ISFC INTERNATIONAL SUSTAINABLE FINANCE CENTRE

Sustainable Investment Roadmap

Climate investing in the V4 countries

December 2022

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List of abbreviations

AC	alternating current
AT/AUT	Austria
BE	Belgium
BG	Bulgaria
bn	billion
CAGR	compound annual growth rate
CAP	Common Agricultural Policy
capex	capital expenditures
CCS	carbon capture and storage
CCUS	carbon capture, utilization and storage
CEE	Central and Eastern Europe
CH_4	methane
CO_2	carbon dioxide
CO_2e	CO_2-equivalent
CY	Cyprus
CZ/CZE	Czechia
DC	direct current
DE	Germany
DK	Denmark
DKK	Danish krone
EA	emission allowance
EC	European Community
EE	Estonia
EEA	European Environment Agency
EL	Greece
ES	Spain
ESG	environmental, social, and corporate governance
ETS	EU Emissions Trading System
EU	European Union (27 Member States)
EUR/€	euro
EV	electric vehicle
FI	Finland
FR	France
g	gram
G20	Group of Twenty
G7	Group of Seven
GDP	gross domestic production
GER	Germany
GHG	greenhouse gas
GJ	gigajoule
GVA	gross value added
GW	gigawatt
HR	Croatia
HU/HUN	Hungary
IE	Ireland
IEA	International Energy Agency
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
ISFC	International Sustainable Finance Centre
IT	Italy
kg	kilogram
km	kilometre
kt	kiloton
ktoe	kilo tonnes of oil equivalent
kW	kilowatt
kWh	kilowatt-hour
LT	Latvia
LU	Luxembourg
LULUCF	land use, land-use change and forestry
LV	Lithuania
m	million
m^2	square metre
MF	Modernisation Fund
MT	Malta
Mt	metric ton
MW	megawatt
N_2O	nitrous oxide
NACE	Statistical Classification of Economic Activities in the EC *(from French)*
NG	natural gas
NL	Netherlands
OECD	Organisation for Economic Co-operation and Development
opex	operating expenditures
PL/POL	Poland
PM	particulate matter
PPP	purchasing power parity
PT	Portugal
PV	photovoltaic
Q	quarter
R&D	research and development
RES	renewable energy source
RO	Romania
RRF	Recovery and Resilience Facility
SAF	sustainable aviation fuel
SE	Sweden
SI	Finland
SIR	Sustainable Investment Roadmap *(this report)*
SK/SVK	Slovakia
SME	small and medium-sized enterprise
SP	national CAP strategic plan
UN	United Nations
UNFCCC	UN Framework Convention on Climate Change
USD/$	American dollar
V4	Visegrad Group
WWF	World Wide Fund for Nature
WWT	wastewater treatment

Introduction

In recent decades, the concept of sustainable investment has gained traction in public debate and been much discussed on the world stage: in the UN, G20, and the EU. However, it has taken the ongoing crisis in Ukraine to make clear both the scale and scope of the benefits to be gained by sustainable investing and, specifically, the need to invest in an energy transition. To ensure energy independence, economic resilience, and secure food supplies across the EU, words must now translate into deeds.

This report outlines the climate aspects of sustainable investing and sustainable economic growth in the Visegrad Group countries of Poland, Czechia, Hungary and Slovakia (V4), countries linked by geographical proximity, economic development and recent history. The report has two central objectives: to highlight areas of investment which are well suited for the acceleration of the economic transition to climate-sustainable growth, and to provide solutions to obstacles that the V4 countries face in their journey towards a more resilient model - geared towards emission reductions and sustainability.

The V4 context is specific in Europe: since 1990, the V4 countries implemented structural reforms to shift from central economic planning to market economies. They joined the EU in 2004 and have benefited from their favourable location, market access and comparatively cheap labour. Propelled by these factors, GDP growth has been outpacing the EU average and it has clocked in at above 4% across the region over the last decade.

However, the V4 countries are mainly engaged in manufacturing tasks, while higher value-added activities such as research and development (R&D) and related services mostly remain concentrated in the more advanced Western and Nordic countries. Since the global financial crisis, technological progress has stalled and hence their integration into global value chains has slowed down. On the cusp of the Industry 4.0 transition, the V4 countries will likely struggle to further specialize in higher value-added activities and fulfil the decarbonisation objectives simultaneously.

The report aims to encourage relevant stakeholder actions which will support and drive the transition to a greener economy. It is not intended to be exhaustive, but rather serve as an illustrative synopsis for public and private investors and other stakeholders to evaluate the potential of climate-sustainable investment areas in the V4 countries. It deliberately refrains from distinguishing whether investment areas are targeted at the public or private investors, as in many cases the interests overlap, complement or build on each other.

Where are we now?

Where are we now?

The Visegrad Group within the EU

The V4 countries represent around 15% of the EU population and around 7% of its GDP, making them important European economic and political players. Their integration into the EU was relatively fast and successful, and all the countries in the group are well integrated in European supply chains. The geographical location of the V4 countries at the EU's border also makes them crucial to maintaining European security. Given the above, they have the ability to influence the EU negotiations.[1]

At the aggregate level, the V4 economies are highly dependent on coal, oil and natural gas. Oil and gas are largely imported (before 2022, mainly from Russia) and current supply disruptions have caused extreme price volatility in the short to medium term. The burning of fossil fuels for energy production and the industrial production of materials such as cement or steel constitute the main sources of air pollution in the region. Per capita greenhouse gas (GHG) emissions are particularly high in the most populous countries, Poland (37 million inhabitants) and Czechia (10 million), with the V4 contributing by around 16% to the EU GHG emissions. The V4 thus has an important role to play in decarbonisation of the EU economy.

Climate change - significant challenge for V4

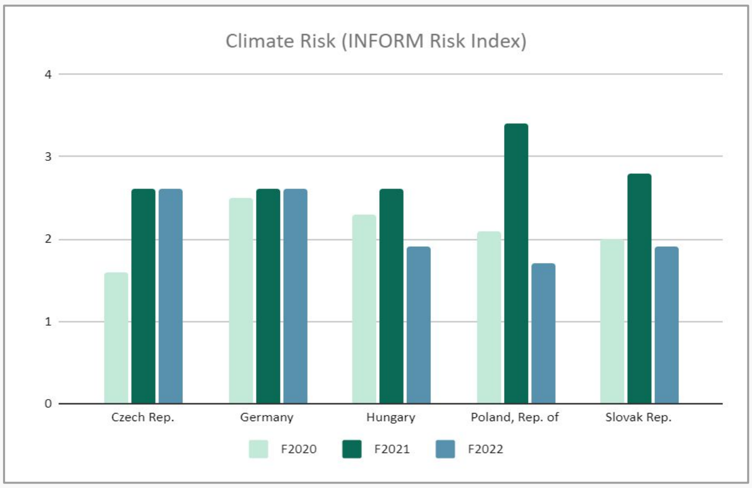
Climate change is already creating economic hardship, political division, and insecurity in the European Union. Droughts, fires, and floods are responsible for ever more deaths and ever more damage to property each year.

The European Commission have noted that extreme temperatures pose the greatest challenge for CEE.[2] Coupled with moderating precipitation in summer, risk of droughts and forest fires will likely increase. Considering that in the CEE region over 34% of the total land area is extensively used for agricultural purposes, an increase in the frequency of droughts will affect agricultural and forest productivity.[3] A study conducted recently by the National Bank of Hungary found that the number of registered weather insurance claims has tripled in the last 40 years.[4]

A two-year drought hit the V4 region in 2018-19, and scientific research warns that these extremes are likely to become more frequent. Based on climate simulations consistent with the IPCC framework, there is a seven-fold increase in the frequency of similar drought events spanning at one third of Central European territories through the second half of this century under the high GHG emissions scenario.[5]

In a high emission baseline scenario, where fossil fuel use remains at a high level and adaptive capacities are low, CEE likely faces a drop in the economic value of land, accompanied by severe economic damage. The IMF[6] and the World Bank[7] assess that resilience in CEE is lower than of Western Europe. At the same time, the climate- driven INFORM Risk Index indicates a moderate exposure of the V4 to climate driven hazards – see Chart 1 below.[8]

Chart 1: Exposure to climate risks



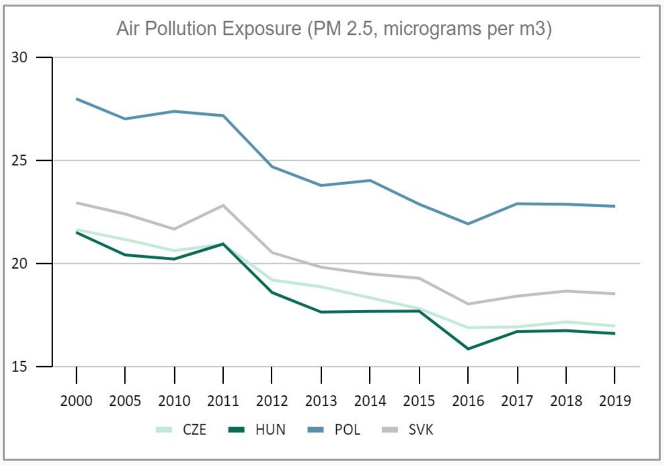
Source: IMF Climate Change Indicators Dashboard, based on the European Commission's Disaster Risk Management Knowledge Centre

Physical risks emanating from climate change also adversely impact financial intermediaries. Acute weather events can lead to large loss events which then erode the available capital. Banking and insurance sectors will grapple with risk quantification as frequency and severity of extreme weather events will change. Chronic risks such as the steady increases in temperatures could lead to a broad-based asset repricing.[9] Devaluation of assets and balance sheet effects are estimated to be a consequence of permanent changes in the weather patterns.

Environmental issues linger

Air pollution is a substantial environmental problem in the V4 region, where heavy industries are concentrated, and fossil fuels are used for power generation. Traffic-related pollutants remain significant especially in the urban areas. The latest Air Quality Report of the EU shows that 1 in 8 deaths are linked to pollution.[10] OECD data indicates that exposure to fine particulate matter (PM 2.5) has decreased since 2000 in all V4 countries, but the levels remain firmly above the average of OECD member peers currently at 13.93 micrograms per cubic metre.[11] Pollution risk is alarmingly high in Poland where fossil fuels consumption remains the cornerstone of the energy sector.

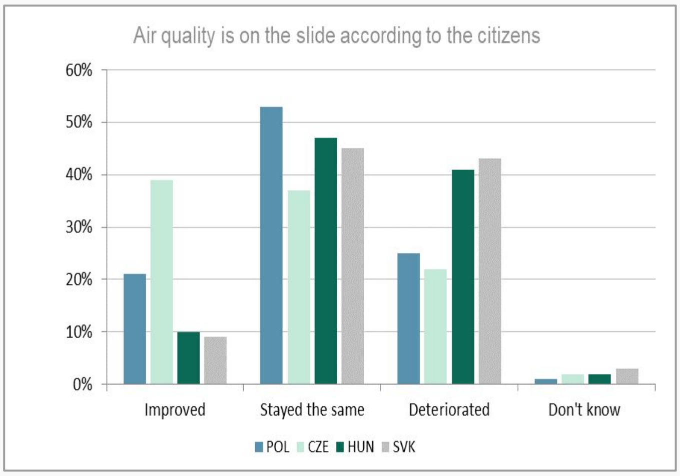
Chart 2: V4 exposure to fine particulate matter



Source: OECD, Air pollution exposure

Despite the measurable improvement in exposure, the general public remained rather pessimistic. According to the latest Eurobarometer poll, most of the population believes that air quality has deteriorated or stayed the same over the past ten years.[12]

Chart 3: Public opinion on air quality in the V4 region



Source: Eurobarometer

Struggle to exit the middle-income trap

The region faces the challenge how to adapt its energy sector and industries to a net-zero future while improving its income status and speed up its economic development.

The V4 countries have been enjoying faster than the EU average GDP growth over the last decade. But the convergence performance has been uneven. Czechia is a clear standout as it managed to close about 50% of its developed gap to Western economies, and its GDP came closest to the EU average before the COVID-19 pandemic hit. Poland, Hungary and Slovakia posted more moderate gains at about 20-30%, and they lag in the purchasing power adjusted measure of GDP. Going forward, IMF's World Economic Outlook expects that Hungary and Poland will have the strongest GDP growth running up to 2025.

Table 1: GDP gains in the region

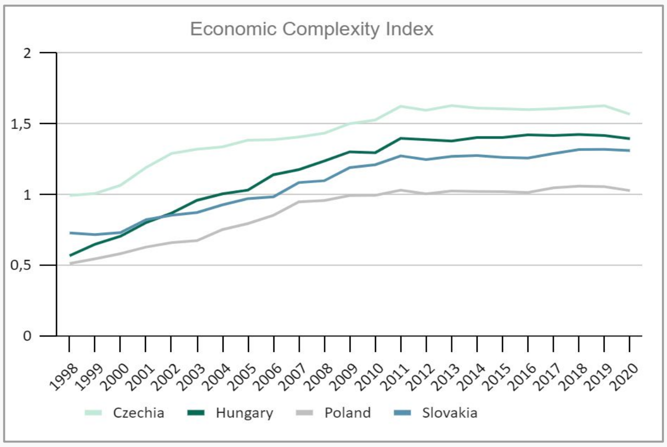
	GDP in 2021 *(PPP)* *EU=100*	GDP per capita in 2020 *(PPP, international dollars)*	Estimated GDP per capita in 2025 *(PPP, international dollars)*	Change in GDP per capita by 2025
Czechia	91	40,791	56,842	*39.%*
Hungary	76	33,144	48,986	*47.8%*
Poland	77	34,226	49,405	*44.3%*
Slovakia	68	33,061	46,883	*41.8%*

Source: Eurostat, estimates based on IMF World Economic Outlook

Looking beyond the mid-term projections however, it is clear that structural bottlenecks could cloud the outlook for the region. Most of the constraining effect stems from strong fossil fuel dependencies and a large material footprint that enabled the economic convergence through the early 2000s. With the prioritization of emission and raw material usage reduction, these dependencies risk becoming future liabilities for the V4 countries. Further, a potential skill constraint may emerge from the labour shortage that the V4 has been experiencing recently, accompanied by a rather slow structural change towards more sophisticated manufacturing activities.

The V4 countries brokered on gains from full integration into the global value chains. Over the last 20 years, all countries increased and diversified their export basket. This is reflected in the "economic complexity index" relative measure which breaks down the country's productive outputs and export markets. Research has identified economic complexity to be strongly correlated with income conditions, thus it can be considered as a precursor to future economic gains.

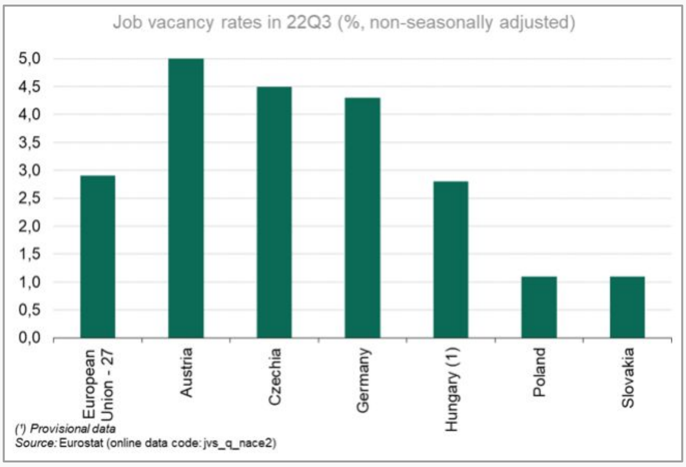
Chart 4: Economic complexity of the V4 countries

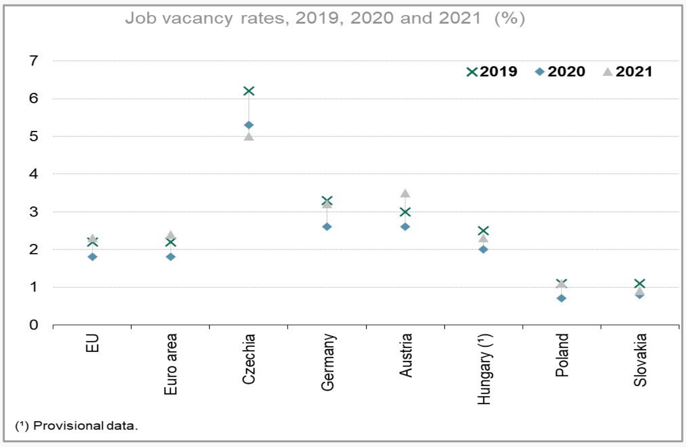


Source: OECD Country Rankings

The indicator suggests a formidable convergence of the V4 before the financial crisis, but gains have been meagre over the last ten years. The slowdown in further sophistication can be interpreted as the region having reached its potential productive output under current structures. This is most alarming for Czechia, where the labour markets have been showing signs of considerable tightness and vacancy rates have been hovering well above the EU average - see Chart 5 below.

Chart 5: Vacancy rate comparison



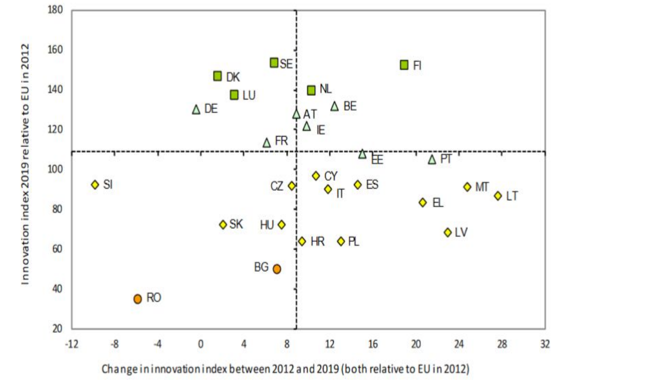


Source: Eurostat (online data code: jvs_a_rate_r2)

Labour specialisation patterns offer a complementary view to the economic complexity measure. Manufacturing in the V4 has been slow to diversify the jobs away from lower value-added activities such as fabrication and assembly-line activities towards higher level tasks such as R&D. Table 2 below summarizes the so-called Balassa index which utilizes the occupational employment shares to estimate the degree of specialisation.

None of the V4 countries managed to post meaningful specialisation in research activities over the 2010s.[13] Despite the impressive headline GDP increases, these countries did not experience a functional upgrading of their production. This is underscored by the European Innovation Scoreboards.[14] The V4 seemed to have got stuck in the slow lane. The Commission's report classifies the Central European countries as moderate innovators whose performance is below the EU average.

Chart 6: Innovation scoreboard - changes since 2012



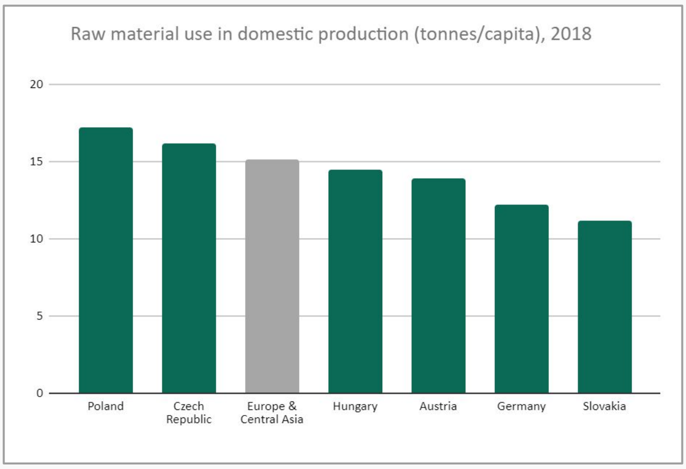
The vertical axis shows Member States' performance in 2019 relative to that of the EU in 2012. The horizontal axis shows the change in performance between 2012 and 2019 relative to that of the EU in 2012. The dashed lines show the respective scores for the EU.

Source: European Commission (2020). Innovation Scoreboard

Economic growth still tied to natural resources

In both Poland and Czechia, raw-material consumption per capita exceeds the European average, and Hungary is only a little below. While the economic development in the region improved living standards and had overall positive welfare impact, these gains have come at an environmental cost which has not been priced in. The region's economic development has been accompanied by intensive raw material use. Resource decoupling in production processes is still some way off.

Chart 7: Raw-material consumption per capita



Source: SCP-Hat http://scp-hat.lifecycleinitiative.org/

Table 2: Sectoral specialization in CEE

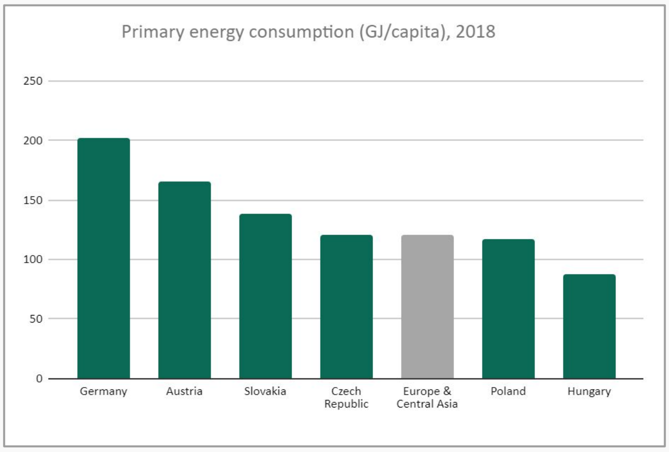
	Specialization by occupation type in 2018			
	R&D	Fabrication	Support	Distribution
Czechia	0.59 [0.36]	1.1 [1.11]	0.92 [0.89]	0.49 [0.59]
Hungary	0.9 [0.88]	1.09 [1.12]	0.76 [0.72]	0.84 [0.54]
Poland	0.71 [0.77]	1.07 [1.06]	0.97 [0.97]	0.44 [0.4]
Slovakia	0.31 [0.38]	1.14 [1.12]	0.85 [0.86]	0.74 [0.43]
Austria	1.07 [0.8]	0.95 [0.96]	1.05 [1.12]	1.47 [1.39]
Germany	1.24 [1.48]	0.87 [0.9]	1.23 [1.12]	1.65 [1.44]

Specialization measured with Balassa index of comparative advantage. Values above 1 reflect specialization in a certain occupation. Values in brackets indicate 2011 values.

