Reform Options for Lithuanian Climate Neutrality by 2050

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Foreword

The Paris Agreement sets ambitious global targets, aiming to limit global average temperature rise to 1.5°C. Achieving this requires considerable climate policy ambition, with countries needing to reach net-zero emissions by mid-century, as recognised by the Intergovernmental Panel on Climate Change (IPCC). At COP26 in Glasgow in 2021, countries reaffirmed their commitment to reaching these temperature targets, submitting updated, more ambitious, Nationally Determined Contributions and thus making progress towards reaching announced net-zero targets.

In 2022, the European Union (EU) set more ambitious emissions reduction targets as part of the European Green Deal, aiming to reduce emissions by 55% by 2030 (up from 40%) and reach net-zero emissions by 2050. Reaching these targets will require member-states to review their current climate policies in order to accelerate decarbonisation pathways.

The European Commission has proposed a Fit for 55 policy package that aims to ratchet-up member states' domestic climate policy ambition in order to meet the EU's 2030 emissions reduction target. The package, put forward in 2021, includes proposals to increase emissions reductions under, and widen the scope of, the Emissions Trading Scheme (EU ETS) and to increase member-state commitments in non-ETS sectors under the Effort Sharing Regulation (ESR).

Lithuania has increased its domestic climate policy ambitions. The National Climate Change Management Agenda (NCCMA) adopted in June 2021 sets ambitious emission reduction targets with a view to reaching net-zero emissions by 2050. Lithuania aims to reduce emissions by 30% by 2030 compared with 2005 levels, targeting a 50% reduction the EU ETS sectors, and a further 25% reduction in non-ETS sectors. This is a significant increase from the previous target of a 9% emissions reduction in non-ETS sectors, and even surpasses the 21% reduction proposed by the European Commission's under the Fit for 55 package.

In order to meet these targets, Lithuania is planning to update its National Energy and Climate Plan (NECP) by 2023, in line with EU regulations. To support these efforts, the Directorate General for Structural Reform Support (DG Reform) of the European Commission and the OECD have agreed to provide technical support to Lithuania in the adjustment of its NECP and the development of pathways towards decarbonisation by 2050.

The technical support initiative aims to:

- Provide recommendations to Lithuania on updating its NECP with a view to achieving ambitious and efficient emissions reductions by 2030, in line with national targets, European Green Deal objectives and the Paris Agreement.
- Provide longer-term policy options with recommendations for possible emissions reduction targets for 2040 with a view to efficiently achieving carbon neutrality by 2050.

This report presents the results of this technical support initiative. Pooling the expertise of four OECD directorates, the report takes stock of current policy plans in Lithuania, models potential climate policy pathways, and provides concrete policy advice across tax, finance and investment and distributional concerns.

Acknowledgements

This project was carried out in close collaboration with the Lithuanian Ministry of Environment. For their constant and active support, the project team would like to thank Vilija Augutaviciene, Marilė Kosaitė, Judita Liukaitytė-Kukienė, Giedrius Uselis and Jurga Valainytė. The project was further undertaken in close partnership with the Directorate-General for Structural Reform Support (DG REFORM), whose mission is to promote the European Union's economic, social and territorial cohesion by supporting Member States' efforts to implement reforms. Lithuania has requested support from the European Commission under Regulation (EU) 2021/240 establishing a Technical Support Instrument ("TSI Regulation"). This fruitful collaboration was made possible through the clear and impactful coordination by Niccolo Costantini.

The project was led by Kilian Raiser under the responsibility of Kumi Kitamori at the OECD's Environment Directorate (ENV) and in collaboration with the OECD's Economics Departments (ECO), Centre for Tax Policy and Administration (CTPA) and Employment, Labour and Social Affairs Directorate (ELS). Kilian Raiser (ENV) conducted the stocktake of climate policies in Lithuania informing Chapter 2. Kilian Raiser (ENV) and Assia Elgouacem (ECO) coordinated the modelling informing Chapters 3 and 7 and co-authored these chapters. Anasuya Raj (CTPA) conducted the assessment of carbon pricing in Lithuania informing Chapter 4. Assia Elgouacem (ECO) conducted the assessment of financial needs informing Chapter 5. Herwig Immervoll (ELS) coordinated the analysis of distributional outcomes of carbon pricing informing Chapter 6. The modelling underpinning Chapters 3 and 7 was carried out by Maksym Chepeliev and Dominique van der Mensbrugghe at the Center for Global Trade Analysis at Purdue University. The modelling underpinning Chapter 6 was carried out by Cathal O'Donoghue at University of Galway, and Jules Linden and Denisa Sologon at Luxembourg Institute of Socio-Economic Research.

The authors would like to thank OECD colleagues Ruben Bibas, Hansjörg Bloechliger, Beth Del Bourgo, Stéphane Carcillo, Jean Foure, Elisa Lanzi, Mark Pearson, Mauro Pisu, Andrew Prag, Dirk Röttgers, Douglas Sutherland, Konstantinos Theodoropoulos, Kumi Kitamori, Kurt Van Dender and Dimitra Xynou for their feedback, input and advice at different stages of the production of the report. Special thanks to Amelia Smith for editing, proofreading and report formatting.

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Reader's guide

This report provides recommendations for climate policy reform options for Lithuania. It offers concrete policy recommendations by 2030 to include in the country's updated National Energy and Climate Plan (NECP), and sets out potential policy pathways for reaching net-zero emissions by 2050. It assesses the current policy landscape and identifies key areas requiring increased policy ambition. The report provides an overview of policy options and assesses them using various cost-benefit analyses. These include:

- a macro-economic modelling exercise assessing the socio-economic impacts of broad policy mixes, both to 2030 and 2050, including an assessment of the adequacy of existing and planned policies;
- an analysis of the current carbon pricing landscape in Lithuania and options for reform;
- a review of the financial requirements of meeting the updated climate targets and recommendations on how to fulfil them;
- a targeted assessment of socio-economic impacts of the transition to net-zero and distributional policy options to mitigate them;
- an assessment of technology and innovation needs to meet long-term climate policy targets by 2050.

As a result, the report provides targeted policy recommendations, including insights on the financial impacts and socio-economic effects of identified policy mixes, and on options for mitigating possible adverse effects.

The report focuses primarily on four sectors: energy, transport, industry, and agriculture and forestry. It is structured as follows:

- Chapter 1 describes the economic context in Lithuania and provides an up-to-date account of greenhouse gas emissions trends, identifying key areas for climate policy action. It draws on recently published assessments such as the OECD's Economic Surveys: Lithuania 2022 (OECD, 2022[1]), 2021 Environmental Performance Review of Lithuania (OECD, 2021[2]), and the IEA's 2021 Energy Policy Review (IEA, 2021[3]).
- Chapter 2 takes stock of the current climate policy landscape, assessing policies implemented and planned under Lithuania's current NECP and their adequacy in achieving the targets set out in the NCCMA. This includes both an assessment of the general economy-wide policy landscape, and of sectoral measures for transport, industry, energy and agriculture and forestry. The chapter also provides good-practice examples of climate policies from other OECD countries.
- Chapter 3 explores potential policy mix scenarios, detailing the results of a modelling exercise that assesses the socio-economic impacts of various policy mixes for achieving the 2030 and 2050 GHG emissions reduction targets.
- Chapter 4 assesses the current carbon pricing landscape and provides recommendations for future carbon pricing reforms.

- Chapter 5 focusses on the financial needs of decarbonisation pathways, providing insights into how these needs can be met through public and private financial arrangements.
- Chapter 6 assesses the socio-economic impact of chosen policy mixes on households and explores means to balance them.
- Chapter 7 details the results of the modelling of policy pathways beyond 2030 to reach net-zero GHG emissions by 2050 and the role of innovation and technology diffusion in enabling net-zero policy pathways.
- The concluding chapter brings all these assessments together, offering main takeaways from the analyses and recommendations for policy reforms to achieve Lithuania's climate policy targets in an efficient, cost-effective, and socially equitable manner.

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Executive summary

Meeting the increased ambition of the EU's Green Deal, and Lithuania's own National Climate Change Management Agenda, both of which target net-zero emissions by 2050, will require significant policy reform. The following report aims to contribute to the National Energy and Climate Plan's (NECP) update by assessing reform options for enabling decarbonisation in Lithuania. It takes advantage of the OECD's multidisciplinary expertise on tax policy, financial markets, social affairs, science, technology and innovation, and economic modelling to highlight a number of key policy insights. Specific analyses include: 1) a stocktake of existing and planned climate policies, including recommendations for reform options based on good practices from around the OECD; 2) a modelling exercise detailing the effect of climate policy pathways on emissions and macro-economic indicators based on existing proposals to 2030 and a high-ambition carbon price trajectory to 2050; 3) an analysis of the effective carbon rates profile of key Lithuanian sectors; 4) an analysis of key financial needs for infrastructure development in the transition to net-zero emissions in Lithuania; 5) an analysis of the distributional impacts of carbon pricing in Lithuania; and 6) an assessment of innovation and technology diffusion needs and policy responses in Lithuania in meeting net-zero by 2050.

The stocktake of current and planned climate policies in Lithuania reveals that Lithuania already has a broad and comprehensive policy mix for all key economic sectors, including extensive economic incentives for decarbonising key economic activities, stringent regulations and complimentary measures such as in capacity building and education, as detailed in its current NECP. This is supplemented by a key policy proposal to increase excise duties and introduce a carbon price in 2025.

The modelling exercise reveals that current policies as detailed in the NDCs will not suffice to reach 2030 climate policy ambitions, with either the implementation of the proposed excise duty reforms and associated carbon price, or the introduction of an ETS 2 for the buildings and road transport sectors at the EU-wide level key to meeting 2030 emissions reduction targets. This highlights the importance of enhancing price signals in Lithuania. Beyond 2030 the modelling shows that a high carbon price trajectory reaching 400 EUR/t CO2 would further decrease emissions to a significant extent. However, such a high-carbon price is not enough to meet net-zero emissions by 2050. Particularly, the transport and industry sectors exhibit hard-to-abate emissions even at high carbon prices. This highlights the importance of innovation and technology diffusion, also for the agriculture sector where non-CO2 GHG emissions remain high in the absence of pricing.

The innovation assessment highlights that Lithuania currently does not sufficiently target key technologies, relying instead on horizontal tax credits. More targeted support for innovation, but particularly also for technology adoption, would ensure hard-to-abate emissions in transport and industry are addressed. Furthermore, enhancing carbon sinks and reduction agriculture emissions is also key, particularly as historical trends show carbon sinks are currently decreasing in Lithuania.

A stocktake of the sectoral carbon pricing landscape in Lithuania shows that carbon price levels and instruments vary with sectors. While within Lithuania, they are highest in the road transport sector, they remain much below carbon prices observed for this sector in most other European countries. Moreover, a "diesel differential" remains, whereby diesel faces much a lower fuel excise tax rate than gasoline, which then translates into a lower carbon price signal and inefficiently encourages the use of diesel. The industry and electricity sectors face relatively high carbon prices, but the price signal in these sectors principally stems from the EU Emissions Trading Scheme (EU ETS), and the large share of free allocations observed in Lithuania combined with permit price volatility may result in uncertainty for investors and firms. The buildings (residential and commercial heating) sector faces the lowest rates and coverage, due to many fuel tax exemptions on households and businesses.

The Draft Law on Excise Duties proposed in Lithuania would increase coverage and rates of fuel excise taxes as well as introduce a carbon tax component with a pre-determined path to 2030. Overall, the full implementation of this law would bring coverage of CO2 emissions by a carbon price to close to 100% and considerably increase rates in certain sectors, particularly road transport and buildings. However, since the carbon tax component would not apply to installations subject to the EU ETS, it would not address the potential issues stemming from exclusive ETS coverage, in particular price volatility. As an alternative, a carbon levy with a pre-determined path complementing EU ETS prices, would provide better clarity to firms.

Considering financial needs for infrastructure development, the role of the public sector as both the provider of funds and enabler for low-carbon investments is central to meeting the country's climate targets. The public sector has thus far relied heavily on distributing grants or subsidies to fund infrastructure investments, potentially undermining incentives for private sector involvement and even crowding it out. There is a substantial financing gap for low-carbon infrastructure that would need to be filled by private sector investment. For the power sector alone, investment needs for expanding renewable generation capacity reach EUR 6.5 billion. EU funds and co-financing from national resources will not be sufficient to meet investment demands for decarbonisation.

Enhancing the absorptive capacity and spending efficiency of EU funds should be prioritised. This can be achieved through the building capacity to clarify and help implement new regulation regarding sustainable activities. Spending efficiency of EU funds can be further improved through the use of repayable financial instruments as reflows can be channelled to other projects. Building robust project pipelines can contribute to a more effective absorption and spending of funds, in addition to helping to crowd-in private sector funds. Furthermore, subnational governments can play an important role in implementing infrastructure projects but currently face a number of challenges that affect their capacity to deliver infrastructure investment. Reaching critical size in capital markets to attract investors and create a larger pool of liquidity is essential for scaling up climate finance for the transition in a small country. Achieving an appropriate allocation of risks between public and private parties, and developing suitable financing channels, vehicles, and risk mitigation instruments will also help crowd-in private investment.

Considering the distributional impacts of carbon pricing, the analysis finds that, at levels currently being discussed in Lithuania, the impact of carbon prices on household living costs is significant, but much smaller than the effects of high levels of inflation seen across the OECD over recent months. The overall effects of carbon pricing are broadly similar across income groups, considering both direct and indirect effects. Overall losses for households sum to about 3.7% of income for most income groups. For the richest 10%, they are found to be lower, however, at 3.2%.

The revenues from carbon taxes are substantial, in the order of 1.3 % of GDP. Channelling them back to households therefore provides considerable room for cushioning losses and shaping the distributional profile as part of a broader policy package. Given the flat distributional impact of carbon pricing on households in Lithuania, the distributional effect of revenue recycling can be designed to target distributional outcomes as desired. For example, paying a lump-sum transfer to everybody, akin to a "basic income", results in a large majority (60%) who would be better off than without the carbon tax.

1

Economic context and greenhouse gas emissions trends in Lithuania

This chapter provides a brief overview of the Lithuanian economy and the country's greenhouse gas emissions trends. It shows that Lithuania's GDP has grown steadily and considerably since the 1990's and has largely decoupled from GHG emissions, which decreased significantly from 1990-2000 but have since plateaued. The chapter provides specific detail on the transport, energy, industry, and agriculture and forestry sectors, discussing key challenges for decarbonisation. These include rising transport emissions and inefficient buildings as well as low fuel prices and increased use of synthetic fertilisers.

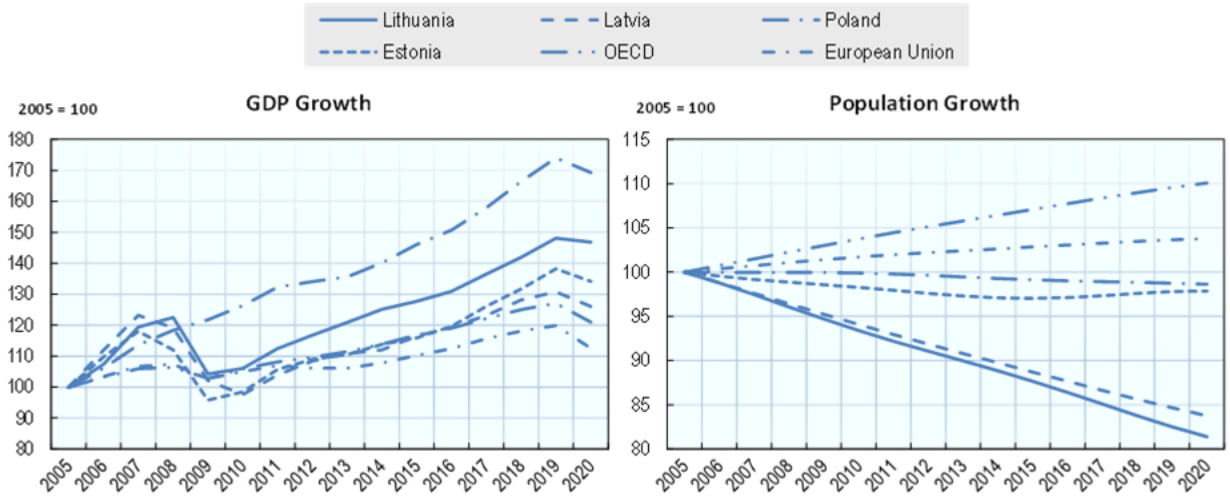
This chapter provides a brief overview of the Lithuanian economy and the country's greenhouse gas emissions trends. The information depicted is sourced primarily from: *OECD Environmental Performance Review: Lithuania 2021* (OECD, 2021[1]), *OECD Economic Surveys: Lithuania 2020 and 2022* (OECD, 2020[2]; OECD, 2022[3]), the IEA's *Lithuania 2021 Energy Policy Review* (IEA, 2021[4]), Lithuania's 2021 Greenhouse Gas Inventory Report (Government of Lithuania, 2022[5]) and the EU's recent assessment of Lithuania's environmental policy implementation and National Energy and Climate Plan (European Commission, 2020[6]; European Commission, 2019[7]). More detail on Lithuania's broad economic structure and performance, and its greenhouse gas emissions trends and decarbonisation challenges can be found in these reports.

Country profile

Lithuania's GDP has grown considerably since its transition to a market economy in the 1990s, more than doubling over the past 20 years (Figure 1.1) (OECD, 2021[8]). GDP per capita is currently USD 38 743 (current PPPs), 80% of the OECD average, up from 38% in 2000 (OECD, 2021[1]). Lithuania has a diverse economy, with no particular goods or services dominating imports or exports. Industry (including energy) makes up around 20% of total value added and trade, repairs, accommodation, food services, and transport 30%. A further 16% of total value added comes from public administration, defence, education, health, and social work. Agriculture makes up 3.7% of total value added. The economy has shown considerable resilience during the COVID-19 crisis, with GDP contracting by only 0.13% in 2020, considerably less than the OECD average, and growing 5.15% in 2021 (OECD, 2021[9]). GDP growth is projected to continue at over 3% in the coming years (OECD, 2021[9]). Lithuania joined the EU in 2004, the Euro in 2015 and the OECD in 2018.

Lithuania has fewer than 3 million residents, making it one of the least populous OECD countries (OECD, 2021[10]). Its population is decreasing (Figure 1.1) and is projected to decline by 200 000 by 2030 (OECD, 2021[10]). Historically, migration has remained outward, with young people in particular leaving Lithuania. This trend has recently reversed, with net positive migration flows since 2019 (OECD, 2021[8]).

Figure 1.1. GDP has grown significantly despite rapid population decline

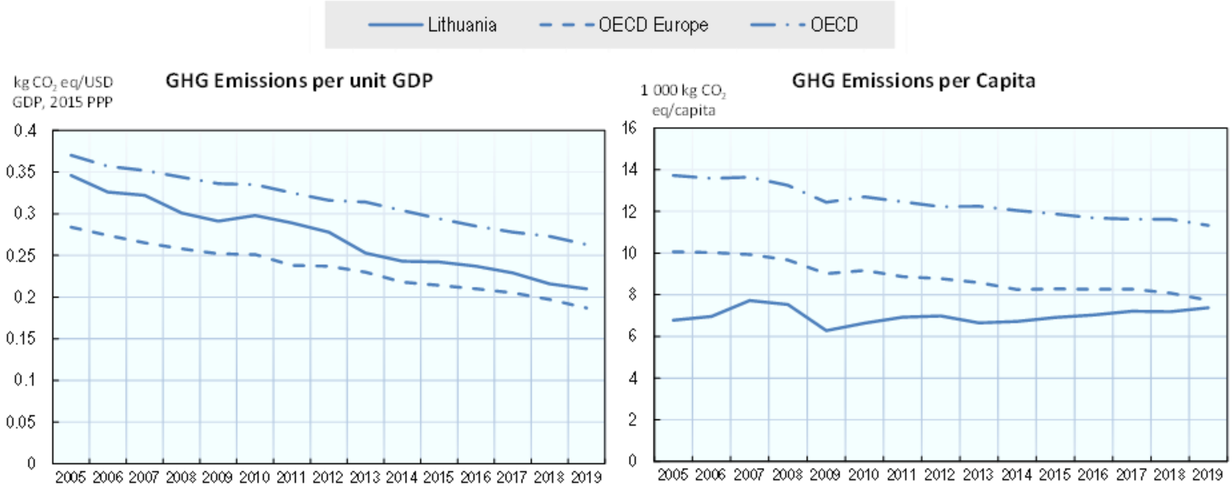


Source: (OECD, 2021[8]).

Greenhouse gas emissions trends

Greenhouse gas (GHG) emissions in Lithuania declined steeply between 1990 and 2000, however they have since plateaued at around 20 $MtCO_2eq$ (excluding removals from LULUCF) (Government of Lithuania, 2022[5]). This accounted for around 0.55% of total EU emissions in 2019 (Jensen, 2021[11]), and around 0.04% of global emissions (Global Carbon Project, 2021[12]). Although emissions per capita are increasing, they remain below the OECD average. GHG emissions have largely decoupled from GDP growth, with the emissions intensity per unit of GDP decreasingly steadily since 2005 (Figure 1.2).

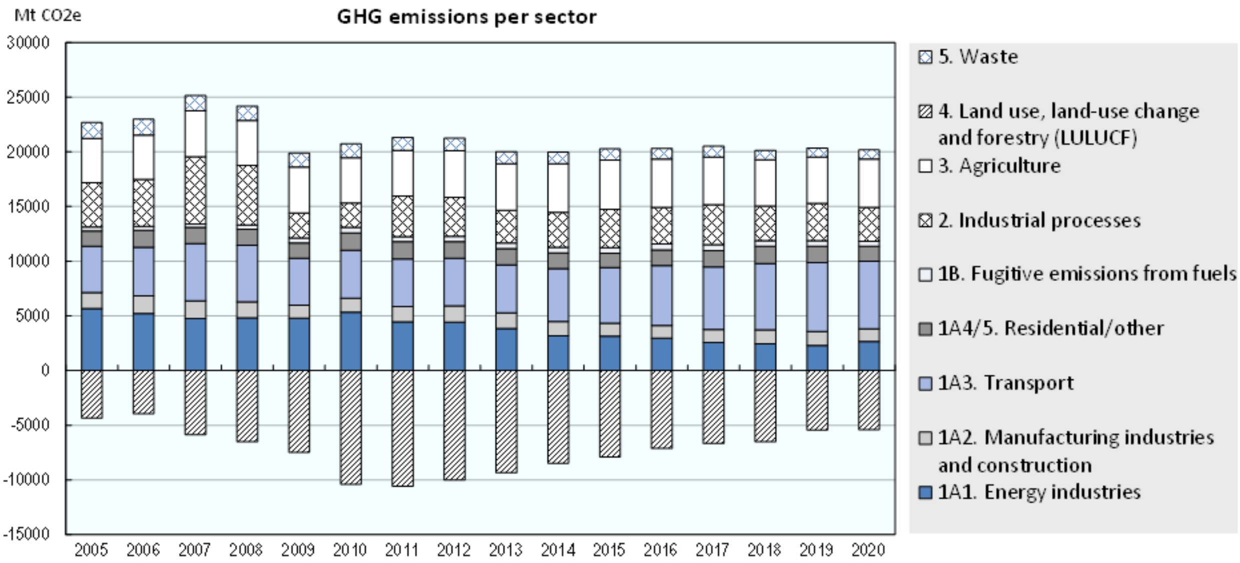
Figure 1.2. GHG emissions have decoupled from GDP growth, but per capita emissions are rising



Source: (OECD, 2021[8]).

Transport, agriculture, and industry make up two thirds of Lithuanian GHG emissions (Figure 1.3).The transport sector is the largest and fastest growing source of emissions, accounting for over 30% of emissions in 2019, up from less than 20% in 2005 (OECD, 2021[8]). This is in line with the OECD average, although here growth in emissions has been slower, increasing 3% from 2005-2019 (OECD, 2022[13]). Annual emissions from agriculture have also increased in Lithuania and were 3% higher in 2019 compared with 2005 levels (OECD, 2022[13]). Forests form an important carbon sink in Lithuania, with GHG removals from LULUCF equivalent to 19% of total reported emissions in 2018 (IEA, 2021[4]). Reported removals from LULUCF under the UNFCCC have, however, been declining since 2012 (IEA, 2021[4]).

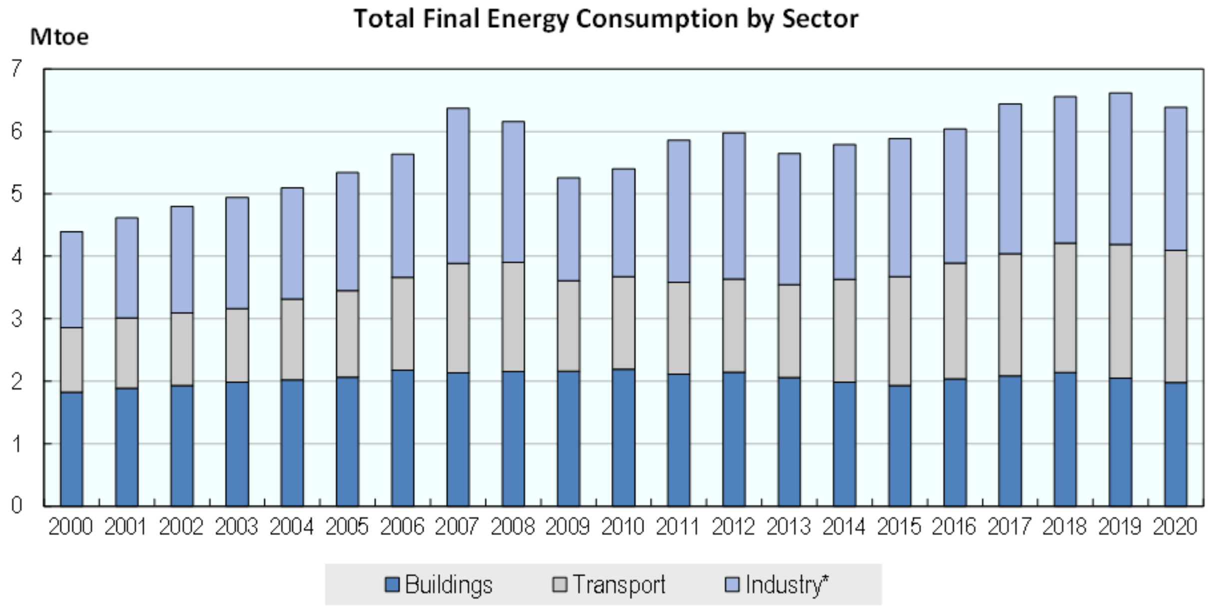
Figure 1.3. Total GHG emissions are stable but emissions from transport are rising



Source: (OECD, 2021[8]).

Total final energy consumption has been rising in Lithuania since 2015, driven primarily by the transport sector, whose consumption rose from 1.4 Mtoe in 2005 to 2.1 Mtoe in 2019, accounting for 32.4% of total consumption (Figure 1.4) (OECD, 2021[8]). In its National Energy and Climate Plan (NECP) Lithuania targeted 4.3 Mtoe of energy consumption by 2020 (Government of Lithuania, 2019[14]). This target has been missed, with total final energy consumption standing at 6.4 Mtoe in 2020 (IEA, 2022[15]).

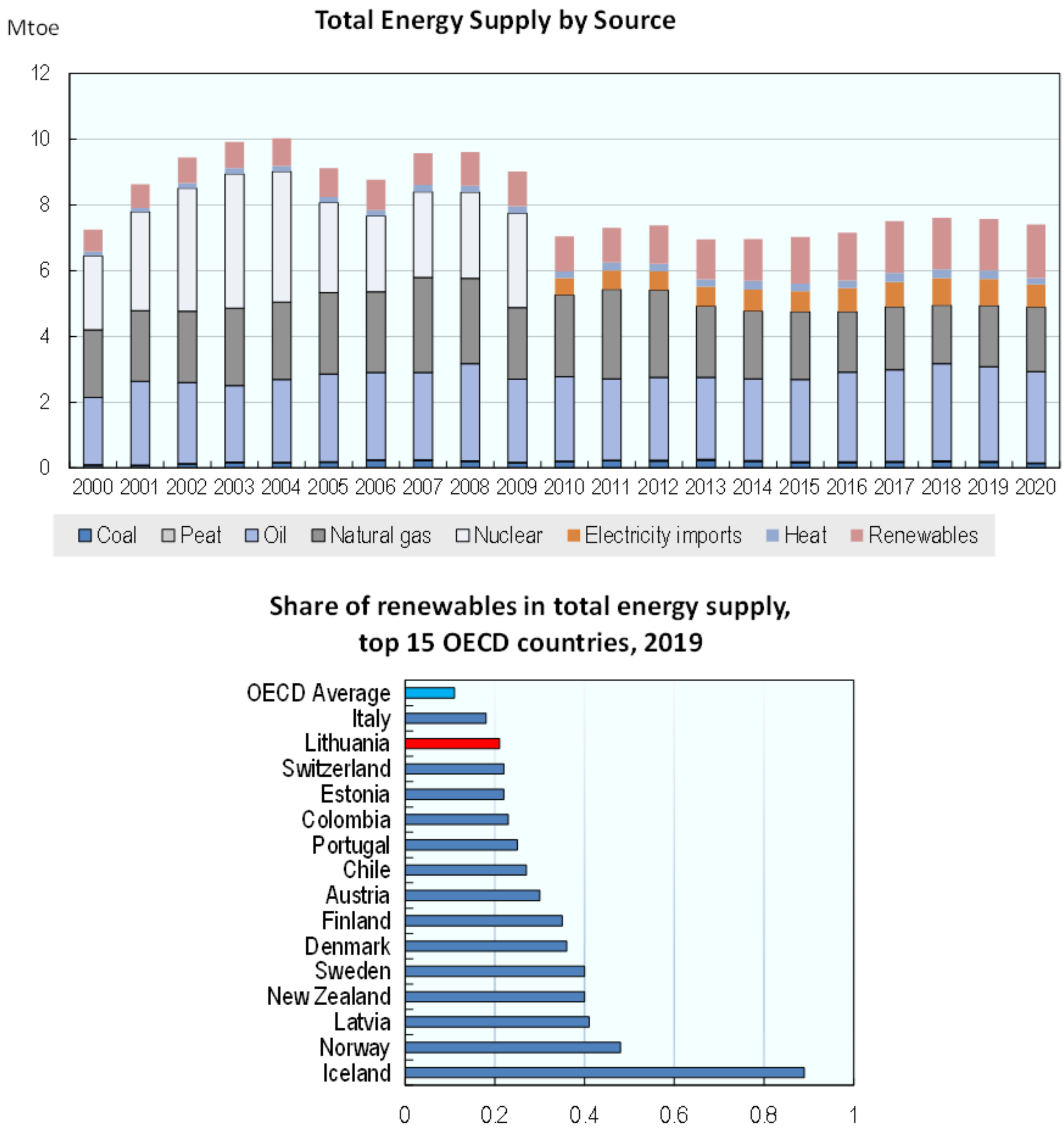
Figure 1.4. Increasing energy consumption is being driven primarily by the transport sector



Source: (IEA, 2021[16]).

Oil and natural gas filled the energy gap resulting from the closure of Lithuania's Ignalina nuclear power station in 2009 (Figure 1.5). The share of natural gas has since declined, with biomass often providing a viable substitute, particularly in heat supply (see subsection on energy below). Oil demand has increased however, reaching 40% of total energy supply in 2019, driven primarily by increasing consumption in transport.

Figure 1.5. The share of renewables is in the top 15 OECD countries and increasing, but oil supply is also increasing

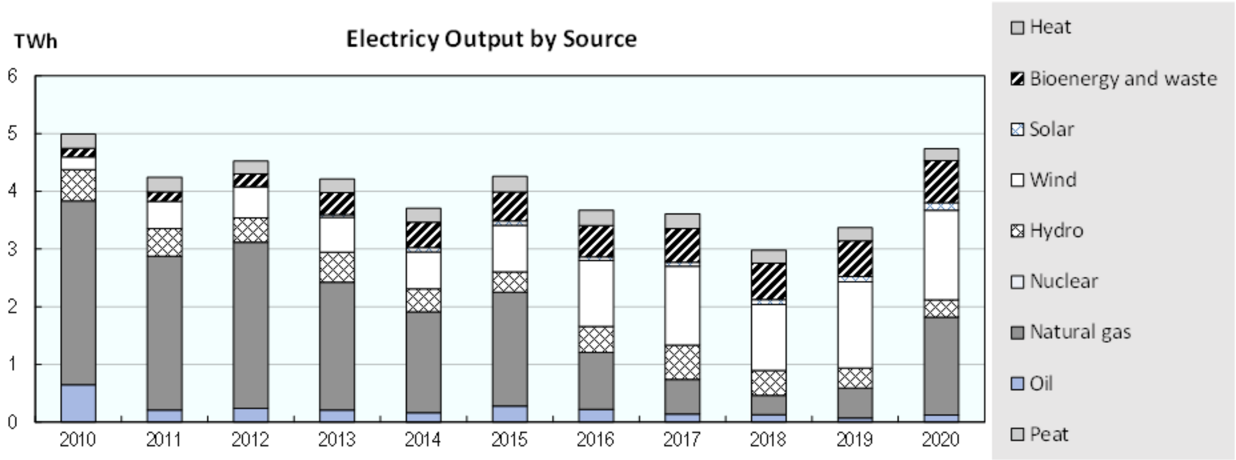


Source: (OECD, 2021[8]) (IEA, 2021[16]).

Renewable energy sources (RES) contributed 21% of total primary energy supply in 2019, up from under 10% in 2005, driven by extensive use of biomass, particularly in district heating (OECD, 2021[8]). Renewables make up 74% of domestic electricity generation, the bulk of this coming from wind energy.

Electricity production increased considerably in 2020, driven by an increase in the use of natural gas (Figure 1.6) However, domestic production makes up only a fraction of total supply, with Lithuania importing three-fourths of its electricity, primarily from Latvia, Sweden, and Russia (IEA, 2021[4]). Lithuania has considerable offshore wind capacity potential, estimated at around 3TWh per year, comparable with current levels of domestic electricity production.

Figure 1.6. Renewables make up the bulk of domestic electricity generation, although natural gas remains prevalent



Source: (IEA, 2021[16]).

Key challenges for decarbonisation

In accordance with the EU, Lithuania has targeted net-zero emissions by 2050. Achieving this will require considerable acceleration of GHG emissions reductions, in line with the proposed the EU Fit-for-55 package. Considering the emissions trends detailed, several key challenges to achieving these targets emerge. Lithuania's considerable progress in decoupling GDP growth from GHG emissions needs to be built upon, and plateauing emissions reductions reaccelerated. This will rely in particular on reversing emissions trends in the transport sector. Expanding domestic renewable energy production will reduce reliance on electricity imports. However, decarbonising economic sectors through electrification will also significantly increase electricity demand. Energy efficiency is therefore key and will require innovation support, particularly in hard-to-abate sectors.

These challenges will need to be met with ambitious climate policies. The planned update of Lithuania's National Energy and Climate Plan (NECP) in 2023, which this report aims to support, thus provides an important opportunity to ensure that increased climate policy ambition is met with commensurate action. In order to ensure proposed policies are as effective as possible, they will need to consider specific sectoral challenges. The remainder of this chapter thus discusses emission trends in the transport, energy, industry, and agriculture and forestry sectors in more detail.

The war in Ukraine has proved to be a critical juncture for Lithuanian energy policy. Lithuania was the first EU country to entirely halt all imports of Russian energy, including coal, oil, gas, and electricity (Ministry of Energy of the Republic of Lithuania, 2022[17]). This was made possible by an existing multi-year energy policy plan to reduce reliance on imports of Russian fossil fuels, including the construction of an LNG terminal on the Baltic Sea coast and more recently of a natural gas pipeline connection with Poland (Ministry of Energy of the Republic of Lithuania, 2022[18]). In April 2022, Lithuania further adopted the renewable energy "Breakthrough Package" to accelerate solar and wind energy projects, with in particular offshore wind development to play a key role in helping Lithuania become self-sufficient in electricity supply in the coming decade.[1]

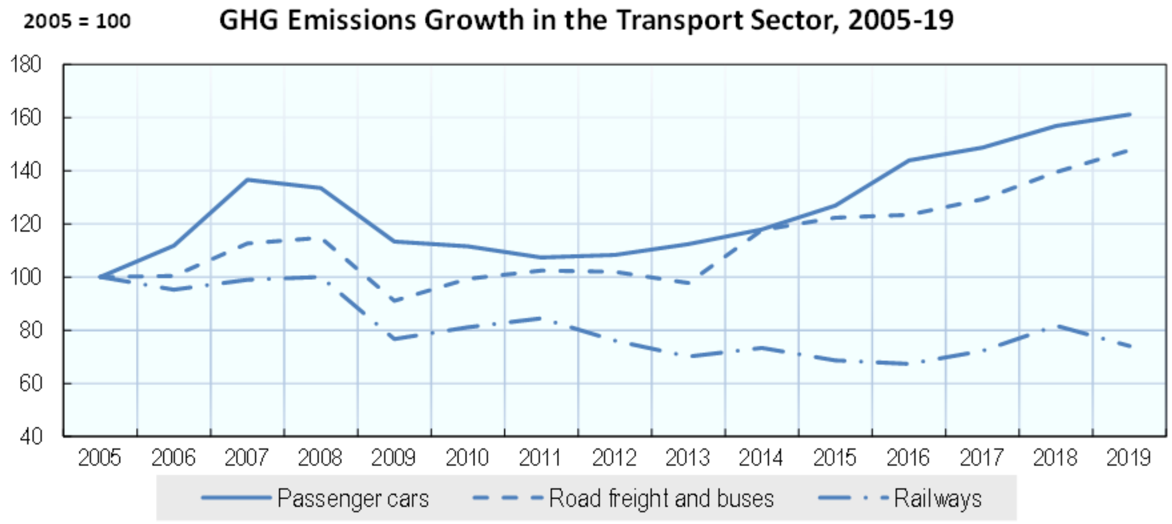
Transport

The transport sector accounts for 30% of total GHG emissions in Lithuania (OECD, 2021[8]), and for more than 50% of energy-related emissions (IEA, 2021[4]). Emissions in the sector are growing, doubling from 3.0 Mt CO_2 in 2000 to 6.3 Mt CO_2 in 2019 (Figure 1.7) (IEA, 2021[4]). Growth in emissions is driven by an old and inefficient vehicle fleet, increasing road freight transport, low fuel taxes, and growing urban sprawl.

Lithuania's vehicle fleet is amongst the oldest in the European Union. Second-hand vehicles account for 77% of the current fleet, with over 60% of cars between 10 and 20 years old and almost 20% more than 20 years old (OECD, 2021[8]). What is more, 68% of the fleet is powered by diesel, versus only 23% by petrol. On average, the fleet emits between 160-170 g/km of CO_2 (OECD, 2021[8]).

GHG emissions from road freight also increased 50% between 2013-2019 (OECD, 2021[8]). This is despite the export value of goods transported to Russia decreasing significantly between 2014-2016, with Lithuanian companies instead reorienting export flows to Western-Europe.

Figure 1.7. Emissions from private vehicles and road freight are steadily increasing

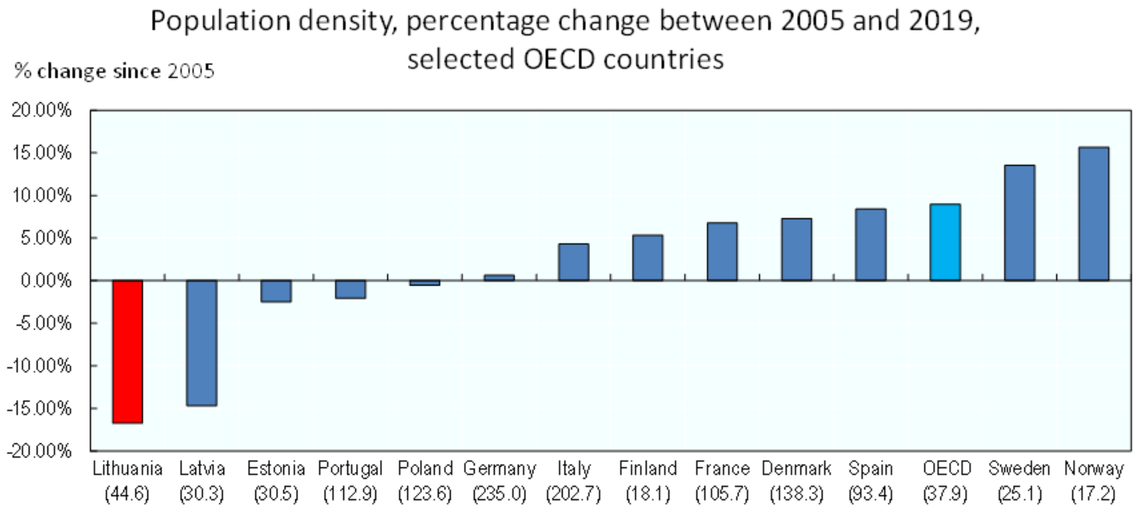


Source: (OECD, 2021[8]).

Fuel taxes in Lithuania are amongst the lowest in the EU (for more detail see Chapter 4). This encourages the purchase of older and less-efficient vehicles, with the high diesel differential (the difference between taxes on diesel and petrol) in particular incentivising the purchase of diesel cars.

A further factor driving emissions in the transport sector is increasing urban sprawl. Population density in Lithuania is decreasing significantly, countering the OECD average trend (Figure 1.8). This encourages the use of private vehicles, further driving emissions increases. For example, the capital Vilnius has one of the lowest population densities of large Lithuanian cities, with only 1400 inhabitants/km2 (OECD, 2021[8]).

Figure 1.8. Contrary to the OECD average, urban population density in Lithuania is decreasing rapidly



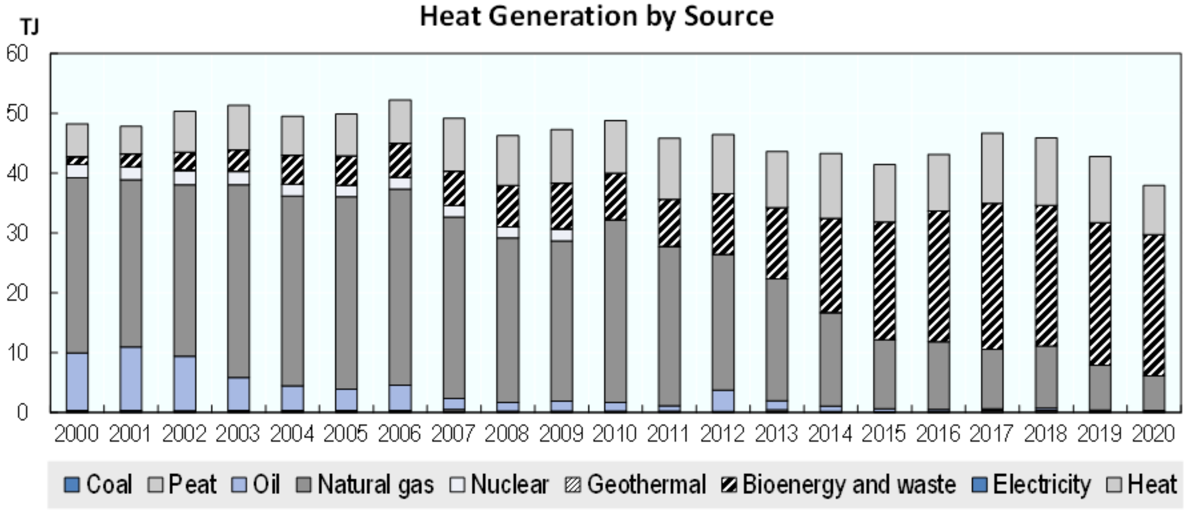
Source: (OECD, 2021[8]).

Energy

Lithuania has approximately 90 installations that are regulated under the EU ETS. These installations span both the energy and industrial sectors, and account for around 30% of total GHG emissions, of which around 17% are from public electricity and heat generation (IEA, 2021[4]). Beyond the EU ETS, the energy sector includes; public sector buildings, smaller district heat suppliers (less than 20 MW) and household accounts. Bioenergy has proven critical to progress on decarbonising these subsectors.

Despite 70% of domestically generated electricity coming from renewable sources, a high reliance on electricity imports results in renewable energy making up only 18% of total electricity supply. Nonetheless, renewable energy has grown significantly in the past decade. Renewable district heat, produced through biomass and waste, has increased more than threefold, from 144 kilotonnes of oil equivalent (ktoe) in 2009 to 456 ktoe 2019 (IEA, 2021[4]), largely displacing natural gas (Figure 1.9). Renewable electricity production increased even further, from 34 ktoe in 2009 to 664 ktoe in 2019, driven by wind power and bioenergy use for electricity production. With a potential 3TWh a year of offshore wind capacity, renewable energy is projected to grow further (OECD, 2021[8]). To ensure the necessary stability and flexibility needed for increased participation of renewable energy, cogeneration capacity will further increase in importance, particularly powered by biomass and waste (IEA, 2021[4]).

Figure 1.9. Bioenergy and waste are displacing natural gas as a source of heat



Note: The source category "Heat" concerns primarily combined heat and power installations and is made-up primarily of bioenergy and waste.
Source: (IEA, 2021[16]).

Lithuania's electricity grid currently remains linked to the Russian, Baltic and Belarusian grids. Plans are in place for shifting the grid connection to the European grid in 2025, and already now, electricity imports from Belarus have ceased due to concerns over the safety of a Belarusian nuclear power plant near Vilnius.

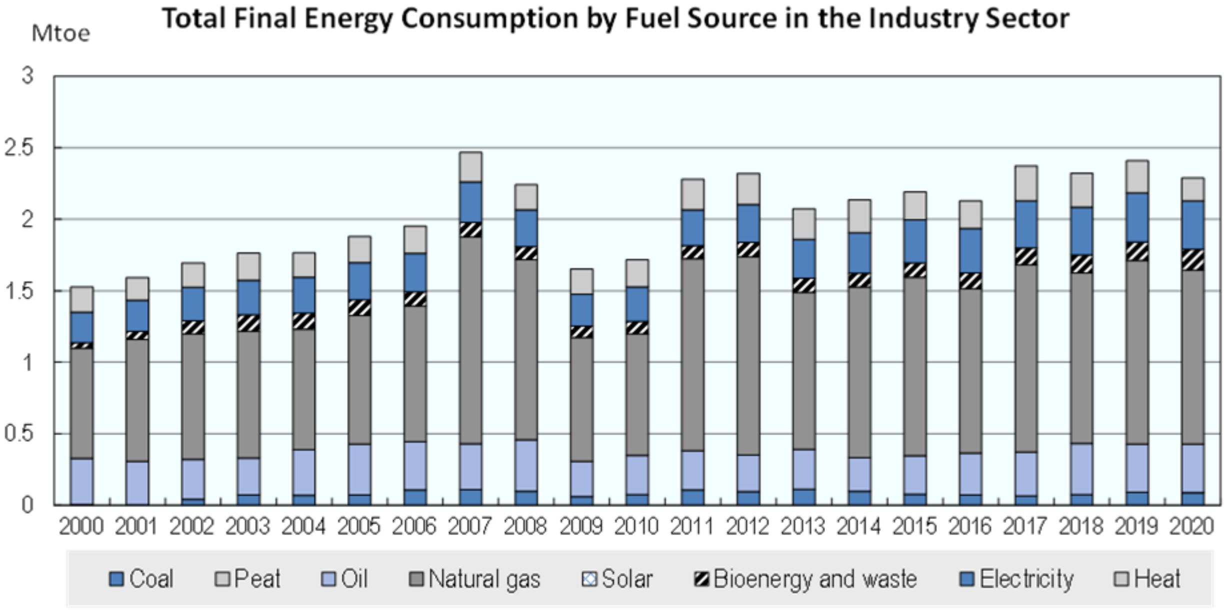
The buildings sector will be key to decarbonising Lithuania's energy sector. Despite the prevalence of renewable energy (primarily biomass and waste) in district heating, energy efficiency could be significantly improved. Of 18 000 apartment buildings supplied with district heat, only 4 200 are new or renovated buildings (OECD, 2021[8]). Average annual heat consumption in Lithuania is 160 kWh/m^2, far more than the 80-90 kWh/m^2 for newly renovated buildings (OECD, 2021[8]). Heating systems in rural areas are similarly outdated and energy poverty is an issue, with 30% of Lithuanians reporting difficulties in keeping their homes warm (OECD, 2021[8]).

Industry

In 2020, the four most important industry subsectors were: manufacture of refined petroleum products, accounting for 13% of total production; the manufacture of food products and beverages, accounting for 20% of total production; manufacture of wood products and furniture, accounting for 16% of total production; and manufacture of chemicals and chemical products, accounting for 11% of total production. Together these four subsectors accounted for 60% of production volume (Government of Lithuania, 2022[5]).

GHG emissions from industry have remained largely stable from 2013-2019 (OECD, 2021[8]). Chemical and mineral production, dominated by ammonia production, oil refining and cement production together make up more than 85% of ETS-regulated installations (Government of the Republic of Lithuania, 2022[19]). However, industrial processes rely primarily on natural gas as an energy source (Figure 1.10), and energy prices in non-ETS sectors in Lithuania historically remained too low to incentivise a shift to renewable energy (IEA, 2021[4]). The impacts of the war in Ukraine and the ensuing energy crisis in Europe have changed this context considerably. Current high gas prices have dramatically increased incentives for industry to decarbonise their energy supply. However, the shift to renewable energy will take time and may require further innovation in particularly hard-to-abate activities.

Figure 1.10. Natural gas still dominates energy consumption in the industry sector



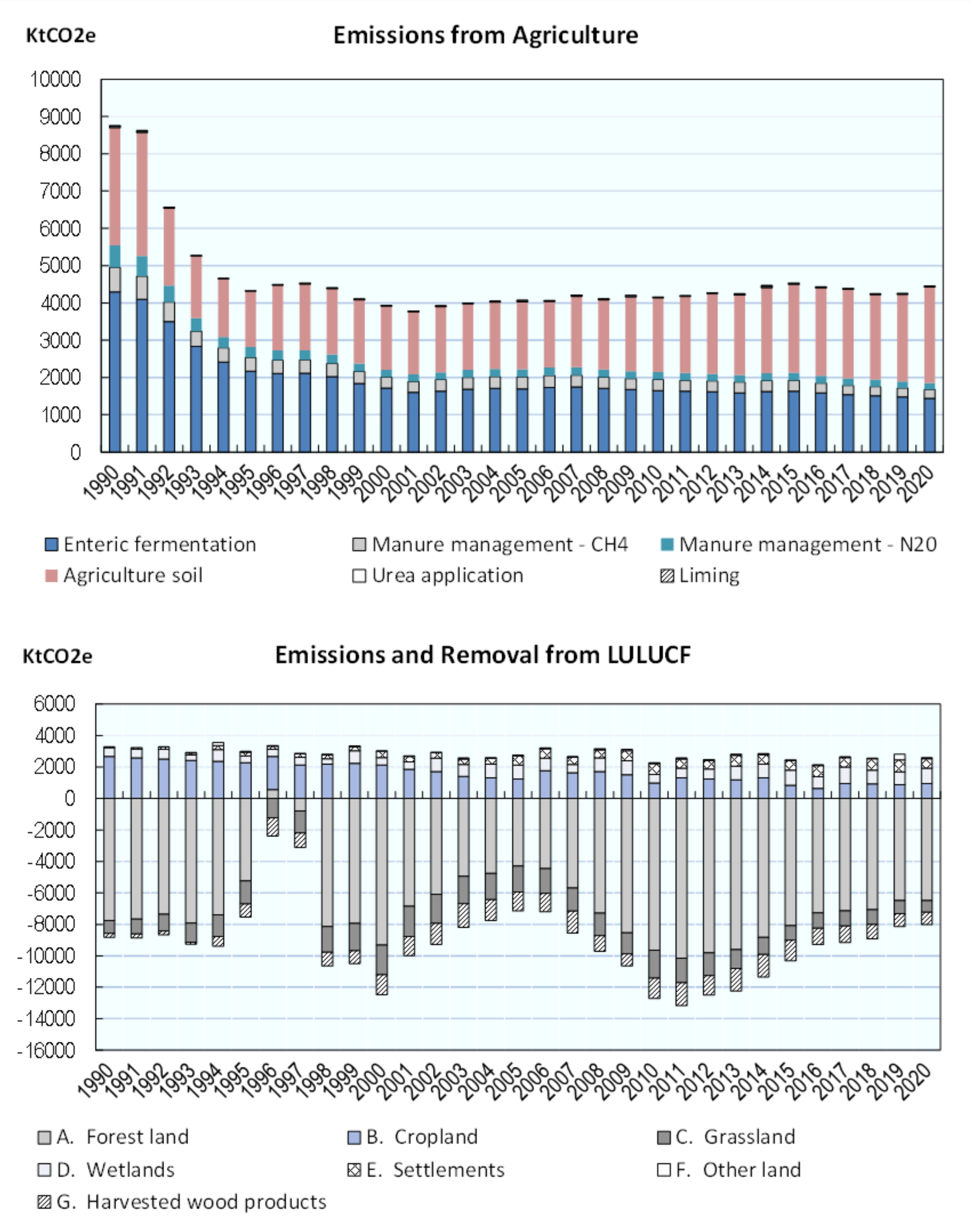
Source: (IEA, 2021[16]).

In addition to shifting away from fossil fuels, decarbonising the industrial sector will require technological change and innovation. Certain industrial processes are particularly hard to abate and cannot simply rely on renewable energy sources for decarbonisation. Here, innovation to increase the energy efficiency of processes and to develop new processes, e.g. relying on hydrogen as an energy source, will be needed to reach net-zero GHG emissions. As discussed in more detail in Chapter 7, public investment here is critical.

Agriculture and forestry

Emissions from agriculture have been rising in Lithuania, driven primarily by increasing use of synthetic fertilisers for crop cultivation (OECD, 2021[5]). Meanwhile, emissions from livestock have been decreasing. For an overview of emissions trends in agriculture, see Figure 1.11.

Figure 1.11. Emissions from agriculture are rising whilst removals from LULUCF are decreasing



Source: (Government of Lithuania, 2022[5]).

Fossil fuel subsidies in agriculture make up almost 30% of total fossil fuel support in Lithuania despite taxes on diesel use in the sector tripling between 2015-2020 (OECD, 2021[8]).

Forest area is increasing, however growing demand for forest products driven particularly by demand for biomass, has increased active forest management, reducing the role of forests as a carbon sink (Figure 1.11) (OECD, 2021[8]).

Conclusions

The Lithuanian economy has successfully decoupled its growth from GHG emissions. However, emissions reductions have stalled, and increasing emissions in the transport sector are cause for concern. Decarbonising the Lithuanian economy will require far-reaching measures. Reducing transport emissions should be a priority, with an old and inefficient car fleet, increasing road-freight and urban sprawl requiring urgent attention. Ensuring the energy efficiency of buildings is a further challenge, with inadequate building stock negating the considerable progress made in decarbonising heating through biomass and waste. In the industry sector, historically low fuel prices have inhibited a swifter shift to renewable energy, although the current energy crisis is shifting incentives. Finally, in agriculture, the growing use of synthetic fertilisers for crop production should be regulated.

Notes

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2 Lithuania's current and planned policy mix

This chapter takes stock of current and planned climate policies in Lithuania, situating these within the current policy context at the EU level. It describes policies included in the National Energy and Climate Plan (NECP) adopted in 2019 and further policies reforms made since, with a focus on the transport, energy, industry and agriculture and forestry sectors. It assesses the adequacy of these policies for meeting Lithuania's revised climate targets, offering good practice insights from other OECD countries on possible policy reform options.

The EU's Climate and Energy Framework, adopted in 2014, set the goal of reducing EU-wide GHG emissions by 40% by 2030 (compared with 1990 levels) (European Commission, 2014[1]). Under this framework, all EU member states were required to submit National Energy and Climate Plans (NECPs) to the EU Commission in 2019, establishing a ten-year plan that details member states' contributions to the EU's 2030 climate targets. The EU has since updated its climate policy ambitions, targeting a reduction of GHG emissions of at least 55% by 2030 in the European Climate Law, adopted in 2021 as part of the European Green Deal. To meet these updated targets, the European Commission has also proposed a number of legislative reforms known as the Fit for 55 package.

A review by the European Commission of current NECPs found that, if fully implemented, they would amount to a 41% reduction of GHG emissions, narrowly surpassing the EU's 2014 target but falling short of the new and increased target under the 2021 European Climate Law (for an overview of current and previous EU climate targets see Table 2.1) (European Commission, 2022[2]). Member states are therefore required to submit updated NECPs reflecting the EU's increased ambition by 2023.

Lithuania's NECP constitutes the primary document detailing Lithuania's intended climate policies for the period from 2021-2030. Adopted in 2019, it integrates a number of previous policy documents including the National Energy Independence Strategy (adopted in 2018), the National Strategy for Climate Change Policy (adopted in 2012 and updated in 2019), and the National Air Pollution Plan (adopted in 2019). It was further developed in parallel to the National Progress Plan, which sets overarching economic, social, environmental and security priorities, also for the period from 2021-2030.

The NECP aims to reach an overarching GHG emissions reduction target of 9% in sectors not covered by the European Union Emissions Trading Scheme (EU ETS), meeting the EU's Effort Sharing Regulation (ESR) target for Lithuania as set in the 2030 Climate and Energy Framework (European Commission, 2014[1]). ETS sectors are subject to an EU-wide emissions reduction target of 43% (European Commission, 2014[1]).

To meet the increased ambition of the European Climate Law and Green Deal, targets set in the NECP have since been updated in the Lithuanian National Climate Change Management Agenda (NCCMA), adopted in July 2021. Although the NCCMA sets overarching climate targets and defines sectoral objectives in meeting them, it does not detail the climate policies and measures to be implemented to meet these objectives. As such, in order to meet the updated targets set in the NCCMA, Lithuania will need to update its NECP. As seen in Figure 2.1, existing and additional policy measures planned in the current NECP fall short of the necessary ambition to reach the NCCMA's targets. This report thus provides policy recommendations to be included in the updated NECP, focusing on the transport, industry, energy, and agriculture and forestry sectors.

For an overview of targets set in the NECP, the NCCMA and the associated EU target levels, see Table 2.1.

Table 2.1. GHG emissions reduction targets in Lithuania and the EU under the NECP/2030 Climate and Energy Framework and NCCMA/European Green Deal

Region	Sectors	Previous Climate Targets (EU Climate and Energy Framework and NECP)				Updated Climate Targets (European Green Deal and NCCMA)			
		2030	*2040*	*2050*	*Source*	*2030*	*2040*	*2050*	*Source*
EU-Wide Targets	*Economy Wide*	40% reduction (compared with 1990)		80% reduction (compared to 1990)	EU 2030 climate and energy framework	55% reduction (compared with 1990)		100% reduction (compared with 1990)	European Climate Law
	EU ETS	43% reduction (compared with 2005)			EU 2030 climate and energy framework	61% reduction (compared with 2005)			Fit for 55 Package (proposed)

	Non-ETS Sectors	30% reduction (compared with 2005)			EU 2030 climate and energy framework	43% reduction (compared with 2005)			Fit for 55 Package (proposed)
Lithuania Targets	*Economy-Wide*	40% reduction (compared with 1990)	70% reduction (compared with 1990)	80% reduction (compared with 1990)	NECP	70% reduction (compared with 1990. 30% compared with 2005)	85% reduction (compared with 1990)	100% reduction (compared with 1990)	NCCMA
	EU ETS	43% reduction (compared with 2005)			NECP	50% reduction (compared with 2005)			NCCMA
	Non-ETS Sectors	9% reduction (compared with 2005)			NECP	25% reduction (compared with 2005)			NCCMA

Note: The ETS and Non-ETS targets proposed by the European Commission in the Fit for 55 Package have not yet been officially adopted and may be subject to change.
Source: (Government of Lithuania, 2019[3]; European Commission, 2014[1]; European Commission, 2022[4]; Government of Lithuania, 2021[5]).

Lithuania's NECP details policies for five primary sectors: transport, industry, energy, agriculture, land-use, land-use change and forestry (AFOLU/LULUCF), and waste. It sets targets for each of these sectors in line with the overarching target of reducing emissions in non-ETS sectors by 9% by 2030. This amounts to targeted reductions of 9% each in the transport, industry and agricultural sectors, 40% in the waste sector, and 15% in the energy sector. Lithuania further plans to offset 6.5 million tonnes of CO_2e through the LULUCF sector. For an overview of these sectoral targets, see Table 2.2.

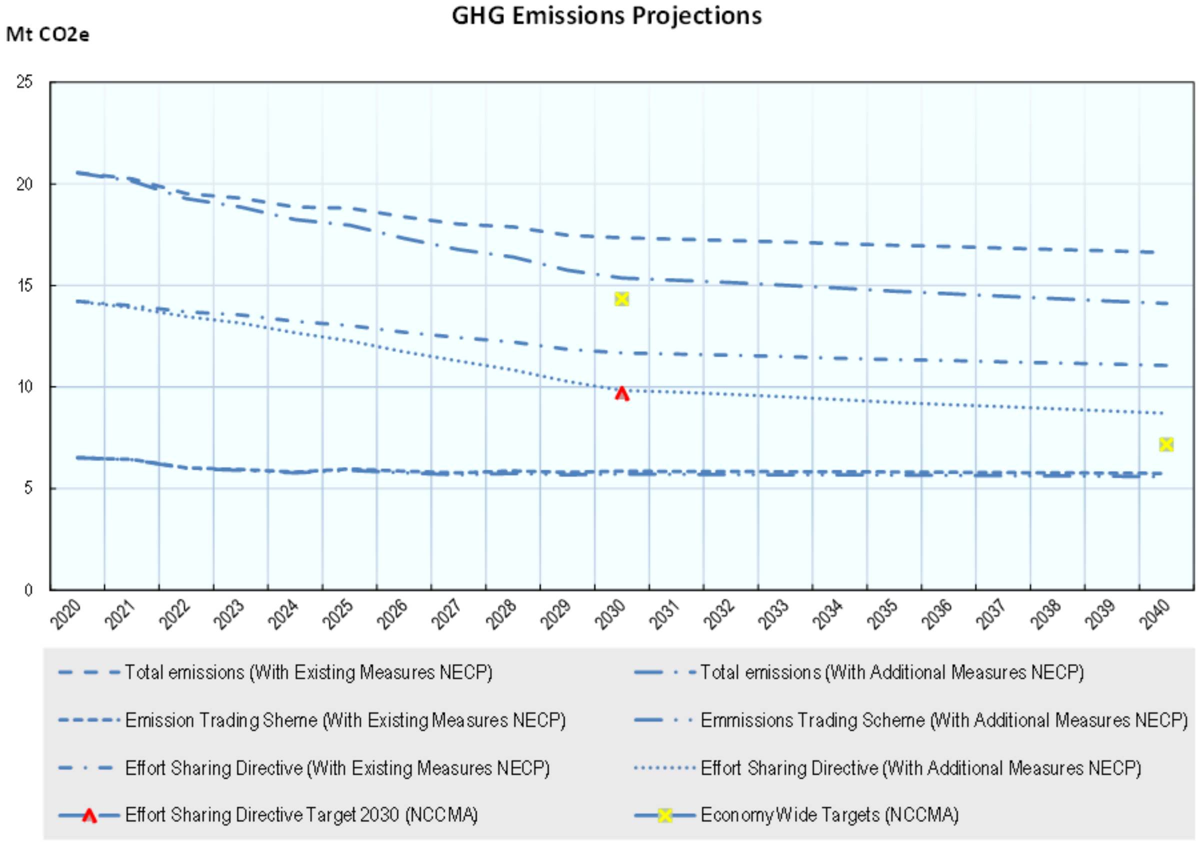
Table 2.2. Non-ETS Sectoral Emissions Reduction Targets for Lithuania set in the NECP and NCCMA

Sector	NECP 2030 Target	NCCMA 2030 Target
Transport	-9%	-14%
Industry	-9%	-19%
Energy	-15%	-26%
Agriculture	-9%	-11%
Waste	-40%	-65%
Total Non-ETS	-9%	-25%

Note: All targets compared to 2005 levels.
Source: (Government of Lithuania, 2019[3]; Government of Lithuania, 2021[5]).

The NCCMA sets a long-term objective of reaching net-zero emissions by 2050, in line with EU targets. It sets interim targets of -85% by 2040 and -70% by 2030 (compared to 1990s levels, -30% by 2030 compared to 2005). The NCCMA further defines sector-specific targets for 2030, with emissions reductions of 50% in ETS sectors and 25% in non-ETS sectors (compared to 2005 levels) (Table 2.1). The NCCMA further differentiates sector-specific targets for non-ETS sectors (Table 2.2) and provides details of near-, medium-, and long-term targets within each sector, for example setting renewable energy and energy efficiency targets for 2030, 2040 and 2050 in each sector.

Figure 2.1. Measures set out in the current climate plans are not sufficient to meet recently updated climate targets



Note: The total emissions trajectories (with additional measures NECP) assume current EU legislative packages. The proposed Fit for 55 Package would significantly steepen the reduction path of this scenario by increasing the reduction target for EU ETS sectors from 43-63% by 2030 (compared with 2005 levels). If the proposed EU updates were also to be considered in the total emissions (with additional measure NECP) scenario, the economy-wide targets set in the NCCMA would potentially be surpassed.
Source: (Government of Lithuania, 2020[6]; OECD, 2021[7]).

To inform these policy recommendations, this chapter takes stock of Lithuania's existing and planned policies and targets, assessing their adequacy to meet the updated targets set in the NCCMA and EU Climate Law. This assessment is based on a) a general equilibrium model providing an estimate of the effectiveness of policies laid out in the current NECP; b) a qualitative review of good practices in other OECD countries; and c) a review of existing assessments of Lithuania's climate policies, including those assessed in the *OECD Environmental Performance Review: Lithuania 2021* and related recommendations, the IEA's *Lithuania 2021 Energy Policy Review* and the European Commission's Review of the Lithuanian NECP.

The chapter is organised into six sections. The first considers recent developments at the EU level, summarising the proposed measures under the Fit for 55 package and European Green Deal. The following five sections detail current and planned policies and measures in Lithuania, each focusing on a particular sector. The first takes an economy-wide lens, with the subsequent sections focusing on the transport, industry, energy and agriculture sectors. The sector specific measures depicted are grouped by the type of measure, using categories from the OECD's decarbonisation framework (D'Arcangelo et al., 2022[8]), including economic measures (subsidies, lump-sum payments, etc.), fiscal measures (taxes or tax-exemptions), regulatory measures, or complementary measures such as education or research and development EU climate policies.

Regional context: EU climate policy trends

The EU's climate policies have changed significantly in the past two years. The 2030 climate and energy framework has been replaced by the European Green Deal, and as a response to the COVID-19 pandemic, the EU has put in place important funding mechanisms, with the aim of financing a "green recovery". While many of the policy processes are ongoing, with particularly the European Green Deal still awaiting adoption of many legislative proposals, the proposed changes would have significant bearing on Lithuania's climate policies in the future. This section briefly describes the current EU climate policy landscape and, where possible, provides insights into the (likely) effects of EU climate policies on Lithuania.

Recovery and Resilience Facility (RRF)

As the central part of the NextGenerationEU plan for recovery from the COVID-19 pandemic, the Recovery and Resilience Facility provides member states funding for recovery projects. Each member state is required to submit a plan for approval to the European Commission detailing how they would use their allotted amount. Of the funding provided, 37% should be spent on climate relevant initiatives (European Commission, 2022[9]). Lithuania's EUR 2.2 billion plan was endorsed by the European Commission in July 2021. It aims to spend more than EUR 800 million, or 37.8%, on climate projects including supporting investments in solar and wind projects, promoting electric vehicles, renovating buildings and restoring peatlands (European Commission, 2022[10]).

EU Taxonomy for sustainable activities

In 2020, the EU established a taxonomy for sustainable activities, a classification system that aims to provide clarity to investors on which activities and technologies are in line with EU climate targets and can be considered as sustainable investments. The taxonomy has gradually been updated and expanded through delegated acts. For example, in 2022, a delegated act detailed conditions under which nuclear energy and natural gas can be considered sustainable under the taxonomy (European Commission, 2022[11]).

Fit for 55 package

The European Green Deal, approved in 2020, is a set of policy initiatives with the overarching goal of a climate-neutral EU by 2050. In light of this ambition, the 2021 European Climate Law sets an interim emissions reduction target of 55% by 2030 (compared with 1990 levels). In order to meet this target, the European Commission has developed a set of proposals, also known as the Fit for 55 package, to review and update EU legislation, putting in place new climate policy initiatives in line with the increased ambition of the Green Deal. The Fit for 55 package was submitted to the European Council in 2021 and is currently being discussed across several policy areas, such as environment, energy, transport, and economic and financial affairs (European Council, 2022[12]). The package includes the following legislative proposals and climate policy initiatives:

EU-Emissions Trading Scheme (ETS)

The Fit for 55 package proposes to update the EU ETS, increasing its emissions reduction target from 40% to 61% by 2030 (compared with 2005 levels) (European Council, 2022[12]). This would entail increasing the annual reduction factor from 2.2% to 4.2%. The proposal also suggests that maritime transport be included in the ETS and that free allowances for aviation and sectors covered by the carbon border adjustment mechanism (CBAM) be phased out. It also includes an offsetting scheme for global aviation emissions through Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). The proposal further calls for an increase in funding availability for the modernisation and innovation funds, to be sourced from the increased ETS revenues. Finally, the market stability reserve (MSR) is to be updated.

In addition to the proposed amendments to the current ETS, the Fit for 55 package also proposes the establishment of a parallel ETS II for the transport and buildings sector. The ETS II would target an emissions reduction in these sectors by 43% (compared to 2005 levels) (European Council, 2022[12]). It would be implemented at the fuel distributer level, encompassing both sectors, with the price determined by the carbon intensity of fuels (Erbach and Foukalova, 2022[13]). The ETS II is proposed for 2025, with mandatory reporting by fuel distributers to start in 2024.

Accompanying the ETS II, the Fit for 55 package proposes establishing a Social Climate Fund to help mitigate potential adverse socio-economic impacts of the new ETS on vulnerable households and micro-enterprises. The fund would receive EUR 75.2 billion from 2025-2032 and fund projects such as, direct income support, energy efficiency renovations in buildings, decarbonisation of heating and cooling and improved access to low-emissions transportation. The financial envelope of the Social Climate Fund should eventually comprise 25% of the revenues generated by the ETS II, with proposed maximum amounts to be received by each member state. Under the proposal, Lithuania would receive 1.02% of the funds (Wilson, 2021[14]). Lithuania currently emits 0.55% of EU GHGs and generates 0.4% of EU GDP (Jensen, 2021[15]; Eurostat, 2021[16]).

Effort sharing regulation (ESR)

The Fit for 55 package proposes to update domestic GHG emissions reduction targets for non-ETS sectors set in the ESR, increasing the EU-wide target for non-ETS sectors from 29%-40% by 2030 (compared with 2005 levels) (European Council, 2022[12]). The distribution of domestic targets would remain determined by each country's GDP per capita, with some flexibility depending on the cost efficiency of targeted reductions. Under the proposal, Lithuania's 2030 reduction target would increase from 9% to 21% (European Commission, 2021[17]).

Regulation on land-use, land-use change and forestry (LULUCF)

The Fit for 55 package proposes to set a binding EU-level target for net removals of CO_2 (European Council, 2022[12]). The proposal sets an overarching target of climate-neutral LULUCF and agriculture sectors by 2035, meaning that all emissions from LULUCF and agriculture are offset by removals. In order to achieve this, the proposal targets removal of 310 million tonnes of CO_2 by 2030 at the EU level. This is to be distributed amongst member states as binding domestic targets based on the area of managed land. A number of options are proposed for how to organise this (Vikolainen, 2022[18]). The proposal further suggests simplifying current accounting and monitoring, verification, and reporting rules. Finally, the proposal suggests expanding the scope of the regulation to include non-CO_2 agricultural emissions from 2031, pending a report on this to be provided by the European Commission in 2025 (European Council, 2022[12]).

Renewable energy directive (RED)

The Fit for 55 package proposes an increase in the targeted share of renewable energy in the energy mix from 32% to 40% by 2030 (European Council, 2022[12]). The proposal also includes a phase-out of biomass from electricity production by 2026, further suggesting new sustainability criteria for bioenergy. These include prohibiting the use of primary forests for bioenergy as well as the application of minimum GHG savings thresholds (Wilson, 2021[19]). It also suggests sustainability criteria for renewable fuels of non-biological origin (RFNBOs). Finally, sector-specific targets and measures are suggested. In the buildings sector, renewable energy is proposed to make up 49% of energy consumption for heating and cooling by 2030, driven by a binding annual increase factor of 1.1%, 2.1% for district heating systems (Wilson, 2021[19]). In the industry sector, the proposal targets an annual increase in renewable energy use of 1.1%, with 50% of feedstock or energy carriers to come from non-biological renewable fuels by 2030 (Wilson, 2021[19]). The proposal further targets a 13% reduction in the GHG intensity of the transport sector by 2030, with a 2.2% use of advanced biofuels and 2.6% of non-biological renewable fuels. Further, a credit mechanism is proposed to promote electric vehicle deployment (Wilson, 2021[19]).

In addition to the Fit for 55 package, in May 2022, the European Commission proposed the REPowerEU package, looking to increase the EU's 2030 target for renewable energy from the 40% envisaged in the Fit for 55 package to 45%. REPowerEU would bring the total renewable energy generation capacity to 1 236 GW by 2030, compared to 1 067 GW in the Fit for 55 package. (European Commission, 2022[20])

Energy efficiency directive (EED)

The Fit for 55 package proposes to implement an "energy efficiency first" principle, ensuring that the benefits of fuel switching are not dampened by sub-standard energy efficiency in buildings (European Council, 2022[12]). The proposal targets an overall reduction in energy consumption of 9% by 2030. This would constitute energy savings of 32.5% in final energy consumption and 39% in primary energy consumption (Wilson, 2021[21]). The proposal sets binding upper limits for energy consumption, suggesting non-binding shares for member-states. The proposal also sets new obligations and rules for public sector buildings, targeting a 1.7% annual reduction of energy consumption and an annual renovation target (to near-zero standards) of 3% (Wilson, 2021[21]). Finally, the proposal includes provisions on targeted measures to support vulnerable consumers.

