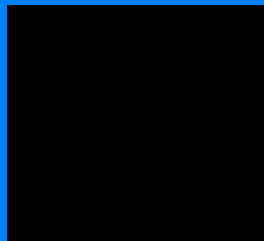
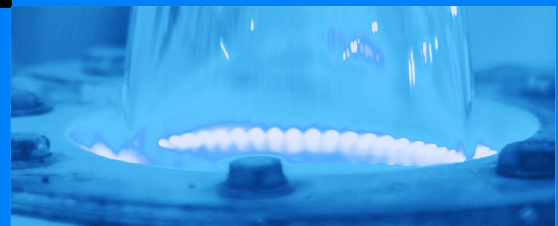
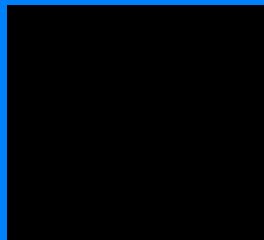


# Energising industry #3

## Electrification on the map of zero-emission solutions for energy-intensive industries

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Warsaw 2025



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**Date of publication**

June 2025

**Recommended citation:**

Janik, K., Anczewska, M. (2025); *Energising industry #3. Electrification on the map of zero-emission solutions for energy-intensive industries*, Warsaw, Poland: Reform Institute.

Source of cover photo: tunart/iStock

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## Executive summary

### Context of the transition

Poland and Europe cannot achieve their climate and energy-transition goals without accelerating the decarbonisation of energy-intensive industries. Yet these sectors depend heavily on the pace of power-system transformation. Without sufficient green electricity, industry cannot reach carbon neutrality. It is therefore essential to accurately assess the volume of zero-emission electricity required to decarbonise industry under potential transition scenarios.

### Key barriers to the decarbonisation of energy-intensive industries

Almost all energy-intensive industries have a high demand for high-temperature heat. The number of mature clean technologies capable of producing such heat is limited. Moreover, many industries remain heavily reliant on the non-energy use of fossil fuels or generate process-related CO<sub>2</sub> emissions that cannot be eliminated without altering the underlying industrial processes. Technologies essential for decarbonising these sectors – such as green hydrogen and carbon capture and storage or utilisation (CCS/U) – are still awaiting commercialisation. Direct electrification, meanwhile, faces economic barriers due to the unfavourable price ratio between electricity and gas.

### Electrification as a path to reducing emissions

Despite these challenges, solutions to reduce emissions in energy-intensive industries can be implemented in the short and medium term. High-temperature heat production can be partially decarbonised through direct electrification (electric and arc furnaces, electrode boilers, heat recovery systems) and through the use of biofuels (biomass, biogas, biomethanol).

Direct electrification will be a viable transition pathway for many industries, including chemicals, cement, ceramics, glass and metallurgy. Decarbonising the chemical industry will require not only zero-emission electricity but also significant volumes of renewable hydrogen and synthetic fuels (e.g., green ammonia and green methanol). For mineral materials – such as in the cement, ceramics and glass industries – CO<sub>2</sub> capture installations will be essential for reducing process emissions.

In steel production, carbon neutrality can be achieved in three ways: by applying carbon capture in traditional steelmaking processes, by producing recycled steel in electric arc furnaces from scrap, or by producing primary steel in electric arc furnaces from directly reduced iron.

## European support framework

At the European level, industrial decarbonisation has become one of the main priorities of economic policy. The European Union is developing a systemic framework and strategies to reduce energy costs, support the growth of clean technologies, and strengthen the competitiveness of European companies. The proposed initiatives give Member States greater flexibility in granting state aid to industrial plants, offer tools to facilitate access to renewable energy, and provide both financial and non-financial support (e.g. through tender criteria) for investments in low-carbon technologies in Europe. Taken together, these measures aim to ensure that industry makes an appropriate contribution to the decarbonisation of the economy by 2030.

## Strategic gap in Poland

Efficient utilisation of available EU funds and the deployment of new regulatory tools require systematic planning at the national level. However, Poland still lacks a national strategy for industrial decarbonisation, as well as a coherent approach to key technologies such as hydrogen, CCS/U and direct electrification.

