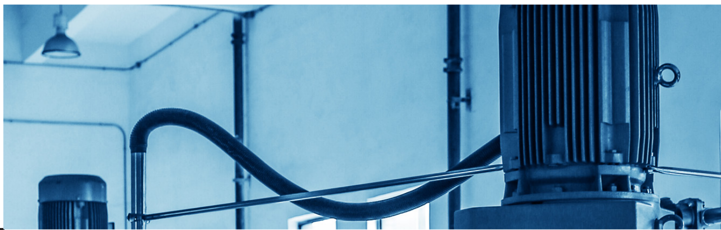
REPORT

Clean industrial heat

Electrification scenarios for selected sectors

Warsaw 2025



REFORM

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Executive Summary

Electrification of process heat has the potential to bring economic and environmental benefits to the Polish industry. With the increase in emission costs and the development of renewable energy sources, powering plants with electricity will become cheaper than using fossil fuels. **We should already be developing competence in the electrification of Polish industrial plants to prepare them for massive investments in the coming years.**

Why now?

From 2027, the ETS2 will come into effect, which could increase the price of gas by up to 50% by 2035 and double the cost of burning coal for small and medium-sized industries. Through electrification, the industry can reduce its dependence on volatile prices and emission costs for fossil fuels and thereby improve its competitiveness.

Why is it important?

The manufacturing sector is one of the pillars of the Polish economy – it generates 15.4% of GDP (Eurostat, 2024)[1] and employs almost 2.8 million people (Statistics Poland, 2025)[2], while being responsible for 20% of the country's energy needs (data from 2023). Much of this energy is used to produce heat – mainly from natural gas, coal and biomass. As a result, the sector is responsible for direct emissions of more than 60 million tonnes of CO_2 per year – more than the entire district heating.

Meanwhile, many technological processes require low- (<100°C) or medium-temperature (100-400°C) heat, which can be efficiently generated using electricity, e.g. using heat pumps.

Which industries are worth electrifying?

A high potential for electrification with heat pumps exists in three industries:

- **food industry** (including beverage and tobacco production),
- **paper industry** (including pulp production),
- **selected chemical industries,** e.g. pharmaceutical production and other sectors where high-temperature heat is less frequently needed.

For each of these industries, we analysed three development scenarios assuming: continuation of current operations (business-as-usual), full electrification or a mixed model (electrification with partial use of biomass).

1 Eurostat (2025), Gross value added and income by main industry – Tables

2 Statistics Poland (2025), Employed persons in the national economy in Poland in December 2024 – Tables

Key findings:

- **The food industry is best suited to electrification,** both with and without utilising biomass.
  - with biomass: savings of PLN 264 million per year in 2040 and PLN 511 million in 2050.
  - without biomass (full electrification): savings of approximately PLN 216 million per year in 2040 and PLN 422 million in 2050.
- **The paper industry will only remain competitive with the high use of waste biomass.**
  - savings of PLN 96 million per year in 2040 and PLN 170 million in 2050.
- **Parts of the chemical industry also stand to gain from electrification,** subject to favourable energy prices after 2040.
  - with a small share of biomass: PLN 89 million per year savings in 2040.
  - without biomass: PLN 51 million per year in 2040 - smaller savings, but without the uncertainty of biomass availability.

Main challenges:

Electrification faces technical, regulatory and market constraints such as:

- increasing competitive pressure on the EU industry from the global economies,
- inflexibility to use low-cost RES energy in industries requiring continuity of production processes,
- difficulties in obtaining high-capacity connections to the grid,
- low RES share in the Polish energy mix, which raises grid energy costs.

Successful decarbonisation of these sectors in the face of the above challenges and often suboptimal operating costs requires the implementation of specific policies to facilitate their development.

Recommendations:

In order to accelerate the electrification of industrial processes, it is recommended to:

- **Launch support mechanisms for industrial electrification,** especially for projects integrating heat or electricity storage;
- **Simplify administrative procedures to accelerate RES investments in industrial plants,** in line with the REDIII directive;
- **Revise direct line regulations** that will allow industrial plants to use energy from their own RES sources;
- **Pursue a clear and transparent energy transition policy,** including:
  - ending subsidies for fossil fuels,
  - harmonising emission charges for different types of greenhouse gas emitters,
  - creating a roadmap for industrial decarbonisation with the necessary regulatory changes and funding sources.

1. Introduction

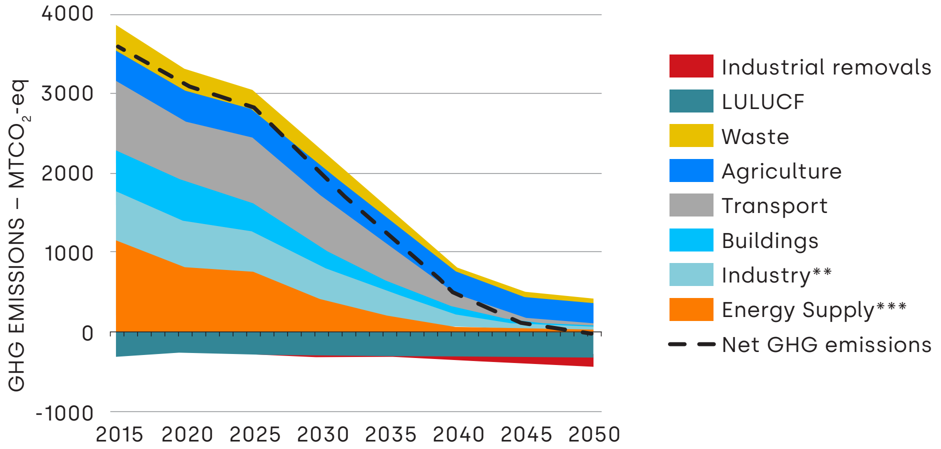
This decade is a very demanding time for most industrial sectors in the European Union. Demand decline stemming from the COVID-19 pandemic, demographic trends and economic uncertainty is worsened by increased competition from other countries. The European industry must remain competitive despite challenges, such as a need to decarbonise its energy mix. Decarbonisation requires broad changes to the production process with high capital costs, but it is, in fact, a necessary step to remain competitive in the long term – most of Europe's rivals have vastly greater fossil fuel reserves and cheaper labour than the Old Continent. Therefore decarbonisation is a way to avoid competing just on price against someone who has cheaper inputs.

Decarbonisation can bolster competitiveness in two ways – first, it provides a local supply of energy, which is not available to foreign competitors. This is important because exporters of fossil fuels always have a price discount on their domestic market, which creates the temptation to develop domestic industry to export goods higher in the value chain. Secondly, most of the technologies for energy transition are capital-intensive but have low operating costs. Therefore investing in decarbonisation (including with support from grants or preferential loans) creates a lasting business advantage – expensive infrastructure will be here to stay, while competitors will have to pay for building it from scratch. Decarbonisation will have to be done eventually everywhere since fossil fuels are both finite and harmful to the planet. Their use will bring ever higher climate and extraction costs. If Europe is the first to decarbonise, the know-how and industrial base for decarbonising other continents will be here creating business opportunities for exporting goods and services related to decarbonisation elsewhere.

Climate neutrality requires phasing out fossil fuels in various applications across different sectors of the economy. In European Union, this includes 90% reduction of its net greenhouse gas emissions by 2040 and net-zero greenhouse gas emissions by 2050[3]. Many branches of industry are hard to decarbonise profitably due to their high reliance on fossil fuels including for heat production. Industrial heat is provided predominantly by fuel combustion while electricity is primarily used for cooling and supplying mechanical power.

3 European Commission (2024), 2040 climate target

Figure 1. GHG emissions targets



European Commission, 2025[4]

4 European Commission (2024), 2040 climate target

As the carbon intensity of electricity is set to rapidly decline, electrification has become the core of climate change mitigation strategy. Replacing fossil fuels with low-carbon electricity would help to avoid risks and costs of other options still in early phases of adoption, such as carbon capture and storage or utilisation (CCS/U) and indirect electrification via synthetic electricity-based fuels (e-fuels) which is burdened by low electricity-to-fuel conversion efficiencies. Moreover, technologies for direct electrification are already mature; such as heat pumps[5], electric boilers and furnaces. However, the implementation of additional decarbonisation strategies will be necessary in industries where fossil fuels serve as a chemical feedstock (e.g., steel production) or where CO_2 is a by-product of the industrial process (e.g., cement production). The use of biomass is controversial since only a limited amount of this resource can truly be called sustainable (that is not contributing to degrading natural ecosystems, displacing food production or competing against higher-value use of biomass). Some sectors, particularly the paper industry and the food and beverages industry have access to substantial amounts of combustible biowaste, which can be used for energy. This publication is focused on the energy mix of industry, not on the biomass market. We treat as sustainable the biomass which is classified as such under the EU regulations.

5 Agora Energiewende, Fraunhofer IEG (2023), The roll-out of large-scale heat pumps in Germany. Strategies for the market ramp-up in district heating and industry.

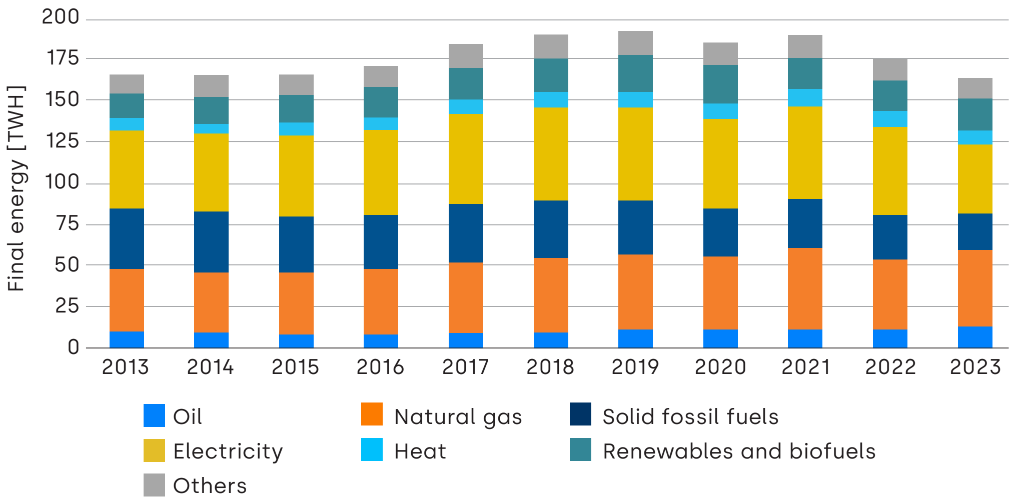
In this report, we describe the importance of the selected sectors for the Polish economy and a brief overview of the technological solutions, followed by sections showing their application in the three industry sectors in question. We conclude with information about the EU regulatory context and support schemes for industry electrification, reported barriers and recommendations to remove these barriers.

2. National context of industrial development in Poland

2.1. Energy use and emissions from manufacturing in Poland

In 2023, industrial final energy consumption in Poland amounted to 14 Mtoe[6], thus accounting for 20% of the country's total final energy consumption. CO_2 emissions from manufacturing have remained at similar levels over the past several years, reaching over 60 million tons annually and accounting for almost 19% of national CO_2 emissions[7].

Figure 2. Final energy consumption in industry by fuel in Poland



Source: Eurostat

Energy consumption in industry has grown steadily on account of the domestic economic growth, except in 2020 when industrial production dropped for the first time since 2013 due to the COVID pandemic and the second time in 2022 and 2023 due to the energy price crisis. The Polish industry is heavily dependent on fossil fuels, as coal and natural gas are responsible for 40% of industrial final energy consumption. Meanwhile, electricity consumption accounts for 30% of total industrial final energy consumption.