Source: Eurostat Labour Force Survey, Pellenyi (2020)

The economic transition model, based on a skilled workforce with lower wages compared to the EU average, contributed to the persisting high share of the industrial sector especially in Czechia and Slovakia and, to a large extent, the higher energy intensity, as shown in Chart 8. There is a clear scope for energy efficiency investment.

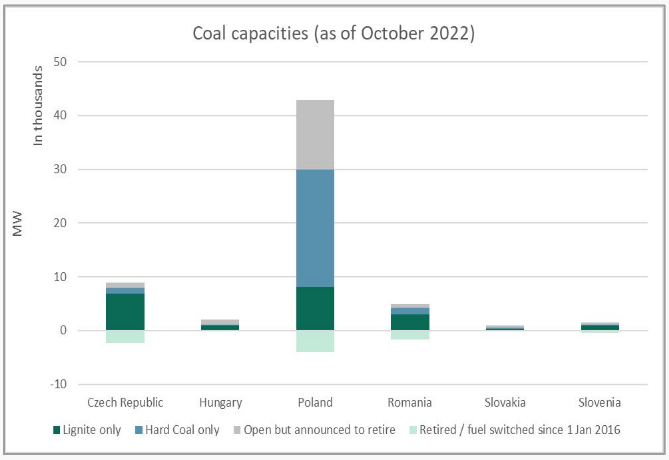
Chart 8: Energy intensity per capita



Source: SCP-Hat http://scp-hat.lifecycleinitiative.org/

Coal dependency in the power generation remains significant in the region. Poland is considered to have the 9th largest global coal reserves and produces a hefty 144 million tonnes per year, while Czechia ranks as the third largest coal producer in Europe with an annual 46 million tonnes output.

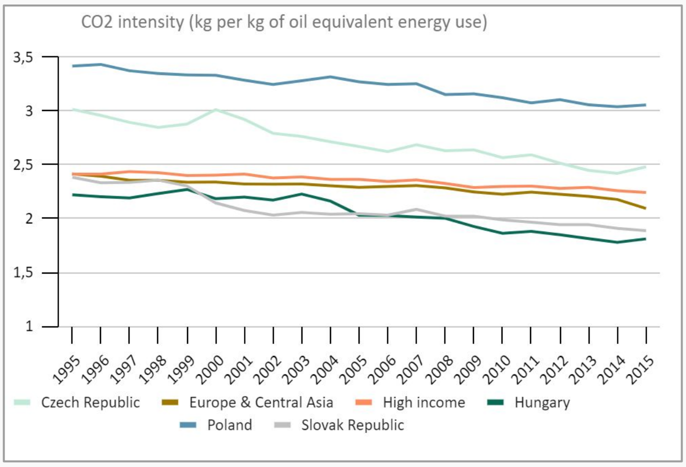
Chart 9: Coal capacities in CEE



Source: Europe Beyond Coal database[15]

Reliance on fossil energy sources keeps the region's carbon footprint alarmingly high. Carbon emission development in the last two decades is shown in Chart 10.

Chart 10: Carbon emission intensity per oil equivalent



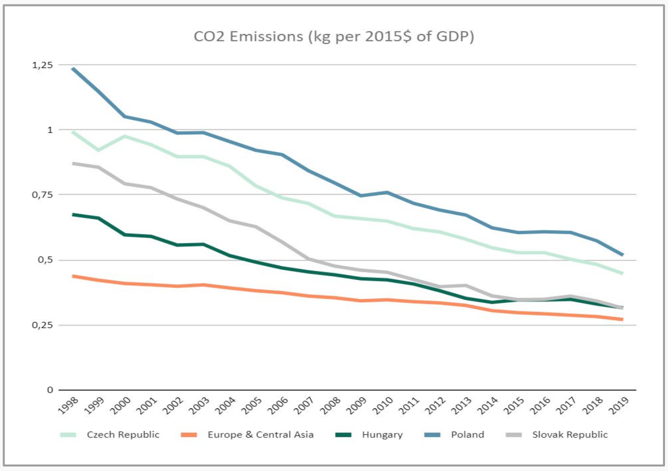
Source: World Bank

At the same time, the share of renewable energy sources barely has budged in all four countries. The latest statistics from 2020[16] show all four countries overperformed compared to their targets, but their RES shares remained significantly under the EU average. Czechia and Slovakia top the V4 charts: both recorded a 17.3% ratio. Poland followed suit with 16.1%, while Hungary lagged with a more modest 13.9%.

Staggering carbon intensity in Poland is a source of concern. The most recent National Inventory Report submitted by Poland to the UN[17] notes that GHG emissions reversed the deceleration around 2012 but started to increase running up to 2017, pushed by accelerating economic growth and favourable fuel prices. The decline only resumed in 2018 due to a slowdown in the industrial sector. If the recent past is anything to go by, dynamic economic conditions tend to worsen the emission statistics.

Despite the significant decrease in the emissions since the late 90s, Poland and Czechia still have much larger CO_2 emissions per GDP compared to peers and the European average. In both countries, the energy sector is the main culprit, accounting for the largest share of the total GHG emissions. And the power sector's efficiency is still lower than of EU peers - therefore the emission intensity of economic output is stuck at a very high level.

Chart 11: Carbon emission intensity of GDP



Source: World Bank

Current energy crisis to accelerate structural changes

Disruptions in Russian gas supplies and the risk of a full shut-off of supplies to Europe have exposed V4's vulnerability. IMF analysis from 2022 found that Hungary, Slovakia and Czechia are the most vulnerable to the shock. Shortages of 40% of gas consumption and a sizable GDP drop by 6% have been estimated.[18] In all four countries household gas demand constitutes a large share of the national aggregate, as Table 3 shows. This is worrying because their dependency significantly reduces the short-term adjustment potential to the supply abruptions.

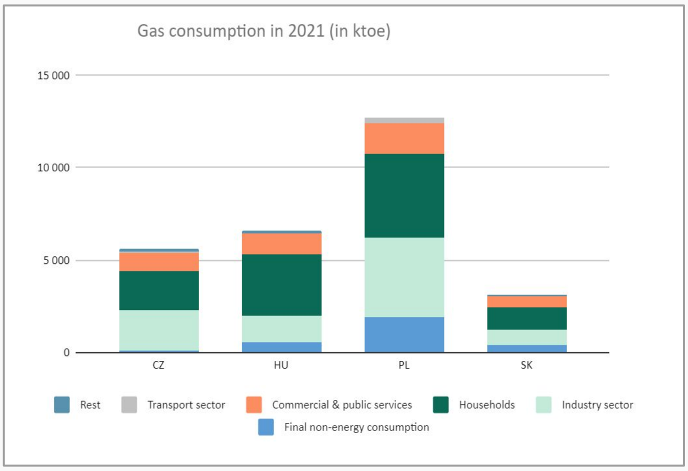
Table 3: Households´ share in gas consumption

	Households' gas consumption (% share)
Czechia	35.3
Hungary	49.8
Poland	31.4
Slovakia	25.4

Source: Eurostat, Energy Balance January 2022 dataset

When gas consumption is considered in absolute terms, the demand from industry and households is dominant. In Poland and Czechia, it is mainly industry demand that stands out, while in Hungary it is household demand that sends the country's gas consumption, in relative terms, to levels above the size of the economy.

Chart 12: Gas consumption breakdown



Source: Eurostat, Simplified Energy Balances, December 2022 dataset

The current crisis can help reignite innovation and decarbonisation investments. The V4 countries are in a dire need of a rethink about the way energy is sourced, utilised and what technologies are used. In industry, the crisis could create the opportunity to implement policies that support employers to focus on higher value-added activities and thus transform business in the region. This is all the more urgent in the case of energy-intensive industries, as there are often technological barriers when it comes to simply changing raw materials or reducing their use. Improving energy efficiency across the region has been an overlooked route contributing to decarbonisation. As for the household segment, a key vulnerability remains the residential solid fuel combustion, while the existing building stock is largely energy inefficient. The main transition initiatives within each segment are explored in more detail in the climate investment areas sections later in this roadmap.

Sustainable investing

Sustainability – A changed approach to investment

Sustainable investing

Sustainable investing refers to the process of taking environmental, social and governance considerations (in addition to financial ones) into account when making investment decisions. The focus of this report is on climate change mitigation areas, a key part of environmental considerations. Climate sustainable investing is intended to support economic growth while reducing, and ultimately eliminating, climate change pressure points by lowering carbon or natural capital footprints.

Implementing climate sustainability into assessment and decision-making processes in the economy, finance and investment is an effective tool to address the global, multifaceted, and complex challenges of climate change. The depletion of natural resources and the high dependence on non-European energy and commodity suppliers have left Europe in a delicate political, economic and strategic position. Transitioning to a sustainable economic system would allow the EU to partially reclaim its energy and economic independence, to strengthen the resilience of its supply chains and to invest in the upskilling of its workforce and its adaptation to new technologies.

The delivery of the objectives of the European Green Deal is dependent on the channelling and redirecting private investment towards economic activities that lead to the transition to a climate-neutral, climate-resilient, resource-efficient and fair economy. The goal is to use private capital flows to complement existing public funding. Prepared in 2020, the European Green Deal Investment Plan aims to mobilise at least €1 trillion of sustainable investments over the next decade.[19]

Embedding climate considerations, data and impact assessment

The development of sustainable finance requires the enshrining of climate and environmental considerations in financial decisions, risk management and impact assessment. Mainstreaming climate and environmental issues in financial practices allows these problems to be tackled on several fronts.

Defensively, the inclusion of climate and environmental risks into investment and lending decisions limits further damage to ecosystems and allows for the identification of business models with a high exposure to climate and transition-related risks. It also enables the adoption of measures to mitigate the risk of stranded assets[20] or carbon bubbles.[21] On the offensive front, investing in sustainable solutions, research and innovation helps the transition – and maybe repair damages – and offers considerable profit potential. The latter emerges from greater resilience of the businesses and financial institutions to withstand climate change impacts such as extreme weather and transition risks such as regulatory or taxation changes that tackle pollution or carbon footprints.

Sustainability enters the mainstream

Climate and environmental issues are currently at the top of the political agenda all around the world. The devastating climate-related catastrophes of recent decades (tsunamis, drought, fires, floods, etc.) have pushed international and national institutions to broaden their strategy to limit emissions and protect the environment. In the past years, governments have mainstreamed environment and climate change in their domestic and international policies.

Political institutions have largely accepted that if they wish to protect their citizens against natural disasters and to ensure continuous economic development, they must support the transition towards green economy.[22] In 2021 alone, the G20,[23] the G7,[24] the UN Environment Program (UNEP),[25] the International Monetary Fund(IMF),[26] and the European Commission[27] published papers and/or adopted strategies to align investments with sustainability goals and assess sustainability risks in public and/or private finance.

From these promises made in the international fora, local, national and international policies have quickly emerged to advance and speed up the economic transition and the development of sustainable finance. The European Union is currently implementing its Green Deal Investment Plan[28] which aims to increase funding for the transition, creating an enabling framework for private investors and the public sector to facilitate sustainable investments, providing support to public administrations and project promoters in identifying, structuring and executing sustainable projects. The United States,[29] China,[30] India,[31] Japan,[32] the United Kingdom[33] have all issued regulations or regulation proposals to limit their emissions and boost green public and/or private investments.

Similarly, cities and local authorities have launched different initiatives to foster sustainability in their communities. The Covenant of Mayors for Climate and Energy, for instance, brings together over 10,000 cities across Europe, committing to implement EU's climate and energy objectives by 2030.[34]

Banks and financial institutions are also looking to improve their products and services to align with climate pledges and consumer demands. They join networks such as the Sustainable Banking and Finance Network (SBFN) to facilitate the collective learning of its members and to support them in policy development to create drivers for sustainable finance practices.[35]

Developing a sustainability approach improves the reliability and reputation of companies and increases their chances to adapt throughout changing times - and potentially take advantage of regulations aligned with sustainability factors. This has also been reflected in the increased interest in issuing green bonds. The market of green bonds has expanded incredibly in the past decade, reaching $2 trillion in value in 2021.[36]

Preconditions for transition

Preconditions for a successful transition

A successful green economic transition can be achieved only if several key preconditions are fulfilled. This section highlights them.

Framing sustainability as a priority

It is crucial that governments and decision-makers consider the transition towards a sustainable economy as a top priority. In the V4 countries, sustainability is often perceived as an additional extra to regular activity in public and private sectors and thus climate ambitions remain low. Sustainable development is often pushed by foreign companies which include it within their social corporate responsibility activities, or it is demanded by civic organisations. However, any business or financial institution effort will have a greater impact if it is pursued in a policy and regulatory environment that is supportive of sustainability considerations. Local ownership of the sustainability agenda, accompanied by transition pathway planning and coherent policies can help governments take advantage of the growing corporate and financial sector interest in improving sustainability performance.

Sustainability awareness

Awareness of the environmental impact of businesses is a necessary precondition to eco-innovation and sustainable investment. A large part of the general population and many businesses still lack sufficient awareness and understanding of the long-term benefits of introducing sustainable practices in their businesses. Despite the noticeable trend in recent year seen in developed countries of investing in products and companies that follow ESG criteria, this has not yet been fully understood by the general public or companies in the V4 region. A lack of relevant information, education and a clear commitment from public authorities in this area remains a major obstacle.
To facilitate comprehensive sustainable (finance) awareness, stakeholders should be involved at every stage of national sustainable strategy preparation (multinational, regional, and local businesses, banking organisations, private and public investors, professional associations, etc.). They all can add valuable inputs, ensure transparency and accountability during the debates, and help develop effective outputs. It has been demonstrated that stakeholder involvement brings forth innovative solutions and increases compliance with new norms.[37]

Policy and regulation consistency

Consistent and coherent public policies are a must-have precondition to unlocking private investment and supporting sustainable projects. They help kick-start investments, decrease risk and costs, and influence investor and project economic position. On the other hand, insufficient policy guidance and data-driven policies or inconsistencies between national policies and the EU regulatory framework represent a significant barrier to long-term investment. Apathetic policy signals have a similar impact. Here, the V4´s National Energy and Climate Policy submitted to the European Commission can be considered disappointing as it is not aligned fully with the European Green Deal targets.[38]

Equally harmful might be ill-devised policies. In Czechia, for example, a combination of decreasing costs of the photovoltaic technology and high fixed feed-in tariffs, which had not been appropriately decreased, led to exponential growth in solar projects in 2009/10, much above the targeted volume. The subsequent heavy burden for public budgets led to additional taxation of the sector and minimum subsidies for new installations. As a result, investors lost interest in the sector for almost a decade.[39] It also damaged the public perception of initiatives supporting renewable energy projects.

Bank, securities, and blended financing

Given the key role the banking sector plays in financing (sustainable) projects in the V4 countries, appropriately targeted incentives have the potential to act as catalysts, accelerating the sustainable transformation. According to the European Banking Federation, maintaining the link between long term risk considerations and capital, the European Banking Authority could explore, using forward looking approaches, preferential capital treatment for certain sustainable assets that show a lower financial risk.[40]

Green securitisation has the potential to support small-scale developments and act as a multiplier to fund sustainable assets as well as transition efforts. Additionally, the inclusion of green assets in the cover pool of covered bonds to create Green Covered Bonds could allow increased financing for sustainable projects by strengthening their economic viability. Developing further incentives encourages (e.g., cities and municipalities) to issue green and sustainability-linked bonds to finance energy efficiency projects such as building or central heating system retrofitting.

Cooperation between public and private sectors through blended finance, public programmes allowing for guarantees to incentivise sustainable projects, or the integration of sustainable finance into promotional structures should be considered.

Public finance support

Public financial support is important to speed up and/or redirect private investments into sustainable projects by offsetting a portion of one-off investment costs. The Czech New Green Savings scheme[41] to retrofit residential buildings and the Hungarian electric vehicle subsidy of over EUR 16m as of 2020[42] are examples of financial support programmes in the V4 countries.

Without well-targeted public financial support, cheaper, less sustainable, solutions might be favoured - causing further negative externalities that are not fully factored into existing prices.

Where green schemes incur additional financial costs, implications for global competitiveness on the relevant markets must be carefully assessed and appropriate compensation mechanisms adopted. Free ETS emission allowances - before the planned implementation of Carbon Border Adjustment Mechanism (CBAM)[43] - were supposed to be such a mechanism. However, while it benefited businesses for a long time, it has been rather ineffective as a decarbonisation tool. Free allowances lead to flawed dynamics in the market.

With the envisaged introduction of CBAM in 2026 and the phasing out of free allowances, proper attention should be paid to quantifying increased costs due to decarbonisation. The measures need to be fine-tuned to effectively support sustainable projects and maintain fair global competition.

Administrative support

Administrative burdens must not deter investors from accessing national and international support programs. In countries such as Czechia or Slovakia, where more than 96% of SMEs are micro enterprise (≤ 2 persons),[44] technical and administrative support would help small players accessing funds. Unfortunately, Czechia ranked 157 of 190 countries in the ease of Doing Business 2020 report by the World Bank Group.[45]

Separately, given the envisaged accelerated technical development, regulators need to be prepared to revisit and update existing standards and codes flexibly and more frequently. Horizontal collaboration across governmental agencies and with R&D institutions and companies is important for timely standardisation and regulatory adoption.

Climate investment areas

Climate investment areas

Climate change can be addressed both by adapting to its impacts and by mitigation, that is, by reducing/avoiding GHG emissions. No single technology or measure can provide all of the mitigation potential in any sector, but many technologies and measures have been shown to be able to contribute to such potential. In this chapter, the selected major investment areas with mitigation potential are listed. Investing in the priority sectors and target areas has the potential to reduce, avoid or even remove GHG emissions in the V4 economy, while also contributing to long-term prosperity in the region.

Although they are not addressed in a separate chapter in the document, efficiency measures represent an important part of emission reductions. Investment areas that lead to or contribute to efficiency improvements are presented in the following individual segments/chapters alongside or as a part of investments directly aimed at emissions mitigation. However, as noted above, efficiency measures alone cannot lead to long-term sustainable development on their own.

More detailed consideration on a case-by-case basis is needed to ensure alignment of the envisaged investments with the EU Taxonomy. While some can be rather straightforward, such as solar PV or wind power production, others need to meet multiple conditions, such as biofuels or bioenergy.[46]

Data & methodology

The segments presented below in this report have been selected based on their current climate impact potential and, hence, GHG emissions reduction potential in the V4 countries.

First, the segments with the highest GHG emissions are identified and ranked. The report uses emissions data for 2020 from the United Nations Framework Convention on Climate Change (UNFCCC) database.[47] The use of CO_2-equivalent data allows comparison with segments where GHGs other than CO_2 represent the major emission component. Here, UNFCCC's conversion methodology is applied: conversion factors represent the global warming potential of the relevant GHG over a 100-year time horizon based on the IPCC Fourth Assessment Report.[48] Methane (CH4), which is mainly associated with agriculture and waste management, has a conversion factor of 25. Similarly, nitrous oxide (N2O) has a conversion factor of 298.[49]

Second, nine segments are identified that together account for more than 90% of the total GHG emissions, as shown in Table 4 below.[50] Public Electricity and Heat Production (with 31% of the GHG emissions) clearly represents the most air polluting segment in the V4 region. Emissions from non-public power/heat production plants are included in other segments according to their sectoral affiliation. Annex 1 provides a detailed definition of the segments according to the UNFCCC category codes. The GHG emissions breakdown by segments for each V4 country can be found in Annex 2.

Table 4: V4 GHG emissions breakdown by segment

Year 2020	kt CO_2 equivalent	% of total	kt CO_2	% of total
Public Electricity and Heat Production	183,295	31%	182 213	38%
Road Transport	98,648	17%	97,502	21%
Agriculture	66,880	11%	15,628	3%
Local Heating	66,108	11%	61,533	13%
Cement, Lime and Other Minerals	32,975	6%	32,832	7%
Chemical Industry (incl. oil refining)	28,677	5%	27,770	6%
Coal Mining & Transformation*	26,023	4%	9,664	2%
Waste	21,536	4%	730	0%
Iron and Steel	19,534	3%	19,494	4%
Others	44,972	8%	26,389	6%
Total emissions**	**588,648**	**100%**	**473,756**	**100%**

* incl. other solid fuels; ** without Land Use, Land-Use Change and Forestry

Source: UN Framework Climate Change Convention GHG database, ISFC calculations

Third, the segments´ contribution to gross value added (GVA) and employment is presented, based on basic breakdowns of the main GDP aggregates and employment (by industry and by assets) reported by Eurostat for 2020 under the annual national accounts.[51] As the GVA and employment data works with the NACE industries definition, and in order to show the emissions-GVA matrix, the UNFCCC emissions data is slightly regrouped (and thus segments moderately redefined) for this particular purpose to match the NACE approach; Annex 1 provides sector (re)definition details. The redefined sectors´ contribution to GHG emissions, GVA and employment in the V4 region is shown in Chart 13 below. Annex 3 provides a matrix for each V4 country separately.

Finally, the above segments are addressed in the following subchapters, except for "Coal Mining & Transformation (incl. other solid fuels)". Coal mining, as a non-transiting sector will be marginalised in the V4 region by 2050.[52] All the other segments are further elaborated with respect to current (climate) status and regulation, selected investment areas and transition accelerating ideas.

The list of segments and possible investment areas is not exhaustive, but it aims to provide an idea of the investment potential in the region and inspire public and/or private investors to support positive change. While the investment areas focus on their climate-change mitigation potential, one should not ignore their potential in reinforcing supply chains, improving sectoral resilience, upskilling workers or supporting socio-economic development.

