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Foreword

This Survey is published on the responsibility of the Economic and Development Review Committee of the OECD, which is charged with the examination of the economic situation of member countries.

The Secretariat's draft report was prepared for the Committee by Catherine MacLeod, Ania Thiemann and Paula Adamczyk, under the supervision of Pierre Beynet. Statistical research assistance was provided by Paula Adamczyk and editorial assistance by Emily Derry.

The economic situation and policies of Luxembourg were reviewed by the Economic and Development Review Committee on 19 September 2022 with participation of representatives of the Luxembourgish authorities. The draft report was then revised in the light of the discussions and given final approval as the agreed report of the whole Committee on 27 October 2022.

The previous Survey of Luxembourg was issued in July 2019.

Information about the latest as well as previous Surveys and more information about how Surveys are prepared is available at http://www.oecd.org/eco/surveys.

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BASIC STATISTICS OF LUXEMBOURG, 2021[1]

(Numbers in parentheses refer to the OECD average)[2]

LAND, PEOPLE AND ELECTORAL CYCLE					
Population (million, 2020)	0.6		Population density per km² (2020)	259.4	(38.7)
Under 15 (%, 2020)	15.6	(17.8)	Life expectancy at birth (years, 2020)	81.7	(79.7)
Over 65 (%, 2020)	14.4	(17.4)	Men (2020)	79.4	(77.0)
International migrant stock (% of population, 2019)	47.4	(13.2)	Women (2020)	84.2	(82.5)
Latest 5-year average growth (%)	2.0	(0.6)	Latest general election		October-2018
ECONOMY					
Gross domestic product (GDP)			Value added shares (%, 2020)		
In current prices (billion USD)	86.6		Agriculture, forestry and fishing	0.2	(2.7)
In current prices (billion EUR)	73.2		Industry including construction	12.3	(26.2)
Latest 5-year average real growth (%)	2.3	(1.5)	Services	87.5	(71.1)
Per capita (thousand USD PPP, 2020)	117.7	(46.1)			
GENERAL GOVERNMENT					
Per cent of GDP					
Expenditure (OECD: 2020)	42.4	(48.5)	Gross financial debt (OECD: 2020)	30.6	(133.5)
Revenue (OECD: 2020)	43.3	(38.1)	Net financial debt (OECD: 2020)	-50.1	(81.2)
EXTERNAL ACCOUNTS					
Exchange rate (EUR per USD)	0.85		Main exports (% of total merchandise exports)		
PPP exchange rate (USA = 1)	0.84		Manufactured goods	38.1	
In per cent of GDP			Machinery and transport equipment	27.5	
Exports of goods and services	212.4	(54.6)	Chemicals and related products, n.e.s.	11.8	
Imports of goods and services	177.0	(51.1)	Main imports (% of total merchandise imports)		
Current account balance	4.8	(0.1)	Machinery and transport equipment	31.7	
Net international investment position (2020)	57.5		Manufactured goods	15.4	
			Chemicals and related products, n.e.s.	12.4	
LABOUR MARKET, SKILLS AND INNOVATION					
Employment rate (aged 15 and over, %, OECD: 2020)	58.7	(55.1)	Unemployment rate, Labour Force Survey (aged 15 and over, %, OECD: 2020)	5.2	(7.1)
Men (OECD: 2020)	62.4	(63.0)	Youth (aged 15-24, %)	16.9	(12.8)
Women (OECD: 2020)	54.9	(47.7)	Long-term unemployed (1 year and over, %, 2020)	1.7	(1.3)
Participation rate (aged 15 and over, %, 2020)	60.8	(59.5)	Tertiary educational attainment (aged 25-64, %, 2020)	51.3	(39.0)
Average hours worked per year (OECD: 2020)	1,382	(1,666)	Gross domestic expenditure on R&D (% of GDP, 2018)	1.2	(2.6)
ENVIRONMENT					
Total primary energy supply per capita (toe, 2020)	5.4	(3.7)	CO2 emissions from fuel combustion per capita (tonnes, 2019)	14.8	(8.3)
Renewables (%, 2020)	10.7	(11.9)	Water abstractions per capita (1 000 m³, 2020)	0.1	
Exposure to air pollution (more than 10 µg/m³ of PM 2.5, % of population, 2019)	68.6	(61.7)	Municipal waste per capita (tonnes, 2020)	0.8	(0.5)
SOCIETY					
Income inequality (Gini coefficient, 2019, OECD: latest available)	0.305	(0.317)	Education outcomes (PISA score, 2018)		
Relative poverty rate (%, 2019, OECD: 2018)	10.5	(11.7)	Reading	470	(485)
Median disposable household income (thousand USD PPP, 2019, OECD: 2018)	43.8	(25.4)	Mathematics	483	(487)
Public and private spending (% of GDP)			Science	477	(487)
Health care (2019)	5.4	(8.8)	Share of women in parliament (%)	35.0	(32.4)
Pensions (2017)	8.5	(8.6)	Net official development assistance (% of GNI, 2017)	1.0	(0.4)
Education (% of GNI, 2020)	4.5	(4.6)			

[1] The year is indicated in parenthesis if it deviates from the year in the main title of this table.

[2] Where the OECD aggregate is not provided in the source database, a simple OECD average of latest available data is calculated where data exist for at least 80% of member countries.

Source: Calculations based on data extracted from databases of the following organisations: OECD, International Energy Agency, International Labour Organisation, International Monetary Fund, United Nations, World Bank.

Executive summary

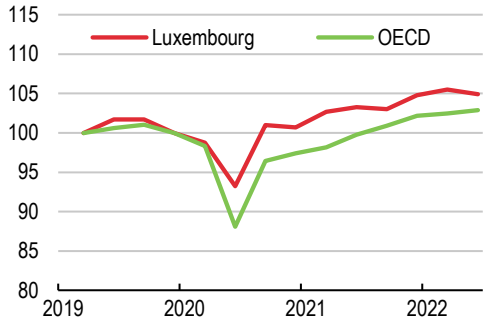
Russia's war of aggression against Ukraine is weighing on the recovery

The economic recovery from COVID has slowed due to war-related uncertainty and inflationary pressures. Public support can help vulnerable households cope with the higher cost of living but should be well targeted and time-bound, and maintain incentives for energy savings.

Economic growth recovered strongly in 2021 (Figure 1). Owing to decisive economic support, the economy escaped the worst impacts of the COVID pandemic, with GDP already reaching pre-pandemic levels by the third quarter of 2020. Post-COVID support measures helped ensure most sectors recovered strongly in 2021.

Figure 1. The economy rebounded quickly

Real GDP, Index 2019Q1=100



Source: OECD Economic Outlook (database).

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The war in Ukraine is worsening the economic outlook (Table 1). Headline inflation reached 8.8% in October, due to high energy prices, rising core inflation, and automatic wage indexation, which tends to push up wage inflation in an already-tight labour market. In the short term, growth is expected to slow, on the back of higher global interest rates, and plummeting confidence. Whilst direct exposure to Russia is low, the economy will be negatively affected through a slowdown in activity in European partners. The EU embargo on Russian oil imports, supply chain disruptions related to the war and China's COVID-related shutdowns will further dampen activity.

Policies to mitigate inflation impacts on incomes should be better targeted, time-bound and maintain energy savings incentives. Generous fiscal policy support of about 3.3% of GDP is weighted towards price support. Such measures may blunt incentives to reduce energy consumption, especially if energy prices remain high over the medium term. Policy should focus more on temporary, targeted income support.

Table 1. Growth is weakening

% change unless noted	2021	2022	2023
Gross domestic product	5.1	1.7	1.5
Private consumption	9.4	2.8	2.0
Unemployment rate	5.7	4.8	5.0
Consumer price index (HICP)	3.5	8.2	4.0
Fiscal balance (% of GDP)	0.8	-0.2	-2.2
Gross public debt (% of GDP)	24.6	27.0	30.5

Source: OECD Economic Outlook 111 and updates (database); debt: Maastricht.

The wage indexation system risks adding to already high inflation in periods of unprecedented price shocks, potentially harming longer-term competitiveness. General wage increases result in proportionately higher monetary gains for wealthier earners. Agreements by the social partners to moderate wage indexation may not be sufficient if energy prices remain elevated for a prolonged period. The government should reform the wage indexation system in consultation with social partners to better safeguard against risks to productivity, employment and inflation.

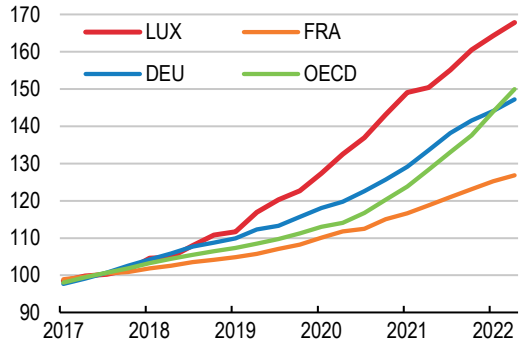
Enhancing resilience to risks

Higher global interest rates will raise risks in the financial sector and housing markets over the short and medium term. Pensions spending represents a large fiscal risk over the long term.

The overheating housing market poses risks for some categories of borrowers. House price inflation has outstripped most OECD countries (Figure 2), worsening affordability and raising household debt levels to 180% of net disposable income in the first quarter of 2022. Macroprudential policy measures have been taken to lower risks for borrowers, and loan-to-value limits introduced in January 2021. Nonetheless, higher interest rates will put some categories of borrowers on variable rates under strain, particularly those with lower incomes. In addition to maintaining heightened vigilance of banks and household indebtedness, the authorities should stand ready to apply a broad range of macroprudential policy instruments.

Figure 2. House price inflation has been very high

Index 2017=100



Source: OECD House Prices (database).

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The fiscal system's resilience to shocks is high but can improve further. High growth, resilient tax bases and a strong commitment to low public debt have been important safeguards, particularly given how small and open the economy is. However, over time, spending pressures are set to increase. Pension expenditure will rise sharply under unchanged policies whilst macroeconomic shocks, linked to climate change, could increase in frequency. Developing a more systematic framework to assess and prioritise spending policies could further increase fiscal resilience.

The current pension review is an opportunity to tackle projected increases in annual pension expenditures of up to 9% points of GDP by 2070 (Figure 3). Debt sustainability projections show that in the worst-case scenarios, this would raise the public debt to GDP ratio to over 140% by 2060, after fully drawing down pension asset reserves. Raising effective retirement ages and introducing actuarially fair adjustments for early retirement would improve the affordability of the pensions system and enhance intergenerational equity.

Raising labour supply and productivity to sustain long-term growth

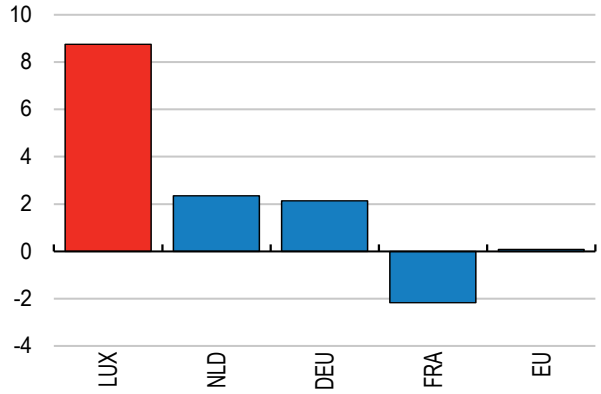
Potential growth is set to slow as the population ages. Labour participation of young and older workers should increase while higher private sector investment, including in R&D, would boost productivity growth.

A number of young workers are at high risk of being excluded from the job market. High dropout rates are concentrated amongst the most vulnerable students, who are less equipped to cope with uneven schooling quality and rigid educational pathways. Any reforms to the schooling system will take time to be effective and need to be accompanied in parallel by a sharp expansion in vocational training for unemployed youth. Programmes should promote in particular highly demanded skills for technical professions.

The current high barriers to employing older workers should be removed. Participation rates of over 55-year-olds are amongst the lowest in the OECD. Generous pension benefits and existing work practices reduce incentives to remain in the workforce. The pensions system could be reformed to allow a phased entry into retirement, including more flexible use of part-time contracts. The existing incentives to hire older workers should be enhanced, including via targeted training to overcome skills gaps, notably in digitalisation. A strengthened system of adult learning, with a focus on life-long learning, would ensure the existing workforce is not left behind in the transition to a green economy.

Figure 3. Pension spending is set to rise rapidly

Difference between 2070 and 2019



Source: European Commission, The 2021 Ageing Report.

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Private investment levels of 8.5% of GDP and 0.6% of GDP for R&D are amongst the lowest in the OECD. The government provides significant support to R&D investment, but total private investment, including for R&D, continues to fall as a share of GDP. SMEs' digital investments also lag peers. Public investment support for R&D is highly dispersed with overlapping structures. Streamlined administration could improve the use of available

funds, which could be redirected from a narrow focus on high-tech sectors to the manufacturing sector. Increasing the share of funds deployed to match private funding of R&D could support more investment by firms.

Administrative burdens are high, representing an obstacle to firm dynamism. Professional licensing rules are amongst the most restrictive in the OECD. Starting a business, whilst possible to do online, remains a cumbersome procedure.

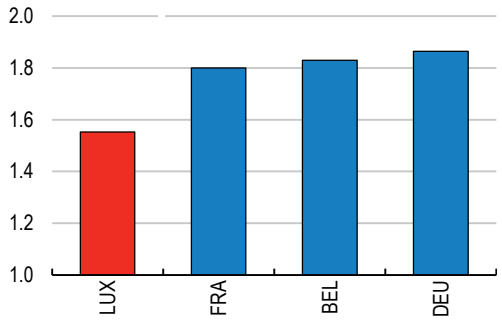
Securing a sustainable green transition for the long term requires a comprehensive policy toolkit

Luxembourg has ambitious climate goals, but deep changes are needed to meet them. Higher carbon prices reinforced by transport and housing policies can improve household choices on where to live and how to move.

The price of carbon must increase in the long term for the green transition to succeed (Figure 4). Energy prices paid by consumers have increased significantly recently but may need to rise even further in the long term to reach net-zero emissions. Low carbon prices have encouraged residents' high levels of car usage and residential heating consumption, and provided little incentive to undertake large behavioural changes or expensive energy efficiency investments. Cross-border fuel sales have also been significant as prices in Luxembourg have been historically lower than in neighbouring countries.

Figure 4. Fuel prices have been below those in neighbouring countries

Fuel prices, USD/unit, 2021 average



Note: Average of diesel and petrol prices.
Source: IEA energy prices (database).

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The current carbon tax lacks the long-term time horizon needed to create clear incentives for the green transition. A rising carbon tax, with a clearly defined trajectory over the long term, will incentivise required investments in energy efficiency. This needs to be accompanied by a clearly communicated policy as to how any additional revenues from environmental taxes may be used. Policies that explicitly tackle distributional concerns tend to increase the political support and sustainability of transition policies.

Ambitious policy targets for the transition need to be accompanied by estimates of the costs of the green transition. The costs of the transition will change over time, and across groups of households and firms. These costs, and how they are affected by policies, need to be carefully monitored. Costing the transition will enable prioritising competing long-term fiscal demands, including for pensions.

High house prices, significant benefits for car usage and planning co-ordination challenges have resulted in urban sprawl and high car dependence. Luxembourg has one of the highest rates of urban sprawl in the OECD. Tax benefits for travel distances and company cars should be removed and gradually replaced with road-use tolls and parking restrictions to encourage more people to use the free, expanded public transport services. Housing supply incentives for municipalities and households should be aligned to encourage building in accordance with the Master Programme for Spatial Planning. Increasing the benefits for households that undertake densification and energy efficiency renovations simultaneously could encourage deeper renovations and improve the alignment between housing and climate objectives.

Biodiversity and the quality of water and soil are under significant threat. The number of endangered species is amongst the highest in the European Union. Intensive cattle farming and fertilizer use are harming biodiversity with very limited attention to environmental impacts in the design of agricultural policy. Regulation of the agricultural sector's use of fertilisers and pesticides must be urgently strengthened. Existing subsidies to the sector must be re-shaped to support green farming.

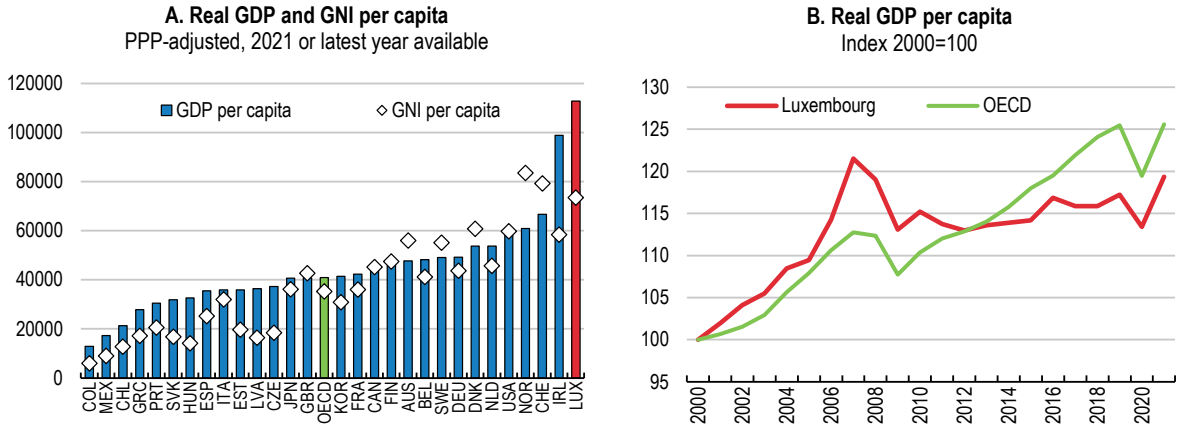
Main findings and key recommendations

MAIN FINDINGS	KEY RECOMMENDATIONS
Enhancing resilience to risks	
Inflation pressures have been broadening. Measures to mitigate the impact from rising energy prices and high inflation have been adopted. In addition, wages and benefits are indexed to inflation. Automatic wage indexation can increase inflationary pressure and benefits the wealthiest the most.	Make income support to households more targeted to the most vulnerable and limited in time, whilst avoiding accelerating domestic demand pressures. Reform the wage indexation system in consultation with social partners to take better account of the productivity, employment, and investment effects.
Macroprudential policy has tightened borrower requirements to reduce tail risks. Rising house prices, high debt-service ratios and variable mortgages could raise some borrowers' vulnerability to higher interest rates.	Expand and publish regular monitoring of all loan types by household characteristics to understand emerging pockets of vulnerability, and be prepared to implement additional macroprudential policies if necessary.
The current fiscal position is strong. However, shocks can affect the composition of spending. Current spending decisions are only weakly linked to evaluation mechanisms. Pensions spending is projected to rise to 18% of GDP in 2070 from 9% in 2022. The effective retirement age is low, and not linked to life expectancy. Participation rates of older workers are very low, depriving the economy of an important source of skills and expertise.	Put in place a more performance-oriented budgeting framework, incorporating spending reviews, to make spending more effective. Link increases in the statutory retirement age to increases in life expectancy. Phase out incentives for early retirement, while providing for more flexible working arrangements for older workers.
Improving labour market outcomes and productivity for sustained growth	
Workers will need higher skills over the medium and long term. There is a higher concentration of low skills among the older workers. School dropout rates are high, and young people face high unemployment rates, excluding them from the workforce and depriving the economy of valuable skills.	Subsidise active on-the-job training schemes targeted to the over-45-year-olds. Expand access to training to help early-school leavers enter the workforce, alongside school system reforms.
Productivity levels are high, but growth has been low and overall investment has declined. Public investment support schemes have overlapping structures. The current incentive scheme design has not had an appreciable impact on business investment, which including R&D, is very low as a share of GDP.	Increase public spending on R&D to match private R&D funding and encourage greater investment by firms. Increase funding to targeted projects by reducing the funds spent on administration.
The business regulatory environment is restrictive, notably for new firms, and for small traders.	Reduce administrative burdens on small firms, notably by streamlining procedures for starting a business.
Improving resilience through the transition to green growth	
The households and firms negatively impacted by the transition will change over time, which needs to be carefully monitored, alongside the revenues and spending implications for the government.	Introduce scenario and sensitivity analysis to estimate the long-term cost of the green transition, including the impact on different households and firms.
A carbon tax was introduced in 2021 and will rise to EUR 30 in 2023. Low carbon prices stimulate cross border sales of fuel and weaken energy efficiency incentives. The speed and scope of changes required to meet targets, particularly households, could increase resistance to change.	Set a rising carbon tax trajectory over the medium and long term, while redistributing revenues to minimise the burden on the most vulnerable.
Public transport use is a low proportion of total trips and car usage costs are very low, due to tax incentives for travel and company car fleets. Urban development and transport infrastructure, alongside housing prices, have reinforced one another to lock in high car usage and urban sprawl in Luxembourg and the greater region.	Introduce and gradually increase road use charges in conjunction with tighter parking policies. Use tax credits and municipal funding incentives to encourage higher urban density, with green homes built in accordance with the Master Programme for Spatial Planning.
Current regulations have failed to keep up with the negative environmental impacts of increased livestock farming and intensive fertiliser use.	Strengthen regulations on fertiliser and pesticide use. Make national agricultural subsidies contingent on the adoption of sustainable farming practices that protect the environment.

1 Key Policy Insights

Luxembourg has the highest per capita income levels in the OECD when measured by GDP, and the third-highest after Switzerland and Norway, when measured by gross national income (Figure 1.1, panel A). Growth is jobs-rich, with the unemployment rate one of the lowest in the OECD. However, growth in GDP per capita has been below the OECD average since the global financial crisis (2008-09), following high growth in the early 2000s (Figure 1.1, panel B). The economy proved resilient in face of the shock from the 2020-21 COVID-19 pandemic, and the recovery has been broad-based. The Russian war of aggression against Ukraine and high inflation in 2022 have affected consumer and business confidence, stifling the economic recovery and making the outlook more uncertain.

Figure 1.1. Incomes remain high despite growth slowing down since the global financial crisis



Note: Gross national income captures the activity of residents, whereas GDP includes consumption by the large share of cross-border workers that enter the country every day.
Source: OECD National Accounts (database).

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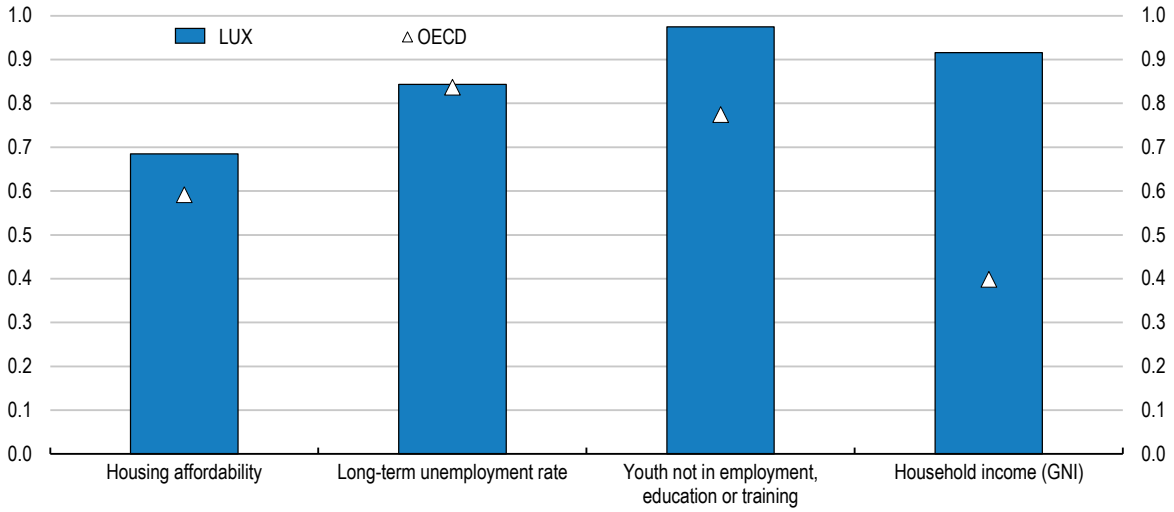
Luxembourg performs well relatively to other OECD countries across several non-economic indicators such as health, civic engagement, and safety, on top of high living standards (OECD, 2020[1]). Trust in government and in public institutions is above the OECD average and public integrity is perceived to be high (OECD, 2022[2]) There is still room for improvement: access to affordable housing is a concern, and educational attainment is uneven and strongly related to students' socio-economic background (Figure 1.2) (European Commission, 2022[3]). While life satisfaction is comparatively high, obesity has been on the rise, in particular amongst younger people (OECD, 2020[1]). This could have an impact on the longer-term health of the population, and associated costs for long-term care of the elderly (European Commission, 2021[4]; OECD, 2021[5]; OECD/European Observatory on Health Systems and Policies, 2021[6]). Environmental factors, such as high air pollution, also weigh on well-being in the country (OECD, 2020[1]).

Successfully maintaining the country's high living standards, whilst transitioning to a green economy that secures the long-term health of the environment, will require fundamental changes in consumption and production patterns, and the effective use of all resources. Higher investments will be critical to enable this change, provided that they are aligned with long-term incentives to reduce carbon reliance and environmental protection. Successfully lengthening working lives, whilst maintaining the population's health, will support growth, and also help reduce the pressure on housing, land and energy-use. This requires tackling longer-term challenges related to sluggish productivity growth and an ageing population, which will put pressure on government spending. Supporting higher productivity growth alongside the sustainable use of resources will minimise waste and the pressure on resources, ensure Luxembourgish firms are well-positioned to take advantage of new markets and reduce the need for drastic decisions on fiscal spending in the future.

Figure 1.2. Household income is high, but long-term unemployment and housing can improve

Well-being indicators, scale 0 (worst) to 1 (best), 2020



Note: This chart shows Luxembourg's relative strengths and weaknesses in well-being when compared with other OECD countries. The index is constructed so that 0 represents worst outcome and 1 represents the best outcome among OECD countries.
Source: OECD calculations based on OECD How's Life? Well-being database.

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In terms of productivity levels, there are sharp differences between Luxembourg's best performers and the global best performers, as well as within Luxembourgish sectors. While productivity in Luxembourg's manufacturing sector, which includes large multinational firms such as Arcelor Mittal, often exceeds the OECD average, the sector is a small part of the national economy. Other sectors perform less well, including the large financial sector, which on average had the second lowest productivity (measured as value-added per person employed) in the OECD, in the period 2001-21 (OECD, 2021[7]). Skills-mismatches are high, which is also weighing on productivity, and those excluded from the labour force are difficult to integrate back into the system.

Strong public investment has not been matched by the private sector, owing partly to the structure of the Luxembourg economy which is characterised by a high share of financial services. Corporate investment as a share of gross fixed capital formation is the second lowest in the OECD, at 45.7% (compared with an average of 60% in the OECD, and 90% of total investment in Ireland), while the share of general government investment is the highest anywhere in the OECD (OECD, 2021[7]). A rapidly ageing population will pose challenges for sustaining workforce growth, particularly if current early retirement rates persist. The old-age dependency ratio will more than double (from less than 25% to more than 56%) by 2070, leading to a steep increase in pension expenditure and the cost of long-term care (European Commission, 2021[8]). Without efforts to raise productivity growth or increase labour supply to offset an ageing workforce, fiscal pressure will increase by more than 10 percentage points of GDP by 2060 (Guillemette and Turner, 2021[9]).

The transition towards a low-carbon and digitalised economy should be taken as an opportunity to support stronger long-term growth. The climate strategy to 2050 outlines a large number of plans to respond to climate risks. Strong co-operation between the state and the private sector in the financial services sector has supported innovation in the financial sector. More generally, the authorities have taken a proactive stance to create the foundations for a flexible, responsive, and fast-growing economy into the future. This is important since, given Luxembourg's high economic openness, the country needs to be resilient to external shocks, such as higher inflation brought by Russia's war of aggression against Ukraine, or supply-chain shocks (Figure 1.3, Panel C).

In this context, this Survey's key messages to strengthen further the resilience of the Luxembourgish economy in the face of new challenges are the following:

- Fiscal support to households vulnerable to the current energy shock should be targeted and temporary to avoid fuelling inflationary pressures and to maintain incentives for energy savings. Significant reforms to the pension system are necessary to reinforce fiscal sustainability.
- Migration policies and incentives to raise the working age in Luxembourg are required to offset the ageing workforce's impact on potential growth. Lifelong learning programmes are needed to ensure workers' adaptability.
- Meeting ambitious green transition goals requires a broad set of policy tools. Reducing overall energy intensity requires adjusting incentives to densify housing and to reduce the reliance on cars. Setting a more ambitious long-term carbon-tax path, accompanied with adequate support for vulnerable firms and households, is also key.
- Raising productivity growth and reducing resource intensity requires laggard firms to absorb better existing innovations, and faster digitisation in small-and medium-sized firms (SMEs). To support productivity growth and economic diversification, public innovation investment should better target specific projects, while corporate R&D investment could be better supported through matching public funding.

Luxembourg rebounded strongly from the pandemic but is facing new risks

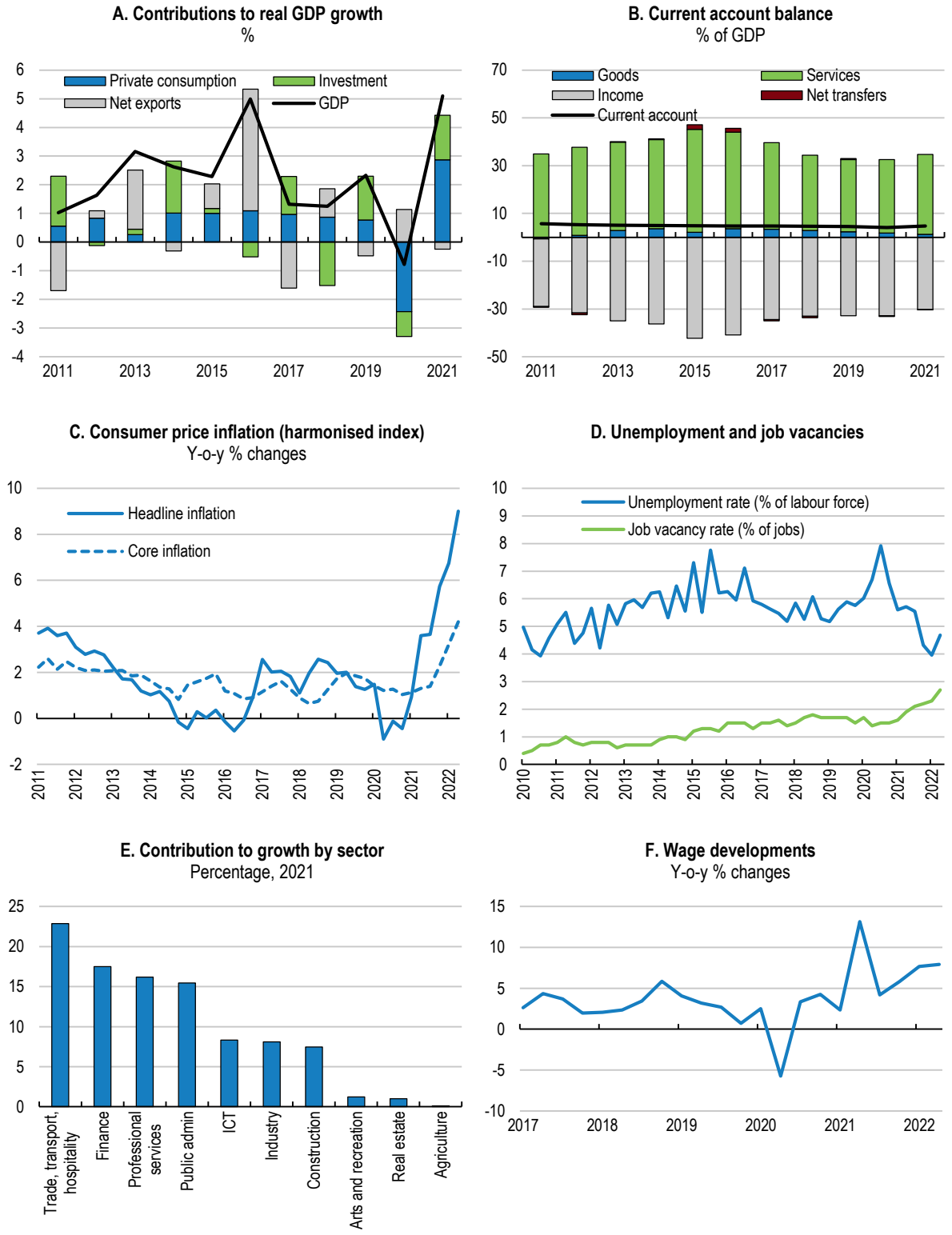
The post-COVID-19 recovery has been strong, but high inflation creates significant risk

The economy proved resilient to the COVID-19 pandemic, thanks notably to decisive government action early on. COVID-19 support measures were sizable and equivalent to just over 4.2% of GDP, including government loan guarantees as detailed in a 2022 OECD report on the Luxembourgish government's response to the pandemic (OCDE, 2022[10]). Household assistance during the pandemic included direct income support, supplemented with financing of partial unemployment. Firm level support included direct transfers as well as furlough schemes to help meet staff costs. COVID-19 related assistance was broad-based and delivered quickly, in keeping with best practice given the breadth and depth of the economic shock. Most of the assistance was directed towards employment support, with a higher share of GDP directed towards wage support than many peers. A relatively high proportion of liquidity support was provided via deferred tax and social security payments, which were almost double the value of guarantees granted. To date, the long-term impact on the economy from bankruptcies and permanent exclusion from the labour force seems limited (OCDE, 2022[10]). Government support has continued to respond to ongoing shocks.

The high share of services that could rely on teleworking also helped limit the impact of the crisis. Nearly 40% of jobs are in the services sector, including public administration. The downturn in 2020 was comparatively mild, and the recovery has been robust, taking real GDP growth to 5.1% in 2021. A strong recovery in financial markets lifted growth in the financial sector, which accounts for around 25% of the economy.

Job creation has been brisk since mid-2021, in step with the recovery. Total unemployment is at its lowest level for over 15 years, and vacancies are high (Figure 1.3, Panel D). Thanks to buoyant activity, the surplus on services trade has supported a persistent current-account surplus in recent decades of around 4%-5% of GDP, despite large deficits on the primary income account (Figure 1.3, Panel B).

Figure 1.3. Growth is broad-based, and pressures are rising in the economy



Source: OECD (2022), Economic Outlook (database); Eurostat, Job vacancies; and STATEC.

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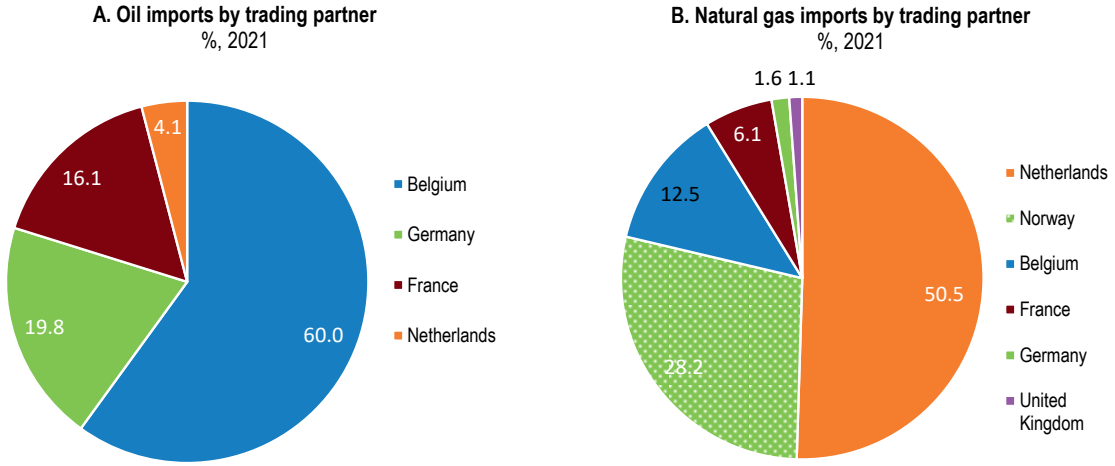
Luxembourg, as the rest of the European Union, has been affected by the rising gas and electricity prices owing to the supply restrictions arising from the Russian war of aggression in Ukraine, even though Luxembourg has relatively little direct exposure to Russia, which accounts for just 1.7% of total trade. Base metals imported directly from Russia account for just 0.4% of all base metal imports, versus 97% from the European Union (some imports may have transited through third-party countries, but this is not accounted for in official data). Oil and gas imported directly from Russia are negligible (Figure 1.4). Natural gas accounts for 25% of all energy consumption and much of the gas imported is used for industrial purposes, mainly steel and glass manufacture, but also in the textile and cement industries, in addition to electricity production. Imported gas runs mainly from LNG terminals in Belgium, which increases potential suppliers, for instance from Canada or Algeria. Luxembourg does not possess its own gas storage facilities, but it participates in the Pentalateral Forum on Energy (comprising Benelux, France, Germany, Austria and Switzerland). An agreement was signed in late March 2022 to improve gas storage co-operation, and to force suppliers to fill stocks before the winter heating period (Gouvernement Luxembourgeois, 2022[11]).

Figure 1.4. Exposure to Russia's oil and gas is negligible

Oil and gas imports, 2020



Source: Eurostat; and IEA.

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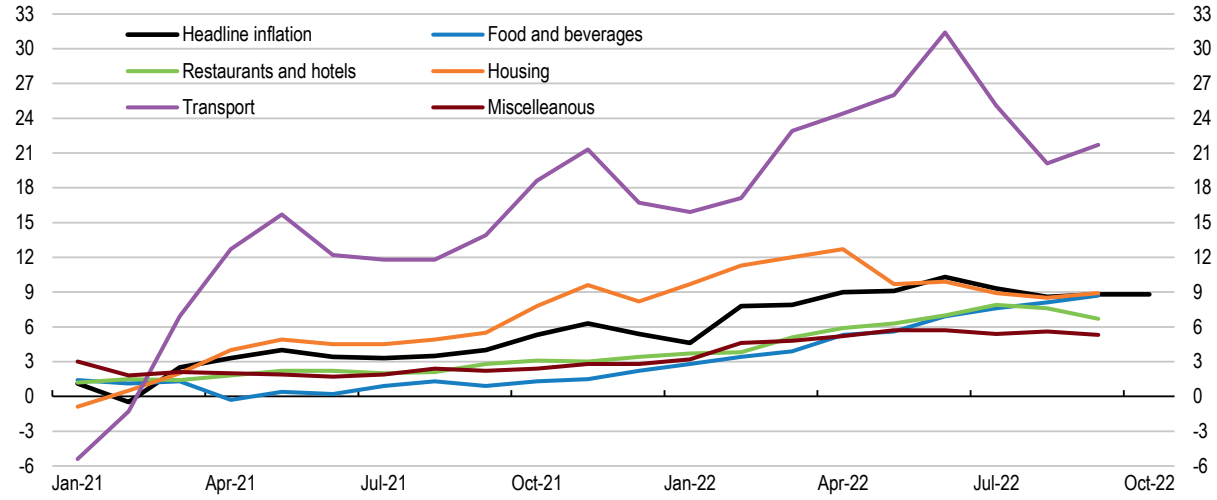
Russia's war against Ukraine has aggravated inflationary pressures, which had already started building towards the end of 2021 on the back of supply bottlenecks. While some increases are supply-driven, rising demand is also contributing, and inflation has broadened to include personal services, travelling and entertainment, as well as clothing and household goods (Figure 1.5). Headline inflation is expected to average 8.2% in 2022 according to the harmonised price index, on the back of higher energy and food price inflation. Rising inflation is eroding consumer confidence and disposable incomes (Figure 1.6) and, combined with labour market bottlenecks, fuels wage pressures. All wages, salaries, and some social benefits, such as pensions and family allowances, are indexed to inflation. They are automatically increased by 2.5% when the price level has gone up by 2.5% since the time the last wage indexation occurred. The total wage rate rose by 5.4% in 2021, in part owing to a wage increase of 2.5% in October 2021 because of the wage indexation scheme. A further 2.5% increase occurred on 1 April 2022 when the automatic indexation kicked in again, contributing to the 6.2% annual rise in hourly wages in the second quarter of 2022.

Figure 1.5. Inflation is broad-based

Headline inflation and its main components, year on year % change



Note: "Housing" includes housing, water, electricity, gas and other fuels; "Miscellaneous" includes personal care, social protection, insurance, and other services n.e.c.

Source: Eurostat, Harmonised Price Indices.

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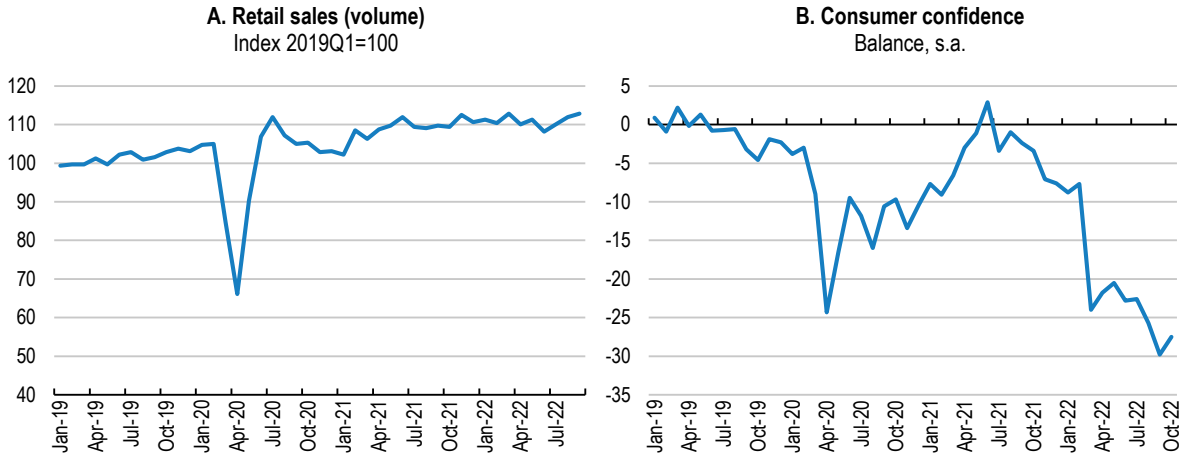
Figure 1.6. War and rising inflation are depressing consumer confidence



Source: OECD, Monthly Economic Indicators (database); and Eurostat, Business and consumer surveys (database).

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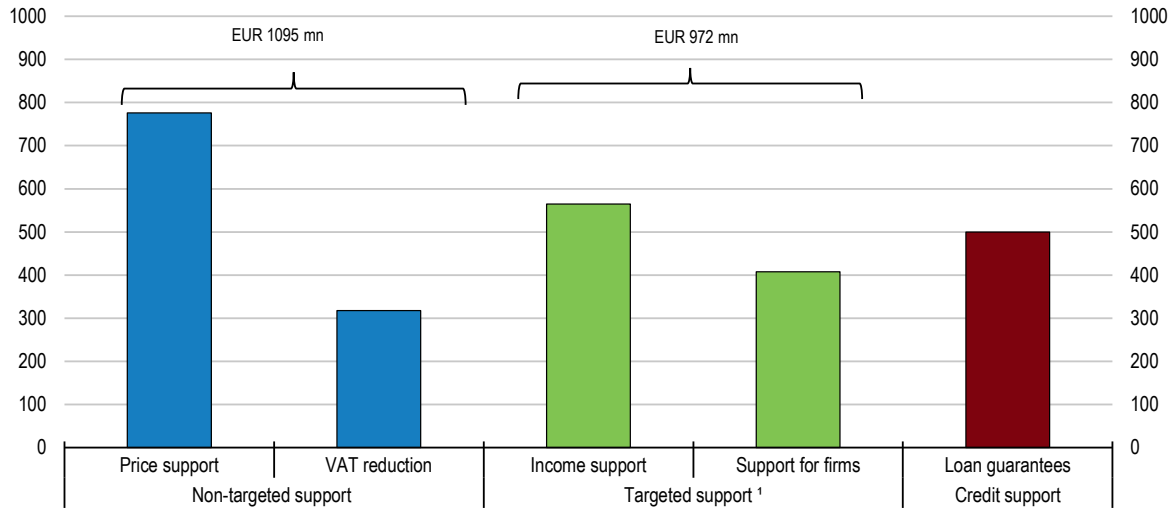
To mitigate the negative effects of rising prices on household incomes and competitiveness, the government responded with a series of support packages costing close to EUR 2.6 billion (3.3% of GDP). The total cost of the latest package, agreed with social partners in September 2022, is EUR 1.1 billion. The latest measures aim to limit inflation increases – and related wage-indexation increases – by capping domestic gas and electricity price increases between October 2022 and December 2023, and reducing most VAT rates by 1 percentage point in 2023. Rent subsidies and an annual energy bonus for lower-income households, introduced earlier in 2022, have been extended into 2023. Until June 2023, businesses can apply, if their energy costs are at least 80% higher than in 2021, for a subsidy covering 70% of their additional energy costs over and above this 80% increase. Moreover, state-backed business guarantees remain in place (Le Gouvernement du Grand-Duché de Luxembourg, 2022[12]). Subsidies for energy efficiency investments were strengthened and introduced for long-term renewable energy power purchase agreements. Social partners agreed that any future wage indexation increases will be

implemented in full. In March, they had agreed to postpone the July 2022 wage indexation increase until 1 April 2023.

Figure 1.7. Policy support is tilted towards non-targeted measures

Budget measures 2022-23, Euro million



1. Targeted measures are directed at households or firms, based on criteria such as income or energy consumption levels.
Source: Ministry of Finance, Draft Budget Plan 2023, OECD estimates.

StatLink https://stat.link/vahuzc

New sizeable energy price increases could pose risks for firms and households that are unable to quickly reduce energy consumption Targeted support measures are welcome as there is a small but growing set of households in energy poverty, at 4.9%. The government's latest support package is estimated to limit expenditure increases from higher living costs to 3% for all income groups in 2022 (STATEC, 2022[13]). In addition, an expanded and free public transport network provides important flexibility to reduce transport-related energy consumption, and subsidies for energy efficiency investments in homes and businesses are available.

The risks arising from policy support in the form of price measures will rise if energy prices are very high over the medium term. Wage increases from indexation would be postponed, and could increase pressure for continued fiscal support. VAT reductions may not be fully passed on by business and could be difficult to phase out. Price caps for gas and electricity will disproportionately benefit those who consume the most, and are likely to blunt incentives to lower consumption. Overly generous support to protect households' income could further increase inflationary pressures, which are already broadening to include personal services, travelling and entertainment, as well as clothing and household goods.

To minimise these risks, the authorities should ensure that support is temporary and well-targeted to the most vulnerable. The government should monitor the impact of VAT reductions, and ensure rates are normalised promptly, as Germany did in 2020-21. More targeted support measures, delinked from energy consumption, would be a more effective tool to support the most vulnerable without blunting the incentives to increase energy efficiency. This is particularly the case in Luxembourg, where the retail price of energy is relatively low compared to neighbouring countries (see Chapter 2). Price caps can be applied to a fixed quantity of energy per household to minimise energy savings disincentives. In the Netherlands, price caps were applied to the quantity of gas consumed by the median household, with higher levels of consumption incurring higher prices.

Government support to firms must avoid the risk of encouraging low-productivity "zombie" firms that are unviable without state support. Support to firms should be targeted to viable firms, whose cost structure

make them particularly vulnerable to high energy costs. Larger firms that have access to finance or pricing power can better manage the transition to higher energy costs. To the extent that government supports these firms in the energy transition, it should encourage the switch to alternative production technology (see Chapter 2).

The current period of high inflation has highlighted the potential risks stemming from the automatic wage indexation system. Wage indexation can induce a price-wage spiral, particularly in the current context of high inflation and tight labour markets. Shocks to inflation can have longer-lasting effects in the presence of second-round effects, and the latter are more are more likely in the presence of wage indexation. There is also a risk of a longer lasting upwards effect on inflation expectations (Lünnemann and Wintr, 2010[14]; Koester and Grapow, 2021[15]; Boissay et al., 2022[16]). Generalised wage increases also disproportionately benefit those with higher salaries.

Although Luxembourg's social partners have demonstrated pragmatism in considering the impact of indexation, agreements can take time to implement. There is no clear policy to guide lawmakers or social partners as to how best apply retroactively any delayed increases in indexation, such as the one that was decided by the social partners in March 2022. Retroactively introducing these increases could exacerbate business cycle effects, if introduced too early or too late in the recovery. After the current period of high inflation, social partners should be consulted, and the government should implement reforms to the wage-indexation system to better guard against the risks to productivity, employment and inflation.

Whilst wage indexation mechanisms are intended to protect living standards, they can have a detrimental effect on competitiveness. In Belgium, the wage formation process is legally prescribed by a ceiling for wage growth, known as the wage norm, and wage indexation. The wage norm varies over time, and is set with reference to historic divergences in wages between Belgium and its main trading partners, projected Belgian inflation, projected wage growth in core trading partners and a "safety margin" to account for forecasting errors (OECD, 2022[17]). The OECD recommended to Belgium to closely monitor the effect of wage and price inflation on international competitiveness (OECD, 2022[17]). Connecting wage indexation to other countries' wage growth could be part of a solution to protect competitiveness. However, a broader range of cost-competitiveness criteria could be considered and be given a sufficiently high weight.

Growth will slow down in 2022-23 and risks are on the downside

GDP will slow to around 1.7% in 2022 and 1.5% in 2023, before picking up to 2.1% in 2024. Falling consumer sentiment, supply constraints in goods exports and slowing manufacturing activity, along with rising global interest rates will hold back economic growth in 2023 (Table 1.1). From a household perspective, higher interest rates will increase payment obligations and the vulnerability of certain borrowers, particularly those with lower incomes or with variable rate loans, and confidence has plummeted to the lowest level in two decades owing to the war in Ukraine and rising uncertainty (Figure 1.6). Nonetheless, government support and a cut in VAT rates, alongside a still-strong labour market, are expected to partially offset the impact of high inflation on disposable incomes and will sustain private consumption in 2023. Spending is set to pick up as energy prices normalise towards the end of the forecast period, and inflation starts falling back during 2023, as a result both of rising interest rates, and some impact from the energy price cap and VAT rate cuts. Core inflation is projected to be sustained in 2023, owing to second round effects of energy price increases, high wage growth and supply-constraints related to COVID-19 lockdowns in China. If energy prices stay high for longer, inflation may remain higher than foreseen, and household demand could be further depressed.

Table 1.1. Macroeconomic indicators and projections

Annual percentage change, volume (2015 prices)

	2018	2019	2020	2021	2022	2023
	Current prices (billion EUR)					
Gross domestic product (GDP)	**60.1**	**2.3**	**-0.8**	**5.1**	**1.7**	**1.5**
Private consumption	20.2	2.3	-7.2	9.4	2.8	2.0
Government consumption	10.1	2.3	7.3	5.5	2.9	3.4
Gross fixed capital formation	9.7	9.3	-3.2	6.1	-2.8	-2.5
Housing	2.3	4.9	-2.8	-11.3	-4.6	-2.2
Final domestic demand	40.0	4.0	-2.5	7.5	1.4	1.3
Stockbuilding[1]	0.4	0.0	-0.3	0.5	-0.2	0.0
Total domestic demand	40.5	4.0	-2.9	8.4	1.0	1.3
Exports of goods and services	118.7	4.5	0.2	9.7	0.8	1.1
Imports of goods and services	99.0	5.7	-0.5	11.9	0.3	0.9
Net exports[1]	19.6	-0.5	1.1	-0.2	1.2	0.8
Other indicators (growth rates, unless specified)						
Potential GDP	. .	2.0	2.1	2.4	2.2	1.9
Output gap[2]	. .	0.5	-2.3	0.3	-0.3	-0.7
Employment	. .	2.7	1.4	2.3	2.7	2.2
Unemployment rate	. .	5.4	6.4	5.7	4.8	5.0
GDP deflator	. .	1.4	4.6	6.1	6.0	1.1
Consumer price index (harmonised)	. .	1.6	0.0	3.5	8.2	4.0
Core consumer price index (harmonised)	. .	1.8	1.2	1.5	4.5	4.1
Household saving ratio, net[3]	. .	8.3	19.0	12.4	12.9	14.9
Current account balance[4]	. .	3.4	4.6	4.7	6.4	5.6
General government fiscal balance[4]	. .	2.2	-3.4	0.8	-0.2	-2.2
Underlying general government fiscal balance[2]	. .	2.0	-2.1	0.6	-0.1	-1.9
Underlying government primary fiscal balance[2]	. .	1.7	-2.3	0.3	-0.3	-2.1
General government gross debt (Maastricht)[4]	. .	22.4	24.5	24.6	27.0	30.5
General government net debt[4]	. .	-54.2	-50.1	-51.9	-48.0	-44.5
Three-month money market rate, average	. .	-0.4	-0.4	-0.5	0.6	3.8
Ten-year government bond yield, average	. .	-0.1	-0.4	-0.4	1.9	5.1

1. Contribution to changes in real GDP.
2. As a percentage of potential GDP.
3. As a percentage of household disposable income.
4. As a percentage of GDP.