Alternative fuels infrastructure and CO_2 emissions standards for cars and vans

The Fit for 55 package includes proposals for new initiatives for deploying electric vehicle and hydrogen charging points, as well as other alternative fuel infrastructure, including CNG and LNG infrastructure and the supply of natural gas in ports. The proposal suggests a minimum coverage for recharging points for light and heavy vehicles (Soone, 2021[22]). The Fit for 55 package also suggests minimum CO_2 emissions standards for new cars and vans. This includes a 100% emissions reductions target by 2035, effectively banning the sale of internal combustion engines after this date (European Council, 2022[12]). The proposal sets intermediate emissions reduction targets for 2030, 50% for cars and 55% for vans (Erbach, 2022[23]).

Energy tax directive (ETD)

The Fit for 55 package also proposes new minimum tax rates for fuels and rules on exemptions under the ETD. The proposal aims to align energy product and electricity taxes with the updated EU climate targets, suggesting to tax fuels according to their carbon content and environmental performance, in order to preserve and improve the internal EU fuel market and ensure that member states' capacity to generate revenues is maintained (European Council, 2022[12]). It further proposes a simpler categorisation of fuels and a phase-out of all fuel exemptions, including those for aviation, shipping and fishing fuels. It also suggests recognising new fuels such as hydrogen (Kostova Karaboytcheva, 2022[24]).

Carbon border adjustment mechanism (CBAM)

The Fit for 55 package proposes the establishment of a carbon border adjustment mechanism, ensuring that the increased ambition of EU climate policy does not result in carbon leakage, i.e. production migrating to countries and regions with less stringent climate rules (European Council, 2022[12]). In effect, the mechanism would introduce some form of import tax based on a product/material's carbon content, using the ETS price as a reference. The proposal includes multiple options for how to structure such a mechanism, including which materials would be covered, and the scope for ETS credit allocations (Kramer, 2022[25]).

Sustainable aviation and greener shipping fuels

The Fit for 55 package proposes two initiatives to reduce emissions from aviation and shipping. The ReFuel Aviation initiative proposes implementing fuel obligations for sustainable aviation fuels. It provides multiple options for how to structure such an obligation, including whether it should fall on fuel suppliers or airlines, whether the approach should be based on fuel volume or carbon intensity, and whether and how to structure possible transition periods (Tuominen, 2021[26]). For shipping, the Fit for 55 package proposes targeting a 75% reduction in the GHG intensity of shipping fuels by 2050, based on increasing annual intensity reductions, starting at 2% in 2025 and rising to 6% in 2030. The FuelEU Maritime initiative further proposes obligations for shore-side electricity use (Pape, 2021[27]).

Economy-wide climate policies

The EU Green Deal significantly increases the region's climate policy ambitions, updating the targets set in the 2014 Climate and Energy Framework. As part of the Green Deal, the 2021 European Climate Law defines new overarching target levels and the Fit for 55 package proposes a comprehensive mix of initiatives with which to achieve these targets. Nonetheless, implementing climate policies remains primarily a task for member states. As such, the EU requires all member states to submit NECPs detailing their national climate policy mixes.

Lithuania's original NECP, submitted to the EU in 2019, draws on a number of domestic policy initiatives such as the National Energy Independence Strategy (adopted in 2018), the National Strategy for Climate Change Policy (adopted in 2012 and updated in 2019) and the National Air Pollution Plan (adopted in 2019). It was developed in parallel to the National Progress Plan (NPP), which sets overarching priorities for social, economic, environmental and security policy. In 2021, Lithuania updated its overarching climate policy targets in the NCCMA.

The policies detailed in Lithuania's NECP are differentiated by economic sector, covering transport, energy, industry, waste, and agriculture and forestry. The NECP also details a number of economy-wide policies, which are detailed below.

Existing policies

Lithuania's NECP sets out a number of horizontal policies targeting economy-wide emissions reductions. Rather than setting economic incentives or introducing new regulations, these are primarily complementary policies, for example integrating GHG emissions reduction evaluations into the legislative process, mainstreaming climate change within educational programmes, extending the scope for green procurement, increasing public awareness, and funding research on climate mitigation (Government of Lithuania, 2019[3]).

Planned policies

Recently, the Lithuanian government also proposed amending current excise duty legislation. The proposed policy would increase excise duties annually from 2023-2030. It further proposes to phase-in a tax based on the carbon intensity of fuels from 2025. The tax would start at EUR 10 per tonne of CO_2 and rise by EUR 10 each year, rising to EUR 60 per tonne of CO_2 in 2030. ETS installations would be exempt from the CO_2 element, with no price floor envisioned. Natural gas would also be exempt from the proposed legislation. Agricultural exemptions from paying excise duties would also remain, although here a quota limit would be phased-in, limiting the amount of fuel that could be consumed free of the excise duty, starting at 100 000 litres in 2024, and further decreasing to 50 000 litres in 2025 and beyond. The proposal does not include measures to recycle the generated revenue. However, due to the current energy price crisis, the Lithuanian Parliament has postponed the consideration of the proposed amendments to the excise duty legislation.

Assessment and recommendations

Lithuania's NECP focusses on detailing sectoral policy measures. Existing economy-wide policies remain primarily complementary, aiming to mainstream climate concerns throughout government decision-making and society more generally. However, as highlighted in Lithuania's EPR, interlinkages between climate policy and other policy domains could be strengthened. Drawing on a number of domestic policy initiatives, the NECP co-ordinates climate action across areas such as energy security and air pollution. However, the NECP is not closely linked to the NPP, as seen by a lack of interlinkages between chapters on the Lithuanian Green Deal and economic development in the NPP (OECD, 2021[7]). This is despite the two plans having been developed in parallel.

The planned excise duty amendment is a welcome initiative that will considerably bolster progress towards meeting Lithuania's climate targets (see also Chapter 4 on effective carbon rates). However, the policy could be expanded on. First, the exemption of natural gas from the CO_2 tax element should be reconsidered, as this will incentivise investments into gas infrastructure that could lock-in fossil fuel technologies for a number of decades beyond 2030. Moreover, introducing a price floor for ETS installations would send a strong signal to businesses and investors that Lithuania is committed to reaching its climate goals, regardless of developments elsewhere in the EU. Revenues generated through the proposed tax on the carbon content of fuels should be recycled, and at least in part given back directly to consumers, as is the case in Ireland and Denmark (Box 2.1). Assessment of the planned excise duty amendment is expanded on in Chapters 3 and 4 of this report.

Box 2.1. Good practices for economy-wide climate policies

A number of OECD countries have implemented broad, economy-wide policies to reduce GHG emissions.

UK carbon price floor

The UK introduced a carbon price floor for electricity sector fossil fuel emissions covered by the EU ETS in 2013. The price floor consists of the EU ETS permit price, and a carbon price support mechanism charged on top of ETS permit prices if these fall below a pre-determined price floor. The carbon price support (CPS) mechanism began at GBP 9 per tonne of CO_2 emissions in 2013 and increased annually to GBP 15 in 2015, targeting EUR 30/tCO_2 by 2020. In 2018, the effective carbon rate reached GBP 36/tCO_2 and the additional cost from the support mechanism was capped at GBP 18/tCO_2 until 2021.

Emissions in the electricity sector fell by 58% from 2012 (before the CPS was introduced) to 2016 (the first full year for which total effective carbon rates were about EUR 30). In 2018, they had fallen by 73% as compared to 2012 levels. The UK Treasury further recouped GBP 1 trillion in CPF tax receipts in 2017, although this is likely to fall as the ETS price increases and the UK decarbonises. Tax receipts go the general budget.

Irish non-ETS sector carbon tax

Ireland introduced a carbon tax on liquid and non-gaseous fuels in non-ETS sectors in 2010 and extended it to solid fuels in 2013. The tax rate increases over time, reaching EUR 26/tCO_2 in 2020 and targeting EUR 100/tCO_2 by 2030. The increase of the nominal carbon tax rate between 2018 and 2020 resulted in a nearly 5% rise in the effective carbon tax rate in the transport sector and a 35% increase in the non-transport sector. Moreover, due to the carbon tax, Ireland is among ten OECD countries to price at least half of their energy-related CO_2 emissions at EUR 60/tCO_2 (a low to midpoint estimate for the social cost of carbon in 2020 (High-Level Commission on Carbon Prices, 2017[28])).

The Irish carbon tax includes a commitment to using the generated revenues to prevent fuel poverty, ensure a just-transition, and finance climate projects. According to the National Development Plan, the tax is expected to yield EUR 9.5 billion over the coming decade. The plan aims to invest half of this in energy efficiency renovations, with a further EUR 1.5 billion to be invested in climate mitigation activities and EUR 3 million on initiatives to limit fuel poverty and ensure a just transition. These include enhancing social welfare schemes, providing support to vulnerable households and retraining workers. As such, the tax contributes to reducing poverty, as average weekly disposable income of households would increase as a result of the budget package.

Danish policy mix approach

Denmark takes a particularly comprehensive approach to climate policy. A climate law adopted in 2020 sets a long-term target of net-zero emissions by 2050, with an intermediate target of a 70% reduction by 2030. To reach these targets, it implements a three-pronged policy mix. First it sets ambitious emissions prices consisting of a CO_2 tax on transport and heating fuels, excise taxes, and the EU ETS. It backs up these pricing mechanisms with regulatory measures such as a ban on new fossil fuel explorations and aiming to cease fossil fuel production from 2050, and banning fossil fuel powered cars from 2035. Finally, these policies are supported by investments into infrastructure and research and development through the Danish Green Investment Fund. The policy process further includes strong stakeholder involvement, targeted policies to attract private investment, and a framework for labour reallocation in order to mitigate possible adverse transitional effects.

Note: The examples presented were not assessed as to their comparability with the Lithuanian case. However, as these are broad economy-wide policies they are applicable in all cases, though their design should consider specific local contexts.
Source: (OECD, 2021[29]; OECD, 2019[30]; Hirst and Keep, 2018[31]).

Transport

The NCCMA sets an overarching emissions reduction target for the transport sector of 14% by 2030 (compared to 2005 levels). This amounts to a 42% reduction from 2019 levels, when the NECP was formally adopted. As such, decarbonising the transport sector is amongst the most challenging areas of Lithuania’s climate policies.

To meet this overarching target, the NCCMA’s objectives for the transport sector are:

- to achieve, by 2030, a 50% share of electric and other low-emissions vehicles in annual vehicle purchases, and to reduce the number of cars powered by conventional fuels in cities by 50%;
- to reduce, by 2030, the use of fossil fuels in passenger cars by 40%;
- to increase the share of renewable energy used in the transport sector to 15% in 2030, and 100% in 2050;

- to increase the share of second-generation biofuels in total fuel consumption in the transport sector to 3.5% by 2030.

As the primary document detailing Lithuania's climate policies, the NECP presents a broad policy mix for transport. This includes measures to renew the public transit fleet, electrify railways, promote sustainable mobility behaviour, reduce the number of polluting vehicles, and incentivise the use of zero-emissions alternatives. It also includes measures promoting the use of renewable energy sources in transport, reducing congestion, and reducing emissions from freight transport and shipping.

The following subsections take stock of these policies, detailing measures currently being implemented as well as planned additional measures, with a view to assessing their adequacy to meet the NCCMA's updated targets. Good-practice examples from other OECD countries for further policy reforms in the transport sector are also provided.

Existing policies

Economic measures

Existing economic measures implemented in the transport sector encompass a wide range of activities. For example, since 2017, urban centres and municipalities have been eligible for funding to purchase buses or similar public transport vehicles powered by electricity or alternative fuels. Further measures to promote fleet renewal are planned. Economic measures also include funding for the electrification of rail transport, with 391.6 km of railway lines to be electrified by 2023, primarily from Kaišiadorys to Klaipėda and including the Vilnius junction and Kena-N. Vilnia line. Further electrification of railways is also planned.

Key economic measures making up the bulk of available funds focus on the transition from polluting to low-emissions vehicles, for example policies aiming to reduce the number of polluting vehicles, and to incentivise the purchase and/or deployment of low-emissions alternatives.

To reduce the number of polluting vehicles, a "cash for clunkers" policy grants lump-sum payments to private vehicle owners willing to replace their polluting car with a new low-emissions vehicle. Under this scheme, vehicle owners can receive up to EUR 1 000 for their old car, with poorer households receiving up to EUR 2 000. Payments are also available for those willing to switch mobility types, for example to public transport, bicycles or electric scooters, or ride-sharing services.

Policies to incentivise the use of low- or zero-emissions vehicles include purchase subsidies for various types of electric vehicles (starting at EUR 4 000 for a new private electric vehicle and EUR 2 000 for a used one).[1] They also include subsidies for the installation of private charging stations, financing for the installation of public charging stations, and obligations to install charging stations in new buildings or parking lots and petrol stations. The aim is to install 54 000 private and 6 000 public charging stations by 2030. Lithuania also provides investment support for the installation of biomethane production plants with the intent of reaching a capacity of 950 GWh of biomethane produced per year by 2030.

Finally, municipalities have prepared sustainable urban mobility plans (SUMPs) detailing how they intend to promote walking, cycling, public transport and the use of alternative fuels. Municipalities can apply for funding from different sources including a national sustainable mobility fund (currently being established) and EU Structural and Investment Funds (available for SUMPs since 2016).

Fiscal measures

A number of fiscal measures have been implemented in the transport sector. These include differentiating the private vehicle registration tax by pollution level, with the aim of reducing emissions from private vehicles by 3.5% annually, and phasing out tax exemptions for self-employed persons.

Beyond private vehicles, freight transport is also being targeted through the introduction of e-tolling and shifting to a higher Euro emissions standard. These measures were introduced between 2019 and 2021 following the adoption of the NECP.

Finally, to promote the use of renewable energy sources in the transport sector, biofuels are exempt from excise duties, with the exemption for blended fuel proportional to the fuel mixture.

Regulatory measures

Existing regulatory measures primarily comprise renewable energy obligations. For example, biofuel blending obligations in accordance with EU standards have been in place since 2011 and were updated in 2021. Advanced biofuels are also being promoted, targeting a 1.75% share of total fuel consumption by 2030. Additionally, natural gas operators are obliged to meet targeted shares of renewable energy of 4.2% by 2025 and 16.8% by 2030.

Complementary measures

To promote sustainable mobility in Lithuania, a study is currently underway to assess options for optimising public transport in the Vilnius area. In order to reduce congestion, traffic management measures were introduced in 2021. These include, for example, planning traffic distribution and restrictions during peak hours and introducing intelligent management technologies such as traffic lights or road crossings. Educational measures are also being implemented, for example informing persons on the climate benefits of teleworking (reducing congestion and fuel consumption).

Planned measures

Economic measures

In addition to the already existing purchase subsidies for transport fleet renewal, further economic measures are planned. These include purchase of electric and hydrogen buses, and the installation of hydrogen and electricity recharging infrastructure using European Regional Development Funds (ERDF). Plans for the purchase of electric buses and the installation of charging stations already exist at the municipal level, with 2030 targets, but are pending approval of funds from the ERDF. With hydrogen technologies at a more nascent stage, plans for procuring hydrogen buses and installing hydrogen refuelling stations remain preliminary. The NECP provides for the possibility of investments into this technology in the future.

Purchase subsidies are further planned for the business and public sector, targeting over 20 000 passenger vehicles, 500 heavy-duty vehicles (of which 200 should be electric or hydrogen and 300 powered by biofuels), 450 electric/hydrogen buses and 50 biofuel buses, as well as support for the production of electric vehicles. Further financial support is planned for the purchase of public, utility, or other commercial vehicles powered by compressed natural and/or biomethane gas, and for the production of second-generation biofuels.

In addition to the rail lines currently being electrified (see previous section), a further 814 km are to be electrified by 2030, with over 70% of goods to be transported by train. This includes the regional Rail Baltica plans that will enable electrified train transport throughout the Baltic states. Freight transport is further targeted through economic measures promoting emissions reductions through shipping. These include financial incentives for the use of combined freight and financial support for the construction of new ships and barges.

Fiscal measures

A key fiscal measure planned for the transport sector was the introduction of an annual vehicle tax based on vehicles emissions standards. This tax was to be implemented from 2023 but has recently been rejected by parliament. Although it has been recommended for resubmission, this is subject to reforms, and the current administration has shifted its focus to passing economy-wide excise tax amendments instead. Planned fiscal measures for the transport sector also include creating a favourable tax environment for the development of inland waterway transport.

Regulatory measures

Accompanying plans for new economic and fiscal measures, the NECP's planned policies also include new regulations requiring the labelling of vehicles according to their pollution standard. New legislation is also planned on green procurement, setting minimum procurement targets with the goal of reaching 100% clean passenger cars by 2030. The NECP further outlines plans to introduce low-emissions zones restricting access for polluting vehicles within urban centres throughout Lithuania, and periodically expanding them over time.

Complementary measures

Educational programmes include trainings, advertisements, and promotion of sustainable mobility throughout society, from kindergarten to private companies.

Assessment and recommendations

The NECP sets policies for the period 2021-2030. Many of these policies are now being implemented, including for example generous economic incentives for fleet renewal and the purchase of low-emissions vehicles. What is more, planned amendments to excise duties will, if implemented, have a significant impact on emissions reductions in the transport sector, marking important steps towards increasing taxes on polluting behaviours that have been identified as key obstacles to climate action in Lithuania (OECD, 2021[7]). For a more detailed analysis of the effect of this amendment see Chapter 4.

The planned vehicle tax is a further measure that, if implemented, would have a significant impact on emissions in the transport sector. The Danish example shows that vehicle taxes can be an effective climate policy tool for the transport sector, as they reduce overall demand for private passenger vehicles and incentivise a shift to low-emissions vehicles through a CO_2 component (Box 2.3). Regrettably, the vehicle tax proposal was recently rejected by parliament. Although subject to a resubmission, it is unlikely that the excise duty amendment and vehicle tax will be implemented simultaneously, particularly in light of the current energy crisis.

Establishing a domestic ETS for transport (and heating), as was done in Germany, would further strengthen the climate policy response for transport (Box 2.3). Such an ETS could also serve as a transition policy should an EU-wide ETS II be adopted, helping to ease possible price shocks and develop domestic capacity (see Chapters 3 and 4 for more detail).

The existing and planned policies detailed in the Lithuania's NECP focus primarily on fleet renewal. These policies are expensive to uphold, however, and may not be enough to reduce emissions. More systematic approaches are needed, for example addressing urban sprawl and overall time spent in transit (Box 2.2). Here, urban planning regulations and road pricing could be ratcheted up, for example through the introduction of area charges (Box 2.3).

Finally, tax base erosion will become a significant issue, with ample support provided to EVs becoming increasingly difficult to finance as fuel tax revenue decreases during the transition (see Norwegian example in Box 2.3). Overcoming this requires a longer-term perspective, for example through the gradual introduction of a distance tax as electric vehicles become more widely deployed.

Box 2.2. Redesigning transport systems for well-being

To design comprehensive decarbonisation strategies for urban transport it is key to consider urban transportation as a socio-economic system. A 2021 OECD report, *Transport Strategies for Net-Zero Systems by Design*, highlights the limitation of addressing only individual components of existing urban transport systems, systems that by design are unsustainable. Current transportation systems are focused on private passenger vehicles, aiming to maximise individuals' mobility. This has come at the expense of proximity, driving urban sprawl, demand for private vehicles, and reduced use of shared and active modes of transport. The report suggests that focusing on individual components within this system, i.e. replacing internal combustion engines with electric vehicles, does little to address the unsustainable design of the system itself. As a result, urban sprawl and reduced shared or active modes of transportation will further increase demand for private vehicles, obstructing mitigation efforts.

Overcoming such design problems requires taking a systemic approach. The report suggests that the aim of transportation is to provide individuals access to places; rather than maximising individual mobility, transportation systems should focus on accessibility, which combines mobility with proximity. With this in mind, transportation policy should focus not on replacing individual components within the existing system (i.e. polluting vehicles), but on street redesign, spatial planning, and increasing shared modes of transportation. This in turn will reduce demand for private passenger vehicles, reducing emissions and making it easier to renew and replace the remaining vehicle fleet.

Source: (OECD, 2021[32]).

Box 2.3. Good climate policy practice in the transport sector

German ETS for transport

The German Climate Action Act agreed upon in 2019 includes the introduction of a carbon pricing mechanism for transport and heating. The emissions trading scheme at first follows a fixed price trajectory, starting at 25 EUR/tCO_2 in 2021, and increases annually to 55 EUR/tCO_2 in 2025. Following this initial phase, a price corridor will be implemented for a year (2026) keeping the price between 55 and 65 EUR/tCO_2. Whether this corridor should then be shut (moving to an entirely market-driven price) will be decided in 2025.

The revenue generated by the scheme is to be used to reduce the current renewable energy surcharge on electricity prices and provide additional income relief for commuters disproportionately affected by the ETS.

Emission-intensive industries will be compensated in order to safeguard competition and avoid carbon leakage, but under the condition that compensation payments are invested in energy efficiency. Biofuels are exempt so long as they comply with EU sustainability criteria.

Danish vehicle tax

The Danish vehicle tax has played an important role in reducing emissions in the transport sector. Under the tax, all cars pay a registration fee based on the value of the car. EVs and low-emissions vehicles receive a deduction based on their battery capacity plus a basic deduction. In addition to this, a CO_2 surcharge based on emissions per kilometre applies to all vehicles.

EV support in Norway

Norway has been very successful in incentivising the uptake of electric vehicles. Extensive tax exemptions, exemptions from congestion charges and the ability of electric vehicles to use bus lanes, as well as support for charging infrastructure, have resulted in the electric vehicle fleet rising to 340 000 vehicles by 2020, representing 16% of total global sales.

Area charges in Stockholm

Stockholm was the second city in Europe (after London) to introduce an area charge with the aim of reducing congestion. The charge changes based on the time of day vehicles enter the area. It had a strong immediate effect on traffic levels and has retained this effect over the long term. It also generates important revenues that can be reinvested into public transportation.

Biofuel support/performance standards in Brazil

Brazil's RenovaBio programme is a good example of how tradable performance standards can be used to reduce GHG emissions through biofuels. The programme sets a GHG emission reduction target for the transport sector of 10% by 2028, and breaks this down into mandatory annual reduction targets for fuel distributors. It then certifies biofuel production relative to the carbon intensity of the biofuel produced. The certificates (equivalent to 1 tonne of CO_2 avoided and linked to sustainability criteria) can then be traded, with fuel distributors required to meet their emissions reduction targets through purchase of certificates.

Source: (IPAC, 2021[33]; Government of Denmark, 2022[34]; Börjesson, 2018[35]; Grangeia, Santos and Lazaro, 2022[36]).

Energy

The NCCMA sets overarching targets for emissions reductions in the energy sector. It differentiates between installations covered by EU ETS and non-ETS sectors, targeting a 50% emissions reduction in ETS sectors and a 25% reduction in non-ETS sectors by 2030 (compared to 2005 levels). It provides more detail on sectoral objectives for energy and industry sector installations covered by the EU ETS. Specifically it targets:

- 45% renewable energy in total final energy consumption and 50% renewable energy in electricity consumption by 2030, increasing to 75% and 95% respectively by 2040, and 90% and 100% respectively by 2050;
- district heating (90% renewable energy by 2030), energy savings (27 TWh final energy savings, including in the industry sector, by 2030) and energy efficiency (reduce primary and final energy consumption by half by 2040 compared to 2017, and by a factor of 2.5 by 2050).

The NCCMA further provides subsectoral objectives for non-ETS sectors, primarily in the buildings sector. Here it targets an increase in energy efficiency, and a switch to non-polluting heat and cooling technologies by prioritising the use of renewable energy sources by 2030. Specifically it aims to:

- save at least 6 TWh of energy consumption through comprehensive renovation efforts in individual houses and public buildings by 2030;
- enable 30% of households to become active electricity-generating consumers (prosumers) by promoting decentralised electricity generation and storage;

- advise end users on energy saving measures and solutions, targeting behavioural or demand-side measures;
- increase the number of households connected to district heating by promoting efficient use of thermal energy.

Together these goals serve to transform the current buildings subsector so that by 2050 it is independent from fossil fuels and energy efficient, striving for nearly zero-emissions buildings[2] and reducing annual energy consumption by 60% compared with 2020 levels, with the share of renovated buildings to reach 74%. The use of primary energy from fossil fuels and GHG emissions will be entirely phased out.

For the energy sector, the NECP details policies in three primary sub-categories: energy efficiency, heat and electricity. The following subsections take stock of these policies, detailing measures currently being implemented as well as planned additional measures, with a view to assessing their adequacy in meeting the NCCMA's updated targets.

Existing policies

Economic measures

Existing economic measures for energy efficiency include various financial incentives and support mechanisms. Financial incentives are in place for individual homeowners to carry out energy efficiency renovations with the aim of renovating 1 000 homes annually, saving 13.5 GWh. The measure also includes support for the modernisation of heating and hot water supply in multi-apartment blocks. Support also exists for energy efficiency renovations of multi-apartment blocks, with the intent to upgrade them to class C buildings, enabling up to 40% energy savings. The measure targets the renovation of 5 000 blocks by 2030. In addition to state finance for renovations, apartment building owners will receive monthly credits or interest payments differentiated between the heating and cooling seasons. A financial mechanism further encourages building owners to upgrade old elevator-type heating points to new single-circuit units. The measure compensates up to 30% of the cost for this retrofit and aims to renew 250 heating points annually, saving 10 GWh a year.

Beyond buildings, financial support also exists for the modernisation of street lighting with the goal of replacing 25% of all lights by 2030, saving 250 KWh annually. Private enterprises can also receive financial support for implementing energy efficiency measures identified in mandated energy audits, projected to save almost 5.5 TWh by 2030.

In the electricity subsector, multiple policies support the deployment of renewable energy sources. These include a feed-in tariff that supplements the price of electricity generated by renewable energy sources. The measure also prioritises transmission of electricity from renewable sources, and exempts electricity generators from being liable for balancing the electricity produced and from reserving capacity during the promotion period.

Offshore wind generation in the Baltic Sea is supported through a tender-based auction process. The winner of the tender process must obtain a construction permit within three years and begin producing electricity six years from receipt of the permit. An offshore substation will be built to connect the planned wind farm to the transmission network. Electricity production is planned to begin in 2028, adding a renewable energy capacity of 350 to 1 400 MW.

Beyond supporting larger-scale renewable energy production, financial support through EU funds and the national Climate Change Programme is available for the deployment of renewable energy in public sector and residential buildings. The measures aim to install a further 50 MW of renewable energy capacity and by 2030 enable 30% of all energy consumers to generate their own electricity through renewable installations (prosumption). Support is also provided for the installation of small renewable energy plants in communities. This support will be provided through a tender process, using revenues generated by agreements on statistical energy transfer between Lithuania and other European countries.

Supporting the deployment of renewable energy sources, new substations are being built and new technologies deployed to enable the integration of renewable energy into the transmission network. The total expected increase in renewable energy generation from 2021-2030 is 1 944.5 MW.

Finally, there are measures in place to support co-generation plants, targeting an additional capacity of 0.4 TWh annually from 2023. For example, a co-generation plant in Vilnius was granted EUR 190 million in 2016. The plant uses municipal waste unsuitable for recycling as well as biofuels and will generate 0.3 TWh annually. Similar projects are also being supported in other areas.

Financial support is also being provided for heat generation measures, for example installation of low-capacity biofuel co-generation plants. Old coal and gas heating supply will be converted to renewable sources, with biofuels providing 70 MW of additional capacity by 2030, and solar, heat pumps and geothermal 200 MW. Support is also being provided for the conversion of boilers to more efficient alternatives, with 50 000 boilers to be replaced by 2030. The measure compensates up to 50% of the costs of conversion for households not connected to district heating.

In order to support these efforts to reduce emissions in the heat sector, the heat transmission network is being modernised, with 42% of pipelines replaced by 2020. Finally, measures exist to promote the use of waste heat generated by industry in district heating networks.

Regulatory measures

Existing regulatory measures for energy efficiency include the Energy Efficiency Act, which legislates that energy suppliers must enter into agreements with the Ministry of Energy, mandating energy savings. The agreements should include the energy savings level or GHG emissions reductions as well as information on energy efficiency improvements. This measure is expected to save around 100 GWh annually by 2030.

In the heat subsector, new regulation enables heat suppliers to raise funds for modernisation. New regulations also exempt natural gas suppliers that already pay for the security component from the requirement to build up reserve fuel stock. Finally, regulations are in place dictating that, by 2027, all heat meters must be replaced by remote scanning, thereby modernising the heat accounting system.

Complementary measures

To promote behavioural changes in energy efficiency and savings, energy suppliers must enter into agreements with the Ministry of Environment, detailing education measures to promote energy efficiency and saving. The measure is expected to enable 3 TWh of savings.

Several studies are also being carried out to assess the potential for further decarbonisation in the heat sector. These include assessments of the legislation necessary for a favourable regulatory environment for sustainable district heating, a review of the reserve requirements for heat production capacity and fuel reserves, and an assessment of the potential for renewable energy sources for cooling. Finally, an inventory of the energy efficiency of household appliances has been collected to inform climate policy measures.

Planned policies

All of the planned policies detailed in the NECP for the energy sector are currently being implemented.

Assessment and recommendations

The extensive economic support provided for energy efficiency, renewable electricity production and heat are important measures enabling considerable emissions reductions in the energy sector. In particular, the generous support programmes available for renewable energy sources and accompanying measures on systems integration and investments into grid connections will greatly increase the supply of renewable energy in Lithuania. This will further increase energy independence, a key priority. Coupled with the planned economy-wide excise duty amendment, these measures will put considerable pressure on energy suppliers to switch to sustainable alternatives, incentivising decarbonisation efforts.

The progress made to shift heat-supply from natural gas to bioenergy is already a significant step towards decarbonising the heat subsector. Reliance on bioenergy, however, needs to be coupled with strict sustainability criteria. Less-expensive Belarusian imports have undermined the sustainability of supply in the Baltpool platform. Co-generation capacity will be key to ensuring the stability of power supply, and current plans emphasise the further expansion of bioenergy to enable this. Here, EU regulations on bioenergy sustainability must be upheld. Moreover, reforms to the EU's renewable energy directive proposed in the Fit for 55 package would see a phase-out of bioenergy from electricity production by 2026. Considering this, and given sustainability concerns, Lithuania's economy-wide plan to phase out biofuel tax exemptions is a highly important policy that will ensure sustainable energy supply in the long term (for a more detailed analysis of emissions pricing for biofuels see Chapter 4).

Finally, renovation targets in Lithuania have not been met in the past. Inefficient heat consumption remains a serious problem, despite the high share of renewable energy sources in heat supply. To tackle energy efficiency deficits, a "fabric first" policy, as suggested at the EU level and implemented in Ireland, would ensure that the gains from fuel switching are not lost due to insufficient building standards.

Box 2.4. Good climate policy practices in the energy sector

Germany: ETS for heat

The German Climate Action Plan agreed upon in 2019 includes the introduction of a carbon pricing mechanism for transport and heating. The emissions trading scheme at first follows a fixed price trajectory, starting at 25 EUR/tCO_2 in 2021, and increasing annually to 55 EUR/tCO_2 in 2025. Following this initial phase, a price corridor will be implemented for a year (2026) keeping the price between 55 and 65 EUR/tCO_2. Whether this corridor should then be shut (moving to an entirely market driven price) will be decided in 2025.

The revenue generated by the scheme is to be used to reduce the current renewable energy surcharge on electricity prices and also to provide additional income relief for commuters disproportionately affected by the ETS.

Emissions-intensive industries will be compensated to safeguard competition and avoid carbon leakage, but under the condition that compensation payments are invested into energy efficiency. Biofuels are exempt so long as they comply with EU sustainability criteria.

For a more detailed analysis of the impact of an ETS for heat on the Lithuanian buildings sector see Chapters 3 and 4.

Denmark: offshore wind tenders

Denmark has very successfully scaled up its renewable energy generation. An electricity tax provides funding for extensive feed-in tariffs for renewable energy sources except for offshore wind which is supported through a tender process. The offshore wind tenders guarantee electricity offtake and grid connections and provide a one-stop shop for permitting and licensing, minimising administrative costs. The plummeting price of offshore wind generation has recently resulted in a contract for differences scheme providing "negative subsidies". The scheme guarantees the winners of each tender a minimum price. If the wholesale price rises above this, the operator pays back the difference to the government.

Ireland: fabric first principle

Ireland has implemented a fabric first guiding principle. Under this principle, renovation plans or policies must consider energy efficiency first, ensuring that the benefits of a subsequent switch to sustainable energy sources are not compromised by insufficient building standards. Regulation mandates that all new buildings meet near-zero energy standards, increasing their energy performance by 25%, with help also provided for phasing out gas and oil boilers in new housing construction. Major renovations (more than 25% of the floor space) are also required to meet minimum efficiency standards. Finally, as part of the "better energy communities" programme, the fabric first principle requires that energy efficiency investments be made before other grants can be approved.

Source: (OECD, 2019[30]; OECD, 2021[29]; IPAC, 2021[33]).

Industry

The NCCMA sets overarching emissions reduction targets for the industry sector, differentiating between installations covered by the EU ETS and those that are not. EU ETS installations are to reduce emissions by 50% by 2030 (compared with 2005 levels) and by 100% by 2050. For non-ETS installations, the NCCMA sets an emissions reduction target of 19% by 2030 (compared with 2005 levels).

The NCCMA further defines sectoral objectives such as a focus on the circular-/bioeconomy, reducing fluorinated greenhouse gases by 79% by 2030, enabling energy savings of 5.45 TWh in industries by 2030, and to generally deploy renewable energy sources wherever possible.

Multiple policies are detailed in the NECP addressing the industry sector concerning both the non-ETS sectors and ETS sectors. The measures detailed cover a number of issue areas, from the introduction of new technologies to the promotion of non-technological eco-innovation. The following subsections will take stock of these policies, detailing measures currently being implemented as well as planned additional measures with a view to assessing their adequacy in meeting the NCCMA's updated targets, and providing good-practice examples from other OECD countries for further policy reforms in the industry sector. The measures depicted are grouped by the type of measure, namely whether they are economic measures (subsidies, lump-sum payments, etc.), fiscal measures (taxes or tax-exemptions), regulatory measures, or complementary measures such as education or research and development (D'Arcangelo et al., 2022[8]). The NECP only details economic and complementary measures for the industry sector.

Existing measures

Economic measures

Existing economic measures for the industry sector promote the use of modern technologies, non-technological solutions, digitalisation, and energy efficiency. Economic support is provided to industrial companies for implementing energy efficiency measures following an energy efficiency audit, with the aim of saving 100 GW of energy a year from 2030.[3] Financial support is also provided for small and medium enterprises (SMEs) and start-ups or innovative businesses for applying new technologies for sustainability. The measure aims to modernise Lithuanian industry as well as incentivising innovation.

In addition to financial support for the energy efficiency measures and the use of modern technologies, targeted support for the deployment of renewable energy is also available. This includes both support for installing renewable energy production capacities, and for carrying out energy audits in industrial enterprises. For example, a measure provides financial assistance for ETS installations to switch from conventional fossil fuels to alternative fuels. The measure targets a 90% reduction in the use of conventional fuels. Support is also provided to the implementation and promotion of technological eco-innovation, with specific funds available for micro-, small- and medium-enterprises for measures such preventing pollution through technological modernisation, or reducing resource use through recycling, and further support offered to all companies for introducing environmentally friendly innovations.

Support is also provided for the application of non-technological solutions. This measure supports companies in finding innovative means to increase the attractiveness of products and services. The measure also aims to share knowledge on non-technological solutions such as resource efficiency, conservation of natural resources, eco-innovation and the like, financing expert advice in particular for SMEs.

A further measure promotes digitalisation in the industry sector, in particular micro-enterprises and SMEs. The measure offers financial instruments for technological audits, the results of which allow these enterprises to better assess the possibilities and prospects for digitalisation. The measure aims to accelerate the digitalisation process and increase productivity. Finally, companies can receive compensation for the implementation of energy efficiency measures, targeting annual savings of 100 GWh annually by 2030.

Fiscal measures

Existing fiscal measure for the industry sector comprise of tax incentives, provided to small enterprises and start-ups in order to promote innovation. These include a one year “tax-holiday”, the ability to deduct research and development costs from corporate income tax, and a preferential tax rate for the commercialisation of new technologies.

Regulatory measures

Existing regulatory measures in the industry sector focus specifically on the reduction of emission of fluorinated gases such as HFCs under the EU F-gases regulation (EU) No 517/2014. This comprises implementing the Kigali Amendment to the Montreal Protocol as well as further measures aiming to reduce the fluorinated gas emissions by two-thirds by 2030 (compared to 2014 levels), for example through banning the use of new equipment with high HFCs content.

Planned measures

Economic measures

There are a number of planned measures for the industry sector, both for installations covered by the ETS and those not. These measures provide financial support for replacing polluting technologies or fuels with more sustainable alternatives. Further planned measures support investments in tangible assets such as equipment with a lower environmental impact, investments in the innovation of cleaner production processes, the use of excess heat for energy production/heating, investments in materials and installation work with a lower environmental impact, and the improvement of products and services. This also includes support for the development and deployment of innovative digital and environmentally friendly technologies by SMEs, with priority given to circular products and production. Financial support is also available for companies to invest in product and service design solutions, for example for projects developing innovative packaging designs.

A number of planned measures aim to promote further digitalisation. Investment support will be provided to companies in the deployment of automated production processes. This includes support for technological audits. EU funding is also available for the establishment of European Innovation Hubs to encourage the development of digital competencies in areas such as high-performance computing and artificial intelligence.

Further planned measures target energy efficiency. For example, providing financial support to SMEs wishing to carry out technological audits for energy efficiency. There are also plans to subsidise energy efficiency in the ETS sectors, encouraging investments into the digitalisation, modernisation, optimisation, and automation of production processes in large and medium-sized manufacturing operations. Subsidies are also planned for the uptake of renewable energy sources in ETS installations as well as for SMEs not covered by the EU ETS.

Complementary measures

Two studies are planned in order to support decarbonisation efforts in the industry sector. First, an industry 4.0 lab will enable joint research and innovation in the areas of smart specialisation. The lab will be funded by European Innovation Hubs. Second, a feasibility study is planned, assessing the potential for the application of nascent technologies such as carbon capture and storage or hydrogen in Lithuania.

Assessment and recommendations

Existing and planned measures in the industry sector provide important incentives for decarbonisation. Modernising technologies and processes, and providing support for non-technological solutions, particularly in SMEs not covered by the ETS are important means to promote sustainability. In addition, the planned amendment to economy-wide excise duties will significantly increase the pressure to shift away from polluting fuels. However, the exemption of natural gas from this planned policy will significantly compromise potential emissions reductions in the industry sector (for more information see Chapters 3 and 4). Industry accounts for most of the natural gas use in Lithuania, and without price increases, few incentives exist to reduce the use of natural gas in the non-ETS sectors.

The price signal from the EU ETS could also be further strengthened through the introduction of a price floor, providing a transparent signal to investors and enterprises. Coupling such a price-floor with innovation support, as is the case in the Netherlands, would encourage research and development into solutions in hard-to-abate sectors (Box 2.5). Innovation support could be increased in Lithuania, focusing on providing funding for pilot projects that enhance knowledge accumulation and have potentially large knock-on effects (for an example of a similar scheme in Norway see Box 2.4). For a more detailed analysis of carbon pricing in the industry sector see Chapter 4.

Box 2.5. Good climate policy practices in the industry sector

Carbon pricing and innovation support in the Netherlands

In 2021, the Netherlands introduced a carbon price floor for the industry sector that complements the EU ETS price. The price floor started at 30 EUR/tCO_2, increasing annually to 125 EUR/tCO_2 in 2030. Enterprises pay a floating contribution on top of the EU ETS price in order to meet the price floor. If EU ETS prices rise above the annual floor price this contribution is zero.

In addition to the carbon price floor, a generous subsidy scheme provides investment support for innovation through public tenders based on technologies abatement costs. Such a two-pronged approach, combining strong price signals with generous innovation subsidies, ensures that decarbonisation efforts are not compromised by a lack of technological solutions in hard-to-abate sectors. Nonetheless, basing innovation support on abatement costs risks disadvantaging more radical ideas that are not yet cost-effective (e.g. green hydrogen).

Innovation support through state-owned enterprises in Norway

ENOVA in Norway is a state-owned enterprise that supports research and development for sustainability, providing investment aid and conditional loans. For example, ENOVA provided around 1/3 of the funding for a pilot aluminium plant validating new technological elements and control systems for more energy and climate efficient aluminium production. Supporting such a pilot project may lead to further innovations, having potentially important knock-on effects.

Source: (Dobrinevski and Jachnik, 2020[37]; Anderson et al., 2021[38]).

Agriculture and forestry (LULUCF)

The NCCMA sets an overarching emissions reduction target for the agriculture sector of 11% by 2030. It further targets an increase in the absorption capacity through the LULUCF sector, amounting to 6.5 million tCO_2e between 2021 and 2030. In order to achieve this, the NCCMA sets a number of sectoral objectives.

In the agriculture sector, the NCCMA targets a reduction in nitrogen-based fertiliser use by 15% compared with 2020 levels. It further proposes to, by 2030, increase sustainable management of manure and slurry to at least 70% of total stock, double the area of organic farming compared to 2020 levels, and to use 50% of pig and cattle manure for biofuels.

In the LULUCF sector, the NCCMA targets a 35% increase in forested area by 2024, increasing grassland areas by 8 000 ha and to use at least 10% of agricultural areas for biodiversity rich landscapes by 2030. It further proposes the restoration of 8 000 ha of wetlands by 2024, and to stop new wetland drainage and development. Finally, the NCCMA promotes sustainable resource management and consumption patterns, as well as other behavioural measures.

The NECP sets a number of climate policy measures, both for the agriculture and LULUCF sectors. The following subsections will take stock of these policies, detailing measures currently being implemented as well as planned additional measures with a view to assessing their adequacy in meeting the NCCMA's updated targets and providing good-practice examples from other OECD countries for further policy reforms in the agriculture and forestry sectors. The measures depicted are grouped by the type of measure, namely whether they are economic measures (subsidies, lump-sum payments, etc.), fiscal measures (taxes or tax-exemptions), regulatory measures, or complementary measures such as education or research and development (D'Arcangelo et al., 2022[8]).

Existing policies[4]

Economic measures

The NECP details a number of economic measures supporting an increase in the absorptive capacity of the LULUCF sector. Financial support is provided for the restoration of forest areas, with the aim of introducing or preserving 8 000 ha of new or existing forests annually. Funding is also available, promoting the farming of catch crops, providing 139 EUR/ha and aiming to cover almost 75 000 ha by 2027. This funding is part of the rural development plan submitted to the EU. Funding is also available through the Recovery and Resilience Facility for the restoration of peatlands, targeting 8 000 ha restored by 2026.

Finally, funding is available for the restoration of stands and shrubs, although this measure is to be discontinued due to low demand.

In the agriculture sector, one-off compensation is provided for the establishment of long-term climate commitments, such as reducing the area not using mineral nitrogen fertilisers. The measure is a priority area under the EU's common agricultural policy (CAP). Investment support is also available for implementing climate friendly livestock farming methods such as the use of manure for biogas production, and slurry as fertiliser.

Support is also available through the EU Modernization Fund for the use of non-till technologies, for example for the purchase of direct and belt seed drills. A further measure promotes the farming of perennial crops, targeting the conversion of 8 000 ha of plows into meadows by 2030. Funding is also available for promoting the optimisation of meadows and pastures by extending livestock grazing, reducing manure production in barns. Finally one-off compensation schemes under the CAP provide funding for experimental short-term climate commitments, such as the cultivation of plans using non-destructive technologies.

Fiscal measures

In the agriculture sector, the air-pollution tax for the livestock and poultry subsectors was increased, and preferential excise taxes for agricultural fuels decreased.

Regulatory measures

No regulatory measures have been implemented in the agriculture and forestry sectors.

Complementary measures

A regional project implemented by partners in Latvia, Lithuania, Estonia, Finland and Germany, establishes national indicators for changes in GHG emissions/carbon stock. These indicators demonstrate the potential for integrated GHG reductions and carbon sequestration in soil management programmes. The project also establishes a network for monitoring and evaluation of climate policy measures and for science-based land-use policy making and climate policy planning.

In the agriculture sector, measures provide education for farmers on good agricultural practices, disseminating knowledge and advice on environmentally friendly activities, and technological and operational solutions for GHG reductions. CAP funded measures further promote sustainable farming practices, such as a reduction in the use of mineral fertilisers, or soil-saving techniques and technologies. Finally, there is a measure in place promoting sustainable livestock and fishing practices with a priority focus on the dairy sector.

Planned policies

Economic measures

A number of economic policies are planned in the LULUCF sector. These include promoting the use of deforestation residues as woody biofuel mass. Reimbursement is also available for the costs of entering overgrown areas as forests into the national forest database, although future changes in the conditions for registering forest areas are likely to change. Funding is also available for replacing eroded land with meadows, increasing green cover on agricultural lands and for planting landscape elements on the edge of cultivated fields.

Fiscal measures

As part of the economy-wide amendment to excise duties, excise duty exemptions for the agriculture sector are to be reduced with the introduction of stricter tariffs on fuel use, and the introduction of quotas for excise exemptions.

Regulatory measures

Planned regulatory measures in the agriculture and forestry sector include the establishment of additional environmental criteria for public procurements, particularly promoting the use of timber and timber products in the construction sector. Finally, regulations will limit the use of mineral fertilisers, with an obligation on farms to provide data on fertiliser use. Following the development of a national methodology on fertiliser use, farms will be required to submit periodic plans on how to implement this.

Complementary measures

A number of studies, educational, and voluntary measures are planned in the agriculture sector. These include a feasibility study of the possibility of growing perennial plants on agricultural land, voluntary agreements with farms on growing meadows in organic soils and promoting their use, information campaigns promoting the modification of the composition of animal feeds to limit methane emissions, and a review of the available fuel for excise duty exemptions. Finally, the NCCMA also sets the objective of introducing a voluntary farm-level GHG accounting system by 2025.

Assessment and recommendations

The NECP sets out a number of important measures for the agriculture and forestry sector. In particular, economic support for expanding forested areas, restoring peatlands, and implementing sustainable farming practices is an invaluable tool for reducing agricultural emissions and increasing carbon sequestration. Extensive information campaigns are equally important and significantly increase understanding of the climate problem amongst stakeholders in the agriculture sector, as well as the acceptability of potential solutions.

The measures detailed above already present a comprehensive policy mix for the agriculture and forestry sectors. Implementing crosscutting measures targeting a just-transition would further avoid adverse distributional outcomes and enable more ambitious climate policy making in these sectors.

Excise duty exemptions remain high, and although quotas will be tightened through the proposed amendments, more ambition could be shown here. Moreover, fertiliser use and agricultural GHG emissions could be priced, either through a tax or ETS, in order to further reduce emissions. Here distributional concerns voiced by key stakeholders in the sector need to be taken into consideration. For example, livestock emissions have already been decreasing so a targeted pricing scheme would be needed to avoid overburdening certain activities. Moreover, any pricing scheme should be gradually introduced and trialled to gradually build capacity – the example of the New Zealand ETS provides a good blueprint here.

Finally, given limited cost-effective solutions, more investment is needed in the research and development of sustainable solutions in the agriculture sector. In Denmark, a scheme providing subsidies for abatement also funds research into sustainable farming practices.

Box 2.6. Good climate policy practices in the agriculture and forestry sector

Carbon pricing for agriculture: establishing an ETS in New Zealand

New Zealand is the first country planning to price carbon emission in the agriculture sector. Agricultural emissions make up approximately 50% of total GHG emissions in the country, consisting primarily of methane from ruminant livestock and fertiliser use. Following extensive consultations with stakeholders in the sector, New Zealand will begin integrating fertiliser production and imports into its national ETS from 2025. Livestock emissions will be priced separately through a farm-level levy or rebate system. This scheme is also set to enter into force in 2025, following a transition period starting in 2024 during which reporting of farm-level GHG emissions becomes mandatory. The implementation of this measure is still reliant on a feasibility study, with alternative options including the pricing of emissions at the processor, rather than farm level.

The forestry sector is already included in New Zealand's ETS, with voluntary registration of removal activities. Units are granted per tCO_2e removed from forests registered after 1990. Older forest landowners will receive one-off free allowances. If forests are harvested/removed or participants deregister, their units must be surrendered.

A comprehensive policy-mix in Ireland

Ireland has established a comprehensive framework for reducing emissions in the LULUCF sector. The framework targets net-zero emissions in the sector by 2050, aiming to reduce emissions, enhance the development of sustainable land-use practices, and contribute to sustainable energy. The framework includes measures for livestock farming, organic farming, tillage farming, land-use, forestry, and energy, as well as for cross cutting measures such as research and development, education, and a just-transition. Activities include enhancing breeding programmes, developing a charter of feed composition, incentives for the use of renewable energy sources and for promoting the role of agriculture in bioenergy production.

Supporting research and development in Denmark

The Danish climate and air proposal dedicates funding to the research and development of sustainable farming practices. This funding is part of a programme promoting carbon capture and storage through forests and farmland, as well as subsidies for the conversion of peatland areas under agricultural production into permanent nature reserves. These resources are particularly needed and welcome in light of the limited cost-effective solutions and lack of regulation for emissions reductions in the agricultural sector to date.

Source: (OECD, 2019[30]; Henderson et al., 2021[39]).

Notes

[1] As of 2 June 2022, electric vehicles are promoted through the EU Modernization Fund instead of the European Climate Change Programme. The Modernisation Fund currently provides EUR 50 million for the period 2022-2026 (EUR 35 million for private individuals and EUR 15 million for businesses). For private individuals, compensation is provided for the purchase of a new (up to six months, EUR 5 000) or used (up to four years, EUR 2 500) pure light electric vehicle. Legal entities and private individuals engaged in economic or commercial activities can apply for reimbursement for the purchase of a new

(up to six months, EUR 4 000) light pure electric vehicle. In order to ensure a unified and non-overlapping reimbursement for the purchase of pure EVs, an additional EUR 79 million is foreseen under the Recovery and Resilience Facility (RRF). A description of the financing modalities is currently under preparation. For legal entities and the public sector, compensation of EUR 4 000 is foreseen for the purchase of a new light pure electric vehicle and EUR 2 000 for the purchase of a used light pure electric vehicle for the public sector. Reimbursements are planned to start early in 2023.

[2] Nearly zero emissions buildings, as defined in the EU's Energy Performance of Buildings Directive, are buildings that have very high energy performance, with the low amount of energy still required to be largely covered by renewable sources. The proposed revisions to the directive, submitted in December 2021 as part of the Fit for 55 package, updates this standard to fully zero emissions buildings, where all required energy is met by renewable sources and no onsite carbon emissions from fossil fuels remain (European Commission, 2022[40]).

[3] Under Article 4(4) of the Energy Efficiency Improvement Law of the Republic of Lithuania, mandatory energy savings from 2021-2030 have been set, amounting to 27.279 TWh of final energy consumption. This includes obligations for energy efficiency improvements in the industrial sector of at least 5 456 GWh in the period specified.

[4] In addition to Lithuania's NECP the Common Agriculture Policy (CAP) Strategic Plan for Lithuania was adopted by the European Commission in November 2022. Policies under the CAP Strategic Plan are included in the updated NECP. This section covers both and therefor already includes some of the planned reforms for the NECP update.

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3

Choosing a policy mix to achieve carbon neutrality – a modelling exercise

This chapter reports on the results of modelling carried out to assess the socio-economic impacts of various policy mixes for achieving the 2030 GHG emissions reduction targets. The modelling compares two possible policy scenarios to a reference scenario that reflects the ambition of Lithuania’s current nationally determined contribution (NDC). Results show that the NDC is not ambitious enough to meet Lithuania’s targets, but that enhancing price signals, either through establishing a national carbon price, or through a second EU Emissions Trading System (EU ETS2), would make significant progress on reducing emissions. Results also show that the economic costs of these policies are minimal, indicating that even before accounting for climate damages and potential co-benefits, climate objectives can be reconciled with economic growth.

Against the background of increasing climate policy ambition at the EU level and domestically in Lithuania, it is necessary to assess the costs and benefits associated with reaching climate neutrality by 2050. The transition to a climate-neutral economy will require policy reforms, new public expenditure, and private investment across key economic sectors, in particular energy, transport, industry, and agriculture. Complementary policy actions will be necessary to facilitate the transition, mitigate potential negative effects and foster the economic opportunities offered by clean technologies.

This chapter reports on the results of a quantitative analysis using a computable general equilibrium (CGE) model applied to the Lithuanian economy to evaluate, under different scenarios, the impact of policies implemented in Lithuania, the EU, and the rest of the world to reach emissions reduction targets for 2030, with a view to meeting the Paris Agreement goal of climate neutrality by 2050. The scenarios modelled focus specifically on pricing initiatives, providing policy makers with important insights on their socio-economic impacts.[1]

By modelling current and planned policy scenarios, the model provides insights into the extent to which these policies suffice to reach 2030 emissions reduction targets and what the socio-economic impact of these policy pathways will be. These results are detailed in this chapter. Second, the model provides insights into long-term policy pathways that are consistent with climate neutrality by 2050. These results are detailed in Chapter 7.

To develop these decarbonisation pathways, the model considers the effect of planned policies in Lithuania and at the EU level relative to a baseline, or reference scenario.[2] The reference scenario consists of currently active policies globally, as detailed in Lithuania's NECP, the EU's 2030 climate and energy framework and Nationally Determined Contributions (NDCs) submitted by countries in the context of the Paris Agreement.

The model further considers two policy scenarios to 2030 based on planned policies in Lithuania and the EU that are not yet implemented, assuming all other countries remain at reference scenario levels of climate policy ambition.

- FIT55 scenario. Domestically, Lithuania implements the proposed excise duty amendment which includes the introduction of a carbon tax component for certain fuels/sectors (see section on economy-wide policies in Chapter 2). At the EU level, member states implement measures to meet the EU's 55% emissions reduction target by 2030, in particular through proposed reforms to the EU ETS and the European Tax Directive (ETD) as detailed in the Fit for 55 package (including for Lithuania), as well as through implementing a carbon price in non-ETS sectors to meet the EU's proposed targets (excluding Lithuania).
- ETS2 scenario. In addition to the reforms to the EU ETS and ETD modelled in the first scenario, the EU (including Lithuania) establishes a further ETS for the road transport and buildings sectors (also under discussion as part of the Fit for 55 package – see Chapter 2), replacing carbon prices for non-ETS sectors from the FIT55 scenario in other member states.

In addition to modelling climate policy trajectories to 2030, the model also considers the impact of the invasion of Ukraine by Russia and the response of governments globally. Specifically, it considers a scenario whereby a selection of OECD countries restrict imports of fossil fuels from Russia. Results are to 2030 and consider the impact of fossil fuel import restrictions both on the reference scenario, labelled Import Ban and the FIT55 scenario, labelled Import Ban+FIT55.

The table below summarises the scenarios modelled to 2030.

Table 3.1. Summary of policies included in scenarios to 2030

Scenario Name	Reference scenario policies: EU ETS 43% reduction (w.r.t 2005), Regional carbon prices consistent with NDCs, 2014 excise tax rates, Assumptions on electrification, renewable energy price trajectories and renewable energy preferences.	Lithuanian Excise Duty Amendment and Carbon Component	EU ETS ambition increase (61% reduction w.r.t. 2005)	ETD ambition increase	ETS II for transport and buildings	Non-ETS sector carbon price consistent with 43% reduction (w.r.t. 2005)(excluding Lithuania)	Russian fossil fuel import ban
reference	Yes	No	No	No	No	No	No
FIT55	Yes	Yes	Yes	Yes	No	Yes	No
ETS2	Yes	Yes	Yes	Yes	Yes	No	No
Import Ban	Yes	No	No	No	No	No	Yes
Import Ban + FIT55	Yes	Yes	Yes	Yes	No	Yes	Yes

The modelling results illustrate the impact of the transition to climate neutrality on:

- GDP and other main macroeconomic variables (i.e. employment, productivity, investment, welfare, debt trajectories);
- energy/climate-specific impacts such as energy consumption and GHG emissions;
- relocation of economic activity, including job reallocation across skills levels and sectors;
- public finance, including revenue and government expenditure;
- international competitiveness and trade flows.

Modelling pathways to net zero: General considerations for a policy mix for carbon neutrality

Achieving climate neutrality will require a broad climate policy mix including pricing initiatives, other economic incentives, regulatory reforms, and complementary policies such as education, infrastructure development, and behavioural demand-side policies (D'Arcangelo et al., 2022[1]). Such a policy mix should focus not only on reducing emissions to the extent necessary, but also on doing so at least cost to society. This includes ensuring economic cost effectiveness, but also a just transition minimising the impact on domestic firms and households wherever possible (OECD, 2021[2]).

Price signals are an imperative part of this climate policy toolbox, in particular as many countries still subsidise fossil fuel use, lacking market-based signals to reduce emissions. Removing such subsidies and implementing additional carbon pricing initiatives not only provides economic incentives for emissions reductions, but also promotes innovation in low-emissions technologies. As such, price signals address two of the primary externalities of the climate problem (OECD, 2021[2]). Carbon pricing is further considered a cost-effective mitigation option because pricing initiatives: 1) equalise marginal abatement costs across emitters, ensuring economy-, or (sub)sector-wide cost-effectiveness, depending on the scope of the pricing initiative and 2) decentralise abatement decisions, overcoming information asymmetries between governments and polluters exhibited in regulatory measures (OECD, 2018[3]).

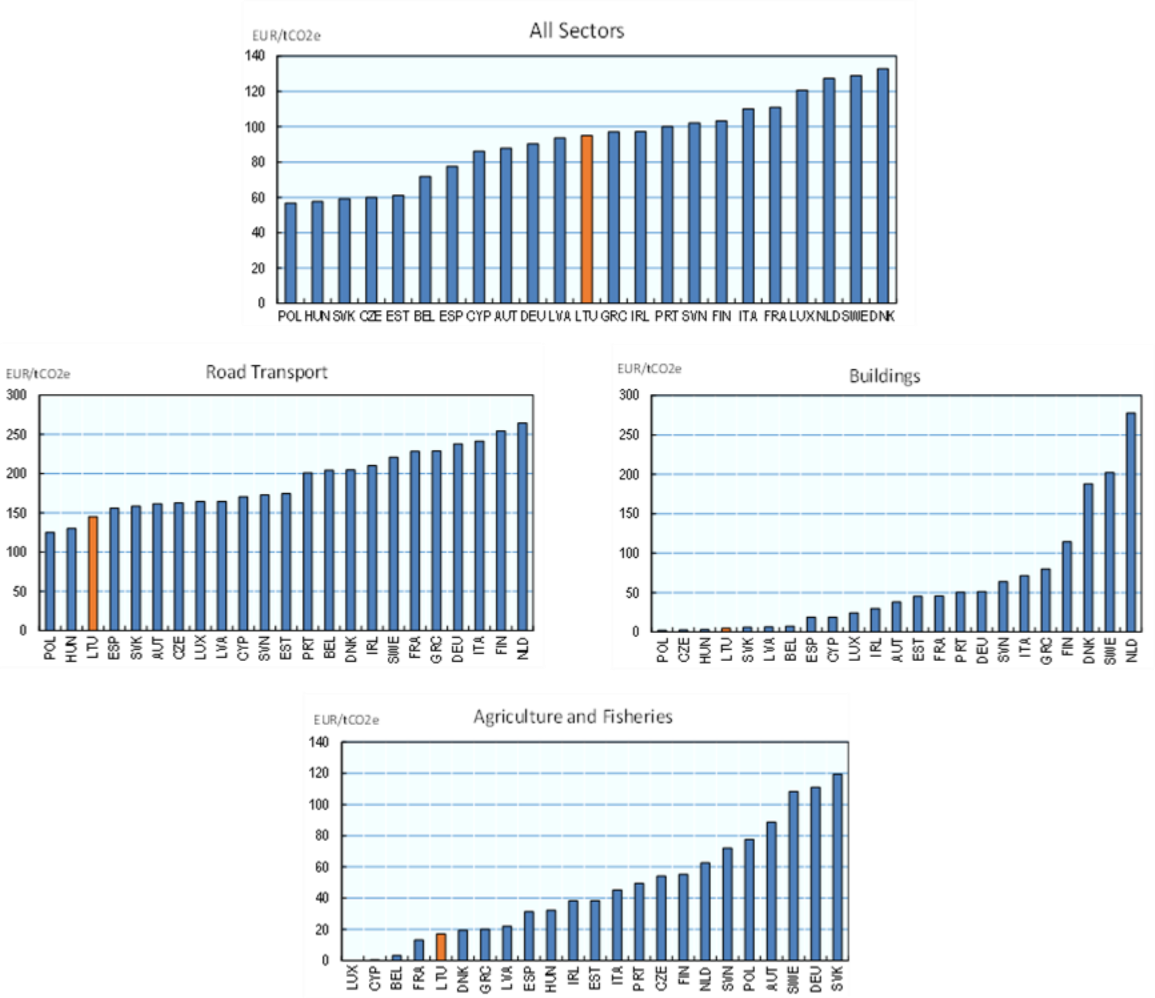
Existing carbon pricing initiatives have been shown to be effective at reducing emissions (Arlinghaus, 2015[4]; Martin, Muûls and Wagner, 2016[5]). Price signals are particularly effective where prior prices remain low, and therefore relative price increases are high (D'Arcangelo et al., 2022[6]). In addition to explicit carbon prices through carbon taxes and emissions trading systems, fuel excise taxes also send price signals regarding fuels use, and indirectly, CO_2 emissions as well. Together these three forms of explicit and implicit prices can be combined into an effective carbon rate (ECR) (see also Chapter 4) (OECD, 2018[3]). Although Lithuania's ECR across all economic sectors remains average amongst EU countries, the transport, buildings and agriculture and fisheries sectors in particular retain low price signals when compared with other EU countries (Figure 3.1). As such there remains scope for increasing prices, especially in these sectors.

Considering this, CGE models are particularly adept at modelling pricing initiatives and their socio-economic impacts over long timeframes. The CGE model employed for this chapter thus considers various price-based policy scenarios in Lithuania. The reference scenario concerns the current policy landscape, reflecting current excise duties on fossil fuels in Lithuania and carbon prices under the EU ETS. Two further scenarios (FIT55 and ETS2) expand on these, including planned reforms to pricing initiatives, both at the EU level under the Fit for 55 package, and domestically within Lithuania.

Beyond these scenarios, non-price-based policy options remain an imperative part of the policy mix for reaching climate neutrality. Chapter 2 of this report provides a more comprehensive stocktake of existing and planned policies in Lithuania and at the EU-Level, looking beyond the pricing initiatives depicted in this chapter. This include good-practice insights from other OECD countries, and recommendations for where the Lithuanian policy mix could be expanded, or reformed. These recommendations are further elaborated on in the concluding chapter of this report, taking into account both the output of the quantitative assessment of pricing initiatives depicted in this chapter, and more qualitative assessments of the broader policy mix throughout the rest of the report.

Figure 3.1. Lithuania's economy-wide effective carbon rate remains average amongst EU countries, but road transport, buildings, agriculture and fishery sectors retain amongst the lowest rates

Effective Carbon Rate (Emissions-Weighted Average), Across the EU, 2021



Note: CO_2 emissions from energy use, excluding biofuels.
Source: (OECD, 2021[7]).

Scenarios to 2030

Reference scenario

The reference scenario considers already existing policies as detailed in Lithuania's NECP, the EU's 2030 Climate and Energy Framework and the unconditional targets detailed in Nationally Determined Contributions (NDCs) submitted by countries to the UNFCCC for the rest of the world. To reach the NDC targets, it is assumed that all countries, excluding the EU and China, implement carbon prices both in ETS and non-ETS sectors. Carbon prices in the non-ETS sectors could be interpreted as an explicit representation of the costs of mitigation in the corresponding activities. Two exceptions are the EU and China, where carbon prices are imposed on ETS sectors only based on the current practices. The price trajectory for the EU ETS is calculated endogenously within the model, based on meeting the EU's 2030 target for ETS sectors under the climate and energy framework (-43% compared to 2005 levels). Table 3.2 below provides an overview of the carbon prices imposed under NDC scenario in 2030 across regions.

Table 3.2. Carbon prices under the NDCs in the reference scenario, \$2014/tCO_2

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
USA	0	0	0	0	0	0	0	0	2.2	4.4	6.6	8.7	10.9	13	15.1	17.2
CHN	0	0	0	0	0	0	0	0	9.5	10.5	11.6	12.9	14.3	15.8	17.5	19.3
RUS	0	0	0	0	0	0	0	0	1.2	1.9	2.6	3.4	4.1	4.8	5.5	6.2
LTU	8.5	6	6.9	19.8	29.5	30	44	57	69	82	95	107	120	132	145	157
X16	8.5	6	6.9	19.8	29.5	30	44	57	69	82	95	107	120	132	145	157
E10	8.5	6	6.9	19.8	29.5	30	44	57	69	82	95	107	120	132	145	157
XOE	0	0	0	0	0	0	0	0	23.2	28.6	33.9	39.3	44.7	50	55.4	60.7
XEC	0	0	0	0	0	0	0	0	1.3	2.7	4.1	5.5	6.9	8.3	9.7	11.1
HYA	0	0	0	0	0	0	0	0	3.9	9.2	14.5	19.7	25	30.7	36.5	42.2
XEA	0	0	0	0	0	0	0	0	2.5	4.5	6.5	8.5	10.5	12.4	14.4	16.3
SAS	0	0	0	0	0	0	0	0	1.4	2.4	3.4	4.5	5.5	6.4	7.3	8.2
MNA	0	0	0	0	0	0	0	0	3.1	5.6	8.1	10.5	13	15.1	17.1	19.2
LAC	0	0	0	0	0	0	0	0	1.9	3.7	5.5	7.4	9.2	10.9	12.6	14.3
SSA	0	0	0	0	0	0	0	0	0.6	1.1	1.6	2	2.5	2.9	3.3	3.7

Note: For all regions except EU and China, the reported carbon prices are imposed on all emitting activities. For the case of EU and China carbon prices are imposed on ETS sectors only. Regional construction:

USA	United States of America (USA)
CHN	China (CHN)
RUS	Russian Federation (RUS)
LTU	Lithuania (LTU)
X16	(EU-16+EFTA+Great Britain) Austria (AUT), Belgium (BEL), Cyprus (CYP), Denmark (DNK), Finland (FIN), France (FRA), Germany (DEU), Greece (GRC), Ireland (IRL), Italy (ITA), Luxembourg (LUX), Malta (MLT), Netherlands (NLD), Portugal (PRT), Spain (ESP), Sweden (SWE), United Kingdom (GBR), Switzerland (CHE), Norway (NOR), Rest of EFTA (XEF)
E10	(Transition economies w/o Lithuania) Czech Republic (CZE), Estonia (EST), Hungary (HUN), Latvia (LVA), Romania (ROU), Poland (POL), Slovakia (SVK), Slovenia (SVN), Bulgaria (BGR), Croatia (HRV)
XOE	(Other HIY OECD) Australia (AUS), New Zealand (NZL), Canada (CAN), Israel (ISR), Rest of the World (XTW)
XEC	(Rest of Europe and Central Asia) Albania (ALB), Belarus (BLR), Ukraine (UKR), Rest of Eastern Europe (XEE), Rest of Europe (XER), Kazakhstan (KAZ), Kyrgyzstan (KGZ), Tajikistan (TJK), Rest of Former Soviet Union (XSU), Armenia (ARM), Azerbaijan (AZE), Georgia (GEO), Turkey (TUR)
HYA	(High income Asia) Hong Kong (HKG), Japan (JPN), Korea (KOR), Taiwan (TWN), Singapore (SGP)
XEA	(Rest of East Asia) Mongolia (MNG), Rest of East Asia (XEA), Brunei Darussalam (BRN), Indonesia (IDN), Malaysia (MYS), Philippines (PHL), Thailand (THA), Viet Nam (VNM), Cambodia (KHM), Laos (LAO), Rest of Southeast Asia (XSE)
XSA	(Rest of South Asia) India (IND), Pakistan (PAK), Sri Lanka (LKA), Bangladesh (BGD), Nepal (NPL), Rest of South Asia (XSA)
MNA	(Middle East and North Africa) Bahrain (BHR), Iran (IRN), Jordan (JOR), Kuwait (KWT), Oman (OMN), Qatar (QAT), Saudi Arabia (SAU), United Arab Emirates (ARE), Rest of Western Asia (XWS), Egypt (EGY), Morocco (MAR), Tunisia (TUN), Rest of North Africa (XNF)
LAC	(Latin America & Caribbean) Mexico (MEX), Rest of North America (XNA), Argentina (ARG), Bolivia (BOL), Brazil (BRA), Chile (CHL), Colombia (COL), Ecuador (ECU), Paraguay (PRY), Peru (PER), Uruguay (URY), Venezuela (VEN), Costa Rica (CRI), Guatemala (GTM), Honduras (HND), Nicaragua (NIC), Panama (PAN), El Salvador (SLV), Rest of Central America (XCA), Rest of South America (XSM), Dominican Republic (DOM), Jamaica (JAM), Puerto Rico (PRI), Trinidad and Tobago (TTO), Rest of Caribbean (XCB), Rest of Oceania (XOC)
SSA	Sub-Saharan Africa) Benin (BEN), Burkina Faso (BFA), Guinea (GIN), Senegal (SEN), Togo (TGO), Rest of Western Africa (XWF), Central Africa (XCF), South-Central Africa (XAC), Ethiopia (ETH), Madagascar (MDG), Malawi (MWI), Mauritius (MUS), Mozambique (MOZ), Rwanda (RWA), Tanzania (TZA), Uganda (UGA), Zambia (ZMB), Rest of Eastern Africa (XEC), Rest of South African Customs Union (XSC), Cameroon (CMR), Côte d'Ivoire (CIV), Ghana (GHA), Nigeria (NGA), Kenya (KEN), Zimbabwe (ZWE), Botswana (BWA), Namibia (NAM), South Africa (ZAF).

Excise taxes across fuels and uses are held fixed at the base year level (2014 - in ad valorem equivalent). A comparison of the petroleum excise taxes for 2014 (base-year) and currently observed 2022 gasoline prices shows that EU-average excise tax rates in both years equal to around 25%.

In addition to the above detailed price-based policies, a number of key policies detailed in Lithuania's NECP, the EU's climate and energy framework, and the NDCs, are already being implemented, including (for a more comprehensive stocktake of existing policies see Chapter 2):

- At the domestic level in Lithuania, as detailed in the current NECP
  - Support for EV purchases and the development of charging infrastructure
  - Support for RE deployment through auction schemes and feed-in tariffs
  - Support for energy efficiency retrofitting and renovation of public and private buildings
- At the EU level, as detailed in the EU's Climate and Energy Framework
  - Multiple regulatory initiatives at the EU level, including, for example, targets for renewable energy deployment under the renewable energy directive (RED) or fuel efficiency standards under the energy efficiency directive (EED).

The CGE model used cannot explicitly include such non-price-based policies. However, in order to account for their effect, they are reflected in the reference scenario's policy assumptions. Specifically, this includes three key assumptions:

- First, the reference scenario assumes autonomous electrification throughout sectors, including, for example, an increase in the share of electric vehicles and the switch from gas-based cooking to electric stoves. This is in line with historical trends.
- Second, the reference scenario assumes continuing decreases in the price of renewable energy technologies, following historical trends.
- Finally, in the reference scenario, an autonomous non-price shift towards renewable energy supply is exogenously applied. In particular, in the case of Lithuania, assumptions regarding the development of solar and wind power generation capacity until 2030 are based on data provided by the Lithuanian Energy Agency, with the broader energy mix development until 2030 calibrated to the Lithuanian Energy Agency's projections.

The discussed reference scenario is broadly consistent with the EU's first NDC commitment (reducing GHG emissions by 43% by 2030 compared to 1990's levels). For more information on the specific assumptions employed in the model, see Annex A.

Planned policy scenarios: FIT55 and ETS2

The model implements two further policy scenarios, the FIT55 and ETS2 scenarios, reflecting planned policies in Lithuania and the EU. Rest of the world climate ambition is assumed to remain at reference scenario levels.

These two scenarios were chosen to reflect 1) a scenario that provides leeway to member-states in determining the policy mix needed to reach the EU's stated targets, and whether the policies proposed in Lithuania suffice in this regard (FIT55), and 2) a scenario where an EU-wide policy approach is taken (ETS2). Under both scenarios, all revenues generated through carbon pricing are recycled back to households through lump-sum transfers.

Both scenarios include the following common components. The first concerns a planned amendment to domestic excise duties in Lithuania that includes a carbon price component. The planned amendment has been submitted to parliament and remains subject to parliamentary approval. It proposes a gradual increase in excise duties for all sectors and fuels from 2023-2024 (Table 3.3). The proposed changes notably phase-out various exemptions for certain fuels in certain sectors, although the agricultural sector remains broadly exempt from these (see Chapter 2 for more detail). In addition to the staggered increase in excise duties, the proposal suggests implementing a carbon price component from 2025, based on the carbon content of different fuels. The carbon price would start at 10 EUR/tCO$_2$e in 2025 and steadily rise to 60 EUR/tCO$_2$e in 2030 (Table 3.4). Installations covered by the EU ETS are exempt from this carbon component.

