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Foreword

The principal aim of the OECD Environmental Performance Review programme is to help member and selected partner countries improve their individual and collective performance in environmental management by:

- Helping countries assess progress in achieving their environmental goals
- Promoting continuous policy dialogue and peer learning
- Stimulating greater accountability from governments towards each other and public opinion.

This report reviews the environmental performance of Luxembourg since the previous review in 2010. Progress in achieving domestic objectives and international commitments provides the basis for assessing the country's environmental performance. Such objectives and commitments may be broad aims, qualitative goals or quantitative targets. A distinction is made between intentions, actions and results. Assessment of environmental performance is also placed within the context of Luxembourg's historical environmental record, present state of the environment, physical endowment in natural resources, economic conditions and demographic trends.

The OECD is indebted to the government of Luxembourg for its co-operation in providing information, for the organisation of the review mission (4-7 June 2019), and for facilitating contacts both inside and outside government institutions.

Thanks are also due to the representatives of the two examining countries, Estelle Vercouter (Belgium) and Laura Platchkov (Switzerland).

The authors of this report are Nils Axel Braathen, Ivana Capozza, Myriam Linster, Eugene Mazur, Sarah Miet, Mikaela Rambali (OECD Environment Directorate) and Jean Cinq-Mars (consultant), under the co-ordination of Myriam Linster. Nathalie Girouard and Ivana Capozza provided oversight and guidance. Sarah Miet provided statistical support, Pascale Rossignol provided administrative support and Mark Foss copy-edited the report. Natasha Cline-Thomas provided communications support. The authors gratefully acknowledge the feedback and comments received by Raphaël Jachnik (OECD Environment Directorate) and Peter Journeay-Kaler (International Energy Agency).

The assessment presented in this report was mostly prepared between July 2019 and January 2020 and does not take into account the consequences of the health crisis caused by COVID-19. However, a few references were added in October 2020 for information.

The OECD Working Party on Environmental Performance discussed the draft Environmental Performance Review of Luxembourg at its meeting on 25 February 2020 in Paris, and approved the Assessment and Recommendations on 27 October 2020.

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Reader's guide

Signs

The following signs are used in figures and tables:

.. : not available

_ : nil or negligible

. : decimal point

Country aggregates

OECD Europe : Europe: This zone includes all European member countries of the OECD, i.e. Austria, Belgium, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, the Netherlands, Norway, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

OECD: This zone includes all member countries of the OECD, i.e. the countries of OECD Europe plus Australia, Canada, Chile, Israel*, Japan, Korea, Mexico, New Zealand and the United States.

Country groupings may include Secretariat estimates.

Colombia was not an OECD Member at the time of preparation of this publication. Accordingly, Colombia does not appear in the list of OECD Members and is not included in the zone aggregates.

Currency

Monetary unit : Euro (EUR)

In 2019, USD 1 = EUR 0.893

In 2018, USD 1 = EUR 0.847

Cut-off date

This report is based on information and data available up to January 2020. A few references to the COVID-19 health crisis were added for information in October 2020.

Disclaimer

*The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

This document and any map included herein are 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.

Abbreviations and acronyms

AEV	Environment Administration (Administration de l'environnement)
AGE	Water Management Administration (Administration de la gestion de l'eau)
ANF	Nature and Forest Administration (Administration de la nature et des forêts)
CAP	Common Agricultural Policy
CBD	Convention on biological diversity
CIDD	Interagency Commission for Sustainable Development (Commission interdépartementale de développement durable)
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CMS	Convention on the Conservation of Migratory Species of Wild Animals
CO	Carbon monoxide
CO_2 eq	Carbon dioxide equivalent
CRA	Climate risk assessment
CSC	Hunting Board (Conseil Supérieur de la Chasse)
CSDD	Sustainable Development Board (Conseil Supérieur pour un Développement durable)
CSP	Fisheries Board (Conseil Supérieur de la Pêche)
CSPN	Nature and Natural Resources Protection Board (Conseil Supérieur de la Protection de la Nature et des Ressources naturelles)
DMC	Domestic material consumption
EAFRD	European Agricultural Fund for Rural Development
EC	European Commission
EEA	European Environment Agency
EGS	Environmental goods and services
EIA	Environmental impact assessment
EIB	European Investment Bank
EMAS	Eco-Management and Audit Scheme
EPF	Environmental Protection Fund
ERDF	European Regional Development Fund
ESD	Effort Sharing Decision
ETS	Emissions Trading System
EU	European Union
EUROBATS	Agreement on the Conservation of Populations of European Bats

FDI	Foreign direct investment
GDP	Gross domestic product
GHG	Greenhouse gas
GNI	Gross national income
GPP	Green public procurement
IEA	International Energy Agency
IED	Industrial emissions Directive
ISEIA	Invasive Species Environmental Impact Assessment
IUCN	International Union for Conservation of Nature
ISO	International Organisation for Standardisation
IWC	International Whaling Commission
LGX	Luxembourg Green Exchange
LIST	Luxembourg Institute of Science and Technology
LSFI	Luxembourg Sustainable Finance Initiative
LULUCF	Land use, land-use change and forestry
MAVDR	Ministry of Agriculture, Viticulture and Rural Development (as of 2018)
MAVPC	Ministry of Agriculture, Viticulture and Consumer Protection
MEA	Ministry of Energy and Spatial Planning (Ministère de l'énergie et de l'aménagement du territoire)
MECDD	Ministry of the Environment, Climate and Sustainable Development (as of 2018) (Ministère de l'environnement, du climat et du développement durable)
MENEJ	Ministry of Education, Children and Youth (Ministère de l'éducation, nationale, de l'enfance et de la jeunesse)
MDDI	Ministry of Sustainable Development and Infrastructure (2009-2018) (Ministère du développement durable et des infrastructures)
Mtoe	Million tonnes of oil equivalent
Modu	Sustainable mobility strategy
NECP	National Energy and Climate Plan
NEEAP	National Energy Efficiency Action Plan
NGO	Non-governmental organisation
NH_3	Ammonia
NMVOC	Non methane volatile organic compounds
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxides
NREAP	National Renewable Energy Action Plan
NZEB	Nearly zero-energy building

ODA	Official development assistance
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
PM_{10}	Particulate matter smaller than 10 microns in diameter
$PM_{2.5}$	Particulate matter smaller than 2.5 microns in diameter
PNDD	National Plan for Sustainable Development
PNPN	National Plan for Nature Conservation
PPP	Purchasing power parity
PRTR	Pollutant Release and Transfer Register
R&D	Research and development
RDP	Rural Development Programme
REDD+	Reducing emissions from deforestation and forest degradation, plus the sustainable management of forests, and the conservation and enhancement of forest carbon stocks
RIA	Regulatory impact analysis
SAC	Special area of conservation
SCI	Site of Community importance
SDGs	Sustainable Development Goals
SDK	SuperDrecksKëscht
SEA	Strategic environmental assessment
SIAS	Multipurpose intermunicipal association
SICONA	Intermunicipal association for nature conservation
SME	Small and medium-sized enterprise
SNB	National Biodiversity Strategy (Stratégie Nationale pour la Biodiversité)
SO_2	Sulphur dioxide
SO_x	Sulphur oxides
SPA	Special protection area
SPMP	Spatial Planning Master Plan
TIR	Third Industrial Revolution
TPES	Total primary energy supply
UCP	Units of pollution load
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States dollar
VAT	Value added tax
VOC	Volatile organic compounds

Basic statistics of Luxembourg, 2018

(or latest available year; OECD values in parenthesis)[1]

PEOPLE AND SOCIETY					
Population (million)	0.6		Population density (inhabitants per km²)	233	(36)
Share of foreigners (residents born abroad) (%)	48		Population annual growth rate, latest 5 years	2.2	(0.6)
Non-resident cross-boarders (million)	0.2		Income inequality (Gini coefficient)	0.30	(0.32)
			Poverty rate (% of population with less than 50% of median income)	8	(12)
			Life expectancy	82	(81)
ECONOMY AND EXTERNAL ACCOUNTS					
Total GDP (EUR, billion)	59		Imports of goods and services (% of GDP)	191	(29)
Total GDP (USD billion, current PPPs)	68		Main exports		
GDP compound annual real growth rate, latest 5 years	2.9	(2.3)	(% of total merchandise exports) Iron and steel	17	
GDP per capita (1 000 USD current PPPs)	112	(46)	Road vehicles	7	
Value added shares (%)			Other industrial machinery and parts	7	
Agriculture	0	(2)	Main imports (% of total merchandise imports)		
Industry including construction	13	(25)	Road vehicles	14	
Services	87	(73)	Oil and oil products	8	
Exports of goods and services (% of GDP)	225	(29)	Metal ores and metal wastes	5	
GENERAL GOVERNMENT Per cent of GDP					
Expenditure	43	(40)	Education expenditure	5.0	(5.1)
Revenue	44	(38)	Health expenditure	4.9	(7.7)
Gross financial debt	31	(110)	Environmental protection expenditure	1.1	(0.5)
Fiscal balance	1.4	-(2.3)	Environmental taxes (% of GDP)	1.8	(1.6)
			(% of total tax revenue)	4.7	(5.3)
LABOUR MARKET, SKILLS AND INNOVATION					
Unemployment rate (% of civilian labour force)	5.6	(5.3)	Patents in environment-related technologies (% of all technologies, average of latest 3 years)[2]	11	(10)
Tertiary educational attainment of 25- to 64-year-olds (%)	44	(36.9)	Environmental management	10	(4)
Gross expenditure on R&D (% of GDP)	1.3	2.37	Water-related adaptation technologies	0.4	(0.5)
			Climate mitigation technologies	7	(8)
ENVIRONMENT					
Energy intensity TPES per capita (toe/cap.)	6.4	(4.1)	Road vehicle stock (vehicles/100 inhabitants)	78	
TPES per GDP (toe/1 000 USD 2010 PPPs)	0.07	(0.10)	Water stress (abstraction as % of available natural resources)	3	(9)
Renewables (% of TPES)	7.5	(10)	Water abstraction per capita (m³/cap./year)	78	(715)
Carbon intensity (energy-related CO_2)			Municipal waste per capita (kg/capita)	614	(520)
Emissions per capita (t/cap.)	14.9	(8.9)	Material productivity (USD, 2010 PPPs/DMC, kg)	4	(2.6)
Emissions per GDP (t/1 000 USD 2010 PPPs)	0.17	(0.23)	Land area (1 000 km²)	3	
GHG intensity[3]			% of arable land and permanent crops	26	(12)
Emissions per capita (t CO_2 eq/cap.)	17.3	(11.9)	% of permanent meadows/pastures	28	(22)
Emissions per GDP (t CO_2 eq/1 000 USD 2010 PPPs)	0.20	(0.31)	% of forest area	36	(31)
Mean population exposure to air pollution ($PM_{2.5}$), µg/m³	10.2	(12.50)	% of other land (built-up/other land)	11	(34)

1. Values earlier than 2013 are not taken into consideration. OECD value: where the OECD aggregate is not provided in the source database, a simple average of latest available data is calculated where data exist for a significant number of countries.

2. Patent applications for higher-value inventions that have sought protection in at least two jurisdictions.

3. Excluding emissions/removals from land use, land-use change and forestry (LULUCF). Emissions expressed in CO_2 equivalent.

Source: Calculations based on data from databases of the OECD, Eurostat, IEA/OECD and World Bank.

Executive summary

Luxembourg has made significant environmental progress ...

Luxembourg is a prosperous economy and financial centre, characterised by a strong international interdependence, an attractive labour market and a growing number of inhabitants and cross-border workers. Until the health crisis caused by COVID-19, its economic growth was well above that of the OECD area. In this context, the country has pursued an ambitious, cross-cutting environmental policy, with some objectives going beyond international and European commitments. The decline since 2005 in energy consumption, greenhouse gas (GHG) emissions and major air pollutants reveals a decoupling from economic growth. This goes hand in hand with a general improvement in air quality. Luxembourg has also caught up in terms of wastewater treatment and tripled the share of renewables in its electricity production.

... but it will have to redouble its efforts to meet future climate and air pollution targets

However, the Luxembourg economic model is beginning to show its limits. Progress is insufficient to alleviate ever-growing pressures and restore a natural environment conducive to biodiversity conservation. The carbon intensity of the economy remains among the highest in the OECD and energy supply remains dependent on fossil fuels. Energy consumption and GHG emissions started to rise again, showing that measures must be strengthened to achieve a 55% reduction in GHG emissions outside the European carbon market by 2030 (compared to 2005), and to achieve climate neutrality by 2050. Further efforts are also needed to eliminate remaining black spots of local pollution, to further reduce exposure to fine particulate matter that remains close to limit values, and to meet emission ceilings by 2030 for nitrogen oxides, volatile organic compounds and ammonia.

... and consolidate the results obtained in waste, materials and water management

Luxembourg encourages waste recovery and the use of secondary raw materials. The Superdreckskëscht system, which has made it a leader in the management of problematic waste, continues to develop. There is, however, a slowdown in progress that could jeopardize the achievement of the recycling targets for 2030 and the implementation of the "Luxembourg Zero Waste" strategy for a circular economy. In particular, an extension of extended producer responsibility and the use of synergies with the development of environmental technologies are necessary.

Luxembourg demonstrates a generally good quantitative management of water resources, but it will need to closely monitor the evolution of water demand in the coming years. Efforts to restore the ecological and hydro-morphological quality of watercourses must be pursued, and the risks of pollution from agricultural sources must be better managed.

Halting the decline in biodiversity requires accelerating the implementation of conservation policies ...

Nature conservation builds on an appropriate institutional, legislative and financial framework. However, biodiversity has been declining for more than forty years. Artificialisation of soils and landscape degradation caused by the intensification of agricultural practices, infrastructure development and urban sprawl are the main causes. Luxembourg is the most highly fragmented country in Europe. The late adoption of the second National Plan for Nature Protection (PNPN) and the delay in the implementation of concrete actions, including the completion of the Natura 2000 network and the network of ecological corridors, have hampered progress. To make up for this delay, Luxembourg has to promptly prepare the next PNPN, with specific objectives, monitoring indicators and increased resources. It will also need to complete the implementation of the management plans for Natura 2000 sites and endangered species.

...and to fully integrate biodiversity into sectoral policies

Integrating biodiversity into policies and decisions on the country's development (transport, land use planning, agriculture, etc.) will be essential. It will also be necessary to support the transition to organic farming and to set up a programme for assessing the socio-economic and cultural value of ecosystem services. This will have to go hand in hand with a review of the costs and benefits of all economic instruments used in biodiversity management or impacting biodiversity, including biodiversity contracts and agricultural and forestry subsidies. Luxembourg has recently renovated its ecological compensation system by introducing ecopoints that give a monetary value to the ecological value of biotopes, and by creating land reserves serving as "pools" for compensation measures.

Reorienting the economy towards a more sustainable model requires more coherent policies and strengthened compliance controls ...

Luxembourg has a solid legal and institutional framework for conducting and coordinating its environmental and sustainable development policies. However, as in other countries, ensuring policy coherence for green growth and sustainable development remains a challenge, particularly in fiscal policy and in the transport, housing and agriculture sectors. One measure that could help is the "sustainability check" of draft laws and regulations foreseen in the Third National Plan for Sustainable Development. Collaboration on compliance monitoring between environmental, water and nature protection administrations could also be strengthened, with increased resources and a proactive planning of inspections based on risk rather than in response to complaints and incidents.

... greener taxation and stronger price signals

Luxembourg has so far made little use of its tax system to achieve environmental objectives. Taxes on road fuels are the main source of environment-related tax revenue. Due to lower tax rates than in neighbouring countries, about 70% of fuel is sold for vehicles not registered in Luxembourg (heavy goods vehicles in transit, cross-border commuters and, to a lesser extent, fuel tourism). Tax advantages for fuel consumption (in agriculture, electricity production and heating) and the generally low cost of energy provide little incentive to invest in renewable energy and energy efficiency. The carbon price signal is among the weakest in OECD European countries.

In recent years, the country has tried to put things right. The introduction of specific carbon pricing announced for 2021 is welcome. It will apply to all petroleum products and natural gas, with an initial price of EUR 20 per tonne of CO_2. The gradual increase, from 2019 onwards, of the tax rates on fuels, especially

diesel, is also a step in the right direction, but may not be enough to curb fuel sales to non-residents. Taxes on road fuels should be increased further to bring them closer to those of neighbouring countries, and the excise rate on diesel should be raised to match the petrol rate. This would bring benefits in terms of GHG emissions, air pollution and road congestion. Losses in revenue due to lower fuel consumption could be compensated by increased use of environmental taxation as part of a broader tax reform. Luxembourg should also introduce a systematic screening and review of potentially environmentally damaging subsidies.

The country can capitalise on its advances in eco-innovation ...

Since 2010, Luxembourg has been a European leader in eco-innovation thanks to increased public funding for research and development, numerous subsidies for environment-related investments and flagship initiatives such as "PRIMe House", "Clever akafen" (Buy Smart) and the Climate Pact with municipalities. However, it is not clear whether all financial support is achieving the desired environmental benefits; their effectiveness could be enhanced. The internal market for "green" goods and services could also be further developed, in particular by acting on the demand side with a clearer policy for green public procurement and stronger price signals for sustainable consumption patterns.

... and is very well placed to develop green and sustainable finance

The Luxembourg Green Stock Exchange, created in 2016, lists half of the world's market for green, sustainable and social bonds. The government committed to develop a national green finance strategy and is active internationally in this area. It could go further: strengthen the legal framework to account for environmental risks and impacts in investment decisions, broaden its scope beyond climate finance (e.g. biodiversity, circular economy), and better exploit synergies with financial technologies (FinTech) and foreign direct investment. In order to ensure the credibility of green financial products and avoid "greenwashing", it should also develop indicators to monitor the environmental impact of investments financed by these products. The climate framework law offers the opportunity to enshrine in legislation the commitment under the Paris Agreement to align capital flows with climate objectives.

Mobility is a major environmental and economic challenge

As a crossroads for goods traffic and a pole of attraction for employment in the Greater Region, Luxembourg attracts every day more than 200,000 cross-border commuters and a dense transit road traffic. This comes with problems of road saturation and air pollution. The vast majority of personal journeys are made by car. More than half of greenhouse gas emissions stem from transport.

To meet mobility needs while improving air quality, the Sustainable Mobility Strategy updated in 2018 (Modu 2.0) sets welcome targets. The aim is to rebalance the modal split and encourage active travel modes (walking, cycling). The country has invested heavily in public transport, rail infrastructure, low-emission buses, park-and-ride facilities, multimodal platforms and bicycle paths. In March 2020, public transport became free of charge in a bid to induce a modal shift. This will have to be accompanied by a better service quality and parking management, the main factors in the choice between private cars and public transport. With the prospect of a private car fleet consisting of almost half of electric vehicles by 2030, the purchase of such vehicles is supported financially and a network of charging stations is being deployed.

Making mobility more sustainable requires a strong collective commitment and coherent incentives

To achieve the country's sustainable mobility objectives, a strong commitment from all actors (state, municipalities, employers, citizens) and an effective cooperation with neighbouring countries and within the European Union is needed. It will also be necessary to exploit the synergies between measures concerning transport, housing, spatial planning, air quality, climate and energy efficiency. This should go hand in hand with an overhaul of the mix of economic instruments applying to transport (fuel taxes, vehicle subsidies and taxes, company car taxes, commuting allowances, road charges) to align it with the objective of sustainable mobility. Finally, the implementation of the package of measures, including free public transport, will need to be closely monitored to assess its real effects on modal split and air quality.

Assessment and recommendations

The Assessment and Recommendations present the main findings of the OECD Environmental Performance Review of Luxembourg. They identify 40 recommendations to help the country make further progress towards its environmental objectives and international commitments. The OECD Working Party for Environmental Performance reviewed and discussed the Assessment and Recommendations on 25 February 2020 and approved them on 27 October 2020.

1. Key environmental trends

Due to its geographical location and size, Luxembourg is characterised by strong international and regional interdependence. Its economy is closely integrated with that of neighbouring countries and is a pole of attraction in the Greater Region.[1] With few exploitable natural resources other than forests, Luxembourg depends on external markets for its energy and raw material supplies. Until the health crisis due to COVID-19, economic growth has been sustained, driven by the financial sector. Services generate 87% of value added, compared to 73% on average in OECD countries (OECD, 2020). Luxembourg is also very densely populated compared with the OECD average. The population has grown significantly since 2005 (+28%) and is expected to continue growing in the coming years. In addition, there are more than 200 000 cross-border workers in the Grand Duchy, representing 44% of the country's labour force.

These characteristics influence levels and patterns of production and consumption (energy, transport, water, land, materials, consumer goods) and housing and infrastructure needs. The resulting pressures on the environment are numerous and strong; some present a challenge, but also represent opportunities for government action. Urban sprawl, landscape fragmentation and the importance of cross-border road traffic entail major social costs, particularly in terms of greenhouse gas (GHG) emissions, air and noise pollution, traffic congestion and ecosystem degradation.

Since 2010, progress has been made in decoupling several environmental pressures from economic growth (e.g. GHG and air pollutant emissions; waste generation; energy consumption; water abstractions) and in wastewater treatment. However, progress remains insufficient to restore a natural environment conducive to biodiversity conservation and to alleviate the growing pressures of demographic development and urbanisation. The economic and institutional context is conducive to further environmental advances and should enable Luxembourg to adopt a greener and more inclusive economic model.

Transition to a low-carbon and energy-efficient economy

Climate and energy policies are closely linked. They are supported by many projects and initiatives in line with European Union (EU) policies, financial aid and information campaigns. The targets are ambitious and progress has been made since the 2010 OECD Environmental Performance Review (EPR) (OECD, 2010). To enable municipalities to play an active role in the fight against climate change and to optimise their energy use in return for financial support and technical assistance, the government has put a Climate Pact in place. An Integrated National Energy and Climate Plan was submitted to the European Commission (EC) in early 2019. The final plan, integrating the EC’s comments, was to be submitted with a slight delay in April 2020. To strengthen the governance and effectiveness of national climate policy, Luxembourg is also preparing a framework law on climate change. This law, whose draft was adopted by the Government Council at the end of November 2019, provides an opportunity to enshrine in legislation GHG mitigation targets and other Paris Agreement commitments, as well as related obligations arising from European climate legislation.

Luxembourg is on track to meet its 2020 energy efficiency targets, but will need to redouble its efforts to meet the 2030 targets

The reduction in energy consumption, particularly in transport and industry following the financial crisis of 2008, puts the country on track to meet its energy efficiency targets under the Europe 2020 strategy. Consumption has fallen by 11% since 2005, much more than the OECD average, and energy intensity has improved (Figure 1). The policies put in place have made it possible to reduce household consumption despite the country's population growth. Transport remains the largest energy consumer, due to the importance of fuel sales to non-residents (cross-border workers, inhabitants of border regions, goods vehicles and private cars in transit). Energy consumption started to rise again in 2016, particularly in transport (IEA, 2020). This shows that current efforts must be maintained and even strengthened to meet

the 2030 energy efficiency targets in a context of sustained economic growth and low energy prices, combined with high purchasing power.

The energy mix is still dominated by fossil fuels

Fossil fuels, mainly oil and natural gas, continue to dominate (78%) the *energy mix*. Their share, which was 91% in 2005, has however decreased in favour of electricity imports and renewable energies. Measures in place to promote renewables have stimulated biogas production from biomass and waste, which has doubled between 2010 and 2018. However, the share of renewables in gross final consumption remains relatively low (9.1% in 2018) compared to the country's 2020 target of 11% (IEA, 2020). To meet the 2020 target, the country uses the co-operation agreements provided in the EU's Renewable Energy Directive. These "statistical transfers[2]" allow countries that have already reached their target to transfer any accounting "surplus" of renewable energy to other countries with a deficit. Luxembourg is also still far from the target of 10% renewables in transport by 2020 (6.5% in 2018), which calls for targeted measures in this sector (Section 4).

National targets to reduce the country's high carbon intensity are ambitious

GHG emissions decreased between 2005 and 2017, due to a shift in the energy mix towards less emitting fuels, and to lower fuel sales to non-residents. However, the carbon intensity of Luxembourg's economy remains high and emissions are rising again. Luxembourg is the fourth largest per capita emitter of GHGs in the OECD; the transport sector is responsible for more than half of these emissions, particularly due to the high share of diesel (78%) in road fuels. The residential sector remains an important source of emissions due to continued population growth and the share of fossil fuels, especially oil for heating. The commercial sector is increasing the most due to the development of services and economic growth (Figure 1).

To achieve its GHG emission reduction target for 2008-12 (-28% compared to 1990), Luxembourg had to make use of the flexibility mechanisms provided for in the Kyoto Protocol, despite an important drop in emissions in the 1990s. Projections indicate that in the absence of strengthened policies and measures, these mechanisms may again be needed to meet current and future targets for emissions not covered by the EU Emissions Trading System (EU ETS)[3]: a 20% reduction in 2020 compared with 2005, and a 40% reduction in 2030 compared with 2005. As part of the draft Integrated National Energy and Climate Plan for the 2021-30 period, Luxembourg has set an even more ambitious target, namely a 50-55% reduction of non-EU ETS emissions in 2030 compared to 2005. By 2050, the aim is to achieve climate neutrality. The high level of these ambitions demonstrates a strong political will that must be translated into equally strong concrete measures, without losing sight of the objectives in the fields of energy, air quality and mobility. As the EU ETS covers only 15% of Luxembourg's emissions, efforts must rely mainly on domestic policies in transport, the residential and commercial sector, and agriculture (AIE, 2020).

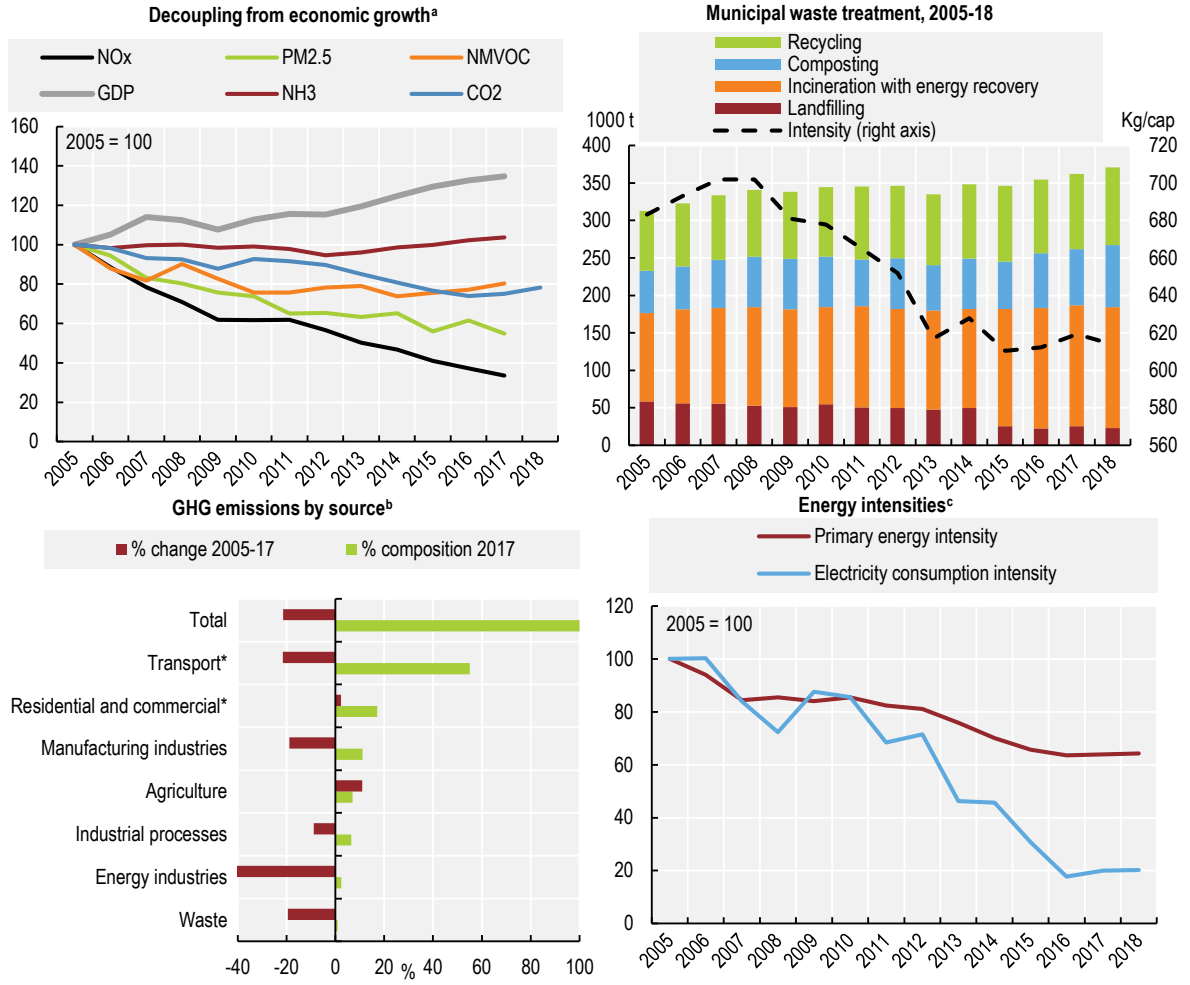
The implementation of climate change adaptation measures should be systematically monitored

Luxembourg is experiencing the impact of climate change, with higher average annual temperatures and more frequent extreme weather events. Flash floods caused a lot of damage and important economic impacts in 2016 and 2018; in August 2019, a tornado damaged the southwestern part of the country and temperatures reached 40.8°C. Scientific forecasts indicate that this trend will intensify. The National Climate Change Adaptation Strategy was revised and expanded in 2018. It identifies the sectors affected by climate change and presents priority actions. The strategy needs to be complemented by a monitoring framework to oversee implementation of adaptation measures. It has also to be noted that despite a highly developed financial sector, insurance instruments do not take adaptation into account as an incentive to invest in risk prevention.

A good decoupling of air pollutant emissions from economic growth, but efforts are needed to meet the 2030 reduction targets

Luxembourg has succeeded in decoupling emissions of the main air pollutants from economic growth: carbon monoxide (CO), sulphur oxides (SO_x), nitrogen oxides (NO_x), fine particulate matter ($PM_{2.5}$), non-methane volatile organic compounds (NMVOC) (Figure 1). Emission reductions are mainly due to the economic crisis of 2008, but also to stricter standards and more efficient technologies in road transport. To comply with the emission ceilings established at European level for 2020 and 2030, Luxembourg will however have to step up its efforts; projections indicate emissions of NO_X, NMVOC, $PM_{2.5}$ and ammonia (NH_3) higher than the ceilings granted. Measures to reduce NH_3 emissions will have to focus on agriculture, which generates 96% of emissions and determines emission trends, on the rise since 2012.

Figure 1. Selected environmental performance indicators



a) CO_2: emissions from fuel combustion. GDP expressed at 2010 prices and purchasing power parities.
b) Total excludes emissions from land use, land use change and forestry. It includes emissions from non-residents. The category "Residential and commercial" also includes fugitive emissions.
c) Primary energy intensity refers to total primary energy supply excluding electricity trade.
Source: OECD (2019), "Air and climate: Air emissions by source", *OECD Environment Statistics* (database); IEA (2019), "Detailed CO2 estimates", *IEA CO2 Emissions from Fuel Combustion Statistics* (database); IEA (2019), "World energy statistics", *IEA World Energy Statistics and Balances* (database); OECD (2019), "Waste: Municipal waste", *OECD Environment Statistics* (database); OECD (2019), "Air and climate: Greenhouse gas emissions by source", *OECD Environment Statistics* (database) ; OECD (2019), "Aggregate National Accounts, 2008 (or SNA 1993): Gross Domestic Product", *OECD National Accounts Statistics* (database).

StatLink https://doi.org/10.1787/888934168322

Air quality has generally improved over the past decade. Average population exposure to $PM_{2.5}$ has decreased by 17% since 2005; it is below the limit value set by EU legislation, but still slightly above 10 micrograms per cubic metre ($\mu g/m^3$), the maximum value recommended by the World Health Organization (WHO) for long-term exposure. The annual average concentrations of particulate matter (PM_{10}) and NO_2 have decreased and are below the daily limit values set by the EU (EEA, 2018). NO_2 concentrations, however, still exceed the annual limit value at critical locations with heavy traffic (City of Luxembourg and surrounding areas). The target values and long-term objectives for ozone (O_3) concentrations are exceeded in rural Luxembourg. This calls for additional efforts to combat pollution in co-ordination with actions in favour of sustainable mobility and increased energy efficiency (Section 4).

Transition to efficient materials and waste management

Luxembourg has few natural resources and largely depends on external markets for its supply of materials. Only 15% of the materials consumed in the country come from the country's natural resources. The relatively high standard of living, the sustained growth of the economy with the daily presence in the country of many cross-border workers and the development of infrastructure generate relatively high consumption of materials and production of waste.

Material consumption is high and generates large amounts of waste

Contrary to the OECD average, domestic material consumption (DMC) has been increasing since 2012. It consists mainly of construction materials, fossil fuels and biomass. Material productivity is among the highest among OECD countries. For 1 tonne of materials consumed, Luxembourg generates approximately USD 3 800 or EUR 3 400 of economic wealth in terms of gross domestic product (GDP) compared with an average of EUR 2 000 in the EU or USD 2 600 in the OECD. Material intensity per capita is high, in particular because of material consumption in Luxembourg by cross-border workers who are not accounted for in national population statistics. A person living in Luxembourg consumes on average 24 tonnes of materials per year. This occurs either in the form of consumer goods or in the form of raw or manufactured materials used in industry or in other sectors of the economy, such as construction or energy production. This level of consumption is well above the OECD average (15 tonnes per capita) and is the source of significant amounts of waste. In 2016, waste generated in the country accounted for almost 75% of materials consumed, with a higher per unit of GDP rate than in most OECD countries.

Luxembourg pursues an active waste and materials management policy

Optimising the use of resources available on the national territory and establishing a circular economy are therefore essential for the country’s development. For many years, Luxembourg has pursued *an active waste and materials management policy* focused on prevention, recovery of high-quality materials and the use of secondary raw materials in the economy. It has a comprehensive regulatory framework and a detailed and ambitious Waste and Resource Management Plan (PNGDR) (the latter was adopted in 2018). This will be complemented by a zero waste strategy and a circular economy strategy. The WRMP includes ambitious targets for waste prevention, reuse and recycling, and for reducing landfilling (MDDI, 2018). It brings the targets of the EU directives for 2025, 2030 and 2035 down to 2022 [recycling rate of municipal waste (55%), recycling rate of packaging waste (at least 70%), landfilling of municipal waste (reduced to 10%)]. This is complemented by training, individual consultancy advice and certification programmes for companies within the framework of the SuperDrecksKëscht© and by numerous information and awareness-raising actions. A first extended producer responsibility system was introduced in 2003. It has gradually been extended and now covers end-of-life vehicles, batteries and accumulators, waste electrical and electronic equipment, and packaging.

Additional efforts are required to maintain a high performance and establish a circular economy

Luxembourg has continued to make progress in implementing its waste management policies and has achieved almost half of its waste management targets (recycling and recovery rates for packaging waste, end-of-life vehicles, and waste electrical and electronic equipment). Other advances include the establishment of areas dedicated to separate collection in residential buildings and supermarkets and on construction sites, and the implementation of food and plastic waste prevention measures (Ecobox, Eco-Sac [Eco Bag]). There has, however, been a slowdown in progress since the last OECD review. Not all measures recommended in the 2010 Waste Management Plan have been implemented; some targets have not been met (the reduction of bulky and infectious waste). Little progress has been made in applying the polluter-pays principle, partly due to the reluctance of some inter-municipal associations and municipalities to establish harmonised cost-recovery systems that take into account the amount of waste for disposal (pay-as-you-throw). The level of recovery of municipal waste (recycling and composting), which had increased in the 2000s, has stagnated at around 50% since 2012 (Figure 1). This reveals an untapped recovery potential. This is especially the case for organic waste, plastics, paper and cardboard, which still account for two-thirds of the mixed waste collected for disposal.

Further efforts are therefore necessary to maintain a high performance and to succeed in the transition to a circular economy. This will need to include measures to encourage municipalities to better co-ordinate their actions, measures to better exploit the stock of materials still contained in mixed household waste, and economic incentives for residents to use the separate collection systems available to them. This is essential to achieve the recycling rate target of 55% of municipal waste by 2022. The application of extended producer responsibility could also be further exploited by extending it to other types of waste such as tyres, furniture or coffee capsules. The implementation of a circular economy will need to encompass measures further upstream of the material value chain. It will also need to draw on synergies with other measures, particularly those concerning the development of environmental technologies and green public procurement. Finally, it must be accompanied by corresponding investment choices. It could be supported by a platform for businesses, banks and other stakeholders to meet and co-operate more widely. The "circular economy" component recently added to the Climate Pact could be used to encourage municipalities to develop initiatives in this area in line with waste objectives and the other components of the pact.

Transition to efficient management of natural resources

A good quantitative management of water resources

Trends show good quantitative management of water resources. Luxembourg has a lower level of renewable fresh water per capita than most OECD countries, but it is not under water stress. Per capita water abstractions are relatively low, but these are projected to increase as a result of population growth, continued economic growth and an expected increase in irrigation. This could be critical during periods of high consumption. This is all the more important as natural groundwater recharge has been largely deficient in the years 2016, 2017 and 2018, resulting in relatively low aquifer levels. The country is also prone to flooding. To ensure the security of drinking water supply, the government is launching water conservation projects for major infrastructure projects. It also intends to strengthen the protection of resources and catchment points, and to assess the potential for using surface water in combination with groundwater.

Insufficient progress in water quality management

With regards to water quality management, Luxembourg has made up for the backlog in wastewater treatment. It completed the infringement procedure launched by the EC to the European Court of Justice for failure to comply with the requirements of the corresponding European directive. Major investments in

the modernisation and extension of the network of treatment plants have been made since 2014. Today all residents are connected; 77% benefit from advanced wastewater treatment. It is further planned to equip the country's main wastewater treatment plants with a fourth level of treatment by 2023, allowing the treatment of micro-pollutants and the elimination of micro-plastics. The wastewater discharge tax is relatively low and does not provide sufficient incentives to reduce the pollution load of discharged water.

Assessments show that the ecological quality of surface waters has improved on average since 2009, but falls short of the results obtained in other countries. This is due particularly to poor hydro-morphological quality, which renaturation efforts aim to restore (Section 5). In 2015, only 3% of natural surface water bodies were classified as being in a "good ecological state" (compared to more than 35% on average in the EU). None of the surface water bodies assessed were in a good chemical state, mainly due to ubiquitous substances. Achievement of the quality objectives set in the EU Water Framework Directive for 2015 has been postponed to 2027. These results can be explained by delays in the implementation of measures foreseen in the water management plans, as well as a lack of coherence between water and agricultural policies. Nutrient surpluses (nitrogen and phosphorus) and pesticides from agricultural sources indicate a risk of soil, water and air pollution (Section 5). Despite declining phosphorus surpluses, stable nitrogen surpluses and a general improvement in nitrate pollution, the latter remains a problem in areas with intensive livestock and dairy farming (EC, 2018). To make farmers more accountable for managing inputs, water and biodiversity, Luxembourg should review the environmental effectiveness of the different economic instruments that apply to agriculture and prepare guides to help farmers adopt more sustainable practices.

Strong pressures on land and biodiversity

Both built-up areas and those occupied by infrastructure have increased in response to demographic and economic growth. This development inhibits the natural functions of soils, contributes to the fragmentation and degradation of natural habitats, and intensifies pressure on biodiversity, which has been in decline for over 40 years (Section 5). The National Plan for Nature Protection (2007-11 and 2017-21) defines national priorities and establishes collaboration between the government and municipalities in certain sectors. The mixed results of the first plan led the government to adapt the national strategy and to adopt more targeted and assessable measures, in line with budgetary and human resources, and to strengthen interdepartmental co-operation.

Progress has been made in identifying areas belonging to the Natura 2000 network, which has paved the way for the creation of specific management plans. However, efforts have not been sufficient to improve the conservation status of habitats and species. One in four known species is threatened. Plants associated with agricultural environments are most at risk of extinction (Section 5).

Box 1. Recommendations on the management of emissions (air and climate), waste and water

Climate and energy

- Adopt the climate framework law as soon as possible; ensure that it includes binding GHG reduction targets and adequate institutional review systems and stakeholder consultation mechanisms; consider incorporating the commitments of the Paris Agreement on financial flows, as well as carbon pricing, into the law.
- Develop scenarios for achieving the 2030 renewable energy and energy efficiency targets, bearing in mind air quality and climate objectives; specify the contribution of each sector to

these objectives, in particular the contribution of current and planned transport measures to reducing road fuel consumption.

- Develop a framework for monitoring the implementation of the Climate Change Adaptation Strategy; ensure that climate change impacts and resilience are duly taken into account in environmental impact assessment (EIA) and strategic environmental assessment (SEA) procedures; include climate risks in insurance products.

Waste and materials management

- Continue implementing the national WRMP; step up efforts to increase the recycling rate of organic, plastic, paper and cardboard waste and to better exploit the stocks of materials in mixed municipal waste; expand the types of products covered by extended producer responsibility: tyres, coffee capsules, furniture, etc.
- Step up efforts to introduce harmonised pricing for municipal waste management throughout the country, taking into account the actual amounts of waste to be disposed of, and encourage municipalities to better co-operate and co-ordinate their actions.
- Adopt a circular economy strategy that sets out the responsibility of each ministry and stakeholder and establishes an implementation roadmap; seek synergies with the development of environmental technologies and green public procurement (GPP); establish a platform for businesses, banks and other stakeholders to meet and co-ordinate their actions.

Water management and agricultural inputs

- Accelerate the implementation of measures to preserve and improve water quality and continue to provide adequate financial and human resources; revise the wastewater discharge tax to strengthen its incentive function; secure the supply of drinking water by applying a more rigorous preventive approach, for example by banning phytopharmaceuticals in sensitive areas.
- Improve the coherence and integration of environmental and agricultural policies; assess the economic and environmental effectiveness of agricultural subsidies; consider introducing taxes or bans on fertilisers and pesticides to help reduce their impact on water and soil quality, biodiversity and human health; encourage the adoption of sustainable agricultural practices by updating the guide on good agricultural practices.

2. Environmental governance and management

Luxembourg has made progress in implementing environmental management recommendations of the 2010 EPR. It has improved co-ordination between the central and local governments and significantly strengthened environmental education. However, more remains to be done with regard to access to environmental information, implementation of SEA and policy evaluation.

Strong environmental authorities need more coherence with other ministries and communes

Three administrations (Environment, Water Management, and Nature and Forest) under the Ministry of Environment, Climate and Sustainable Development (MECDD) perform regulatory and monitoring functions. They have a modern, task-based organisational structure, which increases their efficiency. An issue-specific interagency co-ordination committee oversees implementation of each major environmental law. However, an effective whole-of-government approach to sustainable development could be reinforced, as sectoral interests impede better inter-ministerial collaboration.

Local governments (communes) enjoy substantial autonomy in land-use planning and delivery of environmental services, leading to different practices across the country. Many communes are members of water and/or waste management associations, which are key interlocutors for the central government on local environmental matters. Co-ordination between the central government and communes is challenging, but improving. In addition to routine consultations on draft regulations and strategic plans, the environment ministry has published guidance for communes on several topics to promote good practices. The government also supports local initiatives such as the Climate Pact.

Environmental assessment of policies, spatial plans and regulations requires improvement

Luxembourg's environmental legislation is fully aligned with EU directives and has continued to evolve in such important domains as waste management and nature protection. However, regulatory impact assessment of draft non-environmental laws and regulations does not consider environmental impacts and benefits. The "sustainability check" developed as a tool for such analysis has not yet been implemented. Cost-benefit analysis is not used to evaluate environmental policies, plans and programmes. SEA is undertaken for multiple land use and sectoral plans, but is often superficial and not followed up during their implementation. Ex post evaluation is not consistently used as a management tool.

The system of spatial planning at the national and communal levels is quite complex. It combines strategic, sectoral and locality-specific national plans, as well as two categories of communal land-use plans. Communal plans are not always aligned with national ones and do not sufficiently integrate environmental considerations – they are seldom subject to SEA in their entirety.

Compliance promotion and monitoring are insufficient

Few instances of serious environmental non-compliance are detected. However, few inspections are conducted as a result of the low resources that the government dedicates to compliance monitoring. This means that compliance by classified establishments may be overestimated. Better balance is needed between reaction to complaints (the main trigger for inspections) and proactive risk-based inspection planning. In addition, collaboration in compliance monitoring between the administrations responsible for environment, water and nature protection could be improved. There are some voluntary business initiatives and small incentives for environmental management certification, but more needs to be done to promote compliance and green practices.

In line with a global trend, Luxembourg has recently introduced administrative fines for less serious environmental infringements. However, their use remains minimal. Expanded availability of administrative fines would allow inspectors to use monetary penalties more without resorting to criminal enforcement. In addition, the rates of both administrative and criminal penalties are too low to have a deterrent impact.

There is strict liability for damage to the environment, but financial guarantees against such damage are systematically required only for installations covered by the Industrial Emissions Directive, those treating waste and those storing large amounts of hazardous substances. As part of the implementation of the liability regime, the much-needed new law on soil protection and management of contaminated sites would require the government to develop a remediation programme, a move recommended by the 2010 EPR, but still lacking. Adoption of the law, however, has been delayed.

Environmental information should be more accessible

The country is quite advanced in matters of environmental democracy. Public participation is part of EIA and permitting processes, as well as of the development of sectoral strategic plans, which is a good practice. The administrative justice system is also accessible. Significant efforts have been made in the last decade to improve environmental and sustainable development education.

Access to environmental information is legally guaranteed, but information is not always easily available or user-friendly. Luxembourg has not published a state of the environment report since 2003.

Box 2. Recommendations on environmental governance and management

Strengthening the institutional and regulatory framework

- Reinforce institutional co-ordination to achieve coherent sustainable development policies across the central government and harmonised implementation practices at the local level.
- Introduce environmental aspects into the assessment of draft laws and regulations, including via the "sustainability check"; apply cost-benefit analysis in *ex ante* evaluation of environmental policies and legislation; expand the use of their *ex post* evaluation.
- Ensure consistent application of SEA to all communal land-use plans and their better alignment with national sustainable development policies through increased co-ordination between the ministries responsible for the environment, spatial planning and local government.

Improving compliance assurance

- Enhance resources dedicated to compliance promotion and monitoring; increase the number of proactive risk-based inspections; reinforce collaboration between the three environmental administrations through an integrated compliance assurance strategy.
- Expand the use of administrative fines, while ensuring their proportionality to the gravity of infringements; review the levels of administrative and criminal fines to increase their deterrent impact; provide guidance to inspectors on imposition of sanctions.
- Adopt the draft law on soil protection and management of contaminated sites; establish a programme for remediating contaminated sites, including abandoned ones.

Enhancing environmental democracy

- Improve the user-friendliness of environmental information and its full accessibility for the public, including regular publication of a state of the environment report and related indicators, as well as inspection reports; ensure that sufficient resources are available for dissemination of environmental information.

3. Green growth

Luxembourg is one of the most dynamic economies in the OECD and its growing population enjoys a high quality of life. However, the country's economic model has started to show its environmental and social limits. Luxembourg needs to accelerate its ongoing efforts to diversify its economy towards a greener and more inclusive model that puts people's well-being and the respect for the natural environment at the heart of policy making. The 2016 strategic study "Third Industrial Revolution" is a good basis to continue on the path towards economic diversification. It provides a foundation for exploiting the synergies between environment and innovation, digitalisation, circular economy, renewables and energy efficiency, as recommended by the 2010 EPR. This is all the more necessary to ensure an environmentally and socially sustainable recovery from the economic impact of the COVID-19 pandemic. To this end, Luxembourg should convey strong and consistent price signals, remove potentially harmful incentives (especially in the transport sector) and further promote innovation.

Luxembourg has a comprehensive framework for sustainable development

Luxembourg has a sound legal and institutional framework to co-ordinate the national policy on sustainable development and monitor its implementation. In 2017, it presented the voluntary review of the implementation of the Sustainable Development Goals (SDGs) to the United Nations (UN) High-level Political Forum on Sustainable Development. In December 2019, the government adopted the third National Plan for Sustainable Development (PNDD), which was developed through a broad participatory process. The plan is inspired by the UN Agenda 2030 and encompasses the SDGs. However, as in all OECD member countries, ensuring policy coherence and effective integration of environmental considerations into sectoral policies remains a challenge. Insufficient policy co-ordination is more evident in the transport, housing and agriculture sectors and fiscal policy. Systematic and thorough implementation of the "sustainability check" of proposed legislation and regulations (Section 2), as foreseen by the PNDD, could help improve policy coherence.

There is scope to green the tax system and remove harmful incentives

Road fuel sales to non-residents are the main source of environmentally related tax revenue

Luxembourg has made little use of its tax system to achieve environmental objectives. Environmentally related taxes are levied on energy products, vehicles and water abstractions and polluting discharges. Taxes on energy products, mostly road fuels, make up more than 90% of environmentally related tax revenue. They have traditionally represented an important source of revenue in Luxembourg. This reflects the large amounts of fuel exports to heavy-duty vehicles in transit, daily cross-border commuters and, to a lesser extent, fuel tourists induced by lower tax rates than in neighbouring countries. When considering fiscal revenue, employment and income generated by petrol stations and related services, estimated economic benefits of fuel sales amount to EUR 2 billion per year. However, the estimated environmental and health costs are much higher. They are put at EUR 3.5 billion per year, three-quarters of which are from fuel exports (Ewringmann, 2016).

Declining world oil prices in 2012-16 partly eroded Luxembourg's fuel price advantage and the incentive to travel the extra time and distance just to refuel in the country. This, together with some tax adjustments in neighbouring countries, resulted in decreasing fuel exports and associated tax revenue in the same period (Ewringmann, 2016). Fuel sales and related tax revenue have increased again since 2017. Nevertheless, revenue from environmentally related taxes declined to 4.5% of tax revenue in 2018, below the 6.3% average of OECD Europe countries. This is a marked drop from the second half of the 2000s. At that time, revenue from these taxes accounted for a larger share of tax revenue than in most OECD Europe countries.

Experience shows that tax revenue from fuel exports is not stable, as well as being environmentally questionable. Gradually increasing fuel tax rates to bring them closer to those of neighbouring countries is necessary. This would bring benefits in terms of reduced fuel consumption, GHG emissions, air pollution and congestion, although it could result in substantial revenue losses. Luxembourg's resilience to declining fuel tax revenue in 2012-16 suggests that such losses could be relatively easily addressed. As indicated in the 2010 EPR, Luxembourg would benefit from a broader tax reform to make its tax and benefit system more coherent with the sustainable development ambition of the country. Such reform should coherently consider energy taxes and carbon pricing, taxation of vehicles and road use (Section 4) and levies directly aimed at reducing air, water and soil pollution (Section 1).

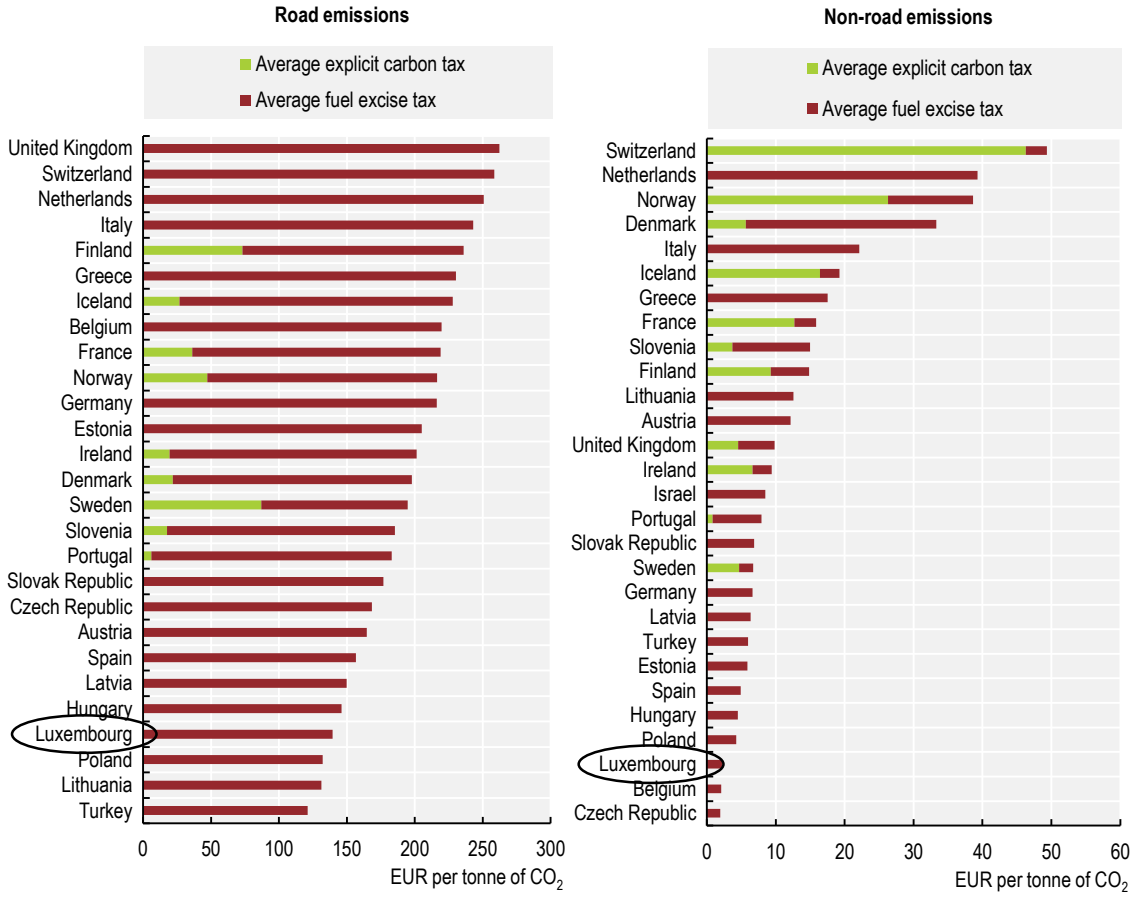
The carbon price signal is weak

Luxembourg puts a price on GHG emissions via energy taxes and participation in the EU Emissions Trading System (EU ETS). The EU ETS covers only about 15% of domestic emissions, due to the country's

service-based economy, largely imported electricity and major share of emissions from transport (Section 1). Most CO_2 emissions are priced via energy taxes, which are low and subject to several exemptions (see below). Effective tax rates on energy-related CO_2 emissions are among the lowest in OECD Europe (Figure 2; OECD, 2019a). In addition, the average tax rate on CO_2 emissions from fuels used in sectors other than road transport is just above EUR 2 per tonne of CO_2. This rate is well below EUR 30 per tonne of CO_2, the low-end benchmark of the climate costs of CO_2 emissions, which is not sufficient to meet the objectives of the Paris Agreement (OECD, 2019a). The 2019 National Energy and Climate Plan foresees the introduction of specific carbon pricing as from 2021. The initial price of EUR 20 per tonne of CO_2 would be gradually increased. This is a welcome announcement.