Chart 13: Contribution of high-emission sectors to GVA and employment in V4

Source: UN Climate Change Convention GHG database, Eurostat - Annual national accounts, ISFC calculations

Electricity & heat production

Status and challenges

The V4 energy sector's carbon footprint is nearly double that of the second most emission-intensive sector - road transportation - and at 31% it has the highest share of overall regional GHG emissions in 2020, with Poland being its most significant contributor. Although the country has been decreasing its electricity generation emission intensity almost every year since 1990, it is still an unequivocal leader in the V4 region accounting for a 72% share, and placed 2nd in the EU with 750 g CO_2e per kWh in 2021. Slovakia has ranked at the other end of the scale thanks to its 4th highest cuts achieved in electricity emission intensity in the EU, totalling about 76% over the 1990-2021 period.[53] It must be, however, noted that such a result was not achieved due to the large-scale deployment of renewable energy, but due to its nuclear power plants covering around half of domestic electricity consumption in 2021.[54] The full commissioning of the third block of the Mochovce Nuclear Power Plant has been scheduled for the end of 2022.[55]

The energy generation market in the V4 region is liberalized and dominated by state-owned or co-owned companies in each country: PGE in Poland supplied 42% of total electricity to the grid in 2021,[56] ČEZ in Czechia supplied electricity to around 40% of collection and delivery points in 2021,[57] MVM in Hungary provided 60% of overall electricity generation in 2020, and Slovenské elektrárne in Slovakia accounted for 64% of electricity generation in 2021.[58] There are dozens of mid-size private electricity producers throughout the region and even more local (heat) energy producers supplying heat to adjacent municipalities and electricity to the grid. The grids are operated by state-owned transmission system operators in each of the V4 countries. There are several major regional distributors in the V4, five in Poland, three in Czechia and Slovakia, and six in Hungary.[59]

Emissions	183 Mt CO_2e
GVA weight	2.9%
Employment	0.3m persons

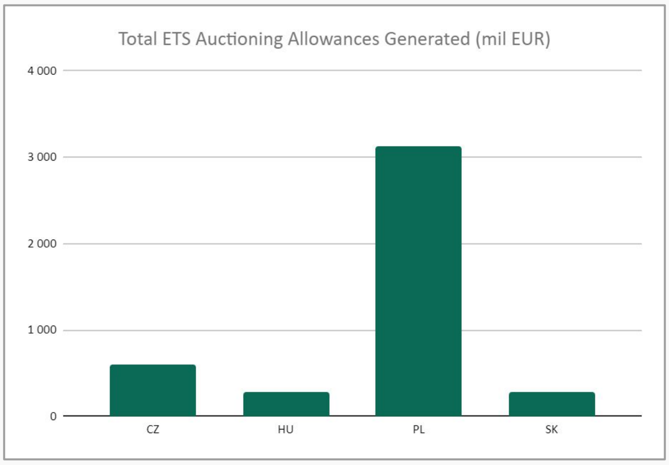
* 2020 data, GVA weight = share of the segment in the total V4 Gross Value Added

The V4 region is heavily dependent on energy from solid fossil fuels. In Poland and Czechia, they account for almost 41% and 31% of energy sources, respectively, making this a decisive factor for regional decarbonisation.[60] Such figures rank them second and third highest in the EU. The V4 countries have a roughly equal share of renewables amounting to 16-17% of the energy mix in 2020, except for Hungary lagging behind with only 14%.[61] While Poland signed a contract for the construction of its first-ever nuclear power plant only in 2022, which should become operational in 2033,[62] Slovakia and Czechia produce substantial amounts of nuclear energy and they ranked 2nd and 6th in the EU in terms of the share in their energy mix in 2020.[63]

The energy sector in the V4 region directly employed around 264,000 people and contributed almost 3% to gross value added (GVA) in 2020. When it comes to the renewable energy sector, its contribution to direct and indirect regional employment is around 188,000 jobs in 2021.[64] Although Poland stands out among the V4, with its vast workforce employed in coal mining,[65] it should also be highlighted in terms of green employment. The country tops the EU list of solar PV market-driven direct and indirect employment and ranks 7th worldwide with about 57,000 green jobs in 2021.[66] The main reason for its leadership is the dominant position of residential rooftop installations, which are typical for higher employment factors.

The EU Emission Trading System (ETS) covers CO_2 emissions originating in electricity and heat generation. Electricity producers have been obliged to buy emission allowances (EAs) needed for electricity generation since the third phase of the ETS introduced in 2013. Modernisation of the power sector is incentivised through the Modernisation Fund (MF) promoting clean investments and a just transition of carbon-intensive regions in 10 Member States, defined as so-called lower-income with a GDP per capita below 60% of the 2013 EU average. These Member States, encompassing all V4 countries, are also in the fourth phase (2021-30) subject to free allocation of EAs under Article 10c of the EU ETS Directive. Such an instrument should accelerate countries' investments in, among others, diversification of the energy mix, a higher uptake of clean technologies, and the modernisation of transmission and distribution systems, all of which are highly relevant for the V4 energy sector decarbonisation.[67]

Chart 14: ETS auctioning revenue



Source: EEA Reportnet portal; revenues as of 2021

There are 10 regions in the V4 classified as coal-mining regions. In late 2022, Poland announced that it would slow down the pace of coal mine closures, but that it will still retain the end date of 2049.[68] The Czech government´s manifesto in early 2022 explicitly stated the country's commitment to end coal mining by 2033. Slovakia is on track to its coal phase-out by 2030 as it plans to close its second-largest carbon emitter, the Nováky lignite Power Plant, by the end of 2023.[69] Finally, Hungary´s last coal-fired power plant, Mátra, which is responsible for around half of CO_2 emissions in the country's energy sector,[70] should be phased out by 2025 (for more details, see Box 1 on the next page).

Enormous investment costs are envisaged on the pathway towards full decarbonisation of the V4 energy sector. For instance, the costs of the energy sector transformation in Poland are estimated to amount to approximately EUR 135bn by 2030.[71] The amount of funds available at the level of EUR 69bn for the energy transition in Poland from EU funds will be insufficient to cover the entire investment gap in the electricity and heating sector, estimated at EUR 77bn, including protective measures. Therefore, in order to cover the expenditure, it will be necessary to, inter alia, search for additional sources of funding at both national and EU levels.

Climate investment areas

As the future energy carrier for heating, transport, and hard-to-abate sectors, electricity decarbonisation remains a key challenge and simultaneously an opportunity on the net-zero pathway by 2050, and the V4 region is no exception. The forthcoming energy-sector and energy-mix transformation also has the potential to improve the V4 countries´ energy security. The path away from fossil fuel-based electricity production clearly leads to renewables.

- **Wind energy**: There is a huge potential for wind deployment across the V4 region. According to recent studies, to achieve the power sector decarbonisation target in Poland, around 75% of overall power production in 2050 could be generated by wind power plants.[72] As the Polish Baltic Sea provides very favourable conditions for offshore wind deployment, it should play an indispensable role supplying slightly over half of the country's power supply by 2050. See also Annex 4 for more details on the Polish wind energy market.

  Hungary can also be ambitious in its wind power targets thanks to its good natural conditions.[73] The country could expand its wind generation by 46 times by 2050, compared to the capacities installed in 2020.[74] Such a development is also in line with the IEA´s latest country assessment in 2022, stating that more wind projects should be added particularly in the north-western region of Hungary in coming years, as they complement PV electricity production.[75]

In Czechia, studies suggest that onshore wind renewable electricity generation could increase by seven times from its current level by 2030.[76] Moreover, considering all known restrictions for the construction of wind power projects in the country, wind power plants could provide almost a third of the current level of Czechia's electricity consumption by 2040, according to the Institute of Atmospheric Physics of the Czech Academy of Sciences.[77]

The only wind farms Slovakia has in operation are nearly two decades old, with a total installed capacity of 3 MW. While respecting all known restrictions on wind power projects, around 20% of Slovakia's territory has been evaluated as conditionally suitable for wind power projects. In practice, at least 667 MW would need to be installed by 2030 so that Slovakia could stay on track towards to achieve carbon neutrality by 2050, when around 2 GW of wind plants would need to be in operation.[78]

- **Photovoltaics:** Based on a recent study, Hungary could expand PV production 20-fold by 2050 compared to the capacities installed in 2020.[79] Furthermore, it could become the main source of zero-carbon electricity for heat electrification and anticipated green hydrogen production.[80]

The PV potential in Poland remains relatively limited, conservative sources estimate PV could cover around 6% of the overall power supply in 2050,[81] though more ambitious estimates also exist. In Czechia, renewable electricity generation from PV could be quintupled by 2030 as compared to the current levels.[82] For more information on PV in Czechia, refer also to Annex 5.

Thanks to many advances in PV technologies in recent years, the average conversion efficiency and power rating of a common standard-sized panel have increased well above 20% and 400W, respectively.[83] Given this, as well as advances in battery storage technologies, the costs of solar energy production have rapidly decreased and PV has become one of the economically viable and scalable sustainable technologies. In the Czech Republic, the Czech Solar Association estimated in October 2022 that the payback period for rooftop solar-plus-storage installations had dropped to 8 years.[84]

The story of Hungary's Mátra Power Plant, described in Box 1 below, can serve as an example of a sustainable energy transformation of a formerly emission-intensive electricity production site in the V4 region.

Box 1: Transformation of the Mátra power plant in Hungary

Hungary operates the 950 MW coal-fired Mátra Power Plant, which is responsible for around half of the country's energy sector CO_2 emissions. It plays a fundamental role in ensuring security of electricity supplies totalling almost one fifth of the overall Hungarian power production. The Mátra Power Plant provides employment to approximately 10,000 people directly and indirectly.[85]

The country's last coal power plant may serve as a remarkable example on how lignite-fired plants may be gradually transformed into sustainable energy facilities. The government plans to move towards its decarbonisation by the use of pumped-storage, biomass and PV technologies combined with large-scale battery storage. In addition, the company operating the plant mentions a pilot project utilising CCUS technology.[86] The Mátra Power Plant should be phased out by 2025.

- **Electricity grid and system flexibility:** Given the increasing penetration of wind and PV in the V4 region and the transformation of hard-to-abate industrial and transport sectors heavily reliant on large amounts of renewable electricity, investments in grid reinforcement and modernisation and increased flexibility of multi-directional electricity systems will be necessary to avoid grid overloading and power outages.[87] Sustainable electricity storage, pumped storage hydropower plants (so-called water batteries), large-scale stationary battery systems, or green hydrogen storage look like the way to go. To the extent necessary, these could be complemented by gas-fired plants combined with CCUS technology.

  While the Government of Hungary has introduced a plan to increase the country's energy storage capacities to at least 1 GW by 2026, a regulatory framework to facilitate large-scale energy storage investments is still lacking.[88] Hungary's 2030 National Energy Strategy calculated that around EUR 1.2 billion investment is needed for grid reinforcements by 2030, which comes in a lot lower than the EUR 30-40 billion estimate by an independent study to meet the economy's electricity demand sustainably by 2050.[89] Poland is also planning a major modernisation of its transmission and distribution network. The Energy Policy of Poland has calculated investments at around EUR 21 billion in the period 2021-30, and EUR 19 billion in 2031-40.[90] In contrast, an independent study has identified the country's investment needs for electricity-grid modernisation to be as much as EUR 75 billion by 2050.[91]

- **District heating systems:** The V4 region is characterised by an extensive district heating infrastructure. The EC criticised Czechia and Poland in October 2020 as countries without comprehensive plans for district heating decarbonisation, with no clear targets for the introduction of more renewables.[92] The case of Poland's heating sector is particularly striking given its enormous reliance on coal. And despite the sharp rise in natural gas prices, Poland is still insisting on a switch from coal to NG in the district heating sector.[93] Given that such a transitional NG phase can delay a real sustainable transformation by decades, waste heat and renewables, large-scale heat pumps, sustainable biomass and geothermal will need to play an increasingly important role in coming years, in addition to energy savings.[94]

  More specifically, Poland has significant decarbonisation potential through industrial-scale heat pump deployment in its heating sector, which could supply one of the largest district heating networks in the EU.[95] Four core principles have been identified for heating sector decarbonisation in Czechia: energy savings, waste heat (including heat pumps), local sources (such as solar thermal collectors, biomass, and geothermal energy), and other sources (i.e., biomethane, renewable electricity, and possibly green hydrogen).[96]

Transition acceleration & roadblock removal ideas

- The energy transformation of the V4 region has long been negatively affected by the ambivalent attitude of its political elite towards green transformation.
  This has significantly hampered the large-scale green energy deployment in all V4 countries.[97]
  Administrative and permitting procedures have continued to slow down further deployment of renewables.[98] This makes the Member States concerned one of the less advanced in terms of wind and PV generated electricity in the EU.
  The governments must demonstrate a clear political commitment to renewable energy and align both the signalling and incentive structures to support RES.

- Instead, the V4 region has decided to double its position in nuclear power plants, including new plants announced in Hungary and Poland in the second half of 2022.[99] These developments also translated into the 2030 renewable targets set in the final NECPs.[100]
  The goals for all the V4 countries were considered by the EC and private companies as not being ambitious enough, with Slovakia having the largest gap of almost 5% percentage points compared to the figure resulting from the national contribution formula.[101]
  The revised targets to be proposed in the updated NECP drafts and final versions by 30 June 2023 and 30 June 2024, respectively, should include firmer commitments to renewables deployment.

- In 2021, IEA noted that the V4 region is struggling to set up frameworks to enable renewable self-consumption and energy communities. This is despite research indicating high interest from companies in all V4 countries to purchase or self-produce renewable electricity.[102] For a long time, Czechia has been one of the last remaining countries in Europe without a law on community power generation; the Ministry of Industry and Trade introduced the first amendment draft to the Energy Act in November 2022, although effective application is not likely until after 2024.[103] Finally, Slovakia remains a noteworthy example of how not to utilise a vast wind energy potential. Further information can be found in Box 2.

Box 2: Why is there almost no wind energy in Slovakia?

Slovakia is noteworthy for not utilising its vast wind energy potential. With only 3MW, currently operates the second lowest installed wind power capacity in the EU.[104]

According to a study by the Slovak Academy of Sciences, wind plants with an installed capacity of at least 667 MW should be built by 2030 if the country is to stay on track to meet its 2050 decarbonisation target.[105] Yet the Slovak government only approved a target of 500 MW for 2030 in its National Energy and Climate Plan and has already failed to fulfil its annual 2021 and 2022 capacity targets.[106]

According to the Study of Wind Development in Slovakia by the Slovak Association of Photovoltaic Industry and RES of late 2022, the Government should remove or significantly reduce a dozen legislative, regulatory, administrative, technical, and other roadblocks that are still hindering large-scale wind deployment.[107]

Road transport

Status and challenges

Emissions	99 Mt CO_2e
Vehicles	43 millions
GVA weight	3.7%
Employment	1.1m persons

* 2020 data, GVA weight = share of the business land transport in the total V4 Gross Value Added, ACEA Report 2022 - Vehicles in use

In this subchapter, we focus on road transport, including both passenger and goods transport. Furthermore, transport can be divided into personal and business use. Business land transport, as based on the NACE activities definition, employed more than 1.1 million people and contributed 3.7% of GVA to the V4 total GVA in 2020.

At the same time, road transport contributed 17% to the V4 total CO_2e emissions in 2020. This was the only year in almost ten years when transport emissions in the V4 dropped - due to the COVID-19 pandemic. Of the total emissions, 60% come from passenger cars and motorcycles, and 40% from trucks and buses. Transport emissions rebounded in 2021 and 2022 as demand recovered after the pandemic. The transport sector is therefore crucial for the mid and long-term EU decarbonisation strategies.

Transport is regulated primarily by the Effort Sharing Regulation,[108] which originally set a target to reduce emissions levels by 30% by 2030 for all major non-ETS sectors combined (buildings, agriculture, waste management, and transport) compared to 2005. Within the current 'Fit for 55' package, a general agreement was reached to adjust the 2030 reduction target to -40%.[109]

According to decomposition method of EEA,[110] there are six major driving forces behind the changes in transport emissions – effect of total transport demand, energy efficiency, biofuel effect, modal split, carbon intensity of fossil fuels, and electrification.

Table 5: Proposed EU legislation or amendments on road transport emissions

Legislation	Key focus	Status
Effort-sharing regulation	Makes the government responsible for reducing the emissions from transport.	Approved amendment to already existing effort-sharing decision. Higher country-specific targets towards 2030.
CO_2 emission standards	Regulates the exhaust CO_2 emissions of newly sold vehicles by the manufacturers.	Approved set of new CO_2 standards for 2030 and 2035. Passenger cars must be 100% exhaust-CO_2-free in 2035.
Alternative fuels infrastructure regulation	Makes governments responsible for availability of public charging and refuelling infrastructure.	Amendment proposal. Higher targets set for building charging and hydrogen-refuelling infrastructure for 2025, 2030 and 2035.
EU ETS2	Includes the transport sector in the emission trading system from 2027.	Legislative proposal. Transport fuels would be included in the emission trading system.
Renewable energy directive	Makes the government responsible for deployment of renewables, including renewable energy use in transport.	Amendment proposal. Sets higher country-specific targets for renewable fuels used in transport.
Energy taxation directive	Incentivises the consumption of renewable energy and use of alternative infrastructure.	Amendment proposal. Fossil fuels would be taxed at a higher rate.
Social climate fund	Supports households to improve access to clean mobility.	Legislative proposal. Fund to help households with rising prices of energy and fossil-free alternatives in transport.

Source: based on European Parliamentary Research Service (EPRS), 2022, Fit for 55 package, available at: https://epthinktank.eu/2022/06/05/fit-for-55-package/.

Zooming in on passenger transport: although energy efficiency and biofuel effect have played a significant role in decarbonising transport since 2009, total passenger transport demand has grown at a much faster pace. Modal split was also slightly negative (more people started to use cars). The same applies to goods transport: Both energy efficiency and biofuel effect played their role in decarbonisation, but these gains were cancelled out by the growing volume of goods transport demand and modal shift, as truck transport grew much faster compared to rail or water transport.[111]

Transport demand at the EU level has been rising steadily since 2013,[112] and is expected to grow until 2050. In the last few years, carbon intensity of fossil fuels rose moderately mainly due to a switch from petrol to diesel fuel. All V4 countries except Hungary missed the 2020 target of using 10% renewable energy sources in transport.[113] Furthermore, electrification is very slow and does not play a significant role. Compared to the EU average of 1.6% share of chargeable vehicles in fleet in 2021, the V4 countries are far behind in the electrification race and would need to increase their electric fleet share by almost 10 times to align with the EU average.

Table 6: Electrification of fleet in V4 countries in 2021

	V4	EU
Share of electric passenger cars	0.17%	1.6%
Number of electric buses	741	8,003
Number of electric trucks	8	1,331

Source: based on European Alternative Fuels Observatory. Data for road transport available at: https://alternative-fuels-observatory.ec.europa.eu/transport-mode/road

Consumers are supported in various ways in the V4 countries, mostly by low-to-zero registration and road taxes, free parking in many cities, tax deduction or lower taxable amounts for the private sector, or tax and depreciation benefits for charging infrastructure. However, direct financial support to individuals and/or businesses is most commonly the game changer. In the V4 region, individuals and firms in Hungary and Poland are eligible.

Based on the Avoid-Shift-Improve methodology,[114] there are theoretically three ways to decarbonise the transport sector. From the investment perspective, we focus on the *improve scenario*, which is based on new technologies, such as electric or hydrogen vehicles, new low-carbon fuels or fuel efficiency. The *shift scenario* focuses on using more energy efficient modes of transportation, i.e., using rail transport instead of road transport. The *avoid scenario* assumes the possibility to limit the length of the transportation routes or to limit the need for transport services.

Current EU policies aim to decrease road transport emissions in the EU by 35% by 2050 compared to 1990 levels. This is projected to be largely driven by 1) electrification of fleet and 2) improved energy efficiency.[115] From the currently known exhaust-CO_2-free technologies, only battery electric vehicle and hydrogen fuel cell electric vehicles are readily available. Hydrogen vehicles, however, are not readily marketable at scale, something which could change in the upcoming years.

Table 7: EVs market share in 2021 & incentives in the V4 countries in 2022

	CZ	HU	PL	SK
Market share (% of new registrations) vs. EU=17.6	3.1	7.0	3.6	2.8
Acquisition taxes (low or zero registration tax)	yes	yes	yes	yes
Ownership taxes (low or zero road/toll tax, shortened depreciation)	yes	yes	yes	yes
Company taxes (tax deduction, low or zero road tax, etc.)	yes	yes		
Purchase incentive for individuals		yes	yes	
Purchase incentive for business sector		yes	yes	
Other benefits (free parking)	yes	yes	yes	
Charging/hydrogen infrastructure (financial support, cost deductible from corporate/income tax, short depreciation period)	yes	yes	yes	yes

Source: based on European Alternative Fuels Observatory, available at: https://alternative-fuels-observatory.ec.europa.eu/transport-mode/ road and European Automobile Manufacturers' Association, 2021, Electric Vehicles: Tax Benefits & Purchase Incentives, November 2021, available at: https://www.acea.auto/files/Electric-Vehicles-Tax-Benefits-Purchase-Incentives-2022.pdf

Climate investment areas

- **Electrification** (*improve scenario*): Most investments connected to e-mobility infrastructure (both passenger and goods transport) will target its critical components – charging infrastructure and update of the available grid. This will be especially important in case of truck charging, where technological complexity is much higher.[116] In passenger transport, currently available charging technology is mostly comprised of AC chargers (usually 7-22 kW power) and DC chargers,[117] usually fast (50-150 kW power) and ultra-fast (>150 kW power). In 2021, EU reached a share of 9.3% of DC chargers, while the V4 reached a share of almost 24% of DC chargers.

  If the V4 was to achieve a parity of charging point density with the EU average in 2021, it would need to increase the number of public charging points by 450%. Furthermore, the current EU strategy aims to increase the number of public charging points threefold, reaching 1 million by 2025, by almost ten times, reaching 3 million, by 2030. Slightly more ambitious targets are set by the scenarios outlined by ACEA,[118] reaching 1.2 million and 3.4 million, respectively. This would require EUR 18.4 and 41.2 billion investments to the grid.[119] Looking at a country specific case-study, Czechia aims to reach between 19,000 and 35,000 public charging points by 2030 from the current 2,600 points. With these targets, the charging-point density gap compared to the EU average would persist.

  While around 75% of the European EV owners relied on home charging in 2020, the share of home charging is predicted to decrease as EVs have so far been purchased mostly by property (family houses) owners with the possibility of installing a private charging point.

