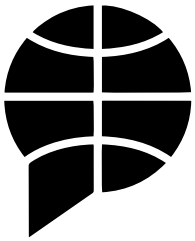
V4 Industry Decarbonization and the Clean Industry Deal



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V4 Industry Decarbonization and the Clean Industry Deal

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KEY INDUSTRY SUBSECTORS AND ENERGY PROFILES IN THE V4

Food processing: Arguably the most consequential (high gas consuming) low-hanging opportunity (low to medium heat temperature processes) across the V4. In Hungary, its inefficiency and outsized effect on inflation has been well-documented, and it is the highest natural gas consuming subsector. Meanwhile it is 3rd in Czechia, 4th in Poland, and 5th in Slovakia.

Natural gas: Chemical production is the most common high energy consuming sub-sector—in the top three of all V4 countries, with the predominant input being natural gas. As such, it is the highest natural gas consuming subsector in Slovakia and Poland and 2nd highest in Czechia and Hungary. Meanwhile, coke production is the second highest natural gas consuming subsector in Poland and Slovakia.

Heat utilization: Slovakia's entire 'manufacturing' group (NACE 10–33) consumes 58 PJ heat, mostly concentrated in three subsectors—metals (16 PJ), coke (13 PJ) and paper (14 PJ) production. In Hungary, roughly 3/4 of heat (9 PJ) is utilized for chemicals production. In Poland direct industrial heat is sourced entirely on-site from fossil-fuels and biomass. Aside from Slovakia's paper production (low temperature and replaceable with clean sources), heat is mostly an input for high temperature intensive industrial processes that should create opportunities for excess heat applications.

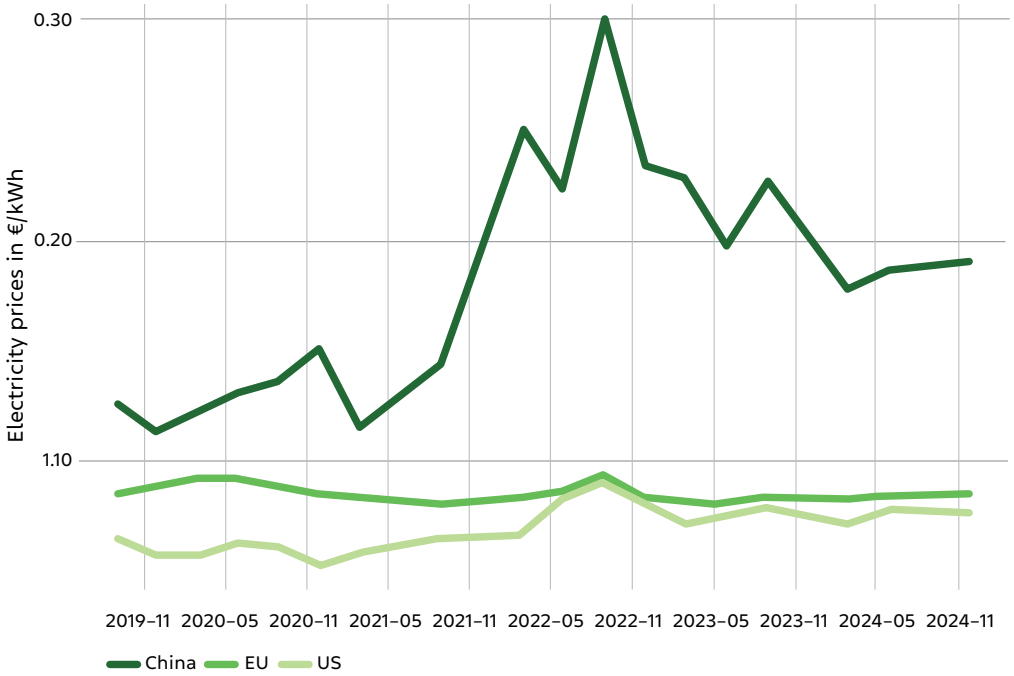
Steel production: Manufacture of metals is the highest energy consuming subsector in Czechia and Slovakia, and 3rd in Poland. There should be more discussion and cooperation between these countries over plans for implementing state support to foster investment into electric arc furnaces.

Greening electricity inputs: Hungary has the most electrified industry, accounting for more than 1/3rd of final energy consumption, compared to 1/4th for Poland and Czechia. This should present ample opportunities for renewable substitution via PPAs.

INTRODUCTION

EU industry is struggling to compete under the weight of high energy prices relative to competitors in the U.S. and China. In 2024, average EU industry prices (EUR 0.199 per kWh) were more than double the US (EUR 0.075 per kWh) and China (EUR 0.082 per kWh).[1] The five year trend is shown in Figure 1.

Figure 1: Retail electricity price, 2019–2024, EUR per kWh



Source: Transport & Mobility Leuven[2]

This can be attributed mostly to costlier imported natural gas, which transmits directly to electricity prices as the marginal price setter, and rising carbon prices under the emissions trading system (ETS). Meanwhile, U.S. rivals benefit from cheap domestic gas and Chinese firms from lax climate policy and generous state aid throughout the supply chain.

With Russia's invasion of Ukraine fundamentally reshaping European energy flows from East-West to West-East, key energy imports feeding industries can be expected to remain costly. This is even more acute for land locked V4 countries Czechia, Slovakia and Hungary which will pay a premium for pricier LNG coming from the West, North or South, accruing additional cross-border transmission fees.

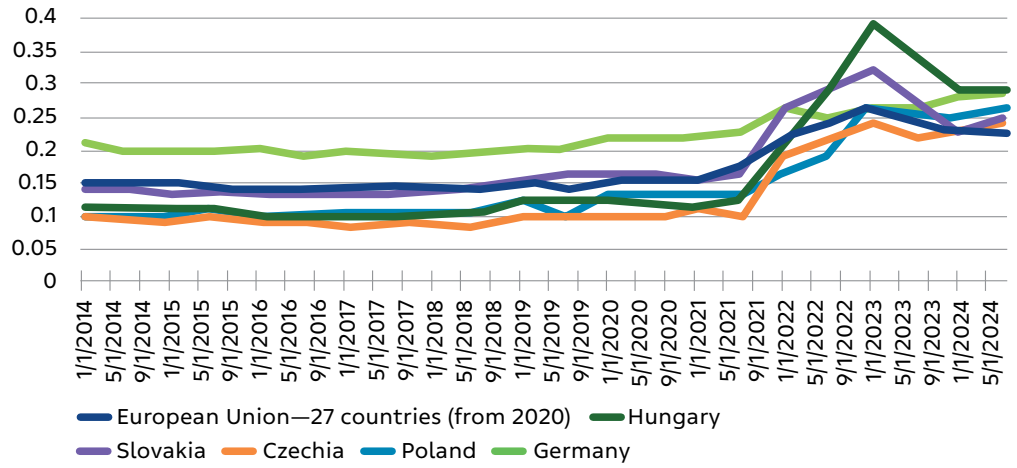
Figure 2 shows average electricity prices for non-household (i.e. industry) including taxes and levies over the past ten years. The same trend can be observed across small, medium and large enterprises: stable prices until the end of 2021, when Russia began strategically reducing EU gas export

1 Reform Barometer 2025, *EU in a new political cycle: Competitiveness as a true priority in a complex global context, Business Europe, March, 2025*

2 *"Monitoring the shift to zero-emissions vehicles in Europe: Key Performance Indicators for light-duty vehicles", Reporting Period Q2 2025.*

volumes, precipitating the full-blown energy crisis in 2022. According to this metric, V4 industry power prices are all above the EU average in 2024. Hungarian industrial energy prices are among the highest in the entire EU, behind only Ireland and Croatia in aggregate electricity spending in 2024[3], and by far the highest average industry gas prices in 2023, nearly triple the EU average.[4]

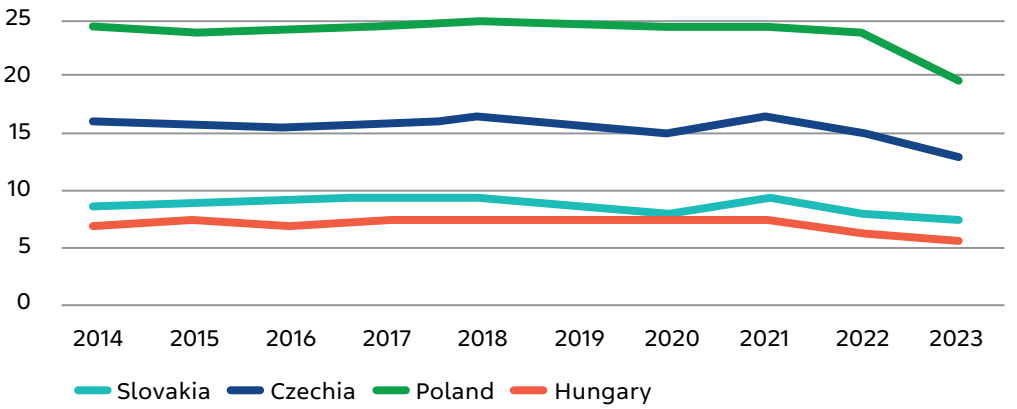
Figure 2: Electricity prices for non-household consumers, all taxes and levies included, 2014–2024, EUR per kWh



Source: Eurostat

Similarly, Figure 3 shows that V4 industrial greenhouse gas emissions have been relatively constant over the past decade before dropping significantly from 2022–2023, presumably due to factory closures and mothballing as a result of the energy crisis. Poland and Czechia experienced the largest declines (20% and 18%), followed by Hungary (8%) and Slovakia (3%).

