Agora Energiewende

Technology and policy options for a climate-neutral energy-intensive industry

Focus on the steel, cement and chemical industries

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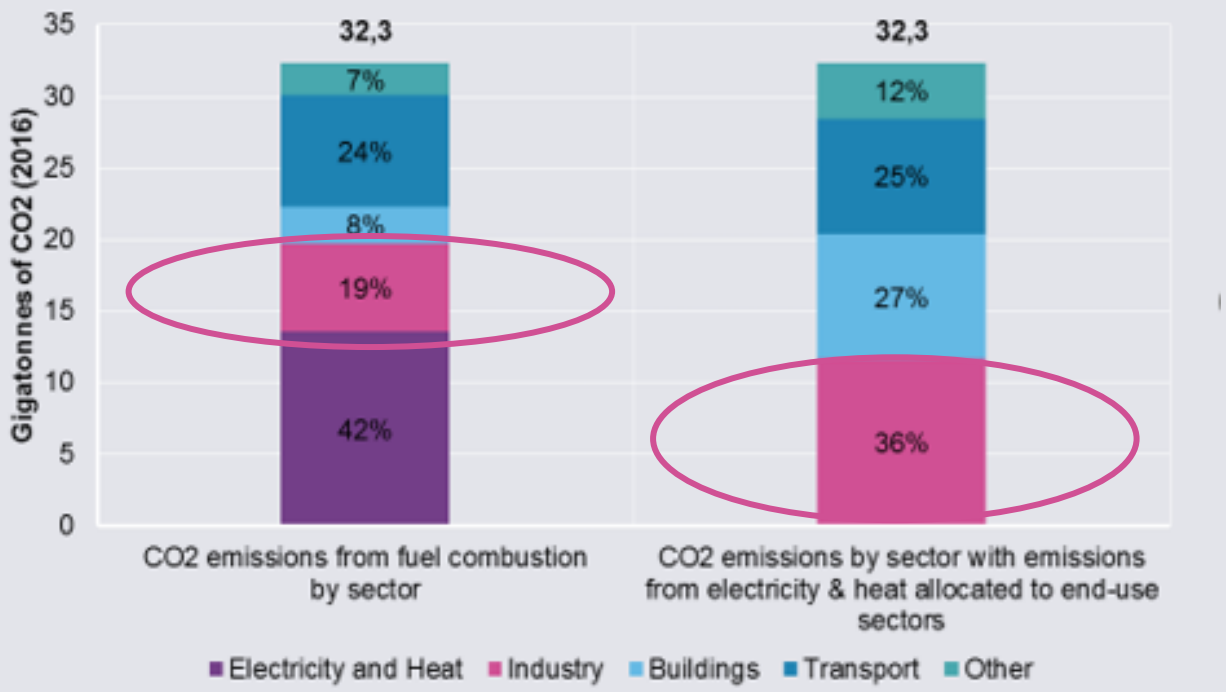
When it comes to decarbonization efforts, the industry sector has long been left out of the discussion… but industry is critical to reach the goals of Paris Agreement

Global fossil fuel emissions by production (left) and end-use (right)



Agora Energiewende based on IEA 2018; McKinsey 2018

Different emission allocation methods

If the emissions by the electricity and heat sector are allocated to the end-use sector, industry is by far the largest CO_2 emitting sector

Hard-to-Abate Sectors (Steel, Cement, Chem.)

Most climate mitigation efforts focused on low-hanging fruits (coal phase-out, buildings, transport)

Rising global demand for basic materials

Exp. yearly production in 2050 compared to 2015:

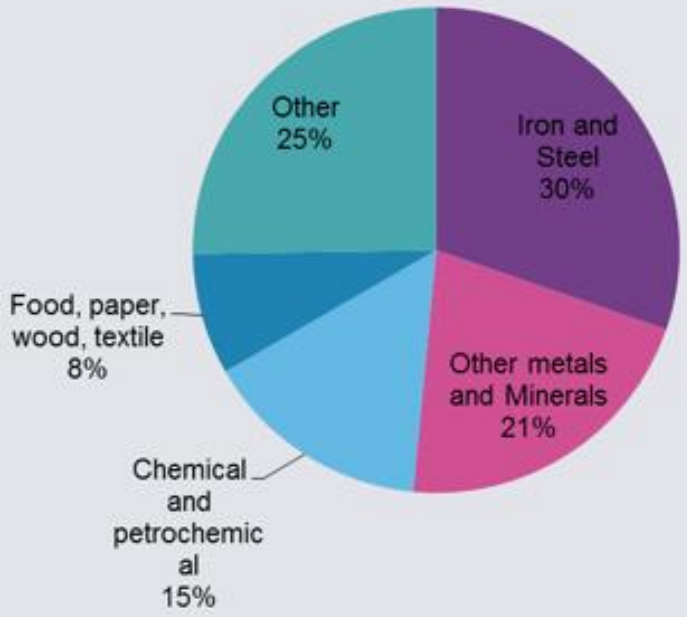
Steel (+30%); cement (+25%); ammonia (+65%)