There is EU-level funding available to build charging infrastructure, CEF Transport[120] being a flagship instrument, and it usually supports part of the capital expenditure. Depending on the specific national programme in the V4 countries, financial support can easily reach up to 60% of capex. Operating costs are covered by the investing company. Poor charging infrastructure creates a vicious cycle: as there are few electric vehicles on the roads, the charging infrastructure and its opex continue to be loss-making in the short-term. Ensuring optimum locations for public charging points can bring advantages in the mid and long-term.

Besides the scale up of electric vehicles and charging infrastructure, the battery industry is expected to grow sixfold to tenfold until 2030 compared to 2021[121] - hand in hand with the electric vehicle boom. Second-life battery use will play a key role in the industry before batteries can be eventually recycled under economies of scale. The overall battery supply chain remains very immature.[122] It is anticipated that the next Volkswagen battery cell production plant will also be built in one of the V4 countries.

Table 8: Charging infrastructure in V4 countries in 2021

	V4	**EU**
Points per highway kilometre	0.69	3.04
Points per 1000 km2	17.9	76.7
Total public charging points	9,548	323,978
Electric vehicles on charging point	7.3	12.0

Source: based on European Alternative Fuels Observatory. Data for road transport available at: https://alternative-fuels-observatory.ec.europa.eu/transport-mode/road.

Box 3: Incentivizing electro mobility in Hungary

In 2021, Hungary had almost three times higher share of EVs in the fleet compared to Czechia and Slovakia. One of the reasons is the incentive for households and companies to purchase electric vehicles, which aims to increase the number of EVs in cities, for example by supporting electric taxis. The subsidy could be up to almost EUR 7.5 thousand per vehicle.[123] Furthermore, tax exemption was applicable to registration and operating fees.

Charging infrastructure increased by almost 34% in 2021,[124] partly due to the newly introduced law on electro mobility and charging infrastructure in 2019 and the National Energy and Climate Strategy from 2020 that provide incentives to build infrastructure.

For further information on Hungarian´s transition to electromobility, see also Annex 6.

- **Hydrogen, bio and e-fuels** (*improve scenario*): Hydrogen, biofuels and e-fuels are expected to play an important role in the more distant future of mobility. These fuels will be mostly used in goods transport or potentially in rail transport. Trucks or trains could partly rely on the hydrogen use in the fuel-cell battery technology[125] as it provides longer ranges and might be cost-competitive with battery electric solutions.[126] However, the drawback remains that both hydrogen and biofuels are more expensive in passenger transport and less energy efficient compared to battery electric technology.

  Although the National Recovery Plans and National Hydrogen Strategies in the V4 countries also envisage and support the use of hydrogen in transport, the adoption of hydrogen technologies is very much in its infancy. In 2021, there were no hydrogen-fuelled buses or trucks in the V4 countries, compared to 14 trucks and 165 buses in the EU.[127] These numbers probably do not reflect pilot projects in cities or company fleets where hydrogen buses and trucks are being tested.

  Moreover, the refuelling infrastructure for hydrogen is completely different from standard fossil fuels and is operated at very high pressure (~700 bars for passenger cars) with the need for special tanks. This infrastructure cannot be built easily by many businesses and will probably end up in the hands of currently operating fuel providers or industrial companies. As in charging infrastructure, governments and their policies play a key role in building public hydrogen refuelling infrastructure.

  In Czechia, for example, the first public hydrogen station was opened in July 2022, built by a private company Cylinder Holdings focusing on steel cylinders and high-pressure tanks.[128] This represents a large gap between already delivered projects and infrastructure needs based on the national strategies towards 2030.

- **Urban mobility** (*switch scenario*): Improved urban management (public transport infrastructure, shared mobility, cycling infrastructure, last-mile mobility) reduces GHG emissions as well as many other negative externalities, including air pollutants, congestion, and space misuse. Passenger cars spend 95% of the time parked, so fewer cars could be sufficient in cities for personal use. Shared mobility can be a material part of the future of mobility. Public transport infrastructure, as well as rail transport, should increase in importance in future mobility and already has a high allocation from the V4 National Recovery Plans.

- **New business models** (*switch/avoid scenario*): Businesses will acquire new methods and know-how connected to vehicle utilisation business models – new leasing schemes and cars paid as a service/paid as you go. Furthermore, innovations in data management and AI should help to optimise businesses to use their own fleet more efficiently,[129] especially in urban areas. This could decrease their operational costs – increasing energy efficiency, decreasing fuel consumption, and/or decreasing the length of trips.

- **Multimodality of transport** (*switch scenario*): Modal shift represents a challenge of building new rail infrastructure or improving the rail capacity management, as well as warehouse and logistics services that would need to comply with higher rail utilisation for goods transport.

Table 9: Sustainable mobility allocation from RRF in V4

Sustainable mobility	EUR 11.1bn
RRF	EUR 55.9bn
Share of RRF	20%

Source: European Commission. Recovery and Resilience Facility, available at: https://ec.europa.eu/info/business-economy-euro/recovery-coronavirus/recovery-and-resilience-facility_en#national-recovery-and-resilience-plans; Hungarian RRF proposal available at https://www.palyazat.gov.hu/helyreallitasi-es-ellenallokepessegi-eszkoz-rrf

Transition acceleration & roadblock removal ideas

Based on the EEA transport emissions decomposition[130] and projection, only the electrification of fleet and improved energy efficiency will have a significant impact on the decarbonisation of road transport, while the modal shift and biofuel effect will have a limited impact. Eventually, these effects will offset the effect of the road transport demand increase.

- Municipalities and other relevant authorities should strive to build a better charging and refuelling infrastructure to keep up the pace of e-mobility adoption and to build a profitable infrastructure for future mobility that would support the municipal budget.

- Available EU funding should aim to electrify the private company fleet, which represents the largest share of new vehicle purchases in the V4 countries, and private and public charging infrastructure.
  This should be complemented with policies addressing the import of older vehicles and limiting their entry into urban centres.

- National operational programmes should support mobility innovations in a technology-neutral way across different technology readiness levels. Although not in the direct scope of this subchapter, many new industrial business models represent an opportunity, for example, the use of second-life batteries or recycling, where pilot projects could still benefit from financial support in form of guarantees, loans or grants.

- Governments, the public sector and municipalities should set more ambitious sustainable transport procurement rules to accelerate the acquisition of new sustainable transport vehicles, ideally supported via National Recovery Plans or other available funding.

- Alongside National Policy Frameworks for alternative fuels and National Hydrogen Strategies, separate cycling infrastructure strategies should be developed and managed on national levels in the V4 countries to support individual mobility in urban centres.

- Outside of the scope of this subchapter – a precondition for a future clean mobility ecosystem is support for 1) growth of renewable energy sources to produce green electricity and hydrogen, 2) monitoring and rules for end-of-life vehicles leakage towards third countries, and 3) sustainable mining as well as raw material recycling.

Box 4: Incentivising electro mobility in Denmark

Denmark is an example of a country with a high share of electric vehicles and a dense public charging infrastructure. In 2021, 2.1% of all vehicles were electric compared to the EU average of 1.6%. Furthermore, 6,000 public charging points were available – equal to 3.7 public charging points per highway kilometre or 140 points per 1,000 km2, which is almost double the density compared to the EU average and eightfold the density compared to the V4.

The Danish government incentivises purchases of zero emission vehicles, such as electric or hydrogen vehicles, with:[131]

1) Registration tax deduction of 40% (which is to be gradually phased-out towards 2035).
2) Further registration tax deduction of DKK 167,500 (~EUR 22,500) will be gradually reduced until 2030 and cannot end in a negative registration tax.
3) Deduction of taxable value (gradually eliminated towards 2025).
4) Minimal possible semi-annual ownership tax rate.

Furthermore, Denmark and its industries have built a bottom-up approach to sustainable mobility. In 2019, the Confederation of Danish Industry (DI) published a strategy, *Together we create green growth*, where sustainable mobility plays a key role. It has been followed by *DI's investment plan for mobility and transport infrastructure 2021-2030* with DKK 75 billion (~EUR 10 billion) investment proposals.[132]

Agriculture

Status and challenges

With more than 1.8m directly employed persons, agriculture is the largest employer among the high emission segments in the V4. Its weight in the economy varies widely among the V4 countries. It is the highest in the lowland countries of Hungary (4% of GVA) and Poland (3%) and the lowest in mountainous Slovakia (1%). While in Poland and Hungary small farms are typical, larger enterprises can be found in Czechia.[133]

The sector contributes 12% to overall GHG emission in V4, of which 69% is emitted in Poland. In order to properly target climate investments, a more detailed breakdown of GHG emissions in agriculture is provided in the table below.

Table 10: V4 agricultural GHG emissions breakdown

2020	kt CO_2 equivalent
Enteric Fermentation	19 069
Off-road Vehicles and Machinery	10 375
Inorganic N Fertilizers	8 850
Manure Management	6 258
Stationary Fuel Combustion	4 472
Crop Residues	4 053
Organic N Fertilizers	3 452
Nitrogen Leaching and Run-off	2 971
Cultivation of Organic Soils	2 853
Others	4 526

Source: UN Framework Climate Change Convention GHG database, ISFC calculations

The vast majority of GHG emissions in agriculture are methane (NH_4) and nitrous oxide (N_2O). As mentioned in the methodology chapter, they have 25x and 298x higher warming potential over 100 years than CO_2.

Agriculture is not included in the ETS, and its emissions are regulated only to a certain extent through the Effort Sharing Regulation (ESR) and the LULUCF Regulation.[134] Under the LULUCF Regulation, emissions and removals in the combined agricultural land (arable crops and grassland) and forest land use must be balanced. Under the ESR, which applies to all non-ETS emissions except LULUCF, each Member State must achieve a reduction target for all non-ETS sectors combined for 2021-30. Emissions from livestock production thus remain directly unregulated.[135]

Emissions	16 Mt CO_2e
GVA weight	2.5%
Employment	1.8m persons

* 2020 data, GVA weight = share of the segment in the total V4 Gross Value Added

Under the new Common Agricultural Policy (CAP), the European Commission is currently developing a regulatory framework for certifying carbon removals resulting from soil-based carbon sequestration, based on robust carbon accounting to monitor and verify carbon removals. If private companies can purchase such certificates, this would provide an additional incentive (on top of CAP payments) for farmers and foresters to engage in carbon sequestration.

Climate investment areas

The climate investment landscape in agriculture is significantly influenced by the following factors:

i. high business fragmentation (dispersed structure) = small average size of enterprises,

ii. the EU's Common Agricultural Policy and related subsidy schemes,

iii. non-CO_2 nature of GHG emissions.

Ad I., the description and analysis of the agricultural investment landscape draws on the sector-wide characteristics rather than the sector leaders' assessment. Here, national agricultural policies significantly shape and/or can shape sector priorities, including investment preferences.

Ad II., national agricultural policies are strongly influenced by the CAP and its subsidy schemes. Changes in the CAP thus have a key potential to influence investment focus in agriculture in the V4.

Ad III., the climate impact of agriculture seems to have received less attention than other sectors (e.g., industries participating in ETS) in recent decades, which has possibly resulted in less climate-related research, development and investment activities.

European Green Deal → EU's CAP → National strategic plans → Investment areas

Until very recently, agricultural policies in the V4 have addressed climate impacts to a very limited extent. For example, in Poland, the National Energy and Climate Plan for 2021-2030, prepared in 2019, anticipated a steady increase in NH_4 and N_2O emissions in agriculture until 2040.[136] Similarly, a slight increase in N_2O emissions due to emissions from agriculture has been expected in the national plan of Czechia.[137]

In December 2021, an agreement on CAP reform was adopted to align it with the European Green Deal and the Farm to Fork Strategy, and the new related legislation should become effective from 2023.[138] The new CAP will be implemented at national level through the CAP Strategic Plans for 2023-27 (SP). The V4 SPs were submitted in 2021.

The V4 SPs reflect climate risks with different intensities, including the balance between adjustment and mitigation measures. The full translation of the European Green Deal into all the national agricultural strategic plans is likely to take place only in the next period after 2027. An overview of the major climate-change risk mitigation areas in the V4 countries is given in Table 11.

Based on available information, V4 agricultural enterprises have reflected on climate-related risks and related mitigation measures to a limited extent. Few farmers (often large players and/or enterprises belonging to international groups) have included climate aspects of farming into their reporting standards or established a working group to address the European Green Deal.[140] Better recognition is likely after the new SPs come into force in 2023 and even more so in the next planning period after 2027.

While some of the investment areas are already available on the market, such as technologies related to precision farming, many others are in the R&D phase.

- **Precision farming**: The implementation of new technologies, using big data management, data collection from satellites and drones or GPS to navigate seed drills and harvesters, is leading to precise fertilisation techniques that allow for effective control of nutrients supplied and to reduce overlapping applications. Precision farming represents one of the earliest transition opportunities in agriculture and has begun to be adopted by frontrunners in the V4 region.[141]

Table 11: Selected climate-related intervention areas in V4 CAP Strategic Plans 2023-27[139]

Poland	Czechia	Hungary	Slovakia
4.P1 - Reducing GHG emissions from agriculture 4.P3 - Increasing the C absorption and storage as a result of afforestation of the agricultural land 4.P4 - Development of sustainable energy based on uses of agricultural biomass 4 P5 - Use and development of alternative energy production possibilities 4.P6 - Raising knowledge on climate change mitigation and adaptation	P4.02 - Reduce GHG and ammonia emissions from agriculture P4.03 - Use the available potential of biomass to efficiently produce energy from RES P4.06 - Secure and improve C soil sequestration and storage	SO5/4.1 - Reduction of emissions of air pollutants and airborne dust SO5/4.2 - National Air Pollution Reduction Program SO8/5.1 - Organization and community-based development of biomass-based renewable energy utilization	4.2 - Reducing the emission of GHG and ammonia 4.3 - Support for practices to increase C sequestration 4.4 - Increasing the share of use of renewable energy sources in agriculture

Source: V4 National CAP Strategic Plans

- **Enhanced, renewable & biochemical fertilisers**: Meta studies have found that nitrification inhibitors and polymer-coated fertilizers on average potentially reduce N_2O emissions by 35-40%.[142] Nitrification inhibitors, which reduce nitrogen losses and increase the amount of nitrogen taken up by plants, are widely used. However, they are still costly and research into them has stagnated. Controlled-release fertilisers, which release nutrients slowly over time, have been commercialised, but they currently represent only a small share of synthetic fertiliser sales. The lack of research into scaling up the use of these fertilisers may be a contributing factor.[143] The recycling of organic waste into renewable fertilisers and/or the production of bio-fertilisers, protein feed and bio-chemicals by advanced bio-refineries are at an early stage of development. Based on recent research, the overall bio-based chemical share in the European chemical market is not expected to increase rapidly due to barriers to development (e.g., production costs). At the same time, major opportunities have been identified and new policy measures could help.[144]

- **Enhanced manure management**: Investing in improved manure management practices also helps prevent air pollution. Digesters can significantly reduce emissions from wet manure compared to baseline, if carefully implemented. Separating wet and solid manure can reduce N_2O emissions generally[145] and help expand transportation options, allowing for more homogenous application on sites. Finally, direct fertilisation technology, which applies organic and farm fertilisers directly to the soil, allows micro and macro nutrients to be deposited simultaneously with the seed.

- **Biogas**: Energy production from biogas and investments in anaerobic digesters for biogas production from agriculture waste and residues such as manure, which reduce methane emissions from livestock, are largely supported in the V4 region and belongs to the intervention areas in the V4 CAP SPs for 2023-27 (see Table 11 above). Here, it must be ensured that biogas is produced from feedstock that do not compete with food and feed crops for agricultural land or increase biodiversity loss.

- **Agricultural vehicles and local heating**: Agricultural machines with alternative power sources (biomethane, electricity or hybrid, hydrogen) are becoming available on the market and may represent one of the early transition areas in agriculture. The transition pace will depend, inter alia, on public incentives for private enterprises.[146] The use of building insulations or renewable sources to heat greenhouses can easily reduce carbon emissions in the sector. See also the chapters Road Transport and Local Heating for further information.

- **Sustainable feed additives**: These include two groups of additives. (i) Additives that help reduce/mitigate methane emissions from ruminants (without affecting productivity). Recent research has examined ten feed additive groups and found that two additives routinely delivered over 20% mitigation of enteric methane by the consuming ruminants. However, insufficient evidence exists as to whether any of these feed additives will deliver a co-benefit of increased production (growth or milk).[147] (ii) Additives that decrease the carbon footprint, such as local-grown plant proteins or alternative feed materials, e.g., bio-economy by-products or insects, to replace for example, imparted soya-based additives.

- **Alternative proteins**: Cultivated (or so-called 'lab-grown') meat produced by in-vitro cultures of animal cells is still being developed, with several leading companies transitioning to pilot-scale facilities to manufacture the first wave of commercialised products following regulatory approval. However, it is unclear how financially viable cultivated meat will be for widespread adoption. Proteins to replace or reduce meat, dairy, and eggs can be sourced from plants, insects or fungi, and many efforts are underway to develop alternatives. While plant-based proteins have been on the market in high-income countries for several years, their market share, while growing, is still small. They are currently more expensive than their animal-based counterparts in most cases. Further R&D of these options is thus needed so that some of them reach price parity with animal-based meat and achieve equivalent consumer acceptance.[148]

- **Soil carbon sequestration** includes farming practices that remove CO_2 from the atmosphere by increasing the organic matter such as crop residues in the soil, switching to low-till practices, planting cover or double crops, and/or converting disturbed to undisturbed land. It is estimated that net soil carbon sequestration could offset 4% of average annual global GHG emissions over the rest of the century.[149] Starting in 2023-27, a new type of CAP subsidy is being provided to farmers in EU/V4 to support, inter alia, carbon farming.

Transition acceleration & roadblock removal ideas

- A precondition for the transition to climate-sustainable agriculture in the V4 is the close alignment of the national Strategic Plans for 2023-27 with the European Green Deal. Even more important will be the next-period plans, where more emphasis should be placed on mitigation measures.

- Support for climate change mitigation should be directed towards both available and developed solutions. While precision farming technologies, machinery with alternative drives, anaerobic digesters for biogas production, direct fertilisation or nitrification inhibitors are available or becoming available, more research and innovation support is needed in other areas. The latter include, inter alia, enhanced fertilisers, sustainable feed additives or alternative proteins.

- Should a balance between GHG emissions and removals be achieved, the sector would clearly need more incentives and regulation. Indeed, the European Commission has come up with an amending regulation proposing that a whole range of agricultural GHG emissions should be covered under the LULUCF regulation from 2031. Also, emissions from the combined agricultural and forestry sector would have to reach net zero by 2035.[150] Recent scenario analyses show that significant climate-impact reductions in agriculture could be possible by 2050 (up to 81%).[151] Such far-reaching regulatory changes, which would significantly impact livestock numbers in the EU/V4, are expected to be the subject of intense debate.

- The inclusion of agricultural emissions in the ETS is another hotly debated topic. Although this would be difficult for the entire sector with 6.2 million livestock farms in the EU (compared to currently 11ths installations in ETS), it has been argued that it could be possible for large-scale intensive livestock farming to take place in closed buildings, as the technologies exists to capture methane and convert it into biogas.[152]

- Given the persistent farming culture in the EU/V4 which combines (i) a spirit of independence and resistance to regulation with (ii) a tradition of seeking and receiving government support, the necessary debate on sustainable agriculture growth must involve and commit farmers, society and government if they are to become aligned toward the same objective. Technical assistance, awareness raising and capacity building in order to support the transition in the sector would go a long way to help.s in the EU/V4 to support, inter alia, carbon farming.

Local heating

Status and challenges

Fuel combustion in households, commercial and institutional buildings contributes 11% of overall GHG emission in the V4 countries,[153] of which 81% is contributed by the residential sector. Based on UNFCCC data, the per-capita emission intensity in all V4 countries is similar and close to the EU average, except for Slovakia with per-capita emissions approx. 30% below the EU average.[154] GHG emissions in this segment in the V4 have decreased by an average of -1.2% annually from the EU accession in 2004 to 2020.[155] The pace of decline would need to multiply to reach net zero by 2050.

For EU Member States, the climate requirements for local heating and building energy efficiency in general are mostly set by the Energy Performance of Buildings Directive (EPBD) and the Energy Efficiency Directive, which reflect the building and renovation climate-related goals set out in the European Green Deal.[156]
The directives aim to achieve a fully decarbonised (climate neutral) building stock by 2050. In October 2022, the Council of the EU agreed on a proposal to revise the EPBD with the following main measures.

- All new buildings must be zero-energy buildings from 2030 (currently must be nearly zero-energy buildings), but from 2028 in case of new buildings owned by public authorities, except for historical buildings, places of worship and defence purpose buildings.
- Long-term national renovation strategies should be enhanced with a roadmap of milestones for 2030, 2040 and 2050 in terms of annual renovation rate, the first plan to be issued in 2026, followed by revisions every 5 years.
- Member States will introduce minimum energy performance thresholds (maximum primary energy used per m^2 annually) for 15% and 25% of the worst-performing non-residential buildings and bring all non-residential buildings below the 15% and 25% threshold by 2030 and 2034, respectively.

Emissions	66 Mt CO_2e
Buildings	13 millions

* 2020 data

- For existing residential buildings, Member States must define a national trajectory of the progressive renovation into a zero-emission building stock by 2050 with two checkpoints: the D energy performance class level in 2033 and, in 2040, a value derived from a gradual decrease of the average primary energy use from 2033 to 2050.
- All new residential buildings must have optimised their solar energy potential from 2030 (new non-residential buildings over 250 m^2 and all deeply retrofitted non-residential buildings over 400m^2 from 2027 and 2028, respectively).

The EU Member States agreed in December 2022 to establish a new ETS II that will apply, inter alia, to distributors supplying fuels to buildings by 2027. ETS II could be postponed until 2028 to protect citizens, if energy prices are exceptionally high. Furthermore, a new price stability mechanism should be set-up to ensure that if the price of an allowance in ETS II rises above 45 EUR, 20 million additional allowances will be released.[157]

Energy-efficient technologies needed to achieve the zero carbon already exist and are mature. Low-carbon solutions are affordable for competently designed new buildings.[158] There may be an increase in design and construction costs, but operational savings more than compensate for this, and with a higher market penetration, the construction cost gap may narrow further.