Figure 3: V4 industrial greenhouse gas emissions, million tonnes



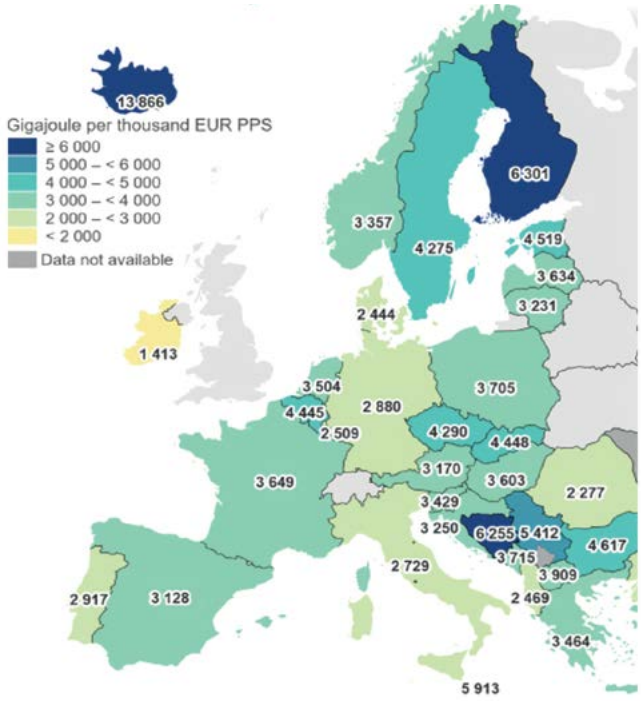
Source: Eurostat

3 https://ec.europa.eu/eurostat/databrowser/view/ten00117/bookmark/bar?lang=en&bookmarkId=34365e0e-b803-41e2-bb6c-db478eb1e68f&c=1755094087766

4 ACER and CEER, *Energy retail—Active consumer participation is key to driving the energy transition: how can it happen?, 2024 Market Monitoring Report, September 2024.*

CEE and V4 countries have a long tradition of industrialization made possible by cheap coal, which was used in the past without addressing the associated negative externalities. Czechia and Slovakia are among the most energy intensive in the EU, shown in Figure 4.

Figure 4: Energy intensity of the economy, 2023



Source: Eurostat[5], Gross available energy divided by gross domestic product PPS

Among V4 countries, Czechia has made the most progress in reducing its energy intensity over the past decade, leap frogging Slovakia, while Hungary and Poland are closer to the EU average (shown in Figure 5).

For V4 countries to lower their industrial energy intensity and CO2 emissions they need companies to invest into clean technologies. Nowadays, there are even more urgent reasons for governments and companies to pursue this pathway: energy security and competitiveness. Indeed, clean technology is as close to a panacea as there is for resolving the EU's trilemma of sustainable, secure and affordable energy. This is why the Recovery and Resilience Facility[6], REPowerEU[7] and the latest Clean Industry Deal[8] are all aligned, building upon the European Green Deal[9] and Fit for 55 package[10], in pushing

5 Energy statistics—an overview, Eurostat, May 2025: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Energy_statistics_-_an_overview#Energy_intensity

6 energy.ec.europa.eu/topics/funding-and-financing/recovery-and-resilience-facility-clean-energy_en

7 https://energy.ec.europa.eu/topics/markets-and-consumers/actions-and-measures-energy-prices/repowereu-3-years_en

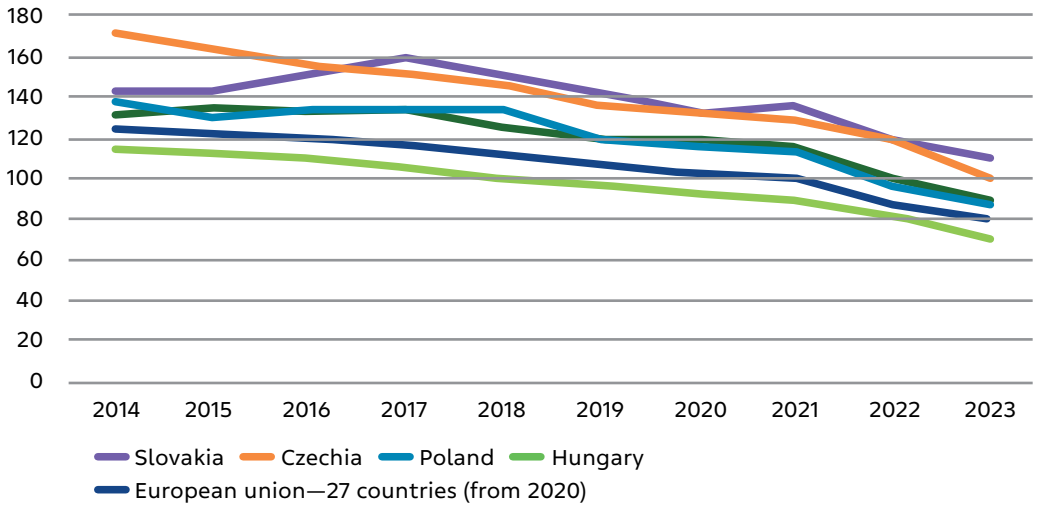
8 'Clean Industry Deal': https://commission.europa.eu/topics/eu-competitiveness/clean-industrial-deal_en

9 https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/story-von-der-leyen-commission/european-green-deal_en

10 https://www.consilium.europa.eu/en/infographics/fit-for-55-how-the-eu-will-become-more-energy-efficient/

for energy efficiency and renewables deployment to reduce dependency on fossil fuels that are either imported, polluting, expensive, or in some cases all of the above.

Figure 5: Energy intensity, 2014–2023, kilograms of oil equivalent (KGOE) per thousand euro



Source: Eurostat

In the aftermath of the 2022–23 energy crisis, more companies are seeking ways to secure affordable and predictable energy. From a corporate perspective, no matter the stated climate or environmental, social and governance (ESG) ambitions the bottom line is the business case, and in many countries mature renewable technologies are already a cheaper alternative to wholesale electricity and fossil fuel prices. For the renewables that are more costly than conventional energy in earlier stages of development, the state needs to fill the gap.

In recent years, V4 countries have made significant strides in renewable energy buildout in the electricity sector—almost entirely solar PV, plus wind energy in Poland[11]—but the transition to clean sources of energy in general, and industry in particular, is happening much slower relative to Western Europe. This is due to a number of challenges and obstacles: higher cost of capital (WACC), higher share of manufacturing to services in the economy, grid connection refusals and queues, long-term regulatory uncertainty, delayed EU climate policy implementation, and less developed energy markets. Furthermore, they do not have the same financial firepower for the provision of state aid.

While events like the 2022–23 energy crisis are driving new interest in these opportunities, it is clear that much more is needed to incentivize companies to break from standard practices and make the needed investments to transition. Switching from fossil fuel based industrial installations and processes to renewables adds complexity and costs for companies in the near term. High upfront, capital investment expenditures can be particularly constraining

11 Maguire, Gavin, *Eastern Europe's stealthy surge in solar generation, June 2025, Reuters: https://www.reuters.com/markets/commodities/eastern-europes-stealthy-surge-solar-generation-maguire-2025-06-03/?utm_source=cbnewsletter&utm_medium=email&utm_term=2025-07-03&utm_campaign=Daily+Briefing+03+06+2025*

SMEs lacking the requisite equity or cash. Furthermore, renewables tend to be profitable over an extended lifespan equating to longer payback periods, which carries greater uncertainty and financial risk.

This is why state support is so vital to address the barriers and pave the way for companies to invest confidently. This is not only direct financial support, but also bureaucratic and administrative streamlining to facilitate new projects, clarity and transparency for taxation policy and regulated energy price components, and guarantees for long-term contracting.

The study is organized into the following order. The first section explains the methodology and assumptions for the data in the study. This will be followed by a summary of green industry potential and most promising clean technologies and subsectors. Next V4 industry profiles are summarized. This is followed by an overview of national auctions and support schemes and EU investment support guidelines. The last section elaborates conclusions and recommendations.

METHODOLOGY

The study aims to compare V4 industry subsectors and identify the most promising for renewables cooperation, investment and development. This is based publicly available industry data that is consistent across V4 countries, which is rather limited to energy consumption and fuel type. Therefore, subsectors are deemed consequential in terms of overall energy consumption with special attention to solid fuels and natural gas with outsized emissions and energy security impact. The next consideration is the maturity of the applicable clean technology, between proven/bankable and developmental pilot projects.

The national 'statistical classification of economic activities' in the European Community (NACE) data was sourced from the Hungarian Energy and Public Utility Regulatory Authority (MEKH), the Czech Statistical Office, the Slovak Statistical Office, and Eurostat. Notably, Hungary and Slovakia do not follow the standardized sequential NACE approach, while Czechia does.