Source: OECD (2022), OECD Economic Outlook: Statistics and Projections (database) with projections from "OECD Economic Outlook No. 111" and updates, November 2022.

Public investment of over 4% of GDP annually will continue to support infrastructure, the green transition, and innovation. Business investment, in contrast, will be subdued in 2022-23 as higher interest rates, labour market shortages and supply constraints delay investment decisions, despite some support from the government Recovery and Resilience Plan (RRP). Because Luxembourg's economy recovered fairly swiftly from the COVID-19 pandemic compared to some other EU member states, the total size of the NextGenerationEU (NGEU) recovery package (of which the RRP is part) for Luxembourg was reduced from an initial EUR 93 million to EUR 82.7 million. The impact on GDP for Luxembourg is highly dependent on spillovers from neighbouring countries. The European Commission has estimated that 0.7 percentage points of the total projected 0.8% GDP impact by 2026 will come from spillovers from the packages of other countries (European Commission, 2021[18]). These estimates do not include the impact of additional structural reforms, which could significantly boost the overall growth benefits (European Commission,

2021, p. 38[18]). Box 1.1, and Table 1.5 present OECD estimates of the impact of these structural reforms. As discussed further in this chapter, the labour market is tight, and several sectors are struggling to find enough skilled workers, including in the construction and the information-communications-technology (ICT) sectors, which may hamper implementation of the RRP. Export growth will moderate, as global financial market conditions remain difficult, and some supply-chain restrictions endure.

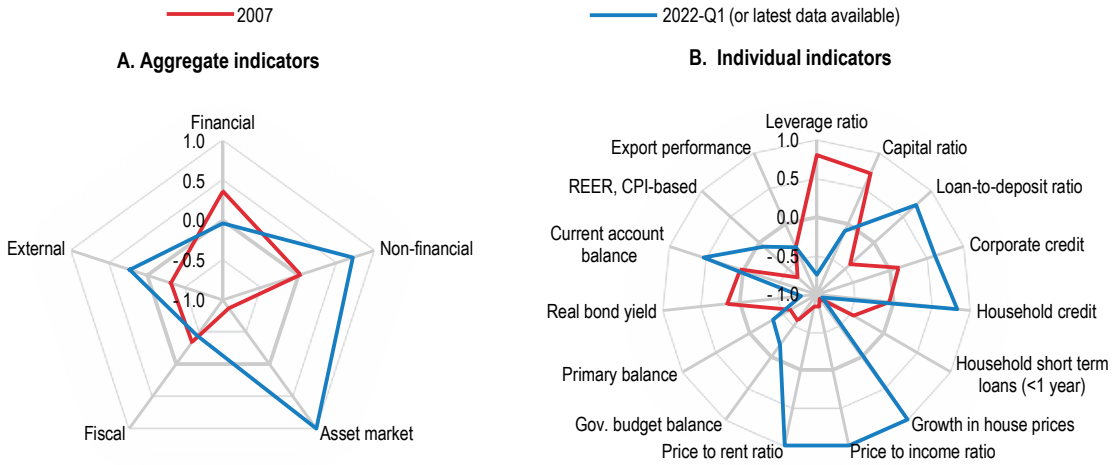
Risks to the outlook are tilted to the downside. Domestically, low interest rates in recent years have compounded the impact of structural factors in supporting rising real-estate prices and increased mortgage indebtedness. Indicators point to historically high risk in the credit and housing markets (Figure 1.8), although holdings of financial assets and wealth gains for past price increases should mitigate the impact of potential shocks. Externally, Luxembourg remains vulnerable to supply-side shocks, which would affect its main trading partners. Further sharp rises in inflation and long-term borrowing rates would worsen financial conditions, and cause stock markets valuations to fall. If this was to be compounded by defaults of bonds or a sharp drop in investment fund assets, for instance in the case of a faster-than-expected tightening of monetary policy, this could create a ripple effect in financial markets, which could harm Luxembourg's growth prospects (see also Table 1.2).

Table 1.2. Low-probability events that could lead to major changes to the outlook

Vulnerability	Possible outcome	Possible policy action
Sharply reduced housing prices	Sharp reversals in real estate prices and steep increases in interest rates could put some households in financial distress and endanger financial stability.	Address structural factors in housing and construction markets that contribute to supply shortages. If appropriate, broaden borrower-based macroprudential instruments.
Escalating trade tensions or heightened financial volatility because of the war in Ukraine could affect the investment fund industry.	A sharp reduction in global liquidity causes heightened redemptions in investment funds and money market institutions, reducing financial sector output globally, including in Luxembourg.	Maintain close supervision of banks and investment funds. Potentially increase minimum reserve requirements to preserve liquidity.
Outbreak of a new vaccine-resistant COVID-19 variant	New waves of vaccine-resistant infections could potentially lead to new lockdown measures, further reducing confidence and lowering domestic consumption.	Monitor health developments closely and continue to encourage vaccination, including booster shots. Keep contingency plans for moving to online work where possible and maintain stocks of personal protective equipment even as infection rates slow.

Figure 1.8. Macro-financial vulnerabilities have increased in the asset and housing markets

Index scale of -1 to 1 from lowest to greatest potential vulnerability, where 0 refers to long-term average



Note: 1. Each aggregate macro-financial vulnerability dimension is calculated by aggregating (simple average) normalised individual indicators from the OECD Resilience Database. Individual indicators are normalised to range between -1 and 1, where -1 to 0 represents deviations from long-term average resulting in less vulnerability, 0 refers to long-term average and 0 to 1 refers to deviations from long-term average resulting in more vulnerability.
Source: Calculations based on OECD (2022), OECD Resilience Database, April.

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Financial sector risks are rising

Fast-rising housing prices pose challenges

House prices have been increasing rapidly since the start of 2019 for both new and existing dwellings. On average, prices have risen by 9.7% per annum over the past five years, almost double the 4.9% EU average. The sharp increases in housing prices have worsened most household affordability ratios. Mortgages account for the bulk of household debt, which stood at 180% of total net disposable income in the first quarter of 2022 (Banque Centrale du Luxembourg, 2022[19]) (Figure 1.9). Price-to-income ratios are well above their long-term trends. Aggregate debt service to income ratios have remained high since 2018 at above 40% for all income categories. Loan-to-value ratios of new loans increased since 2018 from 73.0% to 76.5%. New loans are increasingly weighted towards those with higher incomes.

The risks to the financial sector from the housing market boom require continued monitoring. Aggregate sector exposures are low: household debt makes up just under 10% of the total banking loans issued, and almost two-thirds of that are in Luxembourgish mortgages. However, most of this debt is held by a handful of Luxembourgish banks, who hold on average 22% of their assets in mortgages. This concentration requires intensified monitoring, as these banks could suffer difficulties if house prices decline in response to higher interest rates.

From a household perspective, higher interest rates could increase payment obligations and the vulnerability of certain borrowers, particularly those with lower incomes. 51% of homeowners still have variable rate loans (Banque Centrale du Luxembourg, 2022[19]), even though since 2015, most new loans have been issued at a fixed rate, and central bank estimates of loan origination suggests many households renegotiated at lower fixed rate mortgages (Banque Centrale de Luxembourg, 2022[20]). Valuation gains in houses and holdings of liquid assets should help borrowers smooth any shocks to interest payments. Residential real estate data from the regulator (Commission de Surveillance du Secteur Financier-CSSF), shows that debt-service-to-income ratios of lower- and medium-income households (earning less than

EUR 75 000 a year) are 42%, similar to the 40% average of all households. Debt-to-income ratios are 999% for lower and middle-income households, compared to an average of 1024% for all households. 31% of low-income households in Luxembourg are overburdened by housing costs, compared to 28% in the European Union, according to the 2020 Eurostat *Survey on Income and Living Conditions* (Koulischer, Perray and Tran, 2021[21]). Luxembourg faces a much lower risk of default on mortgages within five years in the case of job loss than t neighbouring countries (3% compared to 10%) (IMF, 2021[22]). Nonetheless, the IMF (IMF, 2021[22]) estimates that low and middle-income households face a much higher risk of default (30%) than this average, in the event of losing their job.

The authorities activated several new macroprudential policy measures in 2021 to protect borrowers from housing market risks. As of January 2021, legally binding loan-to-value limits have been put in place, of 80% for buy-to-let loans, 90% for primary residence loans and 100% for first time buyers. A higher countercyclical capital buffer requirement of 0.5% of common equity tier 1 capital was also introduced in 2021. Macroprudential policy may have helped to reduce tail-risks for new borrowers (IMF, 2021[22]) According to the CSSF, 35% of new loans with a debt-to-income ratio above 900% went to lower-income households in the second half of 2021, down from 41% a year earlier. The current rising interest rate cycle is expected to further reduce risk appetite, mortgage lending and house prices. Nonetheless, authorities should stand ready to apply additional macroprudential measures if needed. In Norway, Sweden and Denmark, countries with buoyant housing markets, counter-cyclical capital buffers are 1.5% and will increase further in 2023.

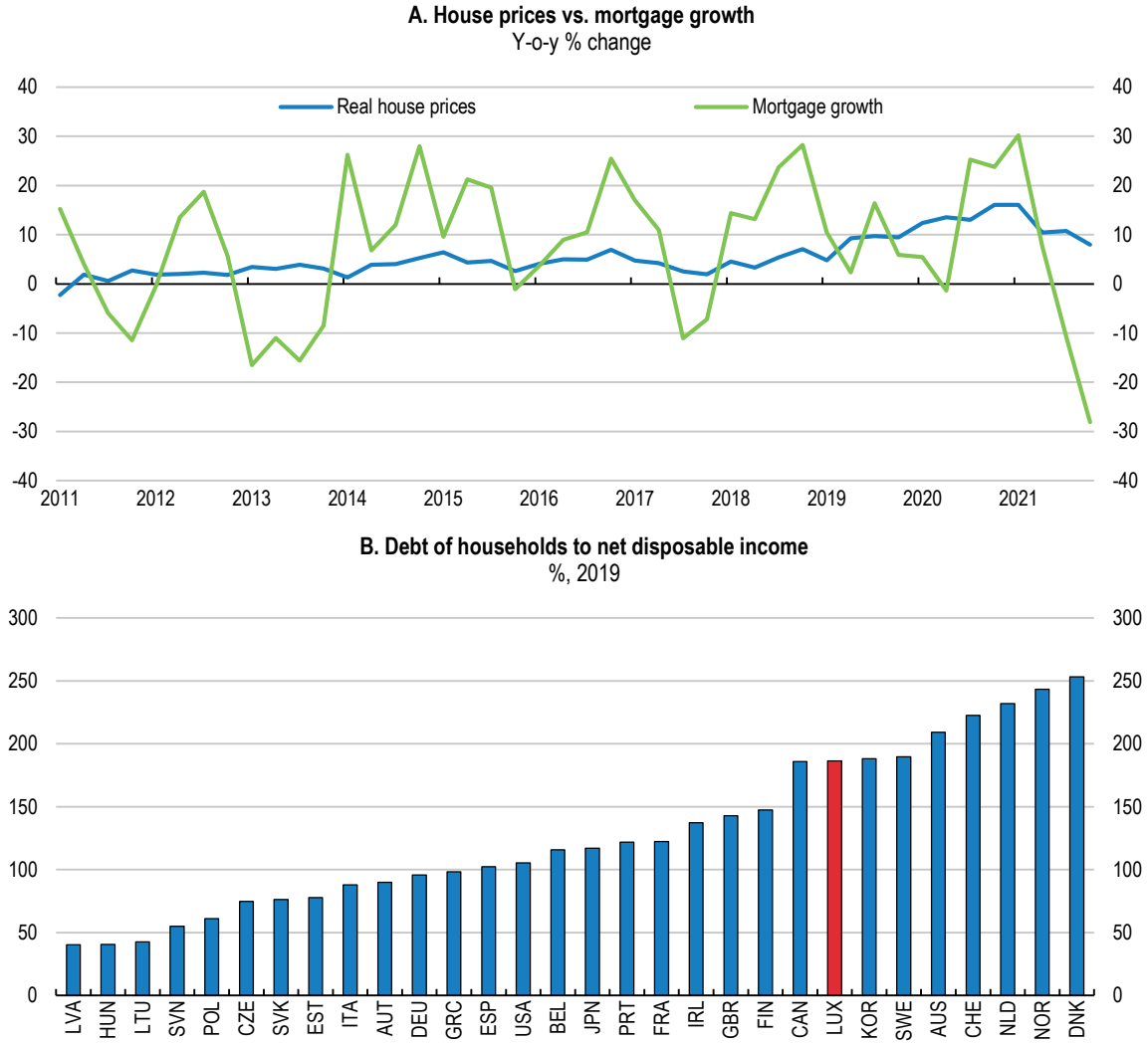
Borrower-based measures such as debt service to income caps can help mitigate risks whilst potentially restricting access for first-time buyers less (OECD, 2021[23]). An expanded set of regularly updated public data to evaluate housing market developments and risks by household borrower types could support policy co-ordination. For example, higher interest rates or macroprudential policy to reduce borrower vulnerability could reduce mortgage access for certain types of borrowers, who might be in a particular need of a mortgage to finance deep renovations to green their homes. A regularly published report, with analysis according to household income categories as well as buyer types, could increase information to policy makers and the market. For example, the Swedish Financial Supervisory Authority publishes an annual report on the local mortgage market, with detailed information on the volume and distribution of household debt, as well as stress-test related information. Expanding the set of aggregate indicators to also estimate the risks of over-consumption and over-investment associated with the housing market would improve understanding of the channels through which the housing boom may affect macroeconomic stability (Svensson, 2020[24]). The Bank of England for example provides estimates of housing equity withdrawal.

In addition to macroprudential measures, a wide range of measures will be necessary to increase the flexibility of housing supply over the long term. Structural factors have played an important role in supporting high house-price growth. Land hoarding and high administrative costs (*e.g.* lengthy building permissions procedures) have hindered investment in the housing stock, exacerbating the impact of continued population growth, shrinking household sizes and demand for larger homes (OECD, 2019[25]; Reinesch, 2022[26]; Paccoud et al., 2021[27]; Observatoire de l'habitat, 2022[28]).

The government has taken steps to raise housing supply (Table 1.3). Planned increases in national tax rates for vacant land and unused buildings to discourage land hoarding are welcome and must be implemented quickly (OECD, 2019[25]). Increasing the supply of affordable housing is a core focus of the government's strategy. The *Pacte Logement 2.0*, released in 2021, includes technical and financial support for municipalities to develop their affordable housing strategies, and financial incentives to increase the supply of rental housing. Social housing must make up a defined minimum amount in new developments under the special development plan, which will be transferred to municipalities or the state. The supply of government-built affordable housing units is expected to increase by approximately 200 units a year. Housing supply incentives should only apply to areas identified for development in the Master Programme for Spatial Planning, to discourage further urban sprawl and car usage (see Chapter 2). Encouraging greater densification of homes alongside energy efficiency renovations could help to reduce the pressure

on the built environment and reduce the potential trade-off between housing supply and resource intensity (see Chapter 2).

Figure 1.9. The housing market continues to place households under pressure



Source: OECD Analytical house price indicators; Banque Centrale du Luxembourg; and OECD, National Accounts at a Glance.

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Mortgage interest deductions for owner occupied property should be removed gradually to reduce distortions in housing demand, which favour wealthier households (OECD, 2019[25]). To ensure that this does not hurt access to the housing market, the interest deduction could be replaced by more targeted measures, such as an income-tested property tax credit (Causa, Woloszko and Leite, 2019[29]). In the United States and Canada, some regional governments provide lump sum exemptions, whilst others provide support in the form of tax credits to low-income families (Brys et al., 2016[30]). Increasing immovable property taxes could bring wider socioeconomic benefits. Whilst corporate wealth taxes are relatively high, Luxembourg currently collects almost no recurrent taxes on immovable property compared to a level of 1% of GDP on average in the OECD. In addition to potentially raising revenue (OECD, 2018[31]) and increasing housing supply, higher immovable property taxes could support a more sustainable housing market and encourage investments in other assets, rather than residential property. The liquidity impact of raising property taxes on people with low incomes and non-liquid assets could be managed by spreading immovable property tax payments throughout the year.

Table 1.3. Previous recommendations to boost economic resilience and access to housing

Recommendation	Action taken
Produce additional macro prudential measures, such as limits to loan-to-value or loan-to-income ratios.	The law of 4 December 2019 sets out the macroprudential framework for activating borrower-based measures, such as limits to loan-to-value, debt-to-income and debt-service-to-income. Binding loan to value limits became effective on 1 January 2021.
To increase the stock of social rental housing while preserving social mixity, directly finance new land acquisition by public providers of social housing.	Public spending on the creation of affordable housing has increased from EUR 40 million in 2017 to EUR 170 million in 2021. Legislation to finance the construction of at least 6000 homes with a cost of over EUR 1.5 billion was approved. The *Pacte Logement 2.0* increased local authorities' power to purchase land and set minimum social housing requirements for developments that will pass to the hands of the state. Developers will in exchange be allowed to densify the land more than current regulations.
Increase taxation of non-used constructible land. Turn recurrent taxes on immovable property into a more important fiscal resource, *e.g.* by regularly aligning the tax base with the market price of the property.	As part of a wider reform to map all properties and update cadastre values, it is planned to impose taxation on unused, constructible land. A full review of the cadastre, with a view to updating property values and mapping unused land and housing is being undertaken in 2022.
Phase out or at least reduce the current mortgage interest deduction	No action taken.
Link housing allowances and rents in the social housing sector to reference rents at the local level, in order to ensure lower-income households' access to areas in the city centre.	No action taken.

Financial risks need to keep being closely monitored

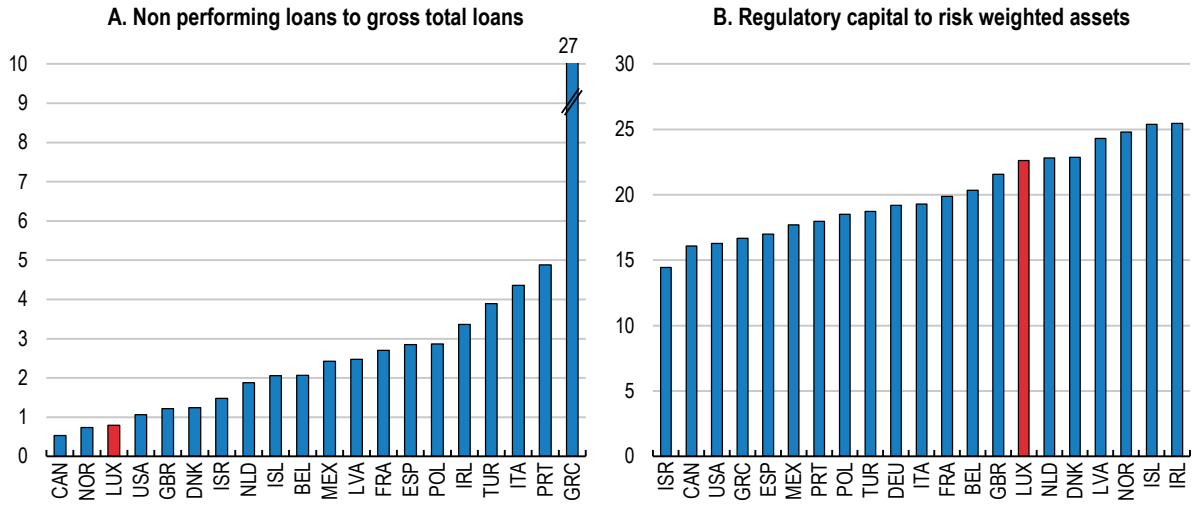
Low interest rates in recent years have been supporting high levels of demand and risk appetite, which in turn have underpinned rising asset prices. Luxembourg has benefitted from the resultant steady growth in financial market activity. However, low rates have also imposed costs. Low interest rates have contributed to low bank profitability, as in most of Europe. More recently, the robust local economic recovery in the context of the low interest rates has contributed to accelerating inflation. The lags in price setting could mean that inflation continues to increase even as economic activity slows in response to higher interest rates. If the euro area monetary policy stance proves too loose for Luxembourg, additional financial (but also fiscal, see next section) measures might need to be taken.

Luxembourg's financial industry is well placed to cope with potential risks, and several steps have been taken since the last *Economic Survey* to raise its resilience (Table 1.4). Assets held by the financial sector grew by a robust 24% between 2019 and 2021. Supportive global fiscal and monetary policy offset market turbulence and the COVID-19 crisis. Non-performing loans are low as a share of total assets compared to OECD counterparts (Figure 1.10, panel A). Regulatory capital buffers are high (Figure 1.10, panel B), and liquidity has been increasing, even as capital buffers have fallen. The banking sector received around 60% of its deposits from financial intermediaries in 2021. Historically, investment funds' bank deposits have increased in periods of high volatility. Authorities have continuously enhanced system-wide oversight of the investment funds sector. The proactive stance of regulators and firms in developing products to best utilise the green and digital transitions has maintained the attractiveness of Luxembourg as a financial market.

Nonetheless, as global monetary policy tightens, strains will increase, warranting continued monitoring. In March 2022, it was estimated that 17% of Luxembourgish banks had made a loss in 2021 (CSSF, 2022[32]). Higher rates should help to restore profits over the long term for both insurers and banks. However, in the short term, both banks and insurers will have to contend with the drop in the market value of their fixed-income holdings. In addition, non-performing loans are likely to rise further in 2022 and beyond, given that the war implies a second shock in quick succession for vulnerable firms, not just in Luxembourg but in Europe as a whole. Support from EU governments for firms affected by the war has not been as large as during the COVID-19 pandemic, although loan guarantee schemes have been increased in many countries including Luxembourg, helping to mitigate credit risk somewhat (Table 1.4). Heightened financial market

volatility could prompt outflows and procyclical asset sales by investment funds, particularly open-ended ones. The authorities should continue to monitor banking exposures, including large cross-border exposures and intra-group transactions. They have undertaken a number of efforts to strengthen the investment fund sector's macroprudential monitoring, including system-wide liquidity stress testing, and these efforts should continue.

Figure 1.10. The financial sector is in a strong position to respond to additional shocks



Note: Data for 2021 for Denmark, Iceland, Latvia, Luxembourg and Poland. All other countries 2020.
Source: IMF Financial Soundness Indicators.

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Table 1.4. Previous recommendations to improve fiscal resilience and financial market surveillance

Recommendation	Action taken
Develop further the capacity to undertake regular system-wide stress tests of fund-bank linkages and consider publishing their results.	The domestic regulator (CSSF) now runs fund-bank interlinkage stress tests twice a year. High-level results are shared with interested external public organisations.
Improve access to credit for SMEs by introducing a central credit registry	Anacredit, a central credit register for Luxembourg, is currently under construction by the BCL in co-operation with the European System of Central Banks.
Continue to engage in international efforts to address tax challenges of cross-border activities and to strengthen tax transparency.	Luxembourg has transposed directives implementing automatic exchange of information and introduced several OECD BEPS measures. Legislation has been passed to strengthen beneficial owners' registers, with a new register created for trusts and requiring foreign nationals to use a national identity number in the companies register.
Allow automatic stabilisers to work in case of a downturn and, if it intensifies, implement a countercyclical fiscal expansion.	The government has responded to ongoing shocks. COVID-19 support measures included direct income support to households and financing of partial unemployment and maintenance of minimum wages. Support to firms included direct transfers and furlough schemes to meet staff costs. The total cost was over 4.2% of GDP and 8.6% of public expenditure. Support packages have also been implemented to respond to high energy prices.

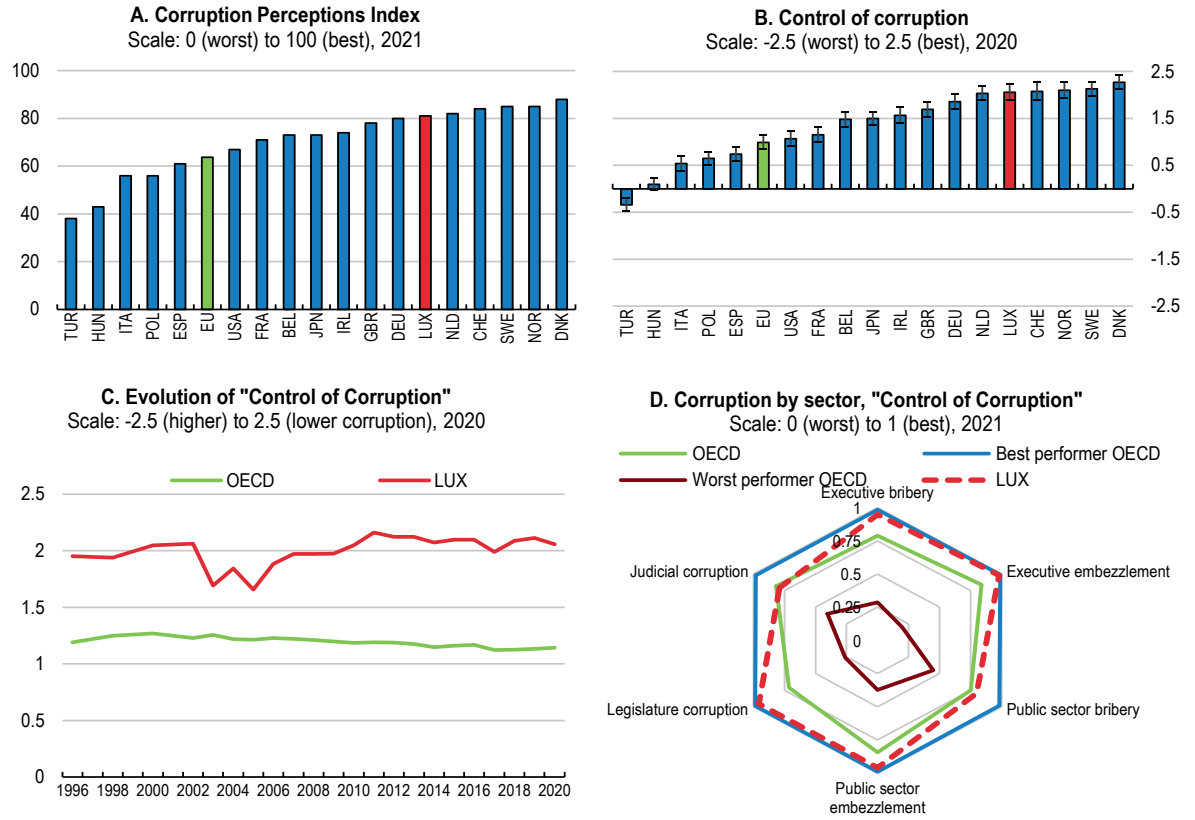
The fight against money laundering has been given greater prominence

The authorities have further strengthened legislation to reduce the risks of money laundering and corruption since the last *Economic Survey*. Important advances include strengthening beneficial owners' registers, with a new register created for trusts and requiring foreign nationals to use a national identity number in the companies register. This activity is appropriate given the need to maintain the standing of Luxembourg in global finance. Compulsory compliance with the national identity numbers system should be accelerated, instead of leaving an open-ended timeline.

Luxembourg's digital sophistication could be better harnessed in the fight against money laundering. Big data techniques are used by the prudential regulator to identify risks related to investment funds. They should be a core part of the strategy employed by the prudential supervisor to assist the Department of Justice to identify an increased number of cases for audit based on risk profiles. In France, for example, the prudential authority makes use of artificial intelligence and machine learning to understand risks. The prudential regulator could also provide guidance on how to manage anti-money laundering risks using artificial intelligence and machine learning, in much the same way it published guidance on the use of distributed ledger technologies and blockchain (CSSF, 2022[33]). In Hong Kong, case studies of "Reg-tech" solutions have been published to provide concrete examples to the market on how to tackle risks, including verifying customer identity and monitoring transactions (Ashurst, 2022[34]). Sharing information across financial institutions can also be a way to investigate risks, if privacy risks are appropriately managed. In Singapore, the monetary authorities have been working with six of the largest financial institutions to create a safe data platform to share information (Ashurst, 2022[34]).

Overall perceptions of corruption remain low in the country, with Luxembourg one of the best performers in the OECD (Figure 1.11) A constitutional amendment is underway to strengthen the independence of the judiciary from an already high standard. It seeks to introduce a council that will select magisterial candidates before they are appointed by the Grand Duke (European Commission, 2021[35]). Legal protection for whistle-blowers was strengthened with the transposition of the European Whistle-blowers Act. The framework to govern conflicts of interest could be strengthened through extending the current revolving doors policy beyond members of government (European Commission, 2021[35]) and the disclosure of assets and gifts (GRECO, 2020[36]).

Figure 1.11. Perceptions of corruption are low



Note: Panel B shows the point estimate and the margin of error. Panel D shows sector-based subcomponents of the "Control of Corruption" indicator by the Varieties of Democracy Project.

Source: Panel A: Transparency International; Panels B & C: World Bank, Worldwide Governance Indicators; Panel D: Varieties of Democracy Project, V-Dem Dataset v12.

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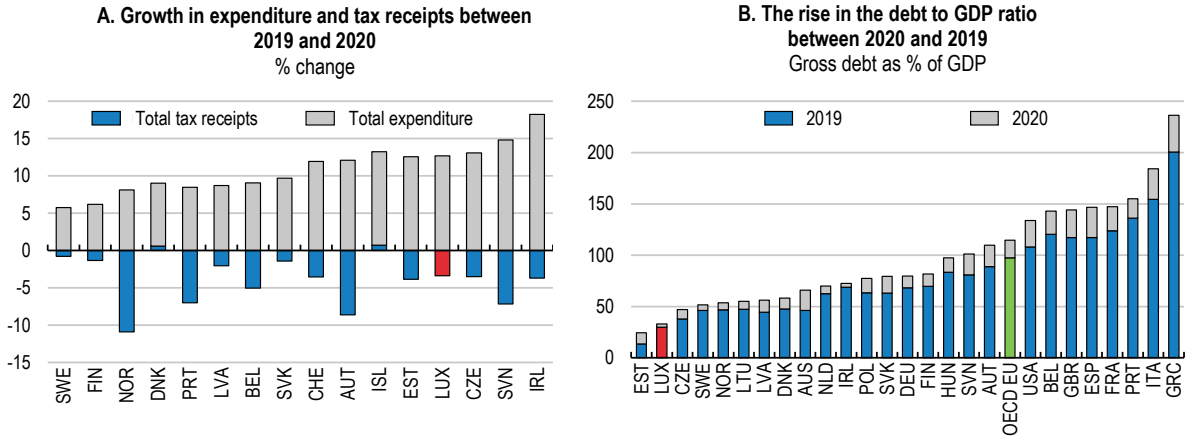
Fiscal policy should be used to tackle long-term challenges

Significant fiscal policy support has been provided, but debt remains low

Policy support during the coronavirus crisis was substantial, mainly thanks to a sharp increase in spending (Figure 1.12, panel A). Nonetheless, the rise in total debt was markedly less than in most OECD peers (Figure 1.12, panel B) and well below the 8.5 percentage points increase in debt following the global financial crisis. This is mainly due to the resilience of tax revenues and economic growth during the COVID-19 pandemic.

The impact of the war in Ukraine accounts for most of the increase in support in 2022, offsetting the withdrawal of COVID-19 related measures. The budget deficit, according to the government's latest estimates (Ministère des Finances, 2022[37]), will gradually return to balance by 2026. In the context of rising but still very low real interest rates, tight labour markets and rising inflation, fiscal policy support should be highly targeted to the most vulnerable, to avoid contributing to cyclical inflationary pressures.

Figure 1.12. Debt levels remained contained despite a strong policy response to the COVID-19 crisis



Source: OECD Government at a Glance (database) OECD calculations.

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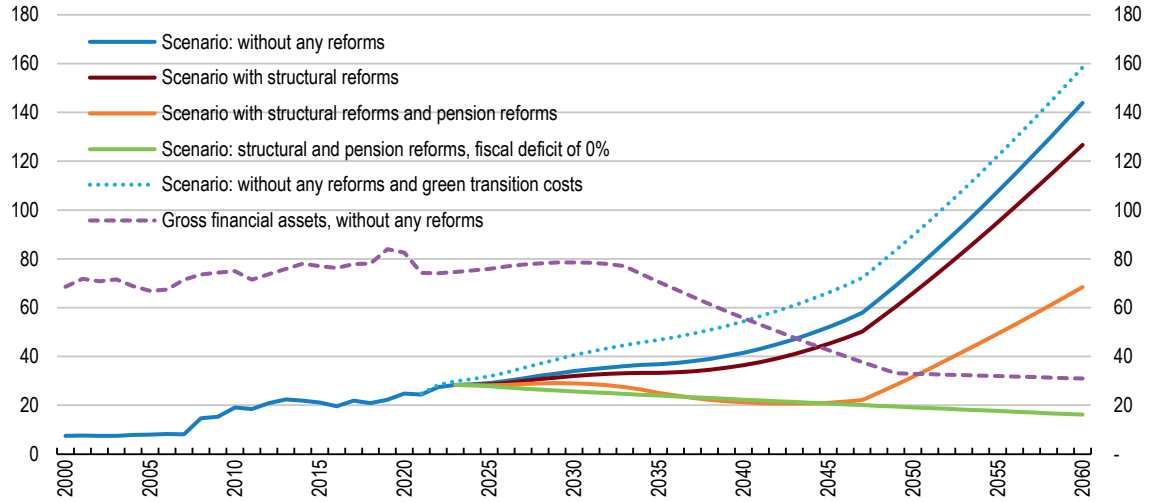
The largest risk to the long-run debt outlook remains pension spending. Luxembourg's very low current levels of gross debt as well as sizeable public assets will provide an important buffer. Total public assets stand at over 80% of GDP, reflecting both large numbers of state-owned companies in key utilities, as well as sizable holdings in certain private companies. Over the longer term, however, spending pressures related to ageing will reduce fiscal flexibility in the face of shocks (Figure 1.13). The draw-down of pension assets between 2030 and 2050 will help to offset rising pension costs, but once these assets are sold, pension liabilities are projected to rise steeply in the absence of meaningful pension reform.

Even a significantly higher rate of growth would require difficult fiscal choices to keep pension liabilities in check. The recent report assessing the pensions system showed employment growth of 2.7% is required alongside a reduction of an adjustment to real wages of benefits, in order for the system to be sustainable over the long term (IGSS, 2022[38]). STATEC's 3% long-term growth scenario (Haas and Peltier, 2017[39]) projects employment growth of 0.7% per annum, with 50% of the workforce as cross-border workers. Employment growth of nearly 3% would imply a substantial increase in growth and demand for housing, transport, and energy, which would further compound the challenges of the green transition. Therefore, pension system reform is crucial for economic resilience.

Figure 1.13. Ageing is the largest long-term fiscal risk and cannot be solved with growth alone

Gross public debt, Maastricht definition, % of GDP



Note: The scenario with no ageing related reforms includes the impact of projected rising net public pensions, long-term care and health costs, consistent with European Commission estimates, which add 8.6 percentage points of GDP to annual government spending in 2060. The drawing down on pension fund reserves from 2027, reflected by the decline in gross financial assets, helps fund pension spending increases until the late 2040s, when pension reserves reach zero. Non-pensions gross financial assets grow at 0.61% per annum throughout the forecast, the average annual return over 2000-20. Pensions reforms including raising contribution rates, raising early retirement to 62 years, linking retirement to life expectancy, increasing migration by 33% and raising the employment rate of older workers by 10 percentage points. The structural reforms scenario assumes real GDP growth is 1 percentage point higher each year compared to the baseline due to structural reform implementation. The costs of the green transition are based on achieving a range of targets set by the government. This list is non-exhaustive and subject to significant uncertainty, including the pace of the transition and the costs of financing, and do not include any revenue effects from the transition.
Source: Adapted from OECD (2021) Economic Outlook: Statistics and Projections (database); and Long-term baseline projections; (European Commission, 2021[8])

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The challenges of the green transition will also need to be accommodated. The government has already undertaken a number of measures to encourage greater energy efficiency, including in response to the energy crisis. Direct investments and subsidies to support the green transition investments will require sustained spending commitments, in addition to private investment. The rate at which spending rises will vary according to the price of carbon, the generosity of subsidies as well as take-up rates. Forecasting the direction of revenues from the transition is less certain. The potential revenue gains or losses from a carbon tax, and how they might be used, will depend on various factors, including the chosen level of carbon tax and how neighbouring countries' fuel pricing will evolve (see Chapter 2). Table 1.7 highlights potential net fiscal implications of the green transition at -0.35% of GDP annually over the medium term. The uncertainty of this estimate increases over the long term, as levels of uptake on subsidies and infrastructure spending plans evolve.

The green transition could also have significant growth implications for Luxembourg. Chapter 2 presents a modelling exercise which suggests the economic impact of a rising carbon tax on the economy would be slightly positive if carbon tax revenues were positive and redistributed. However, there are also downside risks – for example, a disorderly global green transition could have knock-on effects on the Luxembourgish economy, substantially lowering long-term growth. Given the uncertainty of the green transition's fiscal impact, integrating it into the budget framework would allow for a holistic approach to public debates regarding other long-term spending commitments such as pensions. Chapter 2 recommends enhancements to the fiscal framework to take these considerations into account.

Box 1.1. Quantification of the structural reforms recommended in this Survey

This box shows the results of quantifying the effect of some of the structural reform measures proposed for Luxembourg in this Survey, based on an OECD quantification framework (Égert and Gal, 2017[40]; Guillemette and Turner, 2021[10]). The effects are derived from a series of reduced-form regressions on a sample of OECD countries (in some samples, non-OECD countries are included as well). The estimated results are allowed to vary across countries because of differences in factor shares, the level of employment by age group, and a country's demographic composition. The approach is meant to serve as an illustration of a potential impact of reform and is not a projection. Therefore, it should be treated with care.

Additional positive effects could be expected from other recommendations, notably to reduce friction in the labour market and improvements to the business environment, but these are harder to quantify. Examples include a reform to the insolvency regime, streamlining of the administrative burden for firms and broader measures to reduce financial risks (which would have the effect of reducing the frequency and severity of financial crises, and therefore the associated economic risks).

Table 1.5. Illustrative impact of structural reforms on GDP per capita

Effect on GDP per capita levels*

	5-year effect	10-year effect
Product market regulation (PMR)		
Make professional regulations less restrictive	0.6%	0.9%
Labour market policies		
Improve active labour market policies, such as training**	0.4%	0.5%
Capital deepening		
Increase R&D spending by firms through encouraging matching	0.5%	1.1%
Pension reform		
Increase the retirement age by 2 years over 5 years	0.3%	0.4%
Total increase in GDP per capita	**1.8%**	**2.9%**

Note: Calculations are based on (1) a reduction in the OECD Product Market Regulations sub-indicator of professional services regulations to the average of the best-performing (i.e. less restrictive) OECD countries, which corresponds to lowering the overall PMR indicator from 1.68 to 1.33; (2) increasing ALMP spending as a share of GDP by 0.1pps of GDP to approach the top-third of OECD countries (from 0.75% of GDP to 0.80% of GDP); which corresponds to increase spending per unemployed as a ratio of GDP per capita from 27% to 30%; (3) increasing capital deepening by increasing business spending on R&D from 54% of total spending to 62% (against an OECD average of 64%); and (4), increase the legal retirement age by 2 years, gradually phased in over a five-year period, with policies to limit early retirement. * Projected increases in GDP per capital levels. ** Improving ALMP increases multifactor productivity as well as the employment rate, both of which will lift GDP per capita over time.
Source: OECD calculations based on (Égert and Gal, 2017[40]).

Table 1.6. Growth impact of pension reform

Expected growth effect on the variables after increasing the effective retirement age by 2 years

	5 years	10 years
Potential percentage point increase in the growth rate of GDP	0.38	0.20
Employment rate, men and women	2.0	3.33

Source: OECD calculations based on (Guillemette and Turner, 2021[41]).

The fiscal framework's resilience to shocks can be increased

The fiscal framework could be enhanced to improve resilience in the face of more frequent shocks. Economies are exposed to a rising number of physical shocks (Centre for Research on the Epidemiology of Disasters, 2022[42]) (Figure 1.14), whilst the COVID-19 outbreak highlighted how interconnectedness increases the likelihood of pandemics (Marani et al., 2021[43]); (Smith et al., 2014[44]). Russia's war of aggression against Ukraine has ushered in a period of heightened geopolitical uncertainty. At the same time, expectations have risen that policy makers can and should play a significant role in absorbing these shocks, acting as a lender of last resort and protecting the most vulnerable (Office for Budget Responsibility, 2021[45]).

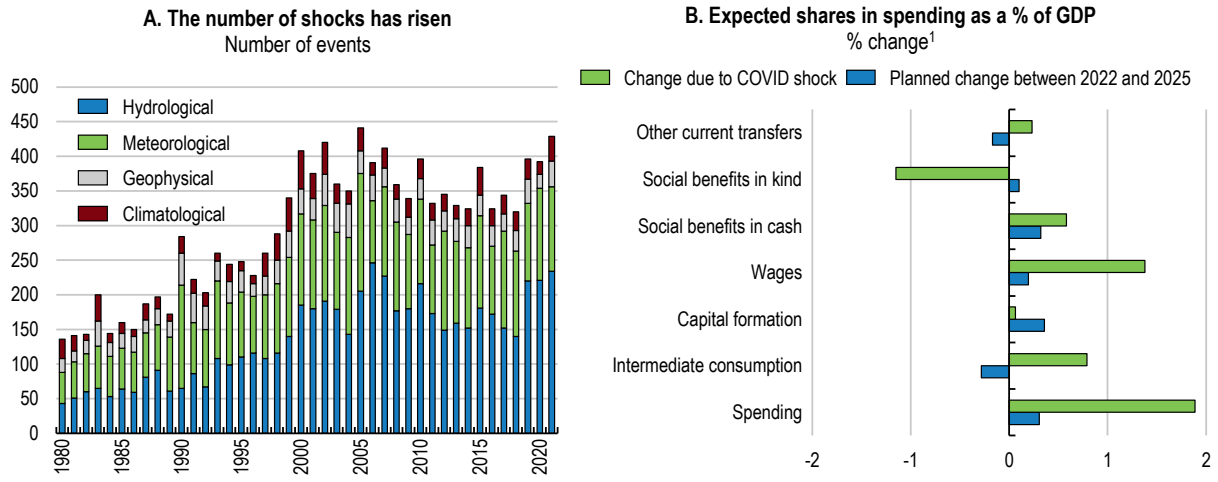
Having a range of policy tools in place contributes to resilience. Automatic stabilisers and fiscal rules are crucial to allow governments to respond quickly to crises (Orszag, Rubin and Stiglitz, 2021[46]). Luxembourg's low level of public debt is its principal fiscal shock absorber, and the government has committed to keeping public debt levels below 30% of GDP. The size of the automatic stabilisers, which are important to absorb immediate shock impacts, are estimated to be in line with that in peers (Maravalle and Rawdanowicz, 2020[47]) or slightly larger (Bouabdallah et al., 2020[48]). Discretionary spending policies are necessary when the impact of the shock is expected to be persistent (Bouabdallah et al., 2020[48]). If the shock is permanent, automatic stabilisers may no longer work as effectively as before because the structure of the economy has changed. In addition, specific policies may be required to address fundamental shifts in behaviour or prices that are not affected by existing automatic stabilisers. In this instance, governments should prioritise high-impact programmes for long-term resilience (OECD, 2021[49]).

The identification of high-impact policies can be difficult. In Luxembourg as elsewhere, evaluation of the impact of policy choices has been insufficient – for example, spending reviews have not been used since they were applied to achieve significant budget cuts in 2014. Budget documentation does not systematically reference performance information or evaluations. Even though periodic *ex-post* evaluations of regulations have been undertaken in Luxembourg, they are not a consistently applied tool (OECD, 2021[50]). The OECD and the European Commission (OECD and European Commission, 2020[51]) noted that a missing culture of evidence-based policy making may result in insufficient investments in human and financial resources to adequately draw on administrative data in the development of policies.

An evaluation framework, including a clear methodology, could help to ensure that regulations remain fit for purpose – and that associated spending is appropriate. A system to link rigorous policy evaluation directly to the budget allocation process would significantly improve the capacity of the fiscal framework to respond to shocks and their aftermath. A large crisis can have a lasting impact on the composition of spending that outweighs the impact of traditional budget planning choices (Figure 1.14, panel B). Greater input from the independent fiscal institution on the quality of spending and its overall growth impact could stimulate greater debate on policy choices, if its mandate were expanded.

Advances in information technology could be used more proactively in Luxembourg to support a performance-oriented budget (see Box 1.3). Notably, a clear policy commitment to open and transparent data evaluation should help motivate additional funding. Anonymised social security data are already provided to public researchers via the Luxembourg Microdata Platform on Labour and Social Protection and were a valuable source of information for understanding the impact of COVID-19. Luxembourg's high quality administrative data could be anonymised and made available to the broader research community. Digitised tax data could allow for more granular impact evaluations. The project to evaluate COVID-19 policy responses (OCDE, 2022[10]) has linked firm-level and administrative data, which can be used to monitor on an ongoing basis where policy support is being directed. Including additional policy measures will develop a credible evidence base, which can be used to inform the design of spending programmes further into the future.

Figure 1.14. Shocks are becoming more frequent – and can have a lasting impact on spending choices



1. Change in spending from the COVID-19 shock is calculated as the difference between the 2022 and 2019 budget projections for 2022 spending. Despite the relatively small changes, the projected increases for investment spending and social spending are sizable, as per OECD and EC recommendations to provide ongoing social support from the crisis. Investment spending will grow 6.5% a year, reaching 4.7% of GDP by 2025.

Source: OECD calculations based on the Emergency Events Database (Centre for Research on the Epidemiology of Disasters, 2022[42]); and Ministère des Finances (2021, 2018).

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Box 1.2. Estimated fiscal impact of reform

The table illustrates the potential impact on the fiscal balance of implementing some of the reforms proposed in this study. The estimates are meant to show the potential direction of change and to provide an indication of magnitude. Actual results may differ, and the estimates below are merely illustrative.

Table 1.7. Fiscal implications of reform

Medium-term expected annual change as a % share of GDP

Measure	Medium term fiscal impact (savings (+)/costs (-)) % of GDP
Carbon tax[1]	-0.1%
Road use charges[2]	+0.2%
Support communities which densify and go green by significantly expanding the density bonus to EUR 25k per home[3]	-0.3%
Increased provisioning for infrastructure investments[4]	-0.15%
Property tax[5]	+0.4%
Pensions savings[6]	+0.7%
Direct income support for households most vulnerable to price increases[7]	-0.11%
ALMP training[8]	-0.1%
Total	**+0.5%**
Of which: Green policies	-0.35%

Notes: 1. STATEC near-term estimates for an increase in carbon tax to EUR 30 per tonne by 2023. Preliminary modelling estimates that consider the direct impact of the carbon tax on revenue suggest a 0.05% decline in revenue in 2025, assuming a carbon tax of EUR 50 per tonne by that time. Over the longer term, revenue receipts are expected to rise (see chapter 2, Box 2.3 for more details). 2. Based on surcharge of 5 cents per km and 20% reduction in car use for travel. Only work-related travel included. 3. Assumes 8 400 homes a year renovated receiving EUR 25 000 a home. 4. Increased infrastructure provisioning to cover the cost of higher maintenance and potential upgrades to *e.g.* hydrogen fuelling. 5. Assumes current municipal tax rates apply to 8% of the existing residential buildings and 1 115 hectares of vacant land. 6. Most pension gains accrue later (see Table 1.5 and Table 1.6). 7. Assumes poorest 40% of households receive the equivalent of a 2.5% wage increase every 15 months. 8. Increase total ALMP spending towards the top 10 OECD performers.

Source: OECD calculations.

Box 1.3. Key elements to consider in designing a more performance-oriented budget framework

A strategic link with the budget. In Chile, the budget law requires evaluations to be considered in the budget process, whilst in Canada, ministries are encouraged to present evidence from evaluations as part of their budget submissions.

A prioritised and planned process. Continuous evaluation should give priority to high value, high risk and politically important programmes. Rather than a fixed schedule, Canada's policy for results prioritises evaluations based on a schedule of risk and other considerations. In the Netherlands, performance information is only selectively presented in the budget, which has increased its relevance. Clarity about the schedule of evaluations also helps stakeholders to prepare for engagements - which is a practice rarely implemented in Luxembourg.

Supporting co-operation alongside accountability. Policy evaluation can become a tick-box exercise, when strategy is sacrificed for completeness; it can also become a compliance tool rather than an instrument for identifying the best tools to use. In Canada, line ministries are responsible for prioritising and undertaking the evaluation of programmes and individual projects. All findings must be made public, and ministries must also explain why they are not evaluating certain programmes. The Treasury Board may also independently evaluate programmes. In the Netherlands, the budget system's performance metrics have been decoupled from the audit process.

An evolutionary approach. The implementation of an evaluation framework involves multiple stakeholders and takes time to implement successfully. In the Netherlands, the performance budgeting system has been evolving since 2008. In addition, generally, evaluations require time for data collection and for policies to impact policy. Australia conducts post-implementation reviews two to five years after policy implementation.

Administrative datasets in the public sector offer a significant opportunity for policy impact assessments, particularly when combined across sources. Tapping this potential requires a strong commitment to preserve confidentiality and anonymity, a well-documented and understood process for combining and analysing administrative datasets, and a secure way of sharing information with external researchers and institutions. In Luxembourg, the General Inspectorate for Social Security has developed state-of-the-art protocols for sharing anonymised social security data, in line with the general data protection regulation, which could be used for other administrative datasets. A single entity responsible for pooling administrative data together is a significant benefit. In Norway, Statistics Norway matches numerous administrative datasets and provides this anonymised and encrypted data to external institutions and researchers.

In Luxembourg, a pilot programme focused on a limited set of policy goals, such as understanding the impact of policies on the green transition (see chapter 2) or on well-being, could be applied to a small set of high-impact, high-value policy programmes as a mechanism to develop the system in practice.

Source: (Barth, 2012[52]); (Budding, Faber and Vosselman, 2019[53]); (de Jong, 2016[54]); (OECD and European Commission, 2020[51]); (OECD, 2018[55]); (OECD, 2020[56]); (OECD, 2021[50]).

Ageing costs from pensions are the largest long-term fiscal liability

OECD projections indicate that pension and health expenditure will increase fiscal pressure significantly by 2060 (Guillemette and Turner, 2021[41]). European Commission projections show a similar trend, with total age-related expenditure projected to rise from 16.9% of GDP in 2019 to 27.3% of GDP in 2070, with the bulk of the increase due to old-age pensions (European Commission, 2021[8]). By 2070, the European Commission projects pension expenditures alone to rise to 18% of GDP, the steepest increase in the European Union (Figure 1.15) (European Commission, 2021[8]), as the old-age dependency ratio will more than double by 2070 (Table 1.8). Domestic projections point to a more contained, but still high, increase in pension expenditure to 14.5% of GDP, based on more favourable assumptions on employment and economic growth related to cross-border workers and levels of immigration (IGSS, 2021[57]).