Table 3.3. Proposed excise duty amendment in Lithuania

Energy products		Current rates of excise duty	Excise duty rates from 01/01/2023	Excise duty rates from 01/01/2024	Excise duty rates from 01/01/2025
Gas oils, energy products[1] and liquid fuels (fuel oils) not intended for heating[2], EUR / 1 000 l		372	410	466	500
Gas oils for heating purposes (domestic heating fuels, energy products and liquid fuels (fuel oils))[3], EUR / 1 000 l		21.14	140	372	372
Gas oils used in agriculture (including aquaculture or commercial fishing in inland waters), EUR / 1 000 l		60	60 (restriction - used in agricultural machinery (including tractors), engines of fishing vessels)	60 (limit - 100 thousand litres of fuel)	60 (limit - 50 thousand litres of fuel)
Petroleum gases and gaseous hydrocarbons for domestic use, EUR / t		0	304.1	304.1	304.1
Coal, EUR / t	Not for business use	7.53	7.53	15	30
	For business purposes	3.77	7.53	15	30
Peat for heating, EUR / t		0	10	20	20
Coke and lignite, EUR / t	Not for business use	8.98	8.98	15	30
	For business purposes	4.63	8.98	15	30
Natural gas supplied to household natural gas consumers and beneficiaries, EUR / MWh		0	0	0	0.50
Natural gas used as heating fuel other than for commercial purposes, EUR / MWh		1.08	1.08	1.08	1.50
Natural gas used as heating fuel for commercial purposes, EUR / MWh		0.54	0.54	0.54	1

Note: 1) falling within subheadings 2710 19 91 to 2710 19 99 of the CN, 2) referred to in Article 38 (2) of the Law on Excise Duties, 3) falling within CN codes 2710 19 91 to 2710 19 99.
Source: Government of Lithuania.

Table 3.4. Proposed carbon tax in Lithuania

Energy products	2025	2026	2027	2028	2029	2030
CO_2 component, EUR / CO_2 t	10	20	30	40	50	60
Petrol, EUR / 1 000 l	24	48	72	96	120	144
Kerosene, EUR / 1 000 l	27.1	54.2	81.3	108.4	135.5	162.6
Gas oils[1] and liquid fuels[2], EUR / 1 000 l	26.2	52.4	78.6	104.8	131	157.2
Liquid fuel (fuel oil)[3], EUR / t	31.2	62.4	93.6	124.8	156	187.2
Petroleum gases and gaseous hydrocarbons (excluding natural gas), EUR / t	30.6	61.2	91.8	122.4	153	183.6
Coal, EUR / t	21.8	43.6	65.4	87.2	109	130.8
Coke and lignite, EUR / t	32	64	96	128	160	192
Peat for heating, EUR / t	16.6	33.2	49.8	66.4	83	99.6

Note: 1) referred to in Article 37 (1) and (2) of the Law on excise duties, CN Subheadings 2710 19 91 to 2710 19 99 classified energy products, 2) referred to in Article 38 (2) of the Law on Excise Duties, 3) referred to in Article 38 (1) of the Law on Excise Duties.
Source: Government of Lithuania.

The second component of both the FIT55 and ETS2 scenarios concerns proposals under the EU's Fit for 55 package. Specifically, they consider the European Commission's proposed reform of the ETD and EU ETS legislations, incorporating new minimum tax rates from the ETD for an overview of these, see Table 3.5), and increasing the EU ETS emissions reduction target to -61% by 2030 (compared with 2005 levels). The minimum rates under the ETD only apply if the new tax rates under the proposed Lithuanian Excise Duty Amendment remain lower than the minimum rates. The EU ETS price trajectory is again determined endogenously, based on a least-cost pathway to meeting the updated emissions reduction target.

Table 3.5. Minimum taxation rates under the EU Energy Taxation Directive

Fuel	Minimum levels of taxation applicable to motor fuels for the purposes of Article 7 (EUR/GJ)	Minimum levels of taxation applicable to motor fuels used for the purpose set out in Article 8(2)[1] (EUR/GJ)	Minimum levels of taxation applicable to heating fuels (EUR/GJ)	Minimum levels of taxation applicable to electricity (EUR/GJ)
Petrol	10.75	0.9	-	-
Gasoil	10.75	0.9	0.9	-
Kerosene	10.75	0.9	0.9	-
Non-sustainable biofuels	10.75	0.9	-	-
LPG; Natural Gas; Non-sustainable biogas; Non-renewable fuels of non-biological origin	7.17	0.6	0.6	-
Sustainable food and feed crop biofuels and biogas	5.38	0.45	0.45	-
Sustainable biofuels	5.38	0.45	-	-
Sustainable biogas	5.38	0.45	0.45	-
Low-carbon fuels; renewable fuels of non-biological origin; advanced sustainable biofuels and biogas	0.15	0.15	0.15	-
Heavy fuel oil; coal and coke; non-sustainable bioliquids; non-sustainable solid products falling within CN codes 4401 and 4402	-	-	0.9	-
Sustainable food and feed crop bioliquids; sustainable bioliquids; sustainable solid products falling within CN codes 4401 and 4402	-	-	0.45	-
Electricity	-	-	-	0.15

Note: 1) Article 8(2) applies to motor fuels used for the following purposes: (a) agricultural, horticultural or aquaculture works, and in forestry; (b) stationary motors; (c) plant and machinery used in construction, civil engineering and public works; (d) vehicles intended for use off the public roadway or which have not been granted authorisation for use mainly on the public roadway.

Beyond these two common components, the two scenarios differ in their treatment of policies for non-ETS sectors (for an overview of scenario components see Table 3.1 above).

FIT55

Under the FIT55 scenario, the model assumes that all EU countries (except Lithuania) implement concurrent policies to meet the EU's climate targets. In order to model this, a carbon price consistent with the EU's 43% emissions reduction target by 2030 (compared with 2005 levels) for non-ETS sectors is implemented in all countries barring Lithuania.

ETS2

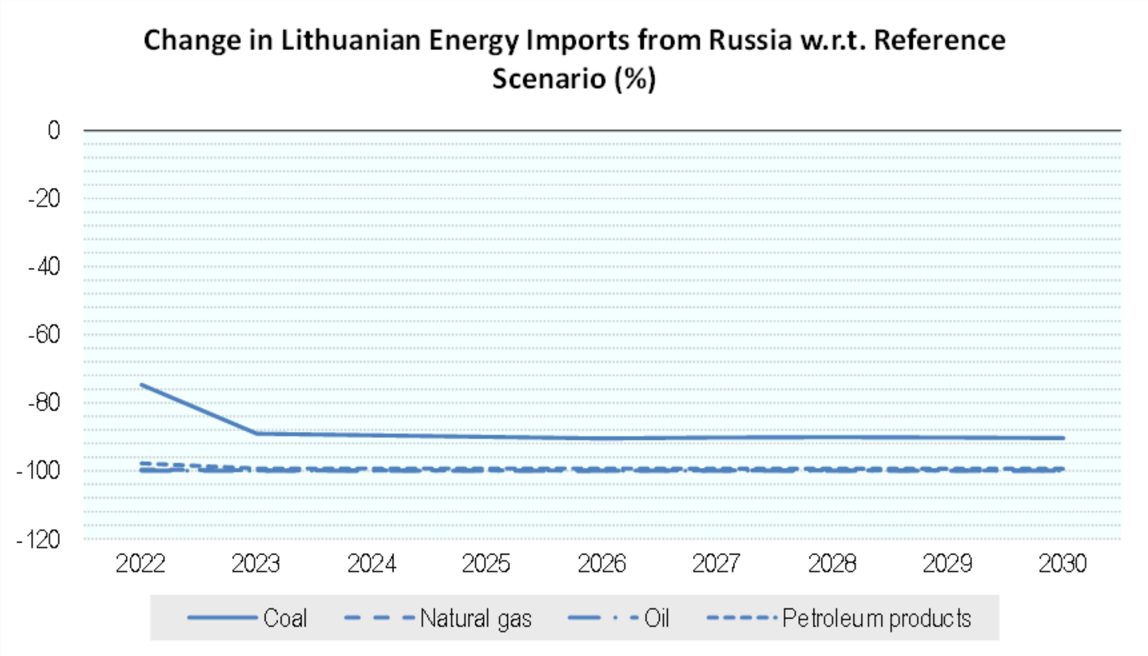
The ETS2 scenario includes the same policies as under the FIT55 scenario, but also introduces an EU-wide (including Lithuania) ETS for the road transport and buildings sectors (additional to the EU ETS), or ETS II. This replaces the non-ETS sector carbon prices in other EU countries implemented in the FIT55 scenario. As part of the proposed Fit for 55 package, the European Commission has suggested the establishment of an emissions trading scheme for the buildings and road transport sectors in addition to the current EU ETS (Chapter 2). Specific details on how such an ETS II could be structured remain under discussion. However, given the centrality of the transport sector to Lithuanian emissions reduction efforts, an ETS for the road transport sector would have significant implications for Lithuania's climate policy pathways.

The ETS2 scenario assumes that an EU-wide ETS covering the road transport and buildings sectors comes into effect from 2025, with the goal of reducing emissions in the sector by 43% by 2030 (compared with 2005 levels), as per the proposal for an ETS II in the Fit-for 55 package. The carbon tax component of the Lithuanian Excise Duty Amendment for fuels in the road transport and buildings sectors would be replaced by the ETS II under this scenario.

Restriction on the imports of Russian fossil fuels

In addition to the reference, FIT55 and ETS2 scenarios detailed above, the model will also take into consideration the impacts of proposed and discussed restrictions on Russian fossil fuel exports imposed by OECD countries in response to Russia's invasion of Ukraine. Under the Import Ban and Import Ban+FIT55 scenarios, countries/regions imposing a ban on Russian energy exports include Lithuania[3], the EU, EFTA and UK, as well as other high-income OECD countries such as Australia, New Zealand, Canada, Israel (for more information see Annex A). Restrictions are imposed on the imports of all fossil fuels, including coal, oil, gas and petroleum products[4], and are implemented via imposition of the import taxes following an approach introduced in Chepeliev et al. (Chepeliev, Hertel and Mensbrugghe, 2022[8]). The Import Ban scenario applies the detailed restrictions to the reference scenario. The Import Ban+FIT55 scenario applies them to the FIT55 scenario, providing an indication of the effect of such a ban on carbon prices needed to meet the EU's 55% emissions reduction target (Figure 3.2) below shows the level of import restrictions introduced by Lithuania relative to the reference NDC scenario. Restrictions are introduced starting from 2022 and are implemented until the end of the analysed period. Starting from 2023 weighted average reductions in fossil fuel imports from Russian by Lithuania exceed 99%.

Figure 3.2. Under the Russian fossil fuel embargo scenario Lithuanian imports of Russian fossil fuels would reduce almost entirely



Results to 2030

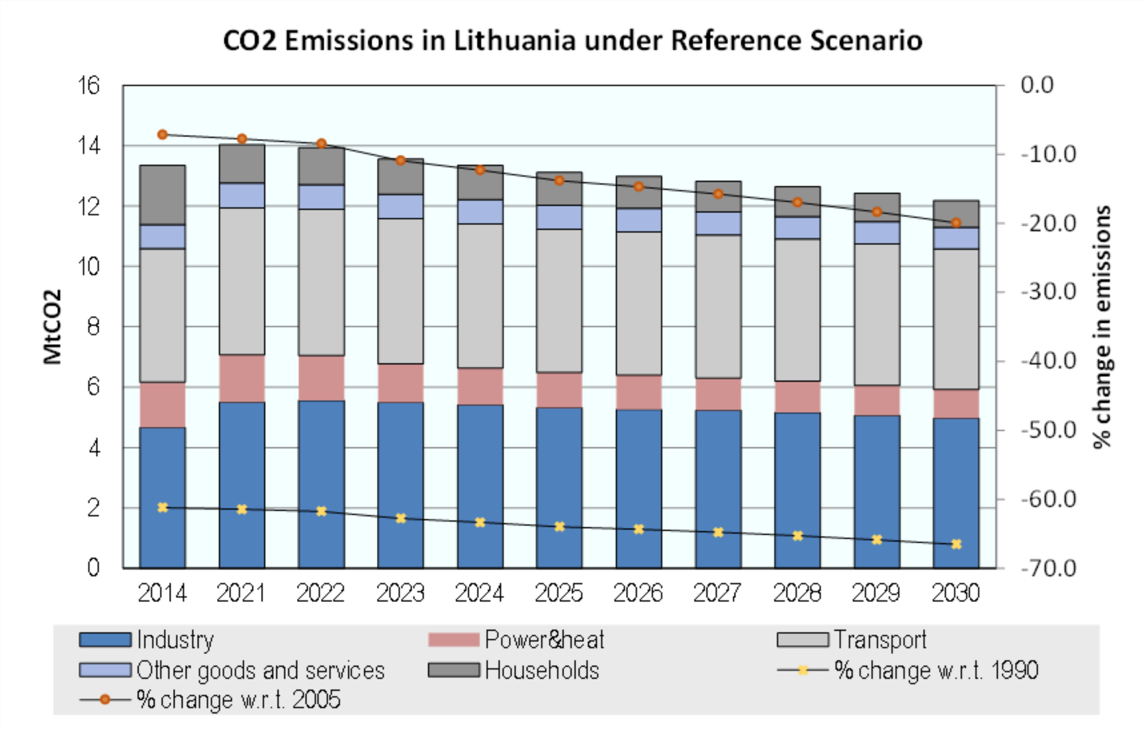
The following sections detail the model results to 2030. All results depicted are specifically for Lithuania, unless otherwise stated.

Reference scenario results

CO_2 emissions

Under the reference scenario, CO_2 emissions in Lithuania decline significantly, almost 20% w.r.t. 2005 levels, or 66.5% w.r.t. 1990 levels (Figure 3.3). This reflects the EU's achievement of its previous emissions reduction target of 40% by 2030 (w.r.t. 1990 levels), and broader implementation of targets set out in the NDCs. The emissions reductions here are for CO_2 only and do not include other greenhouse gases (GHG).[5] As such, emissions reduction levels provided by the model are not directly comparable with Lithuania's GHG emissions reduction targets depicted in Chapter 2. CO_2 emissions from power and heat decline most significantly, with emissions from households and services also declining. By contrast, emissions from industry and transport remain stable, indicating further policy measures may be required in these sectors (Figure 3.3).

Figure 3.3. CO_2 emissions in Lithuania decline under the reference scenario, but transport and industry emissions remain high

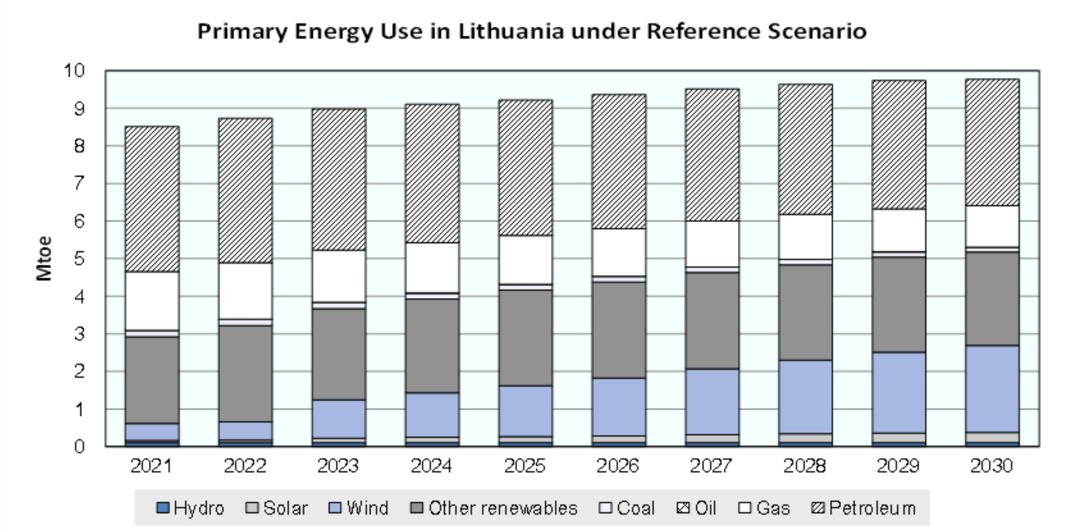


ETS and Non-ETS CO_2 emissions remain equally important, making up around half of total emissions in Lithuania under the reference scenario to 2030. CO_2 emissions in the ETS sector, however, decrease more quickly than those in non-ETS sectors. Importantly, transport sectors emissions make up more than half of non-ETS sector emissions in Lithuania under the reference scenario to 2030.

Energy use and power generation

Under the reference scenario, overall primary energy demand increases by 1.5% per year between 2021-2030. This demand is met through growing renewable energy generation, particularly wind and solar, also making up for a decline in the use of refined oil and gas (Figure 3.4).

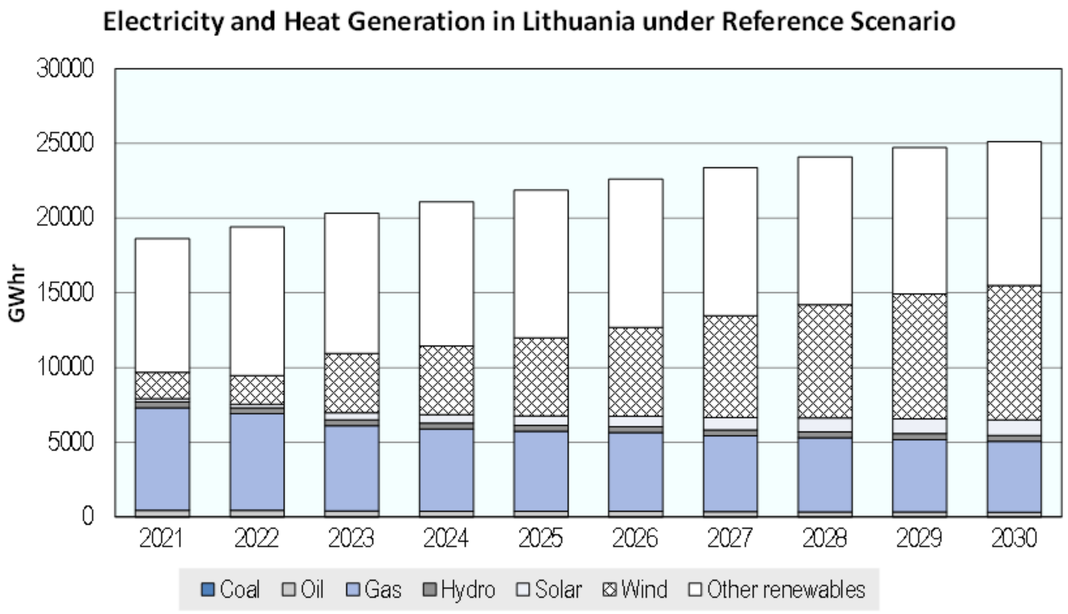
Figure 3.4. Under the reference scenario, primary energy use in Lithuania increases, with particular use of wind energy growing considerably



Note: The other renewables category refers to other renewable energy sources such as hydropower and bioenergy. In the case of Lithuania this comprises primarily biomass.

Domestic electricity and heat generation also grows, at a rate of around 3.4% per year from 2021-2030, contributing to increasing energy security. Solar and wind generation grow at 18% and 20% respectively, with biomass (presented in the figures as “other renewables”) also growing, albeit more slowly (biomass already constituted a major share, particularly of heat generation, in 2021). Gas use for heat and electricity generation declines considerably, at around 4% per year, reflecting increasing costs due to imposed carbon prices and also the increasing competitiveness of renewable energy sources.

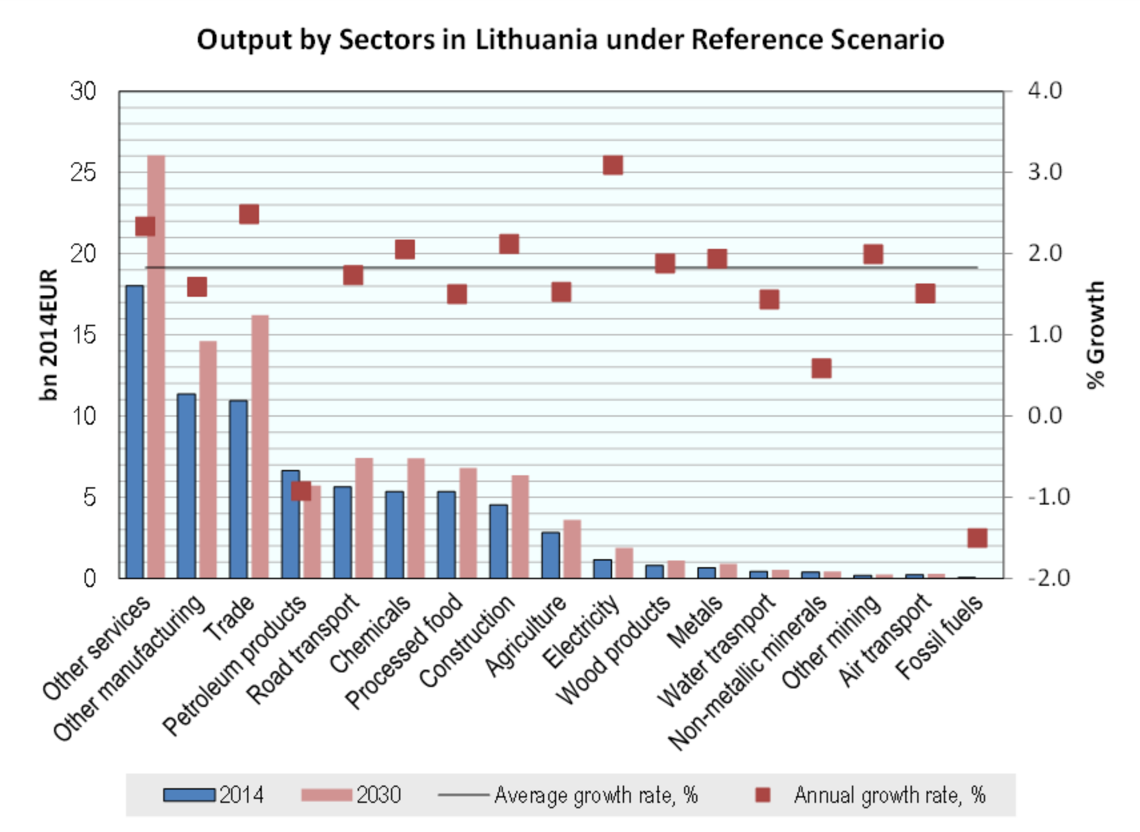
Figure 3.5. Overall electricity and heat generation increases in Lithuania under the reference scenario, driven by large growth in renewables



Economic output

Under the reference scenario, all sectors except petroleum products and fossil fuels are projected to continue growing. The electricity sector is projected to grow fastest, at 3.1 % (compared to 1.8% on average). This is driven by the climate policies enacted under the reference scenario such as the EU ETS, autonomous electrification trend and renewable energy preference. By contrast, the petroleum product and fossil fuel sectors contract due to reduced demand for fossil fuels under the reference scenario. The services, trade, chemicals, and construction sectors also grow at above average rates (Figure 3.6).

Figure 3.6. Output in non-fossil fuel sectors will continue to grow, with particularly energy generation growing above average

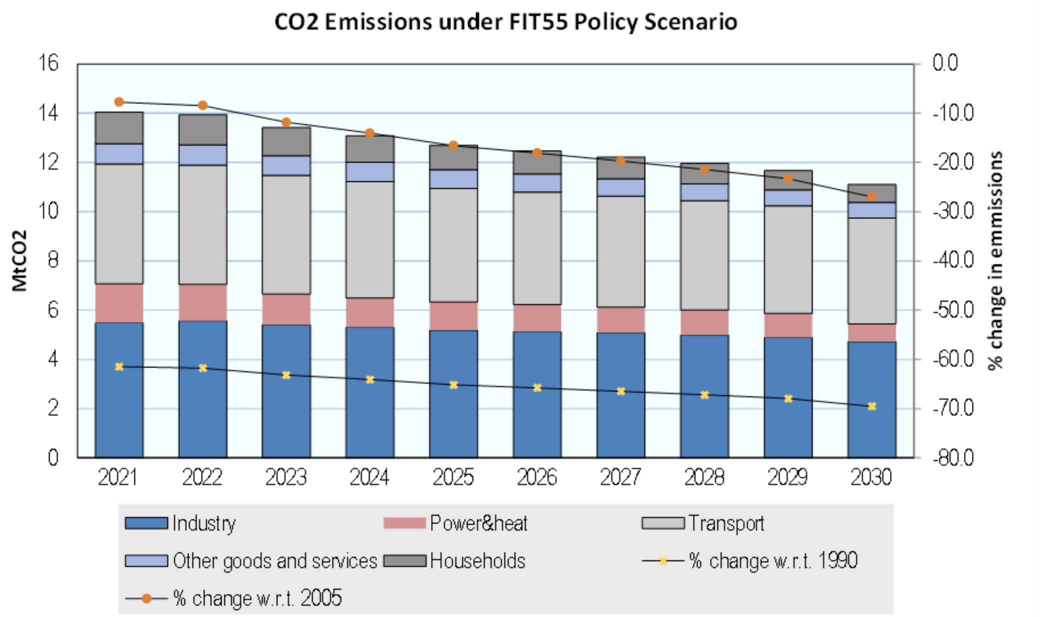


Planned policies results under the FIT55 and ETS2 scenarios

CO₂ emissions

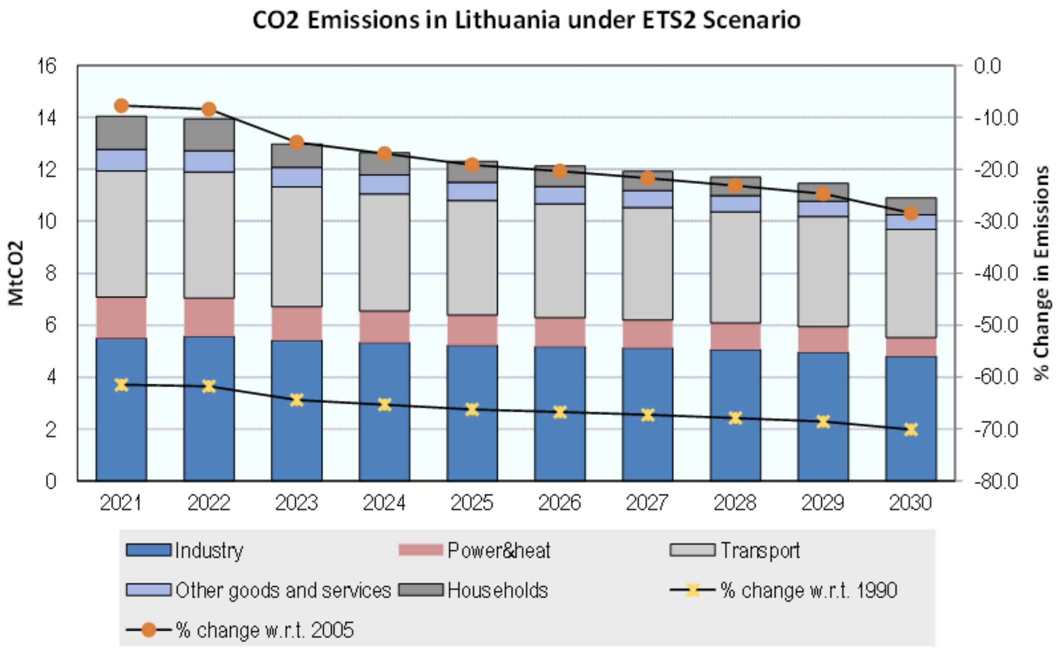
Both scenarios exhibit substantial further emissions cuts in Lithuania with respect to the reference scenario. In the FIT55 scenario, 2030 emissions fall by 27% compared with 2005 levels, 7.1% more than under reference. This indicates that the combination of the increased ambition of the EU ETS and the implementation of the proposed Lithuanian Excise Tax Amendment and carbon price component has a considerable effect on emissions levels. Transport emissions in particular decrease substantially more than in the reference scenario. Industry emissions, however, remain relatively stable, as the excise amendment does not include natural gas and process emissions are not priced in the model.

Figure 3.7. The Lithuanian Excise Tax Amendment, coupled with increasing ambition in the EU ETS, would have a considerable downward effect on emissions



The ETS2 scenario further decreases emissions as carbon prices in the road-transport and buildings sectors increase when compared to the Lithuanian Excise Tax Amendment. Under this scenario, emissions in 2030 fall by 28.5% compared to 2005 levels, 8.5% more than in the reference scenario. In particular, emissions reductions by households and in the transport sector decrease more than in the FIT55 scenario due to higher prices in the ETS2. Industry emissions, as with the FIT55 scenario, remain stable due to the aforementioned limitations in the pricing policies and the model's scope.

Figure 3.8. The implementation of an ETS2 for the transport and buildings sector would lead to considerable emissions reductions by 2030



Carbon price trajectories

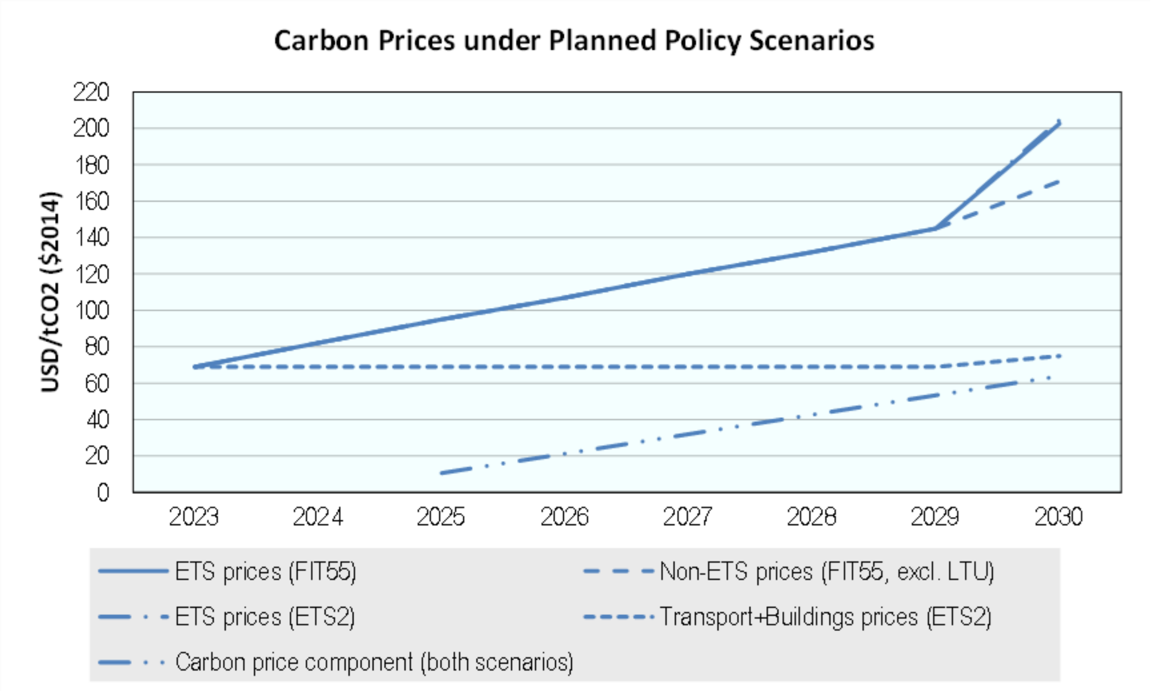
In order to reflect planned increases in policy ambition, the two scenarios considering planned policies both implement carbon prices or indirect excise tax increases in addition to those depicted in the reference scenario (see previous section). Both the FIT55 and ETS2 scenarios increase the ambition of the EU ETS to reflect the proposal of the Fit for 55 package, setting an emissions reduction target in EU ETS sectors of 61%. As a result, EU ETS prices in both scenarios follow the same trajectory, starting at 69 USD/tCO$_2$ in 2023 and steadily increasing to 204.5 USD/tCO$_2$ in 2030. This is almost 50 USD/tCO$_2$ more than the EU ETS price in the reference scenario.

The scenarios differ, however, in their treatment of non-ETS sectors. Here the FIT55 scenario applies a carbon price trajectory to non-ETS sectors, compatible with reaching the 43% emissions reduction target proposed by the EU's Fit for 55 package. The resulting price trajectory follows that of the EU ETS, which is consistent with the least cost emissions reduction approach, while the 2030 carbon price is endogenously determined to achieve the pre-specified emissions reduction target for non-ETS sectors (- 43%), resulting in a price level of 170.9 USD/tCO$_2$ for non-ETS sector in 2030. This provides an indication of non-ETS prices necessary to meet the EU's targets.[6]

By contrast, the ETS2 scenario restricts its non-ETS carbon price to the road transport and buildings sectors only, again targeting a 43% emissions reduction in these. With these two sectors making up more than 70% of Non-ETS CO$_2$ emissions in Lithuania between 2022-2030 under reference scenario, targeting these sectors specifically is integral to reducing emissions.

Resulting carbon prices are flat at 69 USD/tCO$_2$, rising only slightly, to around 75 USD/tCO$_2$, in 2030. The reason for this decidedly lower price trajectory for the ETS2 than for non-ETS sectors in the FIT55 scenario is that the reference scenario assumptions already include quite ambitious climate policies for the road transportation and buildings sectors (e.g. the autonomous electrification assumption and renewable energy preferences). This is further compounded by the fact that the model cannot price certain GHG emissions sources such as process-based CO$_2$ emission in the industry sector, or non-CO$_2$ emissions in Industry and Agriculture. As such, reaching the 43% emissions reduction target for all non-ETS sectors in the FIT55 scenario requires substantially higher prices than when focusing only on road transport and buildings. Considering this, results are not comparable with other modelling of the EU ETSII proposal[7] as these assume a business-as-usual reference scenario.

Figure 3.9. Carbon prices needed to meet EU ETS and non-ETS targets are substantial but current policies under reference scenario assumptions help reduce prices for ETS2

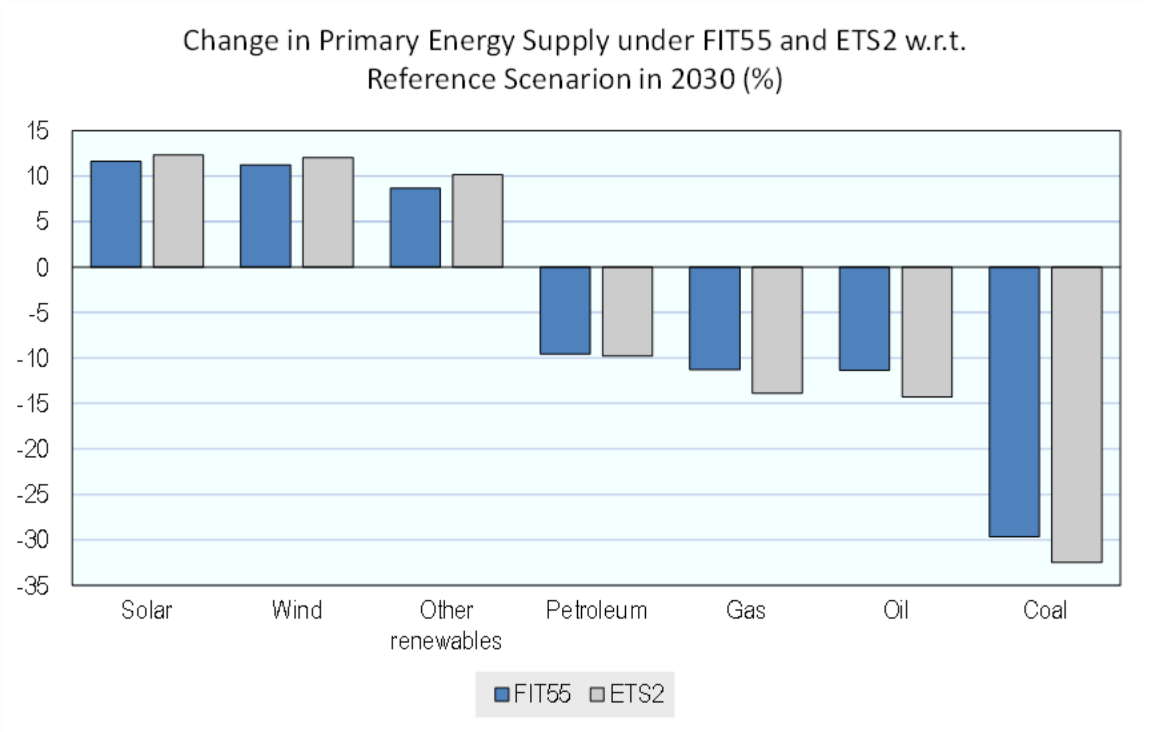


Note: Carbon prices here are only applied to CO_2 emissions, but reduction targets are for all GHG, thus prices may be somewhat inflated. The model also does not consider emissions removals from LULUCF and is unable to price process-based CO_2 emissions. This also contributes to higher prices. Finally, prices seen are relative to the reference scenario which already includes substantial climate action as detailed in the NDCs, thus results are not comparable with those relative to a no-policy baseline.

Energy use and supply and electricity and heat generation

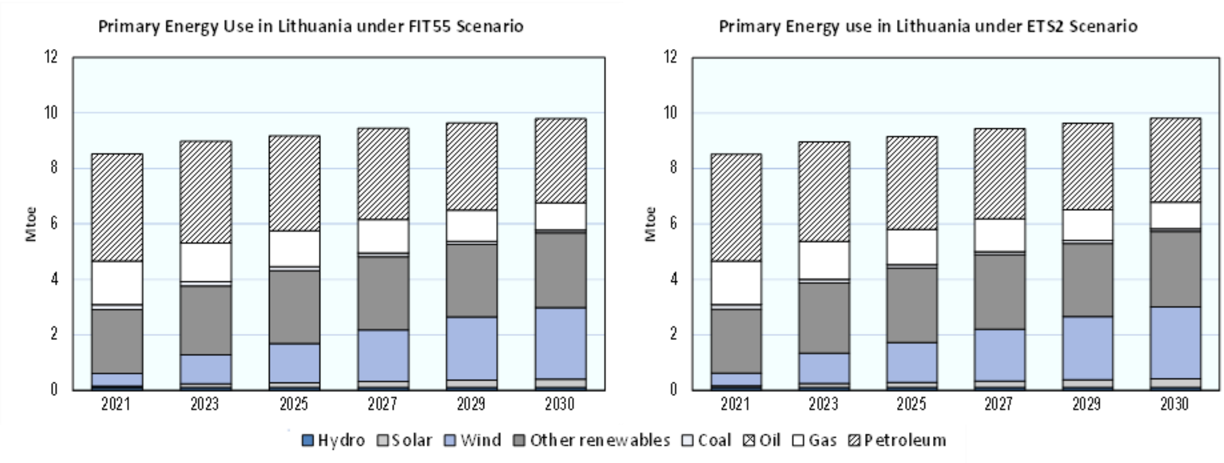
Both FIT55 and ETS2 scenarios exhibit a further shift away from fossil fuels to renewable energy. Compared with the reference scenario, petroleum product use decreases around 10%, with energy supply from gas and oil decreasing a little more (between 10-15%) particularly in the ETS2 scenario. Energy supply from solar, wind and biomass increases in both scenarios by around 10%.

Figure 3.10. Under both FIT55 and ETS2 scenarios fossil fuel supply decreases considerably and is replaced by renewable energy sources



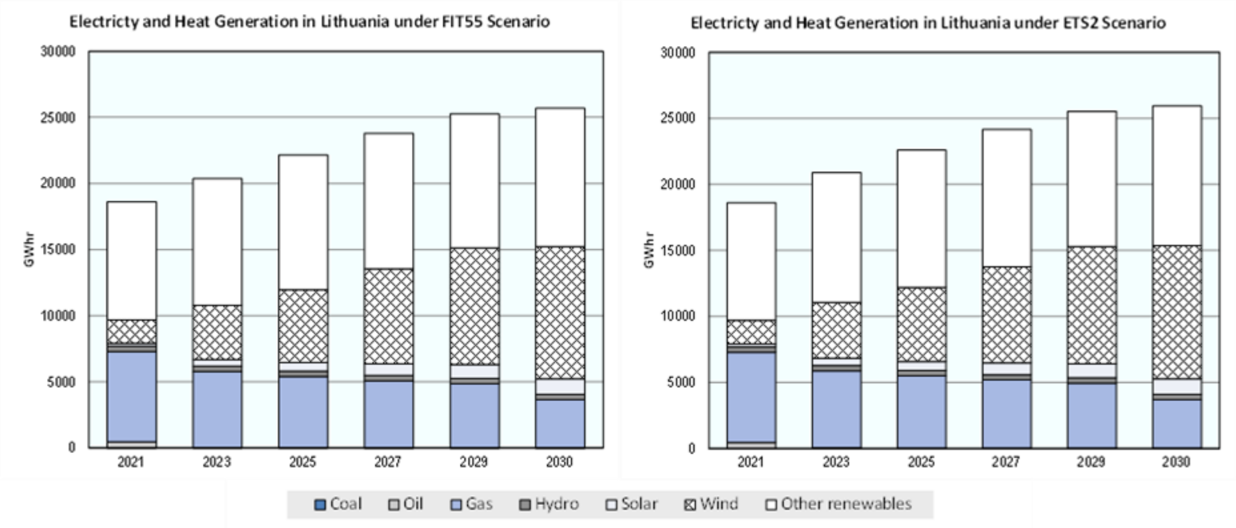
The primary difference between the two scenarios regarding energy use lies in the use of natural gas. Under the proposed Lithuanian Excise Duty Amendment modelled by the FIT55 scenario, natural gas is exempt from the carbon pricing component, whereas it is included in the ETS2 (primarily in the buildings sector). As a result, the ETS2 decreases natural gas use by 2.9% in 2030 compared with the FIT55 scenario.

Figure 3.11. Under both FIT55 and ETS2 scenarios overall energy use increases driven by an expansion in renewables



In both scenarios overall heat and power generation increases, with gas and coal power exhibiting considerable cuts, and wind, solar and biomass considerable increases. Differences between the two planned policy scenarios here remain minimal, with most electricity being generated by renewable sources by 2030 in both cases, with residual gas use (Figure 3.12).

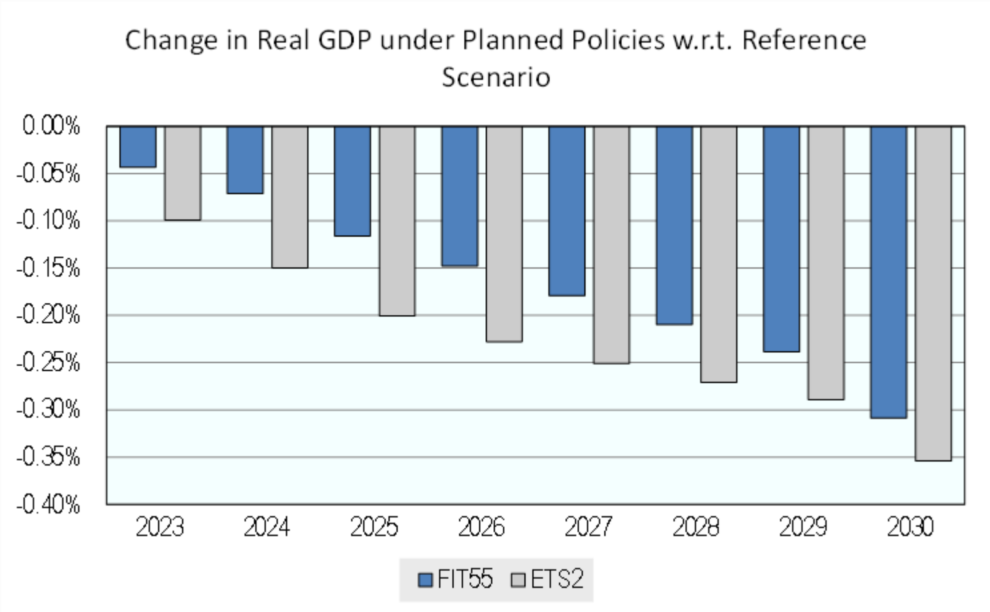
Figure 3.12. Under both FIT55 and ETS2 scenarios overall power generation increases with gas and coal generation increasingly displaced by renewable energy sources



Macroeconomic Impacts

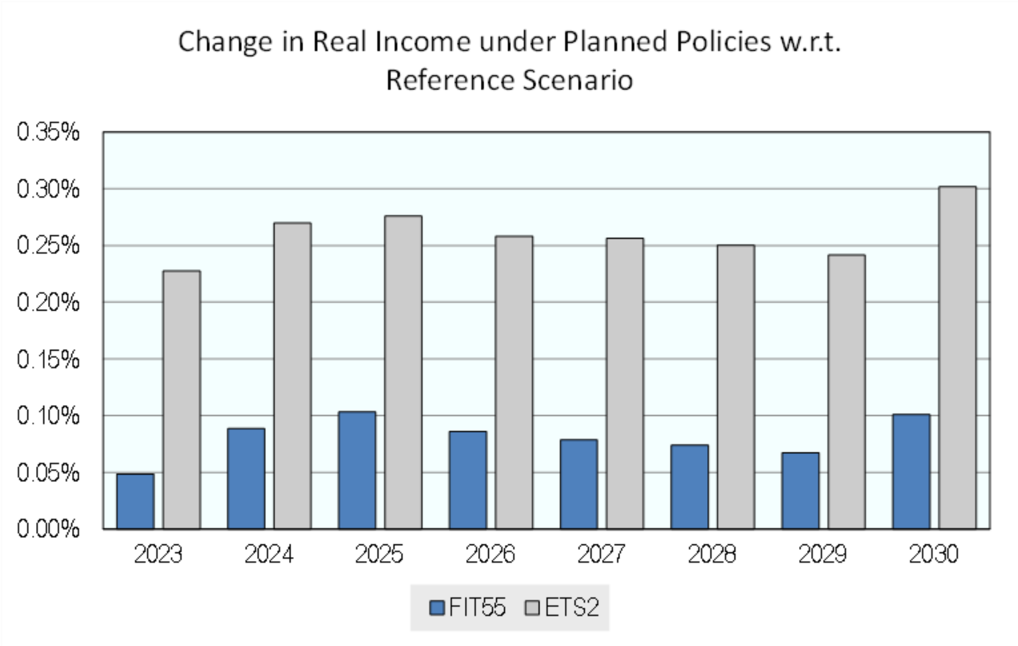
The economic cost of both policy scenarios remains moderate, with the FIT55 scenario leading to a reduction in real GDP of 0.3% in 2030 with respect to the reference scenario, and the ETS2 scenario to a 0.35% reduction. When translated to annual growth rates this implies a moderate slow-down of around 0.04% in both cases. Here it should be noted that these estimates do not take into-account co-benefits that might arise from lower emissions such as improved air quality, ecosystem services, etc.

Figure 3.13. Under both planned policy scenarios annual GDP growth slows only minimally



In terms of welfare impacts, the results indicate slight increases in consumer welfare with increases in real income of 0.1-0.3% in 2030 with respect to the reference case. This is driven primarily by revenue recycling effects (all carbon pricing revenues are recycled back to households in the form of lump-sum transfers) as well as competition effects driven by the low initial carbon intensity of the Lithuanian economy compared with other EU states, particularly under the ETS2 scenario.

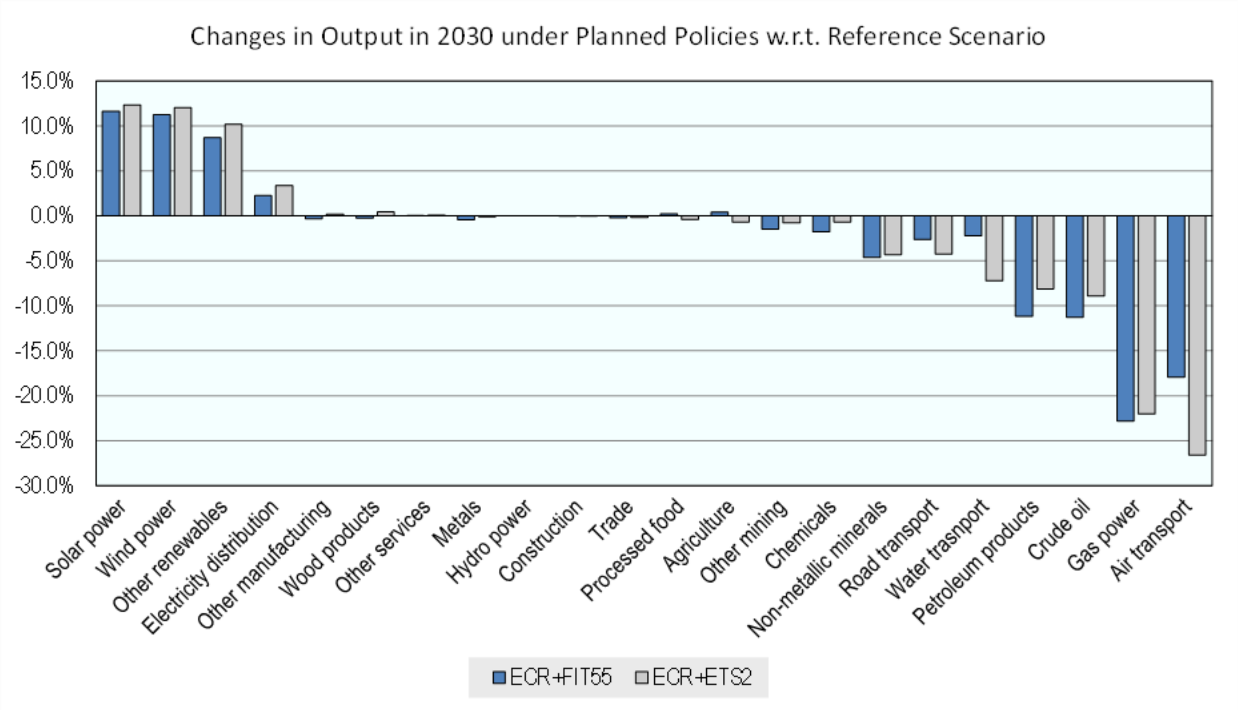
Figure 3.14. FIT55 and ETS2 scenarios indicate potential welfare gains if carbon pricing revenues are redistributed to households



Sectoral impacts

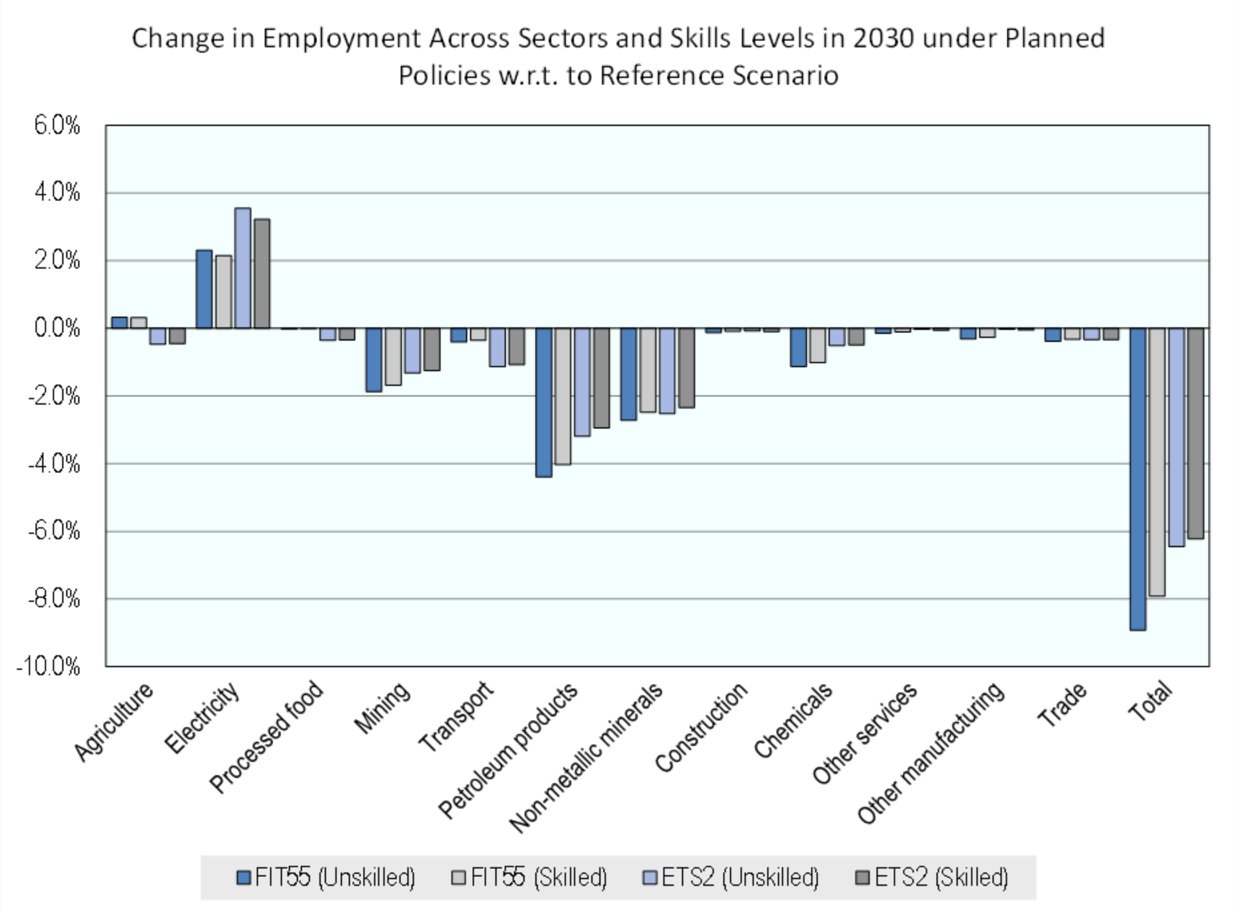
Both scenarios see a structural shift in output from polluting sectors such as transportation, fossil fuel production and distribution, chemical production, and mining, to renewable energy and electricity distribution, resulting in a less emissions intensive economy. The higher carbon prices and broader scope of the ETS2 scenario in Lithuania (when compared with the Excise Duty Amendment and Carbon Component under the FIT55 scenario) make these effects more pronounced (Figure 3.15). This broad structural shift is also exhibited in changes in output prices, with transport and fossil fuel sector prices increasing. Prices for other goods and services, including for renewable energy and electricity distribution, decrease, albeit at very low rates (below 1.5% in 2030 w.r.t. reference scenario).

Figure 3.15. Sectoral output under both planned policy scenarios shifts from fossil fuel and energy intensive industries to renewable energy and electricity distribution



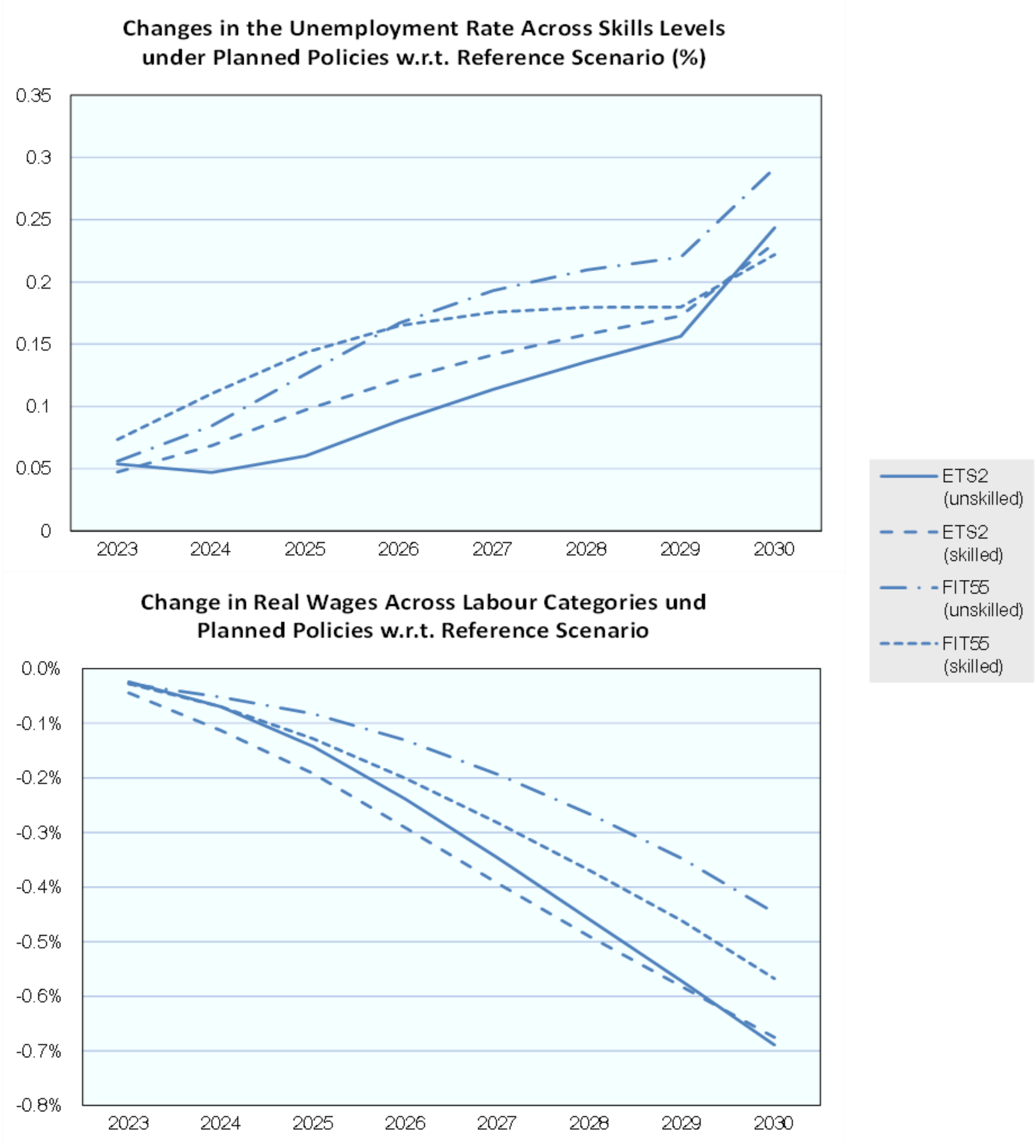
The observed structural changes lead to a reallocation of labour across sectors and skills levels, with an increase in labour demand in electricity generation (including renewables) and a decrease in all other sectors. The most substantial declines in employment, relative to the reference scenario, occur in the petroleum and mining and non-metallic minerals sectors (Figure 3.16).

Figure 3.16. Both FIT55 and ETS2 scenarios would lead to job creation in electricity generation driven by growth in renewables and energy demand but jobs would also be lost in other sectors, notably in fossil fuel reliant and energy intensive sectors



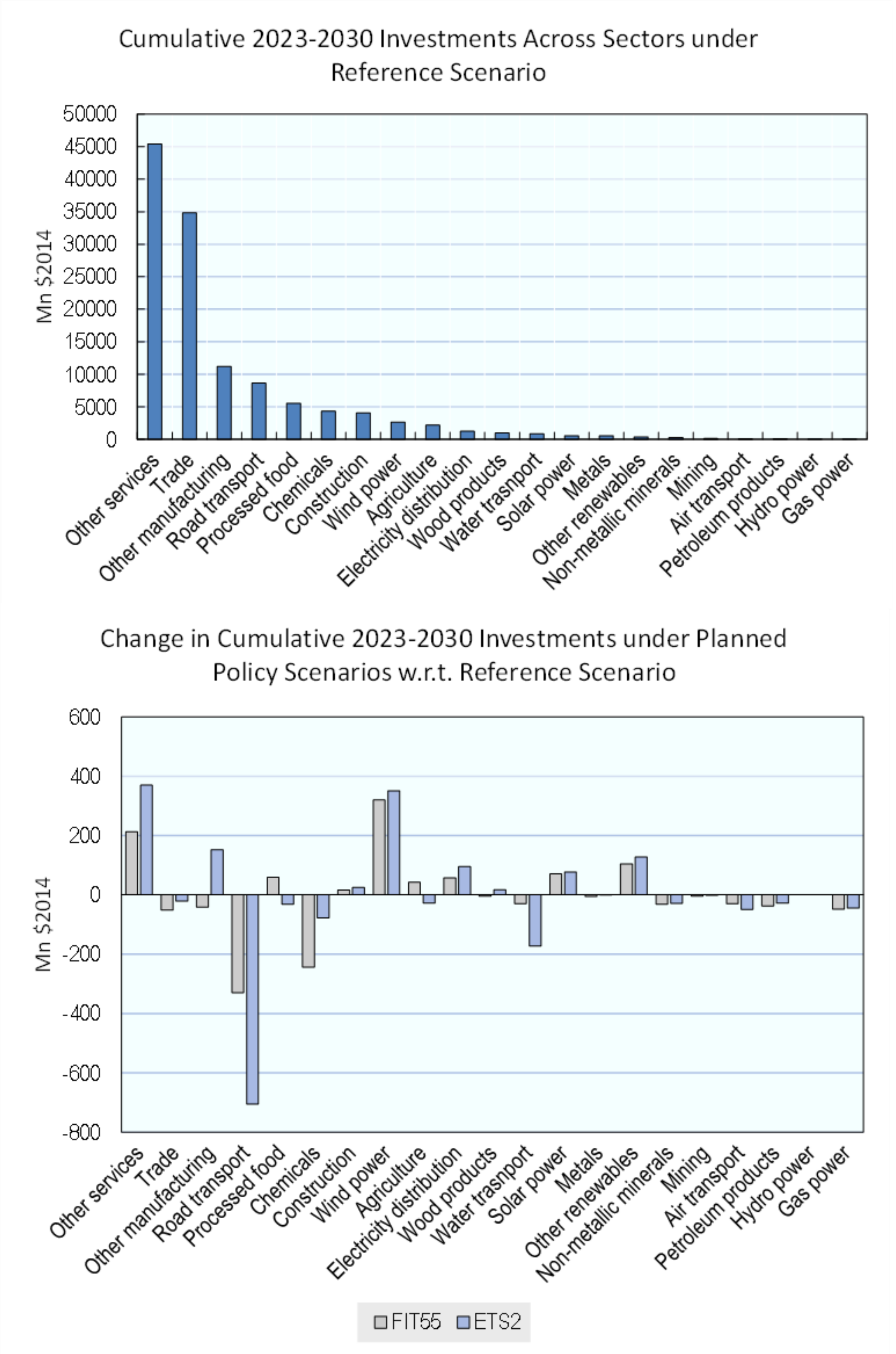
Increasing costs of production lead to moderate increases in the unemployment rate, and a slight decline in real wages across all skills categories in both scenarios compared with the reference case. However, given continued economic growth in the reference scenario, this translates to only a moderate decline in the growth rate of wages in absolute terms. Considering the distributional effects of the two policy scenarios, there is some evidence of the progressive impact of the FIT55 scenario with both unemployment and wage effects less pronounced for unskilled workers (Figure 3.17). Difference between skills levels in the ETS2 scenario are less significant.

Figure 3.17. Both FIT55 and ETS2 scenarios result in moderate declines in the growth rate of absolute wages and unemployment, however, under the Lithuanian Excise Tax Amendment wages for low-skilled labour would decline less



Considering investment effects, cumulative investments do not change across either scenario, although investment is reallocated across sectors following output patterns. Expanding sectors such as renewable energy generation attract new investment, with investments in wind and solar power increasing by 12-14% compared with the reference scenario, whereas manufacturing and transport activities lose investment flows. Effects are more pronounced under the ETS2 scenario, particularly with respect to transport activities and manufacturing, driven by higher carbon prices and competitiveness effects.

Figure 3.18. Both planned policy scenarios lead to considerable increases in renewable energy investments, but particularly the ETS2 leads to reduced investment flows in transport

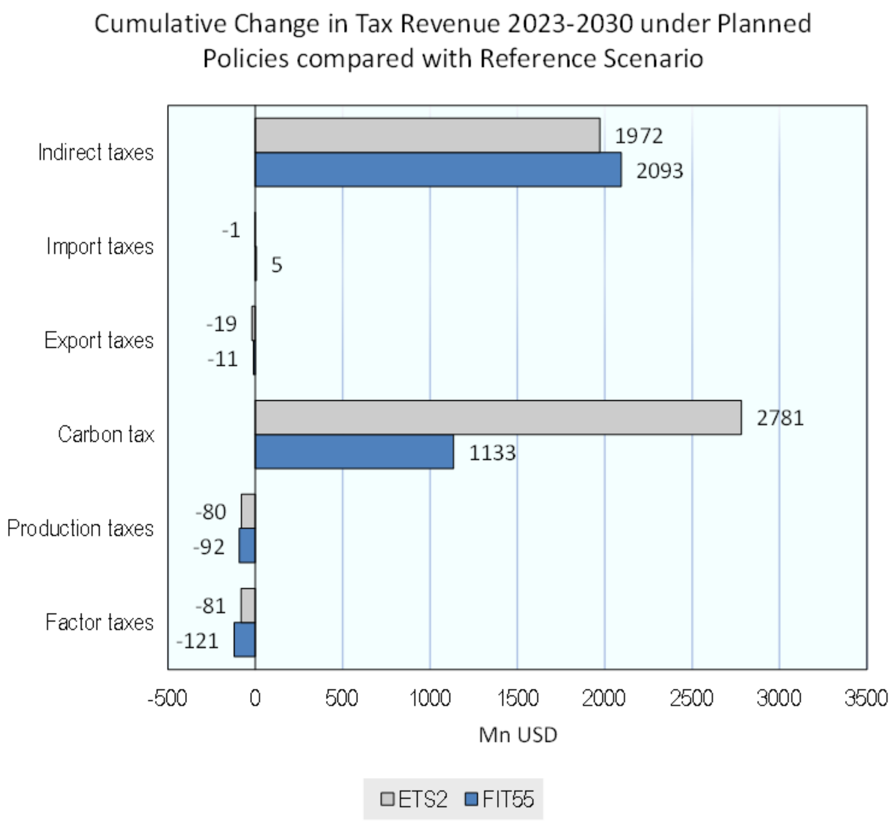


In terms of trade, fossil fuel products such as petroleum and crude oil witness the most substantial reductions in exports (14% and 9% in 2030 respectively compared with the reference case). There is some substitution of transport exports for imports in the ETS2 scenario, as outside of the EU, carbon prices are not specifically levied on the transportation sector (for more detail see Annex A).

Both scenarios produce significant government revenue streams through increasing excise taxes and carbon prices. In the FIT55 scenario, the increase in excise taxes and the introduction of a carbon price component from 2025 results in a cumulative tax revenue of 3.2 Bn USD between 2023-2030. The ETS2 scenario sees a further increase in tax revenue from both indirect taxes and the implemented carbon prices, amounting to 4.8 Bn USD cumulatively over the 2023-2030 period.[8]

It is important to note here that due to a number of factors, base-erosion is not a significant concern in the model results. First, the results depicted are cumulative changes with respect to the reference scenario. Given the reference scenario already includes mitigation ambition, some base-erosion effects may already be occurring in the reference case. Second, the economic effect of the modelled scenarios is minimal, thus production tax revenues, for example, do not fall significantly. Moreover, under the short time-horizon being studied, energy remains an inelastic commodity, with price increases in gasoline, for example, not leading to commensurate decreases in distance driven. While over the long-term (2050) ambitious climate policies (net zero) would have a significant effect on tax revenues, for example with fuel excise-duty revenues drying up as consumers switch to electro-mobility, this is not yet a factor here.

Figure 3.19. Both planned policy scenarios result in considerable revenue generation from carbon prices



Russian fossil fuel ban results: Import Ban and Import Ban + FIT55 scenarios

Imposed restrictions on fossil fuel imports from Russia result in considerable emissions reductions in Lithuania (when applied to the reference scenario), achieving a 29.8% reduction in CO_2 emissions in 2030 compared to 2005 levels Figure 3.20). This surpasses emissions reductions under the two planned policy scenarios detailed above, highlighting the large impact such a ban would have. In particular the ban leads to emissions reductions from industrial processes (11.4% in 2030 w.r.t. reference scenario), which are not covered by the ETS or non-ETS carbon prices in the planned policy scenarios. This is due to rising energy prices as a result of reduced energy supply and a contraction in economic activity. In particular, estimates suggest that the ban on Russian fossil fuel imports could lead to an increase in the price of crude oil and natural gas in a range of 10%, for coal in a range of 12%-14% and for petroleum products by 23%-25% (Figure 3.21). It should be noted that these effects are dependent on all countries included in the scenario implementing the ban. Although Lithuania has already effectively banned all Russian energy imports, without commensurate action from other OECD members this will not have the same impact on emissions (or economic factors) depicted here.

Figure 3.20. An embargo of Russian fossil fuel imports would lead to considerable emissions reductions

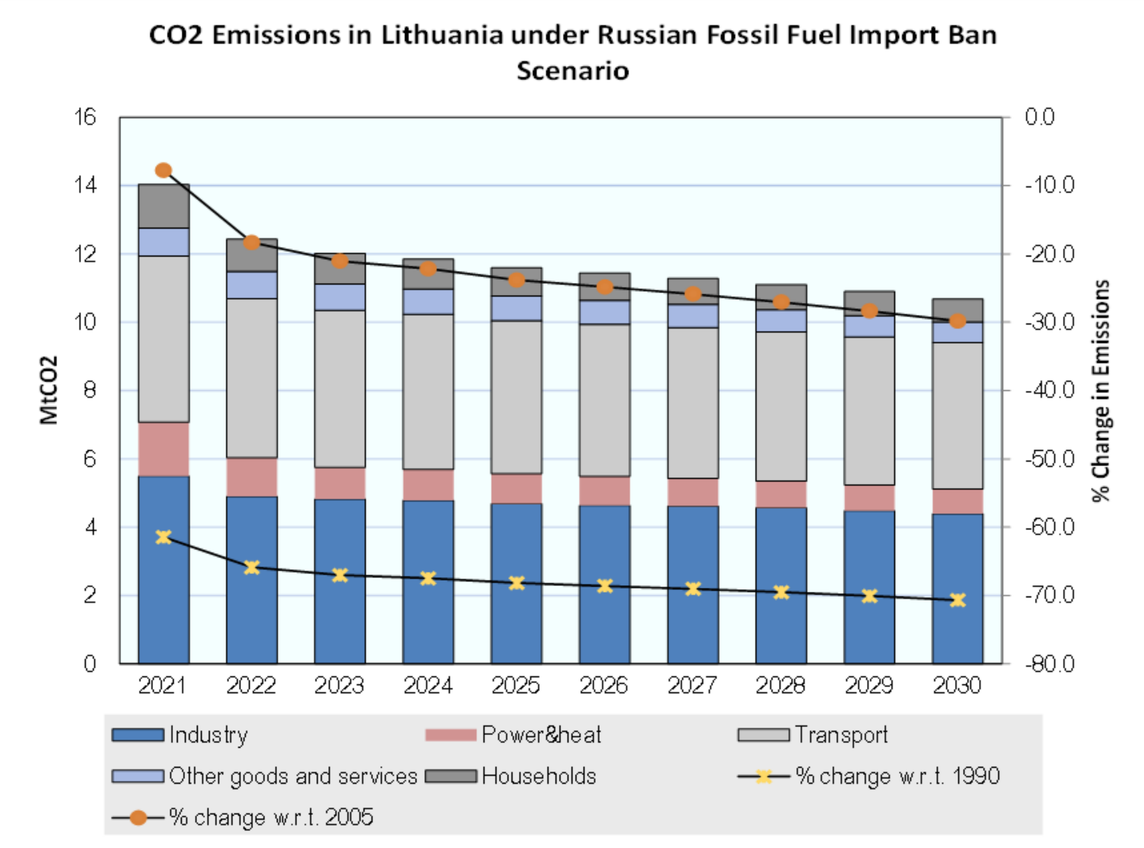
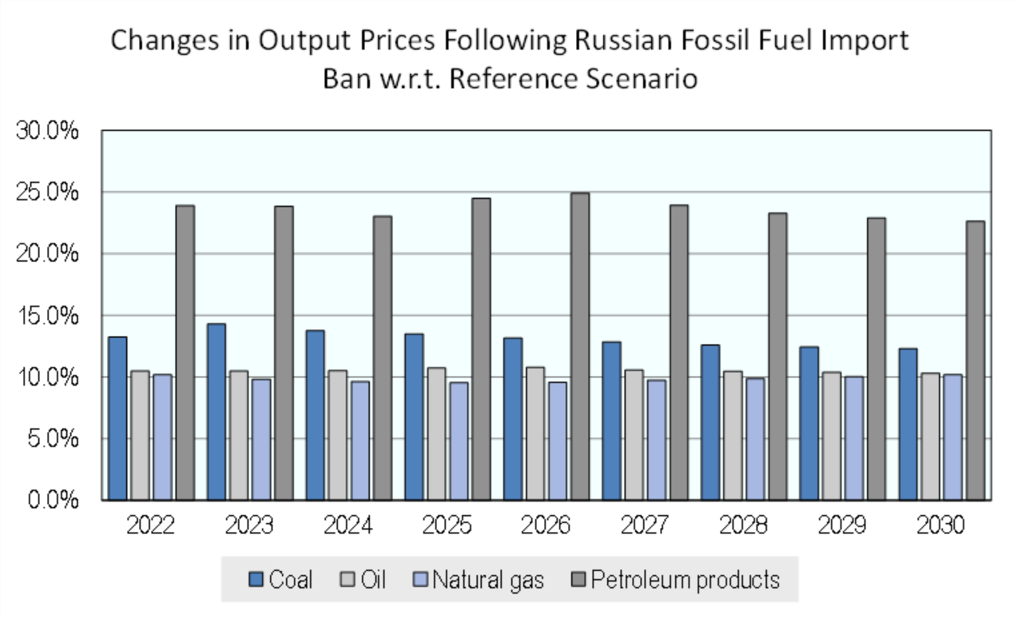
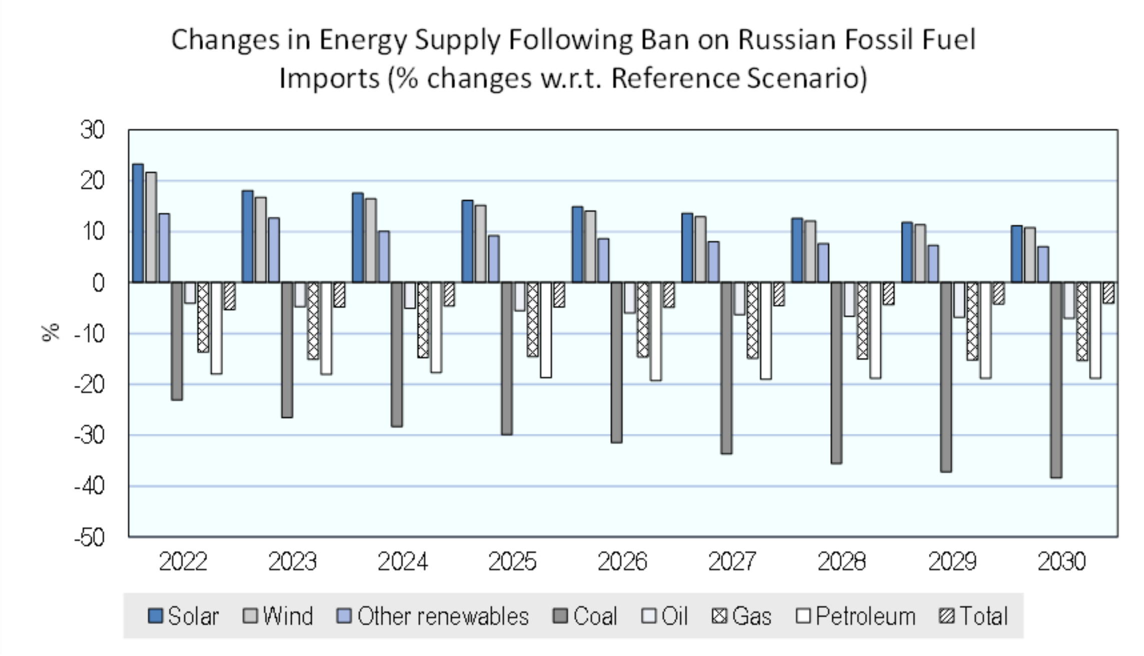


Figure 3.21. An embargo on Russian fossil fuel imports would lead to considerable price increases for fossil fuels in Lithuania



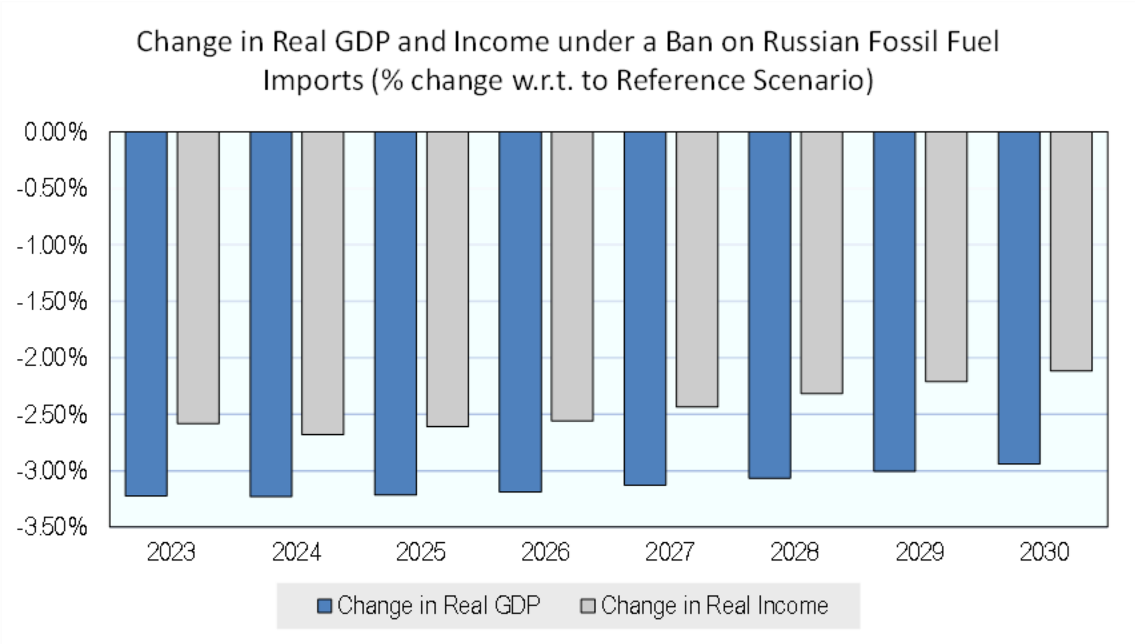
Although there is some substitution of energy imports from other sources, overall energy demand in Lithuania also falls – by around 4%-5% - driven by increasing prices. Solar and wind energy benefit from this, seeing an additional growth of around 11-12% in 2030 compared with the reference scenario. Indeed, in the years immediately following implementation of the ban, growth in renewables is even higher (above 20% for solar and wind (Figure 3.22).