Herein, industry is defined as traditional manufacturing subsectors (NACE 10–32), in line with Eurostat. This omits 'electricity, gas, steam, and air conditioning supply' (the energy sector, NACE 35)—which is reported by Czechia and Slovakia, but not Hungary—nor 'mining activities' (NACE 5–9).

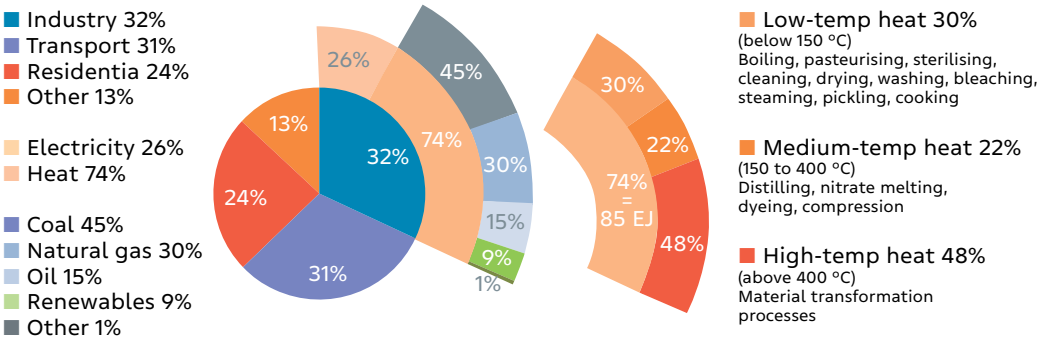
The national statistical data corresponded to Eurostat data with a few glaring exceptions. Eurostat reported far higher levels of electricity consumption for Czechia and Slovakia balanced with far lower solid fuel consumption. Slovakia also reports a much higher level of heat use, while Czechia does not include heat as an input.

The data collection exercise for this study confirms the gap in granular industry data in V4 countries, but this is also the case throughout the EU. There are three main reasons for this. First, and perhaps most importantly, industrial heating is extremely complex, encompassing a wide variety of temperature levels for diverse processes and end-uses that can differ country to country depending on the technology. Comparatively, heating needs for residential and commercial buildings are standardized. Thus, the research undertaking is extremely demanding and resource intensive. Second, there is much less policy focus and public agency in this area compared with other sectors, like electricity and, increasingly, heating of buildings. Third, and not to be underestimated, companies tend to be protective over sensitive data and unwilling to make it publicly available.

Consequently, the indicative data available from past research undertakings is outdated and generalized. Three landmark studies from the IEA, Danish Energy Agency and the International Journal of Energy Research that provide the most insight are highlighted below.

Figure 6 is the result of a very broad 2017 IEA (global) estimate of low, medium, and high heat temperature shares and the matching subsectors.

Figure 6: Shares of industry heat demand



Source: IEA[12]

Figure 7 is the Danish Energy Agency estimation of selected EU industry sub-sector process heat shares from 2020. There are only two heat temperature categories rather than the typical three (low, medium and high).

Figure 7: Industry subsector process heat shares, 2020

Industrial Sector	Share of heating demand at medium temperature (%) (t < ~150°C)	Share of heating demand at high temperature (%) (t > ~150°C)
Food, beverages and tobacco	95%	5%
Commodity production	94%	6%
Cement and non-metallic mineral (+Extraction of gravel and stone)	54%	46%
Chemical industry	89%	11%
Metals, machinery and electronics	36%	64%

Source: Danish Energy Agency[13]

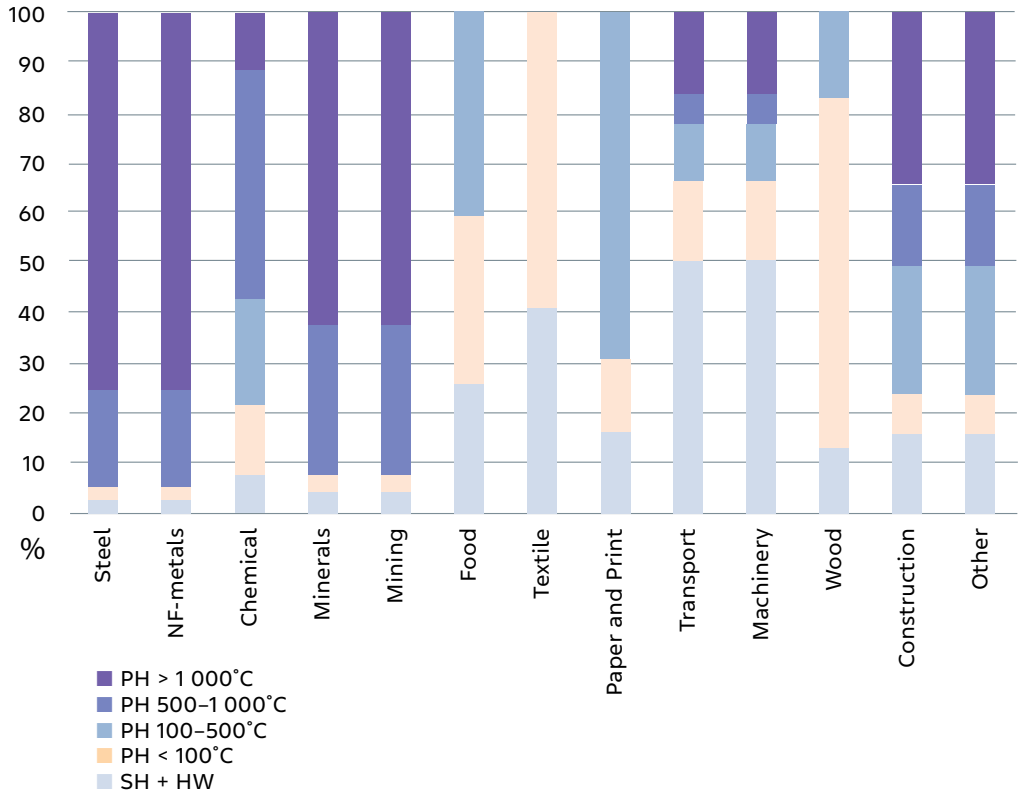
Figure 8 is a detailed estimate of heat temperature levels for German industry branches from 2006 that was published in 2015 by the International Journal of Energy Research (shown in Figure 8).

From this 2006 German data, EU-28 heat temperature shares were extrapolated in 2012, under the (rather generous) assumption that heat shares can be transferred to other EU-28 Member States and remain stable over several years. Figure 9 shows the values for V4 countries based on this extrapolation. Accordingly, Slovakia would have the highest share of high temperature heat (60%), with Hungary, Poland and Czechia near 50%.

12 Philibert, Cedric, *IEA Renewable Energy for Industry: From green energy to green materials and fuels, Insights Series 2017, International Energy Agency, 2017.*

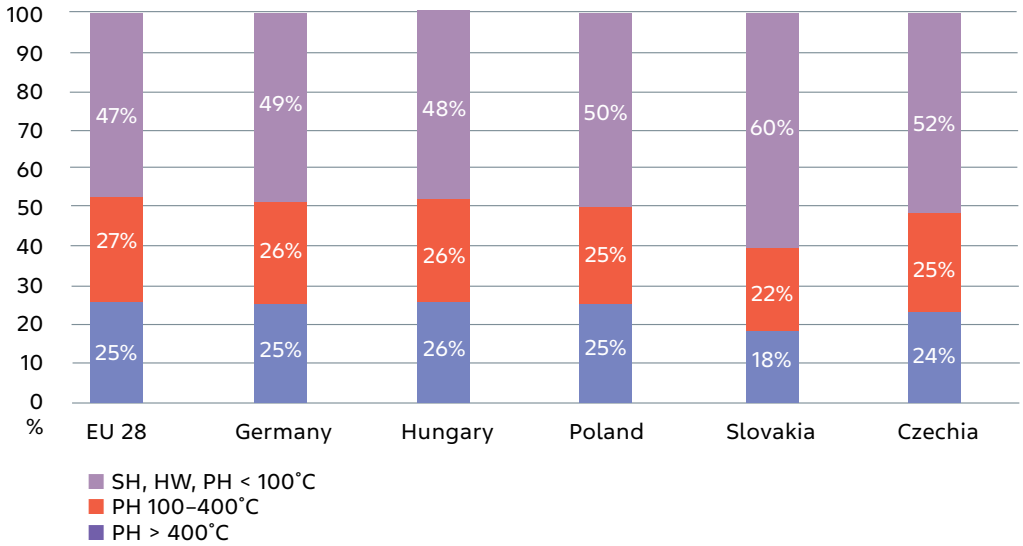
13 Industrial process heat, Technology descriptions and projections for long-term energy system planning, Danish Energy Agency, April 2020.