Reform of the pension system is needed to ensure financial sustainability

The government has undertaken the ten-year review of the sustainability of the pension system foreseen in the 2012 pension reform (see Box 1.4) to assess whether the current total contribution rate of 24% should be revised for the next ten-year coverage period 2023-2032 (IGSS, 2021[57]). An interim review in 2016 recommended no changes. The review provides an important opportunity for new reforms to ensure the pension system's financial sustainability whilst having positive impacts on the labour market. In the near term, the pension system enjoys a surplus of contributions over outlays, thanks to favourable labour market dynamics (IGSS, 2022[38]). Surpluses are accumulated in the pension reserve fund (*Fonds de Compensation*) which stood at 37% of GDP by end-2020 (OECD, 2019[25]; IGSS, 2021[57]; European Commission, 2021[4]). But, if no changes are proposed, simulations indicate the system will move into deficit in the early 2030s, and the authorities will start using the pension reserve fund to make up for shortfalls; the reserve would be depleted in the late 2040s (IGSS, 2022[38]). Therefore, the authorities should explore all possible options, in consultation with social partners, to ensure the affordability of the pension system and enhance intergenerational equity.

Since the 2012 reform, a deficit in the '*prime de répartition pure*'-indicator, which measures the theoretical contribution rate needed to cover the system's current expenditure, is expected to trigger a semi-automatic stabiliser: a reduction of the indexation of pensions to real-wage developments. However, this stabilisation mechanism will be insufficient to prevent the deficit from widening, in part because the large cohorts who moved to Luxembourg during the great economic expansion in the late 1980s and 1990s are set to start retiring from the early-to-mid 2020s boosting pension expenditure (IGSS, 2022[38]). Rather than waiting for the system to tip into deficit, corrective measures should be implemented sooner rather than later. For instance, the indexation of pensions to real wages could be put on hold until replacement rates reach more sustainable levels, whilst ensuring protection of the most vulnerable pensioners.

By delaying action, the size of any future adjustments is likely to be larger, implying that a heavier burden of the adjustment would fall on the contribution rate. Current estimates point to the contribution rate needing to increase to between 31% and 35% by 2070 from 24% currently, under the assumption of no change in policy (IGSS, 2022[38]). This in turn would strongly raise the tax wedge on labour, penalising lower-income and younger workers.

Box 1.4. Overview of Luxembourg's pension system

Luxembourg's general pension system is a mandatory, pay-as-you-go system, with defined benefits. The contribution rate is 24% of gross salary, paid in equal shares by employers, employees, and the state. Occupational pension schemes are a very small part of the total. Since 2019, they have been open to the self-employed. Fewer than 4% of workers have a private pension. There is a separate scheme for public employees.

The statutory retirement age is 65 years for men and women. Early retirement is possible at 57 if an individual has 40 contributory years, and from 60 onwards with 40 contributory and qualifying non-contributory years (*e.g.,* study, or some unemployment), with at least 10 years of paid contributions.

The pension benefit is the sum of four components:

- an income-related part with an annual accrual rate.
- an incremental increase to the income-related part adjusted for years worked and one's age.
- a lump-sum, which depends on the number of years of insurance.
- an end-of-year allowance bonus. The end-of-year bonus (EUR 869.4 per year as of 1 April 2022) is paid only as long as the system is not in deficit.

Benefits are adjusted both for inflation, as part of the general inflation indexation of all wages and benefits, and for real-wage growth.

Rising concern of the financial sustainability of the system led to a reform in December 2012. The reform mainly changed the parameters of the pension benefit formula in order to incentivise people to work longer. It has a transition period of 40 years (2013-52) and left the retirement age unchanged.

Under the reform, the lump-sum benefit gradually rises (from 23.5% of the social reference income in 2012 to 28% in 2052), while the accruals rate is gradually reduced from 1.85% in 2012 to 1.6% in 2052. The age-related element increases gradually so that the sum of pension age and career years will have to be higher than 100 years in 2052 instead of 93 years in 2012 in order to obtain an increase in the accrual rate. For an individual entering the labour market at 22, this would kick in after 36 years working.

The 2012 reform added mandatory ten-year reviews of the system, as well as some stabilisers. In addition to the readjustment mechanism for real wages, the reserves accumulated in the pension fund must be at least 1.5 times the yearly pension expenditures. In 2020, Luxembourg's pension reserves were around 4.8 times annual pension expenditure (some 37% of GDP).

The 2012 pension reform was a step in the right direction but still not enough to guarantee long-term sustainability. A number of more radical proposals, such as fully eliminating real-wage indexation, or a faster decrease of the accruals rate, were not passed, but should continue to be considered. By 2021, the projected rate of increase of pension expenditure by 2070 was still the highest anywhere in the European Union.

Moving to a fully-funded system, with defined contributions, as in Denmark or in the United Kingdom was debated in the 2000s. Such a switch would imply that current cohorts would continue to contribute to the pay-as-you-go system while also needing to contribute to their own pensions, raising the question of intergenerational fairness. These high costs would require substantial socio-economic reforms to be socially acceptable, as occurred in Denmark. As witnessed in countries that have successfully carried out pension reform, it requires a high degree of social consensus about the need and direction for reform to put pension schemes on a firmer footing and ensure that the new system is stable and sustainable. The search for consensus can lead to the watering down of required changes and it may be necessary to phase-in some reforms as those close to retirement have less time to adjust their situation to the new system. However, slow transition implies that the eventual adjustment will be somewhat more costly and carries the risk that reforms may be reversed.

Source: (European Commission, 2021[8]; IGSS, 2021[57]; OECD, 2021[58]; Banque Centrale du Luxembourg, 2013[59]; OECD, 2012[60]; OECD, 2010[61]; OECD, 2007[62]).

Table 1.8. Ageing-related spending is projected to increase substantially

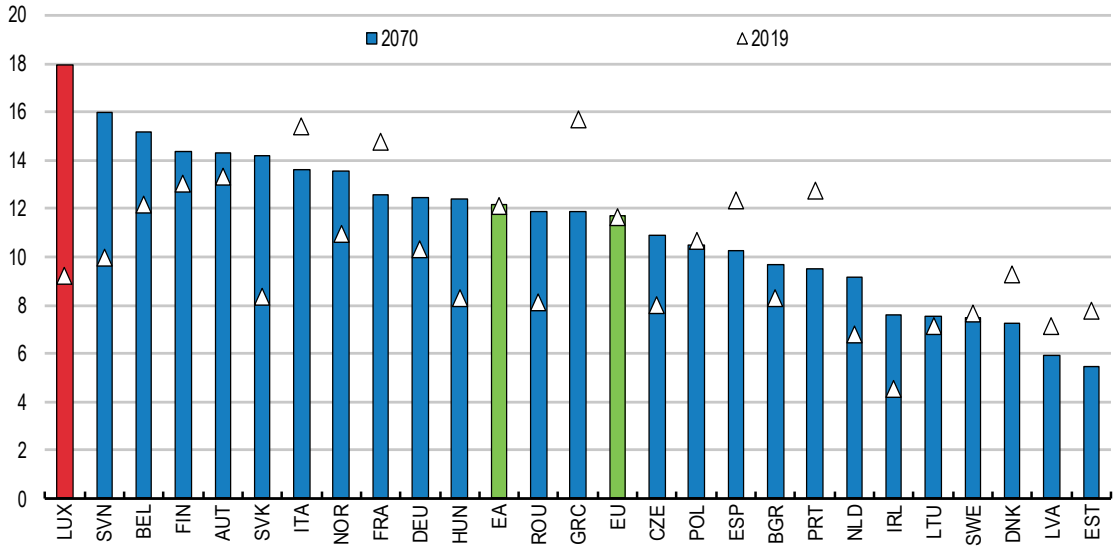
As a percentage of GDP unless otherwise indicated

	2019	2025	2030	2040	2050	2060	2070
Public pensions expenditure, gross[1]	9.2	10.3	11.4	13.0	14.8	16.7	18.0
of which:							
Old-age and early pensions	7.0	7.9	8.8	10.2	11.8	13.5	14.8
Disability pensions	0.7	0.9	1.0	1.1	1.1	1.1	1.1
Survivors pensions	1.5	1.6	1.7	1.8	1.9	2.0	2.1
Projected spending on health care[2]	3.6	3.7	3.8	4.1	4.4	4.5	4.6
Long-term care spending[2]	1.0	1.1	1.1	1.4	1.8	2.2	2.5
Total ageing-related spending	**16.9**	**17.7**	**18.8**	**20.8**	**23.2**	**25.6**	**27.3**
Old-age dependency ratio (20-64)	22.6	25.6	29.6	37.8	45.5	52.8	56.1
Life expectancy at 65[3]	19.1	19.6	20.1	21.1	22.0	22.9	23.7

Note: 1. AWG baseline scenario, 2. AWG Reference scenario. 3. Males.
Source: (European Commission, 2021[8]).

Figure 1.15. Luxembourg's pension outlays will see the fastest increase among EU countries

Gross pensions, as % of GDP[1]



Note: 1. AWG baseline scenario 2019-2070.
Source: (European Commission, 2021[8]).

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Three main levers can be used to limit the increase in pension expenditure: delaying the effective retirement age, reducing the generosity of the pension system, and increasing contribution periods. Tackling early withdrawal from the labour market should be the first action to raise the effective retirement age. The statutory retirement age is 65, about the OECD average, but the effective retirement age is stagnating at 60, one of the lowest in the OECD (Figure 1.16, panel A and C) (Gbohoui, 2019[63]; OECD, 2017[64]). A person aged 57 can retire early, provided they have 40 years' worth of contributions, or at 60, with 40 years' contributory and non-contributory periods (and a total of 120 months' full contributions) (OECD, 2021[58]). Early retirement deprives the economy of an important skilled resource and increases the tax burden of future generations when pensioners currently enjoy a very high standard of living (Figure 1.16, panel B and D). Raising the effective retirement age from the labour market to 62 would lower the projected expenditure increase by at least 0.6%of GDP (Table 1.9).

Table 1.9. Potential impact of pension reform

Changes in pension expenditure as percentage point of GDP, in that year

	2040	2050	2070
Measures to alleviate the increase in pension outlays(total)*	-3.7	-4.7	-4.8
Annual return on the Fonds de Compensation**	-1.4	-1.4	-1.4
Higher employment rates of older people	-0.5	-0.6	-0.1
Link the retirement age to increases in life expectancy	-0.8	-1.1	-1.6
Increase effective withdrawal from labour market to 62 years	-0.3	-0.5	-0.6
Higher immigration (+33%)	-0.7	-1.1	-1.1

Note: Linking the retirement age to increases in life expectancy would yield a decrease in pension expenditure of 1.6% of GDP by 2070, according to the AWG projections. Measures to increase the effective retirement age would extend the number of contribution years, which could add 0.6% of GDP to pension contributions. Delaying the entry of new pensioners would initially have less of an impact, but as the new pension cohorts grow larger, delaying entry by raising early retirement to 62 years, would increase the savings and reduce the length of pensionable years. Higher inward migration with an increase of 33% over the projection period, would lower pension expenditure by 1.1% of GDP. *Simple summation, unweighted. **Assuming a 4% annual return on the pension fund, and no draw-down on the fund after 2027.
Source: OECD calculations based on (European Commission, 2021[8]); (IGSS, 2022[38]); (IGSS, 2021[57]).

Several options could provide incentives to delay retirement. Luxembourg could increase the required contribution period before early retirement to at least 42 contributory years and reduce the possibility of taking early retirement before 62 unless in exceptional circumstances, *e.g.* for trades involving hard physical labour. Pension benefits should be reduced for early retirement, reflecting the longer duration of retirement. Within the OECD, only Luxembourg and Belgium do not impose such a penalty (OECD, 2021[65]). Actuarial adjustments should be applied to the benefits of those retiring early, as in Finland and Sweden. Conversely, most countries have a bonus for those who defer retirement, to compensate workers for the shorter time spent in retirement. These tend to be higher than any penalty for early retirement, with a maximum rate of 12% per year in Denmark (for a ten-year deferral). Only Luxembourg, along with Belgium, Colombia, France and Greece do not have such a bonus (OECD, 2021[65]), although the current pension parameters provide for a small actuarial incentive for longer careers (after approximately 36 years, for someone having entered the labour market at 22).

Figure 1.16. There is room to address key imbalances with a new pension reform

1. Average effective labour market exit age, unweighted average of men and women, (based on labour market participation rates)
2. Net replace rate is defined as individual net pension entitlement divided by net pre-retirement earnings, taking into account personal income taxes and social security contributions paid by workers and pensioners. It measures how effectively a pension system provides a retirement income to replace earnings, the main source of income before retirement. This indicator is measured in % of pre-retirement earnings.
3. Incentives for older people to continue working at an older age are captured by focusing on i) a combination of current retirement ages (men), ii) the gross replacement rates and iii) the impact on benefits when working and deferring pensions.
4. Net pension wealth is the present value of the flow of pension benefits, taking account of the taxes and social security contributions that retirees have to pay on their pensions. It is affected by life expectancy and by the age at which people take their pensions, as well by as indexation rules. This indicator is measured as a multiple of annual net earnings by gender.
Source: (OECD, 2019[66]), (OECD, 2019, p. 29[66]), Net pension wealth (indicator).

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Ultimately, both the retirement age and thus the overall benefits paid out over the time spent in retirement should be linked to life expectancy, as noted in previous surveys (Table 1.10). Longer life expectancy should be reflected by raising statutory retirement ages, as this protects financial sustainability and supports intergenerational pension fairness. Finland adjusts both benefits levels and retirement ages to changes in life expectancy, supplemented by a balancing mechanism adjusting contribution rates if needed. While individually these reforms are unlikely to have a significant impact on keeping older workers in the workforce, the combined impact could be greater, and would make the system more affordable (Box 1.1, Table 1.5). To avoid that a delayed retirement age translates into higher unemployment of older people, pension reform should be coupled with efforts to increase opportunities for older workers in the labour market. Luxembourg should encourage longer and more satisfying careers through more flexibility in work-retirement transitions, including by promoting phased retirement, better balancing work and leisure, and easing taxation for those combining pensions with work income.

Beyond increasing the retirement age, there is room to reduce the pension generosity to support the sustainability of the system. Net pension wealth is the highest in the OECD, and replacement rates are close to 90% for average wages (Figure 1.16, B and D). At the same time, 10% of older people (65+) are classified as poor or vulnerable to poverty (compared with 18.5% in the European Union) (European Commission, 2021[4]). Reducing the replacement rate could support long-term sustainability of the system while targeted measures could support poorer pensioners. For example, the current end-of-year allowance, which is not linked to earnings, could be means-tested, or ceilings for high benefits could be considered. Pension policy measures to take account of socio-economic differences in life expectancy could be included in the benefit formula (granting higher accrual rates for low earnings, as applied in Portugal, or the contribution rates could increase for higher incomes, as in Brazil (OECD, 2019[66]). Reducing the current accruals rate at a faster pace than envisaged by the 2012 reforms, combined with an increase in the time required to contribute before benefiting from a full pension, from 40 to 42 years, reflecting longer life expectancy, would support sustainability while only gradually reducing replacement rates. Alternatively, contribution rates could increase with income, or include a higher wage ceiling for contributions for pension entitlements (as in Norway) (OECD, 2019[66]). The recent reform of the pension system in Portugal is an interesting example of a reform that tries to strike a balance between equity objectives and the need to sustain the long-term financial sustainability of public pensions (Box 1.5).

Box 1.5. Improving financial sustainability whilst offsetting inequalities: example from Portugal

Portugal has implemented several pension reforms since the mid-1990s to improve financial sustainability. These included increasing the period to calculate the reference wage; aligning the retirement age for women; linking the retirement age to life expectancy; reforming the minimum pensions; consolidating the scheme for civil servants with the general regime for private-sector workers; and formalising indexation rules. Following a 2014 reform, the statutory retirement age rises by two-thirds of life expectancy gains at 65, which aims to improve the financial sustainability of the pension system while keeping the ratio of adult working life to time spent in retirement roughly constant. In addition, people with very long careers can retire slightly earlier. A worker with a 43-year career can retire 1 year before the standard statutory retirement age. For someone who started working at age 20, this means that the retirement age in effect rises by half of life expectancy gains rather than two-thirds.

At the same time, higher accrual rates are granted for lower earnings, offsetting the pension disadvantage for low-income earners from lower life expectancy.

There are several advantages to this approach:

- Linking the retirement age to life expectancy removes the need for recurring political debates every time pension parameters need to be adjusted to demographic realities.
- The two-thirds increase maintains a broadly constant ratio of working life to life-in-retirement. This may be more acceptable than a one-to-one link of retirement ages to life expectancy.
- The provision included for long careers represents a progressive element that is beneficial for economically disadvantaged groups, but which nevertheless maintains a link to life expectancy for everyone.

When designing pension reform, sustainability measures need to be included to account for ageing and longer life expectancies. These can be counter balanced by more progressivity in the pension system to make up for the reduction in low pensions that long-term sustainability may entail, to better share the burden across generations.

Source: (OECD, 2019[67]); (OECD, 2021[68]).

Table 1.10. Previous recommendations on pension reform

Recommendation	Action taken
Align the legal age of pension entitlement with increases in life expectancy.	No action taken.
Link more closely the level of pensions to the level of contributions.	No action taken
Increase the retirement age with life expectancy and/or reduce the generosity of pensions.	No action taken.

Health-care spending will rise only moderately

The ageing of the population will also increase spending on health and long-term care, but these are likely to be mostly well contained. Total health spending as a share of GDP is one of the lowest in the OECD, and the finances of the health system appear to be in good shape, while health outcomes are generally above the EU average. Between 2015 and 2019 health expenditure per capita rose by 1.5% a year in real terms, below the rate of economic expansion (OECD, 2021, p. 191[69]). This is quite remarkable and may be a result of the structure of Luxembourg's labour market. Strong inflows of cross-border workers and immigrants over the past decade means that the population is comparatively young in relation to surrounding countries. Around 14.5% of the population was aged 65 and over in 2021, against 20.6% in the EU, meaning less demand on health services. Outpatient care accounts for 33% of total health spending. To contain health spending in the longer term, a greater focus on preventive care and policies where Luxembourg currently spends less than the EU average would help (OECD/European Union, 2020[70]). Specifically, this would involve more preventive action on lifestyle factors that could lead to rising healthcare costs in the longer term: alcohol consumption is among the highest in the OECD, while obesity among adolescents is high and has been rising steadily since 2006 (OECD, 2021[69]; OECD/European Observatory on Health Systems and Policies, 2021[6]).

The cost of long-term care is expected to more than double by 2070

Projections from the European Union Ageing Working Group (AWG) point to long-term care as the fastest-expanding old-age related sector for Luxembourg (European Commission, 2021[8]). The AWG and researchers at the Central Bank of Luxembourg both project public expenditure to rise from 0.7% of GDP in 2020 to 2.5% of GDP in 2070 (European Commission, 2021[8]; Giordana and Pi Alperin, 2022[71]). Life expectancy at 65 is currently around 20 years (slightly more for women), but only 10 of these (50%) are expected to be healthy life-years, defined as the number of years spent without activity limitation, below the OECD average of 51.5% (OECD, 2021[69]). All citizens with health insurance are also entitled to long-term nursing care, whether in an institution or at home. In 2019, 12.7% of adults aged 65 and over received long-term care in Luxembourg, above the OECD average of 10.7%. Of these, 58% do so in their own home, below the OECD average of 68%. Luxembourg has the highest number of long-term care beds in institutions and hospitals per inhabitant in the OECD (81.6 per 1000 inhabitants, against 46.6 for the OECD). The many long-term care beds in institutions suggests there is room to develop further nursing care at home, which is cheaper than institutionalised care and often preferred by the elderly. This would also contribute to improve the access to medical care for people living with limitations in activities, who reported a higher share of unmet long-term care needs (OECD, 2021[69]).

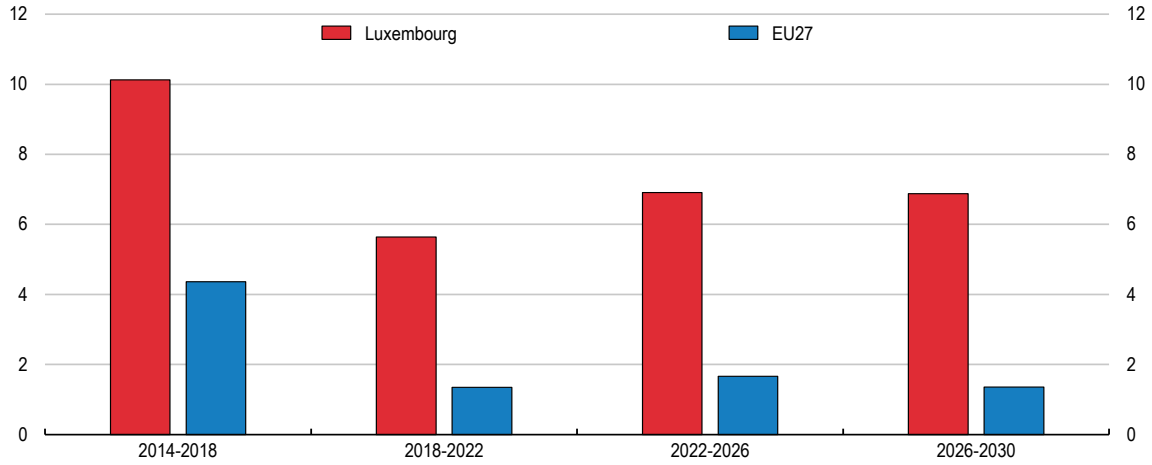
A higher supply of labour and lifelong learning are required for sustained growth

Domestic labour supply remains limited by the small population size, while labour demand is rising fast owing to the dynamism of the economy, creating tensions in the labour market. Those tensions are compounded by skills shortages and mismatches, and frictions related to *inter alia* the need to master one or more of Luxembourg's three official languages (BCL, 2022[86]; Lawson, 2010[98]). In the longer term, labour demand by firms is expected to grow by nearly 2% per year (Figure 1.17), while Luxembourg's population is set to increase by only 0.7% each year (European Commission, 2021[8]). Reducing labour market tensions will thus require an increasing supply of workers, partly by using available resources better, notably older workers, the young and the unemployed, but also by attracting more migrants,

including non-EU nationals. This, in turn, means further facilitating their arrival and integration (OECD, 2017[64]; OECD, 2021[72]).

Figure 1.17. Labour demand will remain strong in Luxembourg

Percentage employment growth in Luxembourg and in the EU-27 past and projected



Note: Data from 2022-2030 is a forecast.
Source: Cedefop, 2020 Skills Forecast (database).

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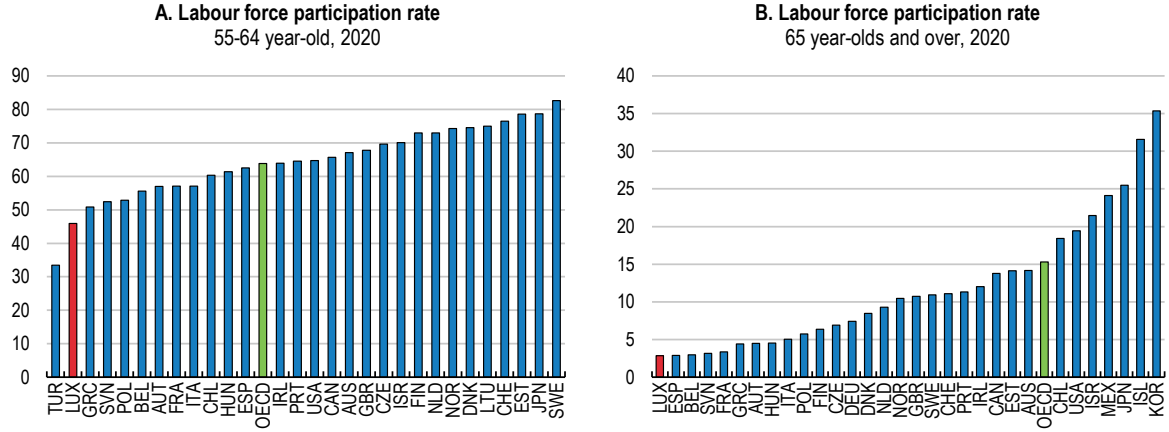
Augmenting labour participation of older workers will be required to increase supply

Luxembourg has one of the lowest rates of labour force participation for older workers (45%) in the OECD (Figure 1.18), largely due to early exit from the workforce. In the period 2013-18, one-quarter of men retired at 54 or younger in Luxembourg, mainly lower-skilled workers (OECD, 2019, p. 42[66]) (Figure 1.19). In addition, relatively low participation rates by the 20-24 year-olds contribute to lowering the overall labour supply. Low levels of domestic labour force participation increase the number of additional, foreign workers required for economic growth, which in turn increases demand for housing and energy for a given level of output. To increase the supply of older workers, the statutory retirement age should be increased while avenues for early retirement should be further restricted unless for exceptional circumstances as discussed above.

Figure 1.18. Low participation rates of older workers are limiting labour supply



Source: OECD (2022), Labour force participation rate (indicator).

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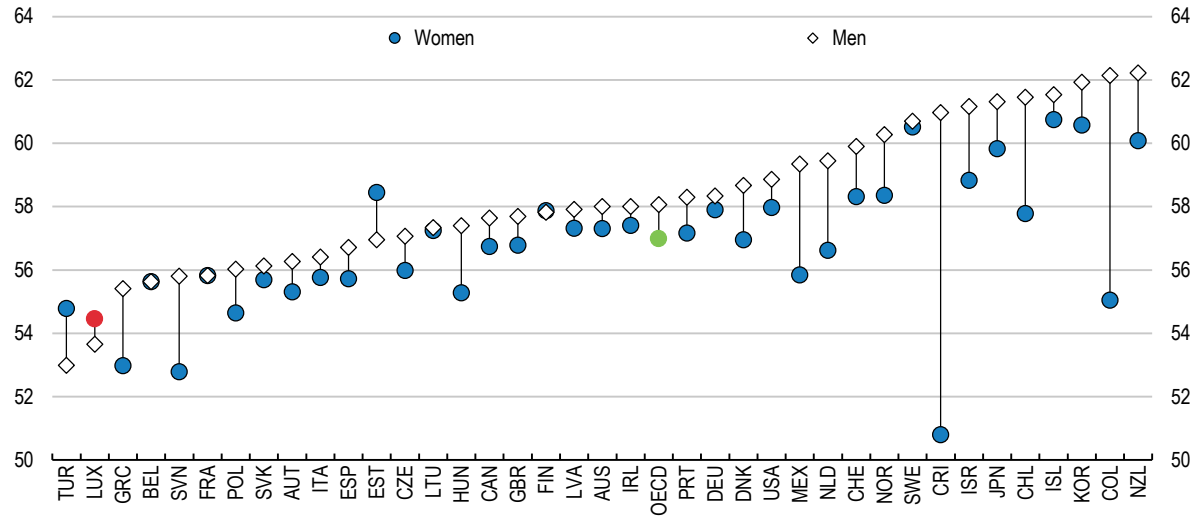
Figure 1.19. A large share of workers that retire, do so well-before the age of 65

Age below which 25% of older retirees left the workforce, 2018



Note: The effective retirement age refers to the weighted average age of labour market exit for persons who were in the labour force in 2013 and aged 40 and over but no longer in the labour force in 2018.
Source: OECD calculations based on the average effective age of retirement dataset (unpublished).

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Keeping older workers in the labour market requires improving their employability, enhancing their incentives to work and a greater openness from employers to hire older people. Countries that perform well in those three dimensions have better labour market outcomes for older people (OECD, 2019[66]). Workers above 55 need to receive better training to increase their employability in growth sectors in Luxembourg (Cedefop, 2020[73]), which will also support long-term productivity growth (OECD, 2021[74]). Though around 28% of 55-64 olds in Luxembourg have tertiary education, above the OECD average (OECD, 2018[75]), older workers are still predominantly lower skilled than younger cohorts, and their skills may not match the requirements of rising digitalisation (European Commission, 2021[76]; Cedefop, 2020[73]; Eurofound, 2017[77]). Nearly 70% of over-55s indicated that older job applicants may be at a disadvantage when looking for a new job (OECD, 2019[66]).

To support older workers' employability, the national employment agency, ADEM, could actively encourage employers to train older workers, by actively subsidising on-the-job training. To optimise the effect, this should be coupled with, on the one hand, measures to limit the possibility to take early retirement, and on the other hand, higher rates of co-financing training for older workers, for instance, as part of the *Skills-Plang* programme that was launched in late June 2022. In Germany, the public employment agency supports training of low-skilled and older workers in SMEs through a 75% subsidy to the training costs of workers aged 45 and older, while micro-enterprises (with fewer than 10 employees) receive a 100% subsidy (*WeGebAU* programme). This has helped participants to increase their time spent in employment (OECD, 2019[66]). Luxembourg could also more pro-actively invest in improving digital skills of older workers and prepare them for new forms of work. Germany implemented a programme to help SMEs develop management strategies with a particular focus on training measures to help workers prepare and adapt to the digital economy (*UnternehmensWert Mensch*). The programme subsidises consultancy services for SMEs for up to between 50% and 80% of these costs (OECD, 2019[66]).

In the OECD, Luxembourg scores very poorly on providing sufficient incentives and opportunities for older workers to remain in the workforce (OECD, 2019[66]). It also performs poorly in enticing employers to hire older workers. Luxembourg could encourage individuals to work longer by allowing phased retirement, which is currently not possible. Australia provides so-called Transition-To-Retirement Pensions (TRIPs)

that let workers move from full-time to part-time work and complement their earnings with pension (superannuation) entitlements (OECD, 2019[66]).

Luxembourg should also further address barriers to hiring older workers, including issues of age-discrimination. In the Netherlands jobs adverts are scrutinised for references to age (OECD, 2019[66]). In France, job seekers applying through the national employment service (*Pôle emploi*) are selected for employer interviews based on aptitude tests and without regard to age or previously held employment (OECD, 2019[66]). Luxembourg already has in place a scheme that subsidises the employment of workers above 45 years of age by reimbursing the employers' social security contributions. A recent study found however that the scheme, costing the state EUR 27 million annually, has had relatively little take-up by qualified firms (Marguerit and Nguyen-Thi, 2022[78]). Although the scheme is not new, employers may need more awareness-building about the scheme, and in particular about the benefits of hiring older workers. ADEM is working on an action plan for workers aged 45 and over, which includes more communication about its benefits. Additional monetary incentives such as short-term tax credits could also be used, as in Sweden, or direct government-contributions to salary costs.

Attracting non-EU foreign workers to help fill vacancies

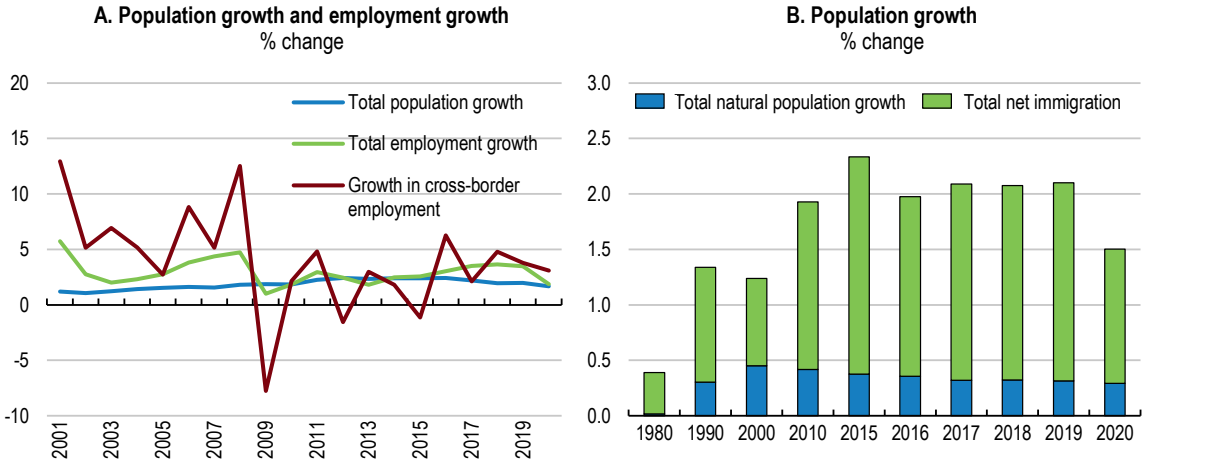
As a small, open economy, Luxembourg relies heavily on foreigners. Employment growth has consistently been supported by high levels of net immigration and cross-border workers (Figure 1.20). In the long term, the EU population will decline, and Luxembourg should aim to attract more non-EU nationals (European Commission, 2021[8]). To continue to attract foreign workers, Luxembourg needs to remain an attractive place to live and work (Cedefop, 2020[73]). However, Luxembourg is the third-most expensive country to live in, after Denmark and Ireland, in the European Union, based on household consumption expenditure, and excluding rental costs (and still the sixth-most expensive country, after the EEA countries, Switzerland, Iceland and Norway, are added) (Eurostat, 2022[79]).

The EU Blue Card visa scheme for highly qualified workers has failed to attract a sufficiently large number of the higher skilled workers required in particular for the green and digital transformation (OECD, 2021[80]). A 2021 EU Directive will harmonise the conditions of entry and residence for high-skilled workers in the EU as recommended by the OECD (Lecerf, 2017[81]; European Council, 2021[82]). However, as in most other OECD countries, Luxembourg enforces its own working permit conditions for non-EU nationals with lower qualifications, assessing whether a particular job could be performed by a job-seeker available on the national labour market, before allowing to fill the existing vacancy with a foreign worker. These remain cumbersome and expensive for prospective employers. Examples include the requirement to offer at least between 1.2 and 1.5 times the average salary for higher-skilled workers and requiring the employer to sign a contract before the prospective worker has obtained a residence permit, while the worker can only obtain the permit once the contract is signed.

Luxembourg should therefore implement additional measures to receive and integrate migrants, including non-EU nationals, as recommended in the 2015 and 2017 Economic Surveys (OECD, 2015[83]; OECD, 2017[64]). Recently, further steps to integrate non-EU nationals have been taken, for instance, allowing voting in municipal elections, without the five-year prerequisite residence, since July 2022. Adding more professions to the accepted EU Blue Card occupations list and lowering the conditions that impose higher salaries for non-EU workers, would support a higher intake of highly skilled non-EU nationals, as also recommended in the 2017 Economic Survey (OECD, 2017[84]). Elaborating a shortage-occupation list both for lower-skilled and higher-skilled jobs may also be an option. The preparation of this list should involve a dialogue between national authorities responsible for migration policies, sectoral representatives facing the shortages, and the public employment service (ADEM), as the vacancy data provider (OECD, 2022[85]), and should be updated every quarter. More intensive language training would also help the integration of foreign nationals living in Luxembourg, such as the Words4Work programme, but also for children of immigrants, to enhance their integration and future job prospects (OECD, 2021[72]). Immigrant workers could help fill current job vacancies, provided the language requirements were relaxed in some

occupations, such as the care sector. Communication could be facilitated by making better use of digital tools, such as hand-held translation software, notably in the care sector or service activities such as cleaning.

Figure 1.20. Net migration is the main contributor to population growth



Note: Net immigration includes EU and non-EU nationals.
Source: STATEC, with OECD calculations.

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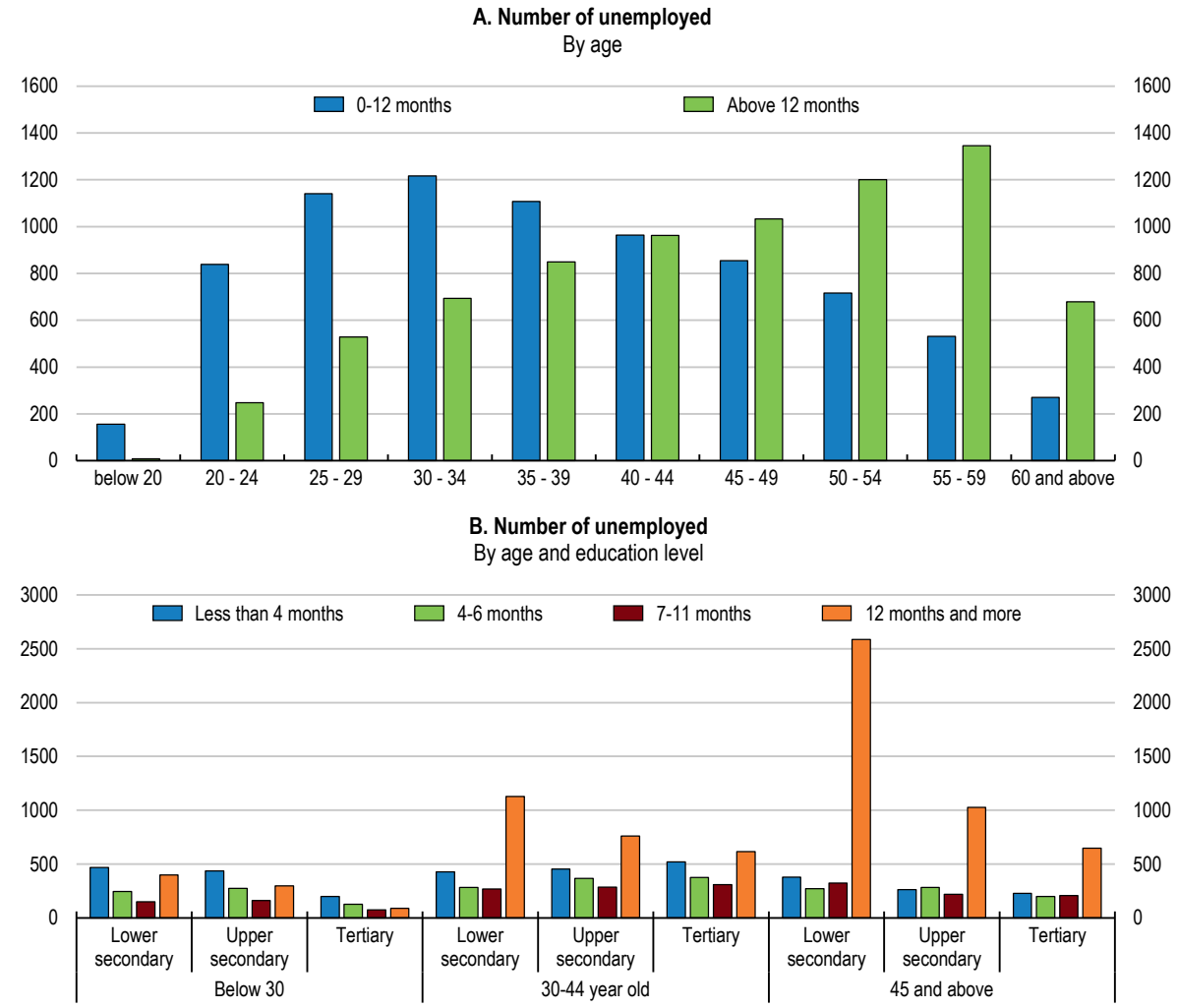
The quality of the labour supply can be improved with more training and active participation of the unemployed and women

Better training of the unemployed is needed to help increase the quality of the available workforce (Cedefop, 2020[73]). Unemployment in Luxembourg affects in particular the low-skilled and older workers (Figure 1.21, panel B) and long-term unemployment is particularly high for the age-group between 45 and 60 (Figure 1.21, Panel A). The national employment agency, ADEM, has several active labour market policies (ALMPs). Official data indicate that around two-thirds of the registered unemployed participate in them, but many of the ALMP remain short-term activation schemes, such as public works, that do not lead to permanent employment (OECD, 2015[83]; Lawson, 2010[86]). Luxembourg also spends less than the best performers on active labour market policies (ALMP), at 1.28% of GDP, compared with nearly 3% for countries such as Denmark or Australia (and only 0.74% of GDP when unemployment benefits are removed, compared with around 2% of GDP for Denmark and Australia on active policies, such as training). Luxembourg's ALMP need to receive more funding. Raising spending on ALMP, especially for training, could also support productivity growth (see also Box 1.1 for estimates of reform impact).

The reactivation programmes could have a larger uptake. Some of the training schemes on offer in Luxembourg are only partially funded and administratively heavy, requiring multiple supporting documents and justifications, which is likely to deter those that need the training the most (ADEM, 2022[87]). A new training programme, *Future Skills*, which teaches soft skills such as digital skills and management skills, was initially aimed at the public sectors and requires speaking French. A requirement to speak Luxembourgish was dropped (Ministère des Finances, 2021[88]; OECD, 2021[89]). Schemes that teach soft skills are welcome and should be extended across the private sector with appropriate incentives for employers to hire the trainees. A new programme, *Skills-Plang*, presented in late June 2022, is an extension of the *Future Skills* programme, and aims at reskilling and upskilling, but still requires French. For success it is important that access to skills programmes is not systematically conditioned on language requirements.

Figure 1.21. Long-term unemployment affects older, low-skilled workers in particular



Source: ADEM, OECD Calculations.

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The green and digital transitions will induce changes in the labour market, as discussed in Chapter 2. Labour needs will become much more skills-intensive (IMF, 2022[90]). Hence, Luxembourg should also focus attention on workers at risk of displacement (Conseil national de la productivité, 2021[91]). Luxembourg should take pre-emptive action to direct workers to those sectors where their skills are still needed or can be upgraded at minimal cost. France has a training subsidy that was originally developed for firms undergoing structural changes. The *Fonds national de l'Emploi-Formation* fully covers training costs (OECD, 2020[92]) and the government compensates workers for 84% of the gross wage but 100% if they participate in training. France also introduced *Transitions Collectives* in January 2021 to provide funding for the re-training of workers at risk of redundancy during the pandemic; fully covering training costs for small and medium-sized enterprises (and partially for larger firms). Such measures help to pre-empt potential disengagement from the labour market for workers in firms that are struggling to adapt (OECD, 2021[93]).

Young workers represent an important potential source of labour. However, young people continue to suffer from high unemployment, which at 17.3% remains well above the OECD rate (Figure 1.22), and above the 3% unemployment rate for 25-54-year-olds in Luxembourg. The comparatively high rate of secondary school dropouts (8.2%), which remains below the European Union target of 9%, reduces the

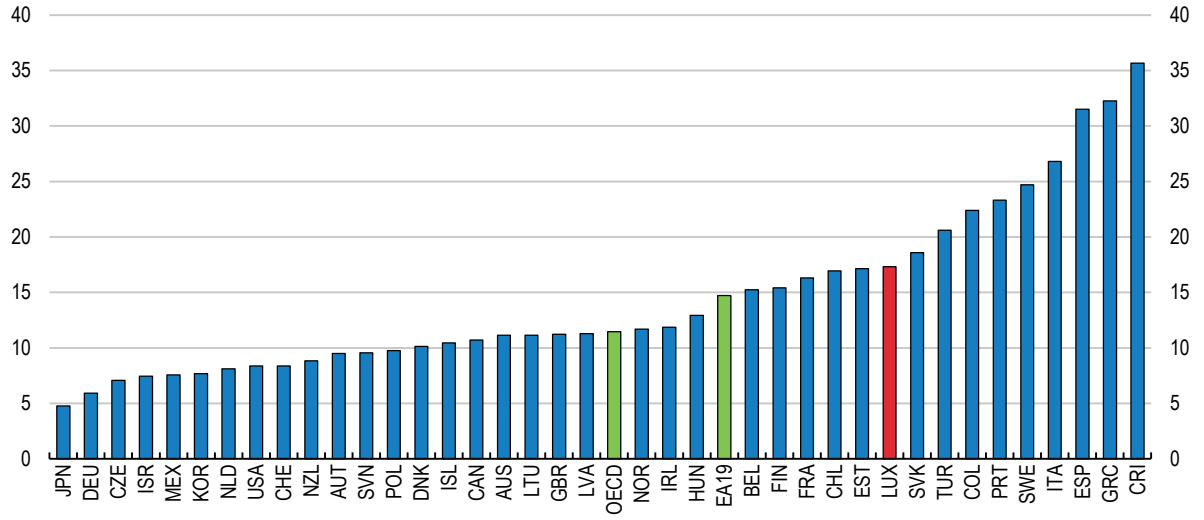
employment chances of the youth. The National Youth Service (*Service national de la jeunesse*) is actively involved in helping reorient young people who have left school. Leaving school before completing secondary education is partly related to the practice of grade repetition (60.9% of early-school leavers have accumulated a school delay of at least two years) (MENJE, 2022[94]). Moreover, 55% of early-school leavers are of immigrant background, although they represent fewer than one-third of pupils (OECD, 2021[72]). Children of immigrants are less well integrated, which is linked to the strong emphasis on the need to master Luxembourg's three languages during schooling, which leads to dropping off the ladder: around 25% of 15-34-year-old second-generation immigrants are neither in education, employment or training (OECD, 2021[72]). As highlighted in previous *Economic Surveys*, Luxembourg should reduce the use of repeating school years (OECD, 2017[64]). The fact that students are oriented towards vocational training at a very young age, also narrows opportunities (OECD, 2016[95]). Rather, the first part of secondary education should be reformed to offer a more general and broad-based education and avoid too early selection (OECD, 2019[96]). More generally, to address early leaving from education and training, the OECD (OECD, 2022[97]) recommends:

- developing early warning systems to identify students at risk of early leaving.
- implementing preventive measures and targeted interventions for young people and their families.
- promoting accessibility of second chance and alternative education to help early leavers re-enter education.
- making flexible pathways accessible to effectively retain young people in education or training.

A bill submitted to parliament in March 2022 will extend compulsory education by two additional years, to the age of 18, and promote access to second chances, which it is hoped will help reduce the rate of school drop-out. It would be important to actively monitor the impact of these legal changes and follow up with further adjustments if needed.

Figure 1.22. Despite strong growth, unemployment remains high for the young

Unemployment rate, 15-24, Q4 2021



Source: OECD Short-term Labour Market Statistics.

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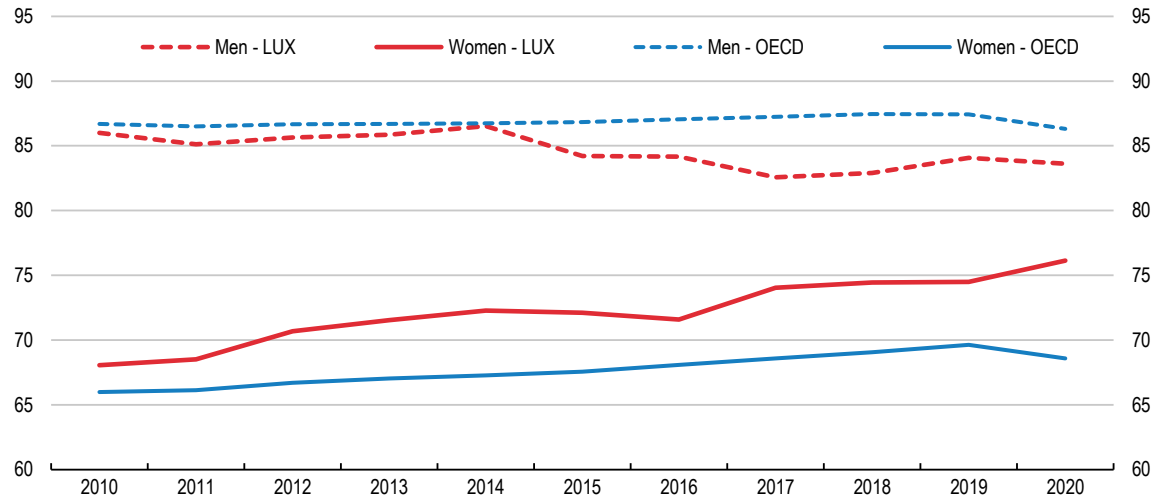
Figure 1.23. Female participation rates outstrip the OECD average but remain below those of men

Labour force participation rate, % of population, 25-64



Source: OECD Labour Force Statistics.

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Female labour force participation should still be encouraged. Participation rates have increased significantly but remain below those of men (Figure 1.23). The government has implemented several measures to help facilitate women's return to the labour market after childbirth, including 20 hours' free provision of childcare per week. Paternal leave, which can also support working mothers, is however limited to ten days after the birth of the child, compared with 30 days in Lithuania, or six months in Denmark and Iceland where 12 months statutory maternity leave is evenly split between the mother and the father (with six weeks transferable between parents). Luxembourg does have in place a scheme of parental leave which can be taken by both mothers and fathers, when the child is older, but before the age of six. Pre-school (nursery school) is now compulsory from the age of four (and available from the age of three). To ensure better equality of opportunity, affordable and good-quality childcare should be made available on a means-tested basis, including during school holidays. The authorities have also made more efforts to make taxation gender neutral. Since 2018, there is an option to be taxed individually for both resident and cross-border married or co-habiting workers. This reduces the marginal taxation of second earners, increasing their work incentives. Since second earners tend to be women, sometimes working part-time, individual taxation is also welcome from a gender neutrality and inclusion perspective. The authorities are still analysing the feasibility of full individual taxation, which would be welcome as it would likely reinforce the impact on work decisions (OECD, 2017[64]; OECD, 2019[25]).

Lifelong learning will be important to ensure skills adapt to changing needs

Luxembourg will need workers who can adapt to the future needs of the labour market (OECD, 2018[75]; Cedefop, 2020[73]; OECD, 2022[85]). The European Centre for the Development of Vocational Training (Cedefop) forecasts that about 50% of all job openings between 2020 and 2030 will be highly qualified positions, and fewer than 10% will be low-skilled (Cedefop, 2020[73]). In particular, occupations such as financial and administration professionals, ICT professionals, medical doctors and technical and logistic engineers are in short support and projected to remain so (Cedefop, 2020[73]). Meeting these needs implies continued efforts to reskill and upskill the workforce, particularly over the long-term as the workforce ages and working lives will need to be extended (OECD, 2016[95]; OECD, 2017[64]; OECD, 2022[85]).

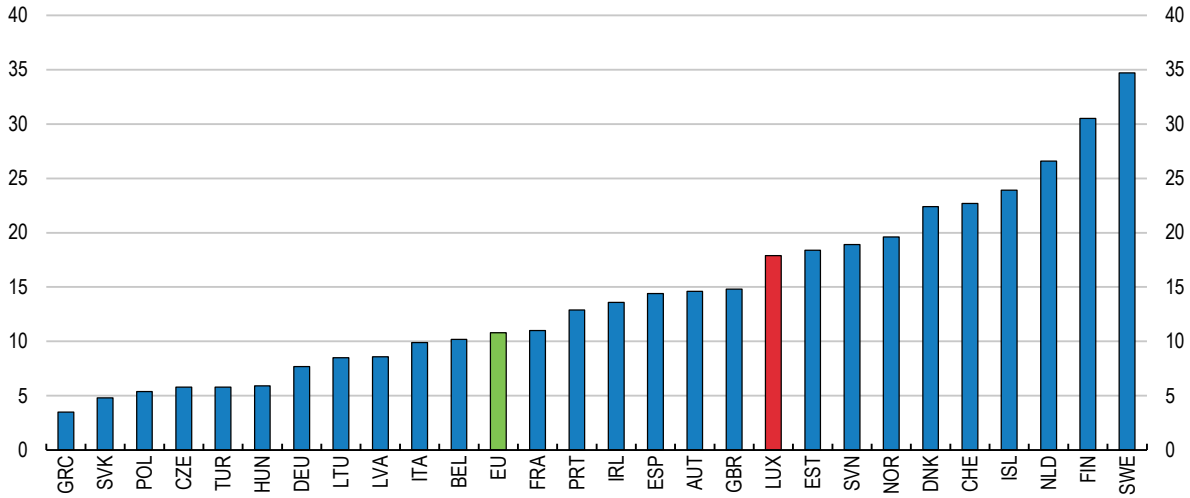
Skills-mismatches as much as skills-shortages weigh on productivity growth and innovation (OECD, 2021[74]; BCL, 2022[98]; OECD, 2017[84]; McGowan and Andrews, 2015[99]). Skills mismatches are

consistently reported as a reason holding back growth by company managers (Conseil national de la productivité, 2021[91]; OECD, 2022[85]; BCL, 2022[98]). About 40% of Luxembourg's CEOs in one survey identified the availability of skills as a threat to their growth prospects (Hauret and Marguerit, 2020[100]; OECD, 2022[85]). 46% of Luxembourg resident workers report that their skills do not match those required for their occupations. As trends such as advances in ICT and artificial intelligence change the demands of the labour market and the skills needed for workers to succeed, people need to rely even more on their ability to "learn to learn" throughout their life (OECD, 2017[101]). The pandemic accelerated the digital transformation and digital skills needs (OECD, 2019[96]; OECD, 2021[89]).