The costs of deep retrofits, however, are significant. Nevertheless, when compared with the costs of shallow or medium retrofits on the specific costs per-unit energy saved basis, the evidence demonstrates that deep retrofits can be delivered at the same specific cost levels. The payback period is estimated to be between 10 and 20 years.[159] However, as the total amounts are still significant, especially for a typical household budget, customised and/or subsidised financing solutions have the potential to stimulate deep retrofits.

A specific approach is needed with regard to protected buildings. Significant advances have taken place in technology and know-how, and many different examples can be found which have reduced operational energy demand by 80% or more while preserving the heritage or monument features of buildings.[160] Moreover, the incorporation of RES into historical buildings has also proven to be possible in many cases despite strict aesthetical constraints.[161]

Climate investment areas

The major investment areas are presented hereunder primarily in the context of deep retrofits but are similarly relevant for new buildings. The areas are grouped according to their major focus: (i) building envelope efficiency, (ii) energy sources, (iii) energy storage solutions, (iv) energy/efficiency management systems incl. digitalization and controls, and (v) district heating features.

None of the individual areas can achieve full carbon neutrality of the segment. This can only be achieved through combining several measures. Estimates of the GHG mitigation potential of individual strategies are summarized in Table 12 below.

Single-family units can be turned into energy plus buildings easily by simply installing photovoltaic panels, but many building types, such as high-rise or commercial, can only be turned into net-zero buildings (using current technology) if their energy demand is carefully minimised. The key to the large-scale realisation of net-zero energy buildings is therefore to substantially improve the energy efficiency of all energy uses in buildings.

Table 12: Selected strategies for GHG mitigation

Strategies	Mitigation options	GHG mitigation potential
Carbon efficiency	Solar domestic hot water system	20%
	Solar electricity generation through roof-top PV installations	15-58%
Technology efficiency	High-performance thermal envelope with efficient heating, ventilation and air conditioning	10–68%
System efficiency	District heating/cooling	30–70%
	Building automation and control systems for space heating, water heating and cooling/ventilation, etc.	25–37%
	Passive House standard	30–70%
	High-efficiency energy distribution systems, co-generation, tri-generation	30–70%
Energy service demand reduction	Behaviour and lifestyle changes of users	20–40%
	Smart metering	

Source: UNFCCC, Compendium on GHG baselines and monitoring: Building and Construction Sector, 2021

Historical buildings represent another challenging group, as RES often cannot be used due to aesthetic or landscape regulatory constraints. Therefore, a combination of specific techniques to improve the envelope energy efficiency (internal envelope insulation, cool coatings, window retrofit), upgraded control systems, ventilation, thermal storage and heat recovery are suggested as ways to reduce the energy demand of heritage buildings. Technologies specifically for historical buildings are listed below separately.

- **Envelope efficiency**
  - *Walls*: the right combination of masonry and insulation thickness (essential for any net-zero buildings), ventilated envelope and facade coatings reduces the need for active heating or cooling.
  - *Roofs*: insulated roofing can be complemented by green roofs (using soil and vegetation) or dynamic cool roofs (reducing their solar reflectance during heating periods), which provide an additional barrier against heat gain and heat loss.[162]
  - *Windows*: double or triple glazed windows installed properly can minimize thermal bridges, possibly with controllable shutters and blinds and/or low-emissivity glass that reflects solar radiation in summer to minimize heat gains, and conversely reflecting irradiative heat from inside in winter to minimize heat loss.[163]

- **Energy sources**
  - *Solar thermal units:* solar thermal energy has been the most commonly used RES solution for space and water heating in buildings to date and its role is expected to remain important.[164]
  - *Photovoltaic panels* are another key element of national policies to bring the segment to net zero, but most net-zero buildings equipped with PV rely on the local grid to provide "free seasonal storage" of energy produced in summer and consumed in winter. While short-term storage can be addressed in a decentralized way by requiring battery installation, seasonal storage needs to be factored into grid design and/or provided by (municipal) energy storage and advanced control.
  - *Heat pumps* are a key technology for space and water heating (and space cooling); their rapid expansion is a major component of all building decarburization scenarios as they are highly efficient and allow heating using clean electricity - heat pumps cut typical energy use for heating by four.[165] Because they distribute water at lower temperatures than boilers, they rely on thermally efficient buildings to be most effective, increasing the need for energy efficiency measures. Heat pumps play an important role especially in regions with moderate climates that require both heating and cooling. Two types of heat pumps are mostly used in the V4 region: air source heat pumps and geothermal systems.[166] In Poland, for example, a combination of regulatory and incentive policies combined with changed perceptions supported their uptake.[167] The Clean Air Program, launched in 2018, will provide approx. EUR 25bn over 10 years to replace ageing coal boilers and improve energy efficiency. The share of heat pumps in new heat-source installations increased to 62% in Q3 2022.[168]
  - *Heat recovery ventilation* helps to minimize heat losses by using heat recovery units that manage air exchange and recover residual heat from the exhaust air.
  - *Others:* other RES options, such as photovoltaic/thermal[169] and solar/biomass hybrid systems,[170] are also available, although they are at an earlier stage of standardization compared to solar thermal or PV systems.

- **Energy storage:** Batteries are used to store some of the electricity produced during the day (which would otherwise be exported to the grid) for the use later in the evening, when demand is higher and solar generation low. This applies similarly to the shift in production and consumption between sunny and cloudy days. As noted above, wider use of PVs would require either adapting grid design, systematic use of decentralised batteries in buildings, municipal storage solutions or a combination of the above.

Thermal energy storage (TES) is one of the direct means of energy storage as it does not require the conversion of energy forms and thus avoids conversion losses. TES is categorized as follows: (i) sensible, (ii) latent and (iii) thermo-chemical. See Table 13 for the TES categories overview

- **Energy management systems**
  - *Energy management systems* are mostly applicable to larger buildings where it is important to account for uncertainty in demand as well as any energy storage applications and/or distributed (renewable) energy sources connected to the building to reduce peak demand for economic benefit.[173] Building-integrated energy generation can be especially important for closer integration of electric mobility, in which renewable electricity is stored in vehicle batteries during periods of lower building energy demand. The charging and discharging of increasingly prevalent plugged-in electric vehicles should thus be properly reflected.[174]
  - *Smart building controls:* digital sensors and smart thermostats are used to better manage, distribute and improve the responsiveness of heating/cooling loads of all major heating/cooling equipment in buildings, both temporally and within the building space.
  - *Thermally Activated Building Systems* integrate the building structure as thermal energy storage into the building services concept; energy savings of 20–30% of the heating/cooling demand can be achieved compared to common zone return pipes, where energy losses occur due to mixing of return water.[175]

- **District heating:** Integrating district heating (cooling) in the decarbonisation strategy relies on zero- or low-carbon thermal energy sources. Multiple examples in European countries show that it is possible to operate low-carbon district heating systems and enable synergies across the network infrastructure. In Sweden, for example, more than 2/3 of district heat production is uses RES. Here, the estimated energy flexibility of an office building served by a district system using integrated heating measures could reduce annual electricity consumption by as much as 35%.[176] Modern district energy networks can take advantage of various energy inputs and technologies that would likely be cost ineffective at the scale of a single building, such as heat recovered from industrial or commercial processes, exploiting geostructures (e.g., metro stations), large-scale heat pumps or district level thermal energy storage that allows for the exploitation of excess electricity (e.g., to avoid curtailment of RES).

Table 13: Thermal energy storage categories[171]

Category	Description	Medium	Capacity (kWh/t)	Efficiency	Application
Sensible	heat is added or removed directly from a medium	usually water; possibly some industrial waste	10 - 50	50-90%	simple, cheap, easy to control, commonly used
Latent[172]	energy stored in the phase transition (solid-liquid) of a phase change material (PCM)	bulk material (paraffin, fatty acids, salt hydrates), can be built into ventilated facades in vessels	50 - 150	75-90%	in limited use - poor PCM stability, high volume required, chemical reactions with a container
Thermochemical	energy stored in / released from chemical bond by a reversible chemical reaction	currently no materials available that satisfy all the requirements for building operations	up to 250	50-90%	in development, no applications, suitable for seasonal storage (high energy density, minimum losses)

- **Solutions for historical buildings:** Deep energy renovations may be technically difficult or cost prohibitive for certain historical building types, but modern energy solutions may be more feasible to achieve net zero carbon emissions in those buildings.
    - *Water source heat pumps:* this type of heat pumps is not commonly used due to its demanding maintenance and conditions - the body of water needs to be large enough to withstand the cooling effect of the unit, e.g., it can be connected to an existing unused well.[177]
    - *Photovoltaic tiles:* they are relatively less visually intrusive than other retrofit systems and contribute to reducing carbon emissions associated with building operations.
    - *Internal envelope insulation:* exterior walls of historic multi-storey buildings have low thermal resistance compared to walls of modern buildings, resulting in high energy loss and cold surfaces/floors in cold climates. When restrictions on changing the exterior appearance exist, interior insulation might be the only option to improve the building's energy balance.[178]

Transition acceleration & roadblock removal ideas

While aligning the new-building construction regulation with net-zero targets might be straightforward, ensuring the transition of the existing building stock to net zero is significantly more challenging.

Public attention should thus focus primarily on renovation projects. Complex programs, covering a significant number of housing units, are needed to mobilise the fragmented ecosystem, allow early-stage investments, and develop industrial scale solutions. Dedicated financing instruments will be needed to support the implementation of large-scale renovation programmes (e.g., grants, guarantees). Here, the new financing scheme “Energy Performance Contracting Plus“ launched in Poland in 2022 to support deep renovation projects is among the pioneers in the V4 region.[179]

- Deep retrofits involve a multitude of permits, companies, and financing. Many actors are involved: developers, banks, architects, engineers and tenants. Each actor has its own priorities, knowledge, and decision-making capacities. The interested owner often does not know where to start or how to coordinate such a process. To overcome these obstacles to deep retrofits and hurdles associated with their arrangements (so-called nuisance factor), a “one-stop-shop” solution for interested building owners could be highly effective, simplifying the process for them, and in line with similar initiatives in other EU Member States.[181]

Box 5: Brussels´ building performance boosting policies[180]

In the early 2000s, Brussels city authorities decided to improve its buildings by adopting the Passive-House standard as a target for their existing and new buildings. In 2015, seven years after initiating the process, the building code came into effect requiring that level of performance.

However, with the industry having had ample notice, by 2014, the year before the code became compulsory, Brussels had more than 800,000 m^2 of passive-house buildings plus other low-energy buildings. Heating energy use per capita dropped by 25% and GHG emissions by 16% between 2004 and 2014.

Building performance boosting policies and actions went through three phases: first, awareness, incentives, and demonstration projects; second, support and large-scale implementation; and finally, a massive investment in new and retrofitted buildings.

- Major retrofits often require tenants to move out or suffer other significant inconveniences. This can delay relevant decisions or lead to less disruptive, shallower retrofits. Partial solutions have been developed in several Member States to overcome these barriers, such as the Energiesprong program,[182] under which buildings of common typologies can be retrofitted with prefabricated and ready-made elements in a matter of days without requiring tenants to move out– see Box 6 below.

Box 6: Energiesprong

Energiesprong carries out complex retrofits to reach net zero buildings. This is achieved through using prefabricated facades (panels based on laser scans of the exterior), insulated roofs with solar panels, smart heating, and ventilation and cooling installations. A complete retrofit is usually completed in less than a week. A warranty on both the indoor climate and energy performance is provided for up to 40 years.

Energiesprong teams work with regulators to tune policy and regulation and with banks to create financial frameworks to make a viable path to scale. Loans are repaid from future energy cost savings plus the maintenance budget over the next 30 years. This allows residents to maintain their cost of living. By creating these market contexts, while simultaneously implementing pilot projects and, subsequently, large scale retrofits (1000's), the momentum needed for stakeholders to act simultaneously is created.

In the Netherlands, more than 5,000 net-zero energy retrofits have been realised and 12,000 more are planned. In France, the first pilot projects were realised in 2018. In Germany, the Ministry of Energy provided funding to a market development team in 2017 to scale the Energiesprong into Germany. In March 2021, a development team was launched to implement and adapt the Energiesprong approach in Italy.

- The significant up-front costs of retrofits can represent a barrier. Direct financial support from public sources in the form of grants can kick-start the uptake of new technologies in older buildings. In Hungary, for example, the Eco Plus project covered 50% of costs of the district heating system refurbishment. More than 110,000 flats were involved, and savings reached 20-25% of heat consumption. In 2015, Czechia launched a boiler upgrade scheme that provided 50% grants to buildings that installed lower-carbon heating systems. More than 100,000 boilers had been reinstalled as of 2021. However, the programme only targeted the oldest coal boilers.[183] More ambitious programme requirements would be needed to kick-start complete building stock retrofits.

- The timing of retrofits in the building life cycle is a key element of a retrofit strategy to capture opportunities as they arise. Incentivising building retrofits prior to building elements reaching the end of their useful life requires far more resources, thereby delaying progress. An adequate annual renovation rate should be targeted within a viable climate mitigation strategy.

- Retrofitting publicly owned buildings poses a straightforward investment target and the integration of cost-effective low-energy solutions should be systematic in public procurement. Changing procurement practices can be particularly difficult for large institutions and governments, often placing low-energy solutions at a cost disadvantage because they are usually based purely on investment costs, not on overall (discounted) costs including future operational cost savings.

- New construction materials and energy efficient technologies (smart buildings, building envelope, digitalisation, heating and cooling, lighting) often have low research investment ratios (percent of revenue spent on R&D). This reflects many factors including the long changeover cycle for new products or the fragmented market nature. Government support and intensified funding to research and innovation would facilitate the envisaged transition pace.

- Public policies should also foster the cross-cutting skill development and the workforce adaptation to new technologies related to digitalisation, implementation of smart buildings technologies, and the development of new tools better adapted to the energy transition.

Cement & minerals

Status and challenges

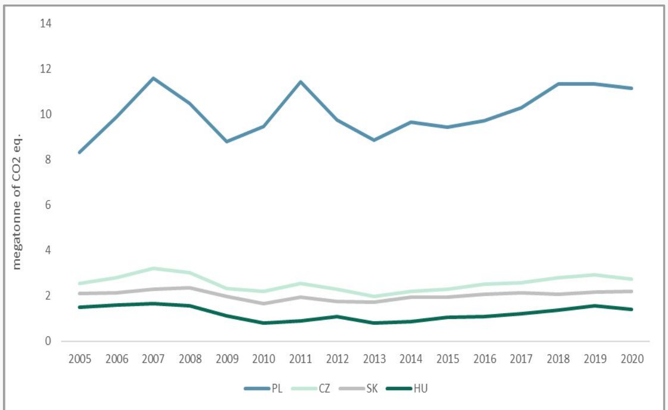
Emissions	33 Mt CO_2e
GVA weight	1.0%
Employment	0.3m persons

* 2020 data, incl. other minerals, GVA weight = share of the segment in the total V4 Gross Value Added

Cement production belongs to high-emitting industry processes. The sector's product is homogenous and often referred to as Portland-type cement. Companies convert calcium carbonate, typically limestone, into clinker, an intermediate product to cement. This process requires 850°C heat and produces about 60% of cement-plant's total GHG emissions depending on the feedstock used.

Over the last 25 years, global cement production expanded by roughly 400%, while carbon abatement has been practically nil. Only negative economic shocks like the 2008 financial crisis and the euro crisis in 2011 led to significant drops in cement sector emissions in Europe. Decarbonisation gains stemming from the gradual reduction of the clinker-to-cement ratio were modest. The shift from coal to alternative feedstock is slowly gaining traction, but in the V4 countries, it is still some way off.

Chart 15: Cement sector emissions in the V4 countries



Source: EU ETS

Unlike other high-emitting industries, cement is not widely traded in the EU and remains a local product due to transport limitations and weight-to-value considerations. European countries typically have production capacities matching their construction needs keeping the carbon leakage risks contained.

Under the EU Emissions Trading System (ETS), the cement industry benefits from free allowances. Total emissions of the cement sector in the V4 repeatedly exceeded the level of free allocation granted under this scheme. The V4 countries together add about 16% of the EU cement production.

The three largest European cement producers by sales have a strong presence in the region (Holcim-Lafarge, Heidelberg Cement and CEMEX).[184] But a few smaller players are also active in the V4 countries (Dyckerhoff/Buzzi Unicem, Miebach Projektgesellschaft, CRH to name the larger ones). The sector contributes 6% to overall GHG emissions, a touch lower than the global share of 7-8% according to market data provider Global Cement. Cement manufacturing has about a 1% share in the region's total gross value added.

The international conglomerates are vertically integrated and have a more diversified portfolio.
All of these top-tier parent companies have made decarbonisation commitments but seem to have taken different routes. Heidelberg Cement is currently betting on CCUS technologies[185] (see also Box 8 on a Polish investment project below). Holcim also has CCUS projects but it leans more heavily into a business profile change and intends to halve its cement business line by 2025.

Poland emerges as the biggest cement producer in the Central Eastern region thanks to its sizable domestic demand. But it is also one of the few countries where cement sector emissions have been rising since 2005. Degradation in the thermal efficiency of Polish kilns[186] and a solid construction recovery have been a boon to emissions.

Climate investment areas

Chemical reaction-related emissions cannot be eliminated through fuel switching or electrification as those two can only address the emissions that stem from heat generation. Bioenergy with carbon capture and storage (also dubbed as BECCS) and the introduction of new binders are emerging as strategies to achieve deep decarbonisation.

Energy efficiency, fuel switching, and clinker reduction projects have demonstrated feasibility and cost benefits. Scaling up breakthrough technologies, however, remains a challenge for the sector. Top international companies, who own 55% of global capacity, are pushing the envelope.

Owing to their access to finance and decarbonisation levers, the largest companies have been able to market novel cement types and engage in projects to create demo plants for CCUS technologies. But many small plants continue to operate in the local markets with ageing asset parks and consequently face high capital costs to overhaul their operations. As opposed to their top-tier peers, they have limited access to the know-how and the global vendor base implementing decarbonisation solutions.

Besides technological advances, material efficiency and end-use recycling have a potential to reduce emissions. The Cembureau estimates[187] that the cement content of concrete can be reduced by 5% by 2030 and 15% by 2050 through process digitalisation and by improving the mixes used.

- **Carbon capture, storage**: Novel technologies are available for the process industries that capture and compress the emitted CO_2. The captured carbon can then be utilised or permanently stored. Some of the capture technologies are still in nascent stages. But some have already matured to a demonstration stage. The EU-sponsored LEILAC (Low Emissions Intensity Lime and Cement) project by Heidelberg Cement provides a good case. Operational since 2019, the Belgian cement plant[188] demonstrated that CO_2 can be separated without compromising operations. Building on this pilot, the second stage of the LEILAC project envisages a full-scale retrofit and scale-up of the existing capture technology.

  In the case of the cement industry, post-combustion carbon capture appears to be the most suitable as the bulk of emissions stem from the clinker production process. The capture is an “end-of-pipe” mechanism that does not interfere with the production reaction, rendering it suitable for existing facilities and new cement kilns.

Box 7: Carbon2Product Austria project

In 2020, Lafarge Zementwerke, a major cement producer, joined Borealis (a high-value chemical producer), OMV and Verbund and agreed to create a full-scale integrated plant by 2030. The cross-sector project will create a first-of-its-kind, industrial scale production site where the carbon captured in cement production will be utilised to produce green hydrogen as well as high-value chemicals

The joint project consists of three phases: First, the consortium partners devise a joint strategy spanning from finance and business modelling to engineering and design. In phase two, a demonstration plant will be built in East-Austria by 2025. In phase 3, the technology will be scaled to utilize 700,000 tons of CO_2 per year.

Box 8: EU Horizon 2020 pilot CCS project in Poland

In 2021, Heidelberg Cement[189] announced a pilot Carbon Capture and Storage (CCS) project at its cement production site in Górażdże. The project’s total cost is estimated at €18 million of which €15 million tranche will be financed from the EU Horizon 2020 programme.

Collaborating with independent research institutions and industrial partners, they envisage a full-chain CCS infrastructure. From 2024, the captured carbon will be transported from the Polish site to Norway. The project will play a pivotal role in advancing the regulatory framework for cross-border CO_2 transport.

- **CO_2 utilisation as part of the business model**: Utilisation technologies have been successfully adopted and proved their benefits. A promising decarbonisation levers for the cement industry to adopt a holistic business model in which the waste heat of the kiln and captured CO_2 are regarded as commodities. A fresh revenue stream from CO_2 can help stabilise cash flows. Similarly, recovering waste heat from the kiln could also provide an alternative energy source.

- **Clinker substitution**: Replacing clinker with supplementary cementitious materials could improve the carbon intensity of production. Some types of clay, in combination with ground limestone, have the potential to replace about half of the clinker used to produce cement without impairing quality. While this mixture is widely available at a low cost, the substitution is not yet commercialised in Europe. The International Energy Agency (IEA) estimates[190] that calcined clay-based cement will account for more than 25% global market cut by 2050.

- **Energy efficiency**: Digitalisation of the production process and optimising the logistics represent hidden pockets. Reportedly, a European cement producer shaved off 6% from its fuel need by implementing a state-of-the-art optimisation for its kiln's heat profile. The LEILAC project roadmap estimates that process optimisation measures could increase cement production efficiency by 14% by 2050.[191]

Transition acceleration & roadblock removal ideas

- Mounting pressure from carbon prices and accelerating coal phase-out is slowly changing the incumbent cement players' conservative bias in doing business. Competition from new, state-of-the-art cement kilns could leapfrog competitors and change the operating environment. We see that top-tier companies are investing in R&D to lock in the first-mover advantage. The industry is slowly becoming comfortable with forming research consortia, which has not been the norm until now.

- While innovative solutions appear on the horizon, uncertainties linger - muting investments in the cement industry: intrinsic uncertainty related to the power market and its regulatory framework, as well as future CO_2 demand and transport infrastructure requirements. V4 companies are paralysed by carbon policy uncertainty. Forward looking information related to policy mechanisms such as carbon taxation and tax incentive schemes could go a long way to encourage early action in the cement sector.

