Slovak Republic 2024

Energy Policy Review

International Energy Agency

INTERNATIONAL ENERGY AGENCY

The IEA examines the full spectrum of energy issues including oil, gas and coal supply and demand, renewable energy technologies, electricity markets, energy efficiency, access to energy, demand side management and much more. Through its work, the IEA advocates policies that will enhance the reliability, affordability and sustainability of energy in its 31 member countries, 13 association countries and beyond.

IEA member countries:

Australia
Austria
Belgium
Canada
Czech Republic
Denmark
Estonia
Finland
France
Germany
Greece
Hungary
Ireland
Italy
Japan
Korea
Lithuania
Luxembourg
Mexico
Netherlands
New Zealand
Norway
Poland
Portugal
Slovak Republic
Spain
Sweden
Switzerland
Republic of Türkiye
United Kingdom
United States

The European Commission also participates in the work of the IEA

IEA association countries:

Argentina
Brazil
China
Egypt
India
Indonesia
Kenya
Morocco
Senegal
Singapore
South Africa
Thailand
Ukraine

Source: IEA.
International Energy Agency
Website: www.iea.org

Table of contents

Executive summary

The IEA peer review of the Slovak Republic took place from 23 to 30 October 2023. It came at an opportune time for the Slovak Republic, which is finalising its updated National Energy and Climate Plan to 2030 towards reaching carbon neutrality by 2050. The updated Plan increases earlier targets for emissions reductions outside the European Union's Emissions Trading System to 20% compared to 2005, the reduction of final energy consumption to 12% compared to 2020 and to reach a share of 23% of renewable energy sources in gross final energy consumption by 2030. Today, the Slovak Republic is not on track to meet its draft 2030 emissions reductions target.

Increasing ambitions of energy and climate targets

The IEA commends the government of the Slovak Republic for the preparation of a draft national act on climate change which would enshrine carbon neutrality by 2050 into law. The proposed law would also require the preparation of sectoral climate plans, which are useful tools to enable co-ordination between ministries, and their implementation. The IEA encourages the government to accelerate the finalisation of the law and the sectoral plans. The IEA also encourages the government to establish monitoring and evaluation systems for their implementation and to enable early corrective action if needed.

The Slovak Republic's energy and climate targets for 2030 lack ambition. The country has not set a national target for economy-wide greenhouse gas emissions reductions for the period to 2050 or sector targets. The targets for 2030 are also not reflective of the substantially increased ambitions of the European Union's "Fit for 55" package and the REPowerEU plan and will likely need to be revised upwards shortly.

The Slovak Republic has a large untapped potential for renewables. The IEA encourages the government to develop a clear roadmap with firm actions to expand and diversify the supply of renewable energy sources. This will not only help meet projected energy demand but also contribute to the large-scale electrification of the industry and building sectors.

The Slovak Republic's industry sector is dominated by energy-intensive industries that are highly vulnerable to energy price shocks. Since 2021, the country has seen reduced industrial production despite substantial energy intensity improvements in the industry sector since 2005. A low-carbon transition in the industry sector will require the availability of reliable low-carbon electricity supply,

which the country is well placed to provide, and which should be strengthened by the proactive expansion of energy from renewable energy sources.

Delivering on the current and future climate and energy targets requires the timely expansion of robust transmission and distribution systems. While some infrastructure bottlenecks have recently been removed, more effort is needed to simplify, streamline and accelerate approval and permitting processes. Moreover, the IEA encourages the government to closely monitor if the recently passed legislation to allow innovative business models in the electricity sector is delivering the expected outcomes.

Nuclear ambitions benefit from a long-term roadmap

The Slovak Republic has a very high share of low-carbon electricity at 85% in 2023, compared to the IEA average of 50%. Nuclear is the Slovak Republic's main source of electricity generation, accounting for 63% in 2023, followed by hydropower with 14%. Fossil fuels only play a minor role in the electricity generation mix at 15% in 2023. The government is committed to maintaining the critical role of nuclear power generation. It is pursuing plans for the construction of additional nuclear power plants and exploring the role small modular reactors could play in the future. The government is also assessing how to better harness the potential of nuclear energy to supply heat and to contribute to the decarbonisation of hard-to-abate industry sectors.

The IEA commends the Slovak Republic for having successfully brought the 471 megawatt electrical (MW_e) Mochovce 3 unit to a successful completion in 2023. The 471 MW_e Mochovce 4 unit is expected to become operational by 2025. Mindful of geopolitical developments, it is important that the Slovak Republic diversify sources of safety-related components and fuel for all operating units.

The Slovak Republic will also need to train a new generation of workers for the proposed new build design, which will be built in the country for the first time. The IEA encourages the government to develop a long-term strategic roadmap covering all elements of the value chain and assess in detail the role nuclear can play in a net zero future. This will also give visibility to industry and set out the enabling conditions to support its nuclear ambitions, including the role of small modular reactors.

Publicly-owned buildings should lead by example

The building sector is the Slovak Republic's largest energy-consuming sector, accounting for 39% of total final energy consumption in 2022. Natural gas accounts for the largest share at 42%. The predominant part of natural gas consumed is imported from a single source. Reducing natural gas consumption in the building sector will contribute to enhanced energy security.

This makes deep renovations challenging as homeowners frequently require not only the financial support, which is currently available through a variety of programmes implemented by various entities with different eligibility criteria, but also technical advisory services.

The IEA encourages the government to introduce a one-stop shop scheme. Such a scheme could offer a start-to-finish project management service, including access to financing for the refurbishment of single-family houses but also for the design and implementation of projects at the regional and local levels. This is important as many rural communities lack the capacity for such complex projects.

The renovation of public buildings is lagging the annual renovation rate required by the European Commission. There is a gap in the renovation of public buildings, compared to the renovation of residential apartment buildings. One of the difficulties is the lack of a centralised system for collecting data on state-owned and central government buildings, which prevents the creation of a targeted public building renovation plan. The IEA encourages the government to create, maintain and make publicly available an inventory of the public sector building stock at the national and local levels and to develop a database to support the design of policies to enhance the energy efficiency performance of public buildings.

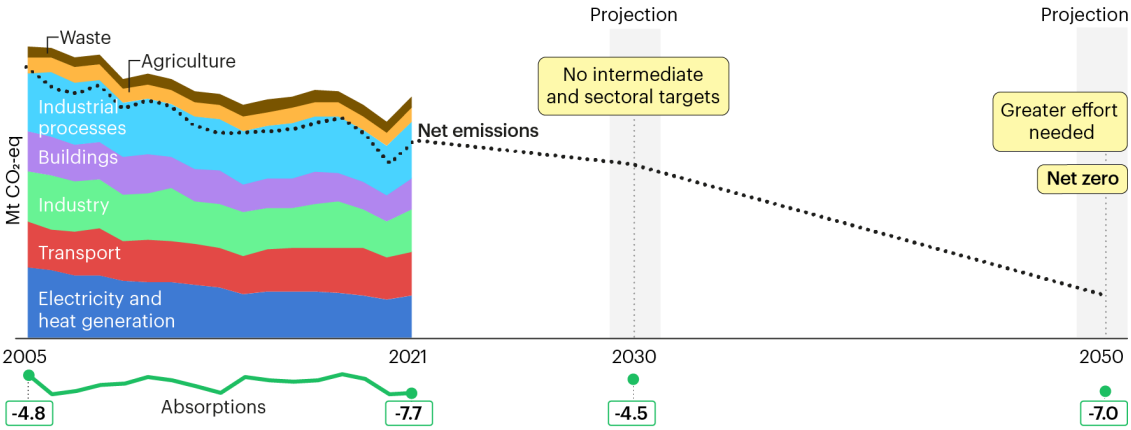
Fiscal policy should support the energy transition

Carbon taxation and fossil fuel prices in the Slovak Republic are not aligned with driving consumer behaviour in support of the energy transition. Fiscal and tax policy should encourage consumers to move away from fossil fuels and support the uptake of low-emission, more efficient, renewable and innovative options. Taxation should ideally reflect the carbon content of fuels. The IEA encourages the government to advance its pledge for a fiscally neutral green tax reform.

The government of the Slovak Republic took swift action to protect vulnerable consumers from the exceptionally high energy prices in 2021 and 2022. The government opted to broaden the definition of vulnerable consumers beyond the entire household segment to almost all small enterprises and large parts of the public sector. It also extended the provision to cap retail prices through 2024.

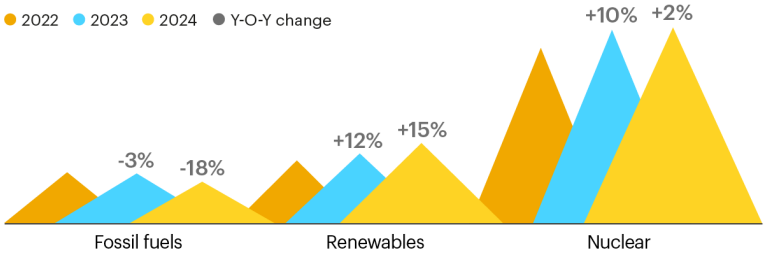
Wholesale energy prices have now widely returned to their pre-crises level and the IEA encourages the government to end the price caps and to quickly put in place a legal definition of energy poverty. This should be complemented by the support mechanism provided as part of the social transfer and protection system, as opposed to through subsidised and artificially low retail prices, as the low subsidised prices run counter to the government's declared priority for the energy efficiency first principle.

19% reduction of **net greenhouse gas emissions** from 2005 to 2021



20%

Drop in fossil fuel generation from 2022 to 2024* caused by displacement of coal-fired generation



*Electricity generation from January to August in 2022, 2023, 2024. Distributed generation not included.

99%

Natural gas import dependency in 2022

13.1 Billion EUR

Cumulative investments required by 2030 to meet the **buildings renovation targets**

47%

Reduction in **energy intensity** in **industry** from 2005 to 2022

1. General energy and climate policy

The Slovak Republic's energy and climate policies focus on achieving climate neutrality by 2050 while creating a competitive low-carbon economy with affordable energy prices. The key documents defining the Slovak Republic's energy and climate policies, targets and supporting measures are the Envirostrategy 2030 and the National Energy and Climate Plan (NECP), both adopted in 2019, and the Low-Carbon Development Strategy until 2030 with a View to 2050, adopted in 2020.

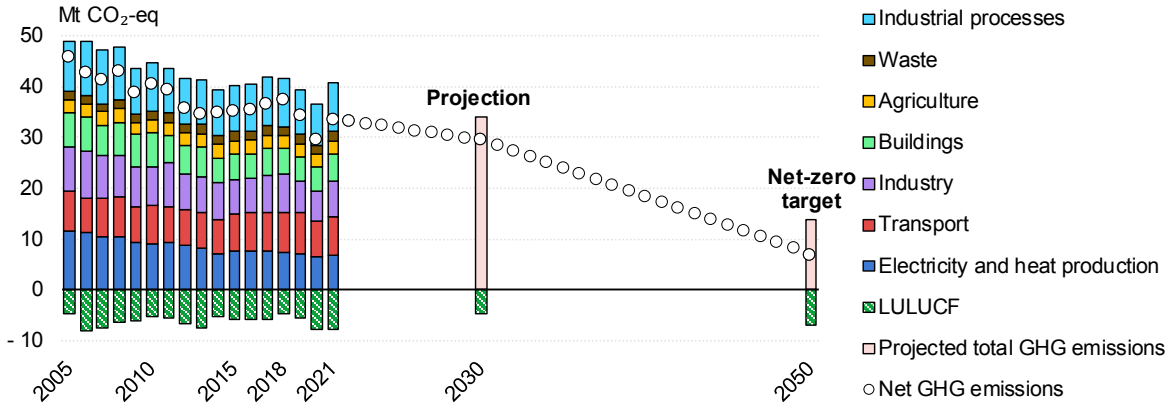
The NECP is required for all European Union (EU) member states and defines how the Slovak Republic will contribute to the achievement of EU-wide climate and energy targets to 2030. In the 2019 NECP, the Slovak Republic committed to a 20% reduction of greenhouse gas (GHG) emissions for sectors outside of the EU Emissions Trading System (ETS) by 2030 compared to 2005. Sectors not covered by the ETS, such as transport, buildings, agriculture and waste, fall under the EU Effort-Sharing Regulation.

The Slovak Republic forwarded the mandatory draft updated NECP to the European Commission in August 2023 and delayed the submission of the final version of the updated NECP, expected to be delivered in June 2024. The draft updated NECP revised the non-ETS GHG emissions reduction target upwards to -22.5% by 2030. Non-ETS GHG emissions have fallen by 7.1% (2021, compared to 2005). According to the European Commission, the Slovak Republic is not on track to meet its revised emissions reduction target for 2030 with an assessed gap of 11.1 percentage points and has not yet fully taken into account the new "Fit for 55" package and the REPowerEU plan in its draft submission. The EU-wide target is to reduce GHG emissions by 55% by 2030 compared to 1990. The Slovak Republic has not yet set any national target for reducing its economy-wide GHG emissions to 2030 beyond the country's obligations as a member of the European Union.

In 2021, GHG emissions in the Slovak Republic reached 33.6 million tonnes carbon dioxide equivalent (Mt CO_2-eq), including land use, land-use change and forestry (LULUCF), a 27% decline since 2005 and 11% since 2018 (Figure 1.1). The energy sector accounted for 67% of the country's total GHG emissions in 2021, of which transport accounted for 18% and electricity and heat production for 17%. Industrial processes account for 23% of the GHG emissions in the

Slovak Republic. The LULUCF sector is an important carbon sink in the Slovak Republic, accounting for 7.7 Mt CO_2-eq in 2021; almost equivalent to the emissions from the transport sector.

Figure 1.1 Total greenhouse gas emissions by sector in the Slovak Republic (2005-2021) and projections (2030 and 2050)



Sources: IEA analysis based on UNFCCC (2023), Greenhouse gas inventory data; Slovak Republic, Ministry of the Environment (2020), Low-Carbon Development Strategy of the Slovak Republic until 2030 with a View to 2050.

Increasing ambitions of energy and climate targets

The country's low-carbon strategy outlines a roadmap setting out sectoral measures to allow the Slovak Republic to reach net zero emissions by 2050. The emissions reduction trajectory estimates that by 2050, a maximum emissions reduction of 90%, compared to 1990,[1] can be achieved if all additional measures are implemented. Despite considering all possible removals from the LULUCF sector, the Slovak Republic would, however, fall at least 7 Mt CO_2-eq short of reaching climate neutrality in 2050. The roadmap discussed several measures, including carbon capture and storage, to address the emissions gap. The roadmap indicates that its modelling scenarios will be updated by 2025 to reflect new policies and targets set at the national and EU level and evaluate the scope of the reductions of the measures identified towards reaching carbon neutrality.

A national act on climate change enshrining carbon neutrality into law is at a draft stage and it is unclear when parliament will take a final vote on this. The draft act includes provisions for the preparation of sectoral climate plans, whose implementation would be the responsibility of relevant sectoral ministries. This legislation would be an effective complement to the roadmap in the Low-Carbon

[1] The Slovak Republic was formed on 1 January 1993 after the dissolution of the former Czechoslovakia.

Development Strategy and could direct the government towards taking early corrective measures if one of the sectors where to get off-track from its emissions reduction path.

When developing sectoral climate plans, it is important to maintain an economy-wide perspective and to involve all relevant stakeholders in each step of the process. Choices on the fuel mix, for example, will impact investments in the industry sector, therefore decisions taken in one sector should be assessed for their implications on the entire energy system.

The draft act omits the energy and hard-to-abate sectors and their requirement for sectoral plans. While these sectors are effectively regulated by the EU ETS, omitting them from the law would make the co-ordination between ministries to implement emissions reductions more difficult. At a minimum, other ministries should be mandated to cover energy and hard-to-abate sectors in their sectoral plans.

The government could assess the viability of creating a task force or steering group that would meet on a regular basis to examine the direction of energy and climate policy and ensure consistency in decision making. This steering group should contain representatives from all sectors, including consumer groups and non-governmental organisations. It could also oversee the development of a strategy setting out the optimal technology mix and the associated investment needs, taking a system-wide perspective that accounts for increased variable generation and other clean energy technologies.

The government may like to explore the experiences and lessons learnt in Ireland, Switzerland and the United Kingdom when developing legislation on climate action and sectoral climate plans. Ireland and the United Kingdom have also established climate change advisory councils to support and advise their governments.

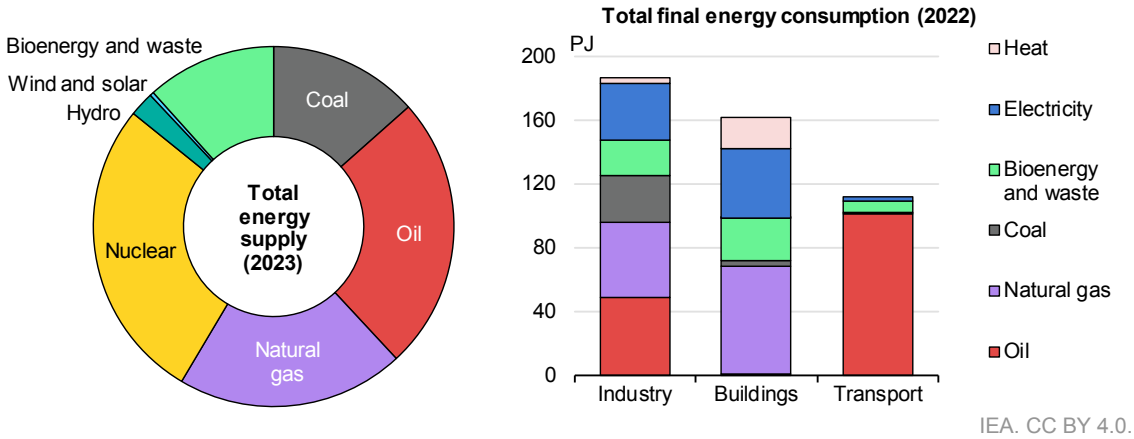
The Slovak Republic's energy system is dominated by fossil fuels, though their share in total energy supply (TES) declined from 64% in 2013 to 60% in 2023, notably lower than the IEA average of 78% in 2023. The decline is mostly attributable to the decrease in coal use, whose share in TES dropped from 20% in 2013 to 14% in 2023. The share of renewables increased from 13% of TES in 2013 to 15% in 2023. Nuclear accounts for the single largest share of TES at 28% in 2023.

Bioenergy and waste dominated total renewable energy supply in 2023. Bioenergy has become an important fuel for heating systems, particularly in the building sector, where it contributed 16% of the energy supply in 2022 (see Chapter 2). In 2022, buildings were the single largest consuming sector (39% of total final energy consumption [TFEC]), followed by industry (34%) and transport (27%).

The Slovak Republic imported 55% of its total energy supply in 2023 and most of its crude oil and almost all of its natural gas imports originate from the Russian Federation (hereafter "Russia"). Transport has the highest demand for oil products, followed by industry, while oil consumption in the building sector is negligible. Natural gas accounts for fifth of TES, a quarter of TFEC, over 50% of heat output and is the most important heating fuel in the building sector (see Figure 1.2).

The country's dependency on direct imports of Russian gas decreased in 2022 (see Chapter 3). The IEA commends the Slovak Republic for its swift and highly effective action in diversifying gas imports in a short period of time, by contracting gas supplies from a wider number of suppliers and making more efficient use of the regional gas infrastructure. Further reducing the share of fossil fuels in TES and TFEC will hence reduce import dependency and enhance security of supply.

Figure 1.2 Total energy supply (2023) and demand (2022) by source in the Slovak Republic



Note: PJ = petajoule.
Source: IEA (2024), World Energy Balances (database).

The country's electricity generation is predominantly low emission, with nuclear accounting for 63% and renewables for 22% in 2023. Coal accounted for 5.7%, a sharp drop compared to 2005, when it accounted for 19% of electricity generation. This reduction reflects the decision of the Slovak Republic to phase out coal-fired power generation with a view to reducing GHG emissions but also due to economic considerations.

The concrete step towards the coal phase-out was the end of operations of 266 MW at the Nováky coal power plant in December 2023, which also signifies the end of operations for the Nováky mine. The government decided in 2018 to remove subsidies for unprofitable domestic coal mining by the end of 2023. The IEA commends the government for this decision and for not reversing this decision

during the energy crises of 2022 and 2023. The last coal-fired power plant in the country, the 220 MW Vojany plant, ceased operations in March 2024, while the last coal mine at Nováky closed in December 2023. Works on the closure of the underground mine, the liquidation of mining operations and the revitalisation of the area affected by mining activity should be completed by 2027.

To compensate for the loss of coal-fired generation, the government is committed to increasing the share of nuclear. In January 2023, the third unit of the Mochovce nuclear power was connected to the grid and, at the end of the energy start-up stage of the commissioning, reached full capacity in September 2023, adding 471 MW_e capacity. Additional nuclear capacity is planned for 2025 when the fourth Mochovce unit, with an output of 471 MW_e, is expected to become operational. With the commissioning of these two nuclear units, the Slovak Republic is to become a net electricity-exporting country. The Slovak Republic has a strong commitment to nuclear power, including the deployment of small modular reactors (SMRs) in the longer term; however, this should not distract from the role other power generation sources can play to meet its net zero targets. The ongoing and welcome shift in the Slovak Republic's energy system needs to accelerate and be supported by more ambitious renewables and energy efficiency policies if the country is to meet its climate targets for 2030 and 2050.

Energy efficiency and renewable targets to 2030

The government has successfully applied the energy efficiency first principle[2] in achieving its targets for both its final energy consumption (FEC) and primary energy consumption (PEC) targets for 2020 as set out in the EU Energy Efficiency Directive (EED). The revised EU EED (2023) came into force on 10 October 2023 and includes an ambition for the overall EU objective of reducing FEC by 11.7% by 2030 with respect to the EU 2020 reference scenario. EU members are required to make their best efforts to achieve the PEC target. However, the FEC target is binding, and the European Commission can use its powers to have the target achieved.