The Luxembourgish authorities are taking steps to improve adult education and vocational training, as mentioned in previous surveys (Table 1.11). 16% of adults participated in education or training in Luxembourg in 2020, above the EU average but still well below the best performers (Figure 1.24). Efforts by the Ministry of Education to enhance digital education are welcome, and should bolster current efforts to provide adult learning and on-the-job training, as noted previously (OECD, 2019[25]; OECD, 2021[74]; OECD, 2015[83]; Lawson, 2010[86]). The lifelong learning programme being implemented as part of the Recovery and Resilience plan goes in the right direction (Ministère des Finances, 2021[88]). Recent evidence indicates that to meet its skills needs and improve the accessibility of adult learning opportunities, Luxembourg should develop a long-term strategy for adult learning, with clear goals and implementation measures; and establish an adult learning quality-assurance agency, similar to the quality assurance system, which exists in France. This includes setting minimum standards to accredit new training providers, as well as regular audits, and evaluations of existing providers (OECD, 2022[85]). In addition, in January 2022, the Ministry of Labour and ADEM presented seven sectoral studies that aim to prepare for future skills needs, by analysing trends in future professions and anticipating skills gaps (Table 1.11). Such initiatives are welcome but need to be followed up with impact assessments. Luxembourg has not taken part in the recent PISA and PIIAC exercises while new programmes are being rolled out.

Figure 1.24. Luxembourg performs relatively well in terms of adult education and training

Participation rate in formal and non-formal education and training in last 4 weeks, % of persons aged 25-64, 2021



Source: Eurostat Adult learning statistics.

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Table 1.11. Previous recommendations to improve the labour market outcomes

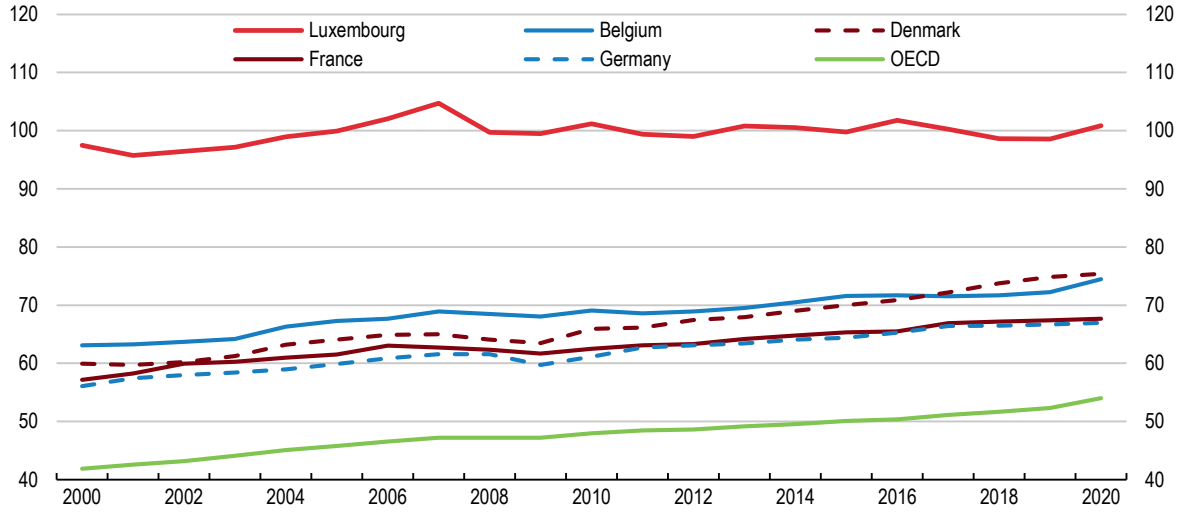
Recommendation	Action taken
Move to a system of fully individual taxation to make the tax system more gender neutral.	No action taken since the past reform (individual taxation remains optional).
Continue to increase public supply of language courses. Diversify language training to take better account of workplace needs	The government introduced several classes for learners of different ages to enhance language skills.
Undertake regular skill foresight exercises and ensure their outcomes feed into enhanced training offers.	Luxembourg is participating in the 2022 OECD Skills Strategy. ADEM in collaboration with employer federations has conducted sectoral studies on skills trends for 7 different sectors. These insights flow into ADEM's training strategy and into the National Skills Strategy elaborated with the OECD.
Improve the evaluation of existing active labour market policies and set and partly publish output measures for local PES offices.	The EvaLab4Lux project will improve evaluation of ALMP by providing systematic studies and conducting impact evaluation studies.
Tailor lifelong learning programmes to the needs of the low skilled and older workers	The State's financial participation increased by 20% for the wages cost of low-skilled and participants over 45 years.
Create individual learning accounts and expand the individual study leave to enhance access to lifelong learning.	No action taken.
Ease immigrants' access to public sector jobs	Since 2017, measures have been taken within the civil service to facilitate the learning of the Luxembourgish language. Some public sector jobs have been opened to non-nationals.
To attract talent and better respond to skill shortages, reduce the time needed for non-EU citizens to obtain a work and residence permit.	The Grand-Ducal Regulation laying down the conditions and procedures for the issue of a residence permit as a salaried worker has been modified to reduce the administrative burden on the applicant and to simplify the procedure for obtaining a work and residence permit.

Faster productivity growth is critical for long-term resilience and economic diversification

Luxembourg enjoys high levels of labour productivity compared with other OECD countries, but productivity growth has been stagnating for the past decade (Figure 1.25) (Conseil national de la productivité, 2020[102]). Productivity gains are needed to maintain high living standards and well-being in the context of an ageing population. Between 2010 and 2019, Luxembourg's economic growth was mainly sustained through high employment growth, which was the strongest within the OECD. The contribution from the productive capital stock and capital quality were more modest, in contrast with countries such as Ireland or Korea where growth was driven by productive capital stock, or Denmark, where capital quality was the largest driver. Multifactor productivity growth, which measures technical advances and efficiency, was negative over the period. Apart from Luxembourg, only Greece and Ireland had negative multifactor productivity growth in the period (OECD, 2021[103]). Faster growth in investment and productivity could help to reduce the resource intensity of growth in the future, which in turn could help to support meeting the goals of the green transition, without compromising living standards.

Figure 1.25. Productivity is high, but has flattened out for over a decade

GDP per hour worked, USD constant prices, 2015 PPPs



Source: OECD Productivity Statistics.

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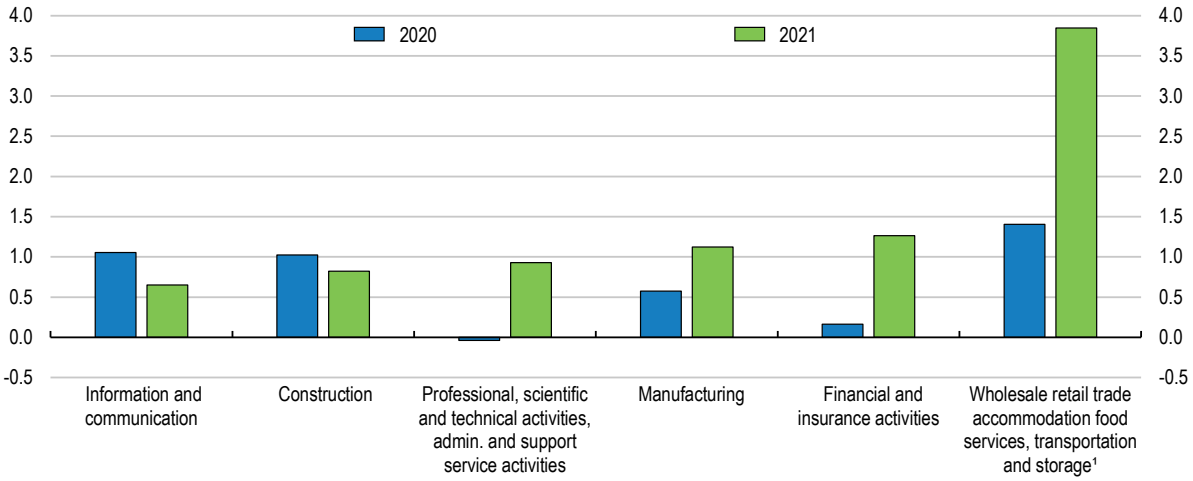
The COVID-19 crisis accelerated digitalisation and spurred more businesses to enhance their ability to operate remotely for business continuity (Conseil national de la productivité, 2020[102]). Many ICT, business and financial services were able to continue to function during the pandemic thanks to teleworking, leading to an increased contribution of these sectors to labour productivity growth in the past two years (Figure 1.26). This demonstrates the importance of increasing innovation and technological diffusion to raise productivity growth in Luxembourg. A better use of ICT tools could boost efficiency among low adopters; this should also support efficiency gains of some of the low-productivity firms (Conseil national de la productivité, 2021[91]). Other levers include addressing persistent skills mismatches (see above) and liberalising the stifling regulatory environment, which is holding back firm creation and expansion.

Figure 1.26. Services contributed positively to labour productivity growth during the pandemic

Annual industry contribution, percentage points, 2020 and 2021



Note: This figure masks some heterogeneity among the sub-sectors: the transport sector performed very well in 2020-2021 whereas the activity in accommodation and food services fell sharply in 2020 and did not totally recover in 2021.
Source: OECD Productivity Indicators.

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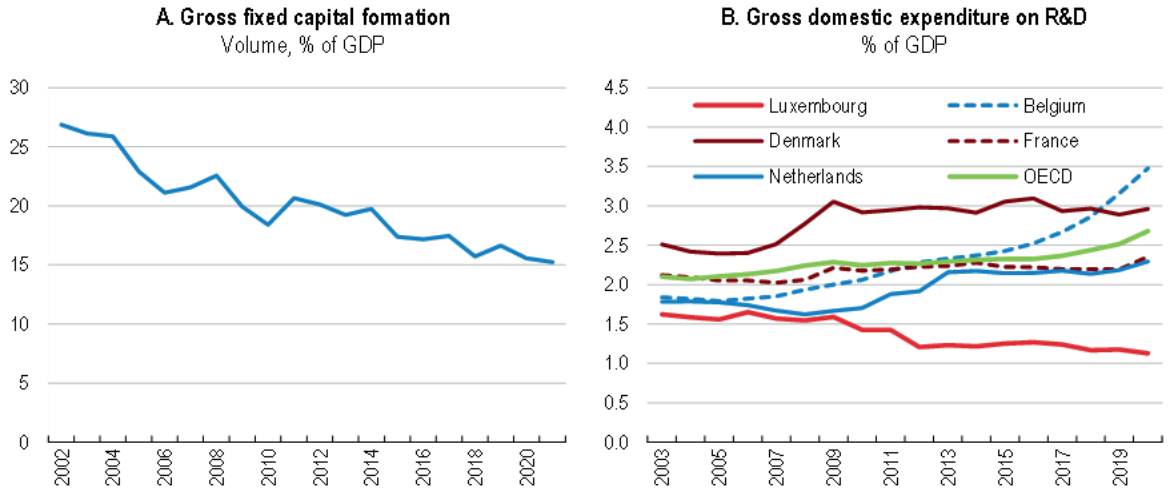
Investment spending, in particular on R&D, could be increased to support more innovation

To support long-term productivity, Luxembourg should increase investment in research and development (R&D), especially for laggard firms (Berlingieri et al., 2020[104]). Technological change (whether it comes from automation or the creation of new tasks) tends to improve productivity, leading to higher incomes and lower prices, ultimately generating greater labour demand even in sectors not directly affected by innovation (Acemoglu and Restrepo, 2018[105]; Bessen, 2018[106]; Autor and Salomons, 2018[107]). Investment in research and development is a key factor in stimulating technological diffusion, especially for firms with slower growth (Berlingieri et al., 2020[104]). However, overall spending on R&D has been declining steadily for the past two decades, in contrast with neighbouring countries and the OECD average. This appears to be part of a broader trend of declining investment since the beginning of the 2000s (Figure 1.27, Panels A and B). Total R&D spending is just 1% of GDP, significantly below the OECD average of around 2.5%. In addition, despite the high concentration of employment in knowledge-intensive services, which is the highest anywhere in the OECD (Figure 1.29, Panel B), the proportion of researchers per employees is low (Figure 1.29, Panel A).

Figure 1.27. Investment and spending on R&D have been falling steadily



Source: OECD Economic Outlook (database); and OECD Main Science and Technology Indicators.

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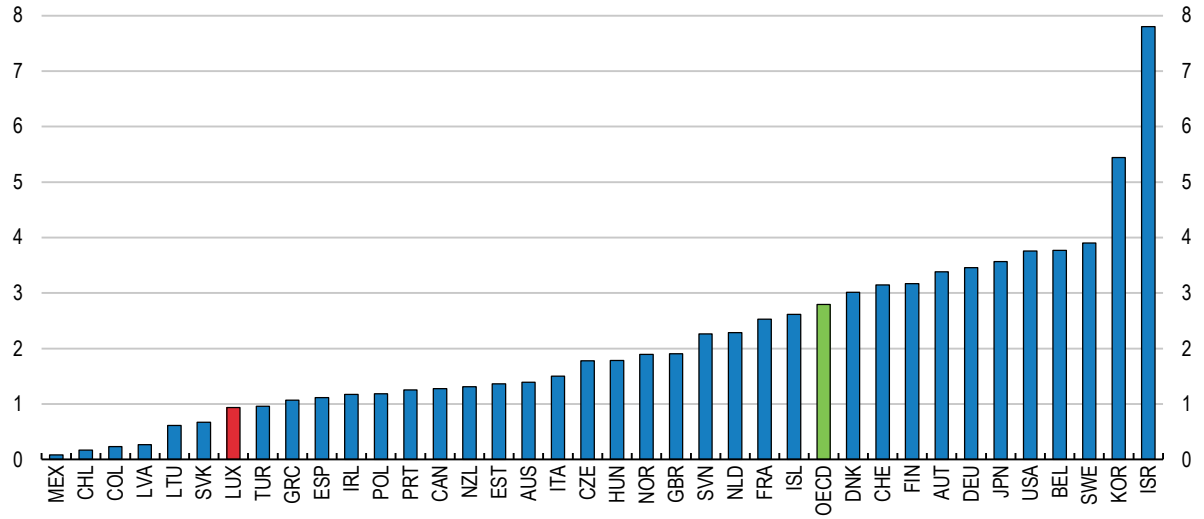
Domestic R&D is government-led, and the public share of R&D is comparatively high, reflecting the government's dedicated innovation strategy, which has been implemented since the first *OECD Innovation Review in 2007* (OECD, 2016[108]). The government budget allocation to R&D is 1.43% of government expenditure, which is around the EU average. This accounts for just over 0.6% of GDP, or as much as in Israel and more than for instance in Italy and the United Kingdom. Conversely, the private sector contributes relatively little to the national R&D effort. Business enterprise research and development (BERD) accounts for 54% of R&D, significantly below the OECD average of 72%, and R&D investment intensity by firms is very low at around 1% of GDP, from 1.5% of GDP in 2010 (Figure 1.28) (STATEC, 2021[109]). Whilst R&D in the manufacturing sector is comparatively high (6.7% of value-added by industry), a rather low R&D intensity in trade and services, which overall account for 40% of business R&D spending, lowers aggregate R&D (STATEC, 2021[109]). This may be due in part to the fact that several large multinational corporations with a presence in Luxembourg carry out their R&D at other sites.

Figure 1.28. Business investment intensity is low

Business enterprise expenditure on R&D, as percentage share of value-added in industry, 2019



Source: OECD Main Science and Technology Indicators.

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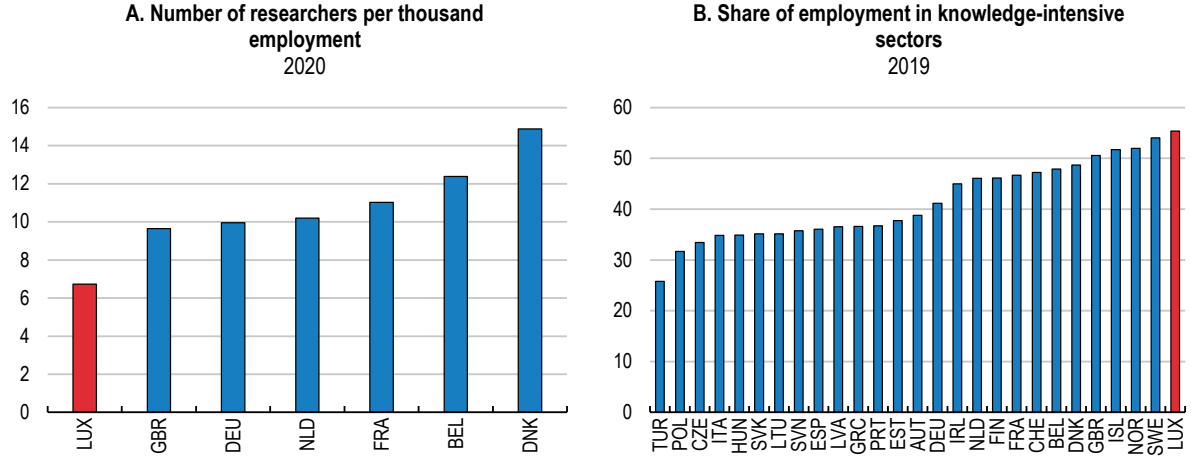
Improving the efficiency of government R&D funding could help generate more private R&D. Unlike most of the OECD and the EU, Luxembourg does not provide indirect support in the form of tax credits or tax relief for R&D. The other countries with no tax relief for R&D are Bulgaria, Cyprus, Estonia, and Latvia (OECD, 2022[110]). Currently, the government allocates 75% of its R&D budget to institutional funding, such as Luxembourg University and other research institutions, and only 25% to specific projects, including those with private partners. Only 6% of business R&D is funded by government. Switching to better targeted funding of innovation projects in partnership with the private sector could optimise the outcomes of its funding. Direct funding of R&D projects through grants, subsidies or procurements may effectively raise firms' absorptive capacity, that is, their ability to integrate and put to use new technology, and might be more effective policies for firms with a growth potential to access support (Berlingieri et al., 2020[104]). With better project-oriented funding, Luxembourg could focus its R&D investment not only on the most innovative sectors, such as ICT where investment is fairly low, but also on manufacturing and small crafts that have seen comparatively little investment in recent years (OECD, 2022[111]). Government support to R&D through direct financing of business expenditures in R&D has the potential to boost diffusion of knowledge, suggesting that it can effectively expands firms' absorptive capacity and support the innovation process necessary for diffusion (Berlingieri et al., 2020[104]).

Figure 1.29. Despite a high number of people working in knowledge intensive industries, few are dedicated to research



Source: OECD Main Science and Technology indicators.

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Luxembourg has an ambitious innovation policy, which has already seen a number of successes, driven by Luxinnovation, the national innovation agency. As recommended by the OECD *Innovation Review* (OECD, 2016[108]), Luxinnovation's mandate runs on four-yearly contracts under the Ministry of Economy, the Ministry of Higher Education and Research, the Chamber of Commerce, the Industry Federation (FEDIL) and the Chamber of Crafts. The next performance contract, based on the *Luxinnovation Strategy 2022-25*, aims to reframe its objectives on activities towards the dual challenges of digitalisation and long-term economic sustainability. However, the new Strategy could be better focused. It includes four strategic priority areas, which are very broad in scope, such as becoming a key enabler to help companies; becoming an efficient accelerator and facilitator of digitally enabled and sustainable economic development; being an organisation that is exemplary for being both data driven and human-centric; and having staff that are interconnected with the ecosystem at all levels. These are further broken down into seven strategic goals, most of which are difficult to quantify, such as providing a good customer experience or empowering the staff (Luxinnovation, 2021[112]). Narrowing down the targets, while identifying measurable indicators for performance, could help maximise the effectiveness of the programme. In addition, Luxembourg's digital innovation programme should establish an actionable roadmap for the development of digital infrastructure and services, with clear milestones that should be re-evaluated at regular intervals. Such a programme could be more explicitly integrated in Luxembourg's Roadmap for a Competitive and Sustainable Economy 2025 (*Ons Wirtschaft vu muer*), which has overlapping aims (Ministry of the Economy, 2021[113]).

Luxembourg could for instance use its series of "Fit4" programmes, which aim to upskill Luxembourg's businesses, to assess the innovation readiness of the firms that participate in the programmes, in order to better target their financial support towards boosting relevant R&D and innovation spending. The *Ons Wirtschaft vu muer* roadmap in particular highlights the role of Luxinnovation to use the Fit4Resilience and Fit4Circularity programmes, designed to provide Luxembourg's SMEs and large companies with the strategic assessment and know-how to set up circular value-chains (Ministry of the Economy, 2021[113]). These programmes can have a particularly important impact on helping future-proof SMEs in light of the fundamental changes required of doing business in the green transition (see Chapter 2). Part of the financing should be used to encourage better co-operation and co-financing between public entities and businesses. While the Fit4 programmes do encourage public-private engagement, there is so far little assessment of their impact. To ensure that the efforts are delivering the expected outputs, firms that receive support should be evaluated against a number of performance indicators, to be established jointly

with the agency and businesses. These could include annual turnover, creation of domestic jobs, the ability to attract foreign investment, or generating export revenues, after a certain number of years of receiving public support.

Other successful ways to support state intervention may be to focus growth poles around existing agglomeration economies. This allows dynamic sectors to exchange and diffuse knowledge and innovations, share pools of skilled labour and infrastructure while minimising the required involvement of public goods and services, to follow good practice (OECD/World Trade Organization, 2019[114]). Luxembourg has implemented a cluster around its steel industry in Belval in the southern part of the country. They can build on such experiences to advance similar spatial policies to target missing skills. In France, a national economic diversification programme around such growth poles, the *Territoires d'Industrie*, is being implemented with a particular focus on trades that lack skilled labour, such as high-tech industries, but also more traditional trades that struggle to find labour, such as furniture, ceramics, leather, or manufacture of precision instruments, amongst others (Ministère de l'Economie, 2022[115]; Versailles GrandParc, 2022[116]).

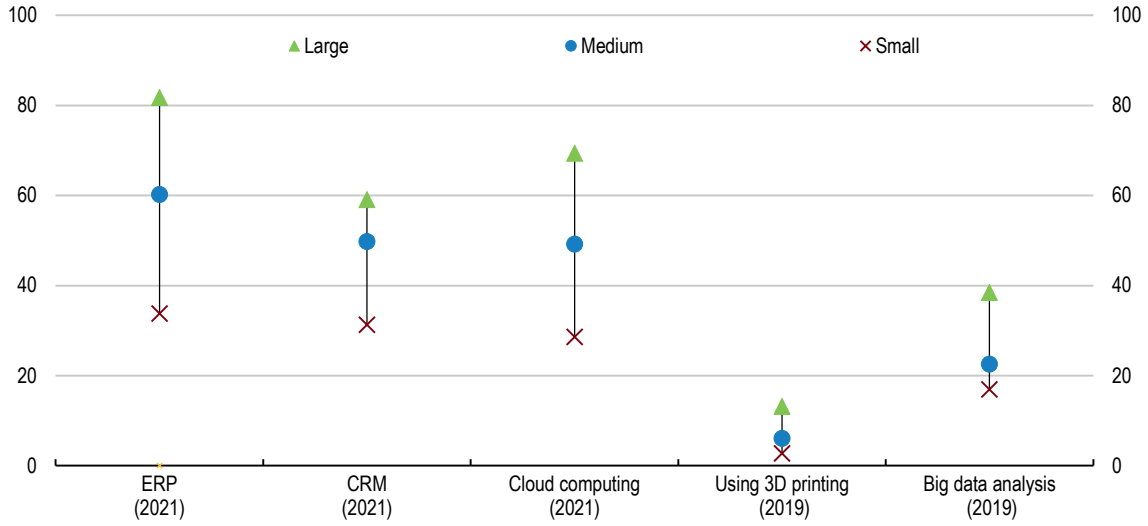
Improving ICT adoption can boost productivity for SMEs

Small and medium-sized enterprises (SMEs) accounted for 99.5% of all non-financial firms in Luxembourg in 2018 (latest available comparative data) and approximately 66% of the labour force. SMEs in Luxembourg have lower innovation intensity than larger firms, with the exception of micro firms. While SME performance, in terms of innovation, is around the OECD average, there is a big gap to the best-performing countries, with around half reporting some innovation activity, against two-thirds in Estonia, Norway, Belgium or Germany (OECD, 2022[117]). Business surveys indicate that among the most important factors holding back growth of SMEs in Luxembourg are the availability of skilled labour and experienced managers, whereas access to finance is only cited by 6% of the surveyed Luxembourgish SMEs as the most important problem they were facing (European Commission, 2021[118]). Nonetheless, more could be done to support R&D and innovation spending by SMEs. The SMEs surveyed reported little use of government guaranteed funding. A structured support programme for SMEs with government guaranteed funds or grants earmarked for investment in R&D could therefore help them to better direct their investment.

The pandemic accelerated the uptake of digital tools, but digitalisation needs to increase further. Business R&D expenditure on information technology is less than 0.05% of GDP (OECD, 2021[119]). In particular, SMEs lag behind in digital adoption (Figure 1.30) despite Luxembourg having a strong ICT infrastructure, with a 98% 4G coverage and 87.9% of businesses enjoying broadband (although only 62% with high speed). Only 10% of SMEs make e-commerce sales, against an OECD average of 25%. With a generally well-educated workforce, the country should be in a good position to rapidly increase the use of digital technologies. However, businesses report persistent shortages of qualified ICT professionals as a brake on digitalisation (Conseil national de la productivité, 2021[91]; European Commission, 2021[118]). Skills-mismatches should be addressed with dedicated adult training programmes, vocational education and training programmes (VET), and earlier introduction to key skills such as programming from primary school. As part of its strategy for digital skills, the Ministry of Education, Children and Youth has included coding and computational thinking in the official curriculum of primary and secondary education since 2021. Regular monitoring and, if needed, dedicated resources should continue to be made available to support and embed the digital transition for future generations.

Figure 1.30. Small firms lag behind in adopting digital technologies

% of firms adopting



Note: ERP = Enterprise Resource Planning software, CRM = Customer Relationship Management software. Small: 10-49 employees, Medium: 50-249, Large: 250.
Source: ECD (2021), ICT Access and Usage (database).

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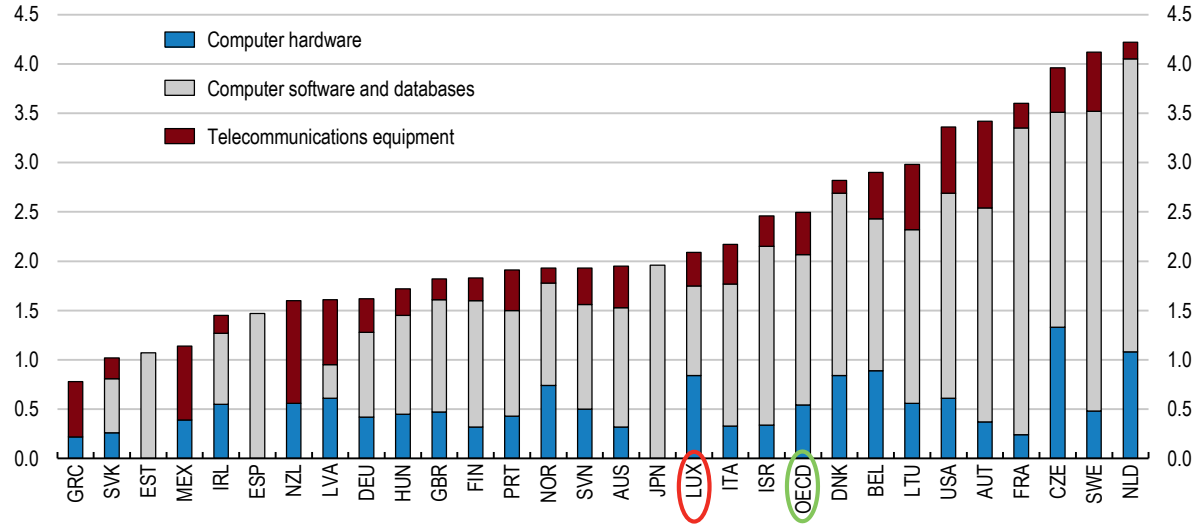
A recent survey of businesses points to the high costs of investment in digital technologies as another reason for the low investment in information and communication where Luxembourg lags behind peers, especially SMEs (Figure 1.31) (Conseil national de la productivité, 2021[91]). OECD research indicates that policies for financing targeted SME investments in ICT technologies may foster their adoption by laggard firms (Andrews, Nicoletti and Timiliotis, 2018[120]). A particular challenge remains to further integrate Luxembourg's businesses into the circular economy (Schosseler, Tock and Rasqué, 2021[121]). Digital technologies can help to overcome some of the obstacles limiting the uptake of circular economy opportunities, through their ability to monitor, interconnect and manage objects in the physical world electronically (Barteková and Börkey, 2022[122]). The Ministry of the Economy's *Ons Wirtschaft vu muer* roadmap, mentioned above, aims to further the readiness of businesses for the circular economy, notably through a set of pilot programmes on data exchange or digital procurement (Ministry of the Economy, 2021[113]). To support the roll-out of the programmes, they should also involve direct financial support to help especially smaller businesses overcome the investment hurdle.

To support a better digital diffusion, particularly to SMEs, Luxembourg should increase direct support to SMEs, including business advisory services and testing facilities. Some measures exist already within the Fit4Digital programmes, intended to support the digitalisation of SMEs, which provides financial support to carry out a business diagnostic (Guichet.lu, 2022[123]). Luxembourg has also recently implemented a Digital Innovation Hub (www.dih.lu), with a mission to be a 'one-stop-shop' for addressing the digital transformation of the Luxembourg industry and in particular the SMEs with offer and demand matching services, skills and trainings service, "test before invest" services and support to find investment at local and European levels for digital transformation projects (Ministry of the Economy, 2021[113]). However, there are little data available on the impact to date of these programmes. While awareness building and diagnostics are important tools, the authorities should also support financing schemes to help smaller businesses invest more directly in IT equipment, as well as offer training onsite on how to use the equipment.

Figure 1.31. ICT investment is relatively low

ICT investment, by type, % share of GDP, 2017



Note: ICT investment refers to gross fixed capital formation (GFCF) of "information and communication equipment" and "computer software databases" as defined by the System of National Accounts 2008 (SNA08).
Source: OECD Going Digital Toolkit.

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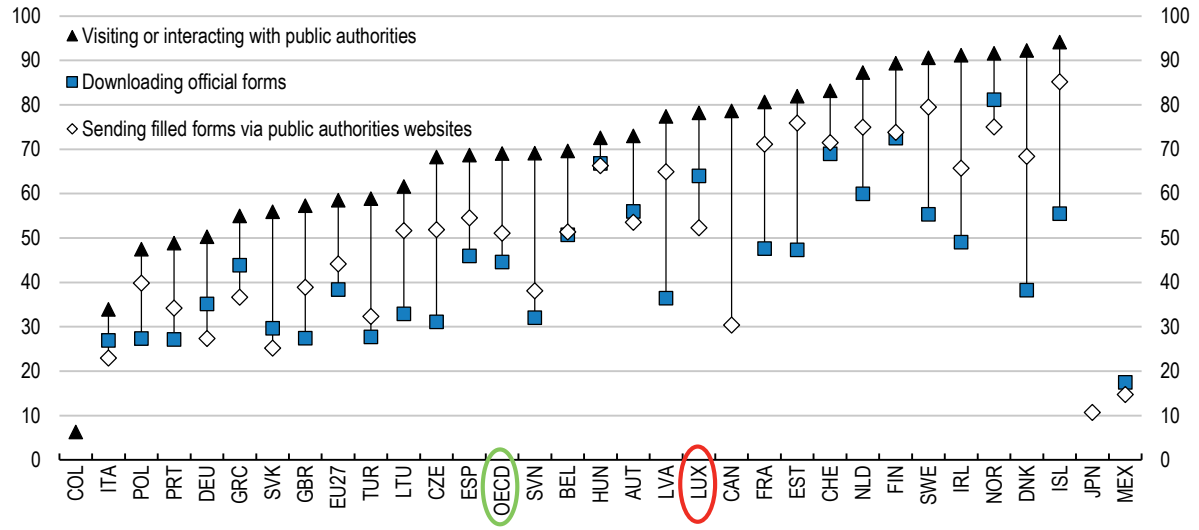
The relatively slow development of public digital services is also a concern. About 80% of the population, aged 16-74, uses the internet to interact with public authorities. While this is above the OECD average, it is below the OECD front-runners, including all of the Nordic countries, but also the Netherlands and France (Figure 1.32). The government is undertaking a *Digital Survey* with the OECD in 2022 to improve digital governance and public sector digital capacity. However, one of the difficulties with the government's e-services remains the high administrative burden (Conseil national de la productivité, 2021[91]). Most current e-services are merely digital versions of paper forms that can be submitted online. The government should use the move to digitalisation to reduce the administrative burden for all citizens. Denmark has developed a single personal digital key ("Easy-ID") which allows citizens to access all public services, including health information and tax payments, in a secure and highly simplified way. For instance, tax forms are automatically prefilled. Housing purchases are also signed electronically using the Easy ID, with no paper or physical deeds changing hands; properties are registered in an electronic cadastre. The Easy-ID is also integrated with a range of private services, such paying utility bill via private banking, using the single digital ID number.

Figure 1.32. Interaction with public authorities is relatively low, hindering efficiency gains

Share of individuals aged 16-74 using Internet to interact with public authorities (%), 2021 or latest



Note: Public authorities refer to public services and administration activities at the local, regional or national level.
Source: OECD Going Digital Toolkit.

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Lifting regulatory restrictions will help increase allocative effectiveness

Enabling allocative efficiency is a key driver of productivity. In Luxembourg, there is some evidence of productivity dispersion between firms following the financial crisis. The frontier firms in non-financial services and in manufacturing have been able to rebound towards their pre-financial crisis levels, while laggards have been in a protracted decline (Conseil national de la productivité, 2021[91]). Keeping non-performing firms in the market acts as a drag on productivity and prevents a better allocation of the best productive resources (Andrews, Criscuolo and Gal, 2016[124]). Successfully reducing Luxembourg's dependence on the financial sector is also an overarching longer-term challenge (OECD, 2019[25]). Over-reliance on a single sector creates potential economic vulnerabilities that can be mitigated with diversification.

To support allocative efficiency, the regulatory environment needs to ease entry and exit of firms and support start-ups and business development. The birth rate of companies in Luxembourg of around 9% is below the OECD average, which is closer to 11%. Data are somewhat dated, but the death rate of firms (2017 data) of around 7.6%, is also below the OECD average of around 8.6%. A low churn rate would indicate a slightly less dynamic business sector (Canton, Ciriaci and Solera, 2014[125]). One driving factor is likely to be that product market regulation in Luxembourg is less business-friendly than in most OECD countries (OECD, 2018[126]). The low churn rate may also be related to Luxembourg's highly inefficient insolvency regime. Some of Luxembourg's current insolvency laws date back to 1935 and are ill-equipped to deal with a modern economy. Recovery rates are around 43%, compared with an average of 70% in high-income OECD countries, and 92% in Norway (the best performing country). The process is lengthy (2 years on average), and the cost is higher than in other high-income OECD countries (World Bank Group, 2020[127]). To enhance allocative efficiency, Luxembourg should speed up the passing of the 2019 EU Directive on Insolvency, Restructuring and Second Chance and take the opportunity to enhance the domestic bankruptcy regime as previously recommended (Table 1.12). Two draft bills implementing the 2019 EU Directive, and which will modernise the Luxembourg insolvency law, are pending review by the Luxembourg Council of State and adoption by the parliament, which is expected by end-2022. Provided these laws are passed, exit and churn rates should improve.

The regulatory framework needs to provide the right incentives

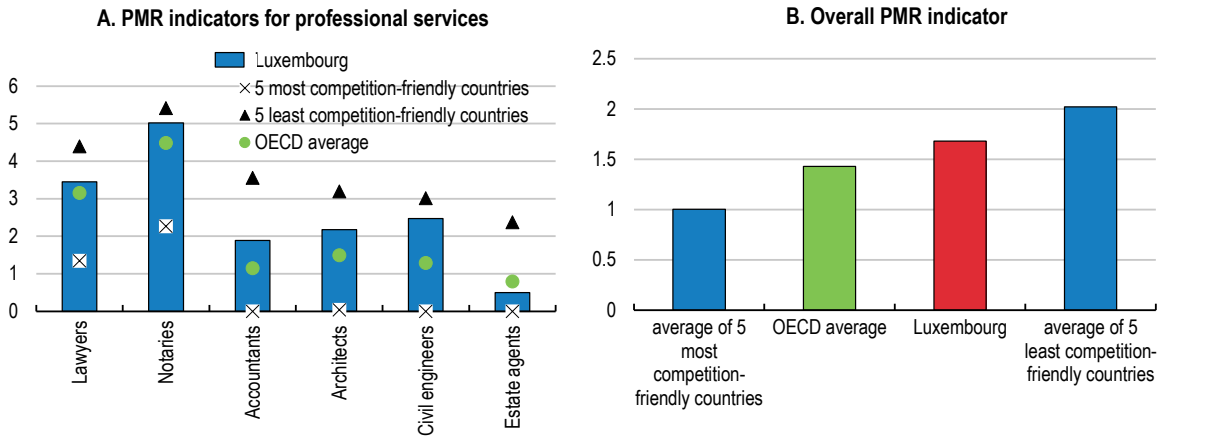
Providing the right incentive framework to attract start-ups and investors is a key factor to support economic diversification and the resilience of the economy to the green transition. Luxembourg is an open economy, with few barriers to foreign investment and trade (OECD, 2018[126]). However, the business environment, in particular for start-ups, is hampered by strict licencing and permit requirements, which act as a drag on business dynamism (OECD, 2018[126]). Luxembourg should take advantage of the current review of its digital strategy (OECD, forthcoming) to simplify the licensing requirements. This includes minimum capital requirements, which have been shown to hold back start-up activity (OECD, 2014[128]). While Luxembourg has created the "Simplified limited liability company" (SARLs) with a one-euro capital requirement for most craftsmen, traders, manufacturers, and certain liberal professionals, this still requires the agents to apply for a business permit first with the Ministry of the Economy, which requires amongst others demonstrating proof of one's professional integrity, required qualifications and physical premises. Moreover, some liberal professions face stricter licensing requirements.

New firms face a cumbersome licensing regime. Starting a business is more expensive and requires more steps than in several neighbouring countries such as Netherlands, France, Belgium and Denmark. New business permits, with the exception of SARLs and sole proprietors, need to be registered by a notary public, which is both a lengthy and costly process. Luxembourg should liberalise business permit rules to allow for easer business creation, including the abolishment of the need to register deeds and business licences with a notary public. Denmark and the UK, for instance, allow business licences to be directly registered online, without a notary.

Restrictive regulations on key professions that deliver business services (such as accounting or engineering) are associated with lower churn rates in the market (Canton, Ciriaci and Solera, 2014[125]). Access to most regulated professions is highly restrictive: barriers to entry and conduct constraints are present in the regulation of most professions (Figure 1.33) (OECD, 2018[126]). The professional licensing rules are highly restrictive, and all tradespeople need an establishment licence in addition to the authorisation to exercise. Only a few foreign (non-EU) qualifications are automatically recognised. The main exceptions are for doctors and most types of nurses, given that Luxembourg opened its first national medical school in 2021 only. Current regulations still require firms to have physical premises in order to obtain an establishment licence, which is a barrier to the development of e-commerce, and property registrations are lengthier and costlier than in other high-income OECD countries (OECD, 2018[126]; World Bank Group, 2020[127]). The physical premises requirement seeks to avoid letter-box companies but there may be other ways to guard against this risk.

Figure 1.33. Luxembourg's business regulatory environment is restrictive

Index scale (0-6) from the most to the least competition friendly (6=most restrictive)



Source: OECD 2018 PMR database.

StatLink https://stat.link/ls1cgb

Luxembourg should undertake a competition assessment review of the regulatory environment for the regulated professions as well as the retail and network sectors. Since the mid-1990s, Australia has systematically carried out a thorough review of all business and product market regulations in the economy, reviewing more than 1 800 laws. Several countries have undertaken such reviews with the support of the OECD, including Iceland, Portugal, and Greece. By lifting the regulator restrictions identified, benefits to the Greek economy exceeding 2.5% of GDP were identified (OECD, 2014[128]).

Table 1.12. Previous recommendations to enhance the business environment

Recommendation	Action taken
Modernise bankruptcy law to ease early restructuring and second chance opportunities, as well as the exit of non-viable firms.	A bill to transpose the 2019 EU Directive on bankruptcy and second chances is before parliament and is expected to be passed before end-2022. This law will also update Luxembourg's bankruptcy regime.
In those professional services, eliminate restrictions on advertising and marketing	No action
Promote the adoption of cutting-edge technologies, inter alia through the demonstration effect of public sector use	A super-computer, MeluXina, has been purchased by the authorities and will be used to improve Luxembourg's performance in research, both industrial and academic.

Competition law and policy need strengthening

Competition policy plays an important role in the expansion of an efficient and diverse private sector. Anti-competitive conduct by dominant firms can seriously inhibit incentives to innovate and diversify. An effective competition law and enforcement framework are necessary to complement regulations that enable firm entry and rivalry (Hasanov and Cherif, 2021[129]; Aghion et al., 2005[130]). Luxembourg's competition agency, the *Conseil de la Concurrence*, is relatively small, with just 11 employees, especially given its remits. In addition to competition law enforcement, since 2021 it also oversees consumer protection, as well as regulatory assessments of new laws (Conseil de la Concurrence, 2022[131]). By comparison, Iceland's competition authority (with half of the population) has 23 full-time staff.

In addition to its small size, the effectiveness of the Council in stimulating competition in Luxembourg is hampered by the fact that the national Competition Law does not provide for merger control powers. Instead, the Council relies on European legislation (Article 102 of the TFEU), as well as a 1973 ruling by the European Court of Justice, on the abuse of dominant position, to verify whether mergers in the Luxembourgish market have an anti-competitive effect. As no merger control law is in place, this occurs after the mergers have taken place, no matter the size or value of the transaction, and only provided the merged entity also has a dominant position in Luxembourg. With these obstacles, it is not surprising that an ex-post dissolution of a merger has never happened in Luxembourg, as the burden of proof of a significant impediment of effective competition in this case falls entirely on the Competition Council (Bleser, 2020[132]; Conseil de la Concurrence, 2022[131]). To strengthen the powers of the Competition Council, more resources, in the form of staff, should be granted to the Council. In addition, the competition law framework could be strengthened, for instance through a Peer Review of Luxembourg's Competition Law and Policy with a view to updating and modernising the competition law.

To embed an economic diversification programme, such as Luxembourg's national research and innovation strategy (Luxinnovation, 2021[112]), the institutions must be able to sustain interventions over time and manage the risks of regulatory capture and rent-seeking, inherent in public-private interaction (OECD/World Trade Organization, 2019[114]). This is a challenge owing to Luxembourg's small size. Public ownership is extensive, and the governance of state-owned enterprises is only partially in line with key OECD best practices (OECD, 2018[126]). In some sectors, there is no separation between the public body that owns the state-owned enterprises and the industry regulator. In addition, there are no rules regulating the interaction between interest groups and policymakers (OECD, 2018[126]). To enhance the effectiveness of Luxembourg's ambitious diversification programme (Luxinnovation, 2021[112]), clear separations between the various agents should be put in place, as well as clear reporting lines, including for accounting

purposes, for projects that are publicly funded. Sector regulators should be granted independence of line ministries.

Table 1.13. Main findings and policy recommendations of the Key Policy Insights Chapter

MAIN FINDINGS	RECOMMENDATIONS (key ones in bold)
Enhancing resilience to risks	
Inflation pressures have been broadening. Measures to mitigate the impact from rising energy prices and high inflation have been adopted. In addition, wages and benefits are indexed to inflation. Automatic wage indexation can increase inflationary pressure and benefits the wealthiest the most.	**Make income support to households more targeted to the most vulnerable and limited in time, whilst avoiding accelerating domestic demand pressures.** Provide targeted support to smaller firms that have inherently high energy costs. **Reform the wage indexation system in consultation with social partners to take better account of the productivity, employment, and investment effects.**
Macroprudential policy has tightened borrower requirements to reduce tail risks. Rising house prices, high debt-service ratios and variable mortgages could raise some borrowers' vulnerability to higher interest rates.	**Expand and publish regular monitoring of all loan types by household characteristics to understand emerging pockets of vulnerability and be prepared to implement additional macroprudential policies if necessary.**
Concentrated ownership, land hoarding as well as regulatory barriers reduce housing supply. Immovable property tax revenues are very low, despite high property valuations. The wealthy benefit disproportionately from lower property taxes.	Implement the planned reforms to cadastral values and the national recurrent taxes on unused land and accommodation. Gradually phase out the current mortgage interest deduction.
Growth in financial assets under management was very strong between 2020 and 2021, thanks to low global rates. While the banking sector remains well-capitalised, the impact of rising rates may be exacerbated by pockets of liquidity and leverage risk.	Maintain heightened levels of oversight and monitoring of banks and investment funds.
Legislation has strengthened the anti-money laundering framework. The financial regulator uses big-data to risk-score entities for investment funds. Big data techniques could be used more extensively for risk identification and investigations.	Intensify the use of big data techniques by regulators to guide more risk-based investigations by the Ministry of Justice. Share best practices for financial sector providers in the use of artificial intelligence and big data for risk-based assessments.
Increasing long-term economic resilience with appropriate fiscal policy measures	
The current fiscal position is strong. However, shocks can affect the composition of spending. Current spending decisions are only weakly linked to evaluation mechanisms. Pensions spending is projected to rise to 18% of GDP in 2070 from 9% in 2022. The effective retirement age is low, and not linked to life expectancy. Pension benefits are high and the replacement rate is close to 90% for average wages. At the same time, 10% of pensioners are poor.	**Put in place a more performance-oriented budgeting framework, incorporating spending reviews, to make spending more effective.** **Link increases in the statutory retirement age to increases in life expectancy.** Raise the required number of contribution years for retirement. Curb early retirement schemes before 62, and link more closely the level of pensions to the level of contributions. Switch indexation to pensioners' living costs rather than the real wage.
Participation rates of older workers are very low, depriving the economy of an important source of skills and expertise.	**Phase out incentives for early retirement, while providing for more flexible working arrangements for older workers.** To encourage employment of older workers, consider additional measures such as co-financing of salary costs**.**
Luxembourg spends relatively little on preventive medicine, and the cost of long-term care is set to more than double by 2070.	Increase the focus on preventive care to favour healthier old age. Consider keeping recipients of long-term care in their homes, rather than in institutions to improve well-being and to reduce costs.
Improving labour market outcomes for sustained growth	
Projected strong growth will require increasing the labour supply, both domestically and with foreign workers.	Improve the working permit system for non-EU nationals, in particular by removing the minimum salary requirement.
Workers will need higher skills over the medium and long term. There is a higher concentration of low skills among the older workers.	**Subsidise active on-the-job training schemes targeted to the over-45-year-olds.**
School dropout rates are high, and young people face high unemployment rates, excluding them from the workforce and depriving the economy of valuable skills.	**Expand access to training to help early-school leavers enter the workforce, alongside school system reforms.** Reduce the use of repeating school years and avoid early selection.

Unemployment is high for the low skilled and the older workers, and those workers are more at risk from displacement because of the green and digital transition.	Involve a larger share of the registered long-term unemployed in active labour market policies, and monitor which policies are most effective in re-connecting them with the labour market.
Female labour market participation rates remain below those of men, despite efforts to improve childcare option for working mothers. The personal income tax system still favours married couples, possibly reducing incentives to work for spouses.	Reduce the income tax discrepancy between single and married households, and provide affordable and qood-quality childcare, in order to improve equality and stimulate labour force participation in women.
Skills-mismatches are preventing firms from expanding and are holding back productivity growth.	Skills mismatches should be addressed through lifelong learning, accompanied by career guidance for individuals and companies.
Friction in the labour market owing to language requirements prevents workers from taking up available positions, including in cleaning, catering and care sectors.	Requirements to speak all three official languages in many sectors, such as the care sector, should be relaxed. Digital tools can provide easy on-the-job translation.
Reviving productivity growth and economic diversification for long-term economic resilience	
Productivity levels are high, but growth has been low and overall investment has declined. Public investment support schemes have overlapping structures. The current incentive scheme design has not had an appreciable impact on business investment which, including R&D, is very low as a share of GDP. The existing innovation policy strategy lacks a systematic impact assessment.	**Increase public spending on R&D to match private R&D funding, and encourage greater investment by firms.** **Increase funding to targeted projects by reducing the funds spent on administration.** Evaluate the impact by establishing performance metrics, including value-added, taxation paid and productivity of targeted firms versus non-targeted.
Laggard firms are slow adopters of innovation, and SMEs in particular are lagging behind in using digital tools.	Increase direct support to SMEs such as business advisory services and financing schemes for IT equipment and training.
Digital public services remain under-developed.	Use the move to digitalisation as part of the Recovery and Resilience Plan to streamline administrative procedures.
The business regulatory environment is restrictive, notably for new firms, and for small traders. Barriers to entry and conduct constraints are present in the regulation of most professions, limiting competition.	**Reduce administrative burdens on small firms, notably by streamlining procedures for starting a business.** Carry out a Competition Assessment Review of the regulated professions, to identify and lift the most restrictive regulations.
In the non-financial services, less productive firms have tended to fall further behind best performers, with laggards in protracted decline, which weighs on aggregate productivity.	Speed up the implementation of the EU Directive on Insolvency while modernising the bankruptcy regime to ease early restructuring and second-chance opportunities, as well as the exit of non-viable firms.
The national competition authority is small, and the Competition Law has no provisions for merger control.	Carry out a full Peer Review of the Competition Law and Policy framework with a view to updating the national Competition Act. Provide more resources to the Conseil de la Concurrence, especially staff.
In some sectors, there is no separation between the public body that owns the state-owned enterprises and the industry regulator.	Sector regulators should be granted independence of line ministries.

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2 Securing a dynamic and green economy

Catherine MacLeod

Paula Adamczyk

Luxembourg announced ambitious climate targets to accelerate progress towards carbon neutrality in 2050. These objectives require significant mitigation efforts, as progress in the green transition has stalled in the past few years. The emissions reductions required in the next 30 years are greater than the declines of the 1990s, which were driven by reforms to the steel industry and the closure of coal power plants. At the same time, the targets can allow Luxembourg to benefit from the green transition. Owing to the specificities of Luxembourg's economy, most of the efforts will need to be focused on the transport and housing sectors. The transition will require deep changes in the behaviour of households, whose high carbon footprint is due to car usage and home heating. Sustainably reducing emissions also requires tackling cross-border fuel sales for both freight and commuters. Furthermore, reforms in agriculture are needed to reduce pressures on biodiversity. A wide range of policy tools need to be used to increase public acceptability. A higher carbon price over the medium and long term would lead to lower fuel sales and greater energy efficiency. Better spatial planning policy could reduce urban sprawl and car dependency. Stricter regulations and enhanced incentives would facilitate more environmentally-friendly agricultural practices.