Figure 3.22. Renewable energy supply increases considerably under a Russian fossil fuel import ban



Considering the ban's macro-economic impacts, cost estimates are higher than for the planned policy scenarios. Real GDP is estimated to be around 3% lower in 2030 than in the reference case, with real income also 2.1% lower. Although these impacts are more substantial than in the planned policy scenarios, they still correspond to only a minor slow-down of economic growth in absolute terms, with effects felt more acutely directly after the ban is imposed before recovering somewhat (Figure 3.23).

Figure 3.23. A ban on Russian fossil fuel imports would have more substantial impacts on GDP and income than planned policy scenarios



If combined with carbon pricing policies needed to reach the EU's 55% reduction target (FIT55 scenario), restrictions on the imports of Russian fossil fuels could significantly lower carbon price levels in both ETS and non-ETS sectors. Results indicate that under this scenario ETS prices would reach USD 171/tCO_2 in 2030, more than USD 30/tCO_2 lower than the FIT55 scenario without the fossil fuel import ban. Non-ETS prices would reach USD 135/tCO_2, USD 35/tCO_2 lower than without the ban. As both the ban and carbon price measures are implemented at the EU level, emissions reductions in Lithuania would also be higher than under just the mitigation policy scenario, with particularly process-based emissions in the industry sector decreasing, driven by increasing fossil fuel prices.

Figure 3.24. A ban on Russian fossil fuel imports would reduce carbon prices needed to reach Fit for 55 targets

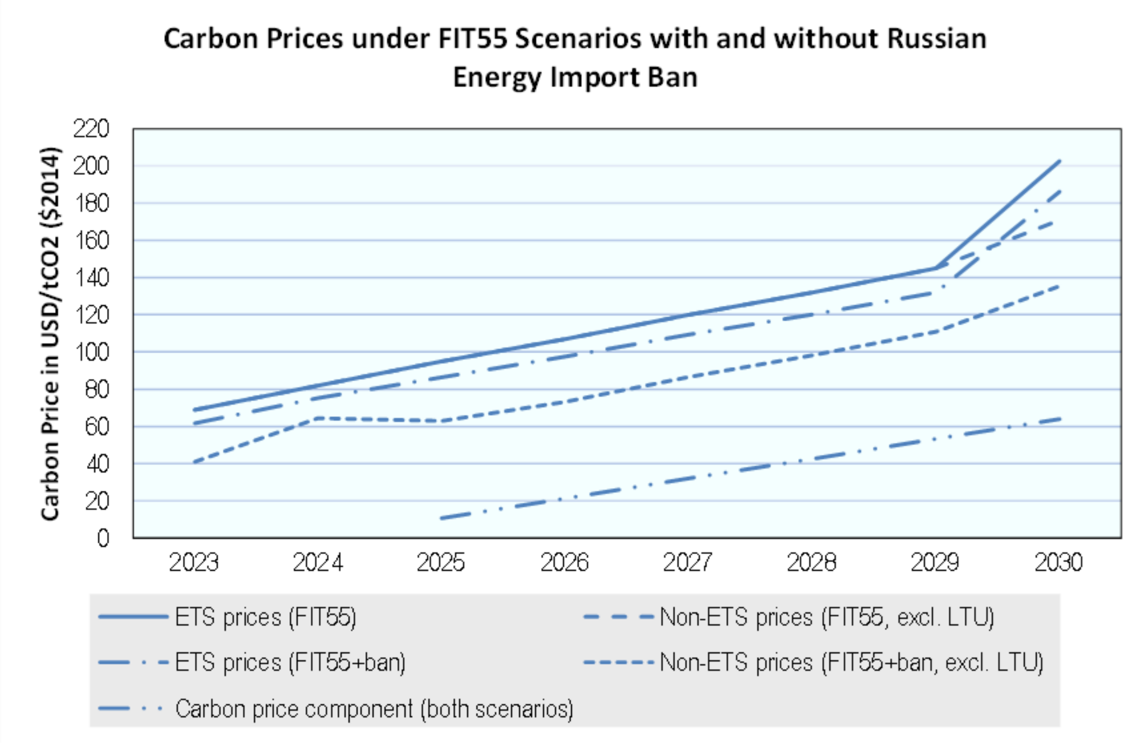
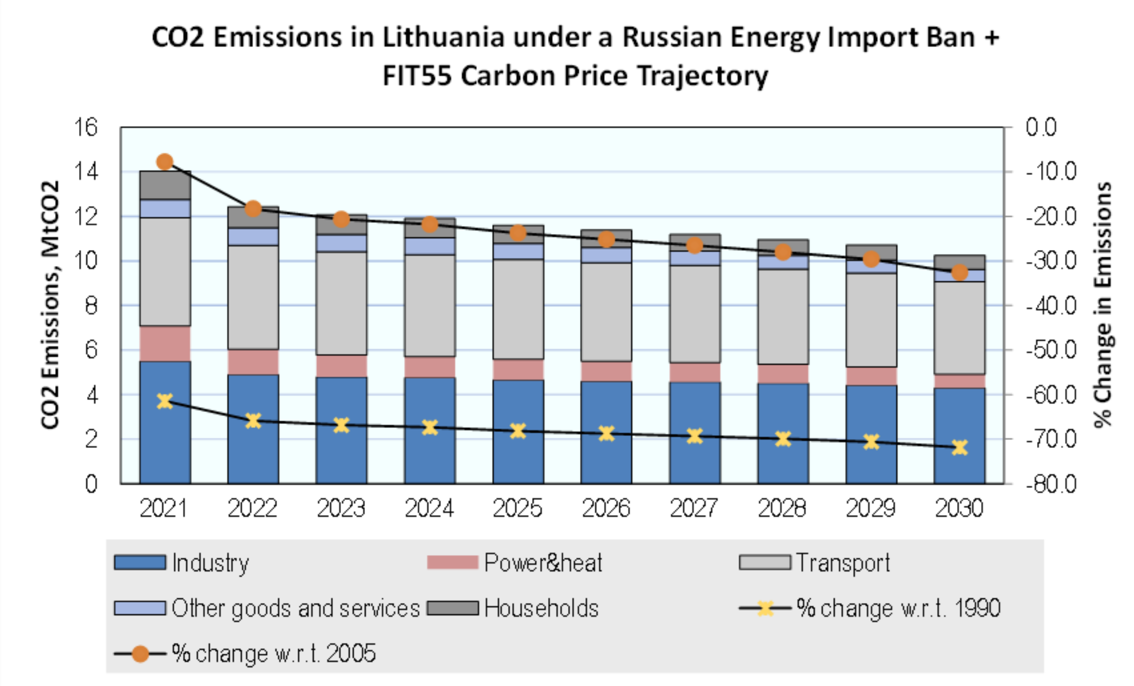
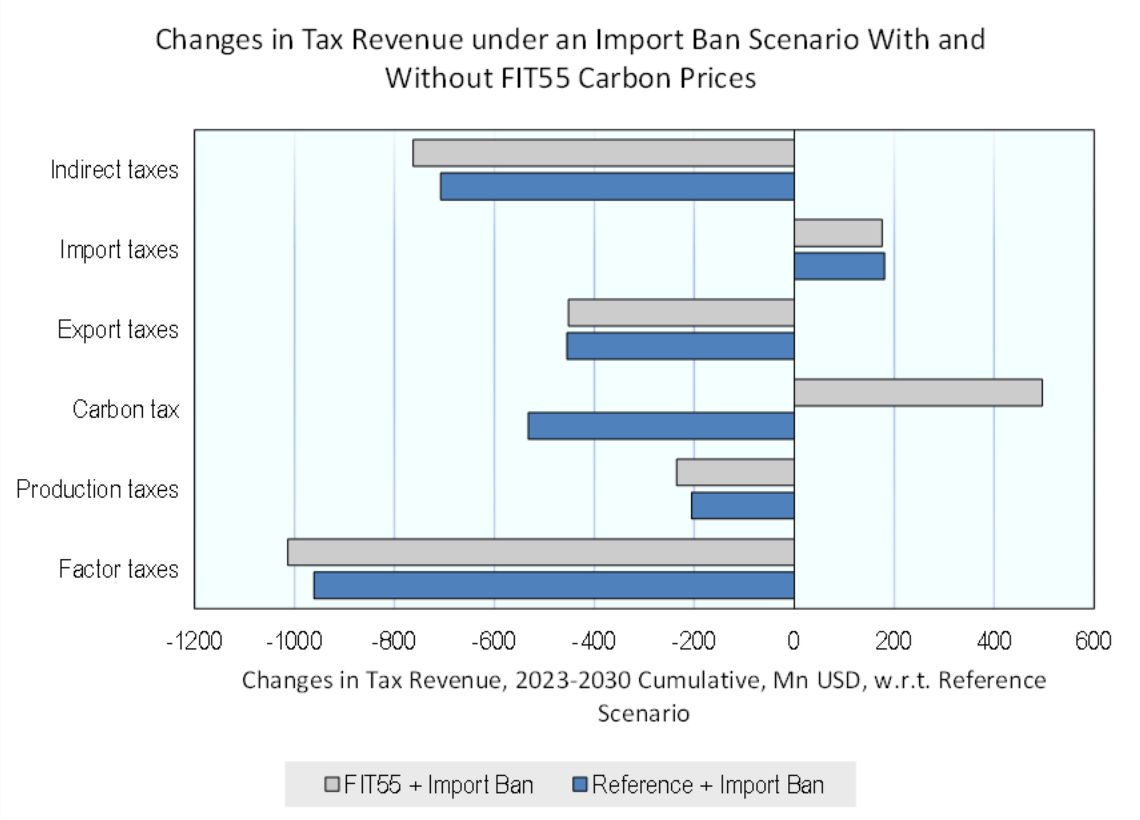


Figure 3.25. If combined with a ban on Russian fossil fuel imports, stringent carbon pricing to meet the Fit for 55 targets would result in even lower CO_2 emissions in Lithuania



No major changes in macro-economic effects are seen when combining the fossil fuel ban with stringent carbon pricing. Introducing carbon pricing does, however, balance out negative tax revenue effects as, under a less stringent mitigation policy scenario the reduction in energy demand due to increasing fossil fuel prices leads to a loss of carbon pricing revenue (Figure 3.26).

Figure 3.26. Introducing carbon prices commensurate with meeting the Fit for 55 targets balances out negative tax effects of banning Russian fossil fuel imports



Assessment and recommendations for 2030 climate policy actions

The reference scenario results show that under current policies, CO_2 emissions in Lithuania will fall considerably by 2030, almost 20% compared to 2005 levels. At the same time, economic growth remains stable, with growth in electricity and renewable energy balancing out contractions in fossil fuel industries. With the model limited to CO_2 emissions, a direct assessment of whether this will suffice to meet the broader GHG emissions reduction target of 30% in 2030 (compared to 2005 levels) set in the NCCMA is not possible. Considering historic GHG emissions data (Chapter 1), significant emissions removals through land-use, land-use change and forestry can be expected in addition to the CO_2 emissions reductions estimated by the model. Lithuanian emissions reduction projections based on current policies further indicate that emissions will fall only marginally short of the targets set in the NCCMA, particularly if the EU ETS target is increased as proposed in the Fit for 55 package (Chapter 2) (Government of Lithuania, 2020[9]).

Considering sectoral trends, the results indicate that additional measures are needed in the transport and industry sectors in order to further decarbonisation efforts in Lithuania. Despite high growth in renewables, the share of petroleum for energy use, and of gas for electricity and heat generation, remain high in the reference scenario. This is driven by the lack of pricing measures targeting these two sectors, with the EU ETS currently not covering the transport or buildings sectors, and process-based emissions in the industry sector not priced in the model. As a result, and despite autonomous electrification and renewable energy preference assumptions, fossil fuel prices do not increase by enough to break inelastic demand in these sectors.

The results of the two planned policy scenarios indicate that additional pricing mechanisms are effective in further reducing emissions at low economic cost. The FIT55 scenario shows that the proposed amendment to the Lithuanian Excise Duty Law, including a carbon price component, would be a particularly effective tool for reducing emissions in the transport sector. However, its exemption of natural gas remains a considerable shortcoming that should be revisited. Should an ETS II at the EU level materialise as is currently being discussed, this would also significantly reduce both transport and buildings sector emissions in Lithuania.

Together, the results indicate Lithuania should further pursue carbon pricing, particularly for the transport and industry sectors, either directly through ETS or carbon taxes, or indirectly through excise duties. Due to projected welfare benefits, an EU-wide ETS2 may be preferable to each EU member state setting individual policies in non-ETS sectors.

The results of modelling a wide-spread ban on Russian fossil fuel imports in OECD countries indicate that, despite short-term economic costs, this would entail considerable climate co-benefits, significantly reducing emissions and carbon price levels necessary to meet climate targets. Although the scope and scale of the modelled scenario may be unrealistic, Russia's threat of withholding fossil fuel exports may result in similar costs and climate opportunities.

Notes

[1] Achieving net-zero climate targets will require a policy mix that goes beyond carbon-pricing. However, the focus of this chapter is the socio-economic impacts of various emissions reductions pathways based on concurrent carbon price trajectories. This is discussed in more detail in the subsequent section below.

[2] In macroeconomic modelling the baseline typically refers to a no (new) policy trajectory. The baseline employed here, however, includes further ambition, assuming countries continue to implement current policies in line with targets set in their NDCs. It is therefore referred to as a reference rather than baseline scenario.

[3] Lithuania has, in fact, already entirely stopped all imports of Russian energy products.

[4] For a more valid representation of the natural gas trade patterns, imports of natural gas by Lithuania were adjusted (compared to 2014 bilateral sourcing) to reflect a more recent (post-2015) trends of LNG imports by Lithuania and falling share of imports from Russia.

[5] In 2020, CO_2 emissions comprised roughly 70% of total GHG emissions in Lithuania (Government of Lithuania, 2022[10]).

[6] Note here that in the FIT55 scenario modelled, Lithuania is excluded from this EU-wide non-ETS price trajectory. However, given Lithuania's small size and minimal contribution to EU-wide emissions levels, its exclusion is not expected to alter carbon prices necessary to reach the 43% reduction target at the

EU level. As such, the given price trajectory provides an indication of prices necessary to reach the EU's non-ETS sector targets even when including Lithuania.

[7] https://ariadneprojekt.de/news/ueber-die-co2-preisgestaltung-zum-europaeischen-klimaziel-2030/.

[8] Note that specific revenue recycling regulations for the ETS II proposal in the Fit for 55 Package such as the Social Climate Fund are not modelled here.

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4

Carbon pricing in Lithuania

This chapter analyses carbon pricing in Lithuania in 2021 and simulates changes to carbon pricing under three policy scenarios. By adopting a sectoral perspective, the analysis highlights areas for improvement in current carbon pricing policies in Lithuania. Depending on the sector, carbon prices in Lithuania are more or less aligned with benchmark rates consistent with attaining carbon neutrality by 2050 or reflecting the externalities caused by CO_2 emissions. In particular, emissions in the road and off-road transport, industry and electricity sectors are priced in line with some of these benchmarks, but emissions from energy use in the buildings as well as the agriculture and fisheries sectors face lower prices. All policy scenarios considered in the chapter would help overcome the gaps observed in the current carbon pricing landscape in Lithuania.

This chapter analyses carbon pricing in Lithuania in 2021 and simulates changes to carbon pricing under three policy scenarios. The policy simulations concern (i) implementation of the Draft Law on fuel excise duties, which proposes changes in fuel excise taxes and the introduction of a carbon tax; (ii) implementation of the proposed revision of the European Union Energy Taxation Directive (EU ETD); and (iii) introduction of a second European Union Emissions Trading System (EU ETS2) on motor and heating fuels. The last section briefly discusses issues related to biofuels.

As highlighted in Chapter 3, carbon pricing is a key policy tool to reduce emissions in a cost-effective way and can raise additional revenue for governments – hence the focus of this chapter on this class of climate mitigation instruments. Other instruments, such as R&D support, technology deployment support or electric vehicle mandates, are discussed in Chapters 2, 5 and 7. Chapter 6 discusses the distributional impacts of carbon pricing in Lithuania.

Carbon pricing in Lithuania in 2021

This section analyses carbon pricing in Lithuania in 2021, drawing on the OECD Effective Carbon Rates (ECR) database (Box 4.1). The ECR database provides detailed information on CO_2 emissions from energy use and corresponding effective carbon rates. These rates result from explicit carbon taxes and emissions trading systems, as well as from fuel excise taxes. According to the latest available data, CO_2 emissions from energy use excluding biomass combustion represent 68% of the total GHG emissions reported in Lithuania's greenhouse gas inventory submitted to the UNFCCC.[1]

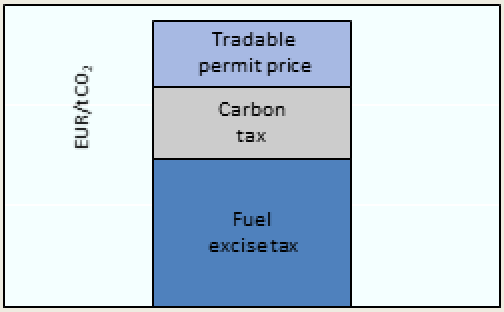
Box 4.1. The OECD Effective Carbon Rates database

The OECD Effective Carbon Rates (ECR) database (OECD, 2021[1]; OECD, 2019[2]) provides a breakdown of CO_2 emissions from energy use and corresponding effective carbon rates for 44 OECD and G20 countries by sector and fuel. Taken together, these 44 OECD and G20 countries represent 80% of worldwide CO_2 emissions from energy use. Effective carbon rates are the sum of explicit carbon taxes, emissions trading systems (ETSs) and fuel excise taxes.

More precisely, the three components of effective carbon rates, depicted in Figure 4.1, should be understood as follows:

- Carbon taxes generally set a rate on fuel consumption based on its carbon content (e.g. on average, a EUR 30/tCO_2 tax on carbon emissions from diesel use would translate into a 7.99 eurocent per litre tax on diesel).
- Fuel excise taxes are typically set per physical unit (e.g., litre, kilogram, cubic metre) or per unit of energy (e.g., gigajoule), which can be translated into rates on the carbon content of these fuels.
- The price of tradable emission permits issued under ETSs, regardless of the permit allocation method, represent the opportunity cost of emitting an extra unit of CO_2.[2]

Figure 4.1. Components of Effective Carbon Rates



Source: Based on Figure 3.1 in (OECD, 2016[3]).

The database covers six sectors that together span all energy uses: agriculture and fisheries, buildings (i.e., residential and commercial heating), electricity, industry, off-road transport and road transport.

Fuels are grouped into ten categories, which in turn can be grouped into two broad classes. Fossil fuels are composed of the categories *coal and other solid fossil fuels*, *diesel*, *fuel oil*, *gasoline*, *kerosene*, *liquefied petroleum gas* (LPG), *natural gas* and *other fossil fuels* (a category consisting in those fossil fuels that cannot be classified under the first seven categories in the list). Other combustible fuels are composed of biofuels and non-renewable waste.

The OECD ECR database is available for the years 2012, 2015 and 2018. A 2021 version is available as well, based on emissions data from 2018, to which tax rates from 2021 are applied as well as average permit price values over 2021. The analysis in this chapter of the report is based on this data.

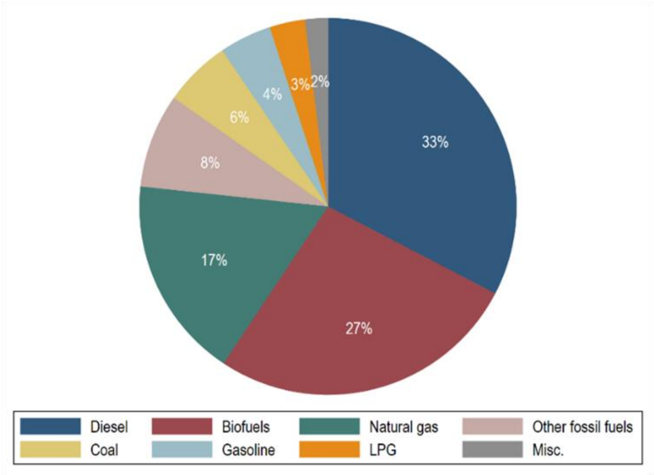
Energy use and carbon pricing in Lithuania

In Lithuania, biofuel, diesel and natural gas use make up more than three quarters of energy use. Diesel accounts for 33% of energy use (mostly in the road sector), biofuels for 27% (mostly in the industry and buildings sectors) and natural gas for 17% (also mainly in the industry and buildings sector) (Figure 4.2., Panel A). As seen in Figure 4.2., Panel B, these shares vary considerably across sectors, for example with the electricity and buildings sector relying predominantly on biofuels, and the transport sectors and agriculture predominantly on diesel. The industry sector exhibits a more balanced use of different fuels.

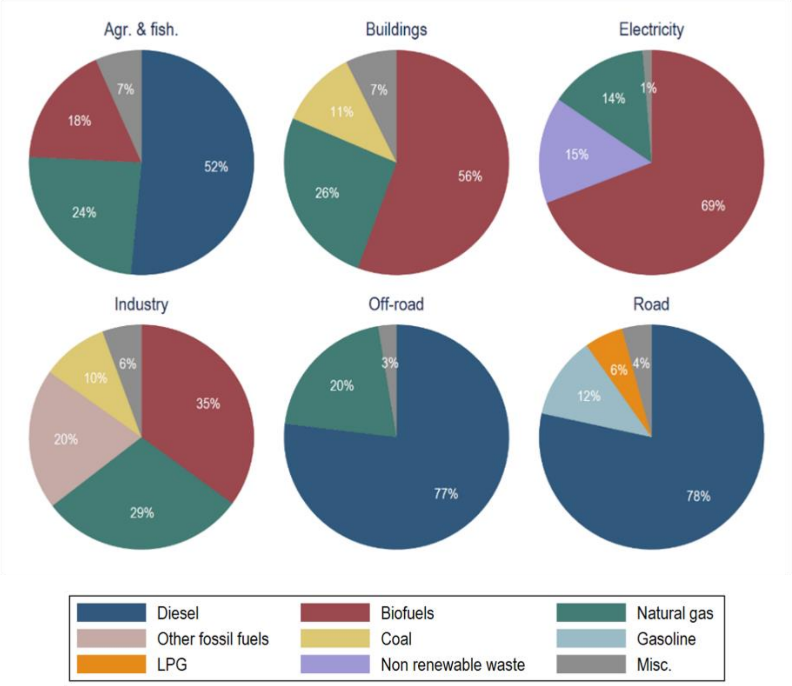
Figure 4.2. Fuel use in Lithuania principally comprises diesel, biofuels and natural gas use

Based on 2018 energy use, % of GJ

Panel A



Panel B



Note: Fuels shares in total energy use are shown as a percentage of total energy use from combustible fuels (219.76 TJ) in Panel A and as a percentage of energy use from combustible fuels for each sector in Panel B. In Panel A, “Misc.” stands for fuels that each represent less than 2% of total energy use from combustible fuels, and which are grouped together. “Misc.” here is composed of fuel oil, non-renewable waste and kerosene. In Panel B, “Misc.” stands for fuels that each represent less than 5% of total sectoral energy use from combustible fuels, and which are grouped together. For the agriculture and fisheries sector, it is composed of coal, LPG, gasoline and fuel oil. For the buildings sector, it is composed of LPG, diesel, kerosene and gasoline. For the electricity sector it is composed of fuel oil. For the industry sector it is composed of fuel oil, diesel, non-renewable waste and gasoline. For the off-road transport sector, it is composed of biofuels, gasoline and kerosene. For the road sector, it is composed of biofuels and natural gas.
Source: OECD.

Box 4.2. CO_2 emissions from biofuel use

While not all biomass is carbon neutral, it can be. Taken at the point of combustion, biomass releases CO_2. However, as discussed in OECD (2019[2]), sustainably sourced biomass may be carbon-neutral over the life-cycle because before being burnt, feedstocks have previously absorbed a similar amount of CO_2 from the atmosphere.

As the combustion of biomass can be carbon neutral, CO_2 emissions from biofuel combustion are not explicitly reported in the greenhouse gas inventories submitted under the UN Framework Convention on Climate Change (UNFCCC). The guidelines of the UN Intergovernmental Panel on Climate Change (IPCC) require accounting for emissions and sinks from biofuels as net changes in carbon stocks under the annual reporting of Land Use, Land Use Change and Forestry (LULUCF).

Most governments do not tax biofuels outside the road sector. Instead, they generally use sustainability standards for biofuels (e.g., the EU revised Renewable Energy Directive, RED II[3]), however this requires gathering reliable sustainability data. This is a challenging task, and such data is often lacking. (Jeswani, Chilvers and Azapagic, 2020[4]; Baudry et al., 2017[5]).

Some governments have attempted to design comprehensive biofuel taxation. For example, the Finnish carbon tax for transport fuels, is based on life-cycle CO_2 emissions – a unique feature in the world today (OECD, 2021[6]). Under the Finnish tax, biofuels are classified in three categories: i) biofuels that do not meet sustainability criteria are subject to the same carbon tax as fossil fuels; ii) sustainable first-generation biofuels are subject to 50% of the rate which applies to equivalent fossil fuels; and iii) sustainable second-generation biofuels are exempt. In 2019, the methodology based on life-cycle carbon emissions was extended to fuels for heating and machinery. While also relying on a comprehensive assessment of biofuel sustainability, this kind of category-dependent tax rate constitutes a novel approach to taxing biofuels that encompasses life-cycle emissions.

Despite its novelty, an approach that only considers the actors responsible for the combustion of biomass does not account for the fact that these are generally not the same actors as those responsible for the CO_2-absorption of biomass. Ideally, taxing the CO_2 emissions from the combustion of woody biomass would have to go hand-in-hand with subsidising forest owners for the carbon they store. This point, along with the trade-offs between forest harvesting levels and forests' potential as a carbon sink are extensively discussed in Kooten, Binkley and Delcourt (1995[7]) and OECD (2021[6]).

The proposed revision to the EU ETD currently considers minimum taxation rates for biofuels for additional reasons. This is in line with other issues raised by the increased use of biomass. Harvesting raises issues for biodiversity, soil health and water quality, while biomass combustion may worsen local air pollution (different from greenhouse gas emissions), especially from particulate matter (PM) and nitrogen oxides (NOx) emissions, which is not compensated for from a lifecycle point of view.

In 2021, CO_2 emissions from energy use in Lithuania are priced through the EU ETS and through fuel excise taxes; Lithuania does not apply an explicit carbon tax. The EU ETS applies principally to the industry and electricity sectors, while fuel excise taxes apply to all sectors, except the electricity sector. Effective carbon rates are positive for 93% of CO_2 emissions from non-biofuel energy use. Biofuels, which make up more than a quarter of energy use in Lithuania (Figure 4.2.), are further discussed in Box 4.2.

Figure 4.3. presents Effective Carbon Rates and their CO_2 emissions base in Lithuania in 2021, by sector (panel A) and fuel category (panel B). The figure distinguishes between the two components comprising Lithuania's ECRs; tradeable permit prices from the EU ETS. As the figures show, the road and industry sectors are responsible for the largest shares of CO_2 emissions from energy use (respectively, 52% and

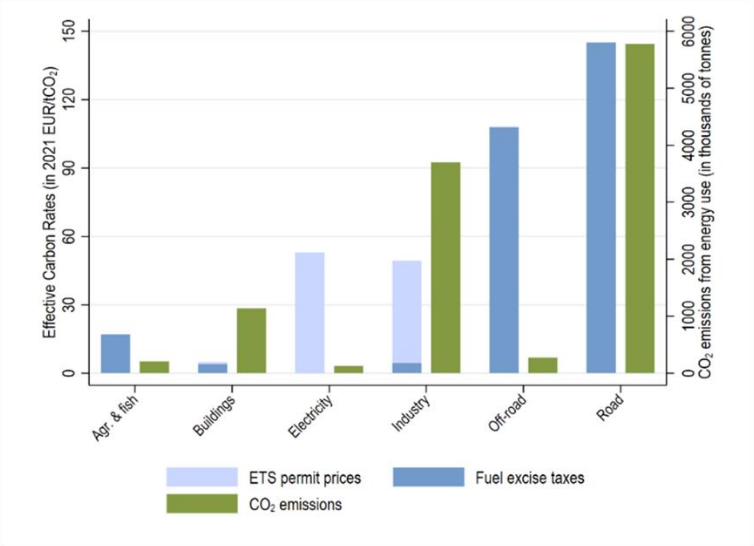
33%). The buildings sector accounts for 10% of CO_2 emissions from energy use, while the electricity, off-road and agriculture and fisheries sectors each account for less than 3%. Consistent with their shares in energy use, the two main combustible fuels responsible for CO_2 emissions are diesel (47%) and natural gas (19%). Coal and other fossil fuels also account respectively for 11% and 9% of CO_2 emissions from energy use.

The six sectors (that together span all energy uses, see Box 4.1) face heterogeneous price levels for their emissions. As in the majority of countries covered by the ECR database, in Lithuania the average price signal is highest in the road sector (see, e.g. OECD (2021[1])), at about EUR 145/tCO_2 due to the relatively high (albeit different) excise tax rates faced by diesel and gasoline. Emissions in the off-road sector face a slightly lower price on their priced emissions, of about EUR 108/tCO_2. Electricity and industry sector emissions are mostly priced through the EU ETS, with slightly different average effective carbon rates (respectively EUR 53 and 49/tCO_2), mostly reflecting different shares of emissions not covered by a pricing policy. Emissions in the agriculture and fisheries as well as the buildings sectors face the lowest rates (at EUR 17 and 5/tCO_2, respectively).

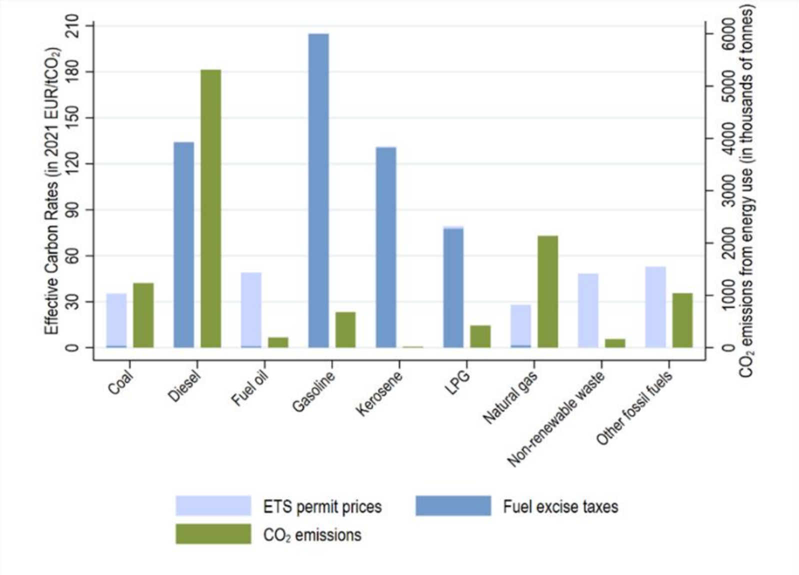
The differences in price levels between sectors arise mainly from two factors: (i) differences in fuel use across sectors and (ii) price instruments used to cover their emissions. Panel B of Figure 4.3. shows that fuels face heterogeneous tax rates. In particular, the most highly taxed fuels are gasoline, diesel, kerosene and LPG, respectively at EUR 205, 134, 131 and 78/tCO_2. Panel A in Figure 4.3. shows the difference in instruments used to cover emissions across sectors. The following subsection takes a closer look at each sector. The more detailed Effective Carbon Rates profiles shown in these subsections highlight unpriced emissions, heterogeneous rates within sectors as well as shares of free permits within the EU ETS.

Figure 4.3. Effective Carbon Rates levels and components are heterogeneous and not necessarily in line with the share of emissions they cover

Panel A. Emissions-weighted average effective carbon rates, by sector, Lithuania, 2021



Panel B. Emissions-weighted average effective carbon rates, by fuel category, Lithuania, 2021



Note: These figures show fuel excise taxes in Lithuania and the EU ETS average permit price over 2021. These figures show effective marginal carbon rates, i.e. they do not account for free allocations. CO_2 emissions are calculated based on energy use data adapted from (IEA, 2020[8]) World Energy Statistics and Balances. In these figures they do not include emissions from the combustion of biomass. The “other fossil fuels” category emissions are composed, in Lithuania, of 91% emissions from refinery gas, 8.8% emissions from crude oil, less than 0.2% from refinery feedstocks and less than 0.05% of additives.
Source: OECD calculations.

Carbon pricing by sector

Road transport

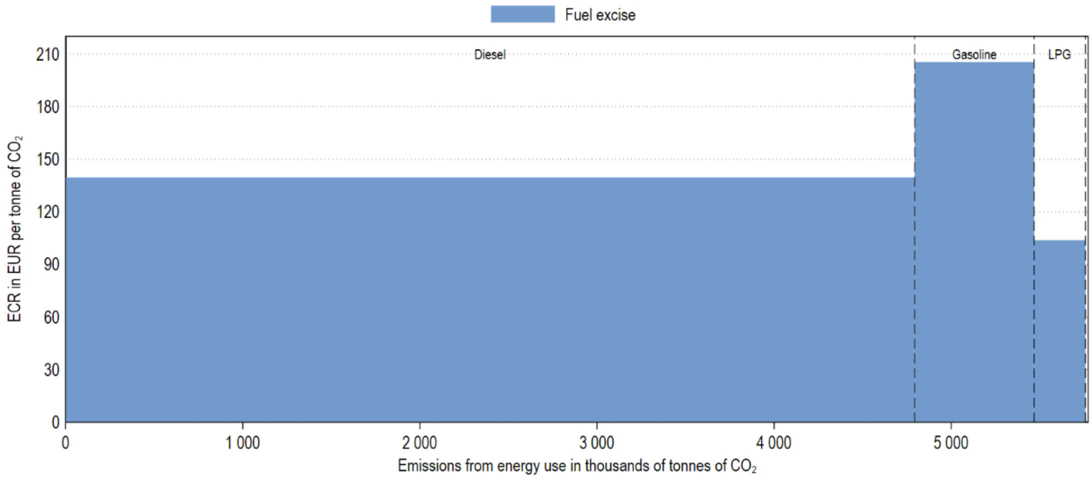
The road transport sector is responsible for 51.5% of CO_2 emissions from energy use in Lithuania and fuel excise taxes are the only of the three ECR components covering emissions in this sector (Figure 4.4). Apart from natural gas use, which faces no price but represents less than 0.3% of road transport emissions, CO_2 emissions in this sector are fully covered by a carbon price. Rates are higher than EUR 100/tCO_2 and reach EUR 205/tCO_2 for gasoline use.

Diesel use represents 83% of emissions in this sector and faces a lower effective carbon rate than gasoline use, at EUR 139/tCO_2 (this gap can be referred to as the "diesel differential", see Harding (2014[9])). This lower carbon price level results from a lower fuel excise tax in EUR per litre for diesel than for gasoline. Indeed, in 2021 in Lithuania, diesel used as a propellant is taxed at EUR 0.372 per litre whereas gasoline used as a propellant is taxed at EUR 0.466 per litre. Given that CO_2 emissions per litre of diesel are about 15% higher than for gasoline, a uniform carbon price would call for taxing diesel at a higher rate per litre than gasoline.[4]

The levels of carbon prices observed in the Lithuanian road transport sector are higher than in most other sectors, but are among the lowest in the EU. At an average of EUR 145/tCO_2, only the ECRS in the Polish and Hungarian road transport sector are lower, respectively at EUR 130/tCO_2 and EUR 125/tCO_2. By contrast, in 2021, ECRs in the road transport sector reached EUR 264/tCO_2 in the Netherlands, EUR 254/tCO_2 in Finland and EUR 241/tCO_2 in Italy.

Figure 4.4. Effective carbon rates in the road transport sector only consist in fuel excise taxes

Emissions-weighted average ECR, by fuel category and coverage type, Lithuania, 2021



Note: This figure shows CO_2 emissions from energy use excluding emissions from the combustion of biomass and the effective carbon rate they are subject to in the road transport sector. For readability purposes, the last category is not named on the graph. These are emissions from natural gas use, which represent 0.3% of emissions in the road sector, and which are not covered by any carbon price.
Source: OECD.

Industry

Industry is the second largest emitting sector in terms of CO_2 emissions from energy use, representing 33% of Lithuanian emissions and in this sector firms mainly face a price signal from the EU ETS, with an average permit price of about EUR 53/tCO_2 in 2021. Emissions from the use of two of the main fuel categories in this sector, namely natural gas (39% of emissions in the sector) and coal and other solid fossil fuels (22% of emissions in the sector), face excise tax rates for emissions of less than EUR 3/tCO$_2$. Fuels belonging to the category "other fossil fuels" face no fuel excise tax. Fuels contributing to a very low share of emissions in this sector face higher tax rates.[5]

In the Lithuanian industry sector, the EU ETS and fuel excise taxes complement each other in terms of coverage: they increase emissions coverage by applying to emissions that would otherwise not be covered by the other instrument. For example, natural gas emissions from combined heat and power installations are exempt from fuel excise taxes even though the installation may be covered by the EU ETS. In a similar way, peat and peat products are exempt from fuel excise taxes.[6] However, installations emitting emissions from the combustion of these fuels may still be covered by the EU ETS. The opposite is more common: given that the EU ETS does not apply to all firms, certain emissions (from smaller firms or certain exempted subsectors) only face fuel excise taxes. These features are visible in Figure 4.5. , which shows, in particular, that part of the emissions from natural gas and coal are only covered by the EU ETS and not by fuel excise taxes.

The lack of complementary policies to the EU ETS in pricing Lithuanian industry emissions may be an issue given free permit allocation for the industry sector and price volatility of permit prices. These issues are further developed in the following.

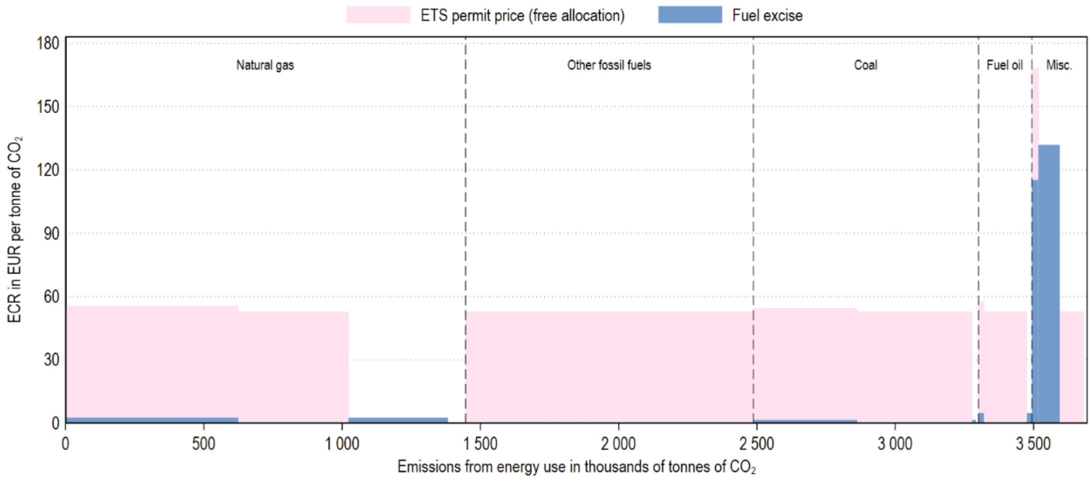
In Lithuania's industry sector 100% of EU ETS emission permits were allocated for free in 2021 (the light pink shading in Figure 4.5. indicates the share of free allocations). Price levels from the EU ETS are about EUR 53/tCO$_2$: effective carbon rates are *marginal* rates, which means that these are rates faced by fuel users for an extra tonne of CO$_2$ emissions. As such, the ETS price level shown on the Figure is the average EU ETS permit price in 2021, and should be understood as the opportunity cost of emitting an extra unit of CO$_2$ for firms (Box 4.1). However, because all EU ETS permits were allocated for free, there is a wedge between the *average* carbon price faced by firms and the *marginal* carbon price. In imperfectly competitive markets, such wedges are important for investment decisions since they can discourage investment of firms in low-carbon technologies (Flues and Van Dender (2017[10])). Other evidence also highlights lower green innovation in firms where a larger share of allocations is distributed for free (Martin et al. (2013[11])). However, as the carbon border adjustment mechanism (CBAM) currently proposed by the European Union is gradually introduced, free permits are planned to be phased out.

Permit prices alone do not provide a stable price signal for investment decisions. Despite the dramatic increase of EU ETS permit prices over 2021 and 2022 (having reached about EUR 88/tCO$_2$ in May 2022 from EUR 34/tCO$_2$ in January 2021[7]), their volatility results in uncertainty for investors. This uncertainty lowers incentives for firms to invest in low-carbon technology and projects (Flues and van Dender, 2020[12]). The difficulty to predict prices for the following years, in turn, also reduces the possibility for firms to plan, adapt and avoid investing in projects that a few years later may cause them to have stranded assets. Carbon price support mechanisms such as those in the United Kingdom (UK) or the Netherlands (Box 4.3) may be useful to address these issues.

A strength of emissions trading systems is that they impose a uniform carbon price on emissions from different fuels and sectors. Contrary to fuel excise taxes, which are generally fuel-specific and are set per physical unit or per unit of energy, emissions trading systems permit prices are expressed per tonne of CO$_2$, so result in all fuels within the covered share of the sector facing the same carbon price.[8] This can help avoid switching to fuels that may be less polluting, but remain carbon-intensive all the same, and increases efficiency, by leaving it up to the polluters themselves to decide how to cut emissions in the least costly manner (e.g. which fuels to reduce use of).

Figure 4.5. Effective Carbon Rates in the industry sector mostly consist of EU ETS permit prices

Emissions-weighted average ECR, by fuel category and coverage type, Lithuania, 2021



Note: This figure shows CO_2 emissions from energy use excluding emissions from the combustion of biomass and the effective carbon rate they are subject to in the industry sector. "Misc." groups together fuels that each represent less than 5% of total energy use from combustible fuels in the sector. In this sector, "Misc." is composed of emissions from diesel, gasoline, LPG and non-renewable waste.
Source: OECD.

Box 4.3. Carbon price support to the EU ETS in the United Kingdom and the Netherlands

The Carbon Price Floor in the United Kingdom

In 2013, the United Kingdom (UK) introduced a carbon price floor (CPF) for the electricity-sector fossil fuel emissions covered by the EU ETS (and now covered by the UK ETS). The CPF consists of two elements: the ETS allowance price and a carbon price support (CPS) mechanism, which is charged on top of permit prices. In 2013, in the electricity sector, the CPS was at GBP 9/tCO_2 emissions and rose to GBP 18 in 2015 (Hirst, 2018[13]). In 2018, this allowed the average effective carbon rate in that sector to reach about EUR 26/tCO_2 while the average EU ETS permit price over 2018 was at about EUR 16/tCO_2.

Leroutier (2022[14]) finds that the UK CPS induced emissions from the UK power sector to drop by 20% to 26% per year on average between 2013 and 2017. (See also Chapter 2, Box 2.1)

The Dutch carbon levy

The Netherlands, as part of its 2020 Climate Agreement, implemented a new carbon levy for industry on 1 January 2021. The new carbon levy complements the permit prices from the EU ETS and implements a domestic price floor for Dutch industrial emissions. The price is intended to increase gradually over time from EUR 30/tCO_2 in 2020 to EUR 125/tCO_2 in 2030, as shown in Table 4.1. This domestic price floor consists of a floating contribution added on top of the price for emission allowances in the EU ETS – so that if the price of emissions allowances exceeds the floor price, the floating contribution becomes zero.

The carbon price path was designed based on current and planned abatement cost curves in the Dutch industry sector.

This carbon levy was implemented in the industry sector, where abatement costs are relatively low when compared to other sectors of the economy, but where the risk that EU ETS allowance prices drop threatens investment in low-carbon assets. The price path was announced from the start of its implementation (with a foreseen review after five years) to allow firms to plan and invest accordingly (see also Chapter 2, Box 2.5).

Table 4.1. The Dutch carbon price path for industrial emissions

Year	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Floor price (in EUR per tonne of CO_2)	30	40.56	51.12	61.68	72.24	82.80	93.36	103.92	114.48	125.04

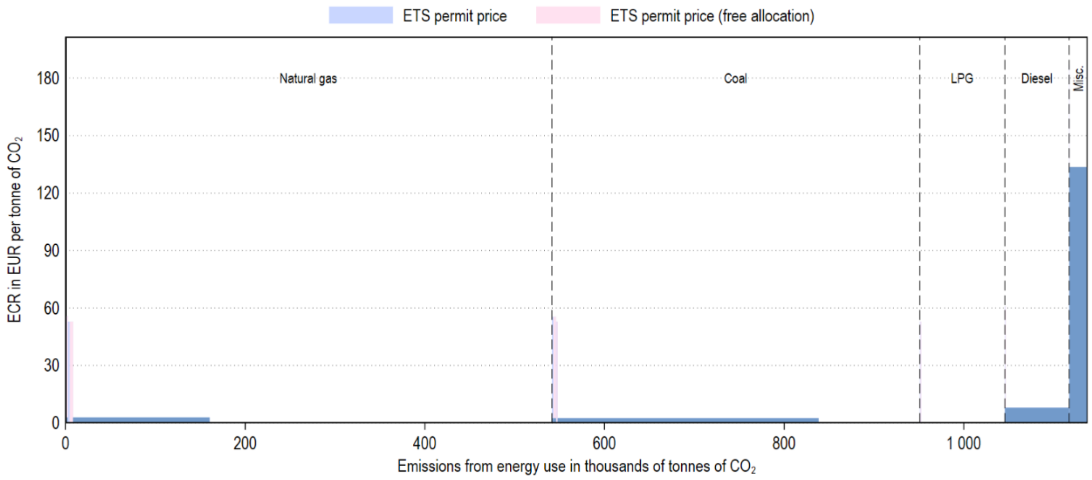
Source: Adapted from Figure 6 in Anderson et al. (2021[15]).

Buildings

The buildings sector (residential and commercial heating) is responsible for about 10% of CO_2 emissions from energy use in Lithuania and overall, emissions in this sector are priced at much lower rates than in other sectors. Biomass is the main source of heating in Lithuania, but as discussed in Box 4.2, emissions from biomass combustion are generally not priced. Abstracting from emissions from biomass combustion, natural gas is the largest source of CO_2 emissions from energy use in the heating sector, representing 47.6% of emissions in the sector. Among these emissions, about three quarters are for residential use, and hence untaxed (Figure 4.6).[9] The priced share of emissions from natural gas (stemming from commercial and public services use) face a fuel excise tax rate equivalent to EUR 2.9/tCO_2 on average. LPG used for heating is entirely untaxed as well, while the priced share of coal emissions faces a slightly higher tax rate on average than in the industry sector (due to a higher rate on residential users), of EUR 2.5/tCO_2.[10] Diesel is the most highly taxed fuel in this sector, at almost EUR 8/tCO_2, even though in this sector it faces the lowest fuel excise rate (EUR 0.02114 per litre) when compared to the road (EUR 0.372 per litre) and agriculture and fisheries (EUR 0.06 per litre) sectors.[11] The EU ETS is not discussed here, as it covers less than 2% of emissions in this sector (with 60% of permits allocated for free).

Figure 4.6. Effective Carbon Rates in the buildings sector are low and result mostly from fuel excise taxes

Emissions-weighted average ECR, by fuel category and coverage type, Lithuania, 2021



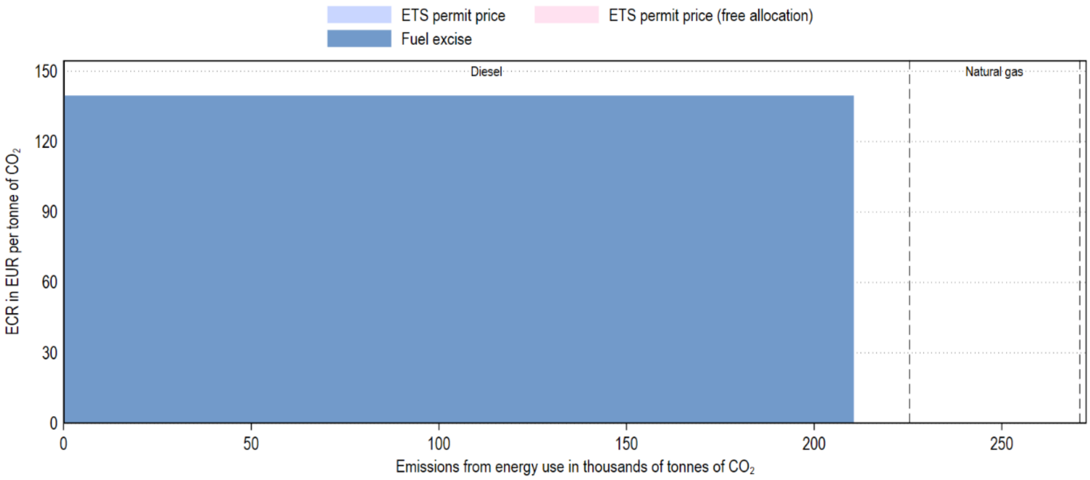
Note: This figure shows CO_2 emissions from energy use excluding emissions from the combustion of biomass and the effective carbon rate they are subject to in the buildings sector. “Misc.” groups fuels that each represent less than 5% of total energy use from combustible fuels in the sector. In this sector, it is composed of emissions from gasoline and kerosene.
Source: OECD.

Off-Road Transport

The off-road transport sector is responsible for 2.4%[12] of CO_2 emissions from energy use in Lithuania and the majority of these either face the same effective carbon rates as in the road transport sector or none. The main fuel responsible for CO_2 emissions from energy use in this sector is diesel (accounting for about 83% of emissions), mostly stemming from rail transport (84% of diesel emissions) and to a smaller extent from domestic navigation (6.6%). These emissions are subject to the same fuel excise tax rate as in the road sector, resulting in a rate of about EUR 140/tCO_2. Natural gas is used for the support and operation of pipeline transport, and its emissions are subject to no tax.[13] Fuels used for the purpose of domestic aviation – gasoline and kerosene – face no tax, although they do when used for other purposes, such as in road transport (Figure 4.4). Within the sector, the EU ETS only covers a share of aviation emissions, which themselves represent less than 0.7% of CO_2 emissions from energy use in the Lithuanian off-road transport sector.

Figure 4.7. Effective Carbon Rates in the off-road transport sector mostly apply to diesel use

Emissions-weighted average ECR, by fuel category and coverage type, Lithuania, 2021



Note: This figure shows CO_2 emissions from energy use excluding emissions from the combustion of biomass and the effective carbon rate they are subject to in the off-road transport sector. Taken together, emissions from gasoline and kerosene represent less than1% of total sectoral emissions, so they were grouped into one category, which is not named for readability reasons. These emissions stem from domestic aviation, and the share of these that is subject to the EU ETS is so low that it is not visible on the graph.
Source: OECD.

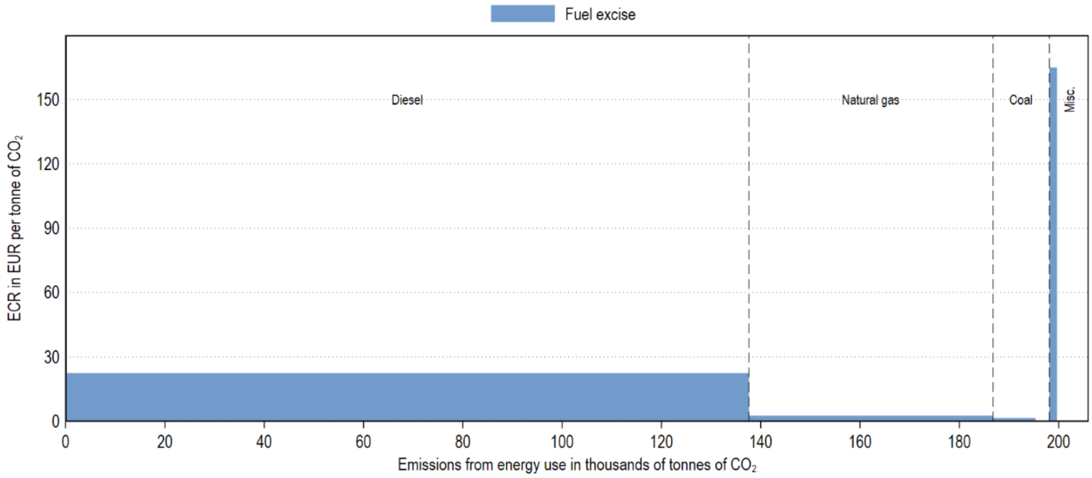
Agriculture and fisheries

The agriculture and fisheries sector represents 1.8% of CO_2 emissions from energy use in Lithuania and as for the road sector, emissions are covered by fuel excise taxes only (Figure 4.8). The largest share of emissions comes from diesel use (66.8%), which faces the highest fuel excise rate in terms of EUR/tCO_2, at EUR 22.5 (a higher rate than in the buildings sector and lower than in the road sector). Natural gas and coal use face much lower rates, both below EUR 3/tCO_2. Gasoline use faces the same rate of EUR 205/tCO_2 as in the road sector but accounts for less than 1% of emissions.

As in the majority of countries, CO_2 emissions from energy use constitute a minor share of emissions in the agriculture and fisheries sector. Methane emissions from livestock and nitrous oxide emissions from agricultural soils are the main GHGs responsible for CO_2-equivalent (CO_2e) emissions in the sector. Currently, these latter emissions hardly face any carbon price. The New Zealand government, within a long-term process of engagement with farmers and growers is one of the first countries to consider the introduction of carbon pricing (at least on methane emissions) in the agricultural sector.[14]

Figure 4.8. Effective Carbon Rates in the agriculture and fisheries sector only stem from fuel excise

Emissions-weighted average ECR, by fuel category and coverage type, Lithuania, 2021



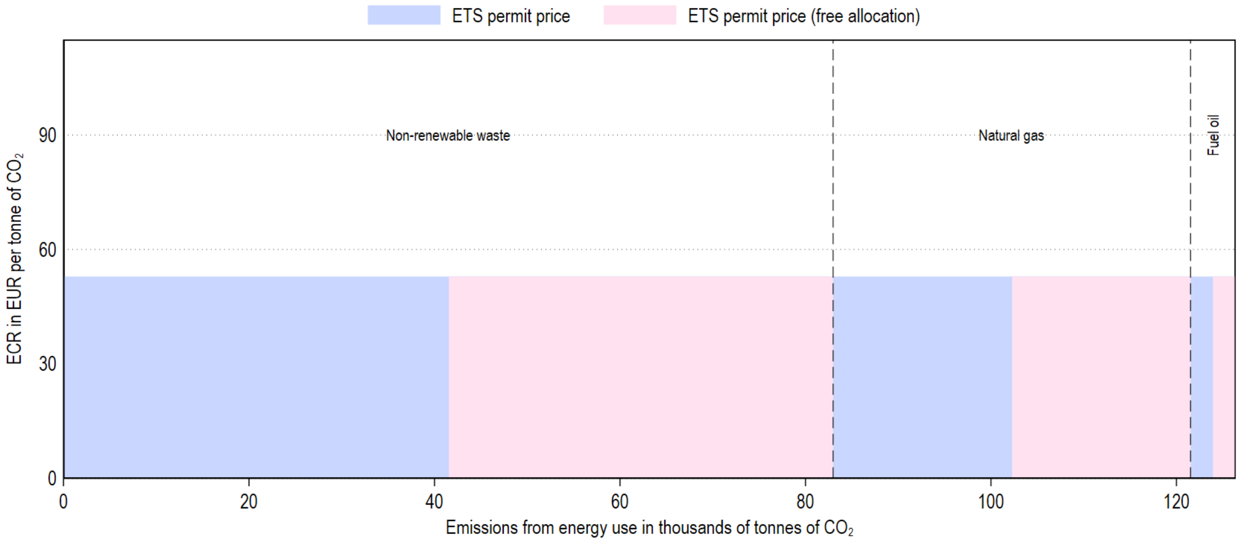
Note: This figure shows CO_2 emissions from energy use excluding emissions from the combustion of biomass and the effective carbon rate they are subject to in the agriculture and fisheries sector. “Misc.” groups fuels that each represent less than 5% of total energy use from combustible fuels in the sector. In this sector, it is composed of emissions from fuel oil, gasoline and LPG.
Source: OECD.

Electricity

The electricity sector (which is made up of plants for which the main activity is to produce electricity) is responsible for 1.1% of CO_2 emissions from energy use in Lithuania and its emissions are exclusively covered by the EU ETS. In line with emission use patterns (Figure 4.2, Panel B), CO_2 emissions from energy use excluding biofuel stem mainly from non-renewable waste and natural gas use.[15] Emissions from non-renewable waste represent 65.7% of CO_2 emissions from energy use excluding biofuels in this sector, while those from natural gas represent 30.5% and fuel oil the remaining 3.9%. However, none of the fuels used in this sector face a fuel excise tax. Thus the EU ETS is the only form of emissions price in the sector (Figure 4.9), bringing up the same potential issues as discussed earlier in relation to the industry sector.

Figure 4.9. Effective Carbon Rates in the electricity sector only stem from the EU ETS

Emissions-weighted average ECR, by fuel category and coverage type, Lithuania, 2021



Note: This figure shows CO_2 emissions from energy use excluding emissions from the combustion of biomass and the effective carbon rate they are subject to in the electricity sector.
Source: OECD.

Alignment with carbon pricing benchmarks

Depending on the sector, effective carbon rates in Lithuania are more or less aligned with benchmark carbon rates consistent with attaining carbon neutrality by 2050 or reflecting the externalities caused by CO_2 emissions. Several studies find that carbon prices of EUR 30/tCO_2 in 2021, of at least EUR 60 in 2025 and around EUR 125 in 2030 would be consistent with carbon neutrality goals – under complementary policies and technological development and deployment assumptions (Box 4.4). A recent study by the European Commission (2021[16]) highlights a central estimate for the social cost of carbon (SSC) of EUR 100/tCO_2.

Focusing on the low-end EUR 30/tCO_2 in 2021 benchmark, the analysis above shows that priced emissions in the road transport, off-road transport, industry and electricity sectors go beyond this benchmark. As in most EU countries, effective carbon rates on priced emissions in road and off-road transport are considerably above the EUR 30/tCO_2 benchmark, due to the high rate of fuel taxes in these sectors. However, high taxation rates in the road transport sector also reflect the many other externalities caused by this sector, such as air pollution, accidents, congestion and noise, which have much more immediate impacts. [16] Van Dender (2019[17]) provides a more detailed discussion of the social costs of road usage, and also highlights mechanisms beyond carbon pricing that can help address these issues.

In the off-road sector, 17% of emissions are unpriced and hence fall short of reaching the EUR 30/tCO_2 benchmark. The EU ETS covers 85% of emissions in the industry sector, and 100% in the electricity sector. These sectors thus largely meet the benchmark, being marginally priced at EUR 53/tCO_2 on average over 2021. The buildings as well as the agriculture and fisheries sectors, which together account for 11.8% of CO_2 emissions from energy use (excluding biofuel use), do not meet the EUR 30/tCO_2 benchmark. Due to reduced fuel excise rates on households and commercial users, the buildings sector exhibits particularly low rates, at an average of EUR 9.8/tCO_2 on priced emissions, with 52% of emissions remaining unpriced. Emissions in the agriculture and fisheries sector face higher prices than in the buildings sector, at an average of EUR 17.8/tCO_2 on priced emissions. This low average mainly stems from the preferential fuel excise rate diesel use faces in this sector. However, only 4% of emissions in the agriculture and fisheries sector are unpriced.

Although the majority of emissions in most sectors in Lithuania were priced at least at the 2021 benchmark of EUR 30/tCO_2, important disparities remain, which can result in inefficiencies. Disparities are caused by exemptions or lower rates on certain users (e.g. business vs non-business users), different fuel excise rates and different pricing instruments. A uniform carbon price rate at least at the sectoral level would enhance cost-efficiency, encouraging emissions cuts where they are cheapest within each sector.

Box 4.4. Carbon pricing benchmarks

The impact of greenhouse gases on climate

There are seven main greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF6) and nitrogen trifluoride (NF_3). Greenhouse gas emissions are directly responsible for climate change through global warming: by absorbing long-wave infrared radiation reflected by the earth's surface, they prevent part of the infrared radiation from being reflected back to space. This results in the absorbed energy being converted into heat.

Externalities and net-zero targets

As a result, any activity involving greenhouse gas emissions results in a climate externality imposed on others. Moreover, steadily increasing global warming could ultimately result in crossing tipping points beyond which sever and disruptive changes to human society would become irreversible. In line with this, the objective of the Paris Agreement is to minimise the threat of climate change by keeping the increase in the global average temperature to well below 2°C above pre-industrial levels and to preferably limit the increase to 1.5°C above pre-industrial levels.[17] In order to implement this objective, countries are seeking to attain carbon neutrality by 2050 with, possibly, mid-term objectives to 2030 such as the European Union’s Fit for 55 proposal.

Carbon pricing benchmarks

Several studies use models to establish carbon prices consistent with these mid-term or longer-term objectives. These models depend on assumptions about energy price pathways, current and future technologies, complementary policies, and carbon capture and storage development and deployment. Kaufman et al. (2020[18]) estimate upper bound carbon prices necessary to reach the United States’ 2030 emissions reduction targets of USD 64/tCO_2 in 2025 and USD 124/tCO_2 in 2030. These figures are slightly lower than the IEA’s latest carbon price trajectory for the electricity, industry and heat sectors in advanced economies (IEA, 2021[19]), which sets prices at EUR 75/tCO_2 in 2025 and EUR 130/tCO_2 in 2030.

A recent study by the European Commission (2021[16]) focuses on calculations of the social cost of carbon (SSC)[18] and, based on a wide range of studies, highlights a central value of EUR 100/tCO_2 through 2030.

Effective carbon rates in Lithuania under prospective policy scenarios

This section simulates three policies reforms that have recently been proposed either at the national or European level, and that if passed, would affect carbon pricing in Lithuania. Each reform would affect the effective carbon rate profile. A detailed examination of the resulting profiles allows an assessment of whether the reforms address certain of the shortcomings of Lithuania's carbon pricing policies highlighted in Section 4.1. Its effect on carbon pricing revenues for Lithuania are also discussed in the case of the Lithuanian Draft Law on excise duties.

Policy scenario 1 considers the implementation of the national Draft Law on fuel excise duties, which proposes changes in fuel excise taxes and the introduction of a carbon tax. Policy scenario 2 considers the implementation of the proposed revision of the European Union Energy Taxation Directive (EU ETD), which sets higher minimum taxation rates on many fuels. Policy scenario 3 considers the introduction of a second European Union Emissions Trading System (EU ETS) for transport and heating fuels.[19]

Policy scenario 1: the Draft Law on Excise Duties of the Republic of Lithuania

The Draft Law on Excise Duties aims at increasing fuel excise taxes and expanding their base as well as introducing a carbon tax component in fuel excise duties to pursue Lithuania's environmental goals while avoiding detrimental effects on economic growth.[20] It was prepared by the Lithuanian government in 2021, and initially planned for excise duty rates to increase from 2023, and for the carbon tax component to come into effect from 2025.

The Draft Law seeks to reduce or eliminate excise duty exemptions on fossil fuels and to increase excise duties on diesel, coal, coke and lignite over the period 2023 to 2025. As part of the new law, rates on natural gas use are meant to slightly increase as well in 2025. The law proposes the simultaneous introduction of excise duties on peat used for heating to avoid substitution into this cheaper heating fuel, which is highly carbon-emitting. The excise duty rates on the use of LPG for household heating would also increase (although only once in 2023, as opposed to many other fuel excise rates which would increase incrementally over the 2023-2025 period).[21]

The Draft Law further proposes the introduction of a CO_2 component to fuel excise taxes in 2025, once the excise duty exemptions on fossil fuels have been eliminated or reduced. The CO_2 tax component would start at EUR 10/tCO_2 in 2025, to reach EUR 60/tCO_2 in 2030.[22] The carbon tax component would not apply to entities already subject to the EU ETS.

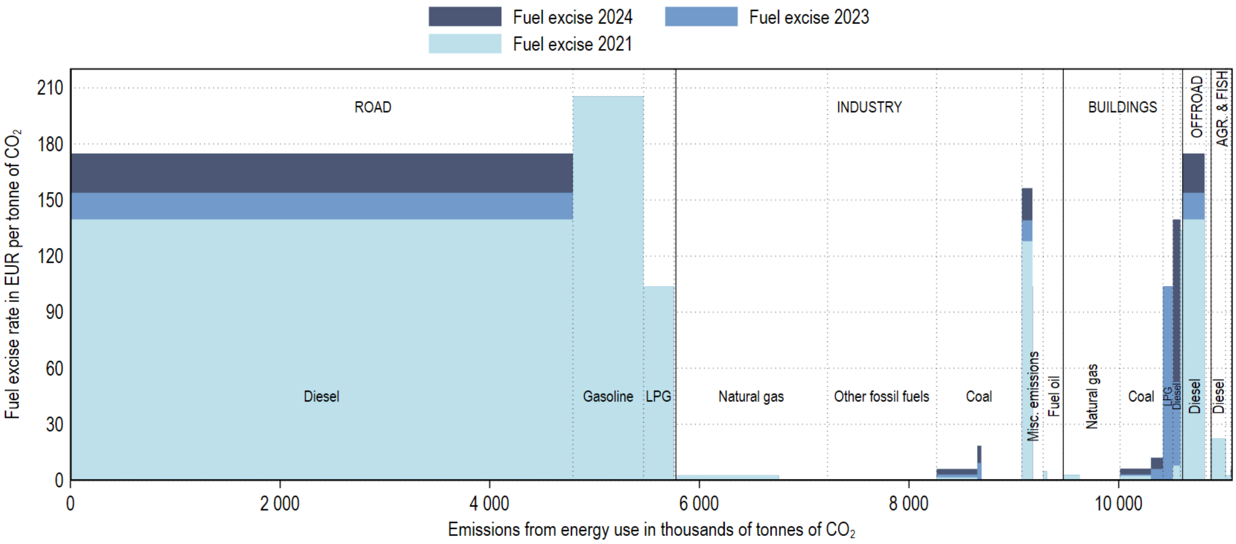
The increases in fuel excise rates and the phasing out of exemptions for 2023 and 2024 would not increase the tax base by much but would considerably increase rates in terms of EUR/tCO_2 for emissions from diesel, coal and LPG for used for household heating (Figure 4.10). On average, tax rates (i.e. fuel excise taxes) on priced emissions are increased by 7.6% in 2023 and 20.4% in 2024 as compared to 2021 levels.

The most affected sector in terms of base-broadening and rates is the buildings sector, which helps it catch-up with other sectors highlighted in Section 4.1, both in terms of coverage (base) and price-level (rates) gaps. The phasing-out of exemptions ensures that 66% of emissions are priced in 2023 and 2024 (up from 48% in 2021), in particular due to the introduction of a fuel excise rate on LPG used for household heating. The increased rates for emissions from coal (triple) and diesel use (17-fold) ensure that the average effective carbon rate on priced emissions goes from EUR 9.8/tCO_2 in 2021 to EUR 36.6/tCO_2 in 2024.[23]

The Draft Law would also partially address the inefficiency of the "diesel differential" highlighted in Section 4.1, by reducing the gap between the ECR for diesel and gasoline. As of 2024, there would still remain a gap of about EUR 30/tCO_2 (down from EUR 66/tCO_2 in 2021). The proposed increase in diesel excise taxes also significantly increases effective carbon rates in the road and off-road sectors, which, as mentioned in the previous section, may also help address other externalities related to the transport sectors such as air pollution. Additionally, rates for business and non-business users would be evened out for coal as well as for coke and lignite use, and this could help minimise inefficiencies cause by heterogeneous rates as discussed in the previous section. Indeed, aligning carbon rates faced by users within a sector increases the efficiency of carbon pricing by allowing CO_2-emission decreases where it is the least costly to do so.

Figure 4.10. In 2023 and 2024 the Draft Law would particularly increase fuel excise rates in the road, off-road and buildings sectors

Emissions weighted average fuel excise rates, in EUR/tCO$_2$, all sectors, Lithuania



Note: This figure shows CO$_2$ emissions from energy use excluding emissions from the combustion of biomass and the fuel excise tax rates they are subject to in EUR/tCO$_2$, in all energy sectors of the Lithuanian economy apart from the electricity sector. Indeed, in this sector fuels are untaxed and would continue to be so under the Draft Law. Fuel excise tax rates are represented for 2021 as a reference, as well as in 2023 and 2024, when only fuel excise taxes are meant to nationally change.
Source: OECD, Draft Law on Excise Duties of the Republic of Lithuania.

As can be seen in Figure 4.11, Panel A, the carbon tax component, which is planned to come into effect in 2025 and to steadily increase with a predetermined path at least until 2030, will mainly apply to emissions in harder-to-abate sectors, thus allowing users in these sectors to adapt and plan, but will not apply to emissions covered by the EU ETS. The carbon component is partly meant to complement the EU ETS. However, its price level in 2025 is eight times lower than the current allowance price level, which is at EUR 88/tCO$_2$ in May 2022. Despite this potential caveat, the fuels used in the sectors to which it applies – the road, buildings and off-road sectors – are subject to much higher excise rates than those in EU ETS-covered sectors. With current EU ETS allowance prices, this results in higher ECRs in these three sectors, which are also hard-to-abate sectors today (be it for technological, affordability or political economy reasons). The relatively high and stable carbon tax proposed for the next 6 years would allow actors in these sectors to carry out a forward-looking switch to cleaner technologies.

In particular, in the road sector, such price levels (on average EUR 195/tCO$_2$ in 2025 and EUR 245/tCO$_2$ in 2030, see Figure 4.11, Panel B) can help prepare the transition to electric vehicles (EVs) by making the substitution from internal combustion engine vehicles to EVs more advantageous. This transition would be in line with the EU Fit for 55 proposal of phasing-out the sales of new ICE cars by 2035.[24] However, the current design of the carbon tax as a non-overlapping instrument with the EU ETS does not allow it to address certain issues raised by the uncertainty of allowance prices. In certain countries such as the Netherlands or the United Kingdom, carbon taxes have been used with this aim by effectively setting carbon pricing floors in certain sectors (Box 4.3).