EU members' contributions to the EU target are calculated as defined in Annex 1 of the EED. In its draft updated NECP, the Slovak Republic sees a 12% reduction in FEC by 2030 compared to the 2020 reference scenario. This means that the government should take measures to ensure a 22% reduction in FEC by 2030 compared to the actual 2021 FEC.

[2] Defined as taking utmost account of cost-efficient energy efficiency measures in shaping energy policy and taking relevant investment decisions.

In its assessment of the Slovak Republic's draft updated NECP, the European Commission notes that both the FEC and PEC targets are not in line with the European Commission's calculation reflecting the requirements of the revised Directive. The Commission hence suggests that the Slovak Republic be more ambitious in its final updated NECP (initially expected by the end of June 2024). According to the European Commission's calculations, the Slovak Republic's contribution to the European Union's FEC cannot exceed 354 PJ by 2030, compared to the proposed target of 430 PJ in the draft updated NECP. The PEC should not exceed 564 PJ. However, under the two scenarios assessed by the government, PEC would be in the range of 687 to 755 PJ.

Table 1.1 Energy efficiency targets for 2030 in the Slovak Republic

	2020		2022	2030
	Status	Targets	Status	Targets
Primary energy consumption	635 PJ	686 PJ	645 PJ	657 PJ or -2%
Final energy consumption	434 PJ	378 PJ	446 PJ	430 PJ

Sources: 2020 target from 2018 review; 2030 target from draft updated NECP.

The Slovak Republic has made continuous progress in reducing FEC led by the industrial sector. The IEA commends the Slovak industry sector for its energy efficiency improvements made in recent decades. The potential for further improvements seems to rely largely on the introduction of innovative technologies and electrification, where possible (see Chapter 2). However, there is an opportunity to increase energy efficiency in the building sector. Much of this potential rests in the stock of public buildings and individual houses (see Chapter 2). The IEA suggests that the government review all policies and measures to support decarbonisation and renewable energy from an energy efficiency perspective.

The Slovak government does not consider renewables to be a primary objective of its energy and climate policy but rather a tool for the transition to a low-carbon economy. The draft updated NECP has raised the overall target for the share of renewable energy sources in gross final consumption from 19.2% in the 2019 NECP to 23% (Table 1.3). This is, however, significantly lower than the overall EU target of 42.5% set by the revised Renewable Energy Directive of 2023.

Figure 1.3 Slovak Republic's renewable energy trajectories (2005-2022) and targets (2030)

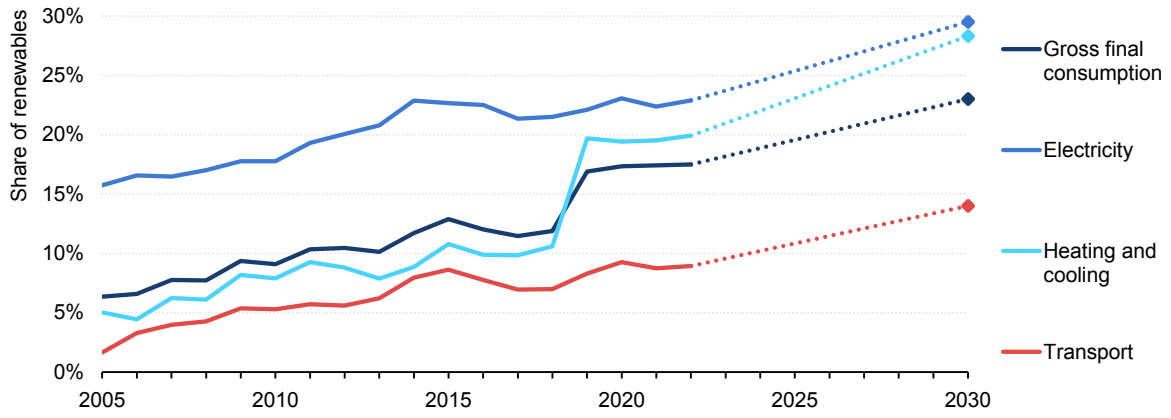


Table 1.2 Renewable energy targets by sector for 2030 in the Slovak Republic

Share of renewables in:	2022 status	2030 target in the 2019 NECP	2030 target in the draft updated NECP
Gross final consumption	17.5%	19.2%	23.0%
Electricity production	22.9%	27.3%	29.5%
Heating and cooling	19.9%	19.0%	28.3%
Transport	8.9%	14.0%	14.0%

Notes: The targets are computed according to Eurostat definitions for consistency with EU targets. Eurostat definitions include the normalisation of wind and hydro renewable electricity consumption, and multiplication factors for advanced biofuels and renewable electricity in transport.

Sources: IEA analysis based on Slovak Republic, Ministry of Economy, (2019), NECP; Slovak Republic, Ministry of Economy (2023), Draft updated NECP; Eurostat (2024), Share of energy from renewable sources.

The Slovak Republic's transition to a low-carbon economy will require significant investments across all energy sectors. A large part of the needed investments to 2030 will come from the Recovery and Resilience Facility, established by the European Union in response to the Covid-19 pandemic. The Recovery and Resilience Facility provides support to each EU member state through recovery and resilience plans (RRP). The RRP of the Slovak Republic consists of 64 investments and 70 reforms supported by EUR 6.4 billion in grants. Of the total funding, 46% was earmarked to support the green transition, a higher share than the 37% required by the European Union. All reforms and investments included in the RRP should be completed by 2026.

The anticipated changes in the electricity generation mix, and especially the coal phase-out, will see future generation largely concentrated in the western part of the country. Investments to extend and reinforce electricity transmission and distribution infrastructure will be needed. There is also a need to make the power system more flexible by, for example, developing demand-side management and additional ancillary services if it is to accommodate a growing share of variable

renewables. Moreover, if the Slovak Republic wishes to electrify the economy, adequate investments in generation are needed to ensure the security of supply. Accelerating the deployment of renewable energy by, among others, reforming the reservation mechanism to connect renewables to the grid will also be important, alongside efforts to develop new nuclear capacity.

Streamline and accelerate permitting

It will be equally important to simplify, streamline and accelerate approval and permitting processes, and environmental impact assessments to allow the timely roll-out of all the infrastructure investments needed. This is a challenge faced by almost all IEA countries and the Slovak government is encouraged to study other countries' experiences. The United Kingdom has commissioned a report on how to accelerate the deployment of electricity transmission infrastructure. Among the recommendations are streamlining the consenting process and introducing a strategic approach to future spatial network planning. Sharing spatial planning information with stakeholders, such as potential project developers and hosting communities, is also important and here digitalisation can play a vital role in accelerating the permitting process.

The operation of a single-window clearance system in which one single point of contact co-ordinates all procedures needed for a given infrastructure investment could be considered, as is done in Switzerland. Requiring just one permit instead of different permits at different project implementation stages with each stage being open for legal challenge could also be considered, like the new procedure in Austria and Germany. Hungary just issued new legislation to support the expansion of wind power by reducing the restriction of the siting of new wind turbines within a radius of 12 km from any populated settlement down to 700 metres. Moreover, a go-to zone of priority investments has also been established. The government now expects a significant expansion of wind energy in the period to 2030. For the European Union as a whole, in 2022, the European Commission issued recommendations to fast-track renewable energy projects, including fast-track processing and assigning overriding public interest to renewable production projects, grid and storage assets, and introducing fully digital procedures.

However, the energy transition will not succeed without the support of the people. Many of the delays arise from challenges from local communities where new infrastructure such as wind turbines or grid infrastructure is being planned. It is therefore essential to gain the acceptance and support of the local community. Many IEA countries are exploring ways to promote more local involvement and ensure that communities benefit from hosting renewable facilities, network infrastructure and other infrastructures needed to support the energy transition.

Specific suggestions have been made in recent initiatives in Denmark, the United Kingdom, the United States and the European Union.

Ireland has taken a particularly interesting approach. It introduced an enabling framework for community participation to facilitate community-led renewable projects. Interested communities receive technical, legal and financial support. Ireland also established dedicated community benefit funds into which all successful bidders must pay a fixed amount per megawatt hour (MWh) to benefit host communities

Just transition policies to support the energy transition and mitigate demographic change

Since 2022, the Slovak Republic has received funds from the European Commission under the Just Transition Fund (JTF), which supports selected regions most affected by the energy transition over the period 2021-27. The JTF operates in the three most affected regions (Upper Nitra, Košice and Banská Bystrica) from the phasing out of coal extraction and coal-fired electricity generation, and the decarbonisation of industries with very high GHG emissions. The JTF supports the training and reskilling of employees in the affected sectors, providing support to local communities affected by the transition and to young people entering the labour market. A 2023 OECD report found that at 20%, the Slovak Republic has a higher share of workers employed in polluting jobs that are vulnerable to the clean transition than the average for OECD countries (11.7%).

The Upper Nitra region is the only coal mining region in the Slovak Republic. From 2017 to 2022, coal production in the country decreased from 1.8 million tonnes (Mt) to 0.9 Mt, as the role of coal declined from 6.2% to 3.0% of the energy production mix. The first mine to close was the Cígeľ mine, in October 2017, given the depletion of its reserves. In 2018, the government decided to cut subsidies to uncompetitive coal mines by 2023, which would terminate coal mining activities in the country. To alleviate the social impact on workers due to the closure of the Handlová (September 2021) and the Nováky mines (December 2023), the European Commission approved EUR 92 million of state aid. In 2018, the coal mines employed 4 000 workers; the number declined to 1 903 in December 2022. Following the mine closure, the miners will receive financial compensation, based on the time worked in the mine, for up to seven years.

The JTF operates in the Košice region as well, where the steel industry is located. Given the region's high decarbonisation potential, the JTF intervenes to reskill and upskill around 2 400 steel industry workers. Banská Bystrica, one of the country's least developed regions, depends on high-emission industries such as mining, mineral products and metal fabrication.

The JTF will contribute to retraining workers and supporting vocational schools in the affected areas. This is also important with a view to maintaining the region's attractiveness for the population and avoiding rural flight by young families and students who follow employment opportunities or may be attracted by a better provision of care services and education opportunities in other parts of or outside of the country.

At the same time, the Slovak Republic is facing overall shortages in the skilled workforce, including in the energy sector. The 2020 OECD Skills Strategy Slovak Republic notes the importance to redress the current skills imbalance and to align skills with the needs of the labour market by ensuring, among other policy measures, that secondary and tertiary education responds to labour market needs and increasing the share of adult learning.

In its 2023 Slovakia country report, the European Commission noted that the country has a higher vulnerability than the EU average with regard to the possible social impact of the transition and pointed towards the need for continuous adult learning and a stronger focus on digitalisation and other skills needed in future, low-emission economic sectors.

Some programmes to provide the required training have already been initiated, but more needs to be done in a systematic way. This could include reskilling existing workers, training young people entering the workforce or bringing in skilled workers from abroad. As new technologies are developed and implemented, it will be important to regularly monitor the skills needed and adapt training and education accordingly. Close co-operation between the public and private sectors will be needed. The government may like to study the initiatives taken by other IEA countries.

Switzerland's education and environment ministries co-operate to integrate environmental topics into the curricula at all levels of education (school/universities, professional and technical vocational education, and continuing workforce education), fund training and inform about the wide array of possible careers in fields critical for the energy transition. Funding and training are provided through a dedicated vehicle with a special focus on training in energy efficiency and renewable energy. Some countries, such as Canada, have launched (paid) internship programmes and training opportunities for green jobs in co-operation with the private sector with a special focus on science, technology, engineering and mathematics. Another best practice from IEA countries is an initiative by German industry which set up its own training facilities to ensure an adequate supply of trained workers to deliver on its orders in a timely manner. A particular innovative feature is the launch of a mobile training rig deployed through Ireland's regional education and training boards that travels to schools and construction sites to promote careers and upskilling in green construction, and

even offers on-site training. In developing dedicated training and reskilling programmes, the Slovak Republic can build on the mapping of skills and employment by regions and by districts as provided by the EURopean Employment Services.

Given the Slovak Republic's nuclear ambitions, a new generation of nuclear workforce will also be needed to meet the goals for new nuclear power plants (NPP) (see section above and Chapter 3). This offers the country an opportunity to train a generation of engineers and a specialist workforce with long-term employment opportunities. There is a need for a national programme of education and training for the future nuclear workforce by upskilling the workforce for new nuclear plants, training the workforce for long-term operation of existing reactors, and funding for degree programmes to expand in-country expertise for planned future nuclear projects. Retraining workers for SMR plants which eventually could use the same facilities and equipment as the former coal plants could be a useful strategy to retain the expertise of that community.

A talent pipeline must also be established for the nuclear regulator. Although the nuclear regulator already has extensive regulatory experience, comprising operating plants, life extension of plans and new builds. Moreover, special attention needs to be given to training staff to prepare for the next phase of new build NPPs which are likely to be a new design for the country.

Carbon taxation and fossil fuel prices to better support the energy transition

Fiscal and tax policy in the Slovak Republic is not well-aligned with driving consumer behaviour towards the energy transition. In 2022, the Slovak Republic's finance ministry calculated total tax receipts from the energy sector to be close to EUR 1.9 billion while support measures for fossil fuels totalled over EUR 3.8 billion according to the OECD. Over half of that amount benefited residential consumers, with the vast majority supporting end-use of natural gas (EUR 1.5 billion), end-use of electricity (EUR 570 million) and a minuscule amount for coal consumption (EUR 200 000).

However, 2022 was an exceptional year as Russia's invasion of Ukraine amplified the energy price crises and the government quickly implemented measures to protect residential, commercial and industrial consumers. In comparison, support measures for fossil fuels totalled EUR 875 million in 2021. All subsidies related to coal were phased out at the end of 2023.

The IEA commends the government for having taken swift action to protect consumers from the energy price shocks of 2022 and 2023, in line with the European Commission's temporary crisis framework in the context of Russia's

aggression against Ukraine. The framework, originally approved in March 2022, was prolonged until June 2024 to grant limited amounts of support over the winter heating period and to compensate for high energy prices.

The Slovak government capped prices of electricity at 199 EUR/MWh and natural gas at 99 EUR/MWh for companies and businesses. In 2022, the state reimbursed 90% of expenditure above that level for small companies and 80% for others. For this, the European Commission approved the provision of EUR 600 million of state aid under the Commission's temporary crises framework in 2022.

In 2023, the share of reimbursement was 80% for all eligible consumers with eligibility broadened to include other entities performing economic activities, including the public sector. The maximum reimbursement limits per business unit were doubled in 2023; but no quantitative consumption limits were set, and business units were also not required to show that they had invested in or improved their energy efficiency.

In 2022, shareholders of Slovenské elektrárne (SE, the power utility) agreed to cap the electricity supply price at 61.2 EUR/MWh (excluding value-added tax) for a maximum of 6.15 terawatt hours (TWh) sales. According to the company, this reflects a subsidy of EUR 850 million with an average saving of EUR 500 for each household according to the government. Households were guaranteed the same regulated price of electricity in 2023 and 2024 as well, leaving the Slovak Republic amongst a small group of countries in the European Union to maintain capped electricity prices (excluding taxes) for households all through 2024.

The capped retail price is available to every household, independent of their income and consumption. The guaranteed final price for natural gas and heat increased by 15% in 2023 compared to 2022.

Prices for heat supply were capped at 199 EUR/MWh for 2023. In 2023, the scheme was extended to include certain social service facilities, social housing owned by public authorities and for state-supported rental housing. Conversely, the government also put a price cap on energy producers who will be taxed at 90% for any amount exceeding the cap.

However, the European Commission noted in its temporary crises framework that these important support measures should be exceptional and temporary, targeting the most vulnerable households and companies. This is not the case in the Slovak Republic, where practically all electricity and natural gas consumers fall under the support schemes.

It is, therefore, necessary to move forward from the protection offered to all residential and business consumers, by setting a firm date to end this support and prepare to phase it out. In this regard, ongoing efforts to define energy poverty

and develop targeted measures to protect such households are welcome and should be swiftly adopted and implemented. The European Commission's review of the Slovak Republic's draft updated NECP also noted the need for a clear legal definition of energy poverty.

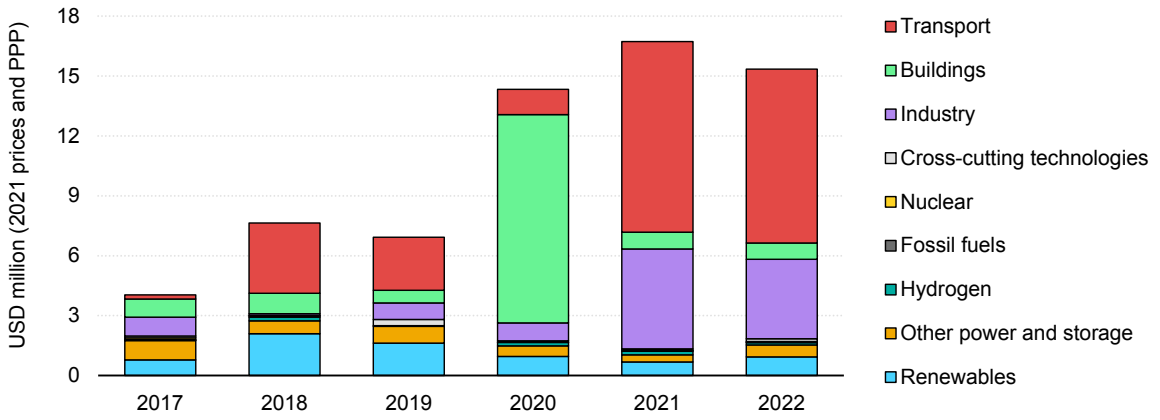
As a guiding principle, changes to fiscal and tax policy should encourage consumers to move away from fossil fuels and support the uptake of lower emission, more efficient, renewable and innovative options. This is applicable to the transport sector, where diesel is taxed at a substantially lower rate than petrol despite its negative externalities. The same is true in the heating sector, where gas is significantly less expensive than electricity, thereby providing a disincentive towards the installation of heat pumps. Taxation should ideally reflect the carbon content of fuels.

The IEA encourages the government to move forward with its pledge in the Envirostrategy 2030 for a fiscally neutral green tax reform. This will also contribute to reducing harmful environmental impacts from fossil fuel use as noted by the European Commission in 2022. Preference should be given to support mechanisms provided as part of the social transfer and protection system, as opposed to through subsidised and artificially low caped prices, as subsidised and artificially low caped prices run counter to the government's declared priority for the energy efficiency first principle. This needs to be supplemented by support programmes facilitating the shift towards cleaner heating and transport options, especially targeting vulnerable and low-income groups at risk of energy poverty, as the government has set out in its RRP. The IEA lauds the approach taken by the government, which highlights again the need to quickly put in place a legal definition of energy poverty.

A dedicated research, development and innovation strategy to underpin the green transformation

The Slovak Republic does not have a dedicated energy research and development (R&D) strategy. Instead, research supporting energy and energy transformation is subsumed under other research strategies that focus on green and digital transformation. Key among them is the National Research and Innovation Strategy 2030, which, however, does not include any specific goals or targets for energy-related R&D.

Figure 1.4 Energy-related R&D public expenditure in the Slovak Republic by sector, 2017-2022



Note: PPP = purchasing power parity.
Source: IEA (2024), Energy Technology RD&D Budgets (database).

Since 2017, the largest share of public R&D funding has been spent on energy efficiency, with nuclear the second-largest area in 2020. Other energy sectors are only allocated a marginal share of the public R&D budget. Compared to other IEA countries, the Slovak Republic was at the lower end in 2022.

To leverage existing research and innovation capacities and funding, the IEA encourages the government to strengthen its international co-operation beyond programmes funded by the European Commission and its active co-operation focusing on Central European and the Visegrad four countries. The IEA Technology Collaboration Programme (TCP) covers a wide range of topics that relate closely to the government's declared energy and industrial objectives. Given the priority on energy efficiency, hydrogen and industrial innovation for the energy transition, the government could consider joining TCPs such as the one on industrial technologies and systems and several of the end-use TCPs. Specifically, in hydrogen, international co-operation is pivotal, and the IEA is promoting different international co-operation opportunities. The Slovak Republic's involvement would highlight the country's commitment to jointly pursue new challenges and emerging technologies, which is a key element in the journey towards a climate-neutral future. As of 2024, the Slovak Republic participates only in one IEA TCP, on solar heating and cooling.

Several large energy companies in the Slovak Republic are owned, or majority owned, by multinational corporations with little interest in supporting local R&D beyond existing activities in their home countries. Small Slovak start-ups have difficulties accessing financing and customers given the absence of dedicated support programmes. Reforms of the Slovak R&D environment are slowly emerging, but they can take years to materialise. Currently, the Slovak R&D

environment relies almost exclusively on public funding, namely the Smart Specialisation Strategy (RIS3) and the EU Recovery and Resilience Facility.

Key recommendations

The government of the Slovak Republic should:

- Advance the preparation of the climate law to enshrine the net zero emissions by 2050 target in law and mandate the preparation of sectoral climate plans, which would include energy production and hard-to-abate sectors.
- Establish a high-level steering committee to monitor and evaluate progress in the implementation of the energy and climate strategy to ensure that the Slovak Republic meets its 2030 energy and climate targets and climate neutrality by 2050.
- Streamline and shorten the planning consent regime so that the investments in renewables, electricity networks, energy infrastructure and other clean energy technologies needed for the energy transition are delivered in a timely manner.
- Ensure that a sufficiently sized and skilled workforce is available to meet the needs of the energy transitions. Establish a national programme of education and training for future nuclear workforce development.
- Incentivise efficient energy consumption by expediting the adoption of the definition of energy poverty and designing and implementing measures to protect those defined as energy-poor and provide support through the social system or through building sector upgrading programmes.
- Develop a dedicated, predictable and transparent energy R&D strategy, with explicitly defined goals and targets to enable fair competition among research institutions, including the robust and transparent allocation of funding.
- Increase financing for innovations in energy, assess new technologies, and make more targeted use of the EU Green Deal and its funding mechanisms.
- Identify and harness international co-operation opportunities such as the IEA Technology Collaboration Programmes and focus on new research topics, such as hydrogen and variable renewables.

