EU industrial competitiveness: measures to address power sourcing costs whilst fostering decarbonisation

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Context and objectives: IDDRI, Agora Energiewende & Agora Industry aim to inform the EU debate on possible measures to support industrial competitiveness and decarbonisation

Study context

- The 2021-2022 European energy crisis substantially worsened the historical energy cost gap for industrials located in Europe compared to other major trading partners such as the US and China.
- The policy objective to preserve industrial competitiveness led many European countries to implement a range of uncoordinated measures to reduce energy costs for some industrial sectors.
- The European Commission (EC) recently put in place the Clean Industrial State Aid Framework (CISAF), in order to provide guidelines for Member States to support the decarbonisation and competitiveness of industry. The EC also plans to strengthen the Innovation Fund and create an Industrial Decarbonisation Bank.
- Understanding how energy cost differences affect the competitiveness of different industrial sectors in the context of decarbonisation is key to assessing potential gaps in the current policy toolbox and defining a more structured and coordinated framework.

Key questions for the study

1. How do energy prices affect the competitiveness of different industrial sectors and decarbonisation incentives?
2. What are the main reasons for the competitiveness gap between the EU, Chinese and American industries, and what factors contribute the most?
3. What measures are or could be implemented to address issues of energy cost competitiveness in the context of decarbonisation?

Our mandate: Provide economic evidence regarding energy cost competitiveness and decarbonisation for different industrial sectors and map the current policy toolbox

The study is structured around 3 workstreams addressing the three sets of questions:

1. **Develop a framework using relevant criteria to assess the degree of exposure of different industrial sectors to competitiveness issues in relation to energy costs.**

2. **Compare unit production costs for 5 industrial sectors in the US, China and selected EU countries and analyse competitiveness issues related to energy costs as well as other factors affecting competitiveness.**

3. **Analyse the existing policy toolbox in Europe to address energy cost issues affecting the competitiveness of industrial sectors, identify gaps and possible improvements to the current approach to address competitiveness and decarbonisation issues.**

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1.

A framework to assess the exposure of different industrial sectors to competitiveness and decarbonisation issues

Methodology – we consider several indicators to assess different industrial sectors' exposure to competitiveness and decarbonisation issues

- **We follow a 3-step methodology with the following objectives**:

1 **Analyse exposure of different industrial sectors to energy costs competitiveness**	▪ Select relevant indicators for the assessment ▪ Compute indicators for 16 applications
2 **Model exposure of different industrial sectors to energy costs competitiveness issues in the context of decarbonisation**	▪ Select relevant indicators for the assessment ▪ Compute indicators for 16 applications
3 **Define a framework to grasp sector-specific competitiveness and decarbonisation issues**	▪ Combine relevant indicators to provide a framework capturing the different dimensions of the competitiveness challenge ▪ Provide an example of a possible visualisation tool for the different indicators

Methodology – We perform the analysis over 16 applications / products in 9 industrial sectors

- We produce an assessment of the vulnerability of EU industries to competitiveness and decarbonisation issues based on 16 applications selected with IDDRI, Agora Energiewende and Agora Industry.
- The 16 applications are representative of most sectors of the EU industry, and amongst the most emission intensives.
- They include both existing industries reporting issues of competitiveness and decarbonisation as well as new areas of development of the EU industry such as battery manufacturing and data centres.

Selection of 16 industrial applications / products

Sector	Industrial application
Chemicals and petrochemicals	Steam cracking for ethylene production
	Low-temperature chemicals steam supply
	Ammonia production
Iron and steel	Primary steel production
	Secondary steel production
	Post-production heating
Aluminium	Primary aluminium smelting
	Secondary aluminium melting
	Alumina digestion
Glass	Container glass melting
	Flat glass melting
Cement	Cement clinker burning
Paper and pulp	Paper drying
Food and beverages	Milk powder production steam supply
Data centres	Data storage / AI computation
Battery	Cell manufacturing

1.1

Exposure of EU industrials to energy costs

Indicators to assess exposure to energy costs in specific applications should reflect intensity of energy costs and ability to pass them through

- Compass Lexecon together with IDDRI, Agora Energiewende and Agora Industry has selected the main indicators for their relevance with regards to industries vulnerability to energy and electricity costs. Importantly, the ability to pass-through those costs in case of variations is key to defining their actual exposure.
- Others were discussed, notably geographical concentration, more granular local differences in processes and economics, etc.
- In the following, we compute these indicators for the selection of 16 applications in scope.

Indicators analysed and their relevance

Indicator	Definition	Relevance
Trade intensity	Level of exposure of a product to international trade and foreign competition *Computation: ratio of imports and exports over turnover and imports*	Measures intensity of international competition in the market and inability to pass through higher energy or carbon costs
Current energy intensity	Exposure to energy costs of current mix of production processes in industrial sectors *Computation: share of energy costs per fuel in Gross Value Added*	Measures vulnerability of industrial processes energy cost variations
Current electricity intensity	Exposure to electricity costs of current production processes in industrial sectors *Computation: electricity cost as a share of total production costs*	Measures vulnerability of current selected processes to electricity cost variations

Trade intensity – All applications/products considered are highly trade intensive and have limited pass-through capability

- A sector's trade intensity measures its exposure to international trade and the associated competitive pressure.
  - A trade intensity of **above 10%** implies that the (sub)sector is exposed to competition in international markets.
  - A trade intensity of **above 25%** indicates that the (sub)sector has very limited ability to pass on costs to final consumers without losing significant market share in favour of its foreign competitors.[1]

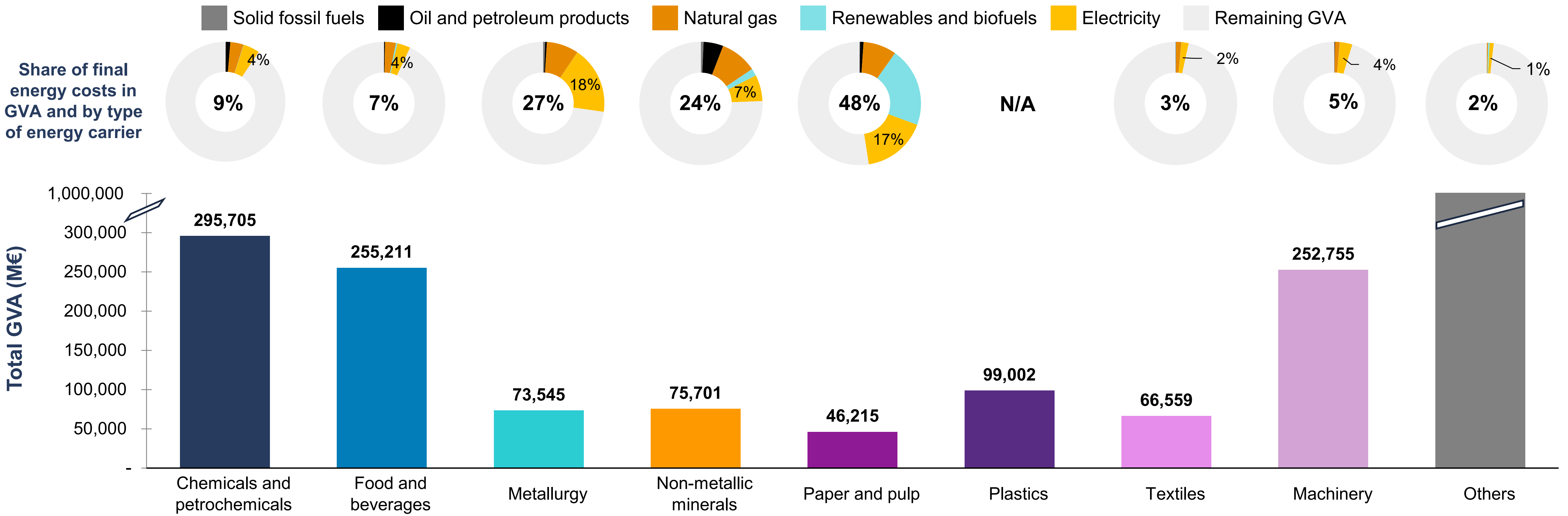
Sector	Industrial application	NACE 2	Trade intensity
Chemicals and petrochemicals	Steam cracking for olefines (ethylene)	20.14	**49%**
	Low-temperature chemical steam supply	20.2 → 20.5 & 21	**55%**
	Ammonia production	20.15	**32%**
Iron and steel	Primary steel smelting	24.1	**26%**
	Secondary steel smelting	24.1	**26%**
	Post-production heating	24.2	**49%**
Aluminium	Primary aluminium smelting	24.42	**35%**
	Secondary aluminium smelting	24.42	**35%**
	Alumina digestion	24.42	**35%**
Glass	Container glass melting	23.11	**24%**
	Flat glass melting	23.13	**25%**
Cement	Cement clinker burning	23.51	**10%**
Paper and pulp	Steam generation for paper drying	17	**22%**
Food and beverages	Milk powder production steam supply	10 & 11	**17%**
Data centres	Data storage / AI computation	63.1	Not applicable
Battery	Cell manufacturing	27.2	**61%**

Source: Compass Lexecon analysis based on EU's Carbon Leakage Regulation
Note: [1] Trade intensity is calculated as the sum of imports and exports divided by the sum of turnover and imports for each sub-sector to which the given application belongs. Trade intensity thresholds are taken from the EU ETS carbon leakage mitigation in Phase 2 of the EU ETS that provided more granularity. Current Trade intensity threshold to determine carbon leakage in EU ETS Phase IV is 20%.

Energy intensity – As of today, metallurgy, minerals and pulp and paper qualify as highly energy-intensive sectors, with chemicals and food and beverages also boasting energy-intensive applications

- A high energy intensity implies that the sector is prone to be impacted by energy market shocks, price volatility or overall costs increases.

Total gross value added (GVA) and share of final energy cost per energy-intensive manufacturing sector – 2021 (M€)

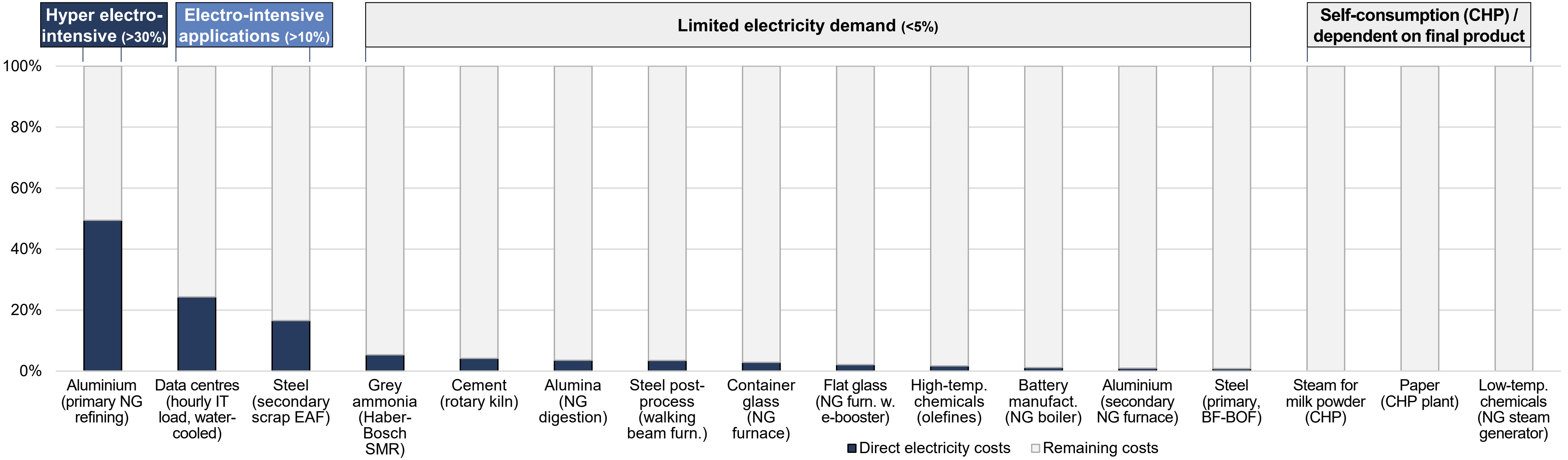


Source: Compass Lexecon analysis in the Enel Foundation study.
Notes: For Chemicals and petrochemicals, the share of final energy costs does not include energy resources that are used as feedstocks.

Electricity intensity today – Common processes used in industrial applications are fossil fuelled, except for aluminium and secondary steel

- Today, most selected sectors have relatively low electricity cost shares because fossil fuels such as natural gas are the primary energy source for meeting the large heat volumes and high temperature requirements of many processes.
- In Europe, large industrial consumers receive rebates on network costs and other levies, fees and taxes. To reflect different national approaches,[1] we suggest a simplified categorisation of electro-intensity based on the share of electricity cost in total costs.

Share of electricity purchasing costs in production costs for incumbent industrial applications by 2024 – average across focus countries[3]



Source: Compass Lexecon analysis based on an in-house bottom-up costs model, various sources (see Technical Appendix); industrial electricity and natural gas prices are based on EU-wide averages published by Eurostat
Note: In primary steel production, off-gases are assumed to be used to generate the electricity needed by for the plant [1] The height of rebates and eligibility differs across countries. In Germany, rebates are based on yearly consumption and electricity cost share to total cost. France categorises electricity intensive users in terms of kWh/ EUR value added. [3] Focus countries include France, Germany, Italy, Sweden, Poland, Spain and Hungary
Abbreviations: BF-BOF…blast furnace – basic oxygen furnace, CHP…combined heat and power, EAF… electric arc furnace, H2-DRI-EAF…Hydrogen direct reduced iron electric arc furnace, NG… natural gas, SMR…steam-methane reforming

1.2

Exposure to energy and power costs in the context of decarbonisation

Indicators to assess energy costs exposure post-decarbonisation focus on the business case to switch to low-carbon processes

- A set of key indicators were identified for their relevance with regards to industries vulnerability to energy costs in the context of decarbonisation.
- Others were discussed, notably geographical concentration, more granular local differences in processes and economics, etc.
- In the following, we compute the following list of indicators for the selection of 16 applications in scope of the study.

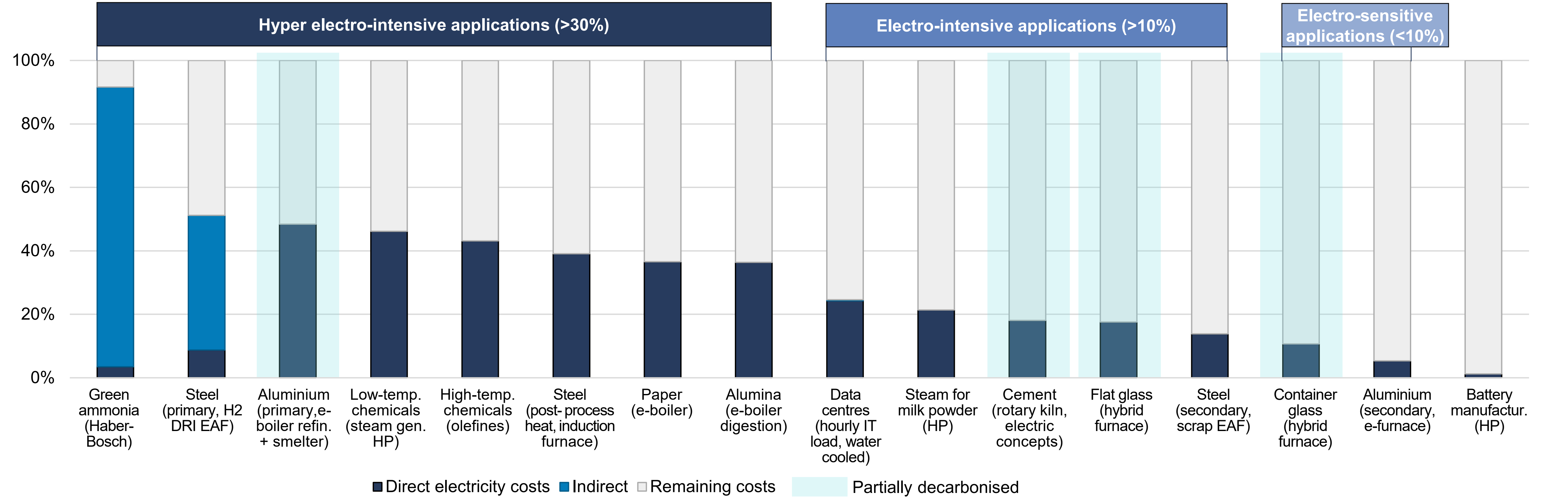
Indicators analysed and their relevance

Indicator	Definition	Relevance
Electricity intensity post decarbonisation	Exposure to direct and indirect electricity costs of electrified processes *Computation: share of electricity (incl. green hydrogen) costs over total production costs*	Measures vulnerability of selected processes following decarbonisation / electrification investments to electricity cost variations
Technological readiness to decarbonise	Time horizon by which mature and scalable decarbonisation technologies are available *Computation: expected year*	Indicates timeline for decarbonisation and public support implementation
Flexibility potential post decarbonisation	Ability of industrial processes to provide services to power grids *Computation: qualitative ranking based on technical flexibility parameters*	Indicates ability to respond to short-term power price signals and generate extra revenues when electrified
Decarbonisation CAPEX cost gap ratio	Difference in CAPEX between decarbonised and incumbent process *Computation: Capex ratio, Capex difference in €/unit, CO2 abatement*	Indicates how upfront investment can hamper the switch to electrified / decarbonised solutions
Decarbonisation OPEX cost gap ratio	Difference in OPEX between decarbonised and incumbent process *Computation: Opex ratio, Opex difference in €/unit, CO2 abatement*	Indicates how much variable energy costs can hamper the switch to electrified / decarbonised solutions

Electricity intensity post-decarbonisation - The share of electricity in total production costs varies largely per industrial sector and application

- Processes that are expected to rely on relatively important electricity consumption levels will be inherently more exposed to electricity price variations. Most decarbonised applications in industrial manufacturing sectors show high shares of electricity in production costs. Container glass via hybrid furnaces, secondary aluminium and battery manufacturing would be less exposed.

Share of electricity purchases in production costs for partially or fully decarbonised industrial applications by 2035 – average across focus countries[2]



Source: Compass Lexecon analysis CL analysis based on an in-house bottom-up costs model, and using various sources (see Technical Appendix)
Note: Indirect electricity costs refer to electricity needed to produce hydrogen. (1) Focus countries include France, Germany, Italy, Sweden, Poland, Spain and Hungary
Abbreviations NG… natural gas, BF-BOF…blast furnace – basic oxygen furnace, EAF… electric arc furnace, H2-DRI-EAF…Hydrogen direct reduced iron electric arc furnace

Technological readiness – Most processes can technically be decarbonised by 2035, with electrified technologies already available for low-temp. applications

- Decarbonised solutions are being deployed and scaled up across most industrial sectors, especially for lower temperature applications. The main technical challenges remain in sectors with high-temperature processes and requiring continuous energy supply.
- We show the earliest availability in terms of maturity equivalent to technology readiness level 9 and economic viability for a large-scale deployment of a decarbonised energy source for the processes.

Sector	Industrial application	Selected decarbonised technology	Temperature requirement	Earliest availability
Chemicals and petrochemicals	Steam cracking for olefines (ethylene)	H2 / Electric furnace	Mid	2030
	Low-temperature chemical steam supply	E-boiler / heat pump	Low	2025
	Ammonia production	H2 / Electrolyser	Low	2025
Iron and steel	Primary steel smelting	H2-DRI-EAF or NG-DRI-EAF	High	2025
	Secondary steel smelting	EAF	Low	Already electrified
	Post-production heating	Electric / H2 / hybrid furnace	Mid	2030
Aluminium	Primary aluminium smelting	Electrolyser with inert anode	High	Anode: 2040
	Secondary aluminium melting	Electric furnace	Mid	2030
	Alumina digestion	E-boiler	Low	2025
Glass	Container glass melting	Hybrid electric furnace	High	2025
	Flat glass melting	Hybrid electric furnace	High	2035
Cement	Cement clinker burning	Electric rotary kiln	High	2040+
Paper and pulp	Steam generation for paper drying	E-boiler / heat pump	Low	2025
Food and beverages	Milk power production steam supply	E-boiler / heat pump	Low	2025
Data centres	Data storage / AI computation	Electricity	N.a.	2025
Battery	Cell manufacturing	Electric boiler	Low	2025

__Source__: Compass Lexecon analysis based on the Enel Foundation study, European Aluminium (2023) Net-Zero by 2030; Fraunhofer ISI (2024): Direct electrification of industrial process heat. An assessment of technologies, potentials and future prospects for the EU. Study on behalf of Agora Industry on Fraunhofer ISI's Direct electrification of industrial process heat study (2024).
__Abbreviations__: NG… natural gas, EAF… electric arc furnace, H2…hydrogen, H2-DRI-EAF…Hydrogen direct reduced iron electric arc furnace

	Low	Mid	High
Temperature range (°C)	100-500	500-1000	>1000
Technological readiness	2025/2030	2035	2040+

Flexibility – Our assessment of flexibility potential in this section relies on core process flexibility, material and thermal storage

Flexibility in manufacturing industries can be divided in 4 types.

- All processes of the application are designed to be continuous, but load can be reduced or fully curtailed;
- Some processes of the application involve the production of material that can be stored or transported;
- Some processes of the application are well adapted to heat storage;
- The firm has installed an on-site battery storage.

Any form of storage, whether for feedstock / input materials or energy (electricity or heat), increases the flexibility potential of the plant.

- In such cases, opportunity costs are limited as no production is lost;
- The costs associated with flexibility provision relate to the CAPEX and OPEX of the storage unit, the possible additional wear and tear of the equipment in the plant and the personnel costs to operate flexibly;
- As soon as the savings or revenues from the valuation of this flexibility outweigh the additional costs of flexibility provision, investing in storage on-site can be beneficial to the business case of the application/industry.

On-site battery storage is available to all industries and can be valued as an additional source of energy security in case of network failure.

Illustration of the variety of flexibility sources in manufacturing industries, and scope considered in this report

Assessed in this section

Core processes	Interruptibility	All or one of the processes can be fully curtailed at once
	Load reduction	All or one of the processes can be slowed down without hampering downstream continuity
	Material storage	One of the processes consists in producing storable material (raw materials milling for cement, mechanical grinding for pulp production)
Core processes adapted to thermal storage	The application uses a form of heat that is storable (e.g. steam accumulation for paper drying, milk powder production, low T° chemicals)	
On-site battery energy storage systems	The firm installs low-carbon back-up power on-site that can be operated in the power markets	

Assessed in section 2

Source: Compass Lexecon analysis CL analysis based on Agora Industry, FutureCamp (2022): Power-2-Heat: Gas savings and emissions reduction in industry and bottom-up costs models, various sources (see Technical Appendix)
Abbreviations: CAPEX … Capital expenditure, F&B… food and beverages, NG…natural gas, OPEX … Operational expenditure

Flexibility – The ability of core processes to use flexibility and reduce exposure to electricity market volatility varies between sectors

- Based on literature and expert interviews, the table below summarizes the extent to which a process is able to deliver flexibility from its core process, material and thermal storages and whether revenues will be large enough to outweigh flexibility provision costs and risks.[1]

Industrial application	Selected decarbonised technology	Technical ability to provide flexibility post-decarbonisation	Potential for flex. revenues
Paper drying[2]	E-boiler / heat pump (+Thermal storage)	• Depending on storage size, industrial heat pumps and e-boilers can adjust their load quickly	High
Milk powder production[2]			
Low-temp chemicals[2]			
Cement clinker burning	Electric rotary kiln	• Raw material and cement milling can be interrupted while oversizing / storage ensure continuous kiln operation	
Primary steel smelting	H2-DRI-EAF or NG-DRI-EAF	• Batch operation and delaying melt-up phase of EAF allows for some flexibility	Medium
Secondary steel smelting	EAF		
Data storage / AI computation	Electricity (+Battery storage)	• Back-up batteries could allow some flexible operation	
Container glass melting	Electric / hybrid furnace	• Long heat-up times and continuous production restrict flexibility	Low
Flat glass melting			
Primary aluminium smelting	Electrolyser with inert anode	• Pot lines can partly shut down or reduce load by 5% on limited occasions only	
Secondary aluminium melting	Electric furnace	• Batches allow for some flexibility, but high opportunity costs reduce incentive for flexibility provision	
Alumina digestion	E-boiler	• Possibility to fuel switch between natural gas boiler and electric boiler though fully electric system has limited incentive due to opportunity cost	
Post-production heating	Electric / H2 / hybrid furnace	• Discontinuous production requires long heat-up phases and stable temperatures ~10h	
Steam cracking for olefines (ethylene)	H2 / Electric furnace	• Flexible operation of electric resistance and arc heating is not desirable but possible to a limited extent	
Ammonia production	Haber-Bosch-Process	• Only the hydrogen production is deemed flexible as HB process needs to run continuously	
Battery cell manufacturing	Electric boiler / heat pump	• Dry room manufacturing requires stable temperatures	

Sources: CL analysis based on literature and industry expert interviews, for detailed list of sources see Technical Appendix
Notes: [1] We consider the core process that requires energy, e.g. for paper we do not look at paper drying process itself as it requires constant influx of steam but rather steam generation itself. The full process may include thermal or material storage. Flexibility from wider production is not considered, i.e. office amenities/lights or optimising heating/cooling as well as previous or subsequent production steps. [2] Only steam supply is considered for the paper drying, milk powder production and low-temperature chemical applications shown here.
Abbreviations: NG… natural gas, EAF… electric arc furnace, H2…hydrogen, H2-DRI-EAF…Hydrogen direct reduced iron electric arc furnace, NG-DRI-EAF…Natural gas direct reduced iron electric arc furnace

Flexibility – Revenues from flexibility provision in 2030 in the EU vary substantially across industrial applications

Core processes in industrial sectors boasts a diverse range of flexibility potential.

- Based on expert interviews and literature review we qualified the flexibility potential of core processes;
- We optimised the technical ability for flexibility in EU markets (wholesale, intraday, ancillary services and capacity remuneration mechanisms);
- We derived potential revenues for core processes' flexibility in 2030, under a range of assumptions on prices and market openness.

We extrapolated those results to applications considered in this study and categorised them as shown in the next slide.

Industry	Process step	Key modelling results: Revenues from upward flexibility provision for a standalone exemplary plant	Key modelling results: Share of decarbonisation cost gap offset [1]
Paper	Hybrid steam production + steam accumulator	340 000 EUR/MW/a 57 EUR/t (15% of prod. costs)	Up to 95%
Cement	Raw material preparation and cement milling	300 000 EUR/MW/a 50 EUR/t (15% of prod. costs)	Up to 30%
Glass	Container glass hybrid furnaces with electric boosters	70 000 EUR/MW/a 7 EUR/t (2% of prod. costs)	Up to 7%
Iron and Steel	Electric arc furnace	50 000 EUR/MW/a 15 EUR/t (2% of prod. costs)	Up to 4%
Aluminium	High temperature electrolysis	35 000 EUR/MW/a 55 EUR/t (2% of prod. costs)	n.a.

Source: Compass Lexecon analysis CL analysis based on smarten (2025) The Business Case for Flexibility Provision in Energy-Intensive Industries
Notes: [1] Decarbonisation cost gap measured between incumbent process with free allowances and decarbonised process.

Comparing greenfield incumbent and decarbonised processes in 2035, five sectors show a significant decarbonisation cost gap (CAPEX or OPEX)

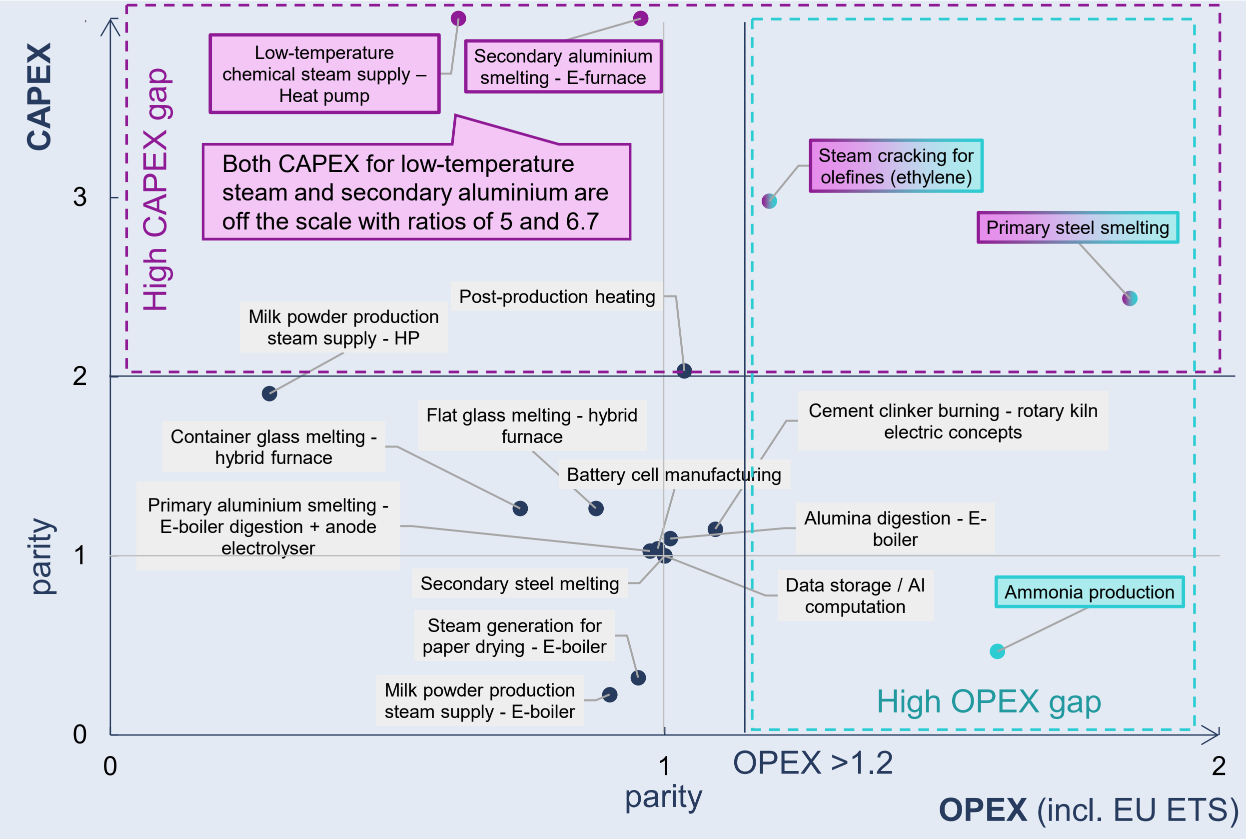
By 2035, for most applications in scope, the decarbonised process is at most 20% costlier than the incumbent process.

- Ratios are calculated as reported CAPEX/OPEX for the greenfield decarbonised process and greenfield fossil-based process;
- CAPEX gaps increase when comparing greenfield decarbonised process to brownfield fossil-based process;
- Low CAPEX ratios are mostly associated with already electrified applications (primary aluminium, secondary steel melting), for steam generation using an E-boiler CAPEX are considerably lower;
- We identify four sectors with CAPEX prices >2 times the incumbent process in 2035, which will likely require support when switching to (in-)direct electrification.

Most applications associated with high OPEX cost gaps rely on indirect electricity.

- A sector's OPEX cost gap measures the increase or decrease in variable costs associated with the decarbonisation of the process including EU ETS costs;
- With carbon costs of ~130 EUR/tCO_2 by 2035, 3 of the applications show significant OPEX gaps. For primary steel smelting and ammonia production, the gap is mainly driven by indirect electrification through hydrogen.

Sector-level decarbonisation cost gap ratios, averages across selected EU-countries – 2035

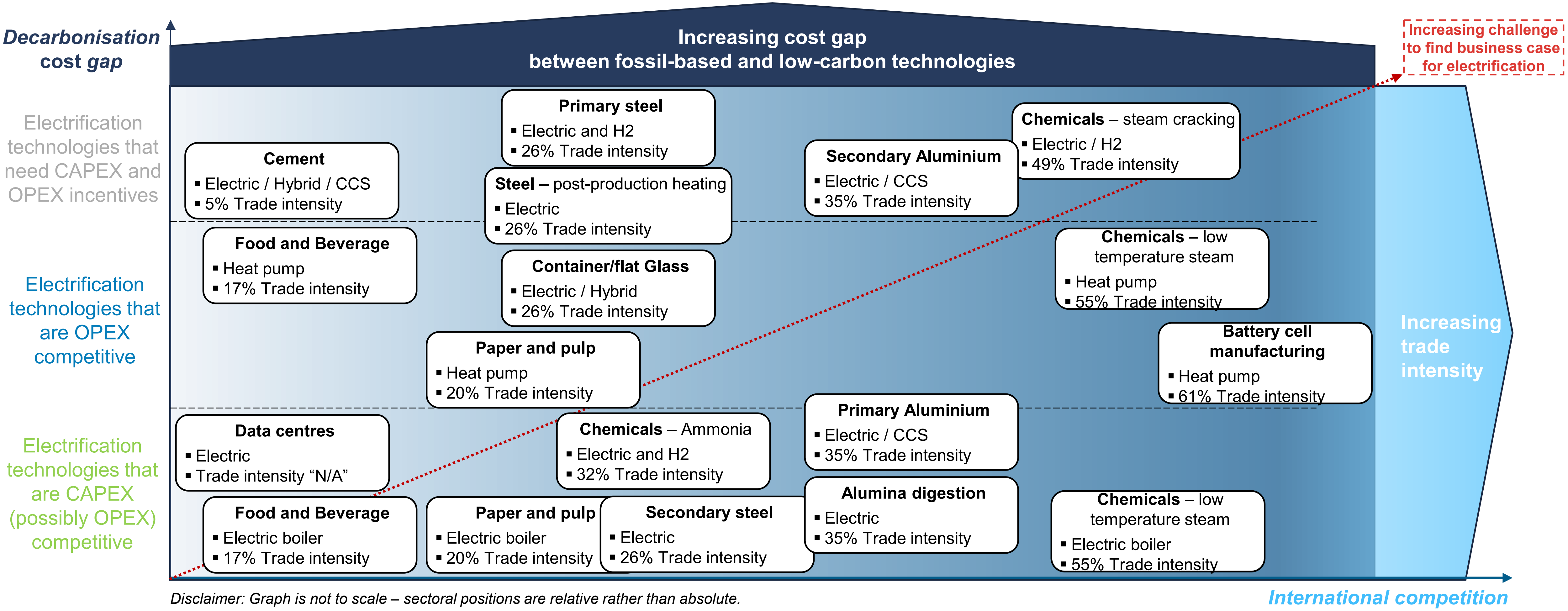


Source: Compass Lexecon analysis CL analysis based on bottom-up costs models, various sources (see Technical Appendix)
Note: CAPEX costs include financing costs. The ratios are between the incumbent process (fossil-based) and the decarbonised process. To assess the OPEX gap ratio we rely on energy requirements of the incumbent and decarbonised process as found in our bottom-up cost-models. For CO2-costs we assume costs of 130 EUR/tCO2 by 2035 and rely on electricity and gas price projections as detailed in section two for selected countries: Italy, Sweden, Germany, France, Poland, Spain, Greece Hungary
Abbreviations: NG… natural gas, EAF… electric arc furnace, H2…hydrogen, H2-DRI-EAF…Hydrogen direct reduced iron electric arc furnace, NG-DRI-EAF…Natural gas direct reduced iron electric arc

1.3

Conclusion: a framework to grasp sector-specific competitiveness and decarbonisation issues

Conclusion: Trade intensity and the decarbonisation cost gap indicate sectors facing greatest competitiveness challenges due to decarbonization



Disclaimer: Graph is not to scale – sectoral positions are relative rather than absolute.

Source: Compass Lexecon analysis based on bottom-up costs models, various sources (see Technical Appendix) and EU's Carbon Leakage Regulation
Note: International competition is evaluated through the trade intensity index which measures the exposure of specific sectors to international trade and thus the competitive pressure they face. Trade intensity is calculated as the sum of imports and exports divided by the sum of turnover and imports. For decarbonisation costs, refer to the previous slides in this section.

Conclusion: Key dimensions to assess sectoral exposure to energy costs affecting competitiveness and decarbonisation

Electrification cost gap

High upfront or operational costs hinder a fuel switch

Defining criteria

- OPEX gap ratio >1.2
- CAPEX gap ratio >2
- Trade intensity > 25%

Power costs exposure

Dependent on electricity, but limited ability to pass power costs through

Defining criteria

- Already electrified
- (Hyper) electro-intensive today
- Trade intensity > 25%

Flexibility potential

Can leverage flexibility to improve costs and thereby competitiveness

Defining criteria

- Direct electrification available
- Medium to high flexibility potential in core processes

Industry characteristics

From the quantitative analysis performed on 16 industrial applications, we identify:

- Four key characteristics **related to electricity** and
- One additional dimension capturing **wider constraints** to industry competitiveness (assessed in Section 2)

Reliance on H2 or syn-gas

High process temperatures or low tech readiness level require an alternative to direct electrification

Defining criteria

- No direct electrification by 2035
- Hybrid solutions available (syn. gas + electricity) or indirect elec. (H_2)

Non-energy issues should also be considered to get the full picture of competitiveness issues

Non-energy issues

Other barriers hindering competitiveness

Defining criteria

- Raw material supply bottlenecks
- Infrastructure bottlenecks
- Global overcapacity
- Other market disruption

Source: Compass Lexecon analysis CL analysis based on bottom-up costs models, various sources (see Technical Appendix)
Note: Gap ratios are calculated as reported CAPEX/OPEX for the greenfield decarbonised process and greenfield fossil-based process.

2.

The EU industrial competitiveness energy cost gap with the US and China

Objective – Mapping key factors of competitiveness and quantifying cost competitiveness gap for 5 key industrial sectors

We analyse both macroeconomic factors and sector specific factors contributing to competitiveness issues for EU industries.

In particular we, develop sectoral case studies covering 5 industrial applications.

Macroeconomic competitiveness factors	▪ What macroeconomic factors impact competition across industrial sectors between EU, USA, China? ▪ How can they be reflected in cost models?
Energy and carbon costs competitiveness	▪ What is the extent of the historical competitiveness gap on energy prices and carbon prices between the EU, the USA and China?
Sectoral case studies	**5 case studies** (aluminium, steel, paper, low T° chemicals and battery cell manufacturing – representative of diverse characteristics across EU countries **5 main outcomes – application / product specific** ▪ **Global market trends**: what can we learn from historical trade volumes and the EU's share of global production? ▪ **Non energy issues**: what do secondary research and industry intelligence tell us on competitiveness issues unrelated to energy costs (overcapacity, raw material bottlenecks, etc)? ▪ **2024 competitiveness gap**: what is the extent and contribution of various elements of production costs, including energy, to the competitiveness gap with USA and China today? ▪ **Incentive to decarbonise by 2035**: what does a projection of unit production costs in the EU for existing and decarbonised technologies show as economic case for decarbonisation? ▪ **2035 competitiveness gap**: what does a projection of unit production costs in 2035 show for EU4s competitiveness against China and the US, including potential effects of flexibility provision in the EU and the CBAM?

2.1

Macroeconomic and policy factors of competitiveness

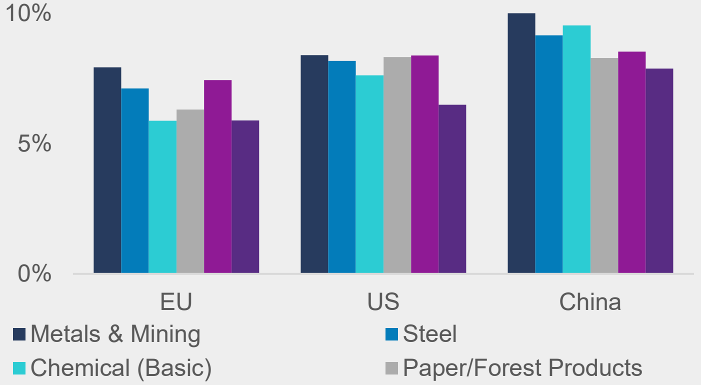
A range of factors beyond energy costs play a role in the competitiveness of industries in the EU compared to its trading partners

- **The EU has the lowest cost of capital across industries compared to the US and China, and labour costs are generally lower than in the USA, although they remain significantly higher than in China**
- **The EU also has more limited access to raw materials than its competitors**

Financing costs

- EU cost of capital for industries are lowest
- EU costs of capital average at 6.76%, US s at 7.90% and China at 9.05% according to reference sources
- For specific projects, China's higher cost of capital is being offset by investment support (subsidies, public participation)

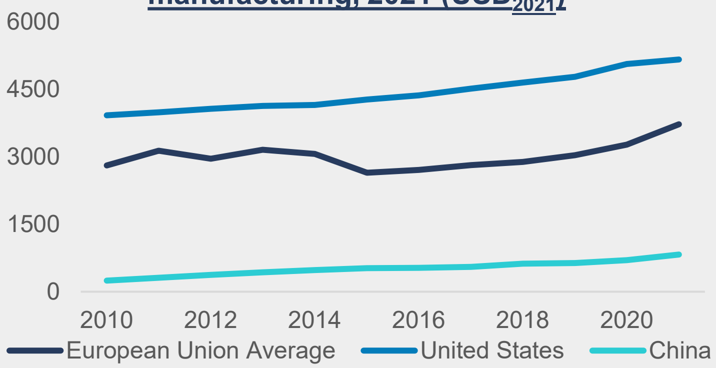
Regional WACC estimates 2025



Labour costs

- Differences in Earnings per worker driven by differences in high-value and low-value industry mix in each region
- China's labour costs are substantially lower than in the US and EU

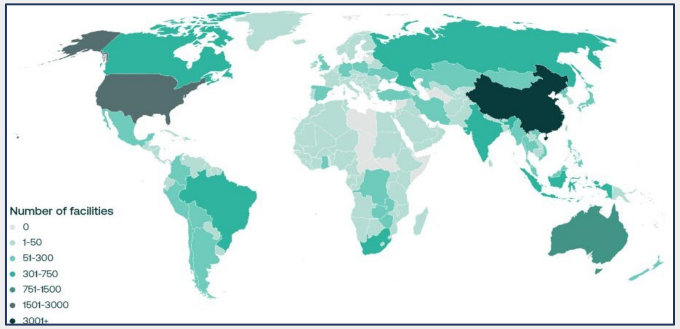
Regional average monthly earnings in manufacturing, 2021 (USD_{2021})



Access to raw materials

- Three countries, China, the US and Australia account for ~45% of global reported large-scale mining and processing facilities
- In Europe, only a few countries have significant number of large-scale mining and processing operations

Global distribution of large-scale mining and processing facilities



Sources: *Compass Lexecon analysis based on, EC (2025) The Draghi report on EU competitiveness,; United Nations, International Labour Organisation, International Council on Mining and Metals – Global mining data set*
*WACC estimates are estimated by Damodaran et al. who use the following formula: Cost of Equity * (Equity/ (Debt + Equity)) + Cost of Debt (1- Marginal tax rate) *(Debt/ (Debt + Equity)), with aggregated debt and market equity values across all companies in the sector, using most recent balance sheet for debt and most recent year-end for equity.*

Different industrial policy paradigms shape cost competitiveness of industries between EU, US and China

Fundamentally different approaches to market organisation and industrial strategy, especially in the use of subsidies, affect differences in competitiveness between regions

- US and EU economies tend to be more reliant on private capital in competitive markets, while China relies on 5-year centralised planning and private public partnerships
- US and China make more extensive use of subsidies and trade protection measures than the EU

European Union

- **Competitive market** (private capital) **+ regulation** (Single European Market)

Industrial strategy

- Specialized and high-tech driven
- Transitioning to a Net-zero economy
- Focus of subsidies: Green-tech and legacy industries via limited state aid under strict conditions (functioning of single-market)

United States

- **Competitive market** (private capital) **+ regulation**

Industrial strategy

- Energy and capital-intensive
- Reshoring industrial capacity
- Focus of subsidies: Re-shoring manufacturing capacity via tariffs; leveraging tax-credits at federal level

China

- **Centralised five-year plans** are guidelines for frequent **public-private partnerships**

Industrial strategy

- Transitioning from labour to capital-intensive
- Green technologies champion
- Focus of subsidies**:** Large-scale subsidies and tax credits for targeted industries (Steel, PV, Batteries, etc.) in line with Made-in-China strategy 25 prescribing autonomy

Sources: *Compass Lexecon analysis based on Asia Society (2023) China's industrial policy – roundtable summary report; The China Briefing – China's 15th Five-year plan, EC (2025) The Draghi report on EU competitiveness, European Think-tank Network on China (2025) Quest for strategic autonomy with China? Europe grapples with US-China rivalry, Bruegel (2023) Sparking Europe's new industrial revolution: A policy for net zero, growth and resilience; United Nations, WIPO*
Abbreviations*: PV…Photovoltaics*

2.2

The impact of energy and carbon costs on competitiveness

Higher regional fossil fuel prices have affected energy-intensive EU industrials' competitiveness since the 2022 energy crisis

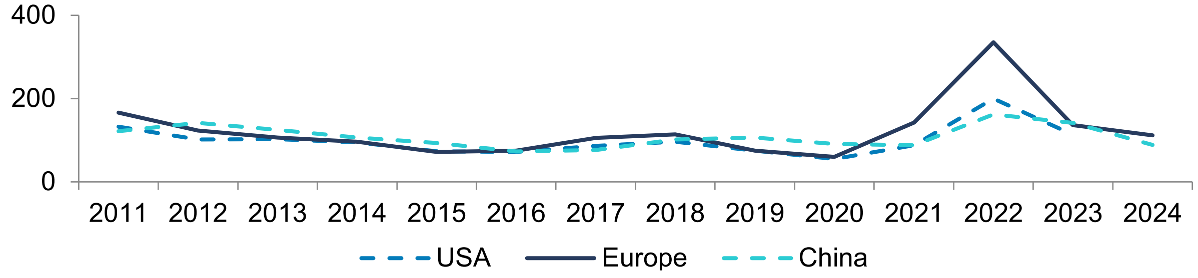
Before 2022 energy crisis, EU fuels prices included a limited premium especially compared to the USA.