Figure 2. Effective carbon tax rates are among the lowest in OECD Europe

Effective tax rates on CO_2 emissions from energy use in the road and non-road sectors, OECD Europe, 2018



Note: 2018 tax rates as applicable on 1 July 2018.
Source: OECD (2019), *Taxing Energy Use 2019: Using Taxes for Climate Action.*

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Tax discounts for fuel use run counter to energy savings objectives

The low cost of energy provides little incentive to invest in renewables and energy efficiency (IEA, 2020), and to move towards sustainable mobility. The government committed to increase tax rates on road fuels. After nearly seven years of stable tax rates, excise rates on road fuels increased in May 2019. New hikes were announced as from the first half of 2020, with a higher increase for diesel than for petrol. This is a step in the right direction, although such increases do not appear sufficient to discourage non-residents,

and primarily heavy-duty vehicles in transit, to refuel in Luxembourg. Energy taxes should be increased further. In particular, Luxembourg should consider raising the diesel excise rate to match the petrol rate. More broadly, Luxembourg should review the mix of taxes and charges in the transport sector (fuel taxes, vehicle taxes and subsidies, taxation of company cars and commuting allowances, and road charges), to make it consistent with the objective of sustainable mobility (Section 4).

Little progress has been made to follow up on the OECD recommendation to identify and remove environmentally harmful subsidies and tax provisions (OECD, 2010). Energy products used in sectors such as farming, electricity generation and heating still benefit from total or partial exemptions from excise duties, as well as a reduced rate of the value added tax (VAT). This further undermines the carbon price signal and the government's efforts to improve energy efficiency and reduce CO_2 emissions across the economy.

The government commissioned a study to identify and quantify environmentally harmful subsidies. The 2018 study identified seven types of such subsidies in Luxembourg. These included reduced excise and VAT rates on energy products, the tax disparity between diesel and petrol, and the favourable tax treatment of company cars and commuting expenses. Overall, the annual cost of these subsidies is estimated to vary between EUR 750 million and EUR 1 billion (Ewringmann and Deloitte Tax & Consulting, 2018). Luxembourg should build on this study to establish a process for the systematic review and screening of potentially environmentally harmful subsidies.

Promoting eco-innovation is, and should remain, a priority

Increased policy focus and investment in eco-innovation have yielded results

The 2016 Third Industrial Revolution study and the 2017 Research and Innovation Smart Specialisation Strategy identify clean technology and the circular economy among key policy priorities on the path towards the country's economic diversification. Eco-innovation and the circular economy are integrated into innovation promotion programmes, such as the Fit4Circularity programme.

With increased public funding for research and development (R&D), Luxembourg has acquired a specialisation in environmental technology in recent years. It spends 3.6% of the government R&D budget on environment-related R&D, putting it among the top ten OECD member countries. Patent applications for environment-related technology reached 12% of all patent applications in 2014-16. The clean technology sector is relatively small, however. Its contribution to the future of Luxembourg's economy is difficult to assess (ODC, 2018). While Luxembourg should continue to support environment-related R&D, it should systematically evaluate the efficiency and environmental effectiveness of its support programmes.

Higher demand is needed to expand the markets for cleaner goods and services

Compared to the EU average, slightly more small and medium-sized enterprises (SMEs) design and produce greener products in Luxembourg. However, the country's SMEs have a lower propensity to invest in improving their environmental performance than on average in the EU, with the exception of investment in recycling and renewables. The environmental goods and services sector remains small. It accounted for about 2% of gross added value in 2008-16.

The small domestic market and still low demand for cleaner technology, products and services are the main barrier to eco-innovation. Measures such as the subsidies for electric cars and bicycles (Section 4) and the nearly zero-energy building standard for new buildings help stimulate demand for cleaner transport and building solutions. The campaign and label "Clever akafen" (Smart shopping) is a good practice to encourage environment-friendly consumer choices. However, more efforts are needed on the demand side, primarily to ensure that prices of energy and of water and waste services adequately reflect the environmental and social costs of resource use and pollution. A clearer GPP policy would also help. While

the public procurement law encourages contracting authorities to look at environmental criteria, these are not mandatory and there are no GPP targets (EC, 2019).

Effectiveness of support for environment-related investment could be enhanced

Luxembourg provides various forms of financial support to environment-related investment by local governments, companies and individuals. Some State aid has been increased as part of the fiscal stimulus to help the economy recover from the consequences of the COVID-19 pandemic. The MECDD manages three investment funds for climate and energy, environmental protection and water management. However, the environmental effectiveness of projects financed by these funds is not evaluated *ex post*. There is a risk of using public funds to finance projects that provide few, if any, additional environmental benefits.

Luxembourg's policy focus on climate change mitigation has led to increasing subsidies to renewables and energy efficiency investment. Feed-in tariffs, premium tariffs and investment subsidies have contributed to the growth of renewable electricity generation (Section 1). In 2015-19, about EUR 20 million was disbursed to finance energy efficiency renovation of residential buildings under the flagship PRIMe House grant programme. In 2017, Luxembourg launched the KlimaBank (Climate Bank) programme, which provides zero- or low-interest loans to households and companies for energy efficiency renovations. All municipalities have signed the Climate Pact, a co-operative agreement though which local governments commit to implement certain environment- and climate-related measures out of a catalogue of 79. In return, they receive government financial and technical assistance, as well as an environmental certification.

It is not clear whether this public financial assistance is delivering energy savings and environmental benefits to the desired extent. The building renovation rate in Luxembourg is low, less than 1% in 2017 (IEA, 2020). There is a lack of interest in energy renovation, mainly due to the high cost of these projects, the overall pressure on the housing market, the complexity of administrative procedures and the nuisance caused by renovation works. Energy prices are too low to encourage renovation investment, especially when considering the high average income of households. Further efforts are needed to increase public awareness about support programmes, as well as to facilitate access to them.

Luxembourg is a green finance hub

The financial sector is a pillar of Luxembourg's economy. Since the first-ever green bond was listed on the Luxembourg Stock Exchange in 2007, the country has grown as a green finance centre. It established the Luxembourg Green Exchange in 2016, which lists nearly EUR 200 billion in green, sustainable and social bonds, or half of the world market. LuxFLAG, the Luxembourg labelling agency, launched the Climate Finance Label in 2016 and the Green Bond Label in 2017. These labels aim to improve the transparency of climate and green investment instruments and ensure investor confidence in this market. In 2018, Luxembourg adopted a legal framework for a renewable energy covered bond. The budget law for 2020 provides the legal basis for the issuance of government sustainable bonds.

The government committed to implement the recommendations of the 2018 Luxembourg Sustainable Finance Roadmap, drafted in partnership with the UN Environment Programme. Under the joint leadership of the environment and finance ministers, it established the Luxembourg Sustainable Finance Initiative to develop a national green finance strategy. Ultimately, the strategy aims to provide a framework to accelerate the development of green and sustainable finance to help meet the goals of the Paris Agreement and, more broadly, the SDGs. This would provide a coherent umbrella to the multiplicity of initiatives.

Luxembourg has adopted a multi-stakeholder approach to green finance, with a strong focus on public-private green finance initiatives and partnerships. The vast majority of initiatives focus on investment to mitigate climate change. Examples include the Forestry and Climate Change Fund, the International

Climate Finance Accelerator and the joint Luxembourg-European Investment Bank Climate Finance Platform. Other environmental issues, including biodiversity conservation, water, pollution and circular economy, deserve more attention. In addition, Luxembourg could further exploit the synergies between financial technology (FinTech) and green finance.

It is difficult to measure the actual environmental impact of the investment funded through green finance instruments. There is a lack of indicators and monitoring measures that would ensure the credibility of financial products, measure their environmental impact and avoid "greenwashing". There is also a need to develop a legal framework for considering environmental risks and impact in investment decisions. Asset managers and institutional investors are not required to disclose their exposure to climate risks. The financial and insurance market regulators do not have a mandate to assess the effects of climate change risks on financial stability, or to take actions to mitigate them.

The climate framework law (under discussion at the time of writing) offers an opportunity to enshrine in legislation the commitment under the Paris Agreement of "making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development" (Article 2.1c). In line with this commitment, the central and local governments could lead by example. For instance, they could pledge to measure, report and reduce the environmental and social impact of public investments, sovereign wealth funds and public pensions.

Luxembourg is a generous donor, but could reinforce the environmental component of its development co-operation

Luxembourg devotes 1% of its gross national income (GNI) to official development assistance (ODA), one of the few members of the OECD Development Assistance Committee to exceed the UN target of 0.7% of GNI. Helping developing countries mitigate and adapt to climate change is a priority, which translates to a high level of financial commitment. Luxembourg pledged EUR 120 million in 2014-20 and EUR 200 million in 2020-25 to support developing countries' climate actions. These funds come on top of ODA. Excluding international climate finance, about one-third of bilateral aid has environmental protection as a primary or significant objective, which is relatively low compared to other donors. Luxembourg launched a revision of its aid database to better assess the allocation of bilateral aid for environmental protection and make more accurate comparisons between countries. There is also scope to further harness the potential of Luxembourg's strong financial centre to leverage private finance for development (OECD, 2017).

The 2018 Development Co-operation Strategy is in line with the SDGs. In 2012, the Luxembourg Development Co-operation Agency developed guidance to consider environmental sustainability, together with the other cross-cutting dimensions (human rights and gender equality), in its development activities. Environmental issues are systematically assessed once projects have been identified. However, environmental opportunities and threats are not strategically considered during the elaboration of country-specific development programmes, and guidance for implementation is not sufficient (OECD, 2017). The agency plans to complement its guidance with environmental and social safeguards. There is also a need to strengthen capacity of authorities to mainstream the environmental and other cross-cutting dimensions into development activities.

Box 3. Recommendations on green growth

Greening the system of taxes and subsidies

- Progressively raise tax rates on energy products to ensure they reflect the environmental and other social costs of energy use in the framework of a broader reform of the tax and benefits system; in particular, raise the diesel excise rate to match the petrol rate, and continue to gradually reduce the tax gap with neighbouring countries.
- Follow through on the plan to introduce carbon pricing in sectors not covered by the EU ETS; ensure systematic monitoring of the effect of carbon pricing on energy use and GHG emissions and adjust prices as appropriate.
- Systematically monitor and assess subsidies and tax provisions to identify and remove those that are not justified on economic, social and environmental grounds.

Promoting eco-innovation and environment-friendly investment

- Continue to support environment-related R&D, with a focus on SMEs; systematically evaluate the efficiency and environmental effectiveness of R&D support programmes.
- Develop and implement a clear policy on GPP by integrating mandatory environmental criteria and targets into public procurement regulations.
- Streamline and better target public financial assistance for environment- and climate-related investment; ensure that financed projects are the most cost-effective and provide additional environmental benefits; conduct systematic ex post evaluation of the environmental impact of the financed projects, and assess their contribution to environmental, climate and energy targets.

Greening financial markets

- Develop a legal framework for taking environmental risks and impact into account in investment decisions, for example by extending the fiduciary duty of asset managers and institutional investors and requiring the financial and insurance market regulators to assess exposure to climate change risks and take actions to mitigate them.
- Consider integrating the commitment under Article 2.1c of the Paris Agreement into the climate framework law.
- Extend the focus of green finance initiatives “beyond climate” (e.g. to water, biodiversity and circular economy) and develop measures to fully exploit the potential of financial technology in greening financial flows.
- Develop official statistics and indicators for green and sustainable finance, with a view to monitoring the environmental impact of green finance products.

Mainstreaming environment into development co-operation

- Maintain the commitment to international climate finance and further increase environment-focused aid; strengthen guidance and capacity for the environmental mainstreaming of development co-operation activities; continue to explore opportunities for leveraging private funds for development.

4. Air quality and sustainable mobility

Luxembourg's economic attractiveness and geographical location represent a challenge

For several years now, Luxembourg has been facing constant increases in national, cross-border and international road traffic, problems of saturation of the road network and a growing need for mobility for professional and private purposes. Due to its geographical location, Luxembourg is a crossroads for goods traffic and a pole of attraction for employment in the Greater Region. More than 44% of jobs are held by cross-border commuters who live in neighbouring countries and commute daily. Added to this is an energy tax system that keeps road fuel prices below those of neighbouring countries and is the source of significant fuel exports (Section 3). About 70% of road fuels are sold for vehicles not registered in Luxembourg. Per capita fuel sales are thus several times higher than in other OECD countries. In the coming years, Luxembourg will continue to attract cross-border residents and workers, which risks further exacerbating problems of urban sprawl and congestion, and the environmental costs associated with them.

These developments represent a particular challenge for the government, which has been working for many years to reduce air emissions and improve public transit. Public transport in the City of Luxembourg is cheap compared with those in cities of a similar size in other countries, and for several years now it has been free on certain weekends. Significant investments have been made in the development of rail infrastructure, the creation of park-and-ride facilities and multimodal platforms, as well as the purchase of low-emission buses. Despite this, the vast majority of personal trips are made by car – 67% compared to only 17% by public transport. The car ownership rate is the highest in Europe (over 600 registered private cars per 1 000 inhabitants). The car fleet is relatively young, but with an average engine capacity higher than in other countries.

Progress on air pollution remains insufficient

Despite significant declines, the transport sector remains a major source of air pollution

Since 2010, Luxembourg has made progress in reducing emissions of air pollutants. However, it will have to redouble its efforts so as to meet the reduction targets set by European directives. Road transport emissions have fallen more sharply between 2005 and 2017 than emissions from other sources (by 76% for NO_x; by 71% for $PM_{2.5}$). These decreases are mainly due to reductions in emissions from fuel combustion. They can be explained partly by the effects of the economic crisis in 2008, which had repercussions on freight traffic and by the renewal of the car fleet with vehicles meeting stricter emission standards, and partly by the fall in international oil prices and a slight increase in taxes on road fuels, which led to a drop in fuel sales to non-residents (Section 3). That said, the share of emissions from non-residents remains high compared to other countries. Rising international oil prices have led to a further increase in export sales in 2017, which will in turn drive emissions upwards (Figure 3). Road transport remains the largest source of NO_x emissions (58%) and a major source of $PM_{2.5}$ (32%), PM_{10} (34%) and CO emissions (38%).

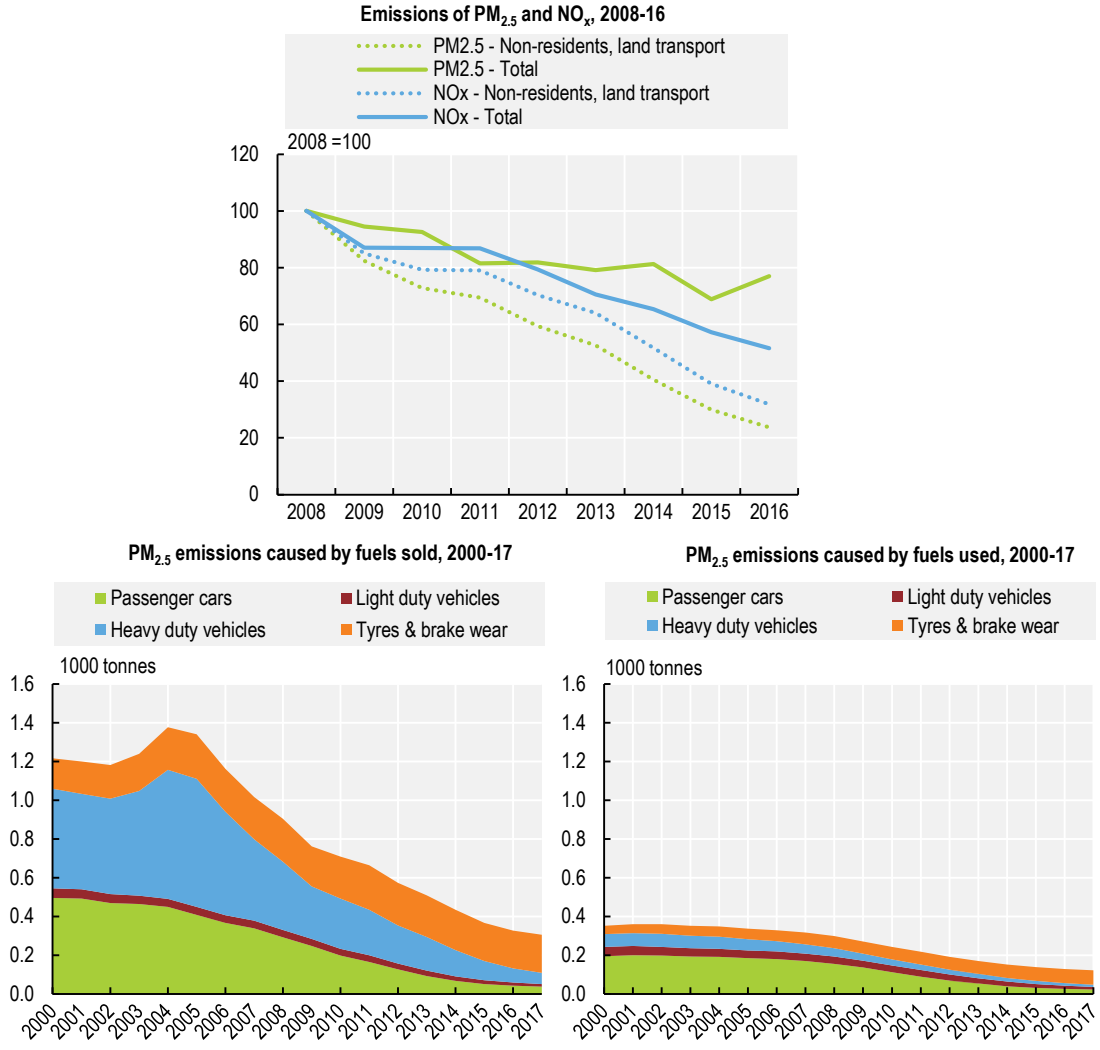
Emissions of $PM_{2.5}$ due to tyre wear and road surfaces deserve special attention. In contrast to combustion emissions, they are increasing. They may increase still further as the car fleet includes more hybrid and electric vehicles, some of which are heavier than others.

The housing sector is a major contributor to fine particle emissions

For CO and PM, the share of road transport is now lower than that of all stationary emission sources as a whole. To achieve the objectives of reducing emissions of these pollutants, more attention will have to be paid to measures concerning stationary sources. One source that should not be neglected is the housing sector, which also plays an important role in achieving energy efficiency and renewable energy targets (Section 1). Like other countries, Luxembourg has for several years been promoting the use of biomass

as a renewable energy source for individual heating and to reduce GHG emissions. However, the combustion of biomass for residential heating currently accounts for almost 40% of $PM_{2.5}$ emissions. There is therefore a trade-off between promoting biomass to meet renewable energy and GHG emission targets and the objective of reducing $PM_{2.5}$ emissions. Biomass would be better used in large cogeneration plants where emissions can be controlled and reduced at lower cost.

Figure 3. Emissions from non-residents are major contributors to transport emissions



Note: Fuel combustion by passenger cars and light and heavy duty vehicles, as well as by tyres and brake wear from all vehicle categories.
Source: OECD (2019), "Air and climate: Air and greenhouse gas emissions by industry", *OECD Environment Statistics* (database); Administration de l'Environnement (2019), Luxembourg's Informative Inventory Report 1990-2017.

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Air quality is improving, but black spots persist

Declining emissions have been accompanied by a general improvement in air quality, but black spots of concern persist. Annual average concentrations of PM_{10} and NO_2 have fallen and are below the daily limit values set by EU legislation. Average population exposure to $PM_{2.5}$ has diminished since 2005. 73% of the population is still exposed to concentrations above 10 µg/m^3, the maximum value recommended by the WHO. However, no one is exposed to concentrations greater than 15 µg/m^3 (OECD, 2019b). The mortality

rate due to exposure to fine particles is estimated to be relatively low in international comparison, but still accounts for nearly 150 premature deaths each year (OECD, 2019b). The estimated social costs of air pollution are high, partly due to the high average income in the country. NO_2 concentrations continue to exceed the limit value in Luxembourg City in areas with heavy traffic. The decrease in pollution levels following the introduction of low-emission buses has not been sufficient to eliminate these black spots ("hot spots"). Further efforts will be necessary.

Luxembourg has adopted an ambitious plan to meet mobility challenges

Measures taken to reduce emissions and improve air quality include both energy efficiency and renewable energy measures (building renovation and construction; heating systems; insulation; industrial processes), and measures related to mobility and transport. Significant efforts are underway to improve mobility within the country and the Greater Region, rebalance the modal split and encourage soft modes of transport (walking, cycling) as part of an ambitious sustainable mobility plan (Modu). The current plan adopted in 2018 (Modu 2.0) defines the objectives for 2025 and proposes a wide range of measures to achieve them. Luxembourg has some catching up to do, especially outside Luxembourg City, in connections between villages and small rural towns and between Luxembourg and its neighbouring countries.

Major investments continue to be made in transport infrastructure and public transport, with the construction of several tramlines in Luxembourg City and a gradual improvement in the rail service by 2023, or even 2028. This is accompanied by a car-sharing scheme that is available to the inhabitants of the Greater Region, as well as by an increase in park-and-ride facilities in the country and its border regions. Efforts are also being made to integrate cycling as a mode of transport into all transport infrastructures and offers, and to set up a national cycling network.

The promotion of public transport also involves the introduction of free public transport on Luxembourg territory from March 2020 (only first class travel will be charged). This measure concerns transport services financed by the state and Luxembourg City and will also benefit cross-border commuters. Full free public transport raises questions as to the economic and environmental relevance of this measure, which is intended to be a strong signal and a catalyst to induce changes in the choice of transport modes. It will be accompanied by strong measures to improve the quality of service and parking space management, the main factors in the choice between private cars and public transport. It will also have to be followed up by an *ex-post* evaluation of the real effects of the package of measures, including free public transport, on the modal split, air quality and the quality of life of residents. Although the sale of public transport tickets now covers only 10% of the costs, full free public transport will increase operating costs and represent a loss of revenue of about EUR 40-45 million per year for the state.

Luxembourg has also launched an e-mobility initiative with the aim of electrifying the transport sector and thus reducing emissions of GHGs and air pollutants. By 2030, the public transport bus fleet is planned to be fully electric. A network of electric recharging stations is being installed and the use of electric and plug-in hybrid vehicles is being encouraged. Starting in 2017, the government has financially encouraged the purchase and use of low- or zero-emission vehicles through income tax reductions for the purchase of electric or hybrid vehicles and through the tax treatment of company vehicles. However, these incentives were too small to have a real impact on the choice of vehicle type. Since January 2019, a new system of incentives has been in place. Luxembourg now directly subsidises the purchase of new electric vehicles by individuals and companies in the form of a bonus. It varies according to the type of vehicle (EUR 5 000 for 100% electric vehicles; EUR 2 500 for plug-in hybrid vehicles; up to EUR 500 for electric motorcycles and up to EUR 300 for regular and electric bicycles).

Greater coherence of measures and a stronger commitment of all actors are indispensable

The measures proposed and the objectives that Luxembourg has set itself are ambitious. Their achievement will depend on the level of commitment of all players (state, municipalities, employers, citizens, cross-border workers); co-ordination between the national and local levels; and co-operation with neighbouring countries within the Greater Region. Policy coherence and Luxembourg's ability to exploit synergies between measures concerning transport and mobility, housing (construction, heating), spatial planning, air quality, climate and energy efficiency will be crucial.

The involvement of municipalities and companies should be encouraged

The transition to sustainable mobility will have to be based on good co-ordination with municipalities and businesses, particularly as regards the necessary reassessment of car parking space requirements, the introduction of car-sharing systems or the organisation of working hours. The commitment of municipalities is particularly important to integrate mobility and air quality issues into local development plans, and to ensure coherence with other spatial planning tools (spatial planning master plan, sectoral master plans) and with climate and energy efficiency measures. This can be supported by the Climate Pact, which includes mobility-related measures and, since 2017, an "air quality" component, and rewards the action of municipalities in these areas.

The effectiveness of the economic instruments that apply to transport needs to be reviewed

The combination of the different financial incentives in place in the transport sector is still not conducive to sustainable mobility and to the internalisation of external environmental costs. Despite the increase in excise duty rates in 2019, petrol and diesel prices remain too low to reduce emissions from fuel sales to non-residents and encourage a shift away from cars to other modes of transport. Fuel taxes, in particular on diesel, should therefore be further increased (Section 3).

The annual vehicle tax does not provide a strong incentive to influence the choice of vehicle type and to encourage the purchase of electric or low-emission vehicles. The tax treatment of company vehicles favours petrol-powered vehicles, but the use of a company vehicle remains a source of fiscal advantages for employees. This encourages car use at the expense of public transport and active modes of travel (cycling, walking), especially at peak times when congestion levels are highest. These benefits could be taxed more heavily with differentiation according to the distance travelled. In addition, the possibility of deducting commuting expenses from taxable income provides an incentive to live farther away from the workplace and thus creates a demand for additional mobility.

In general, Luxembourg will have to continue its efforts to internalise external environmental costs and review the costs and benefits of the various financial aids (premiums, subsidies), taxes (on fuel, cars, service vehicles) and other financial incentives to ensure they contribute to the sustainable mobility objectives set by the government. It should reinforce the pricing policy of parking spaces, so as to relieve congestion of the road network and encourage car-pooling. It could also consider introducing a road toll system.

The impacts of the measures put in place should be monitored and evaluated

In the coming years, it will be important to monitor the evolution of mobility needs and to assess the impacts in terms of costs and benefits of the various measures introduced, including free public transport. This will have to be based on a solid and reliable information base with accurate, complete and up-to-date data, including data on activity levels in the different modes of transport. In the past, such information has been lacking. However, efforts are being made to develop new assessment tools to guide the choices still to be made in terms of sustainable mobility. This will have to be accompanied by sufficient resources to ensure regular monitoring, notably by the mobility observatory that is being established.

Box 4. Recommendations on air quality and sustainable mobility

Air pollution management

- Take the most cost-effective measures across all sources and sectors to achieve the 2030 emission reduction objectives of major air pollutants; assess the social cost and benefits of measures to reduce emissions of local air pollutants caused by stationary sources.
- Limit the use of wood biomass to installations where air pollutant emissions can be controlled effectively and at reasonable costs per unit of heat energy generated (e.g. large heat-generation installations with electrical co-production).
- Carry out *ex post* assessments of various new means of public transport expected to cause low amounts of air pollution to verify these vehicles also have low emissions under real-world operating conditions.

Promotion of sustainable mobility

- Promote increased institutional co-ordination on spatial planning to advance sustainable mobility policies and measures and fully use the synergies with policies and measures concerning energy, climate and air quality.
- Evaluate within two-three years the experiences gained from measures that encourage the use of public transport, car-pooling and active mobility, including the introduction of free public transport; ensure proper investments to improve the quality of public transport (more frequent departures, more comfortable equipment, etc.).
- Review the environmental and economic effectiveness of the mix of economic instruments that apply to transport and mobility; increase vehicle taxation and revise the rates to take account of emissions of both CO_2 and local air pollutants; consider reducing the fiscal benefits accruing to employees when using a company-owned vehicle for private purposes and introducing a differentiation by distance driven; reinforce the pricing policy of parking spaces; and evaluate the possibility of creating road tolls.
- Invest sufficient resources in developing systems necessary for obtaining accurate, comprehensive and up-to-date data for sustainable mobility planning, including data on activity levels in different transport modes.

5. Biodiversity

Luxembourg pursues an active nature protection and conservation policy and has made progress in implementing the recommendations of the latest OECD review. However, despite an appropriate institutional, legislative, financial and strategic framework, progress has been slow. There have been delays in the concrete implementation of action plans on the ground or in the restoration of ecosystems.

Strong pressures and ambitious objectives

The state of Luxembourg's biodiversity is determined on the one hand by a rapidly expanding population and economy, and on the other by environmental pressures from neighbouring regions. These regions are the most populated and most developed on the continent. Pressures on biodiversity are high, with high degrees of soil artificialisation and habitat fragmentation. The conservation status of species is mostly

unfavourable. There has also been continuous degradation over the past four decades of biodiversity-rich habitats such as wetlands, dry grasslands and extensively used orchards. The observed decline follows the trend towards homogenisation of landscapes due to intensification of agricultural practices, urban development and sprawl, and increased density of transport infrastructure (MDDI, 2017). Luxembourg is the most fragmented country in Europe; the built-up area has doubled between 1960 and today.

The objective of the National Plan for the Protection of Nature for 2007-11 (PNPN1) to halt the decline in biodiversity was ambitious; it has not been achieved. Considering current trends, the final assessment of the second national plan (PNPN2, 2017-21) should yield the same result. It is important to point out the six-year delay between the end of the PNPN1 and the adoption and implementation of the PNPN2. As a result of this delay, several actions included in the second plan were delayed. The PNPN2 is more comprehensive than the first plan; it demonstrates a better knowledge of the issues at stake and possible solutions, and includes more precise indicators to measure results (MDDI, 2017).

When faced with a decline that has been sustained for four decades, no time must be lost. Luxembourg needs to accelerate the implementation of interventions at a faster rate than the decline; any delay makes it even more difficult to stabilise, let alone improve, the status of biodiversity. Added to this are new issues: climate change and the appearance of invasive alien species that lead to a loss of natural capital and a reduction in its dividends – ecosystem services essential to the quality of human life. Recognising the need to accelerate efforts, the government strengthened the legislative framework in 2018 and increased budgetary resources for the implementation of the PNPN2.

Advances in the protection of specific sites

Luxembourg has refreshed its strategic framework for biodiversity with the drafting and adoption of the PNPN2. Since the last OECD review, it has made remarkable advances. The Natura 2000 network has been completed with 66 sites covering 27% of the territory. Its management plans are almost finalised, and will include specific measures for the species and habitats concerned. They will thus contribute to the re-establishment of a natural environment favourable to biodiversity conservation. A mixed approach has been adopted. It includes a contractual approach to compensate owners for their participation in the programme, an administrative approach to purchase or manage land of high ecological value, and a regulatory approach to designate certain Natura 2000 areas.

Advances in the observation and restoration of ecosystems

In addition to the conservation of specific sites, advances are being made in the establishment and restoration of ecological corridors. These make it easier for fauna and flora species to migrate and increase the value of individual protected areas. In addition, progress has been made in the restoration of certain degraded terrestrial and aquatic ecosystems so as to increase their contribution to safeguarding biodiversity.

Progress is also noted in the monitoring and reporting of data by the Luxembourg Institute of Science and Technology and by the Natural Environment Observatory. This is essential for assessing conservation measures and preparing national reports on the implementation of European directives.

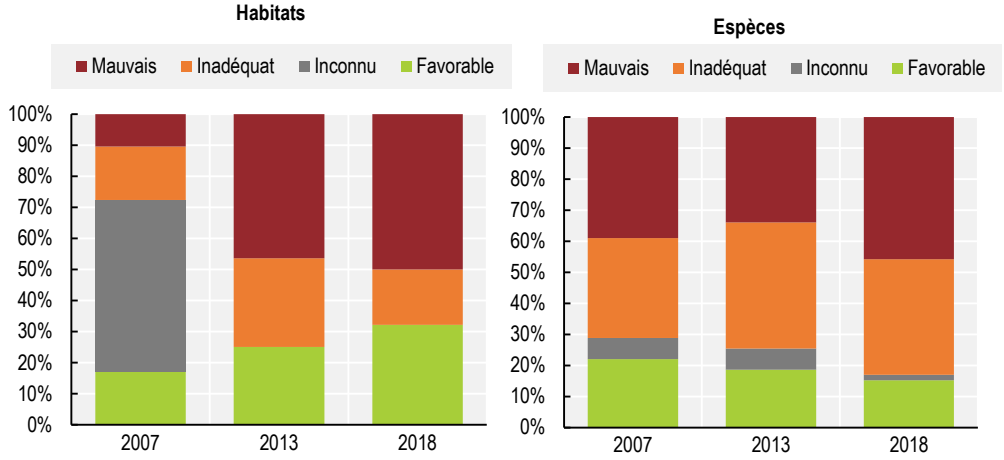
To promote good practice and ensure that conservation measures are put into effect, steering committees consisting of representatives of various public and municipal institutions and non-governmental and private organisations are being set up, as are biological stations in which the municipalities play a part. The implementation of a "Biodiversity Pact" rewarding municipalities for their action in favour of biodiversity and natural habitats, inspired by the "Climate Pact", is envisaged. Other interesting initiatives include biodiversity contracts with farmers and other private landowners; however, these contracts need to be modified and strengthened, as their effectiveness in terms of biodiversity is insufficient. A more recent measure is the introduction of a system of quantification and compensation for habitat destruction during

the implementation of infrastructure and housing projects, based on ecopoints. This system allows more targeted upstream compensation in line with the objectives of the PNPN2 via compensation pools.

The state of biodiversity conservation remains unfavourable and calls for accelerated public action

Despite these advances, the state of biodiversity conservation remains unfavourable (Figure 4). In the coming years, pressures on biodiversity are likely to increase further with the expected increase in the number of inhabitants and cross-border workers and the continued development of transport and housing infrastructure. The delay in finalising the Natura 2000 network, the network of ecological corridors, but above all in the practical implementation of the action plans on the ground or for the restoration of ecosystems, means that the positive returns from these investments are slow to materialise. The challenge of reversing the trend towards biodiversity decline is exacerbated by climate change with the arrival of invasive alien species (which may threaten the survival of native species) and by the ever-increasing intensification of agriculture.

Figure 4. The conservation status of habitats and species is of concern



Note : Ces chiffres montrent le pourcentage d'évaluations biogéographiques dans chaque catégorie d'état de conservation pour les espèces.
Source : AEE (2019), "Conservation status and trends", *State of Nature in the EU: Article 17 national summary dashboards*.

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To meet this challenge, Luxembourg will need to move forward on three key areas. It must accelerate the implementation of the PNPN2. It must complete implementation of the management plans for Natura 2000 sites and threatened species. Finally, it must make the steering committees function effectively and provide them with adequate resources before the end of the PNPN2.

The preparation of the third PNPN for 2022-27 should also be initiated without delay. This third plan should be based on the evaluations of the nature directives submitted to the EC in 2019 and on prospective scenarios of the impact of climate change and biodiversity decline on ecosystem services. It will also be necessary to ensure that biodiversity issues are fully integrated into agricultural, land-use planning and other sectoral policies (climate, housing, transport, etc.) with a good co-ordination between the national and local levels and a strong commitment from the municipalities. This will have to go hand in hand with a review of the costs and benefits of the different economic instruments used in biodiversity management and in sectoral activities that have an impact on biodiversity (biodiversity contracts, ecopoints, support to agriculture and forestry, etc.).

Box 5. Recommendations on biodiversity

Accelerate the implementation of biodiversity conservation and natural habitat protection policies

- Promptly initiate the preparation of the National Plan for Nature Conservation for 2022-27 (PNPN3):
  - Maintain the objective of halting biodiversity decline, while specifying the indicators for species, habitat and ecosystem services.
  - For each objective, present targets that are measurable in real time, the necessary financial and human resources, and the timetable of steps and actions to be taken; make this information permanently accessible on the Internet page of the MECDD.
  - Ensure the effective collaboration of the ministries in charge of agriculture, infrastructure and transport, and stakeholder consultation.
- Set up a programme to improve the standing and appreciation of ecosystem services among the population, the farming and forestry sector, and the ministries concerned:
  - Ascertain the socio-economic motivations of the population with respect to ecosystem services, and evaluate the economic costs of the degradation of those services.
  - Include initiatives to raise awareness in urban and rural areas of the importance of easily perceptible ecosystem services such as preventing heat islands through green spaces, protecting water quality, pollination by insects, carbon dioxide fixation by forests, and reducing the scale of floods through marshes and natural aquatic environments in good ecological state.
  - Set up a "Biodiversity – Ecosystem Services Pact" modelled on the "Climate Pact" and include that measure, if appropriate, in the PNPN3.
  - Introduce a premium for ecosystem services provided by forest environments in favour of private forest owners.
- Complete implementation of the management plans for Natura 2000 sites and threatened species, and assign specific and measurable objectives to them:
  - Indicate what conservation measures or measures to rehabilitate degraded sites are required and prioritise interventions to increase biodiversity.
  - Increase the portion of Natura 2000 areas that are state-owned and develop long-term (25 years +) agreements with landowners or assign conservation easements; consider levying a "Biodiversity – Ecosystem Services" tax on land transactions and associate corporate sponsorship to finance these acquisitions and consider in exchange exemption from the payment of the property tax in Natura 2000 zones.
  - Prioritise new ecological connectivity corridors to be put in place and complete the corridors of primary importance before the end of the PNPN2.
- Increase the human and financial resources budget for implementing the PNPN2, developing the PNPN3 and, in particular, for accelerating implementation on the ground of the actions foreseen in these plans so as to balance strategic planning efforts with concrete achievements.

Integration of biodiversity issues into sectoral policies

- Limit urban sprawl and habitat fragmentation by ensuring that land-use planning takes into account biodiversity, ecosystem services and the quality of life of citizens.

- Actively support the transition to organic farming and agroecology:
  - Value the products and behaviours of organic farmers, and establish a system of financial support for the production of ecosystem services, for the use of mechanical pest control to replace pesticide use and for crop rotation.
  - Continue the measures accompanying farmers in this transition (eco-counsellors).
  - Promote the establishment of organic farms near cities to reduce the harmful effect of pesticides on the population and increase accessibility to organic farming products.

Contribution to the protection of regional and international biodiversity

- Increase Luxembourg's contribution to the protection of biodiversity at international level:
  - Co-operate with neighbouring countries and promote the application of an ecological compensation model in other countries.
  - Contribute to the protection of wintering habitats of bird species nesting in Luxembourg, which migrate to other countries for part of the year.
  - Further integrate the biodiversity component into development co-operation and make it a strategic focus.

Notes

[1] The Greater Region (Grande Région) is the geographical area comprising Luxembourg, the Walloon Region in Belgium, Lorraine in France and two German states (Saarland and Rhineland-Palatinate).

[2] The EU's Renewable Energy Directive allows member states with an abundant and profitable supply of renewable energy to help other countries meet their targets. These agreements stipulate that Estonia and Lithuania will each transfer a certain amount of surplus renewable energy between 2018 and 2020.

[3] As the EU ETS covers only 15% of Luxembourg's emissions, efforts to reduce emissions must rely mainly on domestic policies in the transport sector, the residential and commercial sector, and in agriculture.

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Annex 1.A. Actions taken to implement selected recommendations of the 2010 Environmental Performance Review of Luxembourg

Recommendations	Actions taken
Chapter 1. Environmental performance: trends and recent developments	
Speed up and reinforce implementation of the measures adopted for achieving the Kyoto target; prepare for post-Kyoto by integrating climate change objectives into energy, construction and transport policies (for example, energy efficiency, energy charges and taxes, transport charges and taxes).	The second climate action plan adopted in May 2013 includes more than 50 measures designed to meet the emission reduction targets under the second commitment period of the Kyoto Protocol. The National Integrated Energy and Climate Plan (NECP) will be submitted to the European Commission (EC) in the first quarter of 2020. This plan contains targets and measures for renewable energy, energy efficiency and greenhouse gas emissions reduction by 2030. The NECP also provides for a carbon pricing system starting in 2021.
Establish harmonised and differentiated pricing for municipal waste management across the country, based on the polluter pays principle and cost recovery.	The 2012 law on waste management reaffirmed the obligation for municipalities to implement waste tariffs in line with the polluter-pays principle. In 2016, 25 municipalities applied waste taxes based on the volume and/or weight of residual waste produced; 16 municipalities applied taxes that did not comply with the polluter-pays principle for bulky waste. About 70 municipalities have committed to apply waste taxes that respect the polluter-pays principle by 2020.
Implement the General Waste Management Plan with more efficient measures for achieving the principal objectives, and with the necessary financial and other means.	In 2018, the government launched the project Eco-Box to reduce food waste; 66 restaurants and several canteen caterers participate. A ban on the free distribution of plastic bags (with the exemptions of those needed to ensure food hygiene) was introduced in 2019 (Law of 21 March 2017 on packaging and packaging waste). Nearly 300 shops and retailers participate in the awareness and labelling campaign Clever Akafen (Buy Smart). Of the 110 measures in the General Waste Management Plan, 58 have been implemented, 35 have been partially implemented and 17 have not been carried out.
Achieve economies of scale by encouraging communes to co-operate more effectively and co-ordinate their actions (collection methods, selective sorting, recycling programmes).	The 2012 law on waste management stipulates that the disposal and recovery of municipal waste must be carried out through an integrated and adequate network of facilities taking into account the best available techniques. In 2013, the intermunicipal associations (*syndicats*) SIDEC, SIGRE and SIDOR signed a cooperation agreement for the joint use of certain infrastructures for the disposal and recovery of municipal waste (effective since January 2015). Part of the municipal waste, which was landfilled until that date, has since been subjected to an energy recovery operation in the SIDOR incineration plant.
Establish a database in support of a policy to enhance resource productivity and identify the best measures for achieving it (e.g. use of new technologies and innovation).	A "circular economy" component including waste management has been integrated into the "Climate Pact" with the municipalities. All Luxembourg municipalities are engaged into the "Climate Pact". The EcoInnovation Cluster initiative has created a market for circular urban development projects. The identification of current and future green neighbourhood projects and the products and services offered by construction and building companies is expected to encourage companies to adapt to future needs. The "Fit4Circularity" programme supports companies to develop circular products, services and business models; development of a methodology for circular economic activity zones.
Implement the new Water Law; in particular, promote river basin management through the Water Management Administration and the water district management plans.	The law of 19 December 2008 has been applied since its entry into force. The 2nd river basin management plan was published in December 2015.
Apply the “user pays” and “polluter pays” principles to water pricing for households, industry and agriculture; ensure financing for tertiary-level waste water treatment plants required by the EU Urban Waste Water Directive.	According to the harmonised price method, introduced in 2011, water tariffs consider the costs incurred by water utilities to provide drinking water and sanitation services. Reduced tariffs apply to the agriculture sector. The 2008 water legislation introduced a water abstraction tax and a water pollution tax. The latter does not apply to agriculture. The Water Management Fund finances a wide range of investments in the water sector, including for wastewater treatment plants. Expenditure of the fund increased

	from EUR 50 million in 2011 to EUR 92 million in 2018.
Consider the establishment, on a voluntary basis, of sustainable management plans at the farm level, in order to make farmers more accountable for managing inputs, water and biodiversity.	Each Grand-Ducal regulation creating protection zones around a water catchment used for human consumption requires the supplier of drinking water to put in place agricultural extension measures. The programme of measures must necessarily include measures in the agricultural field. A pilot project has been carried out since 2015 around Lake Haute-Sûre. The first programmes of measures are currently being set up. Biodiversity contracts (with a budget of EUR 10 500 000 for the period 2017-21) aim at the conservation and ecological management of land in agricultural areas hosting species or habitats of particular ecological interest. These contracts apply to almost 9 out of 10 lands (about 5 000 ha).
Strengthen control of drinking water quality; delineate drinking water protection areas around aquifers and protect them.	The monitoring of the quality of drinking water is carried out in accordance with the provisions of Directive 98/83/EC, which was transposed into Luxembourg law by the amended Grand-Ducal Regulation of 7 October 2002. The demarcation of groundwater protection zones is in progress. At the end of 2018, Grand-Ducal regulations for 90% of groundwater catchments were either in force or under public procedure.
Chapter 2. Environmental governance and management	
Ensure better co-ordination of central and local government efforts to implement environmental and land use policies, including European directives (for example, classified facilities, water management, space and species management).	Direct contacts between the central government and communes have increased with the 2015 abolition of district commissariats, which used to serve as intermediaries between the two levels of government. Communes are routinely consulted on draft regulations that concern them, e.g. on nature protection or water protection zones, as well as on all strategic plans.
Continue to implement the law on strategic environmental assessments.	All national spatial plans and sectoral strategic plans undergo mandatory strategic environmental assessment (SEA). SEA covers only parts of municipal land-use plans.
Establish a multiyear clean-up and rehabilitation plan for contaminated sites, including orphan sites, and specify how they will be funded.	Luxembourg has is a cadastre of about 12 000 potentially contaminated sites. Their actual remediation relies on voluntary efforts and financing by responsible parties. There is no programme or financing for remediation of abandoned sites.
Improve the production and dissemination of environmental information for timely compliance with national obligations and international commitments; seek synergies among the different players.	Luxembourg has a national environmental portal containing most of the relevant information such as legislation, data and other documents. The government uses new platforms such as Digital Luxembourg to disseminate environmental information. Many environment-related government web pages are outdated due to a lack of resources to maintain them.
Analyse the interactions of environmental policy with the economy (for example, expenditure data); develop environmental accounting and material flow accounts.	The development of a national system of environmental accounts was initiated in 2010 in accordance with European regulations in this area. The statistical office (STATEC) also produces a dashboard containing the main indicators of the environmental accounts (on the themes of green jobs, green activities, green taxation, support for the green economy, sustainable consumption, environmental damage), and a table integrating economic and environmental statistics that makes it possible to analyse economic-environmental interactions by branch of activity
Pursue local initiatives for implementing the Action 21 Programme.	Communes have recently adopted a voluntary “climate pact” which encourages them to implement measures in six different domains (including land-use planning, construction and mobility) and achieve several levels of certification.
Develop environmental education, particularly in secondary and higher education, as part of the new National Plan for Sustainable Development.	Sustainable development education has been one the horizontal themes of the Ministry of National Education, Childhood and Youth since 2012. The environment ministry created a platform for education on the environment and sustainable development in 2012 and reactivated an inter-ministerial committee for education on sustainable development in 2017.
Chapter 3. Towards green growth	
Develop a “green package” as part of efforts to sustain economic activity and to emerge from the crisis, with a proactive and long-term environmental vision. Promote synergies between the environment and R&D, technology, exports, energy savings and resource productivity in the context of diversifying the national economy.	In 2016, the government presented the strategic study "The Third Industrial Revolution in Luxembourg" (TIR), which provides a long-term vision for the country’s development and economic diversification. The TIR focuses on six sectors (energy, mobility, buildings, food, industry and finance) and three horizontal axes (smart economy, circular economy, and the prosumers and social model.
Adopt and implement the National Plan for Sustainable Development.	The third National Plan for Sustainable Development was adopted in 2019.
Encourage more sustainable modes of consumption through regulatory and economic measures, and	Waste: In 2018, the government launched the project Eco-Box, to which 66 restaurants and several canteen caterers participate. A ban on the free distribution of

appropriate demand management (for example, in the areas of solid waste, mobility, public and private buildings, land use).	plastic bags (with the exemptions of those needed to ensure food hygiene) was introduced in 2019. Nearly 300 shops and retailers participate in the awareness and labelling campaign Clever Akafen (Buy Smart). Mobility: In 2017, Luxembourg introduced income tax credits to promote the purchase of electric or hybrid vehicles: EUR 5 000 for fully electric vehicles; EUR 2 500 for plug-in hybrid vehicles; up to EUR 500 for electric motorcycles and up to EUR 300 for electric bicycles. In 2019, the system was replaced by direct subsidies of the same amount. Buildings: Luxembourg enacted regulations requiring all new residential buildings to meet the nearly zero-energy building standard and launched a voluntary national sustainability certification system for new housing construction (LENOZ). The PRIMe House grant programme and Climate Bank programmes support investment in energy efficiency renovation of buildings.
Reinforce the internalisation of external environmental damage; enforce the "polluter pays" and "user pays" principles more effectively (for example in the management of waste, sewage, energy and transport). Make environmental policies more effective and efficient through the use of economic instruments and closer monitoring of the results of environmental actions.	Waste: The 2012 law on waste management reaffirmed the obligation for municipalities to implement waste tariffs in line with the polluter-pays principle. In 2016, 25 municipalities applied waste taxes based on the volume or weight of residual waste produced; 16 municipalities applied taxes that did not comply with the polluter-pays principle for bulky waste. About 70 municipalities have committed to apply waste taxes that respect the polluter-pays principle by 2020. Water: The legislation requires the costs of water-related services, including environmental and resource costs, be included in water fees and borne by users taking into account user-pay and polluter-pays principles. According to the harmonised price method, introduced in 2011, the Water Management Administration sets water tariffs taking into account the costs incurred by water utilities to provide drinking water and sanitation services. Energy and transport: in May 2019, excise duty on transport fuels increased by EUR 0.01 per litre of petrol and EUR 0.02 per litre of diesel. In December 2019, the government announced additional increases of between EUR 0.01-0.03 per litre of petrol and between EUR 0.03-0.05 per litre of diesel to take effect in February-April 2020. The 2019 National Energy and Climate Plan foresees the introduction of carbon pricing as from 2021, at an initial price of EUR 20 per tonne of CO_2, to be gradually increased.
Review, revise and increase, when necessary, environmental taxes and charges, in particular on transportation and energy, perhaps in the context of a broader tax reform.	In May 2019, excise duty on transport fuels increased by EUR 0.01 per litre of petrol and EUR 0.02 per litre of diesel. In December 2019, the government announced additional increases of between EUR 0.01-0.03 per litre of petrol and between EUR 0.03-0.05 per litre of diesel to take effect in February-April 2020. The 2019 National Energy and Climate Plan foresees the introduction of carbon pricing as from 2021, at an initial price of EUR 20 per tonne of CO_2, to be gradually increased.
Identify and eliminate subsidies and tax provisions that are potentially damaging to the environment.	The government commissioned a study to identify and quantify environmentally harmful subsidies. The 2018 study identified seven types of such subsidies in Luxembourg.
Review subsidies for energy savings and renewable energy and assess their economic efficiency and environmental effectiveness.	The aid scheme for the promotion of energy saving and renewable energy in the housing sector has been revised twice since 2010: to strengthen the renovation component of existing buildings and to extend the aid to the sustainable construction and renovation component. On average over the last five years, about EUR 20 million has been granted under the various PRIMe House programmes.
Continue to strengthen the environmental dimension of official development assistance (environmental projects, environmental impact assessments of other projects, climate change adaptation).	Environment and climate change are among the cross-cutting themes of Luxembourg's development co-operation strategy. In 2012, Luxembourg Development Cooperation Agency developed a guidance for the consideration of environmental sustainability in its development activities. The agency plans to complement its guidance with environmental and social safeguards.
Chapter 4. Air quality and mobility	
Take more effective steps to reduce NO_x emissions and meet the targets of the EU Emission Ceilings Directive (NEC), including action on energy and transportation pricing.	The "Air quality plan for the City of Luxembourg and its surroundings" adopted in 2010 (Directive 2008/50/EC) was updated in 2011 for the period from 2010 to 2020. In 2017, it was supplemented by the "national air quality programme", which provides a framework for policy objectives in terms of air quality and guides the implementation of targeted actions to reduce ambient air pollution by nitrogen dioxide (NO_2) and fine particles (PM_{10}). The measures primarily aim at better regulating the volume of individual motorised traffic and at reducing the impact of diesel passenger cars A national programme to combat air pollution is under development (EU Directive 2016/2284, which repealed the NEC Directive). It sets reduction targets by 2030 compared to 2005. Other measures concern industry (installation of selective catalytic reduction systems),

	the transport sector (promotion of public transport, active and shared mobility, and electromobility; investment in transport infrastructure; strategy for sustainable mobility – Modu 2.0), and road fuel pricing. The Transport Sector Master Plan provides the regulatory framework for the Modu. This is supported by the Climate Pact, which since 2017 includes an air quality component and since 2018 a mobility component and rewards the actions of municipalities in these areas.
Strengthen the benefits of climate change policy for emissions of conventional air pollutants.	Existing climate change measures and those planned in the National Energy and Climate Plan for 2021-30 (NECP) have co-benefits on some traditional air pollutants, such as NO_x. The "Climate Package" adopted in 2011 identifies 35 priority measures aimed at spatial planning and the construction sector, mobility, energy and environmental technologies, biodiversity, forests, water and agriculture. The Climate Pact gives municipalities the opportunity to optimise their energy consumption in return for financial and technical support from the government. Luxembourg also enacted regulations requiring all new residential buildings to meet the nearly zero-energy building standard. The PRIMe House grant programme and Climate Bank programmes support investment in energy efficiency renovation of buildings. Taxes on road fuels are gradually being raised. The 2019 National Energy and Climate Plan foresees the introduction of carbon pricing as from 2021
Pursue efforts to develop public transport, so as to achieve the 2020 objective that it covers 25% of home-work commutes.	Various measures have been taken to promote public transport with a view to making mobility more sustainable: investment in rail infrastructure, construction of a tramway line, new information systems for users, creation of park-and-ride facilities, purchase of low-emission buses; reorganisation of bus lines and free public transport (from March 2020). In 2017, the share of public transport in home-to-work journeys was 20%. Additional measures are planned as part of the sustainable mobility strategy (Modu 2.0) with major investments in public transport (service, infrastructure) and the opening of additional bus and tram lines.
Fulfil obligations and reinforce co-operation regarding air pollution in Europe (European directives, Gothenburg and Aarhus protocols); promote and contribute to the implementation of a regional plan for ground-level ozone.	The air emission reduction obligations under Directive (2001/81/EC) for 2010 have been met for all air pollutants, except NO_X. Annual average concentrations of PM_{10} and NO_2 have decreased and are below the daily limit values set by EU legislation (Directive 2008/50/EC on ambient air quality and cleaner air for Europe). NO_2 concentrations still exceed the limit value at several critical locations with heavy traffic. Target values and long-term objectives for ozone concentrations are exceeded in rural Luxembourg. Luxembourg has defined a pre-information threshold of 160 µg/m^3 as an hourly average for ground-level ozone. When this threshold is exceeded, the maximum authorised speed of motor vehicles is limited to 90 km/h on motorways. The number of days on which the European information threshold (180 µg/m^3 as an hourly average) is exceeded per year for tropospheric ozone has remained below 5 days since 2007. Luxembourg participates in the Benelux Working Group "Air Quality, which is working on the cross-border networking of air quality measurements and on putting these measurements online on the geoportal of the Greater Region.
	Chapter 5. Biodiversity
Establish two strong conservation areas of sufficient size (for example IUCN categories I to III), one in a forest zone and one in a farming area, to serve as biodiversity reservoirs.	The number and extent of protected areas has increased; the country has 66 "Natura 2000" sites covering more than 27% of the national territory; the national area declared as "protected areas of national interest" has increased to more than 8,000 ha. The sites have been evaluated and prioritized taking into account several criteria, including the rarity of the habitat and/or species present; the conservation status of the area; the current pressures and potential threats; the geographical location in the context of the Natura 2000 network and ecological connectivity; the ecosystem function of the area, etc..
Develop and implement management plans, enhance biological productivity in the protected areas (protected zones, Natura 2000 zones, natural parks, Ramsar zones); establish biological corridors linking the Natura 2000 zones in order to facilitate migration of fauna and flora.	Management plans: Steering committees (COPIL) have been set up to ensure the implementation of the "Natura 2000" management plans (Nature Protection Act of 18 July 2018). Four COPILs have been created; four more are planned. Ecological connectivity: seven priority "wildlife crossings" are planned between now and 2021 under the supervision of an interdepartmental group made up of the Public Works, Transport and Environment Departments; 52 priority developments have been identified by the management plan for the parts of the international Rhine and Meuse river basin districts located on Luxembourg territory (period 2015-2021).
Pursue partnerships between the central government and the communes on joint conservation and habitat rehabilitation projects.	A network of biological stations is being set up throughout the country. Their mission is to inventory species and habitats, plan and implement the nature protection measures of the National Plan for Nature Protection, and communicate and raise awareness on issues related to nature and environmental protection. Municipalities are also directly involved in the COPILs.