2.2. Low- and medium-temperature heat demand in Poland

Demand for industrial heat varies with temperature levels and end-uses depending on the industry sector. The greatest technical and economic potential for electrification is held by industries utilizing low-temperature (<100°C) and medium-temperature (100-400°C) heat since these are easiest to electrify with heat pump technologies (see Chap-

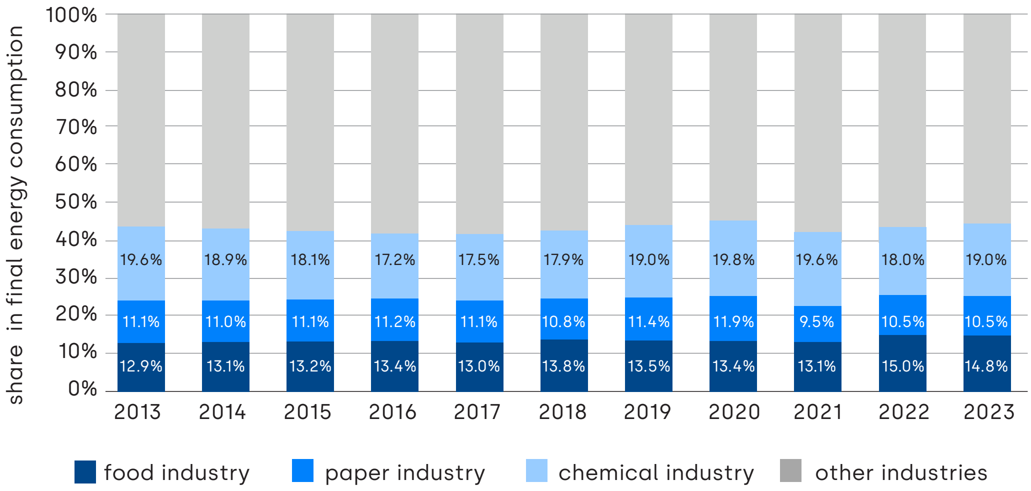
6 According to Eurostat database. Data from Eurostat and from Statistics Poland show differences, since Eurostat includes data from PKD codes B, C and F for the Industry sector, while Statistics Poland includes sections B, C, D and E (with exceptions)

7 According to "Economics aspects of environmental protection" (2023), Statistics Poland

ter 4 and Annex 1) which have a potential to reduce operating costs compared to the current fossil fuel usage. The three biggest sectors with low and medium heat demand in Poland include:

- Paper and paper products – around 11% of final energy consumption in industry;
- Food and beverages – around 13,6% % of final energy consumption in industry;
- – around 18,6% of final energy consumption in industry.

Figure 3. Share of paper, food and chemical industries in final energy consumption in industry between years 2013-2023 in Poland

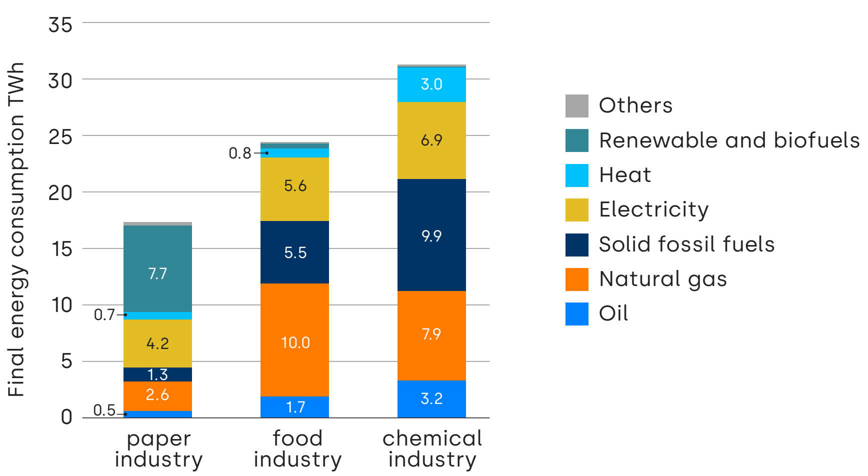


Source: Eurostat

2.3. Energy consumption and emissions in paper, food and chemical industries

Final energy consumption in 2023 in paper, food and chemical industries amounted to 17.2 TWh, 24.2 TWh and 31.1 TWh, respectively.

Figure 4. Final energy consumption by fuel in paper, food and chemical industries in Poland in 2023



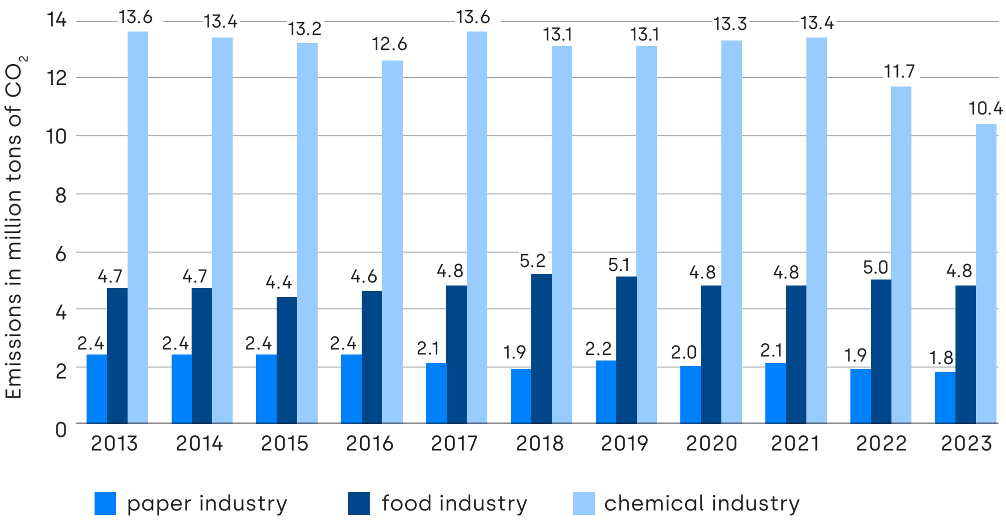
Source: Eurostat

In the paper products industry, 45% of final energy consumption is provided by primary solid biofuels combustion and 25% is supplied by fossil fuels. Electricity accounts for 25% of final energy consumption in the paper sector. The high consumption of biofuels in the paper industry primarily results from the utilisation of waste and by-products generated in the process of manufacturing paper products.

In the other two sectors, fossil fuel usage is much higher – in the food industry, it is responsible for 71% of final energy consumption, while in the chemical industry, it amounts to 68% of final energy consumption. Electricity accounts for 23% of the final energy consumption in the food industry and 22% of the final energy consumption in the chemical industry.

CO_2 emissions from manufacturing have remained at similar levels over the past several years, reaching 60-65 million tons annually. Carbon dioxide emissions from the paper industry amount to 2 million tons annually, accounting for 3% of overall emissions from manufacturing. CO_2 emissions from the food industry are more than twice as high, standing at 4.5-5 million tons. Among analysed sectors, the chemical industry produces the greatest amount of carbon dioxide and is responsible for about 13 million tons of CO_2 emissions per year, equivalent to 20% of emissions from the entire manufacturing in Poland. The decreases in CO_2 emissions in the chemical industry seen in 2022 and 2023 come primarily from production cuts.

Figure 5. CO_2 emissions in paper, food and chemical industries in Poland



Source: Eurostat

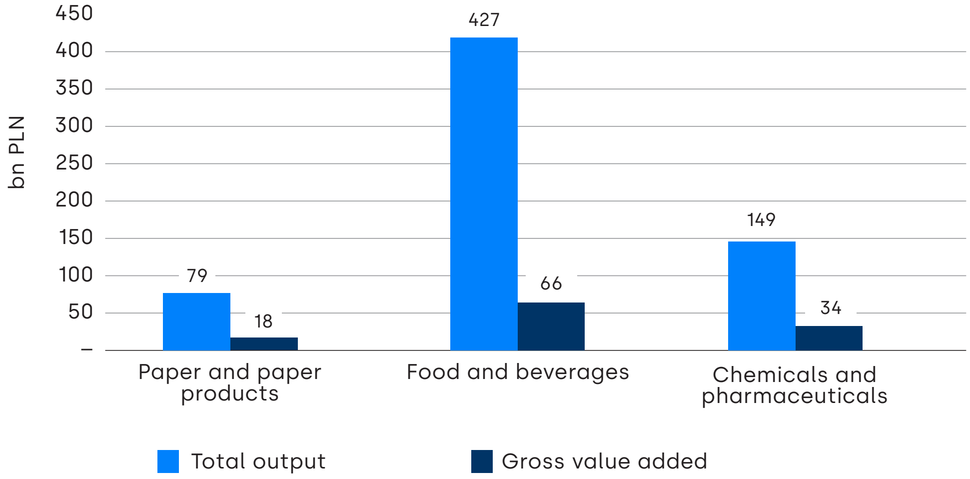
2.4. Economic significance of paper, food and chemical industries

In terms of impact on the national economy, of the three sectors mentioned, the food industry produces the largest output (~ 427 billion PLN), which accounts for 18,9% of the output of the entire Polish manufacturing. The total output of the paper industry and chemical industry is 79 billion PLN and 60 billion PLN, respectively.

The food industry also employs the largest number of employees – 389.9 thousand. The number of employees in the paper and chemical industries is 63.1 thousand and 107 thousand, respectively.

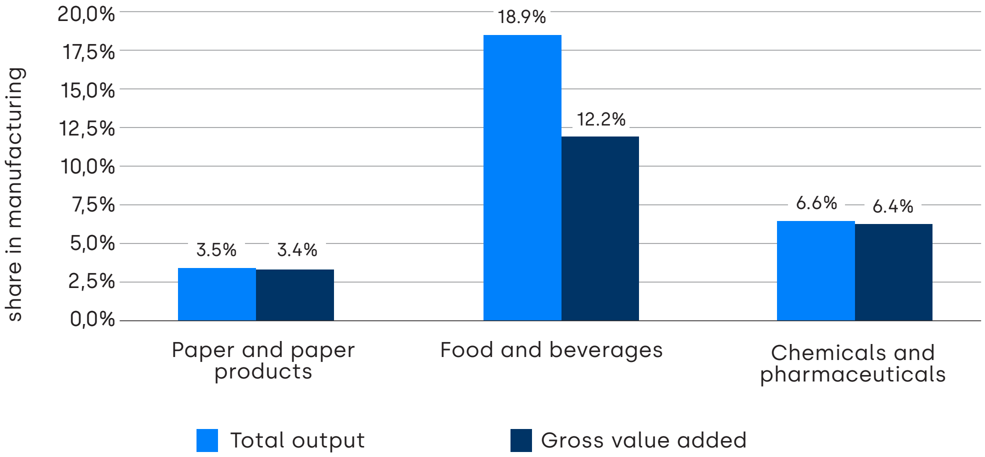
Food and beverages exports account for 12% of total manufacturing exports from Poland. Exports in the paper and chemical industries represent 2.7% and 5.8% of Polish manufacturing exports.