This chapter discusses how to make Luxembourg's economy greener through a more effective and inclusive strategy. The current environmental challenges are assessed (first section) and the key risks posed by the transition (second section). The policy framework necessary to manage these risks, and policy recommendations to achieve climate ambitions and maintain public support are then proposed (third section).

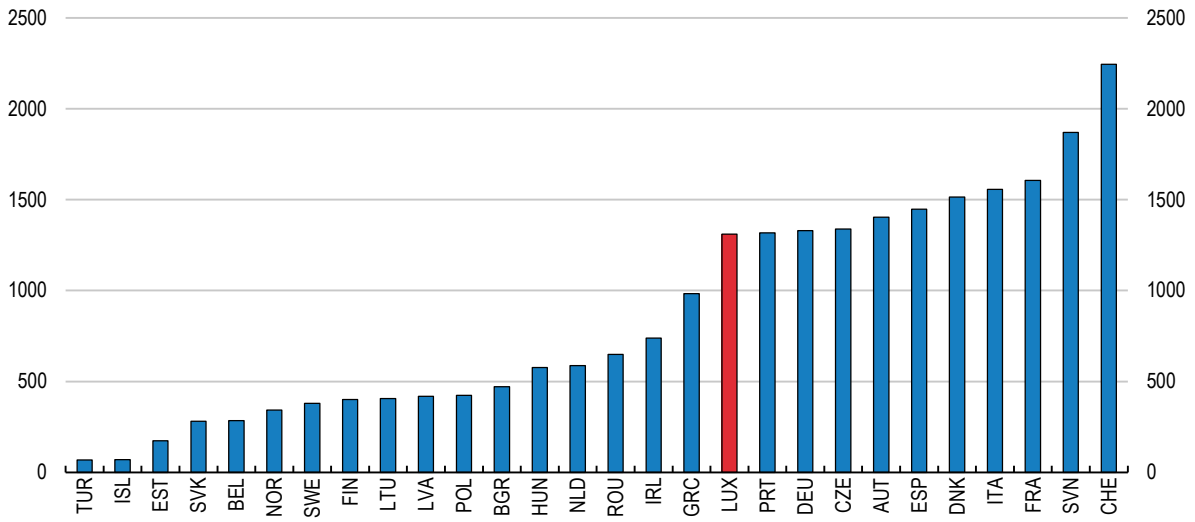
The foundations for greener growth are in place, but efforts need to accelerate

Climate change is currently one of the most pressing long-term challenges and many governments have put it at the forefront of their political agendas. Climate action is needed since increased droughts, flooding and extreme weather events will become more common if sufficient mitigation efforts are not put in place urgently (IPCC, 2022[1]). Recognising these challenges, the Luxembourgish authorities have adopted ambitious climate targets for 2030, with the long-term goal of reaching carbon neutrality by 2050.

This strategy will require enhanced decarbonisation efforts of all stakeholders as well as efficient policy implementation and coordination. Early action can prevent exacerbating the risks but also help benefit from the economic opportunities generated by the green transition. While Luxembourg is not particularly vulnerable to natural catastrophes, evidence shows that it still faces significant potential costs associated with climate-related weather events (Figure 2.1).

Figure 2.1. Climate-related economic losses are relatively high

Economic losses from extreme-weather events, euros per capita, in 2020 prices



Source: European Environment Agency based on CATDAT of RiskLayer estimations.

StatLink https://stat.link/pmsdzk

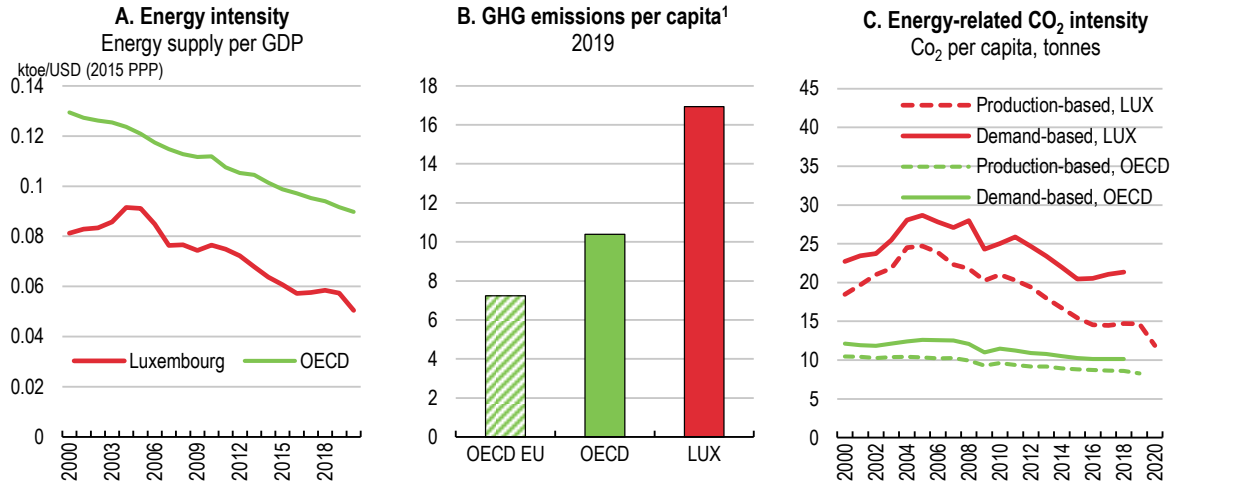
A bird's eye view of green transition challenges in Luxembourg

Luxembourg has made considerable progress towards the green transition. In spite of high economic growth, greenhouse gas emissions have decoupled from GDP and energy intensity remains significantly lower than the OECD average (Figure 2.2, panel A), thanks to the relatively low-carbon intensity of the financial and business services sectors. Substantial investments in renewable energy sources have resulted in the share of renewables in energy supply doubling over the past decade. The government has entered into a Climate Pact with municipalities that provides certification and funding to those implementing environmental and climate measures. The Naturpakt with municipalities aims to encourage nature protection and biodiversity conservation. The government has also implemented ambitious climate targets to accelerate the green transition.

At the same time, there is scope for further improvements to ensure reductions in emissions since 2020 are long-lasting. The consumption and production patterns of Luxembourgish citizens as well as an increasing population have contributed to pressures on the natural environment. The gains in greenhouse gas emissions reductions from early 1990s reforms of the steel sector to arc-furnaces and the phase-out of coal were offset by steady growth in transport sector (including freight) emissions from the mid-1990s (IEA, 2020[2]).

Luxembourg's residents are the largest per capita consumers of carbon in the OECD, even when excluding fuels sales to non-residents, as shown by the production and demand-based measures of CO_2 emissions (Figure 2.2, Panel B). The carbon intensity of demand is much higher than that of production as Luxembourg imports most of its energy needs (Figure 2.2, panel C). Around 95% of energy demand is imported, mainly oil and natural gas, and is not accounted for in the production-based measure. Demand-based CO_2 intensity measures the intensity of CO_2 emissions based on final demand consumption, excluding the impact of fuel sales, reflecting the actual emissions in the economy (OECD, 2017[3]). It is an indicator of how much carbon has to be imported in order to satisfy the final demand of the citizens (Box 2.1).

Figure 2.2. Emissions per capita are high although energy intensity is relatively low



1. Including Land Use, Land-Use Change and Forestry (LULUCF). Because of the principle of territoriality, it includes fuel sales to non-residents.
Source: OECD Green Growth Indicators.

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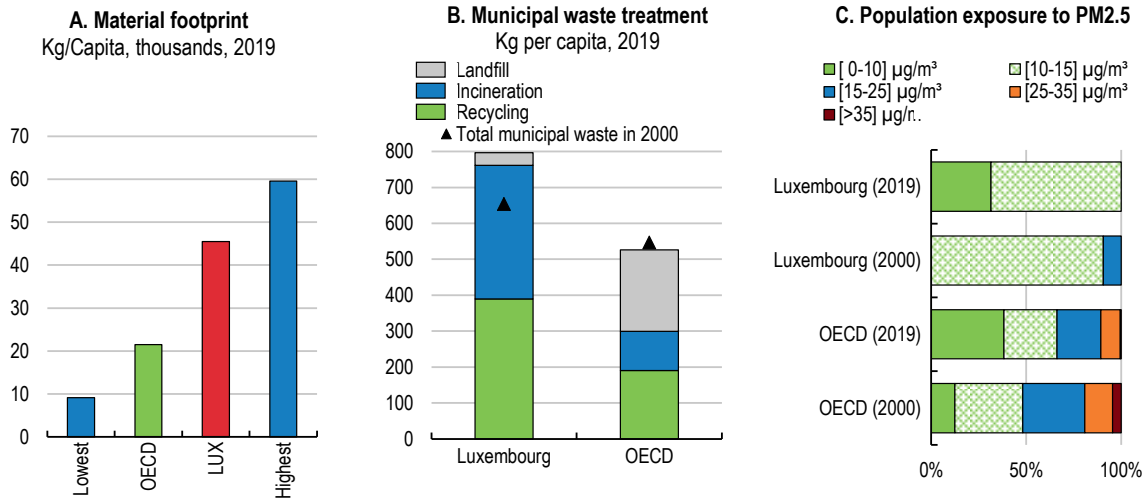
In addition, Luxembourg's consumption patterns generate important amounts of waste per capita. The material footprint, which takes into account resources required to satisfy the final demand in a country, is one of the highest among OECD countries (Figure 2.3, panel A). As a result, the amount of waste produced per capita is also significantly above the OECD average (Figure 2.3, panel B). In part, the high levels of consumption and waste are due to the large numbers of cross-border workers that commute to Luxembourg on a daily basis and essentially inflate the numbers that are measured in per capita of the population (OECD, 2020[4]). Encouragingly, the amount of municipal waste going to landfills has significantly declined and currently represents only 4% of total waste generated, against 47% incinerated and 49% recycled (Figure 2.3, panel B). This is a major improvement from the 21% landfilled in 2000, following the First (2000) and Second (2010) Waste Management Plans. The government has also recently introduced the Circular Economy Strategy aimed at reducing waste and promoting reuse and recycling.

Over the past two decades, emissions of small particulate matter into the atmosphere decreased, resulting in air quality improvements in Luxembourg (Figure 2.3, panel C). However, the country's high reliance on car-based transport and the large number of daily foreign commuters have led to high levels of exposure to other pollutants, in particular nitrogen oxides and carbon monoxide that are the result of burning fuels

in car engines. Nitrogen oxide emission levels are much higher than in neighbouring countries (Figure 2.4, panel A).

Figure 2.3. The amount of waste generated surpasses the OECD average but air quality has improved



Source: OECD Green Growth Indicators.

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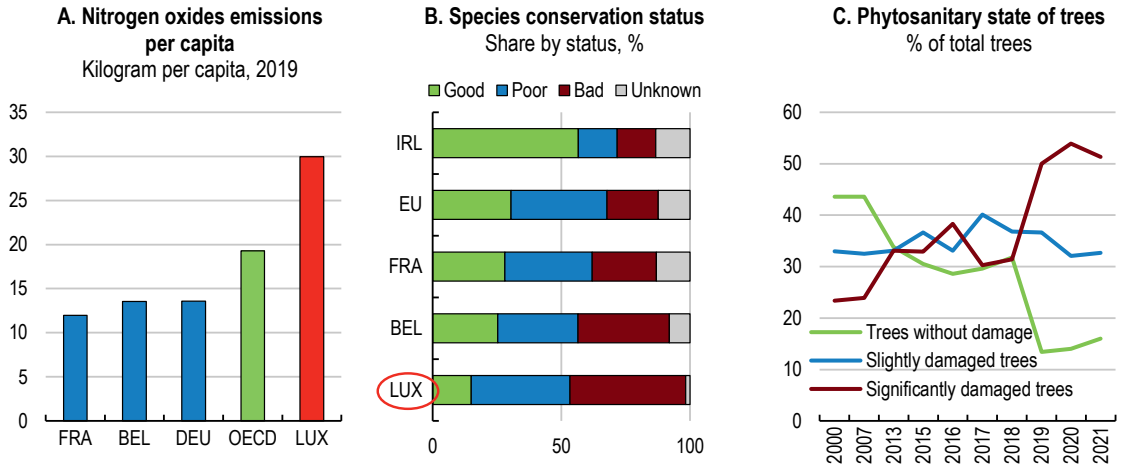
More attention should be paid to the health of Luxembourg's ecosystem whose quality has worsened over the years. Biodiversity, soil sealing, the quality of water and deforestation and the associated loss of species will need to be addressed (Figure 2.4, panel B). The sharp expansion of the built environment, including the extensive and expanding road infrastructure network, exacerbates soil sealing, and increases pressure on land. Intensive farming practices, such as livestock grazing and excessive use of fertilisers and pesticides, have a negative impact on water and soil quality and contribute significantly to biodiversity losses.

Moreover, climate change impacts, notably periods of heat and drought, have facilitated the spread of pests and resulted in Luxembourg losing more forest space than any other OECD country. The health of trees has significantly deteriorated over the past few years. Only 16% of all trees in Luxembourg are currently without damage while half of them are considered significantly damaged (Figure 2.4, panel C). Projected weather change patterns are likely to intensify problems, as warmer weather encourages the proliferation of pests, such as bark beetle, whilst also potentially having a negative impact on yields for crops. This would worsen the impact of the shift to emissions-intensive cattle production underway since 2010.

Figure 2.4. The natural environment is under pressure



Source: OECD Green Growth Indicators; European Environment Agency; and STATEC.

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Greenhouse gas emissions require specific attention

Luxembourg has managed to decouple greenhouse gas emissions from GDP growth since 2005 but progress has slowed over the past few years (Figure 2.5, panel A). After initial reductions in the early 1990s, the rise of transport emissions led to GHG emissions increasing again. Despite a gradual decrease since 2000, total emissions have remained at relatively higher levels compared to top-performing countries (Figure 2.5, panel B).

Box 2.1. International measures of carbon footprints

The territorial-based measure of greenhouse gas emissions is widely used for country emissions targets. It includes fuel sales to non-residents, which would increase Luxembourg's emissions relative to those countries where fuel exports are proportionally smaller relative to resident fuel sales. The territorial-based measure includes power generated in the territory, rather than the power that is used in the territory. As Luxembourg is a net energy importer, this reduces Luxembourg's emissions relative to those countries that generate power for their own consumption, especially those that export power. No distinction is made between residents and non-residents in territorial-based measures.

The OECD produces production-based and demand-based measures of CO_2 emissions from residents alone, excluding the impact of cross-border workers, and fuel sales. The production-based measure includes all energy that is produced within the country, whether used domestically or exported. The demand-based measure also includes the emissions associated with imported energy, which is an important power source in Luxembourg. This indicator provides a clearer pattern of the emissions intensity of how Luxembourgish residents live and work, but is more complicated to measure. It is also only available for the economy as a whole and not disaggregated by sectors. Both the production-based and demand-based measures cover only CO_2 emissions, not all greenhouse gas emissions.

To facilitate international comparisons, emissions are often scaled per capita or by unit of value added produced. In Luxembourg, scaling territorial-based measures by population could introduce an upward bias, since cross-border commuters expand the number of people in the territory by about 30%, but do not affect the total population size. Using the OECD's demand- and production-based measures of emissions per capita avoids the issue of having different samples of population in the numerator and denominator, as both include just the resident population. Scaling territorial-based measures by unit of GDP may under-represent the carbon intensity of production given the importance of economic activities with a limited physical presence in Luxembourg. Using GNI instead of GDP might give a more relevant measure of emissions per value-added produced in the case of Luxembourg.

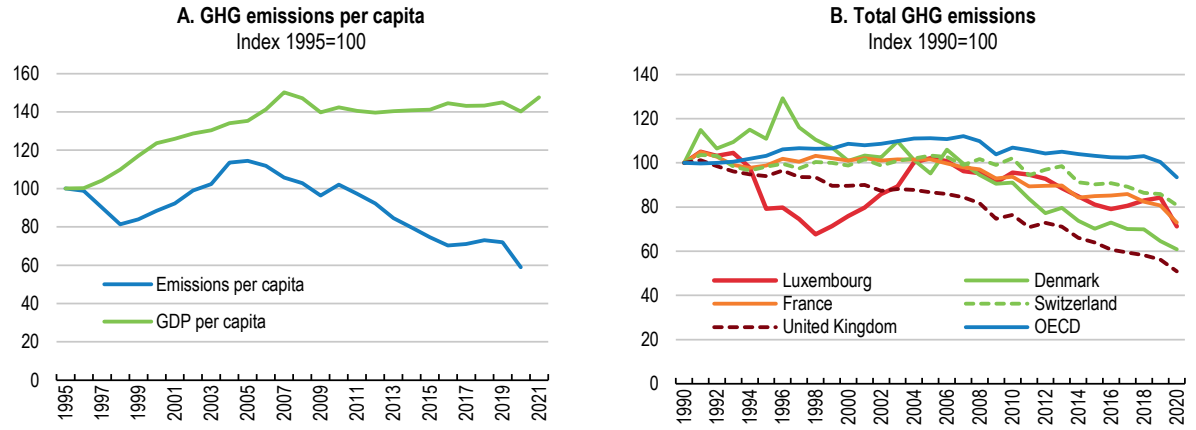
In light of these various caveats, it is critical to consider a range of measures to benchmark performance and policies.

Source: (OECD, 2017[3]); (Yamano and Guilhoto, 2020[5]).

Meeting Luxembourg's international commitments on greenhouse gas emissions will require significant progress in tackling territorial emissions from transport, including cross-border fuel sales, as well as the residential sector (Figure 2.6). The transport sector's share of emissions (57.4%) is more than double its share in other OECD countries. The transport sector drives a heavy reliance on hydrocarbons in total energy needs: oil makes up 65% of total gross energy consumption in the country (IEA, 2020[2]). The importance of fuel sales to non-residents, including freight transport, has played an important role in the rise in greenhouse gas emissions since 2015 as well as the subsequent COVID-related decline in emissions in 2020. Luxembourg is an international transit hub owing to its geographic position and low fuel prices compared to neighbouring countries. Freight trucks, cross-border residents and other fuel tourists are responsible for around two-thirds of transport-related fuel consumption (IEA, 2020[2]).

Sustainably tackling emissions from the residential sector, which makes up 15.5% of total emissions, will require reducing heating-related consumption and increasing the energy efficiency of buildings, as well as switching out of carbon-intensive heating sources. Natural gas accounted for 53.2% of homes' heating systems and heating oil accounted for a further 36% of home heating (Ministère de l'Énergie et de l'Aménagement du territoire, 2020[6]). Residential heating related emissions have risen steadily over time. Despite its relatively small industrial sector, the share of emissions from manufacturing are roughly equivalent to the OECD average. The manufacturing sector's energy needs are dominated by the steel and glass industries.

Figure 2.5. Progress in reducing emissions has slowed since 2015, weakening growth decoupling



Note: Emissions including Land Use, Land-Use Change and Forestry (LULUCF). GDP per capita is based on purchasing power parity.
Source: OECD Greenhouse gas emissions (database); and OECD National Accounts (database).

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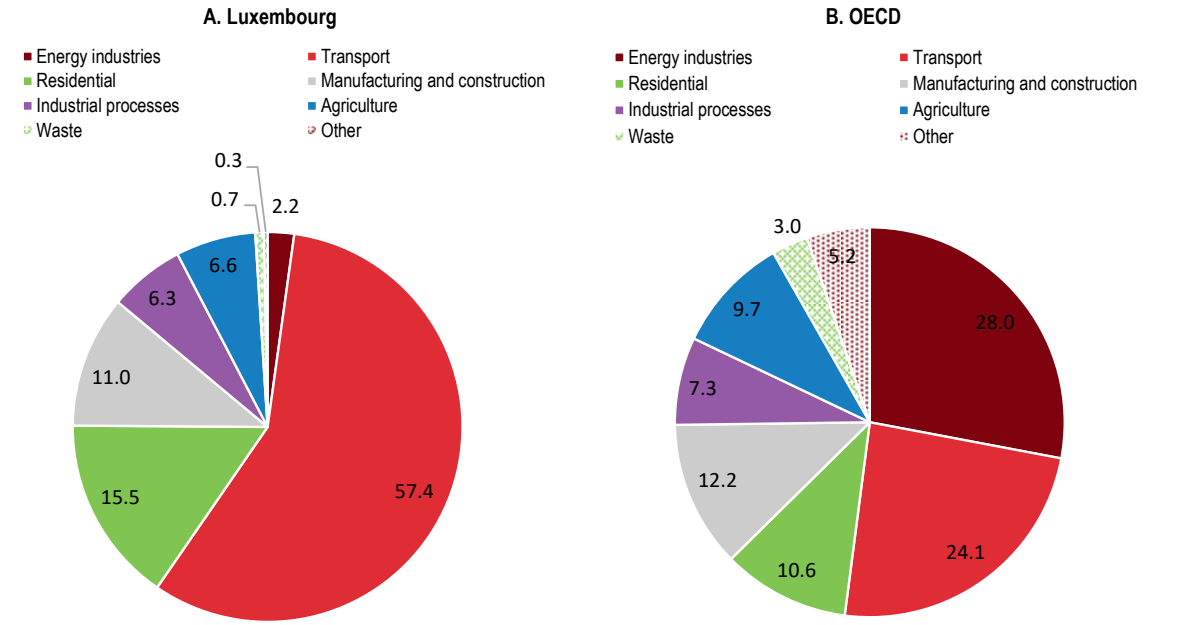
The carbon intensity of the economy stems from the reliance on fossil fuels for energy consumption. Oil makes up 65% of gross energy consumption, mainly in the transport sector, but is also used for heating in the residential and commercial sectors (IEA, 2020[2]). Natural gas accounts for 15% of gross energy consumption. It is an important source of energy for homes and firms, making up 46% and 41% of their energy needs in 2017.

Figure 2.6. The transport sector accounts for most of the GHG emissions in Luxembourg

Greenhouse gas emissions by source, percentage, 2019



Note: Emissions are calculated on a territorial basis. This includes the fuel sales to non-residents and excludes electricity consumed but not produced in the territory. Note that energy not produced within the territory is also excluded. Since Luxembourg imports 95% of its energy, this means energy sectors account for just 2.2% of emissions compared to an OECD average of 28%. Because of its computational ease, this has been the standard that has been agreed to for international greenhouse gas commitments.
Source: OECD, Greenhouse gas emissions by source (database).

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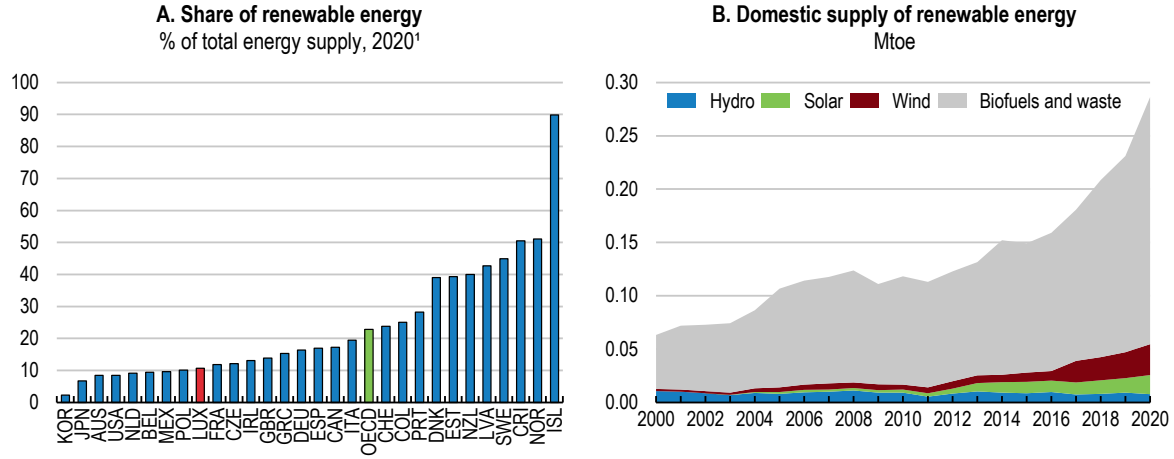
Reducing fossil fuel reliance brings environmental benefits and would make Luxembourg's energy system more resilient, especially in the current context of Russia's war of aggression against Ukraine. An EU-wide embargo on coal has been in place since August 2022 and will be extended to seaborne oil by the end of 2022. Oil imports from Russia are negligible. About 25% of natural gas imports were from Russia in 2020, but they have fallen since given the reduction in supply to Europe (Ministère de l'Énergie et de l'Aménagement du territoire, 2022[7]). Most natural gas comes through LNG facilities in Belgium, primarily sourced from Norway and the United Kingdom, transported to Luxembourg via pipeline. Gas shortages are not expected in the near term, given the recent decline in domestic demand. Gas storage facilities are in Germany, and a multilateral agreement is in place with neighbouring countries. While Luxembourg imports relatively less energy directly from Russia than other EU countries, it is still indirectly affected by the conflict and bears the consequences of higher energy prices. Accelerating the shift to non-fossil fuel resources would thus both reduce the carbon intensity of the economy and improve domestic energy security.

Domestically based renewable energy production has expanded, but remains relatively low, at around half the share of OECD peers (Figure 2.7, panel A). Most of the growth has been from biofuels rather than photovoltaics or wind-based power (Figure 2.7, panel B), even though solar capacity per capita is relatively high compared to other EU member states. The supply of renewable energy sources is supported by feed-in and premium tariffs for electricity produced by renewable sources, as well as investment subsidies for renewable energy deployment.

Figure 2.7. The supply of renewable energy is still one of the lowest among OECD countries



1. Data for Costa Rica refers to 2019.
Source: OECD Green Growth Indicators; and IEA, World Energy Balances.

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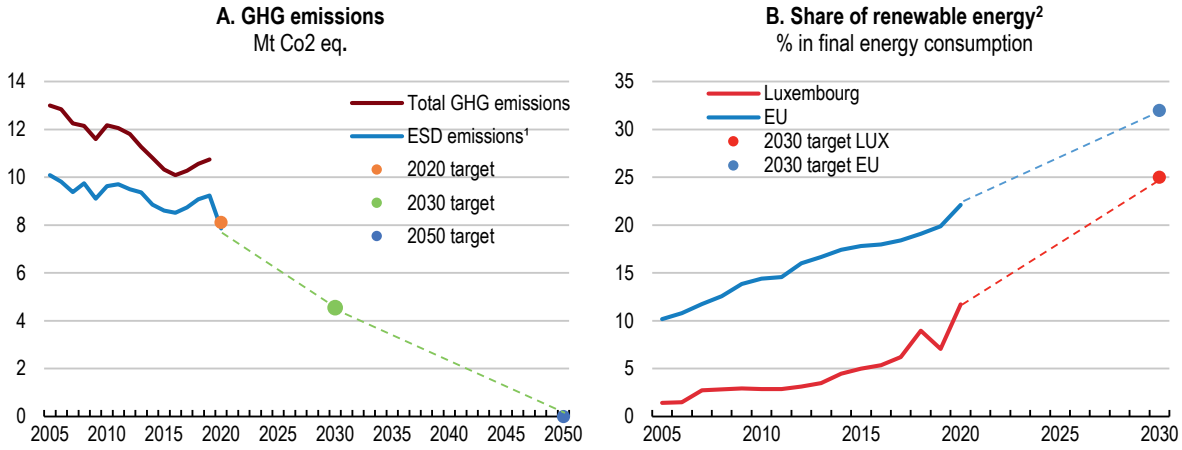
In order to augment its low levels of domestic production of renewables in the context of EU requirements, Luxembourg has purchased statistical transfers of renewable energy, in line with EU regulations. This system allows countries with surplus renewable energy relative to targets (such as Estonia and Lithuania) to sell this renewable energy to countries who fall short of these targets, such as Luxembourg. These transfers are statistical, since they do not require the actual transmission of power between countries - but the money must be used for new measures to develop renewable energies or energy efficiency. In 2020, 1.6 percentage points were added to the renewable share from statistical transfers. This number is envisaged to reach 5.4 percentage points by 2030, as cooperation measures expand to include new instruments such as the European renewable energy financing mechanism.

An ambitious green transition strategy has been put forward to speed up change

Recognising the climate challenges and risks, the authorities have put forward ambitious targets. The government has published two documents to guide its green strategy: the National Long-Term Strategy outlines a vision for the green transition and commits to Luxembourg becoming climate-neutral by 2050. The National Energy and Climate Plan 2021-2030 (NECP) defines Luxembourg's targets for 2030 both at a national and sectoral level. Guided by the priority areas defined by the EU's Fit for 55 strategy (see Box 2.2), the national plan commits Luxembourg to:

- reduce greenhouse gas emissions by 55% in 2030 from 2005 levels (EU requirement: 40%) (Figure 2.8, panel A).
- increase the share of renewable energy to 25% of gross final energy consumption by 2030 (Figure 2.8, panel B).
- improve energy efficiency by 44% in 2030. This is with respect to the business-as-usual scenario (based on the benchmark EU PRIMES 2007 model).

Figure 2.8. The 2030 and 2050 targets call for an acceleration in the pace of change



1. ESD = Effort Sharing Directive. These emissions are covered by the EU Effort Sharing Directive and are not part of the EU Emissions Trading Scheme.
2. Luxembourg's 2020 target for 11% share of renewable energy in final consumption was also supported by statistical transfers from Lithuania and Estonia, as well a large drop in fossil fuel consumption.
Source: Eurostat, Effort Sharing Directive emissions; Eurostat, Air emissions accounts; and Eurostat, Renewable energy statistics.
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Box 2.2. The "Fit for 55" EU Package

Fit for 55 package is a set of proposals to update the EU legislation in line with the 2030 objectives. The name comes from the EU-wide target of reducing net greenhouse gas emissions by at least 55% by 2030. The package covers targets in the EU's emissions trading system, country-specific emissions reductions in sectors not covered by the Emissions Trading Scheme, as well as proposals to increase the EU renewable energy target to 40% and attain energy efficiency improvements of final and primary energy by 32.5-36% and 39% respectively.

Under the EU's Effort Sharing Regulation, each Member State has a specific emissions reduction target for 2030 for sectors not covered by the Emissions Trading Scheme. For Luxembourg, the target is a 40% reduction compared with 2005 levels. In other policy areas, no specific targets are required: countries set out their objectives in their National Energy and Climate Plans, which are guided by the region-wide targets and assessed by the Commission.

Source: European Commission.

The government has outlined stretching sector-specific energy efficiency targets to reach the overall 44% reduction in final energy consumption. The biggest reductions are expected to be achieved in the residential building sector (-40%), followed by road transport (-38%) and services (-24%) (Figure 2.9, panel A). Over time, the pace of change for firms is expected to be relatively steady, with the adjustment for industry relatively slow compared to other sectors between now and 2030.

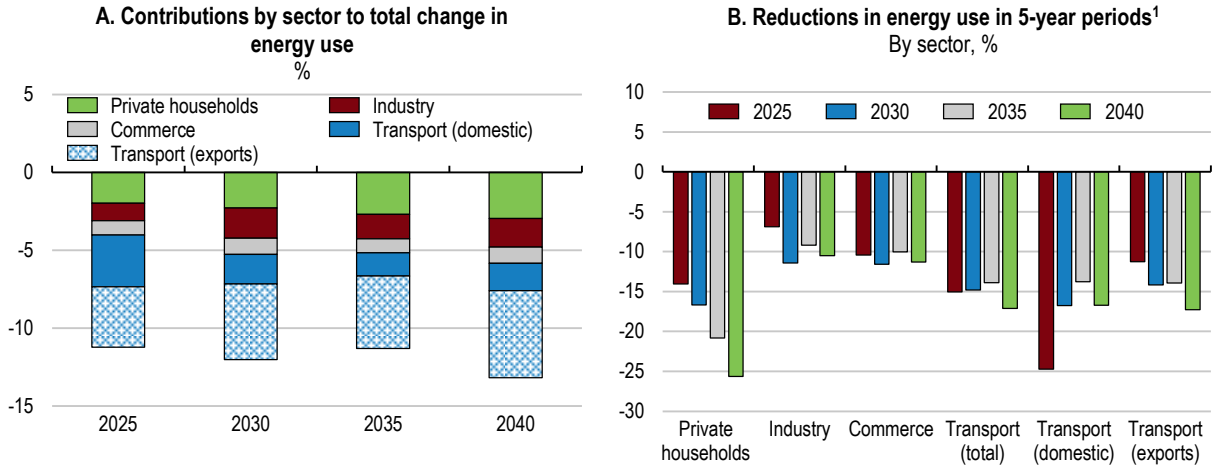
By contrast, the targets imply very sharp changes in households' transport choices in the short term. Households contribute to around half of total domestic transport fuel consumption, which are expected to decline by a quarter between 2025 and 2030 (Figure 2.9, panel B). The government's strategy seeks to raise the use of public transport and increase use of electric vehicles, with the ambitious target of reaching a 49% share of electro mobility in the vehicle fleet by 2030.

Electric and hybrid vehicles currently make up 4.5% of total vehicle stock. To meet the 2030 target, if the replacement rate remains at current levels, electric vehicles would need to make up 60% of all cars purchases by 2025 and 100% by 2030. In 2021, sales corresponded to almost 20.5% of new registrations. Generous subsidies are available for the purchase of electric vehicles. Citizens can receive EUR 8 000 for electric vehicles whose energy consumption does not surpass 180 Wh/km and EUR 3 000 for electric vehicles that do not meet this criterion. To further accelerate uptake, company car benefits will only apply to electric vehicles from 2025.

A national network of public charging points is being expanded with fast chargers installed along the main routes, whilst incentives are available for the installation of private charging points. The Recovery and Resilience Facility will finance a subsidy scheme for private stakeholders to install publicly-accessible and private charging stations from the second half of 2022. There are currently 14 electric vehicles per publicly-accessible charging point in Luxembourg, one of the lowest rates in the European Union, although as the number of cars expands, the number of charging units will need to increase dramatically. If targets for electric vehicle sales are met, reaching an average of 20 electric vehicles per public charging point would require installing over 10 000 charging points by 2030.

The residential sector's energy efficiency gains are expected to accelerate substantially between 2025 and 2040 (Figure 2.9, panel B). The greater emphasis on future gains reflects in part the importance of renovations in reaching these goals. Luxembourg has in place net zero energy standards for new buildings, which will help to improve emissions from residential housing. In addition, a large stock of mainly single-family homes will have to be retrofitted, with home renovation rates needing to rise sharply from the current 1.1% to 3%, the NECP's target to reach the 2030 goals.

Figure 2.9. Stretching targets across households and firms



Note: Each bar represents the annual average reduction in energy use over the five-year period for a given sector.
Source: Luxembourg PNEC; OECD calculations.

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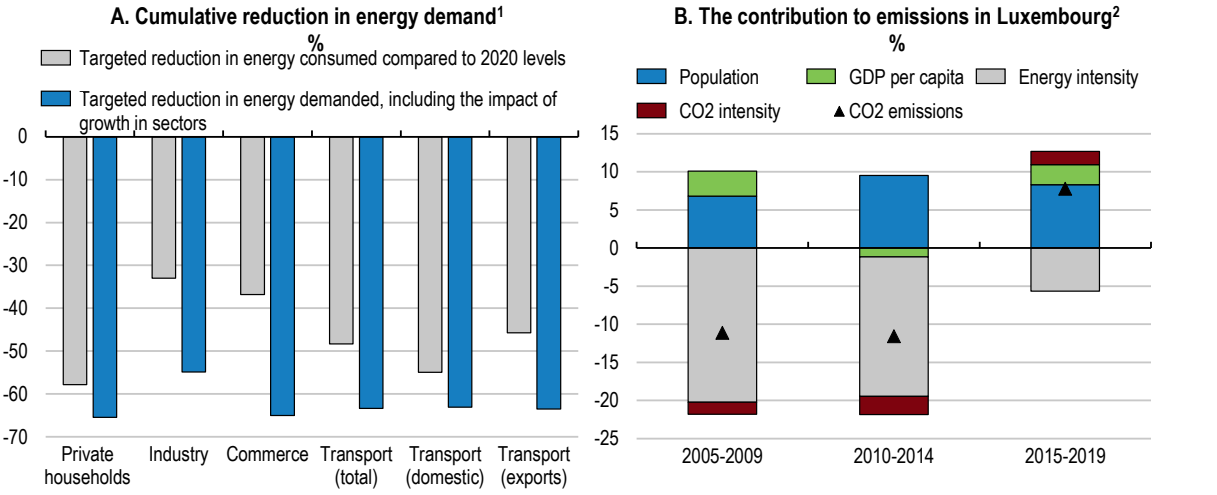
These stretching targets occur in the context of a growing population and economic growth, which implies that even greater savings are required from each sector (Figure 2.10, panel A). Luxembourg's failure to sustain gains in energy efficiency against the backdrop of rising growth is the reason for the increase in emissions between 2015 and 2019 (Figure 2.10, Panel B).

Figure 2.10. Growth both increases the resources for the transition and the required decrease in emissions



1. Households' consumption increases in line with population growth (1.0%, based on STATEC projections), industry at its long-term average of 2% and commercial business at 3%. This is broadly consistent with growth of 2.75%. The domestic transport sector is projected to grow in line with population, and fuel exports at 2% for freight in Western Europe, based on ITF assumptions (ITF, 2021[8]).
2. TES is total energy supplied. Emissions are disaggregated into the contribution of population growth, GDP per capita growth, energy intensity (energy per unit of GDP) and emission intensity of energy (emissions per unit of energy) or Total emissions = Population × (GDP / Population) × (Total energy consumption / GDP) × (Total emissions / Total energy consumption). GDP is in PPP. The sum of (positive and negative) components is approximately equal to the variation in CO_2 emissions.
Source: OECD calculations based on Luxembourg PNEC, IEA, OECD.

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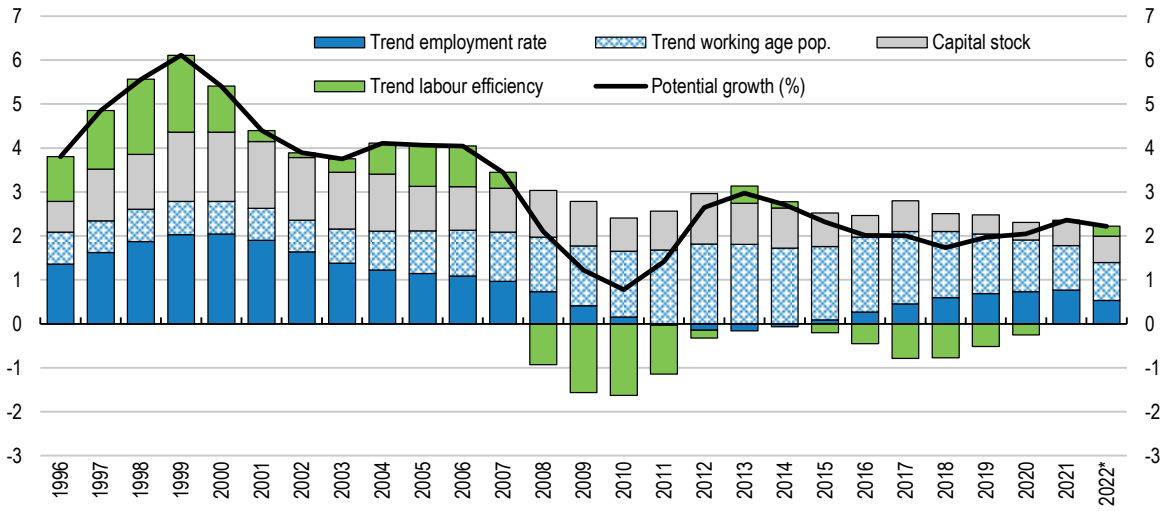
Changing the way in which Luxembourg grows can improve the likelihood of meeting these targets and reduce the trade-offs between growth and environmental targets. In the past, growth has heavily relied on contributions from an expanding workforce rather than investment growth (Figure 2.11), with a significant share of this workforce provided by neighbouring countries. Chapter 1 outlines reforms to increase the contribution of investment and productivity to growth, which have been relatively weak. Supporting higher productivity growth alongside the sustainable use of resources will minimise waste and the pressure on resources, and ensure Luxembourgish firms are well-positioned to take advantage of new markets. Tackling the structural factors that result in high car dependence and low housing density can further accelerate progress in reducing emissions.

Figure 2.11. The sources of growth have been very labour intensive

% point contributions to potential growth



Note: The data for 2022 are projections.
Source: OECD Economic Outlook dataset EO111 and updates.

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In addition, raising the share of older workers in employment has the potential to help mitigate resource pressures in the economy, whilst meeting the need for an expanding workforce. Luxembourg could add an additional 45 000 workers by 2060 if elderly workers' participation rates rose to the average projected for the European Union. In turn, this could meet a substantial proportion of the projected expansions of the workforce under different scenarios (see Table 2.1).

Table 2.1. Longer working lives could reduce demand for employment

Growth scenarios	Assumed increase in workforce between 2030 and 2060[1]	Share of projected employment increase that increased elderly workforce could meet[2]	
		Reaching projected EU participation rates for the elderly workforce[3]	Reaching improved EU participation rates for the elderly workforce[4]
3% growth	223	21%	32%
1.5% growth	167	28%	42%

Note: 1. Based on projections from Table 4 in (Haas and Peltier, 2017[9]), assuming 50% cross border workers in 2030. 2. The elderly workforce is defined as those between 54- 74 years old. Increase in the elderly workforce calculated based on the Ageing Report's (European Commission, 2021[10]) population growth estimates and participation rates for Luxembourg. The size of the workforce increase is calculated relative to the projected size of the elderly workforce. 3. The participation rate increase is based on the central scenario for the EU average over time. 4. The participation rate increase is based on the EU average plus 10 percentage points, consistent with the scenario put forward by the European Commission.
Source: OECD calculations, (Haas and Peltier, 2017[9]); (European Commission, 2021[10]).

The green transition can significantly improve the well-being of the population, but will also carry risks. Managing the recent sharp increases in carbon prices, alongside significantly accelerating the pace of decarbonisation from current levels could pose risks to economic growth, jobs and households' cost of living.

These risks are assessed in the next section, alongside the possible physical risks that climate change poses. On this basis, the last section makes recommendations on how best to enhance the existing policy toolkit's ability to meet these targets, notably in sectors where green challenges are the highest (transport, housing and agriculture).

The transition requires careful management and high levels of resilience

Climate change has wide ranging impacts. The risk of continued lags in global policy commitments and implementation require policy makers to constantly evaluate a number of risks which could impact on livelihoods and the economy:

- the physical risks from climate change, including the cost of more frequent catastrophic events that occur with increased, but still unpredictable, frequency.
- the transition risks facing firms and households, who must absorb higher costs in the short term to reduce current carbon-intensive behaviours.
- the resultant risks that climate change poses for the financial sector, which is exposed to its clients' ability to both adapt to increased physical disasters as well as to undertake the costs of the transition (NGFS, 2020[11]), (NGFS, 2021[12]).

The manner in which these risks manifest themselves will have substantial implications for policy design and how much it is supported by the population. A resilient transition implies that households, communities and nations will be able to resist, absorb, recover from and adapt to hazards that emerge in the transition (IPCC, 2018[13]), (Dornelles et al., 2020[14]). Ongoing monitoring and evaluation of these risks and their interactions is critical to ensure continued support for and success of the green transition as the economy grapples with the current energy crisis as well as over the long term.

Physical changes from the climate can pose risks for public and private infrastructure

The physical risks from climate change in Luxembourg are expected to be relatively mild on average. Changes in weather conditions are forecast to be quite limited relative to other countries. In Luxembourg, temperatures are expected to become warmer, rising from an average of 8.1°C between 1961 and 1990, to 9.2°C between 2021 and 2050. This will primarily be driven by milder winters. Annual rainfall is likely to remain the same, but summers are expected to be drier and winters wetter.

Despite these relatively mild aggregate effects, periods of drought and low water levels will be more likely, as warmer winters result in reduced snowfall and lower buffer tanks, whilst flooding and more severe storms will exacerbate soil erosion challenges (Ministère de l'Environnement, du Climat et du Développement durable, 2018[15]). This could also increase the risks of severe drought for croplands (Maes et al., 2022[16]). Even these relatively mild climate change impacts could have an outsized impact on an already fragile ecosystem (Table 2.2). Between 2017 and 2021, Luxembourg has experienced an additional five days a year of at least strong heat stress exposure compared to 1981-2010 (Maes et al., 2022[16]).

Table 2.2. Main risks from physical climate change

Physical climate change impacts	Key ecological impacts
Higher temperatures	Increased cooling needs in summer
	Increased heat in heat islands
	Increased pathogens and disease
	Increased pests and deforestation
	Increased health risks
Increased incidence of flooding	Increased sewerage stress
Increased dry spells / severe low water	Increased water shortages
Combined impacts	Increased surface pressure and soil erosion

Source: OECD based on selection of measures highlighted by (Ministère de l'Environnement, du Climat et du Développement durable, 2018[15]).

The increased frequency of extreme events, notably flooding, could increase the associated losses. The probability of extreme flooding risks (a 100 year event) in Luxembourg is projected to increase almost 2.5 times between 2021 and 2050 compared to levels between 1970 and 2005 (Alfieri et al., 2015[17]), (Karagiannis et al., 2019[18]). This will bring Luxembourg's extreme flood risk in line with the European average. Although the probability of these events may be low, economic losses can be outsized relative to losses from typical weather condition changes, as protection structures may be overwhelmed, and damages increased (Karagiannis et al., 2019[18]). To date, losses due to weather events have been quite limited – Munich Re assessed historic losses between 1980 and 2018 at USD 797 million, with the majority due to windstorms – about half the European average as a share of GDP (EIOPA, 2021[19]).

Most climate models assume a gradual or linear progression of risks and costs associated with climate change. However, there is growing evidence that breaching certain temperature thresholds could result in non-linear effects and tipping points beyond which the climate is not able to recover, if remedial action is not taken soon enough (Klose et al., 2020[20]); (Ritchie et al., 2021[21]); (Sims and Finnoff, 2016[22]); (Fan et al., 2021[23]). The likelihood of extreme events may thus increase even further if global coordination on climate policies fails, generating non-linear economic costs (IPCC, 2022[1]).

The transition risks for firms and households should be manageable

Decarbonising the economy and the speed with which this occurs will have economic, financial and political consequences. Higher levels of investments should help to improve energy efficiency and reduce operating costs. The transition will nonetheless entail costs – not only for funding upfront investments, but also in the early retirement of certain assets and the obsolescence of others, for example as companies switch to alternative fuels. As firms and sectors close and others open, the sources of employment growth will shift, alongside the skills needed of the workforce.

The distribution of the transition's costs and benefits will vary across households and firms, depending on their capacity to absorb these shocks and the availability and cost of new technologies. The speed of the change will be a critical variable in influencing the sustainability and continued support for the green transition. The speed and size of recent increases in energy prices due to the war in Ukraine could potentially increase the risks of the transition, and need to be closely monitored.

Firms' transition risks are concentrated in transport and manufacturing

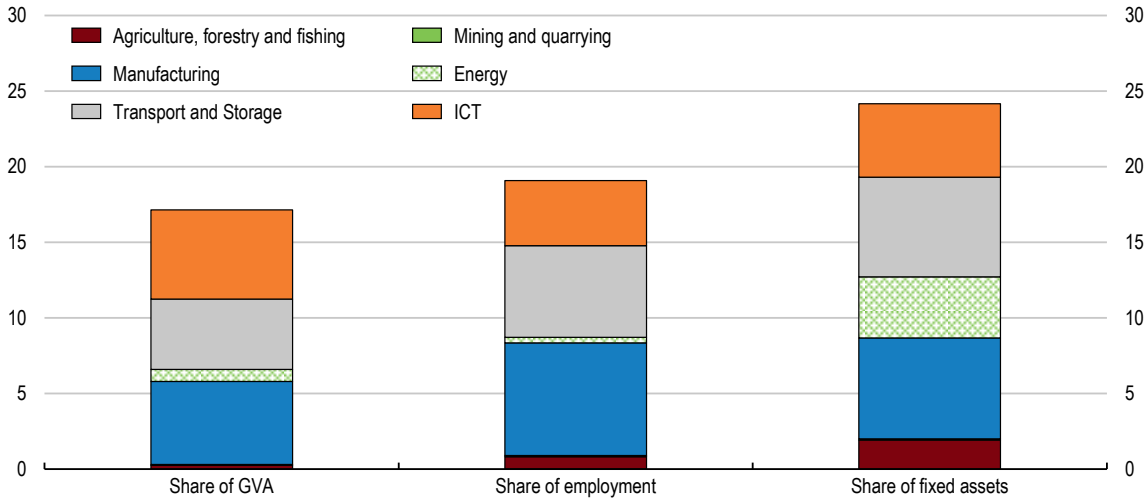
Transition risks capture the extent to which the country faces large disruptions to become green, including how costly those disruptions might be. Changes in technology and shifts in consumer sentiment, alongside policy choices, as well as resilience and productivity of firms can impact the nature of these transition risks (BIS, 2021[24]); (IPCC, 2020[25]).

The total share of firms directly exposed to high transition risks from climate change is expected to be limited. The promotion of the services sector as a source of growth since the 1980s has insulated the economy by reducing the share of – and the potential shocks from – carbon intensive industries. The total

weight of sectors assessed by the ECB's climate stress test procedure (Alogoskoufis et al., 2021[26]) to have high transition risks in Luxembourg make up 17% of GDP. These same sectors account for 31% of GDP in the euro area. Nonetheless, these sectors account for just under 20% of total jobs and 25% of total fixed assets in Luxembourg (Figure 2.12).

Figure 2.12. The structure of Luxembourg's economy insulates it from the highest risks of the green transition, but there are still risks

Importance of industries with medium to high transition risks, % share



Source: OECD calculations based on OECD National Accounts (database) and (Alogoskoufis et al., 2021[26]).

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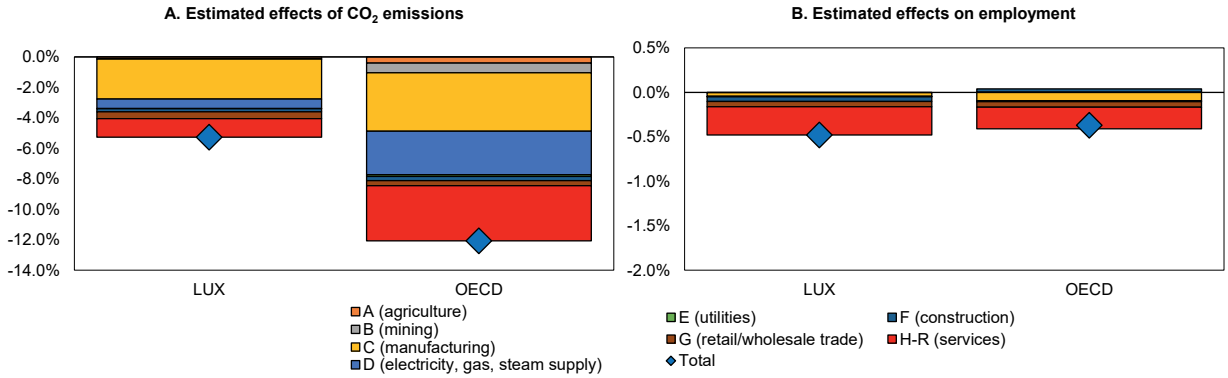
Firms will be able to absorb higher costs depending on the importance of carbon in their production cycle, demand for low-carbon products and their ability to pass on price increases to customers (Box 2.3). The balance of these risks depends not only on how the transition affects firms that are currently operating, but also on the ability of the economic system to support the emergence of new firms. A conducive regulatory environment will allow high-productivity, low-resource intensity firms to emerge and grow. These firms will employ the workers and resources that are released with the closure of resource-intensive and loss-making firms. Chapter 1 highlighted reforms to support this dynamism.