The proposed introduction of a fuel excise tax on households' natural gas use, along with the introduction of a carbon tax on LPG use, both from 2025, would bring coverage of CO$_2$ emissions from energy use in the buildings sector to 100%. This would present important progress from 2024 rates and coverage, and would result in an increase in the coverage of economy-wide emissions from energy use excluding biofuel combustion to 98.5% from 2025 onwards. The residual gap is principally due to emissions from domestic aviation and navigation as well as from pipeline transport remaining unpriced.

In 2025, at current permit prices, the ECR would exceed the benchmark price of EUR 60/tCO_2 for the same advanced sectors in terms of carbon pricing as in 2021, i.e., the road, off-road, electricity and industry sectors, and would still fall short of this benchmark price for the buildings and agriculture sectors. This last statement, however, masks a difference in carbon pricing progress between the two sectors, should the law be passed. Despite not meeting the EUR 60/tCO_2 benchmark, the Draft Law would induce the most change in the buildings sector, both in terms of base broadening and rates increase, while hardly affecting carbon pricing in the agriculture and fisheries sector. Carbon prices in the electricity and industry sectors would remain largely unaffected by the proposed reform: in both sectors, the EU ETS would remain the main driver of both coverage and price levels.

Under the Draft Law, in 2025, more than 95% of emissions would be priced in the buildings, electricity, road, agriculture and industry sectors, and 77% in the off-road sector. Average effective carbon rates would be at EUR 198/tCO_2 on priced emissions in the off-road transport sector, 196 in the road transport sector, 88 in the electricity sector, 84 in the industry sector, 31 in the buildings sector and 19 in the agriculture and fisheries sector. In 2030, abstracting from potential changes to the EU ETS, the proposal would induce progress primarily in the off-road transport, road transport and buildings sectors, with average ECRs on priced emissions of respectively EUR 248/tCO_2, EUR 245.5/tCO_2 and EUR 53/tCO_2.

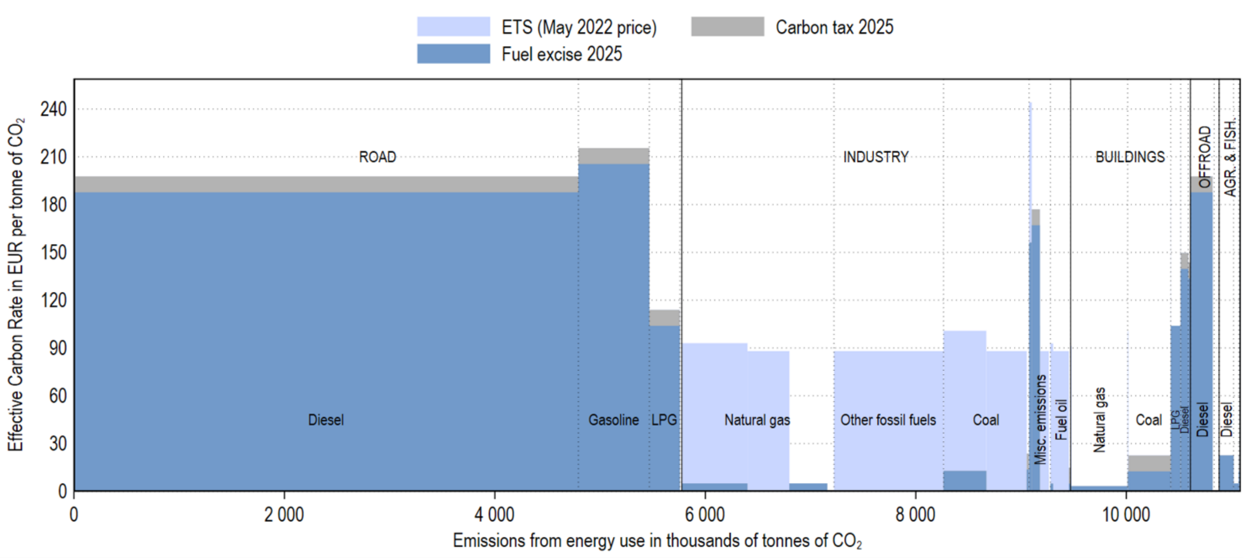
All in all, the proposed fuel excise rate changes, along with the introduction of the carbon tax would (i) help reduce the diesel differential in the road transport sector, improve coverage in the buildings sector and thus more broadly, and bring ECRs close to levels consistent with net-zero goals, but would (ii) miss the opportunity of providing more stability to investors in the industry sector especially. Indeed, with its current design, the carbon tax component adds on to existing fuel excise taxes and only applies to entities not subject to the EU ETS. However, in the industry sector in particular, where fuels are hardly taxed, its design could be adapted in order to act as a carbon price floor (see Box 4.3 for country-specific examples) – hence applying to emissions covered by the EU ETS and addressing the potential volatility and uncertainty issues discussed in Section 4.1. In practice, carbon taxes applying to emissions covered by the EU ETS could work as a complement to the permit price: for example a carbon tax of EUR 60/tCO_2 would kick-in only if the permit price was lower. With such a carbon tax price path, individuals and firms in all sectors would know with certainty which minimum price CO_2 emissions would be facing in the years to come, thus improving their adaptation, investment and planning decisions and possibilities.

This planned series of reforms along with the increase of the EU ETS average permit price to EUR 88/tCO_2[25] (from EUR 53/tCO_2 in 2021) would result in a 4% reduction in CO_2 emissions from energy use by 2030, and a 65% increase in carbon-related revenue. These figures are obtained using recent estimates of CO_2 emission responses to carbon pricing (D'Arcangelo et al., Forthcoming[20]), showing that a EUR 10 increase in the effective carbon rate decreases CO_2 emissions from fossil fuels by 3.7% on average in the long term.[26] Despite their effect on emissions (i.e. on the erosion of the base), it is estimated that the series of increases in effective carbon rates would result in non-negligible revenues of EUR 0.98 billion in 2023, EUR 1.21 billion in 2025 and EUR 1.47 billion in 2030, which would respectively represent 1.96%, 2.43% and 2.96% of the Lithuanian 2020 Gross Domestic Product (GDP).[27]

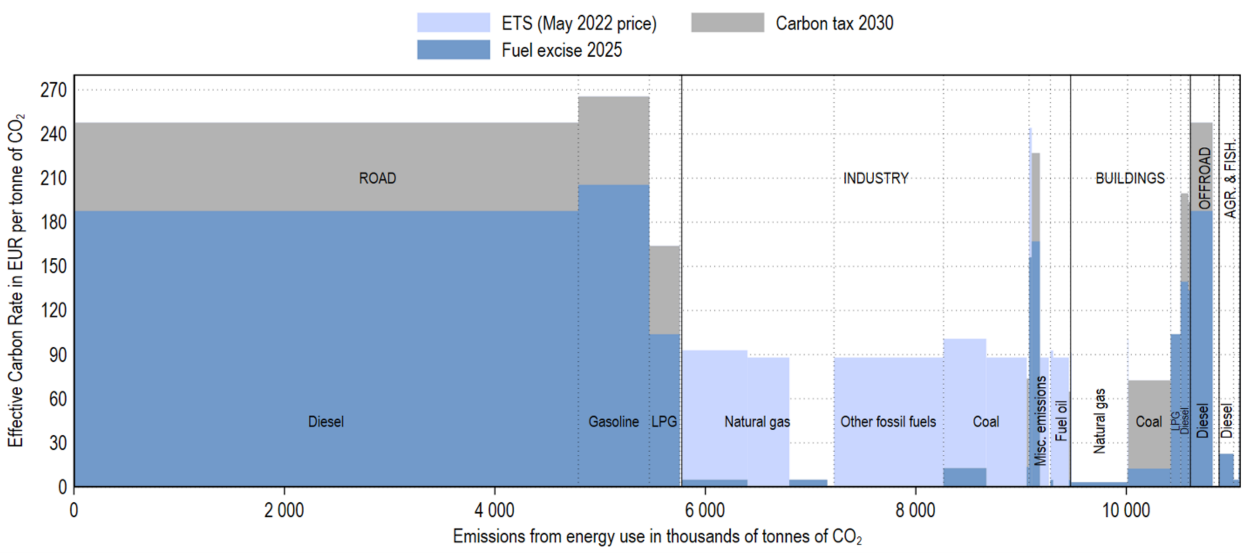
The main revenue source, however, would be from the road transport sector,[28] and these figures do not account for the electrification of the vehicle fleet, which is bound to substantially decrease revenues from carbon pricing in that sector. In order to tackle this issue as well as the externalities (such as congestion and accidents) that would remain despite electrification of the transport fleet, the use of new price-based instruments could be considered. Distance-based taxes and congestion charges are discussed in Van Dender (2019[17]), and could have the added benefit of being better at tackling this issue than carbon pricing.

Figure 4.11. The carbon tax component would mostly affect the road and off-transport sectors as well as the buildings sector

Panel A: Emissions-weighted average ECR, by sector, fuel category and coverage type, Lithuania, 2025



Panel B: Emissions-weighted average ECR, by sector, fuel category and coverage type, Lithuania, 2030



Note: This figure shows CO_2 emissions from energy use excluding emissions from the combustion of biomass and the effective carbon rates they would be subject to in EUR/tCO_2, in all energy sectors of the Lithuanian economy apart from the electricity sector, were the Draft Law passed. Indeed, in this sector fuels are untaxed and would continue to be so under the Draft Law. The figure now includes EU ETS coverage, as a point of comparison with the new carbon tax component, which is in part meant as a complement to this mechanism. In 2025, the carbon tax component of the fuel excise tax is at EUR 10/tCO_2 on all concerned fuels and in 2030, at EUR 60/tCO_2.
Source: OECD, Draft Law on Excise Duties of the Republic of Lithuania.

Policy scenario 2: the proposed revision for the European Union Energy Taxation Directive

Fuel excises taxes in Lithuania are subject to the minimum rates set out by the EU ETD. Its revision proposal would hence also impact fuel excises in Lithuania. This section discusses EU ETD revisions and timeline as they were proposed in early January. For now, however, the negotiations are on hold, possibly until March 2023.[29]

The EU's Energy Taxation Directive (ETD) was first implemented in 2003 and has since set minimum excise duty rates for the taxation of electricity as well as of energy products used as motor fuels and heating fuels for all EU member states. Individual EU member states may set their own rates as long as they are at least equal to these minimum rates. In practice, most member states tax almost all of their energy products and in some cases, considerably above the ETD minimum rates.[30]

Revising the ETD to better reflect the EU's environmental goals is one of the key measures needed to deliver the European Green Deal. On 21 January 2022, the European Economic and Social Committee adopted an opinion on the Energy Taxation Directive; the rates proposed in the 14 July 2021 proposal are for 2023 onwards (European Commission, 2021[21]).[31] This update has been proposed for multiple reasons, including:

- the fading link between the minimum tax rates of fuels and their energy content as well as environmental impacts;
- the development of emerging fuels, to which, for lack of being listed in the current ETD, the tax rate of the fuel that is used for equivalent purposes applies;
- the increasing number of exemptions and reductions across Member States, which damages the possibility for a level playing field between all Members.[32]

To address (i), rates in the proposed revision of the EU ETD are expressed in EUR per GJ, instead of EUR per common commercial unit (e.g. 1000 litres or tonnes). The rates increase with the fuel's environmental impacts, but also account for the fuel's us e and hence the distributional consequences of its taxation. For example, motor fuels are taxed at a higher rate than heating fuels.

To address (ii), the European Commission established a more exhaustive list of fuels, from the most polluting to the most sustainable ones. The most polluting fossil fuels as well as non-sustainable biofuels are subject to the highest rates (EUR 10.75 or 0.9 per GJ depending on their use). Fuels which are considered as transitionary fuels are subject to medium rates (EUR 7.17 or 0.6 per GJ depending on their use), while sustainable but not advanced biofuels are subject to even lower rates (EUR 5.38 or 0.45 per GJ depending on their use). The lowest rates apply to advanced sustainable biofuels and biogas, and renewable fuels of non-biological origin (EUR 0.15 per GJ whatever their use). The rates were set according to the environmentally damaging effects of fuels, and as such, are not carbon-specific. Hence, these minimum rates also apply to sectors subject to the EU ETS.

To address (iii), exemptions such as those on aviation or maritime fuels are to be phased out. For intra-EU flights or navigation, the highest motor fuel rates are applied. International flights and shipments are subject to lower rates, either through reduced rates on motor fuels, or with a slow phase-in to the highest motor fuel rates. Certain reductions remain possible, in particular for the agricultural sector (but not fishery). Moreover, "Member States shall exempt from taxation under fiscal control energy products and electricity used to produce electricity and electricity used to maintain the ability to produce electricity."

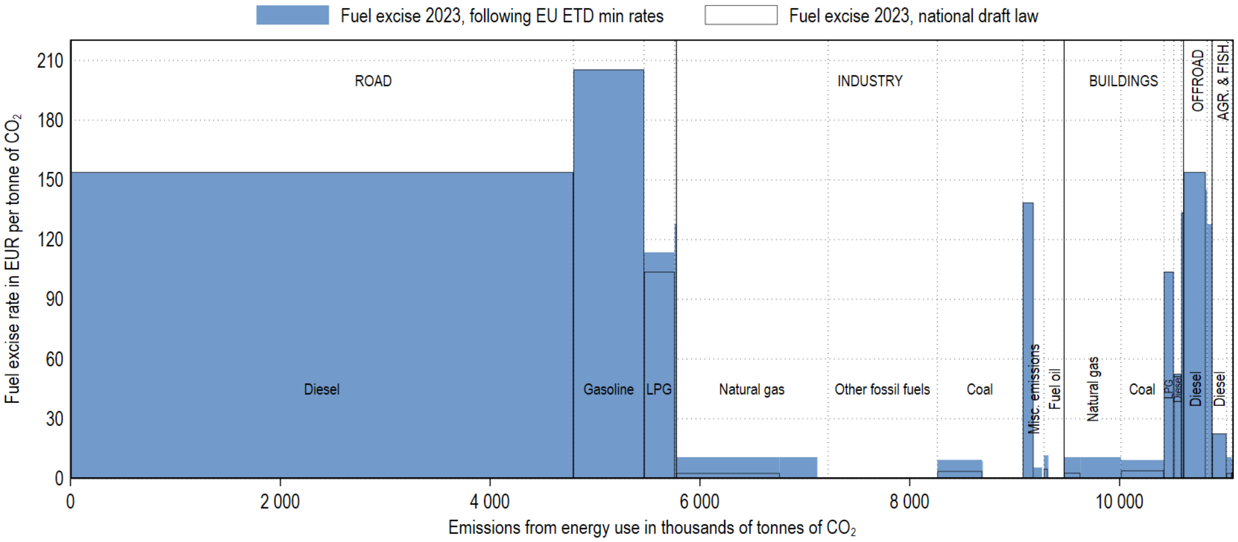
This reform may potentially cause distributional and affordability issues, as the expense share of fuel use in total budgets may be greater for poorer and rural households (see Gore et al. (2022[22]) for a recent analysis), but the goal of the proposal is for the reform to be anchored into a broader package, the Fit for 55 proposal. Under the Energy Efficiency Directive, the public sector will be required to renovate 3% of its buildings each year to drive the renovation wave, create jobs and bring down energy use and costs.

Additionally, a Social Climate Fund was proposed, which would provide dedicated funding to EU member states to help households finance investments in energy efficiency, new heating and cooling systems, and cleaner mobility.[33] Chapter 6 of this report also study potential ways to recycle revenue that could help address these issues.

Figure 4.12 shows that when comparing the 2023 excise tax rates that would result from Lithuania's Draft Law to the proposed minimum rates for 2023, it appears that the main additional impact of the EU ETD proposal would be on the taxation of natural gas. This would increase the base coverage of the buildings sector to 98.5% (as compared to around 52% today and 66% in 2023 with the Draft Law only). The increase in coverage as compared to the Draft Law, however, would primarily hold until 2025, after which a tax on natural gas use by households would also be introduced under the Draft Law (the only difference would then be the increased coverage of natural gas in the industry sector due to the EU ETD revision). The extension to navigation and aviation fuels would increase the base in the off-road sector as well. Given that the minimum rates on diesel and gasoline are lower than those which would result from the implementation of the Draft Law in 2023, the flattening out of the gap between the two would not occur, and the inefficiency mentioned previously would persist.

Figure 4.12. In 2023 EU ETD revised rates would mainly affect the ECR for coal and natural gas use

Emissions-weighted average fuel excise rates in EUR/tCO$_2$, by sector, fuel category and coverage type, Lithuania



Note: This figure shows CO$_2$ emissions from energy use excluding emissions from the combustion of biomass and the effective carbon rates they would be subject to in EUR/tCO2, in all energy sectors of the Lithuanian economy apart from the electricity sector, under the Draft Law or the EU ETD revision. In the electricity sector fuels are untaxed and would continue to be so under the Draft Law.
Source: OECD, current proposal for the EU ETD revision.

Policy scenario 3: The proposed extension of the EU ETS

1. The European Commission (EC) has proposed to extend carbon pricing to the buildings and road transport sectors, through a second emissions trading system, the ETS2. This new system would operate in parallel to the existing one and would regulate fuel suppliers upstream (see also Chapter 2). The proposed starting date was initially 2025, with an emissions cap and from 2026, 100% auctioning of emissions allowances (Gore, 2022[22]).[34] In Germany, a national ETS was implemented in 2021, with similar features. It is described in Box 4.5.

Box 4.5. The German national Emissions Trading System

In 2021, Germany launched its National Emissions Trading System – *Nationales Emissionshandelssystem* or 'nEHS' – for heating and motor fuels.

The national ETS is to be phased in gradually, with a fixed price per tonne of CO_2 from 2021 (EUR 25/tCO_2) to 2025 (EUR 55/tCO_2). In 2026, auctions with minimum and maximum prices are to be introduced.

The system is to cover fuel oil, LPG, natural gas, gasoline, and diesel in 2021. Other fuels such as coal are to be covered from 2023 onwards.

The cap is to be determined annually based on a separate Cap Regulation (adopted in 2021). The cap was set in line with Germany's reduction targets for the non-EU ETS sectors as defined by the European Effort Sharing Regulation (ESR) and is to decline each year.

Source: ICAP (2021[23]).See also Box 2.3.

As the ETS 2 and its various design options remain under discussion, the simulation applied here assumes that the German nEHS design is applied to the EU ETS extension. The simulation assumes that the ETS 2 will be introduced from 2025 and that permit prices are fixed at EUR 55/tCO_2 that apply to 40% of emissions. It further retains fuel excise rates and carbon tax rates as would apply under the Draft Law and the EU ETD revision in 2025 – i.e. the EU ETS extension would take place along with the EU ETD revision and the implementation of the Draft Law, with no other tax changes.

In the road transport sector in Lithuania, such an EU ETS2 would bring ECRs to an average of EUR 218/tCO_2 by 2025, which is in line with currently observed carbon prices in other EU countries such as France, Sweden and Ireland. As such the ETS 2 would provide additional incentive and support to the transition to electric vehicles, while keeping in mind the importance of maintaining an equivalent source of revenue and of finding alternative ways to tackle other externalities caused by circulation.

In the buildings sector, such an EU ETS2 would bring ECRs to an average of EUR 56.5/tCO_2 by 2025, which would almost align carbon prices in that sector with the EUR 60/tCO_2 benchmark for 2025. An increase of permit prices or ETS2 coverage until 2030 would also ensure an alignment with benchmark prices for 2030.

Pricing CO_2 emissions from biofuel use

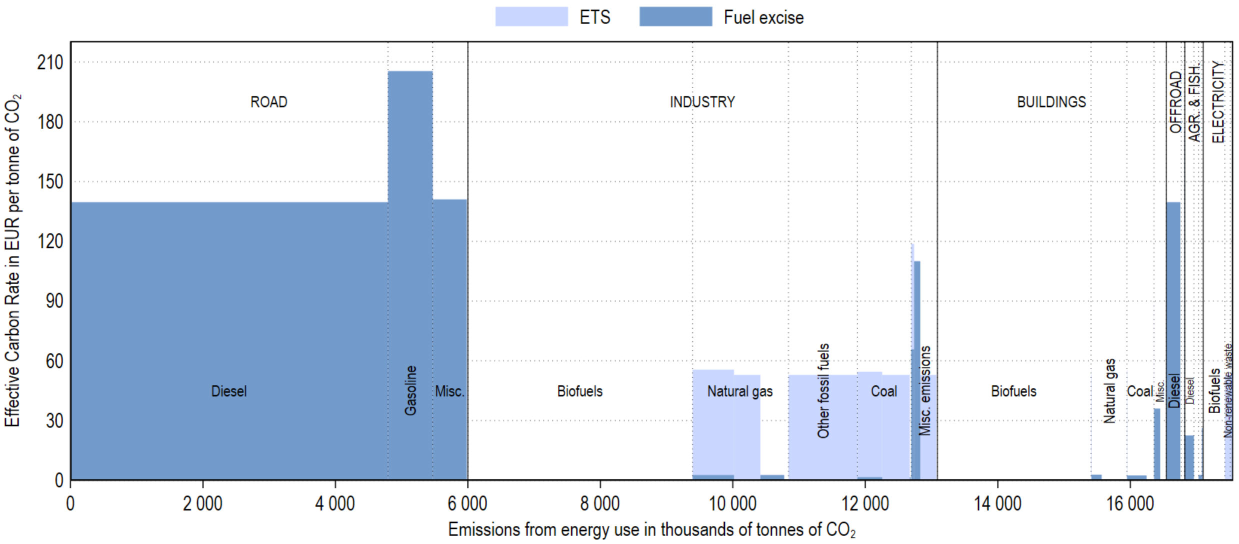
In Lithuania, only biofuels used in the road sector are taxed – consistent with the discussion in Box 4.2 on the scarcity of taxes on biofuel combustion. In Lithuania, biofuel combustion represents a minor share of emissions from fuel combustion in the sector.

As can be seen in Figure 4.13, CO_2 emissions from biofuel combustion account for a much larger share of emissions in the industry, buildings and electricity sectors (consistent with Figure 4.2), none of which are priced. When accounting for these emissions, only 61% of total CO_2 emissions from fuel combustion are priced in 2021.

The Draft Law proposes to phase-in taxes on first generation biofuels and the proposed revision to the EU ETD includes different rates for biofuels depending on their sustainability (Table A.4). As alluded to in Box 4.2, reliable data on biofuel sustainability may not be readily available and may make taxing biofuels according to sustainability categories challenging. Regardless, the EU ETD revision proposes a minimum rate of EUR 0.15 per GJ even for the most sustainable biofuels. This would increase coverage of emissions taken at the point of combustion (hence including biofuels) from 61% to 96%.

Figure 4.13. A larger share of Effective Carbon Rates is null when including emissions from biofuels

Emissions-weighted average ECR, by sector, fuel category and coverage type, Lithuania, 2021



Note: This figure shows CO_2 emissions from energy use including emissions from the combustion of biomass and the effective carbon rates they are subject to in EUR/tCO_2 in 2021.
Source: OECD.

Notes

[1] In 2018, Lithuania's greenhouse gas emissions amounted to 16 400.1 $ktCO_2eq$ including Land-Use Change and Forestry (LULUCF) (see (Government of Lithuania, 2022[24])). Lithuania's CO_2 emissions from energy use excluding biomass combustion amounted to 11 214.7 $ktCO_2$ in 2018 (IEA, 2020[8]).

[2] Thus, effective carbon rates are sometimes also referred to as effective marginal carbon rates.

[3] https://energy.ec.europa.eu/topics/renewable-energy/bioenergy/biofuels_en, as accessed on 30 May 2022.

[4] Note that recent research also shows that emissions per kilometre driven are also higher for latest technology diesel cars than gasoline cars (Dornoff, 2019[25]).

[5] These are diesel, LPG and gasoline not used for heating.

[6] Peat and peat products belong to the fuel category "Coal and other solid fossil fuels".

[7] https://ember-climate.org/data/data-tools/carbon-price-viewer/, as viewed on 16/05/2022. It is also worth noting that the price signal arising from the EU ETS in 2018 was much lower, at an average of EUR 16/tCO_2.

[8] This is not to say that fuel excise taxes cannot result in the same rate per tonne of CO_2. If first expressed per tonne per CO_2 and transformed per litre or GJ for example, this could be the case. However, this is generally not how fuel excise tax rates are set.

[9] Law Nr. XI-722 of 2010, art. 58 1. (4).

[10] In accordance with Law Nr. XI-722 of 2010, art. 43 1. (5-7).

[11] For emissions representing more than 5% of the base.

[12] Note however, that this is only domestic transport – even intra-EU flights and shipments are not accounted for in this figure.

[13] Law Nr. XI-722 of 2010, art. 58 1.

[14] See https://environment.govt.nz/news/consultaton-on-government-proposals-to-price-agricultural-greenhouse-gas-emissions/, accessed on 08 November 2022.

[15] While these represent approximately the same share of energy use (about 15%) in the electricity sector, the amount of CO_2 emissions they generate differs – non-renewable waste being associated with almost twice as many CO_2 emissions per Giga Joule (GJ) as natural gas.

[16] At least as long as vehicles remain of the internal combustion engine (ICE) type rather than electric vehicles (EVs).

[17] 2°C has been established as a critical global temperature after which changes may become dramatic and irreversible; 1.5°C would further reduce the risks and impacts of climate change.

[18] The SCC is defined by Nordhaus (2014[26]) as the economic cost caused by an additional tonne of CO_2 emissions or its equivalent; it rests on the concept of internalising externalities and includes considerations on inter- and intra-generation equity.

[19] This section does not deal with recent measures by the Lithuanian government to address price increases, in particular the “Mitigation of the Effects of Inflation and Strengthening Energy Independence” package – see e.g., https://finmin.lrv.lt/en/news/the-eur-2-26-billion-package-presented-to-counter-the-effects-of-inflation-and-to-strengthen-energy-independence, as accessed on 8 June 2022.

[20] Its exact name is the Law on Excise Duties of the Republic of Lithuania No. IX-569 1, 2, 3, 27, 35, 36, 37, 38, 39, 41, 43, 53, 54, 55, 58 [1], 59, as well as amendments to Section 5 of Chapter II, the repeal of Article 40 and a supplement to the Law as Annex 4 to the Law. It is hereinafter referred to as the Draft Law. Chapter 3 provides additional details.

[21] Tables 3 and 4 in Chapter 3 gives a complete picture of the rate changes.

[22] As in many other countries, this component is expressed in EUR/tCO_2 and then converted into a tax in EUR per common commercial metric (e.g. per 1 000 litres for kerosene, per tonne for coal).

[23] These price levels fix 2024 allowance prices to their May 2022 level, of EUR 88/tCO_2.

[24] https://ec.europa.eu/commission/presscorner/detail/en/IP_21_3541, accessed on 19 May 2022.

[25] May 2022 EU ETS permit price.

[26] "Long-term" here and in the referenced paper is taken to be 10 years.

[27] These figures suppose that free allocation of emission permits remains the same in 2025 and 2030, and that permit prices are fixed at their May 2022 level of EUR 88/tCO_2. Both are conservative estimates. It is probable that these figures represent lower bounds, as it could be expected that EU ETS permit prices will increase in the coming years, and that free permits will gradually be phased out.

[28] Around 90% of revenues would arise from the road sector with the current allocation of free permits and around 75% if free permits were phased out and permit prices remained at 2022 levels.

[29] https://www.taxnotes.com/tax-notes-international/environmental-taxes/meps-put-energy-taxation-directive-negotiations-hold/2022/10/03/7f63c, as accessed on 08 November 2022.

[30] https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_3662, as accessed on 30 May 2022.

[31] https://www.europarl.europa.eu/legislative-train/theme-a-european-green-deal/file-revision-of-the-energy-taxation-directive, as accessed on 7 June 2022.

[32] https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_3662, as accessed on 30 May 2022.

[33] https://ec.europa.eu/commission/presscorner/detail/en/IP_21_3541, as accessed on 7 June 2022.

[34] The starting date is currently being discussed, however; see https://www.taxnotes.com/tax-notes-today-international/environmental-taxes/ep-groups-agree-less-ambitious-cbam-proposal/2022/06/02/7djnk, as accessed on 2 June 2022.

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5

Mobilising low-carbon infrastructure investment in Lithuania

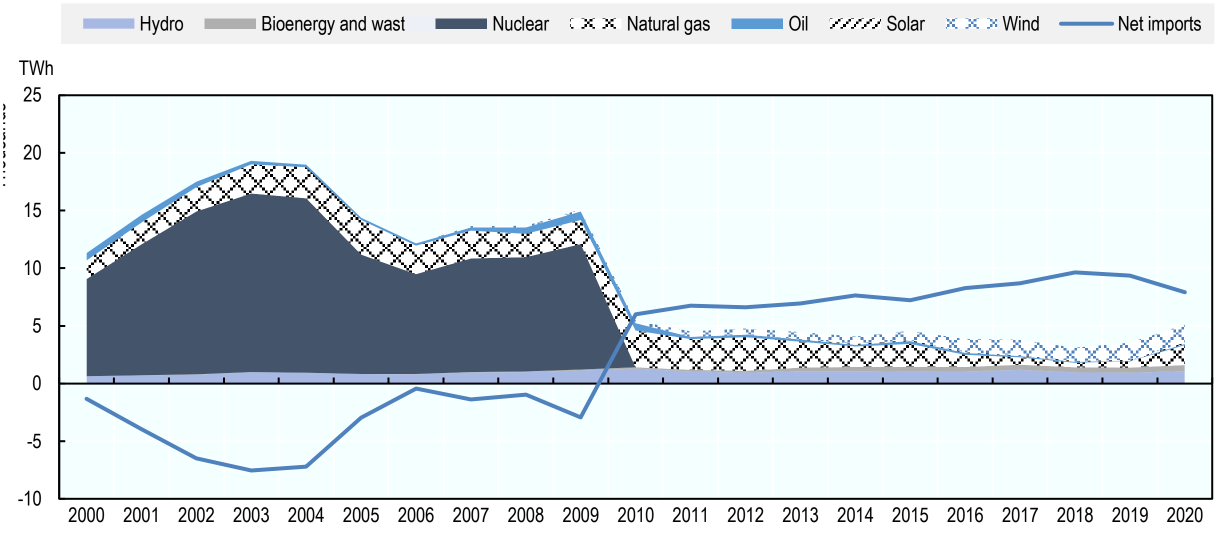
This chapter provides an assessment of Lithuania’s green finance landscape with a focus on low-carbon infrastructure investments. The chapter focuses on the role of the public sector both as a source of finance and as an enabler for private sector engagement. It discusses the extent to which government can anchor investor expectations by providing strong long-term policy signals and regulatory frameworks that are well aligned with its decarbonisation objectives. It also provides avenues for increasing public sector’s absorptive capacity and spending efficiency of EU funds for investments and underscores the importance of engaging local governments. The chapter identifies barriers to private sector investment that are specific to Lithuania and green infrastructure investments and proposes ways that government action can strengthen incentives for private investments through reaching critical mass for investors and providing risk-sharing schemes between public and private actors.

Lithuania's decarbonisation will require a substantial transformation of energy and production systems, as is the case in other countries. The process is complicated as currently, Lithuania imports three-quarters of its domestic electricity needs given limited domestic generation capacity following the shutdown of the Ignalina nuclear power plant in 2009 (Figure 5.1). With a view of reducing energy imports by half by 2030 and a target to reach 100% renewable energy in its electricity sector and 50% in its transport sector by 2050, the infrastructure needs are considerable (Figure 5.2). These ambitions rest on a two-pronged approach of increasing domestically produced electricity and decarbonising the energy system by raising solar and wind generation capacity. This will require an improvement in electricity system flexibility through larger storage capacity, modern system balancing services and synchronisation of Europe's power system (IEA, 2021[1]).

The energy mix of Lithuania's domestic electricity supply has already changed over the past decade in the direction of meeting these goals. The share of natural gas in the energy mix of electricity generation fell from 43% in 2014 to 34% in 2020. On the other hand, the contribution of wind power increased both in absolute and relative terms, from 16% to 30% over the same period; solar power increased by 40% since 2014 contributing 2.5% of total electricity generation (Figure 5.1.). Investments will continue to add more wind and solar capacity to the grid. An auction for 700 MW of offshore wind capacity (doubling the already installed capacity in 2021) is planned for 2023 (LVEA, 2022[2]). This wind farm would generate up to 3 TWh of electricity (which represents about 26% of the country's electricity demand in 2019).

Figure 5.1. Electricity imports exceed domestically produced electricity

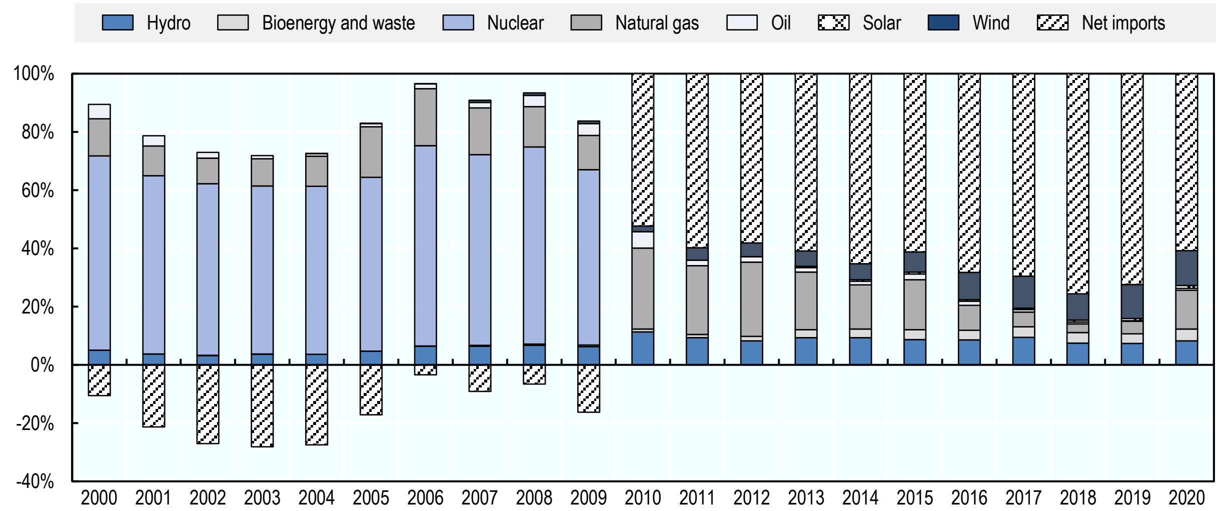
Total electricity generation by energy carrier in TWh (2000 – 2020)



Source: IEA World Energy Statistics.

Figure 5.2. Renewable energy resources will need to increase substantially to make up for reduction in imports

Composition of electricity supply by energy carrier (2000 -2020)



Source: IEA World Energy Statistics.

Emissions from the transport sector continue to grow while the sector has the lowest renewable energy penetration (Chapter 1). There are several policy options available that can encourage the shift towards less polluting energy sources in the transport sector as discussed in Chapter 2. These include infrastructure investment in recharging stations to facilitate the uptake of electric and other low-emissions vehicles (e.g. hydrogen powered ones) and shifting railway transport and to shift freight transport to shipping.

This chapter provides an assessment of Lithuania’s climate finance landscape with a focus on low-carbon infrastructure investments. It identifies the main challenges and proposes ways for public authorities to scale up investments. The following section discusses modelling results for investment needs in the sector electricity sector to align with net-zero targets. The next section focuses on the role of the public sector both as a source of finance and as an enabler for private sector engagement. It discusses the extent to which government can anchor investor expectations by providing strong long-term policy signals and regulatory frameworks that are well aligned with its decarbonisation objectives. It also provides avenues for increasing public sector’s absorptive capacity and spending efficiency of EU funds for investments, including the development of project pipelines as an important strategy to crowd-in private investors. Finally, the section underscores the importance of engaging local governments to participate in the financing and implementation of infrastructure projects.

The final section identifies barriers to private sector investment that are specific to Lithuania and green infrastructure investments. These include market imperfections, such as the lack of critical size in capital markets, complexity of infrastructure investment and evolving risks over the lifespan of projects. To tackle these challenges, government action can strengthen incentives for private investments in green infrastructure, reaching critical mass for investors and providing risk-sharing schemes between public and private actors.

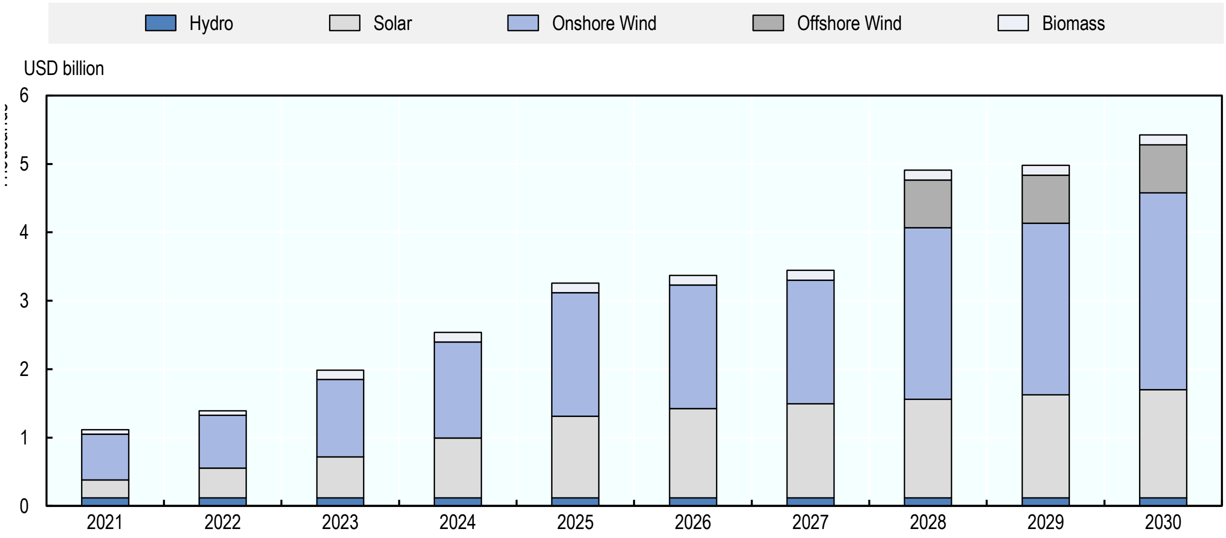
Quantifying investment needs for decarbonisation

Lithuania's energy infrastructure will need to undergo a drastic transformation to meet its dual objective of energy independence and decarbonisation. In order to do so, renewable energy capacity needs to be scaled up considerably, in addition to other investments to reduce emissions. Current plans aim to increase renewable installed renewable energy capacity fivefold, from 1.1 GW in 2021 to 5.4 GW in 2030 (Figure 5.3)

Figure 5.3. , driven mostly by onshore wind and solar energy. The estimated cost of additional capacity in renewable energy amounts to a total of EUR 6.5 billion over the period 2021 to 2030. Additional investments are needed, for instance in grid upgrades and storage, as these together with investments in renewables account for 80% of total investments in the power sector (IEA, 2022[3]).

Figure 5.3. Solar and onshore wind power will dominate renewable capacity expansions

Capital expenditure on capacity expansion in renewable electricity generation (2021 – 2030)



Note: Data on capacity expansions and installation costs may not necessarily be consistent with net-zero targets.
Source: Lithuania Energy Agency.

While the public sector will be a key driver of infrastructure investment, the private sector will have to fund additional investments. The Lithuanian government estimates that a total of EUR 14.1 billion of additional investment will be needed to finance decarbonisation objectives by 2030 (EUR 9.8 billion from public sources and EUR 4.3 billion from private funds). Already, about one third of the EUR 6.4 billion EU Structural Investment Funds package for the period covering 2021 to 2027 has been allocated to supporting the green transition (European Commission, 2022[4]). This includes building renovations and providing incentives to reach 50% of electricity and 67% of heating from renewable sources by 2030. In addition, at least 37% of the Recovery and Resilience Facility funds will be focussed on green transition programmes, adding on another EUR 823 million. Nonetheless, private sector involvement is necessary to fill the financing gap, which is large at EUR 3 billion for the renewable energy sector alone. Government efforts to mobilise private finance will be instrumental to this end.

Historically, the public sector has relied heavily on distributing grants or subsidies to fund infrastructure investments, with the risk of crowding it out private investments. Thus far, EU Structural Investment Funds

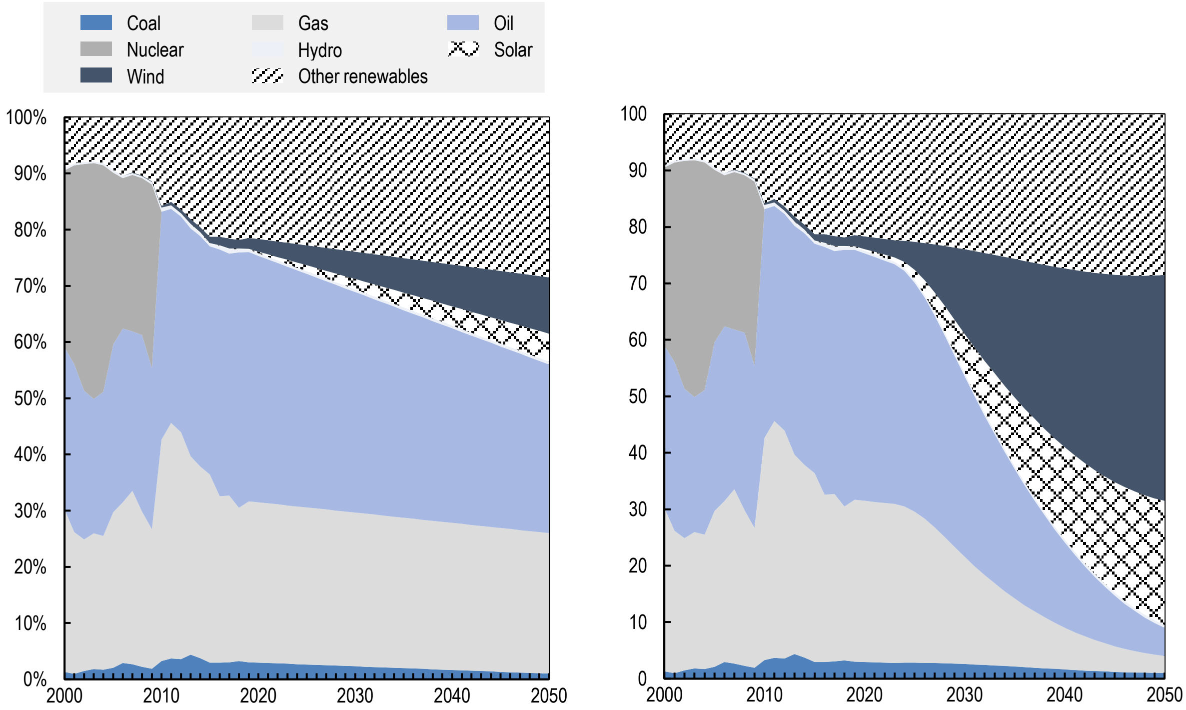
(ESIF) and European Fund for Strategic Investment (EFSI) have dominated climate finance in Lithuania. Over the 2014-2020 period, Lithuania spent EUR 6.3 billion in ESIF (European Commission, 2022[5]), which represented around 60% of its total public investment (EUR 10.4 billion) in the same period (OECD, 2022[6]). National public resources are mobilised as part of the co-financing schemes. EU funding provides financial assistance for a broad selection of sectors and activities, including energy and transport infrastructure and the low-carbon transition. Multilateral banks such as the European Investment Bank and European Bank for Reconstruction and Development have also contributed to funding low-carbon projects. Together, they provided around EUR 2 billion over the 2014-2021 period (EIB, 2022[7]; EBRD, 2022[8]).

Long-run investment needs (to 2050) for decarbonising the energy mix are estimated using the OECD Economics Department Long-term model. This model is used to estimate long-run trends, namely potential output and to assess fiscal sustainability across OECD and eight non-OECD G20 countries (Argentina, Brazil, China, India, Indonesia, Russia, Saudi Arabia and South Africa) and two key partner economies (Bulgaria and Romania). A recent addition to the model is the energy module. It is used to evaluate the impact of decarbonisation on output trajectories under different scenarios. Key assumptions in the model are exogenous energy mixes and effective carbon rates. The model provides projections of CO_2 emissions, output, investment in renewable capacity, and government revenue. This setting allows the model to place the energy transition in a context of other evolving key structural changes, such as population aging, though it provides a partial picture of investment needs, focusing on capital expenditure for renewable capacity expansion.

The modelling exercise involved two scenarios: a Baseline Scenario representing current policies, a Net-Zero Scenario with an energy mix and effective carbon rates path that is consistent with a net-zero emissions goal. The energy mix in the net-zero scenario is set so that targets of reaching 45% renewables in total energy consumption by 2030 and 90% in 2050 are met (Figure 5.4).

Figure 5.4. Primary energy use mix in Baseline Scenario (left) and Net-Zero Scenario (right)

Historical and projected share of energy sources in total primary use (2000 – 2050)

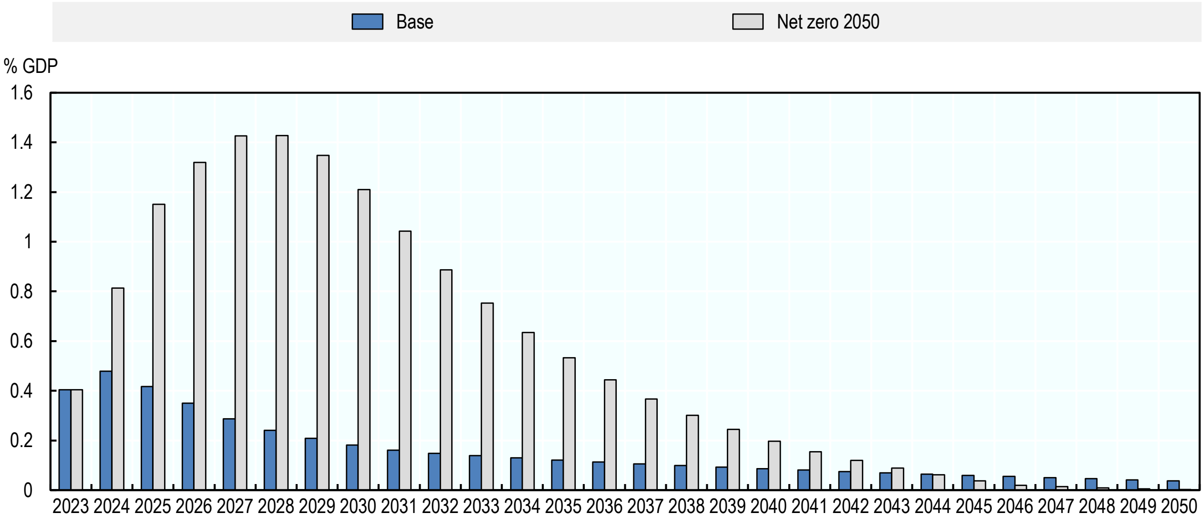


Note: The baseline scenario is that decarbonisation continues at the recent pace, but not enough to reach net zero. The Net-zero Scenario is based on stylised assumptions on energy mix and effective carbon rates to reach net-zero emissions.
Source: OECD long-term model.

The results for investment show that up to 2035, a net zero consistent path would require annual investments between 0.5% -1.4% of GDP, against the average base case of 0.33% of GDP (Figure 5.5).

Figure 5.5. Annual capital expenditure (% GDP) on new low-carbon electricity generation capacity

Projected capital expenditure under Net-Zero Scenario (2023 – 2050)

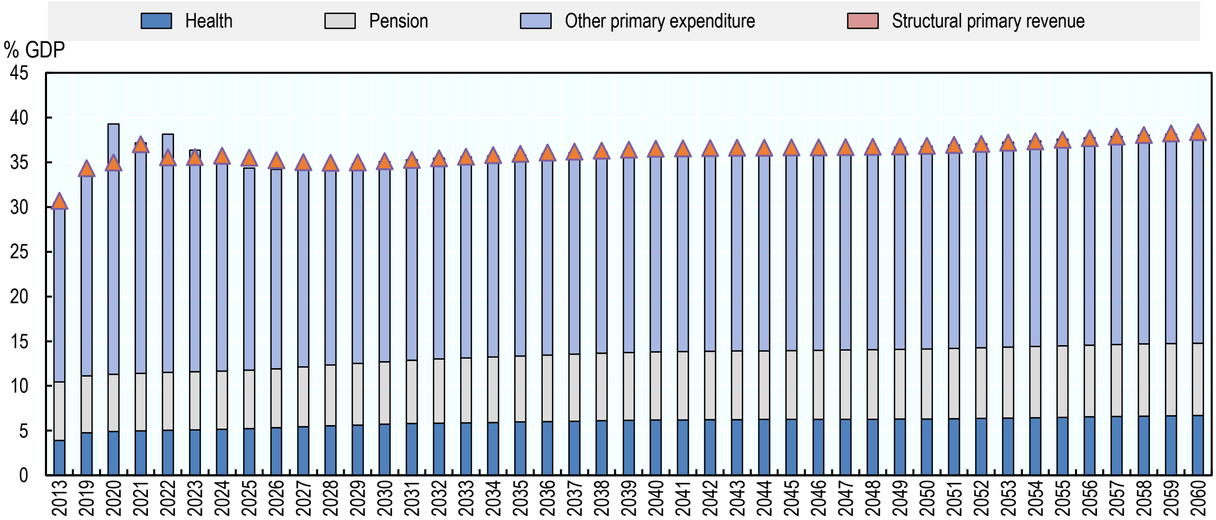


Note: The base scenario is that decarbonisation continues at the recent pace, but not enough to reach net zero. The net-zero scenario is based on assumptions on energy mix and effective carbon rates to reach net-zero emissions.
Source: OECD long-term model.

Long-term structural trends are putting pressures on the public finance of Lithuania (Guillemette and Turner, 2021[9]). Simulations of future health and long-term care expenditure show an increase by about 1.7% of GDP by 2060. Pension expenditure by about 1.6% of GDP by 2060. Other primary expenditures are slightly distorted by the COVID-19-related increase in spending but relative to 2019 they also increase slightly by 2060. Altogether ageing is projected to add about 2.75% of GDP in fiscal pressure by 2060 in a scenario where the debt ratio would be stabilised near the current level (Figure 5.6.).

Figure 5.6. Lithuania public finances in the long term

History and projected government primary expenditure and structure primary revenue (2019 – 2060)



Source: OECD long-term model.

In this context, given that energy transition will require large investments, some of which are quantified as capital expenditure on renewables, there will be additional pressure on public finances. However, an increase in the effective carbon rate to reach net-zero emissions by 2050 – assuming that carbon pricing would be the sole instrument – could generate substantial revenue, seemingly more than the combined increase in fiscal pressure from ageing and required investment for the energy transition. Carbon pricing revenues are estimated in the net-zero scenario to reach up to 6% of GDP between 2033 and 2038 before declining to 1.1% in 2050. Given the model's focus on carbon pricing as the only mitigation instrument, revenues are substantial. Should there be non-pricing measures in the climate policy package, carbon revenues would be lower. On the other hand, these revenues would be temporary and by 2050 would probably be lower than the projected additional fiscal pressure from ageing. Thus, the revenue from carbon pricing would come at the right time to finance low-carbon investments but would be front-loaded with respect to the fiscal pressure from ageing, which will last longer.

Public sector role in scaling up investment for decarbonisation

The public sector plays a central role in aligning the country's infrastructure financing ecosystem with its decarbonisation goals. On the one hand the public sector is an important source of financing and in the choices on how to allocate funds to different projects that will contribute to reaching emission reduction targets. On the other hand, the government needs to ensure that the regulatory and policy framework provides strong signals and incentives to the private sector to invest in green projects.

Establishing long-term policy and regulatory frameworks to boost investment

The right regulatory and policy framework can help to anchor investor expectations and provide greater policy certainty, mitigating risk and encouraging the take up of green investment opportunities. Long-term commitments to climate targets and strong policy signals can inform investors of the depth and breadth of the needed transformation. This will lower uncertainty and help to channel private funds towards green investment opportunities.

National development and infrastructure plans offer long-term visibility on investment priority areas and strengthen the business case for low-carbon projects. In Lithuania, such plans include the 2021-2030 National Progress Plan (2021–2030 m. Nacionalinis pažangos planas), which sets out general long-term strategic goals and policy reforms in social, economic, environmental and security areas (Goverment of the Republic of Lithuania, 2021[10]). Documents specific to climate policy include the National Climate and Energy Plan from 2019 and the National Energy Independence Strategy from 2018, both of which identify policy reforms needed for meeting Lithuania's energy and climate targets (Government of the Republic of Lithuania, 2019[11]; OECD, 2022[6]; Government of the Republic of Lithuania, 2018[12]). The more recent National Climate Change Management Agenda sets and updates the country's climate policy for short-term (2030), medium-term (2040) and long-term (2050) objectives (Government of the Repulic of Lithuania, 2021[13]). Sector specific infrastructure plans such as Lithuanian transport strategy 2050 (Lietuvos susisiekimo plėtros iki 2050 m. strategija) help complete the long-term vision of the green transition by providing a more granular assessment focusing on specific sectors (Lithuania Ministry of Transport, 2020[14]).[1] More broadly, under the EU cohesion policy funds, Lithuania's recently approved Partnership Agreement lays down the country's investment strategy, providing avenues to meet their climate goals in line with EU Green Deal (European Commission, 2022[15]).

Lithuania's climate policy is determined by the domestic policy framework and the EU's supranational institutions, which work in concert and will become more stringent over time. EU's Fit for 55 policy package includes several policy and regulatory reforms that ratchet up climate ambition. In addition to the increasing stringency of EU-wide policies such as the increased target for EU Emissions Trading System (EU ETS) and the planned revision of minimum tax rates under the EU's Energy Tax Directive (ETD) (for more information see Chapters 2 and 4), Lithuania is pursuing its own domestic climate reform agenda. For instance, the proposed amendments to the Excise Tax Law to phase out tax preferences for fossil fuels and the inclusion of a carbon component for non-ETS emissions provide the forward-guidance needed to underpin investment decisions. These reforms go in the right direction by strengthening price signals and setting a long-term trajectory towards higher effective carbon prices.

While Lithuania's climate agenda sets the right level of ambition, it is now important to implement an effective policy mix and set up a coherent institutional framework to design policies and evaluate progress. The government is pursuing a wide range of policies across different sectors to complement its proposed carbon pricing reforms, including several measures for the decarbonisation of the transport sector and energy system (Chapter 2). However, the implementation of policies has yet to match ambition. For example, a study has found that planned investments in electric vehicles charging stations are insufficient to keep pace with planned electric vehicle use and electrification to 2030 (Ministry of Finance of the Republic of Lithuania, 2022[16]).

Expanding this infrastructure is essential for the success of increasing the penetration of zero-emissions vehicles (D'Arcangelo et al., 2022[17]). The experience of Norway (Box 5.1) suggests that the provision of fast charging infrastructure is a strong driver for electric car uptake as users prefer fast and ultra-fast chargers for both inter- and intra-urban travel (Neaimeh et al., 2017[18]; Transport & Environment, 2018[19]). Strong collaboration between ministries and agencies involved in transport policies and those with responsibilities over land use management, energy and others is key to decarbonising the transport sector. It is also important to note that infrastructure investment in Norway complemented an extensive incentives programme that included exemptions from value-added tax and registration tax and reduced toll and parking feed. While the overall government support did help the market reach critical mass, it proved to be much less cost-effective than carbon pricing policies, costing about EUR 1370 per tonnes of CO_2 for battery electric cars. Efforts to scale back incentives and increase their efficiency have been underway since 2021 (D'Arcangelo et al., 2022[17]).

Box 5.1. Norway's support for EV charging stations

As of 2020, there were some 340 000 electric cars in Norway, the largest number among European countries and representing about 16% of global sales. The share of electric vehicles in the vehicle stock is growing. For instance, the share of battery-only passenger cars increased from 9.3% to 12.1% between 2019 and 2020 (the increase in the battery electric cars traffic volume is roughly similar). The impressive outcomes in electric vehicle take-up have been driven by substantial tax benefits and privileges, including exemptions from value-added tax and vehicle registration tax, along with cheaper access to toll roads and parking.

Government support for charging stations has been in place since 2010 and the current scheme aims for fast charging stations every 50km on around 7 500 km of Norway's road network. In 2021, according to the NOBIL database of the Electric Car Association, there were around 5 700 charging points, up from 800 in 2015. In recent years, charging operators have been building fast-charging stations without subsidies, especially in larger cities and along major highways. While un-subsidised stations will probably become increasingly viable, government support will likely still be needed to ensure availability in remote areas.

Source: Adapted from (D'Arcangelo et al., 2022[17]). (See also Box 2.3 in Chapter 2).

The liberalisation of electricity prices has also helped further align energy policy with its climate ambitions. Regulated retails prices have been gradually phased out except for some small electricity consumers (households consuming less than 1 000 kWh annually). While the completion of electricity price de-regulation has been halted in the current environment of high energy prices, there are alternative ways to deliver support to vulnerable consumers more efficiently and fairly than price regulation. Eventually, shifting support from regulated electricity pricing to targeted income transfers would strengthen incentives for energy savings and maintain the price signal needed to support the decarbonisation transition (Van Dender et al., 2022[20]). (OECD, 2020[21]).[2]

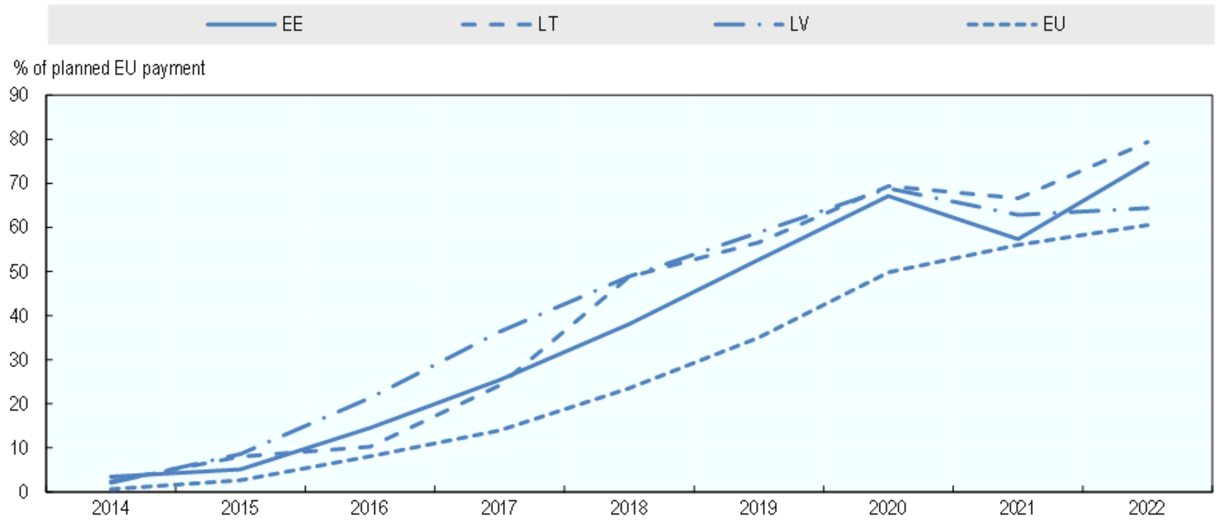
Regulatory reforms are also necessary to strengthen the flexibility of the energy system and encourage investment in energy storage. The share of renewables in the energy mix will grow substantially (electricity from renewable sources from 20% to 50% in 2030 and heating from 50% to 67%), requiring a more resilient energy system to deal with intermittent supply. Recent regulatory reforms amending the Law on Renewable Energy Source (Atsinaujinančių išteklių energetikos įstatyme) and the Law on Electricity (Elektros energetikos įstatymas) have simplified administrative procedures for the construction and issuance of permits for power plants, particularly for small-scale installations and off-grid power generation. These reforms are key to attaining the goal of not only higher renewable energy penetration but the envisaged expansion of prosumers; i.e. households and businesses that generate their own electricity.[3] In the context of the 2021-2022 energy security crisis, the EU is pushing for further simplification of permitting procedures for the deployment of renewables under its RePowerEU plan, aiming at expanding renewable power in Europe and strengthening energy security.[4] These regulatory reforms would contribute to the acceleration of the energy transition for Lithuania.

Increasing the absorptive capacity and spending efficiency of public funds

As a key owner of climate-relevant infrastructure assets, particularly in the energy and transport sectors, the government needs to also ensure that its investment decisions are consistent with climate goals. EU structural investment funds make up the bulk of government public expenditure, including on network infrastructure for energy and transport. Between 2014 and 2020, Lithuania's public investment in energy and transport amounted to EUR 2.5 billion out of which at least EUR 1.3 billion came from EU sources. The key role of EU financing for low-carbon investment underlies the importance of orienting these EU funds toward green projects and to maintain the capacity to absorb and spend them effectively. Thus far, the absorption of ESIFs have been consistent with other Baltic countries, reaching around 70% to the total planned amount and above the EU average of 60% (Figure 5.7).

Figure 5.7. Absorption rate of EU Structural Investment Funds is above EU average in Lithuania

Average payment rate across EU Structural Investment Funds (2014-2020)



Note: ESIF include the European Regional Development Fund (ERDF), European Agricultural Fund for Rural Development (EAFRD), European Social Fund (ESF) and the Youth Employment Initiative (YEI), Cohesion Fund (CF) and European Maritime and Fisheries Fund (EMFF).
Source: EU Cohesion data: https://cohesiondata.ec.europa.eu/.

For the private sector, identifying appropriate projects can be hindered by substantial transaction costs related to the complexity and limited standardisation of investments and of administrative procedures (IPCCC Working Group III, 2022[22]). These create significant opportunity costs of green investments compared with other types of investments. To this end, the Central Project Management Agency (CPMA), the domestic institution responsible for administering the ESIFs, has recently invested in expanding and strengthening its administrative capacity to support the effective and efficiency allocation of funds (European Commission, 2022[23]). By creating specific content units based on project areas, including on environmental sustainability and energy, with qualified personnel, it will be in a stronger position to support investments in line with the decarbonisation agenda.

The EU's taxonomy for sustainable activities along with its sustainability-related disclosure regulation in the financial services sector - Sustainable Finance Disclosures Regulation (SFDR) — may also contribute to lowering costs related to identifying green investments. However, translating the new rules to domestic settings is a great challenge as there is a need for further clarification on the new local rules in order for them to comply with EU disclosure rules. Expanding the country's institutional capacity to provide guidance on these new regulations will go a long way in closing informational gap and reducing related costs and thus lowering barriers to private investors.

A recent report developed jointly by the EU Commission and EBRD identified several recommendations for scaling up sustainable finance in Lithuania. One main priority and cross-cutting recommendation was to establish a Green Finance Institute to co-ordinate climate finance in the country and to develop the know-how on sustainable projects to support the private sector in identifying suitable bankable projects (EBRD, 2021[24]). More concretely, the Green Finance Institute would play a key role in clarifying the new EU taxonomy and implementing the SFDR through consultations with and giving recommendations to private and public stakeholders. The Institute will also act as an advisory body for policy makers and would convene the private and public sector to support sustainable finance initiatives. As such, this institution could also enhance the absorption of EU funds while crowding-in private-sector finance.

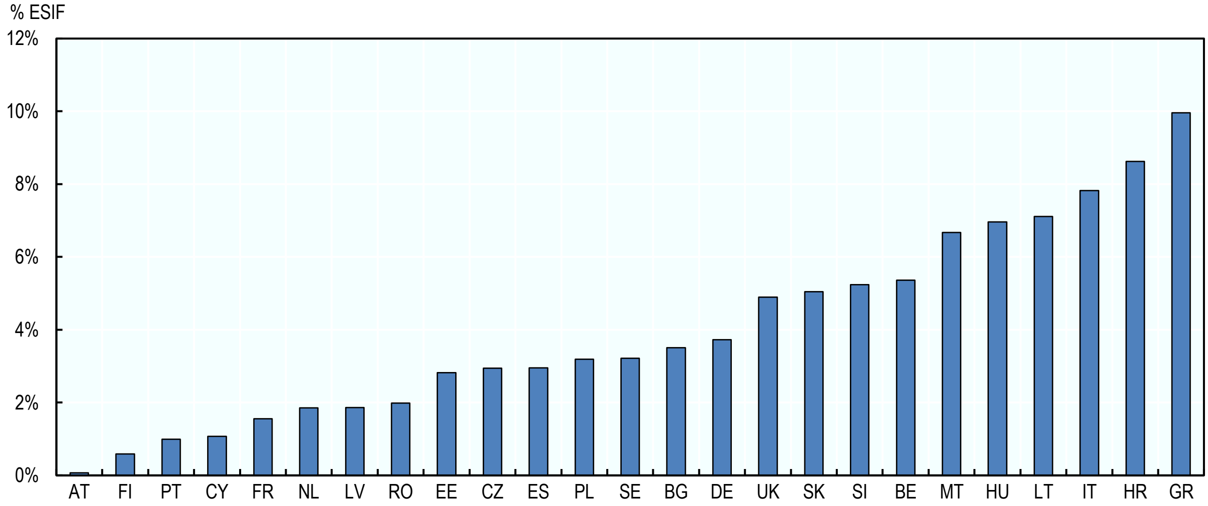
Leveraging the existing institutional architecture and expertise within the EU framework and domestically can facilitate and expedite the allocation of funds to projects that help meet the country's decarbonisation objectives. For instance, the Investment Plan for Europe launched in 2015, not only mobilised private sector funds by providing co-financing opportunities and instruments for risk mitigation in investment funded by the European Investment Bank, but also provided advisory support through the European Investment Advisory Hub. Hence, Lithuania benefitted from the expertise of the EIB and the Advisory hub to launch an energy efficiency investment platform to promote and finance energy efficiency modernisation projects (European Council, 2022[25]). Since the Investment Plan for Europe programme has led to the successful scaling-up of investment, mobilising more than EUR 500 billion in the period 2015-2020, the programme is being extended as the InvestEU programme.

The use of financial instruments, such as loans, guarantees and equity, for part of the ESIF can also contribute to enhancing the efficiency of spending ESIF allocations by targeting projects that could eventually be self-sustainable (European Commission, 2022[26]). The revolving nature of the funds using financial instruments allows the reinvestment of repayments plus interest into other projects, while attracting private sector investment through public-private risk-sharing. At the same time, the repayable nature of financial instruments requires greater accountability from beneficiary compared with grants. Public institutions using financial instruments benefit from the expertise of fund managers (such as EIB) and other administrating financial intermediaries; technical assistance can also be financed since combining loans, grants and technical assistance in the same financial instruments is possible (Interreg Europe, 2022[27]).

While Lithuania ranks among the countries with the largest share of financial instruments, more could be done. For example, the share of ESIF used for financial instruments, remains a modest 7% ESIF (Figure 5.8.). Financial instruments have been used for energy efficiency programmes in the building sector (see Chapter 2). Several barriers have been identified as preventing a wider uptake of ESIF support financial instruments among EU member states during the previous programming period 2014-2020, particularly in sectors where their use has been limited such as the renewable energy sector. The barriers identified are most notably related to the administrative burden and complexity and regulatory constraints related to the targeted sector (including permitting regulation). There has been emphasis on the limited incentives to invest in a specific sector, such as renewable energy generation, and lack of sectoral knowledge and administrative capacity to plan and procure complex infrastructure projects. There are also difficulties in operationalising policy goals and aligning sectoral strategies with ESIF projects. These challenges are compounded by limited experience and capacity in developing a network of market players which would develop a project pipeline suitable for financial instrument support (fi-compass, 2020[28]). Addressing these barriers could thus encourage greater use of financial instruments for financing decarbonisation-related investments.

Figure 5.8. Financial instruments remain a small part of ESIF allocations

Share of ESIF used for financial instruments (2014-2020)



Source: https://www.fi-compass.eu/fisiyc; Cohesion Policy Open Data Platform:

Building investment-ready and bankable project pipelines

Together with strong policy and regulatory frameworks to underpin investment decisions, building robust project pipelines can contribute to a more effective absorption and spending of funds, in addition to helping to crowd-in private sector funds.[5] Project pipelines highlight the scale and scope of investment opportunities and communicate the available tools and policies surrounding them. They also help translate long-term objectives and commitments into tangible projects. For investors, the costs of building capacity in a particular country (e.g. ensuring projects meet regulatory and legal requirements) are difficult to justify for one-off investments. If they have greater certainty that follow-on projects will be available, investors would be better able to gauge risks, invest in capacity building and help foster a market for infrastructure investment. Additionally, increasing the supply of investment-grade projects could help address currently high project valuations. Partnerships between investors and governments can also provide an effective way to share risks, achieve scale and establish a pipeline of investment-grade projects (OECD, 2020[29]).

The government needs to ensure a robust project pipeline linked to the long-term climate mitigation goals. There is no publicly available list of bankable projects aligned with achieving long-term climate targets though the recently issued Partnership Agreement set investment priorities for the current programming period 2021-2027 of ESIF (European Commission, 2022[23]).

The challenge remains to convert project proposals into economically feasible investment opportunities. Project preparation facilities are useful for providing a centralised entity that assists in the development of projects to reach investment ready states. The role of the government is thus to ensure that the design of such facilities, which can be sector and infrastructure-type specific, play to the country's strength (e.g. offshore wind potential) and reduce the barriers that often prevent projects from reaching investors (Box 5.2). The planned creation of a Green Finance Institute and the existence of a co-ordinating body such as the CPMA offer the opportunities to build synergies to strengthen project-preparation capacity for low-carbon infrastructure.

Box 5.2. The need for a project preparation facility

Improving the bankability of projects in the pipeline is an important step to increase the flow of capital towards low-carbon infrastructure projects. A project preparation facility (PPF) is an entity that supports infrastructure investment by channelling a small amount of finance to overcome technical and financial barriers that prevent the project from being bankable or investable to the investment community.

Since these preparation facilities are to be supported with public funds, governments should properly consider and account for these costs when translating climate objective into granular investment plans. Given their magnitude, the costs would significantly affect the overall returns on investment from designing and developing a pipeline of successful projects and they could also be a significant challenge for smaller government, and risk adding a layer of complexity when implementing low-carbon ambitions.

PPFs provide investors with an entry point into pipeline and project procurement, a means to find answers to queries, and ways to identify investment opportunities suited to their individual requirements and appetites. Approaches to support and finance projects on a project-by-project basis may be administratively burdensome and costly for the institutions involved. Standardisation of contracts and processes, for instance, is one such method to lower these transactions costs.

A more holistic approach to project and pipeline development, including the securitisation and aggregation of smaller assets, would bring advantages if it creates a two-way exchange between investors and policy-makers to identify investment barriers and ensure possible gaps are understood earlier on in the project development cycle. This would include the government's interface through which it engages and encourage investment from private sector actors.

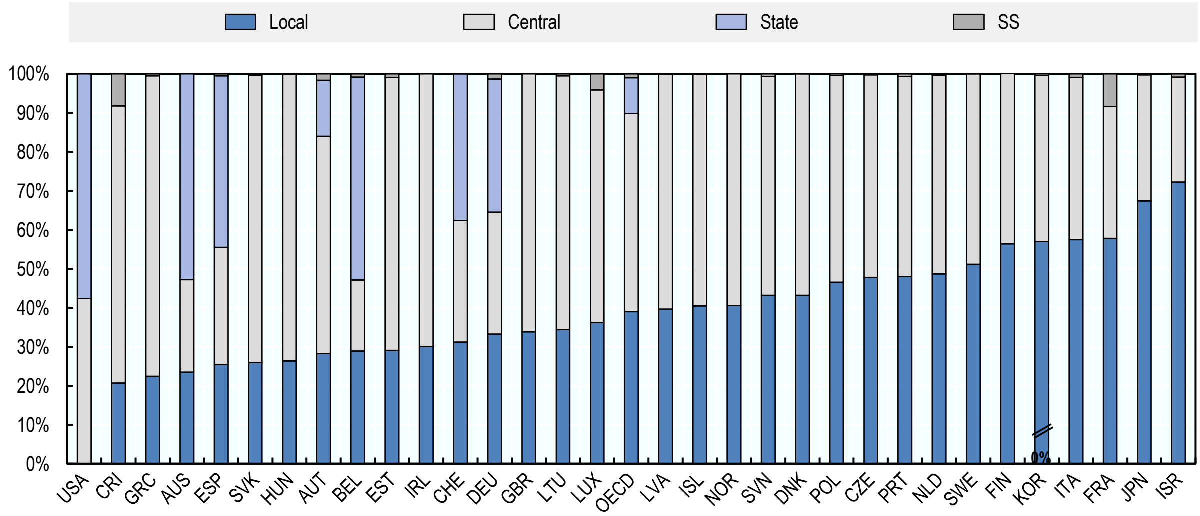
Source: (OECD, 2018[30])

Engaging subnational authorities for funding and implementing infrastructure projects

Subnational governments play a key role implementing strategic investments plans, including those geared towards decarbonisation. As the country strives to reach its climate goals, infrastructure investment by local authorities will need to be aligned with central government goals and policies to tackle the climate challenge. However, subnational governments in Lithuania face a number of challenges that affect their capacity to deliver infrastructure investment (OECD, 2020[21]). Over the period 2014-20, local-government investment as a share of total investment was lower, 35%, than the OECD average of 40% (Figure 5.9).