Avoiding process emissions is key

Due to the long life-times of industrial plants, future reinvestments should be into the new technologies

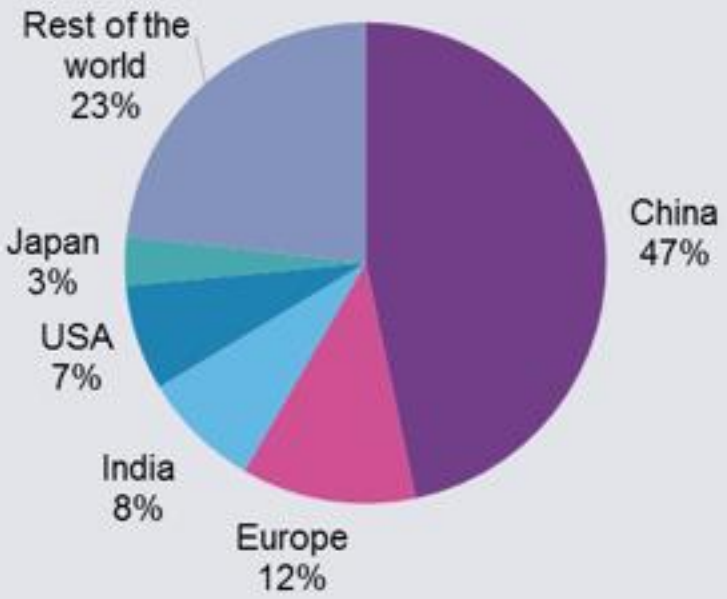
3 sectors account for 66% of the emissions in the industry sector – steel, cement, fertilizers and plastics are the most CO2-intensive products

Industry global CO_2 emissions (2016): the share of key branches



Agora Energiewende based on IEA 2018

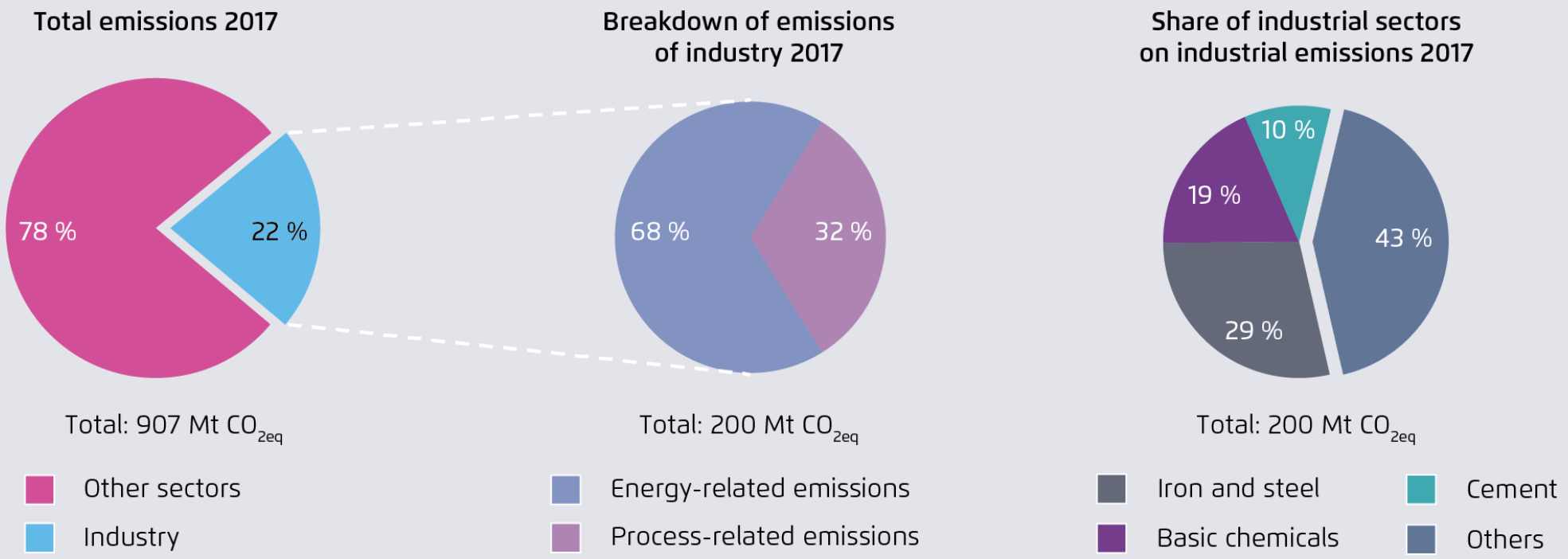
CO_2 emissions of industry (2016): Where do they come from?