Make greater use of economic instruments to encourage landowners to adopt sustainable farming and forestry practices that will favour biodiversity; develop programmes to pay for the economic services that ecosystems provide, particularly aquatic and forest ecosystems.	Biodiversity contracts (with a budget of EUR 10 500 000 for the period 2017 21) are aimed at the conservation and ecological management of land in agricultural areas hosting species or habitats of particular ecological interest. These contracts apply to almost 9 out of 10 lands (about 5,000 ha) and buffer and core zones have been defined. The 2018 nature protection law introduces a system of ecopoints that give ecological values a monetary value. Municipalities, private persons or property developers will have to compensate financially for any damage that their real estate projects may cause to biotopes. An ecopoint is worth EUR .1 and is calculated according to the biotope of the land. The builder has to compensate financially for the loss of ecological value (counted in ecopoints) in order to allow the State to compensate, in the same ecological zone, the points lost in the biotope.
Establish forest management programmes to rejuvenate the forest so that it can supply biomass for energy production and to enhance its capacity to sequester CO_2.	A new legislative text was tabled in 2018 with the aim of revising forest sector laws and regulations in order to develop a new forestry code. This project aims to modernize partly very old legal provisions in order to meet the new challenges faced by all actors in the forest sector (currently in the legislative process).

Source: OECD Secretariat based on country submission.

Part I Progress towards sustainable development

1 Environmental performance: Trends and recent developments

Chapter 1 provides an overview of the main environmental trends observed in Luxembourg since 2005. It describes the country's progress and challenges on its path towards decoupling environmental pressures from economic growth and achieving national and international goals, based on data from national and international sources. It reviews the main economic and social developments, takes stock of changes in the energy, carbon and material levels of the economy and measures progress towards sustainable management of natural resources. Where possible, trends are compared with those of other OECD member countries.

1.1. Introduction

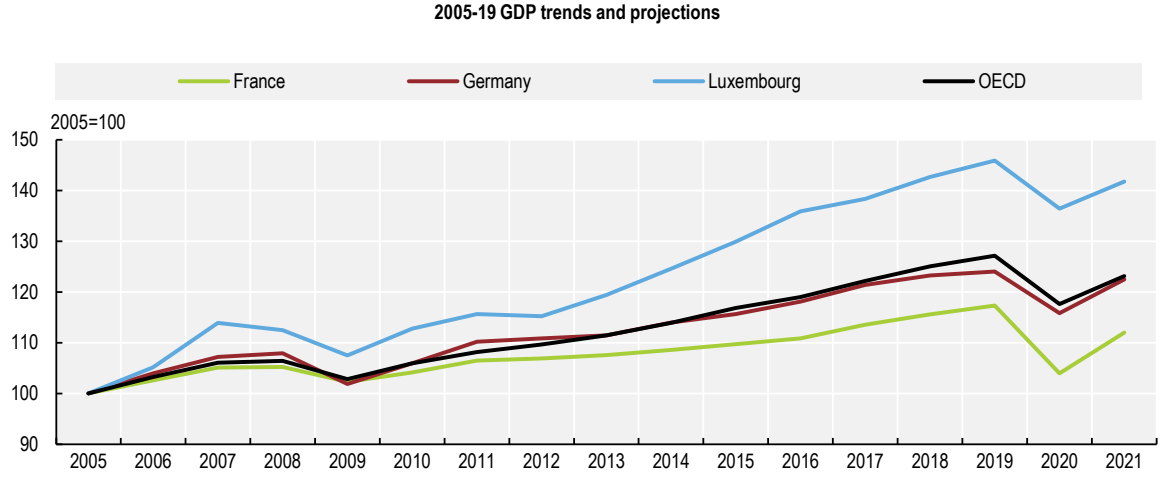
Luxembourg is a prosperous economy that has been experiencing strong growth, driven by banking and financial activity. Its per capita income is the highest among OECD member countries. These characteristics influence levels and patterns of production and consumption, and infrastructure needs. The resulting pressures on the environment are strong. Since 2010, progress has been made in decoupling several environmental pressures from economic growth (e.g. GHG and air pollutant emissions; waste generation; energy consumption; water abstractions) and in wastewater treatment. However, progress remains insufficient to restore a natural environment conducive to biodiversity conservation and to alleviate the growing pressures of demographic development and urbanisation.

1.2. Main economic and social developments

Economic outcomes and structure of the economy

Luxembourg has experienced strong economic growth since 2005 (+39% between 2005 and 2019, i.e. a rate of 2,8% per year on average), well above that of the OECD. It slowed down in 2009 and 2012 as a result of the financial crisis, but continued to grow until 2019 (Figure 1.1). The COVID-19 pandemic hit the economy hard. In the best case scenario, GDP is expected to shrink by 6.5% in 2020 and recover by 3.9% in 2021. New virus outbreaks later in 2020 would make GDP drop by 7.7% in 2020 and rebound by only 0.2% in 2021 (OECD, 2020a). The country managed to maintain a positive productivity differential with other OECD economies, thanks to high-end businesses and skilled workers (OECD, 2017).

Figure 1.1. Luxembourg's economy grew faster than the economies of neighbouring countries



Note: GDP expressed at 2015 prices and purchasing power parities. Projections for a single hit-scenario, i.e. without new virus outbreaks .
Source: OECD (2020), "OECD Economic Outlook No 107 - Single-hit scenario - (Edition 2020/1)", *OECD Economic Outlook: Statistics and Projections (database).*

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The economy is dominated by the service sector, which creates 87% of value added – well above the OECD average (73%) (Basic Statistics). This is due to the dynamism of the financial sector, particularly banks and insurance companies, which alone account for 28% of gross domestic product (GDP) and 10% of jobs (OECD, 2019a). Luxembourg is drafting a strategy called the Third Industrial Revolution. This aims to diversify its economy around digital technologies and renewable energies to reduce dependence on the financial sector. Apart from forests, Luxembourg has few exploitable natural resources (OECD, 2017).

The labour market is dynamic and attractive: it continues to show sustained job creation and a low unemployment rate (5.5% in 2017). Cross-border workers and immigrants (in the sense of residents born abroad) are the fundamental pillars of the Luxembourg labour force, representing 44% and 28% of the workforce, respectively. These immigrants are on average younger and have a higher employment rate than native residents. This reflects their positive impact on the economy, as well as their successful integration into the labour market (OECD, 2017).

Public finances are sound and should remain so. Luxembourg has a fiscal balance surplus (+1.5% in 2017). Public spending has been on the rise since 2015, driven by investment in infrastructure. Government debt is well below the euro area average (EC, 2018). In contrast, environment-related tax revenues have declined and are below the OECD average as a share of total tax revenues (Chapter 3; Basic Statistics).

Population, quality of life and regional disparity

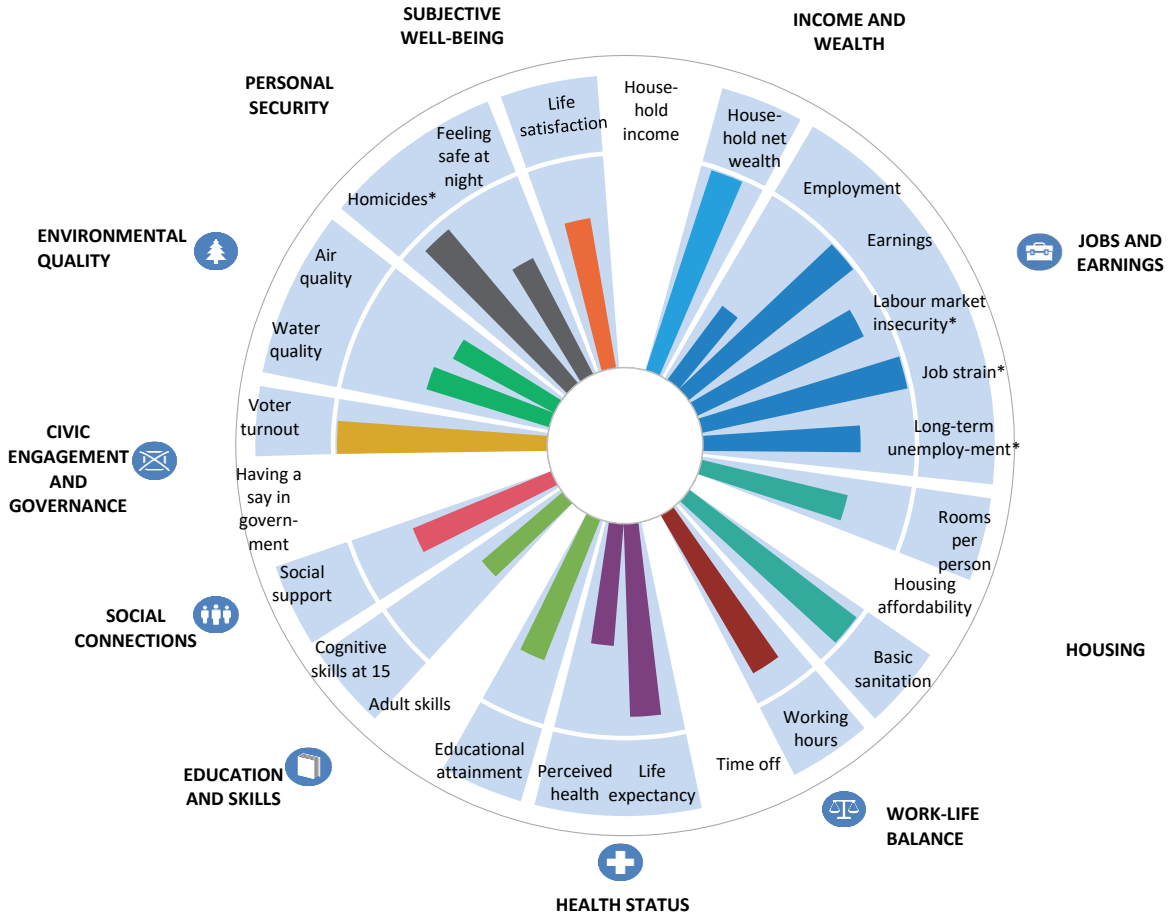
Luxembourg's population has increased by almost 30% since 2005, which was largely due to immigration. Almost half of its residents were born abroad, predominantly in the three neighbouring countries, Italy and Portugal (Basic Statistics). These trends affect energy consumption, urbanisation, urban development and the resulting environmental pressures.

The territorial organisation of Luxembourg is made up of 105 municipalities, the most populated of which are Luxembourg City and Esch-sur-Alzette. Activities and jobs are concentrated in the capital (STATEC, 2018).

Luxembourg has low inequality compared to other OECD member countries, thanks to a system that redistributes taxes and transfers. Despite a recent increase, this system keeps income inequality at a moderate level (OECD, 2019a; EC, 2018). Work stress and poverty are also relatively low, while housing conditions and social connections are better than the OECD average. However, the country is below the OECD average in terms of education and skills and has room for improvement in the area of energy and the fight against climate change (OECD, 2019a; Figure 1.2).

A public opinion study shows that environmental, climate and energy issues are more important at a personal level in Luxembourg than on average in the European Union (EU) (EC, 2019a). According to another EU survey, 86% of respondents in Luxembourg feel directly affected by environmental problems in their daily lives and health. Climate change is seen as the most pressing issue. However, a large majority of respondents are concerned about the presence of plastics and chemicals in everyday products and their impacts on health and the environment. At least half of respondents have seen or heard about EU ecolabels, a higher level than in most other countries. On the other hand, there is a comparatively high level of distrust of ecolabels (EC, 2017).

Figure 1.2. Perceived well-being is generally high in Luxembourg



Note: This figure highlights the areas that constitute Luxembourg's strengths or weaknesses in terms of well-being compared with OECD countries as a whole. For both positive and negative indicators (such as homicides, marked with an asterisk "*"), a longer bar always indicates a better outcome (i.e. a higher level of well-being), while a shorter bar always indicates a worse outcome (i.e. a lower level of well-being). If data are missing for an indicator, the corresponding segment of the circle is white.
Source: OECD (2018), *How's Life? 2017: Measuring Well-being*.

1.3. Transition to a low-carbon and energy-efficient economy

Climate and energy policies are closely linked. They are supported by numerous projects and initiatives in line with EU policies, financial aid and information campaigns. Targets are ambitious and progress has been made since the 2010 OECD Environmental Performance Review. The government has launched a climate pact to offer municipalities the opportunity to play an active role in the fight against climate change and to optimise their energy use in return for financial support and technical assistance. A draft National Energy and Climate Plan (NECP) was submitted to the European Commission (EC) in early 2019. The final plan, including the EC's recommendations, will be submitted with a slight delay in April 2020. Luxembourg is drafting a legal framework on climate change to strengthen the governance and the efficiency of national climate policy. This law provides an opportunity to enshrine GHG mitigation targets and other Paris Agreement commitments in legislation. The draft law also provides for the transposition of elements of the European legislation in this area.

Energy supply and demand

Luxembourg has established a National Energy Efficiency Action Plan (NEEAP) and a National Renewable Energy Action Plan (NREAP). It thus contributes to the EU's energy and climate targets for 2020 and 2030.

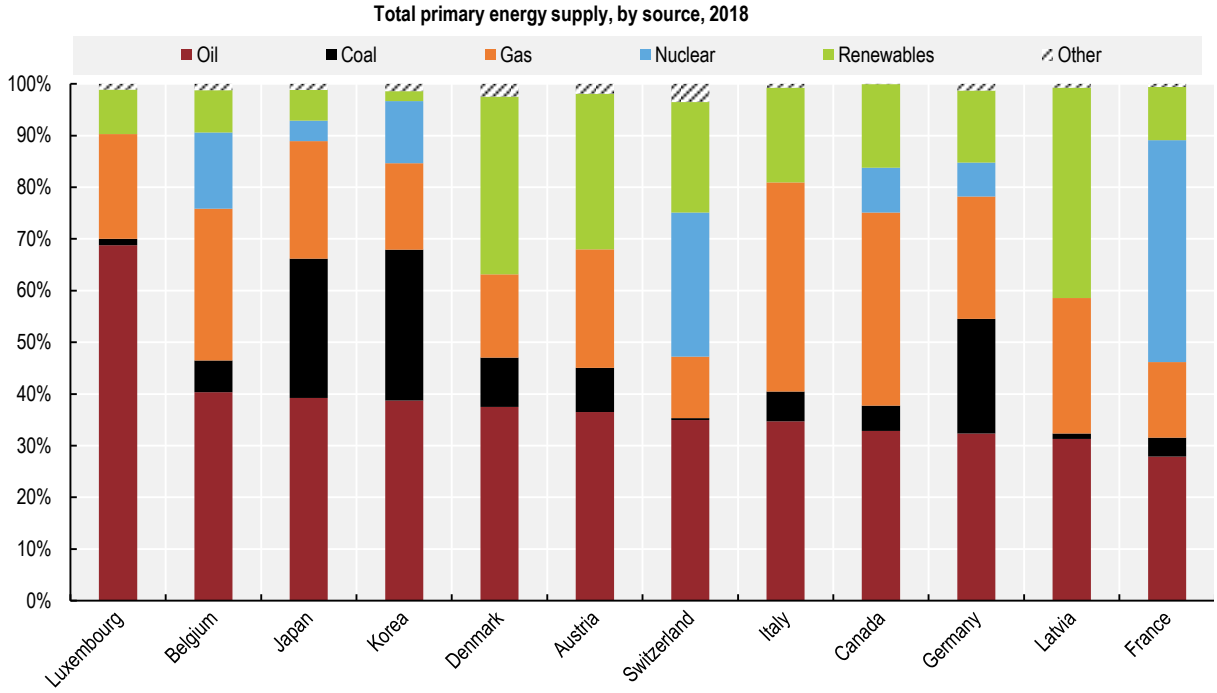
The National Energy Strategy is integrated into the NECP 2021-30. Luxembourg has introduced feed-in tariffs, calls for tender and mandates for the use of biofuels to encourage the development of renewables in the various sectors. Measures to increase the energy efficiency of buildings include financial support for energy-efficient construction and renovation; and the introduction of energy performance certificates and high-performance certificates for new residential ("nearly zero-energy buildings") and non-residential construction (IEA, 2020).

Energy supply and electricity

In 2018, fossil fuels accounted for 78% of the total primary energy supply (TPES),[1] a share slightly below the OECD average (79%) and a significant drop from 91% in 2005. The energy mix consists mainly of oil (59%) and natural gas (17%) (Figure 1.3). Luxembourg depends mainly on imports to meet its energy needs: it neither produces fossil fuels nor refines oil products and it has no nuclear power generation capacity. Since 2005, the share of oil and gas in the energy mix has been declining, replaced by electricity imports and renewable energies. This contributed to a 36% decrease in energy intensity between 2005 and 2016, which has since been stable (Figure 1.5).

Since 2016, there has been a 6% increase in the TPES, driven by an increase (+9%) in oil (Figure 1.3). However, the TPES decreased more rapidly in Luxembourg (-16%) between 2005 and 2018 than the OECD average (-5%). This decline is explained by the financial crisis of 2008-10, the gradual closure of the TWINerg power plant since 2012, and a drop in sales of road fuels (especially to non-residents), which reduced energy consumption.

Figure 1.3. Oil dominates Luxembourg's energy mix



Note: Total primary energy supply excludes electricity trade.
Source: IEA (2019), "World energy statistics", *IEA World Energy Statistics and Balances* (database).

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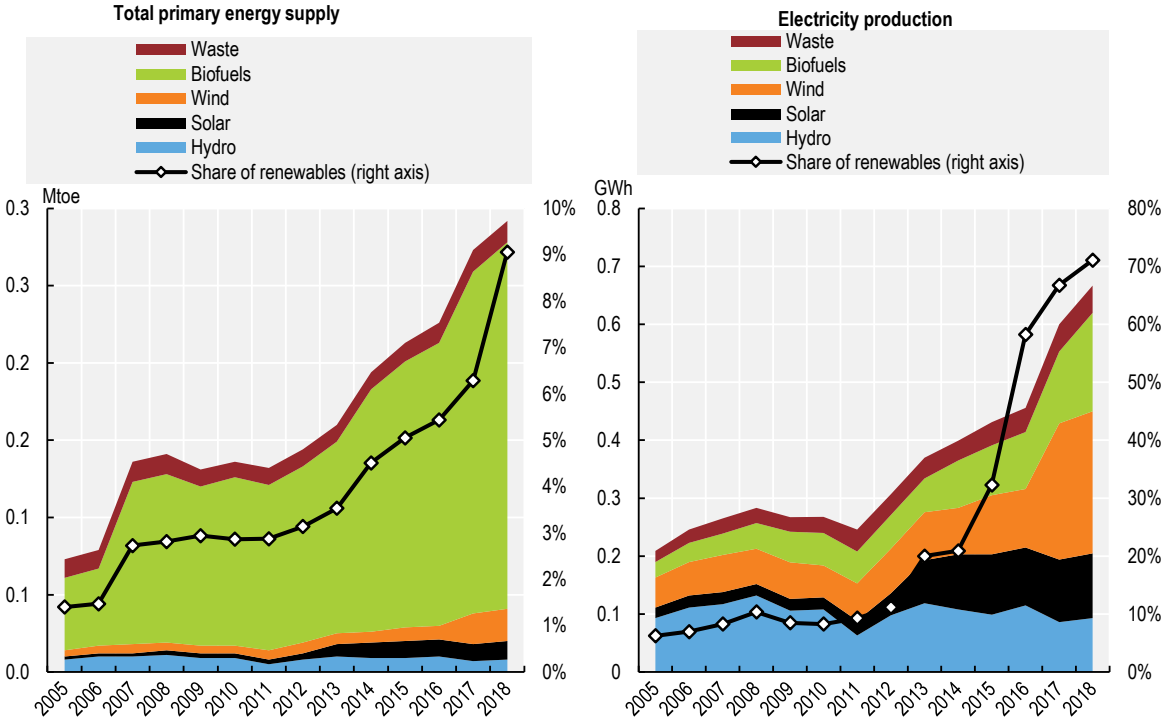
Renewables account for only 7.5% of the TPES in 2018, below the OECD average of 10.5% (Basic Statistics). Biofuels and biogas account for 81% of renewable energy sources, followed by wind power (7%) and waste (5%) (Figure 1.4).

Domestic electricity production covers only a small share of demand, but it consists of 71% renewables. Between 2005 and 2018, domestic electricity production decreased by 72% following the closure in 2016 of the Esch-sur-Alzette gas and steam turbine power plant. However, production from renewable energy sources has increased threefold since 2005. It consists of wind (37%), solar (17%), biofuels (14%), hydropower (14%) and waste (7%). This, combined with the 1997 cessation of coal use in electricity generation, has reduced the carbon intensity of the electricity mix (Figure 1.4).

Figure 1.4. The share of renewables is increasing



Note: Total primary energy supply excludes electricity trade.
Source: IEA (2019), "World energy statistics", *IEA World Energy Statistics and Balances* (database); Eurostat (2020), "Share of renewable energy in gross final energy consumption".

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Measures to promote the use of renewable energies include bonus systems for renewable electricity generation, feed-in tariffs for injecting biogas into the natural gas grid and financial incentives for households. The creation of a one-stop-shop and limits on the duration of authorisation procedures also simplify development of renewable energies (EC, 2018). These measures have boosted the production of biofuels and biogas from biomass and waste, which doubled between 2010 and 2018. Electricity production from wind power also doubled between 2016 and 2018 (Figure 1.4).

The share of renewable energies in gross final consumption increased rapidly. However, it remains relatively low compared to the objectives, set in the NREAP, of 11% in 2020 and 23-25% in 2030 (Eurostat, 2019a). The country uses the co-operation agreements established in the European Directive on renewable energy to reach the 2020 target. It has signed two agreements on statistical transfer[2] of renewable energy with Estonia and Lithuania. These transfers allow countries that have already reached their target and have an accounting "surplus" of renewable energy to transfer it to other countries with a

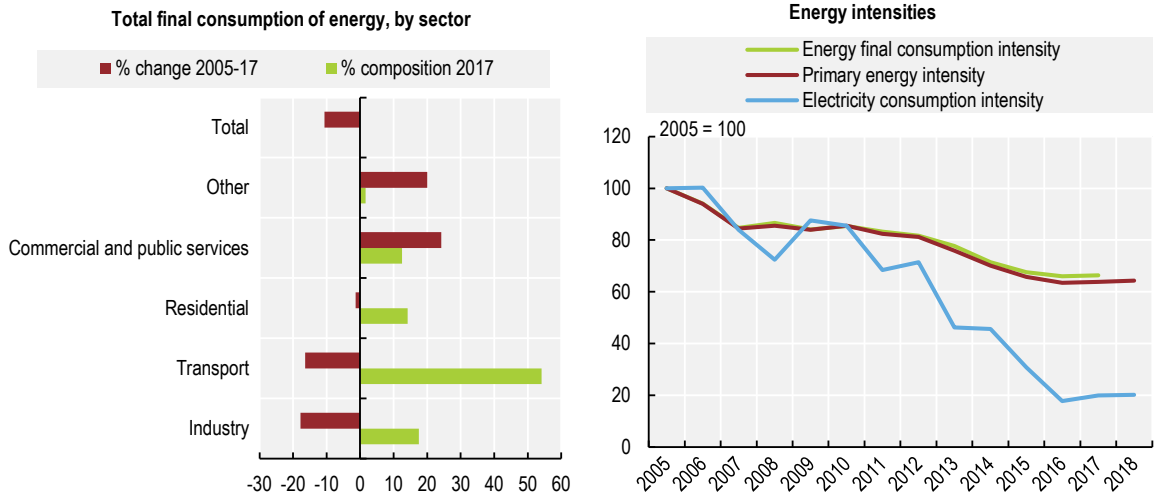
deficit (EC, 2018). These transfers enabled Luxembourg to increase the share of renewable energies in gross final consumption to 9.1% in 2018.

Energy consumption

The main public policy to reduce energy consumption is the NEEAP. Each action plan since 2008 has set more ambitious energy consumption reduction targets. To achieve them, subsidies (i.e. PRIMe House subsidies), voluntary agreements with industries, an obligation mechanism (since 2015) and energy performance of buildings standards are in place (Ministry of the Economy, 2017).

Luxembourg is on track to meet its 2020 energy efficiency target of limiting its final energy consumption to 49 292 GWh. Final energy consumption has fallen much faster (-11% since 2005) than the OECD average (-1%). Policies have led to a decline in household consumption, despite population growth. Luxembourg's energy intensities have decreased – except during the financial crisis, due to the fall in GDP (Figure 1.5). (Ministry of the Economy, 2017). However, energy consumption has increased since 2016, particularly in transport. This shows that challenges remain and that efforts must be sustained and even strengthened to meet the 2030 efficiency target (to limit final energy consumption to 35 568 GWh). In a context of sustained economic growth and low energy prices, the increase in energy consumption coupled with the high purchasing power of a growing population are also stalling progress.

Figure 1.5. Energy consumption has decreased, but progress is slowing down



Source: IEA (2019), "World energy statistics", *IEA World Energy Statistics and Balances* (database); OECD (2019), "Aggregate National Accounts, 2008 (or SNA 1993): Gross Domestic Product", *OECD National Accounts Statistics* (database).

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Transport

The transport sector is the largest consumer of energy: it accounted for 54% of final consumption in 2017, compared with 34% on average across OECD member countries (Figure 1.5). Almost all the energy consumed by the transport sector (94%) comes from petroleum products (78% of which is diesel). This makes transport the main emitter of GHGs and a major source of air pollution. Situated at the heart of the main traffic roads in Western Europe, Luxembourg has relatively dense transit of road traffic for goods and people (especially cross-border workers). This phenomenon is exacerbated by fuel sales to non-residents generated by the relatively low prices and taxes on road fuels compared with neighbouring countries (Belgium and France). Road transport energy consumption has decreased by 19% since its peak in 2005,

due to a drop in international trade and an increase in the price of road fuels (leading to a decrease in fuel sales to non-residents). However, fuel sales to non-residents remain much higher than those to residents (about 70% of total sales), particularly for diesel (almost 60% of total sales) (Chapter 4).

The rate of private car ownership in Luxembourg is the highest in Europe, with 670 cars per 1 000 inhabitants (Eurostat, 2019b). This rate is influenced by cross-border workers whose company cars are registered in Luxembourg. Average CO_2 emissions per km are high for new private cars (127 gCO_2/km) and still far from the 2020 target (95 gCO_2/km) (Eurostat, 2019b). The share of diesel-powered vehicles has decreased but remains high: in 2019 it was 59% for cars, 91% for buses and 97% for trucks (STATEC, 2019c). The share of biofuel is increasing significantly (6.5% in 2018). However, Luxembourg is still below the EU requirement of a 10% share of renewable energy in transport by 2020, which calls for targeted measures in this sector (IEA, 2019; Chapter 4).

Luxembourg has put in place a plan for sustainable mobility called Modu in 2012 (revised in 2018), as well as a sectoral transport plan to improve infrastructure for electric vehicles and to promote public transport (IEA, 2020; Chapter 4). Financial support is also in place to buy low-emission vehicles (Chapters 3 and 4). The vehicle fleet is relatively young, with more than 50% of private cars, buses and vans less than five-years-old (STATEC, 2019a).

Climate change mitigation and adaptation

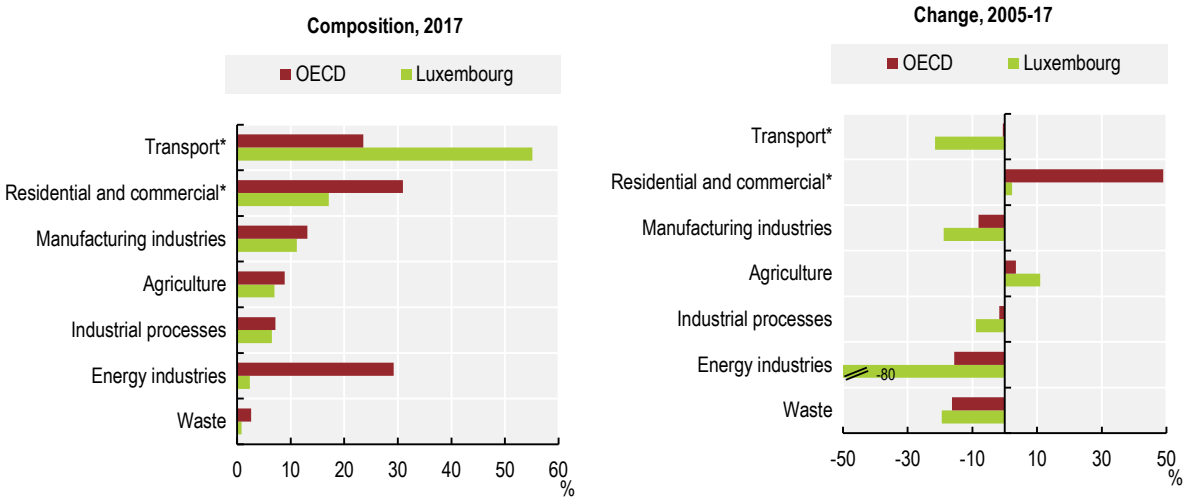
Greenhouse gas emissions profile

Luxembourg's GHG emissions profile is characterised by the importance of the transport sector, which accounted for 55% of national emissions in 2017,[3] well above the OECD average (24%). Its geographical location makes it a transit country for road, rail and air transport of goods and people. As a result, the EU Emissions Trading System[4] (EU ETS), which mainly includes stationary sources and intra-European aviation, covers only a small share (about 15%) of the country's emissions (IEA, 2020). The land use, land-use change and forestry (LULUCF) sector absorbs more GHGs than it emits.

Luxembourg's GHG emissions (excluding emissions and removals from LULUCF) decreased by 21% between 2005 and 2017, much more than the OECD average (-8%). All sectors (except agriculture) contributed to this decline, in particular transport (-22%), energy-producing industries (-80%) and manufacturing (-19%) (Figure 1.6). The financial crisis of 2008-10 followed by the gradual closure of the TWINerg power plant from 2012, as well as a drop in sales of road fuels (especially to non-residents), have reduced energy consumption and made the country more low-carbon. Due to Luxembourg's small size, its emissions are sensitive to changes in energy production processes, as well as to fluctuations in fuel prices that influence sales to non-residents. The quantities of fuel sold in Luxembourg petrol stations – encouraged by differences in taxation in neighbouring countries – are included in GHG emissions inventories. However, a large majority of emissions can be attributed to vehicles registered outside Luxembourg (44% of non-EU ETS emissions in 2017) (IEA, 2020). Diesel sales to transit trucks alone account for 32.5% of non-EU ETS emissions (IEA, 2020). The residential sector remains a significant source of emissions due to oil for heating. Meanwhile, the commercial sector is experiencing the greatest increase as a source due to development of the service sector and economic growth (Figure 1.6). Emissions increased again in 2017 in most sectors.

Emissions of CO_2, which account for 90% of GHG emissions, have declined since 2005 due to the decline in emissions from road transport. GHG emissions per capita and per unit of GDP decreased between 2005 and 2017, due to lower emissions, while population and GDP continued to grow. However, Luxembourg is still the fourth-highest per capita emitter of GHGs in the OECD, mainly due to transport emissions by non-residents (OECD, 2019b).

Figure 1.6. GHG emissions are declining in almost all sectors



Note: Total excludes emissions from land-use, land use change and forestry. Includes emissions from non-residents. The category "Residential and commercial" also includes fugitive emissions.
Source: OECD (2019), "Air and climate: Greenhouse gas emissions by source", *OECD Environment Statistics* (database).

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Main objectives and programmes

Luxembourg contributes to the EU's climate ambitions for 2020 and 2030 under the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol (Table 1.1). It also contributes to the EU's long-term objective of reducing GHG emissions by 80-95% by 2050. In addition, it signed and ratified the Paris Agreement in 2016.

Table 1.1. EU and Luxembourg climate objectives

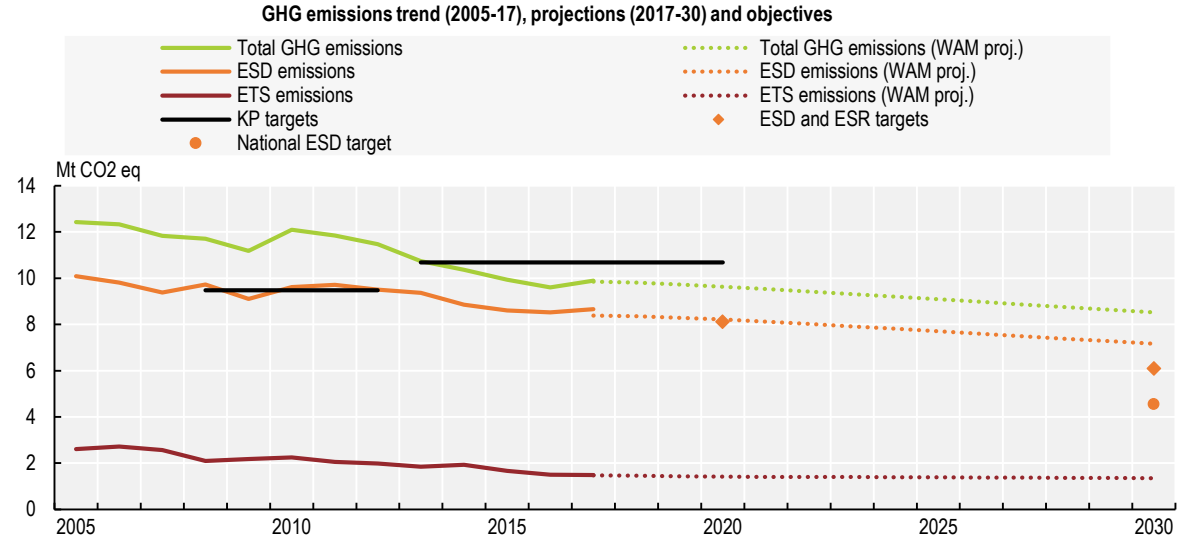
	UNFCCC		EU // non- EU ETS (ESD)		EU // ETS
	EU	LUX	EU	LUX	EU
2008-12	-8% (1990)	-28% (1990)			
2020	-20% (1990)	-14% (2005)	10% (2005)	20% (2005) 8.12 $MtCO_2e$	-21% (2005)
2030	Minimum of -40% (1990)		30% (2005)	-40% (2005) 6.09 $MtCO_2e$ National target -55% (2005)	-43% (2005)

Source: Country submission.

Despite a sharp drop in GHG emissions in the 1990s, Luxembourg only met its target (-28% by 2008-12, compared with 1990 levels) by using the flexibility mechanisms in the Kyoto Protocol (Clean Development Mechanism, Joint Implementation and International Emissions Trading). These mechanisms may again be needed to meet current targets. As its 2020 objective within member states of the EU Effort Sharing Decision (ESD), Luxembourg aims to reduce its emissions from sectors not covered by the EU ETS by 20% from 2005 levels. Projections show it can just about be achieved "with additional measures", but that more efforts will be needed for 2030 (-40% compared with 2005) (Figure 1.7). In addition, the country has set an even more ambitious target of a 55% reduction in non-EU ETS emissions (compared with 2005). By 2050, the goal is to achieve climate neutrality. The high level of these ambitions demonstrates a strong political will that must be translated into equally strong concrete measures without losing sight of energy, air quality and mobility objectives. As the EU ETS covers only a small share of Luxembourg's emissions,

efforts to reduce emissions must rely mainly on domestic policies in the transport sector, the residential and commercial sector, and in agriculture.

Figure 1.7. Additional efforts are necessary to achieve non-EU ETS targets



Note: GHG emissions exclude emissions from land use, land use change and forestry (LULUCF). Dotted lines refer to national projections with additional measures (WAM). Reduction targets linked to the Effort Sharing Decision (ESD) and to the Effort Sharing Regulation (ESR) cover most sectors that are not part of the EU ETS, except the LULUCF sector and international maritime transports. The Kyoto Protocol (KP) covers 2008-12 and 2013-20 periods.
Source: Eurostat (2018), "ESD Emissions"; CDR (2018), "Projections"; EEA (2019), EU ETS Dataviewer; OECD, "Air and climate: Greenhouse gas emissions by source", *OECD Environment Statistics* (database); MDDI (2018), "Seventh National Communication of Luxembourg under the United Nations Framework Convention on Climate Change".

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Discussions in 2018 for a third National Action Plan for the Reduction of Greenhouse Gas Emissions have fed into the NECP project required by the EU. The "climate package", adopted in 2011, identifies 35 priority measures aimed at spatial planning and the construction sector, mobility, energy and environmental technologies, biodiversity, forests, water and agriculture (MDDI, 2018a). The "climate bank and sustainable housing package" includes financial aid (PRIMe House) dedicated to the construction and energy renovation of sustainable housing. Various support measures promote the production of electricity and heat from renewable energy sources. The measures also include a gradual increase in excise duties on road fuels. Part of the revenue from these duties is earmarked for Climate and Energy funds to finance mitigation, among other measures.

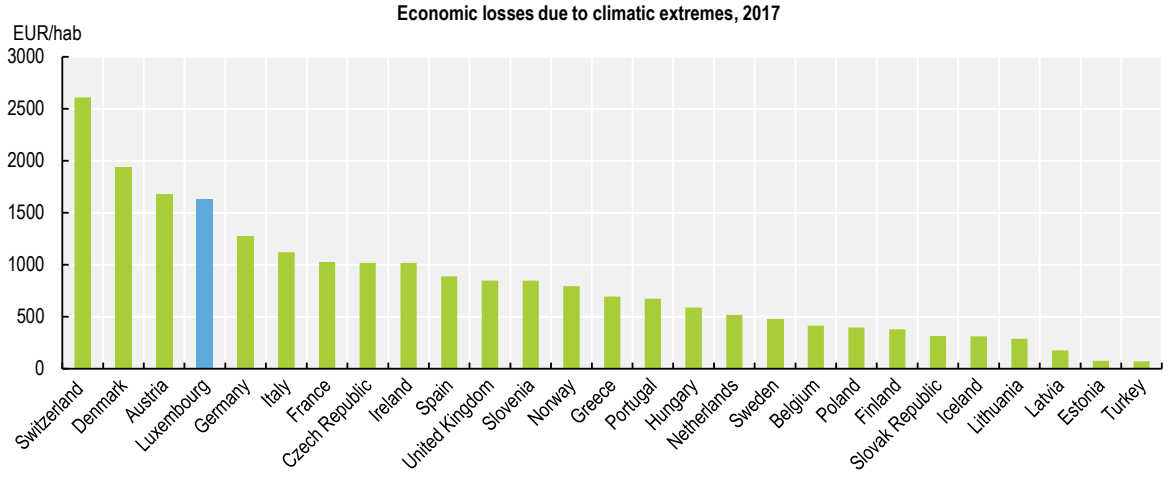
An agreement between the state and the 102 municipalities (the Climate Pact with municipalities) complements action at the local level. Municipalities are required to implement the European Energy Award quality management and certification system and an energy accounting system. In return, the state guarantees financial support and technical assistance to the municipality, which may increase according to the level of certification. Operational since 2013, this pact has included air quality criteria since 2016 and circular economy criteria since 2017 (MDDI, 2018a; Box 3.2; Chapter 3).

Adaptation to climate change

The temperature in Luxembourg City is on average higher than during the last century, especially in winter (MDDI, 2018a). Extreme weather events, including floods, caused significant damage in 2016 and 2018. In August 2019, a strong storm accompanied by a tornado caused a lot of damage in the south-west of the country. In the same month, the temperature in Luxembourg reached 40.8°C, the highest temperature

since the country began keeping weather records in 1838. Scientific forecasts indicate the trend towards higher temperatures will intensify in the future. These damages create greater economic losses in Luxembourg than in most other European countries. These losses, measured by the direct costs of physical damage (for example, destruction of infrastructure) and indirect costs (interruption of economic activity), are explained by the country's high GDP per capita (Figure 1.8).

Figure 1.8. Economic losses due to climatic extremes are high



Note: Prices in Euros (2017), based on damage data from Munich Re's NatCatSERVICE and Eurostat structural indicators.
Source: EEA (2019), *Impacts of extreme weather and climate related events in the EEA member countries (1980–2017)* (database).

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The National Climate Change Adaptation Strategy, adopted in 2011, was revised and expanded in 2018. It identifies 13 sectors[5] affected by climate change and presents priority actions. The first strategy enabled Luxembourg to analyse the impacts of climate change and to make projections on future climate conditions and their effects on vegetation, agriculture, viticulture, forests, biodiversity and water. Water management is one of the priority issues, which has led to increased subsidies for flood control and river ecological-restoration. Other measures aim to save energy, expand infrastructure for solar energy and responsible biomass, and adapt infrastructure to an increase in natural disasters (MDDI, 2018a). The strategy must be complemented by a monitoring framework to supervise the implementation of adaptation measures.

1.4. Atmospheric emissions and air quality

Main plans and programmes

The high level of road traffic in Luxembourg exacerbates air pollution, particularly nitrogen oxides (NO_x). In response, the government has put in place plans and programmes to combat air pollution. These include the national air quality programme and the air quality plan for the City of Luxembourg and surrounding areas (MDDI, 2017a). Luxembourg is also preparing a National Action Plan under a European Directive (2016/2284) on the reduction of national emissions of certain atmospheric pollutants. Under Directive 2008/50/EC on ambient air quality and cleaner air for Europe, limit values, target values and objectives for concentration and exposure are defined. The 2018 strategy for sustainable mobility (Modu 2.0) sets targets for 2025 (Chapter 4).

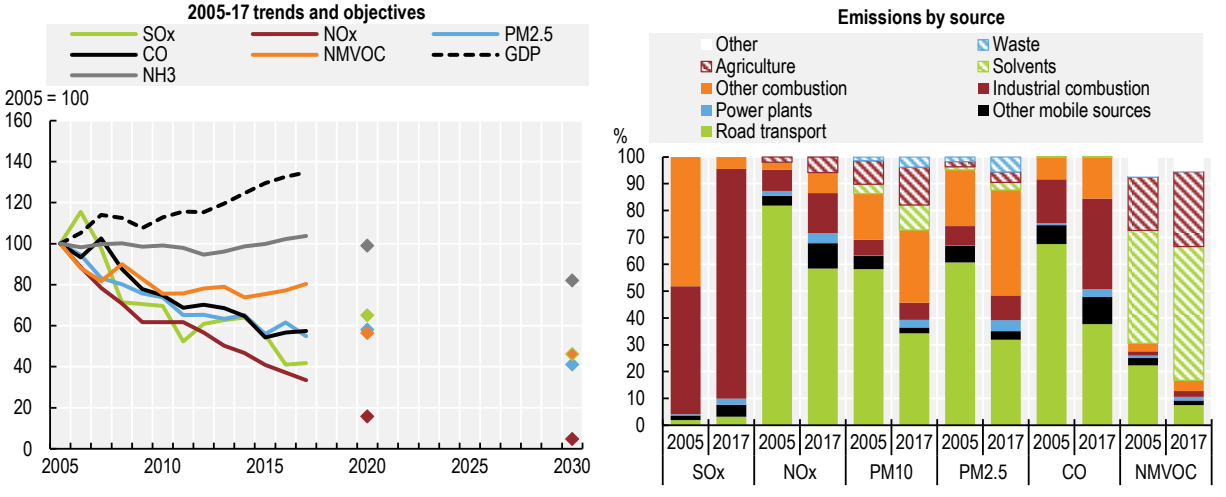
Atmospheric emissions

Luxembourg has succeeded in decreasing emissions of most of the main air pollutants: NO_x, carbon monoxide (CO), sulphur oxides (SO_x), fine particulate matter ($PM_{2.5}$) and non-methane volatile organic compounds (NMVOC) (Figure 1.9). This success can be explained by the economic crisis; less road transport following a decrease in international trade; a higher price for road fuels (leading to a decrease in fuel sales to non-residents); and the continuous renewal of the car fleet (more efficient cars, EURO standard 3 and 4). Other measures have contributed to these results. These include industry's introduction of catalytic converters and limits for solvents; more efficient technologies (particularly in combustion and processes in the metallurgical industry); as well as reductions in the sulphur content of petroleum products and fuels; and the substitution of coal with natural gas in the energy mix (MDDI, 2017b). On the other hand, the increase in agricultural production, and in particular that of livestock, led to an increase in NH_3 emissions compared to 2005 (+4%).

Fewer emissions made it possible to meet the 2010 targets under Directive 2001/81/EC for all atmospheric pollutants except NO_x. However, additional efforts will be necessary to meet the 2020 and 2030 targets. NMVOC, NH_3 and $PM_{2.5}$ emissions have all increased again (since 2012 for NH_3, since 2014 for NMVOC and since 2017 for $PM_{2.5}$) and projections show they will be above the cap (EEA, 2018a). Still, emissions have been decoupled from economic growth and intensities per unit of GDP are well below the OECD average (OECD, 2019b) (Figure 1.9).

Although decreasing, road transport remains the largest source of NO_x (58%), PM_{10} (34%), $PM_{2.5}$ (32%) and CO (38%) emissions in 2017. Industrial combustion is the largest source of SO_x emissions (86%) and the second largest source of CO (16%) and residential combustion remains a significant source of particulate matter. Solvents and agriculture are the largest emitters of NMVOC and their share continues to increase (Figure 1.9). Agriculture is responsible for 96% of NH_3 emissions. To achieve its objectives, Luxembourg will therefore have to step up its efforts in reducing emissions from transport, industrial combustion, solvents and agriculture (Chapter 4).

Figure 1.9. Atmospheric emissions are declining, but more effort is needed to achieve the targets



Note: GDP expressed at 2010 prices and purchasing power parities. Estimates based on fuel sold.
Source: OECD (2019), "Air and climate: Air emissions by source", *OECD Environment Statistics* (database); EEA (2018), *National Emission Ceilings Directive Emission Inventory Data* (database).

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Air quality

Air quality has improved over the past decade. Average population exposure to fine particles ($PM_{2.5}$) has decreased by 17% since 2005, but its level – 10.2 micrograms per cubic metre (µg/m^3) –remains slightly above the maximum value of 10 µg/m^3 recommended by the World Health Organization (OECD, 2019c). The annual average concentrations of PM_{10} and nitrogen dioxides (NO_2) have decreased and are below the daily limit values set by EU legislation (EEA, 2018b). NO_2 concentrations in ambient air still exceed the annual limit value at several critical locations with heavy traffic (canton of Luxembourg). Rural Luxembourg has exceeded the target values and long-term objectives for ozone concentrations.

Networks of measurement stations measure air quality. In addition to fixed stations in the larger cities (Luxembourg City, Esch-sur-Alzette), temporary measures are taken in sensitive areas (MDDI, 2017a). Since 2007, the concentrations of certain pollutants can be consulted in near-real time through a mobile application (MECDD, n.d.).

Exposure to $PM_{2.5}$ and ozone in outdoor air is responsible for the premature death of about 326 in every 1 million people in OECD member countries. This mortality level is slightly lower in Luxembourg (248 people in every 1 million in 2017, i.e. 150 people in Luxembourg). Premature deaths in the OECD translate into a welfare cost comparable to 2% of GDP in 2017 (OECD, 2020; Chapter 4).

1.5. Transition to efficient resource management

The wealth and development of Luxembourg's economy generate relatively high material consumption and waste production. For many years, the government has been pursuing an active waste and materials management policy based on prevention and recovery, as well as on the use of quality secondary raw materials in the economy. However, efforts have been difficult to translate into results, particularly due to slow implementation of certain measures and a lack of coherence and harmonisation at national level.

Material consumption

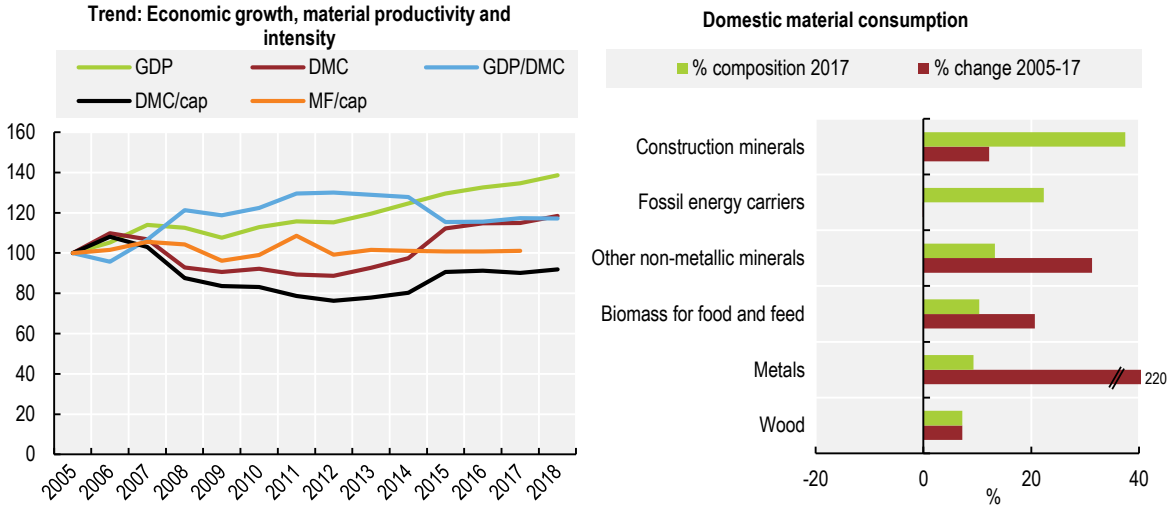
Because of its small size, the country imports a large quantity of materials: those extracted within the country represent only 15% of what is consumed. The country mainly imports fossil fuels (27%), construction materials (23%) and metals (22%).

Domestic material consumption (DMC) consists mainly of construction materials (37%), fossil fuels (22%), biomass (18%), non-metallic minerals (13%) and metals (9%) (Figure 1.10). DMC declined following the financial crisis in 2008, then rose again from 2013 onwards, but less rapidly than GDP and population growth. Material productivity is among the highest among OECD member countries. For 1 tonne of materials consumed, Luxembourg creates approximately USD 3 800 or EUR 3 400 of economic wealth in terms of GDP. This compares with an average of EUR 2 000 in the EU or USD 2 600 in the OECD. Material productivity increased by 30% between 2005 and 2012. It then fell by 11% in 2015 and has since remained stable. This stagnation is partly explained by the increase in DMC due to the creation of infrastructure for public transport, such as the first tramway line and new bus lanes in the City of Luxembourg.

Material intensity per capita is high, particularly because it includes the consumption in Luxembourg of cross-border workers, who, on the other hand, are not included in the population. A person living in Luxembourg thus “consumes” on average 24 tonnes of materials per year. This level is well above the OECD average (15 tonnes per capita) and is the source of significant amounts of waste. In 2016, waste generated in the country accounted for almost 75% of the materials consumed, with a higher per unit of GDP rate than in most OECD member countries.

Considering the raw materials extracted worldwide to satisfy the final demand of the economy, Luxembourg's material footprint amounts to 103 tonnes per inhabitant. At almost four times higher than the average, this intensity is the highest in the OECD (Figure 1.10).

Figure 1.10. Material productivity has strongly increased, but progress is slowing down



Note: GDP expressed at 2010 prices and purchasing power parities. DMC is the sum of domestic extraction of raw materials used by an economy and the physical trade balance (imports minus exports of raw materials and manufactured goods). Material footprint (MF) includes all materials extracted (including from abroad) to satisfy the final demand of the economy.
Source: OECD (2019), "Material Resources", *OECD Environment Statistics* (database); OECD (2019), "Aggregate National Accounts, 2008 (or SNA 1993): Gross Domestic Product", *OECD National Accounts Statistics* (database).

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Waste prevention and management

Status and trends

Luxembourg produced 17 tonnes of waste per capita in 2016: 3.5 times more than in the EU. The construction sector generates 76% of waste, a larger share than in other OECD member countries. Industrial waste accounts for only 7.5% of the total and is largely dominated by metallurgical industries (Figure 1.11). Total waste generation increased by 21% between 2006 and 2016. Following fluctuations in the construction sector, it peaked in 2010, then decreased as a result of the economic slowdown caused by the financial crisis, before growing again from 2014 onwards. Progress has been made in waste recovery: in 2016, 35% of the waste treated in Luxembourg was recycled, 24% was used for backfilling and 2% was incinerated with energy recovery. The rate of landfilling dropped from 49% to 39% between 2010 and 2016 (Eurostat, 2019d).