Figure 5.9. There is scope to increase local government investment (2014-2020)

Distribution of public investment across levels of government over the period 2014 -2020



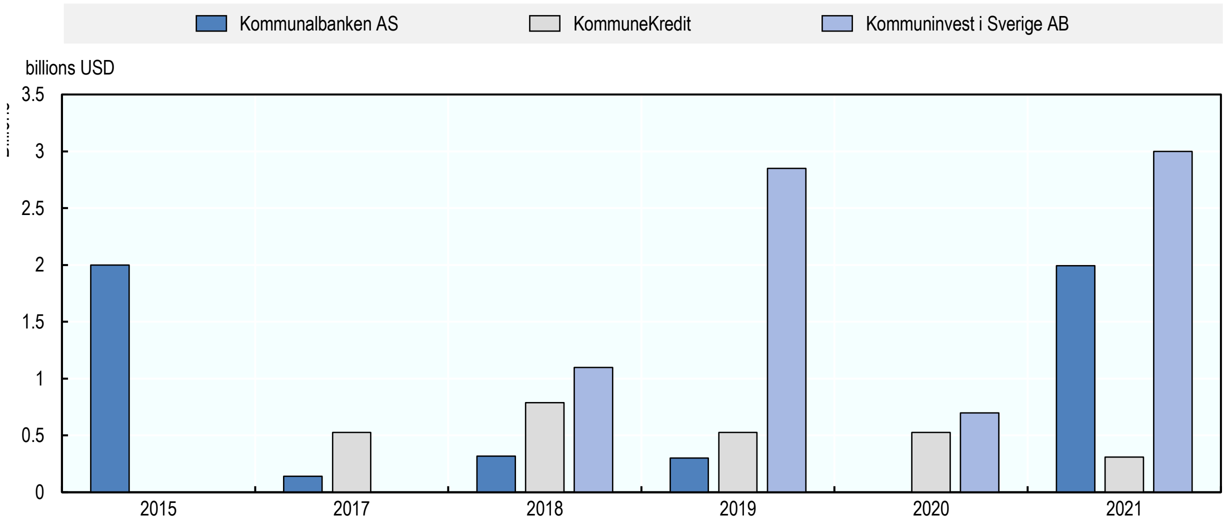
Note: SS stands for social security fund investment.
Source: OECD National Accounts Statistics (database).

Local governments in Lithuania have limited capacity to fund public investment, because own-source revenue is low and the reliance on earmarked intergovernmental grants provides little spending autonomy. They also have limited capacity to plan public investment, because inter-governmental grants are volatile and there is no medium-term commitment from the central government. This is compounded by low administrative capacity, and weak and purely formal (not linked to budget) strategic planning practices. Additionally, central government public investment funds are fragmented and narrowly defined, that results in incentives for local government to develop projects that suit a particular funding source, rather than responding to a need or a development opportunity (OECD, 2020[31]).

To address its segmented local investment ecosystem, the government has recently passed a reform to consolidate public investment funds, notably the main national promotional institutions, Investment and Business Guarantees Agency (INVEGA), Public Investment Development Agency (VIPA), Valstybės investicijų valdymo agentūra (VIVA) and the Agricultural Credit Guarantee Fund, by the end of the year. This reform aims to ensure a unified investment strategy, to exploit the strengths and competencies of the different institutions and synergies among financial instruments available to municipalities. It will also improve the effective use of EU funds and help scale up private financing, including from institutional investors (Ministry of Finance of the Republic of Lithuania, 2022[16]).

There is scope for deeper co-operation among local governments to pool either expertise (shared service centres) or projects to reach larger scales and to increase bargaining power to reduce costs. This also needs to be bolstered through the development of specialised facilities dedicated to municipal investment financing in cooperation with neighbouring countries (OECD, 2020[31]). One example of such a scheme is the pooled funding model prevalent in Nordic countries like Denmark, Finland, Norway and Sweden for issuing bond to fund infrastructure investments. So-called Local Government Funding Agencies (LGFAs) offer a solution to entities with funding requirements that may not be big enough to justify standalone bond issuance or lack bond expertise or in-house resources (Climate Bonds Initiatives, 2018[32]). They are municipality-owned or guaranteed financial institutions with a specific mandate to finance municipalities, cities and counties. Albeit representing a small share of their bond issuance, the three LGFAs in Denmark (KommuneKredit), Norway (Kommunalbanken) and Sweden (Kommuninvest) have raised USD 15 billion in green bonds over the period of 2015-2021 (Figure 5.10.). Thus far, there have been no bond issuances by local governments in Lithuania.

Figure 5.10. Local government green bond issuance in Denmark, Norway and Sweden



Note: KommuneKredit is from Denmark, Kommunalbanken from Norway and Kommuninvest from Sweden..
Source: Refinitiv.

By pooling funding capacities from several municipalities, LGFAs can raise financing from international bond markets and in return can provide financing to a wide range of small projects that would otherwise be too small or too niche for bond investors. This set up also allows for developing and hiring appropriate expertise to assess project quality for lending, to administer loans and to raise finance in a variety of bond markets to best match demand and their funding requirements. Given the ownership of these financial institutions, bond issues can be raised at sovereign-level credit rating thus giving municipalities access to more favourable borrowing conditions (Climate Bonds Initiatives, 2018[32]). Lithuania's local governments can thus consider adopting similar financing institutions for their own decarbonisation projects.

Private finance mobilisation

Infrastructure investment by the private sector remains lower than its potential and insufficient to meet Lithuania' decarbonisation objectives. This is despite infrastructure being an attractive asset class because of inflation-linked cash flows, low correlation with other important assets classes and long-term income. As such infrastructure is suitable for investors with long-term investment horizons (OECD, 2020[29]).

More generally, infrastructure remains a less exploited asset class than bonds and stocks, representing for instance a fraction of institutional investors' portfolio. OECD work finds that out of a maximum of USD 11.4 trillion of investable assets under management (AUM) that can be allocated to infrastructure, institutional investors hold only USD 1 trillion in infrastructure assets, 30% of which in green infrastructure (OECD, 2020[29]).

Several factors contribute to private sector underinvestment in green infrastructure including its complexity and the potential for risks to materialise over the long lifespan of infrastructure assets as well as the illiquidity of infrastructure assets. Additionally, low-carbon infrastructure entails new infrastructure systems and technologies that are diverse with respect to their economic profiles, their stages of maturity, ownership schemes, delivery and financing models. Together, this heterogeneity heightens uncertainty for investors, compounding the effect of regulatory uncertainly and often weak long-term commitment to climate goals such as low carbon prices. The role of the government is to facilitate the uptake of low-carbon infrastructure investment by offering a wide range financial instruments and of risk-mitigation solutions.

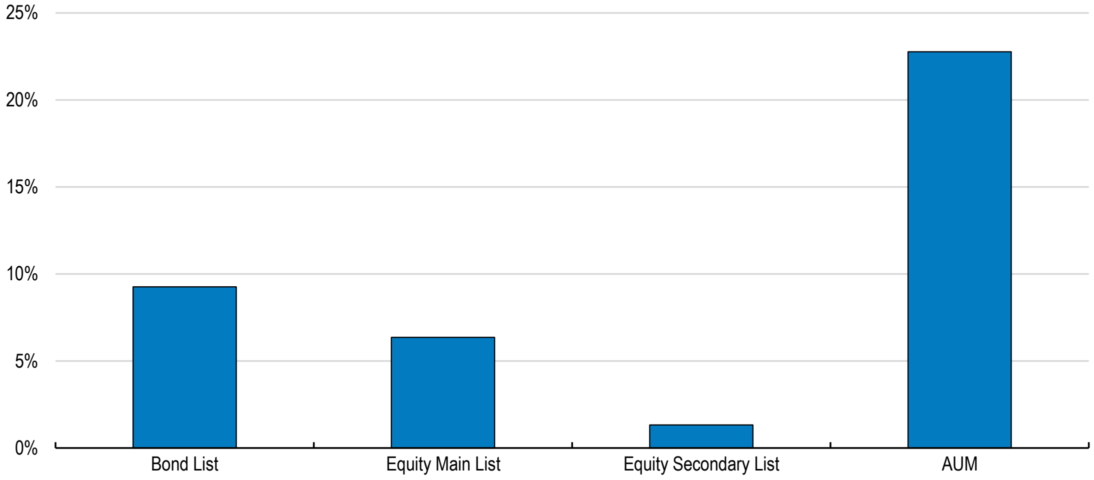
Reaching critical size in capital markets

The private sector still relies heavily on commercial banking sector for its financing needs but has started to look for alternative financing sources in recent years. Regulated utilities and state-owned enterprises will carry out a significant share of green infrastructure investments. This is particularly the case in expanding and upgrading the electricity networks to accommodate for higher renewable energy penetration, more decentralised production with an increase in prosumers, and more effective demand management. Such investments tend to rely on traditional corporate financing models and access to tap into liquid capital markets for both debt and equity (OECD, 2021[33]).

Despite the favourable dynamics in both bond and equity markets, the domestic capital market in Lithuania remains small and with low liquidity. These features tend to be a deterrent to both domestic and foreign investors. While the corporate bond market has expanded, reaching 2.3% of GDP in 2019 (from almost nothing in 2015),), it remains much smaller than that of other European countries (EBRD, 2022[34]). Private equity market growth has also been quite dynamic in large part due to support from national promotional institutions and can be an important alternative source of funding. However, as of 2020, assets under management of institutional investors in the three Baltic states, which tend to be more drawn to longer-term investments, are estimated to have reached 23% of GDP (or EUR 24 billion) while the bond and equity market 16% GDP (or EUR 18 billion) (Figure 5.11.). The difference between the available capital and the size of capital markets hints to lack of investment options forcing investors to seek opportunities outside of Lithuania’s and the Baltic capital market (EBRD, 2022[34]; EBRD, 2021[24]).

Figure 5.11. Size of capital markets vs institutional investor assets under management

Securities listed on the Baltic exchanges and assets under management as a share of 2020 GDP



Note: Bond list includes both corporate bonds and government bonds listed on Nasdaq Baltic exchange in Estonia, Latvia and Lithuania. AUM denotes assets under management for investment funds, pension and insurance companies in Baltic countries. Data on securities and AUM is for year 2020.
Source: (Eurostat, 2022[35]), (Nasdaq, 2022[36]),

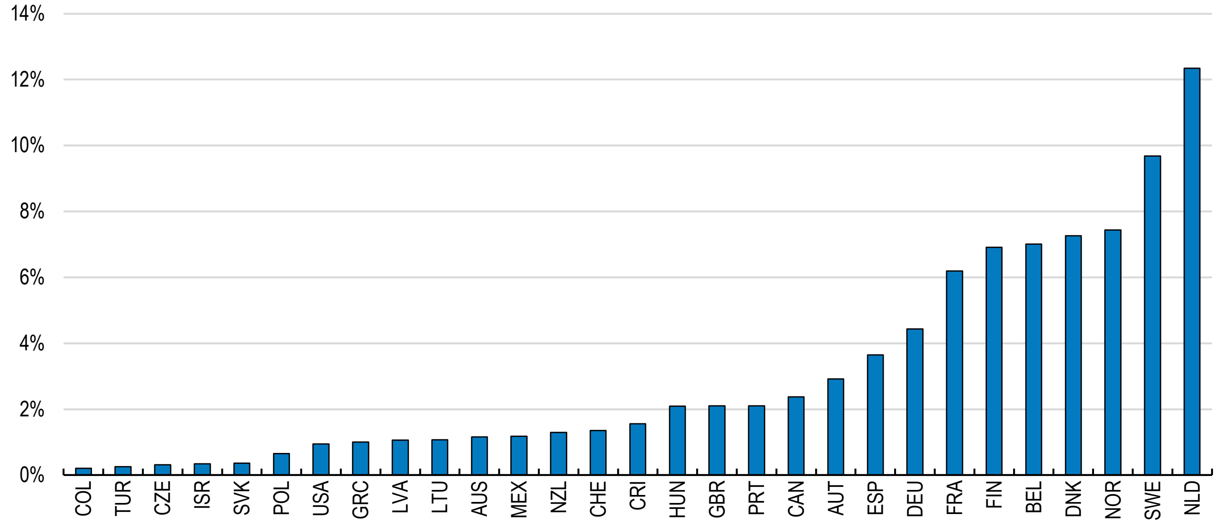
Reaching critical size to attract investors and create a larger pool of liquidity is thus a priority for scaling up climate finance for the transition in a small country. Scaling-up financing for these types of investments will require mechanisms that influence incentives and behaviours in financial markets, particularly with regard to integration of climate-risk considerations.

Policy solutions exist to overcome these problems and attract private capital for projects aligned with climate goals. Ongoing efforts to build a pan-Baltic capital market, with the assistance of EBRD and the European Commission, are a step towards deepening and broadening capital markets. The inclusion of larger SOEs, such as the energy firm Ignitis Group's initial public offering in 2020 (the largest IPO in the Baltic region), in the domestic exchange (Nasdaq Vilnius), has attracted interest from both domestic and foreign investors, thus contributing to expanding the size and liquidity of the market. In addition, encouraging the utilisation of greener investment mandates by asset owners and clarifying the fiduciary duty with respect to climate-risk that asset managers have towards their beneficiaries can increase the share of funds investors are able to allocate to projects contributing to the climate transition.

Beyond using initiatives to deepen capital markets to increase private sector engagement in green infrastructure finance, the government has issued green bonds (EUR 68 million) to co-finance its energy efficiency programmes for the building sector, being the first to do so in the Baltic region. Furthermore, the state-owned energy company Ignitis conducted two rounds of green bond issuance, in 2017 and 2018, worth a total of EUR 600 million. The proceeds were used to finance green generation and network modernisation projects in Lithuania and abroad (OECD, 2022[37]). These issuances were the largest and longest maturity ever offered by Lithuanian companies and the largest and longest maturity green corporate Eurobond among the issuers from Central and Eastern Europe (CEE) (Ignitis Group, 2020[38]). Despite these efforts, Lithuania's issuance of green bonds by both public and private entities pales compared with other OECD countries (Figure 5.12.).

Figure 5.12. Cumulative amount of green bond issuance (2014-2021)

Share of 2021 GDP (%)

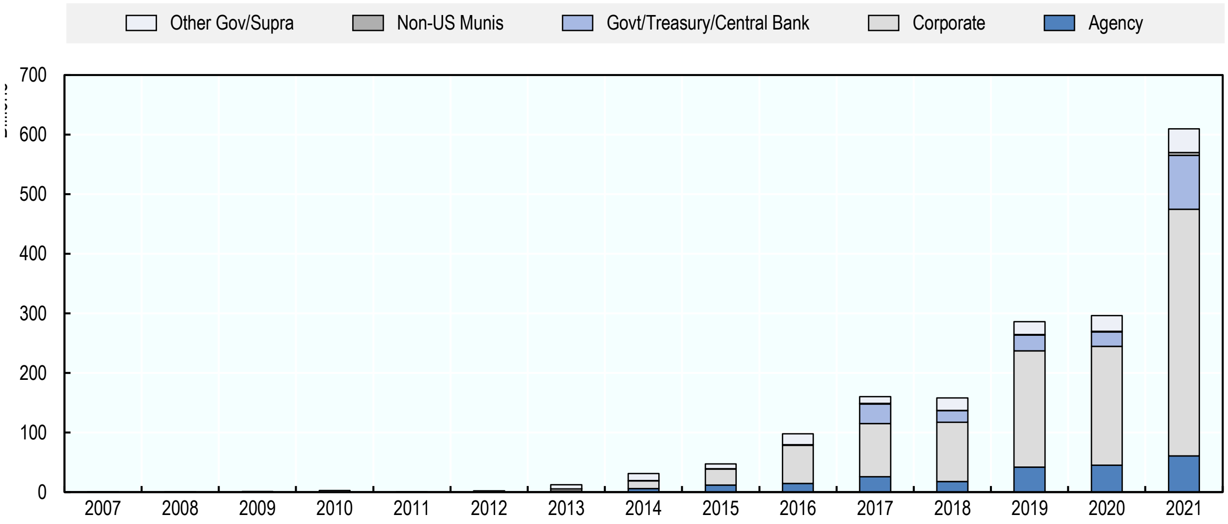


Note: Both public and private sector bond issuances are included.
Source: Refinitiv and OECD.

There is thus scope to scale-up the issuance of green instruments to take advantage of the high demand from investors both domestically and abroad. As the decarbonisation transition accelerates around the world, there has been a strong appetite for green instruments to bolster green investment portfolios. Already, the green bond market has expanded considerably (Figure 5.13.). Increasing the institutional capacity to support better disclosure of climate mitigation-related activities and climate-risk can help bolster the uptake and expansion green instruments and the integration of companies into rapidly developing green indices. Local government funding agencies are a further means to scale-up and draw in infrastructure investments.

Figure 5.13. Green bond issuance (2007-2021) by sector

In billion USD



Note: Agency: government agencies such as national development agencies; Corporate, Gov/Treasury/Central Bank, Non-US Munis: non-US local governments; Other gov/supra: government agencies such as regional agencies and multilateral developments banks are included in this category.
Source: Refinitiv.

Public-private risk sharing for low-carbon infrastructure investment

Complementary policies for crowding-in private sector finance can facilitate the implementation of risk-sharing mechanisms for green infrastructure investment. The choice of infrastructure delivery models shapes financing options. Some long-lived assets operating in stable business environments, such as certain renewable generation projects, can be delivered and financed effectively through project-based vehicles such as public-private partnerships (PPPs) where cash flows are secured by way of long-term contracts. Lithuania needs to improve its capacity to establish and manage such investment vehicles.

Scaling-up financing for such investments will depend on achieving an appropriate allocation of risks between public and private parties, and developing suitable financing channels, vehicles, and risk mitigation instruments. This is key to bridging the cash-flow and risk profile of projects and the preferences of investors (OECD, 2021[33]). Public risk mitigation strengthens the financial liability of projects by transferring extra risk to the public sector. However, caution is needed when undertaking risk-transfer schemes as public authorities should avoid incurring undue costs should the risk materialise. Policy makers should adopt a robust system of assessing value for money that involves classifying, measuring and contractually allocating risks to the partly best able to manage them (OECD, 2012[39]).

Risks evolve over the infrastructure life cycle as different stages of project carry specific financing needs (Table 5.1). These may call for different sources of finance and classes of investors. For instance, green infrastructure investment in the power sector can involve a higher degree of uncertainty during the early phases of a project (i.e. the construction phase), as it may involve high initial capital costs and even continued high operational costs in the case of offshore wind farms. This may deter certain risk-averse investors who prefer predictable and stable cash flows from investing, such as institutional or retail investors, particularly in the early phase of the project, be it equity or debt. Banks and project developers with project finance expertise may have a higher risk tolerance and be prepared to provide debt financing over this early phase based on an assessment of the project and sponsor creditworthiness.

Once the project becomes operational, it may become more acceptable to long-term investors like pension funds and sovereign wealth funds who need low-risk long-term cash flows to match future liabilities. This complementarity implies that institutional investors help take operational assets from banks and project developers, freeing up construction-stage finance for new projects. Here the role for secondary markets is essential for offloading operational assets to more risk-averse investors and recycle capital. The public sector has a role in attracting different types of investors, including institutional investors. Developing secondary markets can help leverage the complementary among different investor types, address liquidity concerns, optimise risk pricing and reduce cost of capital for infrastructure projects (OECD, 2021[40]).

Table 5.1. Risks related to infrastructure assets over the project life cycle

<table>
<tr><th>Risk categories</th><th>Development phase</th><th>Construction phase</th><th>Operation phase</th><th>Termination phase</th></tr>
<tr><td rowspan="8">Political and regulatory risk</td><td>Environmental review</td><td>Cancellation of permits</td><td>Change in tariff regulation</td><td>Contract duration</td></tr>
<tr><td>Rise in pre-construction costs (longer permitting process)</td><td>Contract renegotiation</td><td></td><td>Decommission</td></tr>
<tr><td></td><td></td><td></td><td>Asset transfer</td></tr>
<tr><td></td><td></td><td colspan="2">Currency convertibility</td></tr>
<tr><td colspan="4">Change in taxation (carbon taxation)</td></tr>
<tr><td colspan="4">Social acceptance</td></tr>
<tr><td colspan="4">Change in regulatory or legal environment</td></tr>
<tr><td colspan="4">Enforceability of contracts, collateral and security</td></tr>
<tr><td rowspan="7">Macroeconomic and business</td><td>prefunding</td><td colspan="3">Default of counterparty</td></tr>
<tr><td colspan="2" rowspan="3">Financing availability (link to ESG)</td><td colspan="2">Refinancing risk</td></tr>
<tr><td colspan="2">Liquidity</td></tr>
<tr><td colspan="2">Volatility of demand and market risk</td></tr>
<tr><td colspan="4">Inflation</td></tr>
<tr><td colspan="4">Real interest rates</td></tr>
<tr><td colspan="4">Exchange rate fluctuation</td></tr>
<tr><td rowspan="6">Technical</td><td colspan="3">Governance and management of the project</td><td rowspan="5">Termination value different from expected</td></tr>
<tr><td colspan="3">Environmental</td></tr>
<tr><td>Project feasibility</td><td rowspan="2">Construction delays and cost overruns</td><td rowspan="2">Qualitative deficit of the physical structure and service</td></tr>
<tr><td>Archaeological</td></tr>
<tr><td colspan="3">Technology and obsolescence (electric vs. hydrogen vehicles)</td></tr>
<tr><td colspan="4">Force majeure</td></tr>
</table>

Note: categories in bolded font may be more specific to green infrastructure projects.
Source: Adapted from (OECD, 2021[33]).

The development and expansion of the offshore wind industry in the United Kingdom provides a good example of how governments can play an integral role in mobilising private sector investments by lowering investment risks. The institutional and policy landscape in the United Kingdom has seen the establishment of an investment-enabling environment via policy incentives, public funds and institutional support to overcome low-carbon infrastructure investment barriers, mitigate project investment risks and develop markets for high potential low-carbon technologies. This was ultimately a result of a series of steps that allowed the UK to rapidly develop its offshore wind industry, including an incentive scheme to ensure predictable cash flow through contracts for difference and a Green Investment Bank (GIB) with a mandate to co-invest in offshore wind projects among other green infrastructure investments (Box 5.3).

Box 5.3. Risk mitigation for offshore wind investments in the United Kingdom

The United Kingdom is frequently cited as an example of a country that managed to create an attractive investment environment for renewable energy worldwide. In 2008, the UK pledged to reduce its greenhouse gas emissions by at least 80% below 1990 levels by 2050. To reach this target, the country chose to capitalise on its renewable energy potential, specifically wind resources on land and in the surrounding seas.

The institutional and policy landscape in the United Kingdom has seen the establishment of an investment-enabling environment via policy incentives, public funds and institutional support to overcome low-carbon infrastructure investment barriers, mitigate project investment risks and develop markets for high potential low-carbon technologies. This was ultimately a result of a series of steps that allowed the UK to rapidly develop its offshore wind industry.

In order to offer predictable cash flow to lower the high investment hurdle rates faced by project developers and investors, the United Kingdom provided financial incentives for 15 years through the “contracts for difference” (CfD). For each unit of energy produced by a project, the CfD establishes a "strike" price that accounts for the expenses associated with acquiring low-carbon technologies. This set energy price is an additional payment made to the project developer above the energy market price. This works as a backstop and prevents payments from ever falling below the strike price; but, if the market price rises above the strike price, the project developer is responsible for making up the difference. Compared to market pricing alone, this mechanism offers investors greater predictability, and the government is less liable to the expenses than it would be with set payments like feed-in tariffs. Additionally, because the CfD offers support for 15 years, it is long enough to conform to conventional economic lifetime assessments like cash-flow studies and is comparable in length to support from feed-in tariffs.

To scale up green investment via institutional support, the UK established the UK Green Investment Bank (GIB) to promote low-carbon infrastructure investment with a key focus on offshore wind and crowd-in investors in 2012. The GIB, a state-owned financial institution with a specialised mandate, offers long-term funding and helps develop and sustain market viability for green infrastructure. The UK GIB invested roughly two-thirds of its capital in offshore wind projects while also being an active investor in onshore wind projects in the UK. Overall, the UK GIB was crucial in helping the market mature to the point where it no longer depends on public co-investment.

Note: The UK Green Investment Bank (GIB) was established by the Government of United Kingdom in 2012 as a non-departmental body of the Department of Business, Energy and Industrial Strategy (UK BEIS). It was acquired by Macquarie Group Limited in August 2017 and is now an independent private organisation.
Source: (OECD, 2018[30]).

Policy makers should thus review and where appropriate reform capital market regulation to ensure the availability of appropriate capital market instruments and vehicles for de-risking infrastructure investment. The availability of a wide variety of capital market instruments and vehicles (i.e. pooling mechanism) can help cater to the preferences of different investors and adapt financing to the evolving risk profile as it moves through the life cycle. A variety of capital market instruments may give institutional investors exposure to infrastructure assets at an acceptable risk-return ratio and help them diversify their exposure across multiple assets. Additionally, institutional innovations, such as adjusting the mandates of existing public financial institutions or forming a new institution like a green investment bank can further leverage complementary tools that help deliver more holistic and effective risk-sharing strategies (OECD, 2020[29]).

Different de-risking instruments have different mobilisation potential and public actors need to determine where their participations can have the most impact (Table 5.2). OECD research shows that fund level co-investment is frequently used for more established technologies such as wind and solar, and cornerstone stakes are more suitable for crowding in private money for technologies that are relatively less commercially established or underserved, such as energy efficiency-related technologies. Higher risk-taking by public capital in smaller-scale projects or sectors with new business models and technology creates a demonstration effect, thus proving the viability of the project or technology to incentivise uptake by private investors and foster new markets. To deploy limited public capital to its greatest effect, public actors therefore have to consider the instrument with the greatest possible impact. For example, if a market is established, i.e. sizeable price decreases and leaps in technology development cannot be expected and deployment is beyond a demonstration effect, public actors may consider using funds in other markets (OECD, 2020[29]).

Table 5.2. Risk mitigants to mobilise private finance

Name	Description
Co-investment	Public actor(s) investment alongside private investor(s) with either debt or equity with an equal or lower stake than a private investor (any larger investment would be classified as cornerstone stake).
Cornerstone stake	Investment by a public actor in a fund, issue or project amounting to a majority equity stake to achieve a demonstration effect to attract other investors
Loan	Debt issuance by a public actor
Loan guarantee	Guarantee by a public actor to pay any amount (either in full or part) due on loan in the event of non-payment by the borrower
Public seed capital	Concessional fund allocation using public money
Revenue guarantee	Guarantee by a public actor to pay for the core product to ensure revenue cash flow for a project.
Back-stop guarantee	Guarantee by a public actor to purchase any unsubscribed portion of an issue (debt or equity)

Note: Risk mitigants are defined as either a direct use of public finance or backing a project with public funds which puts public funds at risk. In short, the public actor has a contingent liability.
Source: Adapted from (OECD, 2020[29]).

There are many risk transfer mechanisms, including contractual mechanisms, insurance policies, or guarantees. Guarantees provided by the public sector (including government, development banks, specialised agencies, and multilateral banks) can cover a wide range of risks that impact various actors in the infrastructure financing ecosystem. For guarantees to be credible, they typically require the backing of the Ministry of Finance or a Multilateral Development Banks, and strong transparency and accountability mechanism, including reporting and disclosure of project risk and financial performance.

Lithuania has recently deployed a risk-sharing instrument for improving the energy efficiency of its building sector. Historically, the public sector has relied heavily on distributing grants or subsidies to fund infrastructure investments, potentially undermining incentives for private sector involvements and even crowding it out. An initiative that has overcome this shortcoming is the use of financial instruments from European Structural Investment (ESI) Funds in combination with grants for investments in energy efficiency for the building sector in Lithuania.

Risk-sharing programme for the building sector

Lithuania has placed part of its ESIF allocations in financial instruments for both programming periods 2007-2013 and 2014-2020; financial instruments were used for the purposes of improving the energy efficiency of the building sector. For Lithuania, the Joint European Support for Sustainable Investment in City Areas (JESSICA) programme was oriented towards improving the energy efficiency of its multi-apartment buildings. First it was implemented through a concessional loan programme and then continued as also a concessional loan programme but with a government guarantee to draw in private sector participation through public-private risk sharing (Box 5.4).

Box 5.4. Lessons from Lithuania’s risk-sharing approach in providing energy efficiency loans to modernise old buildings

Modernising multi-apartment blocks to a higher standard of energy efficiency has been a key priority for the government, and an important step towards achieving Lithuania’s broader goals of a low-carbon economy. Approximately 90 per cent of all buildings in Lithuania are over 22 years old, while 66 per cent are soviet-era multi-block apartment buildings in energy classes D or lower. These buildings run high maintenance costs and consume around seven times more energy than modern housing types, disproportionately affecting poorer consumers who tend to reside in such housing. To bridge the gap in funding required for the modernisation of old buildings, the Lithuanian government employed a series of European Regional Development Fund (ERDF) operational programme resources to establish loan and guarantee financial instruments for energy efficiency modernisation.

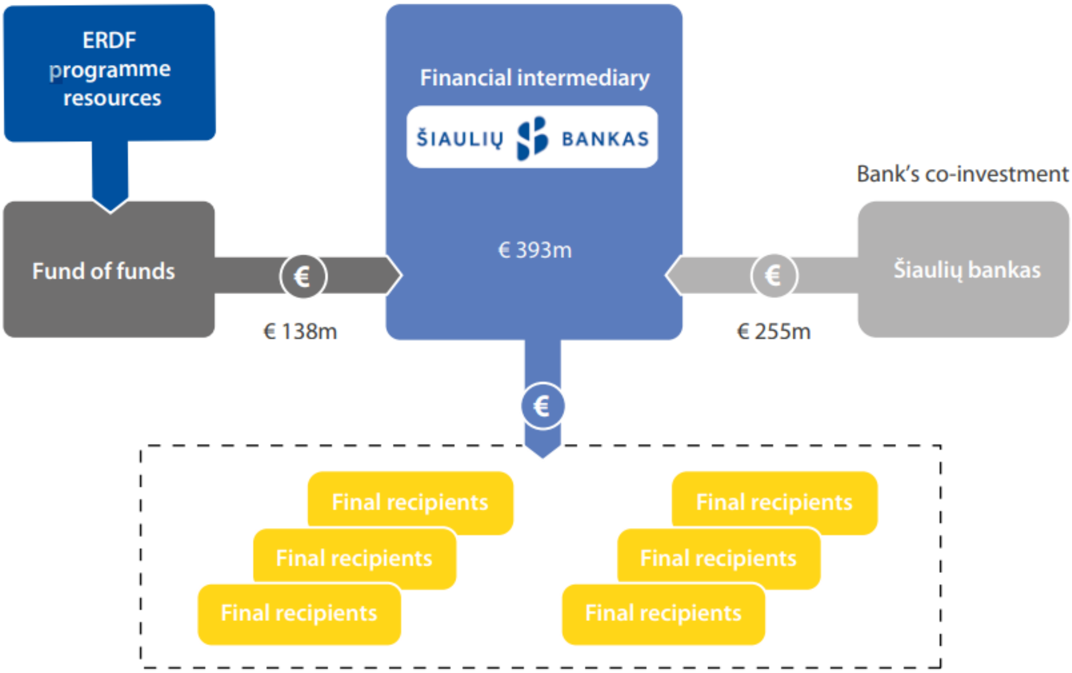
The JESSICA I initiative (2007-2013 programming period) primarily offered preferential loans at a fixed interest rate of 3 per cent, maturing in 20 years. Upon reaching certain energy efficiency goals post-renovation, homeowners were initially eligible for a subsidy of up to 40 per cent. The posterior JESSICA II Fund of Funds (2014¬-2020) was established with EUR 150 million from European Structural and Investment Funds and similarly issued preferential loans to residents. In addition, it set out to maximise the leverage of its assets through private finance in order to lower national public contributions to the scheme. This instrument effectively attracted EUR 180 million of resources from various financial intermediaries, such as commercial banks and public agencies. This was the first time that Lithuanian public sector institutions took on loan-related risks of this kind.

By March 2018, the programmes had reached 47 000 households by improving their energy consumption classification and lowering their energy bills, and reduced greenhouse gas emissions annually by 81 000 tCO_2-e. The programmes enjoyed wide public support at national and municipal level and attracted domestic attention and international recognition for successfully employing financial instruments to tackle the problem of energy inefficiency in housing. In addition, the programme had a positive effect on job creation and economic growth.

Source: (fi-compass, 2020[41]; Housing Evolutions, 2022[42]; VIPA, 2022[43])

The implementation of the “Lithuania Leverage Fund” guarantee instrument has secured significant additional leverage of private sector finance (by a multiple of five), closing the financing gap for the project (fi-compass, 2020[41]). The EIB was designated as the fund of funds manager and through a competitive process selected a single intermediary, Šiaulių bankas, the largest domestic commercial bank (Figure 5.14.). While the instrument was designed to attract several domestic financial intermediaries to provide and distribute the Modernisation Loans, EIB determined that other banks lacked the capacity to provide and distribute the funds. Because of the lack of capacity in the local market to support the guarantee instrument, a structured investment platform was also established to allow private sector investors to join commercial banks and financial institutions to contribute low-risk senior debt, with protection of a first loss piece made up of ESIF resources and co-financed by the financial intermediary.

Figure 5.14. Lithuania's Jessica II Fund of Funds to finance energy efficiency improvements in the building sector



Source: (fi-compass, 2020[41]).

The Fund has allowed the financial intermediary to increase its lending in line with the needs of the building modernisation programme. Rolling out the guarantee has helped to secure significant additional leverage of private sector finance (by a multiple of five) in a period of growing demand for energy efficiency investments in residential housing across the country (fi-compass, 2020[41]). The success that the financial instruments had in lowering risk for investments in energy efficiency projections and mobilising private sector finance is attributable to several factors. First, these instruments were complemented by grants in the form of technical assistance, interest rate subsidies, and capital rebates. Grants are issued to cover the costs related to project preparation, administration, energy audits, and energy certificates. Interest rate subsidies help to reduce the cost of borrowing for households, while capital rebates reduce the overall cost of renovation. An additional capital rebate is also offered to encourage homeowners to save as much energy as possible, with the capital rebate amount increasing as the greater energy efficiency standards are met (fi-compass, 2020[41]). Second, close cooperation between the fund manager (EIB), the provider of the fund and financial intermediaries has been critical in proactively identifying and addressing programme delivery challenges—of particular note were actions taken to monitor compliance at every step of the funding delivery process (Housing Evolutions, 2022[42]).

The JESSICA II programme experienced several challenges highlighting the complexity of implementing such financial instruments (VIPA, 2022[44]). First, it was noted that the timelines of project implementation and preparation for loan agreements did not always align and were cyclical: requests for proposals were published once a year, leading to an uneven distribution of project workload. This proved to be challenging as the agency had to manage huge influxes of loan paperwork at the same time, monitor payments and oversee forecasted disbursements from different funding sources. Moreover, the implementation of the fund of funds faced challenges at different levels—some related to behavioural and motivational peculiarities, some to legal and administrative barriers. Building administrators tended to exhibit a lack of ownership of these projects and were generally slow to reorient themselves from subsidies to loan financing.

Loan maturity timeframe of 20 years also proved too short in some instances: where building condition was extremely poor, higher volumes of investment were warranted, which then exceeded the 20-year payback period. The complexity of implementing the guaranteed loan model, coupled with the inexperience and unreasonable expectations of all market participants also proved challenging, as did the poor quality of the prepared documents, in particular energy audits, which resulted in high individual project administration costs.

The experience from this specific programme delivers important lessons for subsequent initiatives to support the decarbonisation transition in Lithuania. These point to the importance of developing the technical expertise and administrative capacity to evaluate projects and to process funds for the successful implementation of a risk-sharing scheme. The evolution of the JESSICA programme from programming period 2007-2013 to 2014-2020, shows the progress made in introducing more complex use of financial instruments in the second period, which could be attributed to maturing public administration and greater stakeholder awareness and confidence. A similar leveraged fund could be introduced to fund renewable energy projects, especially those at a smaller scale and in need to critical mass. Given the objective to increase the number of prosumers, a combination of energy efficiency and renewable energy deployment project would benefit from a similar risk-sharing scheme, whereby public funds are used to guarantee and finance the riskier stages of the project (fi-compass, 2020[28]).

The extensive experience of financial intermediary in the renovation sector has also been key to ensuring that cooperation between the fund and intermediaries is productive. Indeed, the financial ecosystem supporting the JESSICA initiative benefited from the expertise of both multilateral development banks like the EIB and domestic financial intermediaries, and in close partnership with public agencies (e.g. Housing and Energy Saving Agency – BETA) and municipalities.[6] Thus providing technical assistance throughout the life-cycle of the financial instrument and to the relevant stakeholders facilitates the preparation and implementation of the financial instrument (fi-compass, 2020[28]).

Key findings

- There is a substantial financing gap for low-carbon infrastructure that would need to be filled by private sector investment. For the power sector alone, investments to expand renewable generation capacity reach EUR 6.5 billion. EU funds and co-financing from national resources will not be sufficient to meet investment demands for decarbonisation.
- Public authorities have the dual role of being both the providers of funds for investments and enablers for private sector investments. The public sector has relied heavily on distributing grants or subsidies to fund infrastructure investments, potentially undermining incentives for private sector involvements and even crowding it out.
- Lithuania’s climate agenda sets the right level of ambition, but now it is important to implement an effective policy mix and set up a coherent institutional framework to design policies and evaluate progress.
- There is scope to enhance the absorptive capacity and spending efficiency of EU funds. This can be achieved through the building capacity to clarify and help implement new regulation regarding sustainable activities, including EU taxonomy for sustainable activities and the Sustainable Finance Disclosure Regulation (SFDR). Spending efficiency of EU funds can be improved using repayable financial instruments as reflows can be channeled to other projects. Building robust project

pipelines can contribute to a more effective absorption and spending of funds, in addition to helping to crowd-in private sector funds.

- Subnational governments in Lithuania face a number of challenges that affect their capacity to deliver infrastructure investment. There is scope for deeper co-operation among local governments to pool either expertise (shared service centres) or projects to reach larger scales and to increase bargaining power to reduce costs.
- Reaching critical size in capital markets to attract investors and create a larger pool of liquidity is thus a priority for scaling up climate finance for the transition in a small country. Scaling-up financing for these types of investments will require mechanisms that influence incentives and behaviours in financial markets, particularly with regard to integration of climate-risk considerations.
- Scaling-up financing for infrastructure investments will depend on achieving an appropriate allocation of risks between public and private parties, and developing suitable financing channels, vehicles, and risk mitigation instruments. This can help cater to the preferences of different investors and adapt financing to the evolving risk profile as it moves through the life cycle.
- The experience from the use of a leveraged fund JESSICA II programme as a public-private risk sharing vehicle delivers important lessons for subsequent initiatives to support the decarbonisation transition. These point to the importance of developing the technical expertise and administrative capacity to evaluate projects and to process funds for the successful implementation of a risk-sharing scheme.

Notes

[1] Similar long-term strategies have been developed for other sectors. For example, the Ministry of Economy and Innovation of the Republic of Lithuania, taking into account EU-level policy and assessing the specific needs of Lithuanian industry, initiated, prepared and coordinated with social partners the following guideline documents to create a general vision, including climate mitigation considerations, for Lithuanian industry until 2030: Lithuanian Industry Digitisation Roadmap 2020-2030: https://eimin.lrv.lt/lt/veiklos-sritys/pramone/pramone-4-0/lietuvos-pramones-skaitmeninimo-kelrodis-2019-2030; A roadmap for Lithuania's industrial transition to a circular economy: https://eimin.lrv.lt/lt/veiklos-sritys/pramone/ziedine-ekonomika-klimato-kaita/lietuvos-pramones-perejimo-prie-ziedines-ekonomikos-kelrodis/lietuvos-pramones-perejimo-prie-ziedines-ekonomikos-kelrodis-1; Integration of Lithuanian industry into strategic European value chains: https://eimin.lrv.lt/lt/veiklos-sritys/pramone/pramone-4-0/lietuvos-pramones-integracija-i-strategines-europos-vertes-grandines-1.

[2] Lithuania has recently introduced a temporary support scheme to offset the impact of energy price (electricity and natural gas) hikes on households. The government will subsidise electricity at 9 cents/kwh and natural gas at 54 cents/cubic meter with a tariff floor of 24 cents/kWh (Government of the Republic of Lithuania, 2022[45]).

[3] https://finmin.lrv.lt/uploads/finmin/documents/files/Naujos%20kartos%20Lietuva_2021_05_14.pdf.

[4] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52022DC0108&from=EN.

[5] Project pipelines are defined as: “set of infrastructure projects and assets (accounting for the existing stock of assets), and future assets in early development and construction stages prior to project commissioning, typically presented as a sequence of proposed investment opportunities over time that align with and are supportive of long-term climate and development objectives” (OECD, 2018[30]).

[6] BETA has been merged into the Environmental Project Management Agency (APVA).

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6

Distribution of carbon tax burdens in Lithuania and social policy implications

This chapter lays out an approach for assessing the impact of carbon pricing on household budgets. It first maps the gains and losses at the household level in the short term and then considers possible compensatory government transfers that can be financed through carbon-tax revenues. Results confirm that direct burdens from higher fuel prices fall disproportionately on lower-income households. But indirect effects, from higher prices of goods other than fuel, are sizeable and broadly "flat" across the income distribution, which dampens regressivity. Low-income households are also found to respond more strongly to rising prices, reducing their burdens and, hence, regressivity. The total effect is only mildly regressive. Recycling carbon-tax revenues back to households allows considerable scope for offsetting losses for large parts of the population, in a way that facilitates majority support for carbon tax packages.

As part of strategies to tackle the causes of climate change, different forms of carbon pricing, such as carbon taxes, cap-and-trade systems and phase-outs of fossil-fuel subsidies, have been introduced to shift the marginal private cost of carbon towards its marginal social cost.[1] These measures incentivise a reduction in emissions, as well as a substitution from dirtier to cleaner fuels. They are recommended for their environmental effectiveness, because they are administratively simple and economically efficient without being technologically prescriptive, and because they do not weigh on government budgets (High-level Commisssion on Carbon Prices, 2017[1]; Pigou, 1920[2]; Nordhaus, 1991[3]; Pearce, 1991[4]).

Drawing on an accompanying paper, this chapter applies a modelling framework to simulate the distributional impact of a carbon tax and applies it to study a prospective reform in Lithuania.[2] Currently, Lithuania does not apply an explicit carbon tax. In 2021, CO_2 emissions from energy use in Lithuania are partly priced, through the EU Emissions Trading System (ETS) and through (comparatively low) fuel excise taxes. Recently, the Lithuanian government has proposed to phase-in a tax based on the carbon intensity of fuels from 2025, but a final decision has yet to be approved by Parliament. The tax would start at EUR 10 per tonne of CO_2 and rise by EUR 10 each year, rising to EUR 60 per tonne in 2030, though the carbon tax component in the current proposal does not apply to entities already subject to the EU ETS. EUR 60 per tonne corresponds to a low to midpoint estimate for the social cost of carbon in 2020 (High-Level Commission on Carbon Prices, 2017[5]), though more recent studies mostly support higher values. The US government currently relies on a mean value of USD 51/tCO_2 (Interagency Working Group on Social Cost of Greenhouse Gases (IWG), 2021[6]), a recent report by the European Commission (2021[7]) suggests a central value of EUR 100/tCO_2 through to 2030, while a recent comprehensive review indicates a preferred mean estimate of USD 185/tCO_2, at 2020 prices (Rennert et al., 2022[8]).

The policy simulations in this chapter combine micro-level information on household expenditure and income, with input-output data that allow tracing the carbon content and associated tax burdens across sectors and through different stages of production. Using this approach, it is possible to approximate the effects of a carbon tax on the price of goods across all consumption categories, not just households' direct use of carbon-rich energy products. The chapter quantifies the resulting net effects of the tax on household budgets, and disentangles its key drivers, including consumption of energy and other goods, as well as consumers' responsiveness to price changes from the pass-through of carbon taxes to final products. The approach notably accounts for the effects of policies that seek to compensate selected population groups through government transfers or income-tax concessions, which can be financed through carbon-tax revenues ("revenue recycling").

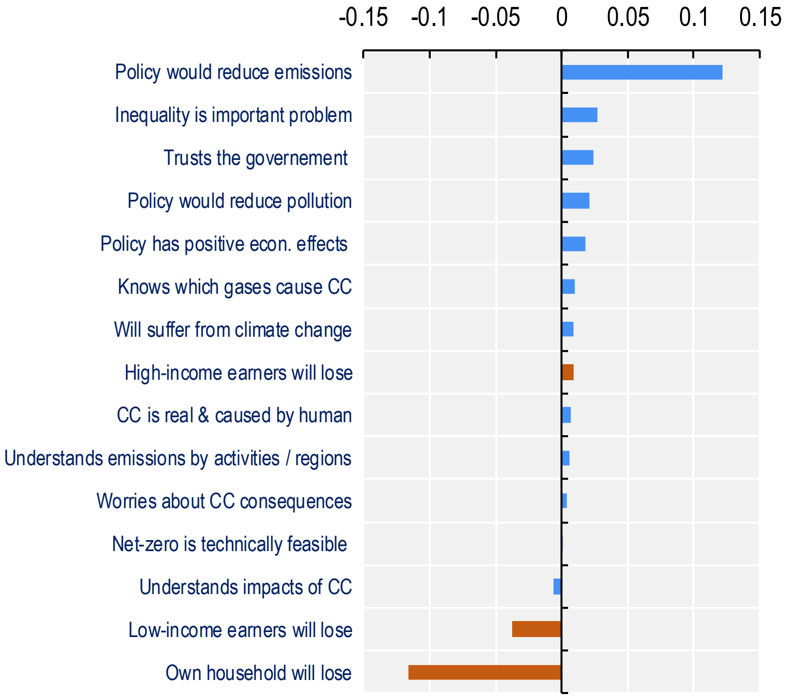
Beyond their effect on consumption expenditures, carbon taxes and other climate-change mitigation measures also alter the incomes of the owners of the different factors of production, including natural resources, "brown industry" equity and labour (Rausch, Metcalf and Reilly, 2011[9]), and may drive the pace and direction of innovation (Dechezleprêtre and Kruse, 2022[10]; Dechezleprêtre and Sato, 2017[11]). Relatedly, changing input prices and consumer demand trigger labour-market adjustments through a reallocation of jobs from high-carbon to low-carbon industries and activities. These gains and losses from labour-market adjustments can be difficult to quantify and are not reflected in the approach presented here. There will clearly be employment losses in firms that see reduced demand due to carbon-intensive technologies (Dussaux, 2020[12]). While this will affect specific population groups, such as older workers, available findings suggest that the net employment impact may be limited (OECD, 2021[13]; Metcalf and Stock, 2020[14]). Available estimates on the broader impact of employment changes on inequality also do not give clear-cut results and Chapter 3 suggests that that unemployment and wage losses resulting from a carbon tax in Lithuania may be less pronounced for low-skilled workers than for other groups (Barreto, Grundke and Krill, forthcoming[15]).[3]

Across countries, current carbon prices are well below levels that are considered in line with national and international commitments, notably the targets affirmed in the Paris Agreement (OECD, 2022[16]).

Numerous governments are therefore considering reforms to introduce or increase them. Yet, in the short term, there can be notable trade-offs between the intended incentives from higher carbon prices, and unintended distributional effects (Baumol and Oates, 1988[17]; Baranzini, Goldemberg and Speck, 2000[18]). The pattern of gains and losses from climate-change mitigation measures can be a key driver of public and political support for fighting climate change (Büchs, Bardsley and Duwe, 2011[19]; Tatham and Peters, 2022[20]). For instance, a recent large-scale survey of 40 000 people across 20 countries, shows that support for carbon taxes hinges on their perceived distributional impacts on lower-income households, and respondent's own assessment of their household's gains and losses (Figure 6.1).

Figure 6.1. Support for climate policies hinges on perceived gains and losses

Correlation between beliefs and support for carbon tax package with cash transfers



Note: Results of regressions of support on standardised variables measuring respondents' beliefs and perceptions. Country fixed effects, treatment indicators, and individual socioeconomic characteristics are included but not displayed. The dependent variable is and indicator variables equal to 1 if the respondent (somewhat or strongly) supports each of the main climate policies. n=40 680, R2=0.378.
Source: Adapted from (Dechezleprêtre et al., 2022[21]).

In part, concerns about the distributional impacts of carbon taxes stem from the fact that home fuels in particular are, at the same time, necessities and a main source of household-level emissions. When prices go up, the poorest households may be ill-equipped to draw on savings or to cut back on other expenditures. As a result, low-income groups could bear a substantial burden from higher carbon taxes and their overall impact could be regressive, increasing inequality, and worsening key aspects of material deprivation and social exclusion, such as fuel poverty or food insecurity. The current cost-of-living crisis has dramatically heightened concerns over the economic burdens on households from rising living costs, and higher energy prices in particular.

Existing studies highlight that net effects of carbon taxes vary strongly between countries and policy measures, depending not only on the features of the tax and consumption patterns, but also on population characteristics and existing inequalities (Ohlendorf et al., 2020[22]). Importantly, carbon taxes and fuel prices affect not only the cost of transportation and heating but, subject to the carbon intensity in the production process, also the prices of other goods. For each household, the overall impact depends on their consumption bundle, and on their propensity and ability to change consumption in response to price movements.

Any regressive effects or a concentration of losses among specific groups may call for accompanying measures to compensate losers, while maintaining the price signals from carbon pricing (Carattini, Carvalho and Fankhauser, 2018[23]). For instance, the carbon tax in Ireland includes a commitment to using the resulting revenues for preventing fuel poverty and ensuring a just transition. Compensation should be timely and may need to be suitably targeted in order to support the political feasibility and sustainability of climate-change mitigation initiatives. Policy models in combination with rich micro-level data ("microsimulation models") allow exploring each of these mechanisms and their likely net effect on different households (Hynes and O'Donoghue, 2014[24]; Immervoll and O'Donoghue, 2009[25]; O'Donoghue, 2021[26]). They also facilitate the assessment of alternative reform scenarios or paths, and can provide timely input into policy debates as carbon taxes move up the policy agenda in many countries.

The remainder of this chapter is structured as follows. Section 2 gives an overview of past assessments of the distributional impact of carbon taxes, lays out a methodology of assessing environmental taxes in a microsimulation framework, and describes the input data that is available for Lithuania. Section 3 presents results, distinguishing between (i) direct effects (via fuel consumption by households); (ii) indirect effects (via household consumption of other goods and services with different carbon content); (iii) behavioural adjustments (rebalancing of consumption patterns in response to price signals); and (iv) revenue recycling (options for using carbon-tax revenues to compensate selected groups). The results section also presents estimates for the scope of emission reductions that can be achieved through an introduction of a carbon tax, via expected changes in consumption patterns towards less carbon intensive (and less expensive) goods.

Distributional effects of carbon taxes: Literature review

Much of the literature on the distributional impact of carbon taxes focuses on their initial impact, without revenue recycling. There is a common conjecture that carbon taxation is regressive in high-income countries (Klenert and Mattauch, 2016[27]). However, home fuel and electricity taxation tends to be more regressive than fuel taxation in the transport sector (Büchs, Ivanova and Schnepf, 2021[28]), which can be progressive, especially in countries with moderate car ownership and well-developed public transport systems (Wang et al., 2016[29]).

Households in countries with lower GDP levels, including within the OECD area, tend to face significantly higher risks of energy affordability (Flues and van Dender, 2017[30]), which tends to render carbon taxes less regressive overall. Outside the OECD, progressive impacts are also generally more common in poorer countries, where consumption baskets tend to be less carbon intensive, energy can be more difficult to access or less affordable for large shares of the population, and home fuels can be less important for heating due to climatic conditions (Ohlendorf et al., 2020[22]; Dorband et al., 2019[31]).

Taxation of both direct and indirect emissions tends to be more less regressive (or more progressive) than taxing direct emissions only, e.g., through excise taxes on fuel (Ohlendorf et al., 2020[22]).

The literature on net impacts, accounting also for revenue recycling, is smaller, though existing studies point to the quantitative importance of revenue recycling for overall distributional outcomes. This also holds for policies that raise effective carbon prices through a withdrawal of energy subsidies (Durand-Lasserve et al., 2015[32]). Notable results include the following:

- lump-sum transfers (such as a basic income financed through carbon taxes) are progressive and poverty reducing (Berry, 2019[33]; Klenert et al., 2018[34]; Owen and Barrett, 2020[35]);
- depending on their reach, social welfare payments support low-income earners and reduce inequality, while across-the-board income tax cuts benefit the top and are regressive (Callan et al., 2009[36]; Klenert and Mattauch, 2016[27]);
- VAT tax reductions for specific goods, e.g. on public transport, can redistribute between regions (Brännlund and Nordström, 2004[37]);
- energy cheques reduce fuel poverty (Berry, 2019[33]), while public transport vouchers are progressive and achieve sizeable emission reductions (Büchs, Ivanova and Schnepf, 2021[28]);
- support for retrofitting residential buildings tends to be progressive (Bourgeois, Giraudet and Quirion, 2021[38]).

Table 6.1 illustrates the scope of modelling frameworks used in a range of distributional studies that employ micro-data and policy simulation. Existing frameworks variously incorporate the features that are desirable or required for informative distributional analyses of carbon taxes, namely the capacity to model carbon emissions associated with different consumption goods, the distributional impact of price changes, households' behavioural response to price changes and resulting CO_2 reductions, as well as policies that can offset unintended distributional effects via revenue recycling. Existing frameworks have generally not incorporated all these dimensions; some are stronger on distributional measures, while others incorporate more detail in relation to behavioural responses or include a comparative perspective across countries.

The modelling of accompanying policies to alleviate unintended distributional consequences, including through revenue recycling, has followed different approaches. The early UK study by (Pearson and Smith, 1991[39]) has used policy simulation in combination with detailed household-level information, similar to the illustration reported here. Other studies have been more approximate, without accounting for the full granularity of household information. This is, in part, due to the fact that models often either proceeded at an aggregate or semi-aggregate level, or relied on household expenditure data alone, without linking it to policy simulation models that require detailed information on household incomes. For example, (Callan et al., 2009[36]) compare carbon tax payments per income decile to revenue-neutral transfers by decile, without modelling the granular incidence of carbon taxes or compensating policies on individual households.

The present chapter integrates revenue recycling with a careful analysis of the incidence of carbon taxes themselves. The objective is twofold. First, to further the discussion around broader policy packages in the context of climate change mitigation. Second, to enable detailed assessments of gains and losses from a carbon tax at the household level and across any population group that can be of interest from a political-economy, or a distributional point of view.

Table 6.1. Overview of existing distributional studies using microsimulation: Scope and modelling choices

Author	Country coverage	Scope	Distributional impact	Distributional metric	CO_2 emission reduction	Taxes considered	Multi-regional IO model	Revenue recycling	Behavioural response (consumption)
(Pearson and Smith, 1991[40])	UK (some results for other EU12	country	Regressive	Expenditure	no	Carbon tax	Country IO	(1) Lump-sum; (2) lower income tax	Yes
(Symons, Speck and Proops, 2002[41])	5 EU	country	Mixed	Income	no	Direct and indirect	no	No	no
(Sterner, 2012[42])	7 EU	country	Progressive	Income and expenditure	no	Transportation fuel	no	No	yes
(Flues and Thomas, 2015[43])	21 OECD	20 country average, country	Mixed	Income and expenditure	no	Home heating, motor fuel and electricity	no	No	no
(Dorband et al., 2019[31])	87 low and middle-income	country	Progressive	Income	no	Transportation fuel	yes	No	yes
(Vogt-Schilb et al., 2019[44])	Latin America & Caribbean	Cross-country	Progressive	Expenditure	no	Direct and indirect	yes	(1) Higher cash-transfers, (2) Higher coverage	no
(Büchs, Ivanova and Schnepf, 2021[28])	27 EU	EU-level	Regressive across EU	Income	yes	Direct and indirect	yes	(1) fuel rebates; (2) green vouchers + infrastructure	Average elasticities by EU quintile
(Feindt et al., 2021[45])	23 EU	EU-level, country	Progressive across country/ regressive across EU	Expenditure	no	Direct and indirect	yes	(1) National / EU lump sum; (2) Targeted to poor	Average elasticities across countries
(Steckel et al., 2021[46])	8 Asian	Cross-country	Progressive	Expenditure	no	Direct and indirect	yes	Lump-sum	no
(Budgetdienst, 2022[47])	Austria	Country	Progressive	Income	no	Carbon tax	Country IO	Lump-sum, differentiated by region	no
(Zhao et al., 2022[48])	China	Country	Regressive	Income	Yes, set to achieve 1.5 degree target	Carbon tax	Yes	(1) Tax exemptions, (2) Subsidies	yes

Note: See also Immervoll et al. (2023[49]), Box 1.

Methodology and data

This section situates microsimulation modelling in relation to carbon taxes and environmental policies more broadly. It then presents the data for the present analysis, which is constructed from three main sources, the World Input-Output Database (WIOD), household budget survey (HBS), and the European Union Statistics of Income and Living Conditions (EU-SILC). The section starts by describing WIOD and the input-output analysis underpinning carbon-intensity estimates for each product category. WIOD is then combined with HBS data to estimate carbon-tax burdens at the household level. It also describes the consumption model used to derive households' behavioural responses. The final steps are an imputation of expenditure patterns into the EU-SILC data and the simulation of selected revenue-recycling measures using the Lithuania module of the EUROMOD tax-benefit model (which requires EU-SILC as input).

There is growing literature on modelling the distributive impact of environmental taxes (see Immervoll et al. (2023[49]), Box 1) All models abstract from the full complexity of the real world. The present analysis makes a number of modelling choices to keep the empirical exercise transparent and tractable.

- In addition to the introduction of carbon taxes, other climate-change mitigation measures are usually planned or introduced in parallel. These include changes in excise duties and changes in the parameters or scope of the Emissions Trading System (ETS). In order to identify the differential distributional impact of the carbon tax, it was decided to model this change in isolation. As there are limited interactions with these other measures, this arguably contributes to a better understanding of the carbon tax specifically.
- In its current version, the carbon-tax proposal in Lithuania does not cover installations that are already subject to emissions trading (Chapter 2). The calculations in this chapter ignore this variation and relate to a "flat" carbon tax that covers all sectors. This simplifies the analysis. It is also informative as non-ETS include transport and buildings, sectors where the effects of carbon taxes on prices are expected to be especially sizeable. Furthermore, by 2030, carbon prices will, to varying extents, also rise for ETS sectors, even if not through explicit carbon taxes. An average carbon price of 60 EUR per tonne probably presents a reasonably lower-bound value.
- The reference period of the policy introduction and simulation is relevant, as household circumstances, consumption patterns and prices change over time, as do preferences, including for consumption. Modelling relies on the latest available microdata including on household expenditures (HBS 2015) and incomes (EU-SILC 2018). Income and price data are updated to 2022 in an attempt to reflect, in particular, large recent price changes. However, although the simulated carbon tax is to be introduced over a period up until 2030, a decision was made not to project household characteristics forward to 2030, but model them on the basis of 2022. The inflationary situation, in particular, is highly volatile and both prices and incomes therefore do not lend themselves to reasonably certain medium-term forecasts. Given this context, it appears more informative to rely on granular information on current or recently observed prices, consumption patterns and living standards, than to make speculative assumptions about the medium-term future. This choice should be kept in mind when interpreting results.
- Relatedly, in terms of changes in the income distribution up until 2022, income levels are uprated uniformly, via price and income inflators, as is standard in the literature, rather than to undertake more ambitious now-casting approaches (O'Donoghue and Loughrey, 2014[50]; Immervoll, Mustonen and Riihelä, 2005[51]). Now-casting of microdata can be informative when the objective is to approximate broader or aggregate measures of inequality. They involve a range of data adjustments, however, which can be problematic when the resulting data are used as input into further modelling or analysis. Essentially, extensive data manipulations can obscure the results from the policy modelling exercise that are of primary interest.

(Immervoll et al., 2023[49]) provide details on each of the key parts of the modelling framework and how it was implemented in the context of this chapter. It describes:

- the input-output model, which captures carbon emissions by sector and allows quantifying the pass-through of carbon taxes from inputs to the price of final consumer products and services;
- the matching of input-output data with a household expenditure survey, which is needed to compute the carbon footprint from household consumption;
- a consumption model that quantifies households' behavioural responses to carbon-tax related price changes;
- the linking of expenditure information (from household budget surveys) with other characteristics needed for distributional analysis (from the EU-SILC survey);
- data adjustments to approximate the situation in the 2022 baseline year with earlier data (2015 for the household budget survey); and
- the simulation of options for recycling carbon-tax revenues, drawing on output from the EUROMOD tax-benefit model.

Results

At carbon tax levels that countries currently apply or discuss, the impact on household living costs can be significant, as can be their distributional effects. At the outset, it is useful to put the resulting burdens into context, however. In Lithuania, the impact on living costs would be much smaller than the effects of high inflation rates seen across the OECD over recent months. A carbon tax at 60 EUR per tonne as currently discussed would increase the consumer price index by less than 5% in total, and over a period of several years (Immervoll et al., 2023[49]).

Consumption patterns across the income spectrum

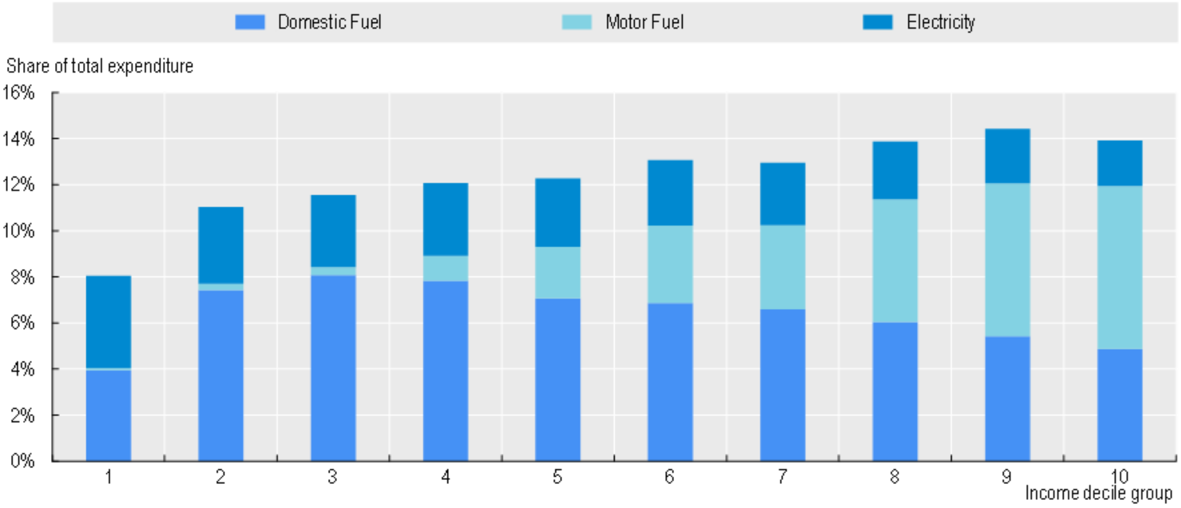
The impact on different population groups depends upon a number of factors including notably the distribution of expenditures across the income spectrum. Carbon taxes affect household budgets directly through fuel consumption, and indirectly via the consumption of other goods and services that give rise to CO_2 emissions during the production process.

The direct incidence of carbon taxes across households is shaped by the pattern of fuel expenditures. Domestic heating fuels are necessities, i.e. people will buy them regardless of income. Low-income households therefore devote a larger share of their total income and expenditures to heating fuels than better-off households. An opposite pattern can emerge for motor fuels, reflecting higher rates of car ownership among middle and higher-income households.

Figure 6.2 describes the distributional shape of fuel expenditure patterns in Lithuania, along with electricity. Spending shares for heating fuel are highest in income deciles 2, 3 and 4. Overall, spending on heating fuels is quite regressive, with a large difference in shares between the bottom and the top. Nevertheless, shares are lowest in the poorest 10%, which may be related to budget constraints and the poorest households needing to prioritise other essentials over adequate heating. Expenditures on electricity are substantially lower than for heating fuel in all but the bottom decile and follow a mildly regressive pattern overall. Spending on motor fuels is very top-heavy, with almost no spending on this item in the bottom 30% but a higher share than heating fuels at the top. Taken together, *overall* fuel expenditure is clearly progressive relative to income in Lithuania, which is increasingly unusual in international comparisons. When adding spending on electricity, patterns are still progressive but less so than for fuel.[4]

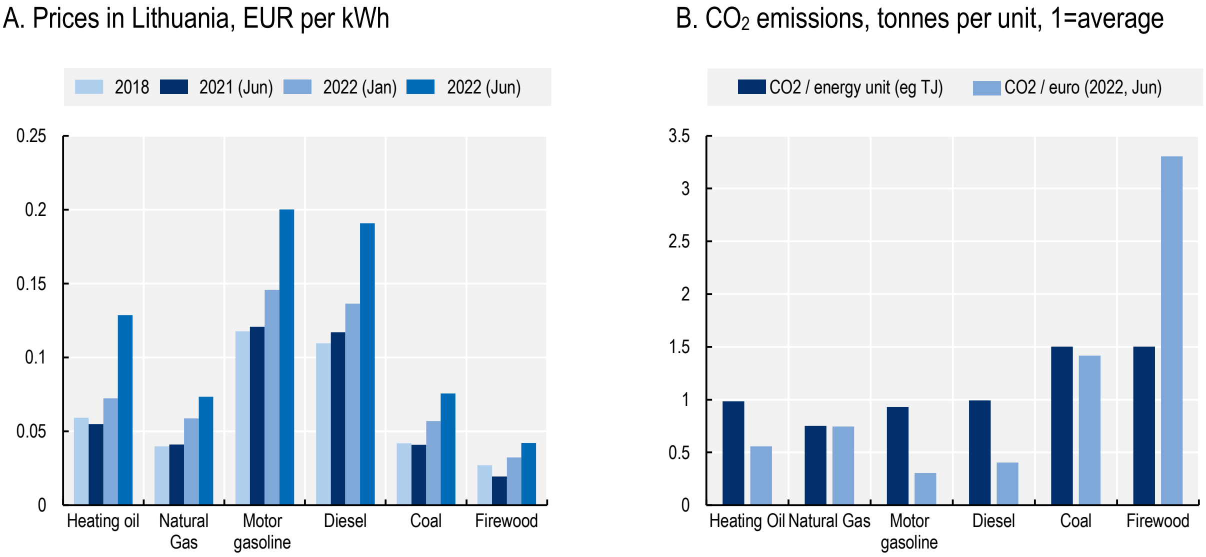
Figure 6.2. High-income households spend large shares of their budgets on energy

Lithuania, approximations for 2022 using latest available spending data



Note: Domestic fuel includes expenditure on gas (natural gas and town gas), liquified hydrocarbons, liquid fuels, heat energy, coal and other solid fuels. Motor fuels includes expenditure on diesel and petrol for transportation.
Source: (Immervoll et al., 2023[49]), drawing on the household budget survey and 2022 price data.

Figure 6.3. Fuel prices and CO_2 emissions



Note: Firewood also includes wood waste.
Source: (Immervoll et al., 2023[49]), drawing on UNFCCC, Eurostat, EC Weekly Oil Bulletin.

Fuel prices and the specific composition of fuel consumption are additional factors that drive distributional outcomes. Population groups that use higher emitting “dirtier” fuels will see a greater absolute impact of carbon taxes on prices. The relative price change depends also on initial prices, with cheaper fuels affected more strongly by a given amount of carbon tax per unit. As is commonly the case, motor fuels in Lithuania are more expensive (due to higher taxation) than domestic fuels (Figure 6.3, Panel A). As a result, the energy usage and emissions per unit of fuel expenditure are higher for domestic fuels (which account for a large share of spending for low-income people) than for motor fuels (which are mostly consumed by higher-income groups). Domestic fuels include high shares of solid fuels (coal, coke, firewood), which have much higher emission than liquid fuel. Emission factors are lower for natural gas (Figure 6.3, Panel B).

Like the direct effects from fuel expenditure, the distribution of the indirect burden from carbon taxes on everything else is also driven by a range of factors, and their net effect is difficult to anticipate. Budget shares for goods other than fuel can be comparatively "flat", with similar shares of total expenditures across income groups. But since poorer household save less, they spend a higher proportion of their income than better-off households. A relatively flat indirect impact of carbon taxes across households with low and high levels of total spending can therefore translate into a distributionally regressive impact across the income spectrum (with carbon tax burdens making up a larger share of income for low-income groups). Figure 6.2 illustrates this for electricity, which is a particularly sizeable category of non-fuel expenditure.

Budget shares and households' responses to price changes in comparative perspective

Along with budget shares, behavioural responses to carbon taxes are central determinants of both distributional results and CO_2 emission reductions. This paper accounts for behavioural changes by estimating a full demand system, including budget elasticities (expenditure changes for a specific good category in response to variations in total expenditure), a broad set of (own- and cross-) price elasticities (expenditure changes for a specific good category in response to price variation), and allowing for different elasticities across expenditure items and household types (Immervoll et al., 2023[49]). Results for Lithuania are presented below, along with comparisons against existing estimates for other European countries. Across all countries, estimates show households' responsiveness based on preferences that are implicit in the budget surveys that were available for this analysis (data from 2015). The five countries (Finland, Hungary, Ireland, Luxembourg, Portugal) were chosen as relevant data and consistent estimates are available as part of a recent related study (see source of Figure 6.4).

Budget shares for domestic fuels are higher in Lithuania (ca. 6.4%) than in four of the comparator countries and slightly lower than in Hungary (Figure 6.4, Panel A). Budget shares for electricity and motor fuel vary less across countries, and Lithuania's share is around 3% in both these categories, which is close to the country average. The Lithuanian shares for motor fuels are however lower than in most countries, except Finland and Luxembourg, where incomes are substantially higher. This is in part explained by very low usage at the bottom of the distribution. Overall patterns broadly resemble Hungary's though spending on all three types of energy is somewhat lower in Lithuania.

Published estimates of *price elasticities* of the demand of fuel vary markedly across countries and studies (see Immervoll et al. (2023[49]), Box 2). In a comparison of results using a cross-nationally consistent estimation method, Lithuania's price elasticities are in a plausible range (Figure 6.4, Panel B). Households in Lithuania are comparatively responsive to changes in the price of domestic fuel, though the elasticity still ranks mid-way between the other countries. Consumption of motor fuel is more responsive to price changes than domestic fuel, and electricity consumption somewhat less so. For both electricity and motor fuel, elasticities are lower than in Hungary, but higher than in the other countries.

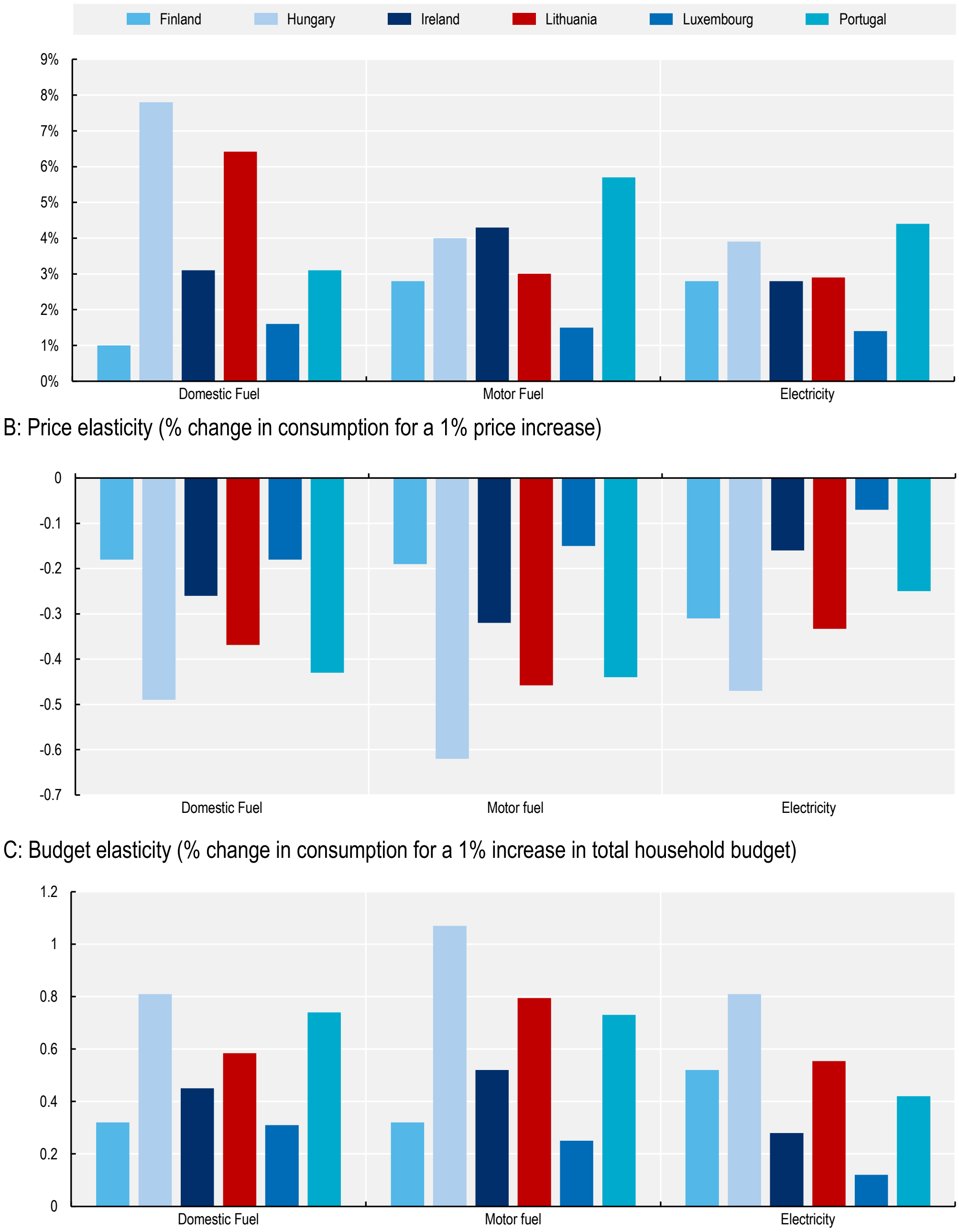
Lithuania's *budget elasticities* for domestic fuels and electricity rank mid-way between the five other countries (Figure 6.4, Panel C). Consistent with the large observed differences in expenditure shares for motor fuels between the bottom and top end of the income distribution, the estimated budget elasticity for motor fuel is significantly higher than for domestic fuel and electricity.