Several strategic documents are currently being prepared, including the National Energy and Climate Plan and the Strategy for the Development of Poland until 2035. However, these strategies focus mainly on changes in the energy sector and fail to consider the growing demand for green electricity necessary for industrial transformation. Although they acknowledge the need for industrial decarbonisation, they do not present a detailed vision of transition pathways for individual sectors, particularly distinguishing between energy-intensive industries and low- and medium-temperature industries. Moreover, the role of the state in steering industrial decarbonisation is not clearly defined.

This creates a serious strategic gap for planning the electrification of production processes, advancing the development of technologies such as CCS/U, and building competitive advantages in selected clean-technology domains. It may also hinder the optimal use of EU funds available for clean industry under the new MFF and tools related to the CID.

## Industrial policy is a prerequisite for effective transformation

If Poland is to preserve its energy-intensive industries, it must develop a coherent set of sectoral strategies. First, a national industrial strategy is needed to provide the foundation for hydrogen and CCS/U strategies. The objectives and actions outlined in these documents should then be reflected in the ongoing update of the National Energy and Climate Plan and subsequently incorporated into the preparation of Poland's Energy Policy 2040 and the Transmission System Development Plan.

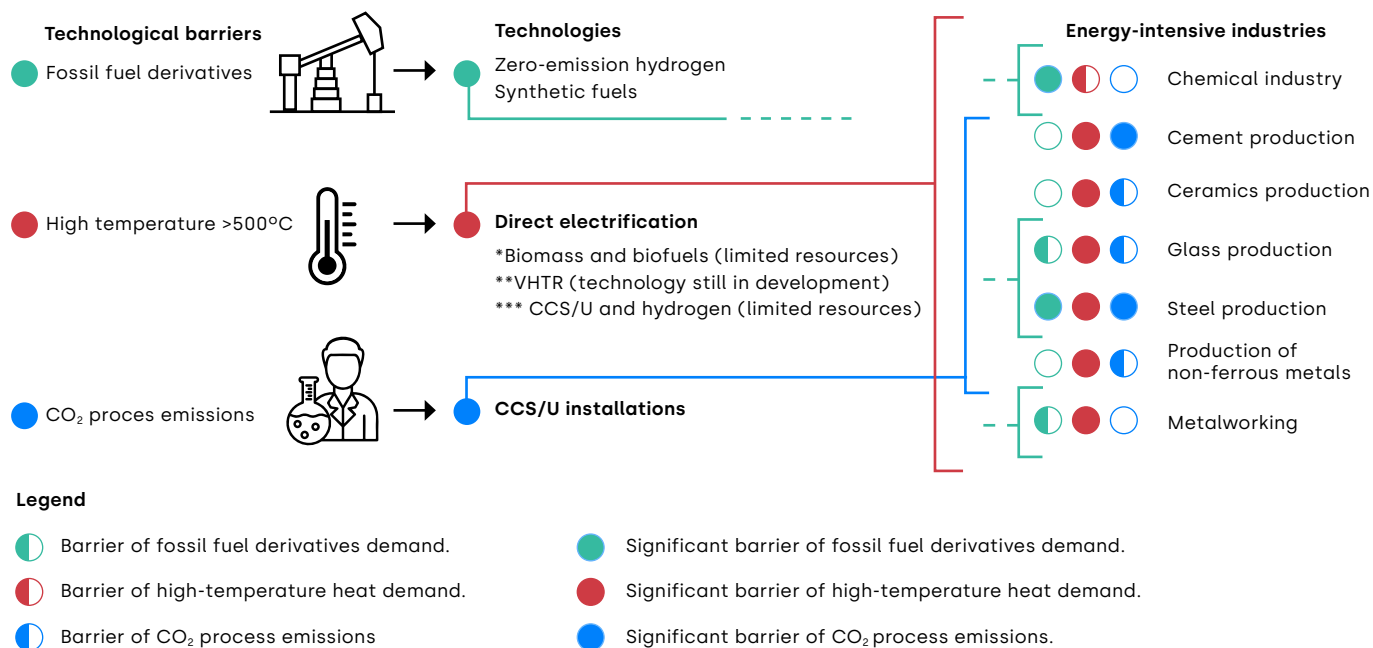
Informed decisions about the direction of national industrial policy are essential for setting realistic goals for power system development. Industrial decarbonisation and the transformation of the power system are interconnected vessels that shape our energy security and economic resilience.