Figure 6. Basic economic data regarding paper industry, food and beverages sector, chemical and pharmaceutical manufacturing in 2022



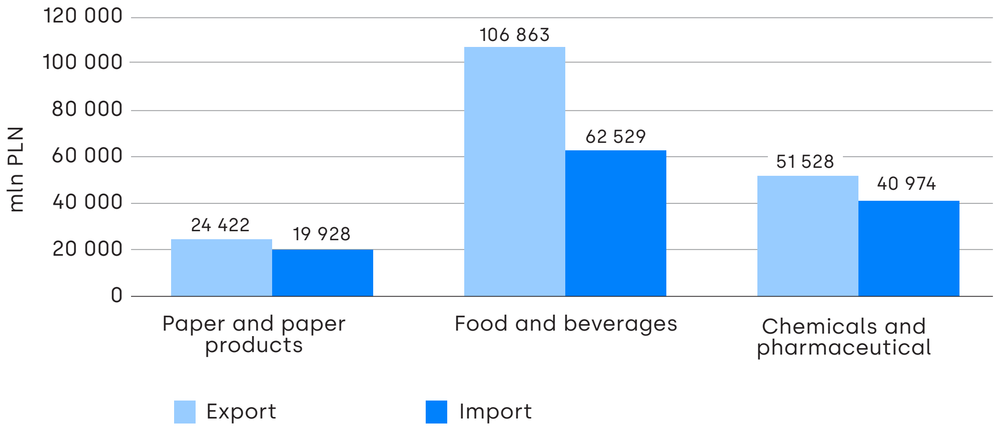
Source: Reform Institute based on Statistical Yearbook of Industry – Poland

Figure 7. Share of selected sectors in manufacturing in Poland in 2022



Source: Reform Institute based on Statistical Yearbook of Industry – Poland

Figure 8. Export and import in paper industry, food and beverages sector, chemical and pharmaceutical manufacturing in 2022



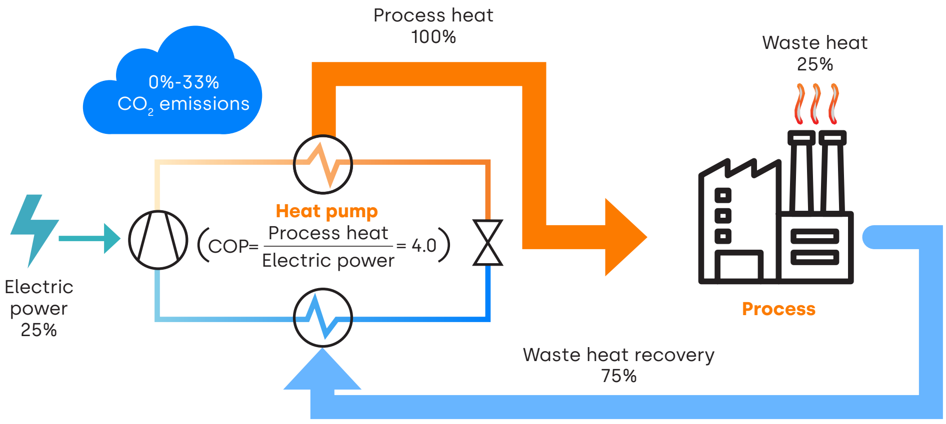
3. Technological scope – possible solutions

Industrial heat can be electrified by employing different technologies. A more detailed description of respective technologies can be found in Annex 1. Here we discuss shortly the benefits and limitations of respective technologies and their most promising applications.

3.1. Heat pump technologies

Heat pump technologies (heat pumps and mechanical vapour recompression) are unique among electrified heating technologies. Rather than directly converting electricity into heat, a heat pump uses electricity to transfer heat from an area of lower temperature (the "heat source") to an area of higher temperature (the "heat sink"). Since the majority of the energy reaching the heat sink comes from a heat source, heat pump technologies achieve several times higher efficiency than technologies which only convert electric energy into heat.

Figure 9. Heat pump – simplified process scheme



Source: de Boer et al. (2020)[8]

The majority of heat pump technologies are based on evaporation and condensation done at different pressure levels. Mechanical vapour recompression uses water vapour from the product itself as a medium, thus it is best suited for distillation and evaporation, such as drying milk into condensed milk. Heat pumps use an intermediary circuit of refrigerant (such as propane, fluorocarbons or ammonia) to extract heat from the heat source into a heat sink.

8 de Boer, R., Marina, A., Zühlsdorf, B., Arpagaus, C., Bantle, M., Wilk, V., Elmegaard, B., Corberán, J., & Benson, J. (2020), Strengthening Industrial Heat Pump Innovation: Decarbonizing Industrial Heat.

The main limitation of a heat pump capacity is the amount of heat available in the heat source and the main limiting factor for its efficiency is the temperature difference between the heat source and the heat sink.

Heat pump technologies are best suited for cases, where the majority of heat can be recovered from the product at a temperature not much lower than the temperature of heating the product. In cases where the heat from the product is dissipated, an alternative is to draw heat from the surrounding environment. However, outdoor temperatures vary and remain low for most of the year, thus this is the solution only for low-temperature heat (such as home heating) or where there is a backup for the coldest part of the year.

Heat pump technologies are also very efficient at recovering waste heat. Every refrigeration system is essentially a heat pump, thus raising the heat discharge temperature or using waste heat as a heat source for a second heat pump allows to transform waste heat into higher-temperature, valuable heat.

Heat pump technologies are usually more complex and capital-intensive than other types of heating sources, and thus are best suited for the constant provision of heat. Provision of intermittent heat, heating in short pulses or very precise application of heat are usually easier provided with the conversion of electric energy into heat.

3.2. Conversion of electric energy into heat

Conversion of electric energy into heat is usually much simpler from the engineering point of view than pumping of the heat, since it does not require building a circuit of refrigerant to recover and transfer heat to the heat sink. Conversion of electricity into high-temperature heat is usually done with almost 100% efficiency, but further transfer of heat to the product or the process of heating the working space (in case of intermittent work) can incur further losses.

Conversion of electric energy into heat can provide heat at almost any temperature, limited only by the material properties of the installation. Electricity is usually converted into high-temperature heat through ohmic resistance and then distributed to the product via conduction, convection or radiation. For practical or safety reasons, the heat is often transferred through an intermediate circuit of air, steam, water or thermal oil, which limits the temperature in the vicinity of the product and/or enables better heat penetration. A different, distinct technology is microwave heating, which transfers heat directly into water molecules in the product via electromagnetic waves of a certain length. Electrode boilers and infrared heaters are examples of the conversion of electric energy into heat through ohmic resistance.

The main advantage of the conversion of electric energy into heat is near-complete independence from the rest of the process since it does not require drawing heat from any heat source or from the environment. Heat can be provided at almost any temperature and can be very precisely controlled. A good example is baking of bread, which requires providing large volumes of infrared radiation or very hot air toward the outer surface of the bread to make it crunchy, while only a small fraction of the heat from water evaporation or cooling of a finished loaf can be recovered at high-enough temperature to use it as a heat source for the oven.

Technologies for conversion of electric energy into heat are usually rather simple and are characterised by low investment costs, have an established presence in the industry and require little consideration, besides electricity supply and operating costs, for their adoption.

3.3. Summary

The most efficient electrification technology available is heat transfer, but its scope of application is limited to processes, where large volumes of similar-temperature heat can be extracted from a consecutive phase of the process. In other applications, the conversion of electricity into heat can successfully replace fossil fuels, albeit often at a significantly increased operating cost.

Table 1. Summary of technologies for low- and medium-temperature industrial heat

Technology	Heat pump technologies	Conversion of electric energy into heat
Examples	Heat pumps, mechanical vapour recompression	Electric boilers, electrode boilers, microwave heaters, infrared heaters
Electric energy conversion efficiency	Largely dependent on application – from 1.6 to 10 or more, for most applications in the range of 2 - 4.5	Usually close to 1 (90-100% efficiency), in case of microwave heating or open ovens can be 0.5- 0.85
Range of application	Wide, but a few processes may have specific requirements that make this way of electrification impractical	Very wide, can displace fossil fuels in almost any application for low- and medium-temperature heat if operating costs are not taken into account
Investment costs	High to very high	Usually low to moderate
Operating costs	Low to moderate due to much better energy efficiency than resistance electric heating	Very high when used as a main (baseload) source of heat, often much higher than a fossil fuel-based alternative
Integration into process	Dependent on application – sometimes easy, sometimes requires reconstructing a sizeable part of a production line	Usually easy, but may require significant changes to electric installation and electric connection
Technology maturity	Dependent on application - established in industry or limited in availability (for particularly high temperatures and/or particularly large temperature differences)	Established in industry

4. Scenario results

This report examines the possibility of replacement of fossil fuels with renewable energy in three important sectors of the Polish economy:

- **Food and beverages industry:** This includes 3 categories, as specified by Statistics Poland: manufacture of food products, manufacture of beverages and manufacture of tobacco products.
- **Paper industry:** This includes 1 category, as specified by Statistics Poland: manufacture of paper and paper products
- **Chemical industry:** The chemical industry as a whole uses a lot of high-temperature heat for processes such as oil refining and fertiliser production. We have limited this study to categories other than "Basic chemicals" in the JRC-IDEES database. These categories are namely "Other chemicals" and "Pharmaceutical products etc.". The corresponding figures by Statistics Poland are: manufacture of chemicals and chemical products and manufacture of pharmaceutical products. **The numbers in the following sections are thus describing a part of the chemical industry, not the whole.**

These three selected sectors have the highest proportion of low-temperature (<100°C) and medium-temperature (100-400°C) heat in their energy use. Low- and medium-temperature heat is easier to electrify than high-temperature heat, since low temperature differences allow the use of heat pumps, which are more efficient than electric resistance heating.

For each of the industries, three pathways have been proposed:

Scenario 1 – Business as usual

There is no change in the energy mix of the industry, however, evolving electricity mix in the country affects the emission intensity of electricity from the grid.

Scenario 2 – 100% electrification

Gradual replacement of all current heat sources (including biomass) with electrified heating by 2050.

Scenario 3 – mixed net zero

Gradual replacement of fossil fuels by 2050, including coal phase-out by 2040. Continued biomass use is allowed.

The pathways were proposed with the aim of achieving 100% net-zero emissions for scenarios 2 and 3, including the transition to 100% electrified heat in scenario 2. **None of**

the scenarios should be considered "most probable" or "recommended". Percentage changes in useful energy mix were added to the model as an input. **The aim is not to show the cost-optimal pathway but to assess the effects of each different trajectory.**

In reality, some industries may adapt using a mix of different technologies (like an existing gas boiler and a new electrode boiler) or may switch to seasonal work in case of decreased demand and high electricity price volatility. This has not been covered by this study, as the effect would be temporary (fossil fuels have to be totally phased-out in the long run) and the savings, while possibly large enough to justify the construction, would not probably be larger than a few percent of the total energy expenditures of each industry.

For the purpose of this analysis, heating demand in the industry is projected to remain at the 2019 level for the foreseeable future. Any gains in efficiency are expected to be offset by growth in output. The efficiency and cost of each technology have also been assumed to be steady since an increase in efficiency often comes with higher capital expenditures. A classic example is a heat exchanger for a heat pump – a heat exchanger providing a smaller temperature difference will have a larger heat exchange surface and thus higher capital cost. For innovative products, such as high-temperature heat pumps, the development of technology and increase of production scale may decrease the costs, however those technologies often rely on relatively expensive and scarce resources, such as copper, or energy-intensive materials such as aluminium and steel, which may be more expensive in the future.

Prices of energy carriers have been taken from Poland's NECP and from in-house assumptions. The emission intensity of the electricity in the national electricity grid has been taken from the NECP WAM scenario and extrapolated into 2050.