- More modest price differences with cost advantages for the US on natural gas (especially since shale gas revolution) and oil
- EU structurally more dependent on imports leading to increased geopolitical exposure

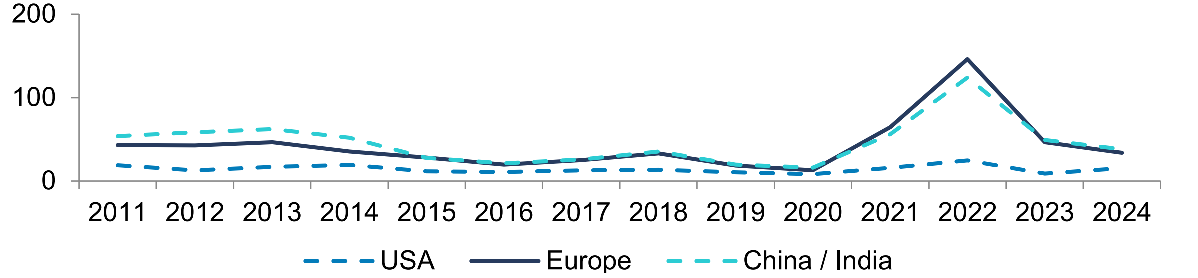
With the onset of the 2022 energy crisis, a major gap has appeared with the US particularly acute for gas, also borne by China, which is slowly receding.

- Geopolitically-induced supply crunch in EU natural gas markets led to extreme price spikes
- Some spill-overs to China due to liquified natural gas arbitrage
- Relying on vast domestic production, US prices remain largely unaffected
- Cross-price effects in global coal markets, again most pronounced in EU
- Global oil markets do not show similar price divergence

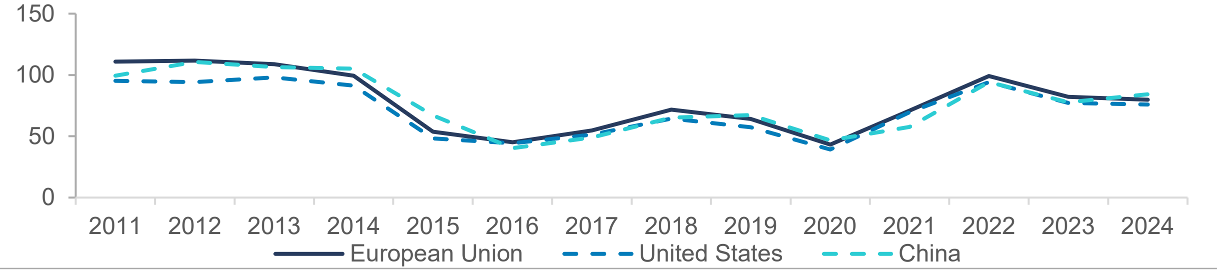
Historical annual coal price[1] (USD/tonne 2023)



Historical monthly gas price[2] (USD/MWh 2023)



Historical annual crude oil prices (USD/bbl 2023)



Sources: CL analysis based on Energy Market Price, BP Statistical review of World Energy, Zhengzhou Commodity Exchange, IMF World Economic Outlook Database, IEA, Bloomberg, Energy Market Price, ICIS
Notes: [1] China Qinhuangdao spot prices, average weekly prices 2011-2021, 5,500 kilocalories per kilogram NAR, including cost and freight (CFR). For 2022 - 2024 figures, yearly average of the spot price. US Central Appalachian coal spot price index (FOB). Europe coal ARA CIF (Amsterdam-Rotterdam-Antwerp). [2]: PEG for France, NCG for Germany, Henry Hub for USA et ICIS DES assessment for China

Electricity costs of electro-intensive industries have increased substantially more in the EU since 2021 than in the USA and China

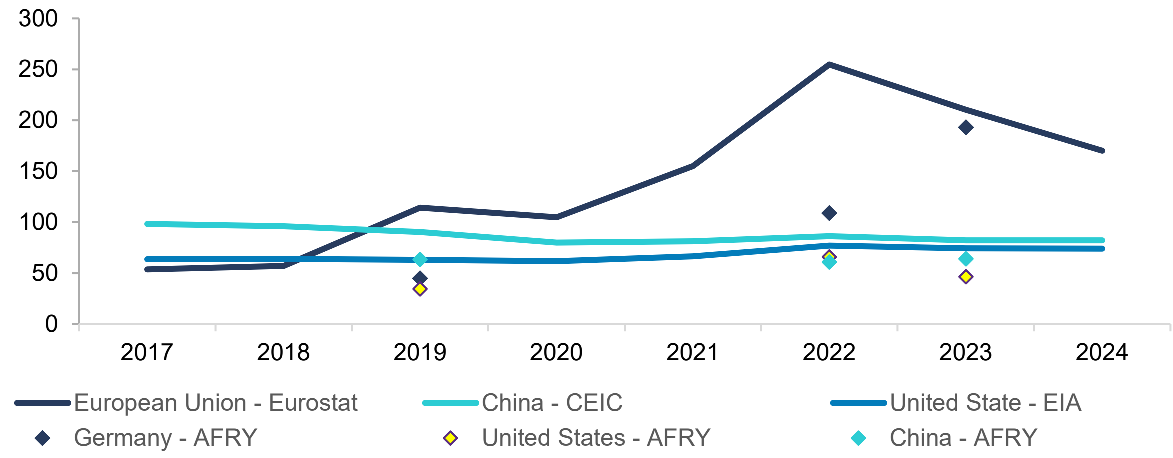
Electricity retail costs for industrials in the EU were in line with US and China's retail costs prior to 2020, now more than twice as much.

- Since 2021, retail electricity prices in the EU affected by multiple shocks (COVID, Russia-Ukraine war) more than doubled compared to the US and China.

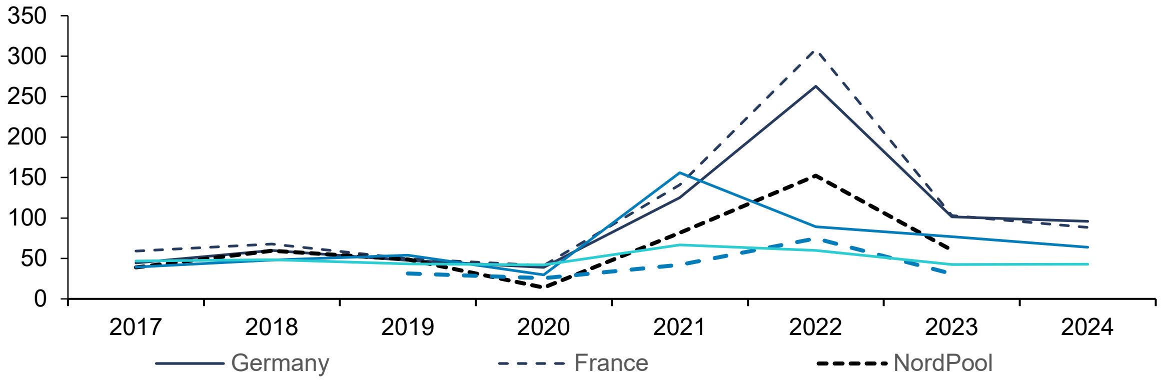
Retail costs for industrials are mostly driven by wholesale electricity prices and production costs, as a result of exemptions on other bill components.

- A large share of the retail price comes from the production costs, in Germany it accounted c.90% of the final price in 2024 against c.80% and c.75% in the US and China.
- Indeed, energy intensive consumers are exempted of electricity levies and system charges and pay a limited share of the network costs in the EU and the US.(3)
- China's direct and indirect subsidies on electricity cost are less transparent but estimated to exceed those of Western peers.(4)

Historical industrial retail electricity prices(2)(EUR$_{2023}$/MWh)



Historical monthly spot electricity price(5)(EUR$_{2023}$/MWh)



Sources: IEA, Solargis and World Bank, Compass Lexecon

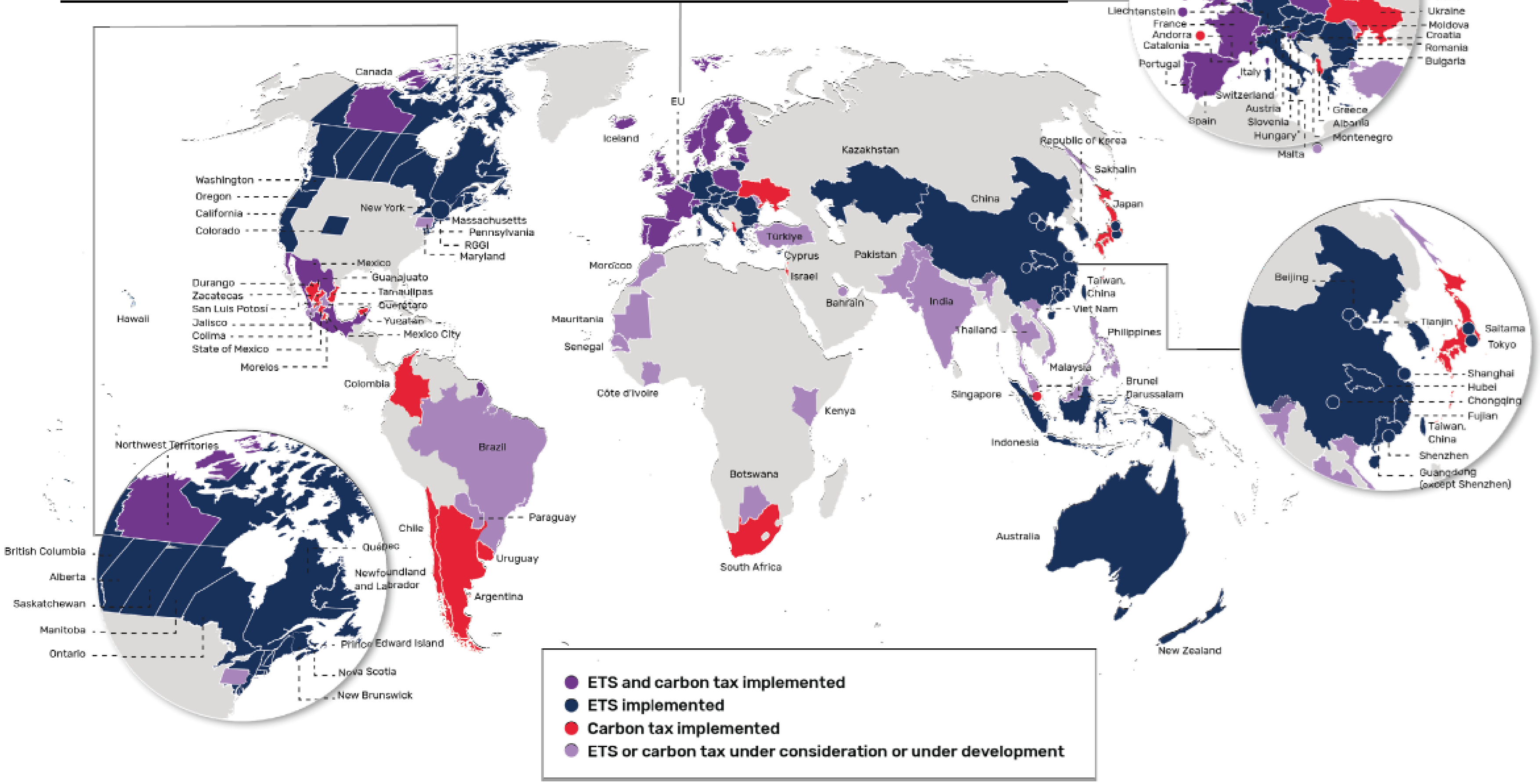
Notes : (1) In the USA and EU, gas-fired plants often set the electricity price as they operate at the margin for many hours each year. These plants have the highest variable costs needed to meet demand, so their costs determine the market clearing price. All generators supplying power during these hours receive this price, making gas plant costs key to wholesale price levels. The only difference is that in the US natural gas prices did not increases as much as in the Europe following the Ukrainian invasion. (2) See the Final Report Network Cost by the European Commission and Trinomics. (2) See AFRY, Brief study: International comparison of electricity prices for industry, 2023 (4) See Kiel Policy Brief 173, On the Scale and Scope of Industrial Subsidies in China. (5) Chinese price is based on an estimate of the generation cost of a coal power plant in China, assuming a carbon cost for China, as implemented in 2021

Although some form of carbon pricing has been introduced in many countries, coverage and level of carbon prices remain very diverse

In 2025, carbon pricing covers around 28% of global GHG emissions

- Increased coverage from 2024 is largely due to China’s national ETS expanding beyond the power sector
- There are now 80 direct carbon pricing instruments in operation around the world, 37 ETSs and 43 carbon taxes

Global map of ETS and carbon taxes implemented, under development, or under consideration in 2025



Sources: World Bank (2025), State and trends of carbon pricing 2025

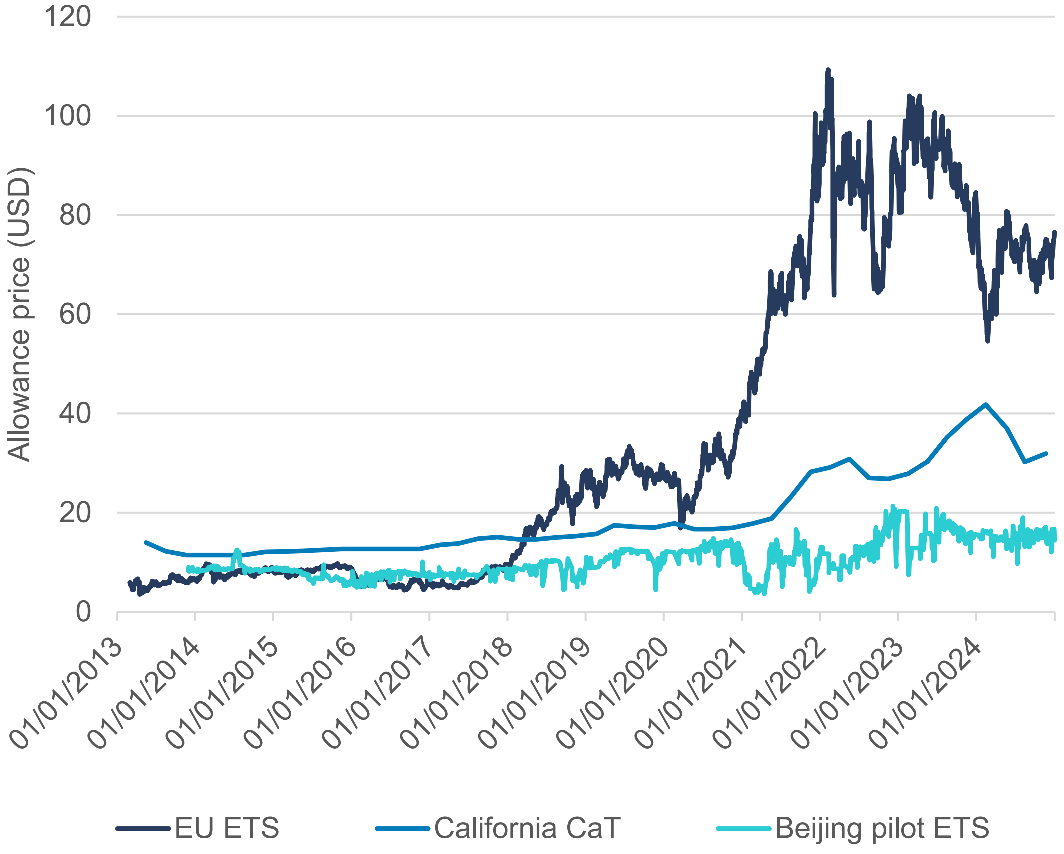
The carbon price in the EU is much higher than in the US states and Chinese ETS schemes

In 2024, carbon prices in the EU were five time higher than in China while the US still does not apply carbon pricing at federal level.

- After EUA prices spiked in 2021–2022, driven by the post-pandemic economic rebound, the EU's strengthened climate targets under the Fit-for-55 package, and the energy crisis, they averaged nearly twice those of California's CaT and 5 times the Beijing Pilot prices.

	Start year	Sector coverage	2024 av. price (USD/tCO2eq)
EU ETS	2005	Industry, Power, Aviation	70.5
California ETS	2012	Industry, Power, Transport, Buildings	35.2
Beijing Pilot ETS	2013	Industry, Power, Transport, Buildings	15.1

Evolution of allowance prices across international ETSs, 2013-2024



Sources: ERCST (2025), 2025 State of the EU ETS Report

2.3
Sectoral case studies

2.3.1
Methodology

Methodology – Each sector's competitiveness is assessed based on macro-trends and a modelling of total production costs, today and in 2035

1	**Global market trends**	▪ Analysis of historical production volumes, imports and exports over the past 10 years ▪ Analysis of EU and Member States' global production shares compared to China and the USA
2	**Non energy competitiveness factors**	▪ Qualitative analysis of industry specific market trends and reported competitiveness issues
3	**2024 competitiveness gap**	▪ Unit production costs comparison between 2 EU countries and most relevant Chinese province and US State, with breakdown of costs in terms of **energy** (net of rebates for electricity and including power emission costs – indirect emissions), **financing**, **raw materials**, **labour**, **non-energy OPEX**, **direct emission costs** and **transport costs** to the EU
4	**Incentive for EU decarbonisation with flexibility revenues**	▪ Projection to 2035 and comparison of unit production costs between **incumbent** and **decarbonised** processes in 2 relevant EU Member States, including **direct emission costs** ▪ Illustration of revenues from flexibility provision for EU industrials to close decarbonisation gap (on-site battery)
5	**2035 competitiveness gap**	▪ Projection to 2035 and production costs comparison between EU **decarbonised** production, in two EU member states and **incumbent** and **decarbonised** production in one relevant Chinese province (+sensitivity) and US state (including **direct emission costs**) ▪ Modelling a theoretical application of CBAM on both **direct** and **indirect** (power) emissions

Methodology – Analysis of EU competitiveness gaps and decarbonisation incentives in 5 industrial sectors compared to the US and China

5 industrial applications were selected to analyse the extent of the competitiveness difference between jurisdictions, both for the incumbent and decarbonised industrial processes.

- The relevant EU countries for the industrial case studies were selected based on their relevance for the sector in terms of production size or innovation.

We define and compute the following:

- *Competitiveness gap*: difference in total costs of production for various processes between regions;
- *Decarbonisation cost gap*: difference in total costs of production between fossil and low-carbon processes, within a given region.

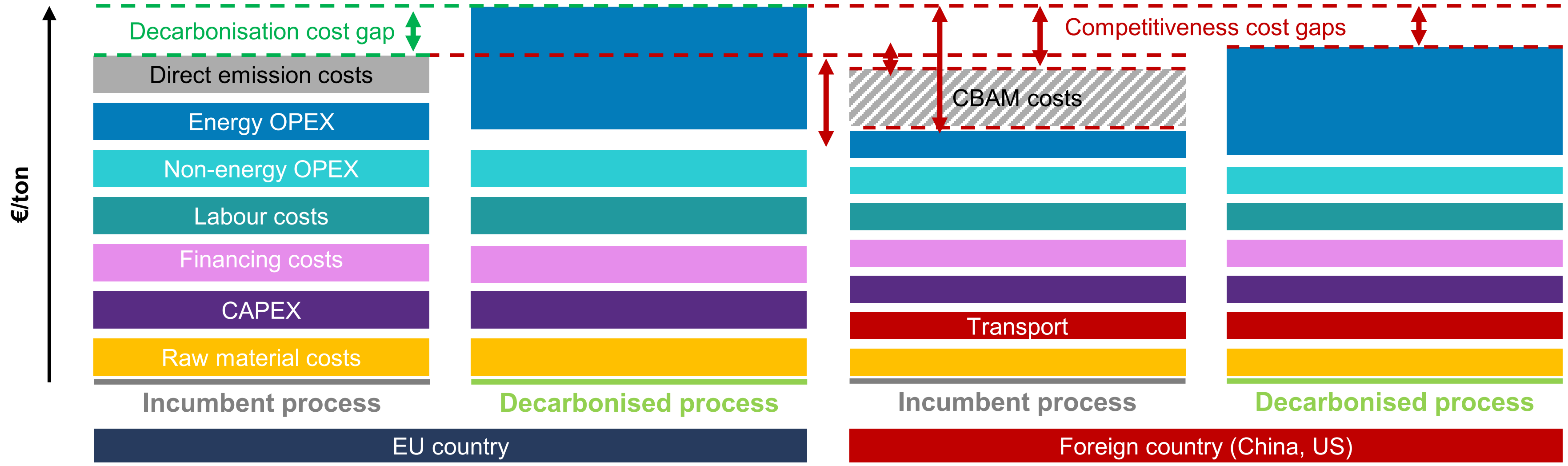
Application	Relevant region		
	EU	US	China
Primary aluminium production		**Kentucky**	**Inner Mongolia**
Primary steel production	SE3	**Indiana**	**Hebei**
Steam supply for low T° chemicals		**Texas**	**Shandong**
Paper drying	ITN	**Georgia**	**Shandong**
Battery cell manufacturing		**Michigan**	**Henan**

Methodology – The extent of the cost-competitiveness gap and the role of energy costs are assessed using a bottom–up model of total production costs, today and projected in 2035

We based the calculations of our bottom-up cost models on publicly available sources for each cost component and verified results with industry-stakeholders. We focus on analysing the energy cost components, while keeping other components fixed across time:

- **Time-differentiated cost components:**
  - **Energy costs:** Based on historic and projected retail rates as seen here and here. For the EU we include indirect carbon costs compensation and assume a phase-out until 2030
  - **Carbon costs:** Based on the EU ETS prices for the EU, including the allocation of free allowances, which are assumed to be phased-out by 2030. For the US and China no carbon costs apply in 2024, but a Chinese carbon price is expected by 2035 (in line with WEO24). For 2035 we include CBAM duties on foreign production.
- **Time-constant cost components:** All other cost components are held constant from 2024 to 2035 but are differentiated across world regions.

Production costs per ton of product (€/ton)



Key outputs

- **Decarbonisation cost gap**: difference in costs between the existing fossil-based process and the alternative low-carbon solution.
- **Competitiveness cost gap**: difference in costs between an EU country, China and the US – with a focus here on energy price differentials.

Methodology – We compute the flexibility potential based on net revenues of a 2h battery storage and its impact on power supply costs

In this section, we further consider to what extent revenues derived from an on-site battery can provide an upside to the decarbonised / electrified processes of each application.

- Revenues that are earned on flexibility markets can cross-subsidise industrial production and ensure a more reliable electricity supply.
- These benefits should compensate for investment cost in the battery storage unit.
- The underlying modelling of the revenues of the on-site battery involves:
  - Co-optimisation of yearly revenues from participation on wholesale, balancing and congestion markets
  - Calculation of net revenues, subtracting capital costs and energy costs from flexibility provision
  - Transformation from total net revenues to EUR/MWh of industrial load and eventually per ton of final product (*see* case studies)
- Cost savings that could be achieved thanks to core process flexibility has not been computed here considering difficulties in sourcing data

Calculation of possible revenues from on-site batteries

Battery characteristics
- CAPEX: 93 k€/MW, OPEX: 18k€/MW.a
- 2h load duration, 20% of the industrial plant’s maximum load

Calculation of attainable yearly revenues
- Co-optimisation of wholesale, congestion and balancing market.

Calculation of net-revenues
- Subtraction of storage investment costs and energy costs

Net-revenues per MWh of industrial load
- Calculations were performed for Sweden and Italy
- The revenues will heavily depend on the availability and openness of markets and future market conditions
- Under our assumptions, the model outputs an achievable power supply cost reduction between 3 and 9 €/MWh

__Note:__ For similar flexibility modelling see Compass Lexecon for smartEN (2025) The business case for flexibility provision in energy-intensive industries. Plexos is an energy system modelling software that performs multiple integer linear programming (MILP) optimisation using the Gurobi algorithm. More information in Technical Appendix. For Sweden we assessed wholesale markets in the SE3 bidding zone, whereas for Italy we focus on ITN (Italy north)

Methodology – Processes' electro intensity typically increase when using electrified solutions

- In WP1 we categorised industrials into levels of exposure to electricity costs based on the following formula, with average power market prices as power purchasing costs for the industries: $\boldsymbol{Electro\ intensity} = \frac{\boldsymbol{Electricity\ purchasing\ costs}}{\boldsymbol{Total\ production\ costs}}$
- In this section (WP2), electro-intensity is calculated including rebates on power purchasing costs available locally. [1]
- Before electrification, the selected processes have varied shares of electricity cost to total cost based on EU-level 2024 industrial electricity prices. Post electrification, most processes would fall into the highest intensity category.

Classification of the sectoral case studies by electro-intensity at the EU level – actual numbers at case study-level may vary

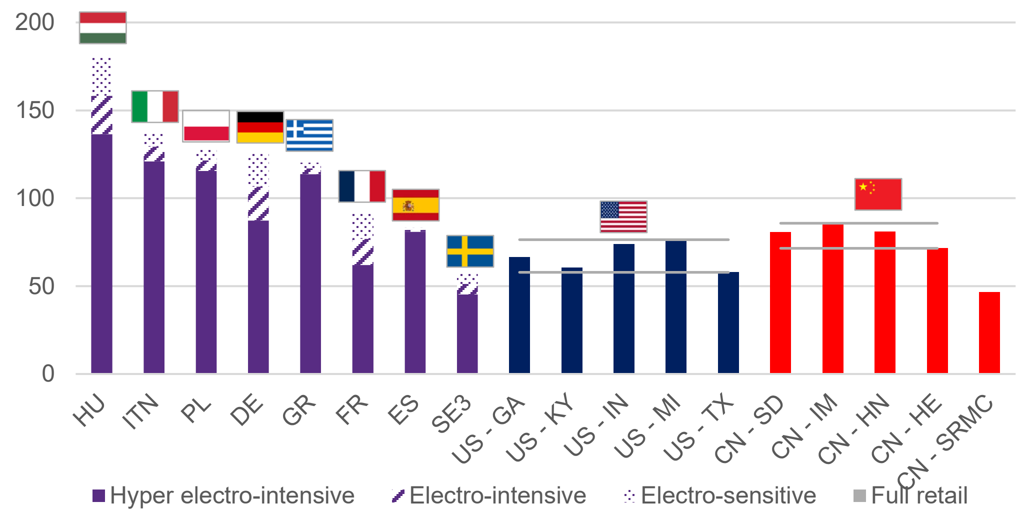
Product	Incumbent electricity intensity 2024 (share of power purchases in total costs)	Classification (incumbent, 2024)	Decarbonised electricity intensity 2035 (share of power purchases in total costs)	Classification (decarbonised, 2035)
Primary aluminium production	50%	**Hyper-electro-intensive**	47%	**Hyper-electro-intensive**
Primary crude steel production	<3%	**Electro-sensitive**	46% (11% direct, 35% indirect)	**Hyper-electro-intensive**
Steam supply for low-temp chemicals	<3% (dependent on process)	**Electro-sensitive**	25%	**Hyper-electro-intensive**
Paper drying and production	CHP-self consumption	**Electro-sensitive**	37%	**Hyper-electro-intensive**
Battery manufacturing	<3%	**Electro-sensitive**	<3%	**Electro-sensitive**

Notes: [1] for instance, the electro-intensity of primary aluminium was calculated in WP1 as 49% and 48% in 2024 and 2035 respectively but is now computed as 39% and 38% in 2024 and 2035 respectively (factoring in rebates and taking the power purchase cost in Greece).

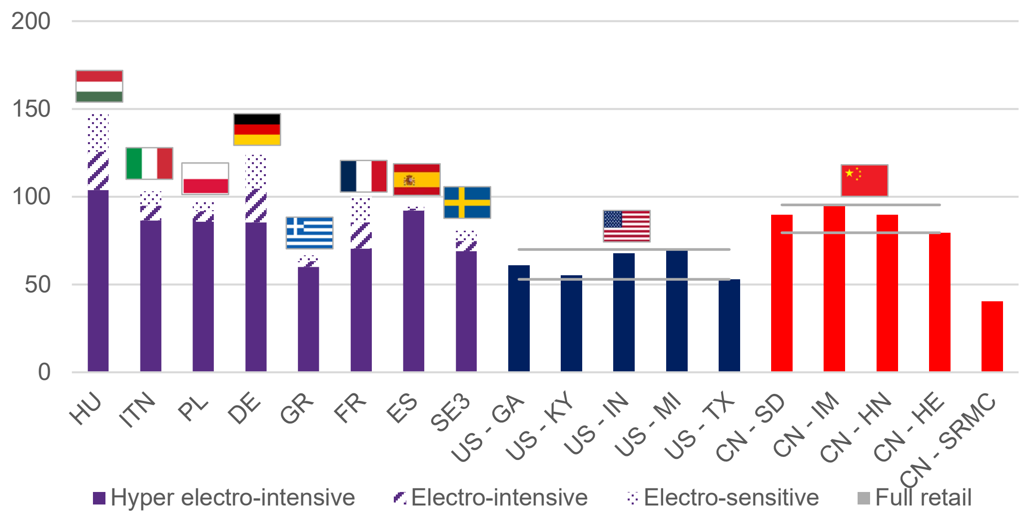
Methodology – Electricity price assumptions vary according to the electro intensity of the processes and are based on reference external sources

- **Retail price assumptions:** industrial retail prices are differentiated between hyper electro-intensive, electro-intensive and electro-sensitive. Final retail rates include procurement costs, network costs as well as taxes levies and fees in Europe. For the US and China, we show relevant industrial retail rates which are equivalent to electro-sensitive rates in Europe.
  - For 2024, we rely on publicly available statistics.
  - For 2035 price assumptions for the EU rely on CL scenario modelling for IDDRI-Agora with main inputs from TYNDP24 and WEO24, US prices are based on the projections of industrial retail prices made by the EIA 2025 Energy Annual outlook and Chinese projections are based on AFRY projections.
- **Additional sensitivity China:** Historically, the Chinese government has subsidised coal-fired power generation, and some industrial facilities operate on-site coal plants. To reflect this, a Chinese "coal SRMC" sensitivity is included, assuming industrial users receive electricity at short-run marginal cost.

Industrial electricity retail price assumptions, 2024, €$_{2024}$/MWh



Industrial electricity retail price assumptions, 2035, €$_{2024}$/MWh



Sources: CL EU competitiveness gap prices scenario, Eurostat, IEA (2024) World Energy Outlook,, EIA (2025) Annual Energy Outlook, , AFRY (2023) Internationaler Vergleich Industriestrompreise and Energy Market Price,

*Notes: EU 2024 procurement costs are based on annual average day-ahead prices, network costs and taxes are from Eurostat non-household consumers with a consumption >150 GWh/a US retail prices are based on to EIA 2024 average US Industrial price converted in EUR/MWh and China retail price Chinese retail rates are based on scholarly work publicly available reports, for more information see Technical Appendix. Retail prices for hyper electro-intensive industries reflect (i) the wholesale price and (ii) rebated non-energy charges. For France, Germany, Poland, and Spain, the rebate is based on the specific national discounts for EIIs. In other countries, an average discount is applied to Eurostat's 2024 data for non-energy charges. Electro-intensive and electro-sensitive industries follow the same methodology, but with half the discount and no discount on non-energy charges, respectively. Projections of electricity prices in the US in 2035 are calculated by applying the growth rate of industrial retail prices from the EIA 2025 Annual Energy Outlook report between 2024 and 2035 to each observed industrial retail price in the states of interest in 2024. Chinese short-run marginal costs are based on historic coal prices as reported on Zhangzou commodity exchange and assume 3 EUR/MWh variable operational costs. Efficiencies represent average between high and low efficiency plants to reflect diverse generation assets. **Abbreviations:** CN…China, GA…Georgia, KY…Kentucky, IN…Indiana, MI…Michigan, TX…Texas, SD…Shandong, IM…Inner Mongolia, HN…Henan, HE…Hebei, SRMC…Short run marginal costs*

Methodology – Uncertainties on post-2030 carbon leakage mitigation are captured using sensitivities on CBAM in each industrial case study

- The first version of the EU CBAM entered its implementation phase in January 2026, with changes announced in December 2025 (*See*. right box).
- For the analysis of competitiveness gaps in 2035, several policy combinations are possible as of today. Uncertainties on the efficiency of CBAM as well as uncertainties on its scope extension to indirect emissions should be captured in the analysis.
- Thus, we perform sensitivities showing costs associated with CBAM duties for foreign products on scope 1 and / or scope 2 emissions and their impacts on products/process specific costs.

Our assumptions for the computation of CBAM duties

$$\textbf{Direct emissions } (\boldsymbol{Scope}\ \mathbf{1}) = \big((EU\ domestic\ CO_2\ price) - (Foreign\ CO_2\ price)\big) \times \boldsymbol{installation\ emission\ factor}$$

Carbon costs in 2035 are based on WEO24 STEPS:
EU: 130 €/tCO_2, CN: 20 €/tCO_2 and US: 0 €/tCO_2

Installation-specific power factors are based on our bottom-up cost model assumptions

$$\boldsymbol{Indirect\ emissions}\ (\boldsymbol{Scope}\ \mathbf{2}) = EU\ domestic\ CO_2\ price \times Foreign\ average\ power\ emission\ factor \times \boldsymbol{installation\ power\ factor}$$

Powers sector average emissions are based on IEA WEO24 STEPS: c. 30% decrease in 2035 from current levels

Product and process specific electricity consumptions are based on our bottom-up cost models assumptions

Our assumptions reflect the theoretical impacts of the CBAM Regulation Delegated acts published in December 2025:

- **The use of default values for calculating CBAM duties is disincentivised (mark-ups)**
  - We assume actual embedded emissions are the basis for CBAM duty calculations
- **Embedded scope 2 emissions are determined using average CO_2 emission factor of power generation**
  - We replicate that methodology for CBAM costs on scope 2 emissions
- **An extension of CBAM to downstream products and additional measures will be implemented to avoid circumvention**
  - We assume CBAM applies to all embedded emissions in imported goods

 Sources: CL analysis based on EC (2025) Report on the application of the regulation on CBAM (available here)

2.3.2
Case study results

Primary Aluminium Production

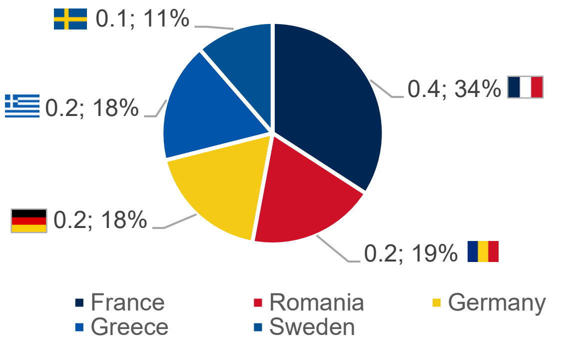
EU production represents 2% of global aluminium production compared to China's 60%, with a historical drop in primary aluminium production

EU aluminium production has been stable over the past 2 decades mainly due to a shift towards secondary aluminium

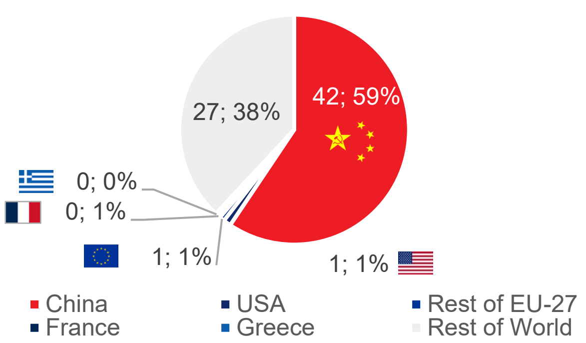
- EU domestic production (primary and secondary) remained relatively stable since 2000 with primary production dropping from 28% to 7% (only 8 smelters in 2023 vs 23 in 2003)[2]
- The increase in EU demand was met by imports which now increased to 54% of the mix.

EU aluminium production is highly trade intensive with EU only representing 2% of global production, and a high share of imports meeting EU demand

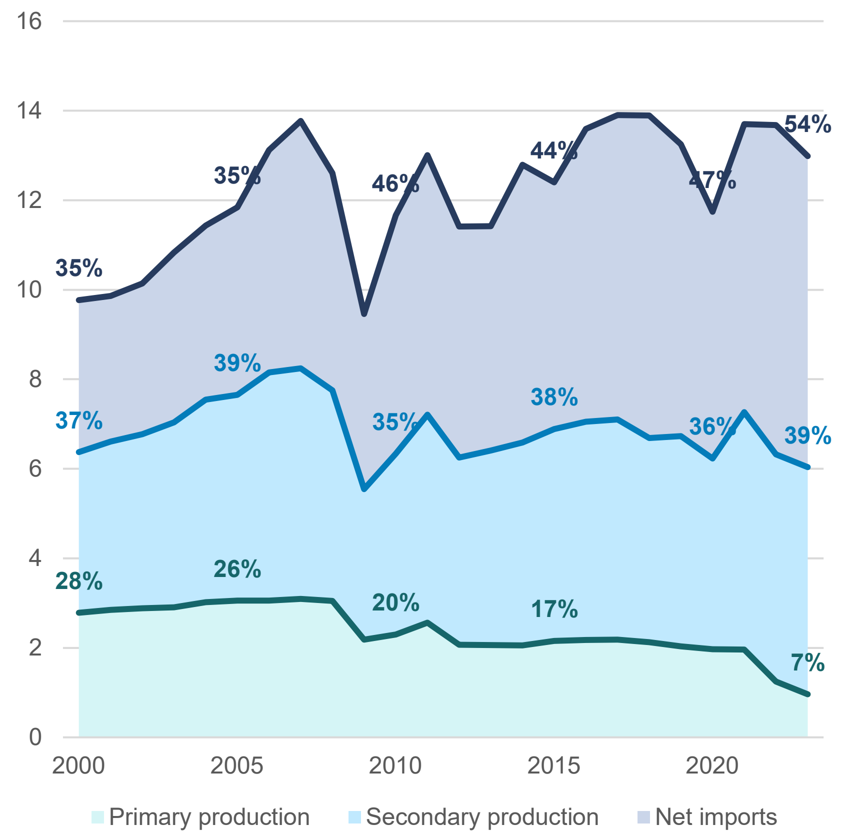
EU production, 2023 (Mt; %)



World production, 2023 (Mt; %)



EU27+UK primary and secondary aluminium production and net imports from 2000-2023, $Mt_{aluminium}$[1]



Source: EU Commission, International Aluminium – Primary aluminium production, World Mining Data 2025, European Aluminium – Industry overview
Notes : (1) EU25 data for 2000-2004, EU27 data for 2005-2013, EU28 data for 2014-2020 and EU27+UK for 2021 onwards. (2) Among EU27 smelters
Abbreviations: EU… European Union

Primary Aluminium Production

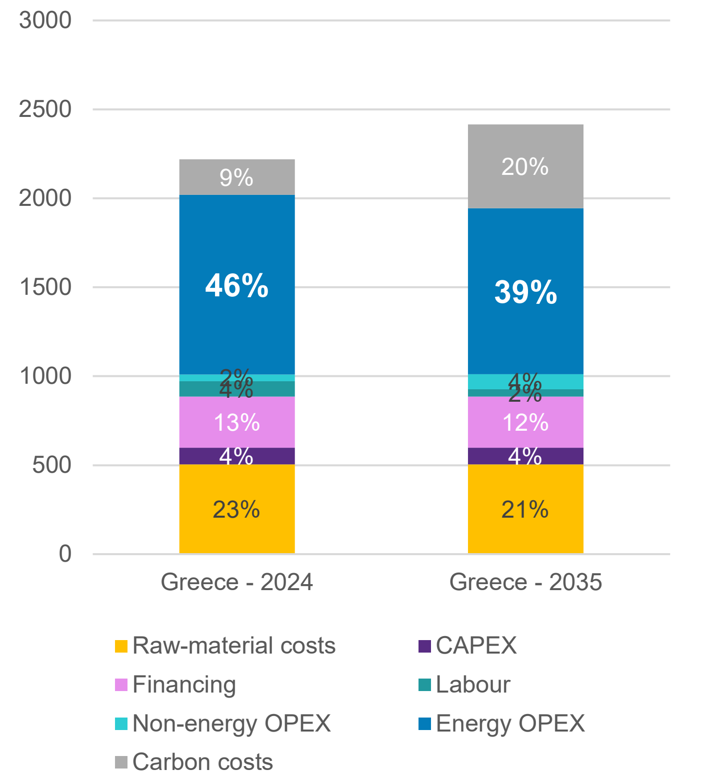
EU aluminium's competitiveness issues arise from electricity and carbon costs as well as limited access to raw materials

Although electricity costs account for c. 45% of total production costs in the EU, the aluminium sector's competitiveness is also affected by:

- Overcapacity in China, though export is restricted by caps to secure supply for downstream production (e.g. automotive).
- Access to raw material with a limited availability of recycled aluminium and China's control over bauxite supply chains
- Main competitors to EU production is India and MENA-region (lower power prices and no carbon costs)

Competitiveness drivers			
Electricity supply	• Volatility of EU electricity prices	• Lowest energy costs but lower quality in network infrastructures	• Significant share of aluminium production is supplied by off-grid coal plants at below market prices
Overcapacity	• Chinese production cap now limits overcapacity • CBAM could regulate carbon intensive imports	• US downstream industry relies on imports from Canada • Historically, largest importer of Chinese aluminium • Trade tariffs impact imports	• Significant structural overcapacity but caps on exports • Firms set up production abroad to avoid cap
Raw material procurement	• Limited domestic supply • Further development of recycling[2]	• Limited domestic supply • Import diversification with joint venture in key producing countries (CBG, Guinea)	• Net bauxite importer but owns 70% of 2024 bauxite supply (largely outside of China)

Primary aluminium net-cost breakdown[1], $€_{2024}/t_{aluminium}$



Disclaimer: Total production costs are estimated based on EU representative installations and should be considered as estimates.

Source: CL analysis based on European Aluminium Action Plan (2025); European Aluminium facts and figures (2024); Eurostat (2025); European Steel and Metals Action Plan (2025)

Notes: (1) Country-level energy cost calculations for 2024 include free allowances and indirect cost compensations. 2035 cost component calculations do not include free allowances due to the phase-out and no indirect cost compensations as current schemes end in 2030. (2) Limited recycling/production capacity is a bottleneck for secondary aluminium production in the EU, with domestic scrap volumes exported abroad.

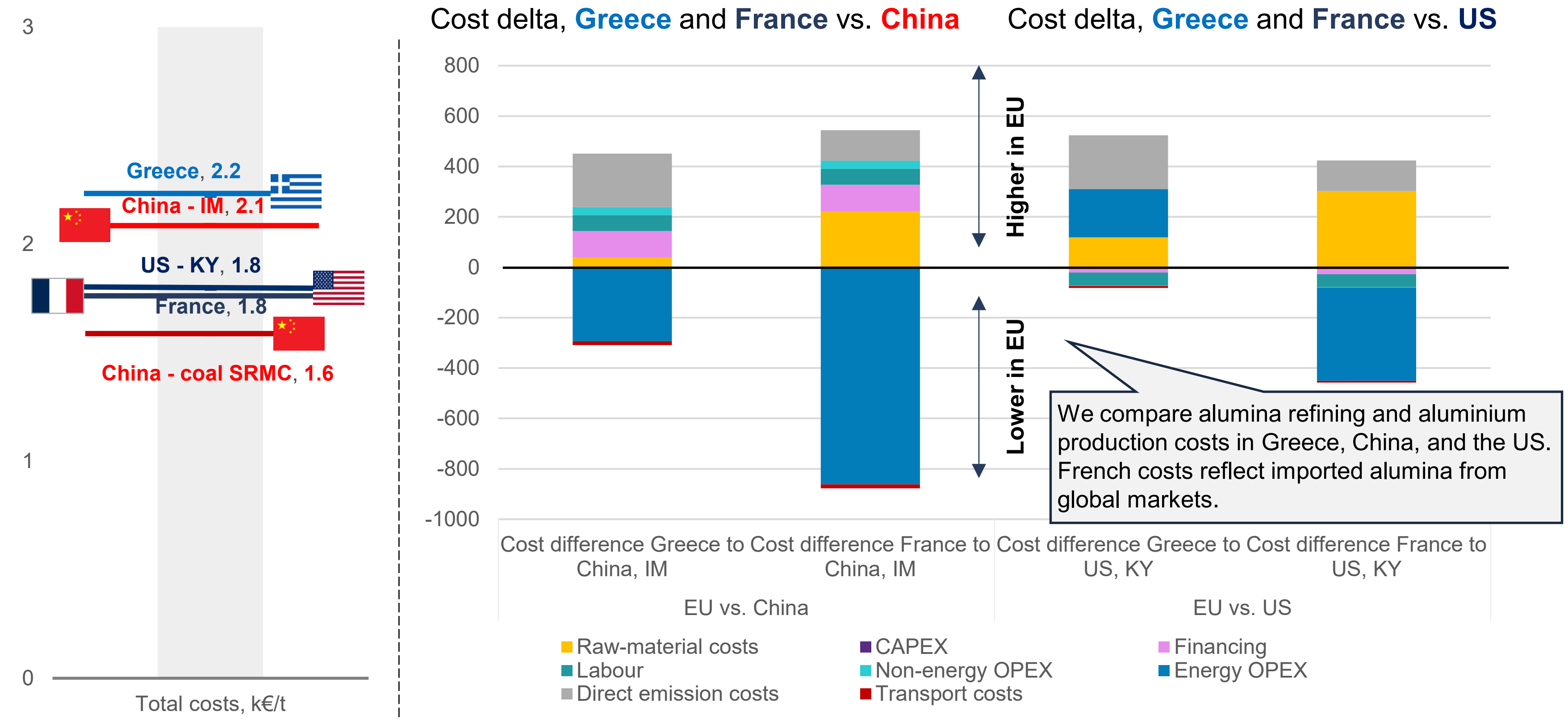
Primary Aluminium Production

As of today, energy and ETS costs make up the majority of the competitiveness gap with the US, while the gap with China is also driven by financing costs

The EU's production cost competitiveness is mainly hindered by energy and direct ETS costs compared to the US, while financing costs also weigh on its position relative to China.

- The overall cost gap between the EU and China ranges between c.-9% and c.+10%
- The overall cost gap between the EU and the US ranges between c.+6% and c.+27%

Net-cost difference breakdown primary aluminium: incumbent (alumina refining + electrolysis) – France and Greece vs. China and US in 2024, $€_{2024}/t_{aluminium}$



Disclaimer: Total production costs are estimated based on EU representative installations and should be considered as estimates rather than true values for real sites.