## Conclusions

**The range of zero-emission technologies for energy-intensive industries is broad, and direct electrification is an integral part of it.**

Due to the complexity and diversity of technological processes in energy-intensive industries, the decarbonisation in each sector may require different set of technologies. Among them, the most important are: zero-emission hydrogen, CCS/U and direct electrification.

**Figure 1. Summary of the most significant technical barriers for energy-intensive industries and the corresponding zero-emission technologies**



Source: Own study by the Reform Institute

Below is a summary of potential decarbonisation pathways for various energy-intensive industries. Direct electrification technologies, such as electric furnaces, play a significant role in most decarbonisation scenarios.

**Table 1. Summary of potential decarbonisation pathways by energy-intensive industry**

Sector	Potential decarbonisation pathways	Electrification technologies	Comments
Chemical industry	zero-emission hydrogen + direct electrification	electrode boilers, MVR-HP technology	Hydrogen demand in the chemical industry is nearly 0.4 million tonnes/year. Producing this amount of hydrogen via electrolyzers would require approximately 20 TWh of electricity. An alternative option is to import green ammonia and green methanol.
	green ammonia and methanol + direct electrification		
Cement production	direct electrification + CCS/U technology	rotary electric furnaces	Process emissions require CCS/U. Another approach would be to research and develop new methods of cement production using alternative raw materials such as silicates. Direct electrification has the potential to reduce CO <sub>2</sub> emissions by approximately 40%.
	alternative raw materials + direct electrification		
Ceramics production	direct electrification + CCS/U technology	electric kilns, hybrid installations	Process emissions account for only 20% of emissions from ceramic production. This means that direct electrification has the potential to reduce CO <sub>2</sub> emissions by up to 80%.
Glass production	direct electrification + CCS/U technology	electric furnaces, hybrid installations	Process emissions account for only 20% of emissions from glass production. This means that direct electrification has the potential to reduce CO <sub>2</sub> emissions by up to 80%.
Steel production	scrap + electric arc furnace	electric arc furnace, plasma furnace, electrolysis	Electric arc furnace technology has been commercially available for years and requires scrap or directly reduced iron (DRI) as feedstock. Domestic DRI production would demand large volumes of hydrogen and, consequently, green electricity. DRI could also be obtained through imports.  Other possible pathways include steel electrolysis – which would require substantial amounts of electricity – or the implementation of CCS/U in the traditional steel production process.
	DRI import + electric arc furnace		
	DRI production using hydrogen + electric arc furnace		
	hydrogen plasma reduction		
	steel electrolysis		
	traditional blast furnace + CCS/U technology		
Aluminium production	rotary electric furnaces + electrolysis (currently used process) + CCS/U technology	rotary electric furnace, electrolysis	Direct electrification could reduce CO <sub>2</sub> emissions from aluminium production by as much as 75%. Reducing the remaining process emissions would require CCS/U technology or research and development of alternative analysis process.
	rotary electric furnaces + electrolysis (alternative process)		
Metal processing	direct electrification	electric furnace, induction furnace	Direct electrification could enable the reduction of all CO <sub>2</sub> emissions from metalworking processes.

Source: Own study by the Reform Institute

### **One thing is certain – energy-intensive industries will need large volumes of zero-emission electricity**

Although the final configuration of zero-emission technologies in energy-intensive industries is difficult to predict, transforming this sector will require substantial investment in renewable and zero-emission energy generation. However, the current assumptions in the National Energy and Climate Plan are insufficient considering the growing demand resulting from:

- the direct electrification of industrial processes;
- hydrogen production in electrolyzers;
- the operation of CCS/CCU installations (liquefaction and injection of captured CO<sub>2</sub> requires the operation of compressors and pumps, which are powered by electricity).