Estimates from the OECD suggest more stringent environmental policy is likely to have a modest impact on Luxembourg's GDP and employment. The OECD Environmental Policy Stringency (EPS) indicator, developed by (Botta and Koźluk, 2014[27]), has recently been revised and updated until 2020. It covers 40 countries and 13 policy instruments, focussing predominantly on climate change and air pollution policies (Kruse et al., 2022[28]). (Frohm et al.[29]) uses this rich dataset and a panel of 30 OECD countries and 54 sectors of activity during 2000-14 to forecast the potential impact of increased environmental stringency. Preliminary results suggest an increase in environmental policy stringency is associated with a significant reduction in CO_2 emissions after 10 years, with negligible aggregate effects on employment or activity (Frohm et al.[29]). Whilst the design of climate-related policies will influence sector and aggregate impacts, these results are largely in line with the international findings relating to the risks of carbon leakage (Box 2.3).

Aggregating the individual sector impacts for Luxembourg suggests a one index point increase in the overall Environmental Policy Stringency index is associated with a statistically significant 5% decrease in CO_2 emissions after 10 years (Figure 2.13, Panel A). This is a smaller effect than for the OECD average, since the share of domestic power generated in Luxembourg is lower than in the aggregate group of OECD countries, lowering the share of fossil fuels in total energy use.

The estimates suggest most sectors would reduce CO_2 emissions, with the manufacturing sector, particularly in non-metallic products such as glass, contributing significantly. The transportation and storage subsectors would experience some of the largest cumulative drops in CO_2 emissions after 10 years, reaching as much as 20%. These sectors in turn drive most of the decline in employment, although on aggregate, employment would fall by just 0.5% in total over the 10-year period (Figure 2.13, Panel B). Whilst the aggregate impact might be small, policies must support these workers' reskilling and their reabsorption into less emissions-intensive firms and sectors.

Figure 2.13. Increasing environmental policy stringency can reduce CO_2 emissions



Note: The effects are calculated using point estimates from a fixed-effects panel regression of the (log of) CO_2 emissions on current and up to 10 years lags of the EPS21 indicator, interactions of the EPS21 indicator with country-sector shares of fossil fuels in total energy use, and additional control variables. Control variables include the current and lagged sectoral (log of) real gross output and country (log of) real GDP, (log of) labour productivity per hour worked, (log of) capital stock, (log of) real labour compensation, a linear country and sector time-trends, as well as country-sector and year fixed effects. The decomposition of the aggregate country effect into sectoral effects is obtained using each sector's weight in CO_2 emissions/total employment in the respective country for the last year of data available (2014). The sector classification is based on ISIC Rev. 4. Fossil fuels include coal, coke and crude, fuel oil, gasoline, diesel, natural gas, other gases and other types of petrol.
Note: Results are preliminary and might still change slightly until final publication as comments are incorporated. The results are indicative and based on past performance. The ultimate outcome of sector emissions, activity and employment impacts will depend heavily on the design of policies.
Source: (Frohm et al.[29]).

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Box 2.3. Carbon leakage and transition risks: international evidence

Carbon leakage arises when countries applying low-carbon policies impact emissions in other countries. If producers and consumers switch to cheaper, imported emissions, local emissions reductions will be offset by increases in global emissions. This will negatively affect domestic producers, lowering their market share. More positively, technology spillovers from economies that are applying low-carbon policies can reduce emissions in countries with no regulations. Finally, if a country is large enough to impact on global markets, it could impact on the demand for energy, reducing prices and encouraging greater consumption.

Evidence of imported emissions offsetting local emissions reductions is relatively limited, with few firms suffering a loss of market share as a result of carbon prices. Empirical studies of cross-country evidence have consistently found impacts around a tenth of the size estimated by forward-looking economic models. Part of the reason for the low impact could be due to past mitigation measures, which cushioned the impact – particularly given that many studies of carbon leakage focus on the European Emissions Trading System. In addition, model estimates rarely take into account frictions such as transport costs that can make it more difficult to substitute domestic for foreign production. Low estimates may reflect the fact that the easiest and lowest-cost reforms were undertaken first.

There is limited evidence of firms divesting from high carbon price areas, but there is evidence from multinationals that new investment is more likely to be located in lower-carbon cost areas. The final impact on global carbon emissions is mitigated by the fact that firms tend to transpose technologies from high carbon price areas when investing in low-carbon cost jurisdictions.

For Luxembourg specifically, (Misch and Wingender, 2021[30]) find a relatively high risk of carbon leakage from higher carbon prices, based on a cross-country estimate of carbon price sensitivity weighted by the share of exports and imports. Luxembourg, like most small economies, will mechanically show a higher risk of carbon leakage due to its high shares of exports and imports.

Source: (Albrizio, Kozluk and Zipperer, 2017[31]); (Dechezleprêtre et al., 2019[32]); (Delera, 2021[33]); (Dussaux, Vona and Dechezleprêtre, 2020[34]); (Misch and Wingender, 2021[30]).

Policy must ensure that the most vulnerable households do not bear the largest risks from the transition

For households, resilience will depend crucially on their ability to fund alternative consumption patterns, especially for transport, as well as to undertake energy efficiency investments in their homes. The ability of workers to reskill towards jobs that are in demand will have an important impact on household income vulnerability (OECD, 2021[35]). The reforms discussed in chapter 1 to improve active labour market policies will be an important tool in ensuring climate resilience.

The transition could have particularly negative effects on lower-income households (OECD, 2021[35]). Households are exposed to the risks of the transition through the impact on their incomes – particularly from employment (D'Arcangelo et al., 2022[36]). Displaced low-skilled workers may be more likely to suffer from long-term scarring effects, as they face higher barriers to reskilling, upskilling and geographical mobility (OECD, 2021[35]); (Phylipsen, Anger-Kraavi and Mukonza, 2020[37]); (Zachmann, Fredriksson and Claeys, 2018[38]). These workers are also most likely to face reduced demand for their jobs regardless of the green transition (see chapter 1).

A clear strategy for managing potential transition risks for employment should be developed, to manage both the displacement of lost jobs and the increase in hiring needs for certain sectors. Jobs that seem most at risk in the transition are concentrated in the transport and manufacturing sectors (see Figure 2.13 and Box 2.4). At the same time, the transition will raise employment in construction, and to a lesser extent the financial and business services sectors (see Box 2.4). This is in line with industry estimates that the number

of workers will need to rise above 10 000 to meet demands for new construction as well as expanded renovations (Ministère de l'Énergie et de l'Aménagement du territoire, 2020[6]). Results from exercises such as these, as well as scenario analysis conducted by banks should feed into the skills strategy. Establishing a clear link between the green transition and the sectoral skills and occupation demand papers produced by ADEM could support workers most at risk of climate change and minimise the risks of inadequate labour supply on the transition (ADEM, 2021[39]); (ADEM, 2021[40]). Chapter 1 highlights measures to both increase residents' labour force participation and the supply of skills through training and migration.

The transition to net zero emissions will imply a higher cost of living, as prices rise to reflect the externalities of carbon usage (D'Arcangelo et al., 2022[41]). The size of the impact will depend on the share of spending on high-carbon activities, the ease with which different consumer groups can change their consumption patterns and the design of policies (Reguant, 2019[42]); (Zachmann, Fredriksson and Claeys, 2018[38]). Although in Luxembourg, lower income households do not have a significantly different share of energy or transport costs in their consumption basket compared to higher income households, they may yet be disproportionately affected by higher living costs, as they are less able to switch to different types of consumption in response to higher prices. This means they must either pay higher prices or reduce their consumption altogether. The current system of wage indexation provides protection from increased costs of living – but it can benefit wealthier households more, and also have other implications for cost-push pressures in the economy (see Chapter 1). As such, targeted measures to help vulnerable groups may be required to manage the social impacts of the transition. The recent responses to the energy crisis could provide useful information both on the impact of the sharp price increases on household well-being as well as on energy-efficiency behaviour. In turn, this could inform the redesign of subsidies and support measures.

Many lower income households tend to live outside city centres for affordability reasons. Their access to public transport options can thus be lower, and their car usage higher. They may find it difficult to alter these consumption patterns despite higher petrol prices, if they face limited access to high-frequency public transport or constraints to financing an electric vehicle or moving into denser, more urban areas. Similarly, less wealthy households who rent will rarely be able to undertake energy efficiency investments to lower consumption and energy costs (OECD, 2021[35]). Landlords, who need to make the investments, face limited incentives to improve energy efficiency, whilst efforts to raise the costs for landlords could simply increase rent inflation.

These potential vulnerabilities suggest the need for a clearer analysis of the transition impact across households' income brackets and possible policy design adjustments (OECD, 2021[35]). If there are significant divergences across income groups, the transition could increase the recent trend in growing inequality in Luxembourg. Whilst per capita income levels in Luxembourg are more than two and a half times those of the OECD, over the past three decades, social polarisation has risen faster than in most OECD countries. The population shares of the rich and poor income groups have risen in roughly equal proportion. Over the same period, the change in the income share of the rich outpaced its population share, worsening inequality (OECD, 2019[43]). The rise in the share of the lower income group is particularly worrying since they face a very high probability of remaining in this group. Some of this may be due to socioeconomic factors such as levels of schooling and past experience. Worryingly, the children of low-income parents are likely to remain low-income too, much more so than in other OECD countries (OECD, 2018[44]). Coupled with the increase in the number of children in low-income families, this could further lock in poverty and polarisation (OECD, 2019[43]).

Box 2.4. Modelling the impact of the climate transition in Luxembourg

The open source ThreeME computable general equilibrium model was calibrated for Luxembourg in order to consider how the economy responds to carbon price changes. This model has been used by policy makers in France, the Netherlands and the United Kingdom. These results are intended to enrich the domestic policy debate, particularly in terms of the potential impact of a forward-looking carbon price. This is one modelling exercise that be considered alongside a range of models to understand the full impact of climate-related policies on income, well-being and inequality.

Key economic impacts from a higher carbon price

The model suggests a carbon price that rises steadily by EUR 10 per annum could support a reduction of emissions in 2050 by 50% compared to a scenario with no carbon price increases.

The economic impacts of the carbon tax are found to be mildly positive. Although the carbon tax increases costs for firms and households, recycling tax revenues from fuel exports to households and firms helps to fund the increases in investments required to respond to higher carbon prices. Employment rises with growth, as well as the fact that tax revenues are redistributed to the most employment intensive firms. Exports decline, primarily due to lower fuel exports, whilst imports fall because of the reduction of fossil fuel imports.

There are a number of reasons for the positive impact:

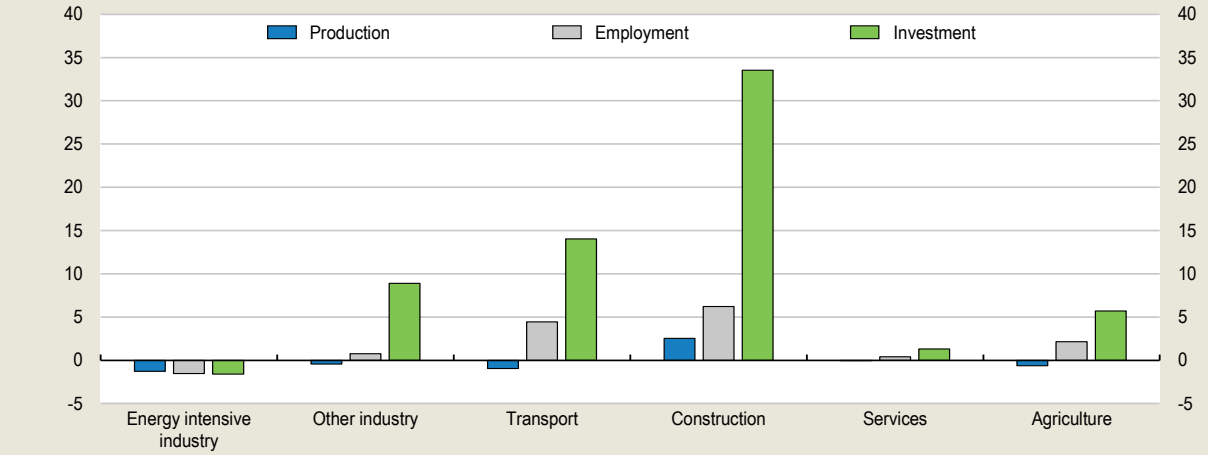
- **The assumption of redistributing carbon tax revenues**. If positive, carbon tax revenues are redistributed: households and firms receive back what they pay in transfers. Fuel-export related revenues are divided between households (1/3), firms (1/3) and the government (1/3). The most employment-intensive firms receive the largest share of the revenue allocated to firms.
- **The carbon tax revenues from fuel exports**. When positive and redistributed to households and firms, export-related carbon tax revenues help offset the impact of rising carbon prices for households and firms. Without these additional revenues from fuel exports, the model suggests a small negative impact from rising carbon taxes.
- **Luxembourg's economic structure**. The share of employment and activity in services sectors is high. The domestic power sector is small and does not require transformation.
- **The model set-up.** The model is of a market-based economy that flexibly adjusts to shocks such as higher carbon prices. Whilst the model includes the costs firms and households must bear when increasing investment, there is no estimate of the income losses associated with stranded assets. The model also does not capture any potential well-being or health benefits.

The industrial sector is expected to reduce output as carbon prices increase, driven by the 2% decline in energy intensive industries relative to the baseline (Figure 2.14). The transport sector faces high transition risks, as increased use of public transport such as rail is not enough to compensate for the decrease in road and air sectors. By contrast, the construction industry expands at a faster rate, as the green transition prompts increased demand for new buildings and renovation. Services output increases in the medium term before stabilising, as it benefits from redistributed carbon tax revenues that allow it to maintain its competitiveness, alongside its role in supplying investment for the green transition.

Sectoral patterns in activity are mirrored in employment changes: overall, job growth is expected to be around 1% higher than the baseline. The construction sector's fast pace of job creation accounts for the bulk of the increase in demand (Figure 2.15). Labour shortages in the construction and services sectors would reduce their cushioning impact in the green transition. Overall investment levels rise by 3.6% compared to baseline (Figure 2.16). Growth in construction is the fastest-rising investment category, contributing about half of the total increase in investment. Investment in machinery and equipment also increases quickly, but its relatively low share in total investment implies a relatively small contribution to total investment growth.

Figure 2.14. Sectoral changes in output, employment and investment vary

% change relative to the baseline



Source: OECD calculations, based on the ThreeME model (2020).

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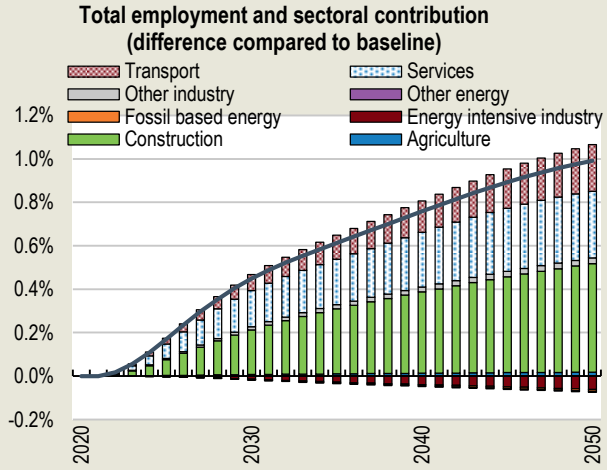
Figure 2.15. The employment impact could be mildly positive



Source: ThreeME Model calculations.

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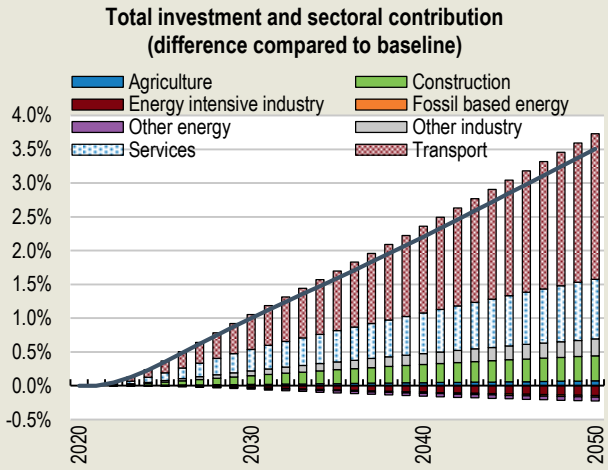
Figure 2.16. Investments will rise, particularly in structures such as buildings and transport



Source: ThreeME Model calculations.

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The model assumes that investment needs are not constrained by domestic savings, and that there are no credit constraints facing households and firms that wish to invest, consistent with Luxembourg's strong and well-developed financial centre. Government spending is determined exogenously, but taxes are influenced by economic activity. Fuel sale tax revenues are not modelled separately, as the assumption is that these revenues will be offset by higher carbon tax revenues.

These results are sensitive to assumptions on how Luxembourgish fuel exports respond to carbon prices, which in part depend on the fuel and carbon tax policies in neighbouring countries. The model assumes that other countries raise their carbon prices by EUR 155 between 2030 and 2050. Higher carbon prices in neighbours raise fuel export sales and carbon revenues – but reduce emission reductions. Efforts to raise productivity and investment, such as outlined in Chapter 1, would help reduce this trade-off by raising growth and revenues. They would also improve the economy's resilience to potential shocks in the carbon price in Luxembourg or its neighbours. Policies to reduce the carbon intensity of the transport sector in Luxembourg and across the region will also be critical.

Source: OECD calculations, ThreeME model (2020).

The financial sector is significantly exposed to transition risks

Globally, the financial sector faces financial stability risks from the economic shifts implied by the green transition. The green transition can impact the financial sector through a variety of transmission channels (see Table 2.3). The ability of clients to repay loans, the value of collateral and possible asset price valuations have been the main risk channels regulators have modelled to determine the risks to financial sector solvency.

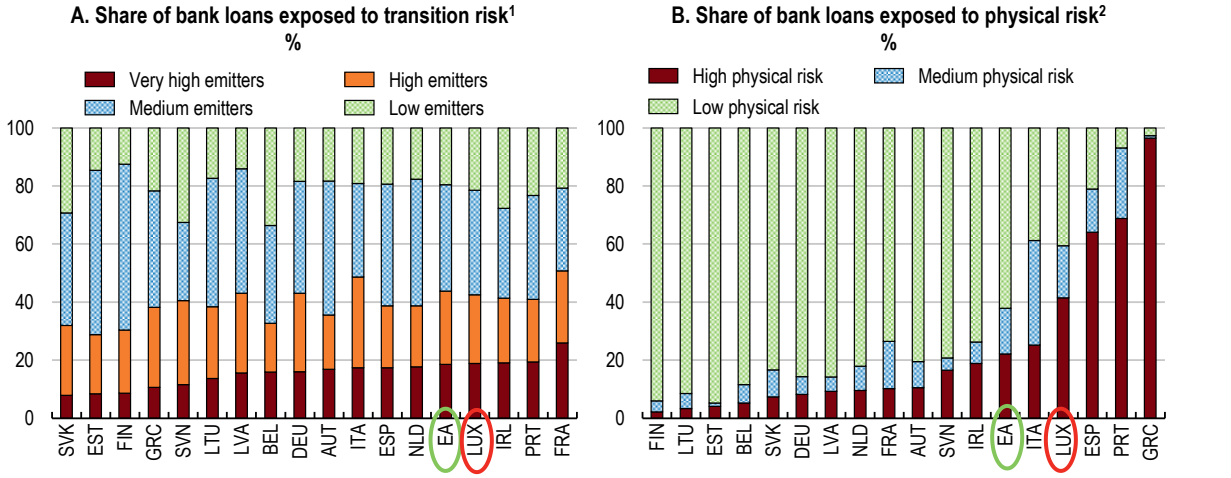
Table 2.3. The key banking sector risks posed by physical and transition risks

Financial risk	Transmission channel
Credit risk	Borrowers' ability to repay is reduced due to transition risks (reduced market share, profitability). Value of collateral falls (stranded assets, damaged assets), reducing recovery rates of defaulted loans.
Market risk	Financial assets lose value as climate risks are increasingly priced into asset prices. The impact will be larger if the adjustment is sudden or if portfolio diversification is affected by the transition. "Brown" assets may be more correlated, compounding losses in the event of adverse outcomes.
Liquidity risk	Access to stable funding may be affected if counterparties draw down deposits or credit lines.
Operational risk	Legal liabilities relating to the accuracy of climate-related disclosures for investment and business could increase. Claims for liability insurance could increase as a result of class action and other disclosure related litigation. Regulatory compliance could increase operating costs and lower profitability.
Reputational risk	Difficulties in communicating the transition could lower credibility and brand value. Climate strategy could be misaligned with changing market or consumer sentiment.

Source: Adapted from (BIS, 2021[24]); (ECB / ESRB, 2021[45]); (ESMA, 2021[46]).

The Luxembourgish banking sector is exposed to effects of the climate transition on its loan portfolio. Just over 40% of loans from the Luxembourg banking sector to non-financial clients are provided to high or very high emitters (Alogoskoufis et al., 2021[26]) (Figure 2.17, Panel A). This is in line with the average exposure in the euro area. These estimates take into account the complex feedback loops between transition and physical risks – where early action can reduce physical risks but increase short-term costs and transition risks. Preliminary estimates of physical risks from (Alogoskoufis et al., 2021[26]) suggest relatively high exposures (Figure 2.17, Panel B), although these conclusions may change as the number of banks surveyed and the granularity of data increase.

Figure 2.17. The financial sector's exposure to climate change is high



1. Exposure are categorised as (very) high emitters if a firm's relative emissions are above the 70th (90th) percentile; exposures are categorised as low emitters if a firm's relative emissions are below the 30th percentile. Emission intensities include Scope 1, 2, and 3.
2. Exposures are categorized as high physical risk if a firm's probability of suffering from wildfire or a river or coastal flood in a given year over 1%, exposures are categorised as low physical risk if a firm's probability of suffering from a wildfire or a river or a coastal flood is less than 0.1%. Exposures are classified based on euro area creditor countries. This is based on a preliminary sample.
Note loans are non-financial corporation loans.
Source: (Alogoskoufis et al., 2021[26]).

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The insurance sector losses associated with asset price valuations are not expected to be particularly large for Luxembourg. (EIOPA, 2020[47]) estimates that under its central scenario, total losses on the sovereign bond portfolio of Luxembourg-based insurers are estimated at around 0.2%. Losses in corporate bonds and equities are around 10%, as the weight of high-carbon assets is about five times that of low-carbon assets. Nonetheless, the combined effect of these losses is expected to be relatively small at 0.7%.

Increased transparency and ongoing data monitoring are critical to help the banking sector manage the operational challenges of responding to these climate risks. The BCL highlighted that currently, banks may be poorly positioned to cope with the required changes, as loans to high carbon-intensity industries actually increased in 2021 (BCL, 2021[48]). Authorities should continue to adapt financial sector regulation and supervision as climate-related risks and vulnerabilities are uncovered by stress-tests and related activities.

The tools to estimate firms' climate-related risks are becoming more sophisticated, thanks to increased global regulatory scrutiny of climate disclosures. A range of emerging reporting standards aim to improve the granularity of information about individual companies (Table 2.4). The adoption of these reporting standards and disclosures has been increasing, as regulatory scrutiny and investor pressure has risen, even if the quality of reporting continues to lag coverage (EY, 2021[49]). Authorities should continue to promote a classification of green financing that is able to support clear and client-focused labelling, whilst allowing for a diversity of products to be delivered that could support a wide range of investor preferences. Greater diversification in climate investment strategies helps to limit systemic risks. Credible guidance for how loans to carbon-intensive industries can be classified as supporting the transition or not would help to mitigate the reputational and financial risks for the banking sector. The recent expansion of the remit of the banking and insurance regulators to cover green financial disclosures provides an opportunity for an independent channel to communicate with customers and investigators.

Even as more sophisticated techniques for estimating climate risks become widespread, the need for more granular information about companies' transition strategies and how they impact risk will increase. With an improved understanding of baseline climate risks, risk management practice will likely begin to shift to estimate how well firms can respond to policy and technology changes. This could become a key differentiator of performance for financial institutions over the long term.

As such, supporting the development of the requisite skills to ensure banks measure and manage climate risk will be critical. Specific programmes targeted to increase the quantitative skills required to manage big data should be prioritised. The current CEDEFOP skills forecast for Luxembourg (CEDEFOP, 2020[50]) projects employment growth in the business services industry of 1.9% per year between 2018 and 2030, with an emphasis on continued demand for clerical skills rather than sophisticated data management. The ADEM projection for the financial sector projects that green analysts will be increasingly in demand (ADEM, 2021[39]). However, data management and skills are not highlighted as a particular focal area – even though demand for these skills rose to around 40% of the financial sector job offers in 2021, from 30% in 2015. Prioritising these skills' prominence in training programmes and efforts to attract international talent could help to mitigate some of the risks of the transition for the financial sector.

Table 2.4. Global non-financial reporting requirements are under development

Regulatory Standard	Task Force on Climate-related Financial Disclosures	International Sustainability Standards Board (ISSB)[1]	Corporate Sustainability Reporting Directive[1]
Disclosure topics	Climate-related goals	Environmental matters (detailed)	Environmental matters
		Social and governance matters (general level, no detailed guidelines)	Social matters Governance matters
Areas of disclosure	Present governance, strategy, risk management, metrics and targets	*In addition*: Financial materiality (with a requirement to mention impact materiality if relevant) Disclose scope 3 emissions[4]	*In addition*: Double materiality[2] Mandatory EU ESG reporting standards and guidelines[3] Must be audited
		.	Greater detail on areas of disclosure Greater detail on green disclosures to include energy consumption and mix, energy intensity, GHG removals and avoided GHG emissions from products and services
	Voluntary disclosure principles Mandatory for UK Will become mandatory for Canada, New Zealand	Guidelines	Mandatory in EU for all large public companies[5] for all reports produced after 1 January 2025, with limited assurance. Reasonable assurance required after 2031. Mandatory for all large companies (including private) and most listed companies from 2027.

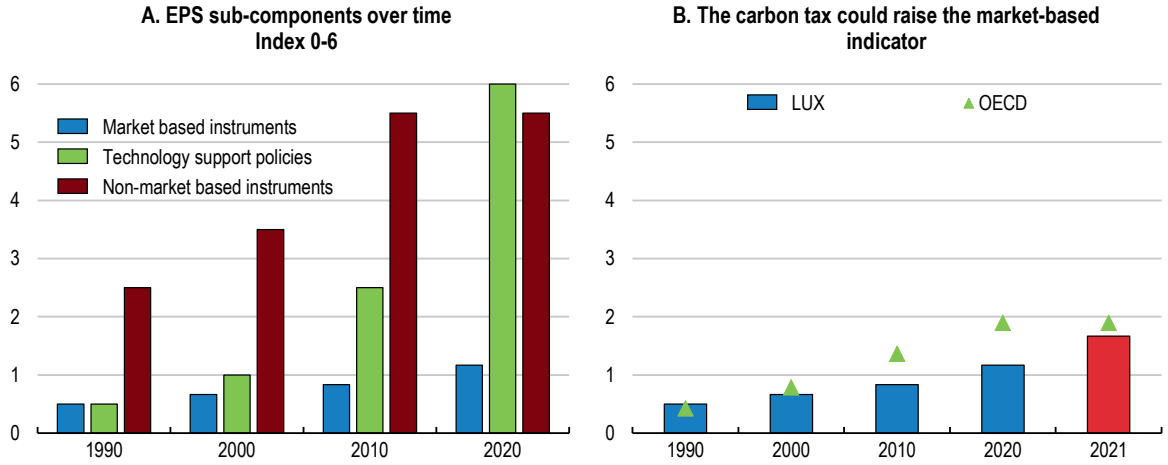
Note: 1. Proposals are in draft format. 2. Double materiality defines a material matter from the impact perspective (of the reporting company on society or other stakeholders), the financial perspective (of the finances of the reporting company, regardless of time horizon), or both. This is much wider than the financial materiality concept defined in financial statements and used in ISSB standards. 3. The EU ESG reporting standards are expected to be finalised by the end 2022, with sector specific guidelines released October 2023. 4. Note that the combination of financial materiality and scope 3 emissions means that these risks only have to be disclosed if they have a material impact on firms. 5. This includes large public-interest companies with more than 500 employees (the same companies currently obliged to report under the Non-Financial Reporting Directive).
Source: (TCFD, 2021[51]); (KPMG, 2022[52]); (Latham and Watkins, 2022[53]); (Davies et al., 2022[54]); (Azzouz and Brisson-Félix, 2022[55]).

A policy framework to support the green transition

A broad mix of policy instruments that complement one another is the most cost-effective way of achieving decarbonisation goals, while also being inclusive and socially acceptable (D'Arcangelo et al., 2022[41]). A strong governance framework provides the legal basis for climate action. A steady, rising future path for emissions prices is required to guide long-term investment choices across all stakeholders in the economy. Subsidies and regulations can help to improve the impact of emissions pricing by encouraging broader behavioural change, since pricing alone cannot overcome typical innovation coordination failures (Bessen and Maskin, 2009[56]); (Stiglitz, 2019[57]). Key cross-cutting policies in spatial planning, housing and transport can support the transition by influencing how readily households and firms adapt. A transparent policy to consider how any revenues generated from the transition will be used is required.

Environmental policy stringency in Luxembourg has risen sharply since 1990 (Figure 2.18). As a result, in 2020, Luxembourg was among the OECD countries with the most stringent environmental policies, together with France, Switzerland and Finland (Kruse et al., 2022[28]). Non-market-based instruments rose primarily due to more stringent regulations for sulphur and particulate matter between 2000 and 2010. Greater use of feed-in tariffs, market premiums and solar electricity tenders drove the increase in technology support policies, with green R&D support rising sharply between 2010 and 2020. This has been augmented by increases in the subsidies to support energy efficiency investments for both households and firms.

Figure 2.18. Changes in Environmental Policy Stringency over time in Luxembourg



Note: Policies are scored on a scale from zero to six and aggregated. The market based instruments sub-index groups policies that put a price on pollution, such as CO_2 trading schemes, renewable energy trading schemes, CO_2, Nitrogen Oxides (NOX), Sulphurous Oxides (SOX) and fuel taxes. The non-market based instruments sub-index puts together policies that mandate emission limits and standards, such as emission limit values for NOX, SOX and particulate matter, and sulphur content limit for diesel. Technology support policies include public R&D expenditure on low-carbon energy technologies and renewable energy support for solar and wind from feed-in tariffs and auctions, relative to the global levelized cost of electricity. Panel B: Other OECD countries may also have introduced changes to their market-based instruments in 2021, which are not reflected in the represented OECD average for 2021, which is equal to the OECD average in 2020.
Source: (Frohm et al.[29]); (Kruse et al., 2022[28]); OECD calculations.

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Nonetheless, there are gaps in the overall policy mix. The current policy mix relies heavily on subsidies and regulations (Table 2.5). Luxembourg's score for market-based environmental policy instruments remains below the OECD average in 2020, reflecting low carbon prices. The recently introduced carbon tax, which is not reflected in the data, will reduce the gap with the OECD average. Increasing the carbon tax to the levels observed in the best performing OECD countries, which would imply a carbon tax rate of around EUR 80 per tonne, would raise the overall EPS indicator by 1.4 points.

Table 2.5. Overview of climate policy tools in Luxembourg

Policy instruments	Cost-effectiveness	Public acceptability[1]	Current implementation in Luxembourg
GHG Tax	High minimisation of abatement costs Moderate to high monitoring costs	Low to moderate	- Carbon tax: introduced in 2021 at EUR 20 per tonne, currently at EUR 25, to be increased to EUR 30 in 2023
Emission Trading Schemes (ETS)	High minimisation of abatement costs Relatively high monitoring costs	Moderate	- Luxembourg is part of the EU-ETS, which cover around 15% of LUX's emissions
Taxes on polluting goods and services		Low (higher support when applied selectively)	- Fuel excise tax (diesel and petrol) CO_2-based vehicle taxation
Environmental standards			- NZEEB standards for new buildings
Subsidies for climate change mitigation actions	Potentially high Lower if they cover actions for carbon sequestration rather than outcomes	High (reduces costs)	- PRIMe House: subsidies for renovations improving energy-efficiency; installations of heat-pumps or photovoltaic panels
Feebates			- Passenger Vehicles: a CO_2-based vehicle tax + subsidies for purchase of an electric car - Feed-in tariff for renewables
Technology-support policies	Low to moderate (but high incentives to invest in R&D)	High	- Financial aid to companies for investment in the fields of environmental technologies and innovation

Note: 1. Based on international evidence of public acceptability.
Source: (D'Arcangelo et al., 2022[41]); (Dechezleprêtre et al., 2022[58]), national sources, and authors' assessment.

Climate objectives should be integrated across key government policies

The governance framework has been strengthened

The climate governance framework has grown significantly in line with Luxembourg's climate ambitions. The governance and accountability of the government's climate strategy is grounded in a climate law passed in December 2020, which provides a legally binding mechanism for action on sectoral targets that are set every ten years. According to the law, government plans must be guided by a national energy and climate plan every 10 years, which includes updated sector targets for energy reductions and the path for policy direction, as well as a 50-year strategy document issued every ten years, which sets the broad objectives for climate policy. The climate law is an important step: without it, those opposing climate policies can block action; the law provides a basis for policies to be advanced or to block policies that run counter to climate action.

Legally binding targets set into the future are an important commitment mechanism and can send important signals for certainty. The targets are reviewed every five years in line with the National Energy and Climate Plan. Regular reviews based on evidence are intended to allow for new information to be taken into account in setting targets, and will include extensive consultation with industry. Clear and regular entry points in the policy-making process for the civil society would help to enhance public acceptance of ambitious green policies (D'Arcangelo et al., 2022[41]). Luxembourg's engagement with civil society and its ability to absorb inputs from those actors outside formal business and labour has been raised as a difficulty in general legislative processes (OECD, 2021[59]); (European Commission, 2022[60]). The 2020 climate law established the climate platform, a panel of experts appointed by government to test government policies. The Luxembourg in Transition project, which included a Citizens' Committee that developed a report with concrete recommendations, forms a good basis for continued engagement. The Citizen's Office for the Climate (KlimaBiergerRot) has been established to develop proposals to influence the 2024 National Energy and Climate Plan (Ministère d'État; Ministère de l'Environnement, du Climat et du Développement durable; Ministère de l'Énergie et de l'Aménagement du territoire - Département de l'aménagement du territoire, 2022[61]). These provide a platform for the public to engage on climate-related research, including that produced by the Climate Observatory.

To maintain good faith, engagement needs to also consistently show that recommendations are taken into account. In France, the President committed to taking forward the recommendations of the Convention Citoyenne pour le Climat with either a referendum, parliamentary votes or direct regulations (Ministère Ecologie, 2021[62]). The "Climate and Resilience Bill" ("Loi Climat et Résilience"), presented in early 2021, sought to implement many of the measures proposed by the citizens' convention and to enhance existing environmental policies (OECD, 2021[63]).

Evidence-based, two-way communication is critical to maintain support for the green transition

Support for the green transition amongst Luxembourg's citizens is high. According to the latest Eurobarometer Survey on climate change attitudes, 78% of citizens consider climate change to be a very serious problem and 63% think the government is not doing enough to tackle the problem (Eurobarometer, 2022[64]). This support may, however, be contingent on the relatively low costs households have faced from the green transition so far. The war in Ukraine and sharp increase in energy prices will test public support.

Government targets imply large changes in household behaviour to reduce transport and residential buildings emissions. This increases the potential resistance to change in the future. Uncertainty about the benefits of the transition, risk aversion, high upfront costs for new investments and learning, and misperceptions of costs can reduce the willingness of firms and consumers to change (see Box 2.5), leaving them poorly prepared in the medium to long term. In the short term, this can increase the risks of a misalignment between policy objectives and the perceptions of firms and households, and itself pose risks for the transition. Experience from other countries, such as in France, suggests that the yellow vests

movement, which opposed environmental taxes in 2018 and 2019, was driven by a poor understanding of the social benefits, the lack of compensation schemes and a lack of responsiveness to the combined impact of global prices and domestic policy choices (CEDD, 2019[65]).

The government has primarily responded to political risks to date by trying to keep the costs for households low, with a heavy reliance on generous subsidies and a very gradual increase in the carbon price. But lowering costs that households face is not necessarily the most effective strategy. Denmark, Sweden and Norway have managed the political risks of the transition in spite of sharp increases in the costs faced by households. Critical determinants of policy acceptance were clear communication campaigns, which stressed the objectives of the transition, and clearly defined programmes to support the vulnerable. Continued engagement will be required as policy choices are likely to become more difficult to ensure that society remains committed to the transition (Dechezleprêtre et al., 2022[58]).

Public debate would benefit from more precise quantification of the impact, costs and benefits of different policy tools – including a range of carbon pricing strategies – as well as the fiscal implications of long-term choices. A recent study has shown that across OECD countries, on average, people are more likely to support subsidies for developing clean technologies or bans rather than direct taxes on fossil fuels (Dechezleprêtre et al., 2022[58]). Politically popular policies are not, however, always economically efficient. Explicit revenue earmarking is generally discouraged, as it creates rigidities in spending priorities and reduces the efficiency of government allocations (D'Arcangelo et al., 2022[41]). Compliance costs for standards and rules can be high, particularly for lower-income households and smaller firms. For example, (Gillingham and Stock, 2018[66]) estimate implementing fuel standards could cost up to USD 2 900/tCO_2. Others such as (Goulder and Parry, 2008[67]) suggest that regulations double the average costs per unit emission reduction compared to price interventions.

The eventual policy mix chosen by authorities needs to take into consideration the individual and combined impact of policies. Box 2.4 outlines the initial results of a modelling exercise conducted for this Survey, in order to estimate the potential impact of different carbon price trajectories. Given the complexity of the transition, no single model will be able to provide a complete picture of risks. A suite of models to consider the implications of various policy combinations should be used, and the results framed in the context of the risks of action and inaction. In the United Kingdom, Netherlands, Denmark and France, independent bodies play a key role in producing, disseminating and commenting on climate-related research and the potential impacts on the economy.

Luxembourg's climate law established a climate policy observatory to lead on technical aspects related to climate policy. By establishing its neutrality and focusing on evidence-based policymaking, the Climate Observatory can play an important role in information sharing and acting as a trusted arbiter for social debates. It can commission and disseminate research, including for climate models that allow for a balanced and broad-based assessment of climate risks. The Climate Observatory should also evaluate potential policy tools' impacts across different types of households, which will allow for a more informed set of public policy debates. Consideration should be given how to best coordinate the work of the Observatory and the considerable expertise in STATEC, which is another trusted body providing neutral assessments of policy choices.

The policy planning framework could better incorporate uncertainty

The timing and costs relating to the realisation of climate risks are not always clear and there can be considerable uncertainty relating to the impact of climate policy. In addition, biases in measuring the risks of acting too soon or too slowly can hamper effective policy formation (Box 2.5). This can pose a considerable challenge in Luxembourg, where individual firms account for a larger share of total employment compared to their OECD counterparts, making it harder to generalise whether changes in firm circumstances are driven by unique events, or market forces. Changes in the fortunes of one firm could have an outsized impact on perceived costs and risks associated with the climate transition. This in turn

could generate resistance to change or encourage overly generous subsidies and offsets. Overly generous support will not only represent an opportunity cost for funds, but could lock in lower carbon production techniques that expose the country to sharper transition costs in the long run. Supporting less productive firms could also lower overall aggregate productivity growth further.

Box 2.5. The biases in assessing climate risks and policy responses

Measurement bias. Uncertainty about the transition stems from uncertainty about the impact of policies on behaviours, as well as technological uncertainty on the timing and availability of alternatives (Table 2.6). Risk analysis tends to gravitate towards measuring what is known and over-emphasise the importance of maintaining the status quo - in this case, the costs of moving too fast, which are particularly salient since they are borne immediately, by a concentrated and identifiable set of stakeholders. By contrast, analysing the benefits of firms or households that do not yet exist seems less precise. The costs of acting too slowly (or the benefits of acting sooner) can seem less salient as they are estimated to take place in the future, and the benefits are often diffuse.

Table 2.6. There are upside and downside risks in transitioning to a greener economy

	Too fast	Too slow
Firm operating risks	Loss of competitiveness and market share in the short to medium term (carbon leakage).	Lack of adaptation leaves firms vulnerable to competitive pressures in medium to long term.
		Lost benefits associated with first-mover advantage in the medium to long term (innovation path dependency).
Firm investment risks	Higher costs due to use of new technology and associated learning costs.	Large capital outlays in "catch-up" investment required in the medium to long term. Build-up of investments with high scrapping risks in the long term.
	Sunk costs from investments in the "wrong" direction in the medium to long term.	Lost medium to long-term benefits from long-life-cycle investments undertaken too early.
Economy wide	Disruptions to employment, exports due to loss of market share in the short to medium term.	Lost benefits from reduced emissions in well-being.
	Forced switch into less productive, more costly investment crowds out domestic demand and other investments in the short to medium term.	Lower productivity by supporting less productive firms. Lost benefits from economy-wide network and innovation effects.

Over-optimism. There is a tendency for policy makers to make unrealistic assumptions about the potential impact of technology on climate goals. Independent audits and assessments of governments' climate strategies can highlight these problems. In the United Kingdom, the Committee of Public Accounts recently assessed the government's net zero strategy, including the plausibility of its assumptions relating to technological change.

Tendency towards the mean. The tendency to focus on central scenarios rather than a range of possible climate outcomes reduces the resilience of policy design to potential catastrophic, low-probability but high-impact events or "fat tail" events that have higher probability than a normal distribution would suggest. Policy making should explicitly include a range of potential climate scenarios and then assess the extent to which it will design policy to respond to non-central case scenarios. In South Africa, a range of potential climate scenarios were calculated based on global models. This was then used to understand the possible impacts on the economy and infrastructure costs, and to design the climate strategy.

Source: (Agarwala et al., 2021[68]); (EIB /Bruegel, 2012[69]); (Lamb et al., 2020[70]).

Integrating the climate transition more holistically into the fiscal framework

The timing and use of climate tools will have significant implications for fiscal policy, which need to be managed. The government has committed that reaching the climate goals will be done in a fiscally sustainable manner. (STATEC, 2020[71]) has produced estimates of the potential impact of the carbon tax on overall revenues. However, as yet, no long-run estimates of the sensitivity of revenues to potential changes in GDP composition associated with the green transition have been provided. On the spending side, it will be critical to estimate the duration and take-up of subsidies (including rebates and tax credits), commitments to new infrastructure, maintenance, and climate adaptations, as well as catastrophe-related spending. Current take-up of subsidies is low, but the generosity of benefits is high. Rapid take-up could substantially increase fiscal costs.

There is room to improve the integration of climate policies in the overall policy framework to better assess policy impacts. Integrated policy making needs to take into account the feedback loops between economic growth, well-being and climate impacts. Chapter 1 has highlighted a number of mechanisms to increase the rate of growth in productivity, which should reduce the resource intensity of the economy if combined with a clear set of prices, regulatory tools and subsidies discussed below. Nonetheless, society will face important trade-offs in deciding which spending, and by implication, which generations and households benefit most. Granular, reliable data is critical to estimate the impact of policies on the economy, environment, and well-being. Better estimates of the potential sensitivity of revenues and spending to the transition can help the government weigh up the potential risks in light of other spending choices, most notably ageing-related spending which will significantly raise debt without pension spending reform, lower spending or higher taxes (see chapter 1).

Clearer estimates of the impact of policies on different households could help to inform the debate. A microsimulation model that allows the fiscal impacts of different tax and spending choices to be interacted with changes in labour market outcomes for households would allow policymakers to better assess the costs associated with the transition across different household sectors, and their interaction with existing policy tools. Making information more readily available on take-up and costs of existing support schemes would allow for alternative assessments of the government's spending plans, which can enrich public debate about the trade-offs necessary in the transition. The National Council of Public Finance could play an important role in developing a research agenda that better considers a framework for evaluating these risks. This should reference work on policy tools that are recommended to be conducted by the Climate Observatory, as well as the foresight work being undertaken by the government under the Luxembourg Stratégie project. The response of households and firms to the energy price shock and the subsequent policies to help manage the energy crisis can provide valuable information to refine policy makers' understanding of the transmission channels.

High uncertainty about technological change as well as how firms and households will respond means there is a large margin of error in estimating the fiscal costs of the climate transition that can compound over long time periods. However, these high levels of uncertainty do not have to stymie policymaking. As is the case with monetary policy decision-making under high uncertainty, sensitivity and scenario analysis can allow policy makers to understand the risks and choose a course of policy action that can be sensitive to how these risks develop over time. Sensitivity analysis allows policy makers to consider how much assumptions on policy design (such as take-up or costs per line of road) might alter final costs and revenues. These estimates can be assigned probability weights. Scenario analysis allows policy makers to consider how policy design might have to change in response to a shock in economic growth or the failure of a programme to affect carbon emissions, and the resultant required policy responses.

The public infrastructure planning framework should be adapted to better cope with the uncertainty of the physical and technological risks of climate change and the implications for infrastructure spending. Whilst estimates of expected annual damage to infrastructure for Luxembourg are quite low compared to the rest of Europe, actual climate outcomes could vary substantially. For example, (Forzieri et al., 2018[72]) estimate

that on average, expected annual damage to infrastructure would be about EUR 8 million a year, rising to EUR 11 million in 2050s. Torrential floods in 2021 caused large-scale economic damage, estimated at EUR 120 million. The government spent EUR 50 million in support for those affected by the devastation (Edde, 2021[73]).

The difference between expected and actual climate outcomes can create very high adaptation costs for infrastructure projects, which lock in resources for a long time and can be costly to convert. At the same time, building infrastructure for the worst-case outcomes can represent a large opportunity cost and may result in high levels of redundancy. These could be higher in the event of technological shifts. Significant infrastructure outlays are planned for rail and road electrification, and there will be the need to adapt road infrastructure for hydrogen or other fuels. Spending on flood defences will rise, along with water reticulation systems. It may be more appropriate to adapt current infrastructure design rather than to build immediately, to lower the cost of future changes in technology or policy. This could include adapting design to allow for hydrogen pipelines in the future, as electric charging infrastructure is increased along roads that can be adapted in time, without building the full infrastructure at present.

Infrastructure planning should incorporate project evaluation techniques that can be used to understand the value for money of different infrastructure design options in light of uncertainty (OECD, 2021[74]). Project evaluation techniques can be used to assess infrastructure projects in the face of climate risks that may vary over time. The most popular forms are known as “real option analysis” or “NPV+”. Investments are considered in terms of the annual benefits from climate proofing, the costs of implementing adaptation measures, and the time at which the investment’s net present value is maximised. This provides a structured framework for understanding the risks of investing now rather than later (ADB, 2015[75]). Policy makers have a framework to help determine whether an infrastructure project should be built now or later to mitigate the impact of climate damage.

This framework will allow the timing of different investment projects to be weighed up against one another – for example, the impact of additional water distribution systems compared to faster road network expansion for commuters. These have been used in Viet Nam, India and Bangladesh to help the government estimate the potential benefits of acting sooner rather than later (ADB, 2015[75]). (Ginbo, Di Corato and Hoffmann, 2021[76]) list over 80 projects where academic papers have been published on the use of these frameworks. Comparing the costs of different types of infrastructure explicitly can further strengthen the case for green infrastructure: public transport and active transport modes such as cycling have much lower capital costs of construction (Buckle et al., 2020[77]); (IEA, 2020[78]).

There could be significant learning and demonstration effects across the economy if the public finance framework could further strengthen the framework for assessing transition costs. Green budgeting is currently applied through a tagging system that records spending linked to programme objectives. This is relatively common. A more comprehensive approach would include an assessment of the emissions associated with individual projects and programmes, whether or not the policy had a green policy objective. This has been applied in the United Kingdom, according to a set of published guidelines. Different policy options available to the government could then be explicitly evaluated in terms of their carbon impact in the near and long term. Whilst it is inevitable given current technologies that many projects will generate net carbon emissions, the learnings from this work would have broader application. An initial pilot could be conducted with projects that are intended to be funded by the Climate and Energy Fund. Enhancing the cost-benefit framework to evaluate the emissions impact of projects at the design stage, including the use of a shadow carbon price, would create an important tool to embed green transition considerations into project design, in advance of the preparation of public budgets.

Supporting physical risk preparedness

The *Stratégie d'adaptation aux effets du changement climatique pour le Grand-Duché de Luxembourg 2018-2023* (Ministère de l'Environnement, du Climat et du Développement durable, 2018[15]) outlines some of the potential adaptive measures that could be undertaken under the most likely climate scenario, but these did not receive much prominence in the 2050 Climate Strategy. Greater emphasis on how government plans to undertake these adaptations is required, as they could entail substantial infrastructure costs and regulatory requirements. The potential measures should be elaborated in more detail in the upcoming update of the *Stratégie d'adaptation aux effets du changement climatique pour le Grand-Duché de Luxembourg*, and given greater prominence in the policy setting framework. The adaptation measures should be augmented with planning systems that consider other potential catastrophic events, including the national flood risk management plan.

Insurance has an important role to play in the policy toolkit to manage physical risks from climate change (OECD, 2016[79]). Increasing insurance coverage can help to mitigate the individual losses for a firm or household, and provides an important public good since it protects those who are not directly responsible for climate change (OECD, 2016[79]). Higher levels of insurance penetration provide governments with greater flexibility to provide fiscal stimulus in the aftermath of a disaster (Von Peter, von Dahlen and Saxena, 2012[80]). In addition, insurers are able to increase understanding about how risks are evolving, and which adaptation strategies are most useful, by sharing aggregated portfolio information (Hudson et al., 2020[81]).

The authorities are considering alternative insurance models for flooding risks (Jans, 2021[82]). Currently, voluntary flood insurance is complemented with state support following particularly severe natural disasters. Coverage for flood insurance seems high, at 50% of households (Jans, 2021[82]). Recent flood events may have heightened awareness of flooding risks, consistent with international evidence (Hudson et al., 2017[83]); (Gallagher, 2014[84]). The insurance protection gap, which captures the difference between insured and actual losses, is not considered material for Luxembourg (ECB / ESRB, 2021[45]). A 2017 regulation capped flood insurance support to EUR 100 000 per annum for homes in flood-risk areas, and EUR 1million for other homes. Limiting payouts probably helps to keep premia affordable, but a study on the quantitative impacts of the policy would be useful. Alternative models could be considered to keep premia affordable (Box 2.6). Increased efficiency in the non-life insurance sector serving the domestic market, for example through increased use of digitalisation to lower operating costs or increasing competition, could also potentially lower costs and insurance risk premia.

Box 2.6. Supporting the provision of affordable flood insurance protection: what other countries do

Insurance for disasters such as floods can become prohibitively expensive, particularly when risk is very localised and events frequent. Including lower-risk policy holders can help reduce payout risks for insurers and keep premia low. In the Czech Republic, Ireland, New Zealand, Portugal and the United Kingdom, mortgage lenders require borrowers to obtain insurance protection against flood risk. In most Swiss cantons, property owners are required to take out all-risk insurance.

Public support is often provided to help keep premia uniform, regardless of the flood risk faced by the policy holder. In Spain, private insurers can pass on certain flood risks to a public re-insurer. In France, private insurers automatically extend coverage to include natural disasters (at a flat rate) and can reinsure up to 50% of their natural disaster exposure with a public reinsurer. In the United Kingdom, the insurance industry runs FloodRe, a fund which compensates insurers for providing homes built before 2009 in the highest flood risk areas with lower-than-market based premia. It is funded by general levies on home insurance and flat fees charged to subscribing insurers. The scheme is intended to end in 2039, after which premia will fully reflect market risks.

Other public support options that can keep premia low include reducing the cost for insurers in the event of extreme flood risk events. In Thailand, the government reinsures a portion of insurers' catastrophic risk. In Belgium, the government provides government support above certain thresholds.

In all these instances, standards and regulations are required to ensure that high-risk individuals take action to lower their risks as much as possible, and to ensure that the product offering from insurers is competitive.

Source: (OECD, 2015[85]); (OECD, 2016[79]); (FloodRe[86]); (Wolfrom and Yokoi-Arai, 2016[87]).