2. End-use sectors

Buildings

Energy savings through efficiency and clean energy

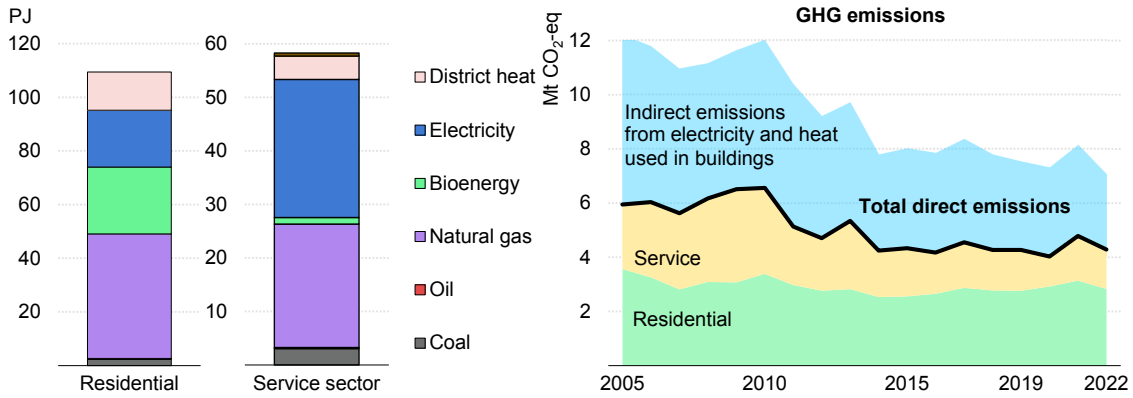
The decarbonisation of the buildings sector is pivotal for the Slovak Republic to achieve its energy and climate goals. The sector accounts for the largest share of TFEC (39% in 2022), with energy consumption from space heating in the residential sector being the largest subsector (26% of TFEC in 2022). The main heating source is still natural gas (46% of residential space heating consumption in 2021), contributing to most of the carbon and energy intensity of the residential sector. In 2022, emissions from direct energy use in buildings accounted for 16% of total energy-related emissions, or 32% if indirect emissions from electricity and heat used in buildings are included.[3]

The draft updated NECP sets a national target of energy efficiency at 30.3% by 2030, lower than the EU target of 32.5%, under the projected PRIMES (Price-Induced Market Equilibrium System) baseline. This target falls into the "ambitious" scenario, as opposed to the "realistic" one (28.4%), both outlined in the draft updated NECP. It is not indicated which target is the official one. No target has been set for each end-use sector. Savings in the buildings sector are crucial to meet energy efficiency targets and will account for 28% of expected cumulated savings under the energy savings obligation, according to the draft updated NECP.

Over 40% of the demand in residential buildings was supplied by natural gas, followed by electricity (27%), bioenergy (16%) and district heating (DH) (12%) (Figure 2.1). Commercial and services buildings are less carbon-intensive, as they are mainly supplied by electricity (42%), natural gas (41%) and DH (10%).

[3] Indirect emissions are emissions deriving from the generation of electricity and heat which then are consumed by end-use sectors (from IEA [2023], Database documentation).

Figure 2.1 Total final energy consumption (2022) and greenhouse gas emissions (2005-2022) from buildings in the Slovak Republic



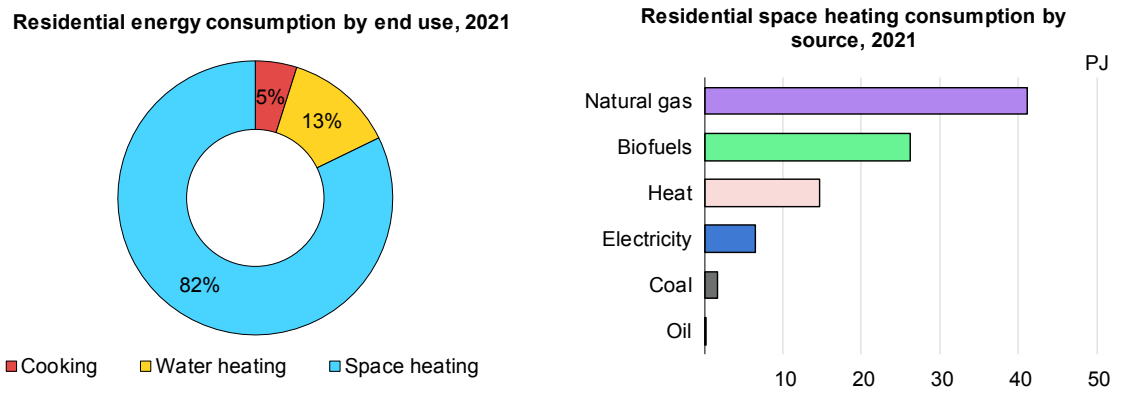
Sources: IEA (2024), World Energy Balances (database); IEA (2024), Greenhouse Gas Emissions from Energy (database).

Policy for the buildings sector focuses on enhancing the performance of buildings through cost-effective renovations, intended to reduce the energy demand in buildings and supply them with energy from renewable sources. Buildings' energy efficiency policy is driven by EU directives: the EED, revised in 2023, and the Energy Performance of Buildings Directive, revised in 2024. These directives have to be transposed into domestic law within two years. EU directives mandate all new buildings to be carbon-neutral by 2030, and the whole buildings stock should be net zero by 2050, as the Slovak Republic planned in its Long-Term Renovation Strategy (LTRS) adopted in January 2021.

Deeper renovations to reach the buildings performance targets will entail higher costs, as noted in the draft updated NECP. Funds for energy efficiency measures in the Slovak Republic mainly come from the European Union. For instance, the 2021 National Recovery and Resilience Plan aims to close the renovation investment gap. One successful national programme is the State Housing Development Fund, which provides loans to renovate houses and reinvests the repayments into new loans, based on social and sustainability criteria.

In 2022, over three-quarters of the energy demand in residential buildings was used for space heating (Figure 2.2). The government will use incentive mechanisms to increase the share of renewable sources in heat production (around 1% annually until 2030) and increase the number of heat pumps.

Figure 2.2 Residential energy consumption and breakdown of space heating fuels in the Slovak Republic, 2021



Source: IEA (2024), Energy End-uses and Efficiency Indicators (database).

The Slovak Republic met its 2020 energy efficiency targets and is now working towards meeting those for 2030 (see Chapter 1). This should be done by prioritising the renovation of older non-renovated residential buildings and extending the renovation to public buildings. The renovation of buildings should also make a greater use of energy service companies (ESCOs), especially in the public sector (see next sections). Also, the government should assess the energy-savings potential of the modernisation of DH systems, with a broader set of clean energy sources, such as high-temperature heat pumps.

Renovation of the building stock needs to ramp up

Half of the Slovak Republic's population lives in single-family houses and almost all the remainder lives in apartment buildings, according to the 2021 census. There are over 1 million apartment buildings and around 1 million single-family houses. Almost all occupied apartments are owned by their dwellers. It is worthwhile noting that half of the single-family houses are in rural areas; the Slovak Republic has only two cities with more than 200 000 inhabitants.

The residential buildings stock is relatively old with almost 70% of buildings built before 1980. Over 80% of apartment buildings and 60% of single-family houses are prefabricated buildings constructed between 1950 and 1980. Half of these were built with single-layer walls, when no strict thermal performance standards were in place, resulting in poorer thermal performance. Overall, the renovation of the outer walls and the replacement of windows has been carried out more effectively in apartment buildings than in single-family houses. In fact, around 70% of single-family houses are not equipped with an insulated envelope and around

half have not replaced the windows. Almost 30% of single-family houses built before 1980 have never been renovated, as opposed to 9% of apartment buildings.

To date, renovations have played a major role in achieving energy savings in the buildings sector. From 2014 to 2021, renovation accounted for 90% of buildings energy savings, with the rest attributable to the construction of new buildings with high performance standards. In view of the 2030 energy savings obligation, the buildings sector is expected to account for 28% of total savings, with the largest energy-savings potential lying in single-family houses. The 2021 census contributed to mapping and computing all energy savings in the residential sector, being the first end-use sector to do so.

The Slovak Republic aims to reach a zero-emissions building stock by 2050, as outlined in the LTRS. The strategy sets emissions and consumption reduction milestones for 2030, 2040 and 2050 and forecasts that at the current pace of renovations, all residential buildings will undergo some sort of renovation by 2030. The strategy promotes cost-effective deep renovation and targets the renovation of the least energy-efficient buildings. Deep renovations, those achieving over 60% of energy savings, are expected to increase in the future.

If the renovation target is met, the cumulative investment needs by 2030 will amount to EUR 8.2 billion for residential buildings and EUR 4.9 billion for non-residential buildings. Financing is expected to come from state subsidies, EU funds and the mobilisation of private funding, including through ESCOs (see sections below). Given the high building ownership rate, raising owners' awareness and providing incentives to owners is critical to increase the renovation rates. The LTRS highlights that homeowners have the legal requirement to set aside financial funds to ensure ongoing maintenance and renovation of their properties. This, in combination with state support and financial incentives, contributes to stimulating renovations.

Better price signals could contribute to improving the renovation rate. In the Slovak Republic, price signals do not promote lowering the carbon intensity of buildings, as effective carbon pricing[4] in the sector is low: in 2021, the average net effective carbon rate of the buildings sector was only 6 EUR/t CO_2, one of the lowest among OECD EU countries (the OECD EU average is 57 EUR/t CO_2). The buildings sector's effective carbon rate is also the lowest among all sectors in the Slovak Republic. A higher carbon price could promote renovations and the use of fossil-free heating sources.

[4] The OECD defines effective carbon pricing as "The total price that applies to carbon dioxide emissions from energy use as a result of market-based instruments (fuel excise taxes, carbon taxes and carbon emission permit prices)" (OECD).

The government established several funding mechanisms to support energy efficiency measures, under different entities and rules, both national and from the European Union. The State Housing Development Fund evolved over time in accordance with the sector's needs and is now the main delivery vehicle for EU funds. It serves the renovation of all residential buildings and operates as a revolving fund, where the repayments of the loans are lent out again, according to social and sustainability criteria. The Restore Home Project under the Recovery and Resilience Facility aims to achieve the renovation of 30 000 single-family houses by mid-2026. The Ministry of Transport and Construction distributes grants for the thermal insulation of single-family houses and additional funding is provided by the Slovak Sustainable Energy Finance Facility (SlovSEFF III). The REPower EU plan offered financial support for a range of measures related to buildings retrofits, with the goal of reducing dependency on imported fossil fuels, and the government plans to use it to renovate public buildings. From 2025, the renovation of vulnerable households' buildings will be funded by the Social Climate Fund. However, the Slovak Republic does not have a specific definition of vulnerable households, currently all households fall into this category (see Chapter 1).

There are also government incentive schemes to support the installation of small heat pumps mainly in single-family houses. The Green for Households II programme, which entered its second phase in 2024, contributed to the installation of 60 000 renewable-energy devices between 2015 and 2023. The second phase of the scheme will support small renewable energy installations and the replacement of old solid fuel heating equipment with low-emission systems, such as heat pumps and biomass boilers. Support comes in the form of vouchers that can cover part of the installation cost. In single-family houses, heat pumps could also be complemented with solar heating. Existing gas boilers could be kept as a backup to deliver peak demand if heat pumps are not available, considering that the 2024 Energy Performance of Buildings Directive calls for a total ban on fossil fuel boilers by 2040.

The size of the pool of support measures across different entities and rules could be difficult to navigate for stakeholders who may encounter difficulties with the specificities and how to apply for funding support. This, in turn, may be creating barriers to the implementation of energy efficiency measures. The government should consider creating a one-stop shop or a similar mechanism for the provision of technical, administrative and financial advice on energy efficiency, including on the available funds, such as Energiesprong, which operates in some European countries. This would facilitate the access to information and funds, as well as the design and implementation of measures in the country, especially at the regional and local levels. This can help better target the renovations to lower income households. It would also contribute to the tracking of savings from each measure to ensure they are in line with the targets outlined in the LTRS.

Energy certification systems need higher numbers and quality

The Slovak Republic operates a buildings certification system, with the application of minimum requirements to the energy performance of buildings. Energy performance certificates (EPCs) can be attributed to the entire building or to single apartments. It is mandatory to certify the building or the apartment when they are sold or rented for public buildings bigger than 250 m^2, and when buildings are renovated or newly built. It is voluntary in all other circumstances.

Table 2.1 Energy certificate by energy class in the Slovak Republic, 2013-2024

A	B	C	D	E	F	G	Total
30 391	136 565	27 117	7 200	4 735	3 135	6 032	215 175
14%	63%	13%	3%	2%	1%	3%	

Note: Data are updated until 17 September 2024.
Source: Institute of Informatics and Statistics, Energy certification of buildings (accessed 17 September 2024).

The government should aim to significantly increase the number of buildings with an EPC, given that buildings with an EPC represent around 10% of the buildings stock. It could, for example, follow Italy's policy, making it mandatory to obtain an EPC before and after any major renovation supported by the government. The government could co-finance their issuance and provide greater support, proportionately to the energy class that the renovation contributes to achieve.

At the same time, the quality of EPCs must be ensured and monitored. According to the law, only certified auditors are allowed to award the certifications. To ensure the quality of the system, the government could enforce a stricter verification process on the EPCs issued. It could introduce a random selection of all the EPCs issued annually, following Portugal's example.

The Restore Home Project is a programme of renovation of family houses funded through the Recovery Plan. The applicant must provide evidence of energy savings of at least 30%, and the achievement of the energy savings of the house renovation will be verified mainly through the EPC. This highlights the importance of the quality of the building's energy certification system, and the need for effective verification mechanisms.

Promote the use of energy service companies for efficiency renovations

ESCOs generate energy efficiency improvements with reduced or no upfront capital from the user by financing the upfront investment and being paid by a part of the resulting savings in energy cost, enabling energy savings and modernisation. To encourage the use of ESCOs in the public sector, since 2019,

the public sector can enter energy performance contracts with guaranteed energy savings (GES). The reformed Energy Efficiency Act regulates energy services and includes provisions for energy performance contracts. The government defines the structure and parameters of energy performance contracts and provides a contract template on its website. Energy performance contracts must include GES and renovations can only be carried out by a given pool of certified auditors. In the past, the lack of trust in the GES providers has hindered their expansion. Decree No. 99/2015 outlines the procedures to ensure the quality of the services, regulating the notification, examination and qualifications required to provide such services. Carrying out energy audits to identify cost-effective energy savings measures serves the quality of EPCs. Eligible public buildings must pay an annual energy bill of over EUR 50 000 and the contracts with the ESCOs shall not be less than 8 years. Furthermore, the contract can be signed provided that the contractual obligations do not impact public debt, as per Eurostat's Manual on Government Deficit and Debt.

Some barriers must be addressed if the Slovak Republic is to develop an energy performance market. The Slovak Republic's Association of Energy Service Providers identified legislation issued in 2019 that only allows GES in the public sector if there is no impact on public debt, thus reducing their scope. In addition, the market could be more attractive to ESCOs if revenues could come from reduced operational costs, on top of energy savings. A study from the World Bank finds that projects for the deep renovation of public buildings would not be attractive for ESCOs, as the payback period (15-20 years) would be longer than the period they usually operate (5-10 years). It will be important to flexibly adapt the regulatory framework to the practical experience of implementing energy performance contract projects responding to the current market situation. To secure finance for the project, the preferred method in the Slovak Republic is a direct loan agreement taken by the ESCO, similar to other European countries.

Public buildings stock needs better data

There are a little over 15 000 public buildings in the Slovak Republic, 90% of which were built before 1990, half of which are schools. There is no centralised system for collecting data on and managing state-owned and central government buildings, which would help to build a targeted public buildings renovation plan.

The lack of specific measures and data leads to a gap in the renovation of public buildings, compared to residential buildings (apartment buildings in particular). Reform of the Energy Efficiency Act allows public buildings to make use of guaranteed energy savings and energy services, which can improve the rate of renovation. In addition, the government sees inexpensive measures such as behavioural changes as a complementary source of energy savings. All new public

buildings built by 2026 require zero-emission performance, in line with the revised Energy Performance of Buildings Directive .

The Energy Efficiency Monitoring System (EEMS) was conceived to improve the monitoring and tracking of energy consumption and efficiency measures. The EEMS is a central data collection and verification system to monitor primary and final energy consumption and to evaluate related energy efficiency measures. The monitoring system allows tracking energy savings to ensure compliance with the EED energy-saving targets. All energy, electricity and heat suppliers (including co-generation of heat and power), energy auditors, providers of guaranteed energy services, municipalities and others are obliged to share information with the EEMS. The coverage of the data monitored through the EEMS helped identify that 90% of renovated single-family houses either do not have an EPC or, alternatively, they completed the renovation without applying for the state support.

Despite its effectiveness, the current data collection processes have several limitations, namely that various datasets are owned by different actors and analytical units at each ministry collect the data separately. There is also a lack of data and information on energy consumption in public and commercial buildings, and energy savings and funding information not related to measures under Article 8 of the EED. This lack of information could hinder the achievement of targets, as not all the information is monitored, especially in the sector which is foreseen to deliver the highest energy savings.

The public sector should lead by example: the 2023 EED set binding targets for the renovation of all public buildings, at a 3% annual renovation rate. It previously targeted only central government buildings. The draft updated NECP did not outline quantitative targets on the annual floor-area renovations and respective energy savings. Setting the rate of renovations requires having an overview of the buildings stock in an inventory of public buildings. Such an inventory should be publicly accessible and cover all heated or cooled buildings with a floor area of more than 250 m^2 and provide, at least, data on their area, their annual energy consumption and their EPC, as per the 2023 EED. That inventory can also enable ESCOs to implement renovation solutions. Estonia's digital building registry could be a good model, as it includes all relevant information, indicators, building permits and an EPC for each building.

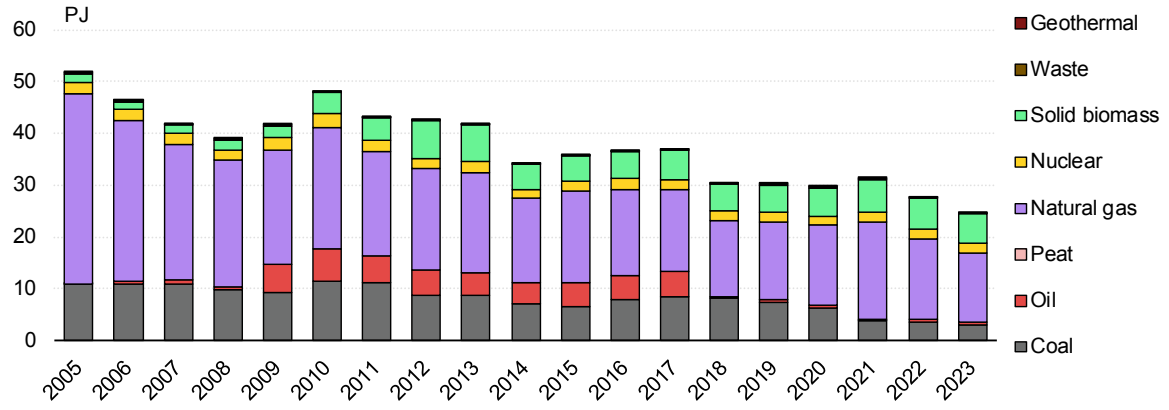
District heating provides a decarbonisation opportunity

The Slovak Republic possesses a widespread DH system: around three-quarters of apartment buildings are connected to DH. In recent years, the demand for DH has decreased due to improved efficiency in buildings and heating systems and milder winters. Heat demand is expected to decrease by over 10% in 2030

(compared to 2020). Furthermore, the increasing shift from central heating to individual heating in the residential sector has resulted in oversized DH infrastructure.

DH is still heavily reliant on fossil fuels, mainly natural gas (Figure 2.3). In 2022, around 60% of DH came from co-generation of heat and power (mainly fuelled by natural gas). The remainder came from heat-only boilers. DH is widespread in densely populated urban areas. The state-owned company MHTH operates the distribution network of the DH system in six of the biggest Slovak cities. The fuel mix varies across the cities: for instance, Bratislava is mainly fuelled by gas and coal, Zvolen by bioenergy, and Trnava by nuclear.

Figure 2.3 District heating supply by source in the Slovak Republic, 2005-2023



Source: IEA (2024), World Energy Balances (database).

The decarbonisation of DH will be achieved through increased shares of renewable sources and improved efficiency in the distribution network. The Slovak Republic's 2030 renewable target in heating and cooling is 28.3%, with around 1% annual increases, from 20% in 2022. To achieve the target, the government plans to replace natural gas and coal in DH production with bioenergy used in co-generation of heat and power. The baseline scenario for DH supply in 2030 from the draft updated NECP forecasts that bioenergy will be complemented by waste heat from industrial processes, heat from nuclear and geothermal energy. The Košice geothermal plant has great potential to supply geothermal heat to DH networks in the future, for instance following the example of the DH in Budapest, Hungary. Considering the planned expansion of the nuclear fleet, heat from nuclear has an even greater potential.