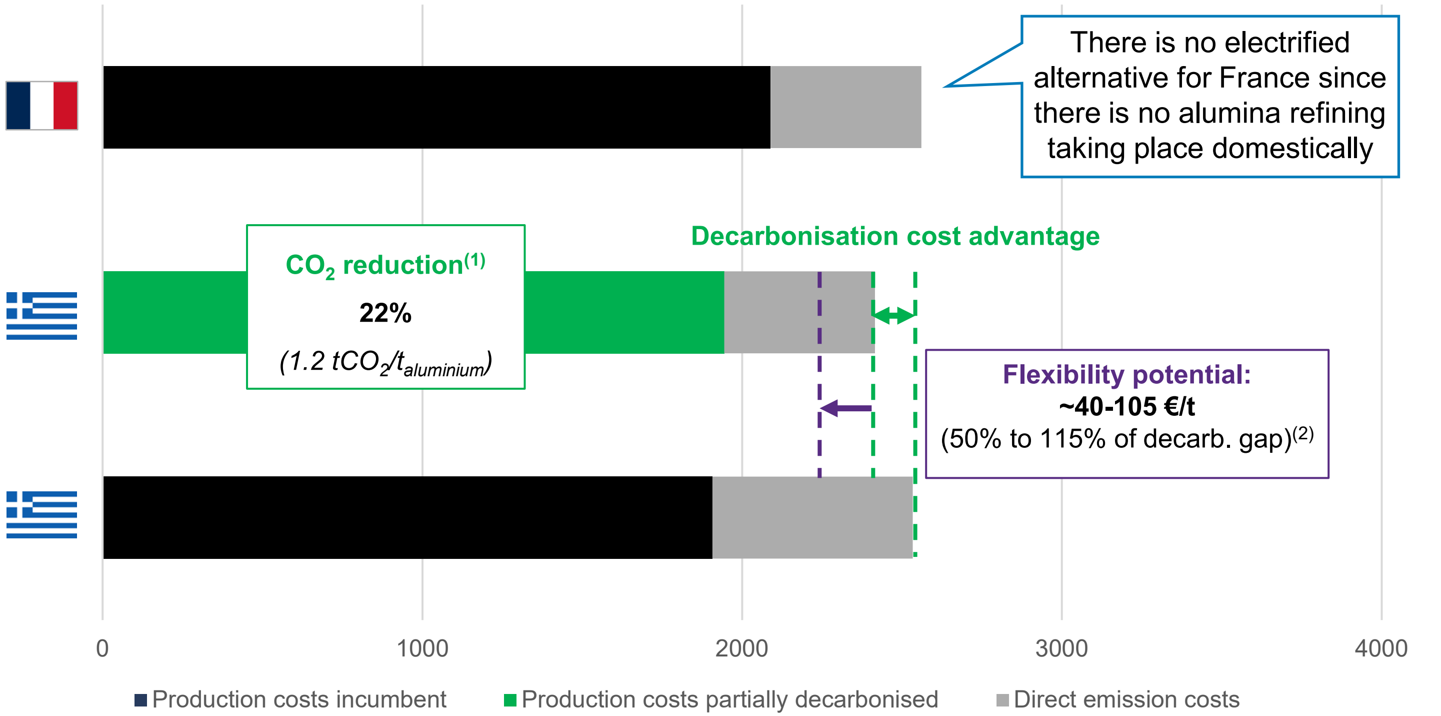
Notes: *Direct emission costs include EU ETS 1 allowance costs, net of free allowances. Electricity costs are shown net of indirect CO2 cost compensation. Chinese short run marginal costs assume that electricity is supplied by an on-site coal power plant that only incurs fuel costs and variable production costs. Capital costs are assumed to be covered by the Chinese state/province.*
Abbreviations*: IM...Inner Mongolia, KY...Kentucky, SRMC…Short-run marginal costs*

Primary Aluminium Production

By 2035, electrified alumina refining in the EU could outperform fossil gas-based production, conditional to the full phase-out of free allocation

- By 2035, two mature processes are considered for primary aluminium production:
  - The incumbent process: NG alumina refining + electrolysis, emitting 4.8 $tCO_2/t_{aluminium}$ (scope 1) [1];
  - The partially decarbonised process: e-boiler alumina refining + electrolysis, emitting 3.6 $tCO_2/t_{aluminium}$ (scope 1) [1]
- Under our assumptions, higher direct emission costs due to the phase-out of free allowances by 2035 may render electrified alumina refining more cost-effective than natural gas alumina refining.

Primary aluminium illustrative cost comparison
France and Greece in 2035, $€_{2024}/t_{aluminium}$



Disclaimer: Total production costs are estimated based on EU representative installations and should be considered as estimates rather than true values for real sites.

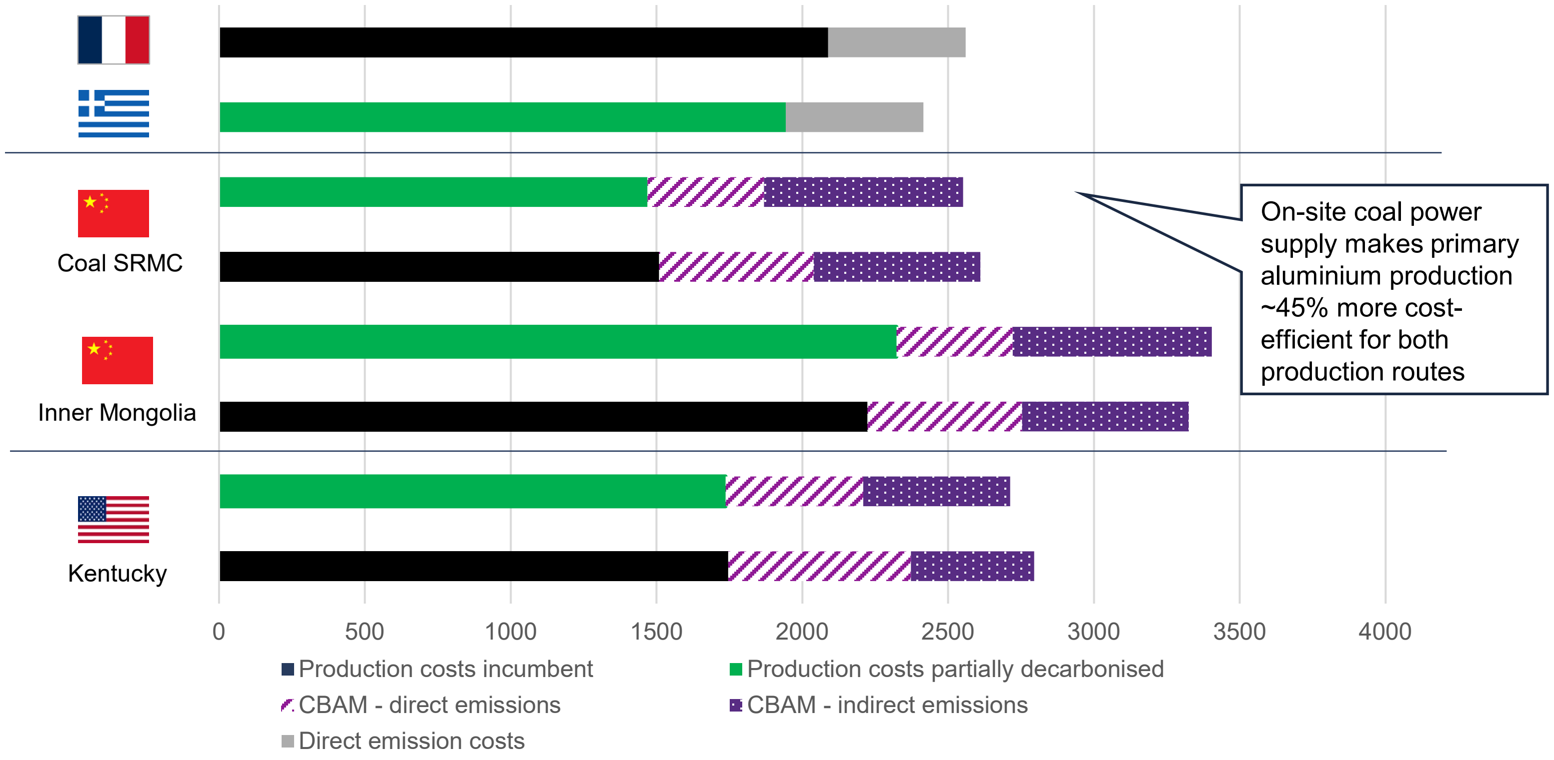
Notes: *(1) Emissions considered for the incumbent and partially decarbonised processes are limited to Scope 1 emissions, i.e. emissions emitted during the production process, they are thus similar between countries/regions. Direct emission costs correspond to the full EU ETS 1 cost (with no free allocation) also, indirect cost compensations are assumed to be phased-out; emissions from smelting and refining are accounted for the incumbent process while only the anode smelter is subjected to emission costs for the partially decarbonised process. (2) For case studies where the electrification/decarbonisation gap (incl. direct emission costs) is already closed, we show flexibility potential in terms of gap size that can contribute to reducing overall costs further.*
Abbreviations: *NG…Natural Gas*

Primary Aluminium Production

In 2035, possible configurations of carbon leakage policy diversely affect the competitive position of EU aluminium production compared to foreign products

- Under our assumptions, 2035 total production costs for the partially decarbonised process are similar to the incumbent process both in China (Inner Mongolia, c.+5% cost) and the US (Kentucky, c.-0.5%).
- In a hypothetical configuration with CBAM on scopes 1 & 2 and no ICCC, partially decarbonised production in the EU could be more competitive than China and US incumbent production.
- The continuation of ICCC could further improve the competitiveness of EU products (see slide 94).
- CBAM on direct emission costs(2) could increase costs between 25% (US) and 35% (China).
- CBAM on indirect emissions(2) could increase costs between 17% (China) and 27% (US).

Primary aluminium illustrative cost comparison under several carbon leakage policy configurations
France, Greece, China and US in 2035, $€_{2024}/t_{aluminium}$



Disclaimer: Total production costs are estimated based on EU representative installations and should be considered as estimates rather than true values for real sites.

*Notes: (1) Emissions considered for the incumbent and partially decarbonised processes are limited to Scope 1 emissions, i.e. emissions emitted during the production process, they are thus similar between countries/regions. Direct emission costs correspond to the full EU ETS 1 cost (with no free allocation) also, indirect cost compensations are assumed to be phased-out; emissions from smelting and refining are accounted for the incumbent process while only the smelter is subject to emission costs for the partially decarbonised process.(2) Direct emissions include process specific emissions and indirect emissions include power system emissions (3) Flexibility potential relies on revenues that are attainable from a 1h and 2h on-site battery, covering 20% of industrial hourly load, that participates in flexibility markets and show a range depending on market conditions. Chinese short run marginal costs assume that electricity is supplied by an on-site coal power plant that only incurs fuel costs and variable production costs. Capital costs are assumed to be covered by the Chinese state/province. **Abbreviations:** CBAM… Carbon Border Adjustment Mechanism. SRMC… Short Run Marginal Cost.*

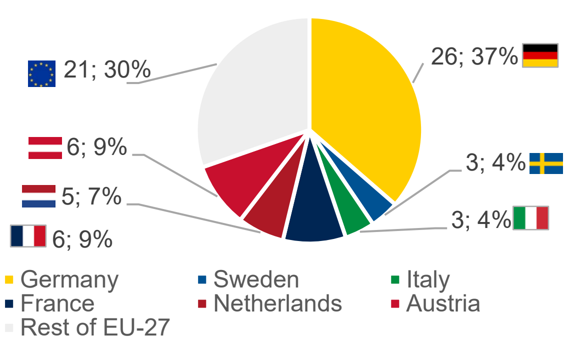
Primary steel production

The EU has moved from a net exporter of crude steel to importing. Today, around 50% of demand is met by primary production. China dominates global production

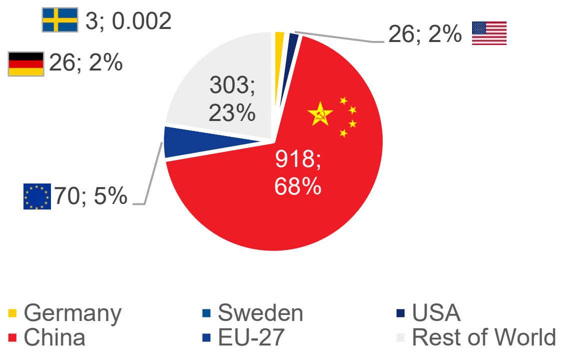
Total EU steel production has been decreasing since 2011 due to foreign overcapacities, during the energy crisis secondary steel production fell more sharply than primary

- Total EU crude steel (primary and secondary) demand decreased by c. 10% between 2011 and 2024.
- In 2015, the EU pivoted from net exporter to net importer of crude steel.
- Since then, primary and secondary steel production dropped both in absolute and relative terms, with secondary (EAF) steel production falling c. 30% due to electricity costs exposure.

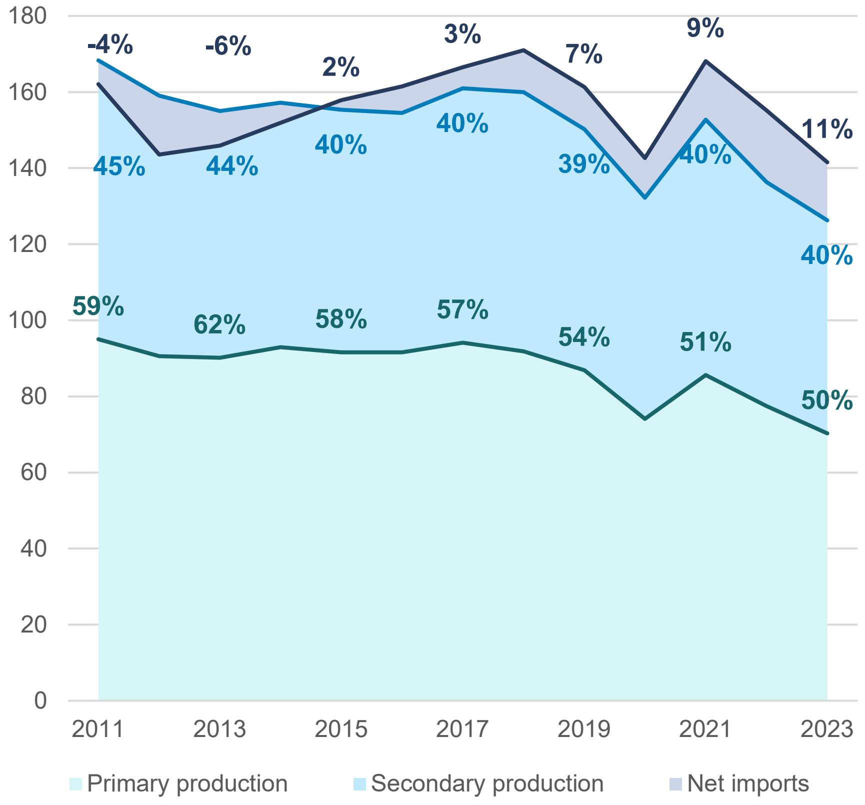
EU oxygen steel prod., 2023 (Mt; %)



World oxygen steel prod., 2023 (Mt; %)



EU27 primary (oxygen) and secondary (electric) steel production and net imports from 2011-2023, Mt_{steel}



Source: CL analysis based on WV Stahl (2025) Statistisches Jahrbuch, World Steel (2025) World Steel in figures
Abbreviations: EAF… electric arc furnace

Primary Steel Production

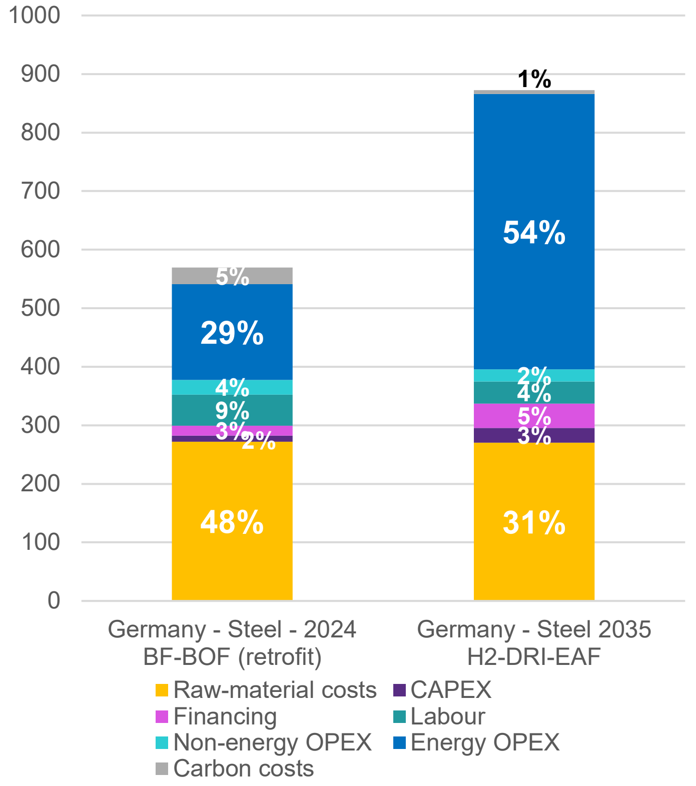
Competitiveness of European steel production is affected by Chinese overcapacity, US tariffs and rising energy costs

Apart from high energy cost shares of ~30% today and ~55% post-decarbonisation other competitiveness issues arise for EU steel:

- Structural overcapacities in China pressurising global crude steel prices
- New tariffs in the US market
- Limited domestic raw material supply, with the EU being a net importer of iron ore

Factor of competitiveness			
Electricity supply *(Today's primary steel production not affected; secondary steel has exposure)*	• Limited impact on BF-BOF, secondary / EAF exposed to EU electricity price levels and volatility	• No effect today; For electric steel: lowest energy costs but lower quality in network infrastructures	• Province with highest steel production (Hebei) has lowest prices among surveyed provinces
Overcapacity	• Global overcapacity affects sector	• Global overcapacity affects sector • New tariffs affect imports	• Significant structural overcapacity of EAF (CBAM resilient)
Raw material procurement	• Limited domestic supply, net importer of raw materials (iron ore), net exporter of steel scrap	• Net exporter of iron ore	• Net importer of iron ore (70% of 2022 world trade volume)

Primary steel production net-cost breakdown[(1)], $€_{2024}/t_{steel}$



Disclaimer: Total production costs are estimated based on EU representative installations and should be considered as estimates.

Source: CL analysis based on bottom-up costs models, various sources (see Technical Appendix), WV Stahl (2025) Statistisches Jahrbuch, World Steel (2025) World Steel in figures, EC (2025) European steel and metals action plan
Notes : (1) Country-level energy cost calculations for 2024 include free allowances and can thus differ from energy-intensity calculations from WP1. 2035 cost component calculations do not include free allowances due to the phase-out and no indirect cost compensations as current schemes end in 2030.
Abbreviations: BF-BOF…blast furnace – basic oxygen furnace, EAF… electric arc furnace, H2-DRI-EAF…Hydrogen direct reduced iron electric arc furnace

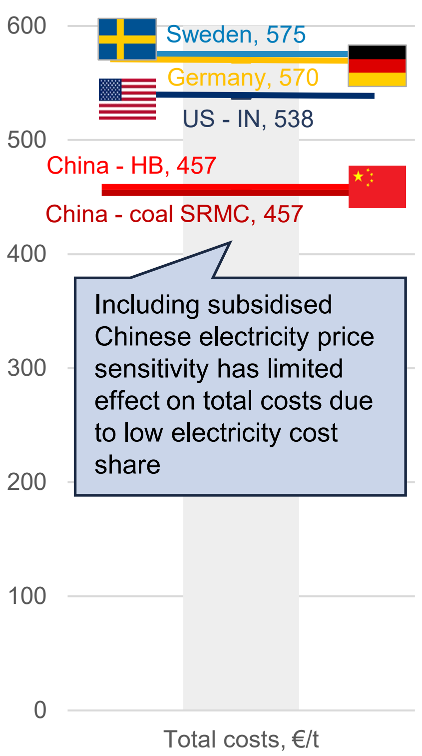
Primary Steel Production

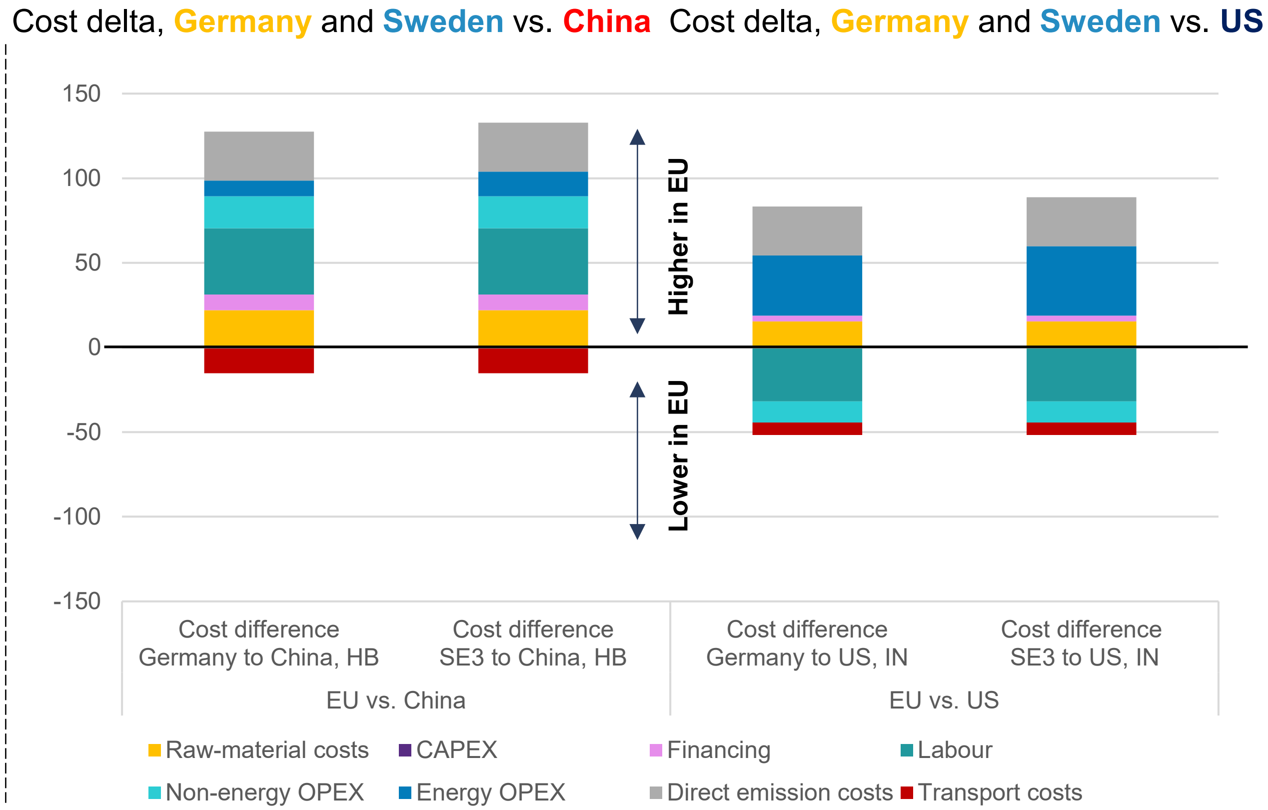
Today, Chinese steel production benefits from lower labour and raw material, costs while the US production tends to have more competitive energy prices

While carbon cost impacts EU industry competitiveness compared to China and the US, lower energy costs in both countries and lower Chinese labour cost drive cost difference.

- Chinese steel production is more cost competitive on all cost components leading to total costs being **c.20% lower** than in Germany and Sweden.
- Compared to the US, EU producers face **a cost gap of c.6%**, due to higher energy, material and carbon costs.

Net-cost difference breakdown primary steel: incumbent (BF-BOF) – Germany and Sweden vs. China and US in 2024, $€_{2024}/t_{steel}$





Disclaimer: Total production costs are estimated based on EU representative installations and should be considered as estimates rather than true values for real sites.

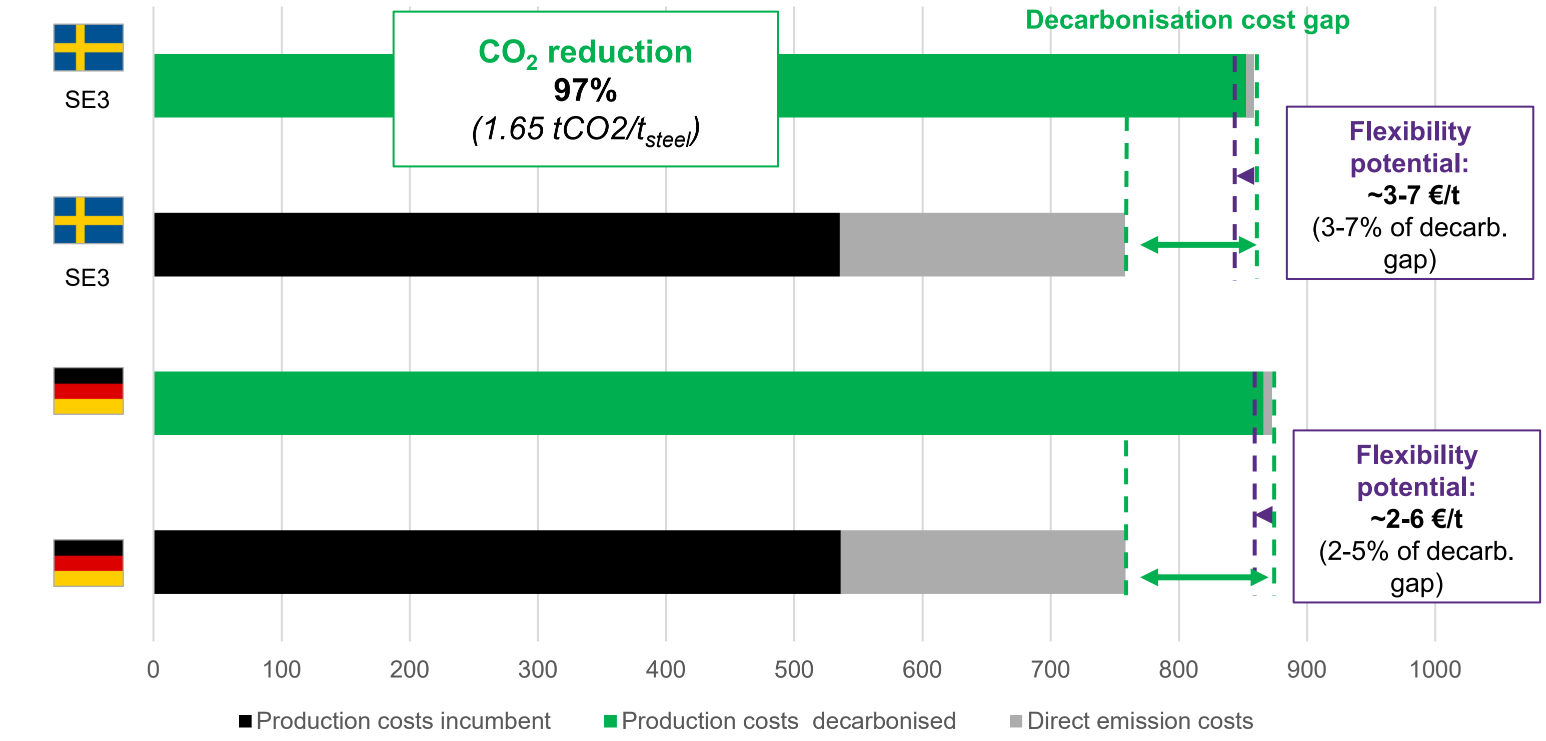
Notes: *Direct emission costs include EU ETS 1 allowance costs, net of free allowances. Electricity costs are shown net of indirect CO2 cost compensation. Chinese short run marginal costs assume that electricity is supplied by an on-site coal power plant that only incurs fuel costs and variable production costs. Capital costs are assumed to be covered by the Chinese state/province.*
Abbreviations *: NG… Natural gas. BF-BOF…Blast Furnace - Basic Oxygen Furnace (production route relying on coal), HE…Hebei*

Primary Steel Production

Despite high carbon costs, the incumbent production route may remain more competitive due to high hydrogen costs

- By 2035, two mature processes are considered for primary steel production:
  - The incumbent process: BF-BOF (retrofit), emitting 1.7tCO_2/t_{steel} (scope 1)[1]
  - The decarbonised: H2-DRI-EAF, emitting 0.05 tCO_2/ t_{steel} of output (scope 1)[1]
- Despite direct emission costs up to c. 30% of total costs, the incumbent process remains more competitive than the decarbonised production by c. 15%. Main cost-driver of the decarbonised solution are high hydrogen costs.
- The flexibility offered by a 2-hour battery could marginally reduce costs of the electrified process, while further core process flexibility has not been priced in and could be explored.

Primary steel illustrative cost comparison Sweden and Germany in 2035, €$_{2024}$/t_{steel}



Disclaimer: Total production costs are estimated based on EU representative installations and should be considered as estimates rather than true values for real sites.

Notes: (1) Emissions considered for the incumbent and partially decarbonised processes are limited to Scope 1 emissions, i.e. emissions emitted during the production process, they are thus similar between countries/regions. Direct emission costs correspond to the full EU ETS 1 cost (with no free allocation) also, indirect cost compensations are assumed to be phased-out; Cost assume baseload operation, no hybrid elements or flexibility revenues. For Sweden we consider SE3 as the relevant bidding zone

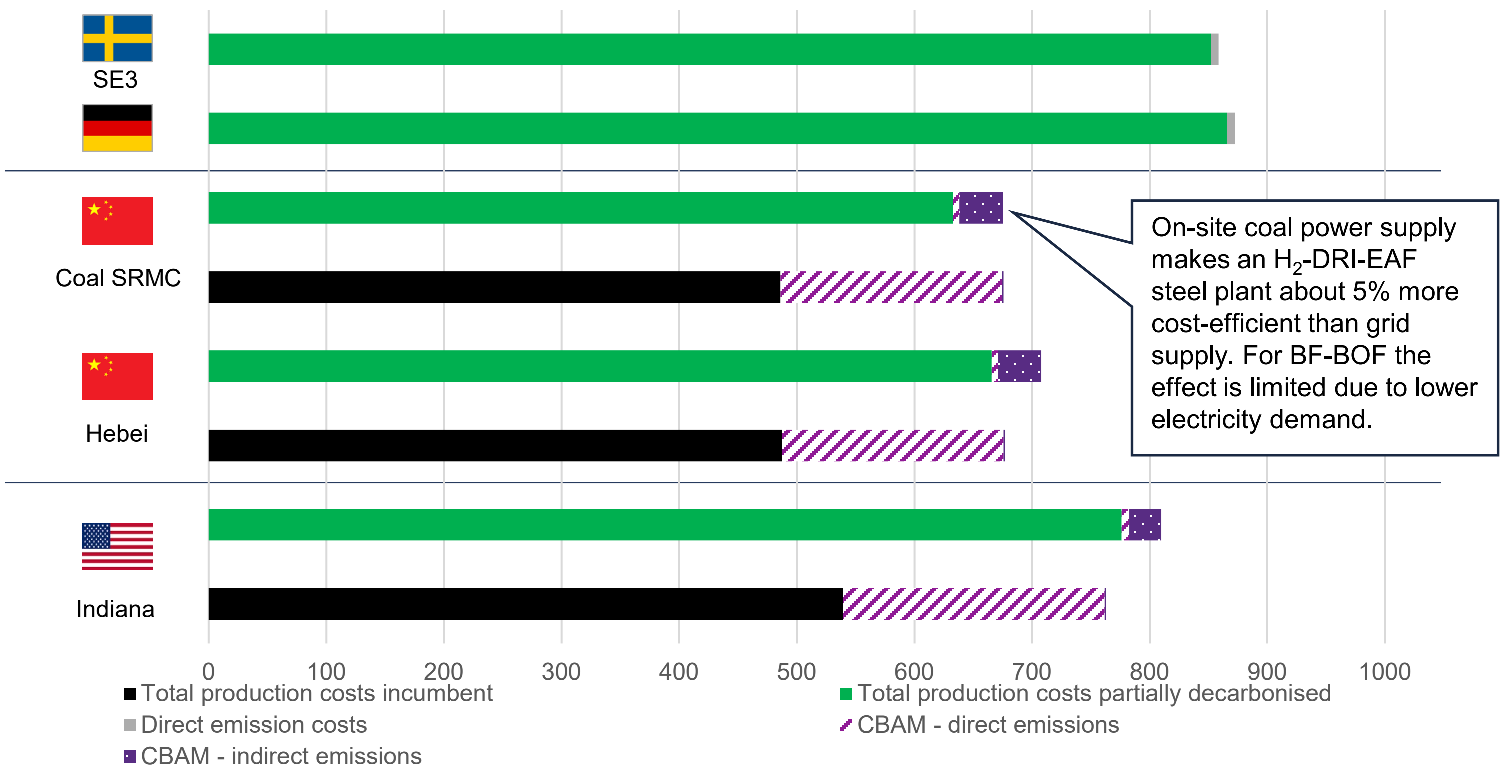
Abbreviations: SE3… Sweden 3 (power market bidding zone), Natural Gas, . BF-BOF…Blast Furnace - Basic Oxygen Furnace; H2-DRI-EAF… Hydrogen Direct-Reduced Iron- Electric Arc Furnace.

Primary Steel Production

In 2035, possible configurations of carbon leakage policy diversely affect the competitive position of EU steel production compared to foreign products

- By 2035, total production costs for the decarbonised process are more expensive than the incumbent process both in China (Hebei, c.+37% cost) and the US (Indiana, c.+45%).
- In a hypothetical configuration with CBAM on scopes 1 & 2 and no ICCC, EU decarbonised production could remain more expensive by c.15-30%.
- The continuation of ICCC and the use of flexibility (batteries and core process) would further improve the competitiveness of EU products (see slide 94).
- CBAM on direct emissions(1) would increase costs between c.29% (US) and c.28% (China)
- CBAM on indirect emissions(1) would increase costs between 3% (US) and 5% (China)

Primary steel illustrative cost comparison under several carbon leakage policy configurations
Germany, Sweden, China and US in 2035, $€_{2024}$//t_{steel}



Disclaimer: Total production costs are estimated based on EU representative installations and should be considered as estimates rather than true values for real sites.

Notes: (1) Direct emissions include process specific emissions and indirect emissions include power system emissions. Flexibility potential relies on revenues that are attainable from a 1h and 2h on-site battery, covering 20% of industrial hourly load, that participates in flexibility markets and show a range depending on market conditions. For Sweden we consider SE3 as the relevant bidding zone. Chinese short run marginal costs assume that electricity is supplied by an on-site coal power plant that only incurs fuel costs and variable production costs. Capital costs are assumed to be covered by the Chinese state/province.

Abbreviations: SE3… Sweden 3 (power market bidding zone), CBAM… Carbon Border Adjustment Mechanism. BF-BOF. Blast Furnace - Basic Oxygen Furnace; H2-DRI-EAF… Hydrogen Direct-Reduced Iron- Electric Arc Furnace

Steam supply for low-temperature chemicals

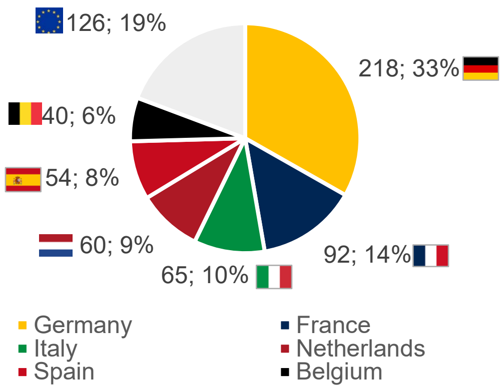
The EU is a net exporter of chemicals but has been losing market shares to China

EU nominal production value spiked in 2022 due to price increases, while losing global market shares and reducing absolute value of exports

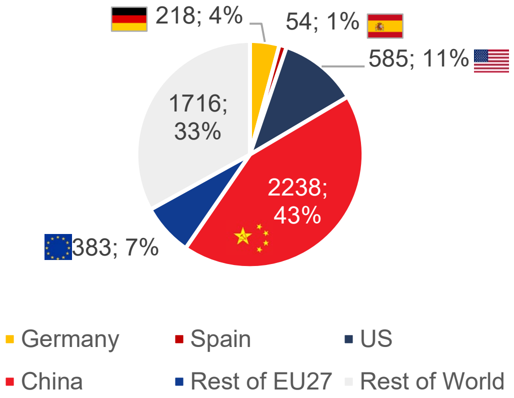
- The EU is a net-exporter of chemicals, but most of the trade in chemicals is within the EU
- Although the EU chemical industry's value peaked in 2022, its global market share dropped from 16% in 2013 to 13% in 2023.
- Over the same period, China's share rose from 34% to 43% and US market shares dropped from 15% to 11%.

Steam generation represents the majority of production costs in low-temperature chemical manufacturing and these costs are shared across chemical outputs. The case study will thus focus on this specific process.

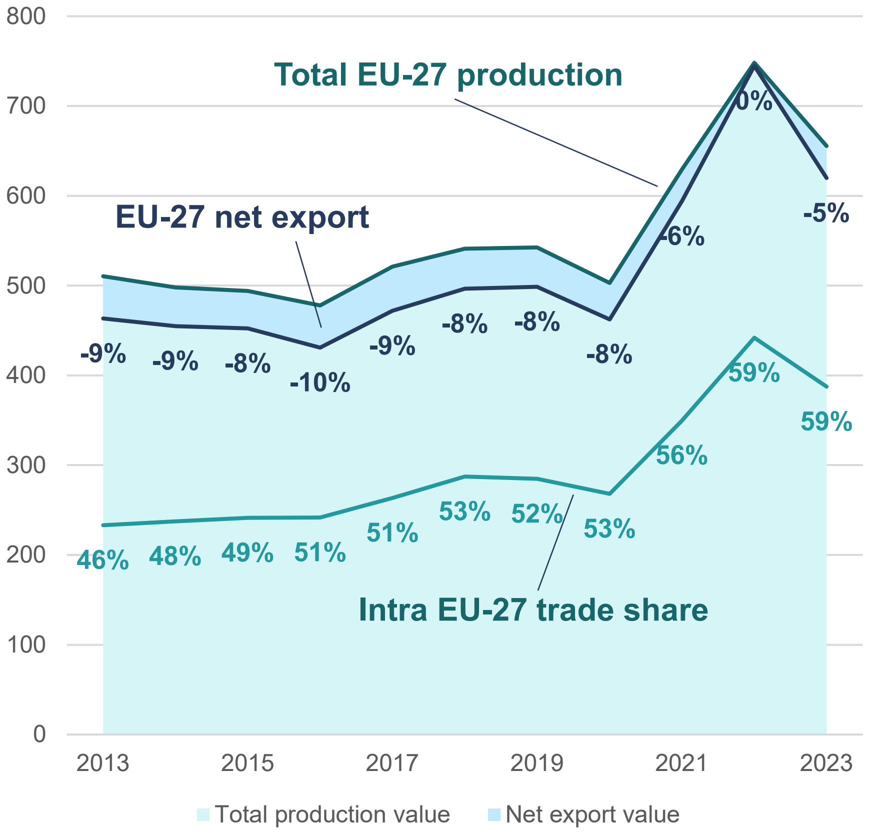
EU chemical prod. value, 2023 (bn€; %)



World chemical prod. value, 2023 (bn€; %)



EU-27 chemical production value and net imports from 2000-2024, bn€$_{nominal}$



Source: CL analysis based on CEFIC (2024) 2024 Facts and Figures, VCI (2025) Chemiewirtschaft in Zahlen
Note: Chemical production value is shown in nominal terms and includes total chemical sector as reported by CEFIC.

Steam supply for low-temperature chemicals

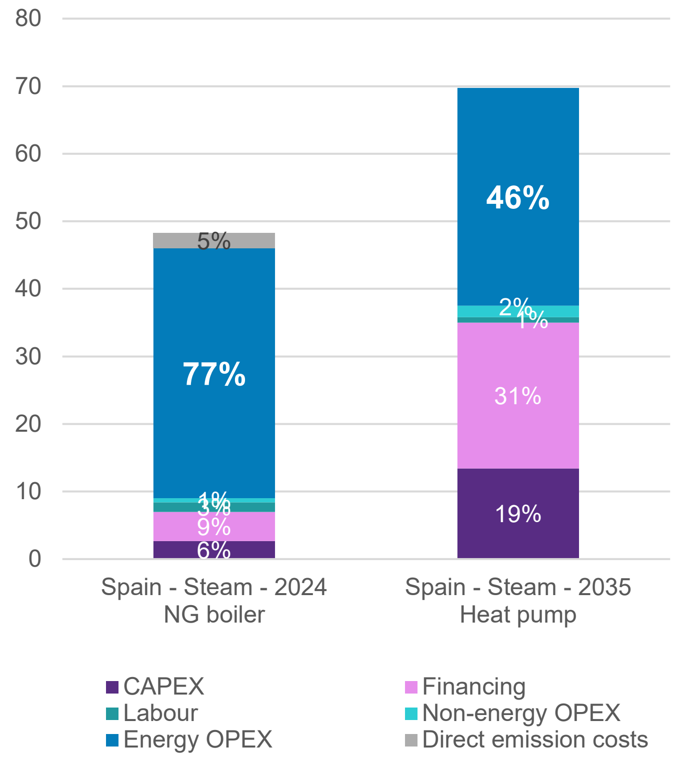
Weaker than expected domestic and global demand growth, high exposure to energy prices and supply chain disruptions impact the EU chemicals industry

With high energy cost shares, the chemical sector is sensitive to energy price fluctuations, but other factors also impact competitiveness:

- Weaker domestic and global demand growth than expected
- Strategic foreign capacity build-up of subsectors, e.g. silicones and other high-value production in China

Factor of competitiveness			
Electricity supply *(Today's steam generation only affected when running hybrid, future electrification is impacted)*	• Full impact dependent upon chemical: exposure to EU electricity price levels and volatility	• Lowest energy costs but lower quality in network infrastructures	• Province with large chemical sector (Shandong) has medium prices among surveyed provinces
Overcapacity	• Global overcapacity across sector due to weak domestic and export demand growth (~11MT announced closures)	• Global overcapacity affects sector • New tariffs affect imports	• Strategic overcapacity in some sectors due to "Made in China" policy, e.g. silicones
Raw material procurement	• Lacks integrated value chain for some chemicals • Outsourcing of less complex production has led to supply chain disruptions	• New tariff policy risks supply chain disruptions	• Controls large shares some in upstream production markets, e.g. 60% in silicone, high investment activity ongoing

Steam generation for low temperature chemicals net-cost breakdown(1), $€_{2024}/t_{steam}$



Disclaimer: Total production costs are estimated based on EU representative installations and should be considered as estimates.

Source: CL analysis based on bottom-up costs models, various sources (see Technical Appendix), CEFIC (2024) 2024 Facts and Figures, VCI (2025) Chemiewirtschaft in Zahlen Cefic-Advancy Competitiveness study (2025); Cefic chemical trends report (2025)

Note: (1) Country-level energy cost calculations for 2024 include free allowances. 2035 cost component calculations do not include free allowances due to the phase-out and no indirect cost compensations as current schemes end in 2030. Net cost breakdown shows baseload operation of NG boiler in 2024 and heat pump in 2035. Cost assume baseload operation, no hybrid elements or flexibility revenues

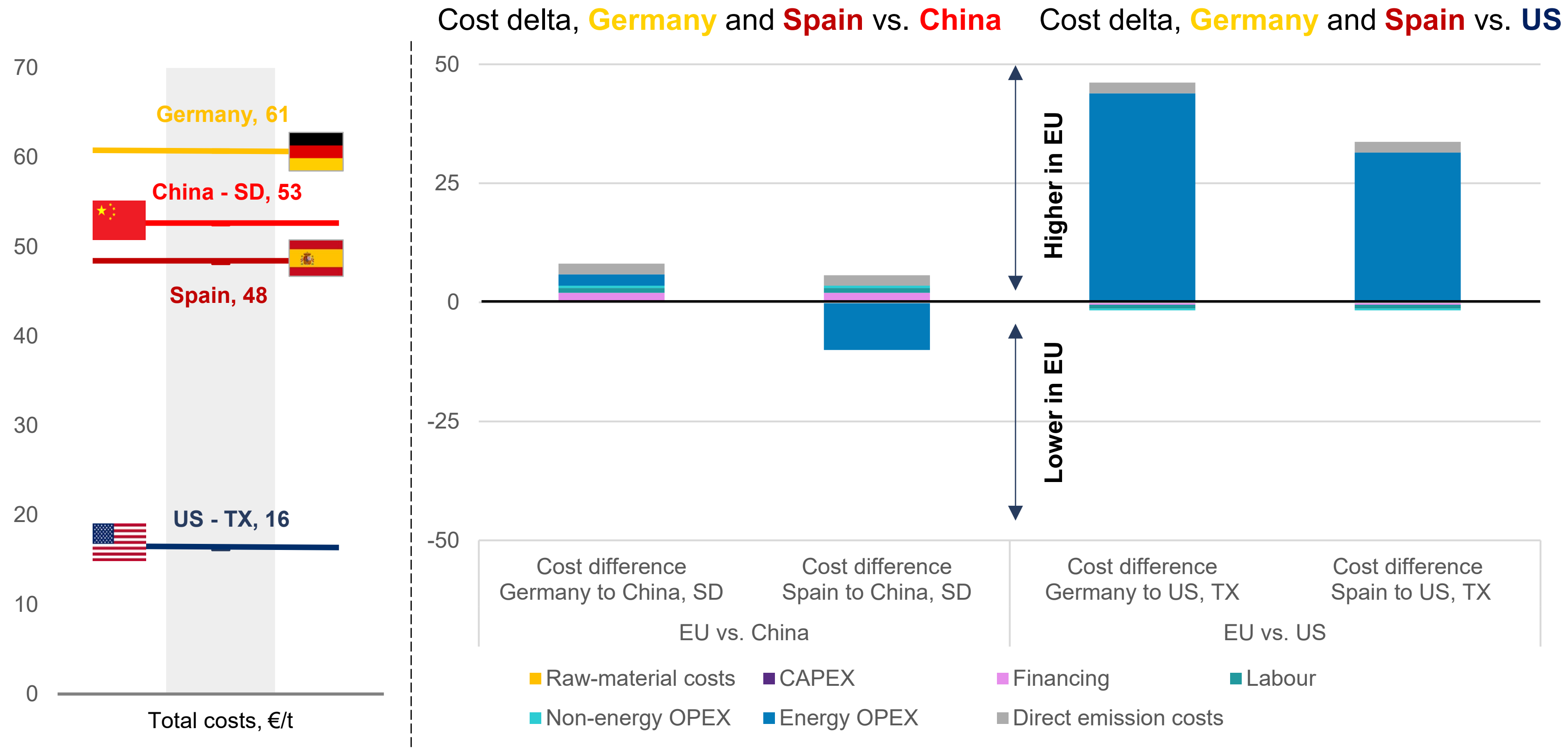
Steam supply for low-temperature chemicals

Today, the total cost of steam supply are primarily driven by regional natural gas prices, leading to a significant US cost advantage

Regional disparities in natural gas prices are the main driver for steam supply. Direct emission and financing costs also impact EU competitiveness.