- Below are outlined a few key areas where barriers could be removed in the medium term by policymakers:
    - Producers along the construction value chain need to make a more concerted effort to reduce demand for materials. The public sector can play a role creating the incentives to do so. Public procurement practices can lead the way.
    - Fuel switching is still not in the pipeline for V4 producers. Some form of extra carbon tax could create incentives to move away from coal more quickly.
    - As the incumbent industry advances new products, regulators need to revisit and update the existing standards and codes on a more regular basis. We see scope for horizontal collaboration across governmental agencies to bring together R&D, cost, and technical analyses with standardisation and protocolar issues.

Chemicals & refineries

Status and challenges

The chemical & petrochemical sector is represented in the V4 region by a dozen large and numerous mid-to-small downstream producers. It is distributed fairly evenly across the countries, with only Czechia having the smaller share in industrial production. The sector participates in the ETS and contributes 5% to overall GHG emission and less than 1% to GVA and employment in the V4 region.

A distinctive feature of this sector is that a significant portion of its emissions stem from the fossil inputs used in chemical reactions. Access to low-cost natural gas in the V4 rendered petrochemicals and fertilisers as one of the fastest growing areas in recent years. The looming fossil fuel supply shocks and physical climate risks (water levels, extreme weather, and heatwaves) can put a dent in the sector's profitability and curtail the V4 production.

In the broader chemical sector (incl. petroleum refining), thermal energy consumption contributes more than 61% of GHG emissions. But emissions also stem directly from chemical reactions during production. Refineries take oil as an input and transform it into gasoline, diesel, and fuel. Production of high-value chemicals such as olefins (ethylene, propylene, butadiene) aromatics, as well as ammonia, methanol, and carbon black have the biggest emission footprint in the chemical downstream.

Deep decarbonisation would require the deployment of multiple innovations. Fuel switching, electrification, adoption of circularity business concepts, and carbon capture and utilisation technologies should move in tandem to achieve the ambitious net zero pledges. However, looming uncertainty around scalability and operating costs of the best available technologies creates an investment conundrum.

The sector is currently challenged by rising energy and fuel prices while softer business demand limits the pass-through of the higher costs to consumers. The deterioration in the operating environments in Europe can put companies at odds with meeting the higher capex needs of decarbonisation. Over the longer term, the region's chemical industry would benefit from weaning itself off gas.

Emissions	**29 Mt CO_2e**
GVA weight	**0.9%**
Employment	**0.2m persons**

* 2020 data, GVA weight = segment share of total V4 Gross Value Added, emissions w refining, GVA and employment w/o refining as NACE data is only provided together with coke production

If the prices stabilise at higher levels V4 producers' competitiveness will wane. Not only do they need to diversify their operating footprint but also their product portfolio to increase their global competitiveness. Specialisation in low-carbon technologies and biobased products offer a way to increase the value added while adding operational flexibility.

Climate investment areas

- **Decarbonised energy inputs**: Meaningful decarbonisation in the chemical sector is conditional on the availability of zero carbon inputs. Renewable electricity demand will need to jump to enable a large-scale electrification of petrochemical processes.[192] At the same time, the chemical sector's net zero transition also appears as an important enabler to balance residual loads in the electricity grid and add essential energy storage (hydrogen or ammonia production).

Box 9: Large electrically heated steam cracker furnaces

BASF together with its partners SABIC and Linde[193] started to build the first demonstration plant for large-scale electrically heated steam cracker furnaces. The plant utilises electricity produced by renewable sources and should come online in 2023.

The German government contributed €14.8 million to the project. The "Decarbonisation in Industry" funding program earmarked a cumulative €3 billion to support energy-intensive industries' transition efforts in Germany until 2024.

BASF will have received an additional €134 million in state funding to expand its green hydrogen production capacities.[194] The hydrogen electrolyser is envisaged to start operating in 2025.

- **Hydrogen**: Global investments in hydrogen electrolyser projects in 2021 reached $1.5 billion, having more than tripled from levels in 2020. Drawing on the ongoing expansion, BloombergNEF[195] and the Hydrogen Council are expecting hydrogen to account for up to 24% and 18% of global final energy consumption in 2050, respectively. But more conservative estimates suggest a much smaller cut for hydrogen, indicating the uncertainties around the scenarios. The IEA's most recent World Energy Outlook pencils in a more modest 5% share in final energy consumption in the cement sector by 2050.

  In combination with captured carbons, hydrogen can be an alternative feedstock for the chemical industry.[196] Hydrogen capacities could also allow for a strategic power reserve for chemical industries to tap into while in-house production allows for supply chain simplification. A promising direction is green ammonia production which is safely transportable and can act as hydrogen storage.[197]

Box 10: Hydrogen strategy in Hungary

Focusing on economically feasible decarbonisation options, the Hungarian government found that about 95 kilotons of emissions could be avoided by a combination of low and no-carbon hydrogen production.

The Hungarian strategy proposed blue hydrogen as the most cost-efficient option for Hungary in the short to medium run. But the plans also count on decentralised, green hydrogen production with electrolysis. The strategy envisages two local clusters near the petrochemical production sites.

- **Biomass** has the potential to replace the fossil fuel feedstock used in steam cracking, ammonia and methanol production. Estimates indicate that the existing technologies would enable a complete switch by 2030-50. To that we can add that biomass-to-electricity, which enjoys administrative support in Czechia and Hungary.

- **Carbon Capture, Utilisation & Storage (CCUS)**: Process-related and unavoidable carbon emissions need to be stored in products. Technologies for capture and storage are nearing economic viability. CO_2 emissions are highly concentrated in steam crackers (olefins production), ammonia and hydrogen production rendering those emissions ideal for utilisation. According to the Global CCS Institute,[198] 20 chemical facilities worldwide already operated a CCS technology in 2020.

- **Investment into product development and specialisation**: Bioplastics technologies are still in a nascent stage and not yet deployed at scale, but early markets have been successful for bottle packaging and cosmetics. The bio-based chemicals can be considered a low or no-carbon alternative to the usual petrochemicals (polymers, fossil-based ethylene). Project Drawdown estimates[199] that bioplastics could grow to 46% of the market by 2050. This could create a high value-added market segment for the V4 chemical sector to tap into.

Transition acceleration & roadblock removal ideas

- Hydrogen strategy planning is missing in some countries. The authorities should give a clearer indication to the markets about the expected public support to hydrogen. Capacities in the region are currently small, so that the roll-out of hydrogen production may be feasible over a longer time horizon.

- Conduct feasibility studies in cooperation with academia and industrial stakeholders to understand the economic feasibility and (prospective) competitiveness of large biobased chemical producers in the V4 region.

- Outline policy scenarios addressing the investment risks (risk pooling) and logistical challenges associated with chemical sector decarbonisation (carbon infrastructures, electricity grid). The 'what-if' scenarios would help investors to figure out the best investment options and avoid asset stranding which remains one of the key financial risks.

- The potential to scale CCS use remains unclear. The authorities should pay special attention to the CCS related challenges. Local availability and feasibility of storage sites should be further analysed.

Waste

Status and challenges

Emissions	22 Mt CO_2e
GVA weight	0.9%
Employment	0.2m persons

* 2020 data, GVA weight = share of the segment in the total V4 Gross Value Added

This segment contributes almost 4% to the overall GHG emissions in the V4 and less than 1% to the overall gross value added and employment. Methane (NH_4) is the main GHG here and the most important source of methane is the anaerobic digestion of organic waste in landfills (the other major part of the biogas produced is CO_2). In the V4 countries, solid waste management accounts for 4/5 of emissions while wastewater treatment (WWT) accounts for the rest. As mentioned in the methodology chapter, NH_4 is a short-lived GHG and has 25x higher warming potential over 100 years than CO_2, but 80x higher over 20 years.

Most of the degradable organic carbon in the solid waste is contained in food waste, garden and park waste, paper, wood, and textiles. Degradable organic sludge from sewage treatment is mostly generated in households and in the food, textile and chemical industries.

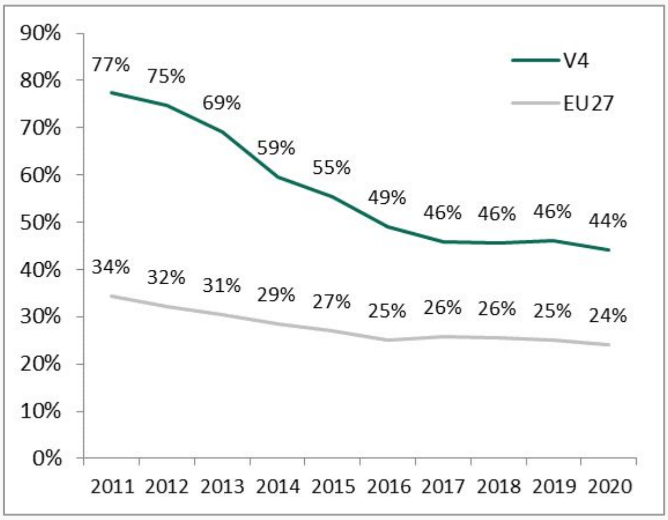
The proportion of waste going to landfill in municipal waste treatment in the V4 declined substantially in recent decades. However, this trend has weakened in recent years and the V4, with 44% of municipal waste landfilled, significantly exceeds the EU average of 24%. The difference can be seen also on a per-capita basis, although this is less pronounced due to the higher per-capita volume of municipal waste in Western/ Northern Europe.

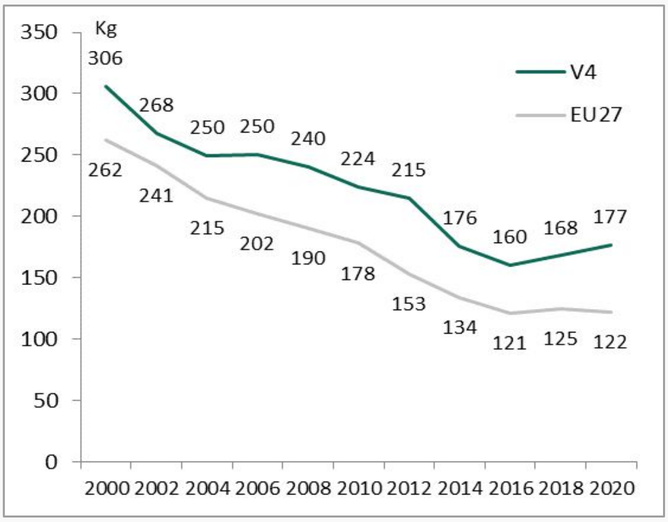
The difference is also significant on the basis of total waste volumes (excl. mineral waste), as landfilling accounts for a third of waste treatment in the V4 compared to the EU average of around a quarter.

Waste management in the V4/EU is regulated primarily by the Waste Framework Directive and the Landfill Directive.[200] The segment does not participate in the ETS and its emissions are regulated under the Effort Sharing Regulation. No agreement appears imminent on the debated inclusion of municipal incinerators in the scope of the ETS.[201]

Under existing policies, the waste sector is expected to reduce its emissions significantly - notably due to the obligation to separately collect bio-waste from 2024 and a ban on bio-waste landfilling.[202] Landfilling of all waste that is suitable for recycling or other material or energy recovery is restricted from 2030 and the share of municipal waste landfilled should not exceed 10% by 2035.

Chart 15: Municipal waste landfill disposal in V4 and EU (as % of total and in kg/capita)





Source: Eurostat, ISFC calculations

Climate investment areas

Efforts are currently focused on both waste prevention and minimising landfilling. As regards the latter, turning waste into a resource is clearly stressed in EU policies as an essential part of closing the loop towards a circular economy, reducing emissions across the entire industrial value chain.[203] At the same time, most GHG is typically produced 5-7 years after landfilling and almost all GHG is produced within 20 years. Small quantities of GHG may continue to be emitted from a landfill for 50 or more years.[204]

Given the current large share of landfilling in the V4 countries, the areas of particular interest in this chapter concern both (landfill) waste prevention and measures to mitigate GHG emissions from (landfilled) waste and WWT. It is estimated that implementing all technically feasible strategies simultaneously could reduce methane emissions from landfills by as much as 80% by 2030.[205] In addition to the measures and technologies already available, those in an earlier stage of development are mentioned hereunder. Waste disposal by incineration is not covered in this chapter, being part of the energy sector.

- **Food waste prevention**: About one third of all food produced currently goes to waste.[206] Significant reduction in food waste can be reached by investments in promoting behavioural changes and/or changing corporate business models. Individual behavioural changes include better food planning, preparation, preservation and storage. Large food retailers can better align their inventories with consumer demand and develop strategies to utilise imperfect or surplus produce, and can also partner with local food banks. Consumers can be better educated, such as about “best before” dates, which are often misinterpreted as expiration dates.
In Poland, a recent study showed that most people had difficulty distinguishing and properly understanding these terms on the label.[207]

- **Fast turnover prevention - textile**: The textile industry, with its current linear textile value chains and fast fashion models producing low-quality items, showed its lack of resilience during the COVID-19 pandemic. Also, two thirds of textile waste are estimated to end up in mixed municipal waste destined for incineration or landfills.[208]
Waste prevention initiatives in the textile sector thus need to be stepped up. The initiatives will have to overcome inherent fast fashion models, consumption patterns, established value chains and economic barriers. Implementing circular economy principles in the textile industry is becoming a key part of the new EU circular economy strategy from 2020.[209]

Box 11: Digital waste marketplace

Cyrkl.com is an interesting initiative that promotes the principles of circular economy in the waste management of companies across all industries. It provides an international online digital platform for matching the demand and supply of recyclable waste and residuals in Europe, including paper, textile and wood. Initially launched in Czechia, it currently covers twelve European countries and more than 17 thousand companies have joined the platform.

- **Consumer source separation**: The Waste Framework Directive requires mandatory separate collection of biodegradable waste and textile from mixed waste from 31.12.2023 and 1.1.2025, respectively.
Whether collected directly at properties or at communal collection points within walking distance, municipalities will have to deal with higher operating cost incl. additional labour, equipment purchases and maintenance, additional space needs, or enhanced sanitation protocols. Improved source separation, however, also increases the homogeneity of individual waste streams, reduces the consequent costs of recovery or other waste use, and thus allows new treatment technologies to become economically viable. Successful source separation of organics may require sustained awareness programmes (covering both ‘how’ and ‘why’) to encourage positive behavioural changes in the face of more burdens on households - such as space required for separate collection receptacles, separate bins, and concerns about uncleanliness, odour, and rodent/pest infestations.

- **Automated organics recovery**: Recovery of organic waste (paper, cardboard, wood, yard waste, food waste) from mixed waste can be achieved via automated sorting in materials recovery facilities. These facilities use unit processes such as magnets, eddy current separators, screens, air density separators, optical sorting, and manual sorting to recover recyclables. Subsequently, a nascent compressive force technology can be used to extract mainly food/organic waste for conversion into a high-yield biogas feedstock ideal for anaerobic digestion. Vendors claim these technologies can recover up to 95% of feedstock from source-separated food waste collection programs. Compressive force technologies are commercially available, but have not yet been widely adopted and their technical effectiveness and economic viability need to be verified.[210]

- **Landfill gas capture systems**: Organic waste that has not been recycled, composted or used for biogas production (see below) is either combusted in incineration plants or deposited in landfills, where landfill gas (LFG) is being produced through anaerobic digestion. LFG can be collected by a series of vertical and horizontal pipes and a vacuum system. LFG capture systems fitted with liners, landfill covers, and other control systems that optimise methane abatement reportedly capture up to 85% of the methane generated at an active sanitary landfill, though the range is quite wide (from 35%).[211] For example, in Poland, out of total of almost 800 landfills, 300 are active, of which almost 90% are equipped with degassing and 98 landfills used the captured LFG for consequent cogeneration, mostly consumed locally.[212] The potential for exploring further investment opportunities in Poland and, in general, in the V4 countries thus seems to exist.

- **Bio-methane** is usually produced by removing CO_2 and other contaminants from biogas. Instead of flaring biogas at landfills and WWT plants (or even allowing it to leak), or using it for local heat/power production, refined biogas can be collected and used as an energy source. Bio-methane is also produced in biogas plants using anaerobic digesters. Here, it must be ensured that biogas is produced from feedstock that do not compete with food and feed crops for agricultural land or increase biodiversity loss.[213] In Europe, biogas technology working with a high content of solids in substrate has become dominant in the last decade because it requires a smaller reactor volume per unit of production.[214]

Bio-methane meets natural gas (NG) industry standards. It can be injected into the existing grid and used interchangeably with conventional NG, i.e., in the energy sector or as a vehicle fuel when compressed (CNG) or liquefied (LNG). Factors that could accelerate cost reduction and production growth include streamlined permitting procedures, factory-style fabrication of standardised biodigesters and related equipment, dedicated biogas financing facilities, and policy measures such as quotas, feed-in tariffs and contracts for difference.

The EU supports the scaling-up of bio-methane as an NG non-fossil substitute. The growth in biomethane production envisioned in the RePowerEU Plan is reported to imply a 40% CAGR in 2023-30 compared to 17% in 2015-21.[215] The technology application in the V4 is however at early stage, perhaps also due to historical uncertainties in the regulatory environment.[216] Czechia is the fifth largest producer of biogas in the EU[217] with approx. 550 biogas stations. However, only two bio-methane installations are in active operation and the permit procedure for the conversion of a biogas station to bio-methane usually takes 2-3 years. In Poland, first bio-methane installations are under construction as of 2022.[218] Similarly, in Slovakia, the first of about 100 biogas plants was expanded to produce bio-methanol in 2022.[219]

Box 12: Bio-methane production in WWT plant Prague

The Prague WWT Plant is equipping its new processing plant with membrane separation technology for bio-methane production. It should be fully operational from 2023, while a pilot unit with an expected annual supplied volume of about 1 mil. m3 is in operation from 2022.

Biomethane will be injected into the city´s gas network.[220] Using multi-stage membrane separation, it separates bio-methane with a 97-99% recovery rate. The plant belongs among 20% of WWT plants that use biogas for energy purposes in Czechia.

- **Advanced biofuels**:[221] Sustainable Aviation Fuel (SAF) has the potential to reduce GHG emissions by 70-99% compared to conventional jet fuel on a life-cycle basis.[222] In view of the limited technological readiness levels of battery-electric and hydrogen-powered flight, especially for medium- to long-haul air transport, SAF may be an emissions abatement solution. SAF is compatible with existing fuel delivery infrastructure without requiring significant infrastructure investments. However, the SAF production itself is highly capital intensive. The net zero scenario in the World Energy Outlook 2022 assumes the global biofuel consumption to increase by 250% between 2021-50 (3.2% CAGR).[223]

  Several production methods are under development. The most mature is hydro-processed esters and fatty acids (HEFA)-based SAF production, but it is based on oil processing and therefore has no relevance for the biodegradable waste recovery. Other methods, which can also recover municipal waste and agricultural and forestry residues, are much lower on the technological readiness scale.[224]

- **GHG leak detection**: At landfills where methane capture technology is installed, comprehensive monitoring can facilitate rapid methane leak detection and repairs. Technologies range from handheld sensors that detect emissions at close range, to optical imaging cameras that can scan an area from the ground, to aircraft and drones sampling and methane-sensitive satellite imagery. Noticeably, huge discrepancies between top-down observations and bottom-up modelling have been recently reported. For example, emissions estimated from airborne imaging spectrometer surveys of landfills in the United States in 2016-21 showed little correlation with emissions reported within national GHG reports.[225]

- **Other R&D areas**: Gasification of waste under high heat and limited oxygen and utilization of the produced syngas (consisting mostly of CO and hydrogen) is among the R&D opportunities that is commonly mentioned but has not yet proved its economic viability (except perhaps under specific conditions in Japan).[226] Methane oxidation in engineered semi-passive biocover systems could be another technology applicable to landfills, but full-scale evaluation of its efficiency has been rare and further research is necessary.[227]

Transition acceleration & roadblock removal ideas

- Community/individual engagement and support is necessary to ensure the success of many strategies such as food waste, garden waste, or other organic waste separation programs. Therefore, systemic and ongoing educational outreach and involvement programs are needed to help communities and individuals develop a deeper understanding of the environmental concerns and encourage their participation in programs or make other changes in their habits.

- In high turnover industries such as textile, there is currently insufficient emphasis on waste prevention in the V4 and across Europe. Waste prevention thus has significant potential through a combination of consumption reduction, eco-design (e.g., use of durable and long-lasting materials) and ultimately reuse. It is appropriate to set specific targets, supporting measures, robust data collection and exchange among the various stakeholders.

- Landfill restrictions are clearly set out in EU regulation, but GHG reductions depend heavily on effective enforcement. In this context, as far as the V4 countries are concerned, the Commission announced in November 2021 that it is taking legal steps against Slovakia for failing to comply with EU laws on waste.Waste is being landfilled without appropriate treatment as landfills do not have sufficient installations to ensure selection of different types of waste.[228] Although the V4 countries cannot be expected to lead the EU in this area, not least because of their historically high share of landfilling in waste treatment, an intensified focus on enforcement of regulations by the competent authorities is clearly needed.

Iron & steel

Status and challenges

The iron and steel sector is represented in the V4 region by five large and numerous mid-sized to small steel producers, with significant presence in the Silesian region (three large steel producers in Czechia and Poland), eastern Slovakia and central Hungary (one large steelworks each).

The sector contributes 2% to overall GHG emission and less than 1% to GVA and employment in the V4 region. Almost 41% of the GHG emissions are related to energy production and the remaining part to metal processing itself. Related production of coke is not reflected in the chapter as supplies to steelworks cannot be distinguished from supplies to other off-takers.

The sector participates in the ETS, with companies receiving free allowances (as they are exposed to competition from countries with no carbon pricing) that provide them with an additional income source to finance climate investments. With free allowances gradually phasing out from 2026, all steelworks are in imminent need of major climate-related capex.