Figure 8: Share of heat temperature in German industry, 2006



Source: Naegler[14]

Figure 9: Share of low, medium, and high temperature heating processes, 2012



Source: Naegler (Approach 1 combining space heating (SH), hot water (HW) and Process Heat (PH) < 100°C into 'low heating category')[15]

14 Naegler, Tobias, *Quantification of the European industrial heat demand by branch and temperature level, International Journal of Energy Research, October, 2015.*

15 Naegler, Tobias, et al., *Quantification of the European industrial heat demand by branch and temperature level, International Journal of Energy Research, October 2015.*

These studies provide an important reference point but even at the time of their publication had considerable limitations; either covering too many or too few countries, or oversimplified heat categories. Therefore, new research is needed to update these findings for specific EU countries and regions, including the V4, as comprehensive statistical data on process temperatures across industry branches will be essential for developing targeted, robust strategies and roadmaps for industrial subsector decarbonization.

MOST PROMISING TECHNOLOGIES AND SUBSECTORS

High temperature, energy intensive manufacturing processes rely predominately on direct heat through the combustion of fossil fuels that cannot be replaced by renewables. Rather decarbonization of these subsectors will require direct electrification via renewable-based electrolysis for the production of green hydrogen.

The dominant share of high temperature process heating in the industrial sector underlines the inherent limitations for renewables in the decarbonization process. However, there are ample opportunities between energy efficiency, excess/waste heat, indirect electrification (heat pumps) and renewables at low and medium temperatures, even up to 400 ˚C under certain conditions.[16] These technologies are mostly mature, commercially available and underutilized.

- **Industry 4.0—**This is a tool that can help solve technical limitations for generating power and commercializing renewable energy with intelligent factories and smart manufacturing techniques that can combine and centralize dispersed and irregular energy sources into a centralized and uniform energy source.[17]
- **Energy efficiency and use of excess heat—**This includes investments into modern equipment, improved insulation or heat recovery. The heat can be used on-site for facility space heating and hot water or sold to other entities like central heating systems using heat pumps. Industrial excess heat and heat residues can be recycled from five typical energy intensive industrial sub-sectors: chemical/petrochemical; iron and steel; non-ferrous metals; non-metallic minerals; pulp and paper production, and oil refineries. However, expectations for excess heat should be tempered in the carbon neutral energy system of the future with improved material and energy efficiencies of industrial processes as well as on-site demand (e.g. on the order of 78–92% reduction for district heating potential).[18]
- **Electrification via heat pumps—**These are considered the most cost-efficient and highest efficiency solutions to industry decarbonization. Heat pumps have huge potential and are being deployed across Europe already, including in combination with vapour compression to deliver 150°C.
- **Geothermal and solar thermal—**These renewable technologies are capable of providing low to medium temperature processing heat as well as facility heating and hot water. However, they are limited by location and daily hours of sunlight respectively.

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16 Bellevrat, Elie, et al., *Clean and efficient heat for industry, Commentary, January 2018:* https://www.iea.org/commentaries/clean-and-efficient-heat-for-industry

17 Pandy, Vaishnavi, et. al., *Accelerating the renewable energy sector through Industry 4.0: Optimization opportunities in the digital revolution, International Journal of Innovation, Science Direct, June 2023: https://www.sciencedirect.com/science/article/pii/S2096248723000103#bib48*

18 Manz, Pia*, The effect of low-carbon processes on industrial excess heat potentials for district heating in the EU: A GIS-based analysis, Smart Energy Volume 10, Science Direct, May 2023: https://www.sciencedirect.com/science/article/pii/S2666955223000102*

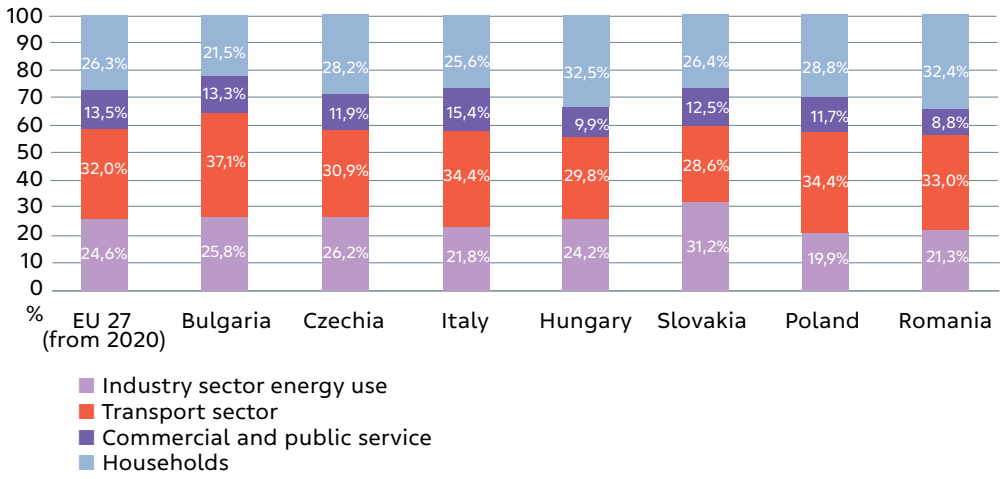
- **Food processing and paper and wood subsectors** have arguably the greatest potential and need for transformation since they are highly inefficient and rely predominately on natural gas. The low-medium temperature processes—low temperature pasteurization and drying for the former, large volumes of hot water and steam for drying for the former—are ripe for renewables. This is most relevant for Hungary and Czechia.
- **Steel production—**Electric arc furnaces are extremely promising not only for decarbonisation but circular economy with the use of scrap iron, a strategically important commodity for the EU's green transformation and energy security. However, there is currently no EU strategic framework for scrap metal management. About 19 million tons were exported to third countries in 2023 with lower environmental and labor standards.[19] This is most relevant for Czechia and Slovakia.
- **Green hydrogen via electrolysis—**A promising technology which is commercially available but almost entirely dependent on state-support and years away from being economically viable.

19 Třinecké železárny, Press Release, January, 2025: https://www.trz.cz/o-nas/tiskove-zpravy/2025-01-30-trinecke-zelezarny-zahajuji-nejvetsi-investici-v-ceskem-ocelarstvi-od-80-let-minuleho-stoleti/

V4 INDUSTRY PROFILING

The share of final energy consumption by sector is relatively similar across the EU, with industry a close third after transportation and households. Among V4, the highest industry share is Czechia (26%) and the lowest is Poland (20%).

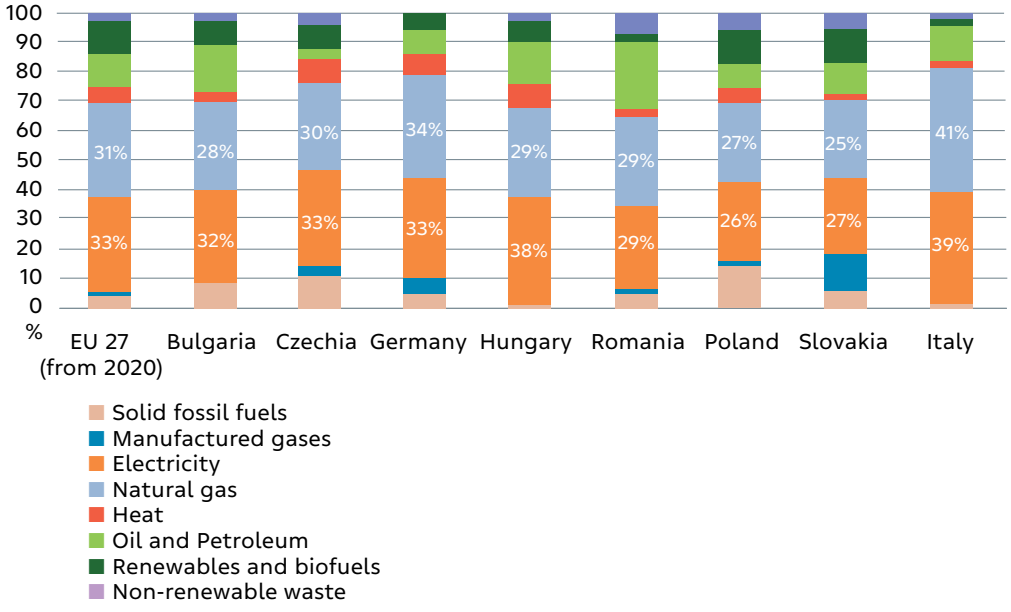
Figure 10: Final energy consumption by sector, 2022



Source: Eurostat

According to Eurostat, natural gas and electricity are the two largest fuel types for industrial final consumption in V4 countries, representing close to one-third each. There is wider variation among the tertiary inputs—for Czechia and Poland the next highest share is solid fossil fuels, for Slovakia and Hungary it is oil and petroleum. However, this seems to be contradicted by national-level data from Slovakia and Czechia, shown below.