The DH system is old and needs modernised, especially to accommodate the lower temperatures of modern DH systems. The Slovak Republic obtained EUR 1 billion in state aid support from the European Union for the period 2021-30 directed at maintaining and building high-efficient co-generation facilities

connected to DH. In the draft updated NECP, the government also proposes to expand the DH system. This will enable consumers to receive heating from fewer central sources, instead of individual smaller boilers. Large-scale heat pumps could be a solution as it will be easier in the future to replace fewer centralised sources than replace thousands of smaller units. They can utilise existing heat sources like wastewater from the sewage system or the treatment plants.

The heating system needs increased flexibility to meet requirements in the electricity system and challenges with an overall reduced heating demand. Energy system flexibility can be increased by efficient coupling of the heating and electricity systems by means of co-generation of electricity and heat, preferably from biomass, and heat production from electricity in large-scale heat pumps. DH systems are, themselves, a heat storage system in the expansive pipes. But combining DH with large-scale thermal storage further improves flexibility. Having access to flexible production and storage assets allows DH companies to respond to the situation in the electricity market and improve system flexibility overall.

Thermal storage provides flexibility by contributing to modulate the excess heat produced by the system. Finland is a world leader in the utilisation of thermal storage in urban areas using various technologies. In addition, thermal storage helps relieve the electricity grid should heat pumps overcharge it in peak hours.

Recommendations

The government of the Slovak Republic should:

- Introduce a one-stop shop scheme offering a start-to-finish project management service, including access to financing for the refurbishment of single-family houses and work to be undertaken by small rural communities.
- Ensure the quality of the buildings' energy certification system through inspection and sanctions for non-compliance.
- Identify and remove barriers to the use of energy service companies to implement energy efficiency measures in the buildings sector.
- Create, maintain and make publicly available an inventory of public sector building stock at the national and local levels, and develop a database to support the design of policies to enhance the energy efficiency performance of public buildings.
- Strengthen and extend the already widespread district heating system with heat pumps in combination with thermal storage to increase the flexibility of the electricity grid and integrate variable renewable energy sources.

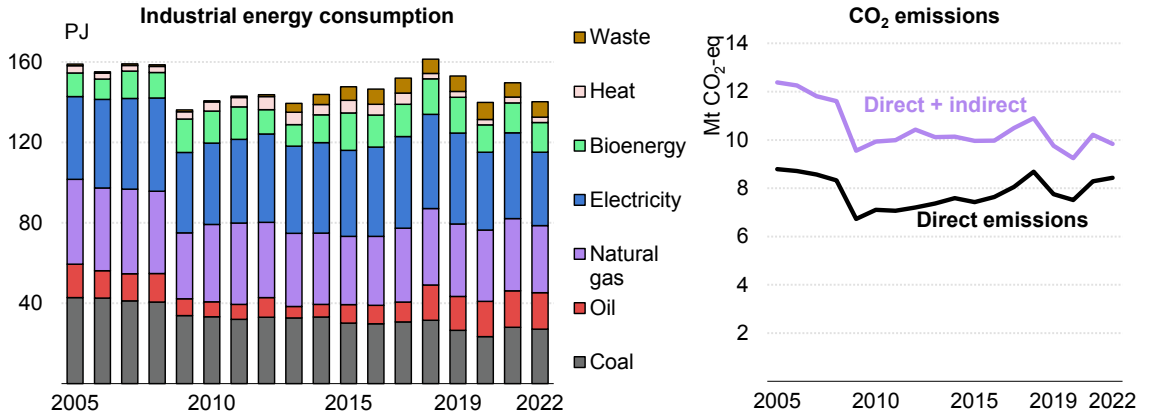
Industry

Industrial decarbonisation is critical to a successful energy transition

The Slovak Republic has a large and energy-intensive industry sector which accounted for 32% of gross domestic product and 34% of TFEC in 2022. Overall, the industry sector's energy consumption has been on a declining trend since 2000 though it has fluctuated in line with the economic shocks driven by the financial crisis of 2008-09 and the Covid-19 crisis of 2020 and partly due to structural factors.

More than half of the sectors' TFEC (56%) in 2022 was met by fossil fuels, with a share of coal equal to 19% (Figure 2.4). Renewable sources, mostly in the form of bioenergy, accounted for less than 11% in the same year.

Figure 2.4 Energy demand and emissions from industry in the Slovak Republic, 2005-2022



Note: Indirect emissions are emissions deriving from the generation of electricity and heat which then are consumed by end-use sectors (from IEA [2023], Database documentation).
Sources: IEA (2024), World Energy Balances (database); IEA (2024), Greenhouse Gas Emissions from Energy (database).

The energy intensity of the industry sector declined by 47% from 2005 to 2022. The reduction is the result of industrial restructuring and the shift towards lower energy-intensive production processes, including the adoption of more energy-efficient technology, process optimisation and modifications to the kinds of products that are made. Yet, the energy intensity of industry in the Slovak Republic is the seventh-highest among IEA countries, as the bulk of the manufacturing industry is the metal industry (mainly iron and steel, accounting for 54% of the demand in 2022).

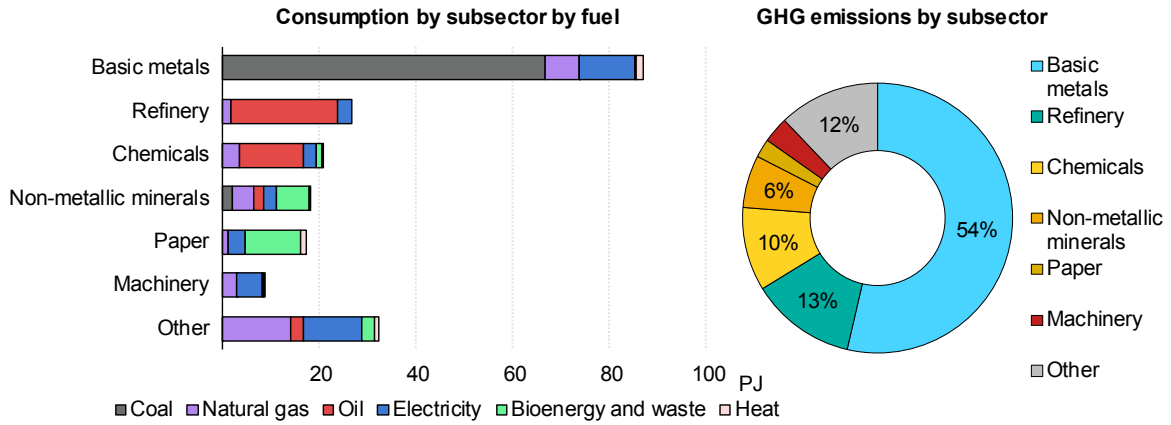
The record energy prices in 2022 due to Russia's invasion of Ukraine forced some industries to stop production partially or even fully. This is a clear indication of the sector's vulnerability to energy price shocks, which should increase the incentives for energy efficiency improvements, fuel switching and the introduction of advanced technologies.

The main industry subsectors in the Slovak Republic are metals, refined petroleum products, chemicals, minerals and paper (Figure 2.5). While coal dominates basic metal, refined petroleum and chemical products have large shares of oil.

In 2022, the industry sector accounted for 29.5% of energy-related GHG emissions in the Slovak Republic. When including indirect emissions from electricity and heat used in the sector, the share rises to 36%. More than two-thirds of industrial emissions are covered by the EU ETS, meaning they will have to decarbonise in accordance with the declining number of EU ETS certificates issued. If industry under the EU ETS fails to decarbonise, they risk having to close operations before 2050. Since 2005, energy-related emissions from industry have declined by approximately 24%.

The Slovak Republic has not set an emissions reduction or energy efficiency target for the industry sector. However, in the draft updated NECP, the government noted that it is considering setting a target to limit the emissions increase from industrial processes and solvent use to no more than 40% by 2030 compared to 2005 for those industries outside of the EU ETS.

Figure 2.5 Energy consumption by source and emissions of the main industry subsectors in the Slovak Republic, 2022



Source: IEA (2024), Energy End-uses and Efficiency Indicators (database).

Investment support for the industrial transition

The RRP includes a dedicated call for industries under the EU ETS to enable the large-scale transformation to decarbonise the iron and steel sector. The call offers financial support for the installation of modern technologies and the upgrade of existing energy-intensive industrial processes, following the Best Available Technology principle. Participation in the aid scheme is granted under the condition that it results in GHG reductions of at least 30%, compared to the reference scenario. The government originally expected an annual reduction of 1.23 Mt CO_2-eq through the programme. An early assessment of the three successful bids anticipates a possible emissions reduction of over 3 Mt CO_2-eq annually, even though none of the projects has entered operation yet. The Modernisation Fund includes a similar call for industrial decarbonisation projects under which seven projects were successful, with an expected reduction of 3.2 Mt CO_2-eq annually once all bids are fully implemented.

The main beneficiary under the bids of both the RRP and the Modernisation Fund is the country's largest steel company, US Steel Košice[5] (USSK). The company will receive EUR 300 million from the RRP to support its plans to close two out of three blast furnaces and to install two new electric arc furnaces using scrap thereby eliminating pig iron production.

Should the plan be carried out, along with other small projects, by 2026 CO_2-eq emissions will drastically drop by around 3 Mt CO_2, which corresponds to 36% of energy-related GHG emissions of the industry sector in 2022, or 7% of total GHG emissions in 2021. It will also reduce coke and iron ore import dependence.

USSK will receive another EUR 300 million from the Modernisation Fund for environmentally sustainable processing of liquid steel by thin strip casting with expectations of similar emissions reductions. As of early 2024, the project has not proceeded, and the government is encouraged to closely liaise with USSK and the Nippon Steel Corporation to ensure the decarbonisation of the steel sector proceeds as anticipated.

Better use of data to exploit the energy efficiency potential

The Slovak Republic has adopted the energy efficiency first principle as a key element in ensuring the green transition of its economy with a special focus on the industrial sector. Several national programmes are in place under the management of the Slovak Innovation and Energy Agency (SIEA). Ensuring and

[5] Nippon Steel is in negotiations to take over USSK by the end of 2024.

expanding these programmes is critical if the Slovak economy is to become more energy efficient and less carbon-intensive.

Since 2014, all large companies are subject to regular energy audits in accordance with the EED. The basic energy audit data need to be notified to the EEMS. The Slovak Republic is currently in the process of evolving the existing system into a more comprehensive Information System of Energy Efficiency to close the identified gaps in the collection of energy efficiency data with the aim to better inform policy making, enhance reporting on energy savings and better design efficient financing measures for energy efficiency improvements.

The Information System of Energy Efficiency's coverage extends beyond the industrial sector. However, it offers enormous potential for the industry sector through the creation of a national register of energy audits which will provide the government and industry with full and detailed results of the energy audits conducted and will hence enable industry and businesses to identify further energy savings. The government also plans to use the data collected for a comprehensive overview of the potential impact of measures and their cost-effectiveness, and to identify the financing needs to support large but also small and medium-sized enterprises (SMEs), and companies with high and low energy consumption. This, in turn, will help inform the design of new and better targeted support programmes of SIEA and facilitate monitoring. The IEA welcomes this important initiative and congratulates the government for having embarked on this comprehensive project, which will not only benefit the Slovak Republic but also the IEA by providing enhanced and more complete data.

Currently, companies are not required to implement the audit results, although the government provides funding support for those companies interested in enhancing their energy efficiency. Since 2020, SIEA is implementing the Program Slovakia, offering measures to support energy efficiency improvements, the use of renewables and the development of intelligent energy systems. For the industry sector, the programme supports measures to improve the efficiency of energy-consuming equipment and existing equipment used to produce electricity, heat and cooling if those were recommended in an energy audit. The government should also increase requirements on industry to implement the findings of the energy audits, which is a common practice in other IEA member countries. For example, the Netherlands' Energy Saving Obligation requires companies with high energy demand to implement measures with a payback period of five years or less. The government may like to study the approach taken by Hungary, which introduced a corporate tax incentive for the implementation and operation of investments aimed at energy efficiency under certain conditions.

Availability of the full set of data on energy efficiency potential in industry could enable new and innovative companies to establish a business providing energy

savings to other companies. This could be especially beneficial for energy suppliers or distribution system operators (DSOs) as they could invest in energy savings in a firm instead of primarily expanding the grid connections. The experiences made in Denmark show how full data availability contributed to the creation of a competitive ESCO market.

The government is already providing support to promote energy audits in SMEs and makes funding available for the implementation of identified measures as part of the EU Leap4SME programme. A commendable initiative has been the organisation of information workshops bringing together policy makers and stakeholders to identify the special needs and barriers for energy audits in SMEs and the subsequent preparation of an illustrative information energy audit guide. In Sweden, SME audits include energy mapping proposals for energy efficiency measures and an energy plan with financial and technical support provided to guide SMEs in performing the audits and implementing the identified measures.

Innovation to support industrial transition

Developing and implementing innovative solutions to reduce energy consumption, especially of fossil fuels, and emissions in the industry sector is a priority of the government. The Smart Specialisation Strategy (RIS3) focuses on the transformation of industrial production to reduce the negative impacts of industrial activity on the environment.

To ensure economic growth and increased economic competitiveness of the country, the government is supporting a wide range of research to facilitate innovation for industrial activities. This is a worthy aim as the current industrial structure of the Slovak Republic is not well prepared for the green transition, which will also entail digitalisation and automation. However, the Slovak Republic has not set targets for energy spending in research and innovation; instead, research priorities are guided by a generic goal within the RIS3 Smart Specialisation Strategy. The government should explore ways to create a supportive environment for public-private partnerships in relevant research areas and to increase private spending on research, development and innovation, as this will also benefit the local research community and the Slovak economy overall. The government may like to study the measures taken by Austria and Korea, both countries with a particularly good track record of public-private research, development and innovation co-operation.

Improving industry performance by means of energy efficiency networks

There are currently over 1 000 industrial energy efficiency networks (EENs) in operation globally. These EENs can lead to increased energy efficiency savings

in participating companies, reduced energy intensity of the industrial sector and lower GHG emissions. Establishing and operating an industrial EEN could prove to be a very effective mechanism by which the Slovak government could work with, and support industry in increasing its energy efficiency, improving its competitiveness and moving to the forefront in terms of innovation.

Industrial EENs generally consist of a group of energy managers from different industrial sites that meet regularly to share knowledge and experience on improving energy efficiency in the sector. These networks act to guide industries in becoming more efficient, in line with government policies, and to improve government insight into industry for more effective policy development. In 2014, for example, Germany introduced the Energy Efficiency and Climate Protection Networks Initiative as a voluntary measure.

To date, over 250 EENs are registered under this programme, with more than 2 000 participating industries. The networks report exceeding their savings targets by over 10%. After three to four years, participating companies improved their energy efficiency significantly more than the industry average, reduced their GHG emissions and increased their energy productivity twice as fast as the industry average. Other examples include Ireland's Large Industry Energy Network, the People's Republic of China's Sino-German Energy Efficiency and Climate Network, and Brazil's Energy Efficiency Learning Networks.

Industry and grid flexibility

The low-carbon transition of the industry sector requires greater electrification, as electricity is to be used throughout the sector. The electricity system will need to deliver reliable and low-carbon electricity (see Chapter 3). The Slovak Republic is in a good position of having a largely decarbonised electricity mix, which could also strengthen its attractiveness for industrial investors. Beyond ensuring continuous low-carbon generation, however, the transmission and distribution system must also be sufficiently robust and flexible to accommodate the anticipated load.

For this, the Slovak Republic should identify possible areas in the electricity system where there is sufficient grid capacity for new connections. This would enable industry to invest in energy parks with solar PVs and/or wind turbines. One possibility would be to explore existing networks, so-called brownfield sites that were previously developed and which already have the necessary infrastructure in place, such as the sites of the coal-fired power plants that are being phased out. This could reduce costs and avoid having to convert sites that have not previously been used. The United States is providing special tax exemptions for industry to convert existing brownfield sites under certain conditions within the framework of

the Inflation Reduction Act. Several countries, including Austria and Denmark, have published maps showing the availability for grid connections, specifically for solar PV in the case of Austria.

While waiting for public investment in the electricity grid to catch up with growing demand, the industry could also consider innovative solutions such as off-grid energy parks with solar PV and/or wind turbines in combination with heat pumps or electrolysers. This will enable companies to start investing in their own supply of process heat or green hydrogen, which are essential for the green transition of the industry sector, especially in hard-to-abate sectors. However, these off-grid parks could still maintain the potential to provide ancillary services and flexibility to the grid if needed. A good example is the chemical company Duslo Sala, which in late 2023 signed an agreement with the EU Modernisation Fund for a state subsidy of EUR 58 million to build a wind and solar park, battery storage facilities, and an electrolyser for green hydrogen production. The hydrogen will be used for fertiliser production.

Some IEA countries are moving ahead with this approach, also with a view to optimise spatial and network planning. For example, Ireland launched a consultation on the role private wires can play in the future electricity system with a view to design a dedicated policy on the topic in 2024. In Czechia, a large industrial developer has launched an initiative to convert a large industrial park into an off-grid energy park and, while becoming independent from the grid, it will still be in a position to supply to the surrounding grids when called upon.

Ensuring the availability of low-emissions gases and critical materials

Natural gas will continue to be an essential part of the Slovak Republic's energy mix, especially in the hard-to-abate industry sectors. The Slovak Republic has ambitions to increase the use of low-emissions gases, but the quantity needed in industry for the clean energy transition requires more than ambition. The initiation of a national register of renewable gases in 2022 is an important and welcome step. The IEA also welcomes the provision for developing a biomethane roadmap in the RRP and encourages the government to accelerate its preparation. The roadmap should also address matters such as ensuring long-term financial support and overcoming any legal and regulatory barriers.

All gas consumers can benefit from the acceleration in the production of biogas. Biogas can be used directly for heat and/or electricity production or it can be upgraded to biomethane and either injected into the extensive national gas grid or used in transport. The production of biogas not only reduces emissions from the abated natural gas consumption, but also from waste management and is an important part of the pathway to net zero, especially in heavily industrialised

economies such as the Slovak Republic. The government could join the IEA Bioenergy TCP that has a dedicated work stream on various options of how biogas and biomethane contribute towards a net zero future.

The government estimates the country's biomethane production potential to be at least 300 million m^3 annually by 2030 and sees the main application in transport and high-efficiency co-generation. It is now important to set out an investment pathway on how to realise this potential. Firm plans to produce around 30 million m^3 of biomethane production annually exist and are intended primarily for use in transport. The government expects that some of the existing biogas plants may be converted for the use of biomethane production after their guaranteed feed-in tariff for electricity supply expires. Since 2021, one converted biogas station, Jelšava III, is producing biomethane with a capacity of between 300 to 600 m^3 per hour, which is fed into the gas grid. Waste company Brantner has initiated a programme to convert part of its waste into biomethane, which will then be fed into high-heat stoves for cement production. It also created a joint venture in 2023 with Slovak energy supplier SPP to establish three regional centres of energy and biological waste recovery; however, details about the expected annual production of biomethane are not yet available.

The Slovak Republic has a long-standing mining tradition which it should leverage for the green transition of its industry sector and beyond. Today, the country is a significant producer of magnesite and magnesium compounds. Critical materials, essential for a range of clean energy technologies, have become more prominent in the policy and business agenda in recent years.

The Slovak Republic has been researching the potential of mining for critical raw materials for several years but has yet to start the mining of such materials. Several geological studies have been conducted. There are plans to map the needs of the Slovak industry for critical materials along with estimates of primary and secondary reserves and subsequently combine them in a national critical materials strategy. This will help the Slovak Republic be at the forefront of the green transition and aid in attracting companies to invest in the country. The IEA encourages the government to proceed with these plans swiftly and to benefit from the work already undertaken by other countries in this area.

Recommendations

The government of the Slovak Republic should:

- Continue to decarbonise hard-to-abate sectors (e.g. steel, chemical) as planned and strengthen the assessment of the supply chain for all materials needed in the transition.
- With the industry sector, explore the possibility of introducing industrial energy efficiency networks in the Slovak Republic.

- Accelerate the roll-out of a database and monitoring system for energy audits to enable industry and businesses to identify potential energy savings.
- Accelerate the work on a critical mineral strategy to future-proof the industry sector in light of its importance for the creation of a competitive low-carbon economy.
- Set up long-term support for increasing the proportion of low-emissions gases to enable continued consumption of gas in the hard-to-abate sectors, including industry.
- Explore the potential for creating off-grid energy parks using renewable energy sources for hard-to-abate industries.
- Create framework conditions to incentivise research activities, attract private investments and strengthen public-private partnerships.

Transport

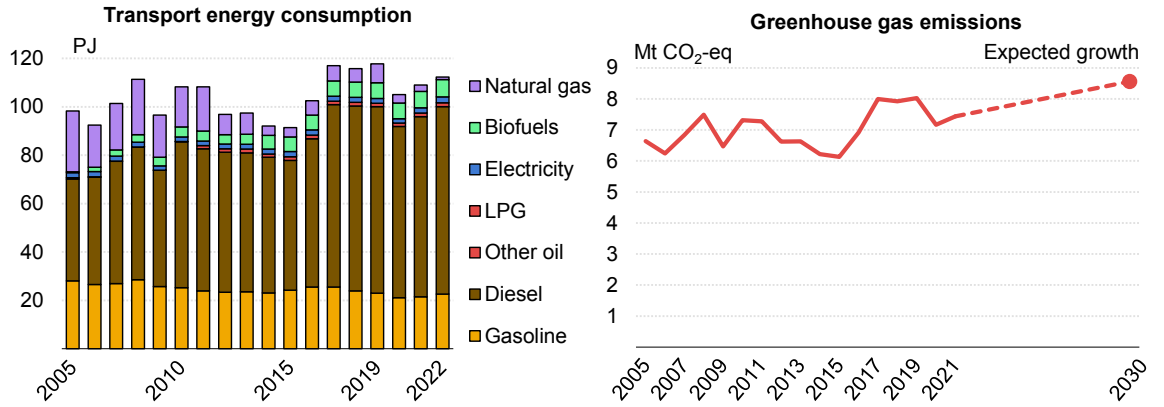
Road transport emissions continue to grow as car ownership becomes more prevalent

The transport sector is the only end-use sector where emissions are expected to grow towards 2030. Transport emissions accounted for 27% of the Slovak Republic's energy-related emissions in 2022, mostly because of road transport CO_2 emissions (97% of domestic transport emissions). Overall transport emissions grew 15% from 2005 to 2022. While emissions from the transport sector fall under the Effort-Sharing Regulation, with an overall reduction target of 22.7% by 2030, the draft updated NECP states that the goal for the road transport sector's emissions is to only limit its growth to 29% by 2030, compared to 2005.