- In the US industrials benefit from advantageous gas prices, leading to a cost gap of c.70% and c.65% compared to Germany and Spain.
- Comparing steam supply costs in China to Germany's, financing, direct emission and energy costs determine the cost difference to Germany of c.-10%. Compared to Spain, total costs are higher to elevated natural gas prices leading to a gap of c. 8%.

Net-cost difference breakdown steam supply: incumbent (NG boiler) Germany and Spain vs. China and US in 2024, $€_{2024}/t_{steam}$



Disclaimer: Total production costs are estimated based on EU representative installations and should be considered as estimates rather than true values for real sites.

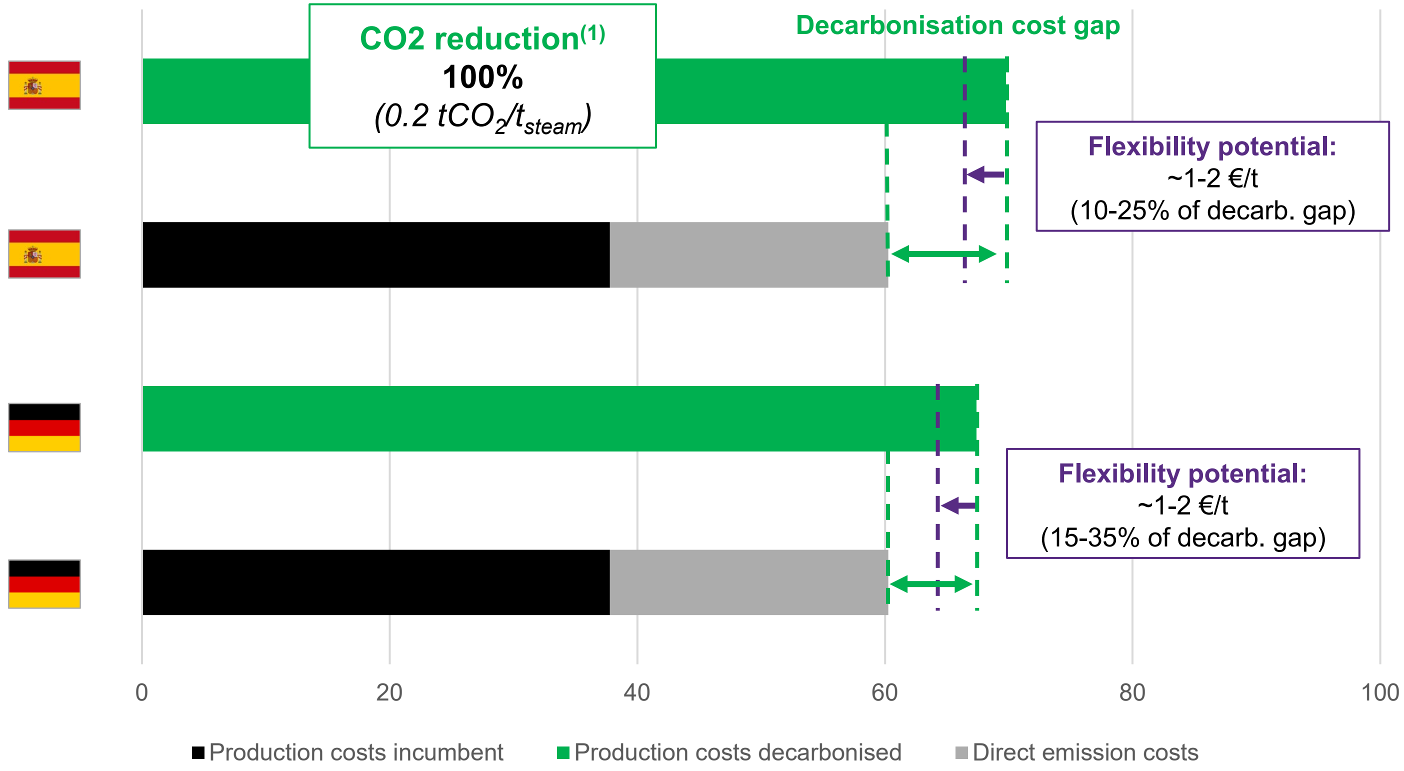
Notes: *Direct emission costs include EU ETS 1 allowance costs, net of free allowances. Electricity costs are shown net of indirect CO2 cost compensation. Cost assume baseload operation, no hybrid elements or flexibility revenues.*
Abbreviation: *NG…Natural Gas, TX…Texas, SD…Shandong*

Steam supply for low-temperature chemicals

In 2035, EU fossil-based steam supply could remain more competitive than the heat-pump based process

- By 2035, two mature processes are considered for steam supply to low-temperature chemicals:
  - The incumbent process: NG boiler, emitting 0.2 tCO_2/t_{steam} (scope 1) (1);
  - The decarbonised: Heat pump, emitting 0 tCO_2/t_{steam} (scope 1) (1);
- With the phase-out of free allocations by 2030, direct emission costs are expected to represent a third of the fossil gas-based process cost. Under our assumptions, the incumbent process would remain more competitive than heat-pump-based production.
- The flexibility offered by a 2-hour battery could marginally reduce costs of the electrified process, while further core process flexibility has not been priced in and could be explored.

Steam supply for low-temperature chemicals illustrative cost comparison Germany and Spain in 2035, $€_{2024}/t_{steam}$



Disclaimer: Total production costs are estimated based on EU representative installations and should be considered as estimates rather than true values for real sites.

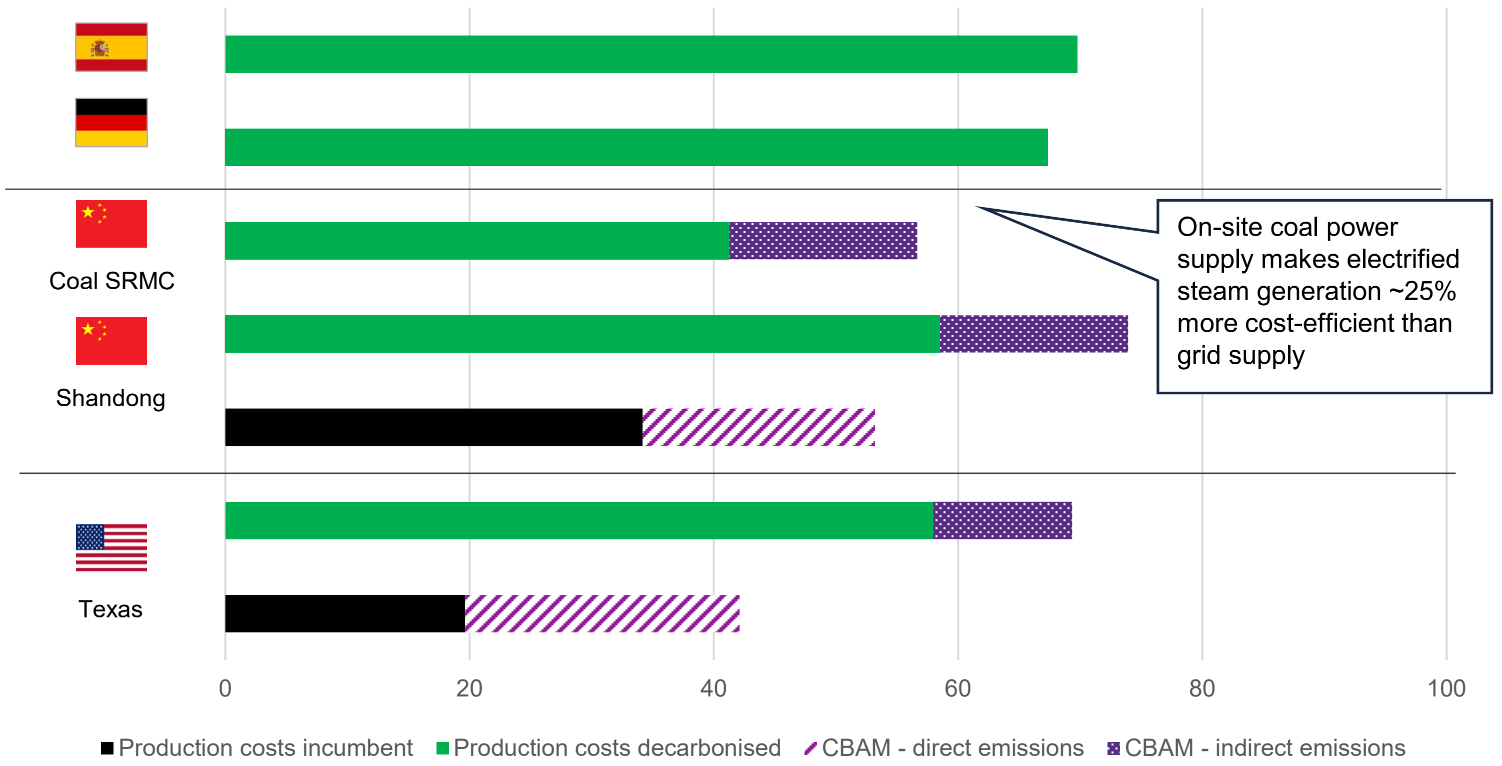
Notes: (1) Emissions considered for the incumbent and partially decarbonised processes are limited to scope 1 emissions, i.e. emissions emitted during the production process, they are thus similar between countries/regions. Direct emission costs correspond to the full EU ETS 1 allowance cost (with no free allocation) also, indirect cost compensations are assumed to be phased-out; Cost assume baseload operation, no hybrid elements or flexibility revenues.
Abbreviations: NG…Natural Gas

Steam supply for low-temperature chemicals

In 2035, possible configurations of carbon leakage policy diversely affect the competitive position of EU steam production compared to foreign products

- By 2035, total production costs for the decarbonised process (i.e. heat pump) might remain more expensive than the incumbent process (i.e. NG boiler) both in China (Shandong) and the US.
- In a hypothetical configuration with CBAM on scopes 1 & 2 and no ICCC, the difference would reduce but foreign production would remain less expensive than EU decarbonised steam production.
- The continuation of ICCC and the use of flexibility (batteries and core process) would further improve the competitiveness of EU products (see slide 94).
- CBAM on direct emissions[(2)] and/or on indirect emission costs[(2)] would increase costs between for Chinese and US exporters to Europe.

Steam supply for low-T° chemicals illustrative cost comparison under several carbon leakage policy configurations
Spain, Germany, China and US in 2035, $€_{2024}/t_{steam}$[(1)]



Disclaimer: Total production costs are estimated based on EU representative installations and should be considered as estimates rather than true values for real sites.

Notes: *(1) Net cost breakdown assumes baseload operation of NG boiler in and heat pump. Flexibility potential relies on revenues that are attainable from a 1h and 2h on-site battery, covering 20% of industrial hourly load, that participates in flexibility and show a range depending on market conditions Chinese short run marginal costs assume that electricity is supplied by an on-site coal power plant that only incurs fuel costs and variable production costs. Capital costs are assumed to be covered by the Chinese state/province.* ***(2)*** *Direct emissions include process specific emissions and indirect emissions include power system emissions.*
Abbreviations: *CBAM… Carbon Border Adjustment Mechanism; SRMC…Short Run Marginal Cost*

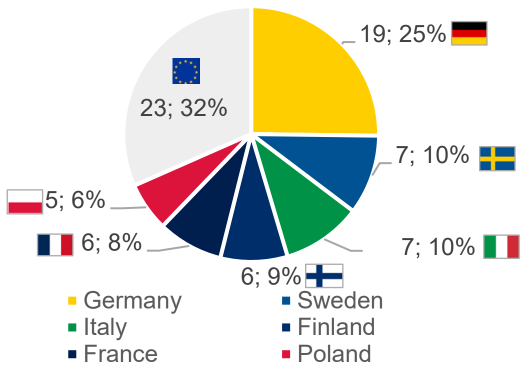
Paper production

EU paper production has been falling since the 2000s due to weaker demand

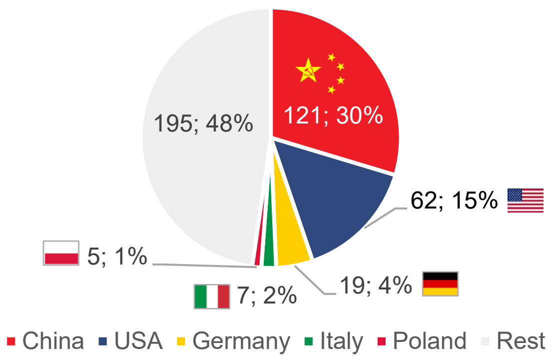
The EU paper industry faces limited pressure from foreign production in the domestic market, but ~10-15% of total paper and board production is exposed to international markets.

- EU domestic production among CEPI members[1] has dropped from 91 Mt in 2000 to 79 Mt in 2024. The decline in EU production can be explained by reduced paper demand, though demand for packaging has recently increased.
- China and the US are the world's largest paper producers in 2023.
- Global trade in paper products is significant but predominantly regional due to low-value per unit weight. Excess production serves nearby regions first and long-distant regions for specialty-grades.

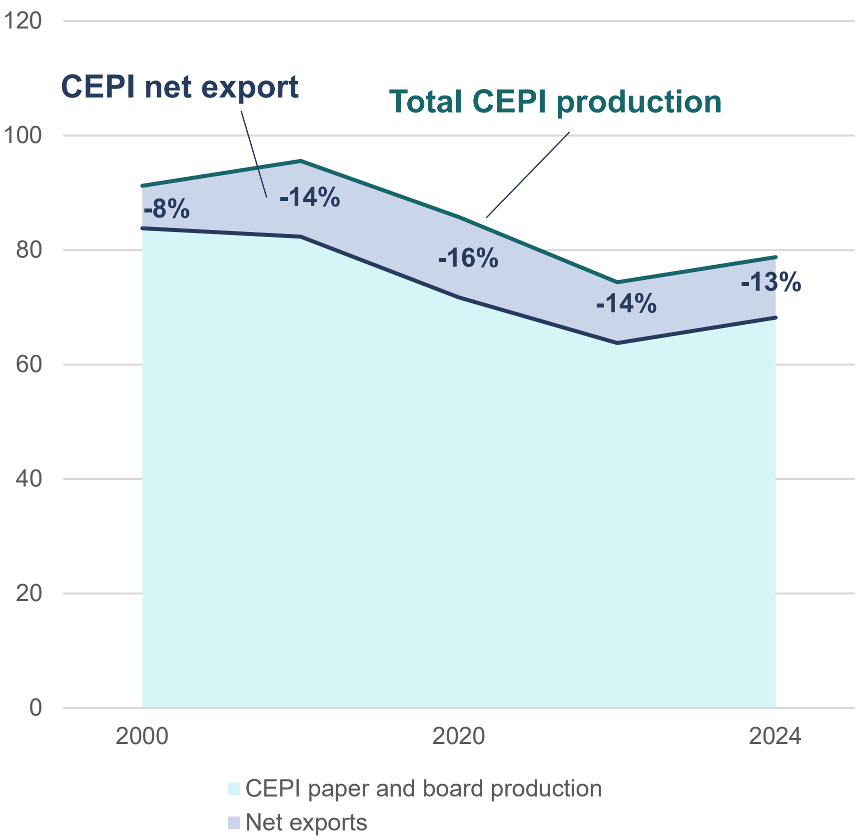
CEPI[1] paper + board prod., 2024 (Mt; %)



World paper + board prod., 2024 (Mt; %)



CEPI-country paper and board production and net imports from 2000-2024, Mt_{paper}[1]



Source: CL analysis based on Die Papierindustrie (2025) Ein Leistungsbericht, CEPI (2025) Key statistics
Note: (1) EU paper and board production relies in CEPI data, which includes 19 out of 27 EU member states including the UK.
Paper and board production includes all final production, regardless of raw material input composition (wood, recycled paper or non-fibrous materials.
***Abbreviations:** CEPI…Confederation of European Paper Industries*

Paper production

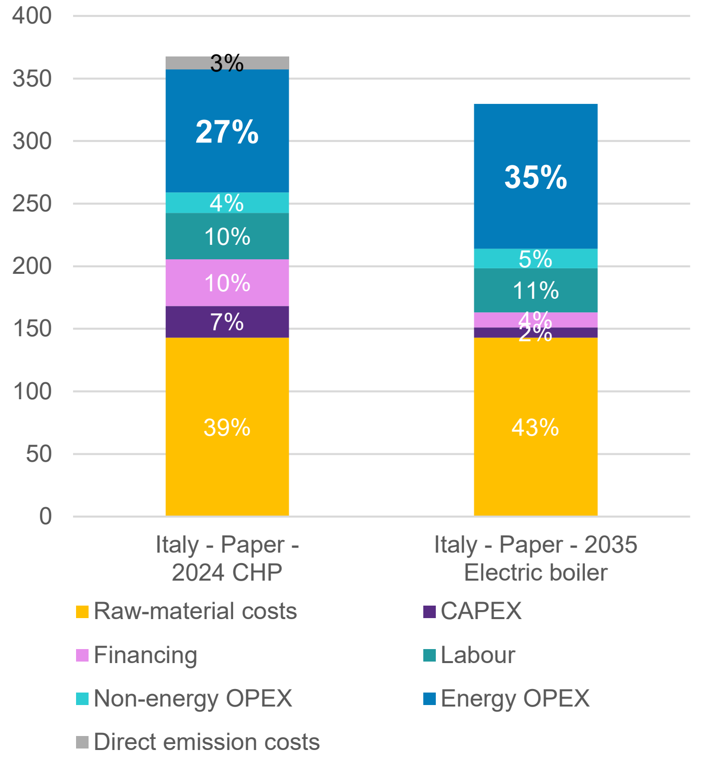
Raw material and energy costs make up largest share of production costs. As a net exporter, EU faces overcapacity issues if energy costs rise.

Apart from relatively high shares of energy costs, the following factors impact the paper and pulp industry:

- Raw material costs make up substantial share. Most EU demand can be met domestically. Recycling competitiveness depends on energy and wood prices, but is not applicable to all paper grades.
- A shifting industry: Most printing and writing paper demand has declined while packaging demand grows. This has led to overcapacity for sub-sectors.
- EU production capacity is larger than domestic demand.

Factor of competitiveness			
Electricity supply	• On-site production: ~42% of electricity supplied by natural gas or biomass CHP[(2)]	• Lowest energy costs but lower quality in network infrastructures • Industry investments into energy efficiency	• Province with large paper sector (Shandong) has medium prices among surveyed provinces
Overcapacity	• Domestic overcapacity: Printing and writing paper faces overcapacity while packaging faces high demand	• Decline in capacity by 2% in 2024, however industry faces continued investment in packaging and tissue sector	• Largely produces for domestic market, net importer (121 Mt production vs. 123 Mt demand in 2023)
Raw material procurement	• High self-sufficiency: ~98% of wood (EU27+UK) from domestic supply and ~50% of raw material supply from recycling[(3)]	• High self-sufficiency in wood supply and high paper recycling rates (~60%)	• Limited domestic resources, net importer of softwood

Paper drying process net-cost breakdown[(1)], $€_{2024}/t_{paper}$



Disclaimer: Total production costs are estimated based on EU representative installations and should be considered as estimates.

Source: CL analysis based on bottom-up costs models, various sources (sources see Technical Appendix) CEPI (2025) Key statistics 2024, Die Papierindustrie (2025) Ein Leistungsbericht, American Forest and Paper Association (2025) US paper production and capacity trends

*Notes: (1) Country-level energy cost calculations for 2024 include free allowances. 2035 cost component calculations do not include free allowances due to the phase-out and no indirect cost compensations as current schemes end in 2030. We show material costs for soft wood and no recycling. Cost assume baseload operation, no hybrid elements or flexibility revenues (2) In CEPI countries and without electricity sold to grid. (3) In CEPI countries and in absolute tonnage, final recycling rates may vary. **Abbreviations:** CHP…Combined heat and power*

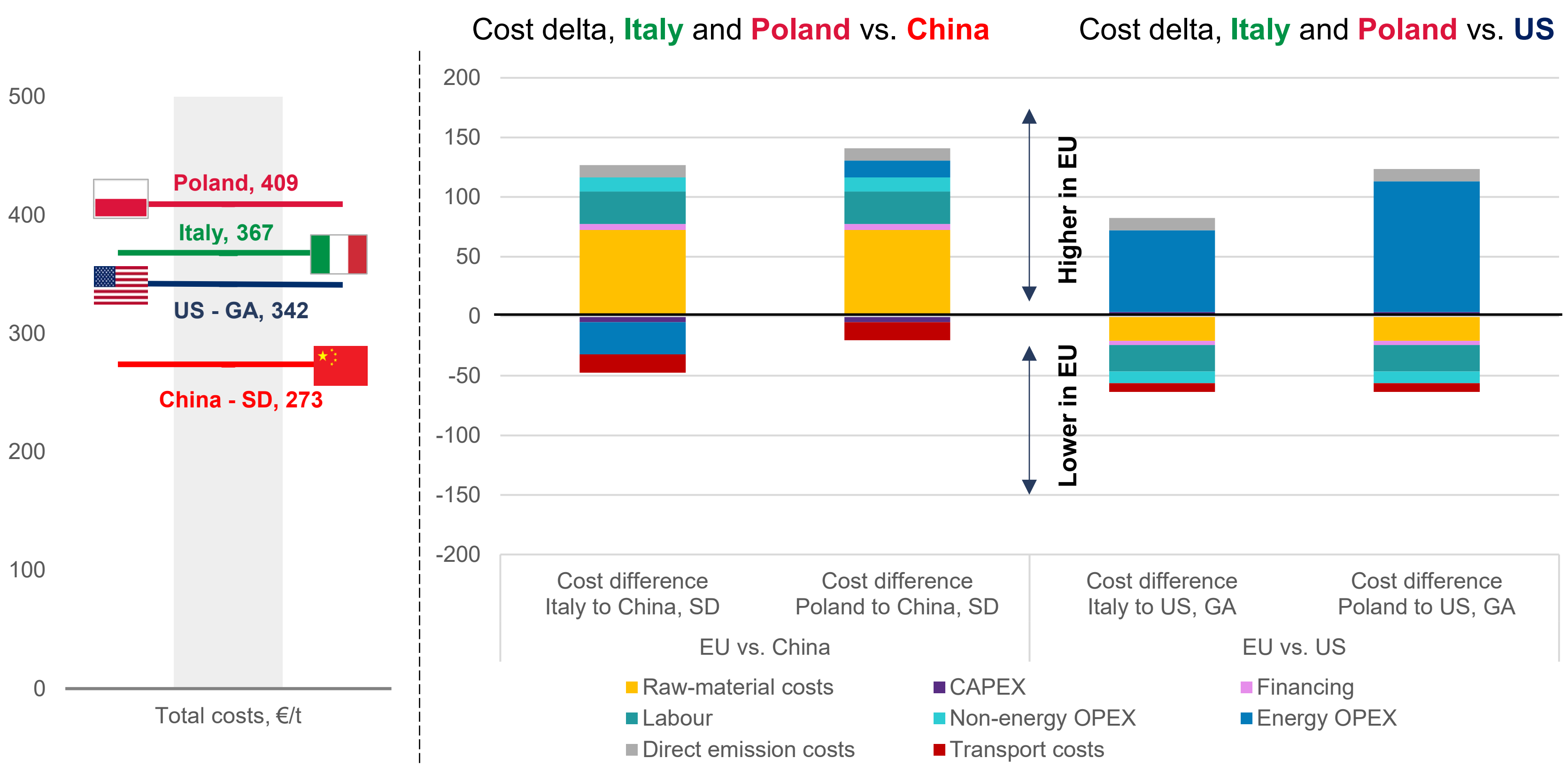
Paper production

As of today, higher raw material and energy costs in the EU lead to a significant competitiveness gap compared to the US and China

European paper producers face higher costs compared to China and the US, mainly driven by both raw material and energy prices.

- China benefits from lower softwood prices (strong negotiation power with bulk purchases), resulting in a cost gap of c.-35% and c.-50% compared to Italy and Poland
- Lower natural gas prices benefit US industry, resulting in a cost gap of c.-8% and c.-20% compared to Italy and Poland.

Net-cost difference breakdown paper drying process: incumbent (CHP plant) Italy and Poland vs. China and US in 2024, $€_{2024}/t_{paper}$



Disclaimer: Total production costs are estimated based on EU representative installations and should be considered as estimates rather than true values for real sites.

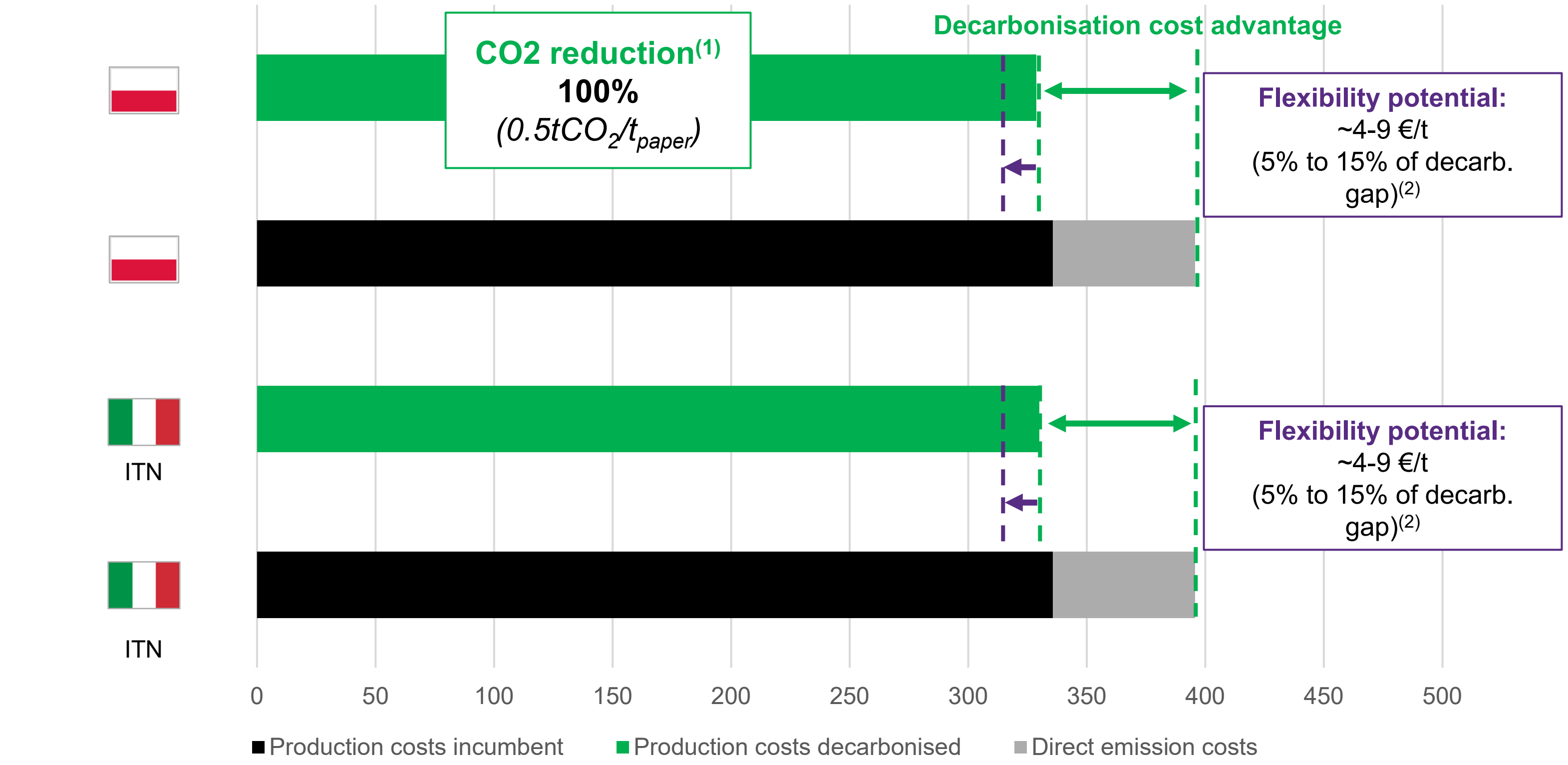
Notes: Direct emission costs include the EU ETS 1, net of free allowances. Energy OPEX include electricity and natural gas costs, net of indirect CO2 cost compensation. Cost assume baseload operation, no hybrid elements or flexibility revenues. Italy nodal electricity zone considered is ITN.
Abbreviations : CHP plant… Combined Heat and Power plant

Paper production

In 2035, EU electrified paper drying may be more cost-efficient than the fossil-fuel based alternative – both with and without carbon costs

- By 2035, two mature processes are considered for paper drying process:
  - The incumbent process: CHP plant, emitting 0.5 tCO_2/t_{paper} (scope 1)[(1)];
  - The decarbonised: Electric boiler, emitting 0 tCO_2/t_{paper} (scope 1) [(1)];
- Assuming a constant raw material cost, using an e-boiler to generate steam for paper drying may be more cost efficient by 2035. In addition, rising direct emission costs can further increase the gap to the fossil-fuel alternative by c.12%.
- The flexibility offered by a 2-hour battery would further increase the cost competitiveness of the electrified process.
- The sector presents significant potential for core process flexibility that has not been priced in here and should also be explored.

Paper drying process illustrative cost comparison
ITN and Poland, $€_{2024}/t_{paper}$



Disclaimer: Total production costs are estimated based on EU representative installations and should be considered as estimates rather than true values for real sites.

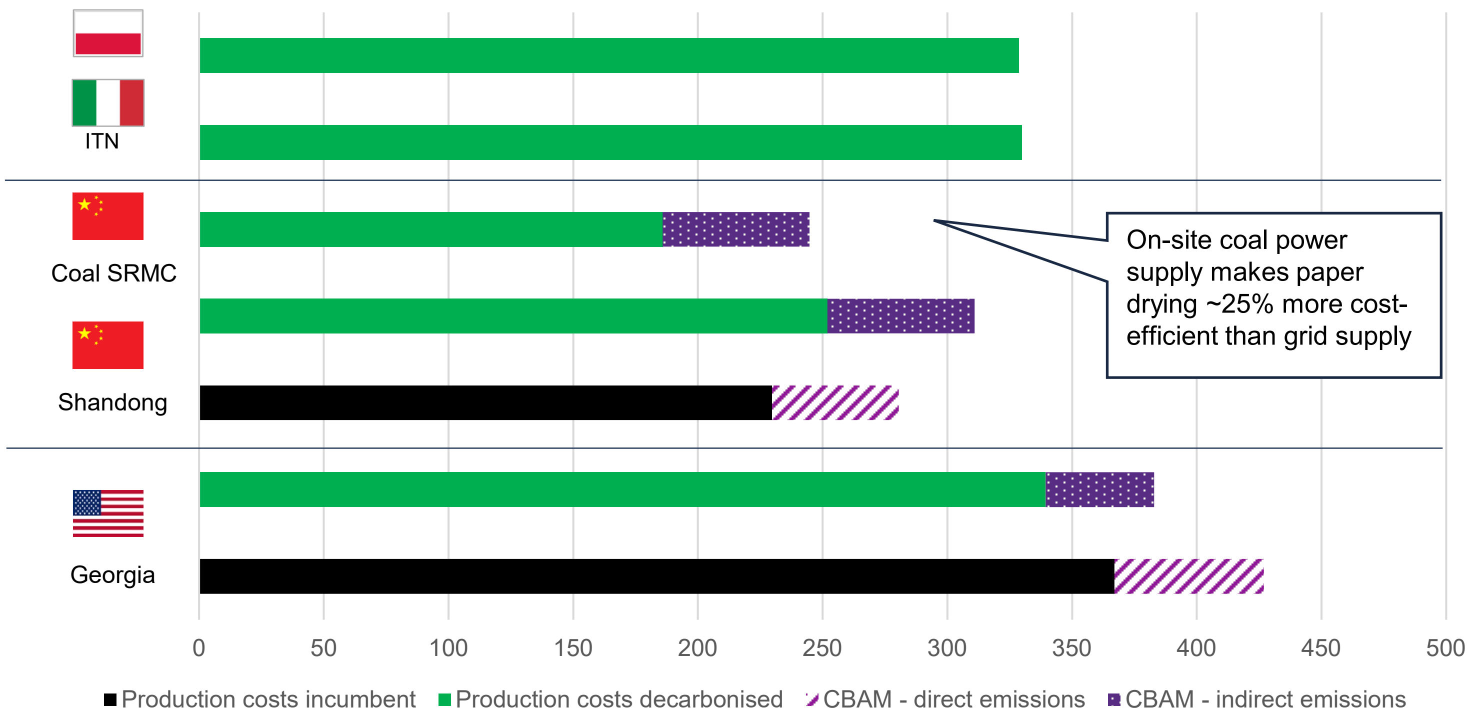
Notes: (1) Emissions considered for the incumbent and partially decarbonised processes are limited to scope 1 emissions, i.e. emissions emitted during the production process, they are thus similar between countries/regions. Direct emission costs correspond to the full EU ETS 1 allowance cost (with no free allocation) also, indirect cost compensations are assumed to be phased-out; Cost assume baseload operation, no hybrid elements or flexibility revenues. For Italy, we consider ITN as the relevant bidding zone. (2) For case studies where the electrification/decarbonisation gap (incl. direct emission costs) is already closed, we show flexibility potential in terms of gap size that can contribute to reducing overall costs further.
Abbreviations: ITN…Italy North (power market bidding zone) NG…Natural Gas, CHP plant… Combined Heat and Power plant

Paper production

In 2035, possible configurations of carbon leakage policy diversely affect the competitive position of EU paper production compared to foreign products

- By 2035, total production costs for the decarbonised process (i.e. electric boiler) might remain more expensive than the incumbent process (i.e. CHP plant) in China (Shandong, c.+5% cost) but cheaper in the US (c.-8%).
- In a hypothetical configuration with CBAM on scopes 1 & 2 and no ICCC, EU electrified paper drying could be more expensive than Chinese paper drying but more competitive than in the USA.
- The continuation of ICCC and the use of flexibility (batteries and core process) would further improve the competitiveness of EU products (see slide 94).
- CBAM on direct emissions(2) and/or on indirect emission costs(2) would increase costs between for Chinese and US exporters to Europe.

Paper drying process illustrative cost comparison under several carbon leakage policy configurations
Poland, Italy, China and US, €$_{2024}$/t$_{paper}$(1)



Disclaimer: Total production costs are estimated based on EU representative installations and should be considered as estimates rather than true values for real sites.

Notes: (1) Net cost breakdown assumes baseload operation of CHP and electric boiler 2035. Flexibility potential relies on revenues that are attainable from a 1h and 2h on-site battery, covering 20% of industrial hourly load, that participates in flexibility markets and show a range depending on market conditions Chinese short run marginal costs assume that electricity is supplied by an on-site coal power plant that only incurs fuel costs and variable production costs. Capital costs are assumed to be covered by the Chinese state/province. (2) Direct emissions include process specific emissions and indirect emissions include power system emissions. For Italy, we consider ITN as the relevant bidding zone
Abbreviations: ITN…Italy North (power market bidding zone), NG…Natural Gas, CHP plant… Combined Heat and Power plant, CBAM… Carbon Border Adjustment Mechanism. SRMC… Short Run Marginal Cost

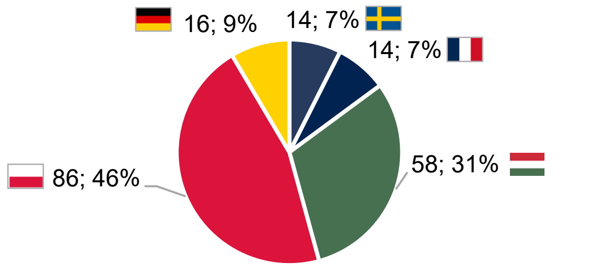
Battery cell manufacturing

Historically, Asian production capacity dominates battery cell manufacturing while EU and US production capacity lags behind

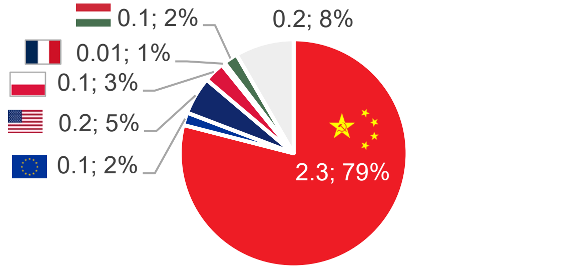
Large parts of global of cell production takes place in China, Korea and Japan. With growing demand from US and EU automakers and power system flexibility additional production capacity is expected outside of Asia

- China is market leader with 79% global market share
- EU has large trade deficit but aims at further capacity expansion, though projects have been cancelled lately
- The US is net importer but recently added manufacturing capacity, the latest administration has stalled further support.

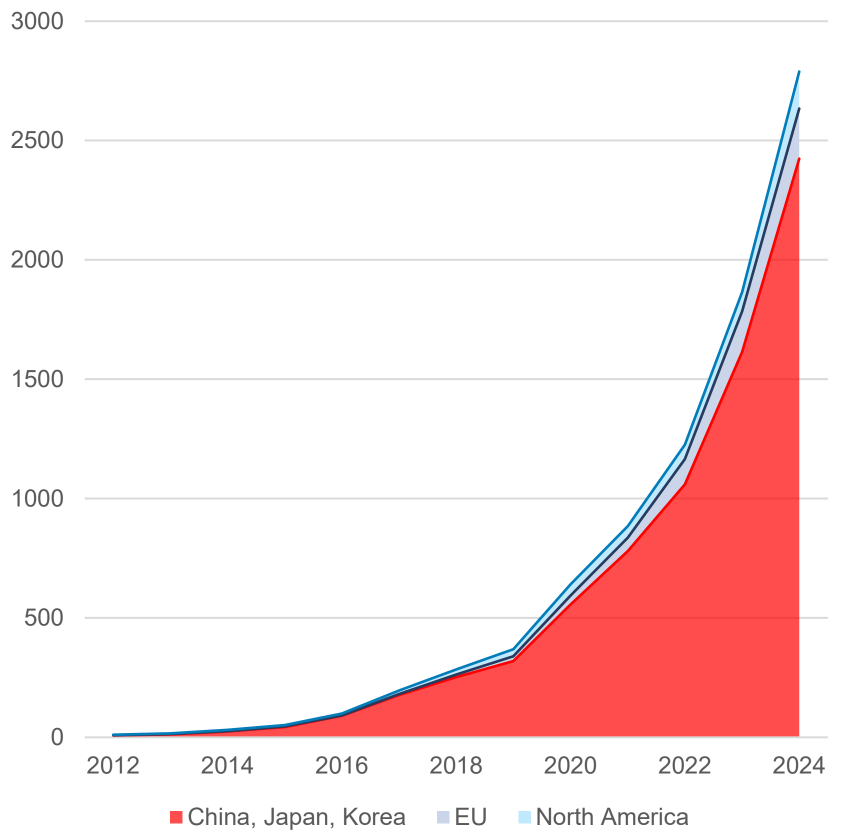
EU prod. capacity, 2023 (GWh_{cell}; %)



World production, 2024 (TWh_{cell}; %)



EU, North America and China, Japan and Korea battery cell production, 2012-2024 ($GWh_{cell\ capacity}$)



Source: CL analysis based on IEA (2023) World Energy Investment, IPCEI and Fraunhofer ISE – Cell production market monitor, EC (2024) State of the Energy Union Report 2024, US Dept. of Energy - FOTW #1351

Battery cell manufacturing

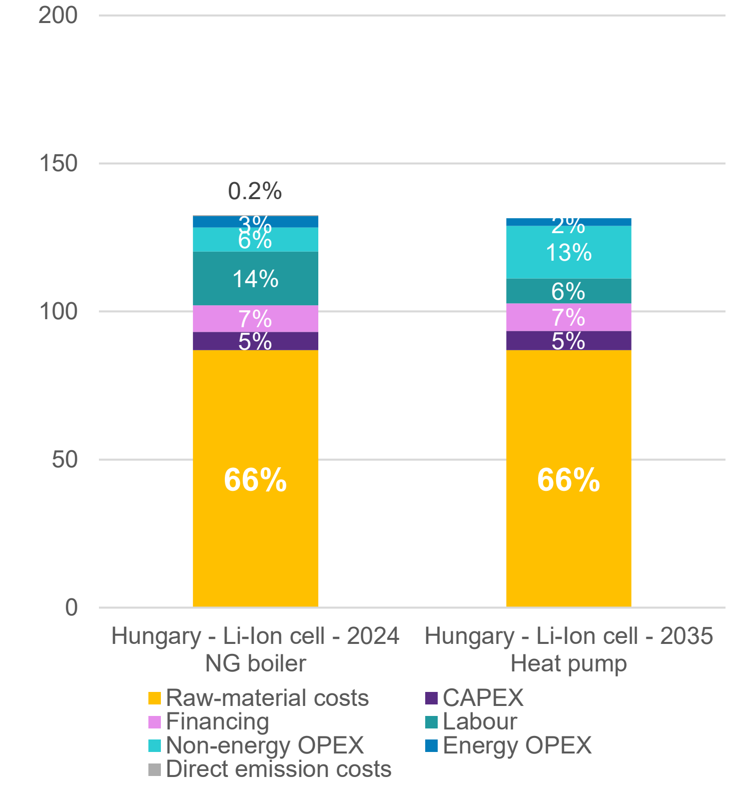
Despite high energy requirements in battery cell manufacturing, technological leadership and control of supply chain determines competitiveness

Although battery cell manufacturing is energy intensive in absolute terms, control of the value chain overcapacity and manufacturing know-how determine competitiveness:

- Currently, world production capacity exceeds demand for batteries with Chinese overcapacity
- China has critical control over the whole value chain in vertically integrated manufacturers (e.g., BYD and CATL) raw material mining processing and cell manufacturing.
- Large-scale production has enabled Asian producers to gain technological leadership across battery technologies

Competitiveness drivers			
Electricity supply	• Exposure to EU electricity price levels and volatility	• Lowest energy costs but lower quality in network infrastructures	• Province with large paper sector (Henan) at high end among surveyed provinces
Overcapacity	• Weaker market demand and price pressure from Asia • Number of delayed or cancelled construction projects	• Limited historic production capacity • Build up of capacity since 2021, unclear future with new administration	• Global production capacity exceeds demand • 79% market share with 2.5 TWh capacity in 2024,
Raw material procurement	• Limited domestic supply • Australia and Canada are promising suppliers • Enhancing circularity can further de-risk	• Limited domestic supply, tariff policy risks supply chain • High investments into battery supply chain post infrastructure law (2021) and IRA (2022)	• Control of complete value chain in vertically integrated companies (e.g. CATL, BYD)

Li-ion-NMC battery cell manufacturing net-cost breakdown(1), $€_{2024}$/kWh_{cell}



Disclaimer: Total production costs are estimated based on EU representative installations and should be considered as estimates.

Source: CL analysis based on Fraunhofer ISE – Cell production market monitor, JRC – Lithium-based supply chain challenges, US Dept. of Energy - FOTW #1351, Oxford institute for energy studies – 2025 EVs and battery supply chain issues and impacts

Notes: (1) Country-level energy cost calculations for 2024 include free allowances. 2035 cost component calculations do not include free allowances due to the phase-out and no indirect cost compensations as current schemes end in 2030.

Abbreviations: Li-ion-NMC…Lithium-ion, Nickel, Mangan, Cobalt; IRA…Inflation reduction act

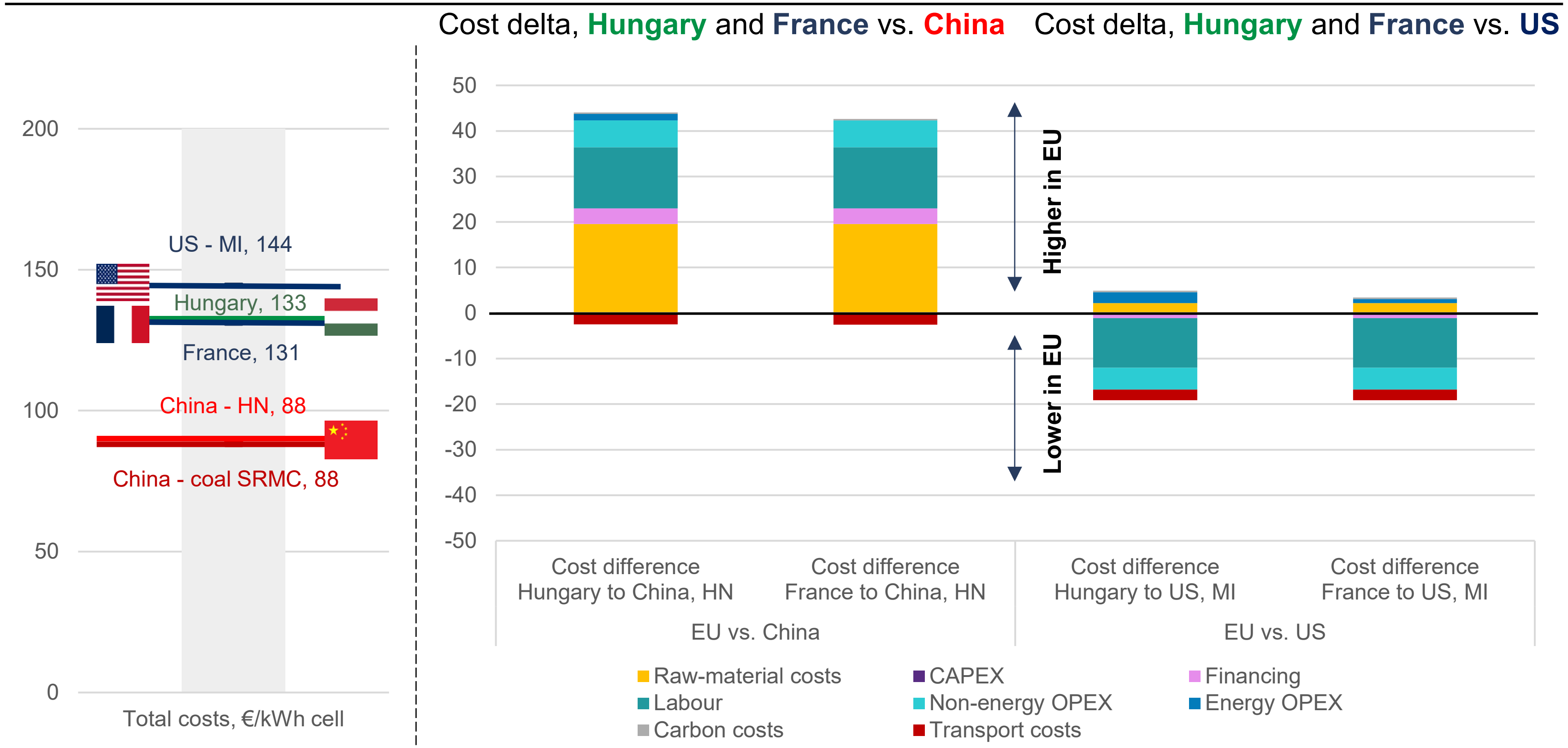
Battery cell manufacturing

Main drivers of EU competitiveness gap to China are raw material costs and labour costs, but US production is more expensive

The production cost of Li-ion batteries is primarily driven by raw material and labour costs as well as maintenance costs.