Emissions	**20 Mt CO_2e**
GVA weight	**0.5%**
Employment	**0.2m persons**

* 2020 data, GVA weight = share of the segment in the total V4 Gross Value Added

Climate investment areas

- **Electric arc furnaces** (EAF): This state-of-the-art technology can reduce carbon emissions by more than 70% and helps ramping up steel scrap use (up to 100%). At the same time, it significantly increases the volume of electricity required, either from the grid or decentralised electricity sources. In Poland, almost half of steel comes from EAFs. In Czechia, Liberty Ostrava, with its annual production of 2.3 mt of steel plans capex of EUR 350m for EAF – see Box 13 for details.
- **Steel scrap leveraging**: Steel can be recycled indefinitely without any loss of quality; its chemical and physical properties do not change. Recycling saves around 75% of the energy that would be otherwise needed to produce brand new steel.[231] In Czechia, steelworks currently use around 40-45% of scrap in the steel production and the share is expected to grow.[232]

Box 13: Decarbonisation investments by Liberty Ostrava

Liberty Ostrava plans to become fully decarbonised by 2030.[229] Modernising and constructing two new electric arc furnaces should significantly contribute to this goal. This technology will start its operations by the end of 2025 and should reduce carbon emissions by 80% by 2027.[230] The total cost of the innovation is EUR 350 million. It also helps ramping up steel scrap use, which brings another complexity to the supply chain. Electrification of the process is the key enabler of decarbonisation. The target is to complete a high voltage power line by 2025.

Altogether, the group plans to invest a total of EUR 750 million in the development of its Ostrava steelworks over the course of ten years. It should be largely funded from emission allowances revenues, with the total value of allowances held by Liberty Ostrava was EUR 698 million in 2022.

- **Hydrogen direct reduction (HDR):** This technology uses 100% H_2 in the direct reduction process instead of conventional natural gas, which may reduce carbon emissions by up to 80–90%. Although the technology is in the later stages of development, it is not yet ready and investment costs remain very high, with its operation is currently far from being cost-effective also due to volume of electricity needed to produce hydrogen.[233] An example of the technology development for its industrial use is the HYBRIT project – see Box 14 below.

Box 14: HDR fossil-free steel production pilot project

The HYBRIT initiative was started in Sweden to develop a new technology for hydrogen-based iron- and steelmaking with the aim to establish a fossil-free value chain from the mine to finished steel product.

A pilot storage facility for fossil-free hydrogen gas is in testing operation as of 2022. New test results from the pilot plant from 2022 reveal that the technology creates a product with significantly improved properties and quality. The project continues towards industrial scale production - a demonstration facility to be built in Gällivare in 2026.[234]

- **Heat and power sources:** Energy production accounts for 41% of GHG emissions in the Iron & Steel segment in the region.[235] Producers must either decarbonise the local sources (similarly to the power sector – see the Electricity & heat segment), switch to external energy (electricity) purchases, invest in CCUS (see below), or combine the above.[236]

- **Carbon capture, utilization & storage (CCUS):** Very few projects of carbon capture and storage are currently under development in the region (e.g., Polish off-shore in the North Sea, more than 500 km from the closest steelworks[237]). High capex needed to build a pipeline network (compared to the average size of steelworks in the V4) and early stages of development are currently delaying implementation in the region.[238]

Transition acceleration & roadblock removal ideas

- Clarify and streamline the targeting of national restructuring funds, innovation funds, recovery plans and operating programs to the above-mentioned investment areas across all technology readiness levels, from research, followed by pilot and semi-operational projects, to fast implementation of proven technology in the sector.

- Correctly fine-tune the boundaries of the so-called carbon duty (Cross Border Adjustment Mechanism) in the transitional phase 2023-25 for production originating from countries without environmental and carbon regulations to mitigate risk of the so-called carbon leakage (outflow of production to third countries with less rigorous environmental standards). This should take into account that the size of the duty, intra-EU steel prices and export competitiveness, including all downstream steel-intensive sectors, are interlinked.

- Implement measures which will increase the share of recycled steel in the V4 to levels seen in other EU countries. Currently, the EU recovers on average 85% of end-of-life steel for recycling and 56% of EU steel is made from scrap.[239] Improve recycling of construction steel and support development and implementation of new technologies for cleaning recycled steel.

- Possibly, launch a guarantee / risk-coverage scheme and instruments for transition technologies, especially in the critical stage between pilot projects and fully operational technology, and/or other state incentives for technology frontrunners (tax relief, accelerated tax depreciation, etc.).[240]

- Although outside of the reach of the sector, sufficient supply of electricity and, later, hydrogen represents a key precondition of current carbon-neutrality plans of all steel producers. It is estimated that the electricity consumption would increase almost fourfold.[241]

Summary

Summary

V4 to fully align with the European Green Deal

The Visegrad Group (V4) countries - Poland, Czechia, Hungary and Slovakia - represent around 15% of the EU´s population and 7% of its GDP. The group is highly integrated into European supply chains and, as important European players, have the ability to influence EU negotiations and legislation.

The region faces challenges in effectively aligning with the RePowerEU and European Green Deal objectives, while improving its income status and sustaining economic development. Its players need to rethink how energy is utilised and which technologies are used.

Role of climate sustainability investments

The depletion of natural sources and a high dependence on non-European energy and commodity supplies have left not only the V4, but the whole of Europe in a delicate political, economic and strategic position. The European Green Deal and RePowerEU should allow the EU to partially reclaim its energy and economic independence and strengthen the resilience of its supply chains on the road to long-term sustainability.

Climate investing promotes long-term investment perspectives and allows climate externalities to be properly taken into account. Climate-sustainable investing supports economic growth while reducing and ultimately eliminating climate change pressures.

Preconditions for a successful transition

However, a successful transition to a sustainable economy will require key preconditions to be met. It is crucial that governments and decision-makers consider the transition towards a sustainable economy as a top priority. In the V4 region, sustainability is often perceived as an adjunct to business as usual in both the public and private sectors, and climate ambitions remain low. Understanding of ESG (environment, social and governance) criteria is limited. Lack of relevant information, expertise, stakeholder engagement, policy coherence and guidance, effective communication on the topic, and a clear commitment from public authorities in this area have been major obstacles.

Available financing represents another prerequisite for a successful transition. Direct support from public finance, public-private co-financing, blended finance and public guarantees incentivising climate sustainable projects will accelerate the transition. A full understanding of sustainability by the local banking sector, reflection of sustainable assets that show lower financial risks, and appropriate targeting of public incentives would all encourage the banking sector to finance sustainable projects.

V4 region´s fossil fuel burden

In terms of the climate aspects of sustainability, the V4 region plays an important role in the decarbonisation of the EU economy, contributing by around 16% to EU greenhouse gas emissions. The carbon intensity here significantly exceeds the EU average and is particularly high in the most populous countries, Poland and Czechia, with the energy sector being the key driver. The V4 energy sector highly depends on coal, oil and natural gas, of which oil and gas are largely imported. As a result, per-capita energy-sector emissions are almost double the EU average.

Energy sector in the spotlight

As the future energy carrier for heating, transport, and hard-to-abate sectors, electricity decarbonisation remains a key challenge and simultaneously an opportunity on the net-zero pathway by 2050, and the V4 region is no exception. The future path away from fossil fuel-based electricity production should focus on renewables.

However, the energy transformation of the V4 region has long been negatively affected by the ambivalent attitude of its political elite towards green transformation. This has significantly hampered the large-scale green energy deployment in all V4 countries. Firmer commitments to renewables are therefore expected from the V4 governments in the revised national energy and climate plan to be proposed by 30 June 2023.

There is a huge potential to exploit wind energy sources in the whole V4 region. In Poland, for example, in order to achieve the power sector decarbonisation target, around 75% of overall power production in 2050 could be generated by wind power plants, studies suggest. Photovoltaic has become one of the economically viable and scalable sustainable technologies. Thanks to many advances in photovoltaics and battery storage technologies in recent years, the costs of solar energy production have rapidly decreased.

Given the predicted increase in penetration of wind and photovoltaic energy sources and the transformation of hard-to-abate industrial and transport sectors which are heavily reliant on large amounts of renewable electricity, large investments in grid reinforcement and modernisation and increased flexibility of multi-directional electricity systems will be necessary to avoid grid overloading and power outages in the region.

Investment conundrum for industry

Similar to the energy sector, the main high-emission industrial sectors – cement, chemical and steel are at the early stages of the transition path. Deep decarbonisation here will require the deployment of multiple innovations. Fuel switching, electrification, adoption of circularity business concepts, technological processes adjustments, carbon capture and utilisation technologies and hydrogen use should move hand in hand to achieve the ambitious net zero pledges. However, looming uncertainty around the scalability and operating costs of the best available technologies and about carbon prices may still pose an investment conundrum.

Agriculture - a lot to catch up on

Agriculture is at the very beginning of its transition. With more than 1.8m directly employed persons in the V4 region, it is the largest employer among the high emission segments. It is also characterized by high business fragmentation, high reliance on the EU subsidy schemes and the non-CO_2 nature of greenhouse gas emissions. The above might have caused the agriculture's climate impact to receive less attention than other sectors in recent decades. This in turn has triggered less climate-related research, development and investment activities in the areas such as the implementation of precision farming, enhanced fertilisers, improved manure management, sustainable feed additives reducing methane production, alternative proteins, etc.

Only in December 2021 was the agreement on the Common Agriculture Policy reform adapted, aligning it with the European Green Deal. Climate aspects have been transposed to some extent in the V4 national strategic plans for 2023-27; full reflection is likely after 2027.

Technology and outreach investing in retail segments

The transition to sustainability in retail segments such as road transport, local heating and waste management clearly requires the intensive involvement of the general public. Technological changes alone may not always be sufficient, modification of behavioural patterns would often be supportive. Electro-mobility, improved efficiency of building envelopes accompanied by decentralized renewable energy sources, automated waste sorting, and efficient landfill gas capture systems with consequent bio-methane production, all represent directly investable technologies. Modal change from road to rail, efficiency improvements in all energy use in households/buildings, food waste prevention or consumer source separation, all belong among behavioural aspects of the transition. Only a broad portfolio of measures and incentives will often lead to success.

For the fragmented segments, systemic and ongoing educational outreach (both 'how' and 'why') and involvement programs are needed to help businesses, communities and individuals develop a greater understanding of environmental issues and impacts, and consequently encourage their participation in the transition. In agriculture, it will be important to involve and commit farmers, society and government towards the same objective. Technical assistance, awareness raising and capacity building in order to support the transition would also be beneficial.

The public sector´s role in accelerating the transition

National policies should support innovations in a technology-neutral way across different technology readiness levels, from basic research to pilot and semi-operational projects. In some segments, new energy-efficient technologies often struggle with low research investment ratios due to, inter alia, a long changeover cycle for new products or market fragmentation. Public support and intensified funding for research and innovation would facilitate the envisaged transition pace. As incumbent industries advance new products, regulators need to revisit and update existing standards and codes more regularly. New solutions are often cross-sector interconnected ("sector coupling"), and there is scope for horizontal collaboration across governmental agencies to bring together R&D, cost and technical analyses with standardization and regulation.

Careful consideration should be given to possible temporary guarantee / risk-coverage schemes and instruments for transition technologies, especially in the critical stage between pilot projects and fully operational technology, and/or fiscal incentives to accelerate the sustainable technology uptake, such as a combination of (interim) tax reliefs, accelerated tax depreciation, tax deduction, etc.

The public sector should set more ambitious sustainable procurement rules which could accelerate the transition to sustainability (e.g., material and energy efficiency in tenders for infrastructure, transport vehicles procurement, deep retrofits of publicly owned buildings). Also, overall (discounted) costs including future operational cost savings should be assessed.

Other transition acceleration ideas include conducting feasibility studies in cooperation with academia and industrial stakeholders to understand the economic feasibility and (prospective) competitiveness of new technologies and product opportunities, or outlining policy scenarios addressing the investment risks and logistical challenges associated with decarbonisation (carbon infrastructures, electricity grid). What-if scenarios would help investors to figure out the best investment options and avoid asset stranding - which remains one of the key financial risks. Also, local availability and feasibility of storage sites should be further analysed as the potential to scale CCS use remains unclear.

Streamlined multi-source sustainable financing

The targeting of available funding from restructuring, innovation and transition funds, recovery plans and operating programs needs to clearly be streamlined to areas that currently or prospectively contribute to the sustainability transition. For transition technologies in the critical stage between pilot projects and fully operational technology, a guarantee / risk-coverage scheme and instruments could be launched.
Direct financial support from public sources then helps to overcome the barrier of high up-front costs, mobilise private investments and kick-start the uptake of new technologies.

Annexes

Annex 1: Definition of segments

Definition of segments according to the UNFCCC category codes

Segment	UNFCCC category codes
Public Electricity & Heat Production	1.A.1.a
Road Transport	1.A.3.b
Agriculture	1.A.4.c.i, 1.A.4.c.ii, 3.
Local Heating	1.A.4.a.i, 1.A.4.b.i
Cement and Other Minerals	1.A.2.f, 2.A
Chemical Industry (incl. oil refining)	1.A.1.b, 1.A.2.c, 1.B.2.a.iv, 1.B.2.a.v, 2.B
Coal Mining & Transformation*	1.A.1.c.i, 1.B.1
Waste	5.
Iron and Steel	1.A.2.a, 2.C.1
* *incl. other solid fuels*	

Matching matrix of NACE sectors and the UNFCCC category codes

NACE sector	UNFCCC category codes
Energy Sector	1.A.1.a, 1.B.2.b
Land Transport	1.A.3.b, 1.A.3.c, 1.A.3.e.i
Agriculture	1.A.4.c.i, 1.A.4.c.ii, 3.
Cement and Other Minerals	1.A.2.f, 2.A
Chemical Industry	1.A.1.b, 1.A.2.c, 1.B.2.a.iv, 1.B.2.a.v, 2.B
Mining	1.A.1.c.ii, 1.A.2.g.iii, 1.B.1.a, 1.B.2.a.i, 1.B.2.b.i
Waste	5.
Iron and Steel	1.A.2.a, 2.C

Annex 2: Detailed GHG emissions breakdown by segment

Detailed GHG Emissions Breakdown by Segment – V4

Year	2020			
Category \ Unit	**kt CO2 equivalent**	% of total	**kt CO2**	% of total
Public Electricity and Heat Production	183 295	*31%*	182 213	*38%*
Road Transport	98 648	*17%*	97 502	*21%*
Cars and Motorcycles	55 868	*9%*	55 269	*12%*
Trucks and Buses	42 780	*7%*	42 233	*9%*
Agriculture	66 880	*11%*	15 628	*3%*
Agricultural Soils (fertilizers, liming, etc.)	26 706	*5%*	2 110	*0%*
Livestock Production (enteric fermentation, manure mng.)	25 328	*4%*	0	*0%*
Fuel Combustion (Stationary, Off-roads & Machinery; incl. Forestry)	14 847	*3%*	13 518	*3%*
Local Heating	66 108	*11%*	61 533	*13%*
Residential	53 473	*9%*	49 049	*10%*
Commercial/Institutional	12 635	*2%*	12 484	*3%*
Cement, Lime and Other Minerals	32 975	*6%*	32 832	*7%*
Cement and Lime Processing	14 504	*2%*	14 504	*3%*
Glass, Ceramics and Other Mineral Processing	3 976	*1%*	3 976	*1%*
Energy Production & Other Fuel Combustion	14 495	*2%*	14 352	*3%*
Chemical Industry (incl. oil refining)	28 677	*5%*	27 770	*6%*
Chemicals Processing	11 173	*2%*	10 325	*2%*
Energy Production & Other Fuel Combustion	17 504	*3%*	17 445	*4%*
Coal Mining & Transformation (incl other solid fuels)	26 023	*4%*	9 664	*2%*
Solid Fuels Processing	18 770	*3%*	2 430	*1%*
Energy Production & Other Fuel Combustion	7 253	*1%*	7 234	*2%*
Waste	21 536	*4%*	730	*0%*
Solid Waste Disposal and Treatment	17 073	*3%*	730	*0%*
Wastewater Treatment and Discharge	4 463	*1%*	0	*0%*
Iron and Steel	19 534	*3%*	19 494	*4%*
Iron and Steel Processing	11 569	*2%*	11 547	*2%*
Energy Production & Other Fuel Combustion	7 965	*1%*	7 946	*2%*
Others	44 972	*8%*	26 389	*6%*
Energy Production & Other Fuel Combustion	22 867	*4%*	22 448	*5%*
Total emissions*	**588 648**	*100%*	**473 756**	*100%*

** without Land Use, Land-Use Change and Forestry*

Source: UN Framework Climate Change Convention GHG database, ISFC calculations

Detailed GHG Emissions Breakdown by Segment – Poland

Year	2020			
Category \ Unit	kt CO2 equivalent	% of total	kt CO2	% of total
Public Electricity and Heat Production	131 954	35%	131 205	43%
Road Transport	62 094	17%	61 362	20%
Cars and Motorcycles	33 490	9%	33 118	11%
Trucks and Buses	28 604	8%	28 243	9%
Agriculture	45 886	12%	11 785	4%
Agricultural Soils (fertilizers, liming, etc.)	17 238	5%	1 459	0%
Livestock Production (enteric fermentation, manure mng.)	17 076	5%	0	0%
Fuel Combustion (Stationary, Off-roads & Machinery; incl. Forestry)	11 571	3%	10 327	3%
Local Heating	39 830	11%	37 051	12%
Residential	33 849	9%	31 176	10%
Commercial/Institutional	5 981	2%	5 876	2%
Cement, Lime and Other Minerals	21 050	6%	20 963	7%
Cement and Lime Processing	9 016	2%	9 016	3%
Glass, Ceramics and Other Mineral Processing	2 724	1%	2 724	1%
Energy Production & Other Fuel Combustion	9 310	2%	9 223	3%
Coal Mining & Transformation (incl other solid fuels)	18 744	5%	4 263	1%
Solid Fuels Processing	16 818	4%	2 341	1%
Energy Production & Other Fuel Combustion	1 926	1%	1 922	1%
Chemical Industry (incl. oil refining)	16 415	4%	15 879	5%
Chemicals Processing	5 360	1%	4 867	2%
Energy Production & Other Fuel Combustion	11 055	3%	11 012	4%
Waste	11 314	3%	599	0%
Solid Waste Disposal and Treatment	8 495	2%	599	0%
Wastewater Treatment and Discharge	2 819	1%	0	0%
Iron and Steel	5 090	1%	5 078	2%
Iron and Steel Processing	1 377	0%	1 368	0%
Energy Production & Other Fuel Combustion	3 713	1%	3 710	1%
Others	23 661	6%	15 337	5%
Energy Production & Other Fuel Combustion	12 511	3%	12 281	4%
Total emissions*	**376 038**	100%	**303 523**	100%

** without Land Use, Land-Use Change and Forestry*

Source: UN Framework Climate Change Convention GHG database, ISFC calculations

Detailed GHG Emissions Breakdown by Segment – Czechia

Year	2020			
Category \ Unit	kt CO2 equivalent	% of total	kt CO2	% of total
Public Electricity and Heat Production	36 949	*33%*	36 729	*40%*
Road Transport	17 412	*15%*	17 215	*19%*
Cars and Motorcycles	10 378	*9%*	10 272	*11%*
Trucks and Buses	7 034	*6%*	6 943	*8%*
Local Heating	11 060	*10%*	10 039	*11%*
Residential	8 370	*7%*	7 362	*8%*
Commercial/Institutional	2 690	*2%*	2 677	*3%*
Agriculture	9 096	*8%*	1 564	*2%*
Agricultural Soils (fertilizers, liming, etc.)	3 963	*4%*	340	*0%*
Livestock Production (enteric fermentation, manure mng.)	3 879	*3%*	0	*0%*
Fuel Combustion (Stationary, Off-roads & Machinery; incl. Forestry)	1 254	*1%*	1 224	*1%*
Iron and Steel	7 827	*7%*	7 809	*9%*
Iron and Steel Processing	5 932	*5%*	5 923	*6%*
Energy Production & Other Fuel Combustion	1 894	*2%*	1 885	*2%*
Coal Mining & Transformation (incl other solid fuels)	5 922	*5%*	4 255	*5%*
Solid Fuels Processing	1 701	*2%*	49	*0%*
Energy Production & Other Fuel Combustion	4 221	*4%*	4 206	*5%*
Cement, Lime and Other Minerals	5 867	*5%*	5 839	*6%*
Cement and Lime Processing	2 542	*2%*	2 542	*3%*
Glass, Ceramics and Other Mineral Processing	669	*1%*	669	*1%*
Energy Production & Other Fuel Combustion	2 656	*2%*	2 628	*3%*
Waste	5 136	*5%*	104	*0%*
Solid Waste Disposal and Treatment	4 143	*4%*	104	*0%*
Wastewater Treatment and Discharge	993	*1%*	0	*0%*
Chemical Industry (incl. oil refining)	4 101	*4%*	3 902	*4%*
Chemicals Processing	1 632	*1%*	1 442	*2%*
Energy Production & Other Fuel Combustion	2 469	*2%*	2 460	*3%*
Others	9 421	*8%*	4 397	*5%*
Energy Production & Other Fuel Combustion	4 355	*4%*	4 249	*5%*
Total emissions*	**112 789**	*100%*	**91 854**	*100%*

** without Land Use, Land-Use Change and Forestry*

Source: UN Framework Climate Change Convention GHG database, ISFC calculations

Detailed GHG Emissions Breakdown by Segment – Hungary

Year	**2020**			
Category \ Unit	**kt CO2 equivalent**	% of total	**kt CO2**	% of total
Road Transport	12 329	*20%*	12 181	*26%*
Cars and Motorcycles	7 198	*11%*	7 122	*15%*
Trucks and Buses	5 131	*8%*	5 060	*11%*
Local Heating	10 918	*17%*	10 399	*22%*
Residential	8 118	*13%*	7 618	*16%*
Commercial/Institutional	2 801	*4%*	2 781	*6%*
Public Electricity and Heat Production	10 431	*17%*	10 356	*22%*
Agriculture	8 952	*14%*	1 872	*4%*
Agricultural Soils (fertilizers, liming, etc.)	4 128	*7%*	239	*1%*
Livestock Production (enteric fermentation, manure mng.)	3 169	*5%*	0	*0%*
Fuel Combustion (Stationary, Off-roads & Machinery; incl. Forestry)	1 655	*3%*	1 632	*3%*
Chemical Industry (incl. oil refining)	4 658	*7%*	4 574	*10%*
Chemicals Processing	2 660	*4%*	2 579	*5%*
Energy Production & Other Fuel Combustion	1 998	*3%*	1 995	*4%*
Waste	3 402	*5%*	25	*0%*
Solid Waste Disposal and Treatment	3 079	*5%*	25	*0%*
Wastewater Treatment and Discharge	322	*1%*	0	*0%*
Cement, Lime and Other Minerals	2 415	*4%*	2 403	*5%*
Cement and Lime Processing	1 072	*2%*	1 072	*2%*
Glass, Ceramics and Other Mineral Processing	238	*0%*	238	*1%*
Energy Production & Other Fuel Combustion	1 104	*2%*	1 092	*2%*
Refrigeration and Air-conditioning	2 001	*3%*	0	*0%*
Natural Gas an Oil	1 688	*3%*	133	*0%*
NG and Oil Processing	1 688	*3%*	133	*0%*
Energy Production & Other Fuel Combustion	0	*0%*	0	*0%*
Iron and Steel	1 287	*2%*	1 282	*3%*
Iron and Steel Processing	1 114	*2%*	1 110	*2%*
Energy Production & Other Fuel Combustion	173	*0%*	173	*0%*
Others	4 739	*8%*	4 058	*9%*
Energy Production & Other Fuel Combustion	3 956	*6%*	3 909	*8%*
Total emissions*	**62 818**	*100%*	**47 284**	*100%*