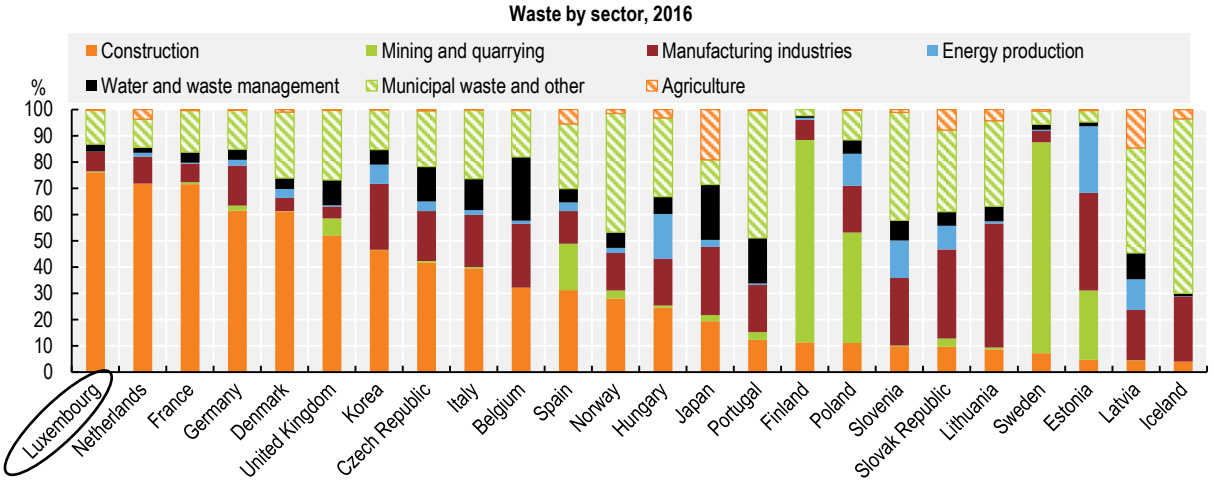
Municipal waste

A person living in Luxembourg produces 614 kg of municipal waste per year, a decrease of 10% (69 kg) compared with 2005, but still among the highest levels in the OECD. This is partly due to the waste produced by cross-border workers on Luxembourg territory, as well as to the economy's high level of consumption. Quantities produced have increased (+19%), but less rapidly than the population and GDP (OECD, 2019f; Figure 1.12). The promotion of sorting at the source and the strengthening of separate collection have helped increase the recovery rate (recycling and composting), which reached 48% of the amounts treated in 2012 and has stagnated since then (MDDI, 2018b). This rate is higher than the OECD average but still lower than that of neighbouring countries (Germany, 66%; Belgium, 54%). In addition, it

still has strong growth potential, particularly for organic waste, paper and cardboard, which still account for two-thirds of the mixed waste collected (MDDI, 2018b).

A large number of municipalities do not yet have all separate collections and/or do not apply a tax on residual waste by weight. Similarly, the target for reducing bulky waste has not been achieved due to inconsistent application of the polluter-pays principle at national level. Similarly, this principle is not applied uniformly in all municipalities (MDDI, 2018b). These issues were raised in the previous review, which recommended (i) introducing harmonised and differentiated pricing for municipal waste management throughout the country; and (ii) achieving economies of scale by encouraging municipalities to better co-ordinate their actions.

Figure 1.11. The construction sector generates the most waste



Note: Data for Japan refer to 2015.
Source: OECD (2019), "Waste: Waste generation by sector", *OECD Environment Statistics* (database).

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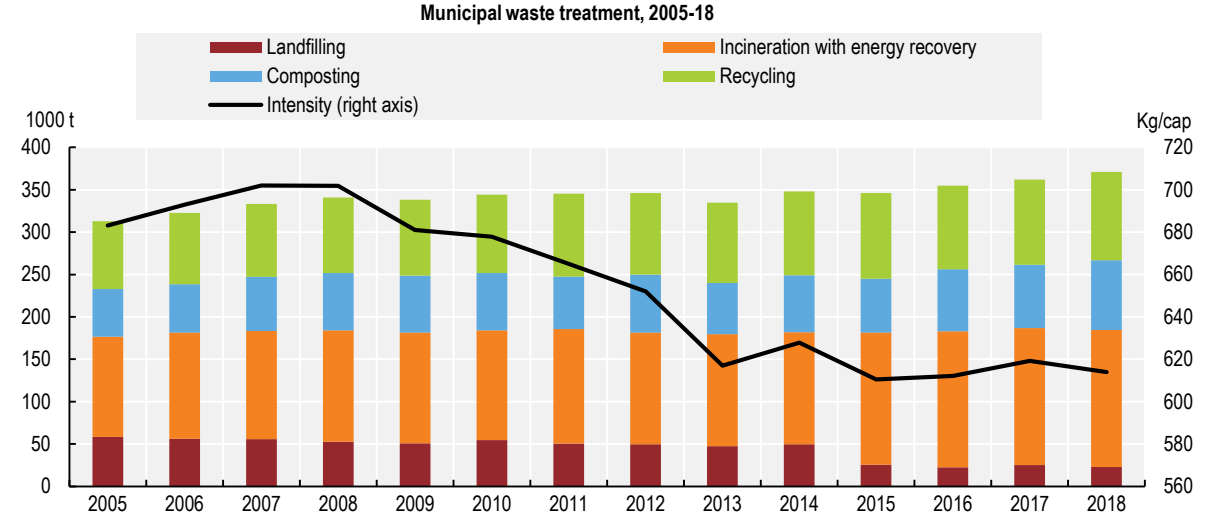
Figure 1.12. Waste recovery is growing faster than production



Source: OECD (2020), "Waste: Municipal waste", *OECD Environment Statistics* (database).

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Specific waste flows and problematic waste

Luxembourg has achieved its targets for recycling and recovery[6] of packaging waste under Directive 94/62/EC: in 2017, 67% of packaging waste was recycled and the material recovery rate reached 98%. Glass, metals and paper/cardboard exceed 75% recovery rates, but wood and plastics have stagnated at around 35%. The targets for end-of-life vehicles have also been exceeded, with a recovery rate of 97% and a recycling rate of 87% in 2015 (MDDI, 2018b).

The generation of hazardous waste almost doubled between 2006 and 2016. It consists mainly of mixed construction and demolition materials, as well as wood, and chemical and pharmaceutical waste. Because of its small size and cost-efficiency considerations, Luxembourg does not have any installation to treat hazardous waste. As a result, it incinerates 11% of this waste within the country and exports the rest for treatment in neighbouring countries.

In 2015, the health sector produced 2.4 tonnes of waste, 77% of which is infectious. Although recommended in the previous review, there is no national co-ordination between the various health sector actors to sort and collect their waste. In addition, Luxembourg dissolved the SANIDEC Association in 2011. This entity had partnered with the Environment Agency and the Ministry of Health to discuss the quantification and categorisation of waste from the health sector. Consequently, each establishment now decides how it sorts and collects waste based on the available recovery and treatment options. Nevertheless, in 2014, 132 health and care institutions were awarded the SuperDrecksKëscht (SDK) quality label, which guarantees compliance with environmental criteria (MDDI, 2018b) (Box 1.1).

Box 1.1. The SuperDrecksKëscht© (SDK)

Since 1985, the SuperDrecksKëscht© (SDK), an initiative of the Ministry of Sustainable Development and Infrastructure (MECDD) in co-operation with municipalities and the Chambre des métiers has enabled Luxembourg to make important progress and to be a leader in the management of problematic waste. The SDK is based on the principles of waste prevention, reduction and recovery. All recoverable materials are recycled to extract as many secondary materials as possible. At the same time, all problematic substances are treated to minimise negative environmental impacts. Flows of substances from production to processing into new raw materials or their environmentally sound disposal must be clearly presented so they can be monitored at any time.

The enterprise component of the SDK action was launched in 1992. It includes assistance in setting up recycling centres on large construction sites. The SDK is ISO 14001 certified and may, since 2009, award a quality label (ISO 14024 certified) for the concrete implementation of prevention measures. In 2018, 5 107 companies were members of the SDK; 61% had the quality label.

The scope of the SDK activities has gradually expanded: it collects separately 159 types of problematic waste from households, sets up separate collection structures in residences and supermarkets, and has initiated prevention measures such as the EcoBox, a multi-use deposit system, and the Eco-Sac [Eco Bag]. The EcoBox is a recycled plastic container, available in participating restaurants, that allows customers to take away their meal in exchange for a EUR 5 deposit. After use, the EcoBox can be taken back to the restaurant to collect the deposit or exchanged for another professionally cleaned Ecobox to take away another meal. Defective EcoBoxes can be exchanged free of charge. The Eco-Sac is a reusable bag made of recyclable materials sold at supermarket checkouts. It has helped reduce the consumption of single-use bags at supermarkets by more than 90% (or 840 million bags) since 2007.

Key plans and programmes

Luxembourg has a comprehensive legislative and regulatory framework in line with European legislation. The government's 2018-23 coalition agreement also foresees the transposition of the "Circular Economy Package" directives on the basis of a "Luxembourg Zero Waste" strategy. The national Waste and Resource Management Plan, adopted in 2018, incorporates the principle of a circular economy: it guides policy implementation and defines qualitative and quantitative targets. It follows on from the general Waste Management Plan, which established general principles (polluter pays, precautionary, extended producer responsibility) and targets by type of waste (MDDI, 2010).

According to the overall review of the 2010-15 plan, almost half of the 110 planned measures have been implemented, 35 have been partially implemented and 17 have not been implemented. The shortcomings identified relate to the management of inert waste, construction and demolition waste, food waste, waste from the health sector and waste from sewage treatment plants. According to the Environmental Implementation Review of EU environmental policy, Luxembourg is on track to meet the 2020 target of recycling 50% of municipal waste. However, further efforts will be required to reach the 65% recycling target that the EU directive sets for 2030 (MDDI, 2018b; EC, 2019b). The 2018 plan incorporates the EC's recommendations to intensify efforts to prevent and reduce waste at the source, as well as to recover waste. In addition, it brings forward to 2022 the targets set by EU directives at more distant years. These include the 55% recycling rate for municipal waste (by 2025 for the EU), limiting municipal waste landfilling to 10% (by 2035 for the EU) and recycling at least 70% of packaging waste (by 2030 for the EU) (MDDI, 2018b).

Separate collection at home includes paper and cardboard, metals, hollow glass, green waste, bio-waste and clothing. However, despite being required by the 2012 Waste Act, separate collection of bio-waste is not yet offered in all municipalities. In 2015, Luxembourg had 22 recycling centres, covering 93% of the population. The new plan aims to strengthen the network of recycling centres, with one centre for every 10 000 to 15 000 inhabitants. The "drive-in recycling" project and the ReBox project aim to increase the sorting and recovery rate of municipal waste. They provide customers with free collection boxes for returning waste and with additional infrastructures (in supermarkets and shopping centres) to sort plastic films and bags, pots, cups, trays and other recyclable items. In 2016, the ReBox was installed in the car parks of 11 supermarkets. The "residences" project, co-managed by the SDK and the *Groupement des syndics professionnels du Grand-Duché de Luxembourg,* aims to install a site dedicated to selective sorting in residences, as imposed by law. In 2019, 320 residences already had such an infrastructure.

The principle of extended producer responsibility was introduced in 2003 and progressively expanded. It applies to end-of-life vehicles, batteries and accumulators , waste electrical and electronic equipment and packaging. This principle is being applied well and could be further extended to other types of waste such as tyres, furniture or coffee capsules (MDDI, 2018b).

Several initiatives have also been launched on the circular economy concept. In particular, the strategic study of the Third Industrial Revolution, which sets out the country's economic and social development strategy for 2050, has addressed the circular economy (Ministry of Economy, Chamber of Commerce and IMS, 2017). Since 2010, several actions – including by the SDK, trade unions and municipalities – have been taken to prevent waste from being generated particularly through advice to businesses and households. Communication and awareness-raising campaigns on waste prevention (Eco-Sacs, reusable cups and the SDK's "Clever Akafen" [Buy Smart] campaign, among others) have been carried out. Second-hand shops in recycling centres have been set up for books, clothing and household items made of metals, plastics or porcelain, among other things. "Repair cafes", run by volunteers, have also been set up in co-operation with the SDK to help extend objects' lifespan through short circuits. An inter-ministerial committee has been set up to bring together all public stakeholders, exchange information and co-ordinate implementation. For instance, as part of a government initiative, the city of Wiltz has been designated future "hotspot" for the circular economy in Luxembourg. This pilot project (Wunne mat der Wooltz) for the

rehabilitation of former industrial wastelands focuses on the sharing economy, materials passport (for buildings) and multimodal mobility. The Fit 4 Circularity programme of the national innovation agency (LuxInnovation) in co-operation with the SDK, has been designed to facilitate and accelerate companies' transition to the circular economy (MDDI, 2018b).

1.6. Land use and natural resource management

Physical context and land use

At 2 586 km^2, Luxembourg is the smallest country in the OECD. It stretches 82 km from north to south and 57 km from east to west, and its altitude ranges from 130 to 560 m above sea level. From a geographical and geological point of view, it is composed of two main regions, Oesling in the north and Bon Pays in the south.

Agricultural land makes up 54% of the country (26% arable land and permanent crops, and 28% permanent meadows and pastures), followed by forests which cover 37.5% of the country. Artificial areas have increased and cover 14.5% of the country: 10% built-up areas and 4.5% infrastructure (STATEC, 2018). The economic development of the Greater Region[7] is accompanied by growth in both its population and the number of cross-border workers, which exacerbates the demand for infrastructure and built-up areas. Luxembourg is the European country that suffers most from a strong fragmentation of its landscapes. (EEA, 2019a), which affects biological diversity and increases soil erosion. Limiting urban sprawl is one of the objectives of the sectoral Landscape Plan, in connexion with other plans relating to transport, economic activity areas and housing (MEA, 2018).

Agriculture and agricultural inputs

Agricultural production increased slightly (+4%) between 2005 and 2016. Luxembourg's agriculture focuses on the production of milk, fodder crops and cattle. Large farms (50 ha and more) account for more than half of the country's farms and have gradually replaced small farms (STATEC, 2019c).

Nutrients

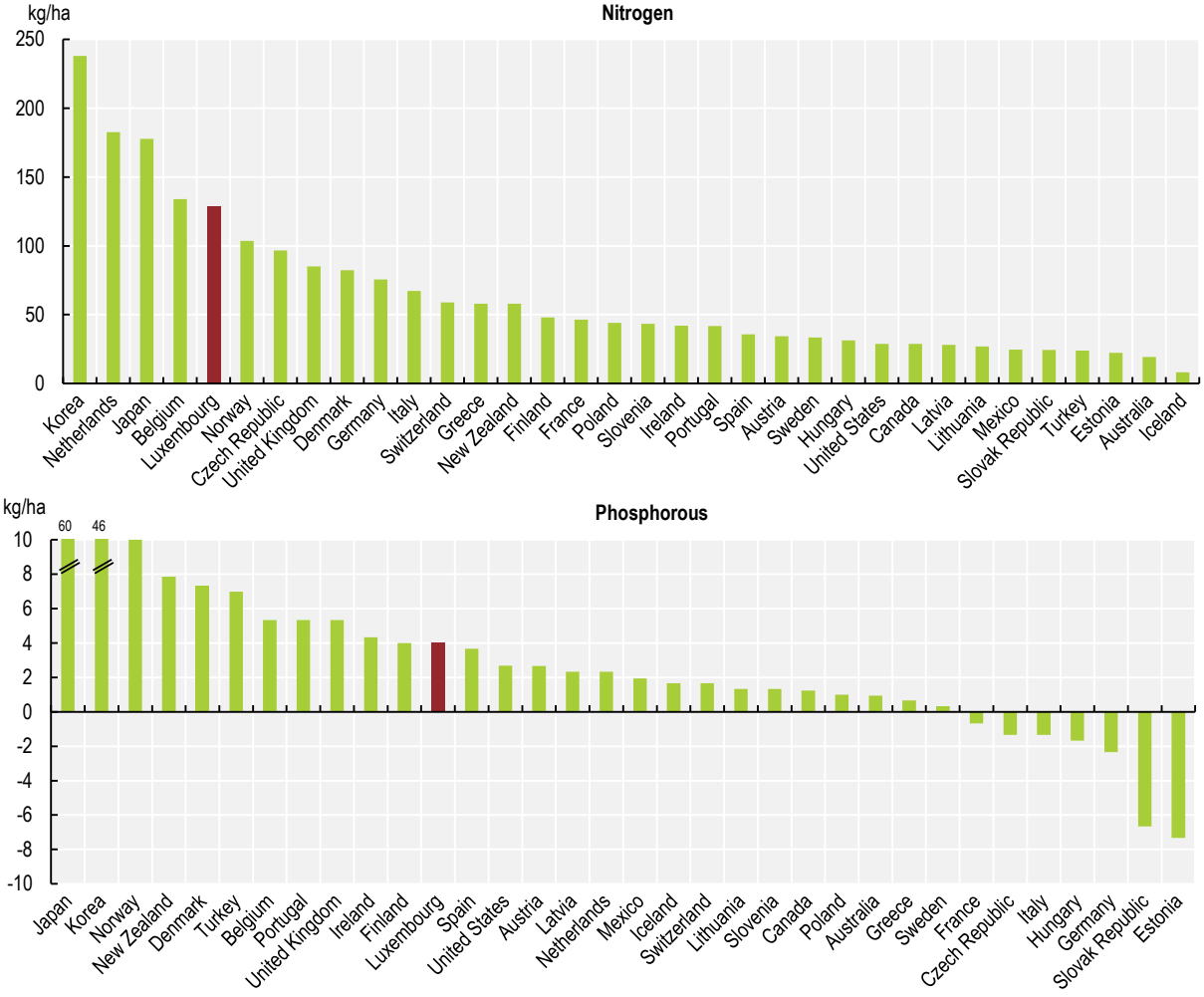
Nutrient surpluses from agricultural sources (nitrogen and phosphorus) indicate a risk of soil, water and air pollution. Luxembourg is among countries in the OECD with the highest nutrient surpluses (Figure 1.13). Nitrogen surpluses are high compared with other OECD member countries (OECD, 2019f; STATEC, 2019c). After a decline between 2006 and 2009, these surpluses stagnated again at their 2005 level. On the other hand, phosphorus levels have decreased by almost 50% since 2005, both in absolute (tonnes of nutrients) and relative (kilograms per hectare of agricultural land) terms. Livestock density is among the highest in the OECD, and 46% of NH_3 emissions come from livestock farming. To help farmers adopt sustainable practices, Luxembourg should review the environmental effectiveness of the different economic instruments that apply to agriculture.

Pesticides

Available data indicate that pesticide sales declined between 2011 and 2016. Herbicides, whose sales fell by 18%, account for 83% of the total. However, the limited number of sellers of plant protection products in Luxembourg means that data on a number of active substances are confidential and limits the evaluation of progress. The country adopted a first National Action Plan for the sustainable use of plant protection products in 2013 and revised it in 2017. The plan foresees a 30% reduction in the use of "big movers" (the most dangerous or widely used plant protection products) by 2025 and a 50% reduction in the use of pesticides by 2030 (compared to 2017). These objectives will be evaluated using indicators such as the

number of unit doses (NODU in French) or the Indicator of Frequency of Treatment, which were developed in the French Ecophyto Plan. The plan also foresees 25 measures, including untreated buffer zones around surface waters; identification, management and prohibition of plant protection products likely to pollute groundwater in at-risk areas; improved knowledge of how these products impact the soil; and more organic farming (MAVPC, 2017). Luxembourg is the first European country to ban glyphosate on its territory: in January 2020, the government announced the withdrawal of the market authorisation from 1 February, a ban on sales from 1 July and a ban on its use from 31 December 2020.

Figure 1.13. Nitrogen surplus remains high



Note: Average on the latest 3 years available.
Source: OECD (2019), "Environmental performance of agriculture - nutrients balances", *OECD Agriculture Statistics* (database).

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Organic farming

Although organic crop areas have increased to 4.39% of the used agricultural areas in 2018, their share remains well below the EU average (7%) (Eurostat, 2019e). Organic agriculture in Luxembourg is specialised in the production of milk, meat, poultry and eggs; most of the organic products consumed are

imported. To support this progress and to better match the supply and demand of organic products, a National Action Plan for the Promotion of Organic Agriculture has been in place since 2009 (MAVPC, 2018). The government seeks to increase the areas under organic crops to 20% of the used agricultural areas by 2025 (MAVDR, 2020).[8] However, current levels of development will not be sufficient to achieve this ambitious goal. A roadmap with concrete and well targeted measures is needed.

Biodiversity and ecosystems

Biodiversity has been declining for more than 40 years due to the loss and degradation of natural habitats (including changing hydrology), landscape fragmentation, agricultural intensification and climate change (MDDI, 2017b; MDDI, 2015).

The law on the protection of nature and natural resources provides for the development of a National Plan for Nature Protection (PNPN) every five years. The first plan (2007-11) identified national priorities and established collaboration between the national government and municipalities in certain sectors. However, it only partially achieved its objectives due to the vagueness of certain measures; inadequate budgetary and human resources; and a lack of inter-ministerial collaboration in implementing certain measures. The review also points to the lack of indicators to evaluate implementation of the measures along the way. As a result, most measures were often localised and restricted. The most recent plan, PNPN 2017-21, includes the National Biodiversity Strategy. It aims to adapt the strategy and measures to address the weaknesses of the first plan (MDDI, 2017c) (Chapter 5).

Natural habitat and protected areas

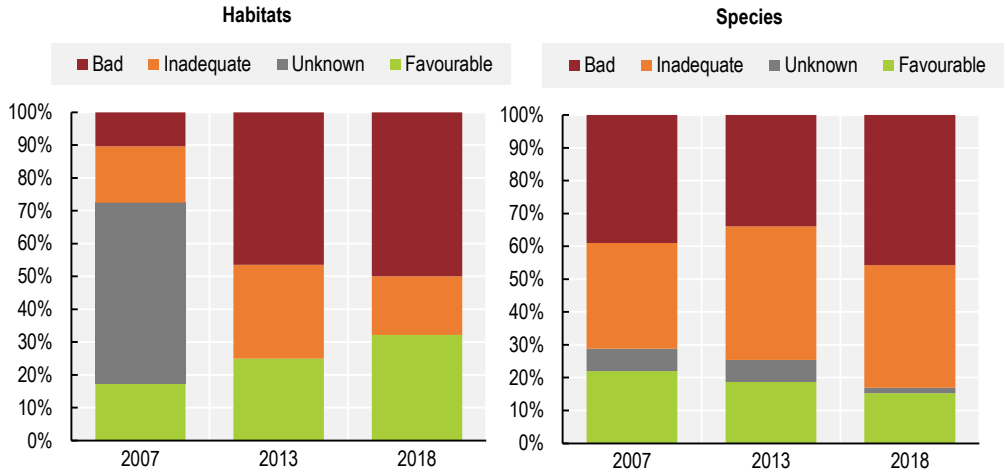
The Natura 2000 network implements the EU Habitats Directive on the conservation of fauna and flora and the EU Birds Directive. Natura 2000 sites cover 27% of Luxembourg's territory, a higher level than the EU average. The network includes 48 special areas of conservation (41 588 ha) and 18 special protection areas (41 893 ha), some of which overlap (MECDD, 2019). Their identification paved the way for the creation of area-specific management plans for biodiversity conservation. Most areas have management plans, as recommended by the previous review (OECD, 2010). However, efforts must be sustained throughout their implementation (BirdLife International et al., 2018).

This European network has stimulated the designation of protected areas, which increased from 46% to 50% of the country between 2005 and 2019 (categories I to IV of the International Union for Conservation of Nature). This national average was well above the OECD average (16%) and the 11th Aichi target (17% by 2020) enshrined in the Convention on Biological Diversity. National parks (category II) cover 33% of the territory and Habitat and Species Management Areas (category IV) cover 15%. The PNPN identifies protected areas of national interest, particularly due to their status as ecological corridors (MDDI, 2017c). They are important tools for connecting Natura 2000 protected areas and thus counteracting habitat fragmentation.

Information on the condition of habitats has improved significantly, but half of them remain in poor condition and 18% are in an inadequate condition. The conservation status of aquatic environments, amphibian areas and open environments along with the species that live in them are of the greatest concern.

The conservation status of the species covered by the Habitat Directive (92/43/EEC) is also of great concern and continues to deteriorate: only 15% are in good condition compared to 22% in 2007 (Figure 1.14) (Chapter 5). Under the Birds Directive, the 2013-18 evaluation shows a decreasing long-term trend for 38% of breeding birds, while the population is increasing in the long term for 25% of them. However, knowledge has improved compared with the previous evaluation (2008-12) (EEA, 2019c).

Figure 1.14. The conservation status of habitats and species is far from favourable



Note: These figures show the percentage of biogeographic assessments in each conservation status category for habitats and species.
Source: EEA (2019), "Conservation status and trends", *State of Nature in the EU: Article 17 national summary dashboards*.

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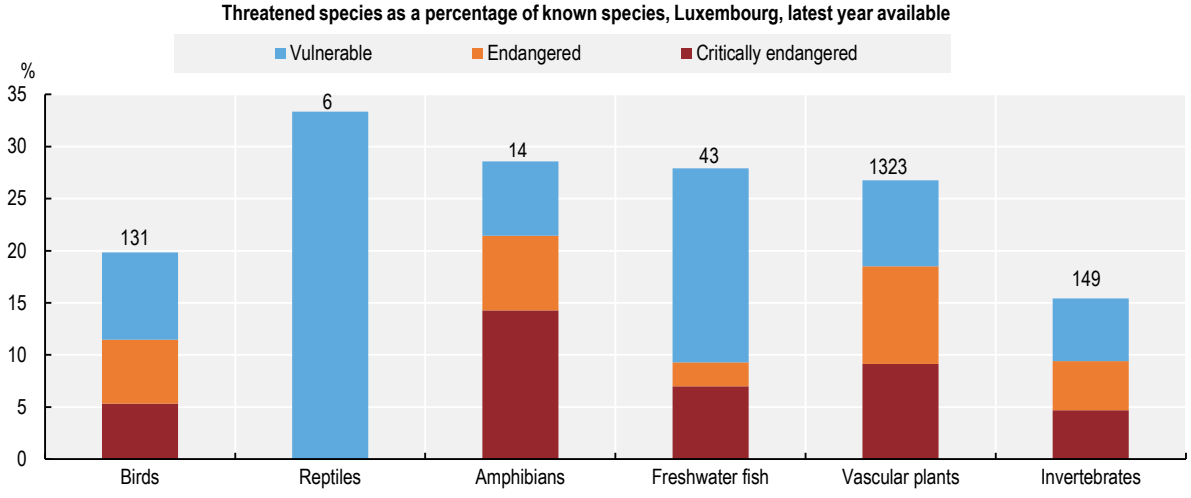
Species status

Luxembourg has more than 1 500 known species, which are mostly vascular plants. The status of these species is critical and has not improved (except for reptiles) since the last review, despite conservation efforts under the first PNPN (OECD, 2010). One-third of reptile species and more than one-quarter of fish, amphibian and vascular plant species are threatened (Figure 1.15, Chapter 5).[9] Plants associated with agricultural environments are more threatened, hence the importance of better integrating conservation into agricultural practices (MDDI, 2015).

Figure 1.15. One-quarter of species are threatened



Note: Invertebrates refers to dragonfly only.
Source: OECD (2019), "Biodiversity: Threatened species", *OECD Environment Statistics* (database)

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Forests

Forests cover 36% of Luxembourg's territory and more than half of them are privately owned. According to the 2013-18 evaluation, 4 of 7 forest habitats – and 8 of 11 species living in these habitats –were in poor or unfavourable condition (EEA, 2019b). In 2018, 31% of trees were "significantly damaged", an improvement from 38% in 2016 (STATEC, 2019d). By 2020, the government aimed to double the area of forests under the forest regime as freely growing forest reserves. These areas without logging should increase to at least 5% of forest area (compared with 2.5% in 2015). Forest management plans, consistent with sustainable forest management practices, are in place for all public forests, as well as for private forest estates exceeding 10 ha (MDDI, 2015).

Water management

Main plans and programmes

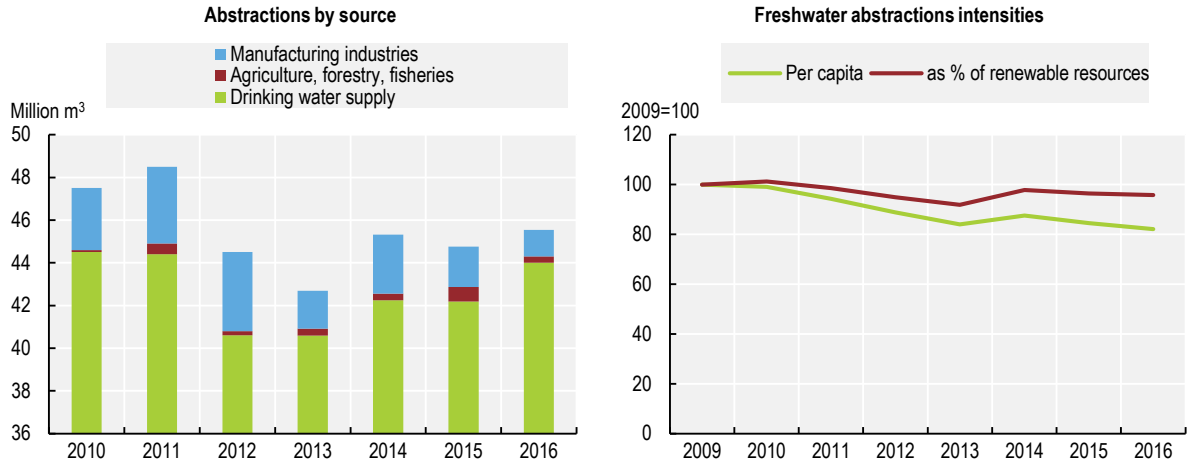
Luxembourg develops its policies in line with the European directives related to water management.[10] The River Basin Management Plan covering 2009-15 has been revised for the second cycle (2015-21). It covers those parts of the international Rhine and Meuse river basin districts within Luxembourgish territory. Public water supply and wastewater treatment are the responsibility of municipalities and associations of municipalities (*syndicats*).

Water resources

Luxembourg extends partly over two international river basin districts of the Rhine and the Meuse, both of which are transboundary. The country has 2 855 m^3 of renewable freshwater per capita, which is less than most OECD member countries. Slightly more than half of these abstractions come from groundwater sources (51%), all of which are in good quantitative status, while the remainder comes from surface water (Upper-Sûre Lake) (EC, 2019; OECD, 2019g). Per capita abstractions (78 m^3/capita/year) are well below the OECD average (717 m^3/capita/year) due to the low share of the agricultural sector. They fell by 17% between 2010 and 2016 as a result of the economic slowdown (lower abstractions in the metal industries) and technological improvements in distribution networks (repair of leaks in sanitation facilities and household appliances) (Figure 1.16). Projections indicate a future increase in water consumption, due to population growth, continued and sustained economic growth, and the expected increase of irrigation. These pressures could be critical during periods of high consumption (between June and October), as well as in the medium term (2030-40).

As the natural groundwater recharge has been largely deficient in the three years between 2016-18, aquifer levels are rather low. To ensure the security of drinking water supply and its sustainability, the government set a strategy based on three axes. First, delimited protection zones were set up around water catchments used for consumption to protect water resources. Second, water conservation projects for major infrastructure projects (construction of housing estates) will draw on new technologies that allow water to go through several cycles. For example, drinking water can be used for toilets before being discharged into wastewater. These projects will be accompanied by awareness campaigns and support for saving measures in the industrial, agricultural and household sectors. Third, additional resources from both surface and groundwater will be captured and rendered potable.

Figure 1.16. Water abstractions for drinking water supply are increasing



Source: OECD (2019), "Water: Freshwater abstractions", *OECD Environment Statistics* (database).

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Water quality

Only 3% of natural surface water bodies were of "good ecological status" in 2015, placing Luxembourg among the worst performing countries in the EU (EEA, 2019d). This is due to poor hydro-morphological quality (interrupted ecological continuity, stabilised banks or bottoms), as well as a high content of nutrients, especially nitrogen. None of the surface water bodies achieved in "good chemical status". These poor results are mainly related to ubiquitous substances. If these substances are not considered, 99 of 110 bodies of surface water achieve "good chemical status" according to the environmental quality standards of Directive 2008/105/EC. Luxembourg was granted an extension of its deadline for achieving its objectives to 2027. The poor results can be explained by delays in implementation of management plans, as well as lack of coherence between water and agricultural policies. In addition, the wastewater discharge tax is relatively low. It does not sufficiently encourage water service providers to reduce the pollutant load of discharged water (Chapter 3). As Luxembourg lies on the dividing line between the Rhine and Meuse river basins, it has mostly small to very small rivers. Each additional discharge thus represents a potential pressure. With a growing population, the loads discharged by wastewater treatment plants are also an increasing pressure. To compensate for this effect, discharge permits for the plants are restrictive, which leads to high construction and operating costs.

As regards groundwater, half of water bodies were classified as being in “poor chemical status” due to high concentrations of nitrates and metabolites of plant protection products. On the other hand, the 11 bathing sites enjoy excellent water quality (EC, 2019b).

The whole of Luxembourg is subject to measures to ensure compliance with the Nitrates Directive (91/676/EEC). To protect water catchments for drinking water supply, 23 Grand-Ducal regulations have been published from 2014 and 29 draft Grand-Ducal regulations are in the regulatory process. Among these projects is the protection zone around the Upper-Sûre Lake. This lake is Luxembourg's main drinking water reserve and accounts for almost half of the water used for human consumption. However, nitrate pollution from both intensive livestock and dairy farming remains a problem (EC, 2019b), particularly due to slow implementation of measures.

Water supply and sanitation

The entire resident population is connected to an urban public sewerage system (OECD, 2019h). In 2017, 75% of the population benefitted from a tertiary ("advanced") treatment and 22% from a secondary treatment. Since 2011, major investments have helped modernise and extend the wastewater treatment plant network. In January 2018, these investments made it possible to close the infringement procedure opened in 2011 by the EC to the Court of Justice of the EU due to the country's failure to comply with the directive. As six treatment plants serving agglomerations of more than 10 000 inhabitants did not comply with obligations in the directive, Luxembourg was sentenced in 2013 to pecuniary penalties. In addition, the government planned to "modernise existing treatment plants with special focus on the treatment of micropollutants and the elimination of microplastics". By 2023, the work to equip the 13 main wastewater treatment plants (87% of urban water) with a fourth level of treatment will have started. Approximately 117 storm basins and about 150 km of sewer/mixed sewerage collectors have been constructed since 2010 (EC, 2019b).

Drinking water is of very good quality: Luxembourg has a high rate (99-100%) of compliance with the microbiological, chemical and other parameters set out in the Drinking Water Directive. Nevertheless, due to pollution by plant protection products (mainly herbicides and their metabolites) and nitrates, many catchments used for human consumption had to be taken out of service. It is estimated that quantities of water that could supply nearly 75 000 people are unusable. This corresponds to 12% of the annual volume of groundwater exploited for drinking water supply. Since 2015, some active substances responsible for a deterioration in water quality have been banned in water protection zones around catchments used for drinking water supply.

Luxembourg should consider a more rigorous preventive approach to guarantee the security of drinking water supply in the long term. For example, it could ban plant protection products in sensitive areas. The country's economic and demographic growth also requires investment in drinking water infrastructure and efficient management of distribution networks.

Recommendations on the management of emissions (air and climate), waste and water

Climate and energy

- Adopt the climate framework law as soon as possible; ensure that it includes binding GHG reduction targets and adequate institutional review systems and stakeholder consultation mechanisms; consider incorporating the commitments of the Paris Agreement on financial flows, as well as carbon pricing, into the law.
- Develop scenarios for achieving the 2030 renewable energy and energy efficiency targets, bearing in mind air quality and climate objectives; specify the contribution of each sector to these objectives, in particular the contribution of current and planned transport measures to reducing road fuel consumption.
- Develop a framework for monitoring the implementation of the Climate Change Adaptation Strategy; ensure that climate change impacts and resilience are duly taken into account in environmental impact assessment (EIA) and strategic environmental assessment (SEA) procedures; include climate risks in insurance products.

Waste and materials management

- Continue implementing the national WRMP; step up efforts to increase the recycling rate of organic, plastic, paper and cardboard waste and to better exploit the stocks of materials in mixed municipal waste; expand the types of products covered by extended producer responsibility: tyres, coffee capsules, furniture, etc.
- Step up efforts to introduce harmonised pricing for municipal waste management throughout the country, taking into account the actual amounts of waste to be disposed of, and encourage municipalities to better co-operate and co-ordinate their actions.
- Adopt a circular economy strategy that sets out the responsibility of each ministry and stakeholder and establishes an implementation roadmap; seek synergies with the development of environmental technologies and green public procurement (GPP); establish a platform for businesses, banks and other stakeholders to meet and co-ordinate their actions.

Water management and agricultural inputs

- Accelerate the implementation of measures to preserve and improve water quality and continue to provide adequate financial and human resources; revise the wastewater discharge tax to strengthen its incentive function; secure the supply of drinking water by applying a more rigorous preventive approach, for example by banning phytopharmaceuticals in sensitive areas.
- Improve the coherence and integration of environmental and agricultural policies; assess the economic and environmental effectiveness of agricultural subsidies; consider introducing taxes or bans on fertilisers and pesticides to help reduce their impact on water and soil quality, biodiversity and human health; encourage the adoption of sustainable agricultural practices by updating the guide on good agricultural practices.

Notes

[1] This includes electricity exchanges.

[2] The EU's Renewable Energy Directive allows Member States with an abundant and profitable supply of renewable energy to help other countries meet their targets. These agreements stipulate that Estonia and Lithuania will each transfer a certain amount of surplus renewable energy to Luxembourg between 2018 and 2020.

[3] Excluding emissions from the land use, land-use change and forestry sector.

[4] The EU ETS is based on a “cap and trade” principle. A cap (which progressively decreases) is set to limit the total amount of certain GHGs that can be emitted by installations covered by the mechanism.

[5] These are housing, energy, forestry, infrastructure, crisis management, land-use planning, agriculture, health, biodiversity, tourism, urban areas, water management and the economy.

[6] Recovery here includes recycling and energy recovery (including incineration with energy recovery).

[7] The Greater Region is the geographical area comprising Luxembourg, the Walloon Region in Belgium, Lorraine in France and two German states (Saarland and Rhineland-Palatinate).

[8] The strategic study of the 3rd industrial revolution for the Grand Duchy of Luxembourg (2016), which explores future opportunities for economic development, suggests a transition towards a 100 % sustainable and organic agriculture by 2050.

[9] Vulnerable, Endangered and Critically Endangered categories of the International Union for Conservation of Nature.

[10] The Water Framework Directive (2000/60/EC); the Floods Directive (2007/60/EC), the Groundwater Directive (2006/118/EC); the Bathing Water Directive (2006/7/EC), the Drinking Water Directive (98/83/EC); the Urban Waste Water Treatment Directive (91/271/EEC); the Nitrates Directive (91/676/EEC).

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2 Environmental governance and management

Luxembourg is a small country with a centralised system of environmental governance. The government has made significant efforts to increase its transparency and accountability and to update environmental legislation. However, resource constraints impede more effective implementation of environmental policies and law and use of good practices in compliance assurance. Chapter 2 analyses the institutional and regulatory framework for environmental management, the setting and enforcement of environmental requirements, and mechanisms of public participation in decision-making, as well as access to environmental information, education and justice.

2.1. Introduction

The last decade has been marked by the increased political profile of environmental issues. Environmental governance has become more proactive and transparent, with many new legislative and policy initiatives. While general regulatory quality, rule of law and government effectiveness in Luxembourg are high, they decreased somewhat between 2012 and 2017 (World Bank, 2017). These trends can also be seen in the environmental domain, where policy implementation often lacks whole-of-government coherence and struggles to deliver expected results.

2.2. Institutional framework for environmental governance

The Grand Duchy of Luxembourg is a small unitary state with a centralised system of environmental governance. However, its 102 municipalities have a large degree of autonomy under the control of the central government, which appoints mayors. The 12 cantons serve as judicial and electoral districts, but do not have administrative functions.

Central government and horizontal co-ordination

The Ministry of Environment, Climate and Sustainable Development (MECDD) is responsible for making environmental and sustainable development policy. Under its auspices, three authorities perform regulatory and monitoring functions: the Environment Administration (AEV), the Nature and Forest Administration (ANF) and the Water Management Administration (AGE). In the water domain, the AEV and AGE have complementary responsibilities. For example, the AEV and AGE both regulate effluents into surface water bodies. The AGE also covers water abstraction, surface water and groundwater quality. In addition, the AGE oversees drinking water supply and municipal wastewater treatment infrastructure (water-related responsibilities were transferred from the Ministry of the Interior to that of the environment in 2013). The administrations have a modern, task-based organisational structure, which has improved their efficiency.

The Ministry of Energy and Spatial Planning (MEA) covers renewable energy and energy efficiency. It also co-ordinates national policies for territorial development and land use. The Ministry of the Interior is in charge of co-ordination between the state and local communities, including urban development and local spatial planning (Section 2.3). The Ministry of Mobility and Public Works is in charge of transport and infrastructure. The MEA and MECDD oversee the Myenergy agency that promotes sustainable energy transition, particularly in the housing sector. Several of these environment-related responsibilities were within the scope of the Ministry of Sustainable Development and Infrastructure (MDDI) in 2013-18. However, the remit of the environment minister (one of two in the former MDDI) has remained virtually unchanged.

Overall, horizontal co-ordination on environmental and sustainable development issues functions well. The Interagency Commission for Sustainable Development (CIDD) oversees the elaboration and implementation of the National Sustainable Development Plan (Chapter 3), bringing together government stakeholders on main strategic matters. In addition, an issue-specific interagency co-ordination committee oversees implementation of each environmental law. For example, the future climate law will likely establish a formal mechanism for collaboration between the MECDD and the MEA on energy and climate issues. At the same time, economic interests of specific sectors (such as agriculture) often impede better inter-ministerial collaboration.

Local governments

Municipalities (communes) are responsible for local land use, water supply, and wastewater and waste management, as well as certain aspects of nature protection (Chapter 5). They are mostly autonomous in their policies and practices. Communes pool their resources to create *syndicats* – associations of several communes for joint delivery of certain environmental (water or waste management) services. Many communes are members of several environmental service associations. This is a good practice also observed in several other OECD member countries (e.g. France, Sweden and Hungary). These associations are often key interlocutors for the central government on local environmental issues. In waste management, communes and their associations could co-operate better to harmonise practices across the country (Chapter 1).

Direct contacts between the central government and communes have increased with the 2015 abolition of district commissariats that once served as intermediaries between the two levels of government. This was in line with the 2010 Environmental Performance Review (EPR) recommendation that Luxembourg ensure better co-ordination between central and local governments to implement environmental and land-use policies. Communes are routinely consulted on draft regulations that concern them, e.g. on nature protection or water protection zones, as well as on all strategic plans. The environment ministry has issued several guides (*vade mecum*) for communes on issues within their remit.

All communes have signed the Climate Pact, a co-operation agreement under which they commit to implement certain environmental and climate-related measures. In exchange, they receive financial and technical assistance from the state and environmental certification (Chapter 3). Communes have recently adopted a voluntary “climate pact” (inspired by the European Energy Award). This encourages them to implement measures in six different domains (including land-use planning, construction and mobility) and achieve several levels of certification. In addition, communes form water partnerships and flood partnerships (usually across the same river). They also adhere to “biological stations” – inter-municipal associations that transpose nature conservation projects to the local level.

2.3. Setting of regulatory requirements

National environmental legislation is brought together in an Environmental Code – a regularly updated online compendium. During the review period, several new important pieces of environmental legislation entered into force, including the 2018 nature protection law and the 2012 waste management framework law. In addition, a number of environmental laws were updated to align them with European Union (EU) directives. These include the 2018 law on environmental impact assessment (EIA) and the 2014 law on industrial emissions. Luxembourg is in good standing with regard to implementation of EU law: it had only two infringements against EU environmental directives, the fewest among member states, along with Denmark (EC, 2019a).

Regulatory and policy evaluation

Regulatory impact assessment (RIA) is undertaken for all laws and regulations through a checklist that focuses on administrative burden and enforcement costs. It does not, however, consider environmental impacts or benefits. Instead, a “sustainability check” for all draft laws is being put in place. The sustainability check, based on priorities of the country’s Sustainable Development Plan (Chapter 3), would be an information and transparency instrument: it will be submitted to parliament and available to the public. Its use would be mandatory, but its conclusions would not be binding.

There is also a lack of *ex ante* evaluation of environmental policies, plans and programmes, particularly evaluation involving cost-benefit analysis. This sometimes results in incoherence between strategies, which reduces their efficiency.

All national spatial plans and sectoral strategic plans undergo mandatory strategic environmental assessment (SEA) in line with a recommendation of the 2010 EPR. However, SEA covers only parts of municipal land-use plans. Where SEA is carried out, it usually stays at a general level. This creates confusion with public consultation, which is usually conducted in parallel with the SEA process. SEA results are rarely followed up during the implementation phase of the plan or programme.

Several *ex post* evaluations have been undertaken in the environmental domain (e.g. the second Climate Plan and the second National Sustainable Development Plan). However, in spite of the 2010 EPR recommendation to closely monitor results of environmental actions, the evaluations are not consistently used as a management tool (OECD, 2018). There are insufficient resources for policy evaluation within the government. Moreover, the Audit Chamber (*Cour des comptes*) does not have a mandate for performance assessment of government activities, contrary to practice in several other OECD member countries (e.g. Estonia and Canada).

Environmental impact assessment and permitting

EIA and permitting are subject to separate procedures. The 2018 law on EIA divides development projects into several categories, with preliminary screening required for most activities. The EIA report is published on a dedicated website and announced in at least four daily newspapers for public comment over a 30-day period. A positive "motivated conclusion" of the MECDD on the EIA report is a prerequisite for submission of an environmental permit application.

Since 2017, "classified" (regulated) installations apply for an environmental permit using a standard application package ("commodo" electronic form). This has reduced incomplete applications and, as a result, sped up the permitting process. In the future, it will also be transmitted electronically to further accelerate the process. Depending on the installation's category, the AEV and the Labour and Mines Inspectorate issue permits separately or in co-ordination. For medium-impact facilities, the local government issues permits. Draft permits are subjected to public comments for 15 days.

For the low-impact category of installations, permitting is replaced by declaration in accordance with standardised environmental requirements (general binding rules) contained in a government regulation. These requirements are not sector-specific because there are too few installations in each sector to justify regulations for each one. There are plans to extend the declaration regime to several other types of economic activity to reduce the administrative burden on small enterprises.

The AGE issues a range of water-related permits: for abstraction from, and discharges to, surface water and groundwater, as well as for relevant infrastructure projects. There are also a number of permits related to forestry and other nature uses (Chapter 5).

Land-use planning

According to the 2018 spatial planning law, a Strategic Spatial Planning Programme (PDAT) should form the basis of land-use planning in the country. The PDAT is supposed to be implemented through four binding sectoral strategic plans (for housing, transport, economic activity zones, and landscape protection) and locality-specific plans (*plans d'occupation du sol*). Locality-specific plans target nationally important infrastructure (e.g. the airport) and take precedence over municipal plans. The PDAT, and sectoral and locality plans, are subject to SEA.

The Government Council approved four sectoral plans in July 2019 after extensive public consultation. However, the current, second PDAT dates to 2003. To ensure better alignment between strategic and sectoral spatial planning, the MEA is developing a new PDAT with a draft expected in 2020.

The Ministry of the Interior oversees the development of master plans (*plans d'aménagement général*) and detailed land-use plans (*plans d'aménagement particulier*) by communes. In the past, municipal plans often

led to conflicts between housing development pressures and environmental considerations. As of March 2020, 48 communes have adopted “new generation” master plans. Their drafts are considered by the Spatial Planning Commission co-chaired by the Ministry of the Interior and the MEA, which issues an opinion. The MECDD, also a member of the commission, can issue an opinion as well, but only with respect to green areas. However, municipalities are not obliged to follow these opinions, which may lead to contradictions between municipal and national sectoral plans.

The MECDD recommends that municipal master and detailed land-use plans in their entirety undergo SEA, as practised in many OECD member countries (e.g. France and Latvia). However, the administrative tribunal has ruled that only parts of these plans that are related to green areas should be subject to SEA. This is the predominant practice, which does not ensure adequate integration of environmental considerations into local land-use planning.

2.4. Compliance assurance

According to AEV statistics, Luxembourg has few serious environmental non-compliance cases. However, the low level of resources for this activity may mean the government overestimates compliance by the regulated community. Indeed, in the water domain, where the AGE has stepped up inspection, the rate of significant non-compliance is high, between 20% and 30%.

Environmental inspections

The AEV’s control and inspection unit created in 2017 conducts compliance monitoring of activities with high environmental risk. The unit’s staff of 4 (among AEV’s staff of about 110) does not cope with all compliance monitoring needs. Among the staff, only two inspectors have special investigative powers of judicial police officers.

Most AEV inspections are triggered by citizen complaints (65% of inspection cases in 2018), and requests by the environment ministry, the prosecutor’s office or the police. The number of complaints grew by 50% in 2018 over the previous year (AEV, 2019), which led to the doubling of complaint-related inspections. However, the recently introduced complaint form has facilitated more targeted response to them.

The frequency of planned inspections is defined in the 2014 law on industrial emissions: it is annual for high-risk installations and once every three years for lower-risk facilities. In practice, annual frequency is not respected for every installation governed by the EU Industrial Emissions Directive (IED, 2010/75/EU). There were only 17 planned inspections of the country’s 35 IED installations in 2018 (AEV, 2019), which is largely due to the lack of human resources. Better balance is needed between reaction to complaints and proactive risk-based inspection planning.

The AEV also carries out occasional ad hoc inspection campaigns covering specific activity sectors. Such a campaign was conducted in the agricultural sector in 2018. Routine monitoring (sampling and measurement) of pollution releases from a wide range of installations is outsourced to specialised organisations accredited by the MECDD. Some 1 200 to 1 500 site visits take place each year.

The AGE established its own inspection and control service in 2017. It verifies compliance with water-related permits and licences, and reacts to water pollution incidents. Inspections more than tripled from 85 to 270 over 2017-19. There is some collaboration between all three environmental administrations (AEV, AGE and ANF) in compliance monitoring, but it is insufficient. The AGE and the ANF maintain their own statistics, making it difficult to assess compliance levels. Indeed, the administrations would benefit from an integrated compliance assurance strategy that the MECDD could develop.

The AEV website includes information on inspection planning and full inspection reports for IED installations, but only until 2016. These include descriptions of instances of non-compliance identified and

corrective actions recommended to, and accepted by, the operator. However, inspection reports do not usually contain information on warnings issued, sanctions applied or compliance achieved after enforcement action. Inspection reports for non-IED installations and unplanned inspections are not available to the public.

Enforcement

Environmental authorities often rely on the national police and customs in criminal enforcement matters. Police and customs officers receive training on environmental legislation, but more specialised training may be necessary. Furthermore, there are no prosecutors or judges specialised in environmental matters. Only the prosecutor's offices in Luxembourg City and Diekirch have two staff each, who work on waste-related crimes (EU, 2019).

Information is lacking on the effectiveness of different sanctions, as well as on how competent authorities ensure a proportionate response to different types of non-compliance (EC, 2017). Administrative enforcement has historically been limited to warnings, compliance prescriptions and orders to stop the non-compliant activity. Environmental inspectors and the police can issue a penalty notice (*procès-verbal*), which is then transmitted to a public prosecutor for further criminal enforcement. However, recent modifications of the waste and water legislation have introduced administrative fines of up to EUR 1 000 for minor violations. Similar changes are expected in enforcement of nature-related offences. Expanded availability of administrative fines would allow inspectors to use monetary penalties more without resorting to criminal enforcement.

Few criminal sanctions are applied: over almost 140 inspections in 2018, the AEV issued only one notice of violation and did not impose penalties. The same year, the AGE took 122 administrative enforcement measures in 231 inspections, but opened only two criminal cases. The reluctance to initiate criminal enforcement is largely due to the resource-intensive efforts needed to collect evidence that would withstand scrutiny in a criminal court.

Fines for most environmental crimes range from EUR 250 to EUR 125 000, while imprisonment ranges from eight days to six months. Small waste-related offences can be punished with a "warning fine" (*avertissement taxé*) of up to EUR 250. These sanctions are lower than in most OECD member countries and are unlikely to have a deterrent effect. The courts determine penalties, but there is no guidance for judges on how to set fines proportional to the gravity of the violation. In 2018, there were 49 criminal convictions for environmental offences. Monetary penalties were imposed in 14 of these cases (in 10 of them the fine was less than EUR 1 000).

Environmental liability

Liability for damage to the environment

According to the 2009 law on environmental liability, a judge orders remediation of damage to the environment by the responsible party at its cost. The order also defines a remediation timeline, which cannot exceed one year, and may impose a financial deposit (*astreinte*) until the remediation is completed. In the last decade, only two cases of accidental water pollution were treated under this law. However, the law's provisions are not retroactive. Pre-2009 cases can be addressed through other regulatory provisions, but not always in a coherent manner.

An operator may be required in a permit to provide financial guarantees to cover estimated costs of site decommissioning and remediation. Such financial guarantees are mandatory for operators of IED installations and facilities storing large amounts of hazardous substances. Operators may choose to buy environmental insurance. However, companies in Luxembourg do not offer environmental insurance of

significant environmental damage (i.e. with high indemnity levels) because there are too few potential clients to make a national environmental insurance market viable.

Contaminated sites

Luxembourg has a cadastre of about 12 000 potentially contaminated sites. However, their actual remediation relies on voluntary efforts and financing by responsible parties. Remediation of orphan sites (i.e. those where the responsible party cannot be found or is financially insolvent) may be funded up to 50% by the Environmental Protection Fund. However, the remaining financing must be provided by communes, which are not always ready to pay. These gaps were already noted in the 2010 EPR, which recommended that Luxembourg "establish a multiyear clean-up and rehabilitation plan for contaminated sites, including orphan sites, and specify how it will be funded".

A new law on soil protection and management of contaminated sites is awaiting adoption. It will require the government to develop a national plan for soil protection, establish a list of high-risk installations for soil contamination, verify sites registered in the cadastre and, eventually, limit registration to sites with a significant degree of contamination. It will define soil as a non-renewable natural resource and lay out responsibilities and procedures for its remediation.

Promotion of compliance and green practices

Environmental authorities do not give sufficient attention to promotion of compliance and green business practices. This gap is partly bridged by trade associations that disseminate information on environmental requirements and ways to comply with them among their members.