5. Electrification in food and beverages industry

The food and beverages industry is the largest and the most important of the three analysed in terms of economic turnover. Details on the assumptions and methods, as well as the results can be found in Annex 2 and 3. Below, the key results are provided.

5.1. Techno-economic assessment

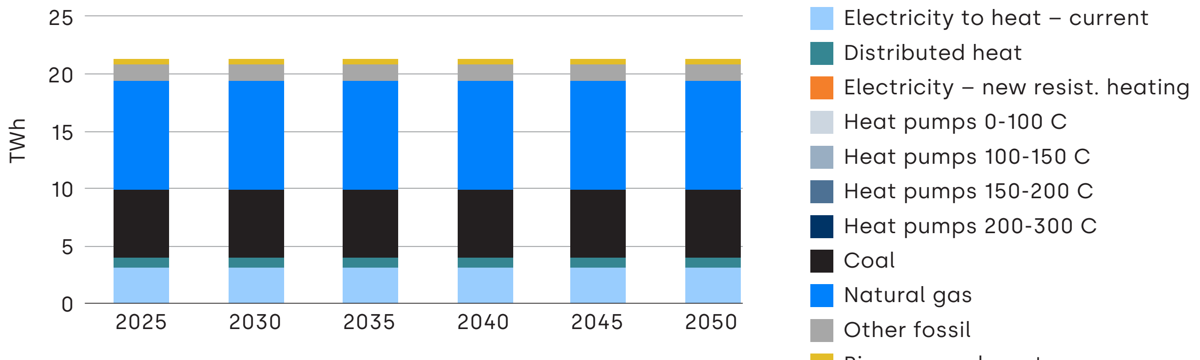
The majority of processes in the food and beverages industry are conducted at atmospheric pressure and temperatures up to 100°C since food products usually contain a lot of water that has to remain liquid. Food and beverage products are usually heated to break plant cells and long, inedible molecules (cooking), to destroy potentially harmful microorganisms (pasteurisation and sterilisation), and to reduce the amount of water (distillation). Some food products require contact with much higher temperatures to undergo Maillard reaction (as in the case of bread with crunchy skin). For some, particularly liquid products, it is possible to efficiently recover heat during the cooling process. Many food and beverage factories also have extensive cooling installations, which can be used as waste heat sources.

The food and beverages industry relies primarily on natural gas and coal, with already a sizeable, roughly 15% minority of heat supplied by electricity. Biomass and waste are used when available, while liquid fuels (such as LPG) are used when natural gas is unavailable or more expensive.

5.2. Results

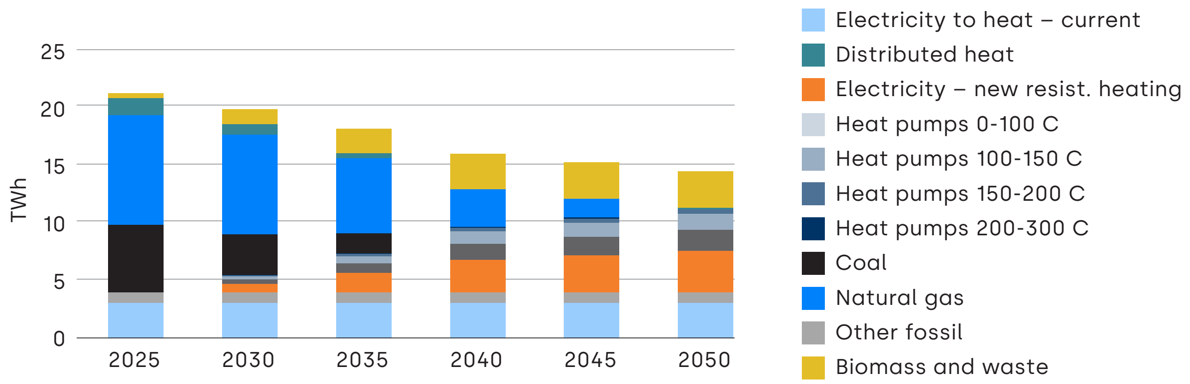
For the assessment of energy transition and its costs, three scenarios were taken into account. They differ by the inclusion of different final energy carriers into the energy mix of each sector. The energy mix for each scenario has been shown below:

Figure 10. Final energy mix in the food and beverages industry under BAU scenario



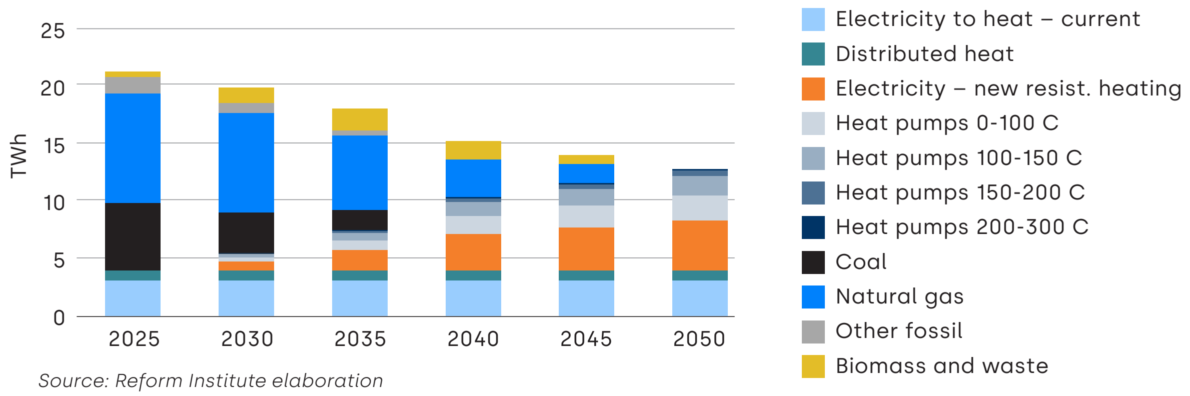
Source: Reform Institute elaboration

Figure 11. Final energy mix in the food and beverages industry under mixed scenario



Source: Reform Institute elaboration

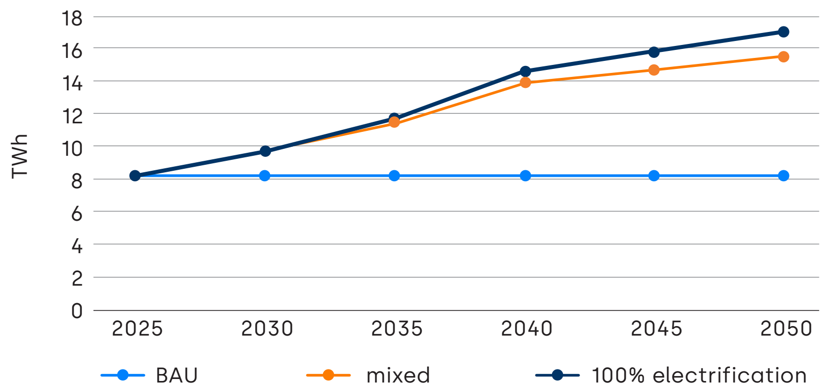
Figure 12. Final energy mix in the food and beverages industry under 100% electrification scenario



Source: Reform Institute elaboration

Increasing use of electric energy for heating leads to a sharp increase in electricity consumption – eventually doubling for the year 2050 in the 100% electrification scenario – even including electricity consumed for other needs than heating.

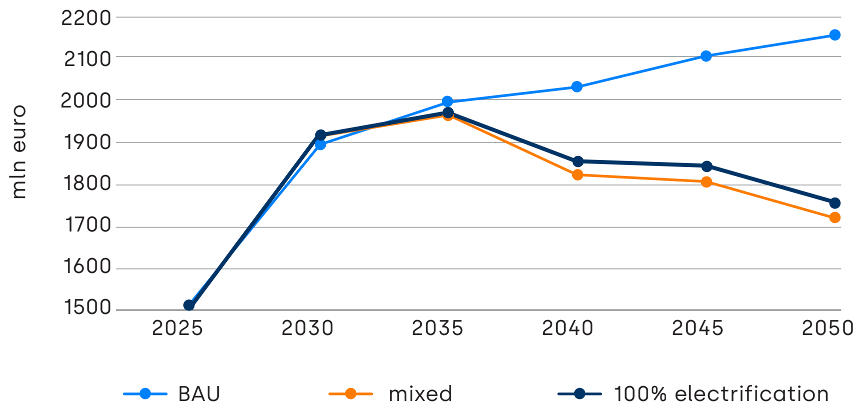
Figure 13. Total electricity consumption in the food and beverages sector in all scenarios



Source: Reform Institute elaboration

The change in the heating mix leads to a change in the total costs of heat. For the food and beverages sector, decarbonisation is a very profitable option since widespread heat pump use allows for a significant decrease in total costs.

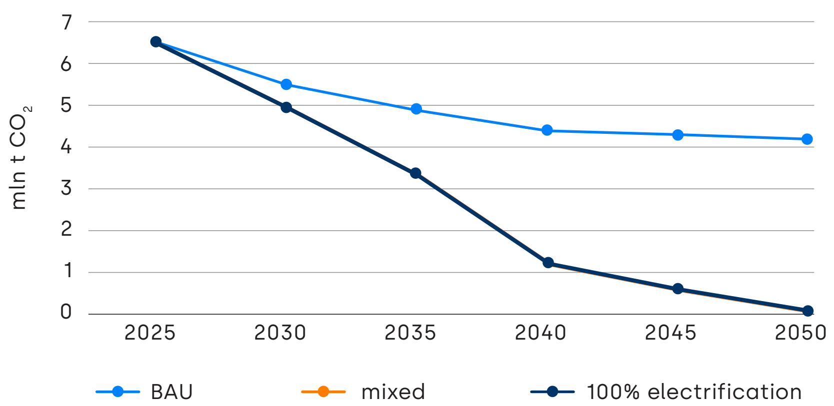
Figure 14. Total cost of heat in the food and beverages sector in all scenarios



Source: Reform Institute elaboration

The replacement of fossil fuels with electricity leads to a significant reduction in greenhouse gas emissions. This is supported by the fact that electricity in the grid and the distributed heat are about to be progressively decarbonised as well.

Figure 15. Scope 1 and 2 greenhouse gas emissions in the food and beverages sector in all scenarios



Source: Reform Institute elaboration

6. Electrification in paper industry

The paper industry is one of the few industry sectors which produce a sizeable fraction of its energy consumption itself and from a renewable energy source (biomass). The study involved looking at a reference factory producing paper from wood. More details about the assumptions for calculation and about results can be found in Annex 2 and Annex 4.

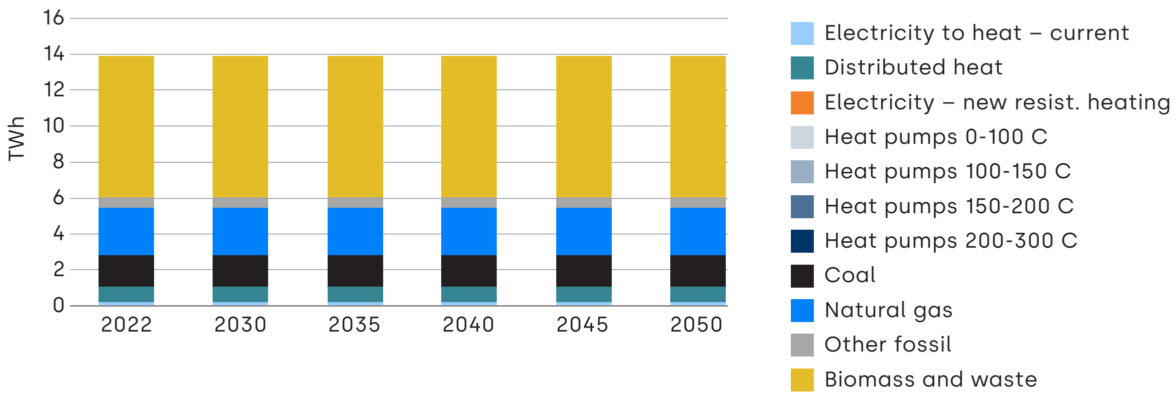
6.1. Techno-economic assessment

Production of paper from wood is done by first producing paper pulp from wood chips, and then turning it into a finished product. The first stage involves the production and recycling of large amounts of combustible byproducts originating from wood. Those renewable fuels include among others black liquor and tree bark. A factory producing paper pulp for sale can be a net exporter of heat and electricity. Production of paper from paper pulp produces much fewer combustible byproducts, while it still requires a large amount of heat and mechanical energy.