** without Land Use, Land-Use Change and Forestry*

Source: UN Framework Climate Change Convention GHG database, ISFC calculations

Detailed GHG Emissions Breakdown by Segment – Slovakia

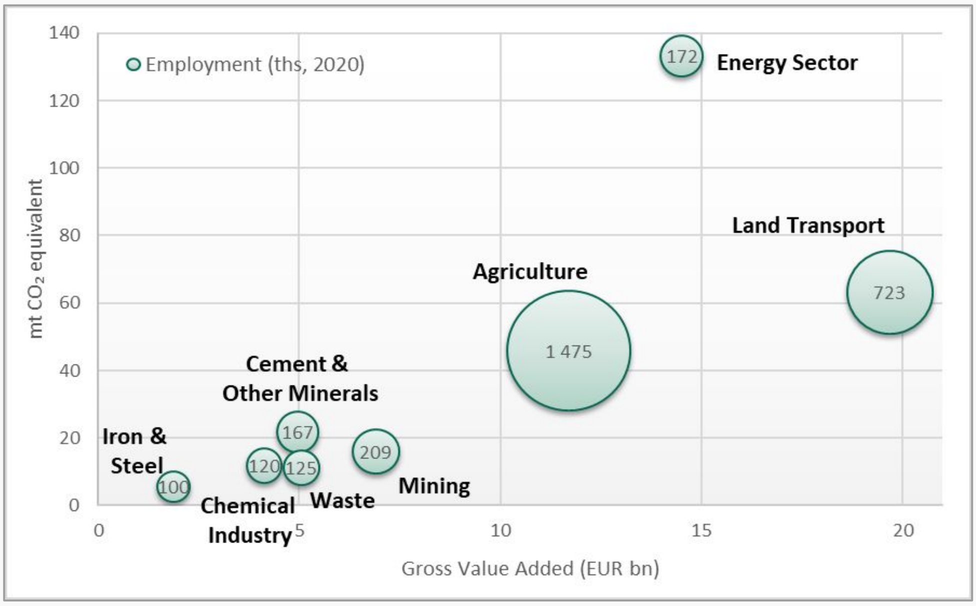
Year	2020			
Category \ Unit	kt CO2 equivalent	% of total	kt CO2	% of total
Road Transport	6 813	*18%*	6 744	*22%*
Cars and Motorcycles	4 802	*13%*	4 757	*15%*
Trucks and Buses	2 011	*5%*	1 986	*6%*
Iron and Steel	5 331	*14%*	5 325	*17%*
Iron and Steel Processing	3 146	*9%*	3 146	*10%*
Energy Production & Other Fuel Combustion	2 185	*6%*	2 179	*7%*
Local Heating	4 299	*12%*	4 044	*13%*
Residential	3 135	*8%*	2 894	*9%*
Commercial/Institutional	1 164	*3%*	1 150	*4%*
Public Electricity and Heat Production	3 962	*11%*	3 923	*13%*
Cement, Lime and Other Minerals	3 643	*10%*	3 627	*12%*
Cement and Lime Processing	1 874	*5%*	1 874	*6%*
Glass, Ceramics and Other Mineral Processing	345	*1%*	345	*1%*
Energy Production & Other Fuel Combustion	1 424	*4%*	1 408	*5%*
Chemical Industry (incl. oil refining)	3 503	*9%*	3 415	*11%*
Chemicals Processing	1 521	*4%*	1 437	*5%*
Energy Production & Other Fuel Combustion	1 982	*5%*	1 977	*6%*
Agriculture	2 946	*8%*	407	*1%*
Agricultural Soils (fertilizers, liming, etc.)	1 377	*4%*	72	*0%*
Livestock Production (enteric fermentation, manure mng.)	1 203	*3%*	0	*0%*
Fuel Combustion (Stationary, Off-roads & Machinery; incl. Forestry)	367	*1%*	335	*1%*
Waste	1 685	*5%*	1	*0%*
Solid Waste Disposal and Treatment	1 356	*4%*	1	*0%*
Wastewater Treatment and Discharge	329	*1%*	0	*0%*
Coal Mining & Transformation (incl other solid fuels)	1 149	*3%*	970	*3%*
Solid Fuels Processing	191	*1%*	12	*0%*
Energy Production & Other Fuel Combustion	958	*3%*	957	*3%*
Others	3 672	*10%*	2 640	*8%*
Energy Production & Other Fuel Combustion	2 194	*6%*	2 156	*7%*
Total emissions*	**37 003**	*100%*	**31 095**	*100%*

** without Land Use, Land-Use Change and Forestry*

Source: UN Framework Climate Change Convention GHG database, ISFC calculations

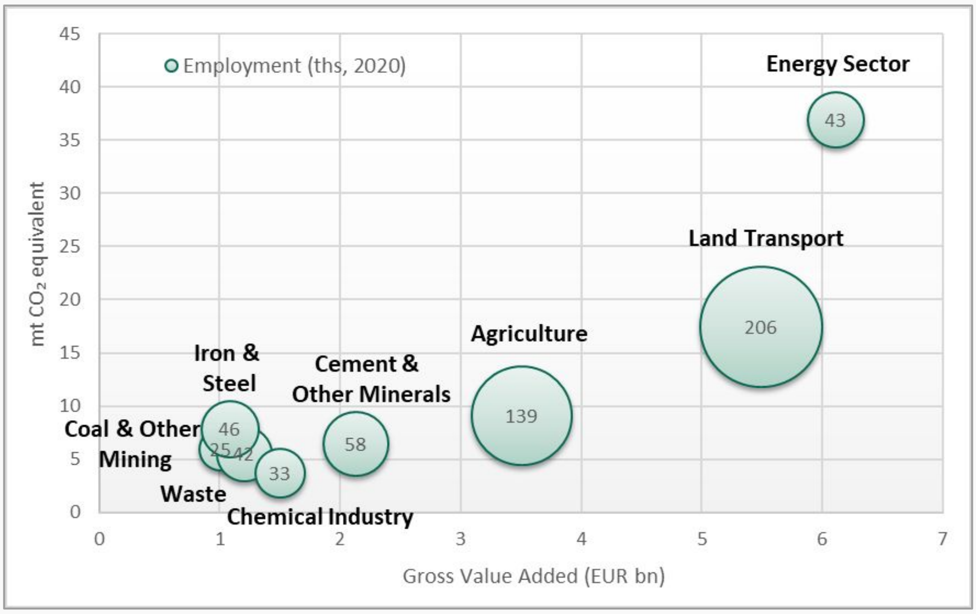
Annex 3: Contribution of sectors to GVA and employment

Contribution of selected high-GHG emission sectors to GVA and employment in Poland



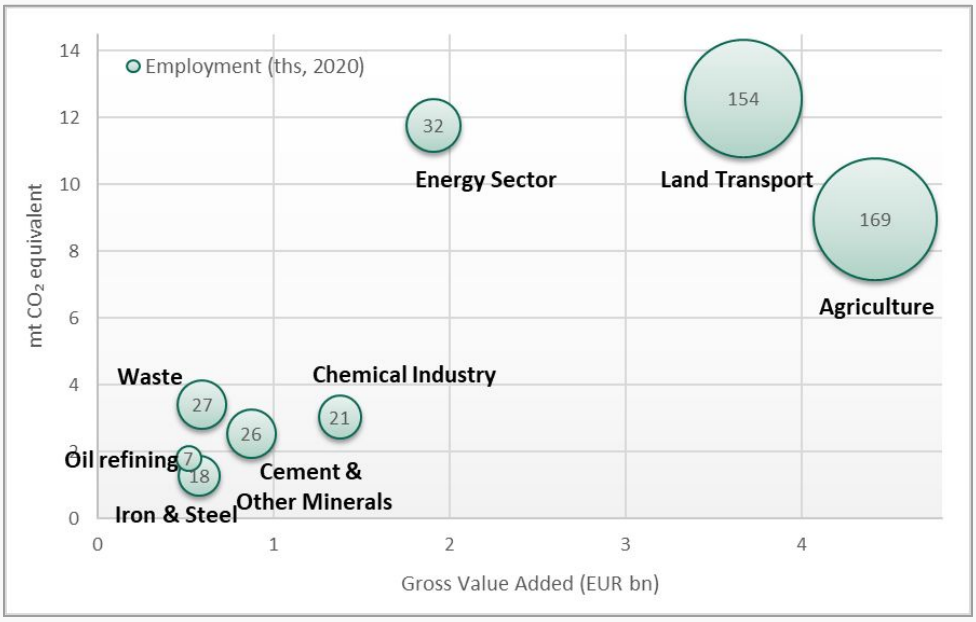
Source: UN Climate Change Convention GHG database, Eurostat database - Annual national accounts, ISFC calculations

Contribution of selected high-GHG emission sectors to GVA and employment in Czechia



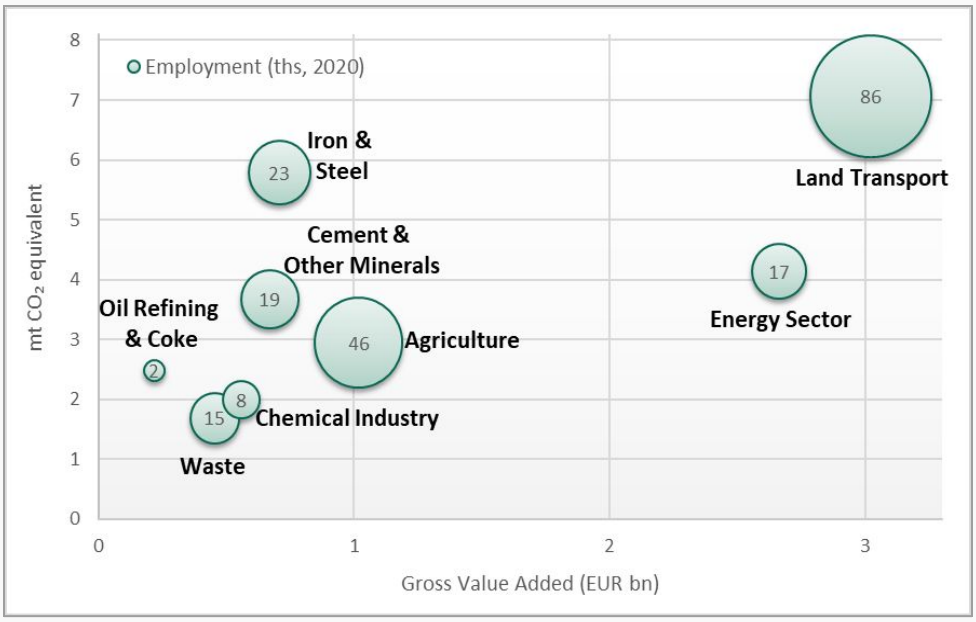
Source: UN Climate Change Convention GHG database, Eurostat database - Annual national accounts, ISFC calculations

Contribution of selected high-GHG emission sectors to GVA and employment in Hungary



Source: UN Climate Change Convention GHG database, Eurostat database - Annual national accounts, ISFC calculations

Contribution of selected high-GHG emission sectors to GVA and employment in Slovakia



Source: UN Climate Change Convention GHG database, Eurostat database - Annual national accounts, ISFC calculations

Annex 4: Wind power in Poland

Energy sector

Coal is still the main energy source in Poland, even though its use has declined considerably in recent years from 65% in 2000 to 45% today.[242] Oil and gas are the other two major energy sources. Poland is the second largest power-sector CO_2 emitter in the EU (after Germany), with the second highest emissions intensity (after Estonia) and a coal share in power generation still above 70%. What's more, in recent years, Poland's power sector emissions have not been declining, but rising.

In its Energy Policy until 2040, the Polish government envisages the coal phase-out by 2049 and plans to increase production and use of RES.[243] However, according to the IEA, OECD countries must end coal power by 2030 to achieve the 1.5C target.[244] The policy also foresees the largest growth in gas-fired electricity generation in the EU (+40 TWh by 2030).[245] Climate ambitions in Poland´s Energy Policy are thus perceived with disappointment.

The reliance on coal and gas puts the country in a delicate economic, strategic and social situation. And the war in Ukraine has further complicated the situation. In April 2022, Russia stopped gas supplies to Poland. Until then, Poland relied on Russia to furnish around 50% of its national consumption.[246] The urgency to wean off Russian energy has clearly heightened Poland´s need for clean local energy.

Wind power

Wind power offers great potential in Poland. Analysis suggest that wind power could become the single largest power source after 2030 and account for about 75% of the total power supply by 2050, of which 2/3 would be produced offshore.[247] This would contribute to making Poland carbon neutral by 2050.

No offshore wind farm has yet been built in Poland and all wind farms that are under development and to be built in coming years are onshore.

However, in the long term, the Polish government seems to focus on developing mainly offshore wind farms. In 2021, Poland adopted its Offshore Wind Act: it aims to have installed 3.8 GW by 2030, 10 GW by 2040 and 28 GW by 2050. This would make Poland the largest market for offshore wind in the Baltic.[248] The first offshore turbines could be operating by 2025. The Polish Wind Energy Association (PSEW) estimates that large-scale offshore wind will unlock €29bn in investments, creating tens of thousands of new jobs and strong industrial clusters.

In 2021, Poland signed its first Offshore Wind Sector Deal.[249] This government-industry collaboration aims to establish a leading offshore wind industry in Poland. As part of the Sector Deal, the industry commits to create up to 60,000 direct and indirect jobs in Poland's wind industry by 2040 and ensure the training and education for 40,000 offshore wind workers by 2040.

In July 2022, the Government of Poland approved legislation that should revitalise the country's wind onshore market. As its deployment has de facto halted since 2016, the new legislation is easing the rules via the introduction of a minimum 500-meter distance between a wind power installation and a residential building, instead of a former limit set to the minimum of 10 times the height of an onshore power plant.[250]

Several onshore wind farms with combined capacity of hundreds of MW are under construction, Krzecin (19 MW) and Kuslin (40 MW) as examples.[251] Also, the European Investment Bank has signed a €66 million green loan to support the construction and operation of six medium-sized onshore wind farms across Poland with a total nominal capacity of 150 MW.[252] And the European Bank for Reconstruction and Development is lending equivalent of €39 million for the construction of two more onshore wind farms with a total capacity of 63 MW.[253]

Annex 5: Solar energy in Czechia

Energy sector

The Czech energy sector needs a thorough reform. Firstly, energy production is the country's major source of GHG emissions, although emissions from the energy sector have been steadily decreasing since the 1990s. Secondly, the war in Ukraine shows how imperative diversification of energy sources is to ensure the country's energy security. In 2021, Czechia imported 87% of its gas from Russia.[254] Finally, the successful decarbonisation of many other economical segments and industries depends on the supply of zero-carbon energy, often in increased volumes. Typically, the industrial segments decarbonisation or the road transport transition to electro-mobility is subject to available sustainable electricity.

The country's energy mix (all direct uses of primary energy sources) is largely dominated by fossil fuels - oil, coal and natural gas. The National Energy and Climate Plan shows that the coal's share of total energy supply declined by 19 percentage points from 2009 to 2019, but still accounts for one third of total energy supply, 46% of electricity generation and over 25% of residential heating.

Renewable energy sources

Phasing out coal will be a challenge for the Czech Republic. Apart from the envisaged enlargement of two nuclear power plants, any new capacity additions are likely to come from smaller renewable energy sources (RES). These have not yet played a major role in the energy mix, reaching 17% of total final energy consumption in 2020,[255] mainly driven by bio-energy. The development of renewables would allow Czechia to catch up with the EU´s decarbonisation efforts and increase Czech energy independence.

RES are regaining support from political actors. In the National Energy and Climate Plan, Czechia pledged that 22% of its total energy consumption should come from RES. Although this is a percentage point less than recommendation of the European Commission (and significantly below the 32% target for the entire EU), it should provide a non-negligible incentive for the RES expansion.

Solar energy

Thanks to renewed government support and electricity prices developments, the solar market in Czechia has recently gained momentum and demand is going to keep rising. Under the New Green Savings funding programme, around 50% of investments are covered by subsidies. And the State Environmental Fund estimates that if all the sources potentially available in the Modernisation Fund for RES were used for photovoltaics, up to 14 GW of new installed PV capacity could be built.[256]

Compared to the currently installed 2.2 GW, the technical potential for PV installations in Czechia was estimated up to 39 GW, if all hypothetical opportunities for installing panels on roofs, facades and brownfields are counted.[257] The economic (i.e., feasible) potential could reach 5.5 GW by 2040. Also, the technical potential for community energy in municipalities and residential buildings was estimated in the reference scenario at 2.6 GW and almost 10 GW for PV and solar-thermal installations, respectively, while the economic (i.e., feasible) potential could reach 1.5 GW and 5.9 GW by 2040, respectively.[258]

Annex 6: Mobility electrification in Hungary

Mobility in Hungary

The transport sector is an important component of the economy and a prerequisite for development. Efficient transport systems lead to positive multiplier effects such as improved access to markets, employment and additional investments.

The sector in Hungarian is still highly dependent on fossil fuels and remains a significant source of pollution. While Hungary´s overall GHG emissions fell by -21% in the 2005-20 period, transport emissions increased by 4%, bringing their share of total emissions up to 20%, the highest of any segment. The expansion of car fleet and increasing popularity of larger vehicles contributed mainly to the increase. With over 4.5 million, cars account for the vast majority of passenger land transport in Hungary.

Electro-mobility

Electrification of mobility is an expanding sector in Hungary for several reasons. First, the technologies are well-know and it becomes easier to draw realistic financial model and predictions. Second, consumers are more and more attracted to electric vehicles (EVs) and the Hungarian market has reached a certain maturity - 28ths passenger EVs were registered in Hungary in September 2022,[259] and the number of publicly available electric chargers increased by 34% to 1,880 in 2021.[260] Third, the electrification of cars, buses and trains is supported by policymakers at European and national level.

In 2019, the Hungarian government aimed to create the conditions necessary for the rapid expansion of electro-mobility to reach 450,000 electric vehicles and 45,000 electric chargers (5,900 public) by 2030.[261] The country has included electro-mobility in its National Energy and Climate Strategy and, along with the electro-mobility and charging infrastructure act of 2019, provides incentives to build infrastructure. Subsidies up to EUR 7.4ths per vehicle, tax benefits on registration and operating fees are offered to owners of environmentally friendly vehicles.[262]

Railway development

The electrification of locomotive fleet to reduce fuel consumption, the rail network modernisation and the development of multimodal mobility effectively support the railway sector greening.

- Currently, 41% of Hungarian railway lines are electrified, but the government pursues its effort to increase the electrification of trains and railway infrastructure, which is expanding rapidly. The two main railway operators, MAV-Start and Rail Cargo Hungaria, are both undertaken a sustainability reform that includes the purchase of e-hybrid locomotives powered from overhead wires and/or built-in batteries.
- Modernizing the railway network is an indispensable step to help establish railway traffic as a backbone of intercity transport. Hungary´s railway network is quite extensive, although needs investments to become an attractive alternative. The development of railway transport and infrastructure in Hungary has been heavily subsidised in the past years, mainly through EU co-financing. Between 2016 and 2024, the Hungarian government is about to spend a total of approximately EUR 14 billion on railway and road investments.[263]
- Multimodal shifts in passengers and freights transport help to achieve ambitious mitigation goals. For example, in Budapest and its close vicinity, about 5% to 10% of the heavy-vehicle road traffic could be a potential business partner for intermodal rail freight, which can mean intermodal transport of up to 50,000 heavy goods trailer per year.[264] The development of multimodal passenger transport may also combine rail transport with other alternative transport such as car and bike sharing.[265]

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- Agrofert, the Czech-based agro-chemical concern, has established a working group on meeting the requirements of the European Green Deal in the concern, see https://www.agrofert.cz/sites/default/files/prilohy/agrofert-annual_report_2021_consolidated.pdf

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[153] Emissions from generation of power and district heat consumed in buildings are not included, they are included in the Energy and Heat Production segment.
[154] The high share of district heating of 54% in total household heat consumption and the relatively low share of coal in heat production contribute to the lower emission intensity in Slovakia compared to the other V4 countries.
[155] While Hungary reported the fastest decline of -2.4% p.a., Poland lagged signicifantly with CAGR of -0.4%.
[156] See https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficient-buildings_en
[157] See https://www.europarl.europa.eu/news/en/press-room/20221212IPR64527/climate-change-deal-on-a-more-ambitious-emissions-trading-system-ets
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[185] Heidelberg Cement is on track to launch its first industrial-scale plant in Brevik (Norway) by 2024. The group also has an ambitious target to spend about 10% of the annual group-level Capex (€100-150 mil) on CCUS. See https://www.heidelbergmaterials.com/sites/default/files/2022-05/06_Finance_CMD_20220524.pdf
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[197] Ammonia can be considered a low-carbon seasonal energy storage and can facilitate electricity trading. Compared to hydrogen, it has advantages as ammonia is more scalable and easier to store.
[198] See https://co2re.co/
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[200] Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives, Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste.
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