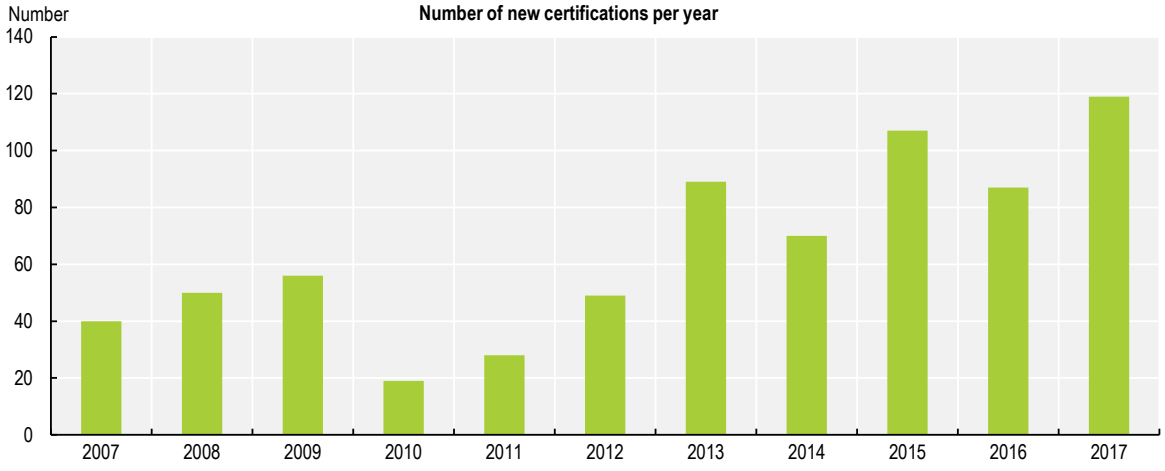
Voluntary business initiatives

Voluntary environmental agreements are not yet widely used. One such agreement between the government and 50 energy-intensive enterprises envisages a 7% reduction of energy consumption over 2017-20. The environment minister recognises voluntary environmental audits and other forms of environmental self-assessment by a certificate of approval (*agrément*). There were 87 physical and legal persons holding such a certificate in 2018 (AEV, 2019). Small business associations have proposed the idea of expanding the Climate Pact (Section 2.2) to small and medium-sized enterprises as a way of promoting energy efficiency and other climate-friendly practices.

Environmental management system certifications

The annual number of new certifications to the ISO 14001 environmental management system standard grew sixfold between 2010 and 2017 (Figure 2.1), with few incentives from the government. The AEV has only recently begun to consider ISO 14001 certification in calculating planned inspection frequencies. Several EU institutions located in Luxembourg and one local organisation have adopted the EU Eco-Management and Audit Scheme (EMAS). Several other local organisations are under consideration. However, EMAS remains unpopular among local businesses. The AEV and the Luxembourg Institute of Science and Technology started a joint programme in 2018 to further promote this instrument.

Figure 2.1. The number of ISO 14001 certifications rose significantly over the last decade



Source: ISO (2018), *ISO Survey 2017*, International Organization for Standardization, Geneva.

StatLink https://doi.org/10.1787/888934168626

Greening public procurement

Luxembourg has neither a national action plan nor a national strategy on green public procurement (GPP). Specific targets or measures to promote GPP are also absent. However, the government's public procurement law encourages contracting authorities to use tender procedures to promote sustainable development. In 2018, the government decided that its own fleet vehicle should be electric or plug-in hybrid vehicles, with justified exceptions. It also set up a working group on challenges and opportunities of public procurement in a circular economy (EC, 2019b).

2.5. Promoting environmental democracy

Luxembourg ratified the Aarhus Convention in 2005, and its Pollution Release and Transfer Register (PRTR) Protocol in 2006. Over the last decade, the presence of the Green Party in the government has contributed substantially to the culture of openness of environmental decision making.

Public participation in environmental decision making

Overall, the central government and the MECDD in particular have been proactive in engaging businesses and the public in policy development. Public participation is part of both EIA and permitting processes (Section 2.3). It is also part of the elaboration of all strategic plans, which constitutes a good practice. Drafts of all relevant laws and regulations are sent for comment to non-governmental organisations (NGOs) and trade associations.

The Sustainable Development Board (CSDD) provides a forum for civil society participation. Its 15 members, nominated on a personal basis by the government, represent the private sector, NGOs and academia. The CSDD meets on average every six weeks; its secretariat, provided by a MECDD officer, is located within the ministry. It issues opinions, generally considered by the government, on key environmental issues and draft government programmes and legislation.

Access to environmental information

Access to environmental information may be required on the basis of the 2005 law on public access to environmental information, which transposes the Aarhus Convention into national law. The 2018 law on transparent and open administration further established public access to all government-held information. However, both provide for an exemption from the right of access in case of commercial confidentiality without going into detail. The grounds for refusing access are to be interpreted in a restrictive manner, taking into account public interest. Information on pollutant emissions reported by companies can thus not be qualified as confidential information.

The 2018 law created a Document Access Commission to consider appeals in case an information request is refused or inadequately answered. Further recourse is available in an administrative tribunal. In practice, environmental authorities often do not have sufficient human resources to adequately address all information requests.

The 2010 EPR recommendation to improve the production and dissemination of environmental information has been partly implemented. Luxembourg has a national environmental portal containing most of the relevant information such as legislation, data and other documents. The main portal can be difficult to navigate; it is not always clear where to find particular information. The government uses new platforms such as Digital Luxembourg to disseminate environmental information: air quality data can be downloaded using a cell phone application. The national Geoportal constitutes a central public-sector platform for the exchange of geospatial data, products and services. The national PRTR covers installations in 9 activity sectors and 91 pollutants. However, many environment-related government webpages are outdated due to lack of resources to maintain them.

Due to lack of resources, the country has not published a state of the environment report since 2003. The MECDD plans to develop such a report in collaboration with the National Statistics Institute and publish it online in the coming years.

Access to justice

Citizens can invoke the constitutional right to a clean environment (Article 11bis of the Constitution) directly in administrative and judicial procedures. No courts deal specifically with environmental issues. Individuals who can demonstrate “direct and certain interest” in the matter can bring environmental claims to court or administrative tribunals. NGOs, including foreign ones, have legal standing if environmental protection has been part of their charter for at least three years (European e-Justice Portal, 2019).

A case can be filed in court before all administrative remedies have been exhausted: this is a good practice not applied in many OECD member countries. Class action suits do not exist in Luxembourg. Apart from seeking legal remedies, people can file a claim against an administrative decision with the Ombudsman, who would mediate between the parties but not rule on the case.

There are no specific exemptions from legal costs on environmental matters, which may be high. However, the state may cover costs of, and provide legal aid to, individuals of insufficient means. There are no public-interest environmental law organisations in the country.

Environmental education

Luxembourg has implemented the 2010 EPR recommendation to develop environmental education as part of the National Plan for Sustainable Development. Sustainable development education has been one of the horizontal themes of the Ministry of National Education, Childhood and Youth (MENEJ) since 2012. The coalition government programme for 2018-23 emphasises integration of sustainable development education into the elementary and secondary school curricula.

The environment ministry created a platform for education on the environment and sustainable development in 2012. In 2017, it had over 200 members. The same year, it reactivated an inter-ministerial committee for education on sustainable development that had been created in 2008 (EC, 2019b). This committee has compiled online guidance on sustainable daily practices drawn from various national campaigns and initiatives. The MECDD and the MENEJ also put together a training process in 2017 called "Forum for a sustainable school" for secondary school teachers.

Over 50 institutions take part in different environmental education initiatives: school and adult education, leisure activities and general information dissemination. The ANF has established several visitor centres in natural parks and other protected areas. The MECDD and AEV conduct regular environmental awareness campaigns (e.g. on energy saving and green mobility), reaching out to all households and enterprises by email.

Recommendations on environmental governance and management

Strengthening the institutional and regulatory framework

- Reinforce institutional co-ordination to achieve coherent sustainable development policies across the central government and harmonised implementation practices at the local level.
- Introduce environmental aspects into the assessment of draft laws and regulations, including via the "sustainability check"; apply cost-benefit analysis in *ex ante* evaluation of environmental policies and legislation; expand the use of their *ex post* evaluation.
- Ensure consistent application of SEA to all communal land-use plans and their better alignment with national sustainable development policies through increased co-ordination between the ministries responsible for the environment, spatial planning and local government.

Improving compliance assurance

- Enhance resources dedicated to compliance promotion and monitoring; increase the number of proactive risk-based inspections; reinforce collaboration between the three environmental administrations through an integrated compliance assurance strategy.
- Expand the use of administrative fines, while ensuring their proportionality to the gravity of infringements; review the levels of administrative and criminal fines to increase their deterrent impact; provide guidance to inspectors on imposition of sanctions.
- Adopt the draft law on soil protection and management of contaminated sites; establish a programme for remediating contaminated sites, including abandoned ones.

Enhancing environmental democracy

- Improve the user-friendliness of environmental information and its full accessibility for the public, including regular publication of a state of the environment report and related indicators, as well as inspection reports; ensure that sufficient resources are available for dissemination of environmental information.

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3 Towards green growth

Chapter 3 analyses Luxembourg's progress towards achieving a greener and more inclusive economy. It looks at efforts to build a sound policy and institutional framework for sustainable development. It reviews steps taken to green the tax system, by using energy and transport taxes to pursue environmental objectives and removing environmentally harmful subsidies. In addition, this chapter examines investment in sustainable infrastructure and services and the country's eco-innovation performance, as well as opportunities for greening the financial sector. Finally, it briefly reviews progress in mainstreaming environmental considerations into development co-operation.

3.1. Introduction

Luxembourg is one of the most prosperous economies in the OECD, and the population enjoys high income levels and well-being. The economy grew rapidly for most of the past decade, outpacing the euro area average (OECD, 2019a). Growth contracted as a consequence of the COVID-19 pandemic and the measures put in place to contain its spread, but could recover in 2021. New virus outbreaks would make the economy shrink further and hamper recovery prospects (OECD, 2020).

Progress was made in decoupling emissions of greenhouse gases (GHGs) and air pollutants, as well as waste generation, from economic growth in the 2010-19 period. The energy intensity of the economy fell and the share of renewable energy increased (Chapter 1). However, progress remains insufficient to mitigate mounting pressures from population growth and urbanisation. Over the last few decades, the expansion of the road network and low-density housing has contributed to high land fragmentation, urban sprawl and car-based mobility. The growing financial and skilled service sectors have attracted increasing numbers of workers from neighbouring countries. Urban sprawl and massive cross-border commuting by car entail major social costs in terms of GHG emissions, air and noise pollution, traffic congestion and ecosystem degradation. Luxembourg needs to accelerate its efforts to diversify its economy towards a greener and more inclusive model that has a stronger focus on well-being.

3.2. Ensuring policy coherence for sustainable development and green growth

Luxembourg has a sound legal and institutional framework for sustainable development. The 2004 law on the co-ordination of the national sustainable development policy established the Higher Council for Sustainable Development, representing civil society, and the Interagency Commission for Sustainable Development, as a government working body (Chapter 2). The law requires the adoption of national sustainable development plans, which must be periodically monitored through a set of sustainable development indicators (OECD, 2010).

In December 2019, the government adopted the third National Plan for Sustainable Development (PNDD), which was developed through a broad participatory process. The plan is inspired by the United Nations (UN) Agenda 2030, encompasses the Sustainable Development Goals (SDGs) and sets ten priority fields of action.[1] In 2017, prior to approval of the plan and as part of its development, Luxembourg presented the voluntary review of the implementation of the SDGs to the UN High-level Political Forum on Sustainable Development. Despite Luxembourg's progress in implementing the SDGs (OECD, 2019c), ensuring policy coherence and effective integration of environmental considerations into sectoral policies remains a challenge. Insufficient policy co-ordination is more evident in sectors such as transport, housing, agriculture and fiscal policy. Systematic and thorough implementation of the "sustainability check" of proposed legislation and regulations (Chapter 2), as foreseen by the PNDD could help improve policy coherence.

Luxembourg does not have a green growth strategy, but authorities have made considerable efforts to diversify the economy towards a greener and more inclusive growth model over the past years. Economic diversification is one of the third PNDD priorities and the ultimate goal of the 2016 "Third Industrial Revolution" study (TIR). The TIR focuses on six sectors (energy, mobility, buildings, food, industry and finance) and three horizontal axes (smart economy, circular economy, and the prosumers and social model). The TIR outlines a comprehensive set of measures to transition each sector into a smart, circular economy. A monitoring committee oversees the implementation of these measures. The TIR study provides a good basis to continue on the economy diversification path and exploiting the synergies between environment and innovation, digitalisation, circular economy, renewables and energy efficiency, as recommended by the 2010 OECD Environmental Performance Review (EPR).

This is all the more important to ensure an environmentally and socially sustainable recovery from the heavy economic impact of the COVID-19 pandemic. In the first half of 2020, the government put in place

several tax, expenditure and financial measures to preserve jobs and support households income and business liquidity. The fiscal stimulus under the government programme “Neistart Lëtzebuerg” (New Start Luxemburg) totalled about EUR 3 billion or 5% of GDP. Part of the support measures target investment in energy renovation of building, renewables, sustainable mobility, eco-innovation and circular economy (Box 3.1).

Box 3.1. Luxembourg’s green recovery measures

Affected by the Covid-19 health crisis, Luxembourg took, in April 2020, measures to stabilise the economy and cope with the immediate consequences of the pandemic[1], followed end of May by a stimulus package "Neistart Lëtzebuerg" (a new start for Luxembourg) for a sustainable and inclusive economic recovery. The direct expenditure for the support and recovery measures represents around 5% of GDP; the final cost of the "Neistart" package alone is estimated at 700 to 800 million euros.

« Neistart Lëtzebuerg »

The Government’s "Neistart" programme runs until the end of the first quarter of 2021. Its measures[2] aim to encourage employment and provide additional cyclical support to the economic sectors most affected by the crisis, notably through the creation of a new "recovery and solidarity fund" for businesses.[3] A new structural aid scheme has also been introduced to stimulate sustainable business investment. It encourages businesses, through higher investment aid than in normal times (up to 50% of eligible costs), to carry out economic development, digitalisation or environmental protection projects. Emphasis is placed on projects relating to the circular economy, process and organisational innovation, energy efficiency or that allow standards to be exceeded.

Seven of the 23 measures in the "Neistart" package specifically aim to accelerate the green transition of the economy by further supporting soft mobility, energy efficiency and responsible consumption. They are set out in a specific package entitled "Gréng Relance fir Lëtzebuerg - E Plus fir d'Klima, d'Handwierk an d'Bierger" (A green recovery for Luxembourg - A plus for the climate, crafts and citizens).[4]

« Gréng Relance fir Lëtzebuerg »

The green stimulus package encourages energy-efficient housing renovation, investment in renewable energy and the transition to soft and sustainable mobility. Aimed primarily at citizens and the craft sector, some of them enhance the measures presented in the National Climate Energy Plan (PNEC).

Two measures are presented under the label "Clever Wunnen" (Live Smart)[5] and are associated with the "PRIMe House" programme:

- A 50% increase in subsidies for the energy renovation of buildings and energy advice;
- A 25% increase in subsidies for solar thermal systems, heat pumps, wood-fired boilers and heat network connections, with an additional bonus when replacing a fossil fuel boiler with a wood boiler or a geothermal heat pump, or when connecting to a heat network.

Three measures relate to mobility:

- A 60% increase in subsidies for electric cars and vans (€8,000 instead of €5,000) ordered by the end of the first quarter of 2021.
- A doubling of the allowances for electric quadricycles, motorbikes and mopeds, and pedal-assisted bicycles and cycles ordered or purchased by the end of the 1st quarter of 2021 (i.e. an allowance of 50% of the purchase price excluding VAT).
- A new financial aid scheme for the installation of "smart" electric charging stations in the home.

Two other measures aim to (i) strengthen private sector support programmes for energy efficiency by temporarily compensating for the administrative burdens caused by these programmes, and (ii) widen the circle of beneficiaries of support for photovoltaic installations above 30 kW, until now only available to cooperatives and civil societies.

1. https://meco.gouvernement.lu/dam-assets/dossiers/Tableau-stab-9avril-FR.pdf
2. https://gouvernement.lu/dam-assets/documents/actualites/2020/05-mai/Neistart-Letzebuerg-Tableau-Mesures.pdf
3. https://gouvernement.lu/dam-assets/documents/actualites/2020/05-mai/Neistart-Letzebuerg-Fonds-de-relance-et-solidarite.pdf
4. https://gouvernement.lu/fr/actualites/toutes_actualites/communiques/2020/05-mai/29-greng-relance.html

Source : Country submission.

3.3. Greening the tax system

Since 2016, Luxembourg has made substantial progress in improving tax transparency and tackling tax avoidance. As part of its engagement in international efforts towards tax transparency, it has been gradually phasing out favourable tax arrangements that once attracted multinationals to the country and helped increase corporate tax revenue (OECD, 2019a). Luxembourg obtains more revenue from corporate income tax than the average of European countries. The tax/GDP ratio was 40% in 2018, among the highest in the OECD.

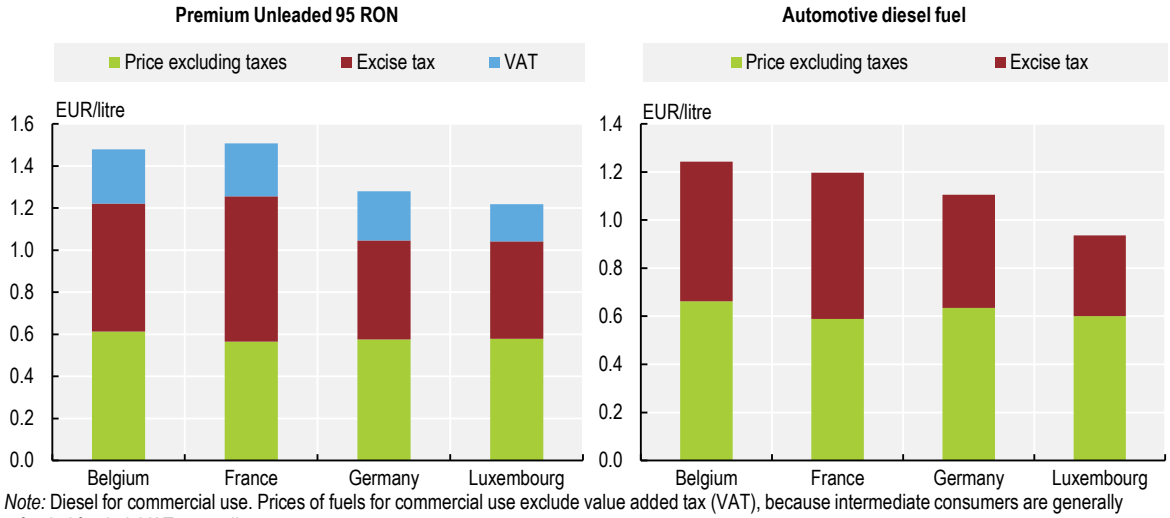
Environmentally related taxes: An overview

Luxembourg has made little use of its tax system to put a price on environmental externalities and encourage efficient use of natural resources. Like all OECD member countries, Luxembourg collects most revenue from environmentally related taxes through taxes on energy products and, to a lesser extent, on vehicles. Taxes on pollution and resource use are limited to water abstractions and polluting discharges, and generate a negligible revenue. Taxes on energy products, mostly on road transport fuels, account for about 93% of environmentally related tax revenue, the highest share in the OECD.

Taxes on transport fuels have traditionally represented an important source of revenue in Luxembourg. This reflects the large amounts of fuel sales to non-residents induced by lower taxes on petrol and diesel than in neighbouring countries, which result in lower fuel prices (Figure 3.1). This tax (and price) differential encourages heavy-duty vehicles in transit, daily cross-border commuters and residents in border regions to refuel in Luxembourg. Total economic benefits of fuel sales go beyond fiscal revenue to include employment and income generated by petrol stations and related services. Total estimated economic benefits of fuel sales amount to EUR 2 billion per year, mostly from fuel exports. However, the estimated environmental and health costs are much higher. They are estimated at EUR 3.5 billion per year, three-quarters of which are from fuel exports. The bulk of these social costs are linked to heavy-duty vehicles travelling through, and refuelling in, Luxembourg (Ewringmann, 2016).

Figure 3.1. Diesel and petrol are cheaper in Luxembourg than in neighbouring countries

Prices of diesel and petrol in Belgium, France, Germany and Luxembourg, 2018



Note: Diesel for commercial use. Prices of fuels for commercial use exclude value added tax (VAT), because intermediate consumers are generally refunded for their VAT expenditures.
Source: IEA (2019), "End-use prices: Energy prices in national currency per unit", *IEA Energy Prices and Taxes Statistics* (database).

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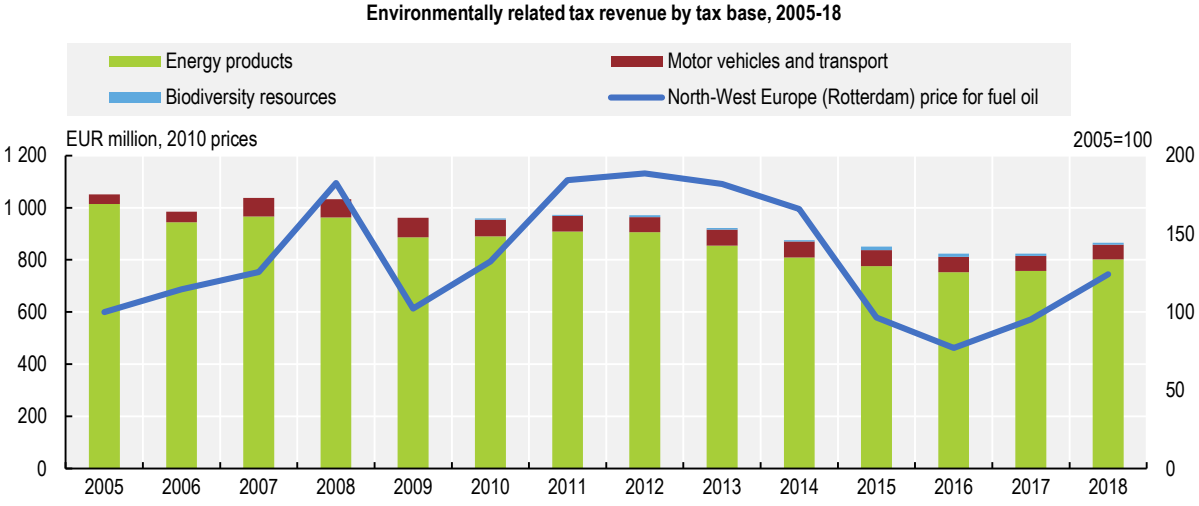
Declining world oil prices in 2012-16 partly eroded Luxembourg's fuel price advantage over neighbours and the incentive to travel the extra time and distance just to refuel in the country. This, together with some tax adjustments in neighbouring countries, resulted in decreasing fuel exports and associated tax revenue in the same period (Ewringmann, 2016). It also led to declining emissions of GHGs and air pollutants (Chapter 1; Chapter 4). Fuel sales and related tax revenue have increased again since 2016, in line with increasing world oil prices (Figure 3.2).

Figure 3.2. Revenue from environmentally related taxes increases with world oil prices



Note: Low sulphur fuel oil price.
Source: OECD (2019), "Environmental policy instruments", *OECD Environment Statistics* (database); IEA (2019), "Oil Product Spot Prices", *Energy Prices and Taxes* (database).

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Luxembourg committed to increase excise rates to counteract the recent increase in fuel exports and related GHG emissions.[2] In May 2019, after nearly seven years of stable tax rates, the government increased the excise duty on transport fuels by EUR 0.01 per litre of petrol and EUR 0.02 per litre of diesel. In December 2019, the government announced additional increases of between EUR 0.01 and EUR 0.03 per litre of petrol and between EUR 0.03 and EUR 0.05 per litre of diesel to take effect in February-April 2020. Part of the tax hikes refer to the specific excise duty named “climate change contribution” (also known as “Kyoto cent”).[3] Revenue from the climate change contribution is earmarked to the Climate and Energy Fund, in derogation of the budgetary principle that revenue should not be earmarked (Section 3.5). Revenue from the rate increase will be allocated partly to the Climate and Energy Fund for measures to support the low-carbon energy transition, and partly to social measures.

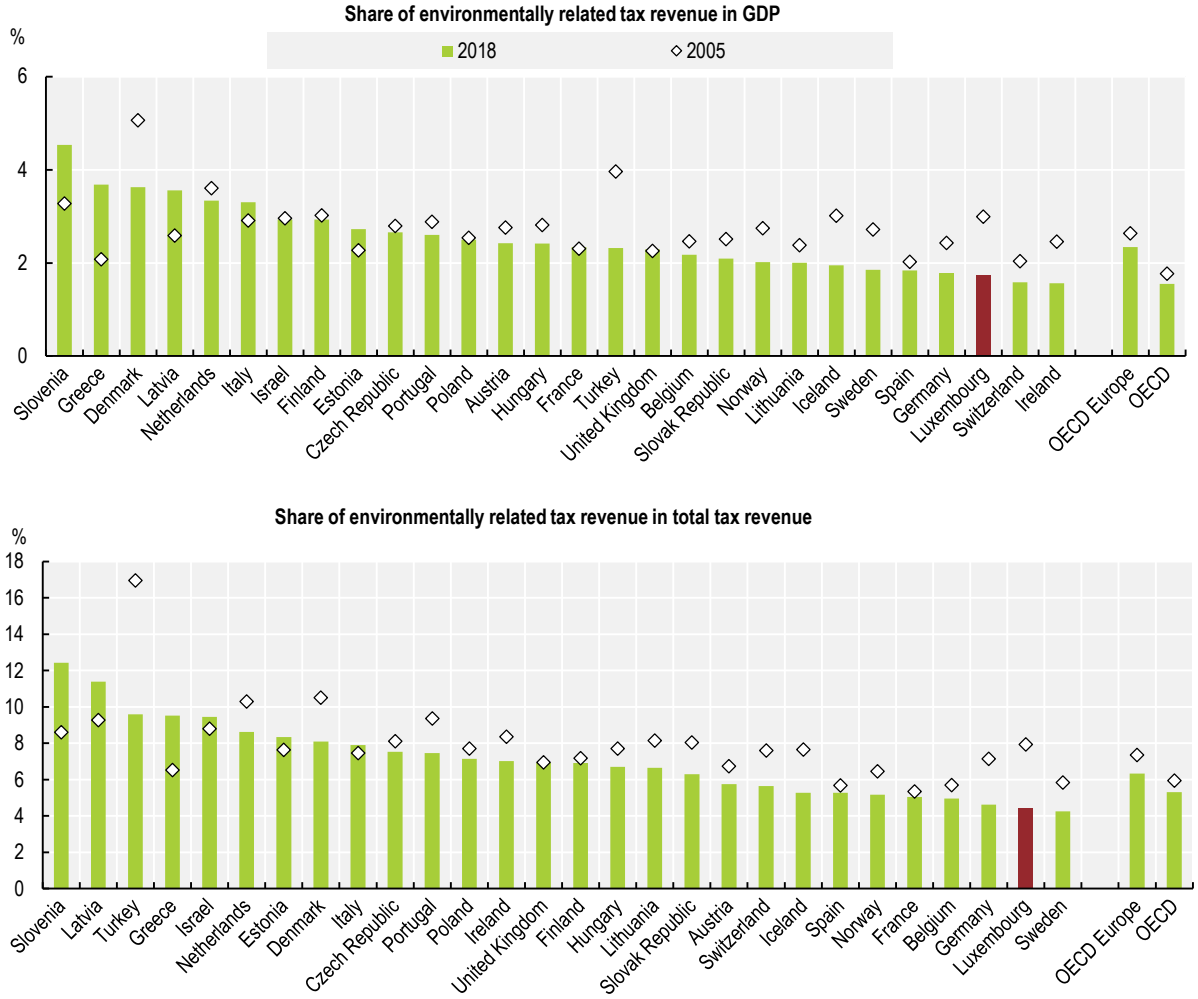
These increases are a step in the right direction, but do not appear sufficient to discourage non-residents to refuel in Luxembourg (OECD, 2019a). They would only bring the excise rate of petrol in line with that of Germany. Moreover, they would only marginally reduce the diesel tax differential with neighbouring countries (Figure 3.1), while diesel sales, mainly to heavy goods vehicles, account for 85% of GHG emissions linked to fuel exports. There is a need to further increase fuel taxes to bring them closer to those of neighbouring countries, although this could result in substantial revenue losses. Luxembourg’s resilience to declining fuel tax revenue in 2012-16 suggests that such losses could be relatively easily addressed. At the same time, narrowing the fuel tax gaps with neighbours would generate benefits in terms of reduced fuel consumption, GHG emissions, air pollution and congestion.

Overall, revenue from environmentally related taxes decreased to 1.8% of GDP and 4.5% of tax revenue in 2018. This is below the average of OECD Europe countries (2.3% of GDP and 6.3% of tax revenue). It represents a marked drop from the second half of the 2000s. At that time, revenue from these taxes accounted for a larger share of tax revenue than in most OECD Europe countries (Figure 3.3).

As indicated in the 2010 EPR, Luxembourg would benefit from a broader tax reform to make its tax and benefit system more coherent with its sustainable development ambition. In this context, the country should increase fuel taxes, remove related exemptions, close the petrol/diesel tax gap and introduce carbon pricing. It should also strengthen vehicle-related taxation and road pricing. In addition, Luxembourg should extend the use of quantity-based waste charges, reinforce the water pollution tax and consider introducing taxes on fertilisers and pesticides to help address the impact of these products on water and soil quality, biodiversity and human health (Chapter 1; Chapter 5).

Figure 3.3. Revenue from environmentally related taxes is low in international comparison

Revenue as percentage of GDP and total tax revenue, OECD Europe, 2005 and 2018



Source: OECD (2019), "Environmentally related tax revenue", *OECD Environment Statistics* (database).

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Taxes on energy use and carbon pricing

Like many other EU countries, Luxembourg puts a price on GHG emissions via energy taxes and participation in the EU Emissions Trading System (EU ETS). The EU ETS covers only about 15% of domestic emissions due to the country's service-based economy, largely imported electricity and major share of emissions from transport (Chapter 1).

Luxembourg applies energy taxes on oil products, natural gas, coal and electricity in the framework of the 2003 EU Energy Tax Directive. Energy tax rates are generally among the lowest in the EU. As in all OECD member countries, fuels are taxed at higher rates when used for road transport than when used for heating and process purposes. This can be justified by the higher environmental and other social costs of road transport (OECD, 2018).

Tax rates on energy products do not fully reflect the estimated environmental cost of energy use. Energy tax rates are low and several exemptions and discounts apply. For example, solid biofuels, fuels used for electricity generation, and diesel used in agriculture and forestry are not taxed. In addition, fuels used for heating benefit from lower excise duties and value added tax (VAT). Electricity consumption is also taxed at a lower rate when used in the industry sector than when used in the residential sector (OECD, 2019d).

The excise duty on diesel is still well below that on petrol, despite the higher carbon content of diesel and its local air pollution cost. This lower duty has contributed to promote diesel vehicles. Diesel cars are nearly 60% of the fleet, one of the highest shares in Europe. Luxembourg should consider raising the diesel tax rate to match that on petrol, although some time-bound discounts may be envisaged for commercial users of diesel. This would help counteract the dieselisation of the car fleet and reduce the incentives for trucks to drive through the country to fill their tanks.

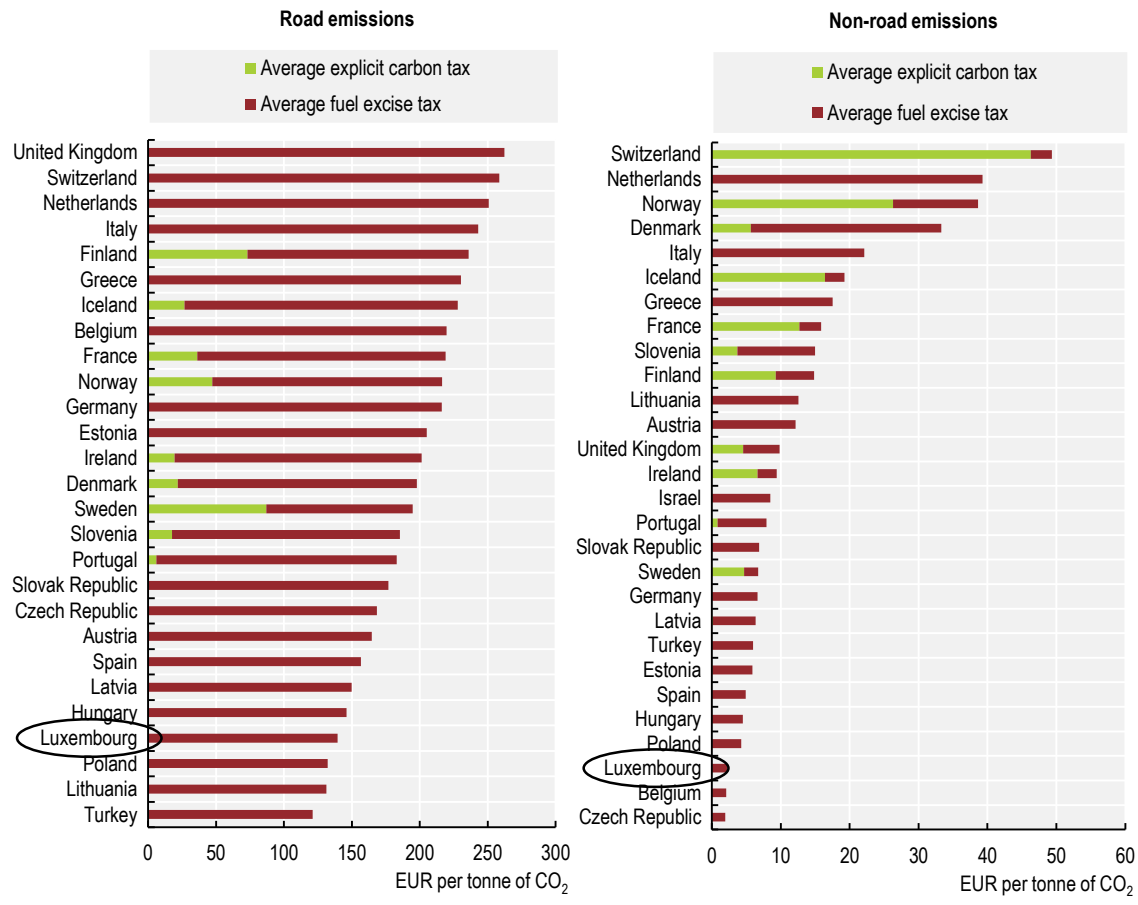
The carbon price signal is weak and tax rates on energy products are generally too low to encourage changes in production and consumption behaviour. Effective tax rates on carbon dioxide (CO_2) emissions from energy use are among the lowest in OECD Europe (Figure 3.4). The effective tax rate on CO_2 emissions from road transport is EUR 139 per tonne of CO_2 (OECD, 2019d). As in most OECD member countries, this is above the benchmark of EUR 60 per tonne of CO_2. The benchmark is a midpoint estimate of the damage of CO_2 emissions in 2020, as well as a forward-looking low-end estimate of carbon costs in 2030 (OECD, 2018).[4] However, in 2018, Luxembourg's effective tax rate was still the fourth lowest in OECD Europe. The 2019 and 2020 increase in tax rates on road fuels would change the ranking only marginally, if at all. In addition, the average tax rate on CO_2 emissions from fuels used in sectors other than road transport is just above EUR 2 per tonne of CO_2. This is well below even the low-end estimate of environmental and other social costs of CO_2 emissions of EUR 30 t/CO_2 (Figure 3.4), which is not sufficient to meet the objectives of the Paris Agreement (OECD, 2019d; OECD, 2018).[5]

The low cost of energy provides little incentive to invest in renewables and energy efficiency (IEA, 2020), and to move towards electric vehicles and sustainable transport modes. As indicated in the previous section, the increase of excise rates in 2019 and 2020 on road fuels are welcome, but not sufficient. Luxembourg should reduce tax exemptions and further raise the energy tax rates in all sectors to reflect environmental and climate damage from energy use. This should be combined with social support measures targeting the most affected poor households.

The 2019 National Energy and Climate Plan (NECP) foresees carbon pricing as from 2021. The proposed initial price is EUR 20 per tonne of CO_2, to be increased by EUR 5 in each of the two following years. This is a welcome announcement. A higher price on CO_2 emissions would help the country increase efficiency of energy use, promote investment in renewables and expand the market opportunities of low-carbon technology, goods and services. It would also bring co-benefits through, for example, reduced air pollution (Chapter 4). Luxembourg should follow through on this plan of introducing carbon pricing in sectors not covered by the EU ETS. It should ensure systematic monitoring of the effect of carbon pricing on energy use and GHG emissions, and adjust prices appropriately.

Figure 3.4. Effective tax rates on CO_2 emissions are among the lowest in OECD Europe

Effective tax rates on CO_2 emissions from energy use in the road and non-road sectors, OECD Europe, 2018



Note: 2018 tax rates as applicable on 1 July 2018.
Source: OECD (2019), *Taxing Energy Use 2019: Using Taxes for Climate Action*.

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Transport-related taxes and charges

The incentive mix in the transport sector is not consistent with Luxembourg's objectives of promoting sustainable mobility, climate mitigation and air quality improvement in major cities. The mix includes fuel taxes, vehicle taxes and subsidies, taxation of company cars and commuting allowances, and road charges. In addition to raising fuel taxes (as indicated in Sections 3.3.1 and 3.3.2), Luxembourg should consider strengthening vehicle taxes and road pricing.

Vehicle taxes

The annual tax on vehicles is based on CO_2 emissions. The tax rate increases with CO_2 emission levels per kilometre and is higher for diesel vehicles (Chapter 4). However, car taxation is relatively low and the rate differentiation is not pronounced. The tax provides few incentives to shift towards lower-emitting vehicles. While the vehicle fleet is relatively young, newly registered cars in Luxembourg are among the most carbon-intensive cars in the EU (Chapter 4). There is scope to increase car taxation and revising it to consider emissions of both CO_2 and local air pollutants.

In 2017, Luxembourg introduced income tax credits to promote the purchase of electric or hybrid vehicles: EUR 5 000 for fully electric vehicles; EUR 2 500 for plug-in hybrid vehicles; up to EUR 500 for electric motorcycles and up to EUR 300 for electric bicycles. In 2019, the system was replaced by direct subsidies of the same amounts to simplify access to the financial incentives and improve their effectiveness (Chapter 4).

Tax treatment of company cars and commuting expenses

The traditionally favourable tax treatment of company cars is among the factors behind Luxembourg's high car ownership rate and the high-carbon intensity of cars. This is because company cars used by cross-border workers are registered in Luxembourg. Company cars (which employees can use for their private travels) account for more than half the car fleet. They tend to be more carbon-intensive than personal cars. In 2017, the government revised the company car taxation treatment to encourage companies and employees to choose less carbon-intensive vehicles. According to the new rules, the estimated taxable benefits, added to the employee's income increases with the CO_2 emissions of the vehicle and is higher for diesel cars than for petrol cars (Chapter 4).

However, like many other countries, Luxembourg continues not taxing the full benefits employees derive from the personal use of company cars. On average, these in-kind benefits are taxed less than the equivalent monetary income. This lower taxation effectively subsidises the employee, which makes it attractive for employees to be paid part of their salary in the form of company cars. This is especially true for higher-income earners, who face a higher marginal income tax rate and are more likely to be provided with expensive company cars. In addition, fuel costs paid by the employer are deductible from the company's taxable income and do not increase the employee's taxable income. As a result, there is no incentive for employees to limit the use of company cars.

Commuting expenses are deductible from an employee's taxable income. The tax deduction increases with the distance travelled to work, which encourages people to live farther away from their workplace and increases transport demand (Chapter 4). Deductions are not differentiated by type of transport and are granted regardless of whether the expenses are incurred. Hence, this system does not discriminate against public transport and active modes of transport such as walking and cycling, but it does not encourage them either.

In addition to burdening the public budget, the favourable tax treatment of company cars and commuting expenses tend to encourage car use and long-distance commuting. They can result in increased fuel consumption, GHG and local air pollutant emissions, noise, congestion and risk of accidents (Roy, 2014). This adds to problems related to urban sprawl, car-based commuting across borders and difficult access to public transport in peripheral areas. Luxembourg should consider further adjusting the tax provisions related to company cars and commuting expenses to reduce incentives to car travel.

Road pricing

Luxembourg is part of the "Eurovignette" co-operation with Denmark, the Netherlands and Sweden. These countries apply a road toll to heavy-duty vehicles (above 12 tonnes) circulating on motorways in their territory. Rates increase with pollutant emissions (on the basis of the Euro standards) and the number of axles. The charge is time-based (with daily, weekly, monthly and annual tolls) and does not change with distance travelled. The toll does not apply to smaller commercial vehicles or to passenger cars.

Luxembourg should consider adjusting road tolls for heavy goods vehicles to take account of distance travelled, in addition to the emission standards applied. It should also extend road tolls to smaller commercial vehicles and passenger cars. In addition, introducing congestion charges in Luxembourg City would help put a cost on travel during peak periods and encourage a shift to public transport. In areas

poorly served by public transport, or where concerns over equity arise, social transfers could be used to partly compensate for road charges.

Complementing fuel taxes with distance-based charges would make pricing of transport more cost-effective (van Dender, 2019). This could also help offset tax revenue losses expected from two sources: the increase of diesel and petrol taxes to match rates applied in neighbouring countries; and the likely erosion of the tax base as Luxembourg and its neighbouring countries move towards electric mobility (especially for domestic and cross-border commuting).

Other economic instruments

Luxembourg has made progress in implementing the polluter-pays and user-pays principles in the water and waste sectors, in line with recommendations from the 2010 EPR.

Water charges

According to Luxembourg's water legislation, users should bear the costs of water services, including environmental and resource costs in line with the user-pays and polluter-pays principles. The law also introduced an abstraction tax and a wastewater discharge tax. Proceeds from these taxes are earmarked for the Water Management Fund in derogation of the budgetary principle that revenue should not be earmarked (Section 3.5). The water price comprises a drinking water charge and a wastewater treatment charge, whose revenue accrues to water service providers, as well as the abstraction and discharge taxes. The rates of the drinking water and wastewater treatment charges are set by communes or associations of communes (*syndicats*). The Water Management Administration verifies that the charges respect the cost-recovery principle.

Anyone who draws surface water or groundwater pays an abstraction tax, based on the volume of water drawn. The water abstraction tax is fixed by law at EUR 0.125/m^3 of abstracted water, with a minimum of EUR 25 per year for withdrawal up to 200 m^3/year. Withdrawals for certain uses are exempt from the tax.[6]

The wastewater discharge tax is proportional to units of pollution load (*unités de charge polluante*, UCP) at a rate of EUR 1.25/UCP. Coefficients are applied to determine the UCPs corresponding to 1 kg of chemical oxygen demand, nitrogen, phosphorus or suspended particulate matter. Installations such as industrial facilities that treat their own wastewater (without using public wastewater treatment plants) pay the tax proportionally to the pollution load authorised by their operating licence. While the tax amount is increased if that load is exceeded, it is up to the Water Management Administration to detect non-compliance. This makes the tax act as a fine. For water service providers, the rate is fixed annually by Grand-Ducal regulation, taking into account the pollutant loads in water discharged by all wastewater treatment plants. The tax is due if the pollutant load exceeds certain thresholds. Discounts are granted to municipalities that have installed rainwater treatment facilities. In 2019, the rate was set at EUR 0.12/m^3 of discharged water. The rate has been reduced constantly in the last few years, reflecting the declining pollutant loads in wastewater due to improved treatment (Chapter 1). However, the tax provides little incentive to reduce water pollution, as the rate is based on average pollution.

Waste charges

The 2012 amended Waste Act requires that municipalities implement waste tariffs in line with the polluter-pays principle. According to the legislation, waste charges should cover all costs of providing waste services and should consider the quantities of waste actually produced. Charges need to include variable components based upon the weight and/or volume of the mixed residual household waste and of bulky waste. Only about one-quarter of municipalities apply quantity- or volume-based waste fees (pay-as-you-throw). Data show that in these municipalities per capita residual mixed waste is well below that produced in municipalities that do not apply pay-as-you-throw charges.[7] About 70 municipalities have committed to

apply waste taxes that respect the polluter-pays principle by 2020. This would bring the total number of municipalities complying with this principle to 95 of 102 municipalities in the country.

Ecopoints for offsetting biodiversity degradation

The 2018 law on the protection of nature and natural resources introduced a system of ecopoints for quantifying the ecological value of biotopes and habitats. This system is used to determine the financial compensation due for biodiversity losses resulting from development projects (Chapter 5). An ecopoint is worth EUR 1; the number of ecopoints depends on the biotope.

3.4. Removing potentially harmful incentives/subsidies

Like other countries, Luxembourg provides subsidies that could harm the environment. These subsidies, in the form of direct support or preferential tax treatment, exist primarily in the energy, transport and agriculture sectors. In general, such subsidies contravene the polluter-pays and user-pays principles. They distort competition, lock in inefficient technology, lead to inefficient allocation of resources and weigh on public finances. Luxembourg has made little progress to follow up on the recommendation from the 2010 EPR to identify and remove environmentally harmful subsidies and tax provisions (OECD, 2010).

The energy and transport sectors provide most subsidies implicitly through favourable tax treatments. As discussed in Section 3.3.2, energy products used in sectors such as farming, electricity generation and heating still benefit from total or partial exemptions from excise duties, as well as a reduced VAT rate. In 2017, the revenue loss due to exemptions and discounts from the diesel excise for these sectors was estimated at EUR 2 million. These exemptions undermine the carbon price signal and discourage an efficient use of energy resources. In addition, energy tax exemptions are not targeted to the most vulnerable population groups and do not help reduce poverty or inequality (Ewringmann and Deloitte Tax & Consulting, 2018). As discussed in Section 3.3.3, the favourable tax treatment of company cars and commuting expenses tends to encourage car ownership and use, as well as long-distance commuting, with several environmental impacts.

Luxembourg's support to agriculture follows the EU framework. As in all EU countries, agricultural support is largely decoupled from production or input use. As part of the so-called green payment, 30% of the direct payment envelope under the Common Agricultural Policy is allocated to agricultural practices that are beneficial in terms of climate change and the environment. The environmental effectiveness of this support has been questioned, mainly due to the low level of requirements, which largely reflect the normal farming practice. The payment had resulted in more environment-friendly farming practices on only around 5% of all EU farmland (European Court of Auditors, 2017). Farmers also benefit from fuel tax relief.

The government commissioned a study to identify and quantify environmentally harmful subsidies. The 2018 study identified seven types of such subsidies in Luxembourg. These included reduced excise and VAT rates on energy products, the tax disparity between diesel and petrol, and the favourable tax treatment of company cars and commuting expenses. Overall, the estimated annual cost of these subsidies varies between EUR 750 million and EUR 1 billion (Ewringmann and Deloitte Tax & Consulting, 2018). Luxembourg should build on this study to establish a process for the systematic review of environmentally harmful subsidies. It could consider introducing a mechanism to screen all current subsidies and new subsidy proposals against their potential environmental impact. This would improve the transparency of the tax and public expenditure system. It could be the basis for reforms of subsidies and special tax treatment that are not justified on economic, social and environmental grounds.

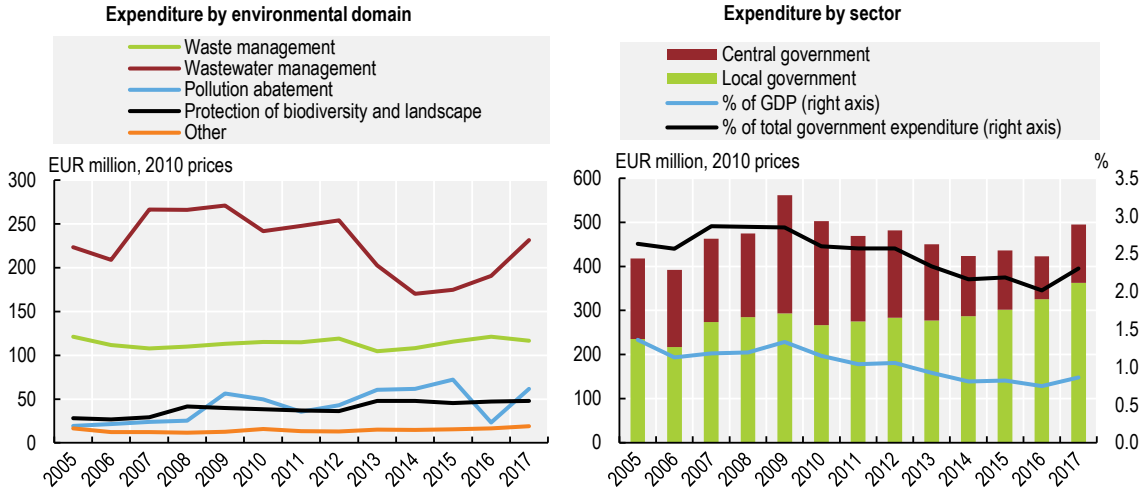
3.5. Investing in the environment and low-carbon infrastructure

Public expenditure for environmental protection

Public environmental expenditure (current expenditure and investment) increased between 2005 and 2009, and then decreased after the financial crisis. In 2017, it was 0.9% of GDP and 2.3% of total government expenditure. Central government expenditure dropped markedly, while local governments – which have major responsibilities in providing environment-related services – increased their spending (Figure 3.5).

Figure 3.5. Public expenditure for environmental protection has decreased after the financial crisis

Public expenditure for environmental protection by environmental domain and government sector, 2005-17



Note: General government expenditure according to the COFOG classification.
Source: OECD (2019), "General Government Accounts, SNA 2008 (or SNA 1993): Government expenditure by function", *OECD National Accounts Statistics* (database).

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As in many other countries, wastewater and waste management absorb most public environmental expenditure. Expenditure on wastewater management declined in the early 2010s, reflecting the progressive application of the polluter-pays principle (Section 3.3). It rebounded in 2014, due to large investment in bringing wastewater treatment plants in line with EU requirements (Chapter 1). Expenditure on waste management has hovered around the same levels in the last decade, as investment in disposal and treatment infrastructure had been already completed. Expenditure on pollution abatement and biodiversity protection accounts for a minor share, but it has been increasing in recent years reflecting renewed policy focus on these areas (Figure 3.5).

Investment needs remain high. Ageing infrastructure, such as urban wastewater pipelines, needs to be upgraded. Networks and services will also need to be extended to accommodate population growth and continuing urbanisation. For example, the government plans to equip the country's main wastewater treatment plants with a fourth level of treatment (micropollutants and microplastic) by 2023 (Chapter 1). In this context, enhancing cost-effectiveness of public spending is essential to ensure access to high-quality services for all. Demand-side management and incentives for less resource-intensive production and consumption patterns could reduce reliance on public expenditure.

Promotion of investment in sustainable energy and mobility

Luxembourg's policy focus on climate change mitigation has led to increasing public financial assistance to investment in renewables, energy efficiency and sustainable mobility (Chapter 4). Some State aid has been increased as part of the fiscal stimulus to help the economy recover from the consequences of the COVID-19 pandemic (Box 3.1). This has been accompanied by a range of regulatory measures and voluntary programmes. All municipalities have signed the Climate Pact, a co-operative agreement through which local governments commit to implement certain environment- and climate-related measures. In return, they receive government financial and technical assistance, as well as an environmental certification (Box 3.2).

Box 3.2. The Climate Pact

Launched in 2012, the Climate Pact aims to strengthen the exemplary role of municipalities in climate policy, to reduce GHG emissions and energy use, and to stimulate investment at local level. The pact was updated in 2018 to include measures related to air pollution and the circular economy. The government is working to improve the design of the pact to reward more quantitative results and extend it past 2020.

Under the pact, each participating municipality commits to implement an energy management system and a number of the 79 climate- and environment-related measures in a catalogue. Municipalities can be awarded a certification within the framework of the European Energy Award based on the number of implemented measures. There are three levels of certification: 40%, 50% and 75% of the maximum score.

The government provides financial assistance and technical support, the latter through myenergy (a government body providing information and assistance on energy efficiency and renewables). The state provides an annual grant of EUR 10 000 to participating municipalities and covers the costs of climate advisers and technical assistance. The Environmental Protection Fund subsidises municipal projects linked to implementation of the pact. Certified municipalities receive an annual subsidy of between EUR 5-35 per inhabitant (with a ceiling of 10 000 inhabitants) depending on the certification level. After the first year, the variable subsidy is linked to the achievements of GHG reduction targets. This aims to encourage municipalities to implement the planned measures effectively and to reward progress.

All 102 of Luxembourg's municipalities signed the pact. As of 2019, 94 municipalities had received certification (7 at 40%, 78 at 50% and 9 at 75%).

Source: PactClimate (2019), *PacteClimat,* website, www.pacteclimat.lu/fr.

Renewable energy

Several support mechanisms have contributed to the growth of renewable electricity generation (IEA, 2020; Chapter 1). However, more cost-effective support measures will be needed to achieve the ambitious 2030 target of 25% of renewables in gross final energy consumption (from 6.5% in 2017) set by the NECP. Support to electricity and heat generation from renewables takes the form of feed-in tariffs, premium tariffs and capital investment subsidies for renewable energy projects developed by households, companies and municipalities. In 2018, Luxembourg introduced a tender system for photovoltaic projects. In 2017, the feed-in and premium tariffs cost EUR 99 million. The Climate and Energy Fund paid EUR 38 million of this amount with the remainder recovered through electricity bills.

Energy efficiency in buildings

In 2017, Luxembourg strengthened its flagship PRIMe House grant programme to provide higher subsidies to energy efficiency renovation and integration of renewables into building, as well as to extend support to sustainable construction. Expenditure under the programme amounted to more than EUR 5 million that year and to about EUR 20 million in 2015-19. In 2017, Luxembourg launched the Climate Bank and Sustainable Housing programme, which provides zero- or low-interest loans to households and companies for energy efficiency renovations, including the use of energy from renewable sources. Low-income households can benefit from grants to replace energy-intensive appliances, as well as from technical advice on how to reduce energy consumption.[8] Luxembourg enacted regulations requiring all new residential buildings to meet the nearly zero-energy building (NZEB) standard. It also launched a voluntary national sustainability certification system for new housing construction (LENOZ).

It is not clear whether this public financial assistance is delivering the desired energy savings, or climate and environmental benefits. The building renovation rate in Luxembourg is low, less than 1% in 2017 (IEA, 2020). There is a lack of interest in energy renovation, mainly due to the high cost of these projects, the overall pressure on the housing market, the complexity of administrative procedures and the nuisance caused by renovation works. The government set up an online one-stop-shop for all housing-related public aid. However, further efforts are needed to increase public awareness about PRIMe House and other support programmes, as well as to facilitate access to them. Low energy prices hamper the effectiveness of support programmes. They are too low to provide sufficient incentives to renovation investment, especially when considering the high average income of households. Gradual introduction of carbon pricing (Section 3.3) would be more cost-effective in driving the energy efficiency investment needed to reduce final energy demand (the NECP foresees reductions of 40-44% in 2030 compared to baseline projections). The government should also track how renovation is helping achieve energy efficiency targets (IEA, 2020).