6.2. Results

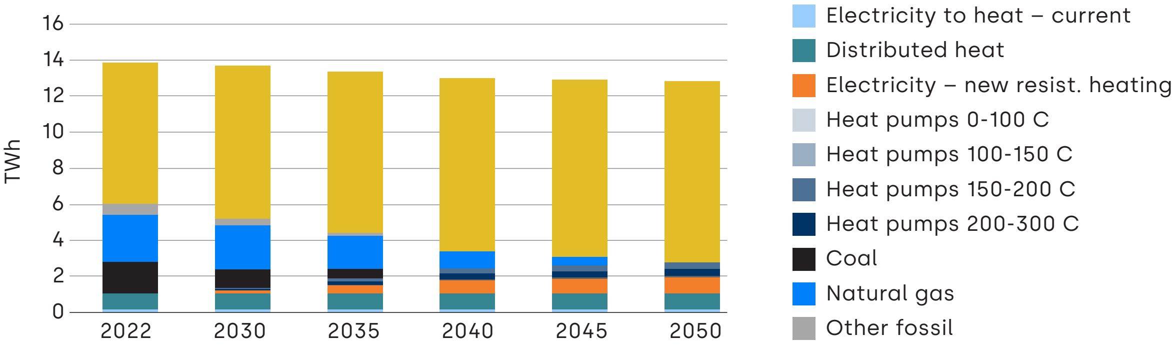
For the paper industry, three scenarios were taken into account. They differ by the inclusion of different final energy carriers into the energy mix of each sector. Summarised results are presented below. More detailed results are presented in Annex 4.

Figure 16. Final energy mix in the paper industry under BAU scenario



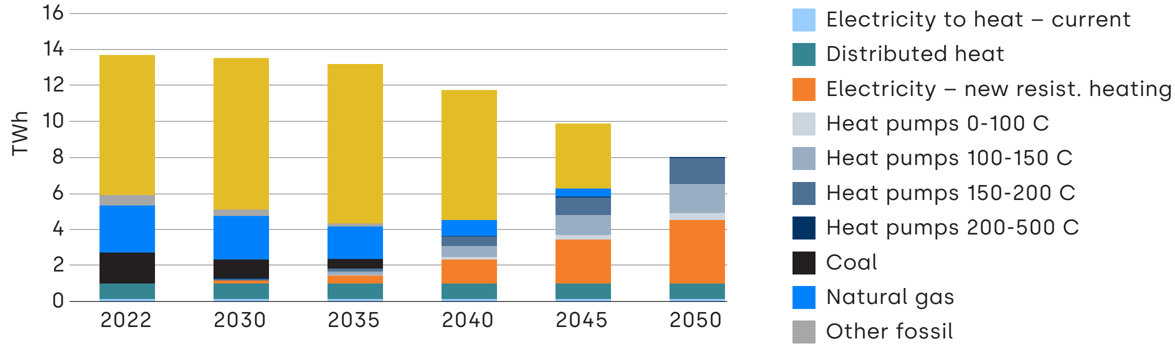
Source: Reform Institute elaboration

Figure 17. Final energy mix in the paper industry under mixed scenario



Source: Reform Institute elaboration

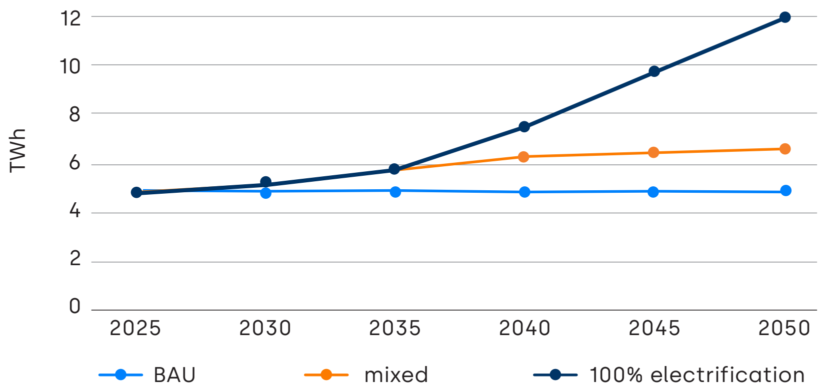
Figure 18. Final energy mix in the paper industry under 100% electrification scenario



Source: Reform Institute elaboration

The mixed scenario for the paper industry involves decarbonisation mainly with biomass. The full electrification scenario sharply increases electricity consumption – almost tripling what is now consumed for all uses.

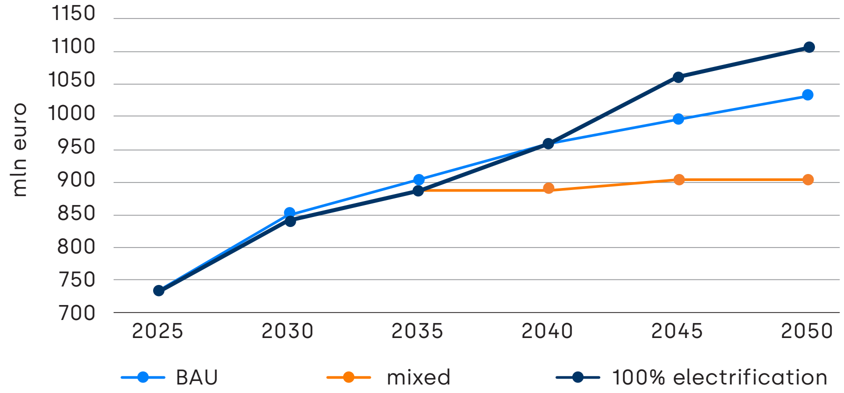
Figure 19. Total electricity consumption in the paper sector in all scenarios



Source: Reform Institute elaboration

The change in heating mix leads has a big impact on the industry's costs. Decarbonisation of the paper industry with biomass and electricity is profitable, while full conversion to electricity is not.

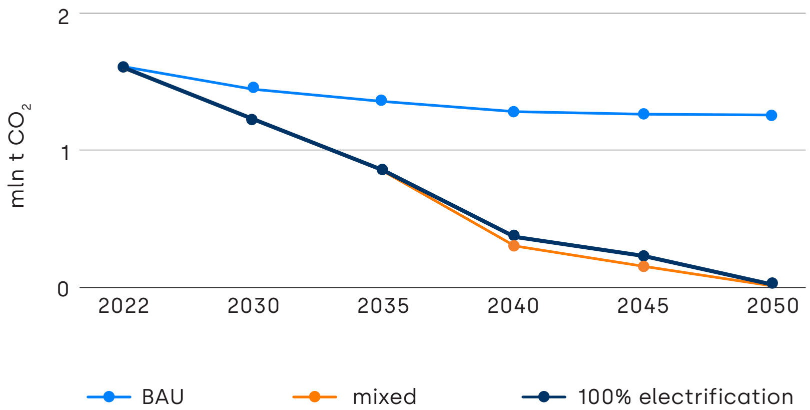
Figure 20. Total costs of heat in the paper sector in all scenarios



Source: Reform Institute elaboration

Two “net-zero” scenarios offer sharply decreasing CO_2 emissions in contrast with the BAU scenario, which includes only the decarbonisation of purchased energy. Since biomass is considered zero-carbon in this study, higher use of biomass leads to slightly lower emissions in the interim, since electricity in the grid will not be completely decarbonised by 2050.

Figure 21. Scope 1 and 2 greenhouse gas emissions in the paper sector in all scenarios



Source: Reform Institute elaboration

7. Electrification in chemical industry

The chemical and pharmaceutical industry is the most diverse of the three analysed. It includes both basic chemicals which are produced in millions of tonnes per year and pharmaceutical products, where annual production may be in kilograms only. Usual feedstocks include fossil fuel molecules, basic minerals and to a smaller degree biomass-derived substances. In this study, "Basic chemicals" were excluded from the calculations, so this section covers only a small part of the overall energy consumption and climate impact of the chemical industry. Details on the assumptions and methods, as well as the results can be found in Annex 2 and 5. Below, the key results are provided.

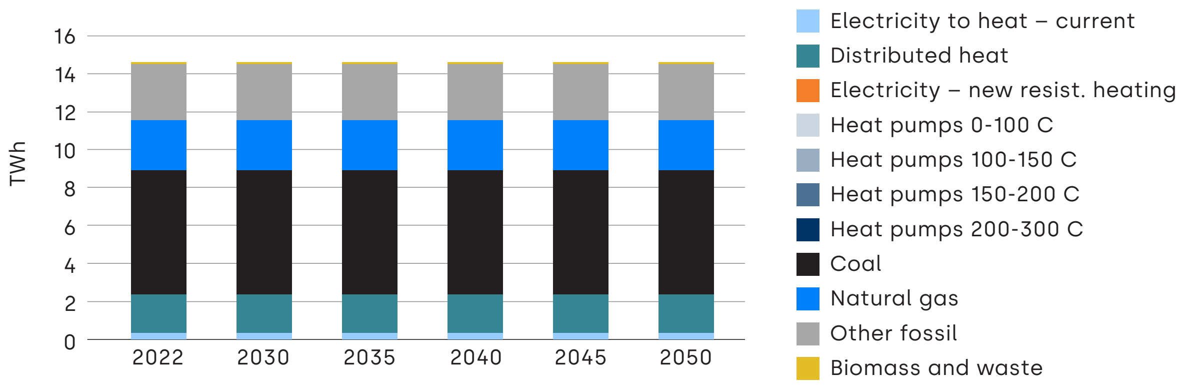
7.1. Assessment of low- and medium-temperature level heat demand in chemical industry

The chemical industry requires vast amounts of heat at very different temperature levels and at very different temperature gradients. The range of products (and process requirements) is very diverse. Some "heat coupling", that is using waste heat from the higher-temperature process to power the lower-temperature process, is possible. This allows to potentially change the temperature range of the process to some extent to achieve heat integration - to reduce energy use or bring energy synergies between various processes. Fairly often waste heat is recovered from the processes at high temperatures, which enables the use of mechanical vapour recompression (of water vapour or other volatiles) and high-temperature heat pumps.