- China's control of the **supply chain for battery raw materials**, combined with **lower labour costs**, results in a competitiveness gap v. Hungary and France of c.-50%.
- **Higher labour and maintenance costs** in the **US** result in higher production costs of c.8% compared to the EU.

Net-cost difference breakdown Li-ion cell production: incumbent (NG boiler) Hungary and France vs. China and US in 2024, $€_{2024}/kWh_{cell}$(1)



Disclaimer: Total production costs are estimated based on EU representative installations and should be considered as estimates rather than true values for real sites.

Notes: Direct emission costs include the EU ETS 1, net of free allowances. As of 2025, no indirect cost compensations applies for battery manufacturing. Costs assume baseload operation, no hybrid elements or flexibility revenues

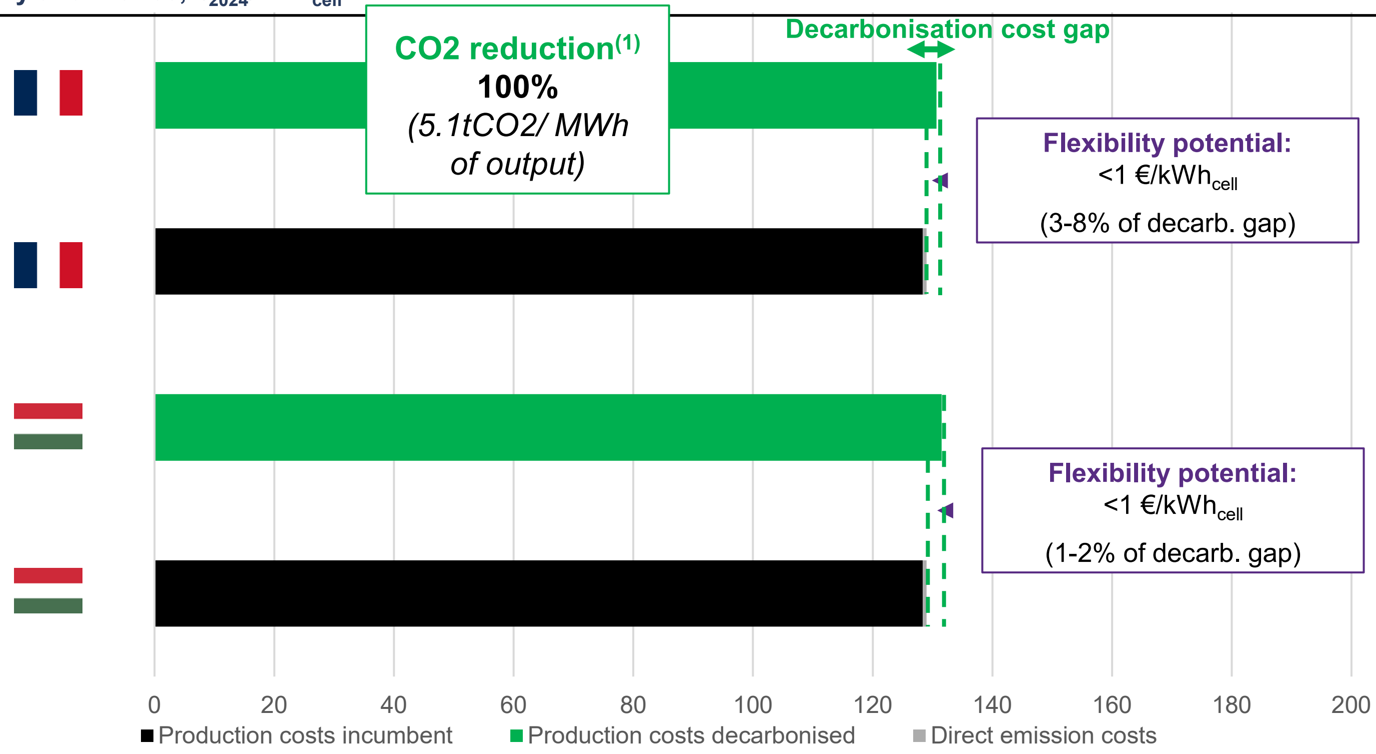
Abbreviations : NG… Natural gas, MI…Michigan, HN…Henan, Li-ion-NMC…Lithium-ion, Nickel, Mangan, Cobalt

Battery cell manufacturing

Switching to an electrified heat source modestly increases total production costs in battery cell manufacturing

- By 2035, two mature processes are considered for paper production:
  - The incumbent process: NG boiler, emitting 5.1tCO_2/ MWh of output (scope 1)[(1)];
  - The decarbonised: Heat pump, emitting 0.0tCO_2/MWh of output (scope 1) [(1)];
- Assuming constant raw material costs, switching to a heat pump to produce Lion-cell batteries modestly increases costs by cost c.2%. The increase is mainly driven by higher maintenance costs.

Li-ion-cell production illustrative cost comparison
Hungary and France, €$_{2024}$/kWh$_{cell}$



Disclaimer: Total production costs are estimated based on EU representative installations and should be considered as estimates rather than true values for real sites.

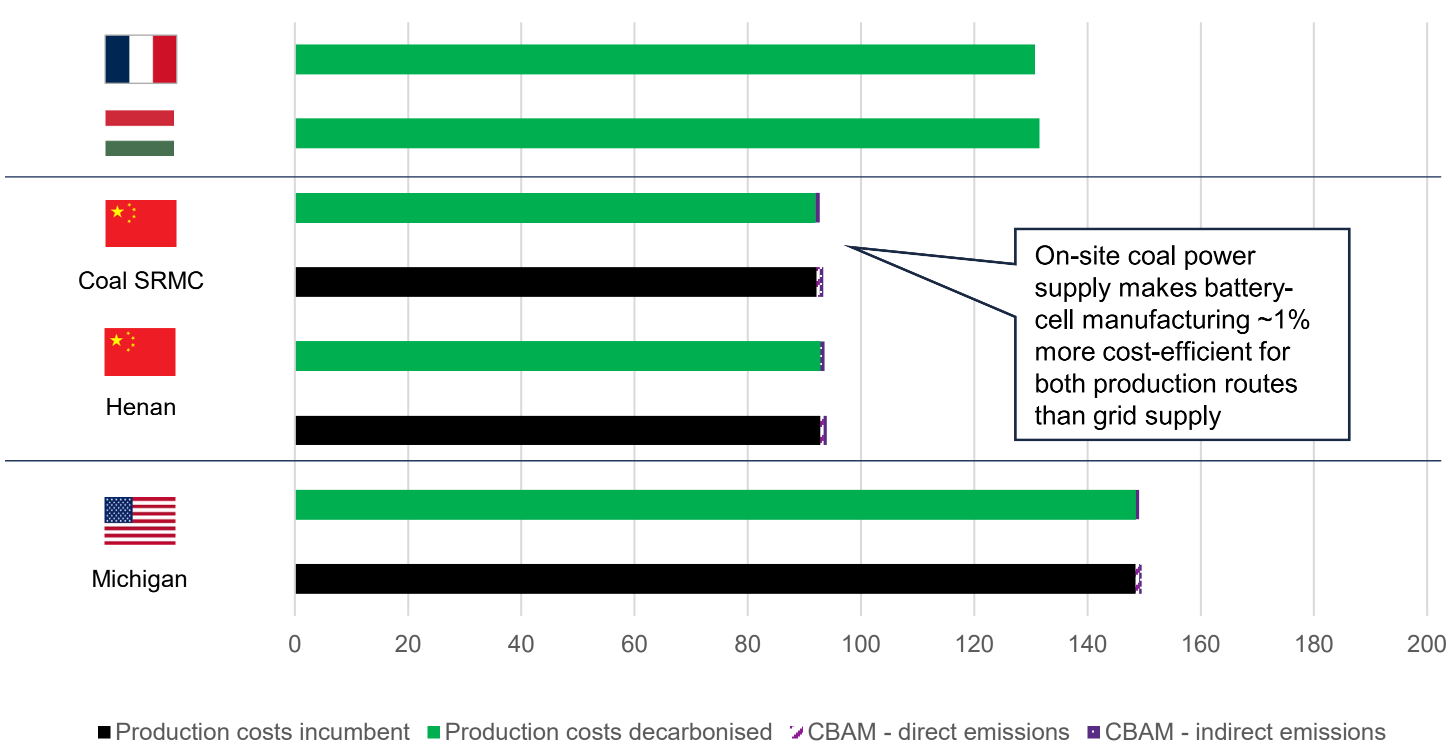
Notes: (1) Emissions considered for the incumbent and the decarbonised processes are limited to the Scope 1 emissions, i.e. emissions emitted during the production process, they are thus similar between countries/regions. The direct emission costs correspond to the full EU ETS 1 allowance cost (with no free allocation). As of 2025, no indirect carbon cost compensation applies for battery manufacturing. Costs assume baseload operation, no hybrid elements or flexibility revenues
Abbreviations: NG…Natural Gas, Li-ion…Lithium-ion

Battery cell manufacturing

In 2035, configurations of carbon leakage policy and energy costs have a limited impact on the competitiveness of EU production as other factors remain decisive

- By 2035, total production costs for the decarbonised process (i.e. heat pump) are similar to the incumbent process (i.e. gas boiler) in China (Henan, c.+0.02% cost) and in the US (c.-0.01%).
- In a hypothetical configuration with CBAM on scopes 1 & 2 and no ICCC, decarbonised EU production would remain more expensive than in China but more competitive than in the USA.
- CBAM on direct emissions or indirect emissions(1) has limited impact on costs of foreign productions

Li-ion-cell production illustrative cost comparison under several carbon leakage policy configurations
France, Hungary, China and US in 2035, $€_{2024}/kWh_{cell}$



Disclaimer: Total production costs are estimated based on EU representative installations and should be considered as estimates rather than true values for real sites.

__Notes:__ (1) The direct emission costs correspond to the full EU ETS 1 cost (with no more free allocation) as the free allocations and indirect cost compensations are assumed to be phased-out; Flexibility potential relies on revenues that are attainable from a 1h and 2h on-site battery, covering 20% of industrial hourly load, that participates in flexibility markets and show a range depending on market conditions Chinese short run marginal costs assume that electricity is supplied by an on-site coal power plant that only incurs fuel costs and variable production costs. Capital costs are assumed to be covered by the Chinese state/province. (2) Direct emissions include process specific emissions and indirect emissions include power system emissions __Abbreviations:__ CBAM… Carbon Border Adjustment Mechanism; SMRC… Short Run Marginal Cost Li-ion…Lithium-ion

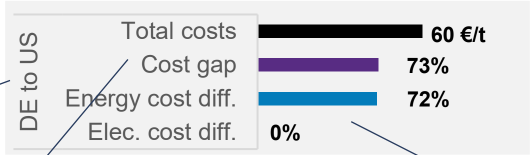
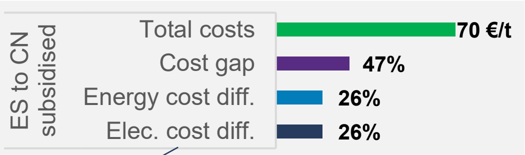
2.4
Conclusion

Findings (1/2): Industrial sectors are diversely affected by energy costs, and power costs in particular, resulting in competitiveness gaps of varying magnitude

- Differences in energy costs and power costs are only one factor among many others (e.g. labour, raw material and financing costs) that can explain the total competitiveness gap for different industrial sectors. The figures on the following slide provide a summary of the main results of the case studies, regarding both the total competitiveness gap and the relative weight of energy and power cost differences.

NB: *These figures are calculated by comparing the case studies with the highest absolute gap in energy costs, to provide an illustration of the "upper bound" regarding the weight of energy costs in the total competitiveness gap. Detailed results, including calculations for other cost factors can be found in the case studies section of the full study.*

How to read the results

	Total production cost gap and energy cost differential (no CBAM – maximum absolute energy cost gap[(1)])		Electrification cost gap EU	Flexibility potential	Main non-energy issues
	2024 - €/$t_{product}$ or €/kWh_{cell} (EU incumbent vs foreign incumbent)	2035 - €/$t_{product}$ or €/kWh_{cell} (EU decarb. vs foreign decarb.)	2035 (EU decarb. vs incumbent)	2035 (On-site battery cost reduction of decarb. gap)	Both, 2024 and 2035
Steam supply for low T° chemicals			**+ 10-15%** (incl. full direct emissions costs, no ICCC)	**10% to 35% gap reduction**	• Strategic foreign capacity build-up • Limited supply-chain control

«DE» to «US» indicates the countries compared for this calculation (i.e. Germany and the US for 2024 plus Spain and China for 2035).

«Total costs» refer to total production costs in the EU member state for 2024 and 2035.

«Cost gap» refers to the competitiveness gap (difference in total production costs as a share of the total costs): *In this case, the total competitiveness gap between Germany and the US equals 73% of production costs in Germany in 2024, while the gap reaches 47% (between Spain and China) for 2035.*

Energy and electricity cost differences are also calculated as a ratio to total production costs: *In this case, for 2024, the difference in energy costs is almost as high as the total competitiveness gap (72% vs 73%). Indicating that the energy cost mainly drive competitiveness, with other cost components offsetting one another and resulting in a limited net effect. For 2035, the energy cost gap represents about half (26/47=55 %) of the total cost gap in 2030.*

Differences in electricity costs have no importance in 2024 (0%). Due to electrification, the energy cost difference equals the electricity cost gap in 2035 and differences in power costs represent 55% of the total competitiveness gap.

Electrification cost gap EU compares the production cost difference between the decarbonised and incumbent processes in 2035.

In this case: In 2035, production costs for the decarbonised process are 10 to 15% higher than the incumbent process for 2035.

Flexibility potential indicates the ratio between the net revenues from flexibility (2h on-site battery) and the electrification cost gap.

In this case: Revenues from a 2h on-site battery contribute to offset the electrification costs by 10 to 35%.

Main non energy issues summarises the main factors that impact the competitiveness of the considered EU industry beyond cost-based factors.

Notes: (1) We compare country case studies that have the highest absolute energy cost gap. Thus, presented cost differentials may not necessarily show case study countries with the highest total competitiveness gap..
Abbreviations:, elec… electricity,CN…China, US…United States, DE…Germany, ES…Spain, ICCC… Indirect CO_2 cost compensation State Aid

Findings (2/2): Industrial sectors are diversely affected by energy costs, and power costs in particular, resulting in competitiveness gaps of varying magnitude

	Total production cost gap and energy cost differential (no CBAM – maximum absolute energy cost gap[1])		Electrification cost gap EU	Flexibility potential	Main non-energy issues
	2024 - €/$t_{product}$ or €/kWh_{cell} (EU incumbent vs foreign incumbent)	2035 - €/$t_{product}$ or €/kWh_{cell} (EU decarb. vs foreign decarb.)	2035 (EU decarb. vs incumbent)	2035 (On-site battery cost reduction of decarb. gap)	Both, 2024 and 2035
Primary aluminium production	GR to CN subsidised Total costs: 2220 €/t Cost gap: 29% Energy cost diff.: 10% Elec. cost diff.: 13%	GR to CN subsidised Total costs: 2415 €/t Cost gap: 39% Energy cost diff.: 13% Elec. cost diff.: 13%	**- 5%** (incl. full direct emissions costs, no ICCC)	**50% to 105% cost improvement [2]** (on top of cost advantage)	• Raw materials • Direct emission costs
Primary steel production	SE to US Total costs: 575 €/t Cost gap: 8% Energy cost diff.: 7% Elec. cost diff.: -0.3%	DE to CN subsidised Total costs: 870 €/t Cost gap: 27% Energy cost diff.: 18% Elec. cost diff.: 4% (+ 12% indirect[2])	**+ 10-15%** (incl. full direct emissions costs, no ICCC)	**2% to 7% gap reduction**	• Raw materials • Overcapacity
Steam supply for low T° chemicals	DE to US Total costs: 60 €/t Cost gap: 73% Energy cost diff.: 72% Elec. cost diff.: 0%	ES to CN subsidised Total costs: 70 €/t Cost gap: 47% Energy cost diff.: 30% Elec. cost diff.: 26%	**+ 10-15%** (incl. full direct emissions costs, no ICCC)	**10% to 35% gap reduction**	• Strategic foreign capacity build-up • Limited supply-chain control
Paper drying	PL to US Total costs: 410 €/t Cost gap: 16% Energy cost diff.: 27% Elec. cost diff.: 0%	IT to CN subsidised Total costs: 330 €/t Cost gap: 44% Energy cost diff.: 19% Elec. cost diff.: 19%	**- 20%** (incl. full direct emissions costs, no ICCC)	**5% to 15% cost improvement [2]** (on top of cost advantage)	• Raw materials • Net EU export • Shifting demand structure
Battery cell manufacturing	PL to US Total costs: 135 €/kWh Cost gap: 32% Energy cost diff.: 3% Elec. cost diff.: 1%	IT to CN subsidised Total costs: 130 €/kWh Cost gap: 30% Energy cost diff.: 1% Elec. cost diff.: 1%	**Similar costs** (incl. full direct emissions costs, no ICCC)	**1% to 8% gap reduction**	• Foreign tech. leadership • Foreign supply-chain control

Notes: (1) We compare country case studies that have the highest absolute energy cost gap. Thus, presented cost differentials may not necessarily show case study countries with the highest total competitiveness gap. (2) For case studies where the electrification/decarbonisation gap (incl. direct emission costs) is already closed, we show flexibility potential in terms of gap size that can contribute to reducing overall costs further. (2) We calculate indirect electricity costs from hydrogen production based on the regional Hydrogen price assumption and subtract capital and transport costs (based on Hydrogen Council & McKinsey (2023) Hydrogen Insights and EWI PtX tool

Abbreviations: GR…Greece, CN…China, SE…Sweden, US…United States, DE…Germany, ES…Spain, PL…Poland, IT…Italy, ICCC… Indirect CO_2 cost compensation State Aid

Possible solutions: Identification of a set of principles to coordinate support measures based on the assessment of production cost competitiveness and non-energy issues

Power cost exposure *Dependent on electricity, but limited ability to pass power costs through*	▪ Addressing power sourcing cost exposure is not a silver bullet as levels of subsidies can exceed power purchase costs. Differences in labour costs and financing costs, especially with China, explain large shares of the total production cost differences with the EU.
Electrification cost gap *High upfront or operational costs hinder a fuel switch*	▪ Direct and indirect electrification solutions can face profitability issues both in terms of CAPEX and OPEX. ▪ By 2035, some electrified processes have lower OPEX than fossil-based processes such as steam supply for milk powder, low T° chemicals and paper drying using heat pumps or e-boilers. The decarbonisation cost gap in this case can be addressed with a one-off investment aid only. ▪ Other applications have comparably higher OPEX than investment costs and would require de-risking and stabilising power purchase costs.
Reliance on H2 or syn-gas *High process temperature or low tech-readiness level require an alternative to direct electrification*	▪ Given the likely OPEX gap for industries using indirect electrification, coordination and least-cost development of the H2 value chain are key prerequisites of their competitive decarbonisation.
Flexibility potential *Can leverage flexibility to improve costs and thereby competitiveness*	▪ Industries with interruptible processes, or where storage can be economically installed on site, can bridge part of the cost-competitiveness gap by monetising their flexibility in power markets. ▪ Measures supporting the development of flexible capacities would address both the competitiveness of electricity supply and power system flexibility needs.
Non-energy issues *Other barriers hindering competitiveness*	▪ Where total production costs are similar (e.g., Chinese aluminium), competitiveness issues arise from structural overcapacity and associated unfair practices more than from energy costs. ▪ CBAM protection on direct emissions could be effective for some sectors, on the condition that circumvention is prevented and some of the implementation issues are addressed.

Coordinating both energy cost competitiveness measures and decarbonisation incentives is required to provide efficient support to industrial sectors / products at risk. In addition, a concept of criticality could be introduced to identify projects / products / sectors where the net benefit of the public support is positive because of their positive spillover effects in the wider value chain, justifying structural / enduring support.

Abbrev.: *(1) EU… European Union, OPEX… Operational expenditures, CAPEX… Capital expenditures, CBAM… Carbon border adjustment mechanism*

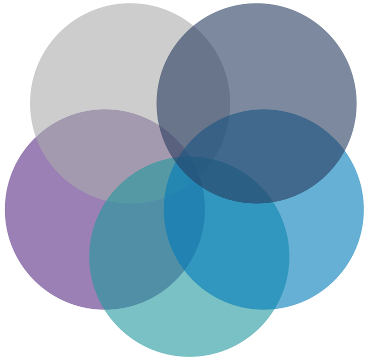
3.

Targeted policy measures to support power purchase costs for EU industry

Methodology & index - We analyse the toolbox of measures with a structured approach to identify objectives, overlaps, key gaps, and best practices for design

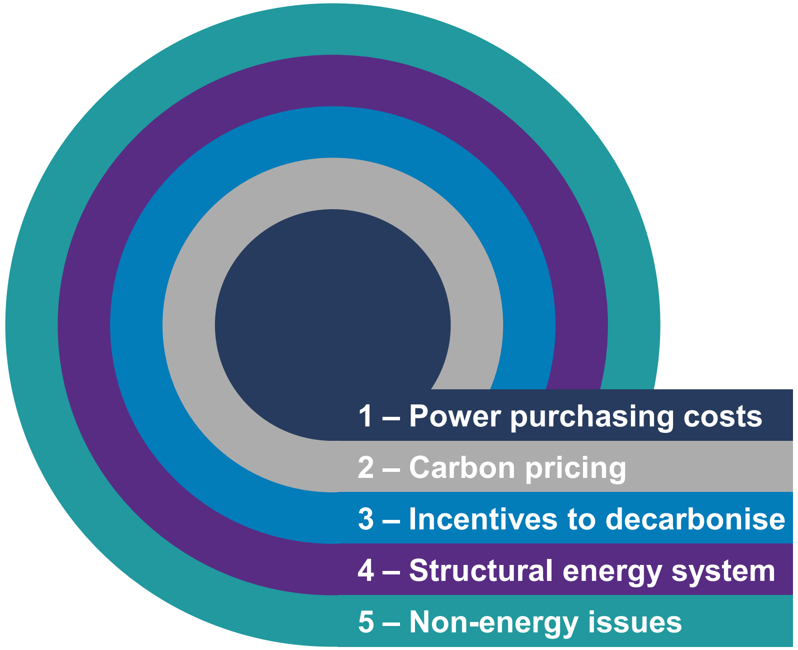
The current patchwork of measures presents overlaps and potential redundancies

Current patchwork of overlapping measures



We propose to analyse this patchwork by taking a comprehensive and organised view of the toolbox, from micro (firm-/sector- level energy costs) to macro (trade flows…):

Toward a coherent typology of measures – proposed structure and index (with non-exhaustive examples)



Context: the EU support framework

1. **Power sourcing cost measures**
   - Long-term supply contracts
   - RES levies / network cost rebates
   - CISAF temporary power price relief
2. **Levelling the carbon pricing playing field**
   - CBAM
   - Indirect CO2 cost compensation
3. **Incentives to decarbonise**
   - Fuel switch CAPEX aid
   - CAPEX and OPEX support
4. **Structural energy system measures**
   - Support for renewables / grid infra.
   - Flexibility contracting & market design
5. **Measures tackling non-energy issues***
   - EU trade policy

Conclusions on the policy toolbox

* Outside the main scope of this report

Source: Compass Lexecon analysis
Abbreviations: CAPEX … Capital Expenditure; CBAM … Carbon Border Adjustment Mechanism; CISAF … Clean Industrial Deal State Aid Framework; MS … Member State; OPEX … Operational Expenditure; RES … Renewable Energy Source; w.r.t. … with respect to

Methodology – We assess the efficiency of measures in achieving policy objectives, their time horizon, and identify best practices for their design

- We propose the following analytical framework to compare the key dimensions of potential support measures:

Impact on competitiveness and / or decarbonisation

- How does the measure contribute to **competitiveness / decarbonisation** objectives?
- What is the extent of power (or other) costs **reductions achieved** by the measure (if publicly available)?
- Does the measure improve short-term or long-term **predictability** of energy (or other) costs for eligible industrials?
- Does the measure maintain or increase incentives to develop industrial demand **flexibility**?

E.g., measures that fix cost components for industrials, such as carbon costs

Timeframe of support

- Does the measure provide **immediate relief**, or does it aim at **delayed structural impacts**?
- Is the support provided as: (1) a **one-off** (1 year), (2) **temporary** (< 5 years), or (3) **long-term** (> 5 years)? What explicit or implicit conditions would lead to a withdrawal or phase out of the measure (i.e., "objective reached")?

E.g., measures that provide a one-off investment grant, or long-term subsidised contracts

Implementation and design issues, incl. potential distortions

- What features of the measures can **limit risks / expenses** borne by the State budget?
- What features of the measure **limit energy market distortions** within / across Member States or industrial sectors?

E.g., measures that include dynamic components that evolve with market conditions

3.1

The existing mix of EU policy interventions and measures to address competitiveness issues

The EU has a patchwork of support measures and policy interventions to address industrial competitiveness issues

- Currently, the EU has a patchwork of support measures to address industrial competitiveness issues which can be grouped into 5 categories displayed below.
- We analyse the current policy framework and other potential forms of support to address the different dimensions of the competitiveness and decarbonisation issues identified in WP1. We focus on measures for ETS costs, flexibility valuation, and measures to offset the remaining competitiveness gap.

Action points

- Non-energy issues
- Flexibility potential
- Power costs exposure
- Electrification cost gap
- Reliance on H2 or syn-gas

Identified types of policy measures available in the EU

	1	2	3	4	5
Objective	Non energy issues	Carbon pricing asymmetry	Structural **power system** costs	Decarbonisation cost gap	Power purchase costs
Approaches	Removing infrastructure bottlenecks Countering unfair trade practices Securing raw materials	Free allowances CBAM Indirect costs compensation	Interconnections dev. Renewables dev. Flexibility dev.	CAPEX support CAPEX + OPEX support	PPA / hedging Preferential access Retail charges exemption Temp. Price relief
Measures	*Anticipatory investment support, circular economy, quotas, customs taxes…*		*Flexibility support schemes, easier permitting, Flexibility products…*	*Investment grants, Carbon Contracts for Difference*	*Public guarantees for PPAs, Tripartite Long-term contracts, network cost rebates…*

Measures highlighted in grey are not studied in depth in the report

This patchwork of measures is framed by the State Aid framework, including guidelines to accelerate approval processes, and other EU texts

State Aid framework

TFEU Art. 107

- **Prohibits State aid** by default, **unless exceptionally justified**, i.e. if the aid is **compatible with the internal market** (c.f. next slide)
- ➢ Thus, Member States wishing to implement State aid must usually notify the European Commission for a formal review (compatibility test)

State aid Guidelines

- Aim to facilitate the process
- Also help to harmonise practices across the EU

Ad-hoc State aid approval

Preferential access

- Examples: Energy Release 2.0 in Italy, BeWatt in Belgium

Climate, energy and environment State aid guidelines (CEEAG)

CRM, RES-E levy exemption

Flexibility contracting

General Block Exemption Rules (GBER)

Regional Aid Guidelines (RAG)

CAPEX support

CAPEX + OPEX support

TCTF

Clean Industrial Deal State Aid Framework (CISAF)

Temp. Price relief

Flexibility contracting

Post-2021 ETS guidelines

Indirect CO2 costs comp.

Other harmonisation principles (see next slide)

EU Electricity Regulation & wider Electricity Market Design

Network cost rebates

PPAs

Preferential access

EU Energy Taxation Directive

Lower energy taxation

Abbreviations: TFEU…Treaty on the Functioning of the European Union, TCTF…Temporary Crisis and Transition Framework (predecessor to CISAF)

3.2

Policies directly targeted at power sourcing costs for industries

A range of measures is available to support the competitiveness of power costs for eligible industrials across European countries

We look at measures addressing all elements of the electricity bill as well as additional subsidies:

- **Wholesale price**: develop private (PPA) and State-funded (CfD) long-term contracts designed upon the best practices of recent / early experiments in Europe
- **Network costs / charges**: coordinate approaches at the EU level to limit EU distortions; incentivise flexibility
- **Taxes / levies**: harmonise and widen the implementation of energy taxation rebates and levy reductions across the EU
- **Temporary price relief**: monitor actual implementation and ensure no overlaps with other State Aid

Wholesale price exposure

- PPA platforms
- Long-term contracts for industrials
- Green power pools

Network costs / charges

- Mostly State aid
- Exemptions / rebates
- Levied on other consumers

Taxes / levies

- Mostly State aid
- Exemptions / reductions
- Levied on other consumers

Temporary price relief

- State aid
- Subsidy

Different measures to de-risk low-carbon electricity purchase for firms can be implemented with various degrees of market interventions

Less complex intervention ⟷ More complex intervention

PPA intervention

Removing barriers to PPAs	State buyer	Public guarantees to SMEs	Centralisation of long-term contracts	State-run green power pool
Regulatory, policy, economic or other barriers to uptake	As a large consumer, the State engages in PPAs to stimulate investment	Widens off-taker base by offering guarantees when small parties engage in PPAs	Public agency acts as central counterparty for PPAs and/or CfDs, shouldering this risk	Public agency runs RES pool, with standard PPA contracts to enable secondary trading
			Be-Watt CAPN	Energy Release 2.0

Forward market intervention

Easing of collateral regulations in forward markets	Expansion of volume and maturity of LTTRs	Voluntary mechanism to stimulate long term liquidity	Incentives for RES under support scheme to hedge
Collaterals accepted by CCPs should be accessible for the wider energy clearing industry	Introduction of 3-year tenor LTTR to match at least forward market product maturities	Selected entities must post minimum buy and sell orders with a maximum bid-ask spread, to boost liquidity	Adapting support linked to day-ahead prices to provide incentives to hedge in forward markets

Source: Compass Lexecon analysis adapted from Eurelectric (2025), Electricity market design fit for Net Zero (link)
Abbreviations: CCP … Central Clearing Platform; CfD … Contract for Difference; LTTR … Long-Term Transmission Rights; PPA … Power Purchase Agreement; RES … Renewable Energy Source, CAPN…Contrats d'Allocation de Production Nucléaire

Varying levels of intervention are starting to facilitate and/or incentivise the development of PPAs

A sparse set of measures to bolster the uptake of PPAs

- Only 4 countries set up such measures: ES, FR, NO, IT
- Approaches differ in depth and design, from guarantees to full market platforms

A common feature is the option to cumulate PPAs with public support mechanisms

- Approaches vary (tender/certif.)
- This helps attract investment while transitioning towards market-based remuneration

Support scheme design increasingly reflects market exposure, and is time-limited

Purpose	De-risking mechanisms *(examples)*	Countries of application
Acceleration of adoption of PPAs and reduction of barriers for developers	Counterparty Risk Guarantee Fund for developers	
	Obligation to source with green PPAs for large users	
	Platform for bringing together supply and demand	
Favouring cumulation of PPA and public support	Possibility to cumulate public support mechanisms (through tenders or green certificates) with a PPA	
Design of RES-E support mechanisms	Support mechanisms with exposure to market price	
	Absence of volume limitations in public support	
	Capped public support schemes (€/MWh)	
	Time-limited public support schemes (10-15 years)	

Example – France

In 2022, France announced a public guarantee fund for PPAs aimed at industrials starting in 2023, which supports onshore wind and solar PV projects and requires contracts with a 10-year minimum duration.

Example – Spain

In 2022, the Spanish market operator OMIE announced the launch of 5–10-year PPA contracts for futures of baseload and solar profiles with underlying delivery in Spain.

__Source__: Compass Lexecon analysis based on E-Cube's Analysis of the dynamics and public support mechanisms for renewable energies favourable to PPAs in Europe (2022).
__Note__: The list of de-risking mechanisms as well as the list of countries of application are not exhaustive.

Tripartite long-term agreements could durably lower power costs for industrials, potential overlap with indirect CO2 cost compensation

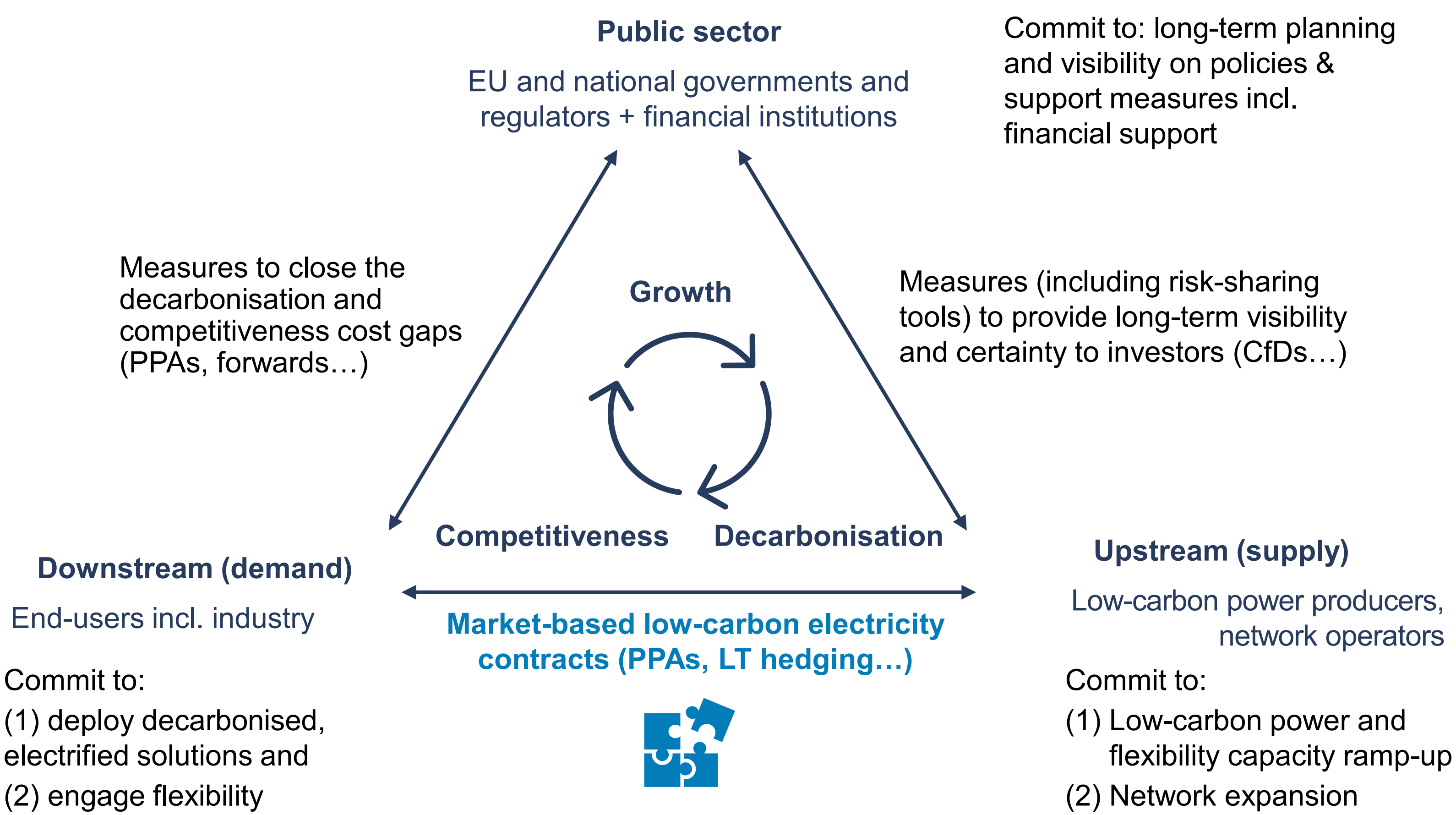
A tripartite agreement framework creates a "virtuous triangle"

- Context: electrification is stagnating on the demand side, and the public sector is struggling to provide long-term visibility
- Voluntary → only a cooperation / coordination agreement
- Market-based clean power contracts will be the key link between demand & supply – e.g., long-term low-carbon PPA for an industrial aiming to electrify & decarbonise

Examples of market-based clean electricity contracts include:

- Tripartite agreements:
  - Italy – Energy Release 2.0 & MACSE
  - Belgium – BeWatt
- Other long-term market-based options:
  - France – CAPN (successor to ARENH mechanism*)

Conceptualisation of tripartite agreements

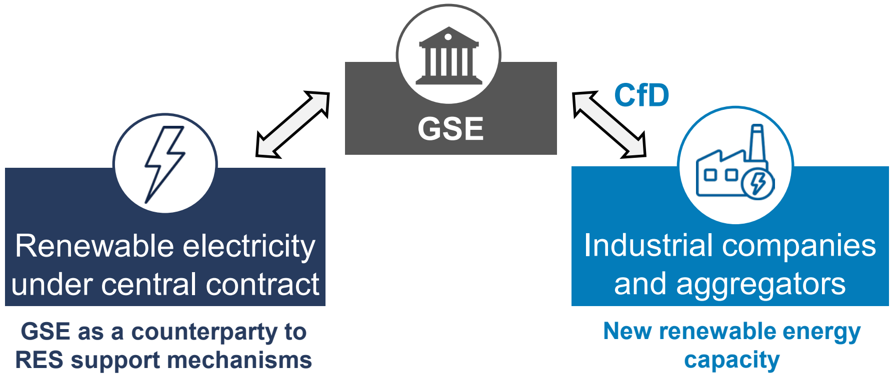


Sources: Compass Lexecon analysis based on CATF (2025) Accelerating the deployment of clean power technologies to reliably decarbonise Europe through enhanced planning and contracting mechanisms (available here), EC (2025) Action Plan for Affordable Energy (available here), Eurelectric (2025), Tripartite Agreements position paper (available here)
Note: *ARENH: Regulated Access to Historic Nuclear Energy offering fixed-price access to industries to a certain amount of EDF's nuclear power
Abbreviations: CAPN…Contrats d'Allocation de Production Nucléaire; PPA…Power Purchase Agreement

Illustration - Italy’s Energy Release 2.0 grants energy-intensive industrials immediate access to stable energy prices in exchange for investments into renewables

Energy Release 2.0 provides 23-year contracts during which a central entity sets up a CfD with energy-intensive industrials to incentivise them to invest in new renewable capacity:

- Stated goal: to encourage energy-intensive industrials to co-finance the ramp-up of new renewable generation capacity (unlike in a traditional CfD where the government takes this endeavour alone)
- Eligibility: firms registered in Italy’s list of energy-intensive businesses[1] (energy use > 1 GWh/year)
- The scheme works in 2 phases:
  (1) 3-year “loan” period: the central entity (GSE) transfers part of (currently 24 TWh/year) the energy produced by existing RES to energy-intensive industrials at the price of new RES in a 2-way CfD (currently €65/MWh)
  (2) 20-year “repayment” period: once the new RES is online, the industrial sells its electricity to GSE in a reversed 2-way CfD



Takeaways from the case of Energy Release 2.0 in Italy (preliminary info. at the time of writing, as the results of the first tender are not yet public[2])

Impact on comp. and /or decarb.

- Provides **monthly power supply at 65€/MWh** during 3 years for a share of annual consumption
- Est. subsidy in the initial 3-year period: Futures price - €65/MWh ≈ €40/MWh[a]
- Lowers electricity prices over the long term as it incentivises RES ramp-up
- **No ties to flexibility**

Timeframe of support

- **Immediate effect** as the scheme is based on existing renewable capacity
- 3+20 year-contracts – i.e., **long-lasting impact**

Implementation, design, and distortions

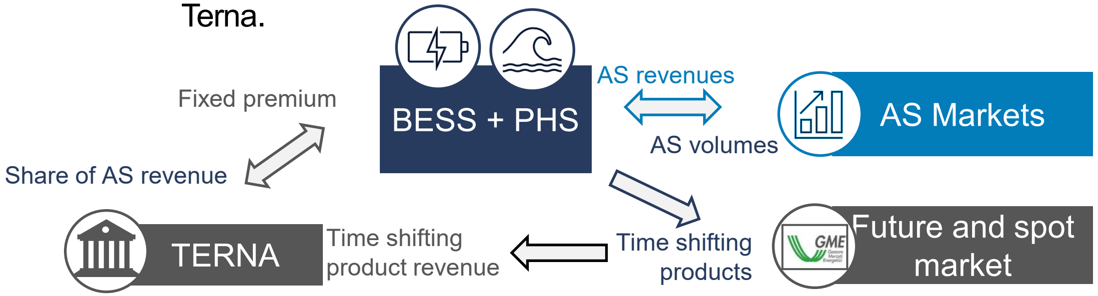
- **Limited regulatory changes** (GSE already existed)
- **2-way CfD:** built-in clawback limits risk of windfall profits / overspending on both sides
- Est. budgetary impact in the initial (3-year) period[a]: 24 TWh/year x (futures price - €65/MWh) ≈ € 1 bn/y
- **Co-financing** of RES by industry (unlike traditional CfD)

Source: Compass Lexecon analysis based on GSE Energy Release 2.0. [1] List available here – includes steel, aluminium, chemicals, among others., [2] GSE press release from 21 Nov 2025
Notes: The European Commission welcomed the Italian measure and approved the fixed price of €65/MWh for energy-intensive Industries on 27 June 2025. [a] assuming a futures price of €104/MWh, retrieved using the EPEX link (provided in the comfort letter) on 13 November 2025 at 19:00 CET.
Abbreviations: CfD … Contract for Difference; PPA … Power Purchase Agreement; RES … Renewable Energy Source; GSE…Gestore dei Servizi Energetici

Illustration - Italy's MACSE derisks flexible asset revenues while offering time shifting products to consumers through centralised markets

MASCE aims to attract new storage capacities by de-risking their revenues, by pooling capacities on future and spot markets in 'virtual batteries' while allowing additional market revenues:

- Stated goal: Support 2030 RES deployment target (131 GW by 2030), particularly 72 GWh storage capacities. The first MACSE tender will aim to contract 50 GWh of storage capacities.
- Eligibility: Open to BESS and PHS not partaking in CRM (now or later). Projects are selected in ascending order of bids, adjusted for storage performance (charging / discharging time, efficiency).
- How the scheme works: De-risking remuneration for storage operators, while allowing additional market revenues
  - (1) Two auctions (BESS and PHS) for fixed premium in €/MWh/year from Terna(1) (BESS: 15 years; PHS 30 years).
  - (2) Available capacities will be used to offer time-shifting products on future & spot markets (GME), revenues will be paid to Terna
  - (3) Residual capacities(2) can still offer ancillary services (AS), awardees repay ≈80% (adjusted by a cap and floor) of income to Terna.



Takeaways from Italy's MACSE

Impact on comp. and /or decarb.

- Fixed **yearly premium in €/MWh/year** during contract + share of ancillary services revenues
- De-risks investment into new capacities
- **Increases power system flexibility and improves RES absorption**

Timeframe of support

- **Immediate support,** post-auction award
- 15- and 30-year support – i.e., **long-lasting impact**

Implementation, design, and distortions

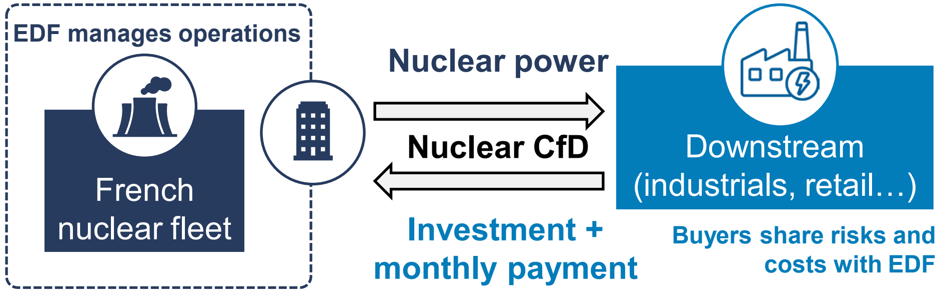
- **Auction design**
- **Limited regulatory changes** but may complicate capacity market calibration (need to co-optimise firm / flexible capacity procurement through the CRM and the MACSE)
- **De-risking of revenues for storage capacity** while Terna bears some price risk

Source: Compass Lexecon analysis based on Terna (2024), European Commission (2023), Greendealflow (2024)
Note: (1) Terna is the Italian transmission system operator, GME is the power exchange. (2) I.e. non-contracted capacities within selected projects, which means storage operators can choose to keep exposure to ancillary service markets to benefit from upside potential.
Abbreviations: MASCE…Meccanismo di Approvvigionamento di Capacità di Stoccaggio Elettrico (Electricity Storage Capacity Procurement Mechanism); RES…Renewable Energy Source; BESS…Battery Electric Storage System; PHS…Pumped Hydro Storage; GME…Gestore dei Merkati Energetici; MSD…Mercato dei Servizi di. Dispacciamento (Italian ancillary services market)

Illustration– France's CAPN offer long-term low-carbon power at a stable price for industrials in exchange for cost- and risk-sharing

The CAPN aims to make buyers invest in and share the risks and costs of EDF's nuclear fleet in exchange for long-term access to low-carbon electricity at a stable price:

- Stated goal: to secure low-carbon electricity supply at a price that reflects the costs of the French nuclear fleet, and thereby, shield buyers from wholesale price volatility
- Eligibility criteria (for up to 50% of buyer's yearly consumption)
  (1) (Industrial) users with consumption > 7 GWh/year
  (2) Retailers or producers able to offer flexibility on demand
- How the CAPN scheme works: In its first stage, EDF will sell 1.8 GW (~10 TWh/year) of CAPN:
  (1) EDF receives an initial down payment from buyers → i.e. **buyers initially commit** to financing EDF's capacities
  (2) EDF determines a monthly fee based on CAPEX and OPEX + fuel costs, and an annual fee covering commercial, contract & risk management costs → i.e., **buyers share the risks & costs**



Takeaways from the case of CAPN in France (preliminary information)

Impact on comp. and /or decarb.