Sustainable transport and mobility

As Chapter 4 discusses in more detail, Luxembourg has been investing heavily in public transport infrastructure and services. This is part of implementing the 2018 sustainable mobility strategy (Modu 2.0). It invested EUR 1.8 billion in public transport in 2015-19. Investment includes the first tramline in Luxembourg City, new bus corridors, and park-and-ride facilities. It also includes the purchase of new buses, many of which were hybrid and electric vehicles. Luxembourg aims to increase the number of public transport users by 50% from 2017 to 2025. The decision to make public transport free across the whole country for all users as from March 2020 is expected to contribute to this goal. In addition, the country has invested in active mobility, for example by extending its bicycle lane network.

Electric mobility is expected to play a key role in the decarbonisation of the transport sector. Large investment has been made in extending the electric vehicle charging network. As of 2019, the network counted more than 200 stations, one of the densest networks in Europe. The government plans to quadruple the number of charging stations by the end of 2020. Subsidies are available to buy electric cars and bikes, and state-owned vehicles can only be electric. These measures aim to achieve the NECP target of 49% of vehicles registered in Luxembourg to be electric by 2030. Another objective is to make the fleet of the regional bus company fully electric by the same year. Achieving Luxembourg's electric mobility goals will entail a significant growth of electricity demand, which may stress the electricity system. As a result, Luxembourg will require increased renewable electricity generation and imports (IEA, 2020).

Public environment-related funds

Luxembourg provides financial support to environment-related investment under various forms to local governments, companies and individuals. The Ministry of Environment, Climate and Sustainable

Development (MECDD) manages three investment funds for environmental protection, water management, and climate and energy. However, effectiveness of support for environment-related investment could be enhanced.

The Environmental Protection Fund was established in 1999 to finance central government expenses in key areas. These include air pollution, noise, climate change mitigation, waste prevention and management, nature and natural resource conservation, clean-up and rehabilitation of landfills and contaminated sites, energy efficiency and renewable energy sources. The fund disbursed nearly EUR 25 million in 2017. Of this amount, more than 40% was used to finance the Climate Pact (Box 3.2), 35% was spent on finance waste management (and primarily the SuperDrecksKëscht©; see Chapter 1) and 12% financed nature protection.

The Water Management Fund, also created in 1999, can support investment in wastewater treatment, flood risk management, watercourse rehabilitation, protection of water quality and efficient use of water resources. It is funded by budgetary allocations and the proceeds of the water abstractions and pollution taxes (Section 3.3). The fund expenditure increased substantially in the last decade, from EUR 50 million to EUR 92 million between 2011 and 2018. This was in part due to increased investment on wastewater treatment plants (Chapter 1).

Established in 2004, the Climate and Energy Fund finances implementation of domestic GHG emission reduction measures, the purchase of international GHG emission allowances and Luxembourg's contribution to international climate finance commitments. The fund disbursed nearly EUR 57 million in 2017. Of this amount, 33% financed feed-in tariffs for renewables, 27% supported international climate finance and 5% supported domestic climate mitigation measures, including investment subsidies for photovoltaic installations and electric mobility. The fund includes an annual budget envelope of EUR 3 million for projects implemented by Luxembourgish non-governmental organisations in developing countries.

In 2019, the fund was well-endowed, with around EUR 600 million unused budgetary appropriations (IEA, 2020). In addition to an annual budgetary allocation, the fund receives the proceeds from auctioning EU ETS emission allowances. It also receives part of the revenue from the excise duty on road fuels (the "climate change contribution" or "Kyoto cent", see Section 3.3) and from the annual vehicle tax (Section 3.3). Many countries participating in the EU ETS, such as France and Italy, commonly earmark revenue from carbon pricing to funds devoted to climate mitigation. The practice can help build support for stronger carbon pricing and secure reliable, sufficient resources. However, constraints on revenue use should be transparent, broad and flexible to ensure efficiency of revenue allocation in the long term (Marten and van Dender, 2019).

As a general rule, the three funds provide financial support to eligible projects on a first-come, first-served basis until available annual resources are exhausted. Financial allocations have been sufficient to support all eligible projects so far. However, Luxembourg conducts no cost-benefit analysis of eligible projects and does not evaluate the environmental effectiveness of the financed projects *ex post*. Therefore, public funds risk not being used cost-effectively to support projects that provide additional environmental benefits.

3.6. Promoting environmental technology, goods and services

Eco-innovation policy and performance

Luxembourg has a strong innovation performance, with an attractive research system and an innovation-friendly environment. The population has a higher level of education than on average in the OECD (see Basic Statistics). Innovative activity is high, as one-third of small and medium-sized enterprises (SMEs) reported introducing new or significantly improved products, services or organisational methods in 2018.

However, these enterprises appear less able to translate these innovations into economic returns than in many other European countries (EC, 2018a).

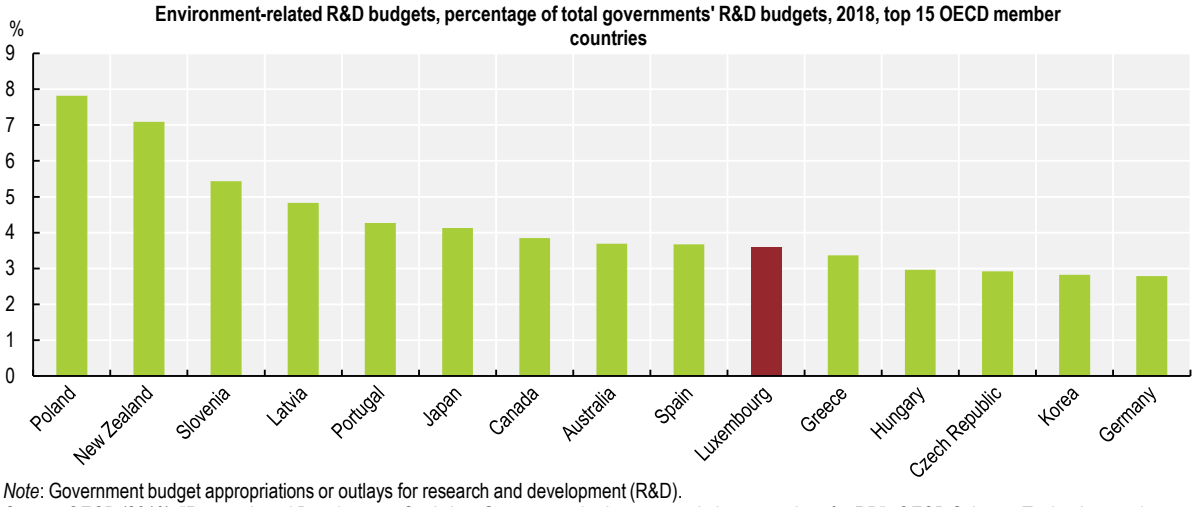
Expenditures on research and development (R&D) are low. At 1.3% in 2017, Luxembourg's share of GDP allocated to R&D activities stands far below the OECD average of 2.4% and its own national 2020 target of 2.3-2.6% of GDP. Luxembourg tripled expenditures for government and higher education R&D over the past decade. It also expanded the grant schemes, amended its R&D tax incentive and broadened the scope for action of Luxembourg's innovation agency, LuxInnovation.

Luxembourg has become one of Europe's top eco-innovation players (EC, 2019). Both Luxembourg authorities and the business community have been placing growing policy focus on eco-innovation. The 2016 Third Industrial Revolution study (Section 3.2) and the 2017 Research and Innovation Smart Specialisation Strategy identify clean technology and the circular economy among key policy priorities on the path towards the country's economic diversification.[9]

Luxembourg provides public support for environment-related R&D in the form of grants and tax incentives, as well as financial support to enterprises for improving environmental performance (Section 3.5). Eco-innovation promotion programmes have a strong focus on the circular economy (EC, 2019). For example, the "Fit 4 Circularity" programme aims to help SMEs integrate the circular economy models into their general innovation activities. Eco-innovation is also among the themes pursued by LuxInnovation in its activities to promote collaboration among companies, research institutes and public organisations for the development and exchange of technology. Sustainable mobility is another key eco-innovation area, with several projects on electric mobility (Chapter 4), intelligent public transport systems and smart mobility. A digital test bed between Luxembourg, Germany and France, for example, promotes connected, automated and co-operative cross-border mobility on the highways between Luxembourg City, Saarbrucken and Metz.

With increased public R&D funding, Luxembourg has developed a specialisation in environmental technology in recent years. It spends 3.6% of the government R&D budget on environment-related research, a share among the ten highest in the OECD (Figure 3.6). Luxembourg is a European leader in terms of environment-related innovations, with nearly 23 environment-related patent applications per capita. Patent applications for environment-related technology do not show a constant trend, but tended to be above the OECD and OECD Europe average for the best part of the last decade. Despite declining in the first half of the 2010s, they reached 12% of all patent applications in 2014-16 (Figure 3.7). Most patents are filed in traditional environmental management fields (air and water pollution abatement and waste management). They are also filed in some climate-related fields, such as energy storage, hydrogen technology, fuel cells, vehicles and GHG emission reduction in metal processing.

Figure 3.6. Government funding for environment-related R&D is among the highest in the OECD



Note: Government budget appropriations or outlays for research and development (R&D).
Source: OECD (2019), "Research and Development Statistics: Government budget appropriations or outlays for RD", *OECD Science, Technology and R&D Statistics* (database).

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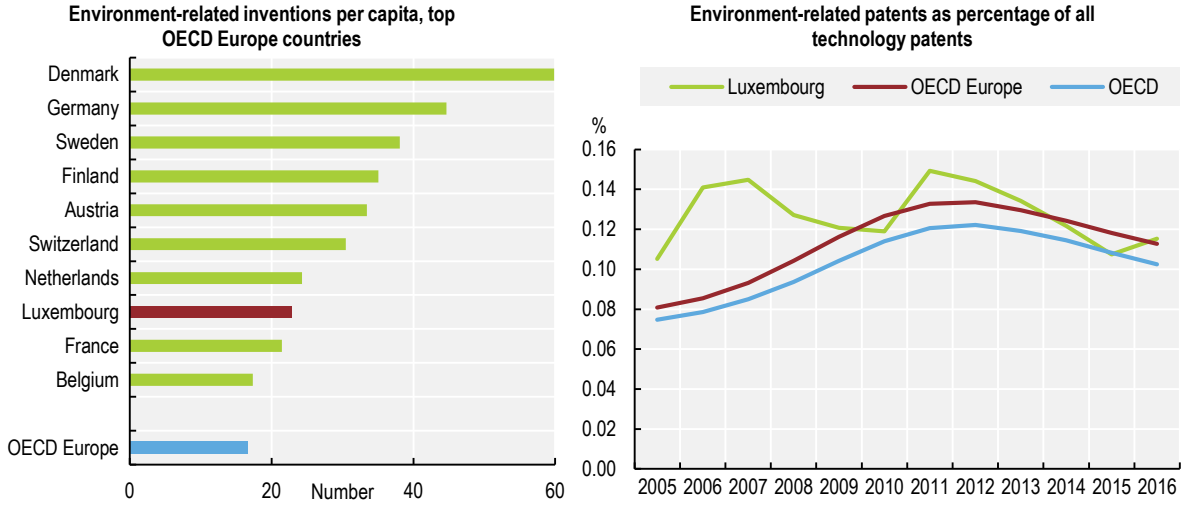
Figure 3.7. A large share of Luxembourg's inventions is environment-related



Note: Per capita data refer to 2014-16 average. Trends data refer to 3-years moving averages. Higher value inventions that have sought patent protection in at least two jurisdictions (family size: two or more). Data are based on patent applications and refer to fractional counts of patents by inventor's country of residence and priority date.
Source: OECD (2019), "Patent in environment-related technologies: Technology development by inventor country", *OECD Environment Statistics* (database).

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Markets for environment-related technology, products and services

The environmental goods and services (EGS) sector is relatively small in Luxembourg. It accounted for more than 11 000 jobs and 2% of Luxembourg's gross added value in 2016, a share that remained almost

stable between 2008 and 2016. The industrial sector, as a whole, produced half the EGS gross added value in 2016; most employment (65%) was in the construction sector.

Compared to the EU average, slightly more SMEs design and produce greener products in Luxembourg (EC, 2018b).[10] However, the country's SMEs are less inclined to invest in improving their environmental performance than on average in the EU, except for investment in recycling and renewables. According to a 2017 Eurobarometer survey, 67% of Luxembourg's SMEs have invested in resource efficiency, slightly below the EU average. Most have invested less than 1% of turnover. Luxembourg's SMEs performed below the EU average in terms of actions to save energy, materials and water, and to minimise waste (EC, 2018b).

The small domestic market and still low demand for cleaner technology, products and services are the main barriers to eco-innovation. Luxembourg has implemented several programmes and measures that could enlarge EGS markets and drive eco-innovation. For example, the subsidies for electric cars and bikes (Chapter 4), the LENOZ certification and the NZEB standard (Section 3.5) can contribute to stimulating demand for cleaner transport and building solutions. The EU acknowledged the campaign and label "Clever akafen" (Buy Smart), launched within the framework of the SuperDrecksKëscht (Box 1.1), as a best practice to encourage environment-friendly consumption choices. Products can be awarded the "Clever akafen" label if they meet a set of environment criteria.[11]

A clearer policy on green public procurement (GPP) would also help increase demand for cleaner products and services. While the public procurement law encourages contracting authorities to look at environmental criteria, these are not mandatory and there are no GPP targets (EC, 2019). Luxembourg should develop and implement a clear GPP policy by integrating mandatory environmental criteria and targets into public procurement regulations.

The impact of the eco-technologies sector on the diversification of the economy is difficult to assess (ODC, 2018). Luxembourg should continue to support environment-related R&D, with a focus on SMEs. At the same time, it should systematically evaluate the cost-effectiveness of its support programmes and their contribution to improve environmental performance, resource productivity and energy efficiency. More efforts are needed on the demand side, primarily by ensuring that prices of energy and of water and waste services adequately reflect the environmental and other social costs of resource use and pollution.

3.7. Greening financial markets

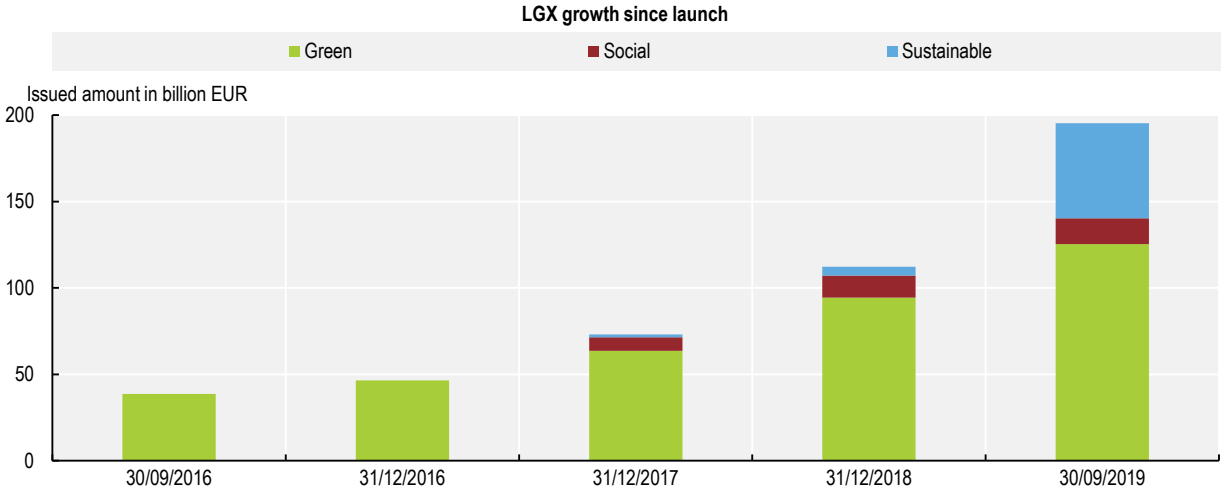
Luxembourg's green finance centre

The financial sector is a pillar of Luxembourg's economy, accounting for 27% of GDP and 11% of total employment in 2018. Luxembourg is home to many international financial institutions, has a solid financial infrastructure and a highly specialised labour market (Dörry and Schulz, 2018). Sound policies and institutions have enabled the financial sector to remain competitive and develop new areas, such as financial technology (FinTech) and green finance (OECD, 2019a).

Luxembourg has grown as a green finance centre since the European Investment Bank (EIB) listed the first-ever Climate Awareness Bond on the Luxembourg Stock Exchange in 2007. The World Bank's first green bond followed in 2008. In 2016, Luxembourg established the Luxembourg Green Exchange (LGX), the first platform dedicated exclusively to green, social and sustainable securities.[12] LGX has grown rapidly and lists nearly EUR 200 billion green, sustainable and social bonds, or half of the world market (LGX, 2019) (Figure 3.8). Luxembourg was ranked second in terms of green finance specialisation (or market depth) and seventh in terms of quality of green finance products in the fourth Global Green Finance Index (Wardle et al., 2019).[13]

Figure 3.8. The Luxembourg Green Exchange has grown rapidly since its establishment

Value of green, social and sustainable bond issues on the Luxembourg Green Exchange, 2016-19



Source: Luxembourg Stock Exchange.

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Policy approach to green and sustainable finance

The government aims to make Luxembourg an international centre of excellence on sustainable finance. For the period 2018-23, it set four main priorities for the Luxembourg financial centre, with a particular focus on sustainable finance and FinTech.[14] Luxembourg is committed at the international level to sustainable and green finance. It actively participates in EU discussions, for example on developing an EU Green Bond Standard and the EU taxonomy of activities that can make a substantial contribution to climate change mitigation. Luxembourg also financially supports the International Network of Financial Centres for Sustainability, which aims to help financial centres redirect their investments to support the goals of the Paris Agreement and of the UN Agenda 2030. Luxembourg also joined the Paris Agreement Capital Transition Assessment initiative, which provides a methodology to assess the climate compatibility of investment and financing by insurance companies and pension funds.

Luxembourg has adopted a multi-stakeholder approach to green finance, with a strong focus on public-private green finance initiatives and partnerships. Since 2015, the government and financial actors have been participating in the Climate Finance Task Force, subsequently integrated into the Luxembourg Sustainable Finance Initiative (LSFI). The task force developed the Luxembourg Climate Finance Strategy with the aim of making Luxembourg an international centre for financing the fight against climate change. Several other initiatives have followed (Box 3.3). The vast majority of green finance initiatives have focused on climate change mitigation. Other environmental issues, including biodiversity conservation, water, pollution and circular economy, deserve more attention.

In 2018, Luxembourg adopted the Luxembourg Sustainable Finance Roadmap, drafted in partnership with the UN Environment Programme. The government committed to implement the recommendations of the roadmap. To that end, under the joint leadership of the environment and finance ministers, it established the LSFI to develop a national green finance strategy. Ultimately, the strategy aims to provide a framework to accelerate the development of green and sustainable finance to help meet the goals of the Paris Agreement and, more broadly, the SDGs. This would help better co-ordinate the multiplicity of green finance initiatives.

Box 3.3. Main green, climate and sustainable finance initiatives

- LuxFLAG, the Luxembourg labelling agency, launched the Climate Finance Label in 2016 and the Green Bond Label in 2017 to improve transparency of climate and green investment instruments and ensure investor confidence in this market. These labels followed those on Microfinance (2006), Environment (2011) and Environmental, social and governance (2014).
- In 2016, the Luxembourg government entered into a partnership with the European Investment Bank to create the Luxembourg-EIB Climate Finance Platform. It aims to mobilise private investment for climate projects by mitigating their financial risks with a state guarantee of EUR 30 million.
- In 2016, the government and eight private partners launched the International Climate Finance Accelerator, which offers technical support for managers of investment funds targeting innovative climate projects.
- The Forestry and Climate Change Fund was created in October 2017 with support from Luxembourg banks and insurers. It aims to support the restoration and good management of secondary or degraded forests in Central America. Specifically, it wants to make the forests economically, ecologically and socially viable by engaging local communities, while ensuring a long-term return for investors in the fund.
- In 2018, Luxembourg adopted a legal framework for a renewable energy covered bond, a new instrument aimed at contributing to the financing of renewable energy.
- The budget law for 2020 provides the legal basis for the issuance of government sustainable bonds up to EUR 1 billion per year, starting from 2020.

Anchoring ambitious targets for sustainable finance, aligned with international environmental goals, would provide a long-term framework to catalyse and better co-ordinate the financial sector's efforts. The climate framework law (under discussion at the time of writing) offers an opportunity to enshrine in legislation the commitment under the Paris Agreement of “making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development” (Article 2.1c). In line with this commitment, the central and local governments could lead by example. For instance, they could pledge to measure, report and reduce the environmental and social impact of public investments, sovereign wealth funds and public pensions.

Impact, risks and opportunities of green finance in Luxembourg

Thanks to its financial expertise, Luxembourg could make a significant contribution to integrating environmental, social and governance (ESG) considerations into financial products and investment decisions, both nationally and internationally. It could do more to ensure that green finance has a positive environmental impact and to manage the financial risks of climate change. Luxembourg can also further exploit the opportunities provided by FinTech and large foreign direct investment (FDI) to advance the sustainability agenda.

As in other countries, it is difficult to measure the actual environmental impact of the investment funded through green finance instruments. There is a lack of indicators and monitoring measures that would ensure the credibility of financial products, measure their environmental impact, enhance the impact of LuxFLAG’s labels (Box 3.3) and avoid “greenwashing”. For example, it is not clear whether the renewable energy covered bonds (Box 3.3) have contributed to additional investment in renewables and energy efficiency projects or whether these projects would have materialised anyway (OECD, 2019a). Luxembourg should develop official statistics and indicators for green and sustainable finance to monitor the environmental impact of green finance products.

At global level, the financial sector is exposed to climate-related risks as many financial institutions hold high-carbon assets. These assets are likely to lose value when countries step up their actions to meet international climate change mitigation targets (TCFD, 2017). A project assessing the current portfolio exposure to climate risks is underway in Luxembourg's insurance sector (OECD, 2019a). However, this remains a voluntary initiative. Asset managers and institutional investors are not required to disclose their exposure to climate risks. The financial and insurance market regulators do not have a mandate to assess the effects of climate change risks on financial stability, or to take actions to mitigate them. Luxembourg should consider developing a legal framework for considering environmental and climate risks and impact in investment decisions. This should complement the 2019 EU Regulation on sustainability-related disclosures in the financial services sector. There is also a need to strengthen non-financial transparency by setting harmonised ESG reporting requirements for companies and investors. For example, France included similar reporting obligations in its 2015 law on the energy transition for green growth.[15]

As a large provider of FDI, Luxembourg needs to ensure that its FDI stocks and flows respect the environment and contribute to the transition towards the green economy at global level. At the end of 2018, Luxembourg's outward FDI stocks stood at 343% of GDP, the highest share in the OECD. Luxembourg adhered to the OECD Guidelines for Multinational Enterprises, which set voluntary standards for responsible environmental conduct for internationally active companies. It also implements the OECD Recommendation on Common Approaches for Officially Supported Export Credits and Environmental and Social Due Diligence (OECD, 2010). More than 30 Luxembourg companies adhere to the UN Global Compact, a voluntary corporate sustainability initiative.

Luxembourg could further exploit the synergies between FinTech and green finance (green digital finance). The country has attracted prominent FinTech companies. These companies perform various activities (e.g. banking, payment or e-money institutions) and service customers all over Europe. Luxembourg House of Financial Technology, a public-private platform that stimulates innovation in the digital finance sector, could develop measures to use FinTech innovation for scaling up green finance and investment.

3.8. Mainstreaming the environment into development co-operation

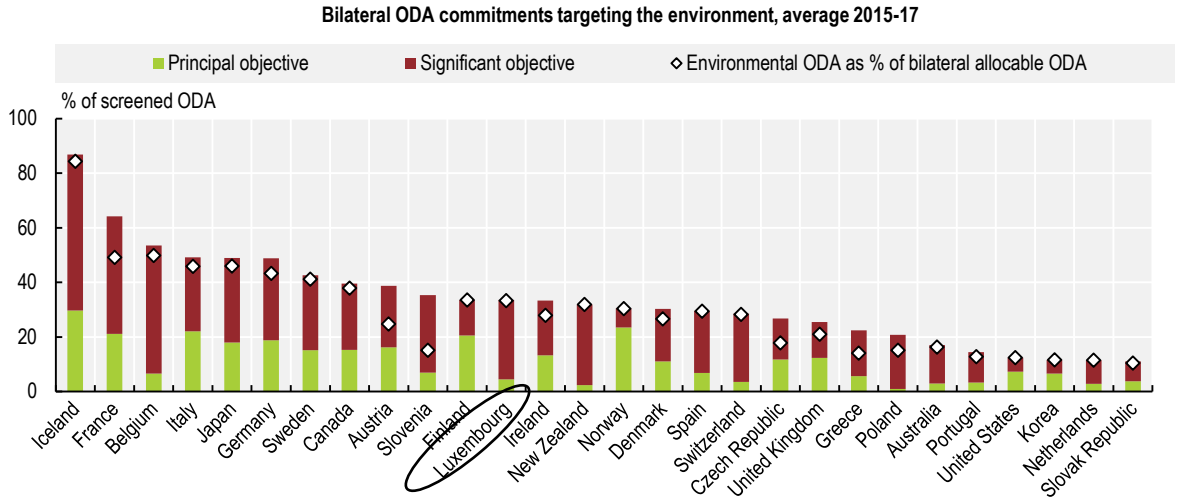
Environment-focused aid and international climate finance

Luxembourg is a generous donor, devoting 1% of its gross national income (GNI) to official development assistance (ODA). This makes it one of the few members of the OECD Development Assistance Committee to exceed the UN target of 0.7% of GNI. ODA consists solely of grants. About one-third of bilateral aid has environmental protection as a primary or significant objective, which is relatively low compared to other donors (Figure 3.9). The environment-focused aid figures exclude international climate finance, however. Luxembourg launched a revision of its aid database to better assess the allocation of bilateral aid for environmental protection and make more accurate comparisons across countries.

Luxembourg provides a large amount of international climate finance to help developing countries mitigate and adapt to climate change. It pledged to provide EUR 120 million in 2014-20 and EUR 200 million in 2020-25 to support developing countries' climate actions. These funds were to focus on the least developed countries, the small island developing states and the Luxembourg development co-operation partner countries. The commitment included an annual envelope of EUR 5 million for the Green Climate Fund. International climate finance comes on top of ODA and is made available through the Climate and Energy Fund managed by the MECDD (Section 3.5). The 2017 strategy for Luxembourg international climate finance funds aims at an indicative allocation of 40% for mitigation measures, 40% for adaptation and 20% for activities to reduce emissions from deforestation and forest degradation (REDD+). In 2019, LuxDev, the country's development agency, received accreditation with the Green Climate Fund. This is

expected to enable the agency to implement more climate-related projects and programmes to complement the development co-operation projects.

Figure 3.9. Environment-focused aid is low in international comparison



Note: Data refer to aid activities designated with the environment policy marker (excluding those activities targeting the objectives of the Rio Conventions not marked for the environment). Activities are classified as "principal" when environment protection is a primary objective and "significant" when it is an important but secondary objective. In comparing data across countries it should be noted that the coverage ratio of the environmental policy objective (i.e. the proportion of aid which is screened against the environment policy marker) varies considerably among countries; low coverage rates can significantly increase the shares of environment-focused aid.
Source: OECD (2019), "Creditor Reporting System: Aid activities", *OECD International Development Statistics* (database).

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Luxembourg should maintain the commitment to international climate finance and further increase the environmental component of its development co-operation. There is scope to further harnessing the potential of Luxembourg's strong financial centre to leverage private finance for climate investment, as well as development more generally (OECD, 2017). This, in turn, would help the country contribute to the global climate finance target of USD 100 billion by 2020. Luxembourg is well-placed to continue to explore opportunities for leveraging private funds for development, building on initiatives such as the Luxembourg-EIB Climate Finance Platform (Box 3.3).

Environmental mainstreaming of development co-operation activities

Poverty eradication is the main objective of the 2018 development co-operation strategy, in line with the third PNDD and the SDGs (Section 3.2). The country's bilateral co-operation focuses on a limited number of countries to maximise the impact of aid. Luxembourg allocates at least half of its bilateral aid to its priority partner countries, and maintains a regional focus primarily in countries in West Africa and the Sahel.

The development co-operation strategy is structured around four priority themes, which are considered to have the largest poverty eradication potential: improve access to basic social services; strengthen the socio-economic integration of women and young people; promote inclusive governance; and promote sustainable and inclusive growth. There are also three cross-cutting dimensions: environmental sustainability; respect for human rights; and gender equality and equity.

In 2012, LuxDev developed guidance for consideration of the cross-cutting dimensions in its development activities. With respect to environmental sustainability, the guidance aims to help practitioners identify and avoid adverse environmental impacts of development co-operation programmes and projects; identify and seize opportunities to improve environmental conditions; promote a better environmental dialogue with

institutions and stakeholders in partner countries; and identify potential climate-related risks to projects and programmes.

All development project proposals go through an environmental and climate screening. This seeks to identify the potential environmental impact, as well as the potential influence of climate change, on the project. The screening indicates whether an environmental impact assessment (EIA) and/or a climate risk assessment (CRA) are needed. For projects that do not require an EIA or CRA, any significant environmental issues identified during the screening should be addressed during the project formulation phase. The formulation phase should identify the necessary measures to mitigate environmental and climate impacts by target groups and ecosystems and provide financial resources to implement them. The project can include an environmental management plan to be executed during project implementation. The environmental indicators included in the project design should be tracked to trigger adjustments in project management when needed. An environmental review of an ongoing project is also possible to identify areas where environmental performance can be improved.

Environmental issues are systematically assessed once projects have been identified. However, environmental opportunities and threats are not strategically considered during the elaboration of multiannual country-specific development programmes (OECD, 2017). In addition, guidance for implementation is not sufficient. The agency plans to complement its guidance with environmental and social safeguards. There is also a need to strengthen capacity of authorities to mainstream the environmental and other cross-cutting dimensions into development activities.

Recommendations on green growth

Greening the system of taxes and subsidies

- Progressively raise tax rates on energy products to ensure they reflect the environmental and other social costs of energy use in the framework of a broader reform of the tax and benefits system; in particular, raise the diesel excise rate to match the petrol rate, and continue to gradually reduce the tax gap with neighbouring countries.
- Follow through on the plan to introduce carbon pricing in sectors not covered by the EU ETS; ensure systematic monitoring of the effect of carbon pricing on energy use and GHG emissions and adjust prices as appropriate.
- Systematically monitor and assess subsidies and tax provisions to identify and remove those that are not justified on economic, social and environmental grounds.

Promoting eco-innovation and environment-friendly investment

- Continue to support environment-related R&D, with a focus on SMEs; systematically evaluate the efficiency and environmental effectiveness of R&D support programmes.
- Develop and implement a clear policy on GPP by integrating mandatory environmental criteria and targets into public procurement regulations.
- Streamline and better target public financial assistance for environment- and climate-related investment; ensure that financed projects are the most cost-effective and provide additional environmental benefits; conduct systematic ex post evaluation of the environmental impact of the financed projects, and assess their contribution to environmental, climate and energy targets.

Greening financial markets

- Develop a legal framework for taking environmental risks and impact into account in investment decisions, for example by extending the fiduciary duty of asset managers and institutional investors and requiring the financial and insurance market regulators to assess exposure to climate change risks and take actions to mitigate them.
- Consider integrating the commitment under Article 2.1c of the Paris Agreement into the climate framework law.
- Extend the focus of green finance initiatives “beyond climate” (e.g. to water, biodiversity and circular economy) and develop measures to fully exploit the potential of financial technology in greening financial flows.
- Develop official statistics and indicators for green and sustainable finance, with a view to monitoring the environmental impact of green finance products.

Mainstreaming environment into development co-operation

- Maintain the commitment to international climate finance and further increase environment-focused aid; strengthen guidance and capacity for the environmental mainstreaming of development co-operation activities; continue to explore opportunities for leveraging private funds for development.

Notes

[1] The priority fields of action of the third National Sustainable Development Plan are: ensuring social inclusion and education for all; ensuring the conditions of a healthy population; promoting sustainable consumption and production; diversifying and ensuring an inclusive and future-oriented economy; planning and co-ordinating land use; ensuring sustainable mobility; halting the degradation of the environment and respecting the carrying capacity of natural resources; protecting climate, adapting to climate change and ensuring sustainable energy; contributing globally to poverty eradication and policy coherence for sustainable development; and guaranteeing sustainable finances.

[2] An inter-ministerial committee (finance, environment, energy and economy) monitors the evolution of fuel sales and defines measures to reduce their impact on Luxembourg's GHG emissions, with a view to achieving the country's climate commitments.

[3] Before the raises, the climate change contribution was set at EUR 0.02 per litre of petrol and EUR 0.025 per litre of diesel.

[4] Rising benchmark values over time for carbon costs reflect that the marginal damage caused by one tonne of CO_2 increases with the accumulation of CO_2 in the atmosphere.

[5] Pricing emissions above EUR 30 per tonne does not guarantee that polluters pay for the full damage they cause, or that prices are sufficient to decarbonise the economy. A price below EUR 30 per tonne does mean, however, that emitters do not face the social costs of emissions and that incentives for cost-effective abatement are too weak.

[6] Exemptions from the abstraction tax are granted to water withdrawals related to aquaculture, water troughs in stream-fed pastures, public or private civil engineering works, rescue services and hydropower generation.

[7] In 2016, the average annual quantity of residual mixed waste was 157.5 kg per inhabitant in municipalities applying quantity- or volume-based waste charges, compared to 208.2 kg per inhabitant in other municipalities.

[8] The grant covers 75% of the appliance price, with a limit of EUR 750 per appliance.

[9] The other priority sectors of the Smart Specialisation Strategy are manufacturing industry, information and communication technologies, space technologies, logistics, health sciences and technologies.

[10] According to a 2017 Eurobarometer survey, 25% of the country's SMEs offer green products and services, compared to the EU average of 24%. In all, 27% of SMEs have taken steps to design products that are easier to maintain, repair or reuse (the EU average is 25%).

[11] The "Clever akafen" criteria include: recyclable packaging; no or low level of dangerous substances; long-lasting product with a low energy consumption at use; and easy recycling of the product after use. The label covers rechargeable batteries and accessories, lighting equipment, lacquer and paint, detergents, personal care products, and school and office material.

[12] A green bond is a debt instrument issued to fund projects that have a positive environmental or climate impact. Social and sustainable bonds are debt instruments whose proceeds are exclusively used to finance or refinance social projects and sustainability-focused projects, respectively.

[13] The fourth edition of the Global Green Finance Index is based on a worldwide survey of finance professionals' assessments on the quality and depth of green finance offerings across 114 international financial centres.

[14] The four priorities are: support to new growth sectors (sustainable finance, digitalisation, investment funds); excellence in regulation and compliance; promotion and communication; and education and research.

[15] Law 2015-992 of 17 August 2015.

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Part II Progress towards selected environmental objectives

4 Air quality and mobility

Chapter 4 examines the road transport sector in Luxembourg, and its relationship to local air pollution and emissions of fine particulates ($PM_{2.5}$), nitrogen oxides (NO_x) and carbon monoxide. It pays particular attention to the implications of tax policies on emissions from land transport by non-residents.

In addition to analysing emissions of $PM_{2.5}$ from transport, Chapter 4 examines the impact of emissions from the housing sector, as well as the costs to society of air pollution. It highlights findings of a special campaign of the Climate Pact to measure NO_2 concentrations through 100 stations established in 36 municipalities. Luxembourg's effort to update its strategy for sustainable mobility (Modu 2.0) is examined, as well as steps taken to promote car-pooling, public transport and active mobility, low-emission vehicle use, rail transport and teleworking.

Chapter 4 ends with a discussion of tax competition between sub-national authorities and fiscal threats from promotion of sustainable mobility abroad.

4.1. Introduction

Luxembourg's economic and population growth of the last decade have led to increasing need for mobility for professional and private purposes. This has translated into a constant increase of road traffic and saturation of the road network. Due to its geographical location, Luxembourg is a crossroads for goods traffic and a pole of attraction for employment in the Greater Region.[1] More than 44% of jobs are held by cross-border commuters, who live in neighbouring countries and commute daily. In addition, Luxembourg's energy tax system keeps road fuel prices below those of neighbouring countries and is a driver of significant fuel exports (Chapter 3). In the coming years, Luxembourg will continue to attract cross-border residents and workers, which risks further exacerbating problems of urban sprawl, congestion and air pollution, and the associated environmental and other social costs.

Luxembourg authorities have acknowledged these challenges and have taken steps to reduce air emissions and improve public transport. Significant investments have been made in the development of rail infrastructure, the creation of park-and-ride facilities and multimodal platforms, as well as in the purchase of low-emission buses. Despite this, the vast majority of personal trips are still made by car, 67% compared to only 17% by public transport. Car ownership is the highest in Europe (over 600 private cars per 1 000 inhabitants); the car fleet is relatively young, but with an average engine capacity higher than in many other countries.

4.2. The transport sector

The road transport sector in Luxembourg is in some respects special compared to most other countries. While the sector's share in value added in Luxembourg's economy (4.4% in 2015) is equal to that found in France and Germany, it is lower than in many other countries. The number of vehicle-kilometre driven per USD 1 000 of gross domestic product (GDP) was 10.0 km in 2015; this was lower than in any other OECD member country for which data are available. Part of the explanation is the large weight that, for example, the financial sector plays in the economy of Luxembourg. This sector does not rely much on road transport. Motor fuel sales per capita (2.7 tonnes in 2016) are several times higher than what is registered in any other OECD member country. Carbon dioxide (CO_2) emissions from the sector per capita are therefore also much higher than in the rest of the OECD. Most of the fuel (75%) is sold to non-resident drivers filling their tanks in Luxembourg, due to the country's historically low fuel-tax rates.

Fuel exports cause only a small part of local air pollution and congestion in Luxembourg. The large number of foreign citizens coming across the borders on a daily basis to work in Luxembourg contributes both to air pollution and to high levels of congestion. According to TomTom's Traffic Index, the City of Luxembourg is the tenth most congested European city with fewer than 800 000 inhabitants (TomTom, 2020).[2] Globally, the city is ranked at 64, across all sizes of cities affected. The congestion value in the City of Luxembourg is 33%; it represents the measured amount of extra travel time spent by drivers in the city across the whole year.

4.3. Emission of air pollutants

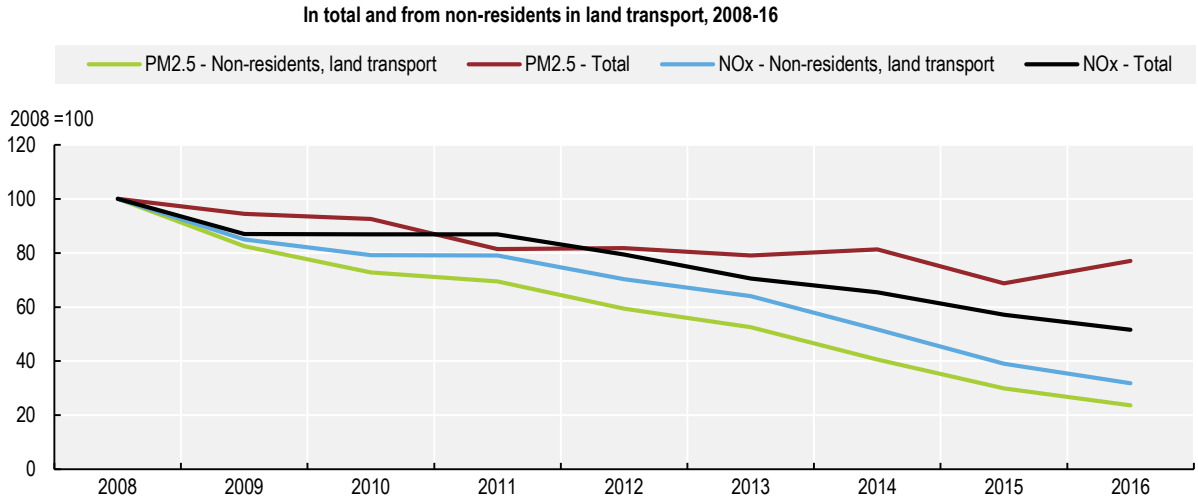
Total human-made emissions of local air pollutants have been decreasing in Luxembourg over the last decade (Figure 1.9; Chapter 1). Total emissions of fine particulates ($PM_{2.5}$) decreased by 45% over 2005-17; $PM_{2.5}$ emissions from road transport decreased by more than 70%. Total emissions of nitrogen oxides (NO_x) decreased by more than 65% over the same period; emissions of NO_x from road transport decreased by more than 75% (OECD, 2020).

Lower $PM_{2.5}$ and NO_x emissions are largely explained by reduced land transport emissions from non-residents. Reductions in land transport emissions of $PM_{2.5}$ and NO_x caused by non-residents were

significant over 2008-16; in both cases, they were much larger than reductions in total emissions (Figure 4.1).

Historically, emissions of $PM_{2.5}$ and NO_x from land transport by non-residents have constituted a much larger share of total emissions of these pollutants in Luxembourg than in any other OECD member country for which detailed emission accounts are available. This is still the case. However, the difference compared to other countries decreased significantly from 2008 to 2016 as a result of the emission reductions (Figure 4.2).

Figure 4.1. Non-residents' emissions of $PM_{2.5}$ and NO_x have decreased rapidly



Source: OECD (2019), "Air and climate: Air and greenhouse gas emissions by industry", *OECD Environment Statistics* (database).

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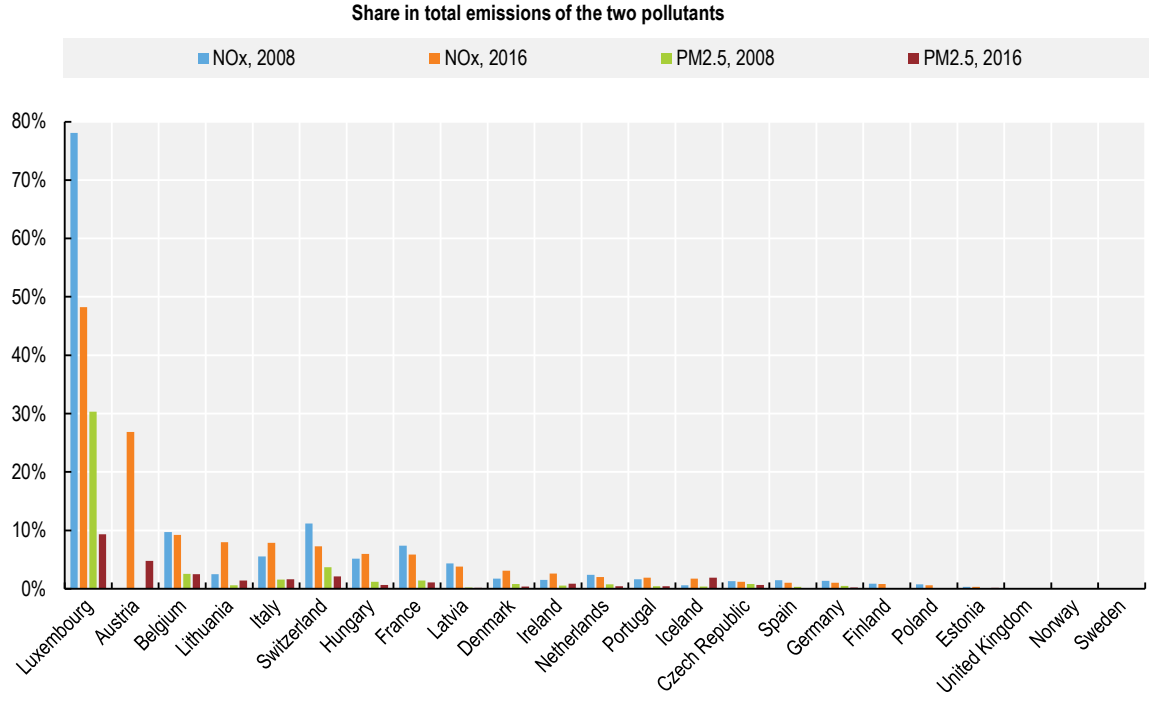
Figure 4.2. Non-residents' emissions of $PM_{2.5}$ and NO_x are high in Luxembourg



Source: OECD (2019), "Air and climate: Air and greenhouse gas emissions by industry", *OECD Environment Statistics* (database).

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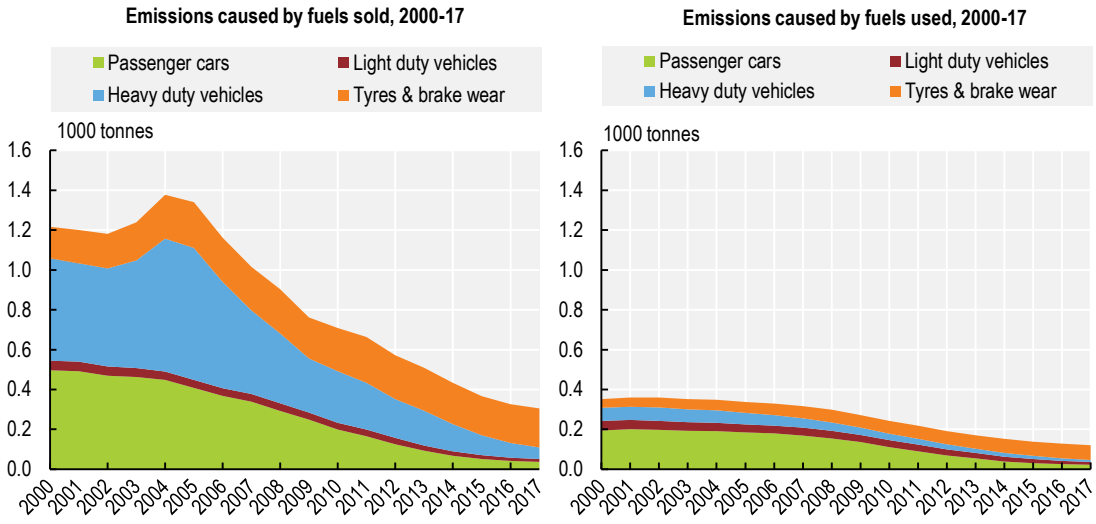
In spite of recent planned tax rate increases, Luxembourg's tax policy regarding motor vehicle fuels still causes fuel prices to be lower than in neighbouring countries. This has been attracting a large number of drivers who visit Luxembourg primarily to fill their tanks with cheaper fuel (Chapter 3). Drivers of passenger cars and, in particular, heavy goods vehicles registered in other countries cross the border to buy diesel. To a lesser extent, they buy petrol, as well as alcohol and tobacco, which are also taxed lower than in neighbouring countries. Most of this fuel will thus be used, and cause emissions, in other countries.

The transport sector also causes major emissions of $PM_{2.5}$ through tyre and brake wear. These sources have in fact caused much larger emissions than what fuel combustion did in recent years (AEV, 2018). This is true both for fuels bought and for fuels used in Luxembourg (Figure 4.3), when considering only emissions of primary particulates. The use of diesel vehicles also contributes importantly to the formation of secondary particulates, via the NO_x emissions they cause.

Figure 4.3. The share of $PM_{2.5}$ emissions caused by tyres and brake wear is increasing



Note: Fuel combustion by passenger cars and light and heavy duty vehicles, as well as by tyres and brake wear from all vehicle categories.
Source: Administration de l'Environnement (2019), Luxembourg's Informative Inventory Report 1990-2017.

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The share of road transport in total emissions of NO_x, PM_{10}, $PM_{2.5}$, carbon monoxide (CO) and volatile organic compounds (VOCs) decreased significantly between 2005 and 2017 (Figure 4.4). For sulphur dioxide (SO_2), there was a minor increase in road transport's share over this period, but from a low starting point.[3]

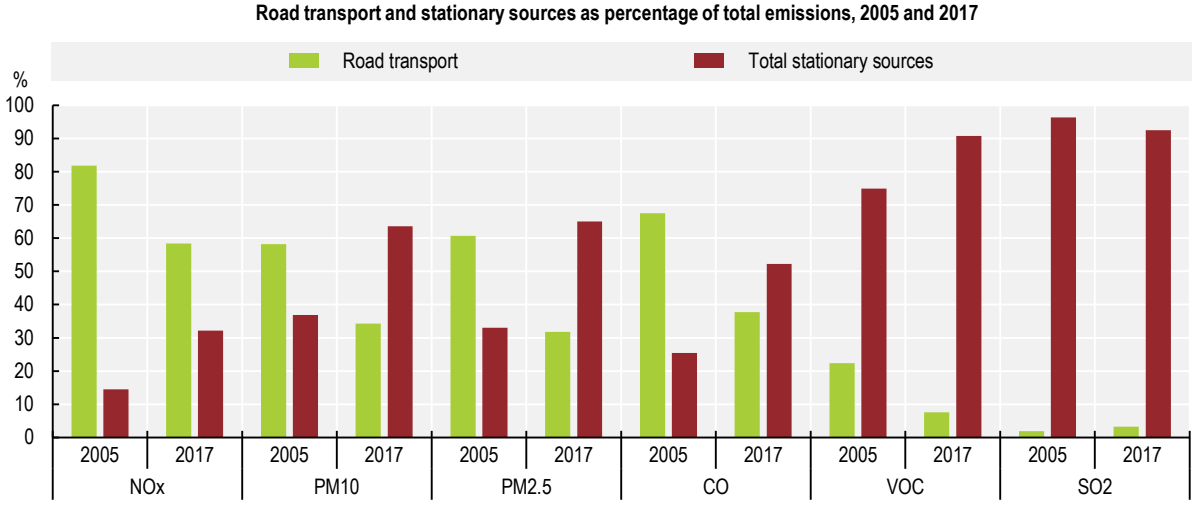
A closer look at emissions that affect air quality in Luxembourg shows that primary $PM_{2.5}$ emissions from the housing sector are significantly larger than *primary* $PM_{2.5}$ emissions from motor fuels *used* in Luxembourg, even if emissions from tyre and brake wear are considered (Figure 4.5).

The emissions in the housing sector stem, among others, from the use of wood biomass for heating. Wood biomass has been promoted as a renewable energy source with the aim to limit emissions of greenhouse gases. As a result, $PM_{2.5}$ emissions from the housing sector have gradually been increasing over the last decade.

The country has set emission limits as an eligibility criterion for public subsidies granted for investments in new wood burners. In addition, in April 2015, the European Commission adopted a regulation with regard to eco-design requirements for solid fuel local space heaters (EC, 2015). This regulation sets emission

limits regarding particulates, NO_x and carbon monoxide (CO), which will come into force from 2022. In spite of this new regulation, there are potential conflicts between climate change mitigation objectives and local air pollution objectives. One response is to focus use of wood biomass for heating on relatively large distance-heating plants. These plants should have a distribution system for district heating, preferably with co-generation of electricity. In such plants, it can be easier to install technologies to limit emissions of $PM_{2.5}$ and other local air pollutants at reasonable costs per unit of heat generated.

Figure 4.4. The share of road transport in emissions of most local air pollutants is decreasing



Note: Among mobile sources, the graph only takes into account primary emissions stemming from road transport. Therefore, the sum of the two bars generally does not add up to 100%.
Source: OECD (2019), "Air and climate: Air emissions by source", *OECD Environment Statistics* (database).

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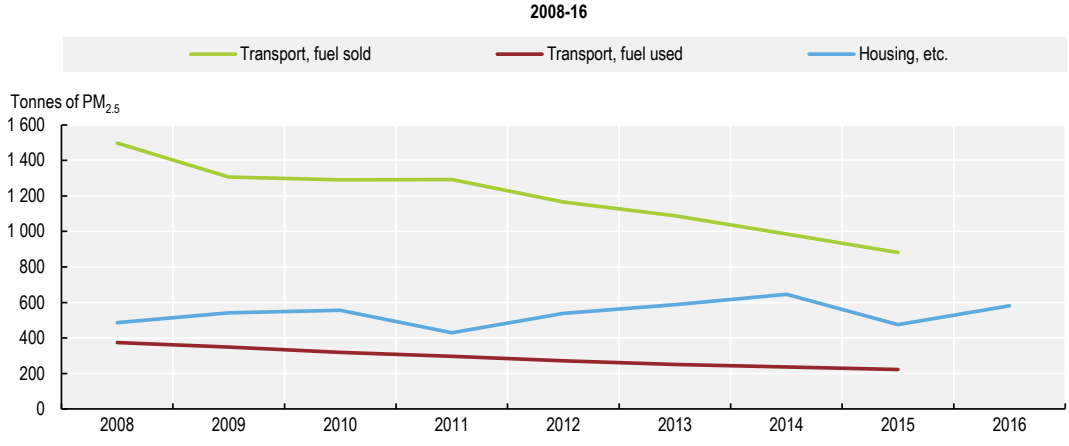
Figure 4.5. $PM_{2.5}$ emissions from the housing sector have increased



Note: Emissions stemming from tyre and brake wear are included in the transport sector numbers.
Source: Administration de l'Environnement (2018), "Luxembourg's Informative Inventory Report 1990-2016"; OECD (2019), "Air and climate: Air and greenhouse gas emissions by industry", *OECD Environment Statistics* (database).