One reason fossil fuel consumption and emissions have been growing is that the car fleet has been expanding. While the Slovak Republic still has a low number of cars per 1 000 inhabitants compared to the EU average (501 versus 574 in 2022), the sale of new cars is significantly lower than the increase in the fleet size, as most of the fleet growth consists of imports of second hand cars, especially from Western European countries. The fleet of privately owned cars grew by 17% from 2018 to 2022, while the EU average in the same period was 5.5%. While imported second hand vehicles usually replace even older and more inefficient vehicles, the Slovak Republic's vehicle fleet remains relatively old and thus less energy efficient than the EU average. Furthermore, the second hand market is not subjected to EU CO_2 emissions standards for cars and vans, which apply only to new vehicles. Hence, a scrappage scheme that encourages the replacement of old vehicles with new and more efficient vehicles could be an effective mechanism to reduce overall vehicle emissions. France and Italy introduced grants for the purchase of new or used electric cars, complemented with a bonus for scrapping old vehicles. France provides an extra bonus for low-income individuals. Lithuania distributes grants for the purchase of electric bicycles in exchange of old cars. Additionally, the import of old and inefficient cars could be limited with targeted measures based on environmental performance standards or by following the model of several EU countries, including Denmark, Poland, Spain and Sweden on taxing imports from outside the European Union.

In 2022, over 90% of transport TFEC came from oil products and 65% of oil products demand comes from the transport sector. Therefore, the decarbonisation of the sector can help meet the climate goals and reduce fossil fuel import dependency (almost 100% of crude oil imports come from Russia).

Figure 2.6 Transport sector energy demand and emissions in the Slovak Republic, 2005-2021 and 2030 projection



Note: LPG = liquefied petroleum gas.
Sources: IEA (2024), World Energy Balances (database).; IEA (2024), Greenhouse Gas Emissions from Energy (database).

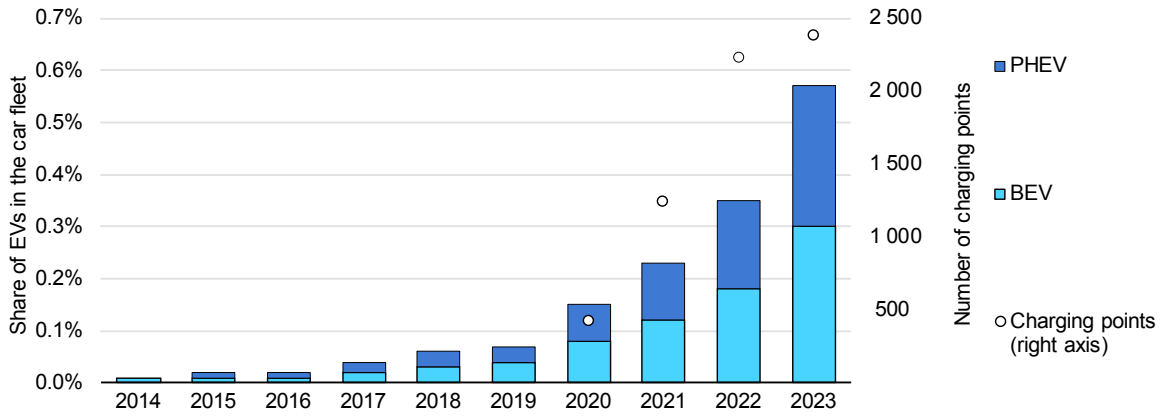
Under the European Union's Clean Vehicles Directive, the Slovak Republic aims to achieve a 100% CO_2 reduction for new light-duty vehicles by 2035, as well as a 15% reduction for heavy-duty vehicles by 2025 and 30% in 2030 compared to the EU average. However, the targets have not been transposed into national law.

Electrification reduces emissions and air pollution

Supporting the uptake of zero-emissions vehicles while addressing the high level of imports of used cars could contribute to decarbonising the ageing car fleet. The Slovak Republic's low-carbon electricity mix is an incentive to electrify road transport and reduce overall emissions. In addition, given its role in the European Union's car manufacturing industry, the Slovak Republic could leverage vehicle electrification commitments from manufacturers such as Volkswagen and Stellantis to clean up the domestic car fleet.

The electric passenger car fleet, although still limited to less than 0.6% of all cars (vs. the EU average of 3.8%), has been expanding over the years (Figure 2.7). The number of electric vehicles (EVs) in the Slovak Republic grew from 50 in 2013 to over 15 000 in 2023. In the same year, EVs reached 6.1% of new sales (compared to the EU average of 22%). The government forecasts that in 2025 the share of battery electric vehicle (BEV) sales will be 10% and the share of BEVs in the overall fleet will be 1.4%. By 2030, the government expects the fleet of electric cars (BEVs only) to be 56 000, representing almost 40% of sales and almost 7% of the on-road fleet. Today, almost half of the EV fleet is located in the area of Bratislava, given that the capital benefits from a widespread charging infrastructure and the greater purchasing power and level of acceptance of consumers.

Figure 2.7 Total share of electric vehicle fleet and charging points in the Slovak Republic, 2014-2023



Notes: PHEV = plug-in hybrid electric vehicle. Data for the number of charging points are not available before 2020.
Source: European Alternative Fuels Observatory (2024), Slovakia.

Sales of EVs were supported by a scheme funded jointly by the government and the Automotive Industry Association of the Slovak Republic, which provided up to EUR 5 000 for BEVs and EUR 3 000 for PHEVs. The subsidy was phased out in 2020, despite the low market share of EVs. In 2022, the government approved the Action Plan for the Development of Electromobility, an update from the 2019 version. The Action Plan outlines a series of financial, legislative and supportive measures that aim to increase the sales of zero- and low-emission vehicles in support of climate targets.

The government is considering reintroducing subsidies for EV purchases in July 2024. Currently, Slovak legislation only provides tax benefits by limiting the registration fee for the purchase of EVs: for BEVs it is limited to EUR 33 (whereas conventional cars could be subjected to a fee of up to EUR 3 900); for PHEVs it is discounted by 50%. The government could consider introducing an annual vehicle tax to provide price signals to consumers, guiding them to purchase zero- and low-emission cars. This can be achieved by linking the tax to emission levels and energy efficiency standards, including the vehicle's environmental impact, as most EU countries do. No incentives are in place for the purchase of EVs or for the development of the infrastructure.

One barrier to the uptake of EVs is their affordability, as the uptake of EVs is related to income. To make EVs accessible to lower income consumers, Hungary introduced EV incentives for cars under a given price in 2020. While incentivising the purchase of cheaper EVs, the measure contributed to push car manufacturers to reduce the price of more expensive cars, aligning them to the price cap, to be eligible for the subsidy. The government should consider introducing incentives for company cars, which represent a sizeable share of the car fleet. Portugal

introduced value-added tax deductions for BEV and PHEV company cars; Denmark offered reduced rates and tax-free charging at work from 2023 to 2026.

To enable further adoption of EVs, the government is supporting the roll-out of charging infrastructure. At the end of 2023, the EV public charging infrastructure comprised around 2 400 units; around six electric cars per public recharging point, which is above the EU average of around 13.

Funding to expand the public charging infrastructure across the country to over 6 000 charging points by 2026 is available through the RRP. Of these, 300 units will be ultra-fast chargers with a capacity of 150 kilowatts (kW) or more. Private charging is more common than public charging, accounting for around 80% of charging, but in 2022 half of the population was said not to have access to home charging. Hence, the government is considering introducing subsidies for non-public charging points. The government is also working on the framework for charging company vehicles at home and charging private cars at work.

There are no regulatory standards in place for the charging infrastructure, even though it is possible to set such standards according to EU guidelines. The government should introduce a regulation on the technology used for plug standards, smart charging and payment solutions to avoid monopoly formation and parallel infrastructure.

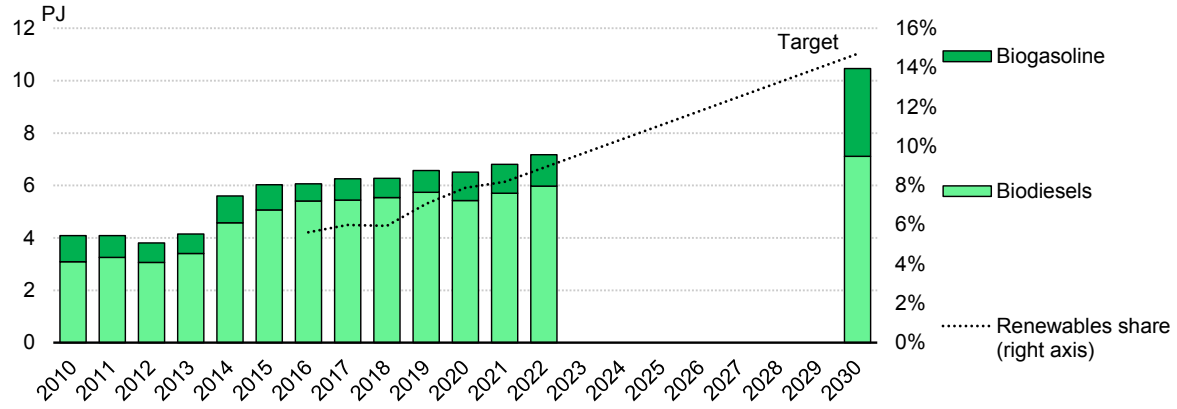
Electrification of heavy-duty vehicles (HDV) will also be important for decarbonising road transport, as HDV accounted for 94% of freight transport emissions in 2019. This may require even more government support because the price difference between internal combustion and electric HDVs and charging challenges are more substantial. In 2024, the European Union reached an agreement to strengthen emissions standards for trucks and urban buses, up to 45% for 2030-34, 65% in 2035-39 and 90% as of 2040. The average age of the Slovak Republic's fleet of trucks/HDVs is higher than the EU average (14 years). There are EU CO_2 emission performance standards for HDVs, but there is no strategy for the direction the Slovak Republic wishes to go. A strategy is needed to build sufficient infrastructure and avoid misdirecting investments. Some other EU countries, like Austria, offer purchase subsidies, depending on the vehicle class. Low- and zero-emission zones in cities have been used (e.g. London and Madrid) to require low-emission vehicles. This measure will benefit the air quality in population centres such as Žilina, Prešov or Bratislava.

Biofuels and alternative fuels

Meeting EU renewables targets in the transport sector can help the Slovak Republic abate transport GHG emissions and reduce dependency from imported fossil fuels, enhancing energy security. In 2022, biodiesel accounted for 5.3% of TFEC and biogasoline for 1.1% TFEC. The government targets a 14.7%

share of renewables in transport by 2030 (from 6.4% in 2022) (Figure 2.8). Special emphasis is placed on advanced biofuels and renewable fuels from non-biological sources. In 2017, the Slovak Republic became the first government in Central and Eastern Europe to introduce a liquid biofuels blending obligation, equal to 6.9% for biodiesel and 9% of a bioethanol component for gasoline. The overall target is 8.8% in 2024, and is set to reach 11.4% in 2030, including at least 3.5% from advanced biofuels. The existing biofuel blending mandates alone do not fulfil the renewables targets in the transport sector; however, given the country's low-carbon electricity mix, electric mobility will also contribute to the share of renewables in transport.

Figure 2.8 Share of renewables in the transport sector (2010-2022) and target (2030) in the Slovak Republic



Sources: IEA (2024), World Energy Balances (database); Slovak Republic, Ministry of Economy (2023), Draft updated NECP.

Fuel cell vehicles are also considered in the country's decarbonisation strategy, with the development of the hydrogen infrastructure that would primarily serve long-distance transport. Three hydrogen refuelling stations are expected to be developed by 2026. LPG vehicles are also expanding, with almost 50 000 units sold from 2009 to 2023, accounting for 1.8% of the total fleet in 2023. The Slovak Republic aims to increase the use of gas vehicles (compressed natural gas and liquefied natural gas [LNG]), especially for HDVs, and increase the blending of biomethane. However, no clear strategy for increased production of biomethane seems to be in place. These alternative fuels are not expected to make a substantial impact on transport decarbonisation.

Modal shift to reduce private car journeys

A key element of transport policy in the Slovak Republic is a shift away from private cars to other forms of transport. To shift demand from private vehicles, the country is reviving its public transport infrastructure. Funds under the RRP were allocated

to strengthen the railway network, by modernising the railway lines and refurbishing older lines. Under the Connecting Europe Facility 2017-2027, EUR 584.7 million is allocated for cross-border railway modernisation, alternative fuels and related infrastructure development.

To encourage modal shift, building park-and-ride areas near railway stations and terminals and creating integrated transport terminals linking buses and trains provides commuters with convenient options and reduces vehicle city traffic. However, rail services are not available throughout the country and there are no dedicated bus services linked to train stations to facilitate modal shift between cities. Given the popularity of cycling, the Slovak Republic aims to build 161.8 km of cycling infrastructure by 2026 to support bicycle transport and bike tourism.

The promotion of multi-modal transport of goods towards 2030 was outlined in the Concept of the Development of Intermodal Transport, aiming to boost eco-friendly intermodal transport by shifting from road transport to cleaner, more efficient and safer ways of transporting goods. Intermodal transport is financed through the RRP as well. However, the draft updated NECP does not provide any indication on the expected benefits or how the modal shift is supposed to be carried out, especially when it comes to road freight transportation and here especially addressing issues linked to the Slovak Republic being a major transit country.

Recommendations

The government of the Slovak Republic should:

- Introduce a scrapping scheme for the most polluting vehicles in the country, providing an incentive to replace old and inefficient vehicles with cleaner more efficient ones.
- Redesign the registration tax and introduce an annual vehicle tax on cars based on CO_2 emissions with the primary goal of influencing consumers' behaviour towards zero- and low-emission cars. This should be extended to road freight transportation transiting the country.
- Introduce regulations to standardise publicly accessible electric vehicle chargers. Develop guidelines for plug standards and payment solutions and enforce them when making calls and tenders for charging infrastructure.
- Prepare a clear strategy for the clean energy transition of heavy-duty vehicles to secure sufficient infrastructure matching the technology expected to be dominant.
- Develop an integrated approach to address the growing share of freight transported by road, including those transiting the country.

3. Energy security

Energy infrastructure must be resilient and climate-proof

Along with sustainability and energy affordability, energy security is one of the pillars of the Slovak Republic's energy policy. Security encompasses several dimensions, among which are: electricity grid stability, climate change risks, the availability of water for nuclear and hydropower plants, and oil and natural gas imports.

To increase security in an increasingly electrified energy system, the Slovak Republic is developing projects to strengthen the digitalisation of regional electricity systems. Key projects in the Slovak Republic include the ACON (Again COnnected Networks) smart grid for the integration and digitalisation of the Czech and Slovak electricity markets. The Danube InGrid is another significant initiative to further strengthen the cross-border connection between the electricity markets of the Slovak Republic and Hungary. These connections address the capacity shortages in the power grids, particularly at the distribution level, and should facilitate the connection of the growing share of variable renewables (see electricity section below).

The Slovak Republic's electricity transmission system operator (SEPS) has not yet conducted a risk assessment for the implications of climate change on the electricity sector. Such an assessment would contribute to maintaining the power grid's resistance to potential climate change impacts. NPPs may be exposed to security risks due to scarce provision of cooling water, particularly with the operation of two additional units of the Mochovce NPP. However, there are no plans to resume the construction of the Slatinka water dam, which may have potentially helped to mitigate this risk.

As for hydropower, insufficient water levels could lead to a lack of production and flexibility for the overall electricity system. The Ipel' pumped storage plant, which accounted for 8% of installed capacity in 2021, may be potentially impacted. High water levels and sedimentation are already causing problems for the Váh River dam chain. These issues might prevent the Slovak Republic from benefiting from up to 1 000 MWh of daily flexibility that is offered by the country's hydro portfolio. These potential risks emphasise the necessity of strong back-up plans and flexible policies. Environmental risks need to be addressed proactively to ensure the continuous availability of hydropower.

Russia's invasion of Ukraine has exposed most European countries to a major security risk in terms of natural gas supply. The IEA commends the Slovak Republic for having diversified its gas supply early, which creates the framework for reducing its dependency on direct Russian gas supplies. However, further efforts are needed (see gas section below).

The Slovak Republic remains very reliant on Russia for oil imports. IEA data show the Slovak Republic imported about 80% of its crude oil from Russia in 2023. The Slovak Republic was granted an EU exemption that allowed it to keep buying Russian crude oil until December 2023. In December 2023, the European Union adopted its 12th package of sanctions against Russia, which provides an extension on exporting fuels produced from Russian oil to Czechia. This means that the Slovak Republic was also given an extra year to continue its exports to Czechia. Without this exemption, the only refinery in the Slovak Republic would have lost its ability to export to Czechia. In 2023, the Slovak Republic exported about 9 thousand barrels per day (kb/d) of fuels to Czechia. An extension of the EU exemption beyond the December 2023 deadline is currently being discussed. As for oil products, only 1.2 kb/d of petroleum products were imported from Russia in 2020 and 0.2 kb/d in 2022. The Slovak Republic has one refinery, Slovnaft, the output of which is higher than the country's domestic demand of oil products, positioning the Slovak Republic as a net exporter of oil products to neighbouring countries.

Recommendations

The government of the Slovak Republic should:

- Request the transmission system operator to undertake a risk assessment for the implications of climate change on the electricity sector.
- Place a greater focus on climate proofing the electricity grid and other energy infrastructure to enhance the preparedness for extreme weather events.

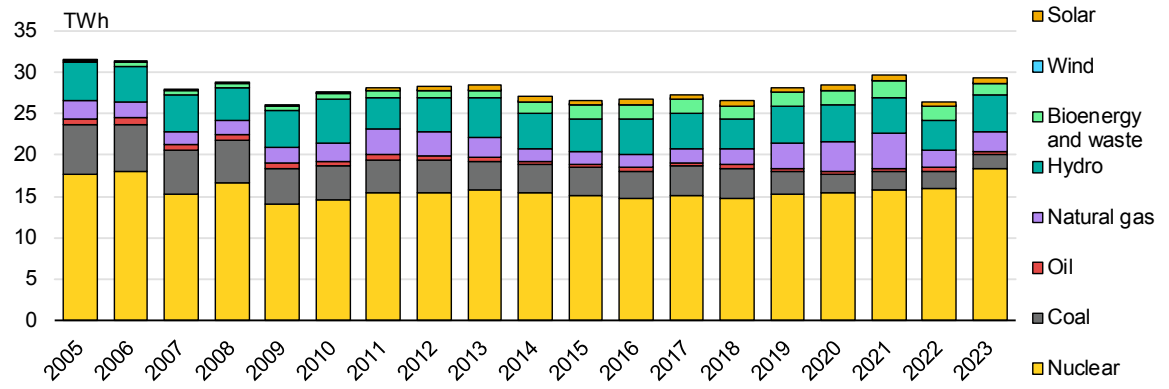
Electricity

The electricity sector will become less centralised

The Slovak Republic has a very high share of low-carbon electricity, at 85% in 2023, compared to an average of 50% for the IEA. Nuclear is the main source of electricity generation, accounting for 63% in 2023, followed by hydropower at 15%. Bioenergy and waste accounted for 4.7%, while solar and wind together accounted for around 2.1%. Fossil fuels only play a minor role in the country's electricity generation mix, at 15% in 2023 (Figure 3.1). The government is committed to maintaining, if not increasing, the dominant role of nuclear in the electricity sector with a view to the decarbonisation of the energy sector to 2050 (see nuclear section below). Nuclear is also expected to replace coal-fired generation, which has been phased out.

The share of coal in the electricity generation mix decreased from 19% in 2005 to around 6% in 2023. At the end of 2023, the 266 MW_e Nováky coal-fired power plant ceased operations. The last operating coal-fired power station, the 220 MW Vojany plant, is expected to cease operations by 2027. The Vojany plant has been co-firing biomass with coal since 2009. With these changes, the government will have taken a huge step towards its 2030 decarbonisation goals. Since 2018, the share of natural gas-fired generation has increased to compensate for reduced coal-fired generation but fell strongly in 2022 owing to the natural gas price hike that followed Russia's invasion of Ukraine.

Figure 3.1 Electricity generation by source in the Slovak Republic, 2005-2023

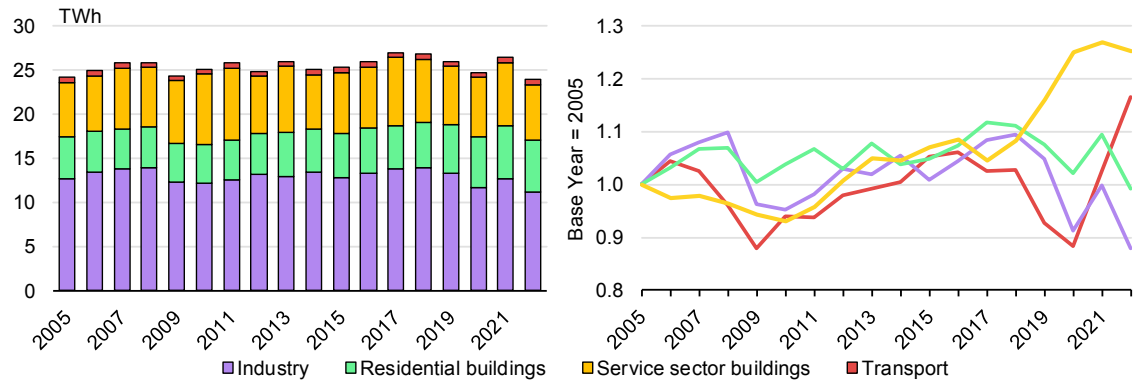


Source: IEA (2023), Electricity Information (database).