- Provides **low-carbon power** at a **stable price** for up to 50% of consumption
- Preliminary estimations anticipate the contracts to be priced around €60 to €70/MWh, i.e., 15-33% above France's day-ahead futures for 2026 (€52/MWh)[1]
- Can expand to tap into a **large pool** of low-carbon power (total operational fleet is over 60 GW in 2025)
- **Integrates flexibility** providers by default

Timeframe of support

- Gradual **phase-in**
- **Immediate** effect for selected industrials
- 10- to 15-year contracts – i.e., **long-lasting impact**

Implementation, design, and distortions

- **No competitive auction:** EDF sets a single price in €/kW, and participants set their subscribed volumes
- Aims to provides **stable long-term funding & risk-sharing** for nuclear → aims to lower the need for subsidy
- Capacity-based contract: energy delivered can vary monthly to reflect maintenance and modulation

Sources: Compass Lexecon analysis based on Le Monde, Senate, EDF & EDF (bis). CAPN = Contrats d'Allocation pour le Nucléaire. [1] reference price of €52.45 retrieved from EPEX (on 13 November 2025 21:20 CET), and range of €60-70/MWh retrieved from a document from the French Parliament (available here).
Abbreviations: CAPN…Contrats d'Allocation de Production Nucléaire, EDF…Electricité de France; CfD … Contract for Difference

Recent discussions illustrate ways to reduce industrial grid charges: network cost rebates or ceilings, structural tariff design, and TSO subsidies

The EU Electricity Regulation set economic and feasibility criteria for network charges, including:

- Network charges must be **cost-reflective**, encourage **efficient use** of the grid and incentivise **flexibility**
- Network charges must be **affordable**, **acceptable**, **transparent**, **predictable**, and **non-discriminatory**

The EC issued a set of recommendations in 2025[1,2,3]:

- EU ruling: **regulators** (not legislators) are competent to set network charges
- **Public funding** on TSO revenue is allowed → i.e., can subsidise tariffs for all via operator
- Special tariffs for energy-intensive users can be justified → **tariff structure adjustment OK**
- **Tariffs** should include **capacity-based** elements → this favours energy-intensive industrials

Network charge rebates

- **Reduction (or exemption) of network charges** for industrial users based e.g., on consumption thresholds
- Principles shown to the left can **limit the use of grid charge reductions** / exemptions, esp. **cost reflectivity**

Network charge ceilings

- **Temporary ceiling:** e.g., freezing tariff increases for a time, then raising them later by the same present value
- **Subsidised ceiling:** TSO revenue remains unchanged but public funding (State aid) lowers grid costs

Tariff structure adjustments

- **Structural cost differentiation favouring industrials:** e.g., setting decreasing charges per energy or power level
- **Separation of regulatory asset bases:** isolate the assets used to serve industrials to allow the TSO to lower tariffs

Direct subsidy to TSOs

- The **State subsidises the TSO's revenue**, allowing it to charge **lower tariffs for all users** (aid is diluted)
  - For instance, the German government plans to inject €6.5 billion of subsidies into the 4 TSOs in 2026[4]
- **Could be cumulated with a separated regulatory asset base** to make the subsidy more cost-effective / targeted

Sources: [1] EU Affordable Energy Action Plan, [2] Draft guidelines on future proof network charges for reduced energy system costs (2025, available online), [3] Recommendation of 2.7.2025 – C(2025) 4024 (2025, available online).[4] German government draft law for a subsidy towards transmission network costs for the year 2026 (available online).

Diverse **network cost rebates** for electro-intensives are in place in the Union, new guidelines push for an integration of flexibility requirements

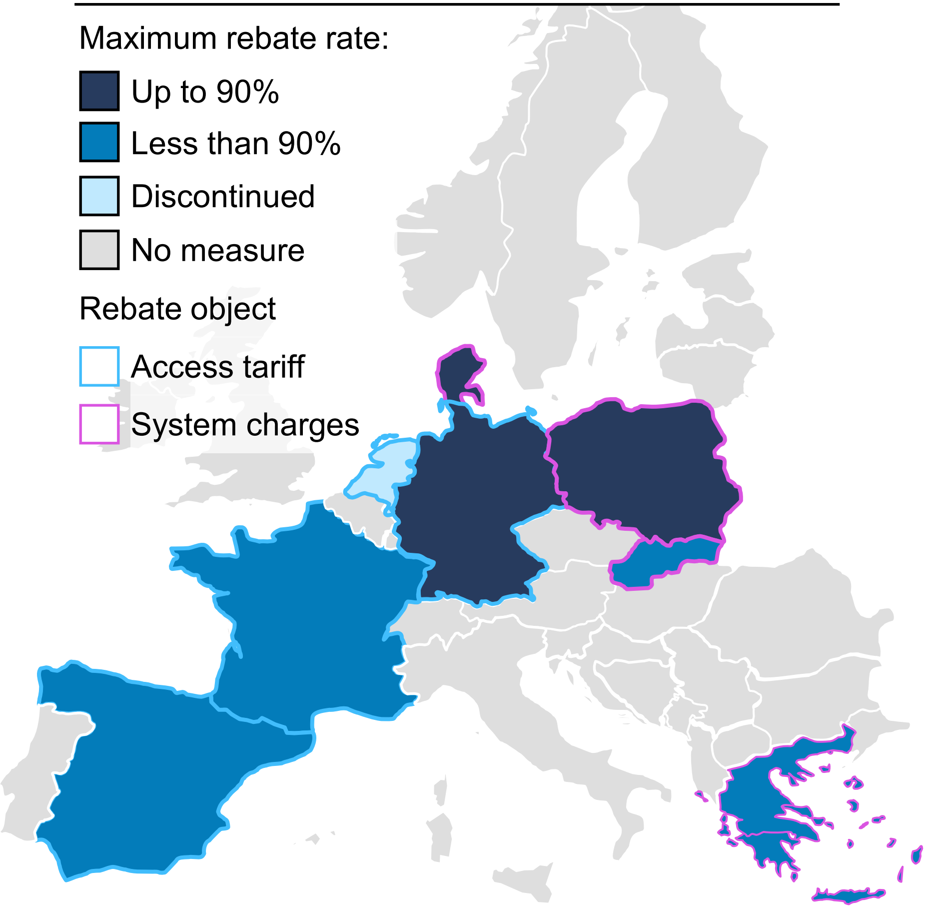
The implementation of network cost rebates is patchy and uncoordinated

- Only 8 Member States implemented them – NL discontinued theirs, ES only renewed until end 2025 for now
- Eligibility criteria for schemes in place are not uniform in type (energy/year, util. rate…) or level (1 vs 100 GWh/y)
- Rebates vary from 20% to 90% and apply to different types of charges

In its network charges guidelines, the EC discourages "unjustified" network cost rebates and encourages linking such rebates to flexibility

"[it is] recommended to justify their cost-reflectivity, e.g., requiring relevant network users adjust their consumption profile, to lower the impact on the grid."

Map of national measures



Aid	Eligibility criteria for max. rebate	Max rebate amount & object
DK[1]	> 100 GWh/y	-90% system charges
FR[2]	>10GWh/y and >80% util. rate	-81% access tariff
DE[3]	>80% utilisation rate	-90% access tariff
GR[4]	> 1,000 GWh/y, > 80% util. rate	-54% system charges
NL*[5]	> 65% utilisation rate	-90% access tariff
PL[6]	Electro-intensive, >400GWh/y, >50% util. rate	-90% system charges
SK[7]	1 GWh/y	-19.24% system charges
ES[8]	Electro-intensive, 1 GWh/y, anti-cyclical	-80% access tariff

Sources: *Compass Lexecon intelligence, ACER (2025) Electricity network tariff practices (available here), EC (2025), Draft guidelines on future proof network charges (available here). [1]: EnergiNet (2025) Current tariff (available here), [2]: French local government (2025, available here), [3]: Netztransparenz (2025) levies and charges (available here), [4]: RAAEY (2023) decision E-21/2023 (p.15, available here), [5]: ACM (2023) press release (available here) - note that the Dutch scheme was discontinued after the regulator found it did not comply with EU legislation – specifically the cost-reflectiveness principle, [6]: ACER (2025) Electricity Network Tariff Annex I (p.65, available here), [7]: ÚRSO (2025) press release (available here), [8]: BOE real Decreto 7/2025 (available here).*

Network cost rebates can have a direct impact on competitiveness by providing significant reductions in electricity costs

Impact on competitiveness and / or decarbonisation

- Covers a **significant (typically > 80%) share of network costs**, which for instance in Germany can exceed €30/MWh[1]→ this **contributes directly** to cost **competitiveness**, and **indirectly to decarbonisation** by lowering the opportunity cost of electrification (lowers electricity OPEX) vs other pathways
- The reduction is typically a percentage (fixed for the duration of the measure) of network costs (variable over time, e.g., with each regulatory period), resulting in **more predictable energy costs** over time.
- Future network rebates schemes could **encourage the uptake of flexibility** under the principle of cost reflectivity

Timeframe of support

- The measure provides immediate relief (whenever in the year the network charge / levy / tax is due)
- Network cost rebates are typically a **long-term** measure (lasting at least one regulatory period which is typically 4-5 years), though the updated EU network charges guidelines discourages their use unless justified.

Implementation and design issues, incl. potential distortions

- Network cost rebates typically differentiate rebates levels by utilisation rate, yearly consumption and electro-intensity
- However, network cost rebates are not competitively allocated, and are usually quite static with market conditions
- Network cost rebates are also different across Member States, with **limited harmonisation**, creating **potential distortions across EU MS** in the prices faced by industrials with similar characteristics.

Electricity levy / tax reductions are implemented unevenly across EU Member States

Uneven implementation shows scope for harmonisation

- Only 10 MS set up RES levy reductions, with wide variations in amounts and budgets
- The disparity of levies in scope reflects the varied structure of energy fiscality across MS, with, e.g., comprehensive excise taxes (FR) or multi-layered targeted levies (DE)

Continuation of schemes upon expiry may lead to harmonisation of eligibility

- Some schemes are slated to expire soon
- CEEAG set eligibility on electro- & trade-intensity criteria (E/TI). This calibration is sensitive, and the fixed list may not reflect shifting dynamics.
- However, harmonisation may be underway if the schemes are renewed under CEEAG

Reforms to shift the subsidy tool from levies to taxes are gaining traction (e.g., in FR, DE)

- Crucially, taxes are a MS prerogative, i.e., no State aid notification is needed, and MS can set rates, eligibility, and durations within the broad limits of the Energy Taxation Directive
- By merging levies under a single electricity tax (e.g. French excise tax), MS can convert levy reductions into lower tax rates

Map of implementing national measures (illustrative, non-exhaustive)

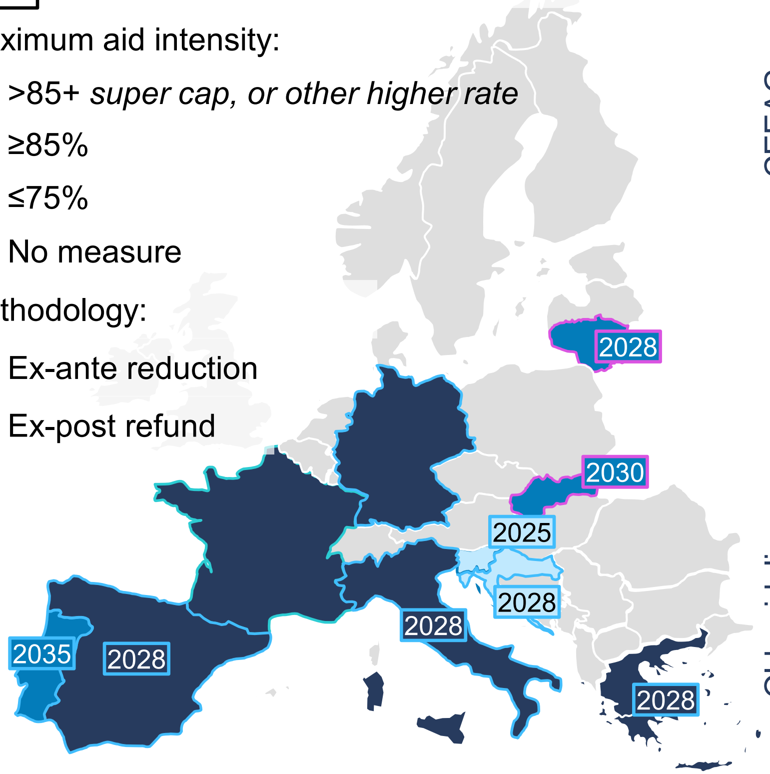
20XX Last year the exemption / reduction applies for now

Maximum aid intensity:

- >85+ *super cap, or other higher rate*
- ≥85%
- ≤75%
- No measure

Methodology:

- Ex-ante reduction
- Ex-post refund



	Aid	Levy / tax in scope	Max. est. levy reduction (yearly budget)
CEEAG	HR	RES, CHP	€ 3.5 / MWh[1] (€ 17.3 m)
	DE	Offshore wind, CHP (excise tax)	€ 13.9 / MWh[2] (€ 1.2 bn) (+excise tax cut by €20/MWh)[8]
	IT	RES, CHP	€ 26.9 / MWh[3] (€ 1.4 bn)
	PT	RES + various	N/A (€ 61.2 m)
	SK	RES	N/A (€ 25 m)
	ES	RES + various	€ 3.2 / MWh[4] (€ 66 m)
Old guidelines	FR*	Excise tax	€ 20 / MWh[5] (€ 1227.5 m)
	LT	RES	N/A (€ 3 m)
	GR	RES, CHP	N/A (€ 200 m)
	SI	RES, CHP	N/A (€ 200 m)[6]

Sources: State aid cases for Croatia, Germany, Italy, Portugal, Slovakia, Spain, France, Lithuania, Greece and Slovenia from DG COMP's website Please note that while we looked at RES levy exemption State aid filings under CEEAG, the levy / landscape is shifting and such filings may not be representative of full exemption / reduction rates that apply (as for instance in France or Germany where it is now higher than notified at first).
Notes: Compass Lexecon estimate based on the respective sources cited above, [1] Recital 5; [2] Recital 23; [3] Recital 13; [4] Recital 1 [5] Recital 4 and 29 [6] combined with RES/CHP support [7] (a): $EI \times TI > 2\%$, $EI \& TI > 5\%$; (b): $EI \times TI > 0.6\%$, $EI > 4\%$, $TI > 5\%$; See Annex 1 CEEAG (available online). [8] The German electricity excise tax is reduced (outside of CEEAG scope) for industrials from €20.5/MWh to €0.5/MWh.
*French maximum aid intensity amounts to 97.78%

Electricity tax/levy reductions are a powerful way to address electricity costs competitiveness but lack a harmonised approach at EU level

Impact on competitiveness and / or decarbonisation

- Like network cost rebates, electricity tax / levy reductions **directly impact competitiveness and indirectly impact decarbonisation** by lowering the opportunity cost of switching to electricity (vs non-electrified / fossil pathways)
- The extent of cost reductions achieved **depends on the MS**, particularly on **whether it is applied to specific RES levies** (smaller tax, smaller impact) or on an all-encompassing **excise tax** on electricity (larger tax and impact)
- As percentage reductions are usually fixed over the duration of the aid and tax amounts are generally stable over time, tax / levy reductions contribute to making energy prices **more predictable** over time
- Tax / levy reduction instruments do not usually incentivise flexibility, but such clauses could, e.g., be built into the reduction factor in future measures.

Timeframe of support

- The measure provides **immediate** relief to the beneficiary (whenever the tax is due)
- Support under such measures **is typically long-term**, though we note that many such schemes are **slated to expire soon** and are up for renewal, amid a potential shift to an excise tax model.

Implementation and design issues, incl. potential distortions

- These schemes are set for the long-term and not competitively allocated.
- Tax / levies and their reductions currently **differ across Member States**. However, the **shift to an excise tax model** with reductions set to the common minimum level (currently €0.5/MWh) under the EU Energy Taxation Directive could result in higher harmonisation in the future.

The CISAF introduced temporary power price relief while simplifying State aid approval on issues overlapping with CEEAG

Scope and overlaps in scope between the CISAF and CEEAG

CISAF

- Temporary power price relief for EIUs
- Non-fossil flexibility contracting
- Clean tech manufacturing
- Risk financing by private parties

General State aid to support the rollout of clean energy supply or demand

CEEAG

- Electricity levy reductions
- Bio- /circular economy
- (C)CfD, FiP and tradeable certificates for industries
- Greenfield investments of new entrants

Overlap includes, e.g.:
- Investment support electrification
- Capacity markets

The CISAF is additional and **complementary** to other State aid guidelines, notably CEEAG, RAG and GBER

CISAF and CEEAG **overlap on most aid, except, e.g.:**
- **CISAF:** power price relief, clean tech manufacturing …
- **CEEAG:** CCfDs, electricity levy reductions …

The CISAF also changes and adds some **principles**:
- It pushes for **competitive bidding**
- It adds the notion of **European preference**
- It **simplifies** and **accelerates** consultation and review processes

The **CEEAG is the main rulebook** for energy or climate State aid, and the **CISAF is the new fast-track pathway**

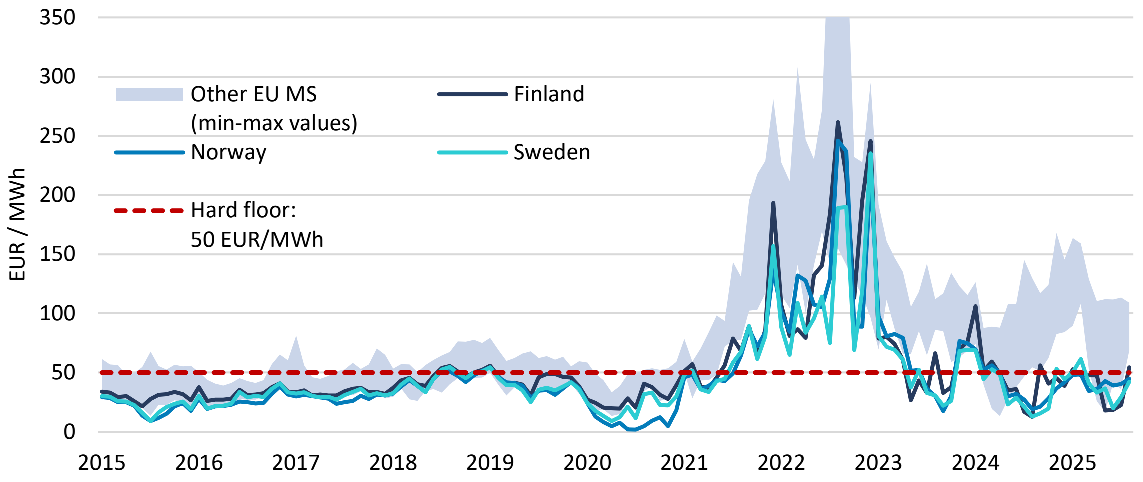
Sources: CISAF Communication (EU) C/2025/3602 (available online), CEEAG Communication (EU) 2022/C 80/01(core text available online, summary also available online).

Temporary power price relief under CISAF offers a wide scope, but the 'four times 50' approach limits aid intensity

Sector eligibility: fulfilment of trade & electro-intensity thresholds under recital 116

Sector	Industrial application	Eligible for relief?
Chemicals and petrochemicals	Steam cracking for olefines (ethylene)	Yes
	Low-temperature chemical steam supply	**No**, except NACE 20.5 (glue, explosives …)
	Ammonia production	Yes
Iron and steel	Primary steel smelting	Yes
	Secondary steel smelting	Yes
	Post-production heating	Yes
Aluminium	Primary aluminium smelting	Yes
	Secondary aluminium smelting	Yes
	Alumina digestion	Yes
Glass	Container glass melting	Yes
	Flat glass melting	Yes
Cement	Cement clinker burning	Yes
Paper and pulp	Steam generation for paper drying	Yes
Food and beverages	Steam generation (milk powder application)	On the fence
Data centres	Data storage / AI computation	No
Battery	Electrode manufacturing	Yes

Country eligibility: comparison of monthly average wholesale power prices in the EU27+EFTA with power price thresholds under recital 120



- **Inclusive** scope for sectors (except low-temp. and data centres) & countries (except Norway, Finland & Sweden where power prices are low)
- **Key sector-country pairings are in scope**, e.g., Greek aluminium, German steel
- **Temporary relief** (only up to 3 years, with no payments after 31 Dec 2030)
- The **amount of the aid is limited and conditional** (<50% of the price for <50% of annual power use, with a price floor at €50/MWh, reinvest 50% to reduce power system costs*), **but cumulable** with other State aid

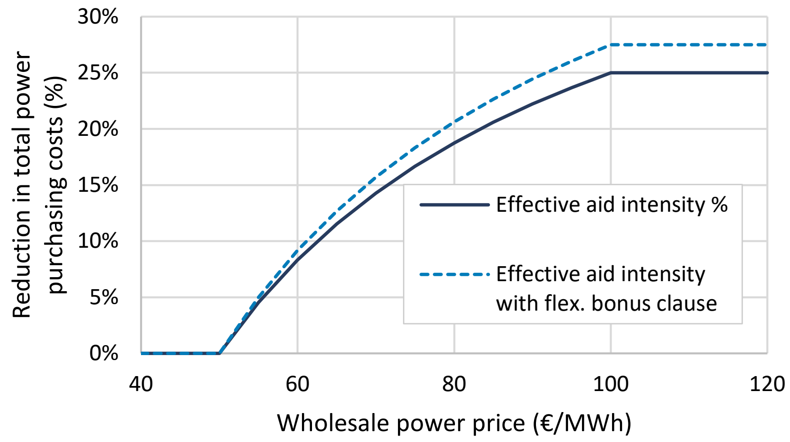
Sources: CL intelligence, based on trade and electro-intensity data from DG COMP, and power price data from Ember
Notes: Eligibility calculated from the thresholds shown under CISAF recitals (116) for sectors, and (120) for countries.
**Investments to reduce power system costs are restricted to certain eligible activities that do not increase fossil fuel consumption for more information see here*

Temporary power price relief under CISAF is a time-limited emergency aid adapted to sectors / applications with temporary trade pressures

Impact on comp. and/or decarbonisation

- Covers ≤50% of wholesale power price (cumulable with indirect CO_2 cost compensation), for ≤50% of yearly power consumption, down until price = €50/MWh
- Effectively, this amounts to a 3-year coverage of:
  - 25% of electricity procurement cost if yearly average wholesale power price > € 100 / MWh
  - 0-25% of proc. cost if € 50 < price < € 100 MWh
  - No coverage below € 50 / MWh
- Fixed power price reduction based on **yearly average**.
- >50% aid reinvestment clause built **to channel investments** into industrial decarbonisation (exact scope remains somewhat open to interpretation)
- An **additional 10%** on the base aid (reduction applied to eligible consumption) can be unlocked if the recipient **invests into clean flexibility (DSR and batteries)**[1]

Max. effective CISAF temporary relief aid intensity (%) as a function of wholesale power price (€/MWh)



Timeframe of support

- Aid provides **instant relief** to energy- and trade-intensive industrials upon approval
- **Up to 3 years (i.e., temporary)**, last payment by 31 Dec 2030

Implementation, design, and distortions

- No competitive bidding, but list of eligible sectors (criteria based on product of electro- and trade-intensity[2]) and '**four times 50**' approach curb risk of wasteful spending
- **Not all MS will benefit equally** as it depends on average national wholesale power prices – e.g., given their prices in 2024, Greece, Germany & Spain could implement rebates up to €25, €20, & €15/MWh respectively[3]

Sources: CL analysis based on: [1] See recital 123 of CISAF: the conditions are more precisely if (1) 75% of this additional aid is invested into indus. decarbonisation, and (2) 80% of total investment amount goes into clean flexibility (DSR and batteries).
[2]: recital 116 of the CISAF communication (available here) describes eligibility as such: "aid can only be granted to undertakings from sectors where such risks are significant. This applies to those sectors listed in Annex 1 CEEAG (66), for which the multiplication of their trade intensity and electro-intensity at Union level reaches at least 2 % and whose trade intensity and electro-intensity at Union level is at least 5 % for each indicator."
[3] Swedish industry association (2025) Note on CISAF electricity price relief (available here).

3.3

Measures to level the carbon pricing playing field

The theoretical level of power price support needed to neutralize the total competitiveness gap could reduce with the CBAM's implementation

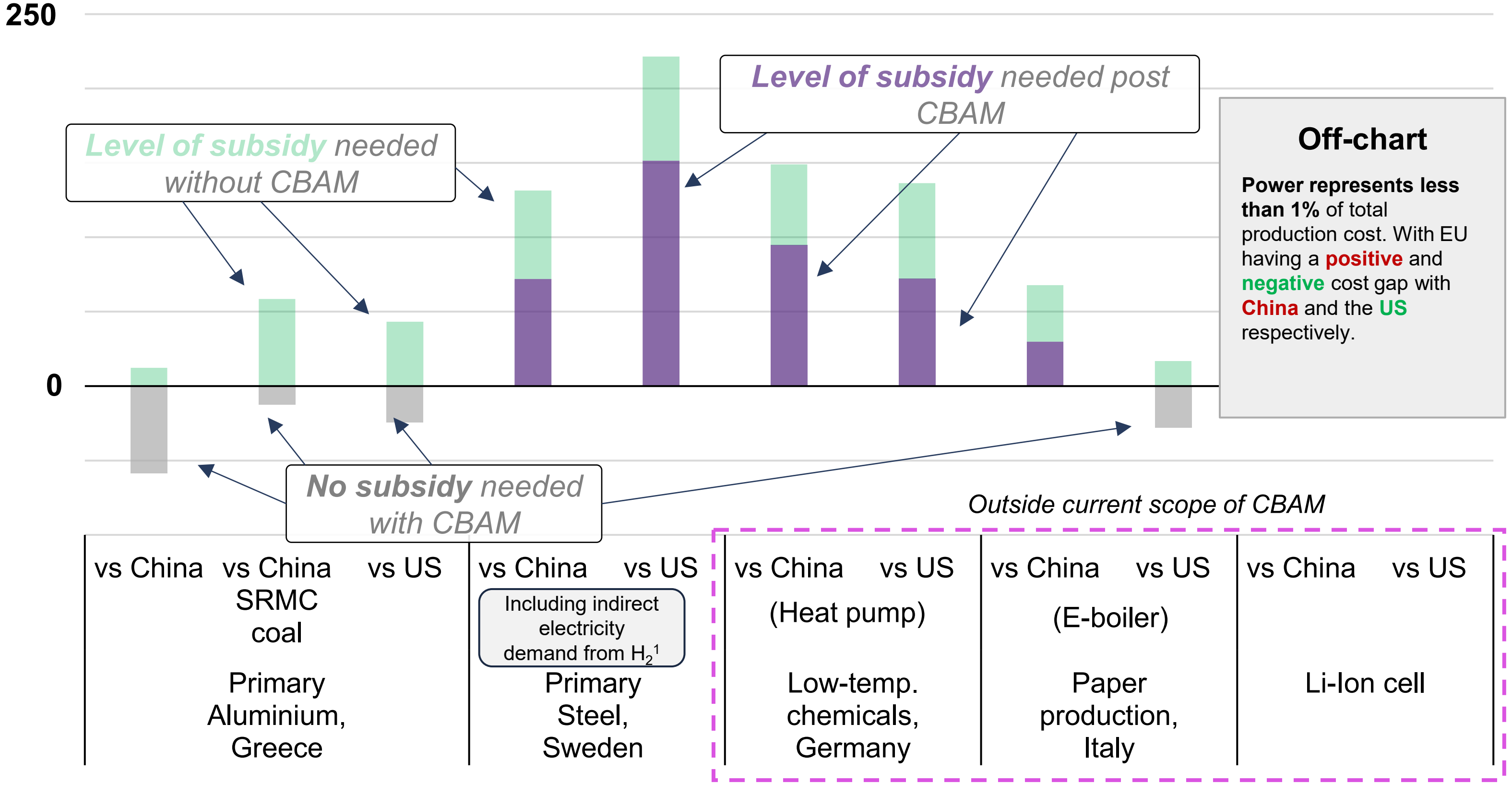
The theoretical cost-competitiveness gap based on our assumptions in 2035 varies across industries.

Effective implementation of CBAM on scope 1 & 2 (see calculation rules here) could be a powerful tool to limit the potential need for public support.

- Green bars reflect a scenario where CBAM is not in place and there is no ICCC in the EU.
- Purple bars represent a scenario where CBAM covers scope 1 and 2 for all EU ETS sectors – with this, the most competitive US and Chinese process is usually fossil-based.
- Differences in results steam supply for low-temp. chemicals versus paper production illustrate how similar T° requirements can translate into different support needs due to energy needs of different technologies.

Therefore, a uniform power price support instrument may not reflect the differentiated cost exposure across industrial sectors.

Theoretical power price subsidy needed for decarbonised EU industrial applications to breakeven with US and Chinese most competitive production routes in 2035, €/MWh



Disclaimer: "Most competitive" foreign production route result in the highest boundary for theoretical support levels and can be the fossil-based process in some sectors.

Notes: (1) Indirect electricity demand from hydrogen production is included in computations of power price support needs. We calculate indirect electricity costs from hydrogen production based on the regional Hydrogen price assumption and subtract capital and transport costs (based on Hydrogen Council & McKinsey (2023) Hydrogen Insights and EWI PtX tool

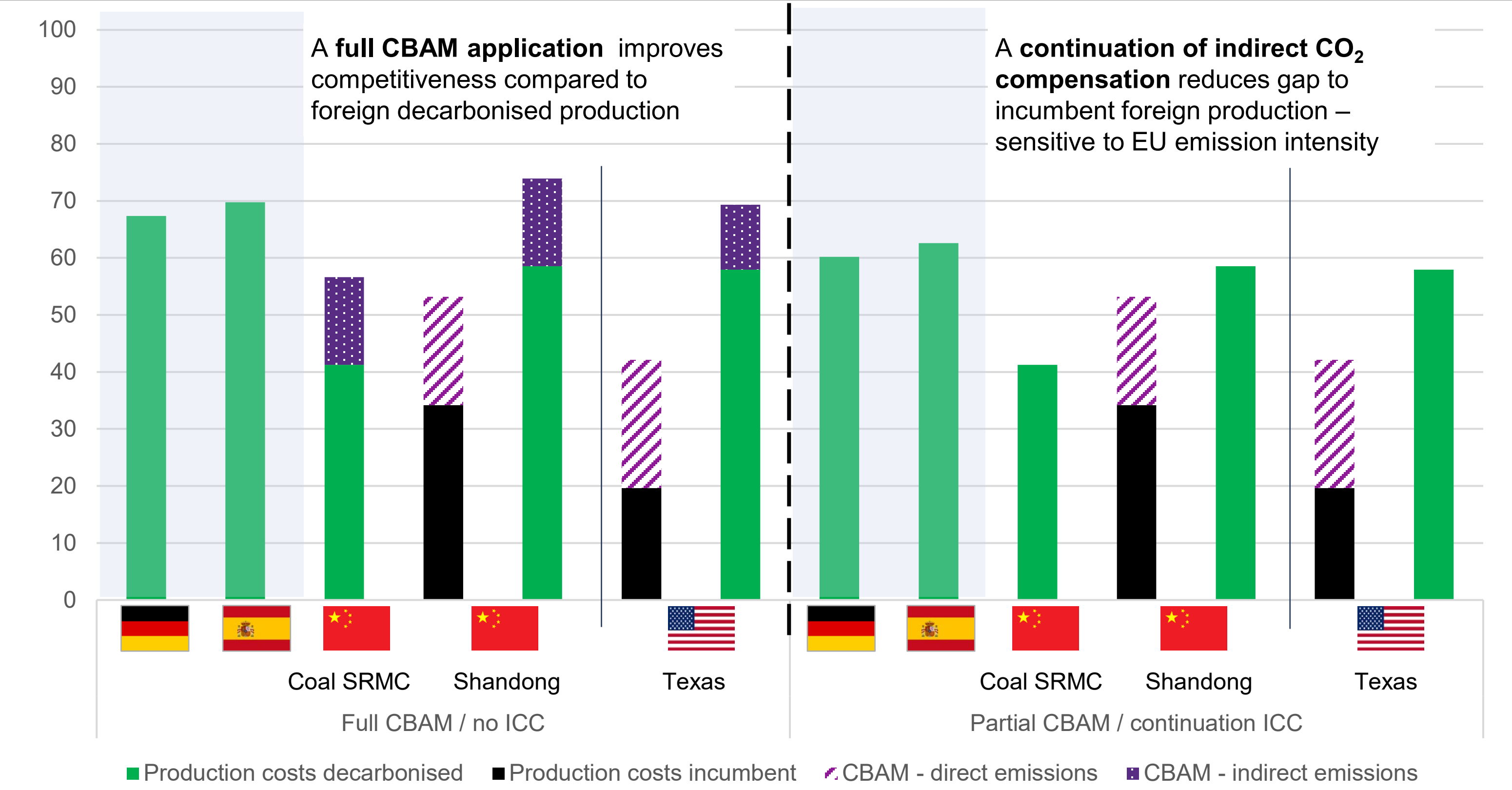
Abbreviations: HP…Heat pumps, CBAM…Carbon Border Adjustment Mechanism, SRMC…Short-run marginal costs, H2…hydrogen, T°… Temperature

The exclusion of scope 2 from CBAM and continuation of indirect CO2 compensation could improve EU position to foreign incumbent production

Based on current methodology to compute embedded scope 2 emissions in CBAM-covered products, exclusion of scope 2 emissions would benefit decarbonised foreign production but improve the EU's position compared to foreign fossil-fuel production routes.

- The current methodology considers the average CO2 content of electricity in countries of origin. EU undertakings pay CO2 content for the marginal electricity prices.[(2)]
- Under our assumptions, for steam supply, a hypothetical configuration with CBAM on scope 1 and 2 and no ICCC, leads to a ~30 €/t cost difference with the cheapest foreign equivalent.
- A configuration with CBAM on scope 1 only and continuation of ICCC, leads to a ~20 €/t cost difference with the cheapest foreign equivalent.

Steam supply for low-temp. chemicals: full CBAM and phase out of ICCC vs. partial CBAM and continuation of CBAM – Spain, Germany, China and US in 2035, $€_{2024}/t_{steam}$[(1)]



Disclaimer: as of December 2025, chemicals (exc. fertilisers) are not covered under CBAM, but we assume coverage by 2035 for illustrative purposes.

Notes: (1) Net cost breakdown assumes baseload operation of NG boiler in and heat pump. Chinese short run marginal costs assume that electricity is supplied by an on-site coal power plant that only incurs fuel costs and variable production costs. Capital costs are assumed to be covered by the Chinese state/province. Direct emissions include process specific emissions and indirect emissions include power system emissions. For the calculation of indirect costs compensation, we use a simplified formula: (installation specific emission factor)(power system emission factor)*(carbon price 2035)*(aid intensity). We assume that post 2030, countries will move from the default-based emission factors to market-based, given current methodologies for market-based method we estimate emission factors for relevant countries.(2) Commission Implementing Regulation (EU) 2025/2547 Article 9 also allows PPAs*

***Abbreviations:** CBAM… Carbon Border Adjustment Mechanism; SRMC…Short Run Marginal Cost, ICCC…Indirect CO2-cost compensation*

In December 2025, the EC updated the CBAM framework to address some of the issues that remained

Delegated Acts (DAs) published in December 2025 by the EC addressed a number of methodological issues associated with the transitional CBAM framework.

Delegated acts included:

- Measures to address potential **circumvention** (deliberate non-compliance) from mis-labelled shipments, falsified data, or undeclared transhipments;[1]
- Measures to address potential **avoidance** (legally leveraging the rules of the system) such as:
  - Importing processed goods out of the CBAM's scope instead of CBAM covered goods;
  - Resource shuffling, i.e., readjusting supply chains to export the least emission-intensive goods to the EU and divert the more polluting goods to other (unregulated) markets.
- Detailed calculation rules for embedded emissions in imported goods and the price of CBAM certificates
- The creation of a Temporary Decarbonisation Fund to channel CBAM revenues into industrial decarbonisation support mechanisms

Announced by the EC, provisions to relieve EU producers of CBAM covered goods from carbon costs for exports have yet to be published.

Issues addressed by the EC during 2025's CBAM and ICCC reviews and remaining issues

Topics	Detail	In Dec 25
CBAM scope	• Expansion of the product coverage to downstream goods	✓
Carbon leakage list	• Review of criteria used to identify sectors at risk of carbon leakage and updated list until 2030	✓
Emissions calculation	• Assessment of technical rules for calculating actual embedded emissions, including indirect emissions	✓
International impact	• Assessment of international impact of the CBAM, focusing on imports from developing countries	✓
Governance system	• Assessment of the governance system, and communications between Customs, the EC and MSs	✓
Exports provisions	• Set up of a WTO compatible rebate on carbon costs for EU exports of CBAM covered goods	See next slides
CBAM scope	• Timeline for the expansion of CBAM to other EU ETS sectors such as glass, paper or chemicals	
	• Expansion of CBAM to indirect emissions for covered goods	See next slides

Sources: EU CBAM Regulation, ERCST (2025), the EU CBAM in practice: the danger of resource shuffling (available here)
Note: [1] mis-labelled shipments: e.g., mis-labelling a CBAM-covered shipment as a non-CBAM good; falsified data: e.g. declaring a product is made from recycled and not primary aluminium, transhipment: falsely declaring a good was produced (or substantially transformed) in a country when it was not, to benefit from the EU CBAM credit under CBAM Article 9
Abbrev. : DA… Delegated acts; MS… Member states; EC… European Commission

An effective CBAM could improve cost competitiveness and support decarbonisation, but practical implementation issues remain

Impact on competitiveness and / or decarbonisation

- The CBAM (assuming no room for circumvention / avoidance) aims at:
  - **Decarbonisation,** levelling the playing field with international competitors for carbon costs and thus reduces the risk of carbon leakage
  - Cost **competitiveness,** as it can reduce the cost gap by, e.g., 75% / €60/t under our assumptions for paper drying between an EU and Chinese process in 2035

Timeframe of support

- The CBAM is a long-term instrument that should be in place as long as 3rd countries have not reached Net Zero emissions

Implementation and design issues, incl. potential distortions

- CBAM entails admin costs for verification and compliance for newly regulated entities, i.e. importers (e.g. checking goods, verifying compliance data, court proceedings).(1)
- Crucial design elements include scope of products covered, de minimis threshold for compliance entities, and calculation rules for embedded emissions. As a world first, the EU CBAM will inform how best to tackle these issues.

Note: (1) For resource shuffling and entity splitting see for example ERCST 2025, The EU CBAM in practice: the danger of resource shuffling, for value chain reshuffling see Compass Lexecon (2025) The EU CBAM

Indirect CO2 cost compensation (ICCC) is uneven but can provide a strong rebate on electricity costs to installations at risk of indirect carbon leakage

$$\textit{Power price reduction} = \textit{aid intensity} \times CO_2\ \textit{price} \times \textbf{\textit{emission factor}}$$

The emission factor is the main differentiator

- Aid intensity and CO_2 price are (mostly) the same for all (75%, €89/tCO_2)
- The emission factor differs across countries and methodologies

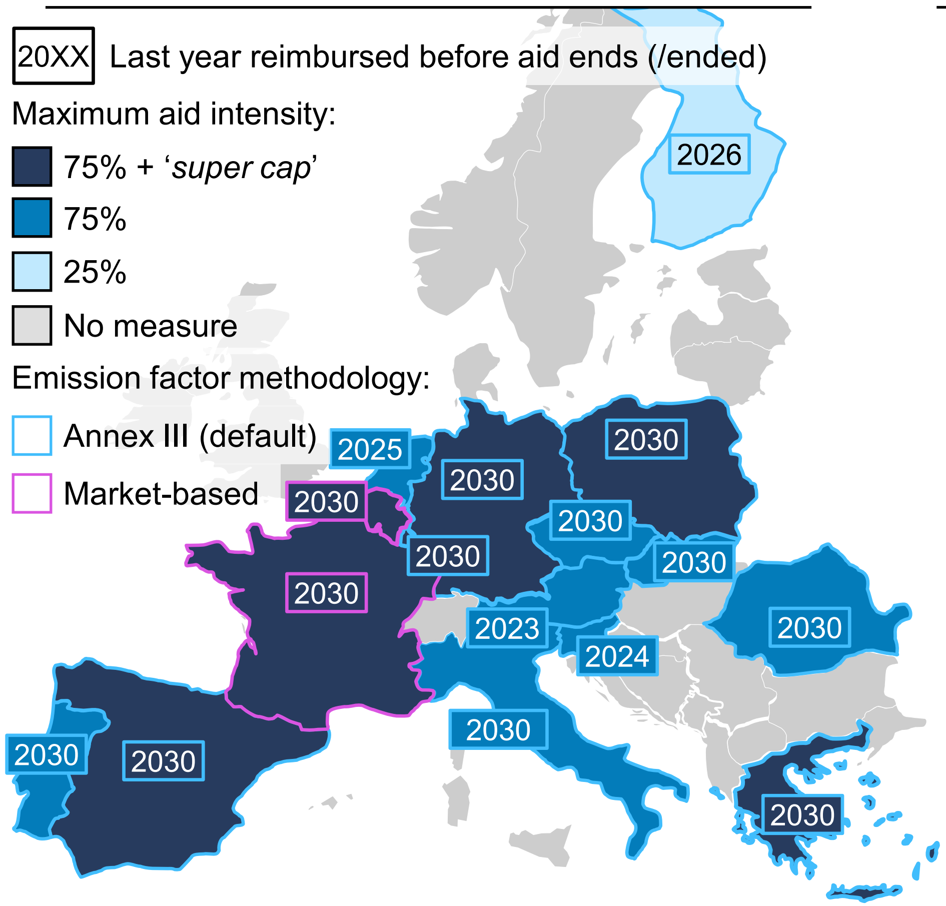
A potentially substantial rebate on power prices

- The induced power price reduction ranges from 25 to 50 €/MWh
- The *super cap* provision can boost total aid spending by, e.g., 12% (FR)

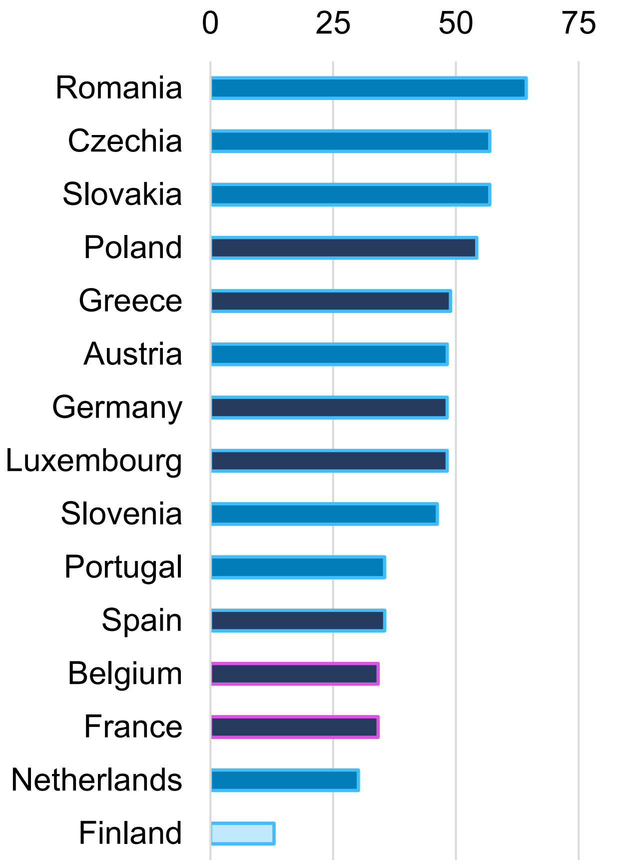
The cost of this aid can be significant

- The ICCC budgets in France & Germany[4] were 0.8 and 2.4 bn€ respectively in 2023

Map of implementing national measures[2]



Power price reduction in €/MWh assuming CO2 price = €89/tCO2



Notes: [1] see Communication (EU) 2020/C 317/04 (available online) recital 67: ""In 2025, the Commission will also assess whether additional data is available allowing to improve the methodology used to calculate the CO2 emission factors as described in Annex III, that is to say to take into account the increasingly important price-setting role of climate neutral technologies in Union electricity markets and the conclusions of the assessments notified to the Commission pursuant to point 15(11) above. Consequently, Member States may have to adapt their respective schemes in order to bring them into line with the adapted guidelines." [2] Compass Lexecon intelligence based on case data collected from the DG COMP case search website. [3] Source: Compass Lexecon intelligence (not publicly available online). [4] French Parliament report (2024, available online) & German Emissions Trading Authority DEHSt (2025, available online)

The list of eligible sectors at risk of carbon leakage could be reviewed to reflect change in context

The list of eligible sector was set before the recent changes in context and may be updated to reflect macroeconomic changes

- Eligibility for the period 2021-2030 relied on a list of sectors deemed at risk of carbon leakage, based on a composite indicator of trade and indirect emission intensity, using data from 2015-2019
- The list of eligible sectors is being revised in 2025 for the subsequent period under ETS guidelines 2021-2030
- The EC ponders an update of the calculation of trade and emission intensity likely altering the list (see below)

Shifting dynamics in the data used to list eligible sectors

+ EU plant closures / relocations to outside of the EU

+ Ageing plants, sector electrification, production shifts to higher-emission regions

Trade intensity x **Indirect emission intensity** = **Indirect carbon leakage indicator**

- Higher EU self-sufficiency, quotas / tariffs reduce imports

- Decarbonisation of the power grid, efficiency gains …

Overall effect is unclear

Example: indicators used to compute the list of sectors at risk of carbon leakage, as of 2019[1]

Three criteria must be met for a sector to be eligible to indirect cost comp.:

I. Trade intensity (TI) **≥ 20%**

II. Indirect emissions intensity (IEI) **≥ 1 kgCO2€**

III. Indirect carbon leakage indicator (= TI x IEI) **≥ 0.2 kgCO2€**

Sector	Trade intensity	Indirect emissions intensity [kg CO2 / EUR]	Indirect Carbon Leakage Indicator
24.10 Iron & steel manufacturing	0.257	1.414	0.363
24.42 Aluminium production	0.352	3.011	1.06
27.20 Manufacture of batteries and accumulators	0.615	**0.322**	**0.198**

→ Iron and steel and aluminium are eligible (all criteria are met) – this is confirmed in expense reports for instance for the French scheme[1]

→ but battery manufacturing **is not** (indirect emission intensity & indirect carbon leakage not met) despite being more trade-intensive

Sources: Compass Lexecon analysis based on EU's Carbon Leakage Regulation and more specifically [1] the EU ETS Phase 4 Preliminary Carbon Leakage List. [2] French gov. (2023), report on indirect cost compensation (available here).
Notes: The sub-sectors considered here are based on the EU's NACE 2 codes. For further details, please refer to the Technical Appendix. Trade intensity is calculated as the sum of imports and exports divided by the sum of turnover and imports; the average of each sector was weighted by the value of each sub-sector application. Emission intensity is the sum of the direct and indirect emission intensity (DEI and IEI) in kg CO_2/€, with the DEI (IEI) being the ratio between direct (indirect) emissions and the GVA entire sector's direct (indirect) emissions, the average of each sector was weighted by the value of each sub-sector application. The carbon leakage indicator is the product of the trade intensity and the emission intensity.