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4.4. Ambient concentrations of air pollutants

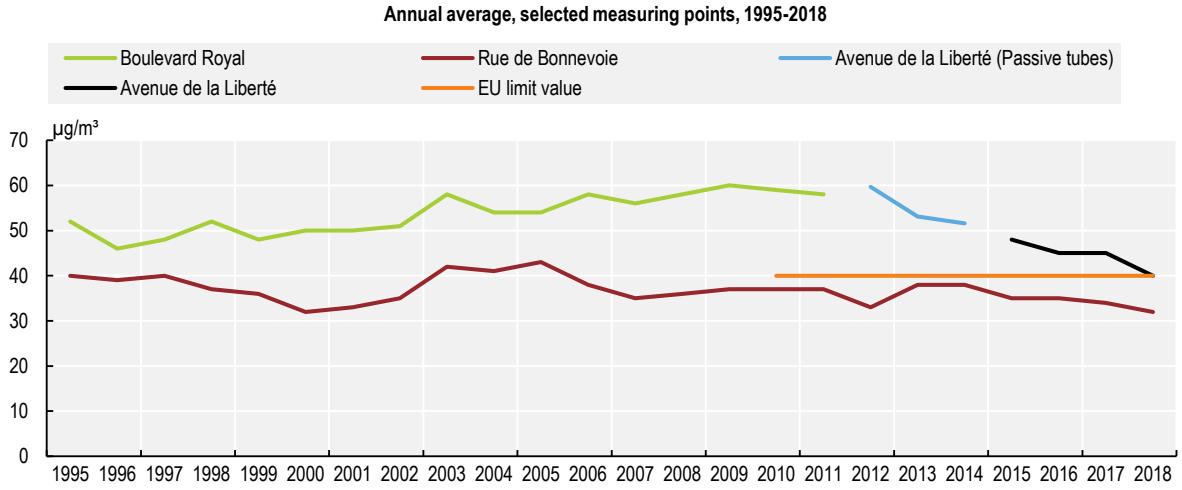
Air quality is monitored through an extensive network of measuring stations located in the City of Luxembourg and in Esch-sur-Alzette, close to the border with France, and in more rural areas of the country. Reductions in air pollution levels have been much smaller than emission reductions otherwise could have suggested. This is because emission reductions in the transport sector have been primarily linked to emissions caused by non-residents. It does not reduce air pollution levels in Luxembourg much if fewer foreign vehicles, mostly used abroad, fill up their fuel tanks in the country.

As part of the Climate Pact, a special campaign to measure NO_2 concentrations was implemented in 2018, with more than 100 measurement stations in 36 municipalities. Average annual concentrations of NO_2 at selected places in the City of Luxembourg have declined somewhat in recent years, but remain close to the EU limit value for these concentrations[4] (Figure 4.6). Buses used to be the main source of NO_2 emissions in the city. However, a recent reorganisation of bus lines and fewer buses at peak hours in the streets with the densest traffic have helped reduce these emissions. The measurement campaign in 2018 indicated that ambient NO_2 concentrations were well below the EU limit value in most parts of the country.[5]

Annual air concentrations of $PM_{2.5}$ have been decreasing. However, they remain above the World Health Organization (WHO) guideline value of 10 µg of $PM_{2.5}/m^3$ of air, both for the national average and at selected places. Thanks to the decreases, the national average is now approaching the guideline value. In remote areas, concentration levels are below the guideline value (Figure 4.7).

There is no known threshold value as regards health damages caused by $PM_{2.5}$ exposure. Shi et al. (2016) did, for example, find significant mortality impacts well below the WHO's guideline value. Even if the number of mortalities per 1 million inhabitants is well below the OECD and European averages, an estimated 150 persons died prematurely in 2017 from exposure to $PM_{2.5}$ in Luxembourg (OECD, 2020).

Figure 4.6. Ambient concentrations of NO_2 in the City of Luxembourg remain high



Source : MECDD (2019), "Historique des valeurs mesurées pour les oxydes d'azote (NOx)" (website).

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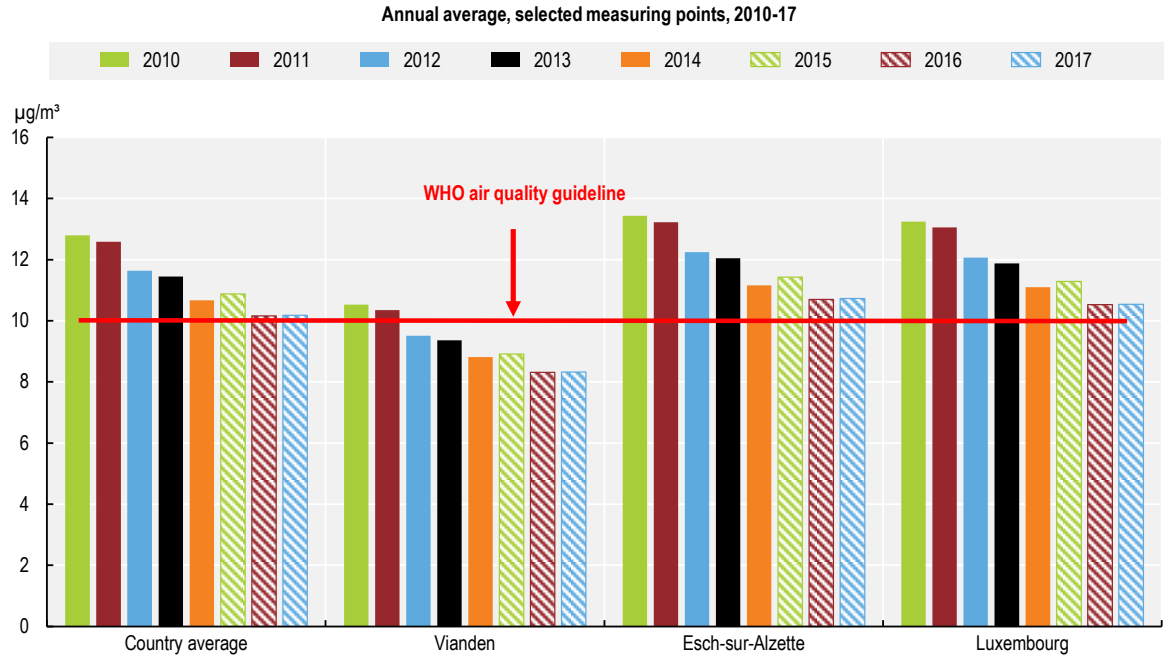
Figure 4.7. Ambient concentrations of $PM_{2.5}$ remain above the WHO guideline in several places



Note: The horizontal red line shows the WHO's air quality guideline regarding annual average $PM_{2.5}$ concentrations.
Source: OECD (2019), "Air quality and health: Exposure to $PM_{2.5}$ fine particles – metropolitan areas", *OECD Environment Statistics* (database).

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4.5. Costs to society of air pollution

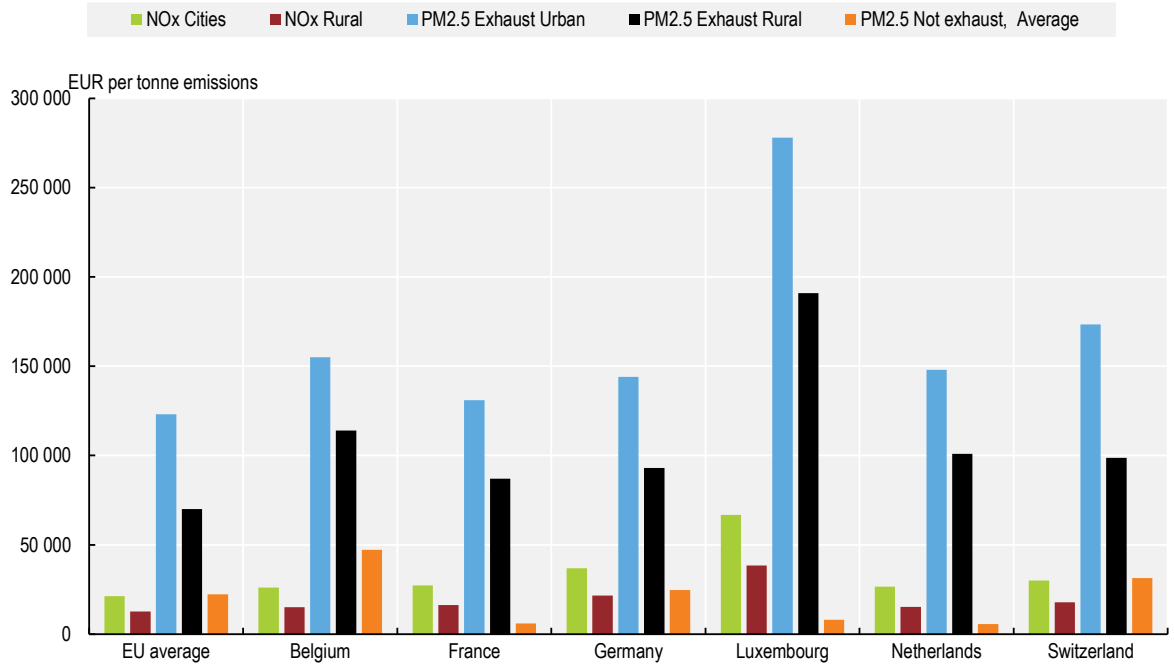
Air pollution imposes costs on society. Hunt et al. (2016) distinguish between three main categories of costs:[6] resource costs, opportunity costs and disutility costs. Resource costs include avertive expenditures, e.g. relocation to area of lower air pollution, staying inside, etc., and mitigating expenditures, e.g. the direct medical and non-medical costs associated with treatment for the health impact. Opportunity costs include costs related to loss of productivity or leisure time due to the health impact.[7]

The disutility costs, which includes pain, suffering, discomfort and anxiety linked to the illness and to any premature mortality, remain the largest of the cost components. OECD (2020) estimates that people in Luxembourg would have been willing to pay an amount equal to more than 2% of GDP to avoid the premature mortalities caused by $PM_{2.5}$ exposure, from all contributing sources. Also, according to OECD (2019b), 25 persons are estimated to have died prematurely in 2017 due to ozone (O_3) exposure. The same study estimates that people in the country would have been willing to pay an amount equal to around 0.35% of GDP to avoid these premature mortalities.

Recent estimates indicate that the external costs of transport in euros per tonne of pollutant emitted are high in Luxembourg (Figure 4.8; van Essen et al., 2019). These external costs include the social costs of air pollution, but also costs related to climate change, habitat damage, noise, accidents and congestion. With the exception of non-exhaust $PM_{2.5}$ emissions, the estimated costs per tonne of pollutant emitted is considerably higher in Luxembourg than in other EU countries. The high cost estimates for Luxembourg are partly explained by the high incomes per capita. These cause the estimated Value of a Statistical Life (VSL) to be much higher than in neighbouring countries. Naturally, for both NO_x and $PM_{2.5}$, the cost estimates are much higher in urban than in rural areas: a given tonne of pollutant emitted in a densely populated area affects more people. The estimated costs of air pollution per passenger-kilometre in cars,

buses and light-duty vehicles are also higher in Luxembourg than in other EU countries. The same is true for the costs per tonne-kilometre for heavy goods vehicles (Figure 4.9, van Essen et al., 2019).[8]

Figure 4.8. Estimated costs of air pollution are high



Note: 2016 money value. Emission costs in metropolitan areas are excluded as there are no such areas in Luxembourg.
Source: van Essen et al. (2019), "Handbook on the external costs of transport".

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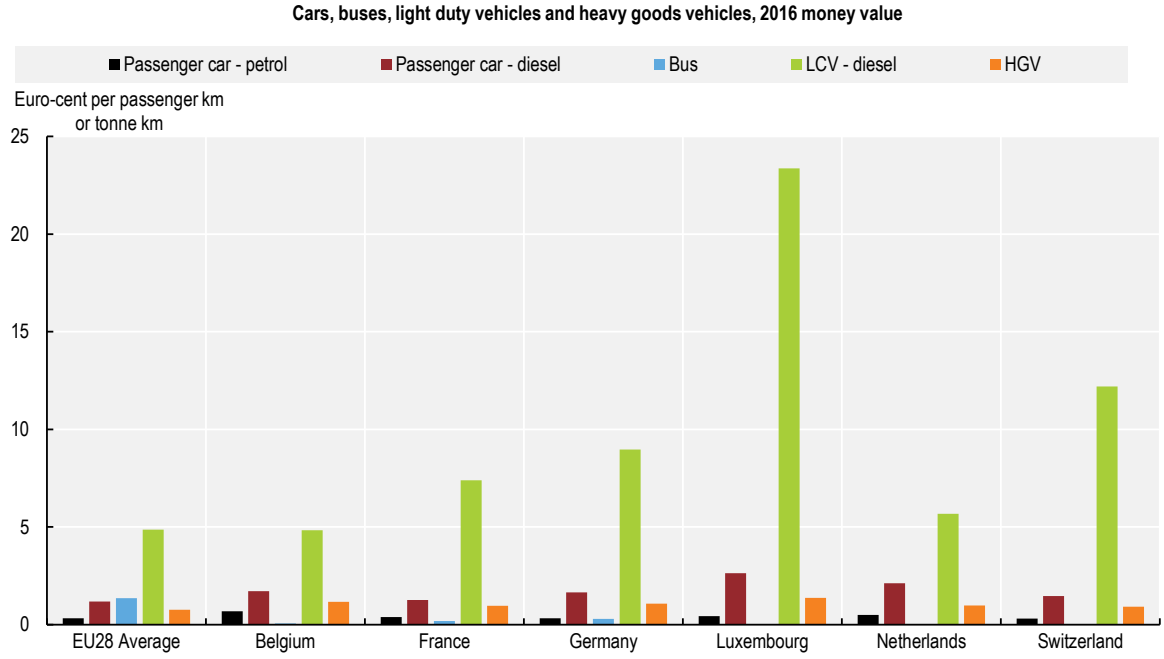
Figure 4.9. Air pollution costs per passenger- or tonne-kilometre are high



Note: Euro-cent per passenger km for cars, buses and light duty vehicles; Euro-cent per tonne km for heavy goods vehicles, 2016 money value. LCV: Light Commercial Vehicle. HGV: Heavy Goods Vehicle.
Source: Based on van Essen et al. (2019), "Handbook on the external costs of transport".

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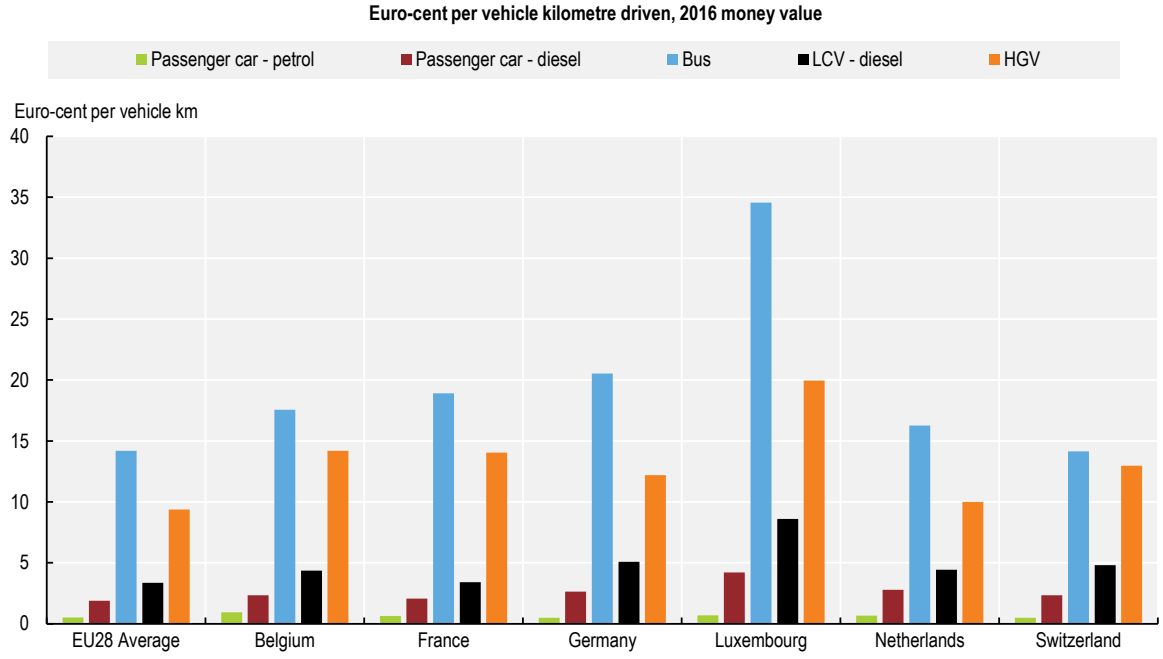
The high VSL value is not the only explanation for high social costs of transport in Luxembourg. Santos (2017) found that external costs caused by heavy goods vehicles in Luxembourg were particularly high. This was mainly because a larger proportion of traffic of heavy goods vehicles the found is taking place on urban roads.

When relating air pollution costs to each kilometre driven by a vehicle, the values for Luxembourg are again higher in the countries used in the comparison, and compared to the EU average. Similarly, the costs per kilometre driven by buses (and by heavy goods vehicles) are much higher than the costs per kilometre for passenger cars and light commercial vehicles. This information in van Essen et al. (2019) refers to 2016. Since then, Luxembourg and other countries have taken measures to introduce hybrid and electrical buses, which would tend to reduce the air pollution costs per kilometre driven. However, such buses may cause large emissions of $PM_{2.5}$ due to tyre and brake wear (Figure 4.10).

Figure 4.10. Air pollution costs per vehicle kilometre are high



Note: LCV: Light Commercial Vehicle. HGV: Heavy Goods Vehicle.
Source: Based on van Essen et al. (2019), "Handbook on the external costs of transport".

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4.6. The strategy for sustainable mobility

There are many ways to make mobility more sustainable. Motorised mobility will, to a varying extent, cause a range of external impacts, including emissions of CO_2 and air pollutants, noise, accidents and congestion. The development of infrastructure to accommodate such mobility will often damage habitats and biodiversity. So-called active mobility – walking and bicycling – will cause much fewer, if any, of these externalities and can be good for people's health.

A number of actions could make mobility more sustainable:

- Reducing the total number of movements of people and goods, e.g. by promoting teleworking
- Reducing the number of vehicles used to transport a given number of people and a given amount of goods, e.g. by increasing the load factors of the vehicles used, for instance through ride-sharing

- Switching to environmentally less harmful vehicles within one mode of transport, such as from fossil fuel-driven passenger cars to electricity-driven cars
- Switching to environmentally less harmful modes of transport, such as from road to rail, or from the use of private cars to the use of public transport, or to walking or bicycling
- Displacing mobility to places where it causes fewer negative externalities, such as by using ring roads around cities, instead of crossing them
- Displacing mobility to times of the day or of the week when traffic is lower, such as from peak hours to late evening, or from workdays to weekends.

In 2012, Luxembourg published a global strategy for sustainable mobility, Modu (referring to the French term *mobilité durable* – sustainable mobility). This plan set a double objective for 2020: 25% of all trips should be non-motorised and 19% of all trips should be made by public transport. These targets were based on model projections built on the incomplete data available at the time of preparing the plans, which makes comparisons to actual achievements difficult.

The 2018 Modu 2.0 is a revised strategy for making mobility in Luxembourg more sustainable (Département des Transports, 2018). It was built, among other things, on responses from some 37 500 persons to the Luxmobil survey in 2017 about their mobility habits, etc.[9] According to this survey, 17% of motorised movements were made via public transport in 2017. Meanwhile, 12% of all movements were made on foot or by bike, excluding "trips" on foot as part of a longer journey by car.

Modu 2.0 focuses on four categories of mobility "actors": employers and education establishments; municipalities; citizens; and the state (Box 4.1). The document also highlights the difference between "traffic" and "mobility": Whereas "traffic" is the movement of vehicles, "mobility" is the possibility and capability to reach a destination. As its key message, the strategy says that mobility in the country can only be improved sustainably and within reasonable timelines if all four actor-categories take a multitude of concrete actions.

The strategy encompasses a number of interrelated actions that the different actors can take to make mobility more sustainable, including the following:

- Undertaking spatial planning in general
- Limiting and managing the availability of parking spaces
- Creating a nice atmosphere for pedestrians
- Making space available for cyclists
- Reducing mobility activity at peak hours
- Stimulating car-pooling and car-sharing
- Promoting use of public transport
- Promoting use of cleaner vehicles.

A strategic objective is to reduce congestion at peak hours while transporting 20% more people in 2025 than in 2017. It sets a number of quantitative targets to reach this objective (Box 4.1). Other objectives referred to include the EU emission reduction targets for 2005-30 (i.e. an 83% reduction for NO_x, 42% for non-methane VOCs and 40% for $PM_{2.5}$).

Implementation of the strategy will be key to the future development of the country. As a strategic document, the Modu 2.0 suggests around 50 measures that the four categories of mobility "actors" could take to make mobility more sustainable. To achieve the paradigm shift from catching up with demand by supply to anticipating it, work has started on the National Mobility Plan 2035. The plan is expected to be presented to parliament in 2021 or 2022. It will be centred on mobility (e.g. measures to reduce individual transport, promotion of public transport, improvement of traffic flows and information measures) and on mobility infrastructure.

Box 4.1. Sustainable mobility targets for 2025

The Modu 2.0 sets a number of targets for 2025, such as:

- Increasing by 50% the number of passengers in public transport through the entry into operation of new infrastructures for the railway company CFL and a reorganisation of the network of the public transport company RGTR
- Increasing to 95% the number of commutes on foot from home to work shorter than 1 km (compared to 56% in 2017)
- Increasing to 10% the number of commutes by cycling from home to work shorter than 5 km (compared to 5% in 2017)
- Increasing to 1.5 persons the average occupation rate of cars used for commutes from home to work
- Increasing to 75% of the movements by foot from home to schools shorter than 1 km (compared to 58% in 2017)
- Increasing to 15% of the movements by cycling from home to schools shorter than 5 km (compared to 3% in 2017)
- Increasing to 50% of the movements from home to primary schools by bus (compared to 29% in 2017), and increasing to 77% of the movements from home to secondary schools by bus or train (compared to 70% in 2017)
- Cancelling fewer than 1 train of 100 (compared to cancelling 1 train of 40 in 2017)
- Reducing by 25% the share of trains delayed six minutes or more (compared to 2017)
- Ensuring that travels by express buses at peak hours between the first stop and the end station are faster than similar travels by cars.

Promotion of public transport

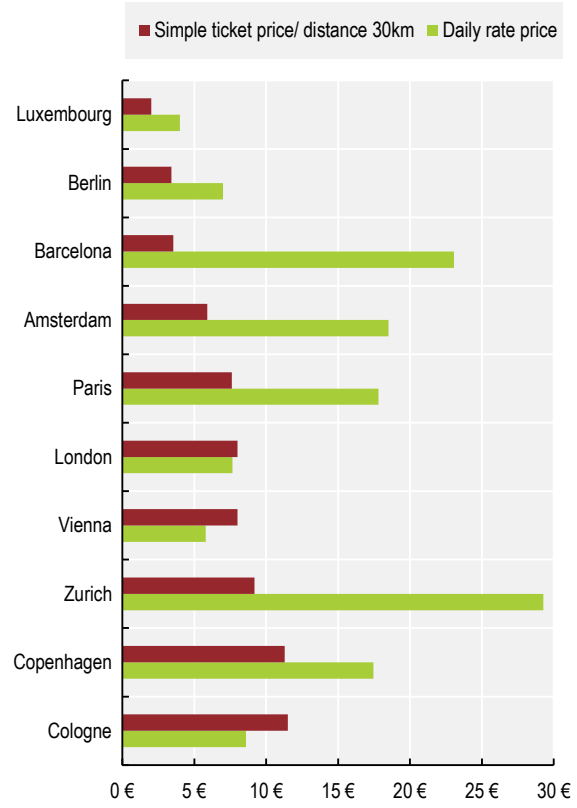
Luxembourg has taken a number of steps to promote the use of public transport to make mobility more sustainable. Between 2015 and 2019, it invested around EUR 1.8 billion in infrastructure for public transport. This includes building a first tramline, establishing new bus corridors, increasing the number of park-and-ride places throughout the country and in border regions, and developing new data systems to provide information to passengers about departure times, delays, etc.

There have also been large purchases of hybrid and electric buses. In 2019, the country introduced 110 new buses in the national bus network; more than 40 of them were 100% electric. This should clearly help reduce combustion-related emissions of local air pollutants. *Ex post* assessments are needed to determine the extent to which hybrid buses run on their batteries rather than on their diesel motors. The batteries add weight to the buses. Therefore, hybrid buses will normally burn more diesel per kilometre driven when the internal combustion motor is used than buses only equipped with such motors (Braathen, N., 2011; Rosendahl, K., 2019).[10] As the experiences with hybrid buses were not so positive, Luxembourg wants to introduce 100% electric buses where possible, and rely on the highest available Euro standard buses elsewhere. It has a set a goal for the bus fleet to be 100% electric by 2030. This will require adequate access for buses to charging stations of sufficient capacity (see below).

A switch to electrical- or hydrogen-driven vehicles will not reduce the emissions caused by tyre and road wear. On the contrary, these vehicles in a given category tend to be heavier than similar vehicles with only an internal combustion engine. Consequently, emissions from tyre and road wear could tend to increase as the share of electrical vehicles in the fleet increases.

The price of public transport in Luxembourg City is lower (in some cases, much lower) than in other European cities of a comparable size (Figure 4.11). It is also free several weekends in the year to encourage citizens to take public transport for their shopping during the sales periods or around special holidays (Christmas, Easter, etc.). As part of its sustainable mobility strategy, the government recently made public transport completely free across the whole country for all users – including a large number of daily commuters from neighbouring countries. Only first class seats continue to require a fee. This measure, introduced in March 2020, is financed by the government and the City of Luxembourg. It is seen as a signal for inducing behavioural changes that would rebalance the modal split and for demonstrating the government's political will. However, it raises questions about the measure's environmental and economic effectiveness. The 2017 Luxmobil survey found that time, comfort and parking possibilities are the most important factors influencing the choice between public transport and other modes of transport among different categories of users. Hence, making public transport totally free is on its own unlikely to have much impact on the choice of transport mode. The measure has also been portrayed as a "social policy measure", but in this case, its targeting is particularly ineffective. It provides subsidies to a large number of people not really in need of such aid.

Figure 4.11. Prices for public transport are low compared to other cities in Europe



Source: Département des Transports (2018), *Modu 2.0 - Stratégie pour une mobilité durable*, Département des Transports, Luxembourg.

StatLink https://doi.org/10.1787/888934169025

Free public transport will deprive the state of some EUR 40-45 million per year in ticket revenue, given current ticket prices. There will hardly be any cost savings related to an abolishment of the ticketing system. This is because the so-called mKaart provides an increasing number of other services to the card holders, which will likely increase operating costs. These services include free access to safe areas for storing bicycles near public transport stations, and payments for the use of charging stations for electrical vehicles. The revenues only represent about 10% of the costs of operating the public transport system.[11] However,

should the government have less money to spend, the loss of revenues from ticket sales could have a negative impact on the quality of its services. Therefore, the effectiveness of this and other measures to promote sustainable mobility should be assessed in a few years.

Stimulation of active mobility

Luxembourg has a number of measures to stimulate active mobility (walking and biking). A national network of bicycle lanes is being developed. In 2019, more than 600 km of bicycle lanes were available, while about 500 km were being planned. Efforts are being made to integrate bicycle use as a mobility mode into all infrastructures and transport offers.

Many cities around the world, including the City of Luxembourg, are promoting different forms of "shared mobility". Through a subscription, participants have the option of using an electric car, or a conventional or electric bicycle. Due to an increasing number of accidents, and to questions about "sustainability", among other concerns,[12] several cities, including the City of Luxembourg, have started to restrict their use (Garrahan, 2019).[13] Luxembourg is revising the road transport regulation. Electric micro-mobility, which achieves speeds of about 25 km/h, will be allowed to use the cycling infrastructure. Meanwhile, non-electric micro-mobility, which achieves speeds similar to pedestrians, will be allowed to use the sidewalks, with priority accorded to pedestrians.

Stimulation of low-emission vehicle use

Luxembourg also has a number of measures in place to stimulate the purchase and use of low- or zero-emission vehicles (electric and hybrid cars, electric bicycles and scooters, etc.). A network of charging stations for electric and plug-in hybrid vehicles has been established. As of January 2019, more than 200 charging stations had been set up. This gave Luxembourg the third densest charging network per capita in Europe, after the Netherlands and Norway (Chargy, n.d.). By the end of 2020, 800 charging stations (each able to charge two vehicles at a time) should be operational. Luxembourg aims for 49% of the total passenger car fleet to be electric by 2030.

An increasing number of European cities have banned vehicles judged to be particularly polluting from entering the city, or certain parts of it. They base their bans on the Euro classification that the vehicles were supposed to comply with.[14] Such measures can help keep some polluting vehicles off the roads, but these measures are not precise. Among other studies with similar findings, Bernard et al. (2018) suggest real-world NO_x emissions can vary significantly across vehicle models that are supposed to comply with the same Euro standard. Furthermore, some vehicles tested according to an "old" standard can have real-world emissions significantly lower than other vehicles approved according to a newer standard.

Luxembourg has not established such a low-emission zone, partly because the vehicle fleet in the country is relatively new. This seems appropriate based on assessments of schemes in other cities, such as Dallmann et al. (2018). Instead, the country promotes the sale and hence later use of low-emission vehicles through the annual motor vehicle tax and through direct subsidies.[15] The latter is the most important instrument. The amount of the subsidy is based on the type of vehicle: EUR 5 000 for battery electric vehicles and fuel cell electric vehicles; EUR 2 500 for plug-in hybrid electric vehicles; EUR 500 for electric motorcycles; and EUR 300 for bicycles. The subsidy, introduced in January 2019, replaced a tax credit for electrical vehicles established in 2017 that had had only a small effect on sales.

The incentive for selecting a low-emission vehicle stemming from the annual motor vehicle tax is modest. For a petrol-driven vehicle emitting 100 grams of CO_2 per km, the annual tax rate is EUR 36. For a diesel-driven vehicle with similar CO_2 emissions, the annual tax rate is EUR 54.[16] These tax rates are unlikely to have much impact on the choice between petrol- and diesel-driven vehicles. Nor will these rates provide strong incentives to select an electric vehicle instead.

Regarding private use of company-owned cars, the estimated taxable benefits added to the employee's income increase with the estimated CO_2 emissions of the vehicle. These estimated benefits are higher for diesel-driven than petrol-driven cars. For full-electric vehicles, 0.5% of the value (including value added tax) is added to the employee's income each month; for diesel vehicles emitting more than 150 grams of CO_2 per kilometre, 1.8% of the value is added to the employee's income each month. For petrol and diesel vehicles emitting between 50-110 grams of CO_2 per kilometre, the imputed income per month for the employee would be 1% and 1.2% of the value of the car, respectively. If the two cars both had a value of EUR 30 000, the difference in the imputed income would be EUR 720 annually. This difference could have *some* impact on the choice between a petrol or diesel version of a car.

Governance for sustainable mobility

In a number of countries, tax competition could occur between different sub-national authorities regarding taxes of environmental importance. For example, some countries have partially devolved vehicle registration taxes to regional governments, but have set minimum rates to prevent tax competition. For instance, some years ago, Mexico transferred such authority regarding the tax on vehicle ownership from national to state governments. As a result, many states abolished the tax, and others compete with larger neighbours to take the tax revenue through lower rates. This is the case for Mexico City and the surrounding states. Consequently, a large proportion of Mexico City residents register their cars in neighbouring Morelos. This means Mexico City's tax is no longer an effective instrument for promoting greener cars. In Luxembourg, such tax competition is not a problem for the annual tax on motor vehicle ownership, as it is managed by the central authorities.

Licensing of micro-mobility (such as the operation of bicycle-sharing schemes, etc.) is often the responsibility of the lowest level of government because of its impact on pavements and on the kerb side. This tends to lead to fragmented smaller-than-efficient service areas for operators of shared mobility services. In response, Transport for London, for example, has issued good practice for licensing operators of free-floating bicycles (Transport for London, 2018). This guidance is not compulsory, but operators get licensed if they follow it. Luxembourg could consider if it could usefully draw on London's experiences in this regard.

In Luxembourg, national and local authorities have overlapping responsibilities. This creates challenges for implementation of certain policy measures that could have contributed to more sustainable mobility patterns and better air quality (Chapter 2). For example, when central authorities tried to impose parking restrictions on municipalities, the *Conseil d'Etat* said they would limit the municipalities' autonomy too much, and conflict with the Constitution. Given that management of parking spaces is the main lever for steering personal motor traffic in a targeted, economic and ecological manner, this constraint penalises mobility planning.

Promotion of rail transport

As the (mostly electrified) rail network in Luxembourg is largely saturated on certain routes, the confirmed purchase of rolling stock that will increase the number of seats by 43% between 2019 and 2024 is absolutely needed to increase the modal shift of passenger transport, and thus reduce pollution. Regarding rail transport of goods, in 2017, an intermodal goods terminal was opened in Bettembourg, close to the border with France. The idea was to shift transport of heavy goods vehicles from road to rail along the North Sea–Mediterranean freight corridor established by the European Union. According to the Département des Transports (2018), transporting a semi-trailer by rail from Bettembourg to Boulou in southern France would cause emissions of 245 kg of CO_2.[17] This compares to 1 843 kg of CO_2 if the semi-trailer was transported by road. In addition, emissions of local air pollutants along the route would be largely eliminated through the rail option. The number of goods train connections being served by this intermodal terminal is steadily increasing (Kiel, Trieste, Poland, People's Republic of China, etc.).

As regards Europe-wide emissions, the building of this terminal seems most welcome. However, as this terminal is close to the border with France, it would not contribute significantly to reduce emissions in Luxembourg. On the contrary, it could attract additional vehicles from countries such as Belgium, Germany and the Netherlands to drive by Bettembourg for further transport by rail. In this case, emissions of both CO_2 and local air pollutants within Luxembourg could actually increase.

Traffic management

Increased use of teleworking could reduce the need for physical movements of people. The large number of cross-border employees in Luxembourg represents a particular challenge in this regard, as teleworking can affect the income taxation of the employee in question. If they work too much from their home in a foreign country, they will be liable for income taxation in that country – potentially on top of income tax liabilities in Luxembourg. A double taxation treaty with Belgium has for some time limited the problem in relation to that country. Luxembourg has also recently ratified a new double taxation treaty with France that could help improve the situation in relation to that country. Previously, the more than 100 000 persons living in France and working in Luxembourg were not allowed to telework from France at all. The new treaty allows them to telework 29 days per year, or a bit more than once every fortnight [see Orliac (2019)]. This is clearly a step in the right direction, but such a limited allowance for teleworking will not have much impact on congestion levels.

As mentioned above (Section 4.2), congestion is a major issue in Luxembourg. Displacing trips to less busier hours could limit congestion at peak hours. At the same time, fewer trips at rush hour could also reduce time lost, overcrowding of public transport and additional emissions of both CO_2 and local air pollutants. Such an option is available to civil servants through a flexitime system. A car-sharing scheme has also been made available to inhabitants of the Greater Region. The Département des Transports (2018) suggests that some high schools could modify the start of their day. In addition, it suggests employers schedule shift changes during off-peak hours. Finally, it suggests that businesses and local authorities could ensure that deliveries take place at times of limited congestion.

Measures to limit congestion and pollution from road transport are, however, partly undermined by the under-taxation of the benefits employees gain if they are allowed to use a company-owned car for private purposes. Based on data from 2012, Harding (2014) estimated that about half of the benefits – relative to a "benchmark" elaborated in the paper – goes untaxed in Luxembourg. At that time, 1.5% of the value of the car was added to the employee's income each month, regardless of the vehicle type. In 2017, differentiated tariffs were introduced, with lower tax rates for low-emission vehicles. This reform has likely reduced the share of benefits being taxed even further than estimated by Harding (2014).

As Harding (2014) and Roy (2014) discuss further, under-taxation of the benefits of private use of company-owned cars can trigger major environmental and other costs for society. Under-taxation will stimulate the use of private cars compared to public transport and to active modes of transport, especially at times when congestion levels are at their highest.

The income tax treatment of commuting expenses can also have an impact on traffic levels. In Luxembourg, such expenses are deductible from taxable income based on the premise that commuting expenses are incurred to earn income from employment. The deductible amount varies according to the distance travelled to work. For example, EUR 396 is the minimum, if the distance to work is 4 km; EUR 2 970 is the maximum for 30 km or more. Such a tax deduction has the disadvantage of giving people an incentive to live farther away from their workplace – or to seek a job farther away from their home – thus increasing overall transport activity. The same deductions are allowed, regardless of whether the expenses were actually incurred. As an advantage, the deduction does not discriminate against active modes of transport. However, this advantage has limited relevance for long-distance commutes. In addition, the system does not give any incentive to use public or active transport compared to the use of private cars.

Fiscal threats from promotion of more sustainable mobility abroad

Historically, Luxembourg has raised large amounts of tax revenue by attracting visitors from other countries who take advantage of less expensive fuel. The low fuel prices are possible through the application of relatively low tax rates on petrol and – especially – diesel (Chapter 3). As indicated above, "fuel exports" have declined significantly over the last decade, but the practice still raises important tax revenues for Luxembourg. Such revenues will likely decrease significantly as mobility becomes more sustainable in coming years. Electrification of the transport sector, for example, will lead to decarbonisation. Electric passenger cars and light-duty vehicles will likely have a shorter range than vehicles with internal combustion engines. Therefore, it will be less tempting to detour across the border to charge the vehicles at a potentially lower cost than in the country of origin.

For heavy goods vehicles, several countries are considering possibilities – or concretely planning – to supply electricity along the roads in question. If implemented, this would eliminate Luxembourg's possibilities to attract tax revenues from such vehicles in the longer term. The country should therefore start to prepare for the day when this change in taxation possibilities might occur. For example, it could gradually increase fuel tax rates to a level more comparable with practice in neighbouring countries (Chapter 3).[18] It should reinforce the pricing policy of parking spaces to relieve congestion of the road network and encourage car-pooling. It could also consider introducing a road toll system.

4.7. Performance outlook

Luxembourg has set ambitious objectives to address air pollution and mobility issues. Their achievement will depend on the level of commitment of all players (state, municipalities, employers, citizens, cross-border workers); co-ordination between national and local levels; and co-operation with neighbouring countries within the Greater Region. Policy coherence and Luxembourg's ability to exploit synergies between measures concerning transport and mobility, housing (construction, heating), spatial planning, air quality, climate and energy efficiency will be crucial. For a successful transition to sustainable mobility, the government will need to co-ordinate with municipalities and enterprises, especially for reassessing the needed parking spaces for cars, introducing car-sharing systems and reorganising working hours. The commitment of municipalities is particularly important to integrate mobility and air quality issues into local development plans, and to ensure coherence with other spatial planning tools (the Strategic Spatial Planning Programme, sectoral master plans) and with climate and energy-efficiency measures. This can be supported by the Climate Pact, which includes mobility-related measures and since 2017 an "air quality" component , and rewards the action of municipalities in these areas.

In the coming years, it will be important to monitor the evolution of mobility needs and to assess the impacts in terms of costs and benefits of the various measures, including free public transport. Luxembourg should specifically review the costs and benefits of the various financial aids (premiums, subsidies), taxes (on fuel, cars, service vehicles) and other financial incentives. The review should assess whether these financial aids contribute to the government's sustainable mobility objectives and to a further internalisation of external environmental costs. Luxembourg will need to base future choices related to sustainable mobility and the monitoring of results on a solid and reliable information base with accurate, complete and up-to-date data. This should include data on activity levels that have been previously lacking for the different modes of transport, and a regular monitoring, notably by the mobility observatory that is being established.

Recommendations on air quality and mobility

Air pollution management

- Take the most cost-effective measures across all sources and sectors to achieve the 2030 emission reduction objectives of major air pollutants; assess the social cost and benefits of measures to reduce emissions of local air pollutants caused by stationary sources.
- Limit the use of wood biomass to installations where air pollutant emissions can be controlled effectively and at reasonable costs per unit of heat energy generated (e.g. large heat-generation installations with electrical co-production).
- Carry out *ex post* assessments of various new means of public transport expected to cause low amounts of air pollution to verify these vehicles also have low emissions under real-world operating conditions.

Promotion of sustainable mobility

- Promote increased institutional co-ordination on spatial planning to advance sustainable mobility policies and measures and fully use the synergies with policies and measures concerning energy, climate and air quality.
- Evaluate within two-three years the experiences gained from measures that encourage the use of public transport, car-pooling and active mobility, including the introduction of free public transport; ensure proper investments to improve the quality of public transport (more frequent departures, more comfortable equipment, etc.).
- Review the environmental and economic effectiveness of the mix of economic instruments that apply to transport and mobility; increase vehicle taxation and revise the rates to take account of emissions of both CO_2 and local air pollutants; consider reducing the fiscal benefits accruing to employees when using a company-owned vehicle for private purposes and introducing a differentiation by distance driven; reinforce the pricing policy of parking spaces; and evaluate the possibility of creating road tolls.
- Invest sufficient resources in developing systems necessary for obtaining accurate, comprehensive and up-to-date data for sustainable mobility planning, including data on activity levels in different transport modes.

Notes

[1] The Greater Region is the geographical area comprising Luxembourg, the Walloon Region in Belgium, Lorraine in France and two German states (Saarland and Rhineland-Palatinate).

[2] www.tomtom.com/en_gb/traffic-index/. The nine cities ranked worse than the City of Luxembourg are all located in either Poland or in the United Kingdom.

[3] SO_2 emissions in Luxembourg are dominated by the emissions of a single industrial plant.

[4] There is also an hourly EU limit value of 200 µg of NO_2/m^3 of air, with which Luxembourg has always complied.

[5] Based on findings of the initial campaign, measurements are continuing at about 40 places.

[6] Chapter 1 in OECD (2014) discusses further the term “cost”.

[7] Recent OECD work by Dechezleprêtre, Rivers and Stadler (2019) found that opportunity costs are much larger than previously thought. Using annual GDP data for a large number of European regions, they found that a 1 µg/m³ increase in $PM_{2.5}$ concentration in the air in a given year caused a 0.8% reduction in real GDP per capita that same year.

[8]van Essen et al. (2019) indicates that road transport performance data are taken from Eurostat, following the nationality principle. This means that transport activity is allocated to countries where the vehicle is registered. In an alternative approach, using the so-called territorial principle, transport activity would be allocated to the country where the activity actually takes place. For example, kilometres driven by Belgian vehicles in Luxembourg would be allocated to Belgium when the nationality principle is applied, and to Luxembourg if the territorial principle were applied. As a detailed EU-wide data set on road transport performance based on the territorial principle is not available, van Essen et al. (2019) used the official Eurostat dataset based on the nationality principle. There is, however, significant uncertainty regarding the transport activity numbers, as Luxembourg is lacking good-quality estimates of tonne-kilometres and passenger-kilometres driven. For example, there is no system to automatically count the number of passengers in a given bus.

[9] See http://www.luxmobil.lu/ and https://transports.public.lu/fr/mobilite.html.

[10] It is sometimes argued to consider the emissions of CO_2 and local air pollutants caused by the generation of electricity by electric buses and other electric vehicles. However, in European countries, CO_2 emissions from electricity generation are covered by the cap of the EU ETS. A higher electricity demand will thus not much affect EU-wide CO_2 emissions. Indirectly, this cap will also affect EU-wide emissions of local air pollutants; see Braathen (2011). Since the EU ETS was modified in 2018, the overall cap is no longer completely fixed. Therefore, generation of electricity to run electric vehicles will cause *some* increase in EU-wide CO_2 emissions, but this impact will be small. Rosendahl (2019) discusses further the impacts of recent changes to the EU ETS.

[11] EUR 45 million would equal 12.5% of the average annual investments in public transport between 2015 and 2019.

[12] Some of these vehicles may only last a few months, especially if they are used in harsh weather conditions. In some places, groups throw such bicycles or scooters in rivers, canals or the sea for “sport”.

[13] According to Garrahan (2019), e-scooters have never been allowed on public roads or pavements in the United Kingdom. Paris recently banned their use on pavements, but they can be used on public roads.

[14] For example, as of 1 July 2019, new circulation limits were put in place in Paris. Diesel-driven passenger and light-duty vehicles older than from 2006 and petrol-driven vehicles older than from 1997 may not be driven in the city between 8:00 and 20:00, Monday to Friday. Similar restrictions are in place for diesel-driven heavy goods vehicles and buses older than from 2009, seven days a week.

[15] See https://transports.public.lu/fr/contexte/initiatives/mesures-fiscales/clever-fueren-steiere-spueren.html.

[16] In addition, for a given vehicle category, a diesel vehicle will typically cause lower CO_2 emissions per kilometre than a petrol vehicle. This would tend to make the differences in the annual motor vehicle taxes even smaller.

[17] Along the lines of the discussion in note 10, this estimate could in fact be too high. The generation of the electricity used to operate the trains is covered by the “cap” of the EU ETS. Hence, running an additional train would not increase EU-wide CO_2 emissions. Leakage effects triggered by the modifications to the EU ETS in 2018 could only increase Europe-wide CO_2 emissions if rail transport were to increase.

[18] Van Dender (2019) discusses in-depth the taxation of motor fuels, motor vehicles and road use.

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5 Biodiversity

Chapter 5 describes the main trends concerning biological diversity and natural habitats in Luxembourg, and the related policy objectives. It examines the country's progress over the past 15 years and the main challenges that need to be addressed. It covers such areas as species at risk, habitat, climate change, ecosystem services and protected areas.

Chapter 5 also examines institutional co-operation and governance, as well as instruments to protect natural areas and threatened species. It highlights the need for accelerating policy action and better integrating biodiversity issues into sectoral policies, as well as Luxembourg's contribution to the protection of regional and international biodiversity.

5.1. Introduction

Biodiversity has been declining in Luxembourg for more than 40 years. The causes range from rapid economic growth, urbanisation, intensified farming to habitat loss and degradation, landscape fragmentation, invasive alien species and climate change. The country has made some progress in key areas, but needs to step up its actions.

Luxembourg has not achieved its ambitious objectives to halt biodiversity set out in the first National Plan for Nature Conservation (2007-11). The final assessment of the second plan (2017-21) will likely also fall short. It needs to prepare its third plan without delay with special attention to the potential impact of the impact of climate change and biodiversity decline on ecosystem services. Biodiversity concerns must be fully integrated into agricultural, land-use planning and other sectoral policies (climate, housing, transport, etc.). This will demand better co-ordination between the national and local levels, as well as a strong commitment from municipalities.

5.2. Status, trends and pressures on biodiversity

Status and trends

Despite its limited size, Luxembourg has a range of biodiversity and different types of landscapes owing to a substantial degree of geological and microclimate diversity. Maintaining species diversity and genetic diversity is vital for ecosystems to deliver ecosystem services that foster resilience to climate change. Yet, biodiversity has been in decline for more than 40 years in terms of species, habitats and ecosystems. Luxembourg is one of the European countries where the number of common species in decline is at its highest. The fall in the number of insects, which are at the bottom of the food chain and are vital to ecosystem survival, is worrying. Luxembourg's strong economic and demographic growth has led to urban developments that contribute to the fragmentation of landscapes and habitats. What is more, intensified farming is putting heavy pressure on biodiversity. Hence, natural ecosystems are threatened.

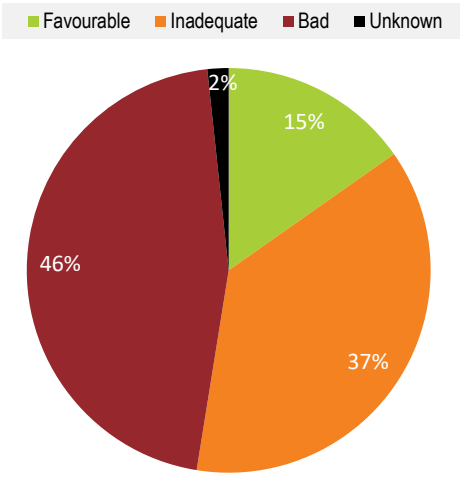
Species

The share of species of European Community interest whose conservation status is regarded as favourable is 15% (compared to 18% in 2013), while the share whose status is considered as unfavourable is 83% (compared to 63% in 2013) (Figure 5.1). This decline is nothing new. At the last OECD review, the situation of threatened species was just as worrying: all reptiles and a quarter of birds, fish, amphibians and vascular plants were threatened.

The International Union for Conservation of Nature (IUCN) Red List of Threatened Species of breeding birds (2020) gives the following figures:

- 13 species are regarded as extinct, including the whinchat (*Saxicola rubetra*), a species still widely found 30 years ago
- 26 species are in critical conservation status
- 24 species have been placed on the alert list for increased surveillance.

Figure 5.1. The conservation status of species is alarming



Note: These figures show the percentage of biogeographic assessments in each conservation status category for species.
Source: AEE (2019), "Conservation status and trends", *State of Nature in the EU: Article 17 national summary dashboards* .

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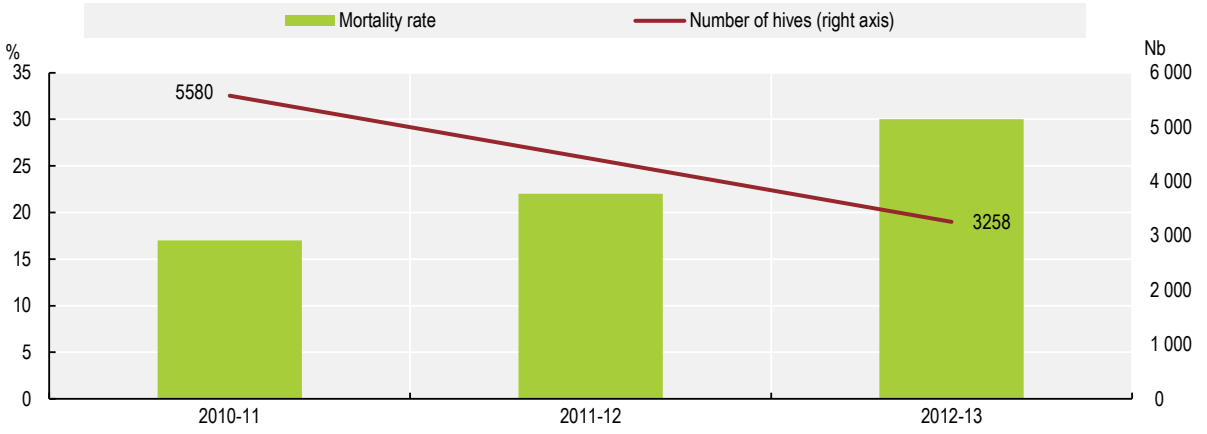
Pollinating insects

The decline in numbers of insects recorded in north-west Europe over the past four decades is alarming. In Germany, close to Luxembourg, insect biomass in protected areas has decreased by 75% in 27 years (Hallmann et al., 2017). This accelerated tumble exceeds worldwide losses of vertebrates, which stand at 58% over the past 42 years. There are two important points regarding this study. First, it examines the disappearance of all populations of flying insects rather than just rare species of insects. Second, it was carried out in areas designated to protect biodiversity. The study thus casts doubt on whether such areas can adequately protect biodiversity. Intensified farming (for example, pesticide use, year-round ploughing, increased use of fertilisers) and the frequency of agronomic measures may be plausible causes. In 2017, Luxembourg had only 4 528 ha of land under organic farming (4.17%).

In Belgium, the abundance, size and diversity of bumblebee populations have changed drastically. Between 68-88% of bumblebee species have declined over the past century; four species have disappeared completely (RTBF, 2018). The same trend is visible in domestic bee populations in Luxembourg (Figure 5.2). Only a few species tend to increase their relative abundance and dominate others. As a result, bumblebee communities have become homogenised. Between 1990-2009 and 2010-16, nearly two-thirds of butterfly populations in Luxembourg also declined in the area they occupy. This finding is valid both for butterfly species in grassland habitats comprising species described as “common” and for “specialist” species of butterflies in meadowlands.

The dizzying decline in insect numbers is very worrying. They are a food source for 60% of birds, while 80% of wild plants depend on them for pollination (Hallmann et al., 2017). The downturn in insect populations inevitably impacts many populations of birds, amphibians, reptiles, fish and small mammals and, of course, the ability of ecosystems to deliver their vital services. At the end of 2019, the government initiated the preparation of a specific action programme with stronger measures to protect pollinating insects on Luxembourg territory.

Figure 5.2. Honey bee mortality is growing



Source: MDDI (2015), *Fifth national report of Luxembourg to the Convention on Biological Diversity.*

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Birds

Although 19% of the conservation status of birds is unknown, the negative trend in this group of species is no different from that affecting all species of European Community interest in the country. Only one-third of birds enjoy a stable, improved status, while the status of half of them is degraded and unstable.

Various species of rural birds have been in decline over the past four decades in Luxembourg. These include the lapwing, the skylark, Cretzschmar's bunting and the great grey shrike, one of the species for priority action in the first National Plan for Nature Conservation 2007-11 (PNPN1). These species are following the same trends as birds in open environments at the European level, declining by 50-100% since 1980.

The fall in numbers among these indicator species for open environments is largely due to the intensification of farming, especially in grasslands, which is leading to fewer areas available for habitats and to a lower quality of such areas.

Some rare and iconic species are growing in numbers, thanks partly to targeted measures. These include the peregrine falcon (*Falco peregrinus*), the eagle owl (*Bubo bubo*), the little owl (*Athene noctua*), the two species of kites (*Milvus milvus* and *Milvus migrans*), the black stork (*Ciconia nigra*) and the reappearance of the white stork (*Ciconia ciconia*) as a nesting bird.

Mammals

The populations of several mammal species in Luxembourg are rather stable. The wild cat is relatively well distributed throughout the country, with an increased presence of hybrid individuals in certain regions, such as the Upper Alzette. Like the wild cat, the marten lives in most regions, and has been a stable occupant for several years. The western polecat, which is difficult to observe, has been spotted during March and April near watering places. The dormouse, a species whose distribution was unrecognised before the surveillance programme was established, has turned out to be fairly uniformly present throughout the country. However, the European otter is no longer seen.

Amphibians

Knowledge of the distribution and numbers of amphibian species has improved. Among the 13 amphibian species assessed, 3 species are severely threatened (*Hyla arborea*, *Epidalea calamita* and *Bombina variegata*), one species is on the alert list (*Alytes obstetricans*), one species is reported as extinct (*Pelobates fuscus*) and 8 species are regarded as not threatened.

Vascular plants

Little information is available about the status of plants in Luxembourg. The continental population of some plants is greatest in the territory of the Grand Duchy. Other populations are known only from a single site at the national level, which thus deserves special attention. A recent study puts the rate of disappearance of plants at three times that of animal species since 1900 (Humphreys et al., 2019).

Invasive alien species

An assessment of 55 alien vascular plant species, published in 2013, reveals that nine species have a considerable ecological impact; they have been placed on the black list of species that require action to reduce their distribution and impact. Ten species with an average impact are on the surveillance list. Eight species not yet present in Luxembourg have been placed on the alert list to watch out for any appearance. The ecological impact of the other 28 species is slight, and they have not been listed.