The design of insurance could strengthen incentives to reduce the impact of flood risks, at both the community and household level (Lé, 2022[88]). Collective investments in localised areas, for example to support faster drainage of water after floods, can help to reduce overall damages in the event of floods, but can be difficult to coordinate. In France, deductibles increase if there are repeated disasters in the same area and the community lacks a risk prevention plan to manage these risks (OECD, 2016[79]). In the United States, certain flood-prone areas require communities to purchase insurance alongside individual homes. Participating in the voluntary community rating system, which considers land-use planning and other risk mitigation measures, can reduce communities' insurance premia (Kousky and Michel-Kerjan, 2017[89]).

Insurance contracts can support homeowners to improve flood defences following floods. In the United Kingdom, homeowners receive GBP 10 000 in addition to their insurance pay-out to better prepare for future floods (FloodRe[86]). Increasing the awareness and market value of flood mitigation investments can also incentivise renovations, particularly if concentrated on the sale of homes. In France, sellers and landlords are required to provide information on any compensation received for natural or technological disasters; the risk of flooding must be disclosed as part of the home purchase process (OECD, 2016[79]). Formal certification could further strengthen this signal to markets. In Germany, flood resilience certificates are issued by experts to homes to improve access to insurance (OECD, 2016[79]) – but could be used in a similar way to energy certification.

A uniform, rising carbon price path can anchor incentives to lower emissions

Many emissions have been priced at rather low rates

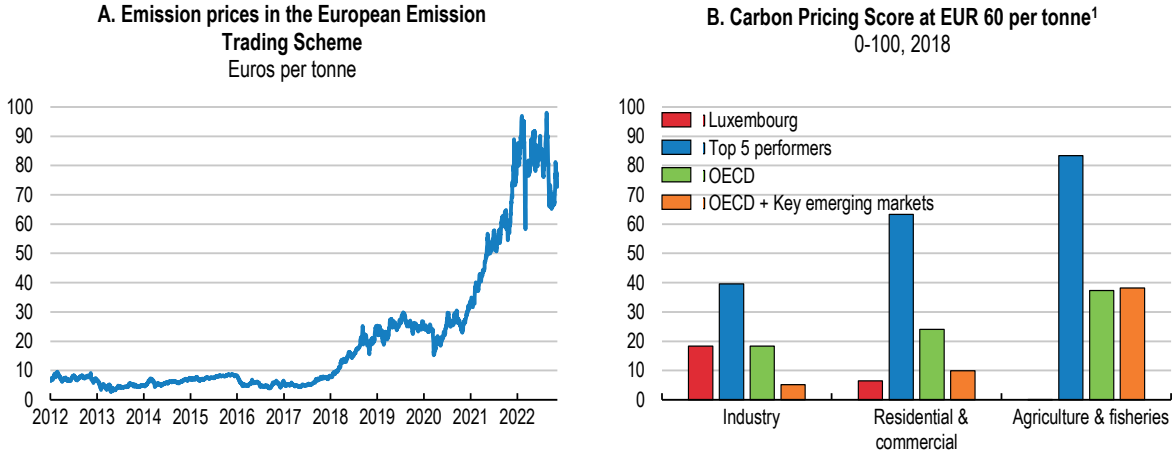
Carbon pricing is one of the most effective and efficient ways to manage the transition in the short term, as it covers the cost of externalities and the largest polluters pay the most (D'Arcangelo et al., 2022[41]);

(OECD, 2021[90]); (D'Arcangelo et al., 2022[91]). A generalised carbon price supports innovation that is broader in application than most subsidy schemes, and as such could increase the impact of existing innovation programmes (EIB /Bruegel, 2012[69]). Carbon pricing in Luxembourg is currently governed by two schemes: the European emissions trading scheme and a carbon tax for emissions not covered by this scheme.

The Emissions Trading Scheme (ETS), which uses a cap-and-trade system to increase the cost of polluters in power stations, energy-intensive industries and civil aviation, covers around 15% of Luxembourg's total emissions. The ETS is currently in its fourth phase, which includes a number of reforms to try and improve the signal from carbon prices. This should increase its overall impact, and the price of carbon is beginning to rise in these schemes to reflect these changes (Figure 2.19, panel A). Participation in the ETS scheme means that Luxembourg's industrial carbon pricing is in line with OECD peers, if lagging best performers (Figure 2.19, panel B). The impact of these prices, however, is not fully felt by firms, who receive free allowances to help offset the impacts of the increases. Luxembourg has been relatively unaffected by the reduction in ETS allowances in the fourth round, which are largely unchanged between 2021 and 2025: only four firms' allocations were reduced by 10% over the period, equivalent to a 0.1% reduction in total allocations by 2025.

In non-ETS sectors, however, the price of carbon is very low compared to OECD peers. Carbon prices faced by the transport and residential sectors, which account for a combined 60% of greenhouse gas emissions, are not included in the ETS scheme. As a consequence, the gap in prices between Luxembourg and peers has been much larger in these sectors (Figure 2.19, panel B). The OECD's carbon pricing score, which measures how close countries are to pricing carbon at the reference price of EUR 60 per tonne shows the residential sector and agriculture have very low carbon prices (Figure 2.19, panel A). In the case of agriculture, no emissions are priced at EUR 60. In the case of road transport, the price of carbon is higher than in other sectors – but still lags behind neighbouring countries, maintaining the incentive to use Luxembourg as a refuelling stop (Figure 2.20). Box 2.7 outlines some of the key issues to consider when comparing Luxembourg's energy pricing to other countries based on aggregate pricing indices.

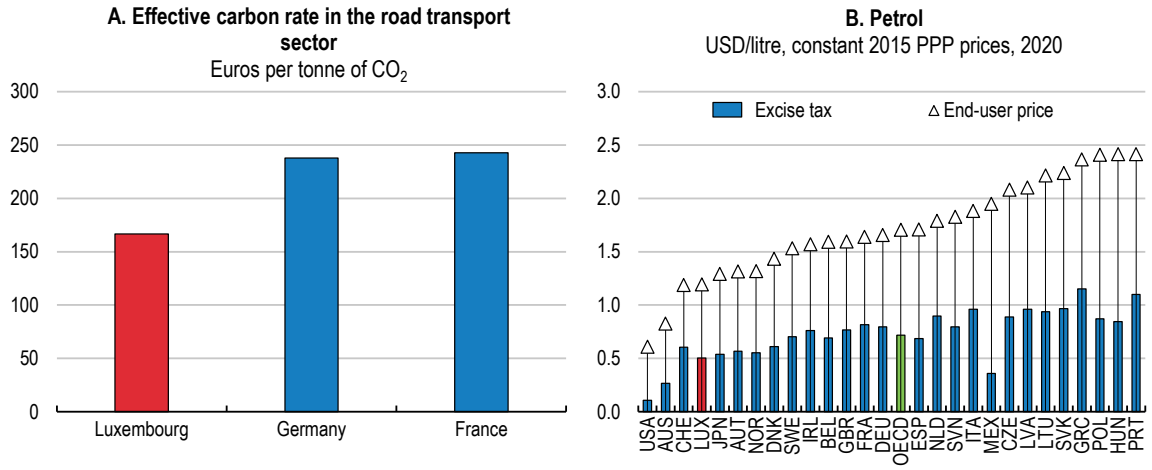
Figure 2.19. Industry faces carbon costs in line with the OECD average thanks to the Emissions Trading Scheme



1. The carbon pricing score measures the extent to which countries have attained the goal of pricing all energy related carbon emissions at certain benchmark values for carbon costs or more. The more progress that a country has made towards the relevant benchmark value, the higher the carbon pricing score. OECD is a simple average of all OECD countries. Key emerging markets includes Argentina, Brazil, China, India, Indonesia, Russia and South Africa. The best 5 includes the countries with the highest sub-sector prices. They are all OECD countries.
Source: OECD Effective Carbon Tax Rates; Refinitiv; and OECD Green Growth Indicators.

StatLink https://stat.link/c0a86g

Figure 2.20. Pricing of emissions in the road sector is lower than in peer countries



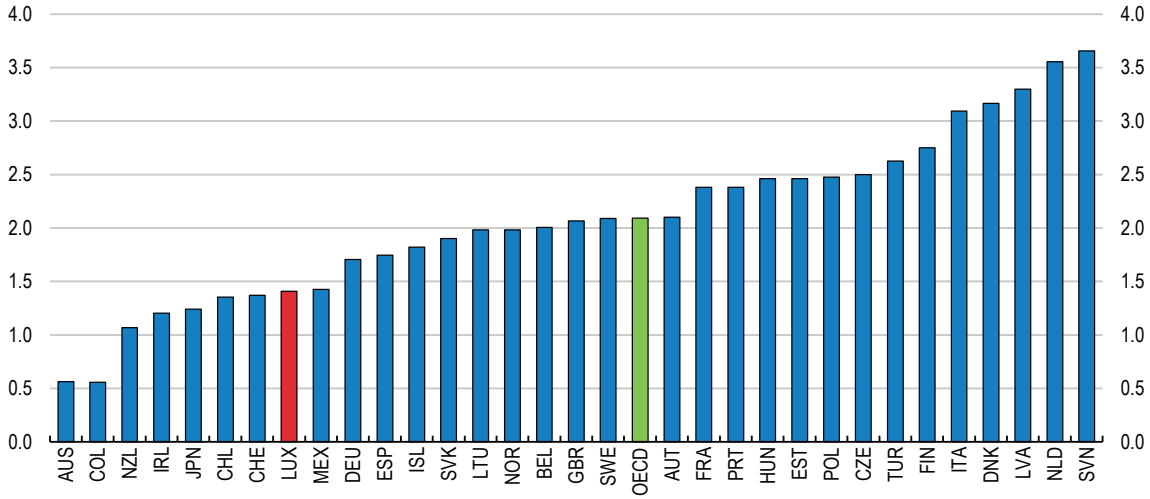
Source: OECD Effective Carbon Tax Rates; and OECD Green Growth Indicators.

StatLink https://stat.link/tlxfoz

The high purchasing power of Luxembourg's residents is likely to further reduce the impact of these already-weak price signals. Global evidence suggests high incomes reduce the sensitivity of demand to price changes across a range of countries and products such as energy and food (Femenia, 2019[92]); (Labandeira, Labeaga and López-Otero, 2017[93]). Current levels of environmental taxation are low (Figure 2.21).

Figure 2.21. There is substantial scope for higher environmental taxes

% of GDP, 2020



Note: For Australia, data refers to 2018.
Source: OECD Environmentally related tax revenue (database).

StatLink https://stat.link/hy93i1

Box 2.7. Measuring the effective carbon price in Luxembourg

The OECD Effective Carbon Rates (ECR) database provides an overview of how emissions are taxed at the economy-wide level and within its main sectors, covering 44 OECD and G20 countries. The ECR is measured in euros per tonne of CO_2 and consists of three main components: emission permit price, carbon tax, and fuel excise tax. The ECR averages carbon prices across the economy.

The Carbon Pricing Score (CPS) measures the extent to which a country prices its emissions at a given benchmark. For example, a score less than 100% at the EUR 60 per tonne benchmark means that some but not all emissions are priced at that level. The CPS allows cross-country comparisons against a given benchmark and, unlike the ECR, is not distorted by high-value outliers that mask the distribution of carbon pricing within an economy. The CPS is calculated for individual sectors and then aggregated to a country level based on the contribution of those sectors to overall emissions.

Luxembourg's aggregate CPS score is heavily influenced by the price of carbon in the transport sector, given its high weight in total emissions (57.4% versus an OECD average of 24.1%, see (Figure 2.5). In most OECD countries, including Luxembourg, emissions in the transport sector are typically priced higher than in other sectors of the economy. As a result, Luxembourg's CPS at EUR 60 was 69% in 2018, the second highest among OECD countries – even though the majority of emissions in non-road transport sector are not even priced at the lowest benchmark of 30 euros per tonne of CO_2 and its road freight sector faces lower prices than many other OECD countries. It is therefore advisable to assess Luxembourg's carbon rates sector by sector, as done above.

Source: (OECD, 2021[94]).

A carbon price has to be set at a level that incentivises a change of behaviour, although there are a range of estimates given the uncertainties as to the behavioural, technological and environmental assumptions used. The World Bank estimates that a price within the range USD 50-100 per tonne by 2030 is needed, together with other policies, in order to not exceed temperature increases of 2 degrees Celsius, the upper end of the Paris agreement (World Bank, 2022[95]). On its part, the OECD has established three benchmarks based on modelling exercises (OECD, 2021[94]); (Kaufman et al., 2020[96]):

- EUR 30 per tonne of CO2: a historic low-end benchmark for carbon cost in the early and mid-2010s
- EUR 60 per tonne of CO2: a low-end benchmark for carbon cost by 2030
- EUR 120 per tonne of CO2: a central estimate of the carbon price needed in 2030 to decarbonise by mid-century, assuming carbon pricing plays a major role in the overall decarbonisation effort

The government recently introduced a carbon price that applies to all sectors other than those in the ETS. The carbon tax rate was raised to EUR 25 in 2022 and will be increased further to EUR 30 in 2023. The main impact of this increase in the carbon tax is expected to materialise in the transport sector as it increases the fuel price and discourages non-resident "fuel tourism". The introduction of a carbon price is welcome, but in order for it to be even more effective, the government needs to provide more clarity regarding the long-term carbon price trajectory that is consistent with its climate objectives. A clear carbon price signal into the future is also needed in order to encourage investments in the green transition. At present, the government has not set a planned target rate for the carbon tax nor announced further increases beyond 2023.

Since the second half of 2021, following the post-covid resumption of growth and Russia's war of aggression in Ukraine, global energy prices have been on the rise. Oil and gas prices reached record levels on wholesale markets. Whilst this could potentially speed up the transition to higher carbon prices, the pace of change poses risks, prompting many governments to take measures to cushion households and firms from the full price increases. In Luxembourg, the government decided to provide energy bonuses for low-income households, provide aid to businesses affected by the increase in energy prices, as well as

cap the increase in gas and heating oil prices from October 2022 (Box 2.8). The energy price caps are intended to avoid what would otherwise be a more than doubling of energy prices between September 2022 and January 2023. The pace at which authorities will exit these price caps will depend on international energy price developments as well as on fiscal, growth, inflation and social welfare considerations.

Box 2.8. Recent energy efficiency measures to respond to the energy crisis

In response to the recent energy crisis, the government in Luxembourg has sought to cap energy price increases and raise transfers to households and business. In addition, it has increased financial support for household and business investment in alternative energy supplies. The generosity of household subsidies for investments in solar panels has been raised.

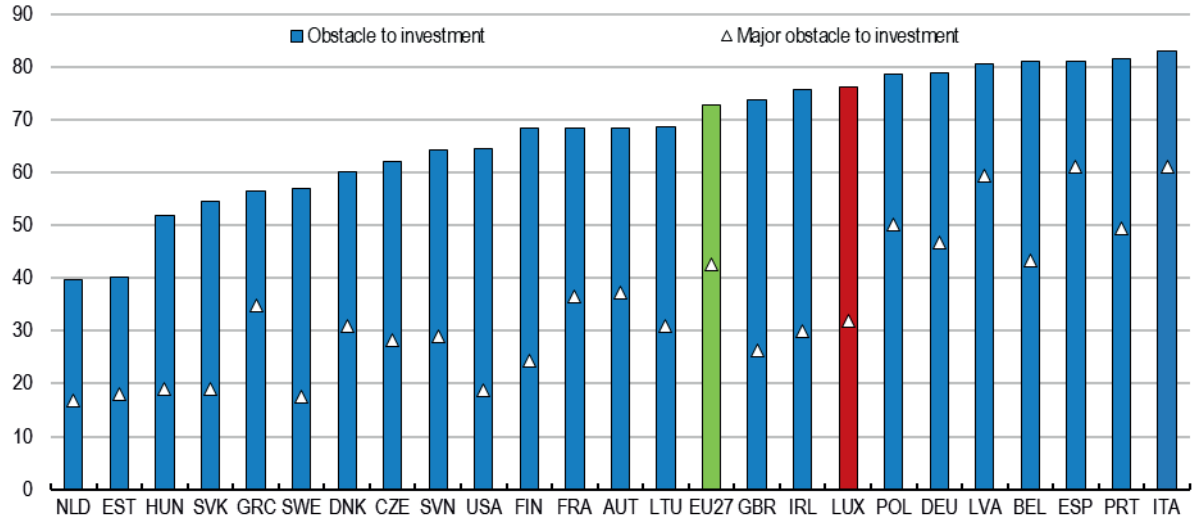
To accelerate the green transition to alternative power sources, companies will receive subsidies to install off-grid photovoltaic energy. In addition, companies are encouraged to enter into long-term power purchase agreements for renewable energy, to further encourage the switch away from non-renewable electricity sources. In order to mitigate the risk of entering into long-term contracts at a time of high energy prices, the government has committed to pay two thirds of the difference between the power purchase agreement and the market price, should market prices fall below the levels in the power purchase agreement, up to a maximum of EUR65 per MWh.

Source: (Le Gouvernement du Grand-Duché de Luxembourg, 2022[97]).

The complexity of factors influencing the eventual withdrawal of the energy price caps could introduce considerable uncertainty about the future path of carbon pricing. Uncertainty about the carbon price is likely to discourage investment (EIB, 2021[98]); (IEA, 2017[99]); (Ren, Shi and Jin, 2022[100]); (Blyth et al., 2007[101]), particularly in the context of already high levels of uncertainty about green regulations and taxes (Figure 2.22). Higher levels of certainty can reduce the level of the carbon price required to impact behaviour. It could also leverage the fact that households and firms tend to respond more to changes in taxes than general price increases (D'Arcangelo et al., 2022[91]); (Chetty, Looney and Kroft, 2009[102]); (Andersson, 2019[103]); (Li, Linn and Muehlegger, 2014[104]).

Figure 2.22. Uncertainty about regulations and taxes is an obstacle to green investment

2019, % of all firms



Note: Share of firms citing uncertainty about the regulatory environment and taxation as an obstacle to investing in activities to tackle the impacts of weather events and emissions reduction.
Source: (EIB, 2020[105]).

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Choices on energy price caps should be communicated within the context of the medium- and long-term carbon price path, as well as their potential impacts on the economy and society. This information could help demonstrate consistency in decision making and reinforce credibility. The authorities could provide certainty by announcing a carbon price path that includes the impact of energy price caps, taxes as well as market-related energy price developments. Committing to ensure that the price of carbon will at least be at a certain level can still send clear signals about the direction of market movements, without unnecessarily increasing hardship in the short term for firms and households. Such a policy would avoid increasing carbon taxes when market prices of most energy types have increased, which could threaten the sustainability of the transition. Indeed, the timing of the French authorities' efforts to implement a carbon tax, in light of rising oil prices, has been identified as a reason for the policy's eventual failure (CEDD, 2019[65]). A clear long-term carbon price would also be compatible with any potential changes that may be introduced at a European level to support the creation of new emission trading schemes (Box 2.9).

Box 2.9. Coordinating the carbon tax and a potentially expanded ETS

To meet the target of net zero emissions by 2050, the European Commission has proposed the introduction of additional, separate ETS schemes to broaden the scope of the current ETS, with a scheme for residential heating and transportation fuels, and a third scheme to govern air emissions. Energy suppliers, rather than consumers such as households, would have to apply for permits for the goods that they sell, passing their higher costs to end consumers. The current proposal has no free allocation to avoid potential over-provision of permits and the associated slack in prices.

A clear, forward-looking carbon price trajectory would be an asset whether or not the multiple ETS scheme is in place, as it allows the government to set a minimum floor for ETS prices that is consistent with its carbon tax trajectory.

- ***It provides a clear price signal to the economy***. In the United Kingdom and the Netherlands, the ETS scheme has been combined with a price floor. The first pillar of the Dutch strategy is a carbon levy on industrial emissions which applies if EU ETS prices fall under a certain level. In this case, emitters pay the differential to the floor price. Implemented in 2021 with a clear pathway, it is expected to reach a total of EUR 125 per tCO_2 in 2030 (including EU ETS prices) adding some certainty to sectors subject to variable prices under the EU ETS.

  In Germany, where a second ETS has been put in place for transport and building heating sectors, the government has pre-published trading prices from 2022 to 2025. In 2026, it will operate within a corridor and thereafter potentially with caps, given that it will be a second trading system, rather than a specific carbon tax. The firms subject to the EU ETS will have an exemption from the costs of this scheme's ETS.
- ***A minimum carbon price also has the advantage of moving towards a more unified carbon price across sectors***, rather than maintaining the current segregated carbon markets. Highly segregated markets can increase welfare losses if sectors with high abatement costs are expected to share a higher adjustment burden.
- ***It provides an opportunity to continue to participate in the broader European project***, whilst still progressing towards the more ambitious policy goals that Luxembourg has set itself.

Source: (European Commission, 2021[106]); (Cornago, 2022[107]); (Benaim, 2021[108]); (Böhringer, Lange and Rutherford, 2014[109]); (Böhringer, Rosendahl and Storrøsten, 2017[110]); (Wettengel, 2022[111]).

The fiscal implications of a move to higher carbon pricing have become more uncertain. In the short term, if sustained, international energy price moves could increase the size of energy-related expenditure, but may be offset by reduced energy consumption as the economy slows. The current energy price shock could have a lasting effect on long-term energy price demand in Luxembourg and the region. Before the crisis, the short-term revenue implications of a carbon tax for Luxembourg were estimated to be slightly

negative (STATEC, 2020[71]). A higher carbon price would reduce fuel sales to non-residents and freight trucks, which in turn would lower excise revenues. (STATEC, 2020[71]) estimated that revenues may be 0.1% lower in 2023 than without the carbon tax, taking into account not only lower fuel sales, but also lost revenues from tobacco sales. In 2021, excise duties on fuel represented about 0.8% of GDP in tax revenues, from 1.1% between 2017 and 2019. In the longer term, a key variable will be the extent to which carbon prices change in the greater region, since this influences the extent to which refuelling behaviour for freight and cross-border workers changes (see Box 2.4). Should revenues materialise in the short and medium term, they could be used to support the transition, offsetting the impacts of a rising cost of carbon.

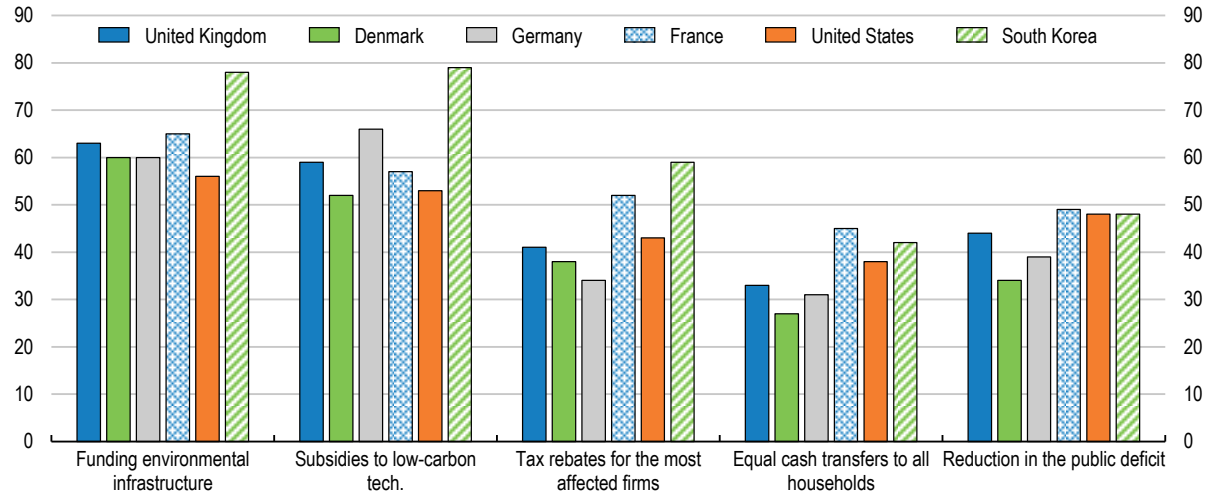
A clear policy for using carbon price revenues is needed

Although environmentally related taxes are intended to alter behaviour rather than generate revenue, carbon and other environmental taxes result in revenue streams in the short to medium term. Over the longer term, revenues from environmental taxes should fall as behaviour changes. Evidence finds that carbon taxes are best accepted when they are clearly not a revenue-generating mechanism (Dechezleprêtre et al., 2022[58]); (D'Arcangelo et al., 2022[91]). The public tend to favour measures such as earmarking of funds to support either those affected by the green transition, or to help lower the overall tax burden (Figure 2.23). Typically, explicit revenue earmarking is not favoured, since it creates rigidities in spending priorities, reducing the efficiency of resource allocations. However, the earmarking of funds can vary along a relatively wide spectrum, with the largest costs being associated with very narrow earmarking (Marten and van Dender, 2019[112]).

Modelling estimates suggest that redistributing carbon tax revenues back to firms and households can help to mitigate the impact of the carbon tax on economic growth, assuming that the impact of the carbon tax on overall fiscal revenues is neutral or positive (Box 2.4). In the event that the carbon tax structurally lowers revenues (for example due to a sharp fall in fuel and other excise revenues), such a policy would involve additional fiscal trade-offs. These should be considered within broader policy goals, including well-being (see discussion above). The choice of how to use any carbon-tax related revenues should be based on a combined assessment of the size of the revenues and their impact on the fiscal framework, the potential economic and social impact of revenue use, and an assessment of their public acceptability.

Figure 2.23. International evidence suggests public support for a carbon tax is higher if revenues are used for environmental purposes

Proportion of people supporting carbon tax if the revenues are used for the following measures (%)



Source: (Dechezleprêtre et al., 2022[58]).

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Higher or more widespread carbon taxes are more likely to require being associated with broad tax reforms or transfers to be socially acceptable (Marten and van Dender, 2019[112]). The distributional consequences of broad revenue redistribution schemes must be estimated, as they could be larger than the direct inequality impacts of the carbon tax itself (Williams, 2016[113]). Revenues could also support green public infrastructure investments that have widespread public support, such as high-speed rail linkages (EIB, 2022[114]). However, revenues should not support higher subsidies for investments to mitigate the impact of the carbon tax, as this is likely to subsidise investments that would likely already have occurred in the presence of the higher carbon tax (Marron and Morris, 2016[115]).

In Luxembourg, higher carbon prices could be associated with reduced tax rates, although the economic case for such a reduction is limited in Luxembourg. Average personal income tax rates are already relatively low, with personal income tax a relatively low share of total incomes earned compared to the OECD average. The system significantly discriminates against single earners, but this group is unlikely to be favoured in tax reform initiatives. Whilst the corporate income tax rate and the effective tax rate are close to the OECD median, the corporate tax rate has declined over time. Immovable property tax rates are also low compared to OECD peers.

It therefore seems sensible to channel at least some of the carbon tax revenues towards transfers. These could be uniform, favouring all households, or targeted towards lower-income households, which the green transition disproportionately affects (EIB /Bruegel, 2012[69]); (OECD, 2021[35]). A portion of the revenues could also be directed towards improving the quality of public transport. In Luxembourg to date, additional carbon tax revenues are used both for social and for environmental measures. The introduction of the carbon tax was associated with higher tax credits for lower income workers, the self-employed and pensioners. Half of the government's current carbon tax revenues fund tax credits for the lowest 40% of households and the remaining half funds climate-related investments.

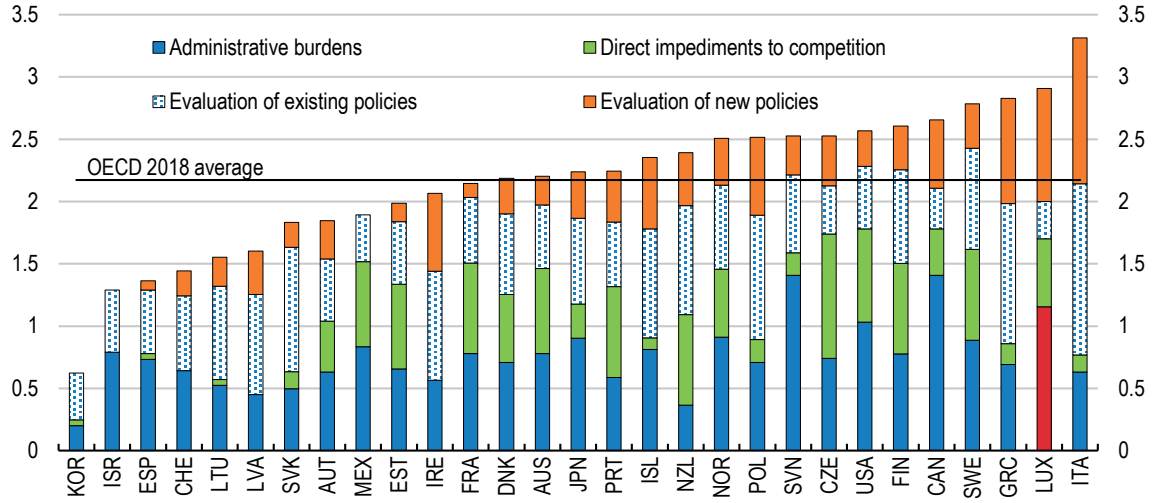
A number of countries have used carbon tax revenues to fund explicit redistribution mechanisms. Sweden explicitly announced in advance that subsidies and taxes would be gradually adjusted over time to reflect a higher carbon price, but coupled this with explicit transfers to benefit lower-income households in particular. The green tax increases of 2001 to 2006 were matched with cuts in income taxes focused on low-income households, and the increases of 2007 to 2013 were matched with sharp reductions in labour taxes (Ministère des finances, 2018[116]). In Switzerland, to compensate for the introduction of a carbon tax on heating fuels, two thirds of the revenue from the tax were earmarked to reduced labour taxes, and one third to energy efficiency and retrofitting investments (Office fédéral de l'environnement (Suisse), 2020[117]).

Regulations can complement carbon prices, but need to be well-designed

Regulations can perform an important role when price responses are likely to be muted by helping to overcome important behavioural obstacles to change, such as information asymmetries, myopia and risk aversion. This can support the attainment of lower emissions prices at lower carbon prices. (Freebairn, 2020[118]) highlights in particular standards for household appliances, building insulation, land clearing and waste disposal as important ways to shift behaviour. Technology and performance standards or bans on certain products are necessary to complement carbon pricing. It is critical, however, that these regulations are designed without increasing the overall regulatory burden facing firms (Berestycki and Dechezleprêtre, 2020[119]). Regulatory compliance costs should be kept low to avoid worsening inequalities (OECD, 2021[35]). Luxembourg's current environmental regulations impose relatively high administrative burdens (Figure 2.24).

Figure 2.24. Luxembourg's environmental regulations could be better designed

Design and evaluation of environmental policies, index scale from 0 to 6, lowest to highest stringency, 2018



Note: The indicator of Design and Evaluation of Environmental Policies (DEEP) measures potential market burdens created by environmental policies and the extent to which environmental policy evaluations take those into account.
Source: (Berestycki and Dechezleprêtre, 2020[119]).

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Regulations are an important factor in supporting change in residential housing. The government introduced regulations which require that all new homes be built to standards that will result in no net emissions by 2023. This follows a transition period between 2018 and 2022 where new homes have been increasingly required to be built to near net zero targets. The policy has been supported by an increase in the number of artisans to help with construction, although there are still concerns about the availability of sufficient supply. The impact of newly built homes on urban sprawl and car use can be reduced if undertaken in conjunction with spatial planning regulations (see below).

Regulations to encourage energy efficiency of existing home supply could be improved. At present, there is no regulation governing energy efficiency standards for existing housing supply, although there are plans to increase thermal insulation requirements by 2023 (Ministère de l'Énergie et de l'Aménagement du territoire, 2020[6]). Ambitious proposals for renovation regulations can be hampered by difficulties in monitoring and implementation. For example, whilst an energy passport system has been implemented in Luxembourg, 56% of home owners and tenants stated that they did not have an energy passport for their building or apartment, or were not familiar with the efficiency class of their building (Ministère de l'Énergie et de l'Aménagement du territoire, 2020[6]).

Estimating the energy efficiency of the existing housing stock can be difficult. France has incentivised compliance to regulations by stipulating that owners of non-compliant homes ('*passoire énergétique*') are not allowed to increase rent from 2021 and are banned from renting the properties from 2023. There is an obligation to renovate all worst-performing buildings as from 2028. However, such a model will place renovation policy in direct conflict with the need to increase housing supply in Luxembourg. The current strategy on housing notes that there are potentially labour shortages to meet construction demands from deep renovations. These same restrictions could also limit the extent to which homes can be classified as energy efficient or not. A simpler approach to defining the efficiency levels of existing buildings may help facilitate more rapid change. There is currently a geo-mapping tool for housing that includes the area and average ages of homes (Raum+), which is underpinning the cadastral valuation project. This model could form the basis of a consistent estimate for the energy performance of buildings, particularly if linked to geo-spatial data from the deeds office. If households feel that estimates differ from reality, they can challenge the ruling with a professional assessment.

Regulations are also an important part of the policy tool kit to enforce new standards in industry. The IEA notes regulations such as minimum energy performance standards on key industrial equipment such as motors, pumps, fans and heating and cooling equipment can be among the best cross-cutting approaches to raise efficiency across key industrial sub-sectors (IEA, 2021[120]). Regulations have also been used to stimulate the substitution of clinker, one of the most the energy intensive components of cement, with alternatives such as blast furnace slag, fly ash from coal plants or calcinated clay (IEA, 2021[120]). Regular benchmarking of productive processes, such as the IEA's heavy industry analysis (IEA, 2021[120]) on steel and cement, would ensure that regulatory standards continue to lead innovation in the sector by ensuring sufficiently ambitious targets. Benchmarking exercises could also provide feedback on the extent to which subsidies for additional investment should be targeted towards specific sectors and companies.

Subsidies should be targeted towards high-cost upfront investments

Subsidies are an important tool to help firms and households overcome high upfront adjustment costs in the green transition. The Luxembourg government has a number of subsidies in place, particularly for households. However, they are unlikely to result in behavioural change if not applied in tandem with other policies, as they rarely address the fundamental behaviour change requirements (EIB /Bruegel, 2012[69]).

Renewable energy supply highlights the limits of relying primarily on subsidies. Despite price subsidies as well as generous subsidies for investments (both can be used simultaneously), households and firms have not invested in expanding renewable supply as fast as the government had hoped.

Competition in renewable energy supply needs to rise. Solar energy tenders, the key instrument to secure higher photovoltaic energy supply in the government's strategy, have undersubscribed bids that do not always reflect falling solar deployment costs. Currently, two private companies and their partly owned subsidiaries generate almost all wind power and a significant share of hydropower, and own most of the biomass plants and all the solar projects developed under the 2018 tender. In addition, local firms could play a greater role in the supply of energy if restrictions on the supply of energy to the private industrial grid were lifted and if feed-in tariffs were more generous for mid-tier sized plants (below 500 MW, but above 30 MW) (IEA, 2020[2]). Making it easier for firms to strike purchase power agreements could also increase overall competition and the supply of power. This in turn will require making it easier to reach regional purchasing power agreements and to remove local obstacles to Public Private Agreements, such as the lack of eligibility for carbon CO_2 surcharges.

Higher energy prices will likely increase the attractiveness and uptake of subsidy schemes. As subsidies are funded through surcharges paid by electricity users, it will be increasingly important to ensure value for money from these subsidies. A more explicit evaluation of subsidy schemes, with a focus on their cost, outcomes and take-up, would encourage faster adaptation and learning. It took some time for the feed-in-tariffs to be adjusted to better meet the needs of small and medium sized enterprises. In Denmark, public tenders of the main support programme are allocated on the basis of least-cost abatement, to ensure an efficient distribution of subsidies.

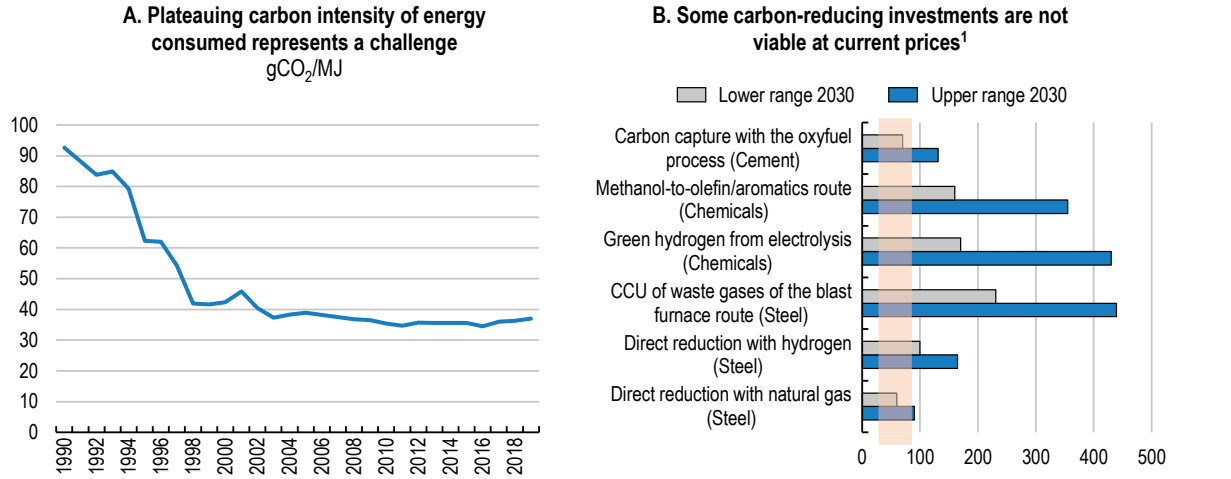
Alternative contracting methods could be used in the tender process. Contracts for difference mean that if the market price were to fall below a certain level, the renewable energy generator would receive a guaranteed price above this, and if market prices exceed that level, the renewable energy generator would return the price difference. This matters because the price of energy has tended to fall systematically over time, lowering the potential profitability of the investment. Contracts for difference can provide protection for the renewable energy generator from volatile market prices but provide a limit on the liability faced by taxpayers and electricity consumers. They are used in the United Kingdom. The Netherlands recently received approval to use them for a number of renewable projects. Germany has run a pilot of such contracts for energy investments undertaken by the steel, lime, cement and ammonia industries.

Further progress in reducing emissions in manufacturing will require a shift in the approach to supporting the transition (Figure 2.25, panel A). Since 2010, a voluntary agreement on energy efficiency between the

government and the Business Federation of Luxembourg (FEDIL) has allowed participating companies to set annual energy efficiency targets, which if reached, lower energy taxes and levies. There are now calls to expand this incentive as the costs of undertaking energy efficiency investments are set to rise. However, these subsidies are likely to take place against a backdrop of rising carbon prices from the EU-ETS. Higher prices would make many of these energy investments self-financing – particularly since Luxembourgish firms are heavily integrated into European value chains, whose customers will increasingly demand greener production. In these circumstances, subsidies carry a high deadweight loss, as investments are likely to be undertaken in any event.

Subsidies for industry should instead be increasingly targeted towards supporting those technologies that are not viable at current carbon prices (Figure 2.25, panel B) and that could reduce natural gas consumption. Natural gas currently accounts for 41% of all energy supply to the industrial sector. The investments that could help achieve this transition have long lifespans and require much higher carbon prices to be profitable, which tends to hold back private investment. This creates a sound rationale for government to support investment in this equipment. Subsidies should be technologically neutral, to allow firms to pick the solution that suits them best. The schemes could either focus on providing direct support or lower the cost of financing to boost the net present value of these projects. Luxembourg is developing a roadmap for supporting the decarbonisation of the manufacturing industry, to identify and evaluate decarbonisation potential for 2030 and 2050. New tools such as direct subsidies, carbon contracts for difference and de-risking tools will be utilised thanks to the December 2021 release of European state aid guidelines and the upcoming general block exemption rules (expected by the end of 2022).

Figure 2.25. The transition in industry will require redoubling efforts



1. The shaded area represents the expected CO_2 range in the EU ETS 2021-2030. Technologies represent potential shifts away from fossil-fuel based production.
Source: IEA and (Sartor, 2021[121]).

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The proposed Fit 4 Sustainability package includes a consultant to provide advice on firms' energy efficiency measures as well as generous subsequent financing for approved projects, which range from between 70% for SMEs and 50% for large firms. The programme could be designed in a way to promote these deep energy savings. Interestingly, Eurobarometer shows that consultancy services to improve resource efficiency, as well as demonstration of new technologies and advice on funding were more important than European counterparts. Grants and subsidies by contrast are seen as relatively less important (27% compared to 36% in Europe) (Eurobarometer, 2022[64]).

Energy efficiency subsidies could still be supported to an extent by existing energy efficiency obligations, which require energy providers to meet efficiency targets for customers. With reduced energy efficiency subsidies elsewhere, the schemes may enjoy greater take-up. Outreach to firms – particularly small and

medium-sized enterprises – on prospective energy efficiency investments, the implementation of energy audits and energy management systems, can best be achieved through information campaigns and training workshops (IEA, 2021[120]). Given the poor pace of change in the commercial sector, consideration should be given to skewing targets towards these users. In addition, data centres should receive particular consideration given their high potential for energy use in the context of higher temperatures.

Policy should clearly outline how ETS offsets are integrated into overall support. Estimates of support, provided for under European state aid laws for the risks of higher carbon prices for manufacturing firms, should take into account not only how much a firm exports, but also what key demand trends are in export markets, as well as pricing power, transport costs and other frictions. Support levels should also take into account free ETS allocations for Luxembourg, which are largely unchanged between 2021 and 2025. There is little evidence of a reduction in manufacturing production levels from the introduction of the European Emissions Trading Scheme (see Box 2.3).

In line with best practice on providing state support, compensation should be time-bound. Support levels should be recalculated if there is a material change in policy such as the introduction of the carbon border adjustment mechanism. International benchmarks can serve as a particularly important tool for considering performance of domestic firms, as published by the IEA on heavy industry (IEA, 2021[120]) or the ECB's comprehensive climate risk assessments at country and regional level. To support accountability, decisions which are confidential for commercial reasons should be made public after a specified time lag. In terms of form, rebates for emission pricing are the most efficient solution, but subsidies for investment in abatement technologies, such as carbon capture and storage are a second-best solution.

A more quantitative evaluation of the obstacles to housing subsidy uptake could improve policy design to support home renovations. The PRIMeHouse scheme aims to improve energy efficiency and renewable energy in residential housing, alongside the use of sustainable renovation materials (Ministère de l'Environnement, 2021[122]). However, despite generous support from the government, take-up of the main programmes has been low. Between 2017 and 2021, 1 800 grants through the PRIMeHouse program were approved, at a total cost of around EUR 20 million.

In its long-term renovation strategy, the government identified a number of potential reasons for low levels of renovations, including the lack of awareness, low minimum building regulatory requirements and low energy prices. However, in its most recent iteration of the PRIMeHouse scheme, administrative processes appear to have been identified by the government as a potential obstacle to take-up: the latest scheme from 2022 has relaxed requirements to use an energy consultant before the project begins. This stands in contrast to the stated regulatory aims of the housing renovation programme, which sought to increase the role of consultants overseeing the projects.

Given the generosity of the subsidies offered and the absence of means-testing, there is a need to ensure that renovation projects are sufficiently ambitious. Energy consultants can help identify whether or not deeper renovations could be implemented instead of smaller projects, and also estimate the size of potential savings. Scrapping the requirement to use them could further entrench the existing pattern of light renovations (which save about 14kWh / square metre per year) dominating renovation projects, rather than deeper renovations that save about 159 kWh/ square metre per year (European Commission, 2019[123]). The recent policy change should therefore be closely monitored and a quantitative impact evaluation conducted, over short time frames, to ensure that any adverse consequences from the policy change are managed.

Coordinating policies on housing and transport can reinforce the transition

Lowering transport emissions sustainably requires a regional approach

As the single largest contributor to emissions, transport represents one of the fundamental challenges for Luxembourg's green transition. Transport emissions are best reduced by i) avoiding unnecessary travel;

ii) shifting mobility to sustainable transport options; and iii) improving vehicle technologies and alternative fuels (ITF, 2021[8]); (D'Arcangelo et al., 2022[41]). However, different sources of transport emissions require specific strategies to ensure effective behaviour change (ITF, 2021[8]). Luxembourg's energy strategy requires a halving of transport emissions between 2020 and 2050. Exported emissions should fall by 46% and domestic transport emissions by 55% over this time frame.

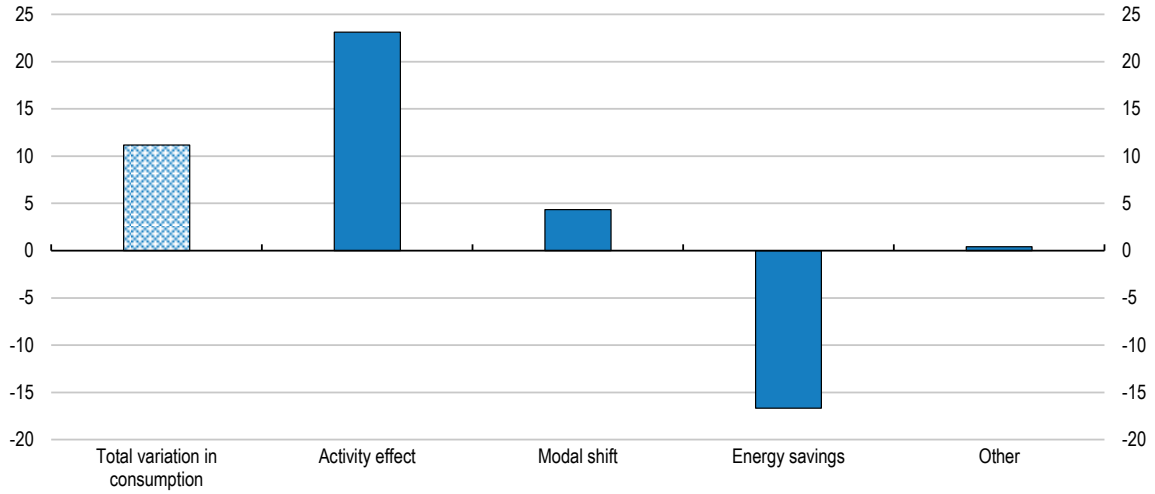
The main tool used by Luxembourg to lower exported transport emissions is higher carbon prices, which will reduce incentives to refuel in Luxembourg. (STATEC, 2020[71]) estimates that for every 1% increase in the price of fuel, foreign demand for fuel falls by more than 1%. A reduction in sales of fuel is not guaranteed, however. The pace at which carbon prices increase relative to neighbouring countries will influence the success of a pricing-based strategy to reduce Luxembourg's direct fuel sales (STATEC, 2020[71]). Specific policies will be required to support change in both cross-border freight and commuter behaviour.

European freight traffic will require infrastructure investments to shift behaviour

Over the past decade, growth in the freight sector has offset the impact of energy efficiency gains (Figure 2.26). Road freight transport in Europe is expected to expand at an average annual rate of 1.9% until 2050 (ITF, 2021[8]).

Figure 2.26. Growth in freight transport volumes has offset energy efficiency gains in the sector

Variation in consumption between 2000 and 2019, Mtoe



Source: Odyssee-Mure (database).

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International evidence suggests that lower freight emissions will require a combination of policies. The ITF estimates that to lower emissions from road freight in Europe by 0.7% per annum, carbon prices must be in the range of USD 150-250 per tonne by 2050, the long-awaited European cross-border rail improvements in TEN-T must be implemented, with a switch from road to rail freight whereby the share of the latter rises from about 2% to 20% in Western Europe (ITF, 2021[8]). Luxembourg is targeting a 3.9% annual reduction in exported transport emissions. The ITF estimated a drop in carbon emissions in European freight traffic of around 4% would be achieved with a carbon price that is double its central scenario, alongside expanded low-carbon charging and refuelling infrastructure being widely available, a much higher share of low emission vehicles (about 20% by 2050), much more widespread digitalisation and autonomous road freight, as well as a doubling in rail freight usage from its central scenario (ITF, 2021[8]).

Whilst on its own Luxembourg will not change behaviour in the European market, it needs to support behavioural change through broader regional initiatives. For freight, this will require monitoring and enforcing stricter EU vehicle standards and regulations, particularly in the short term, as most energy efficiency gains are likely to be focused on energy efficiency (ITF, 2021[8]). Over the longer term, Luxembourg should ensure that its infrastructure encourages users to shift from road to rail and to use alternative energy sources in road freight. This will not require an immediate change for freight transport: unlike for passenger cars, the infrastructure to support alternative fuel technologies, such as hydrogen or electric road systems, is expensive and there is still significant uncertainty about the most viable technology to implement (ITF, 2021[8]). Luxembourg is adapting its road infrastructure to support electric vehicle charging for passenger vehicles and increasing the roll-out of fast charging stations for electric vehicles and trucks. It could be useful to build in additional capacity as this charging infrastructure is rolled out along highways, which could then be adapted to support a particular fuel type – such as hydrogen fuelling, or adaptations to support battery charging. This would complement efforts such as the installation of the first hydrogen fuelling station in 2022.

Shifting to freight rail would help to sustainably reduce emissions across the region. At present, freight rail represents around 3% of total million tonnes per kilometre of freight shipped in Luxembourg. Whilst freight rail will only be suitable for long distances, and the sector poses considerable challenges from a national rail policy coordination perspective, the benefits coordination can be substantial: freight rail infrastructure uses 72% less energy per tonne-kilometre than freight trucks (IEA, 2020[78]). These efforts could be coordinated alongside passenger rail efforts (see below). The energy efficiency obligation scheme provides incentives for modal shifts to freight transport, alongside other energy efficiency measures in freight (Cluster for Logistics, 2019[124]), which are currently being evaluated. Evidence can be used to design future incentives.

Reducing emissions from cross-border commuters

Cross-border workers constitute about half of the total workforce in Luxembourg, implying 200 000 commuting daily, 85% of them travelling by car for an average distance of 49 kilometres (Lambotte, Marbehant and Rouchet, 2021[125]). Cross-border commuter demand is set to grow alongside the economy. STATEC forecasts this workforce could rise to around 300 000 by 2040 (Haas and Peltier, 2017[9]).

Cross-border commuters are being encouraged to use more public transport, given that for longer urban trips, using urban rail instead of private cars delivers a 91% lower final energy use per passenger-kilometre (IEA, 2020[78]). A key part of the strategy to increase public transport usage is to improve user experience. Many commuters are concerned with the quality of public transport and the frequency of services, rather than the price or time spent in transport. The planned expansion of Luxembourg station and an increase in rail line capacity is welcome as it responds to the need for better and more regular services to drive a modal shift towards consumption.

Nonetheless, the targets are challenging. The National Mobility Plan targets 19% of cross-border commuters to use public transportation in 2035, up from 15% in 2017. This 4 percentage point increase represents an increase of about 30 000 daily commuters, roughly double the volume that currently use the public transport system. The share of public transport used by these commuters rose just over a percentage point between 2010 and 2017 (Table 2.7). It seems most likely that cross-border commuters working in the city centre will most easily shift to increased public transport. Their use of public transport is higher at 36.5% (21.2% for the train and 15.3% for the bus) (Lambotte, Marbehant and Rouchet, 2021[125]).

In the short to medium term, it is unlikely that car usage by cross-border commuters will decline sharply, even if fuel prices in Luxembourg rise. Many of these workers are currently not able to use public transport services. A large number of cross-border commuters currently work close to the border, where public transport links are less dense and services less frequent, on both sides of the border (Lambotte, Marbehant and Rouchet, 2021[125]). Their places of residence are dispersed too, with long average travel times. They

often work in districts in Luxembourg that lack train services (Lambotte, Marbehant and Rouchet, 2021[125]). In addition, the abundance of free parking, attractive company car benefits and the relative ease of car use will act as further impediments to change.

Combining the existing policy to increase public transport frequency and quality with carbon pricing and other road use charges could over the long-term help increase the attractiveness of housing choices close to public transport hubs. This will also depend on ensuring business operations in Luxembourg are concentrated around public transport hubs, rather than the current dispersed pattern of activity.