The Slovak Republic is a net importer of electricity, albeit averaging only about 2% of total consumption. The government hopes the country will become self-sufficient and eventually a net exporter of electricity once the nuclear unit currently under construction becomes operational.

Since 2020, the buildings sector has accounted for half of total electricity consumption while demand in the industry sector has fallen under 50% for the first time since 2011. The share of the transport sector is marginal but increased from the 2% in the period 2005-21 to 3% in 2022. Total electricity demand decreased by 9% in 2022 compared to 2021, as high energy prices forced several large industrial installations to reduce their consumption. Some industries, such as SLOVALCO, the country's largest aluminium producer, stopped primary production entirely in September 2022. Total electricity demand fell even further in 2023.

Figure 3.2 Electricity demand by sector and sector electricity demand trends in the Slovak Republic, 2005-2022



IEA. CC BY 4.0

Source: IEA (2024), Electricity Information (database).

Looking to the future, electricity demand is not expected to recover from its 2021 levels before 2030 and is likely to increase only in the period after 2030. The electricity transmission system operator (TSO) SEPS analysed three scenarios reflecting the path of electrification of the energy system (Table 3.1).

Table 3.1 Electricity demand scenarios in TWh in 2030, 2035 and 2040

Scenarios	2030	2035	2040
Expected	30.9	33.4	36.5
Electrification	34.2	38.5	43.1
High electrification	36.9	42.5	48.7

Source: SEPS (2023), Midterm Adequacy Forecast.

Key drivers of demand are: projected increases in electromobility after 2035; a faster transition to decentralised heat supply; the installation of heat pumps, including for large, industrial consumers; new investments in energy-intensive industries (e.g. production of batteries for electric cars); and significant decarbonisation along with demand growth in energy-intensive industries, especially USSK and Duslo Šaľa. This demand forecast assumes that industries which reduced electricity consumption sharply during the high price environment in 2022, will not regain their original consumption level.

A 2023 study by SEPS shows that the Sovak Republic could encounter a shortage of generation capacity if the electrification of the energy sector proceeds faster than expected. This shortage would increase over the period to 2040 and the country would become more import-dependent instead of becoming a net exporter, as aspired by the government.

The Slovak Republic does not have an officially specified reliability standard for its electricity system. Instead, SEPS selects from a set of internationally recognised standards when undertaking its assessment of resource adequacy for illustrative purposes only. The IEA supports SEPS' assessment in its 2023 study that when assessing the country's move towards electrification of the energy system and the increasing share of variable renewables, it would be necessary to establish an official reliability standard. Regular assessments of resource adequacy will also be required given the country's high level of interconnection. It will also be important to clearly assign responsibility in the case of low levels of reliability to specified power sector entities.

The Slovak electricity sector, therefore, requires additional capacity investments beyond the planned expansion of NPPs to meet projected electricity demand in the coming years as well as to provide support to its neighbour, Ukraine. Meeting expected future electricity demand will not only require additional generation capacity but also the expansion of the transmission and distributions systems; the introduction of more system flexibility options and business models; digitalisation; and maintaining, if not further increasing, the already high interconnection ratio with neighbouring countries.

Renewables have a large growth potential

The share of renewables in the Slovak Republic's electricity mix remained constant from 2013 until 2021 despite the country's large identified untapped renewable potential.

Hydropower, both run-of-river and pumped hydro, dominates renewable electricity generation, accounting for an average of about 15% of generation from 2005 to 2022 (see Figure 3.1) However, hydro production fluctuates notably year-on-year depending on water availability. According to the draft updated NECP, hydropower

has further untapped potential. For example, the Sered' hydro plant project aims at exploiting the untapped energy potential in the Sereď-Hlohovec section of the Váh River for electricity generation of around 180 gigawatt hours (GWh) per year. The Ipeľ pumped hydropower plant could add another 600 MW of capacity while also providing a range of ancillary services (see section below). The present status of the Ipel' plant is unclear.

There is, however, insufficient public support for more hydropower installations and given the long gestation period, it is difficult to finance large hydro plants. Consequently, in its 2023 generation adequacy assessment, SEPS does not assume the addition of any additional hydropower in the period to 2040 under the current framework conditions.

Further renewable growth will, therefore, come mainly from solar PV and wind, waste, and bioenergy. In 2021, the Slovak Republic only had five operational wind turbines, with a total capacity of 3 MW, which provided 0.01% of total electricity generation. The draft updated NECP indicates that to achieve its 2030 targets, the Slovak Republic needs to increase installed wind capacity to 150 MW in 2025 and 750 MW in 2030. Solar PV capacity will need to increase from 850 MW in 2023 to 1 400 MW in 2030. In addition, 4 MW of geothermal capacity would be installed by 2030 while there is no geothermal capacity in place now (Table 3.2). When measured against the baseline of 2023, while these are ambitious targets, it will be important to put all necessary supporting measures into place to facilitate the expected capacity build-out.

The Slovak Republic regards biomass and waste as the most cost-effective domestic renewable energy sources and strongly supports their utilisation in heating. The use of biomass and biogas from organic wastes or non-recyclable products for electricity generation could enhance the contribution of renewables and the diversification of electricity supply. However, the draft updated NECP does not foresee the installed capacity of solid biomass increasing beyond 200 MW in 2023. It does, however, expect biogas and biomethane to increase from 95 MW of installed capacity in 2023 to 200 MW in 2030.

Table 3.2 Installed renewable capacity in MW in 2023 and targets for 2025 and 2030

Installed capacity	2023	2025	2030
Solar PV	850	1 050	1 400
Wind	3	150	750
Biomass	200	200	200
Geothermal		4	

Source: Slovak Republic, Ministry of Economy (2023), Draft updated NECP.

A broad set of policy measures is necessary to support the development of renewable energy sources for electricity generation, such as the preparation and publication of a high-level country map of solar PV and wind potential. Reforms to the distribution connection policy and investment in distribution networks will also support the further development of renewable energy. The introduction of new incentive mechanisms, such as auctions rather than power purchase agreements or feed-in tariffs, would also help the transition to a cleaner electricity system and for improving electricity system flexibility.

First steps have already been taken. In 2013, all DSOs stopped enabling distribution and transmission grid connection from any kind of generating capacity of more than 10 kW owing to concerns over grid stability and security of supply. At the end of 2020, this connection moratorium was repealed and new connections, for all types of generation capacity, are again possible. Since then, installed solar PV capacity increased to 531 MW in 2020 and 850 MW at the end of 2023 (see section on interconnection below).

While shortages of transmission capacity were remedied by the addition of more cross-border transmission lines, the distribution grid is now experiencing localised deficiencies resulting from the connection of small renewable facilities (up to 10.8 kW) that tripled from 2020 to 2022. There is an urgent need to strengthen the distribution system in line with the expected increase of such facilities.

In July 2022, the Slovak Republic adopted a legislative amendment to the Energy Act and the Act on Regulation of Network Industries to transpose EU Directive 2019/944, part of the Clean Energy Package, to enable the non-discriminatory participation of renewable energy sources and the management of energy consumption and storage, including through aggregation, in all energy markets. The legislative amendment also allows for the creation of energy communities, community energy production from renewables, introduces the concept of active consumers and the framework for market participants providing storage and flexibility services with a view to increase the overall flexibility of the electricity system.

As part of the legislative amendments, the government also introduced a long-term auctioning plan for new renewable capacity and for high-efficiency co-generation through which it hopes to provide a long-term perspective for investors. The auction will be technology-open except for small hydropower installations, given the environmental concerns related to these. The government hopes that the auctions will achieve 120 MW of new renewable capacity by 2026 and a total of 500 MW of new capacity by 2030. Beyond support for new renewable sources, the legal framework will also provide the framework conditions for the repowering of 83 MW of existing renewable and grid-connected capacity.

The Slovak Republic also adopted the secondary legislation that institutionalised the detailed electricity market rules which came into effect on 1 July 2023. Moreover, since 1 July 2024, the energy data centre, which aims to streamline and accelerate the access of new participants to the electricity market, is fully operational. The data centre facilitates contact management and provides a centralised overview of all products available in the Slovak electricity market, including electricity storage facilities. The IEA welcomes these initiatives and encourages the Slovak Republic to accelerate the implementation of the outstanding regulations.

The country is now preparing for the adoption of additional secondary and tertiary legislation to streamline and speed up the access of new participants to the electricity market by setting out technical conditions for access to the electricity system and the operating rules for the TSO and DSOs.

In response to the grid connection problems, in March 2023 the Regulatory Office for Network Industries adopted the new regulatory policy for the sixth regulatory period from 1 January 2023 to 31 December 2027. It seeks to promote dynamic pricing and the efficient use of distribution system capacity. The exact details of how this regulation will be put in place are unclear at this point.

Enhancing system flexibility and ancillary services

The Slovak Republic's electricity sector is firmly embedded within the larger European network system and the country is benefiting from the investments made in its interconnections with neighbouring countries (see section on interconnections). However, the domestic transmission and distribution system is currently not well placed to support the gradual phase-out of coal-fired power generation and the gradual phase-in of variable renewable generation. The expected increase in demand and the electrification of the industrial and transport sectors will further stress the grid.

Traditionally, the country's transmission and distribution system were conceived to deliver electricity from a small number of large generation facilities to consumers, which are frequently near the generation sites. The closure of the Vojany coal plant is raising concerns about system flexibility and the stability of the electricity grid in the eastern part of the country, which are currently ensured by the coal plant. To address these concerns, the government is considering the construction of a new combined-cycle natural gas power plant on the site of the Vojany coal plant; however, these plans have not yet advanced. The planned Ipeľ pumped storage hydro plant has the potential to supply important flexibility services to the Slovak electricity system. It could allow surplus electricity produced by NPPs over the weekend, when demand is lower, to be stored and then be

released to meet peak loads during the week. Moreover, it would offer balancing services for the growing solar PV and wind generation.

There is an urgent need to upgrade the Slovak Republic's transmission and distribution system at the physical/technical, digital and regulatory levels with a view to making it more flexible, increasing its resilience, providing sufficient capacity for the connection of new generation units and ensuring its readiness for the integration of new business models such as energy communities. With the country's commitment to increase the share of distributed renewable electricity, the ongoing electricity market reforms and the plans to introduce large/new battery storage, the requirements of the system are changing.

The government and electricity sector stakeholders are planning additional investments to modernise and digitalise the transmission system over the coming years. This will ensure that the projected growth in variable renewable capacity additions can be accommodated at the high-voltage level.

The Slovak Republic has already introduced several sources of system flexibility. These include providing financial incentives to deliver at least 52 MW of cumulative increase of balancing capacity through new storage facilities and technical upgrades to increase the balancing capacity offered by the country's four pumped storage hydroelectric power plants (916 MW of installed capacity in total) and demand-side measures. As of 2023, the Slovak Republic already has 2 MW/6.5 MWh of operational battery storage and is expecting to reach 15 MW by 2030 if all planned and under construction projects are operational. Additional flexibility investments, such as the introduction of flexibility tools and enhancement of balancing capacity, will be needed.

The Slovak Republic will need to find a new approach to demand-side management. Until 2022, industrial consumers provided important balancing services by reducing their consumption when needed. However, with the strong reduction of industrial consumption, this option is rapidly declining. On the flip side, the overall reduced electricity demand observed until 2023 implied a lesser need for demand-side reductions. Yet, it will be important to have a set of ready-to-deploy measures in place once electricity consumption picks up as expected by the government.

Digitalisation to complement infrastructure investments

To address the growing tightness of the distribution grid, the Slovak Republic plans to use the possibilities offered by digitalisation to build smart grids, ensure voltage control and distribution grid stability, and facilitate the creation of local distribution networks to support energy communities. Moreover, a supportive legal and regulatory framework is needed to enable the provision and use of flexibility and

non-frequency ancillary services and the IEA encourages the government to expedite its adoption and implementation.

The Slovak Republic employs intelligent metering systems and smart grids in the distribution network. These technologies enable consumers to gain access to objective information about their consumption and suppliers to acquire accurate data as well as for DSOs to improve grid conditions and reduce technical and commercial losses. Nonetheless, the work remains in the initial phase of construction of the basic infrastructure of intelligent networks with the selective introduction of intelligent metering systems. Further cost and benefit analysis is needed to accelerate the implementation of such metering systems.

Deploying smart technologies such as dynamic line rating can help increase interconnection capacities faster than through network reinforcements. Dynamic line rating involves real-time monitoring of weather conditions and line temperatures to adjust the current carrying capacity of transmission lines accordingly. This technology allows lines to operate closer to their thermal limits safely instead of using fixed values, optimising and increasing transmission capacity.

Digitalisation is also a key enabler for the Energy Data Center for the electricity grid. The Energy Data Center also enables creating a unified digital platform to store relevant energy data of buildings and help with demand-side management.

Mindful of the future development of distributed renewable energy sources, the government decided to implement the ACON cross-border smart grid project (the anticipated date of implementation is 2024) between the Slovak Republic and Czechia. The project is recognised by the European Commission as a Project of Common Interest. It is expected to increase the efficiency and safety of the distribution system and the readiness for the integration of distributed renewable sources, particularly in the border areas between the two countries.

Another European Project of Common Interest, co-financed by the Connecting Europe Facility, a joint Slovak-Hungarian smart-grid project (Danube InGrid project), is also being implemented over the period 2020-25. Regulations are in place to support the deployment of smart meters to at least 80% of consumers with an annual consumption of more than 4 MWh. The three largest DSOs in the Slovak Republic have almost completed this process. In this regard, it is welcome that the secondary legislation that became effective on 1 July 2023 defines roles, rights and obligations for every market participant, including aggregators. The introduction of smart grids poses new cybersecurity risks that must be carefully managed.

Electricity prices must support efficiency goals

The Slovak Republic is committed to protect vulnerable electricity consumers, notably during the energy price shocks witnessed from 2021 to 2023. However, the government has not adopted a clear definition of vulnerable consumers. Instead, all household electricity consumers, accounting for around 6.1 TWh of TFEC and all non-household consumers consuming up to 30 MWh of electricity, are considered vulnerable. Since 2022, selected non-household, non-business consumers, accounting for around 0.8 TW of TFEC, are considered vulnerable according to the country's primary electricity legislation, the Act on the Regulation of Network Industries (Act No. 230/2012 Coll.) and the Act on the Energy Sector (Act No. 251/2012 Coll.) (see Chapter 1 for a detailed discussion).

The current definition of vulnerable consumers is undermining the government's policy measures to contain, if not reduce, electricity consumption. It is important that government policy ensures both the social objective of affordable energy for those consumers quantitatively defined, as, for example, in Ireland, and the legal commitment under the EU directives to increase energy efficiency and reduce consumption. Electricity consumers will be reluctant to invest in energy-saving appliances such as heat pumps, adopt smart meters or change their energy consumption behaviour if there are no clear price signals. The same logic is applicable to the natural gas sector.

Nuclear to remain the backbone of the electricity sector

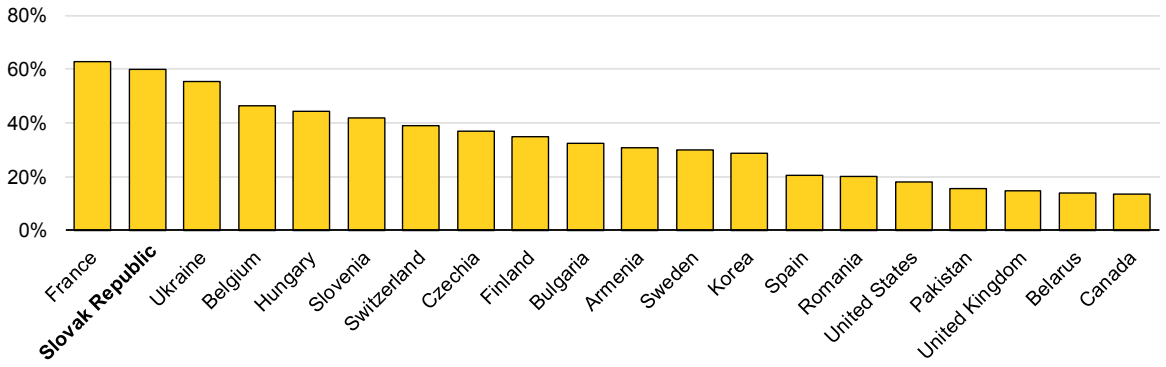
Nuclear plays a central role in the Slovak government's long-term decarbonisation strategy, as well as a strong role in ensuring energy security, especially following the recent energy crisis. The government is, therefore, committed to maintaining a high share of electricity produced from nuclear power to 2050 and beyond.

The Slovak Republic had the second-highest share of nuclear generation in the world after France in 2022 (Figure 3.3). Nuclear power is expected to continue meeting around 60% of electricity demand, which is expected to increase strongly to 2050. For this, the government plans to build additional NPPs and explore the role small modular reactors could play in the future. The government is also assessing how to better harness the potential of nuclear energy to supply heat.

While nuclear power is a cornerstone of the electricity market, the country does not have a dedicated nuclear power strategy addressing all elements of the value chain and assessing in detail the role nuclear can play to support the net zero target for 2050. The IEA encourages the government to develop a long-term strategic roadmap for the nuclear sector to give visibility to the industry and set out the enabling conditions to support its nuclear goals, including the role of SMRs. Such a roadmap could include topics such as siting, technology selection, financing frameworks, opportunities for regional and international co-operation,

and workforce and supply chain localisation needs. The roadmap should also capitalise when relevant on lessons learnt from recent nuclear new build tenders in other countries.

Figure 3.3 Share of nuclear in electricity generation among the first 20 world countries, 2022



Source: IEA (2024), World Energy Balances.(database).

The Slovak Republic has two NPP sites located in the western part of the country at Mochovce and Bohunice. Together these NPPs have five operating reactor units providing 2 420 Mw_e capacity. All units are pressurised water reactors (WWER 440) designed by the former Soviet Union. SE, a government-owned company, is the sole operator of the NPPs.

The IEA commends the Slovak Republic for successfully taking the 471 MW_e Mochovce 3 unit to a successful completion of all power-up stages of commissioning in September 2023 concluding the power escalation phase (SE) and after a successful 144-hour trial run at full reactor power in October 2023, the reactor is fully operational. If operated at full capacity, Mochovce 3 is expected to meet 13% of the Slovak Republic's electricity consumption and the government hopes that this will return the country to electricity self-sufficiency.

A fifth unit, Mochovce 4, is expected to become operational by 2025. Once fully operational, the two additional units will bring the total share of low-carbon electricity from nuclear up to 70%. Furthermore, the government hopes to become a net exporter of electricity once the fourth Mochovce reactor is commissioned. The Slovak Republic will then have a total nuclear installed capacity of 2 945 MW_e.

Moreover, the government plans to commission a new pressurised water reactor at the Bohunice site, for which three potential suppliers are being considered with early discussions taking place with two potential vendors, Westinghouse and EDF. The project is promoted by JESS, a joint venture of the Slovak radioactive waste management company JAVYS and Czech utility ČEZ. A site licence application

was submitted for a reactor with a maximum power output of 1.2 gigawatt electrical (GW_e) in February 2023. Under statutory rules, the Nuclear Regulatory Authority (UJD) issued its decision in April 2024. Land acquisition for the plant is almost completed and JESS plans to apply for a construction licence at the end of 2031. The government currently expects the commissioning of the new NPP around 2040. This is an ambitious plan as it is likely to be a reactor design that has never been built before in the Slovak Republic.

To allow the plant to move forward, firming up the financing framework will be essential. The government should develop a roadmap to ensure timely completion of the nuclear new build by setting clear timelines and targets aligned with meeting net zero goals and outlining the roles and responsibilities of the different stakeholders. The government may like to study the lessons learnt from the establishment of Great British Nuclear, a body created to manage new nuclear projects.

Table 3.3 Nuclear power plants in the Slovak Republic

Plant	Technology type	Power original (MW_e)	Power uprated (MW_e)	Present status	Owner/ licensee	Start-up year
Bohunice A1	HWGCR	110	-	Decommissioning	JAVYS	1972
Bohunice V1	WWER 213	2 x 440	-	Decommissioning	JAVYS	1978-80
Bohunice V2	WWER 213	2 x 440	2 x 505	Operation	SE	1984-85
Bohunice	Tbc	1200		Initial stage	JESS	Expected for 2040
Mochovce 1&2	WWER 230	2 x 440	2 x 500	Operation	SE	1998-99
Mochovce 3	WWER 230	1 x 440	1 x 471	Operation	SE	2023
Mochovce 4	WWER 230	1 x 440	1 x 471	Under construction	SE	2025 expected

Source: Slovenské Elektrárne (2024), Nuclear power plants.

Given the role played by nuclear in the Slovak power sector, the efficient and safe operation of the nuclear fleet are of great importance. The two operating units of the Bohunice NPP were commissioned in 1984 and 1985, respectively. The first two units of the Mochovce NPP were commissioned in 1998 and 2000, respectively, and their capacity was expanded from 470 MW_e to 505 MW_e in 2020 and 2021.