7.2. Results

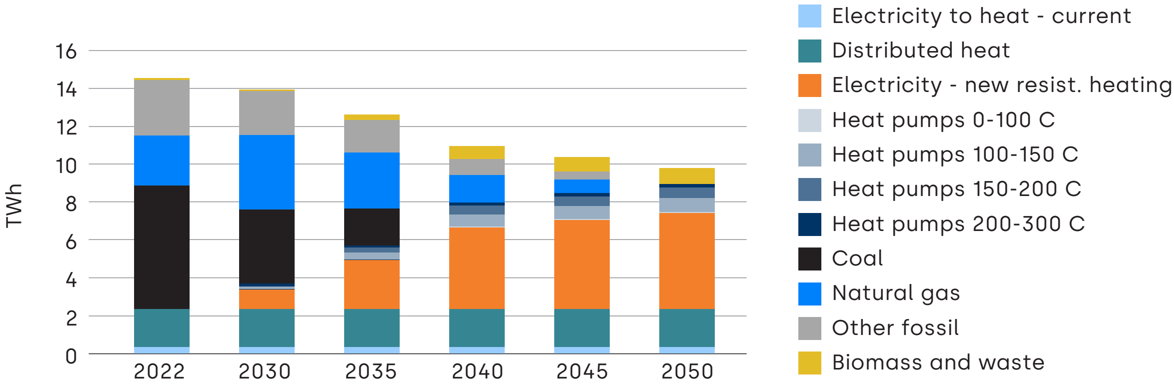
As for the previous two industries, three consecutive scenarios were taken into account. Biomass use was limited to a very small share of the heating mix, even in the "mixed" scenario. For more information, see Annex 5.

Figure 22. Final energy mix in the (part of the) chemical industry under BAU scenario



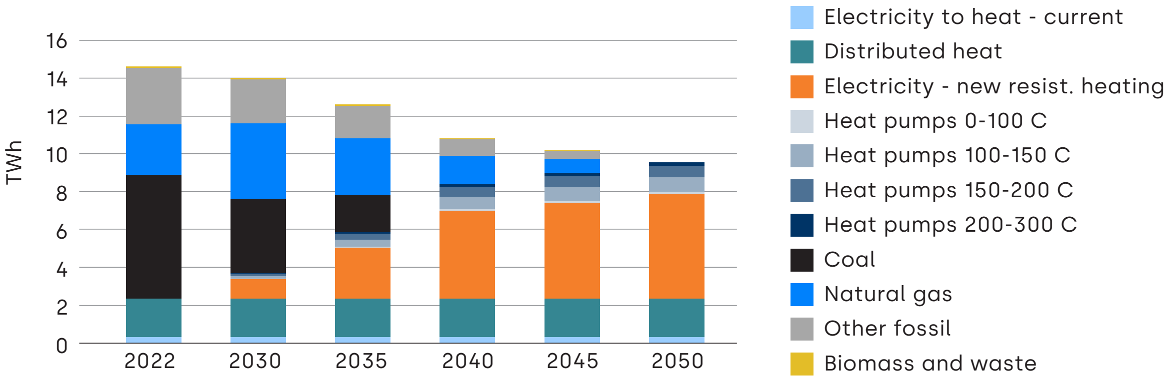
Source: Reform Institute elaboration

Figure 23. Final energy mix in the (part of the) the chemical industry under mixed scenario



Source: Reform Institute elaboration

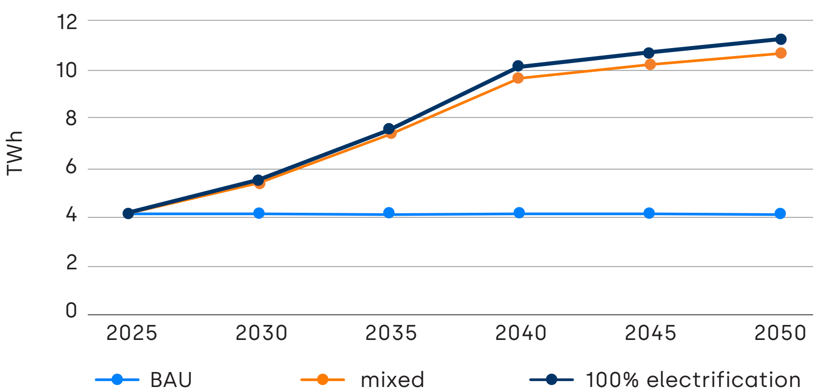
Figure 24. Final energy mix in the (part of the) chemical industry under 100% electrification scenario



Source: Reform Institute elaboration

The chemical industry is to a large extent dependent on relatively high-temperature from fossil fuels right now. Therefore scenarios with decarbonisation based solely or to a large extent on electricity sharply increase electricity consumption – almost tripling what is now consumed for all uses.

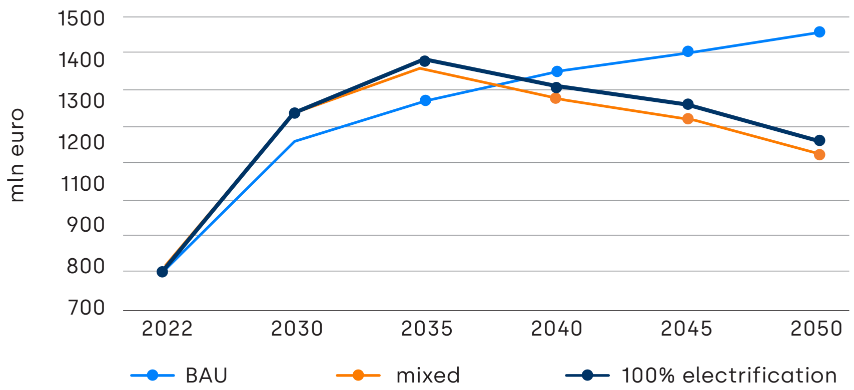
Figure 25. Total electricity consumption in the (part of the) chemical sector in all scenarios



Source: Reform Institute elaboration

The change in the heating mix leads has a big impact on the industry's costs. In the interim decarbonisation increases costs, but in the longer term costs decline, due to a decrease in electricity price and an increase in CO_2 emissions costs under the BAU scenario. This assumes a high price of refinery gas, which should be gradually withdrawn from the energy mix because of the declining role of petroleum products in transport. The limited use of biomass brings tangible cost benefits.

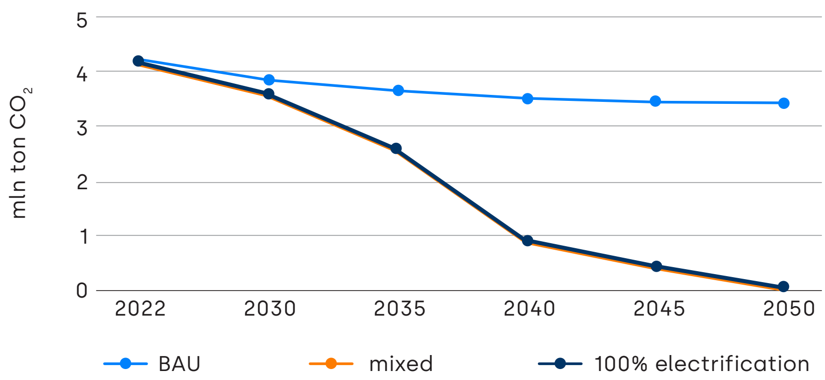
Figure 26. Total costs of heat in the (part of the) chemical sector in all scenarios



Source: Reform Institute elaboration

CO_2 emissions from Scope 1 and 2 are widely different across the scenarios – "mixed" and "electric" scenarios show a sharp decline, while BAU keeps emissions high.

Figure 27. Scope 1 and 2 greenhouse gas emissions in the (part of the) chemical sector in all scenarios



Source: Reform Institute elaboration

8. Summary of scenario analysis results

For every analysed sector it is possible to propose an electrification strategy with full fossil fuel phase-out and net-zero emissions. However, economic results are widely different. The food and beverages industry, which uses mostly low-temperature heat, can be economically decarbonised with or without biomass use. The paper industry requires biomass use (often in the form of process byproducts) to stay competitive. The chemical industry (the part covered by this assessment) suffers from higher costs if decarbonised now, but electrification (with or without small biomass use) will become very profitable after 2040.

9. Barriers and potential risks

9.1. Technical barriers

In terms of technical aspects, both electric boilers and heat pumps are mature, commercially available technologies. However, the economic efficiency of heat pumps greatly decreases with temperature of the heat sink and the temperature difference between the heat source and the heat sink. Moreover, the integration of heat pumps in existing infrastructure is dependent on available heat sources (e.g. waste heat from industrial processes) and may require changes in the on-site production structure. Brownfield investments can also involve risks of longer production stops than the usual yearly refurbishment of existing installations.

The greatest technical challenge in the electrification of industrial heat, however, may prove to be grid infrastructure and the availability of electricity connection capacity. The industrial on-site infrastructure is primarily designed for compatibility with fossil-fuel systems, resulting in high natural gas connection capacities but comparatively low electric connection capacities. The electrification of industrial heat will in almost every case require an increase in the connection capacity of the production facility. This makes potential investment reliant on external factors, such as approving authorities and grid operators, thus resulting in uncertainty and longer lead times.

Furthermore, for a large-scale industrial electrification scenario, the limited number of technology suppliers and contractors could prove to be a barrier, increasing the waiting time for the delivery of components.

9.2. Economic barriers

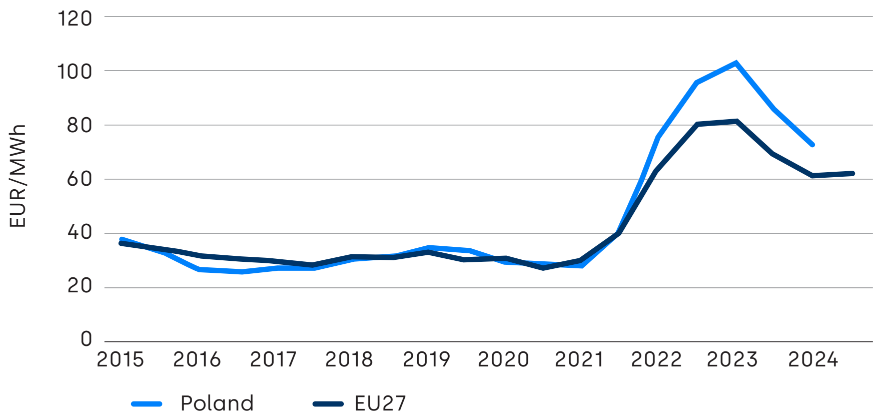
The electrification of industrial heat involves large capital costs, especially for projects integrating heat pumps. CAPEX of high-temperature heat pumps may vary between 959 EUR/kWt and 1933 EUR/kWt (Dumont, Wang, Wenzke, Blok and Heijungs, 2023). Investment costs for electric boilers are much lower, at around 160 EUR/kWt for boilers with capacities up to 10 MW (Zuberi, Hasanbeigi and Morrow, 2022), (Patel, Matalon and Oluleye, 2024).

In most cases, electrification will require upgrading existing electrical connections to the high-voltage grid and installing additional infrastructure on-site, such as transformers. Capital costs of installing high voltage connection range from 85 EUR/kW to 1500 EUR/kW depending on geophysical location (Patel, Matalon and Oluleye, 2024), thus sometimes exceeding the investment costs of the electrified industrial equipment itself.

However, the lion's share of the total costs of ownership (TCO) of a process heat installation is defined by the operational costs (energy costs, CO_2 costs, maintenance costs). Industrial plants therefore will not invest in electrified heat sources if their operating costs are higher than those of conventional sources (primarily gas boilers). The economic feasibility of electrification will therefore depend mainly on fuel prices, electricity prices and CO_2 prices.

The average total costs of gas for large non-household consumers in the second half of 2023 in Poland ranged from 80 EUR/MWh to 105 EUR/MWh. At the beginning of 2024, gas prices for businesses started to decrease, however, they are still at a much higher level than in 2019-2020.