Figure 11: Share of final energy consumption in industry by fuel type, 2023

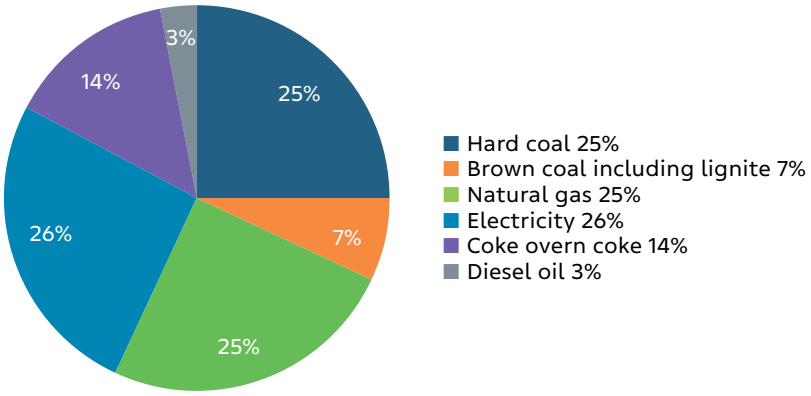


Source: Eurostat

Czechia

Czechia is a major steel and chemical producer. According to Czechia's national statistical office, solid fuels (brown coal lignite, hard coal and coke over coal) make up about half of the industry's final energy consumption, rounded outby natural gas and electricity with about a quarter share each (Figure 12). Notably, heat is not reported as an input.

Figure 12: Czechia industry final energy consumption by fuel type, 2023



Source: Czech Statistical Office[20]

Top three energy consuming industry subsectors:

1. 'Manufacture of basic metals' (NACE 24)—110 PJ
2. 'Manufacture of chemicals and chemical products' (NACE 20)—39 PJ
3. 'Manufacture of motor vehicles, trailers and semi-trailers' (NACE 29)—18 PJ

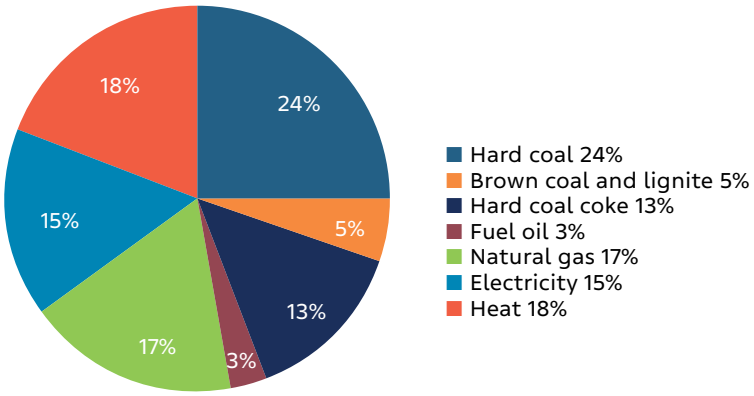
Noteworthy: 'Manufacture of food products' (NACE 10)—5% of total energy consumption and third largest consumer of natural gas (9.6 PJ).

20 Czech Statistical Office, Fuel and energy consumption—2023, October 2024: https://csu.gov.cz/produkty/fuel-and-energy-consumption-2023

Slovakia

Like Czechia, Slovakia is a big producer of steel and chemicals. Therefore, it is not surprising it shares a similar industry fuel mix, with solid fuels representing some 50% of total consumption, and hard coal also 25%. Both countries also have high shares of natural gas and electricity. The difference is the high share of heat reported by Slovakia.

Figure 13: Slovakia industry final energy consumption by fuel type, 2022



Source: Slovak Statistical Office

Top three energy consuming industry subsectors:

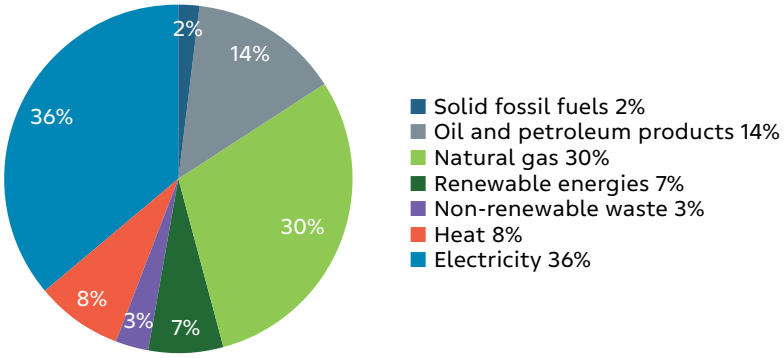
1. 'Manufacture of basic metals' (NACE 24)—149 PJ
2. 'Manufacture of coke and petroleum products' (NACE 19)—36 PJ
3. 'Manufacture of chemicals' (NACE 20)—23 PJ

Noteworthy: 'Manufacturing of basic metals' consumes 3x the electricity of the next highest subsector (11.5 PJ), 'manufacture of motor vehicles (NACE 29).

Hungary

Hungary's largest industrial energy input is electricity followed by gas, which together constitute about 2/3rds of final energy consumption. Notably solid fuels represent a very small share compared to Czechia and Slovakia.

Figure 14: Hungary industry final energy consumption by fuel type, 2022



Source: MEKH

Top three energy consuming industry subsectors:

1. 'Manufacture of chemicals and chemical products' (NACE 20)—43 PJ
2. 'Manufacture of food products (NACE 9)—25 PJ
3. 'Manufacture of electrical equipment' (NACE 27)—10 PJ

Noteworthy: 'Manufacture of food products' is the highest gas consuming subsector representing a quarter of total industry (12 PJ).

Decarbonisation opportunities for food industry SMEs in Hungary—summary REKK report[21]

The project investigated how food sector enterprises can reduce their energy consumption and replace part of the energy used with renewable energy. Although the food industry accounts for only 1% of operating enterprises, it represents 24% of industrial gas consumption and 15% of electricity. A 2023 Hungarian national Bank (MNB) report exploring the causes of domestic food inflation pointed to structural weaknesses of the food industry—low productivity and high energy intensity—which caused higher inflation in Hungary than neighboring countries in the region. With a particularly high concentration of SMEs, there has not been a collective or centralized approach to improving energy intensity in the food sector, with managers hampered by economies of scale and the heterogeneous organizational characteristics of companies. Therefore, the proliferation of energy efficiency investments is something that will not only help individual companies become more competitive but also contribute to national emissions reductions and energy security.

21 *Decarbonisation opportunities for food industry SMEs in Hungary, REKK, October, 2024.*

Based on a preliminary analysis of the food industry, the two most important sub-sectors in terms of energy use by SMEs are the bakery and meat processing sub-sectors. In the research, potential energy efficiency investments were identified on the basis of energy loss mapping studies carried out in three food SMEs by Wattmanager Kft. The energy audits helped identify the potential savings in the sector based on real, practical examples. The identified investment opportunities were assessed on the basis of their discounted payback period, and their savings and investment costs were then projected to the sectoral level. The reference scenario found that SME energy consumption could be lowered by 14% with HUF 51 billion investment that pays back within 15 years, reducing annual energy costs from HUF 71 billion to HUF 58 billion. In the more ambitious scenario, energy savings could reach 39%. In addition to the savings potential estimation[22], Wattmanager and REKK staff have also produced a handbook on the most important savings opportunities for SMEs in the food industry.[23]

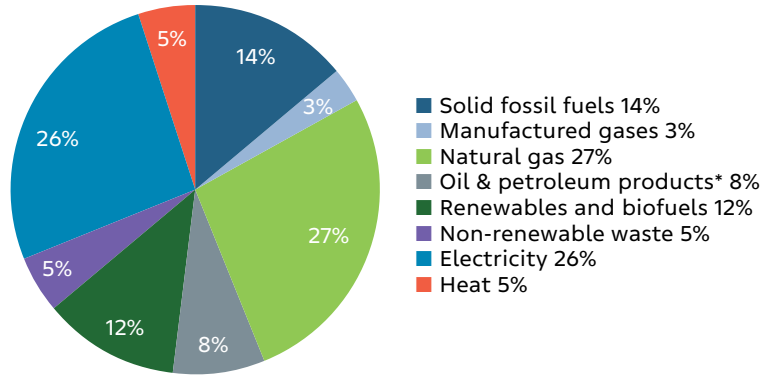
22 REKK (2024), Az élelmiszeripari KKV-k energiahatékonysági potenciálbecslése Magyarországon Final Study on the energy efficiency saving potential estimate of fodd processing SMEs in Hungary (in Hungarian) at: https://rekk.hu/downloads/projects/Az%20%C3%A9lelmiszeripari%20KKV-k%20energiahat%C3%A9konys%C3%A1gi%20potenci%C3%A1lbecsl%C3%A9se_final_study.pdf

23 Handbook in Hungarian: https://rekk.hu/downloads/events/Food%20industry_Leaflet_web.pdf

Poland

Electricity and natural gas are the largest energy inputs for Polish industry, with more than a quarter share apiece, followed by solid fossil fuels.

Figure 15: Poland industry final energy consumption by fuel type, 2023



Source: Eurostat

Poland is the EU's largest producer of nitrogen fertilizers and the biggest player in regional oil refining. Both subsectors rely on hydrogen which almost exclusively uses natural gas as feedstock, making it the largest single consumer of natural gas in Poland (122 PJ).