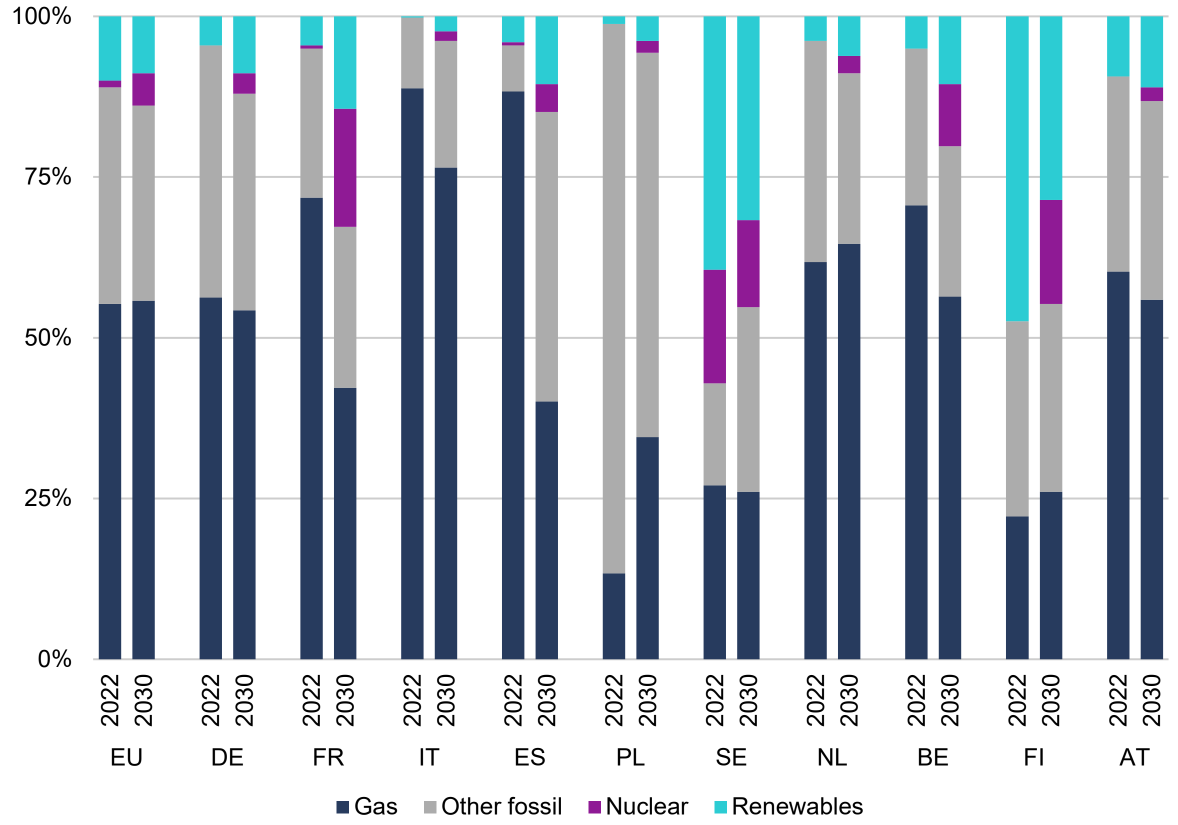
The continuation and extent of support beyond 2030 will be defined in 2027 by the EC proposal for CBAM extension

Parameters for 2025-2030 period under current guidelines are being revised that could generalise a change in methodology for the electricity emission factor, moving to market-based [1]

To prevent double carbon leakage protection beyond 2030, the EC has suggested approaches in December 2025 to scope 2 emissions pricing with a final decision expected in 2027 [2]

- Today, only cement fertilisers and agglomerated iron ore have to account for indirect (scope 2) emissions under the CBAM[2]
- By 2030, the EC could decide to extend the scope of the CBAM to indirect (scope 2) emissions, a definitive decision will be made in a possible proposal in 2027 based on the experience gained with the CBAM
- Technical solution range from immediate phase-out to gradual reduction or CBAM only covering a share of costs not compensated
- Should the EC prolong indirect cost compensation, emission factors, and thus aid amounts, would decrease in the next update for several Member States, due to the decarbonisation in their power systems (*see*. graph, gas marginality receding in FR, ES[4])

Price-setting technology in selected regions, 2022 vs 2030 (JRC[3])



[1] EC (2021) ETS guidelines post-2021 (available here), [2] EC (2025) Report on the application of the regulation on CBAM (available here) [3] Gasparella A., Koolen D., Zucker A. (2023, JRC), The merit order and price-setting dynamics in European electricity markets (available here)

***Abbreviations:** ICCC…Indirect carbon cost compensation*

Indirect CO2 cost compensation measures medium term direct support for sectors at risk of carbon leakage

Impact on competitiveness and / or decarbonisation

- Like network cost rebates and electricity tax / levy reductions, ICCC **directly impact competitiveness and indirectly impact decarbonisation** by lowering the opportunity cost of switching to electricity (vs non-electrified / fossil pathways)
- The power price reduction from this type of measure is significant: typically ranging from €20/MWh to €50/MWh

Timeframe of support

- The measure provides **quick relief** to beneficiaries, as it is provided in Year Y+1.
- This measure offers support in the **medium term with current guidelines covering 2021-2030**, **uncertainty regarding its future past 2030** (especially once the CBAM comes in) and a potential update of EU guidelines changing the maximum applicable level of support

Implementation and design issues, incl. potential distortions

- Crucial design elements include eligibility rules, currently defined based on thresholds for indirect CO2 costs intensity and trade intensity of sectors / products. Member States have flexibility in notifying sectors / products outside the list of industries at risk of indirect carbon leakage established by the EC.
- Not all MS have set up this aid, notably due to budget constraints.

3.4

Addressing the power cost competitiveness gap in the context of decarbonisation

3.4.1
Addressing the CAPEX gap

A one-off investment aid can bridge the electrification cost gap and induce change when the electrified process is OPEX competitive

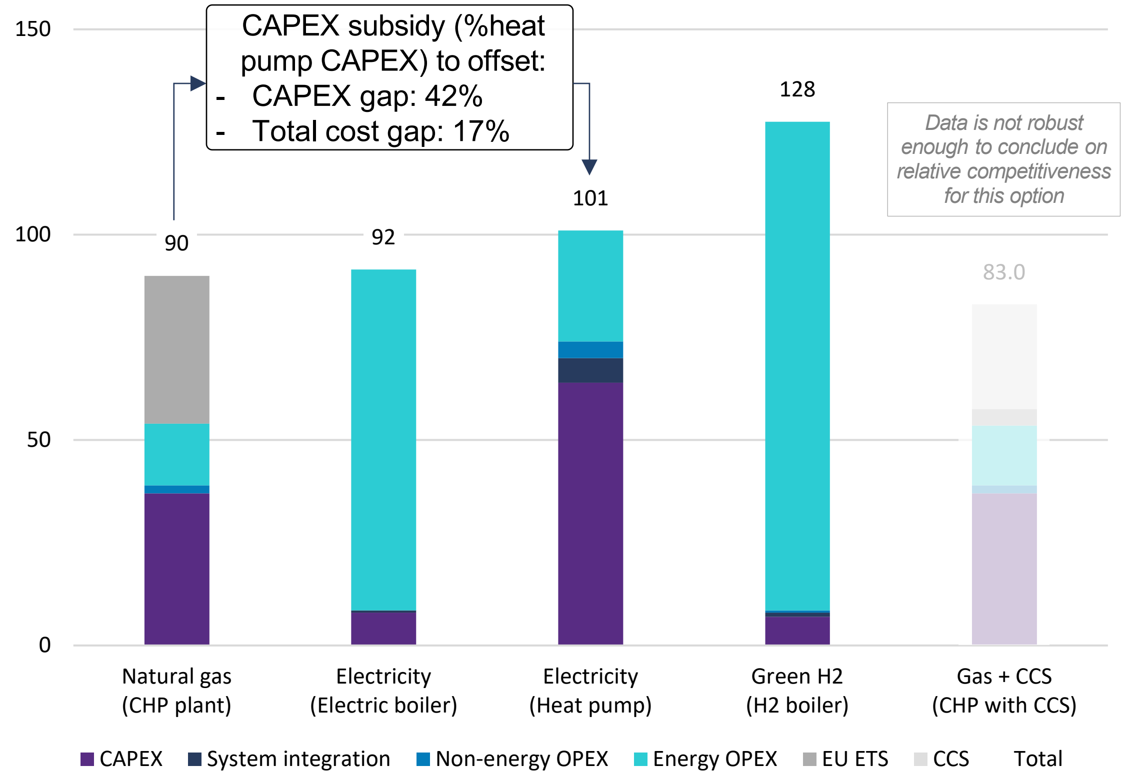
Some processes are more OPEX-efficient (below parity) when they decarbonise by 2030/35. A one-off investment grant offsetting the CAPEX gap improves time to return on investment.

- A one-off CAPEX subsidy of 42%, would offset the difference in CAPEX between a greenfield CHP plant and a greenfield heat pump installation supplying steam to a milk powder plant. This is in line with the EC's calibration of 45% for the aid intensity for investment support under CISAF section 5.
- A one-off CAPEX subsidy of 17% equates the total production costs between the CHP and heat pump installations. Thus, providing similar time to return on investment.

Although, CAPEX grants are available both at EU level and in some countries, deployment is relatively slow, which could be due to:

- Infrastructure hurdles, such as grid connection delays;
- Financing constraints;
- A larger gap to cover due to most installations switching being brownfield, i.e. where the CAPEX gap to offset would be larger;
- Unavailability of State aid mechanisms in some Member States and limited EU funding availabilities.

Illustrative total costs for steam supply for milk powder production across a range of technologies – 2035 (€/tonne)

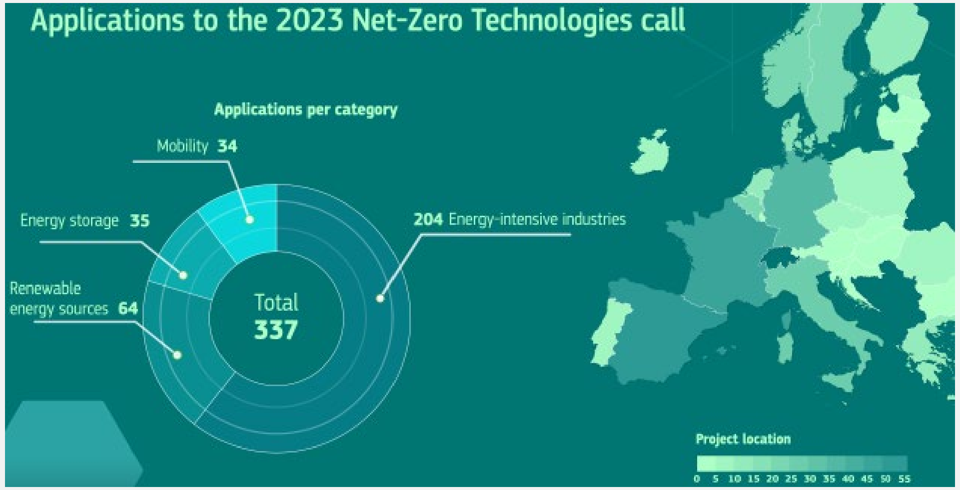


Sources: [1] Compass Lexecon (2024) Reviving Europe's Industrial Power: how to boost competitiveness through energy (available here). [2] European Commission (2025), CISAF Staff Working Document (available here)
Note: CAPEX subsidy need computed as a percentage of the heat pump's CAPEX, for (1) the CAPEX gap between CHP without CCS and heat pump, and (2) the total cost gap between CHP without CCS and heat pump
Abbreviations: CHP … Combined Heat and Power; CCS … Carbon Capture and Storage; CAPEX … Capital Expenditure; H2 … hydrogen; EU ETS … EU Emissions Trading System

Availability of funding limits the amounts of industrial decarbonisation projects supported at EU level, with frequent oversubscription

The Innovation Fund 2023 call for proposal has received 337 applications from all EU countries, with regional disparities.

- Most of the applications come from Western and Central Europe, with Spain, France and Germany representing the majority of the applications.



The Innovation Fund is an example of a funding gap, but the same issue also appears with ***other EU instruments*** *(CEF-E, InvestEU, etc.).*

The total funding requested vastly exceeds the available budget.

- The funding call was 5 times oversubscribed, with applications worth more than 20 bn€ having to be turned down.

Total funding requested **Available budget**

The timeline raises questions.

- The call was launched in November 2023, with a deadline in April 2024.
- 85 projects were selected in 18 countries to receive grants of €4.8 billion in Oct. 2024 and funding will be made available in Q1 2025.
- Given the recent increase in decarbonisation objectives and the pressure on EU competitiveness, the timeline could have been shortened to less than one year between the call and the availability of the funds.

Source: Compass Lexecon analysis based on EC's article on Innovation Fund: Overwhelming response to the 2023 net-zero technologies call (2024); BusinessEurope's study on Energy and climate transition: How to strengthen the EU's competitiveness (2024).

Projects spanning several Member States can access funding by requesting IPCEI status

IPCEIs have become an increasingly central instrument of an innovation-centred EU industrial policy during the last decade.[1]

- The EC can grant the status of Important Project of Common European Interest (IPCEI) to strategic large-scale cross-border projects
- A project labelled as IPCEI can receive national financial support in amounts and intensities that exceed the typical State aid limits
- Member States pre-select candidate projects for the EC to review and approve as IPCEI in EU-wide "waves" of projects sharing a pre-defined technological scope and timeline

However, the IPCEI remain too narrow in scope to be the EU's decarbonised industry State aid vessel today

- The scheme aims at large cross-border (involving ≥ 4 MS[3]) projects, which rules out much of the EU's smaller or more decentralised industrial sectors, like paper & pulp or low-temperature chemicals
- Battery and hydrogen are the only sectors that have seen IPCEI waves, resulting in the selection of 68 and 122 IPCEI adding up to €6.1bn and €18.9bn of public funding respectively
- More clean tech sectors could see IPCEI waves in the future:
  - Planned[1]: nuclear technology, circular advanced materials
  - In discussion[2]: critical raw materials, clean autonomous vehicles
  - Halted[1]: low-emission industry

Overview of approved green industrial policy IPCEI until end 2024[1]

IPCEI scope and wave	# of participants		# of projects	Funding (€bn)		Project period
	EU MS	Industry		Public	Private	
Battery 1	7	17	22	3.2	5	2019-2031
Battery 2	12	42	46	2.9	9	2021-2028
Total battery	12 distinct MS		68	6.1	14	
Hydrogen 1	15	35	41	5.4	8.8	2021-2030
Hydrogen 2	13 + 1 (NO)	29	35	5.2	7	2021-2036
Hydrogen 3	7	32	33	6.9	5.4	2023-2029
Hydrogen 4	7	11	13	1.4	3.3	2022-2031
Total hydrogen	16 distinct MS + NO		122	18.9	24.5	

Sources: [1] Jacques Delors Institute (2025), A European state aid framework for the Clean Industrial Deal (available here); [2] Joint Forum on IPCEI (available here); [3] IPCEI communication (press release, main text)
Abbreviations: MS … Member State, IPCEI … Important Project of Common European Interest

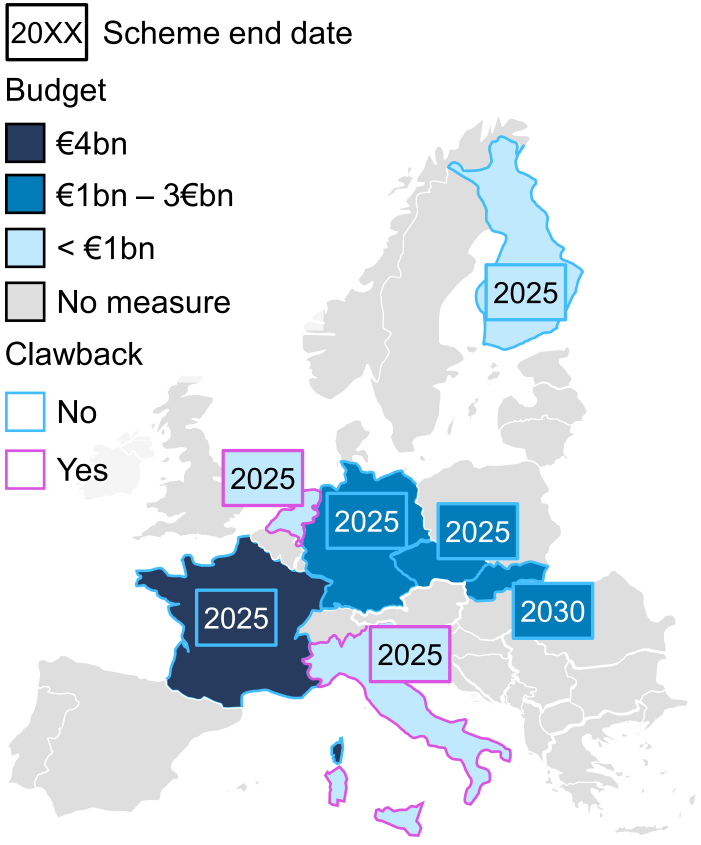
State aid for industrial decarbonisation supporting CAPEX is available in a handful of Member States

Due to its accelerated procedures, many CAPEX aid for industry decarbonisation were set up under the TCTF (expiring end 2025). A new wave of initiatives under CEEAG / CISAF, active until at least 2030, is likely.

Recent State aid developments have focused on hydrogen, a key decarbonisation lever in some hard-to-abate sectors – but not for most of the industry, which will likely opt for direct electrification

- Hydrogen public support measures add up to billions of euros, often spent in large centralised projects. Key support vessels include[1]:
  - At the EU-level: CEF / PCI, Innovation Fund / H2 Bank
  - At the national level: State aid expenditure under the IPCEI, H2 Bank (using the EU auction as a service), CEEAG[2], TCTF[3], and the CISAF[4] which extends support to low-carbon hydrogen
- The EU support and State aid framework theoretically allows for the implementation of State aid directed at electrification of industrial processes – implementation may be needed given the levels of investments required

Map of implementing national measures



Country	Support type	Legal basis	End date	Budget €bn (%GDP 2024)
Czechia[5]	CAPEX grant	TCTF	31 Dec 2025	2.4 (0.75%)
Finland[6]	CAPEX grant	TCTF	31 Dec 2025	0.2 (0.07%)
France[7]	CAPEX grant	TCTF	31 Dec 2025	4 (0.14%)
Germany[8]	CAPEX grant	TCTF	31 Dec 2025	2.2 (0.05%)
Italy[9]	CAPEX grant + clawback	TCTF	31 Dec 2025	0.4 (0.02%)
Netherlands [10]	CAPEX + clawback (60%)	TCTF	31 Dec 2025	0.75 (0.07%)
Slovakia[11]	CAPEX grant	CEEAG	31 Dec 2030	1.1 (0.84%)

Sources: Compass Lexecon analysis largely based on FSR (2025) Unlocking industry electrification: an overview of EU policies and regulatory frameworks (available here). [1] European Hydrogen Observatory (2025), Financial tools and incentives (available here), [2] EC (2022), CEEAG, section 4.1 (available here), [3] EC (2023), TCTF, sections 2.5 and 2.6 (available here), [4] EC (2025), CISAF, sections 4.1, 4.2, 5 – NB. Until the CISAF, State aid for hydrogen was almost entirely for renewable hydrogen (available here), [5] SA.109055 (available here), [6] SA.113721 (available here), [7] SA.108810 (available here), [8] SA.108729 (available here), [9] SA.109439 (available here), [10] SA.112112 (available here), [11] SA.102385 (available here)

3.4.2

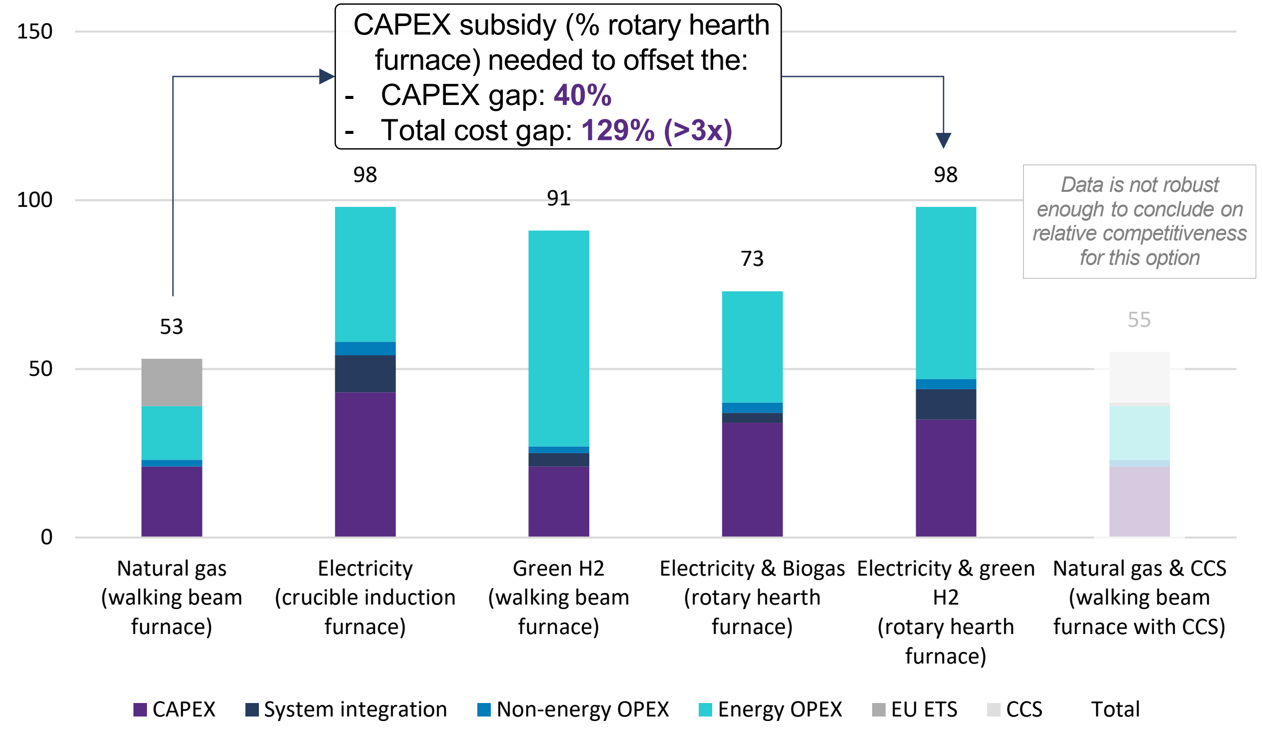
Addressing OPEX competitiveness issues

Some applications require both CAPEX and OPEX aid to offset costs compared to fossil-based processes

Some processes are less OPEX-efficient when they decarbonise by 2030/35. A one-off grant offsetting the CAPEX gap would in this case not be enough to make the decarbonised process the better investment.

- For instance, for post-heated flat long steel, a one-off CAPEX subsidy would not be enough to bridge a third of the total production cost gap between a conventional gas-fed furnace and an electricity and hydrogen-fed rotary hearth furnace;
- Therefore, both CAPEX and OPEX aid may be needed to ensure a competitive decarbonisation of primary steel manufacturing.

Total costs for post-heated flat long steel production across a range of technologies – 2035 (€/tonne)



Sources: [1] Compass Lexecon (2024) Reviving Europe's Industrial Power: how to boost competitiveness through energy (available here). [2] European Commission (2025), CISAF Staff Working Document (available here)
Note: CAPEX subsidy need computed as a percentage of the heat pump's CAPEX, for (1) the CAPEX gap between CHP without CCS and heat pump, and (2) the total cost gap between CHP without CCS and heat pump
Abbreviations: CHP … Combined Heat and Power; CCS … Carbon Capture and Storage; CAPEX … Capital Expenditure; H2 … hydrogen; EU ETS … EU Emissions Trading System

Efficient and market-compatible OPEX support requires the development of new tools such as CCfDs for decarbonisation

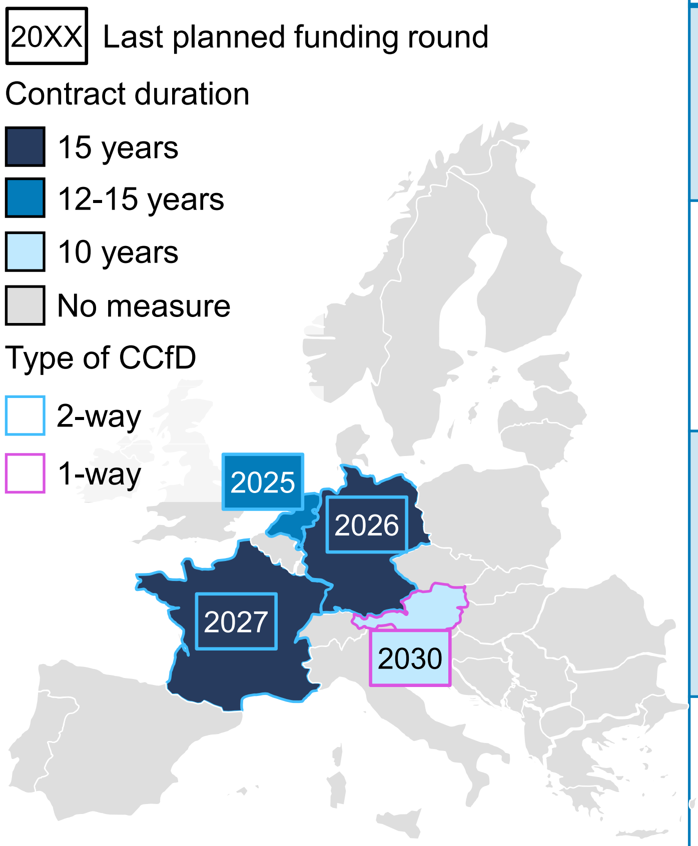
Combined CAPEX and OPEX support is economically sensible when less distortive measures are insufficient

- Structural measures aimed at valuing flexibility or lowering electricity prices should be implemented EU-wide but may not be sufficient to make decarbonised industries viable and competitive with third countries
- In such cases, long-term CAPEX and OPEX aid in the form of 2-way CCfDs granted under competitive tenders and adjustable with market conditions are an economically efficient solution

Yet, CCfDs remain an experiment

- Only 4 MS have implemented them, albeit with significant budgets and contract durations of 10-15 years
- Their heavy budget strain could be a barrier to EU-wide implementation
- They are also planned in rounds, i.e. their future remains uncertain
- Eligibility criteria are disparate, from fully open (NL) to targeted (FR, AT)

Map of implementing national measures



Country	Budget	Clawback	Timing	Eligibility criteria
AT[1]	Until 2030: €2.7bn	No (subsidy is only reduced)[a]	• End: 2030 • Contract duration: 10y	• Emission-intensive sectors excl. O&G[a] • Tech-neutral, open to all GHG reduction techs
DE[2]	By round[b]: 2024: €4bn 2026: €6bn	Yes (2-way CCfD)	• End: 2026 • Contract duration: 15y	• EU ETS sectors • Fuel switch or electrification • GHG emissions cut by >60% in 3y and >90% in 15y
FR[3]	Until 2027: €3bn	Yes (2-way CCfD)[c]	• End: 2027 • Contract duration: 15y	• Energy-intensive • Site > 100ktCO2/y • H2 not eligible, electrification OK • GHG emissions cut by >40% vs baseline
NL[4]	Until 2025: €30bn[d]	Yes (2-way CCfD)	• End: 2025 • Contract duration: 12 to 15y	• Open to all sectors • Techno-neutral (bids ranked by cost-effectiveness of GHG reduction)

Sources: Compass Lexecon intelligence, FSR (2025), Unlocking industry electrification: an overview of EU policies and regulatory frameworks, [1] SA.109730 (available online), and UFG Annex (available online), [2] SA.104880 (available online) and SA.116065 (will be available online here), [3] SA.112361 (available online), [4] SA.104448 (available online)

Notes: [a] No clawback, but aid amount decreases automatically if the EU ETS price rises; eligible sectors include the manufacturing of iron & steel, glass, chemicals, paper, wood and food products but exclude oil, natural gas, refinery and energy sectors as well as construction, machine and vehicle construction sectors. [b] 1st round budget was €4bn but only €2.8bn were awarded, [c] CO_2 reference price is pre-defined, [d] €30bn budget is shared between RES support & industrial electrification / fuel switch

Illustration – the first round of Germany's CCfD scheme provided a large-scale experiment informing the design of the next wave of similar schemes

The scheme incentivises industrials to decarbonise their processes by providing medium-term OPEX relief, based on the decarbonisation cost gap

The first auction round provided a large-scale experiment, which showed room for improvement:

- NCI (2025): "does not fully account for the inherent risks and inefficiencies [of] H2 production and use"
- Blömer, 2025:
  - The scheme is complex by design, making participation and evaluation cumbersome
  - The 1st round was undersubscribed and only awarded €2.8bn of the budgeted €4bn, suggesting entry barriers or limited readiness
  - The €1bn cap per project likely excluded large-scale projects in steel (H2 DRI) or chemicals

As a result, the government will continue the programme with a 2nd round, but will review it[2]:

- Goal: to ensure it is "unbureaucratic, technology-neutral, efficient, and effective"
- This includes making CCU/S eligible in the 2nd round

Lessons learned from the case of Carbon Contracts for Difference in Germany

Impact on comp. and/or decarbonisation

- Covers the **difference between operational energy and carbon costs** between decarbonised project and reference project.
- **No explicit power flexibility** provision but projects remain exposed to short-term market signals

Timeframe of support

- CCfD kicks in at project commissioning / Final investment decision providing **immediate aid** to innovative projects
- **15-year contracts**, covering half of most heavy industries investments cycles of 20-25 years

Implementation, design, and distortions

- **Competitive bidding** and **windfall profit clawback** ensures efficient allocation of public funding. Annual dynamic pricing limits risk of lock-in.
- Internal trade distortions or excess spending limited by design as the annual **dynamic components** of the CCfD formula expose beneficiaries to some market fluctuations[1]

Sources not linked in-text: [1] DG COMP Letter on the State aid case SA 104880 (available online). As of early September 2025, the price of CO_2 on the EU ETS (spot EU ETS futures) is €77.1/tCO_2., [2] German Parliament (2025), Climate protection report 2025 (available here).

Doubling down on the Innovation Fund, the EU aims to deploy €100bn under the Industrial Decarbonisation Bank, after a pilot auction in Dec 2025

The Clean Industrial Deal announced a package of measures for industrial decarbonisation, including the CISAF, but also an Industrial Decarbonisation Bank (IDB) with a pledged €100bn in public funding

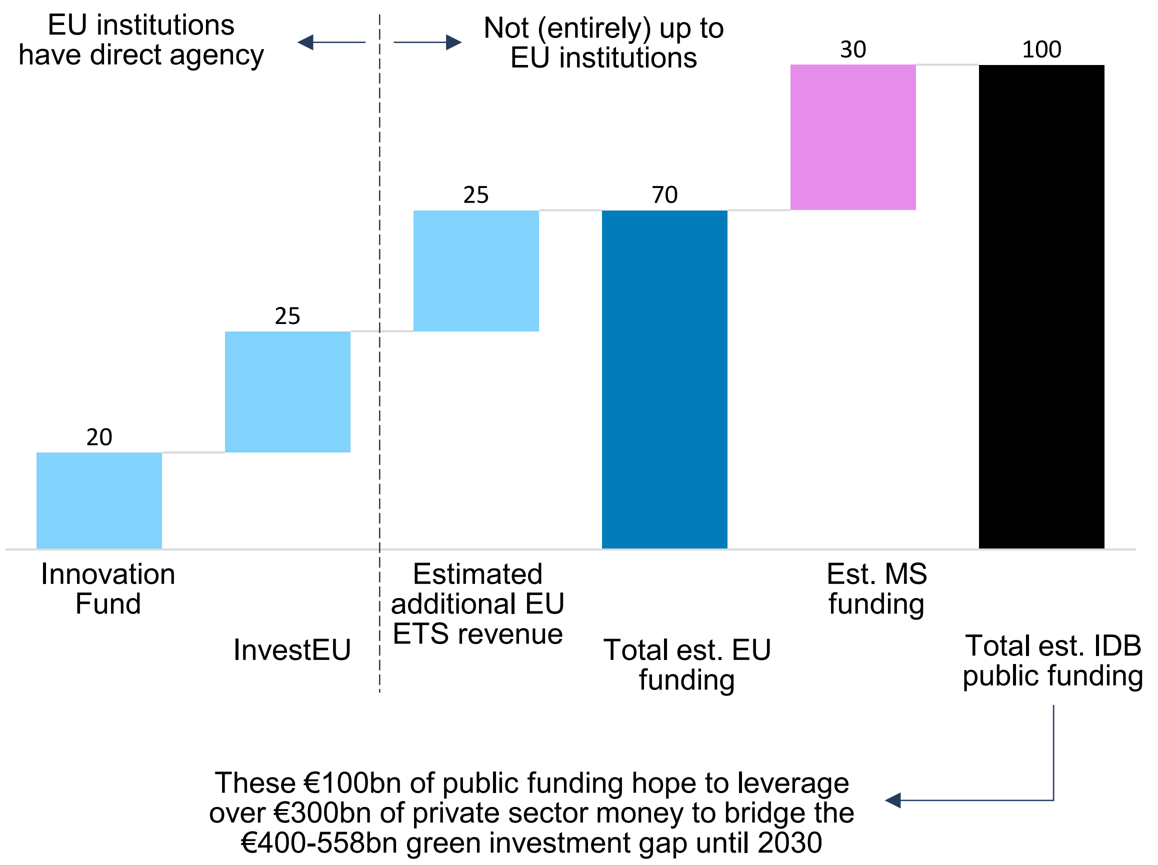
- This includes an estimated €30bn in Member State funding made possible by the "auction-as-a-service" design feature of the IDB

A first €1-billion industrial heat decarbonisation auction conducted in December 2025 aims to explore the terms and conditions for the future, more comprehensive and large-scale IDB[1]

- This pilot will provide Carbon Contracts for Difference (CCfDs) in 3 pay-as-bid competitive auctions run in December 2025: a first €150m auction for medium heat (100°-400°C) size (3-5MW), €350 for medium heat and large size (> 5MW), and €500m for projects above 400°C and 5 MW
- Its scope is wide (e.g., heat pumps, boilers are in scope) but leaves out key applications in aluminium (electrolysis) & steel (electric arc furnaces)
- The scheme incentivises flexibility: aid is limited to 6132h/year (70% full load hours restriction), unless the recipient shows flexible ramping (lifted to 80%) or investments into thermal/battery storage (lifted fully / 100%)

Participation results in this pre-IDB pilot, both from projects and from Member States via the auction-as-a-service feature, will calibrate some of the expectations regarding the future role of the IDB

Estimated public funding by source for the IDB, $€_{2024}$bn[2,3]



Sources: Compass Lexecon analysis based on various sources, including: [1] T&C for the Industrial Heat auction, [2] Carbon Gap briefing and Politico news article on the EU Industrial Decarbonisation Bank, [3] ECB publication on green investment needs in the EU

3.5

Structural measures to foster a least-cost electricity system

Fast-tracking the deployment of interconnections, flexibility and clean technologies is key for decarbonisation and competitive electricity prices

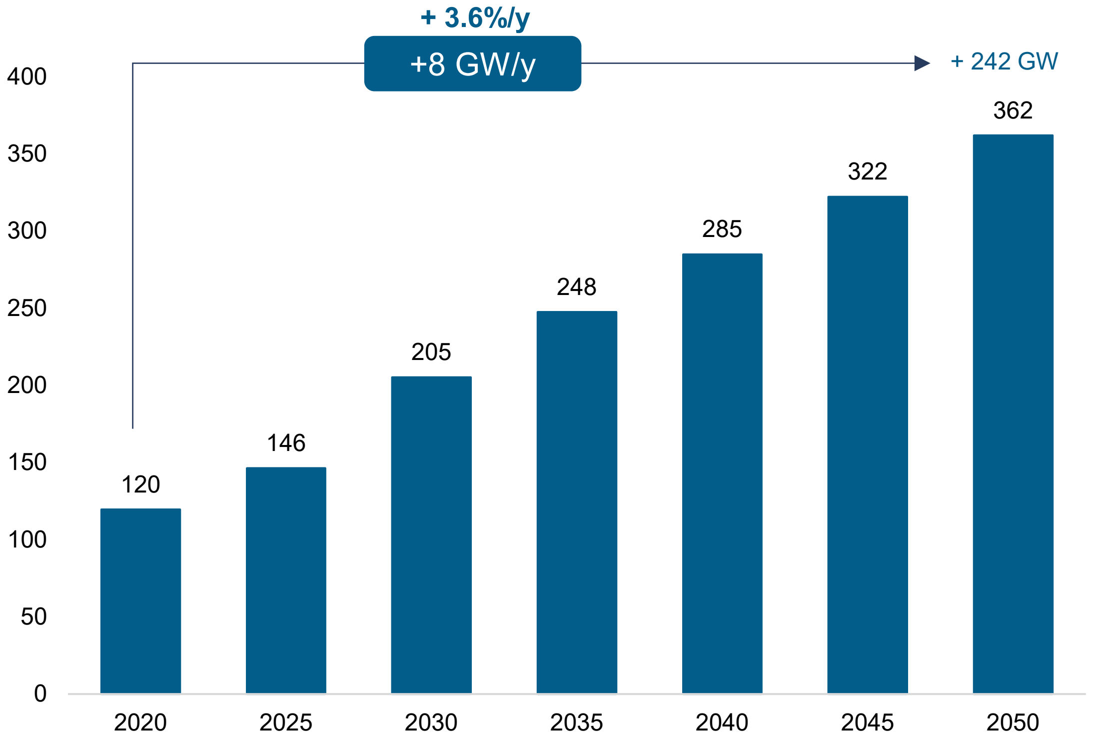
Significant investments in grid infrastructure capacity are required to integrate renewables and achieve Net-Zero targets

- The EC flagged the development of interconnections as a priority investment in its EU-wide push to foster the growth of renewables
- Offshore wind development will be key for North and Baltic Sea countries to meet EU climate and energy objectives. Coordinating this deployment through multi-purpose interconnectors and a growingly meshed offshore grid will mitigate costs while maximising benefits.

Policies supporting timely investment and faster permitting are key to unlocking wholesale power price reductions

- A supportive policy framework would be needed to ensure efficient planning and costs and benefits allocation, and, ultimately, to unlock wholesale power price reductions[1]
- Key measures may include, among others:
  - Reforming regulatory frameworks for TSOs to integrate remuneration for anticipatory (and high-impact) investments
  - Channelling EU (CEF-Energy), MS, TSO, and private funding into the Projects of Common Interest (PCI) identified as key under the Trans-European Networks for Energy (TEN-E)
  - Lifting permitting issues at all levels of electricity supply
  - Defining offshore grids regulatory frameworks, which includes finding crucial political alignments on cost sharing and financing
  - Addressing power equipment supply chain bottlenecks

Interconnection capacity in Europe, 2020-2050 [GW] [1]



Source: Compass Lexecon (2024) for Business Europe (shown here is the Managed Transition scenario): *Energy and climate transition: How to strengthen the EU's competitiveness* (available online)
Note: Interconnections (IC) can have different capacity depending on the direction of travel due to the properties of current. Here, the IC capacity is equal to the average of the capacity in both direction for all lines and summed up. Scope: EU27 + AL, BA, CH, GB, SEM, ME, MK, NO, RS

RES-E development can be optimised through cross-country collaboration targeting least cost areas combined with transmission capacity expansion

Renewable energy sources (RES), in particular wind and solar, will be necessary to decarbonise the European power system and diversify the electricity mix

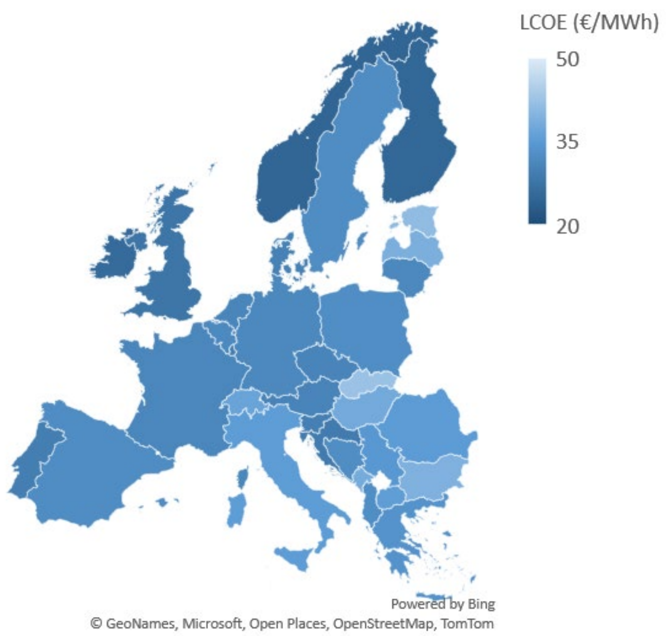
- Even in a scenario with significant roadblocks, RES capacity increases by over 1400 GW across Europe by 2050
- In 2022, the EC estimated a need to invest €86bn/y in PV and wind through 2030[1]
- However, the energy yield and economics of RES are strongly geography-dependent

Thus, a coordinated and targeted deployment of RES will be key to deliver the required clean electricity at least costs

Key enabling measures will include:

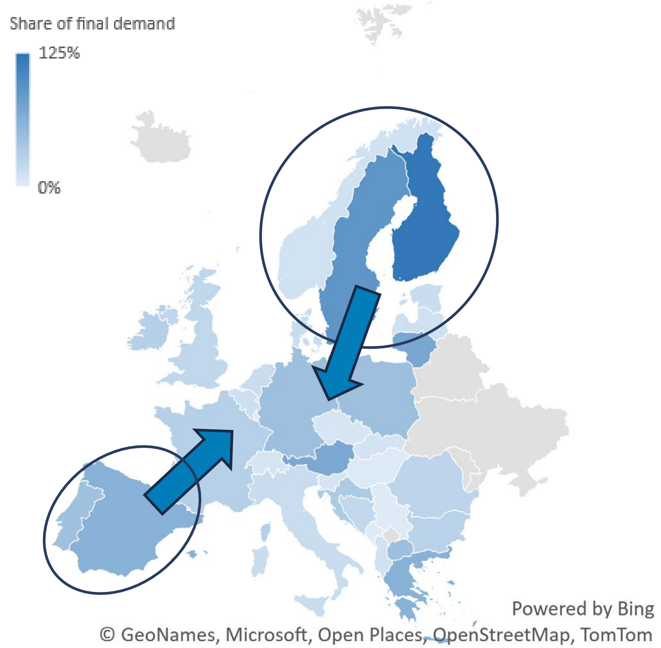
- Cross-border planning and collaboration initiatives, particularly for the high-yield offshore wind zones of the North Sea and Iberian peninsula
- Capacity expansion plans in high-priority areas

Levelised cost of electricity (LCOE) from onshore wind in Europe (€/MWh)



Onshore wind potential is particularly important in the North of Europe, where wind is abundant

Onshore wind capacity in Europe (expressed as share of final demand in %)



Onshore wind development is projected to be stronger e.g. in Iberia and in the Nordics, given the stronger potential for exports to central Europe and cross-country collaboration mechanisms

Sources: Compass Lexecon (2024) for Business Europe (shown here is the Managed Transition scenario): *Energy and climate transition: How to strengthen the EU's competitiveness* (available online). [1] REPowerEU (SWD, available here).
Abbreviations: EC … European Commission; LCOE … Levelized Cost of Electricity; RES … Renewable Energy Source
Note: Interconnections (IC) can have different capacity depending on the direction of travel due to the properties of current. Here, the IC capacity is equal to the average of the capacity in both direction for all lines and summed up. Scope: EU27 + AL, BA, CH, GB, SEM, ME, MK, NO, RS. LCOE constitutes the total cost over the lifetime of a generation asset per unit of generation.