There is no time limit for NPP operating licences in the Slovak Republic. Nonetheless, NPP operators must submit comprehensive safety review assessments to UJD every ten years to assess and ensure a high level of nuclear safety throughout the operation of the NPP. The reviews help identify safety-related improvements and measures to continuously improve nuclear safety.

The outcomes of the periodic reviews also inform decisions on operations, including long-term operations generally considered to be beyond 50 years for older reactors. This is presently evaluated for the two longest operating units of the Bohunice NPP that are currently expected to operate for 60 years. The results of the evaluation will be submitted to UJD in 2025.

The government, in consultation with SE, should set the framework conditions to ensure the operation of the Mochovce 1 and 2 reactors for at least 60 years, to maximise the period of clean power to the grid. Finland has demonstrated that the WWER at Loviisa is currently capable of safe operation for at least 70 years. The two newest units, Mochovce 3 and 4, have an expected operational lifespan of 60 years.

The population of the Slovak Republic is very supportive of NPPs, and the government can leverage this in advancing its future nuclear ambitions. All operating plants had power uprates to 505 MW, after successful consultations with local government organisations. The same consultative process could be applied eventually to the Mochovce 3 and 4 reactors, to ensure power generation is maximised to meet the expected increase in electricity demand in the upcoming decades. Maximising the use of the existing nuclear fleet would also help hedge against any possible delays in bringing new NPPs onto the grid. As experiences in other European countries such as Finland and the United Kingdom have shown, the complexity and length of constructing new plants can easily derail carefully laid timetables. The same experience was made in the Slovak Republic for the Mochovce 3 and 4 units, which have been considerably delayed compared to their originally expected construction completion dates.

To meet its nuclear ambitions, the government needs to develop a supply chain for equipment and fuels needed for new reactors. Well-designed policy can accelerate this development. Given the size and demand prospects for nuclear power, an international supply chain is likely to be further strengthened in the coming years, which the Slovak Republic could harness through co-operation with international partners. Considering the geopolitical developments and the energy crisis of 2022 and 2023, it is necessary to reduce the reliance on safety-related components and fuel from Russian suppliers at all WWER plants in the Slovak Republic. Efforts are underway to address the dependency from Russia on nuclear fuel supply, with both Westinghouse and Framatome developing plans in this field. Commercial supply chains which provide components for other types of thermal power plants could be harnessed for components in the secondary, tertiary and non-safety-related systems.

Since mid-2023, SE is working as part of a European consortium to secure alternative fuel suppliers for delivery from 2027 onward under the so-called APIS project. SE has issued an international tender for the supply of nuclear fuel and

related services in the entire supplier chain for nuclear fuel production. SE and Westinghouse signed a long-term supply agreement in August 2023 for deliveries of nuclear fuel and licensing support. Moreover, a memorandum of understanding was signed with Framatome of France in May 2023 for a global strategic relationship to develop an alternative solution for WWER utilities towards including developing a 100% European nuclear fuel design for the Slovak Republic's reactors. These are important developments, and the country is to be congratulated for having taken swift action.

The Slovak Republic will need to train a new generation nuclear workforce (engineers and specialist workforce) for the proposed new build design which has never been built in the country before and which offers long-term employment opportunities. This can be achieved, for example, through establishing new education and apprenticeship programmes (see Chapter 1). JESS recognises that there is a gap in the talent pipeline to meet its future ambitions and notes the absence of dedicated training programmes for workers, with only one nuclear engineering university degree course being offered in the country. Despite the government's commitment to nuclear in the energy mix, the opportunities offered by a career in the industry lack visibility.

The Slovak Republic will also need to establish new research infrastructure to test and generate licensing data on materials, fuels and computer codes. Such interventions would also support the Slovak ambition to deploy SMRs to decarbonise the hard-to-abate economic sectors.

A potential role for small modular reactors

The Slovak Republic has strong ambitions to deploy SMRs to decarbonise the hard-to-abate industry sectors, supply (district) heating, provide off-grid power, geographically balance power capacity across the country and produce hydrogen to maintain the country's industrial competitiveness in a decarbonised economy.

The government considers deploying SMRs on existing sites to replace coal power generation to support decarbonisation goals while enabling a just transition. This concept can reduce nuclear deployment costs compared to greenfield sites. According to one study from 2023, capital expenditure reductions up to 20% for new nuclear are possible by reusing existing buildings, grid connections and heat sinks infrastructure at coal sites. The Slovak Republic has secured grant funding from the United States' Phoenix project to carry out a feasibility study to investigate the possibilities of repowering coal plants with SMRs. Retraining workers for SMR plants, which use most of the same facilities and equipment as the former coal plants, could be a useful strategy to retain the expertise of that community. In fact, another study from 2022 points to the benefits of transitioning a significant portion of the existing workforce from coal to nuclear operations, while maintaining tax

revenue to support local community development. Initial fieldwork on the feasibility study started in February 2024 and based on the current timeline, project implementation and construction would commence in 2035.

Globally, SMRs are expected to benefit from serial factory production in a standardised fashion, potentially reducing costs and risks compared to large projects. Lower investment costs can ease financing challenges that are typically experienced by larger reactor new builds. However, the economic benefits of SMRs remain unproven.

In this regard, it is welcome that the Slovak Republic has launched initial interactions with international companies to consider the deployment of their SMR designs in the country. However, no binding agreements have been made. Czechia, Poland and other neighbouring countries have demonstrated progress through establishing binding agreements with vendors and applying for licences with regulators which could serve as a best practice example. The Slovak Republic plans to site the first SMR alongside the proposed new large-scale reactor in Bohunice.

UJD currently applies an envelope system where a site licence must be granted before a design choice is required. For SMRs, it might be appropriate to develop the option of a generic design licence, as these could be deployed at multiple sites simultaneously or even be mobile, as well as manufactured off-site. The UK Generic Design Approval or US Standard Design Approval may provide useful examples.

Radioactive waste management strategy

JAVYS is responsible for decommissioning activities, radioactive waste management and the management of spent nuclear fuel. The current interim fuel storage, a wet pool, has an expected lifetime of 50 years after its reconstruction in 2000. It is expected to reach capacity during 2024 and will need to be expanded.

JAVYS is implementing a phased “Upgrading SNF storage capacities” project under which dry storage facilities are being constructed with a lifetime of 100 years. The first stage entered operation in early 2024 and has a storage capacity of 10 115 spent fuel assemblies. The second stage will have a capacity of at least 8 500 spent fuel assemblies. Part of the spent fuel will be transferred from the wet into the dry storage facility until the capacity of the dry storage for the spent fuel is exhausted.

All waste handling and decommissioning activities of A1 reactor of the Bohunice NPP are financed through the National Nuclear Fund. Waste handling and decommissioning of the V1 reactor of the Bohunice NPP are financed through the BIDSF (Bohunice International Decommissioning Support Fund) and the National

Nuclear Fund. The centralisation of the spent fuel storage maximises the ability to leverage economies of scale and hence contributes to reducing storage costs.

The National Nuclear Fund will also fund the development of a deep geological repository (DGR) for the permanent disposal of spent nuclear fuel and non-storable waste from the decommissioning of the Mochovce NPP. The DGR is expected to come into operation from 2065 and preparations are undertaken in phases. Under phase 1, five possible locations for the DGR were selected and under phase 2 exploratory geological work is being undertaken in the two most promising locations from the five selected, namely Tríbeč and Rimavská kotlina. The exploratory work comprises geological mapping, structural geology, petrography, mineralogy, geophysical research, hydrogeological and hydrological research, monitoring, geochemical and hydrogeochemical research, research of geotechnical properties, engineering geology, and drilling wells to a depth of 600-900 metres. The ongoing work is in accordance with the "National Programme for the Management of Spent Fuel and Radioactive Waste in the Slovak Republic", which is currently being assessed as part of the strategic environmental assessment process.

However, the government is also considering the possibility of international disposal options and intends to decide in 2030 if it will continue the simultaneous pursuit of national and international long-term waste storage facilities. The Slovak Republic has not yet made significant progress with planning a DGR for spent nuclear fuel and is currently behind schedule. In fact, an IAEA ARTEMIS review team visit concluded in February 2023 that the milestones set appeared challenging to reach and recommended JAVYS update its implementation plan.

The Slovak Republic may wish to study the experiences made in other IEA countries such as Finland, France, Sweden and Switzerland, which also have long-term waste management plans and ongoing DGR projects. The Slovak Republic could benefit from the lessons learnt in these countries to accelerate its DGR plans.

Recommendations

The government of the Slovak Republic should:

- Develop a roadmap with firm actions to expand and diversify electricity supply by expanding renewable energy sources.
- Expand the electricity distribution network to ensure that variable renewables can be connected, and that interconnection and transmission capacities are sufficient to meet projected demand while introducing smart technologies such as dynamic line rating.

- Improve the flexibility options for the electricity system via well-functioning demand-side management, clearly defined rules for aggregation, enhancing ancillary services, expanding the use of battery storage technology or employing power-to-X technologies.
- Accelerate the implementation of a smart grid to control and monitor electricity consumption in a more organised manner, and to ensure the safety of the distribution system, mindful of possible cybersecurity risks.
- Maximise the use of the existing nuclear fleet by exploring power uprates and leveraging long-term operations. Diversify fuel supply and nuclear-grade components supply and, where possible. collaborate with European countries that operate VVER reactors.
- Continue to increase spent fuel storage capabilities to support long-term operation and potential new build plans. In parallel, continue to progress deep geological radioactive waste disposal and deep geological repository plans and ensure that funding of waste management activities remains adequate over the long term.

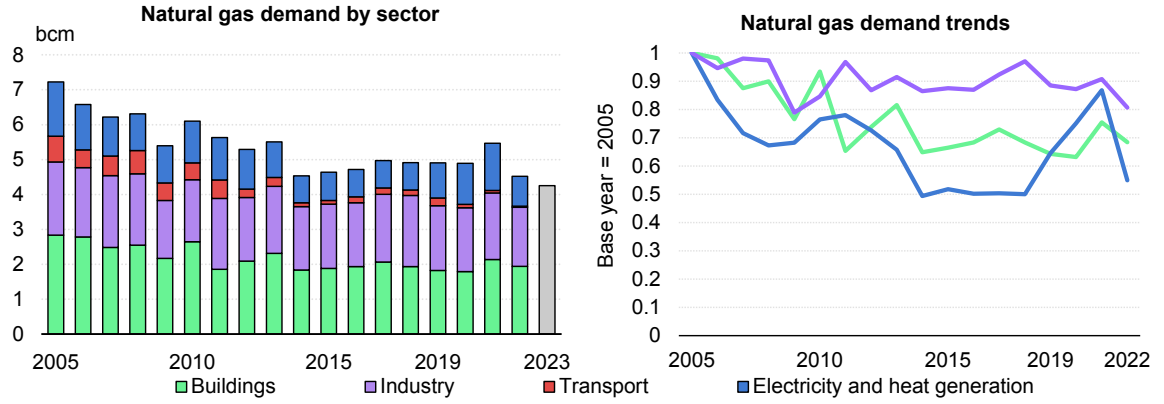
Natural gas

Gas sector transition needs to be mapped out

Natural gas plays a significant role in the Slovak Republic's energy supply, accounting for approximately 23% of TES and 25% of TFEC, but only contributing 7.9% of electricity generation in 2022. Natural gas is used mainly in industry, residential buildings and for DH generation. Most natural gas is imported (99% in 2023) and imports rely strongly on a single supplier despite significant and ongoing efforts for diversification. As such, security of supply remains a concern.

Total gas demand has decreased notably since 2005, dropping from 7.2 billion cubic metres (bcm) in 2005 to 5.5 bcm in 2021. In 2022, natural gas demand dropped by 17% compared to 2021, to 4.5 bcm. The reduction is explained by a warmer than average winter, demand reduction in the household sector resulting from energy efficiency upgrades and reduced industrial production caused by the high gas price environment. The country, therefore, reduced total gas demand in 2022 in line with the EU-wide target of 15%.[6] Preliminary data for 2023 indicate a further decrease to 4.3 bcm, equivalent to a 19% reduction compared to 2022 (Figure 3.4).

Figure 3.4 Natural gas demand by sector (2005-2023) and its trend (2005-2022) in the Slovak Republic



IEA. CC BY 4.0.

Notes: Transport trend is excluded from demand trend chart due to limits in scalability. Data for 2023 are aggregated from 2023 monthly reports and are not available broken down by sector.
Sources: IEA (2024), Natural Gas Information (database); IEA (2024) Monthly Gas Data Service (database).

Heating in buildings accounts for the largest share of gas consumption at 1.9 bcm in 2022; a notable decrease from 2.8 bcm in 2005, mainly attributable to energy efficiency improvements, the adoption of modern boilers and warmer winters (see

[6] Compared with the average gas consumption over the same period in the preceding five years.

Chapter 2). Industry consumed 1.7 bcm in 2022, a 12% decline compared to 2021 resulting from the extraordinarily high gas prices which forced some industries to curtail production. The government does not expect that all industries that either curtailed or even stopped production entirely in 2022 will return to the market. Electricity and heat generation consumed 0.9 bcm in 2022, a 17% drop compared to 2021 owing to technical difficulties at the Malzenice power station. Natural gas demand in the transport sector was negligible in 2022, down from 0.7 bcm in 2005.

Gas consumption will decline only marginally to 2030

Looking forward, the government expects demand for natural gas to stay constant at around 4.3 bcm annually between 2023 and 2027 and then decline only gradually to 2030, before stabilising to 2040. The stable demand will be largely driven by industry and to a marginal degree also by the power sector, as the Slovak Republic is committed to phase out coal-fired power generation. Demand for gas in the industry sector and as a heating source used in co- is expected to remain strong and possibly even increase after 2030 according to the updated NECP. Eventually, natural gas demand in the industry sector will be replaced by decarbonised gases and electricity (see below and Chapter 2). The government is also proceeding with the expansion of the compressed natural gas infrastructure for transport; however, the impact on total demand for natural gas is expected to be small (see Chapter 2).

Over two-thirds of Slovakian households consume natural gas either directly or indirectly in the form of DH for which natural gas is the dominant fuel (see Chapter 2). However, with ongoing refurbishment of the building stock, the zero-energy standards for new builds and the observed milder winters, the government expects residential gas consumption to decline.

At the same time, the Slovak Republic has a very generous definition of vulnerable gas customers which includes every consumer with an annual gas consumption not exceeding 100 000 kilowatt hours (360 gigajoules). Gas supply to these vulnerable gas consumers, which comprise the entire household sector, has been price regulated since 2017. In response to the energy crises, the government expanded the legal definition of vulnerable customers in 2022 to also include apartment buildings with their own heating source, social service facilities, and small consumers of electricity and gas. In total, the government estimates that around 41% of total annual gas demand falls under the extended definition of vulnerable consumers.

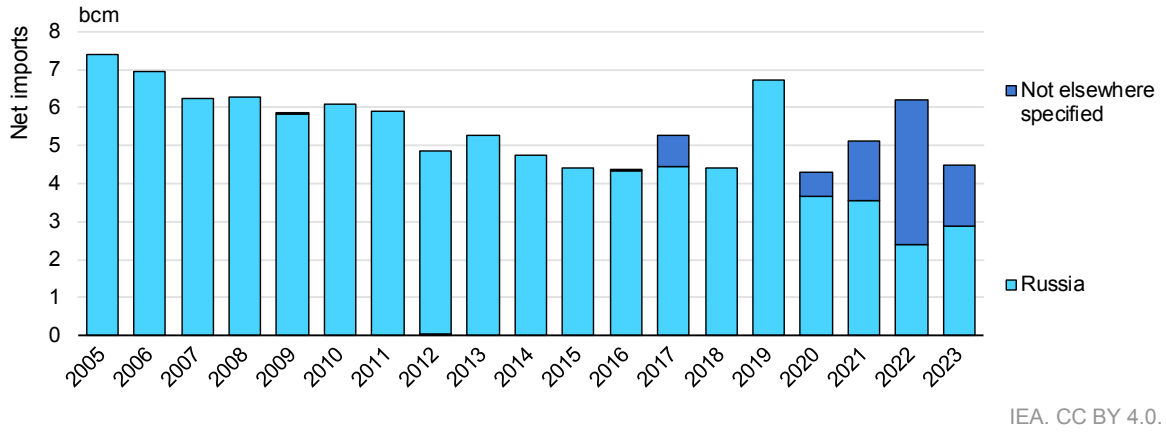
The new definition is applicable the regulatory period from 2023 to 2027; a period in which gas prices have started to witness substantial declines. Moreover, such a wide definition of vulnerability is likely to counteract incentives to reduce gas consumption by investing in the refurbishment of houses/buildings and/or the

decarbonisation of heating. While the support of vulnerable households is a valuable objective, it should be achieved through social transfers and by carefully balancing direct financial support with support for refurbishments (see Chapter 1). The European Commission also noted that policies to ensure a structural reduction of gas demand will not only protect consumers from high prices but also reduce the Slovak Republic's reliance on imports and enhance security of supply.

Infrastructure expansion to diversify gas supply

Historically, the Slovak Republic was almost 100% dependent on natural gas imports from Russia, via Ukraine. The pipeline traverses the Slovak Republic and connects to neighbouring nations. The Slovak Republic imported marginal amounts of natural gas in 2009 (0.04 bcm) and 2016 (0.05 bcm) from countries other than Russia (Figure 3.5). The first time the country imported a more significant amount of natural gas from a country other than Russia was in 2017 (0.81 bcm). However, in the following two years, all natural gas imports again originated from Russia before imports from other supply sources resumed, albeit at low levels, in 2020.

Figure 3.5 The Slovak Republic's natural gas supply by source, 2005-2023



Source: IEA (2024), Natural Gas Information (database).

Uncertainties regarding the reliability of pipeline gas flows from Russia since Russia's invasion of Ukraine in 2022 have highlighted the necessity for increasing preparedness, anticipating changing sources of supply and, consequently, diversifying gas supply sources. Moreover, the risk of gas supply from Russia coming to an end is imminent, possibly by the end of 2024 with the expiry of the Russia-Ukraine transit agreement. So far, the European Union and Ukraine have ruled out any extension of the agreement. In March 2024, Ukraine's Prime Minister Denys Shmyhal said that Ukraine would be ready to provide a transit service if European countries acted as a consortium or one European country acted as a gas transit partner. In May 2024, SPP, the Slovak Republic's largest gas supplier,

said that it considers as “feasible” the creation of a European consortium to take delivery of gas at the Russia-Ukraine border to ensure continued supplies of Russian gas via Ukraine post-2024.

In its meeting on 4 March 2024, the EU Energy Council confirmed the need for further diversification of gas supply and gas supply routes with a view to ensure security of supply and prepare for the winter 2024-25. The Council also debated the need to avoid barriers for gas transit in the EU single market and to support efforts for diversification.

SPP has successfully concluded contracts with several alternative gas suppliers through alternate supply routes. In the case of a disruption of pipeline gas flows from Russia, SPP and other suppliers can ensure relevant gas quantities and has booked enough infrastructure capacity for gas to be shipped to the Slovak Republic. The magnitude of contracts signed could meet around 70% of consumption from non-Russian sources.

IEA monthly data for 2023 indicate that net imports from the interconnection with Ukraine amounted to 11 bcm, accounting for 94% of Slovak gas net imports. Other net imports came from the connection with Hungary (0.6 bcm) and Czechia (0.2 bcm). The imported gas is partly rerouted mainly to Austria (7.1 bcm) and Poland (0.1 bcm), and otherwise used domestically to satisfy the annual demand of 4.3 bcm. Annual data reporting for country of origin to the IEA is unfortunately incomplete and no details have been provided for the category “not elsewhere specified” and how this category is different from the category “other”. The IEA encourages the Slovak Republic to closely co-operate with the IEA to ensure consistency, accuracy and timely delivery of all data.

The Slovak Republic’s natural gas infrastructure is operated by Eustream, the independent TSO. The Slovak Republic is an important transit country for Russian gas into the European Union. The total annual transmission capacity is substantially larger than the country’s domestic consumption. There are five major gas pipelines running through the country, connecting to Austria, Czechia, Hungary, Poland and Ukraine (with two entry/exit points).

Prior to the Russian invasion of Ukraine, the Slovak Republic started to build infrastructure to protect against interruptions of Russian gas. The Slovak Republic now has the potential to become a transit country for gas sourced elsewhere than Russia and to be delivered to Ukraine. Firm exit capacity towards Ukraine is 27 million cubic metres (mcm per day) at the Budince interconnection. Any enhancement of this connection is a decision of the TSO and is dependent on the confirmed interest on the Ukranian side.

The most recent interconnection added is the Poland-Slovakia Gas Interconnection. The new interconnector started operating in November 2022, giving access to the Polish LNG terminal in ŚwinoujŚcie and linking to the Croatian LNG terminal on Krk Island. This bi-directional pipeline forms an important part of the new north-south interconnection in the eastern part of the European Union and offers a transmission capacity of 5.7 bcm/year from the Slovak Republic to Poland and 4.7 bcm/year in the reverse direction (compared to a total final gas demand in the Slovak Republic of just over 5 bcm in 2022). The Slovak Republic has concluded contracts for Norwegian gas and for gas coming from LNG terminals and is considering taking a share in LNG terminals on the Baltic Sea to further diversify its gas supply sources. This interconnection is of high significance for the Slovak Republic as it is now connected with all its neighbouring countries. The IEA congratulates the Slovak Republic for adding this important piece of infrastructure.

The Solidarity Ring Initiative of the Slovak Republic, Azerbaijan, Bulgaria and Hungary and supported by the European Commission is in the initial phase of preparation. It intends to double regional pipeline capacity to strengthen security of gas supply in Central and South East Europe in the medium term by allowing additional gas supplies from Azerbaijan. The interconnection point between the Slovak Republic and Hungary would be expanded to a bi-directional capacity of 5 bcm/year. There are certain risks associated with this initiative, including a possible lack of funding owing to the absence of a sustainable business case for building new fossil fuel infrastructure in the context of the transition to a decarbonised energy system. Consequently, alternative options for ensuring energy security and resilience of the gas supply system would need to be developed.