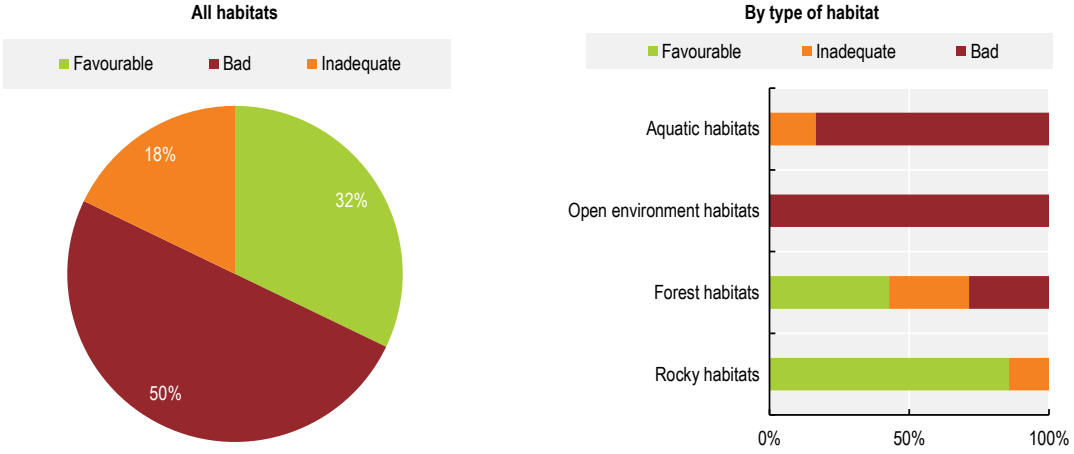
An assessment of 25 alien vertebrate species in 2014 reveals that 3 species present a high risk and have been blacklisted; 5 species with an average impact are on the surveillance list; 2 species have been placed on the alert list. Fifteen species are not on any list, as their impact was considered to be slight. The study used the Invasive Species Environmental Impact Assessment (ISEIA) protocol.

An assessment of 52 alien invertebrate species using the ISEIA protocol was carried out in 2016. It found that eight species present a high risk; they have been blacklisted. Five species with an average impact are on the surveillance list; 6 species have been placed on the alert list. Thirty-three species are not on any list, as their impact was considered to be low. (MDDI, 2017a).

Habitats

Habitat degradation in Luxembourg is a cause for concern: habitat quality has declined over 1962-2007 by an estimated 78%. According to the latest report (2018) on the conservation status of species and habitats covered by the EU Habitat Directive, 32% of the biogeographical assessments of habitats are favourable (25% in 2013); 18% are unfavourable-inadequate (29% in 2013); and 50% are unfavourable-bad (46% in 2013) (Figure 5.3). The rise in the overall quality of habitats is a positive development that needs to be maintained.

Figure 5.3. The conservation status of habitats raises concerns



Source: AEE (2019), "Conservation status and trends", *State of Nature in the EU: Article 17 national summary dashboards*.

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Habitat loss and degradation

The main factors in the deterioration of the natural environment in Luxembourg are habitat loss and degradation, landscape fragmentation, invasive alien species and climate change. The combined effects of climate change are likely to accentuate that negative trend, with unpredictable repercussions on the functioning of land and water ecosystems.

Accessible environments, like open or aquatic environments, are the most affected, while rocky and forest environments, being less accessible, are better preserved (Figure 5.3). Habitats rich in diversity, such as wetlands, dry grasslands and extensively used orchards, have shrunk seriously over the past 30 years, demonstrating the ongoing homogenisation of the landscapes. Open-environment habitat, such as rough hayfields and heather moorland, accounts for the greatest surface area; it is receding yearly at an alarming rate. Another habitat where the conservation status is “unfavourable” is the Stellario-Carpinetum oak stands. Their structures and functions are degrading due to a lack of regeneration of the oaks and the pressure on them from herbivorous game, as well as changes in humidity levels or in water tables.

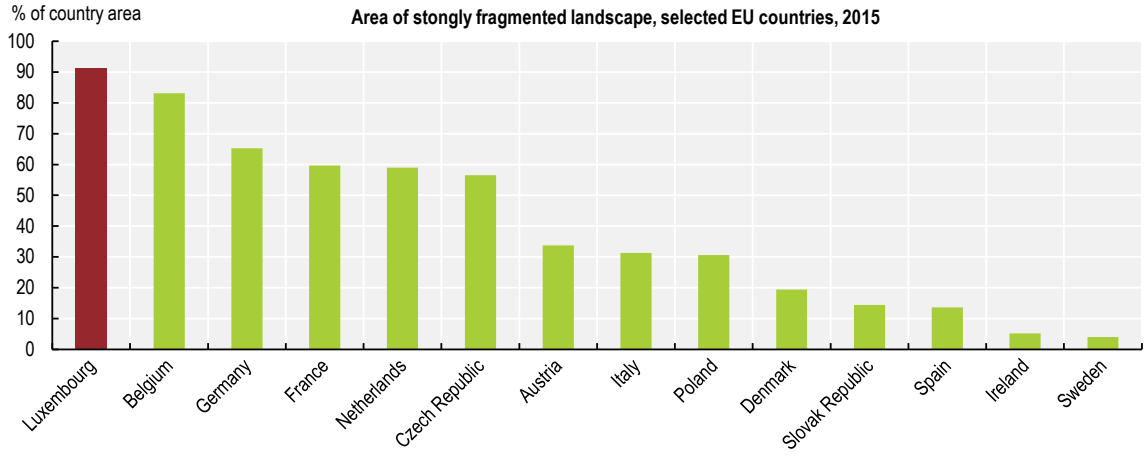
Only 2% of surface water bodies are in a good ecological condition. This low percentage results from the depletion of the biological diversity of water courses and changes in their hydromorphology. The chemical status of water courses is poor due to the presence of polycyclic aromatic hydrocarbons, heavy metals and pesticides. The situation is no better for groundwater bodies; two-thirds are classified as being in poor chemical condition, especially because of the presence of nitrates and pesticides (MDDI, 2015).

Landscape fragmentation

Landscape fragmentation in Luxembourg is the highest in Europe, with 93% of the country classified as highly fragmented (Figure 5.4). The density of the transportation and urban infrastructure web stands at 136 meshes/100 km^2. One-quarter of this fragmentation is in densely concentrated population areas, while two-thirds are in more sparsely populated areas (EEA, 2019a). The fragmentation is caused by rising population numbers, economic growth and increasing development of transportation infrastructure.

Fragmentation is seen as one of the main causes of the degradation of biodiversity and ecosystems. However, there is less fragmentation inside Natura 2000 areas than outside. Smaller habitats and less connectivity between them reduces the living space for fauna and flora. This, in turn, lessens their potential for reproduction.

Figure 5.4. Luxembourg is the most fragmented country in Europe



Note: Measured by areas with more than 50 landscape elements per 1 000 km² that are considered very strongly fragmented (based on a statistical distribution).
Source: EEA (2019), "Landscape fragmentation pressure and trends in Europe", *Indicator Assessment.*

StatLink https://doi.org/10.1787/888934169101

Climate change

Climate change may lead regionally to the disappearance of certain species and the appearance of new ones. The climate is continuously exposed to a range of natural or human-made factors that cause variations at different speeds and for different lengths of time. The effects of climate change are likely to become more pronounced in future and bring about major changes in the phenology and areas of distribution of species. Such changes are already affecting biodiversity and ecosystem services in Luxembourg. For example, at the end of July 2018, cyanobacteria or blue-green algae proliferated across the whole Upper-Sûre Lake, leading to an early ban on swimming. At the same time, the Water Management Agency issued a notice against taking surface water from the lake to avoid compromising the survival of aquatic organisms.

The hydrological regime can be seriously affected by climate change, leading to overabundance of water and floods. It can also be considerably reduced in times of drought, which usually leads to higher temperatures. The habitat for several species of aquatic organisms can thereby be put at risk. Climate change is a major cause of decline in biodiversity, added to the effects of other trends that work against ecosystem conservation.

Ecosystem services

Four types of ecosystem services are recognised: supply, regulation, support and cultural services. In Luxembourg, ecosystem degradation and biodiversity loss, coupled with the effects of climate change, have reduced the ability of ecosystems to supply certain vital socio-economic goods and services: water supply, flood prevention, temperature regulation and pollination.

During heatwaves, demand rises for water for consumption or swimming. At the same time, restrictions are imposed to avoid contamination due to the impact of effluents from sewage treatment plants on surface water quality or to maintain the quantity of water for aquatic fauna. The lack of wooded spaces, particularly in the urban environment, raises the ambient temperature. This especially affects the health of children and the elderly. In contrast, when rainfall is heavier than usual, the poor quality of aquatic and wetland habitats is detrimental to the regulation of water flows, which leads to more serious flooding. Lastly, the decline in pollinating insects may be harmful to agriculture and lead to serious economic effects.

Expanding knowledge of the status of ecosystems and the services they deliver in Luxembourg is important. It should be supported by a campaign to raise awareness among national and municipal decision makers of the need to protect ecosystems for their vital socio-economic services, and by concrete interventions to restore degraded ecosystems so they can provide those services.

Protected areas

Protected areas in Luxembourg cover nearly 50% of the territory. However, these are often small in size and multifunctional. Their potential for conserving biodiversity and delivering ecosystem services is thus limited. It can be enhanced by implementing various measures such as restoration, reintroduction of species and eradication of invasive alien species or by increasing ecological connectivity with neighbouring protected areas. Several protected areas enjoy more than one protection status because they contribute to various conservation objectives. A Natura 2000 site, for example, may also be a Ramsar site in its capacity as a wetland environment of international value. In such cases, the area has to meet the conservation requirements of each of the statuses.

Protected natural areas of national interest

Luxembourg has made important strides to create protected natural areas of national interest in the decade between 2008-18. Such areas benefit from the highest level of protection for biodiversity in Luxembourg

since they prohibit several types of human activity. Protection may take the form of a protected landscape. As such, it may be subject to easements and encumbrances designed to safeguard conserve habitats and species, safeguard the countryside, or people's well-being. At the last OECD review, 3 734 ha had been designated for these protected natural areas (OECD, 2010). They now cover more than 8 000 ha, which is a remarkable progress. The latest such area, created in 2018, encompasses a large forest massif and supplies 6% of the Luxembourg population with water – an irreplaceable ecosystem service.

Natura 2000

The Natura 2000 network occupies 27% of the national territory compared to an EU average of 18%. Luxembourg has 66 Natura 2000 sites, among which 18 special protection areas under the Birds Directive covering 16% (EU average: 12%), and 48 sites of Community importance (SCI) under the Habitats Directive covering 16% (EU average: 13.8%). (MECDD, n.d.).

Luxembourg completed the establishment of the Natura 2000 network in 2018. In 2008, the network covered 45 260 ha; it now has nearly 70 000 ha, representing a 55% increase. The management plans are almost complete, and most of the steering committees for the various sites have been set up. It should be stressed that the designation of an area as a Natura 2000 site is only the first stage in a process that aims to add to the conservation effort by adding an area. The potential of the site for biodiversity has to be enhanced by restoring it, by limiting certain activities, by establishing connectivity with other protected areas or by engaging in specific activities that are compatible with the environmental characteristics of the site. The late date of completion of the management plans is not conducive to maximising the potential of these sites for conserving biodiversity or halt its decline.

Nature parks

Areas covered by nature parks in Luxembourg have increased substantially since the last review, and will continue to grow. Building on its first two nature parks (Upper-Sûre and the Our), Luxembourg created a third nature park, Mullerthal, in 2016. Mullerthal Nature Park brings together 12 municipalities and covers an area of 256 km^2 with a population of 23 000 inhabitants. Like the other two nature parks, Mullerthal is not a closed area like a national park. Instead, it is a region for the promotion of sustainable development. The area covered by nature parks is now 785 km^2, an increase of 69% since the last OECD review in 2010. A fourth park, the Three Borders Nature Park straddling the border with Germany, is still in the planning stage. The nature parks are managed by joint syndicates made up of representatives of the municipalities and the state based on ten-year contracts. The Upper-Sûre and the Our parks are managed in co-operation with nature parks in Belgium and Germany.

Ramsar wetlands

Luxembourg has two wetlands of international importance on the Ramsar list: Haff Remich in the municipality of Schengen (Box 5.2) and the Upper-Sûre Valley, a transfrontier zone. There has been no change since the last review (OECD, 2010).

Effectiveness of protected areas

Biodiversity in Luxembourg has been in decline for more than 40 years (MDDI, 2017b). The conservation status for species and habitats are 68% and 80% unfavourable, respectively (Figure 5.1; Figure 5.3). These assessments apply to the whole country.

The aim of protected areas is to provide the various species with a refuge. They also act as a biodiversity reservoir for the colonisation of neighbouring ecosystems and even of remote ecosystems for the benefit of migratory species. However, they have obviously not succeeded in halting the decline in biodiversity.

Ascertaining the reasons for this lack of success may help point the way towards solutions or to prioritise actions that may have a domino effect from which biodiversity would benefit.

Luxembourg has not assessed the effectiveness and impact of individual protected areas nor of the network as regards threatened species and biodiversity in general. The country has few closed areas corresponding to the IUCN's strict conservation categories I and II. Despite its intensive land use, Luxembourg should make major efforts to establish strict conservation zones, first in agricultural environments and then in forests.

Biodiversity protection rests mainly on the Natura 2000 network, completed in 2018. The network groups multi-purpose areas where biodiversity protection has to coexist with socio-economic activities. It is therefore important to optimise these sites through (i) the implementation by the steering committees of management plans adapted to each of these sites and including precise objectives and targets, (ii) a system of accountability to local stakeholders, and (iii) regular assessments of the effectiveness of the measures implemented at each site. The management plans may also include steps to restore degraded sites and reintroduce species. Where appropriate, the plans could also include light infrastructure to enable the public to connect with nature and to better appreciate its value and importance.

This network of paramount importance to the country, will however only be able to make a tangible contribution to conservation if the biological connectivity between the different sites is ensured. This connectivity must be completed by setting up terrestrial and aquatic biological corridors. It must also provide passages to facilitate the crossing of transport infrastructure. In addition, for connectivity to be optimal, it must be based on sites of ecological quality, and where appropriate include sites restored in the case of biological degradation.

Available information and data

Biodiversity management and conservation must be based on information and data that incorporate multiple parameters. The establishment of a biodiversity surveillance system co-ordinated by the Luxembourg Institute of Science and Technology (LIST) in 2008 was a considerable step forward (Box 5.1). Its main purpose is to meet the reporting requirements of the Birds and Habitats Directives, under Article 17 of the Habitats Directive.

It is essential that the various geographical databases are integrated and interoperable to ensure data can be accessed directly and are continuously updated. This is especially true for data from the Ministry responsible for environmental matters, the National Museum of Natural History (MNHN), the Nature and Forest Agency (ANF), Water Management Agency (AGE), the Administration of Technical Agricultural Services (ASTA), the Department of Spatial Planning and Development, and the Land Registry and Topography Administration.

The MNHN and its "Recorder" database are recognised as the central databank for species observations. For the aquatic environment, the AGE centralises information concerning surface water, groundwater, chemical and biophysical characteristics, and aquatic fauna and flora.

The ANF has a centralised database for the many players involved in managing natural areas, such as municipalities, consultancies, non-governmental organisations (NGOs), etc. All data that are essential for managing protected areas, including information about "biodiversity" programmes, agreements with private individuals, practical maintenance operations, grants, and management units are available for consultation. They may even be encoded by the various site managers.

Box 5.1. The Luxembourg Institute of Science and Technology

The Luxembourg Institute of Science and Technology (LIST), set up in 2014, is a research and technology body active in the fields of materials, the environment and information technology. LIST reports to the Ministry of Higher Education and Research. It houses the Observatory for Climate and Environment that compiles data on the environment for research and management of development projects, and to comply with the country's legal obligations, particularly those of the European Union regarding water management, the climate, air quality and biodiversity.

The Observatory runs a dense network of hydroclimatological measures in co-operation with the Water Management Administration and the Administration of Technical Agricultural Services. To that end, it operates several stations to measure hydrological and climate changes that might affect the country. The Observatory participates in the international classification of soils through the World Reference Base. It also carries out spectral laboratory profiles in the field (soil, vegetation, artificial surfaces) and undertakes small- and large-scale airborne thermal mapping (back-up for scientific projects in precision farming, vegetation stress and disease detection). In the field of air quality, the Observatory carries out applied research and provides services to better understand air pollution and thermal stress for public health.

On behalf of the Ministry of Environment, Climate and Sustainable Development, the Observatory implements and maintains a programme of biodiversity surveillance in Luxembourg that focuses on species of European interest. This includes preparations for the drafting of European reports on species conservation status and the production of habitat quality models. The Observatory also works on drawing up new protocols for species surveillance, species distribution modelling, diagnosis and the designing of conservation strategies. Lastly, the Institute has set up various means to communicate the results of its research, inventories and analyses to stakeholders.

Source: https://www.list.lu/fr/.

With regard to the compensation pools, Luxembourg has developed an online application for preparing ecological balance sheets based on the quantification system mentioned above. This application provides a single, compulsory tool for preparing such balances for compensation and development projects. It is made available to all the players concerned (ANF, biological stations, consultancies). In addition, a computer registry of compensation measures will be developed.

5.3. Policy objectives, institutional co-operation, governance and integration

The national objectives set in the second National Plan for Nature Conservation **(**PNPN2) are geared to the objectives of the European Union's 2020 biodiversity strategy that aims, in particular, to halt the decline in biodiversity by 2020. These objectives also match the Aichi targets of the Convention on Biological Diversity for 2020. In addition, the country has committed to put in place the requisite measures to help attain the UN Sustainable Development Goals (2015-30), particularly goals 14 and 15 on marine and terrestrial ecosystems.

Institutional, legislative, financial and strategic framework for the conservation and reasonable use of biodiversity and the management of protected areas

Institutional framework

The Ministry of Environment, Climate and Sustainable Development (MECDD) fulfils a political and administrative role. This involves drawing up, implementing, co-ordinating and overseeing decisions related to the natural environment. It also plays a pivotal role in all endeavours aimed at incorporating nature protection principles in other fields and sectors, especially as the direct interface with the ministries and administrations concerned. Putting policy decisions and guidelines on nature protection into practice is mainly the task of the ANF and AGE. They work in collaboration with the MNHN, municipality associations, NGOs and foundations working in the field of nature protection, universities, research centres and the ASTA. The wide range of players involved ensures that certain projects and studies are decentralised, in particular at the municipal level.

Since 1965, the ANF has been responsible for nature protection. The agency is also responsible for the management of forests covered by the forestry scheme (state, municipalities, public institutions), assistance for and surveillance of private forests, and hunting. It is under the authority of the MECDD. The AGE, also under MECDD authority, is responsible for nature protection in respect of water courses (renaturation, ecological continuity, restoration of banks), protection of aquatic species and fisheries.

The advisory bodies are the Nature and Natural Resources Protection Board (CSPN) and, to a lesser extent, the Hunting Board (CSC) and the Fisheries Board (CSP). A number of municipalities have set up advisory committees on the environment.

The Natural Environment Observatory, set up in 2005, monitors, assesses and guides national policy. It consists of representatives of the MECDD, ANF, AGE, MNHN, municipalities and municipal unions, as well as associations in the field of protection of nature and of the environment. The Observatory helps the environment minister and its partners, especially municipalities and municipal unions, to define the guidelines and content of nature protection policy and assess the conservation status of the natural environment in Luxembourg. It plays a key part in the PNPN by monitoring its implementation. To carry out these duties, the Observatory depends on a scientific analysis of the data managed by the MNHN, the ANF and the AGE. The LIST is also contributing to this exercise.

Legislative framework

Protecting nature is a long-standing concern in Luxembourg. The first law, adopted in 1885, aimed at regulating hunting and game management. A number of laws and regulations were subsequently adopted. These include the law on nature protection (1965) and the law on protection of nature and natural resources (2004). The latter provides for the minister to establish a national plan for nature conservation and revise it every five years (Articles 51 and 52). In 2018, Luxembourg approved a major amendment to the above-mentioned 2004 law. It specifies the terms and conditions for authorising construction and for granting compensation where protected biotopes, habitats of Community interest and habitats of species of Community interest assessed as unfavourable are reduced or destroyed. This compensation system is based on a calculation of ecopoints deriving from an ecological review. This system is akin to the polluter-pays principle.

Financial framework

The Environmental Protection Fund (FPE) is financed by annual budget allocations and revenue from ecopoints. To protect the natural environment, the FPE provides aid to municipalities and public service associations for development work, study costs and land acquisitions to set up the network of protected

areas and to ensure the ecological coherence of the network. The Water Management Fund can finance up to 100% of the costs of watercourse renaturation.

The MECDD initiates "biodiversity" contracts that promote biodiversity in agricultural areas on top of the agri-environmental measures financed by the Ministry of Agriculture. The MECDD also offers support to preserve biodiversity in forested areas and to improve the natural environment.

A Game Fund, financed primarily by a levy on hunting permits, is intended to increase game stocks. But the fund has not paid out any grants for several years. A Special Hunting Fund, also financed by a levy on hunting permits, is intended to provide compensation for harvests damaged by game. Its annual outlays are around EUR 300 000. A Fisheries Fund, financed by a tax on fishing permits, supports the re-stocking and development of fish habitats.

The major Community financial instruments such as the European Regional Development Fund (ERDF) and the European Agricultural Fund for Rural Development (EAFRD), as well as the LIFE+ programme, are available and contribute to various projects. Luxembourg has received EAFRD funding of EUR 0.1 billion for 2014-20.

Strategic framework

The PNPN2, adopted by the government for 2017-21, includes the National Biodiversity Strategy. The PNPN2 puts forward detailed measures in the fields of biodiversity and natural resources. It sets out the objectives of the strategy and the planned measures. The national strategy keeps with the EU's strategy on biodiversity. It thus aims to set up green infrastructure; restore ecosystems and their services; and bring about a favourable conservation status for protected species and habitats. It is also the main implementing instrument for Agenda 2030, particularly objectives 14 and 15.

The aims of the PNPN2 are to:

- Fully implement the legislation on biodiversity protection
- Preserve and re-establish ecosystems and the services they deliver
- Considerably reduce land consumption and landscape fragmentation
- Strengthen the contribution of agriculture and forestry to maintaining and improving biodiversity
- Combat invasive alien species
- Raise public awareness
- Contribute to halt biodiversity loss throughout the world.

According to the 2012 assessment of the PNPN1, the threats and pressures weighing on biodiversity and the ecosystems were extending widely to cover the whole country. This was occurring despite proven efforts and measures put into effect, although they were often localised and limited in scope. The PNPN1 aimed to halt biodiversity loss by 2010.

As a consequence, measures under the second plan aim to increase considerably the effectiveness of the PNPN1 on the ground and to produce a greater degree of accomplishment and success. Compared to the first plan, the second has the advantage of having seven objectives and 27 actions. It includes measurement indicators that are more precise over time, making it easier to assess results.

Opportunities to harmonise national and municipal policies for the management of threatened species

Effective governance over environmental legislation and policies, including policies on biodiversity in the EU and in the country, calls for several measures. These comprise a proper institutional framework; consistency and co-ordination of policies; the application of legal and non-legal instruments; and a

commitment to non-governmental stakeholders. Successful implementation also depends on central and municipal administrations carrying through legislative and administrative tasks. These include adoption of sound implementing provisions and co-ordinated action to live up to biodiversity conservation objectives.

The Act of 3 August 2005 on the partnership between municipal unions and the state provides a legal framework for decentralising nature conservation at the municipal level and for state cofinancing of projects carried out by municipal associations for nature conservation. Thus, municipalities promote at the local level, the preservation of biodiversity, the conservation and restoration of natural landscapes, and the ecological coherence. They help raise public awareness in favour of nature conservation, and can delegate this mission to an association of municipalities.

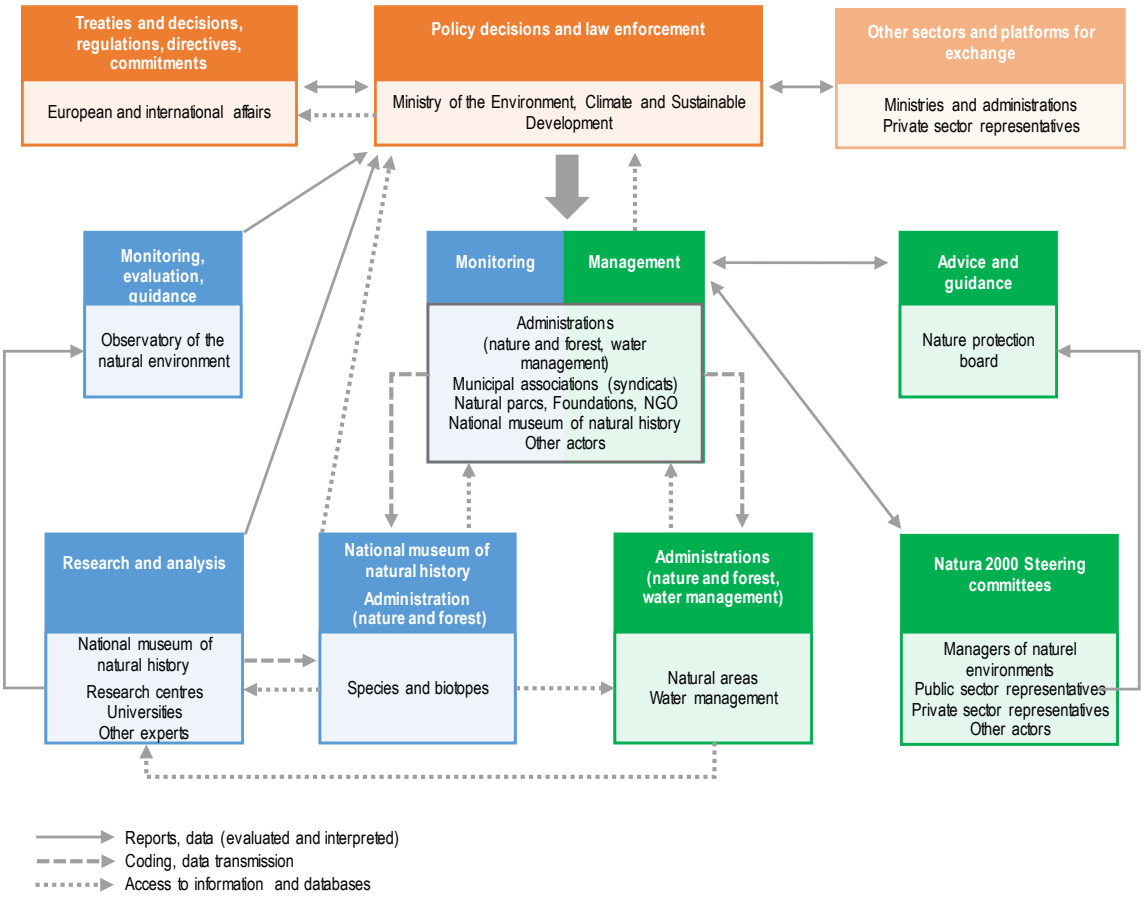
Action laid down in the PNPN1 to speed up the adherence of municipalities to biological stations has been a great success. There are six biological stations, which transpose nature conservation plans into the partner municipalities. Biological stations cover approximately 75% of the national territory, and the area covered increased from 1 400 to 1 900 km^2 between 2011 and 2016. The municipalities are grouped together in intermunicipal associations in the form of biological stations (Sicona West, Sicona Centre, SIAS, Upper Sûre Nature Park, Our Nature Park and Mullerthal Nature Park). These operate in the field of nature conservation through contracts with the ministry responsible for nature conservation. A seventh station (Biological Station East) is being set up. By 2021, all municipalities under contract, which are not members of an intermunicipal association, will have to be affiliated to an intermunicipal association working in the field of nature conservation to benefit from the same subsidies as municipalities that are members of an association.

Institutional capacities and vertical and horizontal co-ordination mechanisms

The Nature and Natural Resources Protection Board (CSPN) is the government's advisory body for all large-scale projects relating to nature conservation. Primarily it advises on draft Natura 2000 management plans and applications for the classification of protected areas of national interest, and oversees their implementation. On the ground, many actors are involved in nature protection with often complementary activities and multiple data flows and exchanges. (Figure 5.5).

The pivotal element in horizontal and vertical co-ordination is the steering committee. The Natura 2000 steering committees aim mainly to establish a dynamic and proactive regional platform. Such platforms engage local, municipal and regional players more effectively in maintaining biodiversity while considering environmental, economic, social, and cultural and regional requirements. A Natura 2000 steering committee enables more effective co-ordination of actions taken by local players with those of national administrations, and facilitates the implementation of contractual measures. For example, the Oesling steering committee is made up of representatives of ministries and regional departments of national administrations, the 14 municipalities concerned, the Our Nature Park, farmers and farming advisers of the Chamber of Agriculture and of CONVIS s.c. (an agricultural co-operative); the foresters' group; the Our Electricity Company; the regional section of Nature&Environment and the Ecological Movement; the not-for-profit association *Frënn vun der Schlënner;* and the Regional Tourist Office for the Luxembourg Ardennes.

Figure 5.5. Nature conservation involves many actors and information flows



Source: https://environnement.public.lu/dam-assets/documents/natur/general/pnpn2.pdf.

Integration of biodiversity into sectors of the economy

As policies for the protection and management of water resources are closely linked to biodiversity protection and conservation and to climate change adaptation, the different actors are consulted when drawing up of plans and strategies. Development of the management plan for hydrographic districts and the flood risk management plan, for example, involved consultations with the ANF, the AGE and the MECDD. Similarly, measures included in water management plans have been integrated into the PNPN2, as well as into the Natura 2000 management plans. The strategy for adapting to the effects of climate change also refers to the water and nature management plans. Lastly, every watercourse renaturation project, essential to achieve water and biodiversity objectives, is drawn up in close collaboration with the ANF, the AGE and the MECDD. Such projects are essential for achieving both water and biodiversity objectives. Regular meetings of the “renaturation group” are held to co-ordinate the measures.

Notwithstanding these consultation efforts, biodiversity and ecosystem conservation is still too often considered in isolation and seen as being in direct conflict with other areas of activity. Consequently, various measures have been put forward in five sectors where the integration of biodiversity principles is a priority: urban planning and transportation, land-use planning, farming and rural development, forestry and water management.

Role of NGOs and the private sector in the management and financing of programmes relating to biodiversity in and outside protected areas

NGOs play an important role in the programmes relating to biodiversity conservation. Through the CSPN, they are involved during the planning of major policy orientations such as the drafting of the PNPN2. In addition, they are involved in the implementation of the resulting management plans, such as the Natura 2000 management plans through the steering committees. NGO representatives are also on the "managing committee", with responsibilities in the area of compensation measures. Stakeholder delegates are also members of the Natural Environment Observatory.

Stakeholders further take part in the Sustainable Development Board (CSDD), a forum for discussion of sustainable development. The CSDD proposes research and studies in all fields related to sustainable development, and sets up links with similar committees in EU member countries. In addition, it fosters the widest possible involvement by public and private bodies and citizens in the achievement of these objectives.

5.4. Instruments for the protection of natural areas and threatened species and for the sustainable use of biodiversity

Assessing the contribution of economic methods and instruments to biodiversity conservation

Economic instruments such as taxes, subsidies, licences, tax charges and economic compensations are not often used in Luxembourg. Environmental tax receipts were at 5% of total receipts from taxes and social security contributions, while the average for OECD Europe was more than 6% (Chapter 3). Such instruments can be effective and efficient, but often need information and awareness-raising campaigns to be accepted by the public or the groups concerned. The PNPN2 provides for new economic instruments, but the delay in setting them up has meant they have not yet lived up to their promise.

Biodiversity contracts

Luxembourg uses the biodiversity contract as one economic instrument to bring about a favourable or improved status for two-thirds of natural habitats and thus respond to the EU's "nature" directives. This contract system aims at the conservation and ecological management of land that hosts species or habitats of particular environmental interest. The instrument was put in place in 2002, has a budget of EUR 10.5 million (2017-21) and applies to more than 5 000 ha with a growing trend.

A programme of aid for the forest environment, covering half of the country, is available. In tandem with it, major efforts are being put into raising awareness and providing technical training. The aim is also to improve biodiversity and re-establish the ecosystem services that forests deliver.

Acquisition of land

The acquisition of land for nature conservation by public bodies such as the state, municipalities or public-interest foundations is often the only way of securing permanent protection for a rare biotope or one under long-term threat. From a financial point of view, the acquisition of stocks is, despite the high price of land, often more advantageous than paying long-term compensation. The PNPN2 aims at acquiring 50% of the land included in the protected areas and 100% of the land in their core areas. It also seeks to encourage such acquisitions and to support municipalities and foundations in implementing their action plans. In its assessment of the PNPN1, the Natural Environment Observatory emphasised that scant use was made of this measure. For the period covered by the PNPN2, the budget for this measure is EUR 4.8 million.

Given the high price of land, Luxembourg could consider increasing that budget. It could levy a "biodiversity - ecosystem service" tax on real-estate transactions in conjunction with corporate sponsorship for the funding of such acquisitions.

Compensation pools

The Natural Environment Observatory has devised a system to quantify the environmental value of biotopes and habitats (ecopoints). The system is a way of assessing compensation for losses from the setting up of a project likely to affect natural heritage. Compensation pools at the national and regional levels act as land reserves with high potential for environmental improvement. This enables compensation for projects that have led to deterioration of the natural heritage. A list has been set up to record the measures carried out in the compensation pools and to manage the allocation of these measures for future projects. Municipalities or municipal associations set up and manage the regional compensation pools. The estimate for purchases and management of land to constitute compensation pools stands at EUR 25 million (2017-21).

Luxembourg should take steps to prevent biodiversity loss caused by undue compensation by following best practice (OECD, 2016). It should ensure that compensation is not considered until after the crucial avoidance and reduction stages have been completed. One way to maximize the benefits of offsets would be to allocate them to affected ecosystems. Luxembourg could also co-operate with neighbouring countries and promote the application of a compensation system in other countries.

Integrating protected areas and threatened species in the process of assessing impact on the environment and in land-use planning

Environmental impact assessment (EIA) is an important tool for incorporating biodiversity conservation concerns into decision-making on development policies and programmes. EIA is applied during project planning to determine potential impacts and to make changes that eliminate those impacts or make them acceptable.

This approach is also a way of applying the precautionary principle to the environment. This principle, governed by a European directive adopted in 1985 and frequently amended, was transposed into national legislation by the 2018 Environmental Impact Assessment Act. This transposition came late compared with other countries; swifter transposition might have prevented any negative impact on biodiversity such as the fragmentation or degradation of important biotopes.

EIA incorporates the requirements of the Habitats and Birds Directives. Thus, any project likely to have a significant impact on a protected area or on a species of Community interest or threatened (Natura 2000 network) is subject to special assessment. This focuses on the conservation objectives defined for the protected area of Community interest concerned. The MECDD will take care, through its various opinions and advice to the project owner, to ensure the best possible co-ordination between the "Natura 2000" assessment and the EIA.

Integrating biodiversity in other sectors and policies

Agriculture and forestry

Intensive farming and land abandonment are two key factors in the decrease of biodiversity in Luxembourg. Agriculture, which manages 54% of the national territory, has the highest potential for nature conservation and protection through changes in agricultural practices, including use of fewer inputs.

The PNPN2 sets out to extend the cultivated areas in fields and meadows, arable land and permanent crops covered by biodiversity conservation measures to at least 10% by 2020. Most of the diffuse pollution

in Luxembourg consists of nutrients and pesticides from farming and from public and private domains. The PNPN2 also seeks to eliminate subsidies harmful to biodiversity by 2020. Intensive farming still has a negative effect on the natural environment, which is primarily owing to the difficulty of eliminating subsidies harmful to the environment. The lack of available land for establishing green and blue belts limits the success of the measures in the plan.

Since 2009, Luxembourg promotes organic farming through a dedicated national plan. In 2017, there were 132 producers (4.8% of Luxembourg farmers) engaged in organic farming, occupying 5 446 ha, or 4.15% of farm land in the country. The aim is to increase the area to 20% by 2025 (MAVDR, 2020; MAVPC, 2019). Since 2007, the Institute for Organic Agriculture Luxembourg has been working to improve and provide support for organic farming through research, advice and knowledge transfer. The Institute helps farmers transition to organic or biodynamic farming.

Luxembourg differs from most other EU member states in having a twofold aid system. It encompasses on the one hand, agri-environmental measures (AEMs) cofinanced by the EU's ERDF fund, and on the other hand a national aid scheme supports biodiversity. AEMs aim to reduce environmental impact in the broad sense (reduction of inputs, reduction of emissions, etc.) through extensification of farming practices. The national biodiversity aid scheme is aimed at the conservation and environmental management of land that hosts species or habitats of special environmental interest.

The area of agricultural land under contract is the highest in the EU, although this is due to the high participation (89% of agricultural land) in the landscape maintenance premium. This premium, which is part of the AEMs, is aimed at basic extensification but without having an impact on biodiversity. Luxembourg does not implement any LIFE integrated projects.

Approximately 90 000 ha, or more than one-third of the territory of the Grand Duchy, is under forest; private forests account for 54% of Luxembourg's forests. Forests, the ecosystem least affected by economic development, host a considerable number of species and habitats and provide citizens with the greatest number of ecosystem services. However, their state of health has steadily deteriorated over the past 30 years. They are being fragmented by channels of communication and urbanisation; they are affected by air pollution and climate change; and, lastly, they are old.

To meet the objective of sustainable forest management, the government has launched a review of forestry law. It aims to draw up, by 2020, sustainable forest management plans for all publicly owned forests and for privately owned forests exceeding 10 ha. It has set up a financial aid system that promotes the improvement and strengthening of forest ecosystems. A cluster innovation programme for woods set up in 2016 contributes to the more effective local and regional upgrading of woods and acts as a model of the circular economy.

Economic development has put enormous pressure on aquatic ecosystems through high demand for drinking water and diffuse pollution of watercourses. Action to restore sound environmental status is underway; these efforts will, nevertheless, have to be stepped up. Close collaboration between the water management sector and nature conservation is crucial to incorporate all the objectives into the various types of management plans, especially for river basins.

Urbanisation and infrastructure

Economic and population growth in the country have led to a huge expansion of urbanisation and infrastructure development at the expense of biodiversity. Most jobs are in the territory of the capital city and the surrounding municipalities. Meanwhile, housing has been displaced to the periphery of urban conglomerations and to rural areas following the boom in housing prices. Moreover, nearly 200 000 workers come from surrounding countries and cross the borders every day. Non-built-up areas, such as farmland and woodlands, shrank by 1 386 ha at the national level between 1999 and 2007.

Various policies have to be articulated to reverse this trend, including those relating to housing, public transport, land management and land-use planning, construction and taxation. Governance is a major challenge, particularly in a country where space is in short supply and where the preservation of ecosystems is important because of their vital services. The PNPN2 provides for integrating biodiversity objectives and promoting green infrastructure that can deliver different services to urban areas and their inhabitants.

Assessing the application of regulations on biodiversity protection

Responsibility for detecting environmental infringements lies with the Grand-Ducal Police, as well as with officers of the ANF, AGE and the Customs and Excise Agency.

The low number of infringement proceedings and complaints or petitions seems to reflect an effective approach to the protection of human health and the environment. The resources allocated to compliance assurance are however modest. Directives are generally transposed in good time; compliance checks normally identify only minor problems. Cases of improper implementation are rare (Chapter 2).

The PNPN2 provides for a Grand-Ducal regulation to determine the implementing rules and set out a catalogue of infringements according to the various amounts of tax to be levied. A working group will draw up a strategy paper and a training programme for the prosecution of environmental infringements. It will consider whether agencies that detect infringements and courts that conduct prosecutions have adequate powers. If appropriate, the working group will recommend deterrence and consistent prosecution for infringements to ensure adherence to environmental standards.

Investment in environmental infrastructure and the rehabilitation of degraded ecosystems

Luxembourg is the most fragmented country in Europe; the built surface doubled between 1960 and the present day. The PNPN2 sets out to protect, conserve and rebuild land and water-borne migration corridors that are affected by urbanisation and habitat fragmentation. It also includes programmes for the rehabilitation of 15% of wetland areas, semi-open countryside and dry grasslands, among other things.

There is green infrastructure on a local scale: it includes green areas alongside transport infrastructure and in public squares, parks, streams, woods to provide wildlife crossings and fish ladders. On the regional or national scale, green infrastructure consists of river basins, of forests of high natural value such as the protected areas network and of all components important for ecological connectivity.

The PNPN2 has detailed plans for restoration, renaturation work, acquisitions and defragmentation of habitats. Efforts to rehabilitate and restore habitats are planned as long-term back-up for conservation. The restoration of a gravel pit in the alluvial soils of the Moselle is a striking example of the successful rehabilitation of degraded terrain. The zone concerned is now a Ramsar zone, a wetland of international importance (Box 5.2).

Efforts began in 2017 to incorporate biodiversity into public-sector construction and to rehabilitate the Alzette. These projects, although coming late, are also becoming increasingly important in the context of climate change adaptation strategies.

Box 5.2. Haff Réimech: Rehabilitation of a site for biodiversity and for the people of Luxembourg

Haff Réimech is an eloquent example of how the restoration of a degraded site can help protect and even increase biodiversity.

For nearly 20 years, sand and gravel have been extracted from the alluvial soil of the Moselle near Remerschen. These operations left depressions of an average depth of 5 m. These were gradually filled with water from underground springs and runoff from the vineyards and other surrounding areas. As with all gravel pits, the water that accumulates is stagnant and has little attraction for fauna and flora. It is often loaded with plant protection residues and agricultural fertilisers, and the absence of abundant aquatic vegetation often prevents the degradation of these pollutants. In addition, the banks are steep and do not provide a good habitat for fish and amphibians.

The partial closure of the sand pits at the end of the 1960s triggered the preparation of a project to turn the ponds into a 100-hectare natural area and recreational zone, the "*Haff Réimech*". Work has been undertaken to reduce the slope of the banks, replant the perimeter of the ponds, reduce their depth at certain points and reforest some sections. The biotope is made up of about forty ponds often bordered by reed beds and marshland. A welcome centre (the *Biodiversum*), a discovery trail and many observation points are available for visitors.

The natural area *Haff Réimech* was classified as a national nature reserve in 1998. It is part of the European Natura 2000 network, and on the list of areas of international importance protected under the Ramsar Convention. It is the most species-rich wetland in Luxembourg: on 0.1% of the total surface area of the country, 76% of the bird species spotted in Luxembourg have been observed there. It is an important stop-over point for many protected bird species as they migrate.

The *Biodiversum* was opened in 2016; it describes the development of the Moselle valley and the importance of biodiversity through the ages. The centre is heated using geothermal energy. Its architecture is remarkable: made entirely of wood, it has the shape of an upside-down boat hull. Is the message that by informing people, biodiversity will be preserved, as with Noah's Ark? The use of wood, a renewable material that captures carbon from the atmosphere, also conveys another message: to consider using wood for construction in the fight against climate change.

The welcome centre plays its role well in raising awareness of biodiversity conservation and of the problems that society faces. It is also proof that efforts to restore the environment can be successful. The *Biodiversum* is part of a network of five nature and forest centres, all located in protected areas and home to species that are often threatened.

Source: https://environnement.public.lu/fr/natur-erliewen/centres-d_accueil/biodiversum.html.

Assessment of the effectiveness and efficiency of policy instruments

The PNPN1 (2007-11) included two strategic objectives:

- to eradicate biodiversity loss, particularly by maintaining and re-establishing favourable conservation status for threatened species and habitats of international or Community interest
- to preserve and re-establish ecosystem services and processes at the countryside and national levels.

An assessment by the Natural Environment Observatory and submitted in 2017 (PNPN2) concluded that a number of measures, even some considered as priorities, had not been carried out in full, or even begun. Biodiversity decline had not been successfully halted; the conservation status of a certain part of the threatened species and habitats was far from favourable. The Observatory identified both strong and weak points.

Strong points:

- Notable progress had been made in the legislative framework.
- Monitoring of species and habitats had been initiated in 2009.
- A biotope register had been set up.
- Action plans had been drawn up.
- The threshold of 5 000 ha managed under biodiversity contracts had been reached.

Weak points:

- The amount of land acquired for nature conservation was negligible.
- Work on the renaturation of watercourses had been delayed.
- There was reluctance to launch the premium for landscape maintenance.
- Procedures for designating national protected areas were slow.
- There was little sign of progress in establishing total coverage of the territory by biological stations.

The PNPN2 was based on the Observatory's findings, consultation with stakeholders and the objectives of the European Union's Biodiversity 2020 strategy covering 2011-20. It was officially adopted in 2017, i.e. six years after the end of the PNPN1. One would have expected a plan to be adopted at the end of the PNPN1 as the law provides. Moreover, the PNPN1 assessment might better have been carried out before the plan ended to avoid interrupting the positive actions and to correct the less effective ones.

In 2018, a group of NGOs assessed implementation of the Birds and Habitats Directives in 18 EU countries (BirdLife International et al., 2018). put forward the following observations:

Strong points:

- management of the protected sites
- species protection
- avoidance of site deterioration and species disturbance; implementation of appropriate assessments
- landscape connectivity
- financing and resources
- surveillance of habitats and species
- non-native species
- stakeholder commitment, public involvement and communication.

BirdLife International et al. (2018) also stressed the need to implement the directives in practical terms.

A report to the European Commission under Article 17 of the Habitats Directive and Article 12 of the Birds Directive was submitted in 2019 (EEA, 2019b).

International co-operation and development aid granted for biodiversity conservation

Luxembourg has signed and ratified nearly all the Multilateral Environmental Agreements, including the Convention on Biological Diversity; the Ramsar Convention on Wetlands (Luxembourg has designated two wetlands of international importance); the Bonn Convention on the Conservation of Migratory Species of Wild Animals; the Agreement on the Conservation of African-Eurasian Migratory Waterbirds; the Agreement on the Conservation of Populations of European Bats; the Convention on International Trade in Endangered Species of Wild Fauna and Flora; the International Whaling Commission; the Berne Convention; and the OSPAR Convention.

In the PNPN2, Luxembourg has committed to increase funding of projects beneficial to world biodiversity. This involves assessing the environmental impact of action likely to have a major impact on biodiversity internationally. In addition, biodiversity conservation will be factored into trade negotiations and discussions with third countries.

Budgetary resources allocated to biodiversity conservation

FPE-funded projects include the multiannual planning of expenditure on the PNPN2. In 2018, the ANF's budget was EUR 42.8 million (0.28% of the ministry's budget). A substantial increase of EUR 94.6 million was made for implementation of the PNPN2 (2017-21), including the compensation pools. Furthermore, incorporating nature conservation principles into sectors for which other ministries are responsible also entails cross-sector budget integration, thereby supporting budgets specifically targeting nature conservation.

Table 5.1. Investment projects

Year	Projects	Amounts (EUR)
2011	10	1 013 914
2012	17	3 264 042
2013	6	653 918
2014	40	4 130 742
2015	19	2 262 440
2016	59	3 184 857
2017	108	7 342 404
2018	273	21 769 920

Source: Ministry of the Environment, Climate and Sustainable Development (MECDD).

State participation in the funding of agreed projects relating to management and maintenance of the natural environment by the municipal sector stands at EUR 2.5 million.

5.5. Research, development and innovation

The PNPN2 aims to set up surveillance and monitoring to help fill a gap in the time series data on biodiversity. This task, entrusted to the LIST, fulfils reporting requirements to the EC under the Birds and Habitats Directives. In 2019, Luxembourg was to send EU authorities the latest observations from 2013-18. LIST also conducts research into natural resources, which includes natural disasters.

The MNHN also plays an important part in maintaining scientific collections and databases. It conducts research into all areas of the natural heritage as a contribution to its conservation. As Luxembourg's national node, it participates in the Global Biodiversity Information Facility, an international data structure that makes the data available on a single portal. The museum is also a partner of the Barcode of Life project, a database containing sequences of DNA references for every species on earth.

The Natural Environment Observatory monitors the PNPN. It conducts research into various aspects of biodiversity conservation. Every two years, it draws up a detailed report on environmental policy and implementation of that policy at the governmental and municipal levels.

The PNPN2 provides for a major research project to expand knowledge of the status of ecosystems (particularly the Natura 2000 network) and of the services they deliver. This new knowledge will be used to upgrade the socio-economic value of ecosystem services by 2020.

Luxembourg has made remarkable progress on research into the natural environment since the 2008 review. There was a need to catch up, and the projects run by the various research institutions need to be continued. However, in a global context in which ecosystems are increasingly linked and threatened by systemic risks such as climate change and biodiversity loss, it would be appropriate to undertake research in a different direction. These new research threads would analyse how the effect of climate change, combined with the accelerated decline in biodiversity (Chapter 1), may affect the environment, society and economy of Luxembourg. Such studies would make it possible to develop approaches to strengthen the country's resilience in the face of these systemic challenges. It would also enable the setting up of green infrastructure to adapt the natural environment to compensate for the deficiencies of an environment increasingly transformed by our mode of development. This forward-looking approach is a vital component of better risk management in the face of these systemic challenges.

5.6. Performance outlook

Luxembourg pursues an active nature protection and conservation policy and has made progress in implementing the recommendations of the latest OECD review. In particular, it has made progress in protecting specific sites including through the Natura 2000 network, as well as in the observation and restoration of ecosystems.

But despite an appropriate institutional, legislative, financial and strategic framework, progress has been slow. Concrete implementation on the ground or in the restoration of ecosystems has been delayed, and positive returns from Luxembourg's efforts have been slow to materialise. Pressures on biodiversity are high, with high degrees of soil artificialisation and habitat fragmentation. The objective set out in the PNPN1 (2007-11) to halt biodiversity decline was ambitious; it has not been achieved. The final assessment of the PNPN2 (2017-21) should produce the same result. The conservation status of species is mostly unfavourable. There has also been continuous degradation over the past four decades of biodiversity-rich habitats. Added to this are new issues: climate change and the appearance of invasive alien species that lead to a loss of natural capital and a reduction in its dividends – ecosystem services essential to the quality of human life.

To improve its performance, Luxembourg needs to implement interventions at a faster rate than the decline in biodiversity. It must complete implementation of the management plans for Natura 2000 sites and threatened species. It needs to make steering committees function effectively and provide them with adequate resources before the end of the PNPN2. It also needs to initiate preparation of the PNPN3 without delay. This third plan should be based on evaluations of the nature directives submitted to the EC in 2019 and on prospective scenarios of the impact of climate change and biodiversity decline on ecosystem services. It will also be necessary to integrate biodiversity issues fully into agricultural, land-use planning and other sectoral policies (climate, housing, transport, etc.) with good co-ordination between the national and local levels and a strong commitment from municipalities. This will have to go hand in hand with a review of the costs and benefits of the different economic instruments used both in biodiversity management and in sectoral activities with an impact on biodiversity (biodiversity contracts, ecopoints, agricultural support, etc.).

Recommendations on biodiversity

Accelerate the implementation of biodiversity conservation and natural habitat protection policies

- Promptly initiate the preparation of the National Plan for Nature Conservation for 2022-27 (PNPN3):
  - Maintain the objective of halting biodiversity decline, while specifying the indicators for species, habitat and ecosystem services.
  - For each objective, present targets that are measurable in real time, the necessary financial and human resources, and the timetable of steps and actions to be taken; make this information permanently accessible on the Internet page of the MECDD.
  - Ensure the effective collaboration of the ministries in charge of agriculture, infrastructure and transport, and stakeholder consultation.
- Set up a programme to improve the standing and appreciation of ecosystem services among the population, the farming and forestry sector, and the ministries concerned:
  - Ascertain the socio-economic motivations of the population with respect to ecosystem services, and evaluate the economic costs of the degradation of those services.
  - Include initiatives to raise awareness in urban and rural areas of the importance of easily perceptible ecosystem services such as preventing heat islands through green spaces, protecting water quality, pollination by insects, carbon dioxide fixation by forests, and reducing the scale of floods through marshes and natural aquatic environments in good ecological state.
  - Set up a “Biodiversity – Ecosystem Services Pact” modelled on the “Climate Pact” and include that measure, if appropriate, in the PNPN3.
  - Introduce a premium for ecosystem services provided by forest environments in favour of private forest owners.
- Complete implementation of the management plans for Natura 2000 sites and threatened species, and assign specific and measurable objectives to them:
  - Indicate what conservation measures or measures to rehabilitate degraded sites are required and prioritise interventions to increase biodiversity.
  - Increase the portion of Natura 2000 areas that are state-owned and develop long-term (25 years +) agreements with landowners or assign conservation easements; consider levying a “Biodiversity – Ecosystem Services” tax on land transactions and associate corporate sponsorship to finance these acquisitions and consider in exchange exemption from the payment of the property tax in Natura 2000 zones.
  - Prioritise new ecological connectivity corridors to be put in place and complete the corridors of primary importance before the end of the PNPN2.
- Increase the human and financial resources budget for implementing the PNPN2, developing the PNPN3 and, in particular, for accelerating implementation on the ground of the actions foreseen in these plans so as to balance strategic planning efforts with concrete achievements.

Integration of biodiversity issues into sectoral policies

- Limit urban sprawl and habitat fragmentation by ensuring that land-use planning takes into account biodiversity, ecosystem services and the quality of life of citizens.

- Actively support the transition to organic farming and agroecology:
  - Value the products and behaviours of organic farmers, and establish a system of financial support for the production of ecosystem services, for the use of mechanical pest control to replace pesticide use and for crop rotation.
  - Continue the measures accompanying farmers in this transition (eco-counsellors).
  - Promote the establishment of organic farms near cities to reduce the harmful effect of pesticides on the population and increase accessibility to organic farming products.

Contribution to the protection of regional and international biodiversity

- Increase Luxembourg's contribution to the protection of biodiversity at international level:
  - Co-operate with neighbouring countries and promote the application of an ecological compensation model in other countries.
  - Contribute to the protection of wintering habitats of bird species nesting in Luxembourg, which migrate to other countries for part of the year.
  - Further integrate the biodiversity component into development co-operation and make it a strategic focus.

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OECD Environmental Performance Reviews

LUXEMBOURG

Luxembourg has made progress in decoupling environmental pressures from economic growth, treating wastewater and managing waste and materials. It has also positioned itself as an international centre for green finance. Yet, it remains one of the most carbon- and material-intensive economies in the OECD. The country is a crossroads for freight traffic and attracts thousands of daily cross-border commuters. This exacerbates greenhouse gas emissions, air pollution and road congestion. Urban sprawl, landscape fragmentation and agriculture exert strong pressures on biodiversity.

To steer its economy towards a greener model, Luxembourg has set ambitious environmental objectives. Greening taxation, providing stronger price signals, promoting eco-innovation and the circular economy, mainstreaming biodiversity into all policies, and investing in low-carbon infrastructure and sustainable mobility, should be priorities.

This is the third Environmental Performance Review of Luxembourg. It evaluates progress towards green growth and sustainable development, with special chapters focusing on two major issues: air quality and mobility, and biodiversity.

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