Top three energy consuming industry subsectors:

1. 'Manufacturing of coke and petroleum products' (NACE 19)—315 PJ
2. 'Manufacture of chemicals' (NACE 20)—207 PJ
3. 'Manufacture of basic metals' (NACE 24)—182 PJ

Noteworthy: Natural gas is the largest input across nearly all sub-segments of industrial energy consumption (representing close to half of Poland's total consumption, 406 PJ). See the following breakdown (natural gas share in parenthesis):[24]

- Direct heat (37%)—2/3rds of total heat consumption
- Indirect heat (54%) 0 1/3 total heat consumption (mostly through district heating networks), followed by hard coal (25%) and a mix of renewables (25%)
- CHPs are mostly supplied by hard coal (38%), followed by renewables (18%) and then gas (14%)
- Electricity (43%)—out of the 22% share of industrial CHP units (the rest is from the grid)

24 Dusilo, Marcin, *Industrial decarbonisation: where to begin for Poland?, Forum Energii, November, 2024.*

Figure 16: Poland fuel mix of direct heat production for industry, 2024

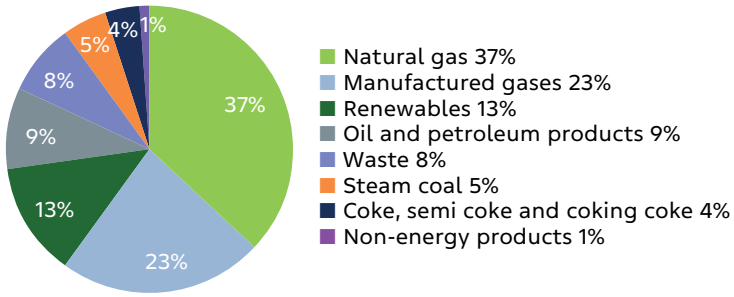
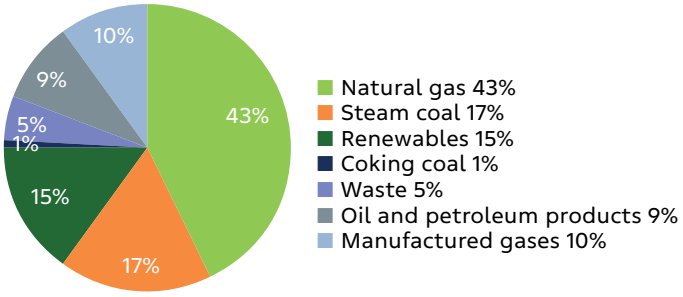


Figure 17: Poland fuel mix of electricity generation for industry, 2024



Within the share of renewables used in direct heat production (13%), 'peat and wood' is the dominant input (69%). The renewables share of electricity generation (15%), 'solid biomass and animal products' account for almost half, followed by 'peat and wood' (39%) and 'biogas' (23%).

Figure 18: Renewable mix of direct heat production in Poland, 2024

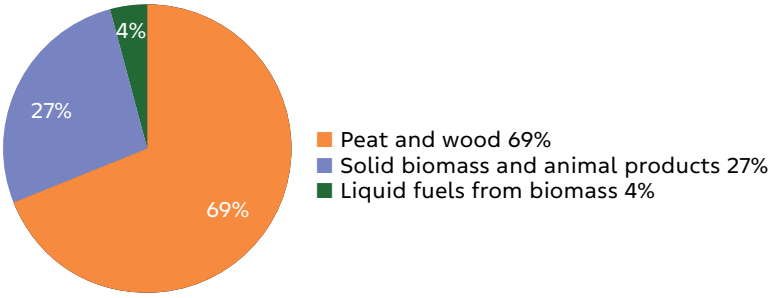
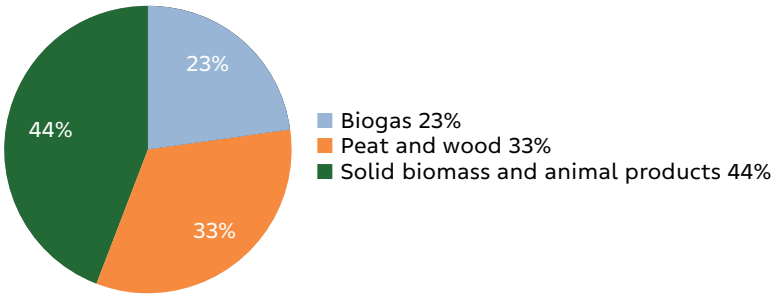


Figure 19: Renewable mix of electricity generation for industry in Poland, 2024



UNLOCKING INDUSTRIAL DECARBONIZATION

PPAs

EU guidance and support

The EC has made corporate power purchase agreements (PPAs) a cornerstone of industrial decarbonization and competitiveness premised on capturing low and stable renewable pricing reflective of the technology cost and performance. As such, the EC has progressively introduced new legislative measures and guidance to help companies unlock the potential; first under the Renewable Energy Directive (RED) and most recently through the Clean Industry Deal.

A PPA is a long-term contract that ensures the supply of electricity to a customer from one or more power plant(s), making it possible to secure a long-term fixed price per MWh of electricity. While an off-site PPA is located outside the customer's premises, an on-site PPA takes into consideration the source of electricity directly on the rooftop or land of the company. The investment in the power plant is repaid only by payments for the consumed green electricity, meaning the generating company will have to provide the initial equity. The arrangement benefits both the investor and power producer by allowing greater certainty for planning. However, long-term arrangements of this nature entail high risk premiums which the government can mitigate with guarantees. Going a step further, the two-way contract for difference (CfD) is a direct long-term agreement between the company and the state. The agreed to strike price is effectively hedged with the provision of a price floor and ceiling around the wholesale price which protects each side from excessive profits or losses.[25]

The relevant RED provisions to be implemented by Member States are the following:

- RED requires Member States to identify and remove existing barriers to PPAs in their NECPs.
- RED II Article 4 calls for national renewable schemes to be reformed to take advantage of the declining cost of renewable technologies and to encourage cost reductions, while ensuring that the design of the auction is compatible with corporate sourcing. This reform should make PPAs a more interesting option for producers of renewable electricity.
- RED II Article 19 encourages the establishment of harmonized GO systems and an EU-wide label for renewables generated by new installations.
- RED III Article 21 ensures better rules for self-generation and self-consumption, encouraging open and standardized EACs to incentivize the renewables that bring the most value to the system and ensure that PPAs are accurately counted towards national renewable targets.

25 Richsteinetal, Jörn C., *Carbon contracts for difference: How to de-risk innovative investments for a low-carbon industry?, Science Direct, 2022.*

REDIII proposes liberalization of the retail electricity segment to allow large corporations with the expertise and demand profile to negotiate PPAs and enable the emergence of aggregators to develop clean electricity products for companies with smaller load profiles.

The Clean Industrial Deal and Action Plan on Affordable Energy picks up from here, providing new and improved tools for industry to decarbonize and preserve global competitiveness across a mix of technologies with different timelines—from hard-to-abate heavy industry down to Scope 2 facility power and heating. This includes the Industrial Decarbonisation Accelerator Act, new state aid frameworks, clean trade and investment partnerships, revision of public procurement rules, action plans for affordable energy, the Circular Economy Act, strengthening grid infrastructure and measures against carbon leakage. It also proposes made in EU quotas to stimulate demand.[26]

Additionally, within this framework, the EC has proposed launching a pilot programme for corporate PPAs with the European Investment Bank.[27] This type of public supported bank guarantee is meant to increase the attractiveness of PPAs and level the playing field for SMEs that are most disadvantaged, lacking the strong credit profiles of larger companies capable of mitigating counterparty risks.

Natural barriers

When it comes to corporate sourcing of renewables, the two biggest obstacles are regulatory and policy uncertainty followed closely by higher costs compared to 'standard' grid electricity.[28] In fact, there is a natural convergence between the two since the most consequential uncertainties facing companies are related to the costs of energy—available state aid schemes and regulated components of electricity prices.

PPAs set the energy price component, but network costs and non-recoverable taxes depend on national legislation. These regulated components can be used as a lever to incentivize or disincentivize companies from procuring their own energy in the first place. Industry end-user prices are based on a complex system of taxes and levies on top of the wholesale (energy) price, varying significantly from subsector to subsector depending how much energy companies need, when they need it, how they source it, whether they compete internationally, and several other factors. Often larger companies are exempted from additional costs, in order to remain globally competitive, while smaller companies pay more with surcharges.

The other key financial uncertainty revolves around the credit risk connected to long-term PPAs. Bank guarantees requested to off-takers can be prohibitively costly, especially for SMEs. In addition, such guarantees reduce the ability of smaller companies to borrow additional money for other investments.