Figure 6.4. Average budget shares and behavioural response: Lithuania and other countries

A: Budget shares, % of total household expenditure

B: Price elasticity (% change in consumption for a 1% price increase)

C: Budget elasticity (% change in consumption for a 1% increase in total household budget)



Note: (Immervoll et al., 2023[49]) provides details on the method used for estimating a demand system, including price and cross-price elasticities, and budget elasticities. Domestic fuel includes expenditure on gas (natural gas and town gas), liquified hydrocarbons, liquid fuels, heat energy, coal and other solid fuels. Motor fuels includes expenditure on diesel and petrol for transportation.
Source: (Immervoll et al., 2023[49]) and (Sologon et al., 2022[52]).

Distribution of carbon tax burdens across income groups

The overall incidence of the carbon tax is shaped by (i) the distributional patterns of households' fuel expenditures, (ii) the modelling of indirect effects of a EUR 60 carbon tax on the cost of other goods, based on emissions released during production in different parts of the value chain, and (iii) households' behavioural responses to the resulting price changes.

To aid transparency, it is useful to first consider results without behavioural responses. On this basis, the carbon-tax burden on domestic fuels (ca. +1.3% of household Income on average across all income groups) is much higher than for motor fuels (+0.3% on average). This reflects the higher expenditure on heating, as well as the higher emissions per unit of domestic fuel. In line with fuel expenditure profiles, the direct carbon tax burden for domestic fuels is concentrated in the bottom half (regressive), while carbon taxes on motor fuels are progressive. The direct burden on households from overall fuel expenditures (just below +2.3% of expenditure on average) is regressive, though burdens are higher for deciles 2-5 than for the bottom 10%.

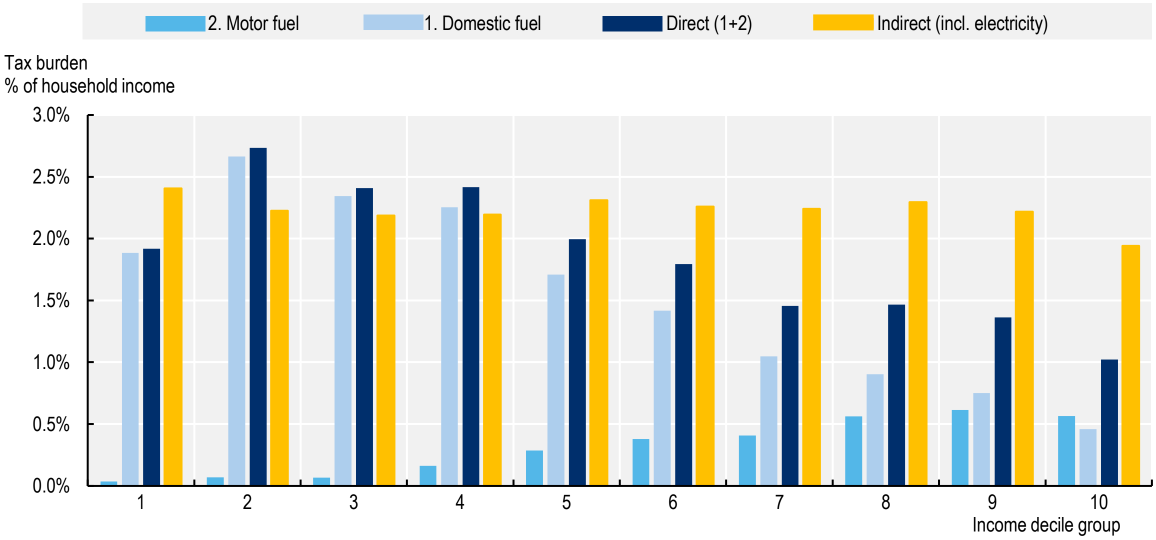
At close to +2.0% of household income on average, the costs from *indirect* emissions related to the production of other goods and services exceed the direct effects (1.6% on average). This highlights the quantitative importance of a careful Input-Output analysis. The scale of the indirect effect is partly driven by spending on electricity, and the carbon intensity of electricity generation. Although the lowest-income households spend somewhat greater shares of total expenditure on electricity than higher-income groups (Figure 6.3) the carbon content of electricity is lower than for other energy sources, and overall indirect effects are essentially flat as a share of income.[5]

As households respond to the incentives from higher prices and rebalance expenditures towards less carbon intensive products, behavioural adjustments reduce effective tax burdens. Estimates indicate a reduction by up to 16% (Figure 6.6).[6] Consumption responses lead to a bigger reduction in carbon-tax burdens in the bottom half of the distribution, as prices of cheaper goods (and dirtier fuels) are more strongly affected by a given carbon tax than expenditure categories with significant shares of more expensive and luxury products. Reductions are, however, smaller for the poorest 10%, who are likely to have fewer margins for adjusting consumption without cutting into essentials (compare distance between the results with and without behavioural response).

Overall losses for households are remarkably flat, with around 4% of income for the bottom half of the distribution, and 3.5% for the top half. The largest burdens are found for decile 2, and the smallest for decile 10. The "flatness" is arguably a striking finding given the granularity of the analysis, accounting for 56 sectors, 35 expenditure categories, and the full heterogeneity of consumption patterns found in the HBS micro-data. As discussed above, multiple drivers and country idiosyncrasies shape this result for Lithuania. There is no a-priori reason to expect it to carry over to other country settings or, e.g., to other distributional dimensions, such as age or region.

Figure 6.5. Incidence of a €60/t carbon tax, without behavioural response

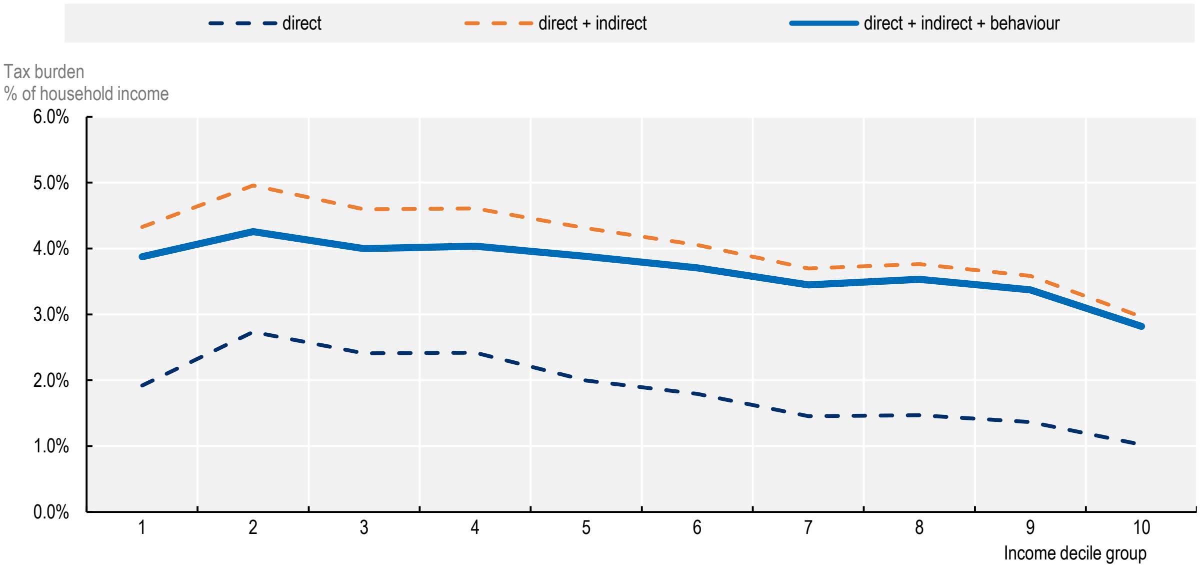
Share of household income



Source: Immervoll et al. (2023[49]), using data on household expenditure, emission levels and industry inputs and outputs.

Figure 6.6. Incidence of a €60/t carbon tax, with and without behavioural response

Share of household income



Source: Immervoll et al. (2023[49]) , using a consumption model in conjunction with data on household expenditures, emission levels, industry inputs and outputs.

Revenue recycling

The carbon tax generates revenue, which can be used to shape its overall distributive impact via revenue recycling. This section illustrates the scope for redistribution measures as part of a broader carbon-tax policy package and analyses the resulting gains or losses for different income groups.

Each revenue recycling option has strengths and weaknesses (Nachtigall, Ellis and Errendal, 2022[53]). In what follows, three stylised compensation measures are considered. All three are budget-neutral and can thus be fully financed through the carbon tax. In addition to the options considered here, there are clearly many other possible uses of carbon-tax revenues, including those that do not immediately benefit households but may do so indirectly and in later periods (such as increasing investment or paying off public debt).

Option 1 is a stylised lump-sum transfer, paid at the same individual rate to all residents (same rate for adults and children). Similar to a universal basic income, a lump-sum payment is often less redistributive than established social transfers. When conceived as a standalone benefit that replaces other transfers, a basic income is difficult to finance without a substantial tax increase (Browne and Immervoll, 2017[54]). However, in the context of a carbon tax, lump-sum compensation can be an attractive option, as it is built around a novel revenue source, and can be introduced "on top of" existing transfers, without needing to substitute for them. It is also simple to communicate and, as everyone receives a recurring payment, it may act as a signal that the carbon tax aims to alleviate climate change, without creating an additional overall burden for households. The universal lump-sum payment to everybody is indeed sometimes argued to be the optimal revenue recycling option (Klenert et al., 2018[34]).

Alternatively, carbon-tax revenues can be used to compensate households more selectively, e.g. by adapting/expanding existing transfers or introducing new targeted support payments. The specific reform considered here is a proportional increase of all social benefits **(Option 2)**. A uniform increase can be attractive if existing social transfers are seen as a suitable vehicle for targeting support to those in need. The approach has similarities to strategies that seek to alleviate the impact of price increases by indexing benefits for inflation (OECD, 2022[55]).

Option 3 is a cut in labour taxes (all income taxes and workers' social insurance contributions). As in Option 2, taxes are reduced by the same proportion for everybody. Packaged with a carbon tax, this type of scenario is commonly discussed under the heading of "environmental tax reform" (Metcalf, 1999[56]). A common argument for environmental tax reforms is that they may create a "double dividend", by simultaneously improving environmental and economic conditions, through lowering harmful emissions and distortionary labour taxation (Pearce, 1991[4]; Ekins et al., 2011[57]; Antosiewicz et al., 2022[58])

For each option, Figure 6.7 reports different measures of gains/losses by income group:

- average gain or loss of a carbon tax with revenue recycling;
- average gain or loss after accounting for households' consumption responses to the carbon-tax package (including revenue recycling);
- share of individuals with net gains.

In addition to income, further distributional dimensions can be important. These can be explored in future work and some of them may be of specific interest also in Lithuania (e.g. differential impact by age, region or activity status, including employees, self-employed or micro-enterprises).

Two types of behavioural response enter the results. First, and similar to the earlier analysis, the price response stems from the price change triggered by the carbon tax. Second, the income change from revenue recycling induces a change in expenditures on different items, in line with the estimated budget elasticities.[7]

Figure 6.7, Panel A first shows losses without any compensating transfers as a baseline, to facilitate assessing the impact of revenue recycling. The results are the same as those shown earlier in Figure 6.6 and can be interpreted as a scenario where the government does not spend the carbon-tax revenue. The overall revenue from the carbon tax amounts to around 1.35% of GDP, after accounting for consumers' responses to higher prices. The exact scale of these resources will depend on implementation of the carbon tax, and will be smaller if it is not applied uniformly (Section 3). It is clear, however, that revenues are sizeable and provide the government with considerable scope to cushion losses and shape the distributional profile as part of a broader policy package. In addition, knock-on effects on other taxes, such as VAT, can create significant additional revenue effects, which are not currently included in the estimates.[8]

When all carbon-tax revenues are channelled back to individuals via a lump-sum transfer (Figure 6.7, Panel B), most people are better off than without the carbon-tax package. Revenues are sufficient for financing a per-capita lump-sum of EUR 22 per month. All households in the bottom decile gain, and at least half do throughout deciles 1 to 7. Low-income households pay smaller absolute amounts in carbon tax than better-off households because they spend less. With everybody receiving the same flat-rate payment, the overall carbon-tax package creates a sizeable income boost at the very bottom. As a percentage of household income, gains then quickly decline as one moves up the income spectrum.

Average gains do not turn negative until the 8th decile (i.e., well above the income of the "median voter"). Even for high-income earners in the top decile, the lump-sum payment cuts the average net carbon-tax burdens in half (compare Panels A and B). The lump-sum scenario examined here is very simple and its distributional properties could be further tailored, e.g. by making it taxable. Instead of a uniform per-capita amount for all, the compensation could also feature differentiation by age, or provide supplements to those with greater energy needs, see e.g. the "climate bonus" adopted recently in Austria (Budgetdienst, 2022[47]).

A pro-rata increase of all existing social transfers (Figure 6.7, Panel C) redistributes the entire carbon-tax revenue to benefit recipients only. Because carbon taxes are paid by everybody and then distributed to a smaller group, average gains would be large for recipients of existing benefits. Lithuania currently spends about 9.2% of GDP on (cash) social benefits, including pensions. Carbon-tax revenues are therefore sufficient to finance a benefit increase of around 16%, well in excess of the adjustment that would result from straight inflation indexing of social transfers (which is below 5%, see Immervoll et al. (2023[49])). The gains are spread across fewer beneficiaries than in the lump-sum scenario, and gains are more concentrated among the bottom deciles, which comprise most benefit recipients.

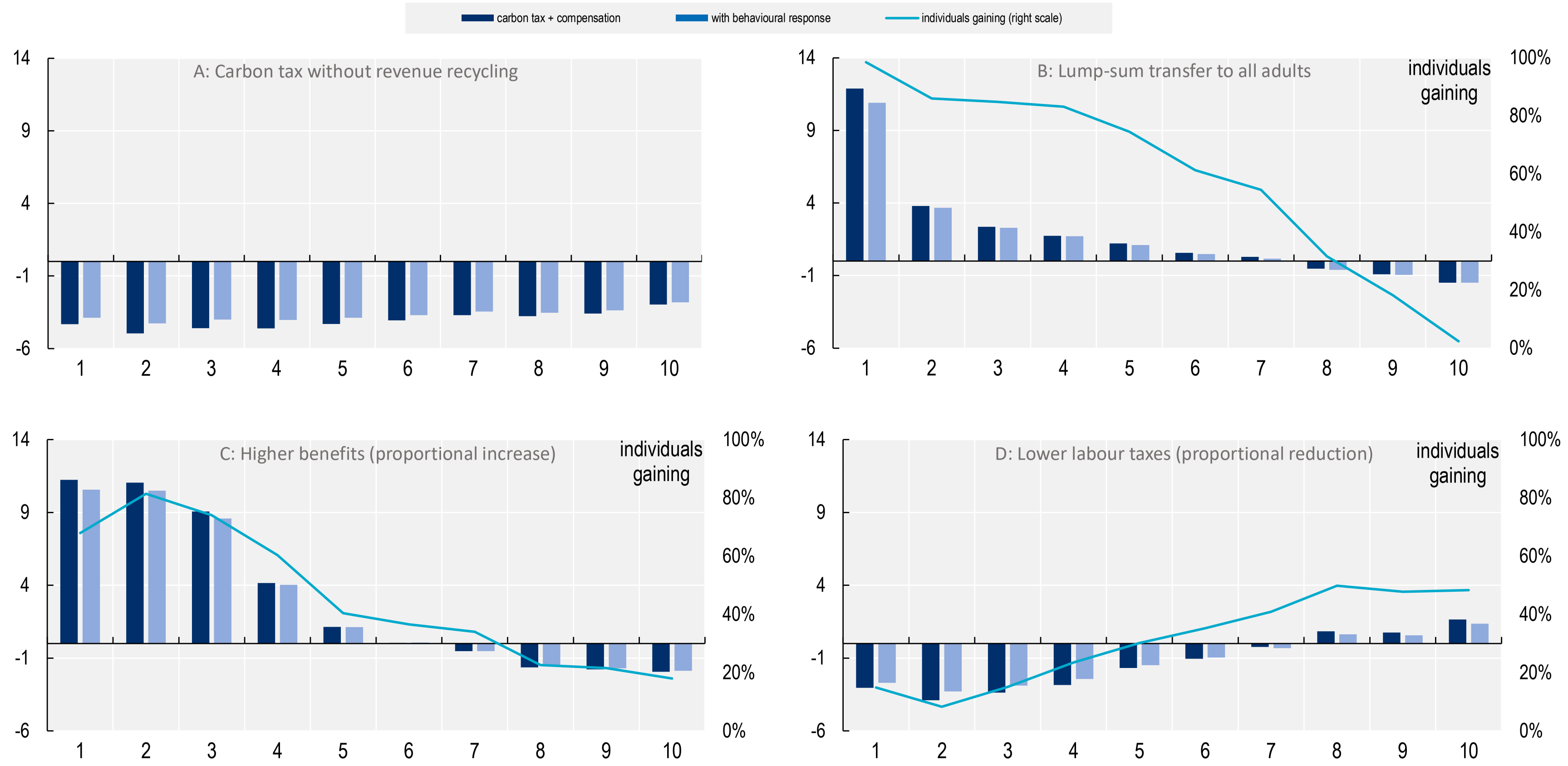
Unlike in the lump-sum scenario, not all poor households are better off. This reflects coverage gaps in the existing benefit system and, in particular, the commonly high degree of non-take-up of means-tested benefits. Both these factors explain the substantial share (>30%) of net losers in the bottom decile. Furthermore, and also in contrast to the lump-sum compensation, even the highest-income group includes some people (ca. 18%) who are better-off than without a carbon tax package. While there are fewer recipients of social benefits among high-income households, benefit entitlements (e.g. from pensions) among some of them are sufficiently large to ensure that a pro-rata increase outweighs their carbon-tax burden, resulting in a net gain. Across all middle and upper-income deciles, however, fewer than half gain from such a carbon-tax package. This is relevant when considering political support for such a policy. Without accompanying measures, significantly higher benefits for lower-income earners may also weaken work incentives.

Lowering taxes on labour (Figure 6.7, Panel D) has the opposite effect of a benefit increase, with net gainers concentrated at the top of the distribution. Lower labour taxes can strengthen work incentives (the "double dividend" argument). Tax reductions provide support for low-income groups, by easing income tax burdens for some of them, and reducing losses from the carbon tax itself (compare Panels A and D). But more than 85% of the poorest third of Lithuania's population would be worse off with such a carbon-tax package. By contrast, close to half of the top 30% would gain from with this reform package. Even for high-income groups, gains are modest in percentage terms, however (<2%). Compared with the other two revenue-recycling scenarios, the patterns of gains and losses for the labour tax reduction therefore appear less favourable for building strong voter support.

From a broader inclusiveness point of view, the carbon tax combined with additional transfers reduces inequality. The redistributive effect is stronger for the proportional increase of existing benefits (a reduction by 2 Gini points) than for the lump-sum transfer (a reduction by 1 point). The package with lower labour taxes is regressive (an increase by 0.5 Gini points), though without accounting for possible positive employment effects.

Figure 6.7. Carbon tax package with revenue recycling

Different scenarios for revenue recycling. Gains and losses by income group (deciles)



Source: Immervoll et al. (2023[49]), drawing on a consumption model and EUROMOD, in conjunction with data on household expenditure, emission levels and industry inputs and outputs.

Environmental impact

Greenhouse gas (GHG) emissions in Lithuania declined steeply between 1990 and 2000 but have since stabilised at around 20 $MtCO_2eq$, which accounted for around 0.55% of total EU emissions in 2019 (Jensen, 2021[59]), and around 0.04% of global emissions (Global Carbon Project, 2021[60]). Although emissions per capita are increasing, they remain below the OECD average. Emissions have largely decoupled from economic growth, with emissions intensity per unit of GDP decreasingly steadily since 2005 (OECD, 2021[61]). Transport, agriculture and industry make up two thirds of Lithuanian GHG emissions. The transport sector in particular is the biggest and fastest growing contributor to total emissions, accounting for over 30% of emissions in 2019, up from less than 20% in 2005 (OECD, 2021[61]).

The estimated adjustments of household consumption in response to the carbon tax and revenue recycling can be translated into an equivalent estimate of CO_2 emissions. This approach applies the same input-output model used to trace carbon emissions, and the resulting carbon tax, from different stages of production to consumer goods. Reversing this approach gives emissions reductions from re-balanced final household consumption of around 9.5% resulting from price changes alone. This relates to emissions released in all parts of the value chain, including foreign production of goods and inputs imported into Lithuania, but is limited to the direct consequences of changing final household consumption. [9]

Revenue recycling increases household income and spending in line with estimated budget elasticities and, hence, lowers emission reductions somewhat. Altogether, and depending on the revenue recycling scenario, overall emission reductions are estimated to range between 7 and 8% for carbon-tax policy packages that redistribute tax receipts back to households.[10]

The policy implications from these findings are twofold. First, at current consumer preferences and the tax rates currently considered, emission reductions are relatively modest, even for a comprehensive carbon levy that does exempt specific industries or products. At existing or proposed levels, carbon taxes alone are not sufficient for meeting national and international climate commitments. Second, the type of revenue recycling strongly shapes the distributional outcome of a carbon-tax package, but the choice makes only a very modest difference in terms of environmental objectives. This suggests that there is no major immediate trade-off between achieving social and environmental objectives.

However, the sizeable share of gainers in some of the revenue recycling scenarios implies that it may be possible to limit direct compensation measures to less than the total carbon tax revenue. This could allow financing other forms of government expenditures. Some authors have explored combining transfers with scaling back other distortionary taxes, in line with the “double dividend” arguments (García-Muros, Morris and Paltsev, 2022[62]). An alternative would be scaling up of programmes that support and accelerate a green transition. This includes measures that tackle households’ underinvestment in energy efficiency, e.g., through subsidies for home insulation or installations such as heat pumps (D’Arcangelo et al., 2022[63]), or that facilitate a reallocation of jobs towards less carbon-intensive production (unemployment insurance and active labour-market policies).

Notes

[1] (Nordhaus, 2017[64]) defines the social cost of carbon as the economic cost caused by an additional tonne of CO_2 emissions or its equivalent; it rests on the concept of internalising externalities, considering both inter- and intra-generation equity.

[2] (Immervoll et al., 2023[49]).

[3] Emerging results using micro-data illustrate that losses for displaced workers in carbon-intensive sectors can be sizeable (Barreto, Grundke and Krill, forthcoming[15]). These studies are informative but necessarily based on past layoff events, with dismissals in "brown" sectors largely driven by globalisation and offshoring. The associated restructuring patterns and subsequent re-employment opportunities are imperfect indicators of the pattern of employment gains and losses that may result from climate-change mitigation measures and a green transition.

[4] These consumption patterns are a snapshot at a single point in time. It should be noted that Lithuania has changed very significantly in terms of its economic and consumption structure over recent years. It is likely that Lithuania will continue to converge towards European patterns over the planning period for the Carbon Tax which may affect medium term conclusions.

[5] As for all goods except fuel, carbon tax payments for electricity are calculated using the WIOD input-output data, resulting in CO_2 emissions per euro for 24 expenditure categories and then applying the EUR 60 per tonne tax accordingly (Immervoll et al., 2023[49]). The WIOD reflects Lithuania's use of nuclear, gas, coal and renewable in 2014. The carbon intensity of electricity generation changed since then (less than 10%, from 227 gCO_2/kwh in 2014 to 209 gCO_2/kwh in 2021).

[6] It is worth noting that the reduction of carbon-tax burdens in Figure 6.6 exceeds the adjustment one would obtain through a straight price elasticity. The reason is an assumption of unchanged savings; in the context of a price increase, unchanged savings imply a fall in consumption over and above the pure price elasticity. The suitability of this assumption can be questioned, especially in the very short term, where dissaving can provide a cushioning mechanism for households confronted with rising prices. The present version assumes unchanged savings, as the methodology cannot reliably incorporate inter-temporal decision making in relation to savings.

[7] The expenditure changes for each consumption category are calculated assuming that households spend the entire additional income that they receive from revenue recycling, i.e. savings remain unchanged, in line with Footnote 6.

[8] For illustration purposes, it was decided to limit revenue recycling to the carbon tax itself, also because additional revenues from other taxes may be more difficult to earmark in practice.

[9] Noting that the model keeps the savings rate constant (see Footnote 6). Using a pure price elasticity (with overall savings allowed to respond to prices, and expenditure shares increasing when prices go up) would result in a smaller reduction in emissions, though differences are likely to be minor (perhaps less than 0.5 percentage points).

[10] This reduction is derived from consumption adjustments by households in Lithuania and, hence, relates to domestic consumption by households only. It is therefore lower than recent estimates of more encompassing emission reductions from higher carbon prices (D'Arcangelo et al., Forthcoming[65]). Those estimates point to a reduction of 3.7% per 10 EUR increase on average across countries. Their scope is quite different, however, as they rely on a large cross-country dataset, look at long-term reductions for the economy as a whole, notably including adjustments on the production side. They also consider carbon taxes alongside other forms of carbon pricing, and do not account for revenue recycling.

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7

Beyond 2030: policy pathways for meeting net zero by 2050

This chapter considers Lithuania’s longer-term emissions reduction targets and pathways to reaching net-zero emissions by 2050. It reports on modelling carried out to assess the socio-economic impact of reaching net zero through a high ambition carbon price scenario, finding that such a high carbon price alone would not be enough to meet the net-zero target. The chapter therefore highlights the importance of innovation for enabling further emissions reductions. Here, Lithuania could make significant progress by focusing more on targeted innovation support to key technologies including for technology adoption. The chapter also highlights the importance of carbon sinks in enabling the necessary emissions reductions for meeting net zero.

Beyond meeting climate policy targets for 2030, reaching net zero will require considerable climate policy efforts in the subsequent decade. This will have profound implications for economies worldwide and comes with considerable transition risks in its own right. In order to minimise these risks it is key that countries ensure an orderly transition to net-zero emissions, including by setting clear policy trajectories early.

To this extent, this chapter considers climate policy pathways beyond 2030 in Lithuania consistent with net-zero emissions by 2050. It does so through two key analyses; First, the chapter reports on the results of a modelling exercise considering a high-ambition policy scenario whereby Lithuania implements an economy wide carbon price from 2030. This modelling analysis shows both the extent of ambition possible through such a pricing approach, and the resulting economic impacts. It provides sectoral emissions reductions trajectories, enabling policy makers to infer interim emissions reduction targets for 2040 for key sectors. Second, it assesses the technological needs given particular hard-to-abate sectors, presenting key policy approaches for fostering technology adoption and innovation.

The first part of the chapter builds on the modelling depicted in Chapter 3. Chapter 3 concerned the modelling of existing and planned policies and their effect to 2030, contributing to the ongoing update of the Lithuanian NECP to which this project contributes. In this chapter, the planned policy scenarios developed in Chapter 3 serve as a starting point for further policy ambition to 2050 with the intent of depicting possible cost-effective decarbonisation pathways for Lithuania.

The resulting analysis, however, lays bare that certain sectors in Lithuania remain hard-to-abate, even at very high carbon prices. This exemplifies the need for technological innovation, to lower marginal abatement cost curves for high carbon price trajectories. The second part of the chapter therefore considers the innovation policy landscape in Lithuania, drawing OECD work on science, technology and innovation, and on the recent Economic Survey of Lithuania (OECD, 2022[1]).

Together these two parts provide a key initial assessment of Lithuania's policy needs in the long-term. As such, the chapter's findings serve as impetus for an ongoing discussion on how best to meet the net-zero target in Lithuania.

Modelling net-zero policy pathways

Decarbonisation pathways to 2050 for Lithuania

Chapter 3 of this report details the results of a modelling analysis considering planned climate policy pathways in Lithuania to 2030. This aims to inform the process for updating Lithuania's NECP – detailing climate policies to be implemented to reach the 2030 targets.

Beyond 2030, explicit policy pathways are more difficult to project. However, modelling can be used to indicate possible emissions reductions trajectories compatible with cost-effectively reaching net-zero emissions by 2050, and therefore contributing to meet the Paris Agreement's targets. Lithuania has already set a 100% emissions reduction goal by 2050 (i.e. net-zero emission target) in its NCCMA. This chapter assesses the extent to which net-zero emissions can be reached under high-carbon price scenarios, and what effect such a policy trajectory would have on the economy.

The policy scenario modelled assumes economy-wide carbon prices are implemented globally to assess the impacts of meeting net-zero targets (assuming regionally differentiated carbon-prices and net-zero timelines[1]). The emissions reduction pathway, and concurrent carbon prices for Lithuania, are generated endogenously within the model based on a least-cost pathway to climate-neutrality by 2050. In effect, the price trajectory reflects the highest possible ambition within the modelling framework because marginal abatement cost curves flatten at even higher prices leading to negligible emissions reduction gains.

Assumptions detailed in Chapter 3 remain relevant for the modelling framework beyond 2030, with renewable energy costs continuing to decline, and autonomous preferences for renewable energy and energy efficiency gains sustained. Critically, it is also still assumed that only already existing technologies are available, with not-yet-on-the-market technologies such as green hydrogen or large-scale carbon capture and storage assumed to play no role in the decarbonisation trajectory. This final assumption limits the findings somewhat, as it is likely that there will be considerable innovation over the coming 25 years. However, under this assumption, the model's results can be interpreted as providing an indication of what is possible under high carbon prices considering current technologies, and what the economic costs of this are. This analyses then offers a lower-bound estimate for the emission reduction potential and upper-bound estimate for economic costs.

This section continues by presenting the scenario framework modelled, detailing both the reference scenario and high-ambition policy scenario. It then presents the results, illustrating the impact of the transition to climate neutrality on:

- GDP and other main macroeconomic variables (i.e. employment, productivity, investment, welfare, debt trajectories);
- energy/climate specific impacts such as energy consumption and GHG emissions;
- relocation of economic activity across sectors, including job reallocation between skills levels and sectors;
- public finance:
  - revenue and government expenditure;
  - impact of potential revenue recycling from carbon pricing, assuming revenues are recycled as lump-sum transfers to households;
  - International competitiveness and trade flows.

Reference scenario

The reference scenario post-2030 is an extension of the reference scenario to 2030 (Chapter 3), whereby countries are expected to reach their NDC 2030 and 2050 targets. Carbon prices are imposed on all emitting activities, i.e. ETS and non-ETS emissions for all countries including China. For the EU, carbon prices post-2030 are imposed only on ETS activities. Since post-2030, there are no specific mitigation commitments, apart from aspirational targets, assumptions about mitigations efforts are needed.

For the post-2030 period, carbon prices are assumed to grow at 3% annually instead of being endogenously determined by the model. This growth rate is close to what is used as a central discount rate by governments when estimating the social cost of carbon (Interagency Working Group on Social Cost of Greenhouse Gases, United States Government, 2021[2]). It is also assumed that minimum carbon prices are set for 2031 in modelled countries and regions, with a USD 20/tCO_2 minimum price for developing countries and a USD 50/tCO_2 minimum price in high-income countries. This implies that minimum carbon prices bind for all countries except EU countries and XOE countries (e.g. Australia, Canada, New Zealand and Israel) where carbon prices under the reference scenario in 2030 are already higher than the minimum carbon price (Table 7.1)

Table 7.1. Carbon prices under NDC scenario, 2014 USD/tCO_2

	USA	CHN	RUS	LTU	X16	E10	XOE	XEC	HYA	XEA	SAS	MNA	LAC	SSA
2030	17.2	19.3	6.2	157.0	157.0	157.0	60.7	11.1	42.2	16.3	8.2	19.2	14.3	3.7
2031	50.0	20.0	20.0	161.7	161.7	161.7	62.5	20.0	50.0	20.0	20.0	20.0	20.0	20.0
2032	51.5	20.6	20.6	166.6	166.6	166.6	64.4	20.6	51.5	20.6	20.6	20.6	20.6	20.6
2033	53.0	21.2	21.2	171.6	171.6	171.6	66.3	21.2	53.0	21.2	21.2	21.2	21.2	21.2
2034	54.6	21.9	21.9	176.7	176.7	176.7	68.3	21.9	54.6	21.9	21.9	21.9	21.9	21.9
2035	56.3	22.5	22.5	182.0	182.0	182.0	70.4	22.5	56.3	22.5	22.5	22.5	22.5	22.5
2036	58.0	23.2	23.2	187.5	187.5	187.5	72.5	23.2	58.0	23.2	23.2	23.2	23.2	23.2
2037	59.7	23.9	23.9	193.1	193.1	193.1	74.7	23.9	59.7	23.9	23.9	23.9	23.9	23.9
2038	61.5	24.6	24.6	198.9	198.9	198.9	76.9	24.6	61.5	24.6	24.6	24.6	24.6	24.6
2039	63.3	25.3	25.3	204.8	204.8	204.8	79.2	25.3	63.3	25.3	25.3	25.3	25.3	25.3
2040	65.2	26.1	26.1	211.0	211.0	211.0	81.6	26.1	65.2	26.1	26.1	26.1	26.1	26.1
2041	67.2	26.9	26.9	217.3	217.3	217.3	84.0	26.9	67.2	26.9	26.9	26.9	26.9	26.9
2042	69.2	27.7	27.7	223.8	223.8	223.8	86.5	27.7	69.2	27.7	27.7	27.7	27.7	27.7
2043	71.3	28.5	28.5	230.6	230.6	230.6	89.1	28.5	71.3	28.5	28.5	28.5	28.5	28.5
2044	73.4	29.4	29.4	237.5	237.5	237.5	91.8	29.4	73.4	29.4	29.4	29.4	29.4	29.4
2045	75.6	30.3	30.3	244.6	244.6	244.6	94.6	30.3	75.6	30.3	30.3	30.3	30.3	30.3
2046	77.9	31.2	31.2	251.9	251.9	251.9	97.4	31.2	77.9	31.2	31.2	31.2	31.2	31.2
2047	80.2	32.1	32.1	259.5	259.5	259.5	100.3	32.1	80.2	32.1	32.1	32.1	32.1	32.1
2048	82.6	33.1	33.1	267.3	267.3	267.3	103.3	33.1	82.6	33.1	33.1	33.1	33.1	33.1
2049	85.1	34.0	34.0	275.3	275.3	275.3	106.4	34.0	85.1	34.0	34.0	34.0	34.0	34.0
2050	87.7	35.1	35.1	283.6	283.6	283.6	109.6	35.1	87.7	35.1	35.1	35.1	35.1	35.1

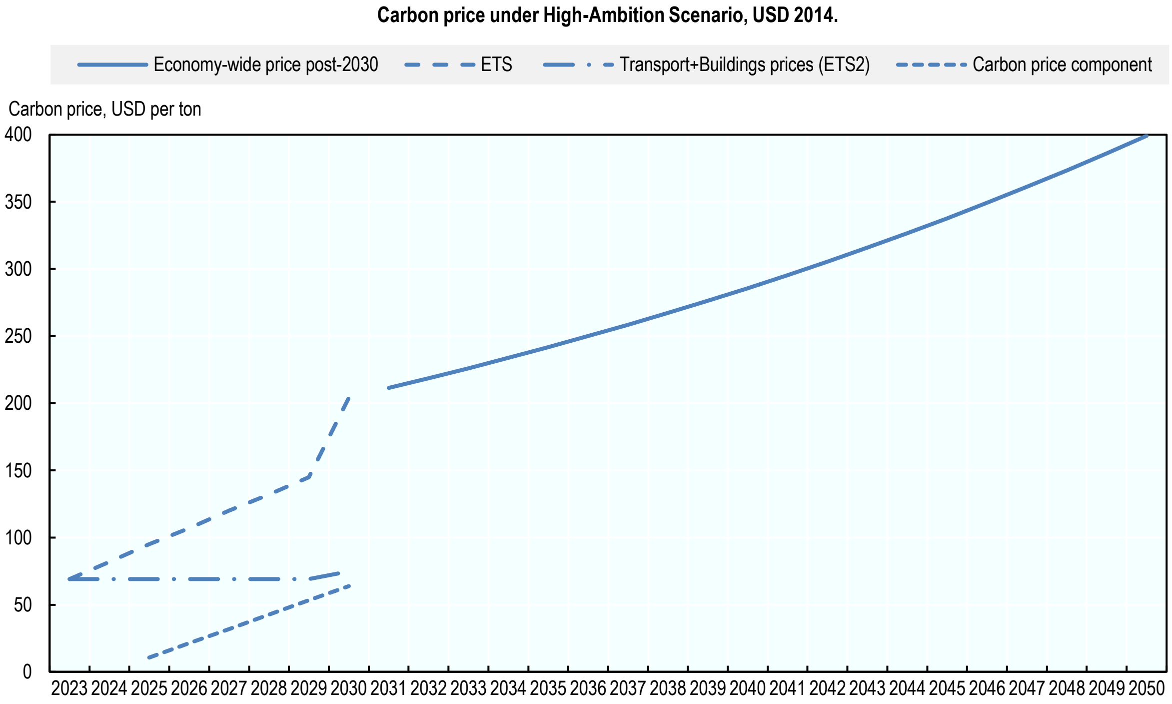
Note: For all regions except EU and China, the reported carbon prices are imposed on all emitting activities through 2050. For the case of EU and China carbon prices are imposed on ETS sectors only till 2030. For China post-2030 carbon price is also imposed on all activities. For EU post-2030 only ETS sectors are covered with carbon price. Prices are expressed in 2014 USD.

In addition to carbon pricing, the reference scenario for the post-2030 period continues the policy assumptions detailed in Chapter 3. Specifically, the scenario assumes, an autonomous electrification trend, a downward trend in the price of renewable electricity technologies and a non-price shift towards renewable technologies. In addition to continuing trends in technological development, these exogenous policy assumptions serve to account for the effect of non-pricing climate policies. In the case of Europe, renewable energy share in 2050 is assumed to reach 45% in the absence of a change in relative prices of renewable energy sources. A drop in renewable prices would accelerate these trends. Changes in these shares in the rest of the world are variegated across the modelled regions. In the case of Lithuania, pre-2030 trends for renewable energy generation and the broader energy mix, as modelled in Chapter 3, are assumed to continue beyond 2030. These are based on data and projections provided by the Lithuanian Energy Agency.

Post-2030 high ambition policy scenario

Post-2030, it is assumed that all fossil fuel combustion activities are covered by carbon pricing including in the EU. Starting from 2031, ETS and non-ETS sectors face the same carbon price, which grows at a constant rate of 3.4% over time to reach around USD 400 per ton of CO_2 in 2050. As suggested by additional model simulations, the marginal abatement cost curve in the model becomes relatively flat after this level of carbon prices, so that any further increase in carbon prices leads to only marginal reductions in emissions. This is because the model does not include non-yet-mature technologies and energy sources, such as CCS or hydrogen, and therefore the resulting mitigation potentials are entirely based on existing technologies (see Chapter 3 and Annex A).[2] Emergence and higher penetration of new technologies can shift abatement costs curves and lead to more substantial and/or cheaper emission reductions compared to those presented in the current assessment.

Figure 7.1. Carbon price trajectories for the reference scenario and High-Ambition Scenarios (2023-2050)



Note: Economy-wide price post-2030 refers to the price trajectory in the High-Ambition Scenario.

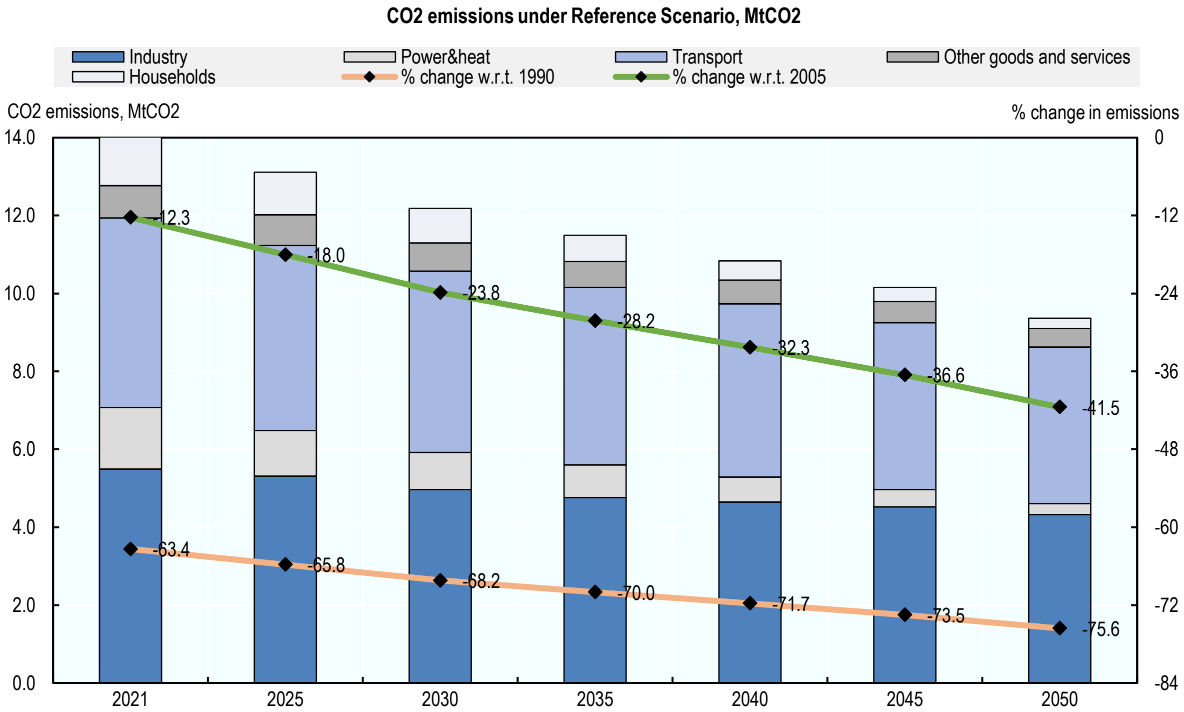
Beyond 2030 decarbonisation scenarios for Lithuania

Reference scenario results

CO_2 and GHG emissions

Under the reference scenario, where carbon prices are expected to increase at a 3% annual rate in ETS sectors for Lithuania and EU at large, CO_2 emissions decrease by 41.5% in 2050 relative to 2005 and by 75.6% relative to 1990 levels.

Figure 7.2. Emissions from transport and industry remain high



Sectoral composition of emissions under the reference scenario changes over time. With growing carbon prices, the share of emissions from power generation sectors reduces substantially. Emissions related to the transportation sector (a non-ETS activity) and industry (partly covered by ETS) also decrease, but at a slower pace. Emissions from final consumption (i.e. households) fall, as consumers switch more toward electricity and substitute away from other fuels, such as gas for heating and petroleum for private transport. These trends resulting from reference scenario assumptions do not reflect more ambitious mitigation efforts, e.g. the EU Green Deal.

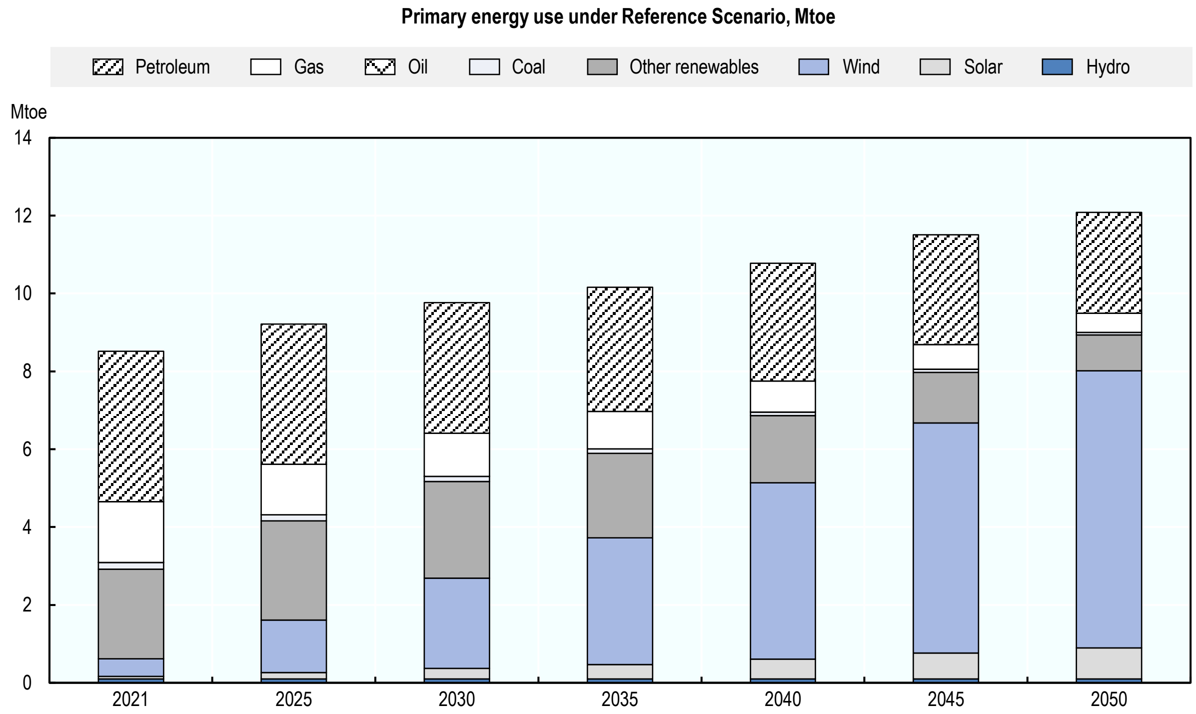
There are substantial variations in CO_2 emission changes relative to 2005 across various sectors (Figure 7.2). In relative terms, emissions from power and heat generation decrease the most, reaching 92% reduction in 2050 (relative to 2005). Substantial reductions are also observed in household emissions, as they decrease by almost 86% relative to 2005 levels. Household-related emissions in the model include emissions from the use of personal vehicles. Emissions from manufacturing and service sectors reduce by almost 59% in 2050 (w.r.t. 2005 levels). While industrial emissions reduce over time when compared to 2021, their slow reduction rate in the reference scenario is largely driven by rising CO_2 emissions from industrial processes.

At the same time transportation emissions reduce by only 7% in 2050 (w.r.t. 2005), as no specific mitigation measures that target the transport sector are implemented in the reference scenario and emissions in transport remain hard-to-abate due to steep abatement cost curves in the sector as a result of low substitutability (for more information see the next section on Innovation). Emissions from energy intensive industries even by 2050 remain above 2005 levels (+7.5%).

Energy use and power generation

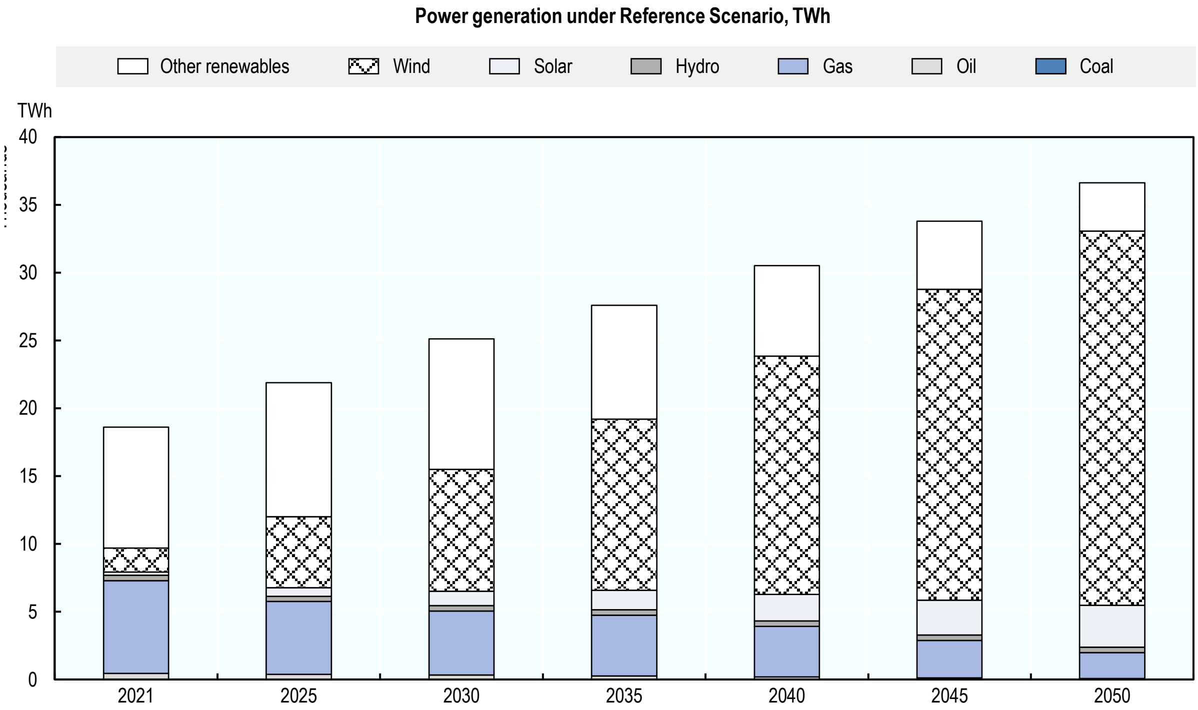
In the reference scenario, the primary energy use increases by around 1.2% per annum between 2021 and 2050—with a large part of the growth occurring in renewable power, in particular, solar and wind generation. Refined oil and gas are in absolute decline (Figure 7.3).

Figure 7.3. Renewable energy sources dominate primary energy use



Power and heat generation grow at around 2.4 % on average per annum between 2021 and 2050, with significant growth from renewables—around 9%-10% for solar and wind power, respectively. Gas thermal power declines in absolute terms—at a rate of around 4 percent per annum, driven in part by the carbon tax, which lead to the substitution by rapidly expanding wind and solar power generation.

Figure 7.4. Rapid expansion of wind power in the electricity mix



Economic output

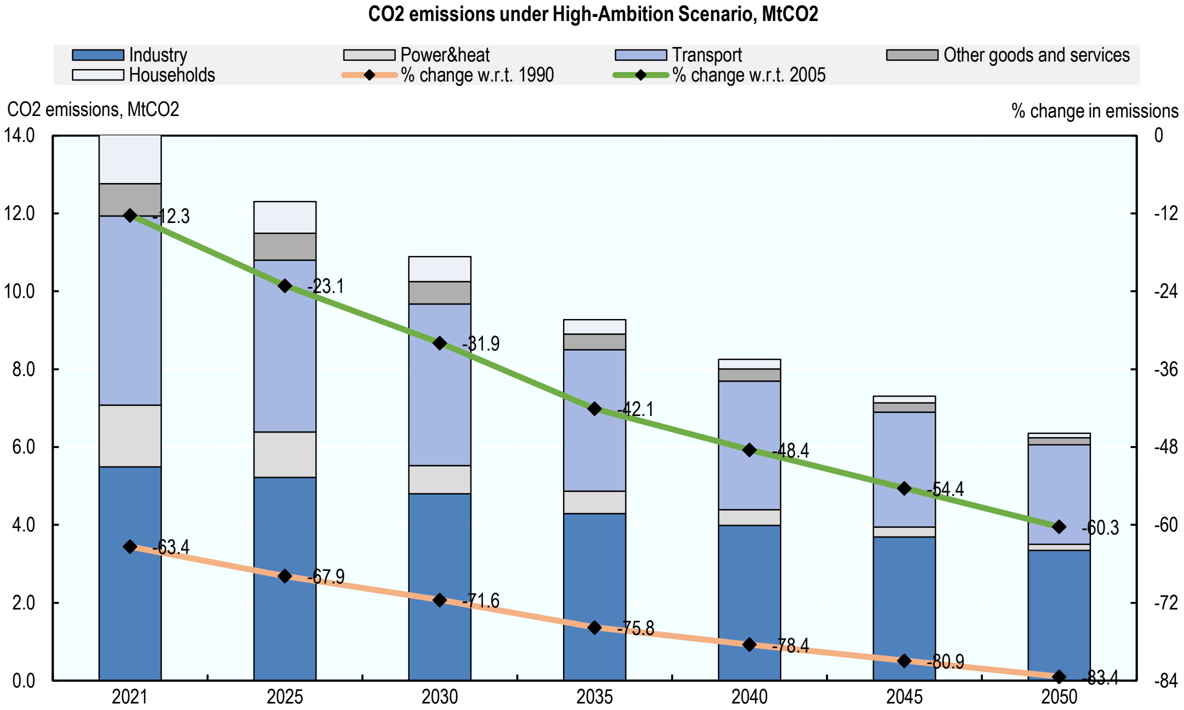
Under the reference scenario, all sectors are expected to continue growing beyond 2030 except the fossil fuels sector. Electricity generation (ELY) experiences the fastest growth, on average 2.5% growth per year. In part this is driven by the assumptions of accelerated electrification, but also by assumed expansion of renewable generation capacity within the reference scenario. Refined oil and fossil fuel sectors see an absolute contraction in output, due to the lower demand for fossil fuels.

High-Ambition Policy Scenario Results

CO_2 emissions

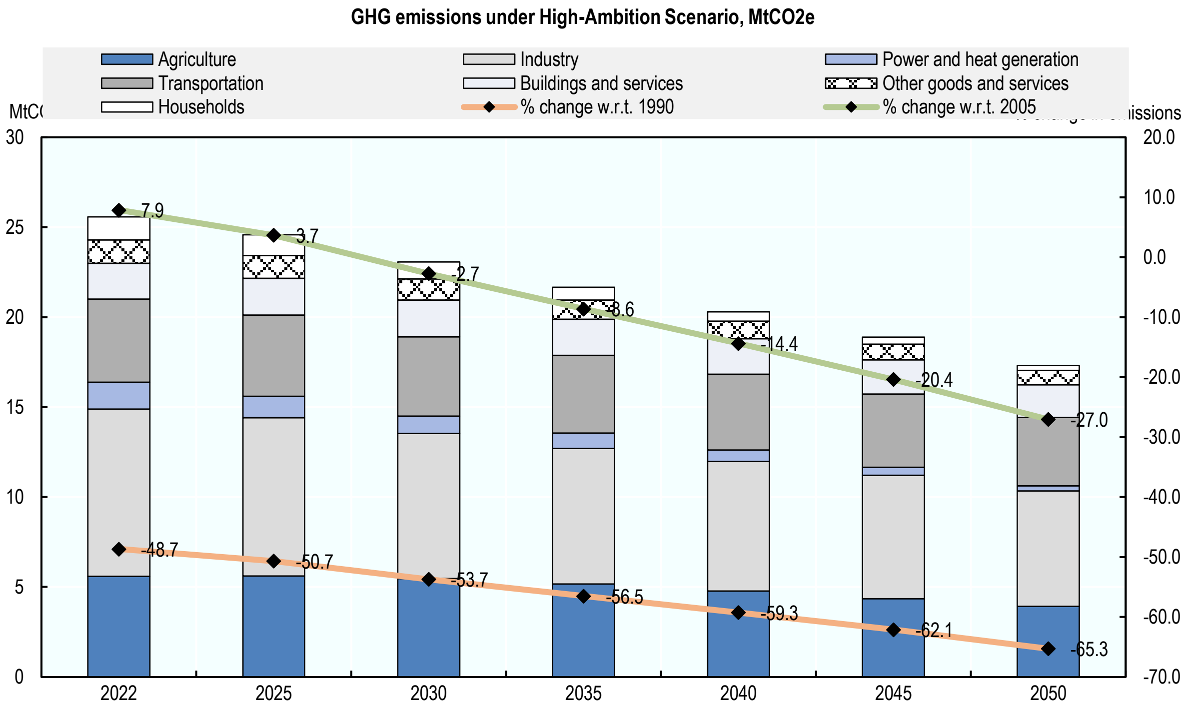
When implementing the stricter policy scenario, results suggest Lithuania would be able to achieve 83% reduction in CO_2 emissions in 2050 w.r.t. 1990 or 60.3% reduction w.r.t. 2005 level (Figure 7.5). This is almost 20 percentage points above the emission reductions achieved under the reference scenario. Looking across sectors, power and heat and households achieve over 93%-94% reduction in emissions w.r.t. 2005 by 2050, while the other services sector and light manufacturing reduce emissions by over 84%. Following implementation of carbon pricing in non-ETS sectors, transportation activity also substantially decarbonises reducing emissions by over 40% in 2050 w.r.t. 2005. Industry-related emissions remain the hardest to abate, largely due to the treatment of industrial process emissions discussed in Chapter 3. At the same time, it should be noted that this result is in alignment with earlier literature that suggests relatively high abatement costs in such sectors like cement industry, iron and steel, and chemicals (Paltsev et al., 2021[3]).

Figure 7.5. Ambitious carbon pricing significantly reduces CO_2 emissions, but hard-to abate sectors remain threatening emissions reduction targets



For comparability with Lithuania’s emission reduction targets, the resulting CO_2 reductions need to be expressed as part of overall GHG emission reductions. Given that the model only integrates policies that price CO_2 emissions, any non-CO_2 emission reductions result only from assumptions on exogenous productivity and efficiency trends and reduced emissions factors under this scenario. Lithuania would thus be able to achieve 27% reduction of its GHG emissions by 2050 w.r.t. 2005 and 65.3% reduction w.r.t. 1990. Reductions in non-CO_2 emissions are mostly driven by agriculture and industrial sector, given their substantial contributions in these sectors to non-CO_2 emissions (non-CO_2 emissions contributed 94% to agricultural emissions and 40% to industrial emissions in 2022).

Figure 7.6. Carbon pricing on combustion-based CO_2 emissions alone is not enough for reaching net-zero GHG emissions by 2050

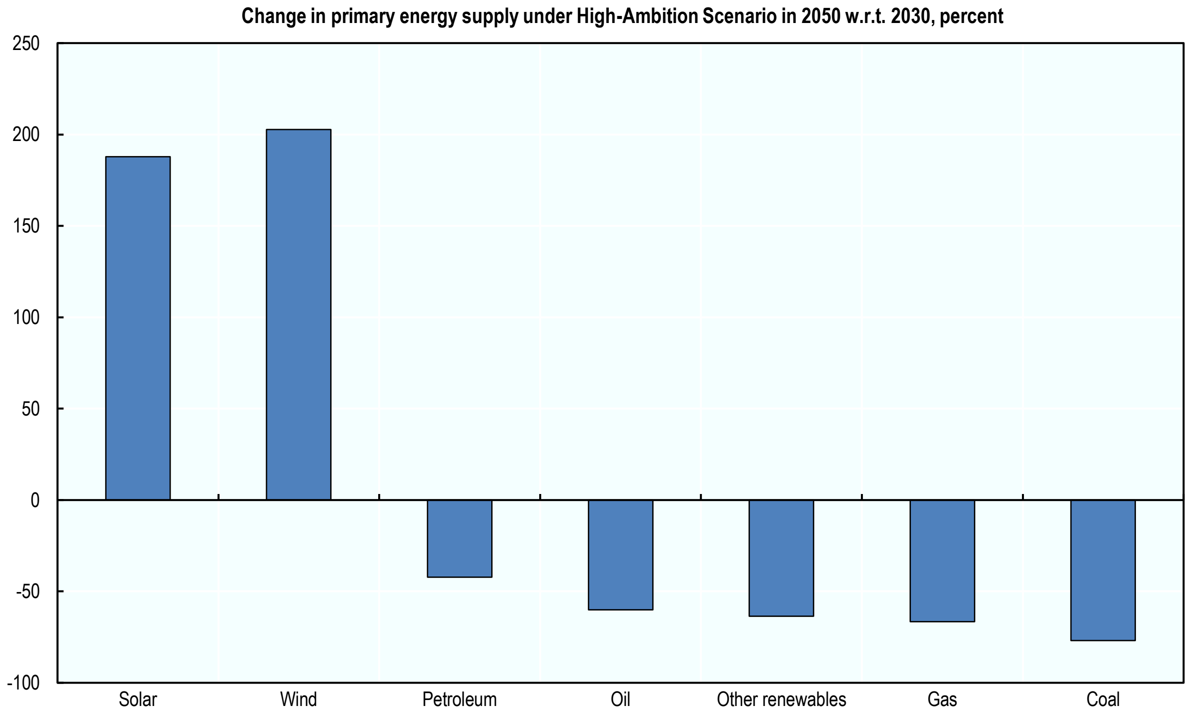


Unsurprisingly, these results indicate that a CO_2 price on combustion emissions alone will not be sufficient for meeting Lithuania's long-term mitigation goal of reaching net-zero emissions by mid-century and that other policy instruments and levers will be indispensable. Additionally, the model does not account for the sequestration potential in the land use land use change and forestry (LULUCF) sector. Assuming historical trends continue, Lithuania's average annual emissions abatement from sequestration amounts to 5 $MtCO_2e$ (see Chapter 1, Figure 1.3). Accounting for this sequestration brings down total emissions reductions to 55% w.r.t to 2005 and 74% w.r.t 1990. Supplementary mitigation efforts are warranted to bring down total GHG emissions to reach net zero, for example through enhancing carbon removal potential, developing new technologies to enable further efficiency gains and emissions reductions in hard-to-abate sectors, or implementing more stringent climate policies.

Energy use and power generation

Post-2030, the High-Ambition Policy Scenario leads to substantial shifts in the primary energy supply compared to the reference scenario. When compared to 2030 levels, the use of petroleum products decreases by over 42% in 2050. Even higher levels of reduction are observed in the cases of crude oil and natural gas – in a range of 60-67%. The use of coal drops by almost 77%, from an initially low level. At the same time, we observe an increase in the use of energy that is coming from renewable generation. By 2050, solar and wind energy supply increase forty-fold relative to 2021 levels and seven-fold to 2030 levels. Overall energy demand increases by around 22% between 2030 and 2050.

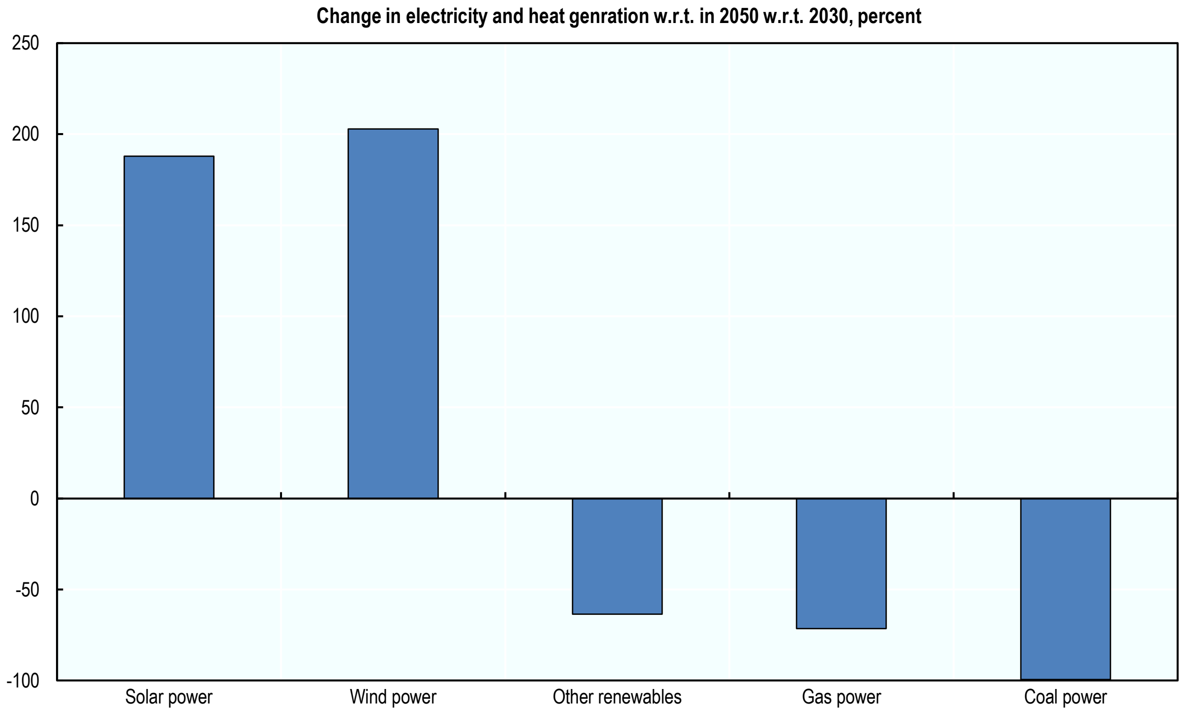
Figure 7.7. Substantial shift towards renewables in primary energy supply between 2021 and 2050



Note: As in Chapter 3, the category "Other renewables" refers primarily to the use of biomass.

In terms of power and heat generation mix, between 2030 and 2050, the share of renewable generation increases over time. In particular, solar and wind increase their output volumes by around 200% each in 2050 w.r.t. 2030, while other renewables and fossil fuel power generation decrease their output substantially. In 2050, the volume of natural gas power generation declines by around 71% relative to 2030, while coal power generation drops to zero. A reduction in other renewables (biomass-based) generation is also observed, as the latter are substituted by solar and wind generation. Overall electricity demand increases by around 50% in 2050 relative to 2030, as consumers switch away from direct consumption of fossil fuels, including gas and petroleum products, and transition toward electricity use.

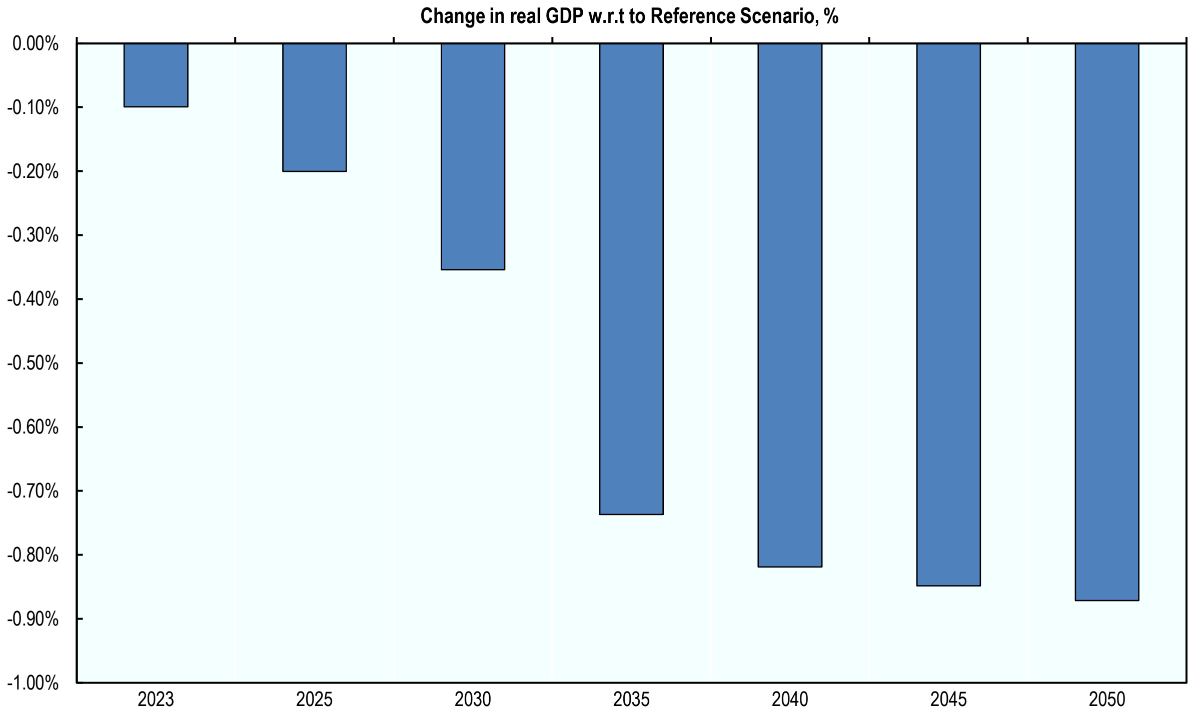
Figure 7.8. Solar and wind power generation increases by 200% in 2050 (w.r.t 2030)



Macroeconomic impacts

The cost of the implemented policies is relatively moderate even under ambitious mitigation efforts by 2050. The reductions in real GDP are around 0.9% in 2050 relative to the reference scenario. When translated to the annual growth rates, these represent a very moderate slowdown of the annual growth rate of around 0.03 percentage points. These impacts are measured relative to the reference scenario, which already assumes relatively high level of carbon pricing in the ETS sectors and therefore cannot be compared with other modelling projections showing GDP cost estimates for climate policy compared to a business-as-usual baseline.

Figure 7.9. Impact of ambitious carbon pricing on GDP (w.r.t to the reference scenario) is limited

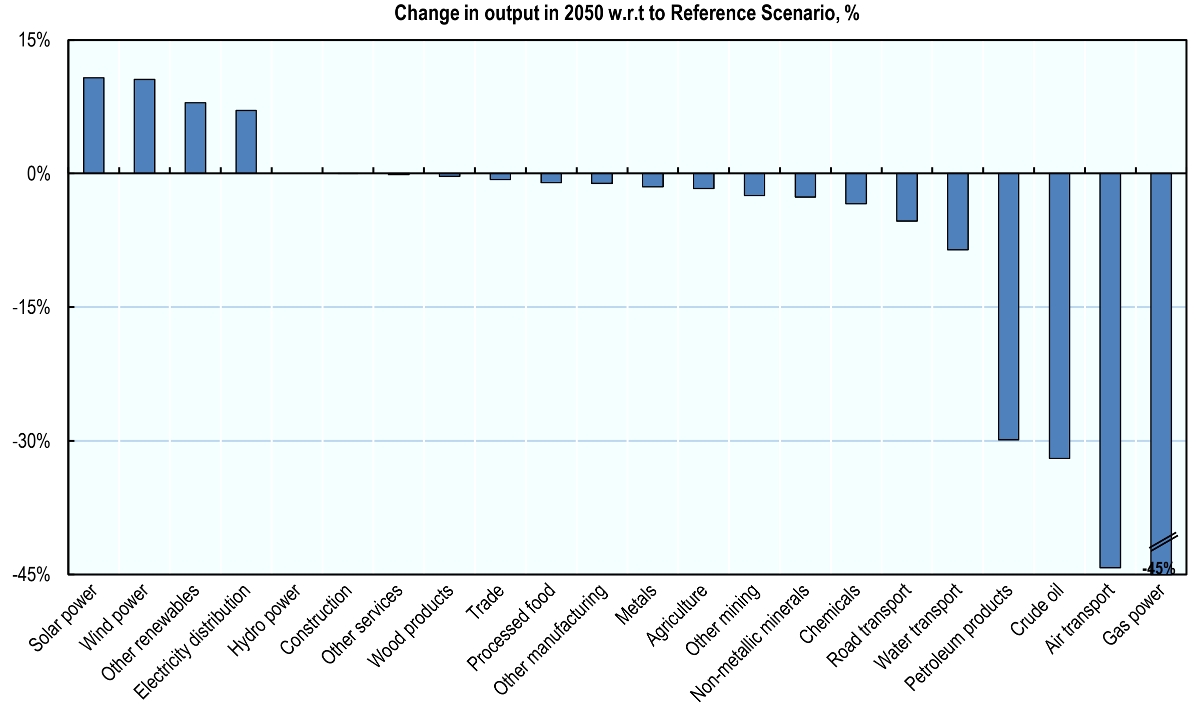


Consumer welfare increases by 0.3% in 2050 w.r.t. reference scenario. As in the results to 2030, the increase in welfare is driven by carbon pricing revenue recycling whereby households receive lump sum transfers. It is also due to the fact that carbon intensity of Lithuanian economy is lower than EU average, including the carbon intensity of services and final users, and thus the country gains relative advantage to most other EU member states when the regional carbon price (through the EU ETS) is applied.

Sectoral impacts

Implementation of the ambitious mitigation efforts results in a moderate increase in renewable generation, as solar, wind and biomass-based generation grows by 8%-11% in 2050 relative reference scenario (Figure 7.8). Most adversely impacted sectors are air transportation, natural gas-based power generation, crude oil and petroleum industries. The recorded reductions in output range from 44%-45% in the cases of gas power generation and air transport, and to 30%-32% in the case of crude oil and petroleum products. A substantial impact on the air transportation sector, compared to other transportation activities, is explained by a large share of petroleum products in the overall cost structure of this activity. The value share of petroleum products in the total inputs costs of air transport exceeds 35% in Lithuania, while in the case of water transport the corresponding share is around 14%.

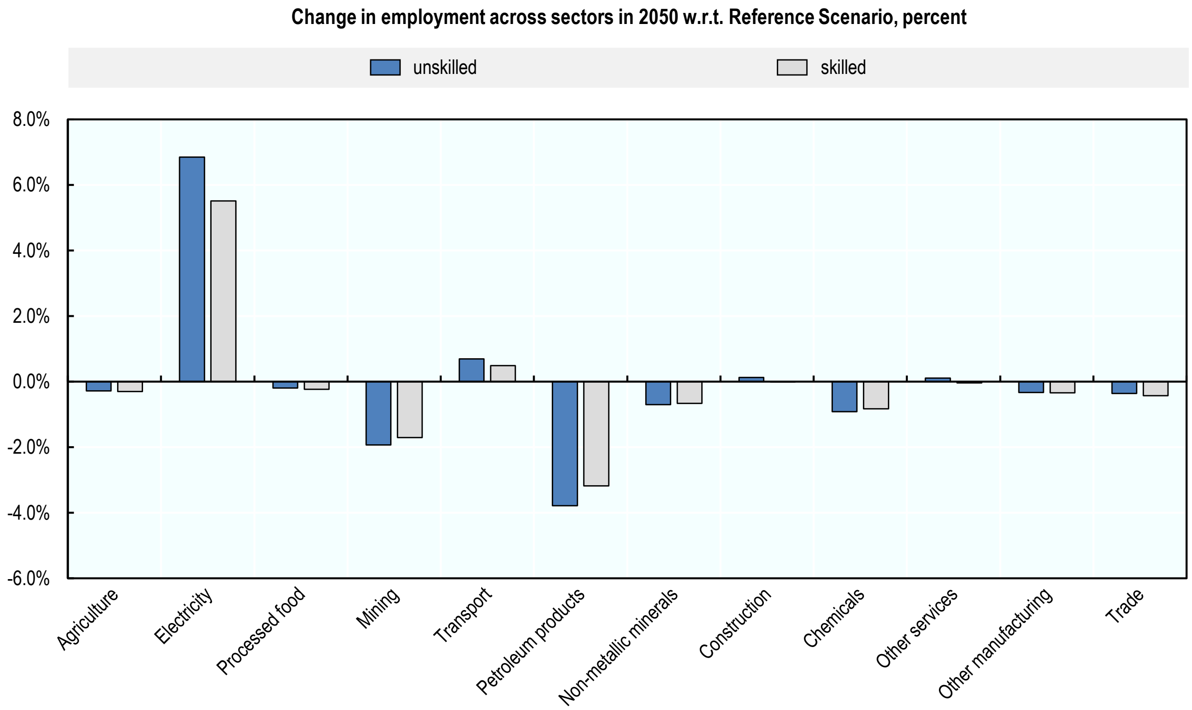
Figure 7.10. Output gains (w.r.t reference scenario) concentrated in renewable energy sectors



Carbon pricing also shrinks output in other transportation activities, as both road and water transport record a reduction in output of 5% and 9% respectively. Such structural changes result in an overall reduction in the GDP emission intensity.