The decarbonisation of energy-intensive industries is a long-term challenge. Some technologies will not be commercially available until 2040–2050, which further underscores the importance of strategic planning. It is now necessary not only to support research and development activities but also to determine the required pace of power system decarbonisation. We must identify potential decarbonisation pathways for individual sectors with realistic assumptions regarding both indirect and direct electrification.

### **We need to develop a coherent set of sectoral strategies as soon as possible**

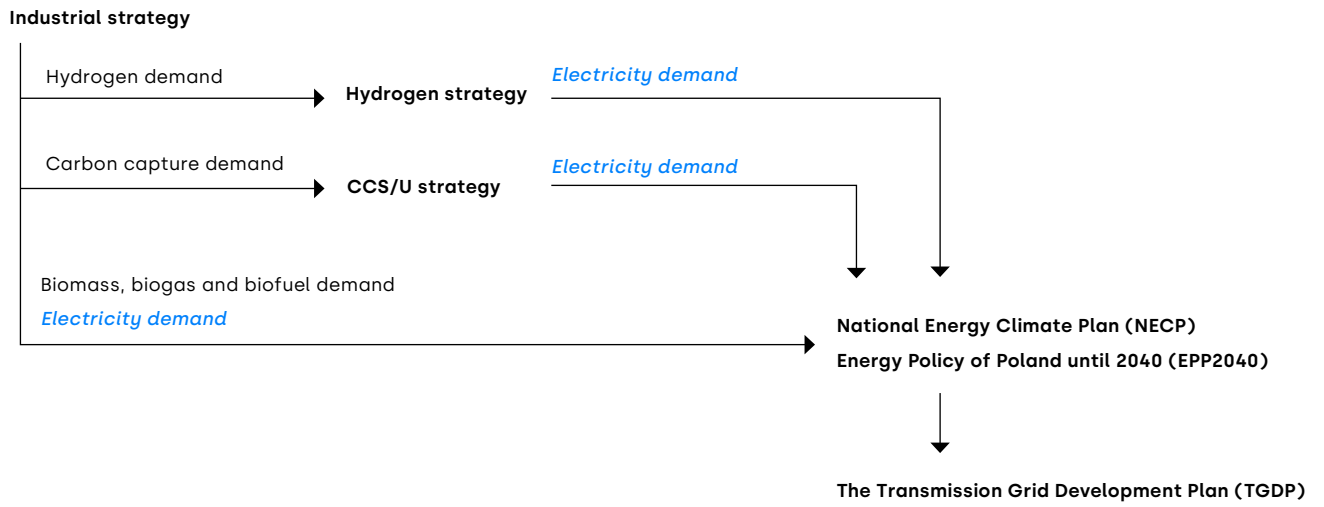
In the 2025–2028 perspective, the priority is to prepare an industrial strategy that systematically maps electricity demand for the alternative decarbonisation pathways of energy-intensive industries.

The chemical, mineral (cement, glass, ceramics) and metallurgical industries should undergo in-depth analysis. These assessments should determine, the demand for:

- zero-emission electricity;
- hydrogen (including domestic and imported);
- CO<sub>2</sub> capture;
- imports of green ammonia and methanol;
- DRI imports.

This assessment should form the basis for the national hydrogen strategy and the national strategy for CCS/U. Together with the industrial strategy, they should inform updates to the NECP and Poland's Energy Policy 2040 – specifically the targets for renewable and nuclear electricity generation, as well as the grid development objectives in the Transmission Grid Development Plan. These strategies should also support Poland's active participation in shaping European industrial policy and ensure adequate support for Polish companies under new EU financial instruments. ■

**Figure 2. Structure of dependencies between national sectoral strategies**



Source: Own study by the Reform Institute