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26 Weise, Zia, *EU pushes 'buy European' quotas in major plan to revive industry, Politico, February 2025: https://www.politico.eu/article/eu-europe-major-plan-industry-clean-industrial-deal-climate-targets-donald-trump/*

27 *IEEA welcomes EU Clean Industrial Deal but warns of LNG lock-in risk and overreliance on CCS, Institute for Energy Economics and Financial Analysis, February, 2025:* https://ieefa.org/articles/ieefa-welcomes-eu-clean-industrial-deal-warns-lng-lock-risk-and-overreliance-ccs?utm_campaign=Weekly%20Newsletter&utm_medium=email&_hsenc=p2ANqtz-97B0YGbkygRGsuWHi7y-HxIhKLYooEzG8XSMnzKMqxHJc3piJg60bgrLo5UdnKGqsZdswbmbZEAt9QMkZP2giNk64STSA&_hsmi=349589472&utm_content=349589472&utm_source=hs_email

28 IRENA, *Corporate sourcing of renewables: Market and industry trends, Remade Index 2018, International Renewable Energy Agency: https://resource-platform.eu/wp-content/uploads/files/statements/IRENA-Corporate-sourcing-Market-Industry-trends-June-2018.pdf*

Finally, especially for more complex commercialization contracts, there are concerns about the administrative burden for the state regulator and private companies to avoid ETS double counting.[29]

V4 developments

V4 countries have yet to implement the aforementioned RED III measures in their NECPs, undermining the proliferation of PPAs. Nonetheless, PPAs are showing encouraging signs of growth in Czechia, Poland, while conditions remaining grounded in Hungary and Slovakia.

Poland

In Poland, there is no doubt PPAs are becoming more popular in response to rising electricity prices, however, the data is conflicting. According to Statista, by the end of 2023 there were 30 PPA contracts totaling 1.4 GW (distributed evenly between solar and wind energy) which would place Poland 6th in the EU.30 More recently, RE Source Poland reported that in May 2024 84 PPA contracts have been signed.

There are two general types of customers—the more energy intensive (Cemex Polska, Lafarge Cement, Boryszew), seeking primarily to stabilize energy prices, and international subsidiaries and service providers (Leroy Merlin Polska, Auchan Polska, Decathlon Polska, Play and Orange Polska or Amazon) fulfilling international climate strategies. Currently, the most active companies on the PPA market are Polenergia, Statcraft, GoldenPeaks Capital, R.Power or Quair Polska.

In 2021, Volkswagen Poland signed a PPA with Polenergia to deliver 1.2 TWh energy across all of its facilities in Poland for three years. Already, its factories in Poznan and Wrzesnia are fully supplied by renewables. In 2024 Mercedes-Benz Manufacturing Poland signed a similar contact with Polenergia to deliver energy for a three year period. Meanwhile, one of the most energy intensive companies in Poland—steel producer Commercial Metal Company Poland—signed a PPA with Statecraft (400 GWh annually in 2025–2034) and Polish state PGE Obrót (0.8 TW in 2024–2030).

Polish e-commerce platform Allegro, dominant in the domestic market and also active in V4 countries, signed a PPA in 2024 with R.Power for 200 GWh over the 2025–2035 period. This unique project was likely motivated not only for energy price stability but also for branding.

Czechia

In Czechia PPAs have also been proliferating, led by national utility ČEZ ESCO, which is currently overseeing nearly 10 MW of installed capacity in various stages of development, all on-site PPA photovoltaic.31 However, in February 2025 the company signed a first of its kind three-year off-site PPA contract with the largest steel making company in Czechia—Třinecké železárny group.

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29 GLOBSEC online workshop: *Slovakia 'Fit for 55', A European Green Deal balancing act: The present and future competitiveness of industrial deacrbonisation, May 2021: https://www.globsec.org/what-we-do/events/05052021-european-green-deal-balancing-act-present-and-future-competitiveness*

30 Pangarkar, Tajammul, *Power Purchase Agreement Statistics 2025 by best energy purchase, Market.us Scoop, January 2025:* Power Purchase Agreement Statistics and Facts (2025)

31 ČEZ ESCO, February, 2025: https://www.cezesco.cz/cs/produkty/ppa

This will supply emissions free electricity with a GO for 4.4 GWh per year from the Vrskmaň photovoltaic power plant (itself a brownfield investment built on an abandoned mine).[32]

Another Czech company, Rezolv Energy, is at the forefront of VPPAs (Virtual Power Purchase Agreements) in the CEE region with its ladnmark VIFOR wind project in Romania, which is expected to be completed by the end of 2025. Contracted in 2024, this was the first cross-border Czechia-Slovakia VPPA enabling the construction of what will be one of the largest wind farms in Europe (461 MW after the second phase). The deal is between T-Mobile Czechia (50 GWh/year), Slovak Telekom (40 GWh/year) and CE Colo Czechia (10GWh/year).[33]

Hungary

In Hungary, the spread of PPAs is hampered by the low level of environmental awareness and financing risks, as well as tax factors: The Robin Hood tax, which wipes out 41 percent of pre-tax profits, affects only domestic companies, giving electricity providers across the border a significant competitive advantage. This situation ultimately encourages electricity imports, while hindering investment and job creation in Hungary.[34]

However, there is one VPPA project commenced in January 2025, whereby the Austrian-based renewable energy provider Enery is supplying Dreher Breweries with certified renewable electricity at an annual volume of approximately 14 GWh.[35]

Slovakia

Similar to Hungary, PPAs are not widely used in Slovakia, mainly due to legislative barriers. Slovak energy law (Act no. 251/2012 Coll.) requires renewable energy producers to deliver electricity exclusively through the distribution network, which prevents direct agreements between producers and consumers.[36] Also the physical grid infrastructure is outdated and struggles to accommodate larger renewable energy projects envisioned under PPAs.

Also similar to Hungary, Enery has partnered with a brewery in Slovakia—Plzeňský Prazdroj—to initiate the first VPPA contract in the country. This will see the construction of a new solar park in eastern Slovakia which will cover 92% of the brewery's consumption, about 7.2 GWh annually.

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32 ČEZ ESCO, February, 2025: http://cez.cz/cs/pro-media/tiskove-zpravy/cez-esco-uzavrelo-svuj-prvni-off-site-ppa-kontrakt-na-dodavky-elektriny-z-konkretni-fotovoltaiky.-zakaznikem-jsou-trinecke-zelezarny-209049

33 https://www.solarninovinky.cz/100-gwh-unikatni-ppa-smlouva-o-virtualnim-nakupu-pre-shranicni-elektriny-podpori-rozvoj-moderni-energetiky-v-cesku/

34 https://www.mnnsz.hu/a-ppa-alapu-napelemes-termeles-hazai-elterjedeset-gatolo-tenyezok/

35 https://www.portfolio.hu/gazdasag/20240205/merfoldkonek-szamito-aramvasarlasi-szerzodest-kotott-tiz-evre-a-dreher-667231

36 Hriadel Hager, December 2023: https://www.hriadelheger.eu/zmluva-o-kupe-elektriny-ppa-v-com-je-vyhodna-a-ake-su-moznosti-na-slovensku/

EU financial support

There are abundant EU financial programs available to V4 companies for the transition to renewable electricity and heat, notably:

Horizon Europe—EUR 40 billion for Green Deal research and innovation in partnership with industry.

Cohesion funding—around EUR 100 billion available for the green transition, including the Just Transition Fund, which will be mobilized in support of the Net Zero Industrial Plan[37]

Innovation Fund (IF)—Initially projected EUR 10 billion from auctioning 450 million ETS allowances between 2020 and 2030, but with higher than anticipated carbon prices the amount could grow considerably.[38]

Modernisation Fund (MF)—Initially estimated EUR 57 billion from ETS auction revenues (2% 2021–2030 and 2.5% 2024–2030), like the IF, more funding should be available with higher than anticipated carbon prices. Industry is eligible in the energy efficiency priority area.[39]

It should be noted that both ETS compensation schemes (IF and MF) are meant to ensure that electricity-intensive companies wishing to source renewable electricity are not disadvantaged vis-à-vis their competitors relying on conventional (grid) electricity.

The Innovation Fund is noteworthy for its relevance, abundance and underutilization in the V4. Managed by the EIB, it is one of the world's largest funding programs for the demonstration of innovative low-carbon technologies, yet only two of 62 supported projects have been implemented in V4 countries (Poland and Czechia).[40] Furthermore, the European Parliament has proposed increasing financing options and synergizing with STEP.

37 European Commission, A Green Deal Industrial Plan for the Net Zero Age, February 2023

38 McWilliams, Ben, Zachmann, Georg, *Commercialisation contracts: European support for low-carbon technology deployment, Bruegel, July 2021.*

39 https://climate.ec.europa.eu/eu-action/eu-funding-climate-action/modernisation-fund_en

40 European Investment Bank, Innovation Fund—Project Development Assistance: https://www.eib.org/en/products/mandates-partnerships/innovation-fund/index

State aid

Meanwhile, over the years the EC has progressively moved to streamline its state aid framework to encourage the development and adoption of green technologies and ultimately achieve EU climate targets. State aid schemes have also evolved in recent years, with more complex instruments like contracts for difference (CfD) gaining prominence and carbon contracts for difference (CCfDs) emerging. CCfDs are industrial carbon abatement contracts separated into technology baskets with similar abatement costs. They are tailor-made for older, inefficient CEE industrial complexes with lower marginal abatement costs, providing them with a built-in advantage compared to newer, modern Western European facilities.[41] However, they have not yet been applied in V4 countries.