Table 2.7. Cross-border transport patterns are heavily dominated by cars

		2010			2017		
	Share of domestic employment (%)	Car use	Train use	Bus use	Car use	Train use	Bus use
Germany	10.2	90	2.5	7.5	89.7	3	7
Belgium	10.3	88	9	3	88.2	7.9	3.9
France	22.6	83	11.5	5.5	80.8	12	6.9
Total	43.2	86	9	5	84.6	9	6.2

Note: Refers to non-resident cross border workers that are employees in 2019.
Source: STATEC and (Lambotte, Marbehant and Rouchet, 2021[125]). Note 2010 data from the mobility survey of cross-border workers 2010, CEPS/INSTEAD (7,235 respondents); 2017 data from Luxmobil survey 2017, Ministry of Public Works.

Increased railway use also requires more international prominence to resolve persistent coordination challenges. The closure of the Brussels-Luxembourg-Strasbourg-Switzerland direct daytime trains, the last of which were withdrawn in 2016, was due to the inability of the four incumbent railway undertakings to agree on an upgrade plan for the winding Belgian section (TEN North Sea-Mediterranean Corridor). This situation was exacerbated by timetabling conflicts, and the introduction of the European Train Control System in Luxembourg, for which SNCF had no suitably equipped locomotives (European Commission, 2021[126]). International rail coordination is not easy, as evidenced by continued slippage on the European TEN-T rail projects. The agreement "*A cross-border operational strategy for the Greater Region*" to try and support carbon emissions reductions was released in January 2021. This could form the basis for more engagement at national level. Denmark and Sweden have an agreement that helps to inform the key cross-border priority policies (Box 2.10).

Box 2.10. International cross-border transport agreements

The Greater Copenhagen Committee, an organisation composed of politicians at municipal and regional levels elaborated a so-called Traffic Charter, a shared vision document. The Charter can be used as a basis for dialogue with national governments as well as with other national level actors, such as the train operators in Denmark and in Sweden. It sets out two specific goals in relation to travel – the promotion of a coherent public transport system in the region and that it should take a maximum of one hour by train to get either to Copenhagen or Malmö from all parts of the region.

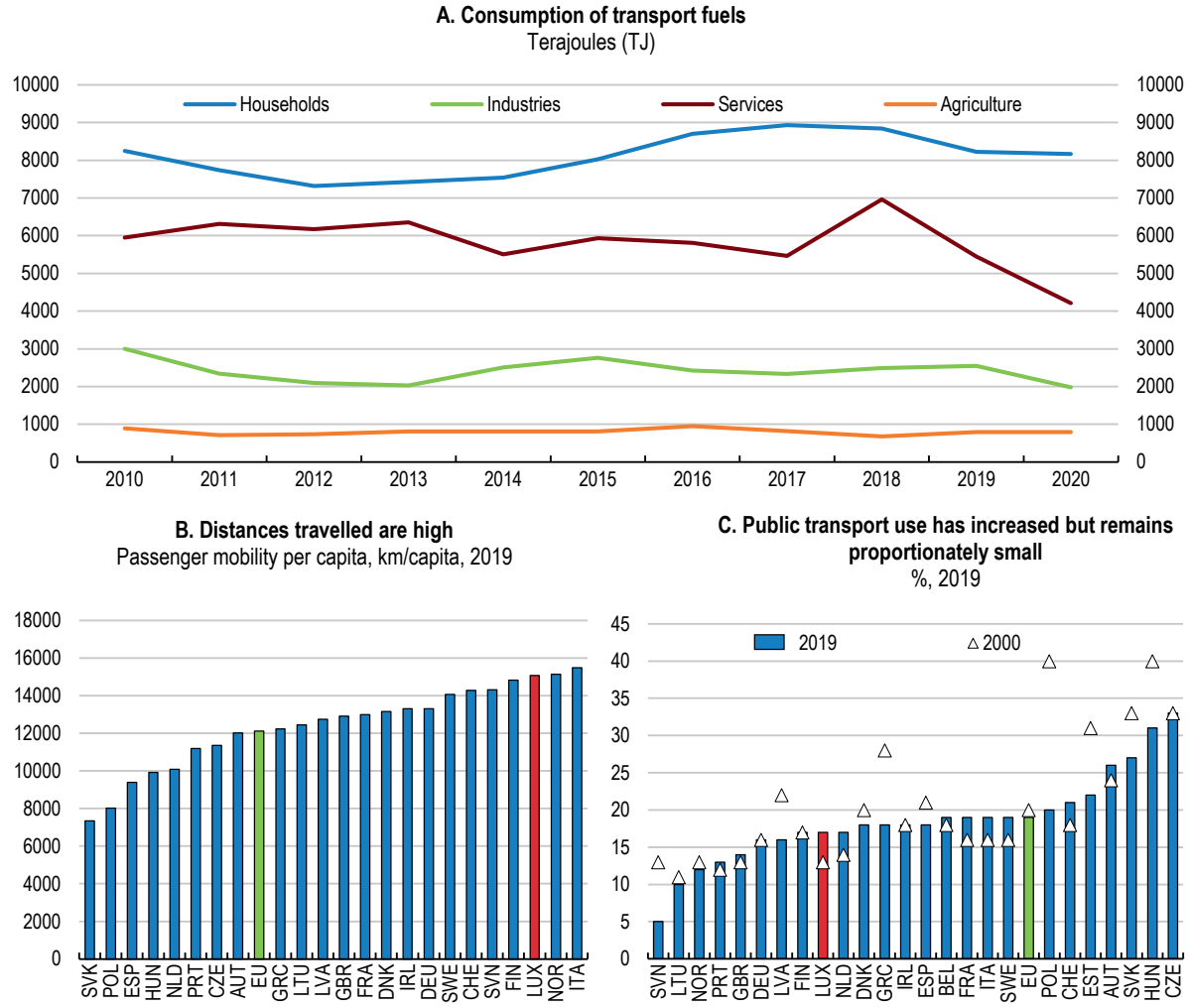
Source: (Grunfelder, Huynh and Lidmo, 2020[127]).

In addition, employers could be encouraged to employ greater flexibility in hours for cross-border and other workers to further reduce the pressure on traffic nodes at peak times. More active encouragement of teleworking may also help to reduce worker flows, but it could inadvertently support even greater sprawl in the region, pushing up travel needs (ITF, 2021[8]). For this reason, teleworking needs to be combined with other efforts to reduce urban sprawl and encourage public transport use. In addition, increased teleworking allocations could be difficult to negotiate, given the potential loss of workforce and revenue flows for neighbouring countries. At present, the maximum number of days are 19 for Germany, 24 for Belgium and 29 for France (Lambotte, Marbehant and Rouchet, 2021[125]). Belgium and France have agreed to increase the number of days to 34 (PWC, 2021[128]), although the increases are not yet effective.

Reducing domestic transport emissions

The government is targeting a 55% reduction in domestic transport emissions by 2040. By 2025, these emissions are supposed to fall by 25% relative to 2020 levels, which were already sharply lower than in previous years due to COVID-19 (Ministère de l'Énergie et de l'Aménagement du territoire and Ministère de l'Environnement, 2020[129]). Households currently make up just under half of total domestic fuel consumption (Figure 2.27, panel A). Car use is the dominant form of transport for households, who tend to use their cars very intensively - by contrast, public transport usage is relatively low, although it has been increasing (Figure 2.27, Panel B and C).

Figure 2.27. Households' high car reliance drives fuel consumption and emissions



Source: STATEC; and Odyssee-Mure Database.

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Improving the relative attractiveness of other modes vis-à-vis the car can help decrease the time / cost threshold at which a motorist would be discouraged to drive. The government's strategy to reduce domestic transport emissions focuses on lowering the use of internal combustion engines by increasing the public transport offering and lowering the costs of electric vehicle adoption through purchase subsidies and improved charging infrastructure.

The government has plans to expand the public transport service offering over time, particularly for trains and trams in the centre, with buses used as the main public transport service in outlying areas (Ministère

de la Mobilité et des Travaux publics, 2022[130]). Public transport has been free since March 2020 for anyone within the borders of Luxembourg. The impact of free public transport is not yet clear, although initial indications are positive (see Box 2.11). In addition to making public transport free, regional bus networks have been reformed, and by July 2022, almost all residents will live within less than a kilometre of a public transport point, and will be able to access the free bus service at least every other hour. An app (MaaS - Mobility-as-a-Service) simplifies door-to-door travel planning across the bus, tram, train, bike, and walking networks.

Box 2.11. Free public transport and its impact on car use

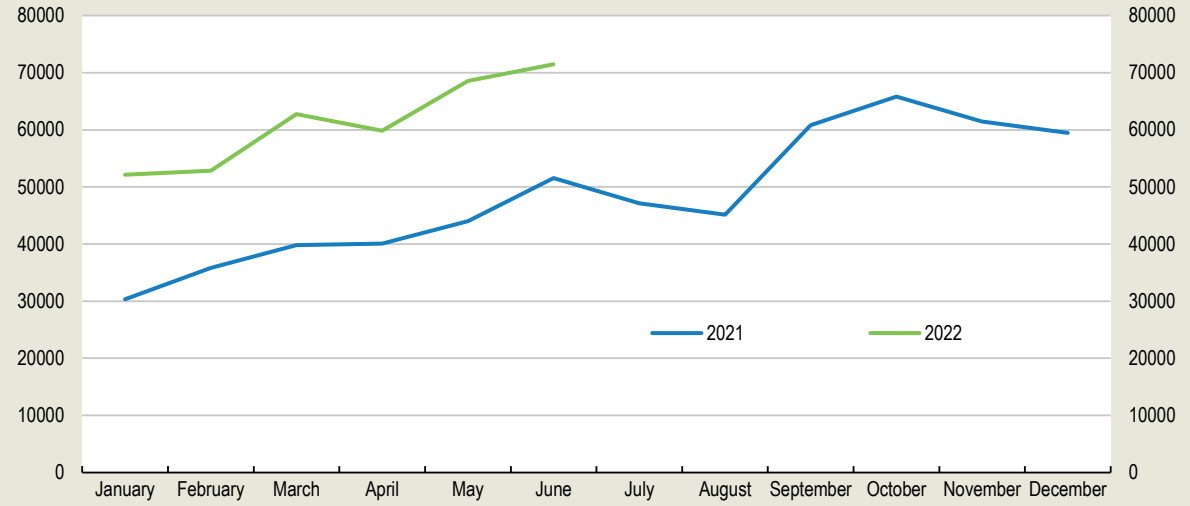
As of March 2020, Luxembourg introduced free public transport across all modes of transport in the country, expanding eligibility from the youth, young students and the lowest income households. In addition, to try to encourage greater public transport use, the government recently extended free bus use from a park and ride scheme across the French border in a pilot programme to see if this would encourage greater public transport use. The objectives include improving access to public transport and reducing car usage.

A number of cities have implemented temporary free public transport, to help encourage uptake of public transport (Gothenburg) or to lower traffic (Milan, Prague and Turin). However, the evidence of free public transport in cities suggests it is not the main vehicle to encourage car users to switch. Evidence from other cities with free public transport suggests increased public transport from free fares tends to come from people who previously walked or cycled. (Proost, 2018[131]) finds car users make up only 15 -35% of new public transport passengers attracted by lower public transport prices. The low conversion rate of car users may be because car usage is priced too low, which would suggest the costs of car usage must increase, rather than to rely on a lower cost of public transport.

In Luxembourg, public transport was made free following significant efforts to increase the availability and quality of public transport. Data suggest users of the tram, where daily passenger data is available, have increased significantly – average usage in the first half of 2022 is up 52% compared to 2021 (see Figure 2.28).

Figure 2.28. Tram usage has increased steadily

Average daily number of passengers between Monday and Friday



Source: Ministère de la Mobilité et des Travaux publics.

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An annual evaluation of free public transport will be conducted, with the next release scheduled for 2023. The study should take into account international experiences and analyse not only increased usage, but also the degree of switching from different modes such as cars, walking or cycling and whether the lowest-income households have benefitted the most, as was anticipated. Results from the pilot park-and-ride scheme to encourage cross-border commuters should also be included.

Source: (ITF, 2021[8]); (OECD, 2020[4]); (ITF, 2018[132]); (Ministère de la Mobilité et des Travaux publics, 2022[130]); (OECD, 2021[133]); (Proost, 2018[131]).

The government is in the process of promoting cycling as a transit mode, seeking to leverage the fact that 58% of residents own a bicycle and 54% of resident's trips are shorter than 5 kilometres. At present, less than 5% of trips between 1 and 5 kilometres are done by bicycle, compared to two thirds by car (Ministère de la Mobilité et des Travaux publics, 2022[130]). The National Mobility Plan – 2035 places an important role for cycling in the multimodal transport network. Key cycling objectives include ensuring all major public transport stops are safely accessible by bicycle within at least a 2.5 kilometre radius and the creation of high performance cycle routes linking the three major urban agglomerations ((Ministère de la Mobilité et des Travaux publics, 2022[130]). The emphasis on creating safe, continuous cycling infrastructure and traffic junctions is critical to both increase the use of bicycles and the safety of those using them (ITF, 2013[134]).

Enhanced policies to encourage shared mobility services could improve the environmental impact of the policy on electric vehicles. Shared mobility can be broadly defined as the common use of a vehicle by multiple users, such as ride- and car-sharing. Encouraging shared mobility services would lower the total environmental costs of the current electric vehicle strategy, and mitigate the risks of missing emissions targets from personal consumption. The IEA estimates that electric vehicles and batteries will be responsible for about half of the quadrupling demand for total mineral consumption over the next 20 years to meet net-zero goals by 2070 (IEA, 2021[135]). These can have significant environmental impacts in the countries in which mining occurs. "Rebound" risks – when travel demand increases due to lower costs – are rarely taken into account in estimates of travel switching modes (OECD, 2021[133]). Global estimates of long-term rebound effects can be substantial, in the range between 15% and 30% (Litman, 2021[136]) – which would mean that a 50% improvement in energy savings could be reduced by between 7.5 and 15 percentage points.

On-demand micro-transit services can encourage shifts away from private vehicles that are more tailored than public transport (although more expensive) – but cheaper and more environmentally friendly than private taxi use (ITF, 2019[137]). The state set up a mobile app ("CarPilote") to encourage ride sharing amongst citizens, although with low fuel prices and the COVID-19 pandemic, it may be too early to judge the success of its take-up. The draft law to allow greater use of private ride sharing apps such as Uber (Ministère de la Mobilité et des Travaux publics, 2021[138]) has not been enacted. The government has stated its commitment to greater use of ride sharing, to encourage shared mobility and reduce prices paid for taxi services (Schnuer, 2021[139]); (Delles, 2022[140]).

The enabling framework for both the taxi industry and ride sharing apps needs to be carefully designed. Most recent global evidence suggests that ride-hailing services have not helped to reduce emissions, since they currently foster private rides and low occupancy rates at the expense of other shared modes of transport (Crozet, 2020[141]); (OECD, 2021[133]). Ride sharing has not been common. A stringent regulatory framework is needed to ensure that both traditional and ride-sharing apps help lower emissions (ITF, 2020[142]). This can help balance the fact that in many cases, restrictions on the size of the taxi sector have artificially depressed the "normal" levels of usage of these services. Luxembourg has already taken steps in the draft taxi law to ensure that fleets of taxis and chauffeur services would need to be low emitting (Ministère de la Mobilité et des Travaux publics, 2021[138]), but more stringent standards should be applied over time. Consideration could also be given to providing more favourable treatment for pooled transport services.

Increasing the supply of shared scooters and electric bicycles can increase the radius and speed of active transport options, reducing the need for cars (ITF, 2020[142]). Concerns about "wild" parking of shared scooters and bicycles and the safety risks they pose are often disproportionate to the same problems with cars (Brown et al., 2020[143]); (ITF, 2020[142]). Nonetheless, many operators tend to flood the market in order to achieve economies of scale, which can combine with public transport systems that have not been adapted for their use, creating competition for space between pedestrians and other vehicle users (OECD, 2021[133]). This has driven practices such as hard caps on the number of providers (such as in Amsterdam or Mexico City) or high fees (in Mexico City) (ITF, 2020[142]). A better approach is to use softer regulations that change based on surveillance of supply and demand levels, and finding ways to embed space for

shared scooters and bicycles in parking and street use objectives (OECD, 2021[133]). Minimum standards that can increase longevity of these shared vehicles and lower energy consumption can further improve their impact (EIT, 2022[144]).

In the medium term, as electric vehicle use expands, a carbon tax would be a less useful way to estimate the other environmental costs generated by cars, such as congestion and space. An expanded form of pricing for car use should be considered. The government is modifying the company car benefit schemes in order to make it solely eligible for zero emission vehicles, but only from 2025 (Ministère de la Mobilité et des Travaux publics, 2022[145]). California went even further, replacing in-kind car benefits with cash. This resulted in many workers pocketing the cash and using public transport (OECD, 2021[133]). Removing company car benefit schemes altogether once the price of carbon is sufficiently high could encourage further behavioural change.

Parking can be an important component of drivers' convenience costs. (Franco and Khordagui, 2019[146]) find that increasing on-street parking by 10% is associated with a 1.3% increase in the probability of driving, and (Franco, 2020[147]) shows people tend to drive walkable or bikeable distances if parking is easily available. In Lisbon, parking prices differ by three zones, which are determined by public transport services and parking density. Copenhagen has a three-zone parking pricing scheme which is higher in central areas of the city. In Strasbourg, a concentric three-zone parking pricing scheme imposes higher parking prices as well as shorter parking times in the city centre, compared to the periphery of the city as well.

The government has identified parking as a key determinant of car use, and will release a national parking strategy in 2023 to provide guidelines for this municipal competency. This strategy should include guidance on switching requirements in building regulations to drop minimum parking allocations in favour of maximum parking allocations, alongside pricing and taxing strategies for existing parking spaces. Building applications should include multi-modal transport impact assessments, rather than just car transport impact assessments (OECD, 2021[133]).

Road-pricing schemes can also play an important role in delivering behavioural change and climate and well-being goals - if designed with the aim of efficiently using road space, rather than simply increasing traffic speeds or reducing congestion (see Box 2.12). Road use charges could also increase for lower rates of user occupancy (OECD, 2021[133]). The compliance costs of introducing congestion charges are falling as the infrastructure is constantly evolving. Concerns about confidentiality can be managed through stringent standards. These schemes also have the benefit that unlike parking and other planning regulations, they can be implemented at a national level, ensuring a level of consistency in travel pricing across the country.

Box 2.12. Evolving best practice in road user charges

While not yet widely used, urban road-pricing schemes are growing in number. Cities like London, Stockholm, Milan and Singapore have congestion-charging schemes for specific areas, and Tel Aviv has plans to implement them. California, and Seoul, among others, apply road tolls to particular corridors. These schemes have worked in reducing the number of private vehicles on the road in the city centre - by 21% in London, 28.5% in Milan and 29% in Stockholm.

The most efficient road-pricing schemes are those where prices vary according to the scarcity of space – which includes varying over time. The road-pricing scheme in Singapore is an example of best practice. It has electronically applied differentiated pricing based on time and location, and is implemented in both the central part of the city and for several highways. The system has three daily pricing peaks: the morning and evening rush hours and a third peak at 2:30 pm due to the tendency for offices to schedule meetings during this time of day. An electronic road-pricing system also supports lower speeds. Prices are reviewed and adapted as needed on a quarterly basis.

The Norwegian government is considering introducing a GPS-based distance, location and time-contingent road charge along these lines to ensure road users internalise congestion costs and related externalities. Flat pricing schemes, such as applied in London, penalise short trips and could encourage car use once the charge has been paid. They may also not be effective in managing fast-growing transport sectors such as delivery vehicles and taxis. However, they can be easier to communicate and understand. Stockholm opted for a simpler charging structure, which was more politically acceptable to residents. The charges are applied each time the congestion cordon is passed, although the charges vary between peak and off-peak periods.

In order to increase the social acceptability of road charging schemes, exemptions have often been applied, often with unintended consequences. Exemptions for residents in charging zones can raise prices in the centre, compounding inequalities of higher house prices and homes in the (richer) centre compared to those outside. Exemptions can benefit (richer) residents, whilst poorer outsiders have to pay congestion charges to go to work. In Norway, exemptions for electric vehicles from congestion charges and allowing them to use bus lanes may have increased overall congestion and locked in overall car use.

Governments should instead focus on ensuring that complementary policies are in place to encourage greater support. In Stockholm, to encourage social acceptance of congestion charges, the scheme was initially introduced for a seven-month trial period. The trial scheme was accompanied by significant investment in the public transport network.

Source: (D'Arcangelo et al., 2022[41]); (Holtsmark and Skonhoft, 2014[148]); (ITF, 2018[132]); (OECD, 2021[133]); (OECD / ITF, 2018[149]).

There are concerns that transport-based policies could generate significant political backlash given the importance of car use across all income levels in Luxembourg. The availability of alternatives will be a key determinant of how severe the impact is. (Mattioli et al., 2019[150]) show that there can be large variations in car use within income groups. Measures of spatial vulnerability are required as well as identifying the availability of alternatives. In the United States, the government uses the housing and transport affordability index to determine levels of support for households, based on the availability of public transport alternatives available to them (OECD, 2021[133]).

Communication is important, as is framing the nature of choices. Surveys in Lyon, Helsinki, Gothenburg and Stockholm showed congestion charges were considered unfair until respondents needed to choose a better option (such as queuing, government allocation or a lottery) (Eliasson, 2016[151]). Evidence suggests support is higher if it is clear that the policy is not a revenue-generating source. In the United Kingdom, it was clear that the congestion charge revenues would be recycled and that environmental effects were more important for the scheme (OECD, 2021[133]).

In addition, policies could be phased in over time, and do not have to be introduced simultaneously. Initial policies should focus on reducing the company perks on cars, as well as raising carbon taxes. A plan for higher road use charges should be clearly flagged to encourage higher occupancy rates as well as to discourage car use.

Spatial planning could be better leveraged to reduce transport emissions and resolve tensions between housing supply and the environment

Households' use of private transport is not just a personal choice, but one influenced by necessity in terms of housing and work (OECD, 2021[133]). Induced demand and urban sprawl are key dynamics determining car dependence and high emissions globally (OECD, 2021[133]) and Luxembourg is no exception. More than 30% of the urban population in Luxembourg in 2014 resided in areas of very low population density, which the OECD defines as a density of 150-1 500 per square kilometre. (Lambotte, Marbehant and Rouchet, 2021[125]) show public transport use is lowest for residents in outlying regions, where many workers have moved in order to benefit from lower house prices and a relatively small increase in commuting times. Many of these homes are not located in central locations, but scattered, and work tends to be in outlying areas, clustered around shopping malls close to the border (Lambotte, Marbehant and Rouchet, 2021[125]). As a result, reliance on cars is high. The Luxembourgish own the highest number of cars per household in Europe (Eurostat, 2021[152]) and rely on cars for over 65% of trips between 1 and 5 kilometres (Ministère de la Mobilité et des Travaux publics, 2022[130]). The government needs to find ways to reduce the number of cars owned by households towards the European average, as well as the extent of car use.

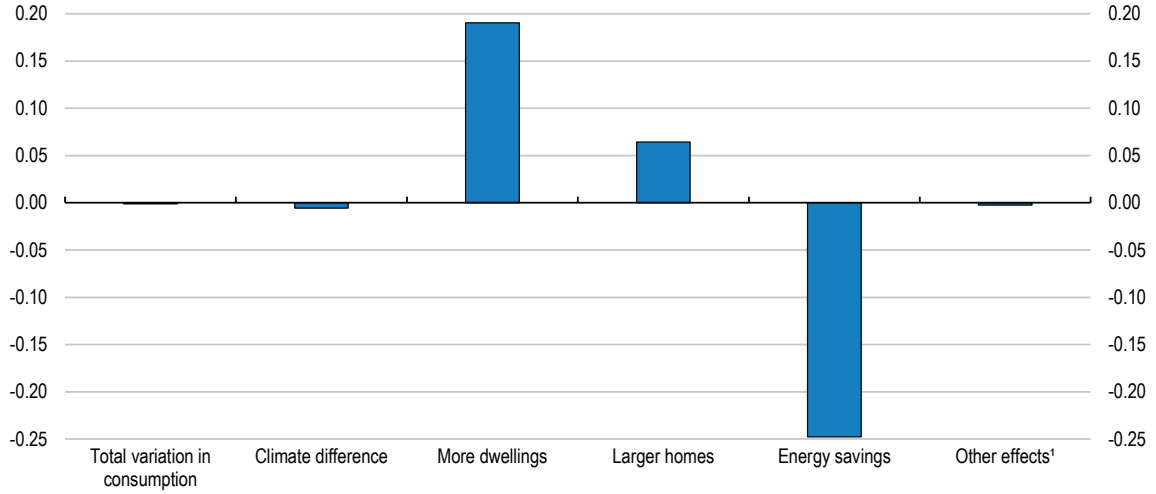
Integrating land-use decisions and transport planning can reduce transport demand and trip lengths, while improving accessibility for citizens in addition to limiting urban sprawl (OECD, 2018[153]). Model estimates suggest significant gains from spatial planning at a global level. (Fulton, Mason and Meroux, 2017[154]) and (Fulton, 2018[155]) estimate total transport emissions can decline by approximately 76% with integrated spatial planning compared to a 44% reduction when the focus is just on reducing emissions through switching to cleaner technologies (such as electric vehicles). The main impacts come from reducing distances travelled and supporting more intensive use of public transport and shared mobility services. The same studies also estimate that such a strategy lowers costs by about 40%, thanks to the lower number of vehicles that need to be purchased and reduced road and parking infrastructure needs.

Reducing car use will help to reduce the space dedicated to cars, which can increase green or recreation spaces (OECD, 2021[133]). This has important implications for encouraging greater densification in urban areas, to improve perceptions of living in urban neighbourhoods. Despite being one of the least dense countries in the OECD, surveys show that perceptions of noise are relatively high (Stráský, 2020[156]). The COVID-19 crisis could exacerbate urban sprawl by encouraging more people to move out from the centre (Ahrend et al., 2022[157]). Reduced space for cars, densification and brownfield development can also help to reduce the risk of soil sealing. On average 0.46 hectares of soil are urbanised daily in Luxembourg (Ministère de l'Énergie et de l'Aménagement du territoire, 2022[158]). The EU Soil Strategy for 2030 commits countries to reach no net land take by 2050 (European Commission, 2021[159]).

In a small country such as Luxembourg, the competition for space for green use and the need to increase the number of homes by at least 4 000 units a year increase the potential frictions between housing supply and environmental policy objectives (Figure 2.29). The government commissioned research on whether green belts needed to be redesigned to meet potential housing supply needs. The study concluded that no change in green belt policy was necessary, given the potential land available already zoned for development (LISER et al., 2021[160]). For this to hold true in practice, significant barriers to faster densification of housing in existing areas need to be lowered. This in turn requires tackling inconsistent policy objectives between national and municipal authorities and the incentives for land development.

Figure 2.29. Housing-related emissions have increased

Variation in consumption between 2000 and 2019, Mtoe



1. Other effects refers mainly to change in heating behaviours.
Source: Odyssee-Mure (database).

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Strides have been made in improving the coordination of national and municipal land-use planning. Luxembourg has envisaged a Master Programme for Spatial Planning that supports densification through the development of three urban centres, reducing pressure on the city of Luxembourg and increasing growth nodes on both sides of the country. This is intended to address the key challenge of ensuring the sustainable use of land and natural resources alongside citizens' well-being and the need for development. Legislative changes in 2018, strengthened in 2021, increased the legal reach of national policy, requiring that all municipal planning processes are consistent with the four published sectoral master plans for housing, transport, landscapes and economic activity zones. These sectoral plans in turn are drawn up by national government to implement the Master Programme for Spatial Planning (PDAT). The department of the Interior is responsible for monitoring the compliance of municipal land use plans.

This should improve the overall coherence of the system but will not be a panacea for governmental coordination. National policymaking should be consistent with the Master Programme for Spatial Planning. Investment project coordination with the Master Programme for Spatial Planning should be mandatory, including at national level. National tax policy could increase supply by raising the costs of undeveloped land through national taxes, as is currently under consideration (see chapter 1). This would be an important complement to the often under-utilised provisions for municipalities to tax unused land. National tax policy can also reduce excess demand by gradually phasing out the current mortgage interest deduction (as discussed in chapter 1) and reducing incentives for urban sprawl by scrapping current generous national income tax deductions based on the distance travelled to work, which can reach up to EUR 2 970 per year (OECD, 2020[4]).

There is strong resistance to densification in a number of larger municipalities identified for densification. Municipalities are the primary decision makers in the approval of building permits, and the designation of the status of building sites. Frictions between municipal and national priorities may be elevated to national parliament, since over a third of the legislative assembly are also representatives of their local councils.

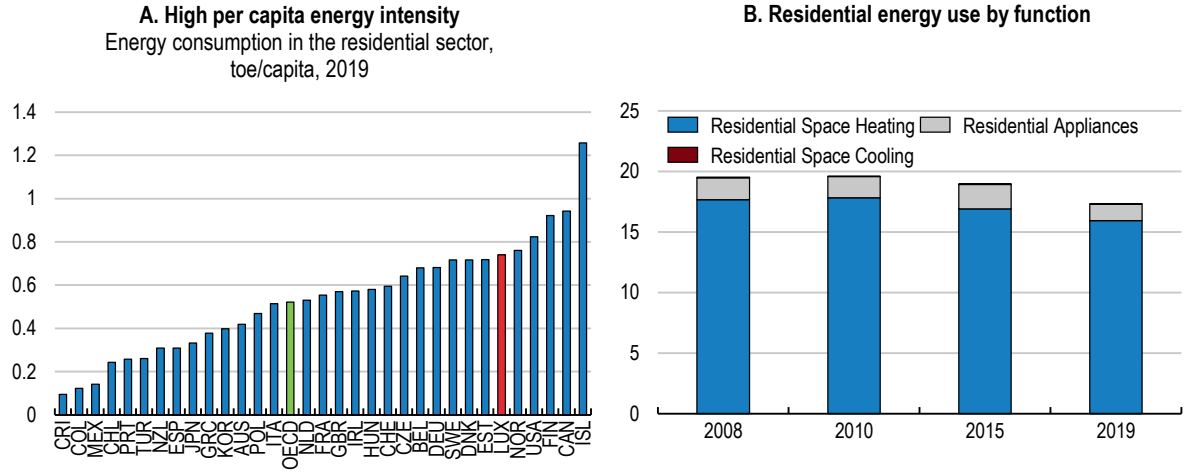
Incentives of municipalities need to be aligned to support the strategy, allowing their experience and expertise to be properly utilised. Current incentives for housing supply, embodied in the Housing Pact (*Pacte Logement*), provide cash incentives for homes built, regardless of their location or building characteristics. This has encouraged smaller municipalities to expand faster; it has in turn done little to incentivise the larger municipalities facing more opposition from residents to allow more building (Carr and

Hesse, 2020). The *Pacte Logement* incentives to encourage housing supply should be aligned with – and possibly strengthen – the Master Programme for Spatial Planning. This should include making the subsidies available only for housing in areas identified for densification in the Master Programme for Spatial Planning. Additional criteria could include requirements on encouraging density or the occupancy rate.

Care needs to be taken to improve homeowners' incentives to support densification. The home-voter hypothesis predicts that homeowners turn to local politicians to protect the value of their housing investment by restricting the additional development of land (Fischel, 2002[161]); (Gyourko and Molloy, 2015[162]). By focusing on broader incentives for households, the supply of land by the private sector can be encouraged. The amendments to the Modified Law of 19 July 2004 concerning Municipal Land Use Planning and Urban Development that deal with the building land contract (*Baulandvertrag*) aim to speed up procedures for amending land-use plans and allow for ministerial intervention to force the reorganisation of parcels of land (Ministère de l'Intérieur, 2021[163]). The government has currently envisaged the use of transferable development rights as a way of providing new development rights to landowners who are not able or willing to invest within the timeframes dictated by the building land contract bill (Di Stefano et al., 2022[164]). Transferable development rights have been used extensively in the United States, where lessons suggest the benefits from the policy require that the total amount of housing be carefully estimated, and that the transfer of rights is consistent with the rest of the development plan, to avoid urban sprawl.

New housing construction should aim at increasing residential density, namely by constructing higher buildings, in particular around transport hubs (Stráský, 2020[156]). Ambitious renovation policies to reduce emissions could be leveraged to increase the density of existing housing, much of which is single-family dwelling units. Meeting the government's target of reducing residential emissions by 57% by 2050 will require tripling current renovation rates of the existing housing stock to 3%. This will help to reduce heating costs, which make up the bulk of the residential sector's emissions (Figure 2.30). The costs of renovations can be substantial. Average investment costs for deep energy renovations of residential buildings in Luxembourg were 30% higher than in neighbouring countries between 2012 and 2016 (European Commission, 2019[123]). The current subsidy scheme (which provides a EUR 10 000 bonus for densifying houses) could be supported with reform of the permitting regime, which in many municipalities limits the density of residences. Allowing the property to be split into more than one dwelling could increase the profitability of renovation projects for homeowners, raise housing supply and improve overall energy efficiency gains, since more dense living tends to help lower energy requirements.

Figure 2.30. Energy intensity of the residential sector in Luxembourg is high due to heating



Source: IEA, Energy Efficiency Indicators.

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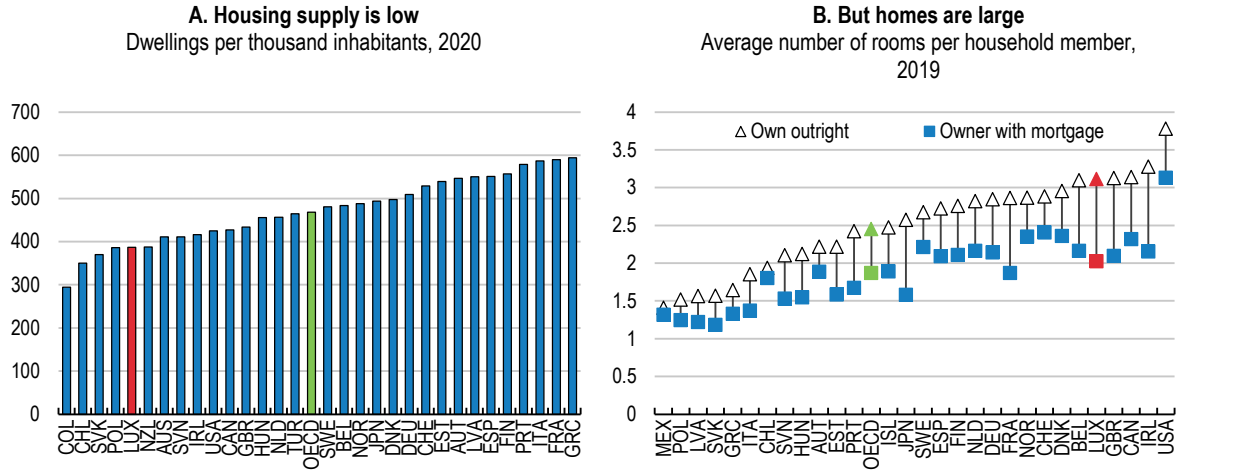
The policy may need to be complemented with additional support for homeowners that continue to live in the neighbourhood (Figure 2.31). (Wicki, Hofer and Kaufman, 2021[165]) document that in large metropoles, survey respondents tend to resist densification projects that are close to them, but this can be lessened with increased participatory planning as well as a clear policy that improves social equity.

Figure 2.31. There is some room to improve density of existing housing



Source: OECD Affordable Housing Database.

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Resistance to densification could in part be driven by concerns about quality of life and already elevated concerns about noise levels. An explicit strategy to consider the space used for streets could improve the quality of living in denser neighbourhoods (OECD, 2021[133]). The current transport strategy provides guidance for municipalities on how to consider parking design, and the national parking strategy will provide further guidance. The ambition of these strategies could be expanded to include the link and place methodology, which explicitly considers how space is used (Box 2.13).

Box 2.13. Changing city design to reduce car use

City design requires confronting the notion that streets are for cars, a notion that was aggressively promoted in the 1950s and 1960s. Streets function as both a link and a place, and explicitly recognising this allows policy makers to re-imagine physical spaces that allow for greater densification, whilst still providing quality of life.

In Barcelona, the authorities introduced the concept of the SuperBlock, which sought to balance access and mobility with reduced car space. Inside each block, space is dedicated to pedestrians, cyclists and green space who have access through the superblock; cars and delivery vehicles only have one point of entry and exit into each block. Outside each block, a grid system of buses has increased access to public transport from each block.

In Pontevedera, the city sought to revitalise itself, arresting suburban sprawl and re-attracting people back to the city centre. This required altering the relationship with cars. Half of all wide streets were dedicated to pedestrians, alongside a revamped parking strategy and improved public transport. The changes have resulted in an increase in residents in the city centre, alongside reduced traffic.

In New Zealand, the link and place methodology was used with the aim of better integrating land use and transport by cities such as Tauranga and Christchurch. This then guided the national framework for road planning and investment decisions, by providing a higher weight to the strategic significance of roads and its adjacent land use. The methodology has also been used in London in order to classify municipal bids for road funding. The government of South Australia used it to upgrade its street network.

To help better integrate the existing physical arrangements, a network of 15 minute cities, which seeks to create proximity and accessibility for citizens by defining three radii accessible by foot and bike within which authorities need to ensure access to a certain number of services. This can help to improve access and reduce car usage.

Source: (Duany and Steuteville, 2021[166]); (OECD, 2021[133]); (Waka Kotahi NZ Transport Agency, 2021[167]).

Radically changing urban spaces can cause resistance, however. Cities have experimented with “tactical urbanism” in order to allow citizens to experiment with space to see whether new structures deliver expected benefits (OECD, 2021[133]). Key success factors include using temporary rather than permanent structures, to allow citizens to become accustomed to the new systems and to see what works in each setting. Numerous cities have used temporary projects to reallocate road space, for example in Copenhagen in Nørrebrogade, the Plaza Programme in New York City, the Yarraville Pop-up Park in Melbourne and the Parklet Program in San Francisco (Rowe, 2013[168]). The city of Brussels benefited from the COVID-19 lockdown to implement tactical urbanism projects. City authorities took advantage of the confinement in early 2020 to accelerate the implementation of the recently developed 2020-30 regional transport plan Good Move (Bruxelles Mobilité, 2020[169]). In addition, high levels of consultation are required in order to ensure success (Box 2.13).

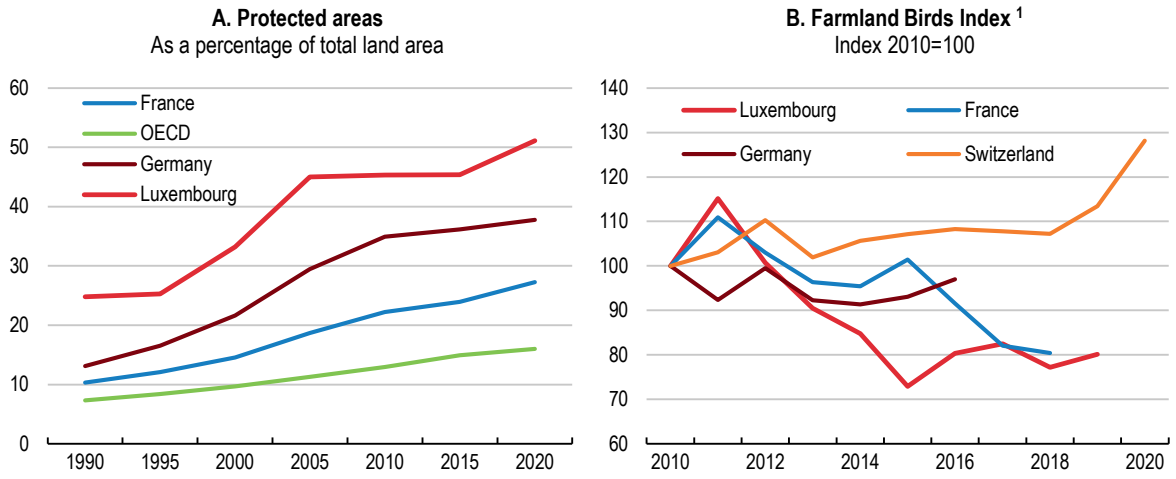
Agriculture needs to be more environmentally friendly

Agricultural policy needs to be significantly strengthened to better support climate goals. Much more progress is still needed to improve biodiversity in Luxembourg. Despite the fact that the surface of protected areas doubled between 1990 and 2020 (Figure 2.32, panel A), most of them are in poor condition. The Natural Environment Observatory, a body that evaluates the state of biodiversity in Luxembourg, assesses that two thirds of habitats in the country and three quarters of observed species are in a concerning or bad condition (Observatoire de l’environnement naturel, 2022[170]).

While urban expansion and construction are contributing factors to the loss of biodiversity in Luxembourg, most of the environmental damage is attributed to the agricultural sector. The high proportion of livestock

farming in agriculture as well as high fertilizer and pesticide use, have contributed to the deterioration of natural habitat. The use of fertilisers and pesticides should be carefully monitored as overuse can impose important costs to the environment and human health. EU-wide studies have shown that the use of pesticides has had negative impact on agricultural biodiversity (Sud, 2020[171]). The Farmland Birds Index, which is a common proxy for farmland diversity, shows that in the case of Luxembourg, there has also been an important deterioration over the past decade (Figure 2.32, panel B).

Figure 2.32. Although the surface of protected areas increased, biodiversity has deteriorated

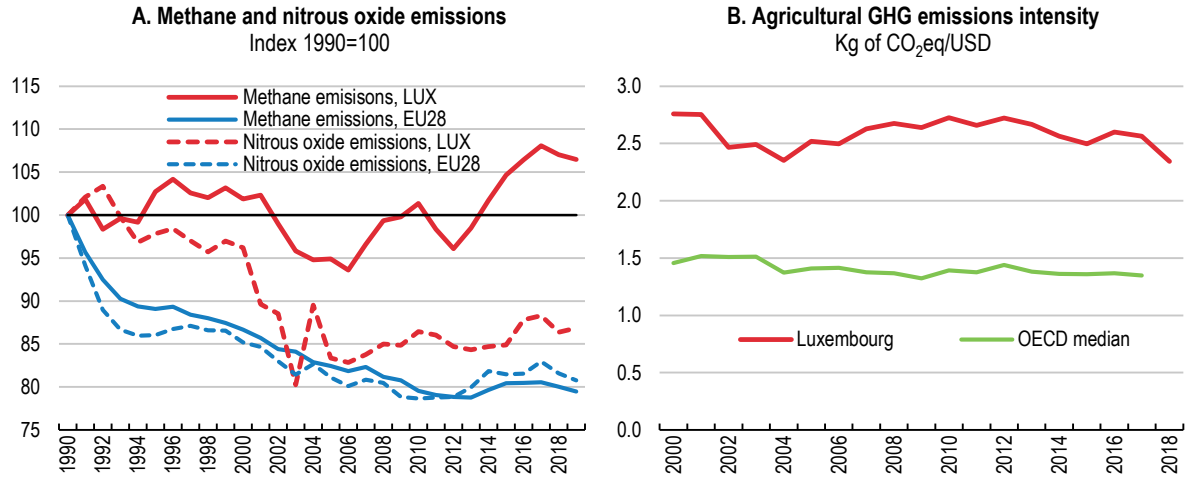


1. Aggregated index of population trend estimates of a selected group of breeding bird species that are dependent on agricultural land for nesting and breeding. Data for Luxembourg is not available before 2010.
Source: OECD Statistics on Protected Areas; and OECD Agri-Environmental Indicators.

StatLink https://stat.link/asynvt

In addition to its impact on biodiversity, agriculture contributes to climate change through greenhouse gas emissions. Although the share of agriculture in total GHG emissions in Luxembourg is close to 7%, it is a major source of nitrous oxide and methane, two powerful greenhouse gases. Methane is a gas emitted by ruminant livestock, through manure and gastroenteric release, while nitrous oxide emissions come primarily from nitrogen application in soils, including their inefficiencies (IPCC, 2020[172]). Although nitrous oxide emissions have decreased since 1990 by the same magnitude as the EU average, methane emissions increased in Luxembourg despite a downward trend in the European Union (Figure 2.33, panel A). The intensity of agricultural emissions has also been significantly higher than the OECD median (Figure 2.33, panel B).

Figure 2.33. Methane emissions have been on the rise and overall emissions intensity is high



Source : OECD Agri-Environmental Indicators.

StatLink https://stat.link/co0ygv

Despite the adverse impacts that agriculture may have on climate change and biodiversity, sustainable land management can contribute to reducing negative impacts of climate change on the ecosystem and society (IPCC, 2020[172]). It is therefore essential to improve agricultural practices, by reducing the livestock intensity and moving to more organic farming in order to preserve biodiversity.

The impact of these regulations could be enhanced by reforming agricultural subsidies so that they incentivize farmers to adopt more environmentally friendly farming practices. Such a reform was carried out in Switzerland for example, which included removing direct payments to livestock farmers and increasing them to farmers able to meet biodiversity goals (OECD, 2017[173]).

The new EU Common Agricultural Policy (CAP) which will be implemented from 2023 and puts a greater emphasis on “green agriculture” will introduce “eco-schemes” as part of pillar I, which are voluntary actions going beyond farmers’ obligations, for example practices related to better nutrient management, agro-ecology or animal welfare (European Commission, 2022[174]). Member States will be required to spend at least 25% of direct payments budgets on eco-schemes, with no upper limit, and will have the flexibility of adopting the schemes to suit the country’s needs. It will therefore provide an opportunity to steer agriculture into more sustainable practices. Luxembourg has already embraced the opportunity to develop eco-schemes in line with the new directive. Transitional payments could be made to the farmers in the short term to allow them to adapt to the changes and improve the social acceptability of such reforms.

Table 2.8. Policy recommendations to secure a dynamic and green economy by 2050

Findings	Recommendations (key ones in bold)
Ensuring good anticipation of climate risks	
The financial sector faces transition risks but has been a key player in developing green financial instruments. Globally, gaps between available data, labelling and investor expectations could pose communication, credibility and legal risks.	Continue to adapt financial sector regulation and supervision as climate-related risks and vulnerabilities are uncovered by stress-tests and related activities. Simplify communication on green transition by further developing clear labels that support investor choice and diverse approaches to the transition.
Public support for the green transition is high, but may fall as households are expected to make major behavioural changes. The 2050 Climate Strategy envisages more citizen involvement.	Civil society engagement should be converted into regular interactions with the citizens, relying on analyses published by the Climate Observatory.
Transition risks are low on aggregate, but there are pockets of vulnerable households and firms, who are not systematically identified, whilst policy impact assessments are ad-hoc. There is no framework for assessing the combined impact of policies, which raises risks for policy coordination.	The Climate Observatory should: • On a regular basis, disseminate research on the impact of the climate transition to inform policy makers and public debate. • Suggest policy tools, with particular attention to their impact on different types of households, including on their levels of income.
The households and firms negatively impacted by the transition will change over time, which needs to be carefully monitored, alongside the revenues and spending implications for the government. Although there is a commitment to ensure the climate transition is fiscally sustainable, the long-term impact on the fiscal framework has not been estimated. The green budget, like in most countries, remains focused only on green tagging, rather than an estimate of the environmental impact of government policies. Investment projects do not assess how climate risks could affect design options.	**Introduce scenario and sensitivity analysis to estimate the long-term impact of the green transition, including the impact on different households and firms.** Introduce a shadow carbon price in cost-benefit analysis of the largest projects. Advance the current green budget into a carbon budget to include short and long-term environmental impacts of the largest projects. Public infrastructure evaluations should better incorporate uncertain, but high-impact climate risks, including unlikely but catastrophic events.
Policy currently focuses on central climate risk but tail risks could prove more frequent than expected. There is no systematic strategy to encourage private insurance to manage flooding risks.	Develop all-hazards risk-management approaches involving key stakeholders. Encourage insurance policies that incentivise adaptive behaviour at household and municipal levels.
Improving the policy toolkit for accelerating progress	
A carbon tax was introduced in 2021 and will rise to EUR 30 in 2023. Low carbon prices stimulate cross border sales of fuel and weaken energy efficiency incentives. The speed and scope of changes required to meet targets, particularly households, could increase resistance to change.	**Set a rising carbon tax trajectory over the medium and long term, while redistributing revenues to minimise the burden on the most vulnerable.**
Renewable energy supply lags European counterparts. Public tenders are poorly attended. Administrative barriers such as restrictions on feed-in tariffs and cross-country purchasing power agreements, and unattractive pricing for small installations reduce private renewable energy supply further.	Increase tender competition in renewable energy by introducing market best practice, such as least-cost abatement tenders and contracts which provide fixed long-term prices. Review and remove regulatory barriers on private renewable energy supply installations.
Energy efficiency subsidies for firms have been helpful in supporting incremental energy consumption reductions, but are not suited to supporting high-cost investments that can allow firms to switch from natural gas and other fossil fuels (e.g. to hydrogen).	Industrial sector subsidies should increasingly be directed towards the development and adoption of new technologies that reduce greenhouse gas emissions. The design should also take into account support from ETS schemes.

Administration can affect overall take-up of subsidies. However, there is no systematic framework for the evaluation of subsidies or their design.	Assess the impact of the April 2022 change to administration processes for home renovation subsidies, to mitigate any potential negative impacts on households' incentives to undertake deep renovations.
Targeting the top emitting sectors of transport and residential buildings	
Higher carbon prices alone will not lower congestion, road freight or car use, which require active policies to overcome the bias towards private road use. Cross-border commuters often live and work far from public transport, while low fuel costs, generous car subsidies and road network expansions reduce car use costs. Cross-border freight traffic in Western Europe is set to expand steadily over the next 30 years. Cross-border rail services face severe coordination challenges across certain routes, limiting their expansion.	Elevate cross-border rail cooperation to a national priority and prioritise resolving coordination problems. Reinforce urban zoning to ensure businesses are set up close to public transport infrastructure nodes. Upgrade highway infrastructure to include electric charging infrastructure as well as an eventual expansion of hydrogen refuelling to support behavioural change in cross-border freight and commuters.
Public transport use is a low proportion of total trips and car usage costs are very low, due to tax incentives for travel and company car fleets. The expanded public transport network, a key strategy in the government's plans, currently does not include a comprehensive shared mobility strategy.	**Introduce and gradually increase road use charges in conjunction with tighter parking policies.** Remove generous tax benefits for travel allowances and company cars. Enhance shared transport infrastructure services to encourage greater use of public transport.
Urban development and transport infrastructure, alongside housing prices, have reinforced one another to lock in high car usage and urban sprawl in Luxembourg and the greater region. Housing supply efforts risk entrenching car reliance. Municipalities earmarked by the spatial master plan to become larger and denser have not raised housing supply as fast as outlying areas, where fiscal incentives may have had a greater impact on municipal decision making. There is a strong tendency to move out of urban spaces for quality of life that may increase following COVID-19.	**Use tax credits and municipal funding incentives to encourage higher urban density, with green homes built in accordance with the Master Programme for Spatial Planning.** Overcome local residents' resistance to densification by implementing the planned transferable property rights policy and neighbourhood-based compensation schemes that are consistent with the Spatial Development Master Plan. Encourage inner-city living, including concepts such as the 15-minute city design, with temporary urban redesign projects to help citizens consider redesigned street usage away from car use.
Housing renovation rates are low, despite generous subsidies. Low energy prices reduce the attractiveness of the renovation process. Regulatory processes have reduced uptake, and have recently been eased.	Increase the potential profitability of energy efficiency renovations by combining them with additional subsidies for renovation projects that densify existing homes, which will increase housing supply.
Current regulations have failed to keep up with the negative environmental impacts of increased livestock farming and intensive fertiliser use.	**Strengthen regulations on fertiliser and pesticide use.** **Make national agricultural subsidies contingent on the adoption of sustainable farming practices that protect the environment.**

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