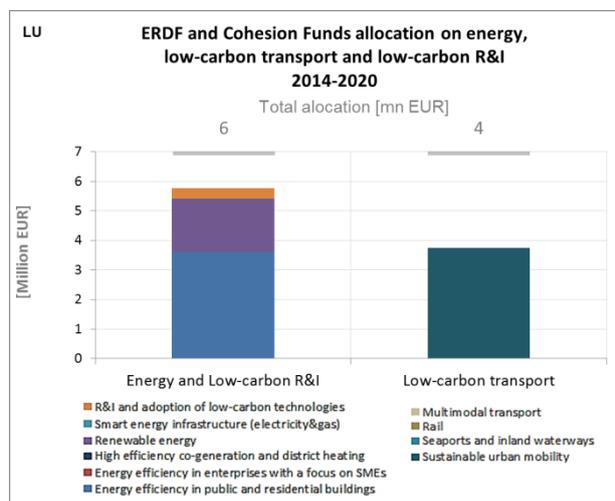
(source: JRC 2016. Notes: SEAP=sustainable energy action plan, GHG=greenhouse gas emissions)

In Luxembourg, by September 2016, no cities have yet committed to conduct vulnerability and risk assessment and develop and implement adaptation plans in the framework of the Covenant of Mayors for Climate and Energy.

8. Cohesion policy and EU-supported clean energy investments

EU cohesion policy makes a key contribution to delivering the Energy Union objectives on the ground, including investment possibilities to implement energy policy objectives in Luxembourg which are complemented by national public and private co-financing, aiming at optimal leverage. It also ensures integrated territorial solutions to energy and climate challenges, supports capacity building and provides technical assistance.

Over the period 2014–2020, cohesion policy is investing some EUR 5 million in energy efficiency improvements in public and residential buildings, as well as in renewable energy in Luxembourg. Cohesion policy is also investing significantly in R&I and in SME competitiveness in Luxembourg, based on the national strategy for smart specialisation. For Luxembourg, the strategy includes a focus on eco-technologies and key enabling technologies. At this stage, at least EUR 360,000 is foreseen for investments in R&I and adoption of low-carbon technologies in Luxembourg, but this might increase further in line with the evolving content of the smart specialisation strategy. A further estimated EUR 4 million is invested in supporting the move towards an energy-efficient, decarbonised transport sector.



(source: DG REGIO)

These investments are expected to contribute to around 60 households with improved energy consumption classification, a decrease of around 150,000 kWh per year of primary energy consumption of public buildings, and around 5 MW of additional capacity of renewable energy production. Overall, the EU cohesion policy investments in Luxembourg over the period 2014–2020 are expected to contribute to an estimated annual decrease of GHG emissions of around 15 000 tonnes of CO₂eq.

For example, the ZAC-eMovin project focuses on the electric car, with the aim of creating a network of charging stations across the country to encourage widespread use. ZAC-eMovin aims to propose innovative solutions to work-related commutes by trialling and studying e-car sharing in three industrial activity zones around Luxembourg City. A charging station and electric car will be available to employees at a participating company in each location. Car-sharing to travel to meetings and events is envisaged as the primary use, but car-pooling from home to work may also be organised. A specially designed electronic registration system will monitor e-car use by employees to better understand the potential for wider implementation at business locations around Luxembourg. The total cost of the project amounts to EUR 327,356, of which EUR 81,839 from the European Regional Development Fund (ERDF).

As another example, the composting biogas Mondercange plant transforms an important part of the waste stream in the southern part of Luxembourg into biogas and compost. With an annual intake of 35,000 tonnes of organic waste generated by some 200,000 inhabitants, the plant produces some 10,000 tonnes of compost, all of which is sold off for use in agriculture and gardening. A sophisticated gas refinery on site allows for the plant to feed its biogas directly into the local network and to contribute to the energy supply of the equivalent of 1,300 households. The total cost of the project was EUR 23.4 million, of which EUR 4 million from the European Regional Development Fund (ERDF).

Through its support to sustainable transport systems, The **Connecting Europe Facility** (CEF) also contributes to the goals of the Energy Union. Following Luxembourg's participation in the CEF – Transport 2014–2015 calls, the Luxembourgish action portfolio comprises 5 signed grant agreements, allocating EUR 71.6 million of actual CEF Transport Funding to beneficiaries in Luxembourg (state: February 2017)²⁵. The transport mode which receives the highest share of funding is rail (99.2 % of actual funding). The CEF programme provides a significant contribution to new rail lines and implementation of The European Railway Traffic Management System (ERTMS). Luxembourg's portfolio also includes a multimodal action with the objective to promote the use of a new and innovative technology for production and supply of alternative fuel for transportation partly based on regenerative sources (biogas).²⁶

²⁵ Note that European Economic Interest Groups and International Organisations are excluded from the analysis.

²⁶ Source: INEA