A comprehensive framework is required to harness the potential of flexibility to reduce power supply costs and unlock additional revenue

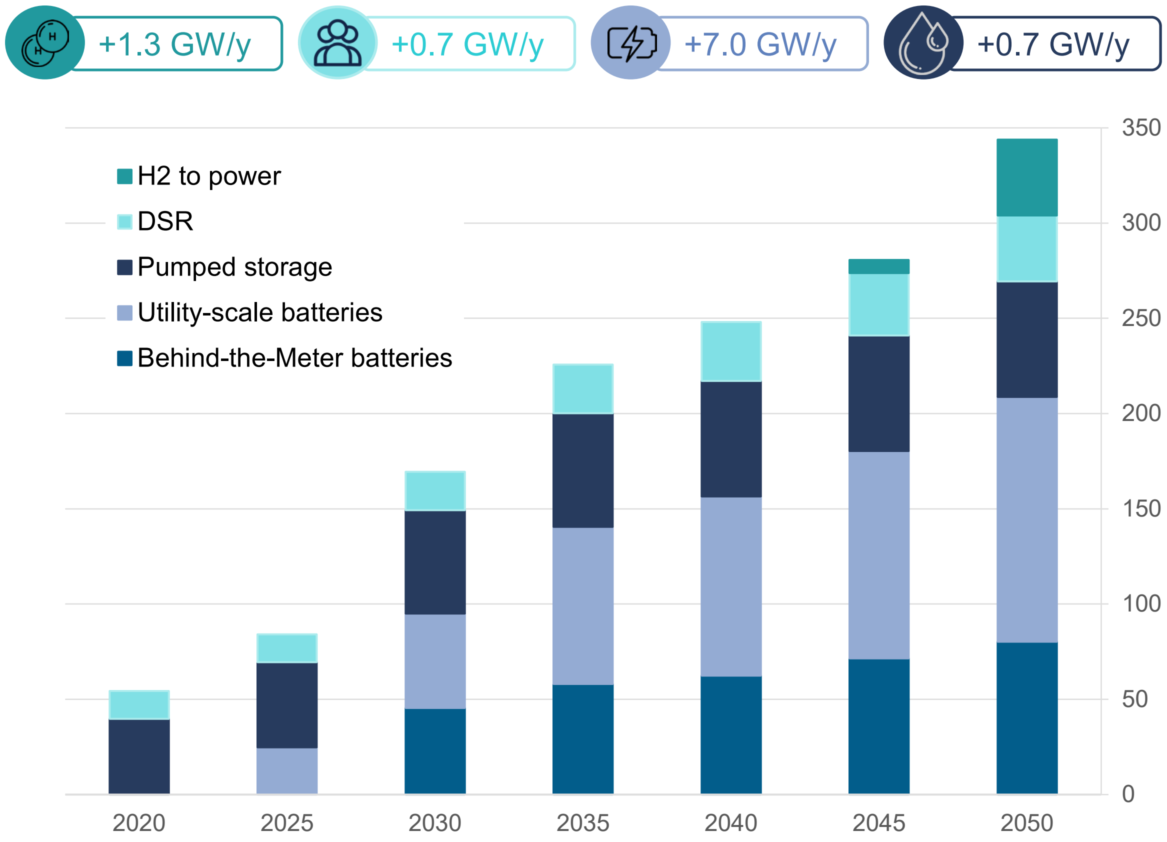
Flexibility must diversify and grow manyfold across Europe to unlock predictable and affordable electricity prices

- A diverse mix of flexible capacities will be required by 2050, incl.:
  - An expansion of the current stock of demand-side response (DSR) and pumped hydro storage capacities,
  - Over 200 GW of new utility-scale and behind-the-meter batteries
  - New hydrogen-to-power capacity, when technologically and economically viable

A comprehensive market design and contracting framework is needed for flexible capacity to rise to the challenge

- At stake are cost reductions in the form of more predictable and stable electricity supply throughout the grid, and additional revenue for industries that can harness their flexibility potential
- Key measures include:
  - Implementing the EU Electricity Market Design framework's provision for demand response participation in markets
  - Reflecting system needs and the implicit value of flexibility in market products
  - Establishing long-term de-risking frameworks for all flexible assets

Flexibility capacity in Europe, 2020-2050 - MT [GW]



Source: Compass Lexecon (2024) for Business Europe (shown here is the Managed Transition scenario): *Energy and climate transition: How to strengthen the EU's competitiveness* (available online)
Abbreviations: DSR … Demand Side Response
Note: xxx

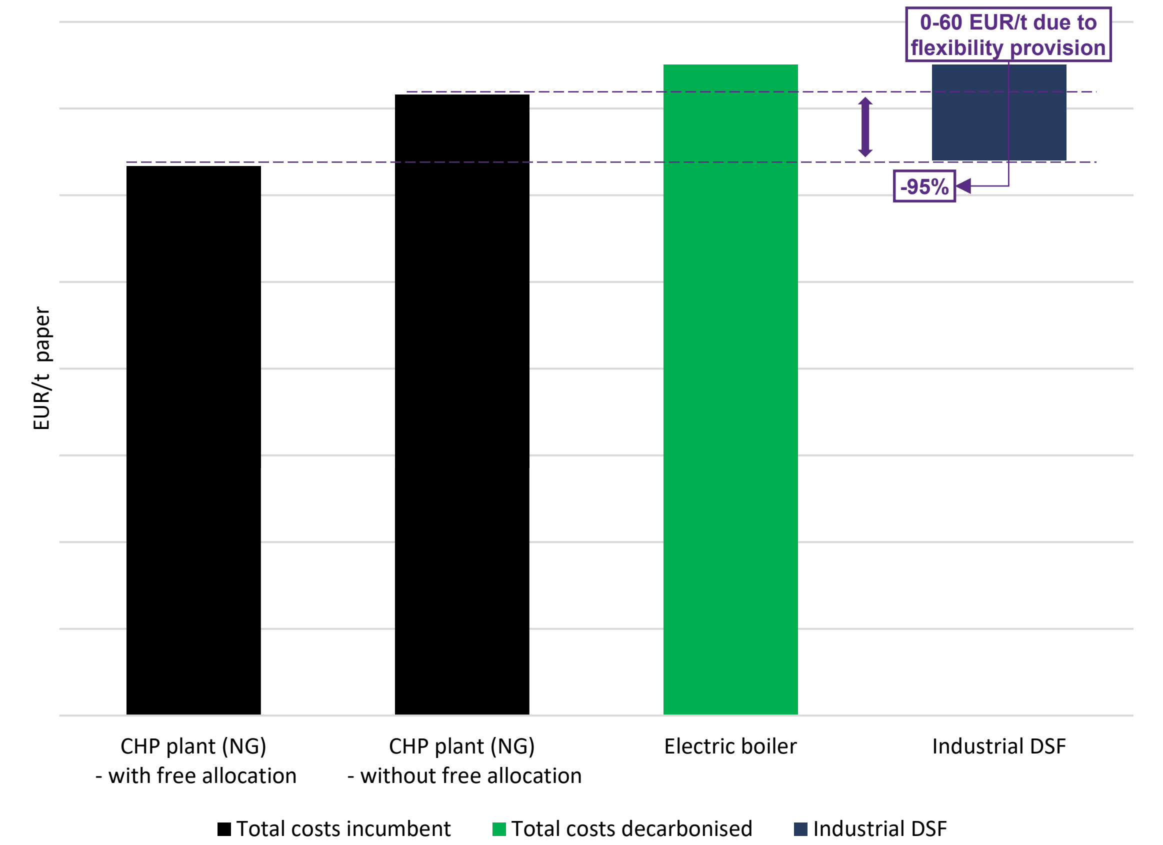
In some cases, flexibility provision from storage in energy intensive industries can bridge up to 95% of the decarbonisation cost gap

Flexibility provision can help bridge the competitiveness gap between fossil-based and electrified processes.

- The 4 types of industrial flexibility identified in section 1 are diversely available to processes and applications.
- In some cases (*paper drying with steam accumulator, see right graph*), revenues significantly bridge the difference in total costs between fossil and decarbonised processes.
- Additionally, we show in section 1, that:
  - Processes where material storage is inherent to the process or thermal storage is well adapted can harness the value of providing grid services without much impact on production (e.g. cement, paper)
  - Some Processes running in batches and continuous processes can be interrupted or operate at reduced load but incur high opportunity costs (e.g. steel, aluminium, glass)
  - Processes running on hybrid systems can switch fuel source to some extent but technical constraints may limit flexibility potential (e.g. container glass)

In all sectors, flexibility could be provided by battery energy systems when revenues offset investment and operating costs.

Impact of flexibility provision on production costs: Hybrid steam generation for paper drying with steam accumulator - EU in 2030, $€_{2024}/t_{paper}$



Sources: Based on CL for smarten (2025) The business case for flexibility provision in energy-intensive industries
Notes: The CAPEX costs of the decarbonised production route via an e-boiler and steam accumulator we assume additional oversizing requirements of 20% for the e-boiler and accumulator size of 6000 m³ . We show an exemplary EU installation and potential range of revenues depending on the country.
Abbreviations: CRM…Capacity Remuneration Mechanism, FCR…Frequency Containment Reserve; aFRR…automated Frequency Restoration Reserve; mFRR…manual Frequency Restoration Reserve, OCGT… Open-cycle gas turbine, EUA..:European Union [Emissions Trading System] Allowance

Industrial flexibility could be valued using the range of opportunities provided by power markets available in the EU

Explicit market participation of demand-side flexibility is possible in two ways:

Standalone unit
Consumption site participates on its own, either directly, through its electricity supplier or through a third-party flexibility service provider

Aggregation
Consumption site is managed by an aggregator as part of a diversified portfolio of electricity-producing and electricity-consuming assets

In most Member States, the range of existing power markets can provide the basis for flexibility valuation, provided the market design allows distributed resources to participate **(see next slide).**

Current valuation opportunities European markets for Industrials flexibility

Market / Mechanism	Industrial DSF	Remuneration	Market readiness	EU-wide adoption
Wholesale markets (Day-Ahead, Intraday)	Implicit/Explicit	Energy payments and arbitrage earnings	High	Low
Ancillary services (FCR, aFRR, mFRR)	Explicit	Capacity and energy payments	High	High
Other System Services (CRM, interruptibility schemes)	Explicit	Capacity payments	High	Medium
Congestion management (market or ad-hoc redispatching / local DSO flexibility markets)	Explicit	Capacity and/ or energy payments	High / Emerging (local DSO flexibility)	Medium / low (local DSO flexibility)
Cost-reflective network tariffs	Implicit	Rebates on network use tariffs	Emerging	-

Note: Implicit demand flexibility = change in baseline load patterns, due to exposure to dynamic retail price signals, in order to minimise bills; Explicit demand flexibility = change in baseline load patterns, following the acceptance of a bid to sell demand reduction or increase in an organised electricity market or following the orders of network operators under bilateral agreements
Abbreviations: CRM…Capacity Remuneration Mechanism, FCR…Frequency Containment Reserve; aFRR…automated Frequency Restoration Reserve; mFRR…manual Frequency Restoration Reserve; DSO…Distribution System Operator

A sound framework and market design is required so that flexibility capabilities can improve industry's business case

To date, industrial demand flexibility can be valued either implicitly or explicitly, with uneven development of the regulatory framework across Europe

- Northern and western European countries are the most advanced in allowing participation of demand-side flexibility in all markets. Several Member States do not allow / have no mechanisms in place for demand-side flexibility participation in wholesale markets.
- Ancillary services are the most open and often most profitable valuation opportunities.
- Capacity remuneration mechanisms / flexibility contracting mechanisms are not available in all Member States.
- New valuation avenues in relation to network services are emerging on top of existing congestion management schemes.

Going further requires that the approach below is in place across the EU

	Address barriers to the participation of flexible resources in the different markets	Ensure that the market design adequately reflects the full value of flexibility for the power system	A contracting / de-risking regulatory framework to support timely investment in flexible resources

Potential solutions	➢ **Ensure level playing field for participation of all flexible resources to all market segments**, either directly or through aggregation
	➢ **Allow third party access** for distributed and behind-the-metre resources
	➢ **Review eligibility and technical participation rules** so that they do not create barriers for small, distributed and/or energy storage assets
		➢ Fill the gaps: **Ensure markets and products** reflect the **full range of system needs** (black start, fast frequency response, etc)
		➢ Enhance **price signals granularity** to reflect value of flexible assets
		➢ Enable **revenue stacking** for flexible resources across markets
		➢ Foster efficient **spatial distribution:** flexible resources can be deployed at nodes of the network that need them most
			➢ A range of **potential market failures may prevent timely investment**, including uncertainty about flexibility needs and/or revenues, missing money
			➢ Different **contractual and regulatory approaches are possible to reduce risks and provide visibility** to investors:
			  ➢ **Assessment of long-term flexibility needs**
			  ➢ **Flexibility contracting scheme:** either standalone or co-optimised with capacity remuneration mechanisms, backed up by long-term contracts

Source: Compass Lexecon 2025,

Illustration – French TSO bridges missing money for flexible industrial assets using long-term capacity contracts

France implemented a complementary mechanism to remunerate specific flexibility technologies interlinked with the CRM

- Stated goals: reach national target of 12.5 GW of daily flexibility by 2030
- Budget: 1.3bn€ over 2024-2032
- Eligibility: Low-carbon flexible capacities not yet developed (additionality)

Mechanism is a State aid that was submitted under CEEAG para 4.8 with the following characteristics

- Annual competitive tenders open to flexible capacities separated between <1MW and >1MW;
- CfDs calculated against the revenue that can be perceived in the capacity market;
- 1 or multi-year contracts of up to 10 years;
- Price cap.

Lessons learned from the case of CAPN in France

Impact on comp. and /or decarb.	Covers **missing money** of flexible assets, whether industrial DSR or on-site batteries **Improves business case** for storage and flexibility provision lowering power costs
Timeframe of support	**Immediate** effect for selected capacities From 1 to 10-year contracts
Implementation, design, and distortions	**Competitive tenders** for lowest CfD premium CfD design limits windfall profits for asset owners Price cap at 65k€/MW/year Tender closes when selected capacity reaches demand for the tender or budget for the tender

Source: European Commission (2023), SA.107352 (2023/N) – France : mesure de soutien aux flexibilités décarbonées de court terme en France par appels d'offres, ; RTE (2024), Cahier des charges de l'appel d'offres portant sur le développement de capacités de flexibilités décarbonées pour l'année 2025 et le S1 2026

3.6

Extending the competitiveness analysis to non-energy issues

Measures to support the competitiveness of the European industry should take a wholistic perspective and not focus solely on energy cost issues

Comparatively higher energy costs are only a part of the problem; non-energy issues can be significant

- Our survey of the barriers to fuel switching[1] points to energy costs, but also missing infrastructure, inadequate or uncertain regulatory frameworks, supply chain costs or uncertainties, or firm-specific constraints
- Likewise, our 2024 study has shown that, where total production costs are similar (e.g. Chinese aluminium) competitiveness issues arise from structural overcapacity and associated unfair practices, more so than from energy costs
- Our 2024 study has also highlighted (1) the criticality of the CBAM in levelling the playing field between decarbonised EU processes and incumbent (cheapest) US and CN processes by 2035, but also (2) possible avenues of CBAM circumvention or avoidance

➢ **Thus, measures to support the competitiveness of the European industry should take a wholistic perspective and not focus solely on energy cost issues**

Illustrative, non-exhaustive overview of non-energy dimensions, current measures, and proposed holistic solutions package[1]

Category	Specific barriers	Measures deployed today	Proposed holistic solutions package
Raw materials supply chain issues	▪ Input supply costs / disruptions / risks ▪ General shortage of skilled labour ▪ Upstream (H2, RES…) raw materials costs pass-through	▪ Critical Raw Materials act ▪ EU Steel and metals action plan ▪ Support for recycling / circular econ.	▪ Circular economy ▪ Training & retaining talent ▪ Diversifying imports ▪ Bilateral trade agreements
Infrastructure bottlenecks	▪ Uncoordinated network development ▪ Insufficient network capacity ▪ Grid connections delays / long permitting processes	▪ EU Grid Action plan ▪ Funding: TEN-T / PCI list / CEF-E	▪ EU coordination ▪ Faster permitting ▪ Anticipatory investments ▪ Grid-enhancing technologies ▪ Flexible connections, digitalisation
Overcapacity and unfair practices	▪ CBAM avoidance / circumvention risks ▪ Dumping / overcapacity ▪ Asymmetrical tariffs	▪ Quotas / tariffs ▪ FDI screening ▪ CBAM	▪ EU trade policy to shield most at-risk industries at least during transition phase

Sources: [1] CL analysis based on survey results shown in Reviving Europe's Industrial Power: how to boost competitiveness through energy

3.7

Conclusion on the policy toolbox to address energy cost competitiveness issues

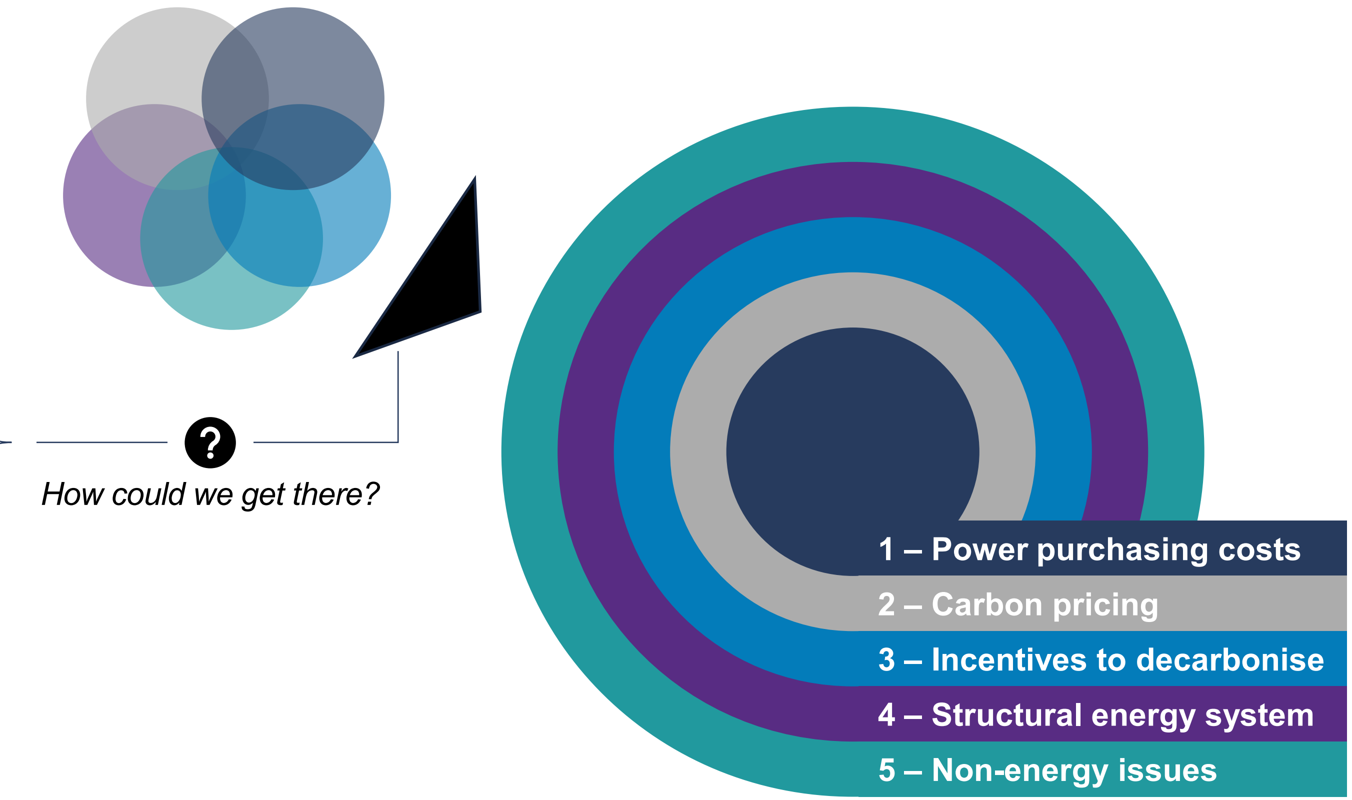
We identify four priority principles for an enhanced policy framework to address energy cost competitiveness and decarbonisation issues

Our analysis suggests the need for a more comprehensive and coordinated policy toolbox

We identify four key considerations :

1. **Foster coordination to define eligibility of measures** at the EU & MS levels
   - Harmonise eligibility criteria across MS and measures for different sectors
   - Use objective and measurable eligibility criteria
   - Identify overlaps and gaps to optimize allocation of public funding
2. **Calibrate support levels for each sector** via an analysis of the **production cost gap** in the EU & abroad and of the role of energy cost – to maximise the efficiency of public support, this calibration effort should be paired with the coordinated development of a least-cost electricity system
3. **Align the temporality** of support measures with the different challenges faced by the sectors
4. **Take a holistic approach to energy and non-energy issues** affecting competitiveness with focus on carbon costs and other macro drivers

Transition from the current patchwork to a comprehensive toolbox of measures



Structural measures to foster a least-cost electricity system are the foundation on which to build efficient and targeted support

Ensuring a least-cost decarbonisation and operation of the power system is the key prerequisite to minimising the need for targeted electricity cost support (for both direct and indirect electrification).

Potential measures to foster a least-cost electricity system include:

- **Fast-tracking the buildout of the transmission and distribution networks**: this includes the development of “transmission corridors” with accelerated buildout of interconnection and offshore grids through, e.g., reforming regulatory frameworks for TSOs including remuneration for anticipatory investments, enhancing the PCI framework with more coordinated planning, costs sharing, and financing, addressing permitting issues, and defining offshore grid regulatory frameworks.
- **Supporting optimal RES-E development**: supporting the optimal development of RES-E and low-carbon power across Europe through increased EU-level coordination, planning, and support approaches.
- **Ensuring efficient and timely development and market participation of low-carbon flexible capacities**: this entails e.g. implementing the Electricity Directive's provision for demand response participation in markets, reflecting system needs and implicit value of flexibility in market products, and setting up long-term derisking frameworks for all flexible assets

Fast-tracking the buildout of interconnections and offshore grids[2]

Interconnection capacity in Europe:

2025: 146 GW → 2050: ~300 GW

+6 GW/y

+ 3%/y

Fostering the development and market participation of flexibility [2]

Flexibility capacity increase by 2050:

+7.0 GW/y

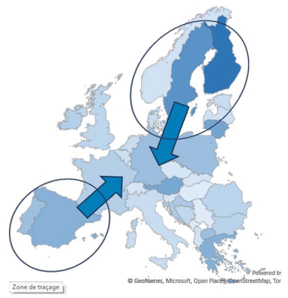
+2 GW/y

+0.7 GW/y

+1.5 GW/y

Supporting the optimal development of renewable and low-carbon power [2]

Onshore wind development areas and transmission pathways



A policy push for market integration & clean power could, by 2050, result in [2] :

30% Lower total electricity costs incl. infrastructure costs

40% Lower wholesale electricity prices (EU average)

[1] European Commission, Grid Action Plan (available here). [2] Compass Lexecon study for Business Europe (2024, available here).

Eligibility for energy cost compensation should be based on a set of objective and measurable criteria

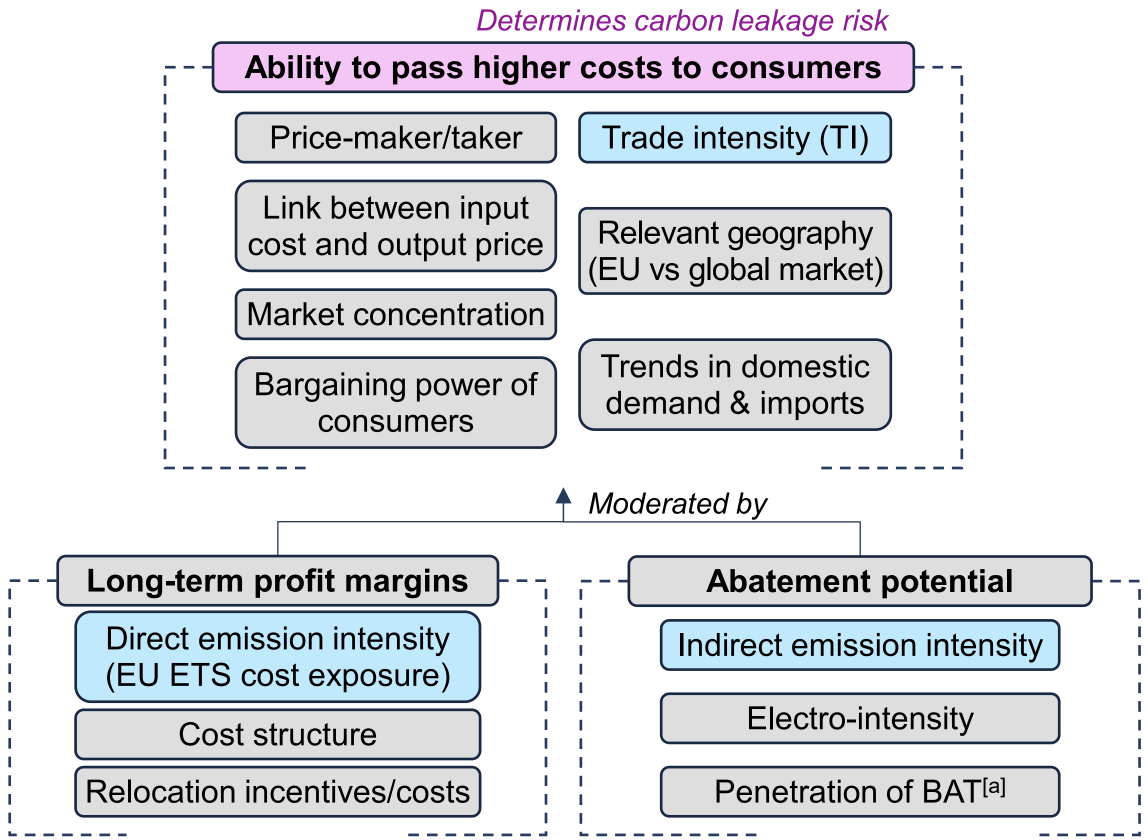
The ability to pass additional / higher costs through to consumers determines broad exposure to energy cost competitiveness issues:

- The economic framework to define eligibility is being used today in carbon cost pass through analyses to identify sectors' exposure to carbon leakage risks
- An extension of this economic framework to define eligibility for energy cost compensation could enhance the targeting of aid / support and integrate the twin goals of competitiveness and decarbonisation

Although the existing carbon leakage framework is a stepping stone, the Trade intensity indicator may not be sufficient to accurately capture industrial sectors' exposure to power costs and competitiveness issues.

- Fast changing market conditions could require regular updates of indicators defining list of eligible sectors / products
- Likewise, a more granular view could better capture product level complexities
- The carbon leakage framework could be expanded to, e.g.:[1],[2]
  - Include more market structure inputs into the ability to pass costs indicator
  - Include other inputs key to profit margins and abatement potential

The ability to pass higher costs through to consumers is considered in the carbon leakage risk mitigation framework today



Key variable, proxied as trade intensity today | Considered in the framework today | Not considered

Sources: Compass Lexecon analysis, based on [1] Compass Lexecon (2025), the EU Carbon Border Adjustment Mechanism (available here), [2] Roques, F., Laroche, H. (2020), Combined retrospective evaluation and prospective impact assessment support study on Emission Trading System (ETS) State aid guidelines" (available here) and
Notes: [a]: Best Available Technology

Further coordination at the EU level could focus on harmonization of measures based on best practices and addressing overlaps between instruments

Non-cumulation criteria generally apply to State aid measures.

- Network cost rebates may or may not constitute State aid[1]
- Likewise, non-selective (i.e., no preferential rate) low taxation on energy goods may not constitute State aid[1]
- EU funding generally prevents double subsidisation by default
- Lastly, some of the long-term supply contract arrangements may blur the line between market instrument and aid

Uncoordinated cumulation rules could put into question the proportionality or necessity of some State aid tools.

This would depend on the specific case:

- Case A: the rules seem to consider overlaps correctly
- Case B: if electricity supply is mostly based on low-carbon baseload fixed-price contracts, then the relevance of setting indirect carbon cost compensation may be questioned
- Case C: non-cumulation is in line with temporality of tools: CISAF is for temporary issues, CCfD is long-term/structural

➢ **Given the fast-evolving nature of the support landscape, a comprehensive review of cumulation rules could help identify overlaps creating issues.**

Illustration – potential overlaps on power purchasing costs

Case A: Indirect CO2 cost compensation (ICCC)[2] + CISAF 4.5 (temporary power price relief)[3]	• CISAF rules: '*When cumulated with [ICCC], the combined aid amount may not exceed the highest amount applicable under any of the two guidelines*' • CISAF aid intensity is typically lower than ICCC ➢ In practice, CISAF and ICCC are **mutually exclusive**
Case B: Indirect CO2 cost compensation (ICCC)[2] + Energy Release 2.0 (36-month €65/MWh supply contract, Italy)[4]	• Industrials receive power via Energy Release 2.0 at a fixed price (currently €65/MWh) for 36 months ➢ They **remain eligible** for ICCC, whose rules state: – The emissions factor (i.e., aid intensity) is the same for all power supply sources (grid, contracts, self consumption) – ICCC is cumulable with other State aid, incl. aid on the same costs up to the max. aid intensity • However, the use of ICCC may be **disproportionate** – ICCC aims to compensate for the pass through of the EU ETS into power purchasing costs – This pass through could be limited / minimal in the Energy Release 2.0's fixed-price contract (depends on the price)
Case C: CISAF 4.5 (temporary power price relief)[3] + Germany CCfD[5]	• CISAF tolerates cumulation up to the highest of the 2 intensities • The German CCfD allows cumulation[5], but any aid received is deducted from CCfD payments, and audits are performed ➢ Thus, CISAF and the German CCfD are **mutually exclusive**

Sources: Compass Lexecon analysis based on [1] EU affordable energy action plan (footnote 22, available here) and EC notice on the notion of State aid (available here, see recital 156 on MS' freedom to set their own taxes), [2] ETS guidelines post 2021 (available here), [3] CISAF rules and staff working document, [4] Energy Release 2.0 explanatory website and comfort letter. [5] BMWE Klimaschutzverträge.info (recital 7.5)
Notes: [a] in Italy for instance, demand-side units that partake in the capacity market receive an exemption from the capacity market charge as remuneration.
Abbreviations: CISAF … Clean Industrial Deal State Aid Framework; ICCC … Indirect CO2 cost compensation, CCfD… Carbon contracts-for-difference

A holistic framework is needed to address energy and non-energy issues affecting competitiveness and decarbonization and refine the policy toolbox

Wider constraints call for support beyond power price subsidies, which may be necessary but not sufficient to make EU industries cost-competitive	Policymakers can and have picked from an arsenal of measures – though they can come at a cost	A holistic solutions package could be deployed to tackle these challenges
Raw materials supply chain issues	▪ Critical Raw Materials act ▪ EU Steel and metals action plan ▪ Support for recycling / circular econ.	▪ Circular economy ▪ Training & retaining talent ▪ Diversifying imports ▪ Bilateral trade agreements
Infrastructure bottlenecks	▪ EU Grid Action plan ▪ Funding: TEN-T / PCI list / CEF-E	▪ EU coordination ▪ Faster permitting ▪ Anticipatory investments ▪ Grid-enhancing technologies ▪ Flexible connections, digitalisation
Overcapacity and unfair practices	▪ Quotas / tariffs ▪ FDI screening ▪ CBAM Risk of retaliation / diplomatic cost	EU trade policy to shield most at-risk industries at least during transition phase

The level of energy cost support could be better specified for the different sectors using an analysis of the total production cost gap and the relative importance of energy costs

The proportionality of State aid is usually assessed through a funding gap analysis.

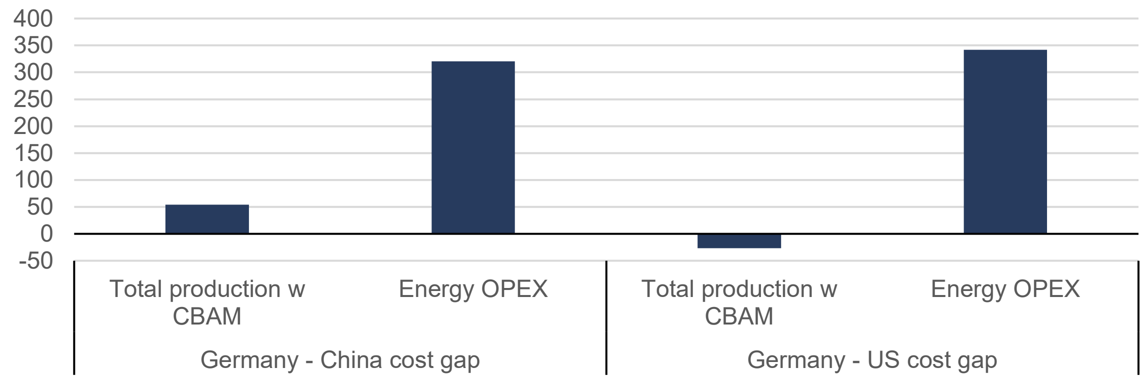
- Such funding gap analyses for support for decarbonisation could consider the cost gap with foreign countries and the relative importance of energy costs, in order to:
- Calibrate the proportionate support level; and
- Identify the optimal mix of measures between energy cost support and measures targeted at other issues affecting competitiveness.

Proportionate energy cost support levels could be differentiated depending on the sectors :

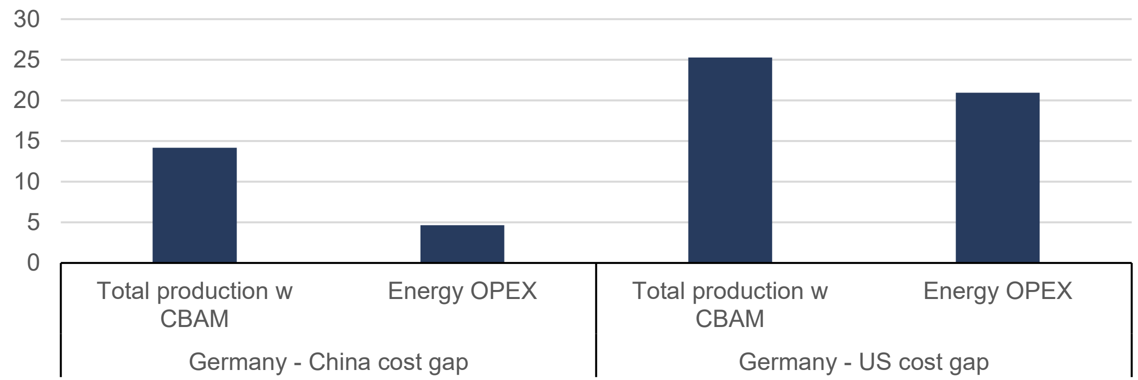
- Case A – e.g. primary steel in 2035:
  - Total cost gap < energy cost gap
  - Here, energy cost support should only offset the difference in production costs, not the difference in energy costs
- Case B – e.g. Steam supply for low T° chemicals in 2035:
  - Total cost gap > energy cost gap
  - Here, energy cost support should only offset the difference in energy costs, and other support is mandated

➢ **Energy cost competitiveness support measures may not be a silver bullet to offset the overall competitiveness gap.**

Primary steel total production and energy opex cost gaps in 2035, $€_{2024}/t_{steel}$



Steam supply for low-temperature chemicals total production and energy opex cost gaps in 2035, $€_{2024}/t_{steam}$



Source: CL analysis based on bottom-up costs models, various sources (see Technical Appendix)
Notes: Germany uses the decarbonized processes (H2- DRI-EAF for primary steel and a heat pump for steam generation) while US and China use the incumbent process (BF-BOF (retrofit) for primary steel and a NG boiler for steam generation). In 2035, we assume that CBAM applies to actual embedded emissions in scope 1 for foreign products, and Indirect CO_2 cost compensation has been phased out.
Abbreviations: CBAM… carbon Border Adjustment Mechanism, OPEX… Operational expenditures

The choice of measures bears implications for the States' budgets and required EU funds

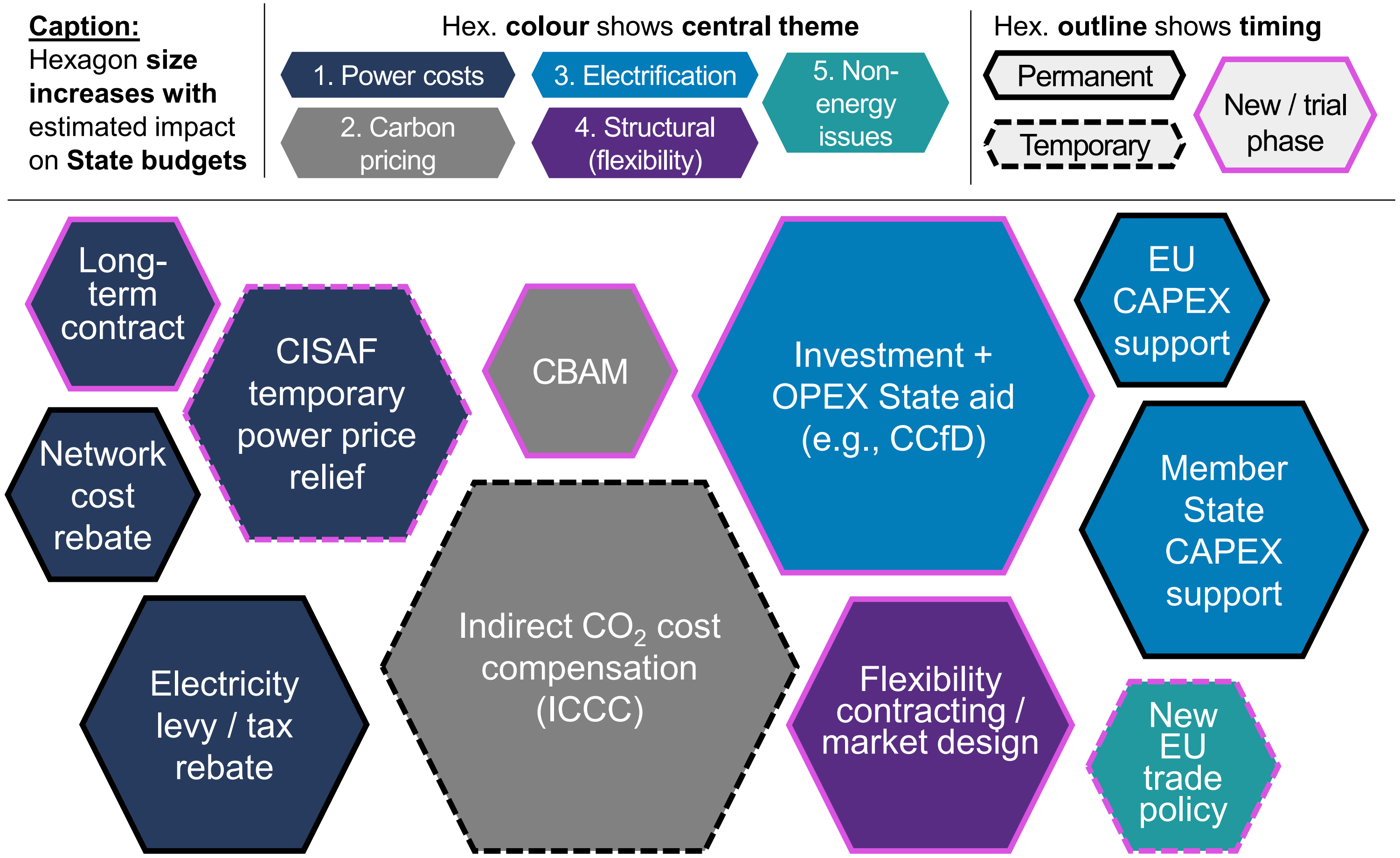
Different measures affect States' budgets differently, from large out-of-pocket support like CCfDs to EU-only funding (e.g., IF calls).

This could potentially create disparities in the types and levels of support across MS:

- Larger or wealthier MS can and tend to[1] spend more on State aid, and thus may opt to deploy:
  - Direct electricity subsidies, like ICCC or CISAF temporary price relief
  - Comprehensive long-term fuel switch aid, such as CCfDs
- Other MS may not be able to support industrial competitiveness at the same rates, and may opt for:
  - De-risking measures
  - Measures with clawbacks
  - Public-private financing
  - Relying on EU grants / funds

➢ **This reinforces the need to monitor and control state aid measures across Europe to avoid distortions.**

Clusters of key support measures in place for EU industries (illustrative, non-exhaustive)



Abbreviations: CAPEX … Capital Expenditure, CBAM … Carbon Border Adjustment Mechanism, CISAF … Clean Industrial Deal State Aid Framework, CO2 … carbon dioxide, ETS … Emission Trading System, FDI … Foreign Direct Investment, ICCC … Indirect CO2 Cost Compensation, OPEX … Operational Expenditure, IF…Innovation Fund

Notes: [1] See Compass Lexecon (2024) Reviving Europe's Industrial Power: how to boost competitiveness through energy (p. 63, available online)

The criticality of a sector / site could be used to define a more targeted support framework but would require a definition and identification of such sites at EU level

The concept of "criticality" of an industrial sector is not precisely defined but could provide a tool to target support to sites that condition the economic viability of sectors.

The criticality of a sector / site could be assessed across multiple dimensions, including:

- Relevance for strategic autonomy and the risk of losing the last remaining production capacity
- Importance as a precursor / input for strategic sectors, both current (defence, health, energy) and emerging (AI)
- Economic and industrial contribution at the EU, national, and local levels
- Vulnerabilities of processes, regions, or value chains in which the product / application plays a key role
- Etc …

The definition of 'criticality' should reflect the specific characteristics and challenges of the industry and its broader relevance for the EU economy and sovereignty, enabling the effective identification of sites that may require targeted policy interventions and support measures.

Overview of current definitions of criticality used at EU or national level

EU	**Critical Raw Materials Act**	*"Critical raw materials are of high economic importance for Europe while being also highly vulnerable to supply disruptions"*
EU	**Critical Medicine Act**	*"A critical medicine is identified by combining two criteria: the seriousness of the disease it targets and the availability of suitable alternative medicines"*
UK	**Criticality Assessment**	*"raw materials that are crucial for the economic prosperity, national security and ongoing technological development of the UK, but have a significant risk of supply disruption"*
NL	**Vital Assessment**	*"The assessment of whether a process or service is vital is made by the responsible ministry. This involves analysing whether disruption, failure, or manipulation of a process or service could have such serious consequences that they could harm national security"*

Measures addressing issues materialising over different time frames are needed; in particular the visibility on the post-2030 framework remains limited and must be improved

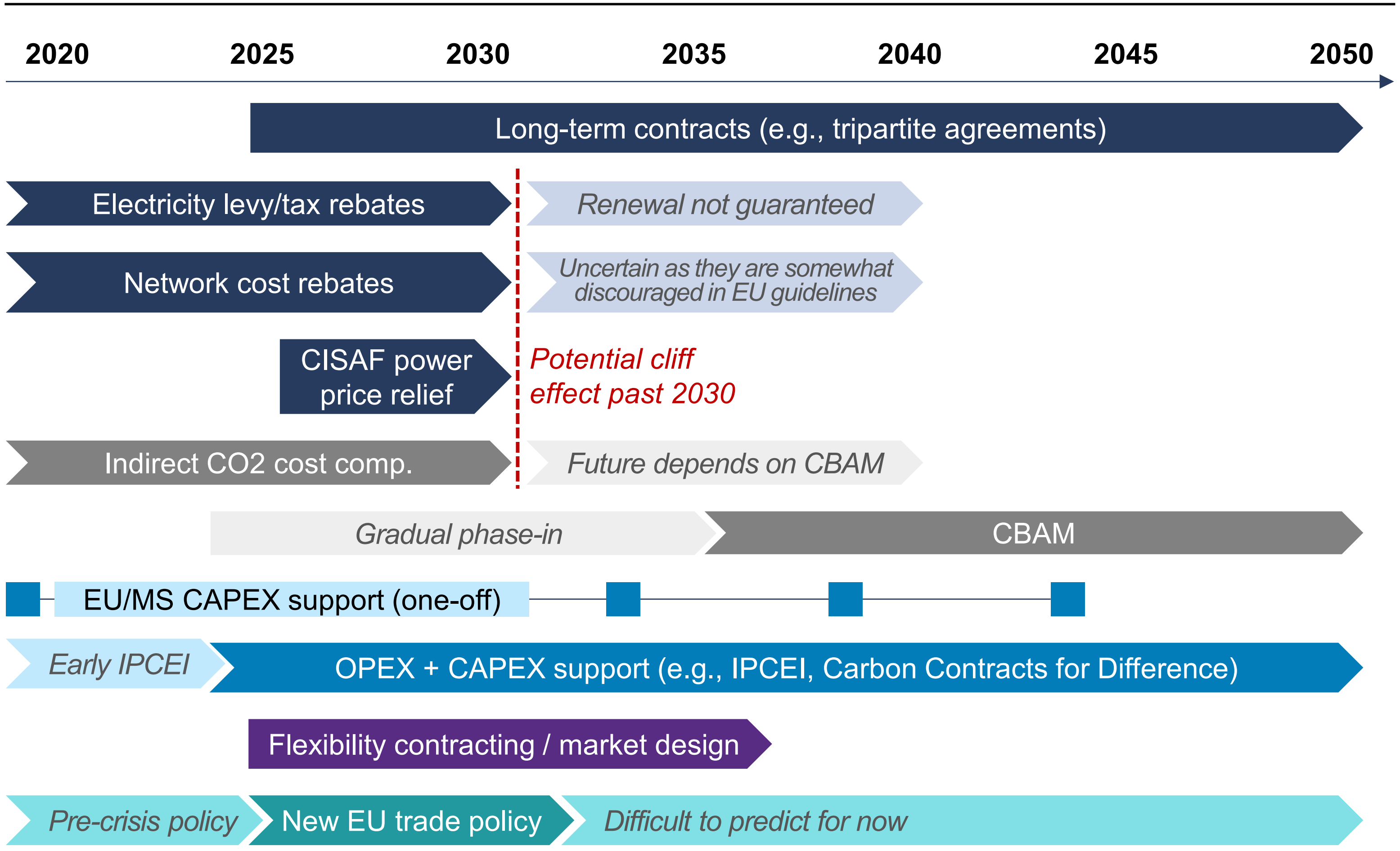
EU interventions span across different time frames corresponding to the issue they seek to address:

- One-off investment support using tenders should be favoured when feasible
- Temporary or short-term measures (≤ 5 years, e.g., CISAF temp. price relief) should be deployed to tackle transitory issues or market shocks / idiosyncratic situations[1]
- Enduring / long-term instruments (> 5 years, CCfDs, network cost rebates, etc) should be used to resolve structural challenges[2]

However, the current EU policy toolbox lacks predictability in the long term (e.g., on duration of support), esp. post 2030:

- Some schemes like ICCC or RES levy reductions are due to expire by around 2030; renewal is likely yet needs confirmation
- Similarly, clarity on CBAM should be provided in 2026 with the CBAM and ETS review to prepare the next phase of decarbonisation

Overview of the temporality of the measures of the toolbox and the challenges they address[3]



1. Power costs | 2. Carbon pricing | 3. Electrification | 4. Structural (flexibility) | 5. Non-energy issues

Abbreviations: CAPEX … Capital Expenditure, CBAM … Carbon Border Adjustment Mechanism, CISAF … Clean Industrial Deal State Aid Framework, CO2 … carbon dioxide, ETS … Emission Trading System, FDI … Foreign Direct Investment, ICCC … Indirect CO2 Cost Compensation, OPEX … Operational Expenditure
Notes: [a] e.g., maintaining indirect CO2 cost compensation while waiting for full watertight CBAM phase in., [b] e.g., 15-year CCfDs to bridge a structural residual total production cost gap with foreign counterparts. [c] the figure is illustrative and non-exhaustive.

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