Eustream is also pursuing projects to increase the capacity at interconnection points. Specifically, it is investing to automate the operating modes at the interconnection points in Lanžhot (Czechia), Baumgarten (Austria) and Veľké Zlievce (Hungary). The projects should be completed by the end of the third quarter of 2024.

Low-emissions gases to support decarbonisation

The Slovak Republic is committed to advance the production and use of low-emissions and renewable gases to replace natural gas in view of reaching the country's climate targets, enhancing security of supply and reducing import dependence. The 2019 NECP and the draft updated NECP of 2023 both note the government's commitment to work towards the production, supply and injection of

biomethane and hydrogen into the existing gas infrastructure. Biomethane and low-emissions hydrogen[7] are primarily anticipated to be used in the industry and transport sectors.

To support the country's hydrogen ambitions, the government published a National Hydrogen Strategy "Prepared for the Future" in 2021 and subsequently in 2023 an Action Plan for the Development of Hydrogen towards the creation of a hydrogen ecosystem. While the Strategy focuses on producing, distributing, storing and using emission-free and low-emissions hydrogen, the Action Plan already addresses necessary framework conditions such as setting legislation and regulation, subsidising hydrogen technologies, and supporting technology start-ups. Close co-operation between the various levels of government, businesses and research institutions is identified as critical for a successful implementation of the Strategy and Action Plan. The Action Plan sets out ten measures that are to be undertaken by 2026, when the Action Plan ends. If evaluated successfully, the Action Plan will be renewed for the years 2027-30.

According to the government, hydrogen would replace natural gas notably in industrial applications, e.g. in the chemical, petrochemicals, steel and metallurgical industries, both as an input material for industrial processes, and as an energy carrier. Moreover, hydrogen will also be used as an energy carrier in the transport sector and for heating (see Chapter 2). By 2030, the Slovak Republic could be consuming 300 kilotonnes (kT) of hydrogen annually according to the government: 190 kt would be consumed by the chemical and petrochemical industry, 100 kT by other industry, and 10 kT by the transport sector. Today, the country's chemical and petrochemical industry consumes 196 kT of hydrogen derived from fossil fuels such as coal and natural gas with only 1 kT of low-carbon hydrogen.

The government therefore foresees a gradual replacement by renewable and low-carbon hydrogen. For this, it has allocated funding under the RRP to support pilot projects for the initial production and consumption of renewable and low-carbon hydrogen through the installation of new renewable sources to supply to-be-built electrolysers and the roll-out of consumption points. The government also sees a role for nuclear energy in the production of low-carbon hydrogen.

Beyond the physical infrastructure, the establishment of a regulatory framework for hydrogen infrastructure, including for hydrogen storage and technical and safety standards, is necessary. The government has initiated work to prepare new or amend existing legislation and regulation, including permitting processes for

[7] The government of the Slovak Republic defines low-carbon hydrogen as having a 70% lower carbon footprint compared to hydrogen production in the natural gas reforming process. The IEA defines low-emissions hydrogen quantitatively to include hydrogen produced through water electrolysis with electricity generated from low-emissions sources (renewables, i.e. solar, wind turbines or nuclear). Hydrogen produced from biomass or fossil fuels with carbon capture, utilisation and storage technologies is also counted as low-emission hydrogen.

individual hydrogen technologies with a view to simplify and accelerate those processes, while ensuring alignment with European Commission requirements.

The Slovak Republic has well-developed gas transmission and distribution infrastructure and over 90% of the population is connected to the gas grid. This presents an ideal condition for the use of hydrogen in the heat economy and the gas sector in general. To accelerate the development of the hydrogen economy, the Slovak Republic has submitted several projects to the European Commission's Important Projects of Common European Interest (IPCEI) list. All submitted projects are expected to become operational from 2030 onward with the exception of one project which is to start from 2025 onward.

The country's gas transmission operator, Eustream, has undertaken extensive testing for blending hydrogen with natural gas and is confident to be able to transport gas with up to 5% hydrogen content by volume by the end of 2024. Eustream is exploring the technological requirements to increase the share further by researching the impact of hydrogen on the transmission system through the development of a testing polygon, including a laboratory and practical research.

The Slovak Republic is also implementing several hydrogen projects at the distribution level. SPP-distribúcia is undertaking two projects: the upgrading of existing distribution lines to be hydrogen-ready and planning the construction of new hydrogen-ready lines to supply the largest industrial consumers and large urban areas.

SPP-distribúcia developed its own hydrogen strategy in 2020 under which it has undertaken the H2 Pilot project that tested a 10% hydrogen blend into the local gas grid. The pilot was undertaken in 2022 in the Blatná na Ostrove village where the gas distribution grid supplies 300 customers, consisting of houses, apartments and SMEs, which together utilise 255 boilers, 203 stoves and 6 water heaters. The pilot scheme demonstrated that a 10% (by volume) blending ratio did not have any negative impact on the safety, reliability or standard operation of gas facilities and common gas appliances. The H2 Pilot project will now serve as a best practice example to advance the hydrogen readiness of the distribution network. SPP-distribúcia is also planning to build dedicated hydrogen distribution pipelines to supply the largest industrial sites and urban areas and to repurpose existing pipelines.

With its central geographic location and robust gas transit infrastructure, the Slovak Republic offers high potential for switching from gas to hydrogen transits and connecting Austria, Czechia, Germany and Ukraine. Realising this potential requires the establishment of renewable energy and hydrogen production, transit pipelines, storage facilities, hydrogen-ready natural gas plants and industrial offtake within the Slovak Republic. It also requires co-operation with prospective producers and offtake countries, ensuring the availability of financing for

necessary hydrogen infrastructure and the acceleration of permitting procedures for the construction and refurbishment of hydrogen infrastructure in the Slovak Republic. The Slovak Republic has taken significant steps in these areas to advance its ambitions of creating a hydrogen economy.

Eustream is actively engaged in promoting the creation of a European hydrogen backbone and for this has joined several international partnerships. Among the projects it has planned is the retrofitting of an existing transmission line for the exclusive transmission of hydrogen; and the construction of a new, hydrogen-ready compressor station. In February 2024, Eustream obtained IPCEI status for the "H2 Infrastructure – Transmission Repurpose" project, with an estimated investment cost of EUR 400-500 million and aims to allow the transmission of hydrogen derived from renewables in Ukraine. The hydrogen will transit the Slovak Republic and be delivered to Austria and Czechia. In the initial phase, the capacity would reach 10 GWh at the entry point from Ukraine. The hydrogen backbone will be bi-directional to allow the eventual transfer of renewable hydrogen from North Africa. The project forms part of the larger Hy2Infra Initiative under the European Union's Hydrogen Strategy. The Slovak Republic will use the hydrogen to support the decarbonisation of hard-to-abate industries in the Slovak Republic, such as its steel plant and refinery (see Chapter 2).

Eurstream is actively engaged in the H2EU+Store partnership for the production, transmission, storage and supply of renewable hydrogen. Regarding the production of hydrogen in the Slovak Republic, Eustream singed a memorandum of understanding with three partners to produce low-carbon hydrogen in the country for onward transmission to Germany via a repurposed Eustream pipeline from 2030 onward. Moreover, Eustream has also joined four TSOs, including Ukraine, to develop a Central European Hydrogen Corridor to supply renewable hydrogen from Ukraine to Germany. The project would have a capacity of up to 144 GWh per day from 2030. In addition, Eustream formed the SunsHyne Corridor partnership with four other European TSOs to facilitate the transmission of renewable hydrogen from North Africa via Italy and also a joint initiative with other TSOs for the South-East European Hydrogen Corridor. It will be important to ensure that Eustream has the necessary and sufficiently skilled staff and resources to successfully proceed in implementing this ambitious hydrogen portfolio over the next decades. Ensuring the availability of skilled staff and continuous skills development in line with requirements will be important.

Beyond hydrogen, the government is also supporting the development of biomethane (see Chapter 2). Biomethane is upgraded biogas that can be either injected into the natural gas grid or consumed in transport. In December 2022, the legal provision for the creation of a registry of renewable gases became effective. The registry will be operated by SPP-distribúcia a.s. and will allow the electronic issuance, transfer, application for and cancellation of guarantees of origin for

renewable gases, primarily for biomethane. It is applicable to quantities of 1 MWh of renewable gases injected mainly into the distribution grid. The law prescribes that SPP-distribúcia a.s. will pay up to 75% of the cost of building a pipeline, of a maximum length of 4 km, from the biomethane plant to the distribution network. In addition, public support for biomethane production facilities was expected to be provided under the European REPowerEU initiative but that has so far not materialised. The government estimates that the current available support for biomethane production facilities is insufficient to reach the targeted production of 300 mcm (or 0.3 bcm) by 2030.

The government offers a fixed purchase price for electricity produced from biomethane and used in the DH systems. There are, however, questions whether the fixed purchase price is sufficiently high at 96 EUR/MWh to attract biomethane producers. Biomethane and natural gas are levied with the same level of excise duty. There are currently 103 operational biogas plants, and the biogas is primarily used to produce electricity and heat. Since 2021, the country has one production facility for biomethane.

Given that natural gas in the Slovak Republic has historically been a relatively cheap and reliable fuel for buildings and industry, reducing natural gas consumption over the short term will be a challenge. The government should outline a transition trajectory for the phase-out of natural gas towards achieving its economy-wide decarbonisation goal. The roadmap would show how part of the transition will be achieved through alternative energy sources, including decarbonised gases. Another part of the transition trajectory should focus on the replacement of heat from gas with heat pumps, geothermal energy and heat from nuclear power generation. Equally important is to promote and support the implementation of the most energy-efficient technologies, such as condensing boilers and co-generation units and a higher renovation rate of the buildings stock.

Recommendations

The government of the Slovak Republic should:

- Ensure the security of gas supply in the transition period by continuing to diversify gas supply sources and routes to safeguard stable energy provision.
- Develop a transition plan for decreasing natural gas consumption, especially by formulating and refining concrete targets and measures for natural gas use.
- Increase ambitions for ramping up the production of low-emission gases, and particularly a future hydrogen economy, including setting and implementing milestones for the delivery of the Hydrogen Strategy and Action Plan and develop a co-operation programme to realise the hydrogen corridor between Ukraine-Slovak Republic, Austria, Czechia, and Germany.

Annexes

Acknowledgements

The Energy Policy Review Team visited Bratislava from 23 to 30 October 2023 and met with government officials and public and private sector stakeholders across the energy sector. This report is based on information from these meetings, the review team's assessment of the Slovak Republic's energy policy and detailed research by the IEA. The members of the review team were Cristina Cardoso (Portugal and team leader); Mehmet Yalılı (Türkiye); Lisa Bjergbakke (Denmark); Asbjørn Hegelund (Denmark); Andreas Kaiser (Germany); Chiara Trovati (European Commission); Shahnaz Hoque (Nuclear Energy Agency); and Dagmar Graczyk, Kieran McNamara and Anders Caratozzolo from the IEA Secretariat.

Dagmar Graczyk managed the review and is the main author of the report. Anders Caratozzolo wrote the sections on buildings and transport in Chapter 2. The following IEA colleagues provided valuable contributions in the preparation, drafting and publication of the report: Nicholas Howarth, Kiyomi Hyoe, Mine Isik, Oskar Kvarnström, Cuauhtemoc Lopez-Bassols, Martina Lyons, Kieran McNamara, Gergely Molnár, Emma Mooney, Alison Pridmore, Fabian Voswinkel, Jacques Warichet and Michel Berthelemy (Nuclear Energy Agency). Alessio Scanziani and Anders Caratozzolo designed and prepared the energy data sections of the report, dedicated analysis, figures and tables, supported by Eloi Borgne, Edoardo Campo Lobato, Stella Jun and Naomi Trick. Roberta Quadrelli, Zakia Adam, Stève Gervais and Dionysia Lyngopoulou, provided support on statistics and data. Isabelle Nonain-Semelin and Astrid Dumond managed the editing, layout and publication process. Jennifer Allain edited the report. Nicolette Groot supported the organisation of the Energy Policy Review Team's visit.

The IEA extends thanks to Jan Petrovic (Director General, Section of Energy), Alena Zakova (Director of Department on International Relations in Energy Sector, Section of Energy) and Martin Pitorak (Director of Department on Fuel and Energy, Section of Energy) from the Ministry of Economy for providing strategic overview on the energy policies of the Slovak Republic. The IEA also wishes to thank Peter Barborik, Veronika Carna, Peter Drotar and Bronislava Leroux (Principal State Counsellors, Department on International Relations in Energy Sector); Michaela Majorová (Senior Policy Energy Advisor); and Stanislava Fruhauf (Energy Advisor, OECD Permanent Delegation of the Slovak Republic in Paris), for their tireless efforts throughout the entire report process.

The IEA also thanks the numerous individuals from the following organisations who provided valuable insights for the report: APES (Association of Energy Services Providers); Applia; Association for Better Management of Apartment Buildings; AZZZ SR (Federation of Employers' Association of the Slovak Republic); Buildings for the Future; Comenius University (Department of Political Science); ESCO Slovensko, a.s.; Eustream; Friedrich-Ebert Foundation; GLOBSEC; Upper Nitra mines Prievidza; IFP (Institute for Financial Policy); IHA (Institute of Economic Analysis); Institute for Passive Houses; JAVYS (Nuclear Decommissioning Company); JESS (Nuclear Power Company of Slovakia); Main Mining Authority; Ministry of Economy; Ministry of Environment; Ministry of Investments, Regional Development and Informatization; Ministry of Transport; MH Teplárenský holding, a.s. (holding of six state heating companies); NIKA (National Implementation and Coordination Authority); NJF (National Nuclear Fund); OKTE (short-term electricity market operator); RÚZ (National Union of Employers); SAPI (Slovak Association of Photovoltaic and Renewable Energy Industry); SAV (Slovak Academy of Sciences); SE (Slovenské elektrárne); SEPS (Slovak electricity transmission operator); SEVA (Slovak Electric Vehicle Association); SFPA (Slovak Foreign Policy Association); Slovak University of Technology (Bratislava); SHMÚ (Slovak Hydrometeorological Institute); SIEA (Slovak Innovation and Energy Agency); SK8 (Association of Self-governing Regions); SPP (national gas company); SPP-distribúcia (gas distribution company); SSD (electricity DSO); Staré Hory municipality; SVVT (Slovak Association of Heat Producers); SZ CHKT (Slovak Association of Refrigeration and Air Conditioning Engineers); URAD (Regulatory Office for Network Industries); VAIA (Research and Innovation Authority); VSD (electricity DSO); VUJE (Nuclear Power Research Institute); ZMOS (Association of Towns and Communities of Slovakia); ZPOE (Association of Industrial Consumers of Energy); ZPVVO (Association of Research and Development Industrial Organizations); and ZSD (electricity DSO).

Abbreviations and acronyms

ACON	Again COnnected Networks
BEV	battery electric vehicle
DGR	deep geological repository
DH	district heating
DSO	distribution system operator
EED	Energy Efficiency Directive
EEMS	Energy Efficiency Monitoring System
EEN	energy efficiency network
EPC	energy performance certificate
ESCO	energy service company
ETS	Emissions Trading System
EU	European Union
EUR	euro
EV	electric vehicle
FEC	final energy consumption
GES	guaranteed energy savings
GHG	greenhouse gas
HDV	heavy-duty vehicle
IEA	International Energy Agency
IPCEI	Important Projects of Common European Interest
JTF	Just Transition Fund
LNG	liquefied natural gas
LPG	liquefied petroleum gas
LTRS	Long-Term Renovation Strategy
LULUCF	land use, land-use change and forestry
NECP	National Energy and Climate Plan
NPP	nuclear power plant
PEC	primary energy consumption
PHEV	plug-in hybrid electric vehicle
PPP	purchasing power parity
PRIMES	Price-Induced Market Equilibrium System
R&D	research and development
RRP	recovery and resilience plan
SE	Slovenské elektrárne
SIEA	Slovak Innovation and Energy Agency
SME	small and medium-sized enterprise

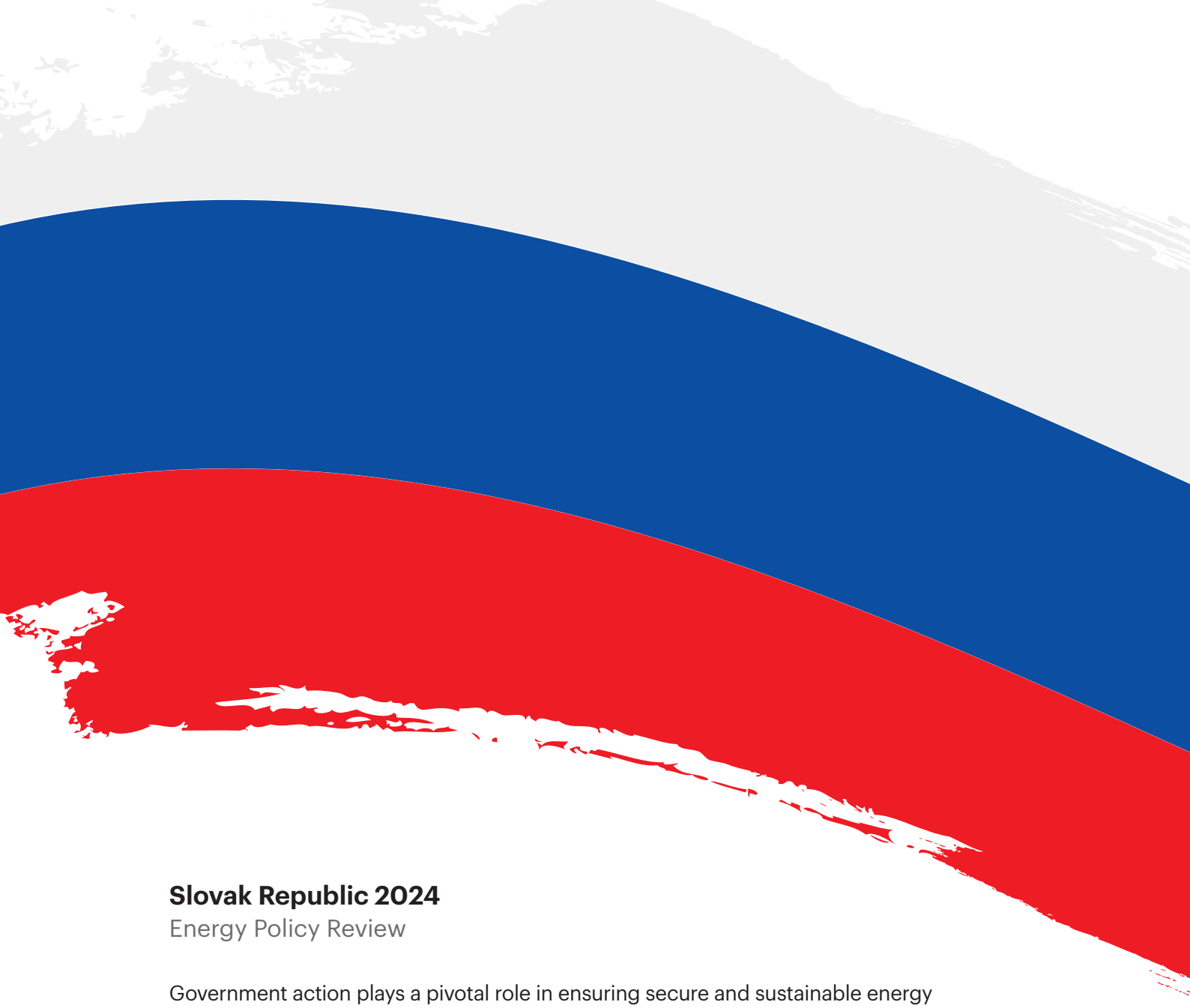
SMR	small modular reactor
TCP	Technology Collaboration Programme
TES	total energy supply
TFEC	total final energy consumption
TSO	transmission system operator
UJD	Nuclear Regulatory Authority
USSK	US Steel Košice
VVER	water-water energetic reactor

Units of measure

bcm	billions of cubic metres
GWh	gigawatt hour
GW_e	gigawatt electrical
kb/d	thousand barrels per day
kT	kilotonne
kW	kilowatt
mcm	millions of cubic metres
Mt	million tonnes
Mt CO_2-eq	million tonnes carbon dioxide equivalent
MW	megawatt
MW_e	megawatt electrical
MWh	megawatt hour
PJ	petajoule
t CO_2	tonne carbon dioxide
TWh	terawatt hour

IEA Publications
International Energy Agency
Website: www.iea.org
Contact information: www.iea.org/contact

Typeset in France by the IEA - November 2024
Cover design: IEA



Slovak Republic 2024

Energy Policy Review

Government action plays a pivotal role in ensuring secure and sustainable energy transitions and combatting the climate crisis. Energy policy is critical not just for the energy sector but also for meeting environmental, economic and social goals. Governments need to respond to their country's specific needs, adapt to regional contexts and help address global challenges. In this context, the International Energy Agency (IEA) conducts Energy Policy Reviews to support governments in developing more impactful energy and climate policies.

This *Energy Policy Review* was prepared in partnership between the Government of Slovak Republic and the IEA. It draws on the IEA's extensive knowledge and the inputs of expert peers from IEA member countries to assess Slovak Republic's most pressing energy sector challenges and provide recommendations on how to address them, backed by international best practices. The report also highlights areas where Slovak Republic's leadership can serve as an example in promoting secure clean energy transitions. It also promotes the exchange of best practices among countries to foster learning, build consensus and strengthen political will for a sustainable and affordable clean energy future.