Reallocation of workers across sectors largely follows the output change patterns. Increasing cost of production leads to the moderate increase in unemployment rates – by around 0.15-0.25 percentage points in 2050 relative to the reference case. As the mitigation effort is substantially increased starting from 2031, we observe a short-term increase in unemployment relative to the reference scenario. Post-2035 structural adjustments lead to the reallocation of labour across sectors and a reduction in the overall unemployment rate relative to the reference scenario.

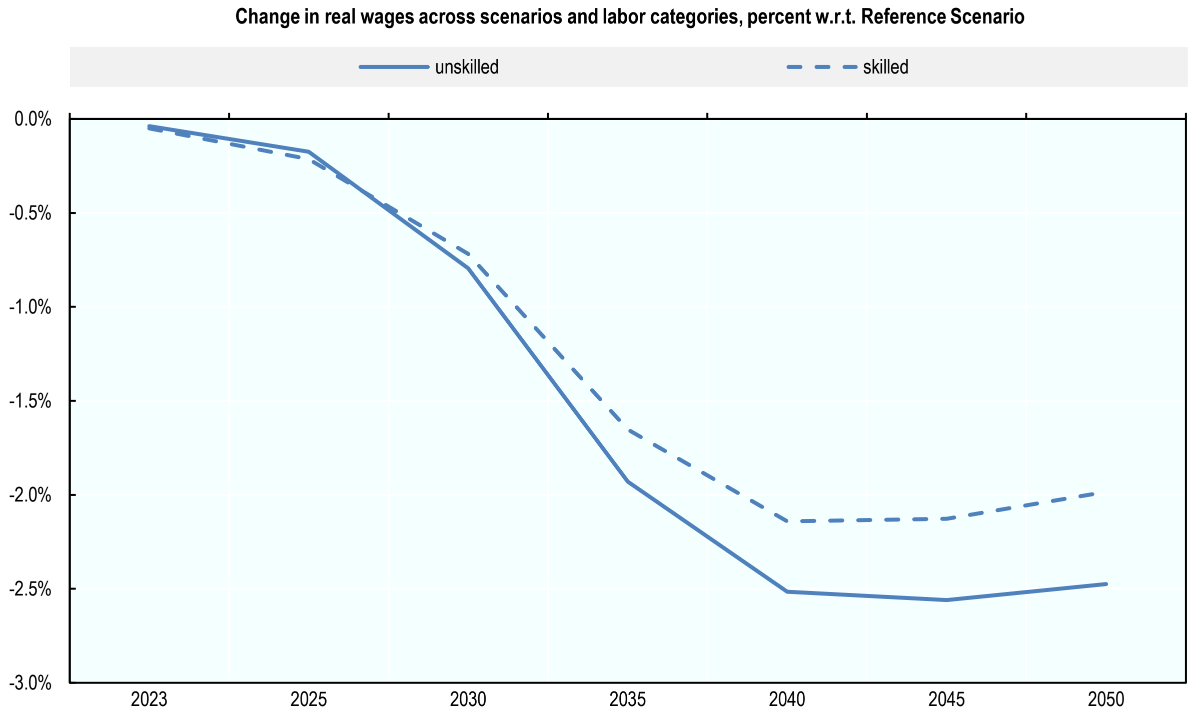
Figure 7.11. Reallocation of labour from fossil-fuel intensive industries to electricity sector (in 2050 w.r.t reference scenario)



An overall moderate decline in real wages is also observed: by around 2%-2.5%. This implies that relative to the global GDP deflator, which is used as a numeraire in the model, real wages decrease by a respective amount. At the same time, in absolute terms, this implies only a moderate decline in the growth rate of wages over time.

Looking at the results across skill types (unskilled vs skilled labour force), there is moderate evidence of the potential regressive outcomes across workers under the High-Ambition Scenario in the long run, as both wage and employment reduce somewhat more for unskilled workers compared to skilled workers. This reverses broadly progressive trends under the 2030 policy scenarios depicted in Chapter 3, implying more attention needs to be given to redistributive policies in the long-run.

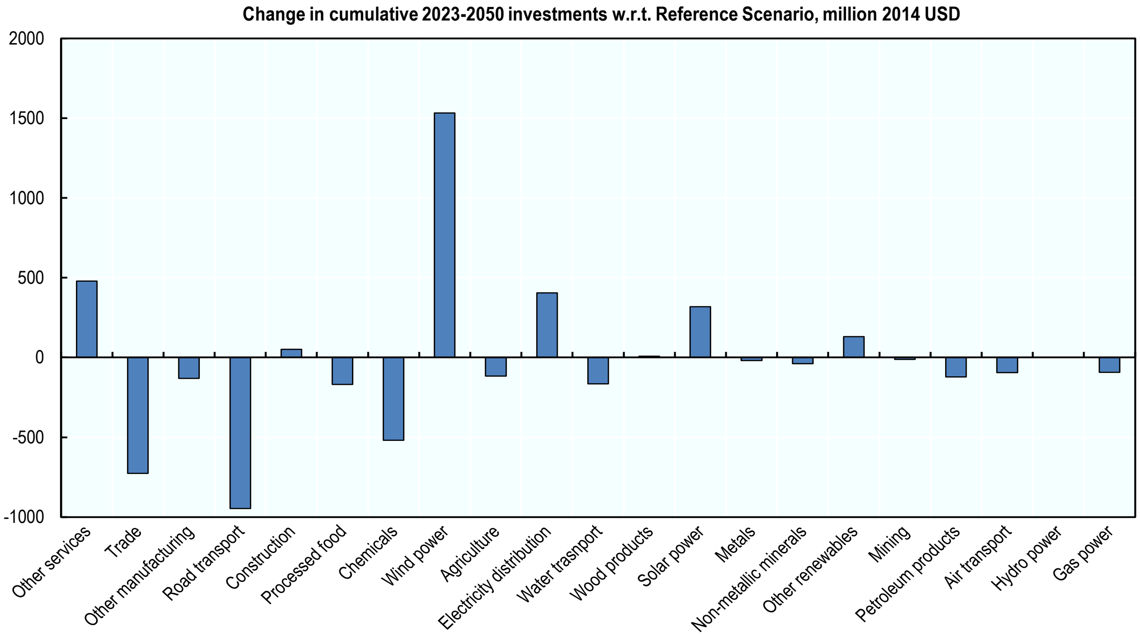
Figure 7.12. Slightly regressive long-term effect of High-Ambitious Policy Scenario on labour



Observed structural shifts also result in the reallocation of labour across sectors. Due to an expansion in renewable generation, the electricity and heat production sector sees a moderate increase in employments (of both skilled and unskilled workers), while most other sectors see a moderate decline. In relative terms, an increase in labour demand by electricity generation activity is in a range of 6%-7%, while the most substantial (in relative terms) declines are faced by petroleum products (3%-4%), mining (1.7%-1.9%) chemicals (around 1%) and non-metallic minerals (0.7%) activities. All four of the aforementioned sectors see a reduction in demand due to the decarbonisation activities and thus reduce output and the use of production factors. Trade activity shows the largest reduction in employment in absolute terms (0.5-0.8 thousand workers), but this represents only 0.4% of the total labour force employed in this sector.

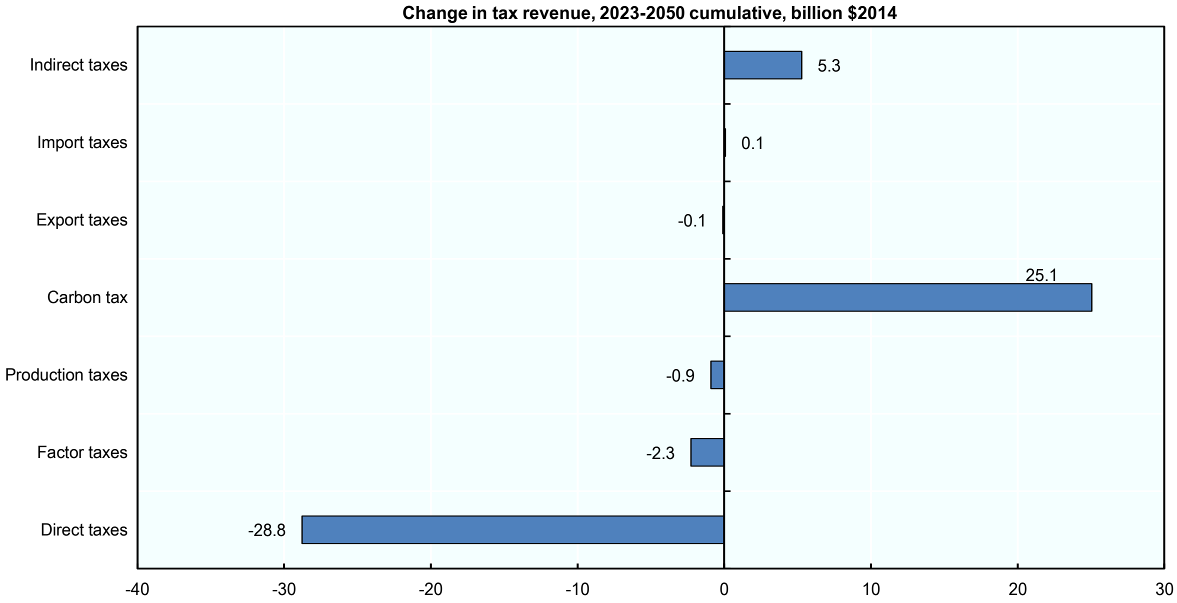
Cumulative investments over the 2023-2050 period virtually do not change under both scenarios, while a reallocation across sectors is observed. The latter largely follows the output change patterns. Expanding sectors, such as renewable generation and services attract additional funds, while shrinking sectors like heavy manufacturing and transport activities see a decline in the investment flows (Figure 7.13). A relatively large increase in investments in absolute terms for the case of other services represents a small number in relative terms (0.3%). Investments in wind and solar power generation increase by around 12%.

Figure 7.13. Expanding renewables energy sector attract the most investment w.r.t to reference scenario



Increasing carbon taxes generate additional tax revenues. A moderate increase in tax revenue from indirect taxes is observed as ECR fees rise. The cumulative revenue amounts to around USD 30.4 billion or about ~ % of GDP, raised from indirect taxes and carbon taxes. There is a minor reduction in revenue from other taxes due to reallocation of production patterns, but most of the revenue collected via higher excise taxes and carbon taxes is transferred to households in a form of lower labour income tax (USD 28.8 billion or about ~ of GDP) (shown in the figure below as direct taxes).

Figure 7.14. Higher carbon taxes and fuel excise taxes generate substantial revenues (2030-2050)



Policy implications of decarbonisation post 2030

The modelling presented in the previous section shows that decarbonisation is possible at moderate economic costs in Lithuania. The model assumes, however, current levels of technological progress, and so does not factor in the possibility of further innovation. The model also does not consider the role of carbon sinks and the potential for enhancing these through agriculture and forestry policies. As such, decarbonisation efforts through carbon pricing and a broader climate policy mix can be further assisted through innovation and technology diffusion, particularly in hard to abate sectors. Innovation both serves to fill gaps where carbon price signals are not enough to enable decarbonisation, as well as reducing the overall costs of decarbonisation by enhancing the cost-effectiveness of emissions reductions technologies (placeholder for reference to carbon elasticity paper).

The modelling results indicate in particular the potential for further efforts to aid decarbonisation in the Industry, Transport and Agriculture and Forestry sectors, as these exhibit the least drastic emissions reductions through the modelled policy scenarios. In all three of these sectors, innovation and technology diffusion is key to enhance mitigation ambition and implementation.

In the industry sector, hard to abate processes such as in ammonia production (which makes up a substantial portion of total GHG emissions in Lithuania – see more below) require further technological innovation as no viable electrification solutions exist. In particular, carbon capture and storage and green hydrogen have been identified as key technologies for industry decarbonisation, and indeed, hydrogen is a key pillar of Lithuania's NECP. The IEA's net-zero scenario estimates that together, these two technologies will make up 50% of the required emissions reductions in the industry sector by 2050 (IEA, 2021[4]). Much of this progress relies on further research and development to ensure these CCUS and hydrogen technologies are operable at scale and at low enough costs to ensure their economic viability (IEA, 2021[4]).

In the transport sector, while electric vehicles present an important technological breakthrough enabling the decarbonisation of private vehicle use, the modelling results indicate that hard-to-abate emissions in the sector remain. This is because abatement cost curves in the sector remain steep when compared to other sectors such as electricity generation, meaning emissions are relatively inelastic to higher prices due to a lack of low-carbon technologies that can readily substitute current fossil fuel technologies. For example, road freight transport is not as easily electrified as private vehicles, nor is air and water transport. Here, only very few mature technologies exist, indicating the key importance of further innovation in heavy transport vehicles, shipping and aviation to enable deep decarbonisation of the transport sector (IEA, 2021[4]). Hydrogen and bio-based fuels will play a key role in this regard (IEA, 2021[4]).

In the agriculture and forestry sector, the potential to maintain and enhance Lithuania's carbon sinks is key to its decarbonisation ambitions. As depicted in the previous section, through stringent carbon pricing and complementary policies a GHG emissions reduction of 63% is possible by 2050 (w.r.t 1990 levels). At current levels, carbon sequestration through the LULUCF sector would mitigate a further 5MtCO_2e, resulting in total GHG emissions reductions of 74% (see previous section). As such, enhancing the carbon sequestration potential of Lithuania's LULUCF sector remains key. Natural carbon sinks through careful land-use management remain one of the most cost effective means of enabling such negative emissions (Vass and Elofsson, 2016[5]; Harper et al., 2018[6]). Carbon dioxide removal, for example through direct air capture or BECCs technologies, may also play an important role, although here too, innovation is key (IPCC, 2018[7]). Finally, a number of technologies can help to reduce emissions in agriculture (Fellmann et al., 2021[8]). The mitigation potential of these, however, remains somewhat limited and uneven. For example, a recent study shows that global abatement cost curves for methane are steepest in the agriculture sector, implying there is only limited mitigation potential here (Höglund-Isaksson et al., 2020[9]).

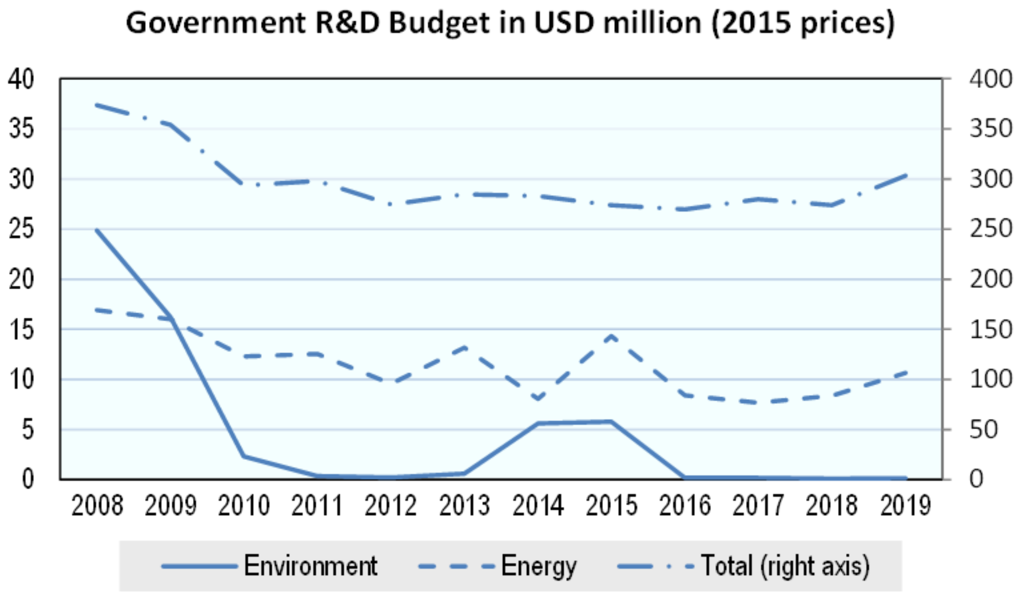
Considering this, it is clearly important to assess existing and planned innovation policies in Lithuania in order to, post 2030, create conditions conducive to develop and deploy technologies needed to reach net zero, at low economic cost (or even overall economic benefit). This section thus focuses on innovation and technology diffusion, first taking stock of the existing innovation policy landscape in Lithuania, and then offering recommendations for policy adjustments based on good-practice insights from other EU and OECD countries.

Innovation policy in Lithuania – taking stock

Lithuania's innovation performance has improved in recent years. According to the data of the Lithuanian Statistics Department, in 2021 A total of EUR 622.4 million of GDP was allocated for R&D works in Lithuania. This is the highest amount of R&D expenditure in the entire history of this indicator. Compared to 2020, R&D expenses in Lithuania increased by 10 percent, or EUR 57.5 million. This is a clear signal that the focus of Lithuanian economy participants on innovation and R&D is growing rapidly. It also shows that the government's efforts to promote R&D and innovation are yielding more and more results.

Data from the EU innovation scoreboard show further that the level of development of the Lithuanian innovation ecosystem in 2022 reached a historical maximum, and that Lithuania's innovation ecosystem continues to be rapidly improving: however spending on research and development (R&D) remains below EU averages, reaching only 0.88% of GDP in 2020 (OECD, 2021[10]). This increased somewhat, to 1.2% of GDP in 2022, but remains below the EU's average of 2.2% of GDP .(Figure 7.15) (OECD, 2022[1]) and it is yet to recover from the fall following the global financial crisis of the late 2010s.

Figure 7.15. Government R&D spending on environment and energy collapsed after 2008



Source: (OECD, 2021[10]).

Lithuania aims to increase R&D spending to 1.5% of GDP by 2024, an improvement, though not enough to bridge the gap with the EU average. While public funds will play a key role in enabling this increase, it is also vital that the low share of business spending on R&D, less than 0.54% of GDP in 2020, is increased (OECD, 2022[1])(also see Chapter 5 on financing the transition to net zero). Here Lithuania primarily offers generous tax credit schemes to encourage private sector innovation (OECD, 2021[11]). Take-up of these tax incentives, though, is modest. Lithuania's overall public support for private innovation is low compared to OECD average (OECD, 2022[1]).

In order to support its climate policy ambitions, Lithuania has adopted a number of key policy initiatives aimed at enhancing innovation in the energy sector. In 2018, the National Energy Independence Strategy was adopted, setting the high-level objective that Lithuania becomes an energy technology exporter by 2030, supported by actions detailed in the NECP. This is supported by the National Progress Programme (NPP), adopted in 2019, which aims to promote a smart-economy, specifically through channelling and encouraging investment in green technology development. Alongside promoting technological development, the NPP also aims to better integrate Lithuania within EU strategic value chains, such as on battery and hydrogen technology.

In order to implement these broad targets, the Smart Specialization Programme and its associated funding programme set various priority areas for innovation investment, including energy and a sustainable environment. The next programming period for the programme, running until 2027, sets two key themes in the energy sector: renewable energy resources and smart and effective consumption of energy. Since 2021, the Innovation Promotion Fund further acts as an overarching financial instrument aiming to promote research, innovation and development (IEA, 2021[12]).

Specifically focused on the energy sector, the Action Plan for Strengthening the Lithuanian Energy Innovation Ecosystem aims to strengthen innovation in eight key areas over the period 2020-2023: funding, human resources, infrastructure, products and services, science and technology, regulatory environment, consumers, and communication and innovative culture. In total, 51 measures are detailed in the plan spread across these priority areas. As such the plan provides a comprehensive strategy for innovation in the energy sector, making it easier to access funding, prepare energy project pipelines (see also Chapter 5 on the importance of scaling finance for project pipelines), and also enabling collaboration at the EU level under EU research frameworks (OECD, 2021[10]).

The Action Plan also intends to develop a system of indicators to measure progress on energy sector innovation. IEA and European Commission reviews of Lithuania's energy sector innovation progress highlight monitoring and evaluation of innovation policy as an area for future improvement (IEA, 2021[12]; European Commission, 2020[13]). Management of public funds was also highlighted as an area to review, with the OECD's 2020 Economic Survey of Lithuania suggesting considerable efficiency gains could be made through consolidating the number of innovation agencies (OECD, 2020[14]).

Of further importance to the energy sector, recent amendments to the Law on Energy stipulate a regulatory sandbox environment whereby innovators in the energy sector are able to test and develop new approaches and technologies without being subject to the strict permitting regulations otherwise applied to the sector (IEA, 2021[12]). The regulatory sandbox is particularly focused on smart energy systems and demand response, although other energy technologies can also profit from it (IEA, 2021[12]).

Although innovation performance in Lithuania remains below EU averages, recent plans, programmes and strategies point to possible improvements. In particular, the Action Plan for Strengthening the Lithuanian Energy Innovation Ecosystem and the regulatory sandbox approach promise an energy sector considerably more conducive to innovation. Under these two policies, monitoring and evaluation of innovation will also enhance considerably.

Despite these positive trends, new technologies such as green hydrogen or storage are likely to require different innovation approaches. To this end, the Lithuanian Hydrogen Platform already brings together members from across research, industry, and the public sector to help develop new programmes and plans to promote hydrogen development in the country (Ministry of Energy of the Republic of Lithuania, 2020[15]). Recently the process for drafting national guidelines for hydrogen development has started, indicating further future progress in this regard.

In order to inform and assist these processes, OECD analyses highlight good practices based on other countries experiences. The remainder of this chapter distils these into key recommendations for Lithuania.

Innovation needs in Lithuania and good-practices for innovation policy and technology diffusion

As a small open economy, ensuring an enabling environment for technology adoption in Lithuania is key to exploit innovation happening in other, larger, markets. As a member of the EU, trade barriers to technology adoption are less significant and Lithuania can profit considerably from EU-wide collaboration on research and development initiatives. Indeed, it has already aligned its national hydrogen strategy with that of the EU. Further EU-wide synergies are also already underway, such as the Projects of Common Interest supporting a Baltic energy market integration, covering both electricity grids and gas (European Commission, 2021[16]).

Although EU membership eases trade barriers, other barriers to technology diffusion remain. Knowledge gaps, capacity constraints, costs, language barriers, etc. all obstruct effective technology adoption (OECD, 2022[1]) (EBRD, 2022[17]). Here, the Lithuanian government will need to play a key role in incentivising not only innovation, but also technology diffusion and adoption.

A number of policy options exist for enhancing technology adoption. First, clear carbon price trajectories are key to signal to markets and businesses that technology adoption will be cost-effective in the medium- to long-term (Anderson et al., 2021[18]; Cammeraat, Dechezleprêtre and Lalanne, 2022[19]). Supporting carbon pricing, countries have implemented direct technology support initiatives. For example, the Netherlands supports technology adoption through a combination of subsidies and tax credits (for more information see Box 2.5 in Chapter 2). The Dutch approach grants supports on technology neutral criteria favouring the most cost-effective options, thereby disadvantaging technologies that are not yet close to market. For decarbonisation efforts in hard-to-abate sectors, such an approach may fall short of incentivising the deep-innovation and technology adoption needed, as for example with green-hydrogen (Cammeraat, Dechezleprêtre and Lalanne, 2022[19]).

Further good practice examples for technology adoption include the use of contracts for differences whereby countries ensure a minimum price for greenhouse gas abatement is met, paying the difference if the market price does not meet this and with firms paying the government if the market price is above the contracted price. This is a key difference to feed-in tariffs or similar schemes (see Box 5.3 in Chapter 5 for an example from the UK). Contracts for difference have been piloted around the EU, notably concerning green hydrogen adoption in Germany (Cammeraat, Dechezleprêtre and Lalanne, 2022[19]). They have also been highly successful as a tool to incentivise the development of off-shore wind projects in Denmark, with tenders so competitive that minimum prices were set at close to 0 resulting in operators paying back governments as whole-sale prices rise (see Box 2.4 in Chapter 2 and Box 5.3 in Chapter 5).

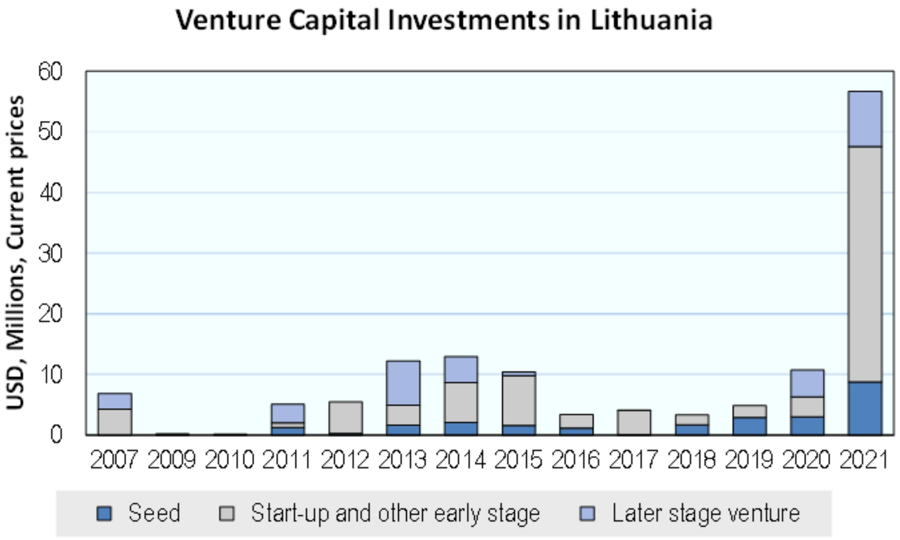
Considering the industry sector in Lithuania, chemical production accounted for 2/3 of GHG emissions in the sector in 2021 (Government of Lithuania, 2022[20]). The majority of these emissions result from ammonia production, comprising 13.1% of total national CO_2 emissions in 2020, with a total annual ammonia production capacity of over 1 000t (Government of Lithuania, 2022[20]). Decarbonising ammonia production relies primarily on the provision of green hydrogen to replace natural gas (a primary feedstock in the production of ammonia) (Cammeraat, Dechezleprêtre and Lalanne, 2022[19]).

Green hydrogen production currently remains three times as expensive as the conventional alternative, grey hydrogen, which is made from natural gas and is thus emissions intensive (Cammeraat, Dechezleprêtre and Lalanne, 2022[19]). Major cost reductions are projected but rely critically on further reductions in the cost of electrolysers. Alongside R&D policy, large-scale demonstration projects are key to ensuring economies of scale are realised and further to easing technology adoption.[3]

Supporting scientific research and innovation, particularly in developing more cost-effective electrolysers for green hydrogen, will need to be a key priority for Lithuania. Targeted and direct support here is key, with current tax incentives ill fitted to enabling such deep innovation. This is primarily because the tax incentives favour large companies with considerable capacity, and profits, to take advantage of tax breaks. Smaller companies, who are often more directly involved in deep innovation, may lack both the capacity to apply for tax breaks, or the profitability needed in order for tax incentives to become valuable (OECD, 2022[1]). Instead, direct and targeted support can help spurn innovation in small and medium enterprises, helping to generate a healthy start-up ecosystem for energy innovation.

Enabling private investment is also key in this regard, with recommendations for how to best employ public funds to enable further private finance highlighted in Chapter 5 also critical for innovation. Venture capital trends in Lithuania are positive in this regard, having experienced a large increase from 2020-2021, particularly for start-up and other early-stage companies. There remains scope for further increases however, with venture capital investments still lower than 0.1% of GDP in 2021 (OECD, 2022[1]). To this end, exploring the possibilities for establishing a venture capital ecosystem with neighbouring Baltic countries and Poland could enhance the contribution of venture capital to low-carbon innovation. Similar regional ecosystems have been developed in Scandinavian countries (Nordic Innovation, 2022[21]). What is more, venture capital investments remain focused on early-stage start-ups and do not address business upscaling needs (OECD, 2022[1]).

Figure 7.16. Venture capital investments in Lithuania increased dramatically from 2020-2021 indicating strengthening innovation support from the private sector



Source: (OECD, 2022[22]).

Relying primarily on innovation breakthroughs alone, however, ignores the possibility that other countries/regions are quicker to developing new technologies, particularly in a small country like Lithuania. Therefore, innovation policy must also be supplemented by technology adoption policies. As shown in Chapter 2, the current NECP already includes considerable technology adoption subsidies for both the transport and industry sectors, particularly for SMEs in the latter. Such policies are integral and should be further sustained. However, larger-scale demonstration projects will also increasingly be needed in order to take advantage of economies of scale. Here, contracts for differences, guaranteeing a price for green hydrogen for example, would be an appropriate policy approach to ensure key technologies are adopted.

Such a policy could draw key lessons from other European countries and could be tailored specifically to the technology's needs.

Similar considerations also apply to the transport sector. Alongside private vehicles, freight transport emissions have grown considerably, by 50% since 2005 (Chapter 1, Figure 1.7). Unlike private vehicles, where electrification is already a cost-effective low-carbon alternative, technologies are not yet available to decarbonise freight transport at scale, particularly for air and water transport. Technologies are, however, emerging that may have the potential to offer significant fuel efficiency gains, and alternative, low-carbon fuel options. These include using wind-propulsion in shipping, or redesigning aircraft to increase efficiency (IEA, 2021[12]).

Electrification of heavy trucks is projected to account for 30% of road freight by 2030 in a net-zero policy scenario, up from just 0.3% in 2021 (IEA, 2021[12]). Achieving this will require significant, targeted, government support. China already heavily supports electrification of road-freight, and other countries are following suit. For electrification, technologies are close to market and cost-competitive enough for deployment subsidies – and should be rolled out immediately and as quickly as possible. However, decarbonising road and other forms of transport will rely on a broader technology mix, including hydrogen and bio-based fuels in addition to batteries (IEA, 2021[12]). As with the industry sector, for both hydrogen and bio-based fuels, direct and targeted innovation support combined with adoption incentives such as contracts for difference would provide a strong policy framework for ensuring new technological development and deployment.

Finally, the same lessons also apply when considering the need for innovation and technology adoption support for negative emissions technologies. Direct air capture, for example, will require significant innovation and cost reductions before it can be employed at scale. Even already existing measures to enhance carbon sinks through land-use changes such as a- and re-forestation rely on setting adoption incentives and can benefit from innovation in land-use management practices and technologies.

Assessment and recommendations for 2040 and 2050 climate policy action

This chapter has depicted climate policy pathways beyond 2030, in line with Lithuania's plans to reach climate neutrality by 2050. From the two-part analysis, focusing on modelling emissions trajectories under high carbon prices and complementing such pricing with innovation and technology adoption support, the chapter offers a number of key policy insights.

First, the chapter shows that high carbon prices can lead to significant emissions reduction at low economic cost, even if assuming no further technological innovation, and without pricing process based or non-CO_2 GHG emissions. This clearly demonstrates the value in continuing to send strong price signals. To this extent, the Lithuanian government could begin to indicate intentions for carbon pricing beyond 2030, in particular in its engagement with the EU. For example, the EU could indicate whether it plans to expand the scope of emissions trading to further sectors post-2030, integrating the current ETS and the proposed ETS2[4] and including further sectors as well.

Second, the modelling results show that, under current technological progress, the industry and transport sectors remain hard-to-abate even when faced with high carbon prices. As such, targeting these sectors will be of key importance for longer-term climate policy strategies. Here innovation and technology adoption policies are key and an area where Lithuania can make significant progress. Specifically, innovation support should become more direct and targeted rather than relying on horizontal, or technology-neutral, tax-incentives as it currently does. In addition, technology adoption should be further enhanced, particularly given Lithuania's small market size, in order to take full advantage of innovation happening in other countries or regions. The NECP already includes generous technology adoption subsidies. Implementing further policies, such as a contract for differences programme for green hydrogen, would serve to support larger-scale demonstration projects and the development of a domestic market for new low-carbon technologies.

Third, the limits of high carbon prices also exemplify the importance of enhancing carbon sinks and engaging the agricultural sector in mitigation efforts in order to enable the deep-decarbonisation necessary. Lithuania's carbon sinks are significant but have been decreasing in the past decade, indicating that reforms in forest and land-use management could have a large influence on emissions reductions.

Notes

[1] For example see the IEA's Roadmap to Net-Zero Emissions, Table 2.2, Pg. 53 (IEA, 2021[4]).

[2] The economic and climate feasibility of the corresponding technologies is still not clear. For instance, a recent report of the Institute of Energy Economics and Financial Analysis (IEEFA, 2022) finds very limited success of the CCS technologies based on the assessment of 13 flagship cases (10 in operation, two that have failed and one that has been suspended) comprising about 55% of the total nominal capture capacity operating worldwide have been reviewed in detail.

[3] Current high gas prices due to gas supply shortages are strengthening the economic case for green hydrogen. The same is true of strong carbon price signals imposed on gas. Combined with technology adoption, such price signals have been found to be very effective at promoting technology adoption.

[4] The ETS2 remains under discussion. However, some EU countries have already started preparing for its potential launch, with Germany for example introducing a national ETS for the transport and buildings sectors to then be integrated in the ETS2 when/should it arrive. Lithuania could similarly do so, preparing for the ETS2 before 2030, and then looking beyond to possible economy wide pricing frameworks between 2030 and 2050.

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8

Main takeaways and policy recommendations

This final chapter brings together the findings of the analyses carried out for this report, providing main takeaways and recommendations for policy reforms to achieve Lithuania's climate policy targets in an efficient, cost-effective, and socially equitable manner.

This report reviews reform options for decarbonisation in Lithuania and seeks to inform the update of its National Energy and Climate Plan. It draws upon the OECD's multidisciplinary expertise on tax policy, financial markets, social affairs, science, technology and innovation, and economic modelling to highlight a number of key policy insights:

- **Lithuania's existing policy mix is broad and comprehensive**, with generous financial incentives for climate mitigation actions and technology adoption, regulations, and complementary measures across all key economic sectors. However, greater ambition is needed to reach Lithuania's climate targets.
- **Enhancing price signals is key**. Lithuania's current policy mix relies primarily on expensive subsidies, with carbon price signals still broadly below needed levels. The proposed excise duty amendment would increase price signals considerably, particularly due to its carbon price component, making up the ambition gap to 2030. The ETS 2 would have a similar effect, enhancing climate policy ambition. Both proposals could be supplemented by carbon price floors to further increase price signal credibility. Moreover, the revenues generated by carbon pricing would allow for important recycling measures, helping to alleviate the social burden of climate ambition.
- **Carbon pricing alone is not enough for Lithuania to reach net-zero by 2050.** Certain CO_2 emissions in the transport and industry sectors remain hard to abate at current levels of technological development, even at very high carbon prices. This underlines the importance of innovation and technology diffusion in these sectors, with hydrogen in particular likely to play a key role given the prominence of emissions from road freight transport and ammonia production. **Targeted technology support is essential to promote technology adoption and innovation.** Lithuania currently relies too heavily on horizontal tax breaks for technology support. **Enhancing carbon sinks** will also be key to balancing out residual emissions, particularly in the agriculture sector.
- **The economic costs of high climate ambition are minimal.** Even excluding co-benefits and avoided damages, modelling shows that significant emissions reductions only cause a small slowdown in annual growth rates at constant technological development. Factoring in innovation, co-benefits and avoided damages would likely balance out these minimal economic costs.
- **Public finance needs to be used more efficiently.** A current focus on grants and subsidies threatens to crowd out private investment. Small capital markets should be further expanded regionally to leverage considerable interest in green spending amongst investors, with financial instruments tailored to different investor needs. Capacity-building to enhance finance absorption will be key.
- **The distributional incidence of proposed carbon prices is flat.** This implies that revenue recycling can be devised to target distributional outcomes as desired, with lump-sum transfers to all households in particular offering broad progressive outcomes.

Annex A. Details on the modelling framework for Chapters 3 and 7 and its implementation

Model description

Dimensions

The GTAP V10A Power database has been aggregated to 14 regions and 27 sectors – the detailed aggregation mapping is available in Tables A.2 and A.3 below. Europe has been split into three regions: Lithuania (LTU), an aggregate of the other 10 Eastern European countries members of the European Union (E10), and an aggregate of the remaining 16 EU countries plus the countries that form EFTA and Great Britain (X16). The aggregation of sectors places great emphasis on the energy carriers: coal, gas, oil (crude and refined) and a disaggregated power sector (coal, gas, oil, nuclear, hydro, wind, solar and other renewables). Another area of emphasis is the ETS sectors such as wood and paper, chemicals, non-metallic minerals and metals.

The simulations have a reference year of 2014. The model is solved in annual steps through 2030, and five-year steps between 2030 and 2050.

Key model features

The Envisage Model at its core is a recursive dynamic and global computable general equilibrium model (CGE) (van der Mensbrugghe, 2019[1]). It follows the circular flow of an economy paradigm. Firms purchase input factors (for example labour and capital) to produce goods and services. Households receive the factor income and in turn demand the goods and services produced by firms. And equality of supply and demand determine equilibrium prices for factors, goods and services. The model is solved as a sequence of comparative static equilibria where the factors of production are exogenous for each time period and linked between time periods with accumulation expressions.

Production is implemented as a series of nested constant-elasticity-of-substitution (CES) functions the aim of which is to capture the substitutability across all inputs. Three production archetypes are implemented. The first is for crops that reflects intensification of inputs versus land extensification. The second is for livestock that reflects range-fed versus ranch-fed production. The final, also referred to as the default, revolves largely around capital/labour substitutability. Some production activities highlight specific inputs (for example agricultural chemicals in crops and feed in livestock) and all activities include energy and its components as part of the cost minimisation paradigm. Production is also identified by vintage – divided into *Old* and *New* – with typically lower substitution possibilities associated with *Old* capital.

Each production activity is allowed to produce more than one commodity – for example the ethanol sector can produce ethanol and distiller's dried grains with solubles (DDGS). And commodities can be formed by the output of one or more activities (for example electricity). Envisage therefore uses a different classification of activities and commodities. One of the features of the model is that it integrates the GTAP power data base that disaggregates GTAP's electricity sector ('ely') into 11 different power sources plus electricity transmission and distribution (Chepeliev, 2020[2]). Though the database has both the supply and demand side for all 11 power sources, the aggregation facility permits the aggregation of electricity demand into a single commodity and the 'make' matrix specification combines the output from the different power activities into a single electricity commodity.

Income accrues from payments to factors of production and is allocated to households (after taxes). The government sector accrues all net tax payments and purchases goods and services. The standard preference function is based on the constant-differences-in-elasticity (CDE) utility function that is used in the core GTAP model (Hertel, 1997[3]; Corong et al., 2017[4]). Investment is savings driven and equal to domestic saving adjusted by net capital flows.

Trade is modelled using the so-called Armington specification that posits that demand for goods are differentiated by region of origin. The model allows for domestic/import sourcing at the aggregate level (after aggregating domestic absorption across all agents), or at the agent-level. In the standard specification, a second Armington nest allocates aggregate import demand across all exporting regions using a representative agent specification. Note that a newer, though minimally tested version, allows for sourcing imports by agent—also known as the MRIO specification. Exports are modelled in an analogous fashion using a nested constant-elasticity-of-transformation (CET) specification. The domestic supply of each commodity is supplied to the domestic market and an aggregate export bundle using a top-level CET function. The latter is allocated across regions of destination using a second-level CET function.[1] Each bilateral trade node is associated with four prices: 1) the producer price; 2) the export border price, also referred to as the free-on-board (FOB) price; 3) the import border price, also referred to as the cost, insurance and freight (CIF) price; and 4) the end-user price that includes all applicable trade taxes (but before domestic sales or VAT taxes). The wedge between the producer price and the FOB price is represented by the export tax (or subsidy if negative) and the wedge between the CIF and end-user prices represents the import tariff (and perhaps other import related distortions). The wedge between the CIF and FOB prices represents the international trade and transport margins. These margins represent the use of real resources that are supplied by each region. The global international trade and transport sector purchases these services from each region so as to minimise the aggregate cost.

The model has two fundamental markets for goods and services. Domestically produced goods sold on the domestic market, and domestically produced goods sold by region of destination. All other goods and services are composite bundles of these goods. Two market equilibrium conditions are needed to clear these two markets.

The model incorporates four types of production factors: 1) labour (of which there can be up to 5 types); 2) capital; 3) land; and 4) a sector specific natural resource (such as fossil fuel reserves). The model allows for regime switching between full and partial wage flexibility. Capital is allocated across sectors so as to equalise rates of returns. If all sectors are expanding, *Old* capital is assumed to receive the economy-wide rate of return. In contracting sectors, *Old* capital is sold on secondary markets using an upward sloping supply curve. This implies that capital is only partially mobile across sectors. Aggregate land supply is specified using an asymptotic supply curve, with an upward bound that provides the maximum expansion. Land is allocated across activities using a nested CET specification. Natural resources are supplied to each sector using an iso-elastic supply function with the possibility of differentiated elasticities depending on market conditions.

Envisage incorporates the main greenhouse gases – carbon, methane, nitrous oxides and fluorinated gases – as well as an additional set of 10 emissions, such as particulate matter and black carbon. Emissions are generated by consumption of commodities (such as fuels), factor use (for example land in rice production and herds in livestock production) and there are also processed base emissions such as methane from landfills.[2] A number of carbon control regimes are available in the model. Carbon taxes can be imposed exogenously—potentially differentiated across regions. The incidence of the carbon tax allows for partial or full exemption by commodity and end-user. For example, households can be exempted from the carbon tax on natural gas consumption. The model allows for emission caps in a flexible manner – where regions can be segmented into coalitions on a multi-regional or global basis. The model allows for countries/regions to be in multiple trading systems simultaneously—such as Europe's Emission Trading System (ETS). In addition to the standard cap system, a cap-and-trade system can be defined where each region within a coalition is assigned an initial emission quota.

Dynamics involves three elements. Labour supply (by skill level) grows at an exogenously determined rate. The aggregate capital supply evolves according to the standard stock/flow motion equation, i.e. the capital stock at the beginning of each period is equal to the previous period's capital stock, less depreciation, plus the previous period's level of investment. The third element is technological change. The standard version of the model assumes labour augmenting technical change—calibrated to given assumptions about GDP growth and inter-sectoral productivity differences. In policy simulations, technology is typically assumed to be fixed at the calibrated levels. Detailed documentation of the ENVISAGE model is provided in (van der Mensbrugghe, 2019[1]).

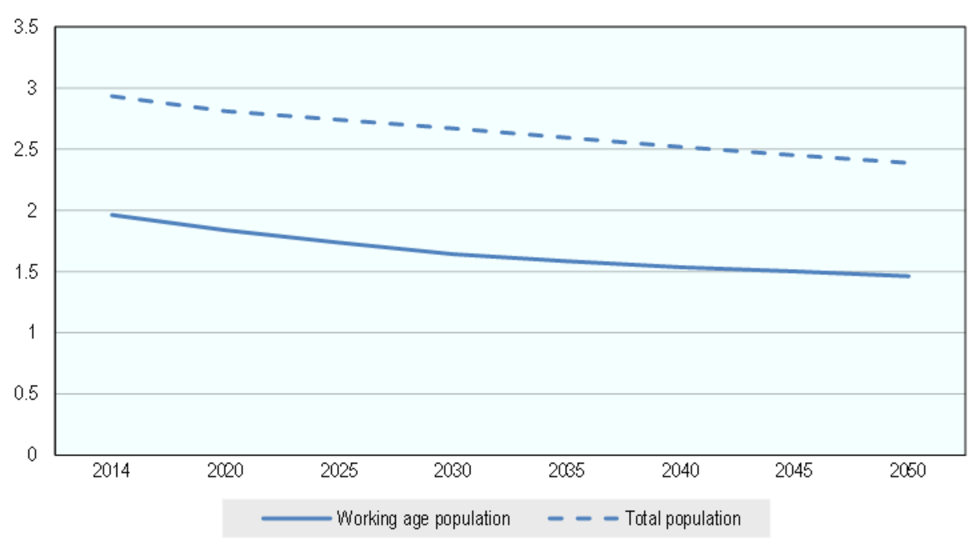
Key reference scenario assumptions

Macro assumptions

The demographic projections are provided by the UN Population Division's 2015 Revision. Labour force growth is equated with the growth of the standard working age population (those aged between 15 and 64). Growth across labour skills (unskilled and skilled) is assumed to be uniform. The chart below shows the UN's 2015 assumptions for Lithuania with a steadily declining rate of population at around 0.5% per annum and declining labour force growth (under our assumptions)..This would see Lithuania's population decline to 2.4 million in 2050 from a 2014 reference year level of 2.9 million.

Figure A A.1. Population trends for Lithuania

Million people

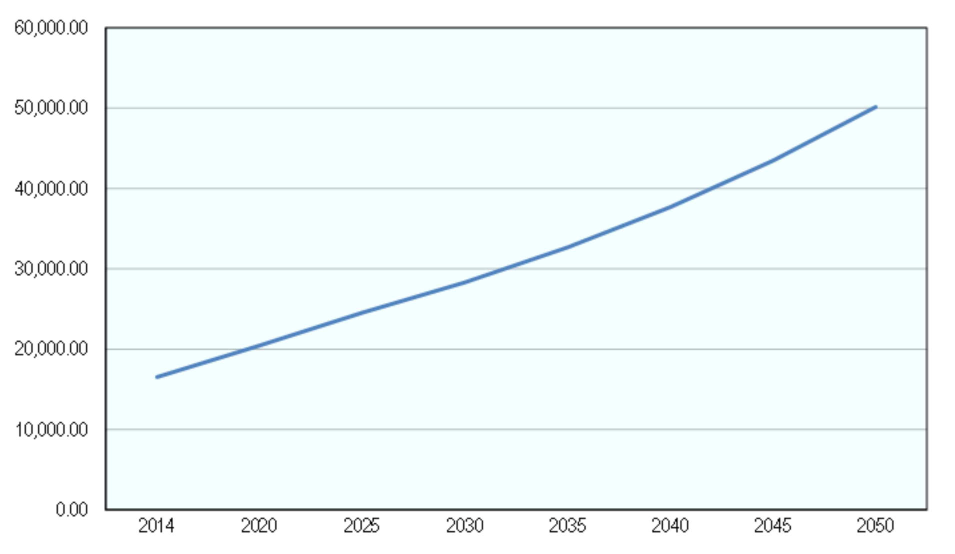


The GDP projections are sourced from the WEO Fall 2021 forecast, which provide the consistent global coverage. The WEO forecast has observed or estimated GDP trends between 2014 and 2021 and projections for the period 2022-2026. Post-2026 GDP growth rates converge to the Shared Socioeconomic Pathways (SSP) middle of the road (SSP2) scenario. For the case of Lithuania, 2020-2030 growth rates constructed in this way are very close to the provided OECD LT projections (the cumulative difference in

2030 is less than one percent). Corresponding projections can be refined when the simulated period would be extended post-2030.

The chart below reports GDP trend for the reference scenarios for Lithuania (in terms of per capita GDP at USD 2014 market exchange rates. Under this projection, Lithuania's per capita GDP would rise from around USD 21 000 in 2021 to over USD 50 000 by 2050 (in constant $2014 at market exchange rates).

Figure A A.2. GDP per capita for Lithuania, constant $2014



Capital accumulation is generated by the standard neo-classical growth expression: current capital is equal to last year's depreciated capital plus last year's investments. The annual depreciation rate is set at 5%. Investment is savings-driven: private, public and foreign. The latter two are fixed at base year levels. Private savings in the reference scenario adjusts to smooth out changes to the aggregate rate of return to capital.

Productivity assumptions

The key productivity assumptions are divided into 3: (1) agricultural productivity is assumed to improve at a rate of 1% per annum (this is measured as output per hectare or yield), (2) energy efficiency is assumed to improve at a rate of 1.5% per annum; and (3) labour productivity is targeted in the reference to match the GDP growth projections. Labour productivity is held fixed in policy scenarios. Assumptions regarding agricultural productivity and energy efficiency changes under the reference scenario are driven by the historically observed trends and can be refined upon additional data availability.

Policy assumptions

In the reference scenario, we include an interpretation of the Nationally Determined Contributions (NDCs) across countries. The latter are constructed as emission reductions relative to no-mitigation (lower-ambition mitigation) case in 2030. To reach the NDC targets, it is assumed that all countries, excluding EU and China, implement carbon prices both in ETS and non-ETS sectors. Carbon prices in the non-ETS sectors could be interpreted as an explicit representation of the costs of mitigation in the corresponding activities. Two exceptions are EU and China, where carbon prices are imposed on ETS sectors only based on the current practices. For the case of Canada, which is included to the Rest of OECD (XOE) region, a carbon price trajectory is imposed exogenously based on the available projections that carbon prices would reach 170 CAD per ton of CO_2 in 2030.[3] Corresponding carbon price trajectories for Canada are emission-weighted with other countries in the XOE region. The table below provides an overview of the carbon prices imposed under NDC scenario in 2030 across regions.

Table A A.1. Carbon prices under NDC scenario, \$2014/tCO_2

USA	0	0	0	0	0	0	0	0	2.2	4.4	6.6	8.7	10.9	13	15.1	17.2
CHN	0	0	0	0	0	0	0	0	9.5	10.5	11.6	12.9	14.3	15.8	17.5	19.3
RUS	0	0	0	0	0	0	0	0	1.2	1.9	2.6	3.4	4.1	4.8	5.5	6.2
LTU	8.5	6	6.9	19.8	29.5	30	44	57	69	82	95	107	120	132	145	157
X16	8.5	6	6.9	19.8	29.5	30	44	57	69	82	95	107	120	132	145	157
E10	8.5	6	6.9	19.8	29.5	30	44	57	69	82	95	107	120	132	145	157
XOE	0	0	0	0	0	0	0	0	23.2	28.6	33.9	39.3	44.7	50	55.4	60.7
XEC	0	0	0	0	0	0	0	0	1.3	2.7	4.1	5.5	6.9	8.3	9.7	11.1
HYA	0	0	0	0	0	0	0	0	3.9	9.2	14.5	19.7	25	30.7	36.5	42.2
XEA	0	0	0	0	0	0	0	0	2.5	4.5	6.5	8.5	10.5	12.4	14.4	16.3
SAS	0	0	0	0	0	0	0	0	1.4	2.4	3.4	4.5	5.5	6.4	7.3	8.2
MNA	0	0	0	0	0	0	0	0	3.1	5.6	8.1	10.5	13	15.1	17.1	19.2
LAC	0	0	0	0	0	0	0	0	1.9	3.7	5.5	7.4	9.2	10.9	12.6	14.3
SSA	0	0	0	0	0	0	0	0	0.6	1.1	1.6	2	2.5	2.9	3.3	3.7

Note: For all regions except EU and China, the reported carbon prices are imposed on all emitting activities. For the case of EU and China carbon prices are imposed on ETS sectors only.

Excise taxes across fuels and uses are held fixed at the base year level (in ad valorem equivalent). A comparison of the petroleum excise taxes for the 2014 and currently observed 2022 gasoline prices shows that for the case of EU-average for both years excise tax rates equal to around 25%.

Figures below provide comparison of the excise tax carbon rate equivalents as observed in GTAP and estimated in the OECD databases. It should be noted that provided estimates (GTAP vs OECD) represent different reference years (2014 vs 2021) and thus are not directly comparable since correspond to different energy price levels addition, production subsidies in fossil fuel mining and transportation sectors in EU are removed, by setting production taxes to 3% (consistent with average production taxes observed in other activities across EU, in particular, in manufacturing sectors).

Energy technologies/preferences

These are broadly in three categories. The first is an autonomous electrification trend. This assumption is driven by the historically observed trends, including an increasing share of electric vehicles, transitioning from gas-based cooking to electric stoves, etc. The share of electricity is assumed to double across the economy, while for the case of households and air transport it is assumed to increase three times. Note that in the reference year the share of electricity is relatively low in most activities, including air transportation. In the latter case the share is below 1% of the total energy consumption and the increase in electricity use could be interpreted as an increase in electricity use for related service activities, such as airport-related passenger and cargo transport. In land transport and water transport, we assume a four-fold increase of the share of electricity (but the shares are capped at 30% and 10% respectively for the 2050 target). The shift in the electricity share is independent of changes in relative prices. Should electricity prices fall relative to other sources of energy, the increase in its share would be accelerated. The second is a downward trend in the price of renewable electricity technologies – continuing trends seen over the last decade or two.[4] The third is an autonomous non-price shift towards renewable power technologies. In the case of Europe, we assume that renewable share in 2050 would be 45% in the absence of a change in relative prices. A drop in renewable prices would accelerate these trends. Changes in these shares in the rest of the world are variegated across the modelled regions. In the case of Lithuania, assumptions regarding solar and wind power generation volumes till 2030 are based on the data provided by Lithuanian Energy Agency. Energy mix till 2030 is also broadly calibrated to the Lithuania's Energy Agency projections.

The discussed reference scenario is broadly consistent with the first EU's NDC commitment of 40% emissions reduction target. It is assumed that most of the technological and efficiency changes would be occurring without any specific policy measures. For instance, as older cars retire and new cars enter the market, an overall efficiency of passenger cars would increase, even without any additional measures. Even considering all these changes, observed emission trends are less ambitious than the Fit for 55 target and thus additional mitigation efforts are needed, as further discussed below.

GTAP Concordances

Table A A.2. Regional concordance

No.	Region	GTAP concordance
1	United States (USA)	United States of America (USA)
2	China (CHN)	China (CHN)
3	Russian Federation (RUS)	Russian Federation (RUS)
4	Lithuania (LTU)	Lithuania (LTU)
5	EU-16+EFTA+Great Britain (X16)	Austria (AUT), Belgium (BEL), Cyprus (CYP), Denmark (DNK), Finland (FIN), France (FRA), Germany (DEU), Greece (GRC), Ireland (IRL), Italy (ITA), Luxembourg (LUX), Malta (MLT), Netherlands (NLD), Portugal (PRT), Spain (ESP), Sweden (SWE), United Kingdom (GBR), Switzerland (CHE), Norway (NOR), Rest of EFTA (XEF)
6	EU-10: Transition economies w/o Lithuania (E10)	Czech Republic (CZE), Estonia (EST), Hungary (HUN), Latvia (LVA), Romania (ROU), Poland (POL), Slovakia (SVK), Slovenia (SVN), Bulgaria (BGR), Croatia (HRV)
7	Other HIY OECD (XOE)	Australia (AUS), New Zealand (NZL), Canada (CAN), Israel (ISR), Rest of the World (XTW)
8	Rest of Europe and Central Asia (XEC)	Albania (ALB), Belarus (BLR), Ukraine (UKR), Rest of Eastern Europe (XEE), Rest of Europe (XER), Kazakhstan (KAZ), Kyrgyzstan (KGZ), Tajikistan (TJK), Rest of Former Soviet Union (XSU), Armenia (ARM), Azerbaijan (AZE), Georgia (GEO), Turkey (TUR)
9	High income Asia (HYA)	Hong Kong (HKG), Japan (JPN), Korea (KOR), Taiwan (TWN), Singapore (SGP)
10	Rest of East Asia (XEA)	Mongolia (MNG), Rest of East Asia (XEA), Brunei Darussalam (BRN), Indonesia (IDN), Malaysia (MYS), Philippines (PHL), Thailand (THA), Viet Nam (VNM), Cambodia (KHM), Laos (LAO), Rest of Southeast Asia (XSE)
11	Rest of South Asia (XSA)	India (IND), Pakistan (PAK), Sri Lanka (LKA), Bangladesh (BGD), Nepal (NPL), Rest of South Asia (XSA)
12	Middle East and North Africa (MNA)	Bahrain (BHR), Iran (IRN), Jordan (JOR), Kuwait (KWT), Oman (OMN), Qatar (QAT), Saudi Arabia (SAU), United Arab Emirates (ARE), Rest of Western Asia (XWS), Egypt (EGY), Morocco (MAR), Tunisia (TUN), Rest of North Africa (XNF)
13	Latin America & Caribbean (LAC)	Mexico (MEX), Rest of North America (XNA), Argentina (ARG), Bolivia (BOL), Brazil (BRA), Chile (CHL), Colombia (COL), Ecuador (ECU), Paraguay (PRY), Peru (PER), Uruguay (URY), Venezuela (VEN), Costa Rica (CRI), Guatemala (GTM), Honduras (HND), Nicaragua (NIC), Panama (PAN), El Salvador (SLV), Rest of Central America (XCA), Rest of South

		America (XSM), Dominican Republic (DOM), Jamaica (JAM), Puerto Rico (PRI), Trinidad and Tobago (TTO), Rest of Caribbean (XCB), Rest of Oceania (XOC)
14	Sub-Saharan Africa (SSA)	Benin (BEN), Burkina Faso (BFA), Guinea (GIN), Senegal (SEN), Togo (TGO), Rest of Western Africa (XWF), Central Africa (XCF), South-Central Africa (XAC), Ethiopia (ETH), Madagascar (MDG), Malawi (MWI), Mauritius (MUS), Mozambique (MOZ), Rwanda (RWA), Tanzania (TZA), Uganda (UGA), Zambia (ZMB), Rest of Eastern Africa (XEC), Rest of South African Customs Union (XSC), Cameroon (CMR), Côte d'Ivoire (CIV), Ghana (GHA), Nigeria (NGA), Kenya (KEN), Zimbabwe (ZWE), Botswana (BWA), Namibia (NAM), South Africa (ZAF)

Table A A.3. Sector Concordance

No.	Sector	GTAP Concordance
1	Agriculture (AGR)	Paddy rice (PDR), Wheat (WHT), Cereal grains nec (GRO), Vegetables, fruit, nuts (V_F), Oil seeds (OSD), Sugar cane, sugar beet (C_B), Plant-based fibers (PFB), Crops nec (OCR), Bovine cattle, sheep and goats, horses (CTL), Animal products nec (OAP), Raw milk (RMK), Wool, silk-worm cocoons (WOL), Forestry (FRS), Fishing (FSH), Processed rice (PCR), Sugar (SGR)
2	Natural resource products (NRS)	Other Extraction (formerly omn Minerals nec) (OXT)
3	Coal (COA)	Coal (COA)
4	Oil (OIL)	Oil (OIL)
5	Gas (GAS)	Gas (GAS), Gas manufacture, distribution (GDT)
6	Processed food (PFD)	Bovine meat products (CMT), Meat products nec (OMT), Vegetable oils and fats (VOL), Dairy products (MIL), Food products nec (OFD), Beverages and tobacco products (B_T)
7	Wood and paper products (WDP)	Paper products, publishing (PPP)
8	Refined oil (P_C)	Petroleum, coal products (P_C)
9	Chemical products (incl. rubber and plastics) (CHM)	Chemical products (CHM), Basic pharmaceutical products (BPH), Rubber and plastic products (RPP)
10	Non-metallic minerals (NMM)	Mineral products nec (NMM)
11	Metals (MET)	Ferrous metals (I_S), Metals nec (NFM)
12	Oth manu (XMF)	Textiles (TEX), Wearing apparel (WAP), Leather products (LEA), Wood products (LUM), Metal products (FMP), Computer, electronic and optical products (ELE), Electrical equipment (EEQ), Machinery and equipment nec (OME), Motor vehicles and parts (MVH), Transport equipment nec (OTN), Manufactures nec (OMF)
13	Electricity transmission and distribution (ETD)	Electricity transmission and distribution (TnD)
14	Nuclear (NUC)	Nuclear power (NuclearBL)
15	Coal power (CLP)	Coal power baseload (CoalBL)
16	Gas power (GSP)	Gas power baseload (GasBL), Gas power peakload (GasP)
17	Wind power	Wind power (WindBL)

	(WND)	
18	Hydro (HYD)	Hydro power baseload (HydroBL), Hydro power peakload (HydroP)
19	Oil power (OLP)	Oil power baseload (OilBL), Oil power peakload (OilP)
20	Other power (XEL)	Other baseload (OtherBL)
21	Solar (SOL)	Solar power (SolarP)
22	Construction (CNS)	Construction (CNS)
23	Trade incl. warehousing (TRD)	Trade (TRD), Accommodation, food and service activities (AFS), Warehousing and support activities (WHS)
24	Other transport (XTP)	Transport nec (OTP)
25	Water transport (WTP)	Water transport (WTP)
26	Air transport (ATP)	Air transport (ATP)
27	Other services (XSV)	Water (WTR), Communication (CMN), Financial services nec (OFI), Insurance (formerly isr) (INS), Real estate activities (RSA), Business services nec (OBS), Recreational and other services (ROS), Public Administration and defense (OSG), Education (EDU), Human health and social work activities (HHT), Dwellings (DWE)

Effective Carbon Rates

Table A A.4. Effective carbon rates for Lithuania (EUR per ton of CO_2)

No.	Code	Fuel Name	Sector Name	Permit Price	ECR (2023)	ECR (2024)	ECR (2025)
1	ADDITIVE	Additives	Industry	52.9	52.9	52.9	52.9
2	AVGAS	Aviation gasoline	Off-road	52.9	206.5	206.5	206.5
3	AVGAS	Aviation gasoline	Off-road	0.0	153.6	153.6	153.6
4	BIODIESEL	Biodiesels	Off-road	0.0	175.6	175.6	175.6
5	BIODIESEL	Biodiesels	Road	0.0	175.6	175.6	175.6
6	GBIOMASS	Biogases	Electricity	0.0	2.7	2.7	2.7
7	GBIOMASS	Biogases	Industry	0.0	0.0	0.0	0.0
8	GBIOMASS	Biogases	Buildings	0.0	2.7	2.7	2.7
9	BIOGASOL	Biogasoline	Road	0.0	302.8	302.8	302.8
10	BIOGASOL	Biogasoline	Road	0.0	2.1	2.1	2.1
11	BITCOAL	Bituminous coal	Agriculture & fisheries	0.0	1.6	1.6	1.6
12	BITCOAL	Bituminous coal	Industry	0.0	3.2	6.3	12.6
13	BITCOAL	Bituminous coal	Industry	52.9	56.1	59.2	65.6
14	BITCOAL	Bituminous coal	Industry	0.0	3.2	6.3	12.6
15	BITCOAL	Bituminous coal	Industry	52.9	56.1	59.2	65.6
16	BITCOAL	Bituminous coal	Buildings	52.9	56.1	59.2	65.6
17	BITCOAL	Bituminous coal	Buildings	0.0	3.2	6.3	12.6
18	BITCOAL	Bituminous coal	Buildings	52.9	56.1	59.2	65.6
19	BITCOAL	Bituminous coal	Buildings	0.0	3.2	6.3	12.6
20	CHARCOAL	Charcoal	Buildings	0.0	1.3	1.3	1.3
21	OVENCOKE	Coke oven coke	Industry	0.0	3.0	4.9	9.9
22	OVENCOKE	Coke oven coke	Industry	52.9	55.9	57.9	62.8
23	CRUDEOIL	Crude oil	Industry	52.9	52.9	52.9	52.9
24	RESFUEL	Fuel oil	Agriculture & fisheries	0.0	153.9	174.9	187.7

25	RESFUEL	Fuel oil	Electricity	52.9	206.8	227.8	240.6
26	RESFUEL	Fuel oil	Industry	52.9	206.8	227.8	240.6
27	RESFUEL	Fuel oil	Industry	52.9	206.8	227.8	240.6
28	RESFUEL	Fuel oil	Industry	0.0	153.9	174.9	187.7
29	RESFUEL	Fuel oil	Industry	0.0	153.9	174.9	187.7
30	GASDIES	Gas/diesel oil excl. biofuels	Agriculture & fisheries	0.0	22.5	22.5	22.5
31	GASDIES	Gas/diesel oil excl. biofuels	Industry	0.0	153.9	174.9	187.7
32	GASDIES	Gas/diesel oil excl. biofuels	Industry	0.0	153.9	174.9	187.7
33	GASDIES	Gas/diesel oil excl. biofuels	Industry	52.9	206.8	227.8	240.6
34	GASDIES	Gas/diesel oil excl. biofuels	Industry	52.9	206.8	227.8	240.6
35	GASDIES	Gas/diesel oil excl. biofuels	Industry	52.9	206.8	227.8	240.6
36	GASDIES	Gas/diesel oil excl. biofuels	Off-road	52.9	206.8	227.8	240.6
37	GASDIES	Gas/diesel oil excl. biofuels	Off-road	0.0	153.9	174.9	187.7
38	GASDIES	Gas/diesel oil excl. biofuels	Off-road	0.0	153.9	174.9	187.7
39	GASDIES	Gas/diesel oil excl. biofuels	Off-road	52.9	206.8	227.8	240.6
40	GASDIES	Gas/diesel oil excl. biofuels	Buildings	0.0	52.5	139.6	139.6
41	GASDIES	Gas/diesel oil excl. biofuels	Buildings	52.9	105.5	192.6	192.6
42	GASDIES	Gas/diesel oil excl. biofuels	Road	0.0	153.9	174.9	187.7
43	INDWASTE	Industrial waste	Electricity	52.9	54.0	54.0	54.0
44	INDWASTE	Industrial waste	Industry	52.9	52.9	52.9	52.9
45	INDWASTE	Industrial waste	Industry	0.0	0.0	0.0	0.0
46	JETKERO	Jet kerosene	Off-road	0.0	150.3	150.3	150.3
47	JETKERO	Jet kerosene	Off-road	52.9	203.3	203.3	203.3
48	JETKERO	Jet kerosene	Buildings	0.0	132.5	132.5	132.5
49	JETKERO	Jet kerosene	Buildings	52.9	185.5	185.5	185.5
50	LPG	Liquefied petroleum gas	Agriculture & fisheries	0.0	9.5	9.5	9.5
51	LPG	Liquefied petroleum gas	Industry	0.0	0.0	0.0	0.0
52	LPG	Liquefied petroleum gas	Industry	0.0	103.9	103.9	103.9
53	LPG	Liquefied petroleum gas	Industry	52.9	156.8	156.8	156.8
54	LPG	Liquefied petroleum gas	Industry	52.9	52.9	52.9	52.9
55	LPG	Liquefied petroleum gas	Buildings	0.0	103.9	103.9	103.9
56	LPG	Liquefied petroleum gas	Buildings	52.9	156.8	156.8	156.8
57	LPG	Liquefied petroleum gas	Road	0.0	170.4	170.4	170.4
58	MOTORGAS	Motor gasoline excl. biofuels	Agriculture & fisheries	0.0	205.4	205.4	205.4
59	MOTORGAS	Motor gasoline excl. biofuels	Industry	52.9	52.9	52.9	52.9
60	MOTORGAS	Motor gasoline excl.	Industry	0.0	205.4	205.4	205.4

		biofuels					
61	MOTORGAS	Motor gasoline excl. biofuels	Buildings	0.0	205.4	205.4	205.4
62	MOTORGAS	Motor gasoline excl. biofuels	Buildings	52.9	258.4	258.4	258.4
63	MOTORGAS	Motor gasoline excl. biofuels	Road	0.0	205.4	205.4	205.4
64	MUNWASTEN	Municipal waste (non-renewable)	Electricity	52.9	54.6	54.6	54.6
65	MUNWASTEN	Municipal waste (non-renewable)	Industry	52.9	52.9	52.9	52.9
66	MUNWASTEN	Municipal waste (non-renewable)	Industry	0.0	0.0	0.0	0.0
67	MUNWASTER	Municipal waste (renewable)	Electricity	0.0	1.5	1.5	1.5
68	MUNWASTER	Municipal waste (renewable)	Industry	0.0	0.0	0.0	0.0
69	NATGAS	Natural gas	Agriculture & fisheries	0.0	10.7	10.7	10.7
70	NATGAS	Natural gas	Electricity	52.9	55.6	55.6	55.6
71	NATGAS	Natural gas	Industry	52.9	58.3	58.3	58.3
72	NATGAS	Natural gas	Industry	52.9	58.3	58.3	58.3
73	NATGAS	Natural gas	Industry	0.0	2.7	2.7	5.0
74	NATGAS	Natural gas	Industry	0.0	5.3	5.3	5.3
75	NATGAS	Natural gas	Off-road	0.0	127.8	127.8	127.8
76	NATGAS	Natural gas	Buildings	52.9	63.6	63.6	63.6
77	NATGAS	Natural gas	Buildings	52.9	63.6	63.6	63.6
78	NATGAS	Natural gas	Buildings	0.0	0.0	0.0	2.5
79	NATGAS	Natural gas	Buildings	52.9	63.6	63.6	63.6
80	NATGAS	Natural gas	Buildings	0.0	5.3	5.3	7.4
81	NATGAS	Natural gas	Buildings	0.0	5.3	5.3	7.4
82	NATGAS	Natural gas	Road	0.0	127.8	127.8	127.8
83	PEAT	Peat	Industry	52.9	52.9	52.9	52.9
84	PEAT	Peat	Industry	0.0	0.0	0.0	0.0
85	PEAT	Peat	Buildings	52.9	62.2	71.6	80.9
86	PEAT	Peat	Buildings	0.0	9.3	18.6	27.9
87	PEATPROD	Peat products	Agriculture & fisheries	0.0	0.0	0.0	0.0
88	PEATPROD	Peat products	Industry	0.0	0.0	0.0	0.0
89	PEATPROD	Peat products	Industry	52.9	52.9	52.9	52.9
90	PEATPROD	Peat products	Buildings	52.9	58.5	64.1	69.7
91	PEATPROD	Peat products	Buildings	0.0	5.6	11.2	16.8
92	PETCOKE	Petroleum coke	Industry	52.9	55.8	57.7	62.5
93	SBIOMASS	Primary solid biofuels	Agriculture & fisheries	0.0	1.3	1.3	1.3
94	SBIOMASS	Primary solid biofuels	Electricity	0.0	1.3	1.3	1.3
95	SBIOMASS	Primary solid biofuels	Industry	0.0	0.0	0.0	0.0
96	SBIOMASS	Primary solid biofuels	Buildings	0.0	1.3	1.3	1.3
97	REFFEEDS	Refinery feedstocks	Industry	52.9	52.9	52.9	52.9
98	REFINGAS	Refinery gas	Industry	52.9	52.9	52.9	52.9
99	SUBCOAL	Sub-bituminous coal	Industry	52.9	57.1	61.2	69.5
100	SUBCOAL	Sub-bituminous coal	Buildings	0.0	4.2	8.3	16.5
101	SUBCOAL	Sub-bituminous coal	Buildings	52.9	57.1	61.2	69.5

Notes

[1] The model allows for perfect transformation, which is the standard specification in the GTAP model.

[2] The current version of the model is not tracking carbon emissions linked to changes in the land use and forestry activities.

[3] https://www.imf.org/en/News/Articles/2021/03/17/na031821-four-charts-on-canadas-carbon-pollution-pricing-system.

[4] The cost reduction is implemented using a hyperbola specification with a cost asymptote. The curve is calibrated to three parameters – the asymptote (relative to current costs), a targeted reduction and the year the target is reached. For wind and solar, the asymptote is 50% of 2014's price and the costs are dropping by 40% between 2014 and 2050. For other renewables, the asymptote is 90% and the costs are dropping by 10% between 2014 and 2050. For the case of Lithuania, for wind and solar, the asymptote is 40% of 2014's price and the costs are dropping by 50% between 2014 and 2050. It should be noted that between 2014 and 2019.

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Annex B. Effective carbon rates sectoral decomposition and fuel category breakdown

Table A B.1. Sectoral decomposition in the OECD Effective Carbon Rates Database

Sector	Definition
Road	All energy used in road transport.
Electricity	All fuels used to generate electricity for domestic use (rather than the amount of energy generated from each fuel). Note that fuels used in the auto-generation of electricity are classified under industrial production.
Industry	All energy used in industrial processes, in heating (incl. inside industrial installations) and in the transformation of energy, including fuels used for auto-generation of electricity in industrial installations.
Buildings	All energy used for commercial and residential heating.
Off-road	All energy used in off-road transport (incl. pipelines, rail transport, domestic aviation and maritime transport).
Agriculture & fisheries	Energy used in agriculture, fisheries and forestry. Energy used in on-road transport in this sector is included in the road transport sector.

Source: (OECD, 2016[1]).

Table A B.2. Fuel category breakdown in the OECD Effective Carbon Rates Database

Energy type	Fuel category	Energy Products
Fossil fuels	Coal and other solid fossil fuels	Anthracite; Bitumen; Bituminous coal; Brown coal briquettes; Oven coke; Coking coal; Gas coke; Lignite; Oil shale; Patent fuel; Peat; Peat products; Petroleum coke; Sub-bituminous coal
	Fuel oil	Fuel oil
	Diesel	Gas/diesel oil excluding biofuels
	Kerosene	Jet kerosene; Other kerosene
	Gasoline	Aviation gasoline; Jet gasoline; Motor gasoline
	LPG	Liquefied Petroleum Gas
	Natural gas	Natural gas
	Other fossil fuels	Additives; Blast furnace gas; Coal tar; Coke oven gas; Converter gas; Crude oil; Ethane; Gas works gas; Lubricants; Naphtha; Natural gas liquids; Other hydrocarbons; Other oil products; Paraffin waxes; Refinery feedstocks; Refinery gas; White and industrial spirit
Other combustible fuels	Non-renewable waste	Industrial waste; Non-renewable municipal waste
	Biofuels	Bio jet kerosene; Biodiesels; Biogases; Biogasoline; Charcoal; Municipal waste (renewable); non-specified primary biofuels and waste; Other liquid biofuels; Primary solid biofuels

Note: Energy products are defined as in IEA (IEA, 2020[202]), World Energy Statistics and Balances.
Source: (OECD, 2019[3]).

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Reform Options for Lithuanian Climate Neutrality by 2050

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