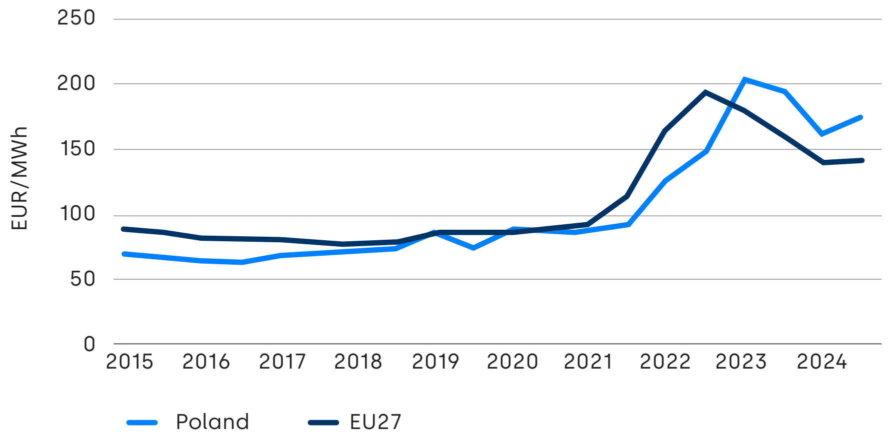
Figure 28. Average gas costs for industry in Poland and the EU



Source: Reform Institute based on Eurostat

Electricity prices in Poland also continue to rise due to the still significant share of fossil fuels in the energy mix and the associated CO_2 costs. The total cost of electricity for the industry reached a historic peak in 2023 at more than 200 EUR/MWh, before falling to around 170 EUR/MWh in 2024.

Figure 29. Average electricity costs for industry in Poland and the EU



Source: Reform Institute based on Eurostat

With a total cost of gas of 90 EUR/MWh and a total cost of electricity of 250 EUR/MWh for the industry in the same period, the cost of heat produced from a heat pump with SCOP of 3 would be lower than the cost of heat produced from a gas boiler even without CO_2 emissions cost.

For these price assumptions, an investment in an electric boiler would only be profitable with a CO_2 price of 750 EUR/t. At the time of the preparation of this report, the CO_2 prices in the EU ETS system were around 60-70 EUR/t.

Subsidies programmes for industrial cogeneration, particularly gas-fired can act as another barrier the decarbonisation of heat since they incentivise continued fossil fuel use. Such subsidies are introduced as part of a climate policy. This however leads to prolonged fossil fuel use and may increase the total emissions of an industrial facility during its lifetime.

In addition to the price of CO_2, the electricity-to-gas price ratio is also of major importance for the cost-effectiveness of electrifying industrial heat. With an electricity-to-gas price ratio between 2.5 and 3.5, the cost of heat from a pump would be similar when compared to the cost of heat from a gas boiler even with low CO_2 prices. Whereas for an electric boiler to have similar operating costs to a gas boiler when CO_2 prices are low, the total cost of electricity would have to be equivalent to the cost of gas.

Therefore, it can be expected that the electrification of industrial heat will take place primarily with heat pumps, but only with sufficiently low electricity costs. Solutions based on the conversion of electric energy into heat suffer from high electricity prices. Options for use of electricity storage and heat storage are limited and suffer from other problems. To reduce the cost of electricity and so improve the cost-effectiveness of replacing a fossil fuel-fired boiler with a heat pump, the industry can invest in its on-site RES. The total operating costs are heavily influenced by the final electricity price for the industry, which partly depends on grid fees and taxes. Taking into account the specific needs of the industry, including its potential for grid services, may increase the profitability of heat electrification.

The industry requires a favourable electricity-to-gas price ratio to electrify, but also a certainty of investment's profitability. Economic uncertainty or financial crises discourage companies from commencing capital-intensive investments and getting ahead of the crowd. Some managers may believe that it is safer to rely on proven and popular technologies, particularly when the market price of the product still depends on the cost of production using mainstream fossil-powered factories.

9.3. Impact on the electricity grid

As the electrification of heat production will lead to a significant increase in electricity demand, it will have a consequential impact on the operation of the electricity grid.

According to the interviews with the paper and food industries, the demand for process heat is relatively constant over time. This means that the electrification of industry without the additional use of on-site energy storage solutions will not change the magnitude of hourly fluctuations in electricity demand, but will only "elevate" the national profile of electricity consumption. Therefore, it may appear that the electrification of industry will not pose major risks to the electricity grid operation. However, a significant increase in electricity demand will necessitate the construction of additional renewable energy capacity and thus increase the scale of the challenges associated with it – primarily the issue of the mismatches between renewable electricity generation and demand.

This means that when planning the large-scale electrification of industry, it is important to consider technological solutions that will support the safe operation of the electricity grid. By providing the flexibility of an electrified industry, we would manage to achieve synergies between large-scale electrification and the development of an electricity system based primarily on renewable energy sources.

Without interfering with the shape of industrial processes, there are two options for ensuring the flexibility of a fully electrified industry - either through on-site electricity storage or on-site heat storage. On-site energy storage would not only have a positive impact on the stability of the operation of the power system but would also help reduce the operational costs of the electrified industrial heat source. Heat storage will be primarily applicable for sectors where the hot water is used as a heat medium. Electricity storage has a more universal character and will be suitable for any industry. Electrified heat sources integrated with on-site RES and electricity storage will be a particularly good solution from the electricity grid perspective, as they will reduce the need for long-distance transmission of electricity and therefore will increase the available capacity of electric distribution lines.

Another solution that can systemically benefit the power system is the utilization of electrification technologies for the Demand Side Management (DSM). This solution could be particularly applicable to the pulp and paper industry, where a relatively large share of heat production is decarbonised through biomass. In this case, an electric boiler could serve as a backup source to the existing biomass boiler and operate only during times of high generation from renewable energy sources, thus reducing the RES curtailment.

This study aims to show a conservative estimate of the possibilities of industrial electrification. For some factories, the deployment of electricity storage, heat storage or DSM may bring substantial benefits. For most baseload uses of heat, this is however not profitable or hardly possible at all. We have therefore included baseload electricity price into the calculation, to simplify the calculation and limit potential errors.

10. EU Regulatory Context

Poland's energy and industrial transformation policy is shaped by the wider context of the EU legislation stemming from the European Green Deal strategy, and from 2025 onwards – Clean Industrial Deal. The end goal of climate neutrality by 2050 requires intermediate planning for the next steps of decarbonisation. Towards the end of the previous Commission's term of office, the first measures to further support industrial transformation were adopted, including the EU Net-Zero Industry Act (NZIA), and further legislation has been identified as an important priority for the new Commission under the Clean Industrial Deal. Finally, legislation on the circular economy can play a supporting role in mobilising and facilitating the transition to greener technologies in industry. The 2040 target is currently under discussion. The key elements of the EU legislation that are most relevant to national industrial policies and promoting the transition are briefly outlined below.

10.1. Fit for 55 package

General emission and energy use targets

The overall reduction target for GHG emissions to be achieved in 2030 is set at 55% compared to 1990 levels. In the ETS sectors, the reduction is to be 62% compared to 2005 levels, and in other sectors 40%, with specific national contributions outlined for individual Member States (Poland currently has a declared contribution of 18.2% reduction).

The share of renewable energy sources in the EU's total final energy consumption should reach 42.5% (with 45% as the recommended target). Poland has tentatively reported a 32.6% national contribution to this target. Specific national targets have been set for electricity generation, buildings, the heating and cooling sector, industry and transport.

The energy efficiency targets are to ensure that primary energy consumption is reduced to no more than 992.5 Mtoe across the EU by 2030 (for Poland the indicative national contribution is 79.9 Mtoe, and 14.4% savings compared to the PRIMES 2020 scenario) and no more than 763 Mtoe in final energy consumption (Poland's indicative contribution is 58.5 Mtoe and 12.8% savings compared to the PRIMES 2020 scenario).

Together, these targets imply the need for changes in many sectors of the EU economy to reduce emissions, decrease energy consumption and replace fossil fuels with renewable energy generation, thus becoming key drivers for the electrification of EU economies, including industry.

EU Emission Trading System (ETS 1 and ETS 2)

Increased emission reduction target (from 43% to 62% compared to 2005 levels), an adjusted trajectory of the annual reduction in the overall cap of emission allowances on the market together with a gradual phaseout of free allowances allocations between 2026-34 will increase the financial pressure to cut emissions in covered industries. The inclusion of fuel-related emissions from small industry under ETS2 will put pressure on smaller-scale industries to decarbonise their operations and value chains, even though, for the time being, the emission from industrial processes of such entities will not be covered.

Carbon Border Adjustment Mechanism (CBAM)

The Carbon Border Adjustment Mechanism, which will put a price on embedded emissions of imports of six types of commodities: steel, cement, aluminium, hydrogen, energy, and fertilisers, will attempt to prevent carbon leakage and level the playing field for EU's domestic producers in the covered sectors. CBAM is intended to limit the possibility of industries to circumvent emission controls with imports, thus requiring investments into their own cleaner capacities, including via the electrification of processes.

Revised Renewable Energy Directive

REDIII introduces industry-specific targets: an indicative target of a 1.6 percentage point annual increase in the share of renewable energy used by industry by 2030 and a target of at least 42% of industrial hydrogen use coming from non-biological renewable sources by 2030 and at least 60% by 2035. This will have a direct effect on the proliferation of electrification technologies across the industry. Furthermore, the application of the cascading principle of biomass use will reduce the energy use of biomass to a last-resort measure, limiting the availability of biomass for energy generation and forcing industries reliant on that resource to adjust their processes accordingly.

Revised Energy Efficiency Directive

Aside from the general target for Member States to collectively reach an 11.7% reduction in energy consumption by 2030, the Directive includes an industry-specific target of an increased contribution to annual energy saving of 1.5% (up from 0.8%). Combined with a requirement to apply the "energy efficiency first" principle and the requirement for large companies to conduct energy audits at least every four years or implement energy management systems, these measures shall be conducive to the prioritisation of electricity in industrial energy generation and industrial processes.

Financing

Increased revenues from the EU ETS, as well as financing instruments such as the Innovation Fund, Modernisation Fund and Just Transition Fund, shall improve the availability of funding for the development and commercialisation of energy innovation. Funds from these instruments fuel current and future national support schemes supporting green and to a lesser extent, industrial transition.

10.2. Clean Industrial Deal

The CID was announced as a strategy and legislative package to adjust the implementation directions of the European Green Deal initiated during the previous European Commission's term of office, seeking to combine the latter's climate objectives with an increased focus on competitiveness and transformation of the EU's industrial base. The CID was published on 26 February 2025. At the same time, the first new regulatory initiatives complementing the European Green Deal with industrial issues (including the NZIA) were adopted back at the end of the previous European Commission's term of office, as part of the Green Deal Industrial Plan.

Net Zero Industry Act (NZIA)

The purpose of NZIA is to enhance the EU's manufacturing capacity for net-zero technologies (including final products, components, and manufacturing machinery) in order to facilitate the transition towards a green and circular economy based on the increased share of domestic EU production. The act states that:

- the Union's overall strategic net-zero technologies manufacturing capacity shall approach at least 40% of annual deployment needs by 2030,
- decarbonisation of energy-intensive producers of key industrial materials (steel, cement, chemicals) is to be encouraged,
- regulatory framework for the manufacturing of green technology, permitting procedures and support schemes is to be facilitated and streamlined, primarily through the establishment of net-zero strategic projects and Net-Zero Europe Platform,
- non-price criteria of sustainability and resilience are to be established as basic criteria in relevant public procurement and for 30% of volume in renewable energy auctions (along with social sustainability, cyber security and timely delivery obligations).