The first state aid instrument was the Important Projects of Common Interest (IPCEI), launched in 2018, targeting the expansion of EU battery and hydrogen ecosystems. However, it became evident with the ambitious targets of the European Green Deal, announced the following year, that more support would be necessary. This prompted the EC to launch an extensive review of state aid rules (so-called fitness check) in 2019, which resulted in a revision of the legal framework governing state aid to favor decarbonization projects.[42]

This process resulted in the adoption of the Guidelines on State Aid climate, environmental protection and energy (CEEAG) in 2022, replacing the guidelines for environmental and energy aid (EEAG), which expired 31 December 2021. This introduced a more flexible framework for Member States, serving as a legal basis for green industrial projects with longer timelines, mostly based on competitive calls for tenders, and introduced new instruments like CCfDs.

In parallel, the EC amended the General Block Exemption Regulation (GBER) framework in July 2023 to significantly increase the notification threshold for EC assessment of research, development and innovation (RDI) state aid. GBER offers more flexibility for Member States to implement support measures for net zero industry, though it remains a very broad category that does not only cover green transition. Several CEE countries lead the ranking in GBER spending (notably Czechia, Hungary, Poland, and Slovenia[43]). In addition, Slovakia, Hungary and Poland are among a small handful of countries approved under its Regional Aid Guidelines to support the manufacturing of batteries, battery components and electric vehicles.[44]

The EC also adopted the temporary crisis transition framework (TCTF) in 2023, which amended and prolonged the temporary crisis framework (TCF) from the year before (in response to Russia's invasion of Ukraine), enabling support measures needed for the transition towards net zero industry—specifically the rollout of renewable energy and energy storage and the decarbonization of industrial processes—until 31 December 2025.

Overlapping with the CEEAG, TCTF (covering direct grants, repayable advances, loans/guarantees, or tax advantages as well as CfDs for no more

41 McWilliams, Ben, Zachmann, Gregory, *Commercialization contracts: European Support for low-carbon technology deployment, Bruegel, July 2021.*

42 Florence School of Regulation, *'State aid and industrial decarbonisation', July, 2025. https://fsr.eui.eu/state-aid-and-industrial-decarbonisation/*

43 Eisl, Andreas, A European state aid framework for the Clean Industry Deal, Jaques Delors Institute, February 2025.

44 European Commission, DG Competition, State Aid Scoreboard, 2024, published April, 2025.

than 20 years) was favored by Member States because it was more lenient with faster approval. The intensity for state aid could reach 100% of the investment cost if it was granted in a competitive bidding process, otherwise it was capped at 45%.[45]

This is being replaced by the new Framework for State Aid measures to support the Clean Industrial Deal (CISAF) and remain in force until December 31, 2030. Its main objectives are to accelerate the rollout of renewables and facilitate industrial decarbonization by ensuring sufficient clean technology manufacturing capacity and de-risking private investments. Direct price support schemes for electricity from renewable energy will take the form of two-way CfDs with a contract duration of up to 25 years. The eligible costs will take into account the main costs and revenues over the lifetime of the project discounted by WACC.[46]

There are two areas of concern that will need to be addressed in this open season for state aid. First, the risk of an uneven subsidy race among Member States with varying degrees of fiscal availability and maneuverability. V4 countries less willing or able to provide fiscal support have expressed concerns over big spending Member States like Germany.[47] Second is related to data availability and transparency. A recent Special Report of the European Court of Auditors draws attention to the lack of sufficient and reliable data on the overall amounts of state aid granted by Member States to each sector, like green industrial policy, in relation to the RRF.[48] This is on top of a recent IMF report highlighting data constraints in EU Member State industrial policy, noting that some EU authorities, including Poland, do not report to the EU Transparency database. [49]

45 Trichkovska, Irina, et al., The European Commission loosens state aid rules to foster energy transition and prevent the flight of green technologies from Europe, White & Case, March, 2023: https://www.whitecase.com/insight-alert/european-commission-loosens-state-aid-rules-foster-energy-transition-and-prevent

46 Draft Communication from the Commission, Framework for State Aid measures to support the Clean Industrial Deal, (Clean Industrial Deal State Aid Framework), March 2025.

47 Von der Burchard, Hans, et al., *Germany's big spending splurge gives EU the jitters, Politico, March, 2025:* https://www.politico.eu/article/germanys-friedrich-merz-radical-spending-election-berlin-green-energy-fund/

48 *Green transition: Unclear contribution from Recovery and Resilience Facility, Special Report, European Court of Auditors, 2024*

49 Hodge, Andrew, et al., *Industrial Policy in Europe. A single market perspective, IMF Working Paper, December 2024*

CONCLUSIONS AND RECOMMENDATIONS

V4 companies have immense potential to modernize and upgrade outdated industrial infrastructure and processes to run more efficiently, decarbonize and create long-term savings. To date, large international subsidiaries located in the V4 have taken the lead in decarbonization efforts following their ambitious global climate strategies and facing rising costs of carbon allowances. A past V4 survey from 2021 revealed a strong appetite for on-site production (11 out of 38 companies), which has surely increased among a larger number of companies following the energy crisis.[50]

First and foremost, the industrial sector needs to reduce its energy intensity and overall energy use through digitalization and efficiency measures; essentially the application of smart, connected technological solutions and modernization through new material equipment. Second V4 countries—especially Czechia and Slovakia with their heavy industry make-up—have huge potential for the utilization of excess heat, both on an off-site.

Especially for low and medium temperature heat processing, but also for remaining facility power and heat requirements, companies can turn to mature renewable technologies to replace fossil fuels, namely heat pumps for electrification, geothermal and solar thermal. Slovakia and Hungary in particular have especially strong geothermal potential that can be exploited for industry, but geothermal heat pumps can also be exploited in Czechia and Poland. In Hungary there are several such projects underway that can be used for case studies in the other countries.

SMEs, which make up the lion's share of companies operating in the V4, often lack awareness about technologies, available incentives or support schemes, costs and best practices. These companies are more conservative and financially constrained to begin with, and have limited in-house skills and expertise in the realm of energy procurement. Companies in the same subsectors should be aligning and seeking government leadership and support for investing into renewable sources of electricity and heat that meet climate aspirations and competitive needs. On site, group or sectoral benchmarking exercises can further help identify opportunities, including more strategic and costlier investments that have been successfully deployed elsewhere.

Raising awareness about the available renewable solutions and positive impacts on business performance, especially the potential cost savings and mitigation of energy price volatility, should have a substantial impact on company demand for renewables following the energy crisis. PPA solutions already embraced by larger companies in the region should be promoted and passed along to SMEs.

National governments, in turn, should have a framework in place that supports capital intensive, long-term investments by reducing risk factors and allowing for the development of market based state aid mechanisms including:

- Consistency across various policy objectives where industrial contributions are encouraged and counted towards national renewable targets and energy security objectives.

50 Heilmann, Felix, Popp, Rebekka, *Boosting Renewable Energy in The Visegrad Region, Briefing Paper, E3G, April 2021*

- Standardized and transparent reporting and data collection to inform policies and measures for various industry subsectors.
- Stable regulatory and legal framework empowering companies to pursue clean energy PPAs and CfDs.
- State guarantees providing long-term contractual security with collateral improving liquidity in forward markets.

While crucial for the transformation of all industrial subsectors to clean, reliable and cost-effective renewable sources, the need for long-term government support and commitment is most evident for the less mature technologies, like hydrogen electrolysis and electric arc furnaces. The current situation in Czechia with Třinecké železárny group is a case in point. They estimate an investment cost of around EUR 1 billion to convert about half of production to electric arc furnaces using scrap metal (increasing electricity consumption by about 30%). They also calculated that this would require state subsidy support of some 70% to match that of neighboring European countries.[51] After announcing in January 2025 a timeline to start construction of the smelter in 2026 and complete it by the end of 2028, the company withdrew the pledge only two months later, saying it would not be built until 2030 at the earliest due to "insufficient public support, uncertainty about the future direction of Europe in the rules related to the Green Deal, the current negative situation on the steel market and unclear rules for protecting the market from imports from countries without regulations and with lower steel production costs," according to the company spokesman.[52]

The main point is that current, mostly outdated, industrial practices and infrastructure in V4 countries will have to be modernized in order to remain viable in the climate neutral EU energy system of the future. However, it is not only decarbonisation but increasingly economics and resiliency that is now pushing companies to pursue clean sources of energy. If governments can provide the forward-looking policy clarity, flexibility and, in some cases, direct financial support, companies will begin to make the necessary investments to transform themselves, and in doing so become a driving force in the wider energy transformation. Therefore, V4 industry and governments must collaborate more closely to meet what are increasingly common objectives of reducing dependency on fossil fuels, improving energy independence and remaining competitive in a rapidly evolving global landscape for decades to come.

51 Třinecké železárny, Press Release, January, 2025: https://www.trz.cz/o-nas/tiskove-zpravy/2025-01-30-trinecke-zelezarny-zahajuji-nejvetsi-investici-v-ceskem-ocelarstvi-od-80-let-minuleho-stoleti/

52 Karban, Pavel, *Třinec Iron and Steel Works is slowing down plans, the construction of the electric arc furnace will be delayed by at least two years, Novinky.cz, April 2025: https://www.novinky.cz/clanek/ekonomika-trinecke-zelezarny-brzdi-plany-stavba-elektricke-obloukove-pece-bude-mit-minimalne-dva-roky-zpozdeni-40518385*