The Act covers the key technological areas, such as:

- solar photovoltaic and solar thermal technologies,
- onshore and offshore renewable energy technologies (including wind),
- battery/energy storage technologies,
- heat pumps and geothermal energy technologies,
- hydrogen technologies, including electrolysers and fuel cells,
- sustainable biogas/biomethane technologies.

Industrial Decarbonisation Accelerator Act (IDAA)

IDAA has been announced as a preliminary legislative proposal aimed at expediting the decarbonisation of energy-intensive industries. It should have at least an indirect positive impact on industrial electrification via such measures as:

- setting green product share quotas in the lead markets (e.g. green steel in the automotive sector and green cement for construction sector),
- improving the conditions for industrial operators investing in green technologies,
- streamlining of permitting procedures for industrial decarbonisation projects.

European Competitiveness Fund and the Competitiveness Coordination Tool

The European Competitiveness Fund should create a more streamlined funding ecosystem for innovation through a merger of 11 existing financing instruments, including elements of Horizon Europe, Innovation Fund, InvestEU and European Defense Fund. The Coordination Tool proposal is based on Draghi's report's observations and seeks to coordinate national policies towards contributing to the overarching EU competitiveness goals, synchronise industrial policies, optimise resource allocation, create more uniform standards for performance assessment and provide tools for the Commission to identify and help solve structural issues in the specific markets.

10.3. Circular Economy

Revised Industrial Emissions Directive (IED 2.0)

Aiming to minimise pollution from industrial installations, IED, under the Integrated Pollution Prevention and Control Approach, requires operator of such installations to employ the best available technologies. Under the criteria outlined in the Directive and its Annexes, (emission intensity and limits for NOx, SO and particulate matter, energy efficiency reduction of waste), electrification technologies such as heat pumps or electric furnaces can qualify as BAT with relative ease.

Chemical Industry Package

The Package is a forthcoming legislative initiative aimed at enhancing the competitiveness and sustainability of Europe's chemical sector. Its backbone is the Transition Pathway for the Chemical Industry, published in January 2023 and developed in cooperation with Member States and relevant stakeholders. It seeks to decrease the role of fossil fuels in the chemicals sector and increase the role of renewables (with electricity as a logical replacement), increase the safety and sustainability of production with re-use and recycling, align with the updated EU industrial strategy and deliver on the commitment to the sector's climate neutrality by 2050. The package's objectives also include:

- simplifying the Registration, Evaluation, Authorisation, and Restriction of Chemicals (REACH) process for downstream users, article manufacturers, and importers,
- supporting the development of markets for sustainable carbon and improving the competitiveness of the chemical industry.

Other EU acts regulating the circular economy

The Waste Framework Directive and Waste Shipment Directive create a waste disposal framework that is conducive to recycling and re-use of critical materials or equipment necessary for electrification and encourages the capture and use of waste energy, such as heat, thus indirectly leading to improved market availability of relevant solutions and optimised use of resources at hand. The revised Battery Regulation regulates sustainable production, recycling, and disposal of the key components for technologies powered by electricity, seeking to create a sustainable lifecycle for them.

11. Support schemes for industry

Existing financial measures benefitting industry in Poland mainly include support for the development of RES, high-efficiency cogeneration and the improvement of energy efficiency.

No support instruments directly dedicated to supporting the electrification of the industry have been identified at this time. However, an investment in a heat pump using waste heat from technological processes is among the investments that improve energy efficiency and could therefore be supported under the "Support for Energy Intensive Industries" and the "Energy-intensive industry – improvement of energy efficiency" programmes funded under the Modernisation Fund, as described below.

Some of the programmes allow for the construction of new cogeneration plants burning fossil fuels. This is an outdated solution, given that a partial decrease in fossil fuel usage will not bring us to climate neutrality. The emission intensity of electricity in the grid will soon be lower than even the most efficient on-site fossil fuel boiler.

Below we present schemes and programmes to which industrial producers can apply for financial assistance that could help them implement electrification measures and projects.

11.1. Domestic Funds

Energy Plus programme: A financial instrument for companies that includes support for the decarbonisation of energy sources[9]. So far, four editions of the programme have been held. Support under the programme included the modernisation of installations leading to a reduction in the consumption of raw materials and emissions, as well as the construction of power generation units using renewable energy, waste heat, cogeneration (excluding coal cogeneration), low-carbon gas fuels and hydrogen. Beneficiaries of the programme could receive loans ranging from PLN 0.5 million to PLN 500 million. The budget for the 4th edition of the programme amounted to PLN 567 million.

9 NFOŚiGW (2024), Nabór IV wniosków 2023-2024.

11.2. EU Modernisation Fund

Poland is the biggest beneficiary of the EU Modernisation Fund[10] (34% of the allocation), which is intended to support the decarbonisation of the economy, via the improvement of energy efficiency, and investments in RES and storage. The Fund was launched in 2021 and since then Polish operator – NFOŚiGW – has prepared several schemes that can support the decarbonisation of the industry. In total available support amounts to EUR 1.9 bn.

10 Modernisation Fund (2025), How it works.

Key programs:

Energy Intensive Industries – RES programme (pol. Przemysł energochłonny – OZE).[11] The facility financially supports investments in the construction or conversion of electricity generation units from renewable energy sources together with energy storage or their connection to the plant and/or distribution/transmission grid. The condition for support for an energy storage facility is that it is integrated with the energy source to be implemented in parallel as part of the investment. Support includes co-financing in the form of a loan of up to PLN 650 million.

11 NFOŚiGW (2025), Przemysł energochłonny – OZE.

Cogeneration for Energy and Industry programme (pol. Kogeneracja dla Energetyki i Przemysłu)[12]. The programme supports investments involving the construction and/or reconstruction of generating units with a total installed capacity of not less than 10 MW, operating under high-efficiency cogeneration conditions (excluding energy generated in a coal-fired cogeneration unit), together with their connection to the transmission network, where energy production uses either:

12 Fundusz Modernizacyjny (2025), Kogeneracja dla Energetyki i Przemysłu - II nabór wniosków.

- waste heat,
- energy from renewable sources,
- gaseous fuels, gas mixtures, synthetic gas or hydrogen.

Installations from which no more than 30% of the useful heat generated in the cogeneration unit will be released into a public district heating network are eligible. Installations co-firing solid fossil fuels with other fuels (e.g. biomass) in multi-fuel combustion installations as well as dedicated multi-fuel combustion are excluded from support.

Support includes:

- co-financing in the form of a loan (overall budget: PLN 2 billion),
- co-financing in the form of a grant (overall budget: PLN 1.5 billion).

Energy-intensive industry – improvement of energy efficiency (pol. Przemysł energochłonny – poprawa efektywności energetycznej).[13] The investments eligible for funding under the priority programme are primarily those involving:

13 NFOŚiGW (2025), Przemysł energochłonny – poprawa efektywności energetycznej.

- construction of installations for the recovery of technological heat and its use in further technological processes;
- increasing energy efficiency resulting in a reduction in the consumption of electricity drawn from the grid, including the construction of IT systems for the supervision of energy consumption, production and storage with the function of optimising energy management.

The instrument includes co-financing in the form of a loan (pool PLN 350 million).

Support for Energy Intensive Industries programme (pol. Wsparcie dla Przemysłu Energochłonnego)[14]. The instrument is intended to support, among other things:

14 NFOŚiGW (2025), Wsparcie dla przemysłu energochłonnego.

- energy efficiency improvement projects;
- projects for the construction or conversion of renewable energy generation units with energy storage or connection to the on-site and/or distribution/transmission grid.

Instrument includes co-financing in the form of a loan (total budget up to PLN 4 billion).

11.3. Other EU Funds

Additionally, structural EU Funds can cover measures that are complementary to electrification and support R&D needed to develop solutions.

Table 2. Overview of support schemes for environmental projects and energy research and development programmes

Funds	Description
European Funds for Infrastructure, Climate, Environment 2021-2027 (FEnIKS)	Its main objective is to improve the country's development conditions by building technical and social infrastructure in line with sustainable development. It is an extremely important tool for the implementation of Poland's energy, climate and environmental policies. It supports, among others, the increase in energy efficiency, reduction of greenhouse gases and adaptation to climate change. The total budget earmarked for investments and undertakings is almost EUR 29.3 billion. The EU funds available under FEnIKS 2021-2027 for the energy sector amount to EUR 6.08 billion and for the environment sector to EUR 3.67 billion.
EU Operational Programme Intelligent Development	It is another important source of the EU funding for research and development in Poland. It provides funding to entrepreneurs and scientists to support research and development projects aimed at commercialising technologies, products and services. The programme budget amounts to around EUR 10 billion. Support includes, among others, greening of enterprises and implementation of projects within the Strategic Technologies Platform for Europe (STEP).
Norwegian and EEA Funds - Environment, Energy and Climate Change Programme	The Programme aims to mitigate climate change and reduce vulnerability to climate change. The programme will support efforts to decarbonise the economy. The aim is to build a more resilient society living sustainably. The programme will additionally fund research and innovation, justice, improving resilience to natural disasters, culture and natural heritage and local development. The total volume of funds committed to the Programme in the environment sector will be approximately EUR 160 million. The main source of funding for the Environment, Energy and Climate Action Programme is the Financial Mechanism of the European Economic Area (EEA). Support is supplemented by the national budget.

11.4. Planned measures for industry

The draft National Energy and Climate Plan does not present support instruments directly dedicated to industrial electrification. The planned instruments are mainly aimed at supporting:

- construction of RES installations;
- improvement of energy efficiency
- high-efficiency cogeneration;
- development of hydrogen production;
- development of Small Modular Reactors (SMRs).

The overview of measures planned for industry in Polish NECP is in the Annex 6.

12. Recommendations

Economic solutions

Industry in the European Union has to remain competitive and as any other branch of the economy, has to react to financial stimuli. A successful strategy of electrification shall envision shaping the economic environment of the industry to make electrification reliably the most profitable solution. That should include:

- Long-term planning of the energy transition with clear pathways of prices of major energy carriers and the cost of their adoption – creates macroeconomic stability and incentivises long-term investments.
- Dedicated support schemes for electrification of industrial heat, designed to fill gaps between the cost of continued fossil fuel use (if lower) and electrification – creates economic viability of early adoption.
- Incentives for on-site heat storage and electricity storage for the benefit of the stability and economic efficiency of the electricity grid – improves stability and competitiveness of grid electricity.
- Auctions for decarbonised (particularly electrified) heat – a tool to kickstart decarbonisation in selected applications closest to non-subsidised commercial viability.
- More elastic grid fees for electricity – to incentivise more flexible electricity use, particularly for electric boilers connected to heat storage.
- Equal pricing of greenhouse gas emissions from the Scope 1, Scope 2 and from international competitors – to level the playing field.
- Cessation of subsidies for continued fossil fuel use, such as subsidies for fossil energy (including from local cogeneration), subsidies for fossil fuel extraction and artificial lowering of energy prices subsidised from state budget – to cancel unfair competition from companies still using fossil fuels.

Regulatory and strategic solutions

These measures address the second barrier, which is inadequate and/or unstable legislation.

- RES legislation should be revised to simplify RES development in industrial sites – that would provide business opportunities for many degraded sites.
- Legislation on onshore wind should be liberalised to allow for placement of wind turbines 500 meters from buildings and other protected sites – this will greatly increase onshore wind potential and decrease electricity price for everyone.
- Direct electricity lines regulation should be revised to ease their construction and to provide actual economic benefits for bottom-up RES development.

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