Agora Energiewende based on IEA 2018

Germany: Industry is responsible for about one fifth of total emissions – about 60 percent of which is accounted for by the steel, chemical and cement industries

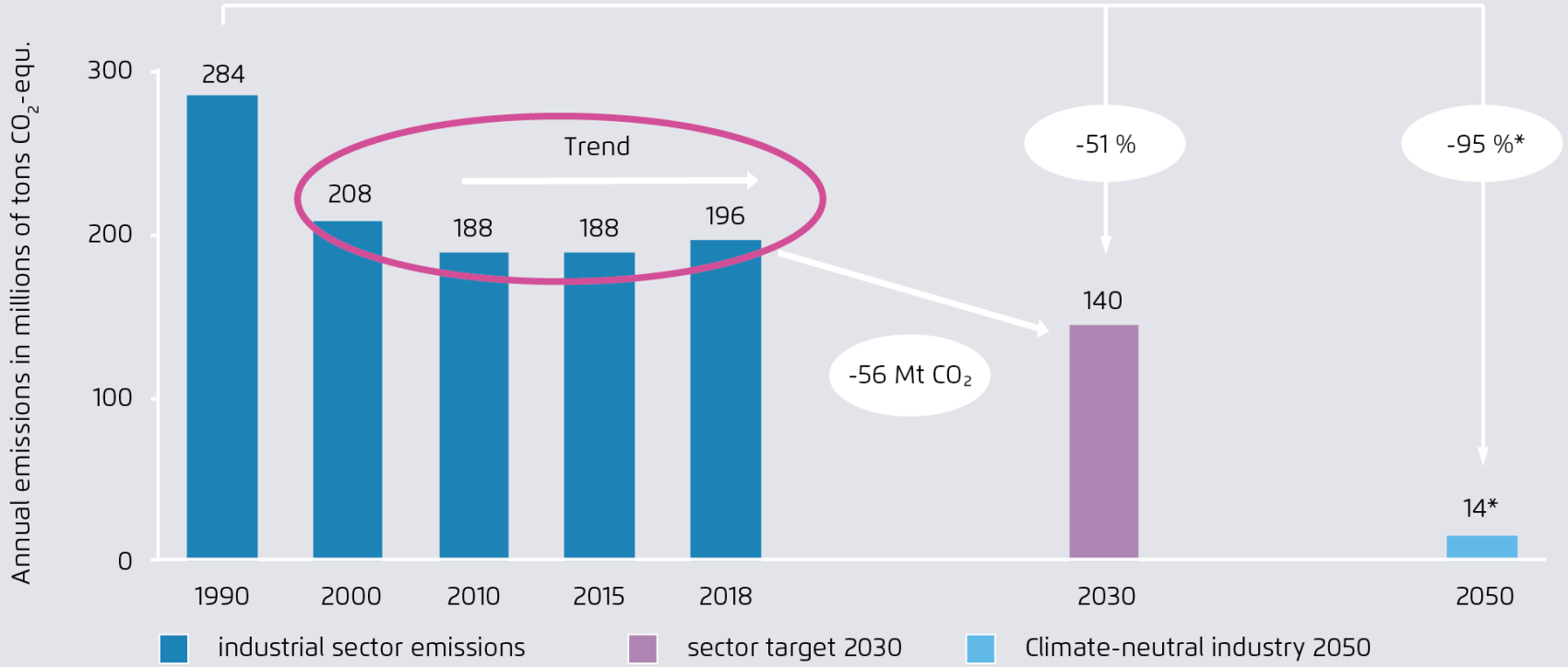
German industrial sector emissions in 2017 in Mt CO_{2eq} (by source balance)



Sources: UBA, 2019a; WV Stahl, 2018; VDZ, 2018; Wuppertal Institute, 2019

Industrial emissions in Germany remained rather constant since 2000 – as energy efficiency gains were compensated for parts by production growth

Emissions in the German industrial sector 1990 - 2018 (according to Germany's climate protection plan) as well as German sector targets for 2030/2050 for the industrial sector



Sources: UBA, 2019a; BMU, 2016; * Residual emissions 2050 must be offset

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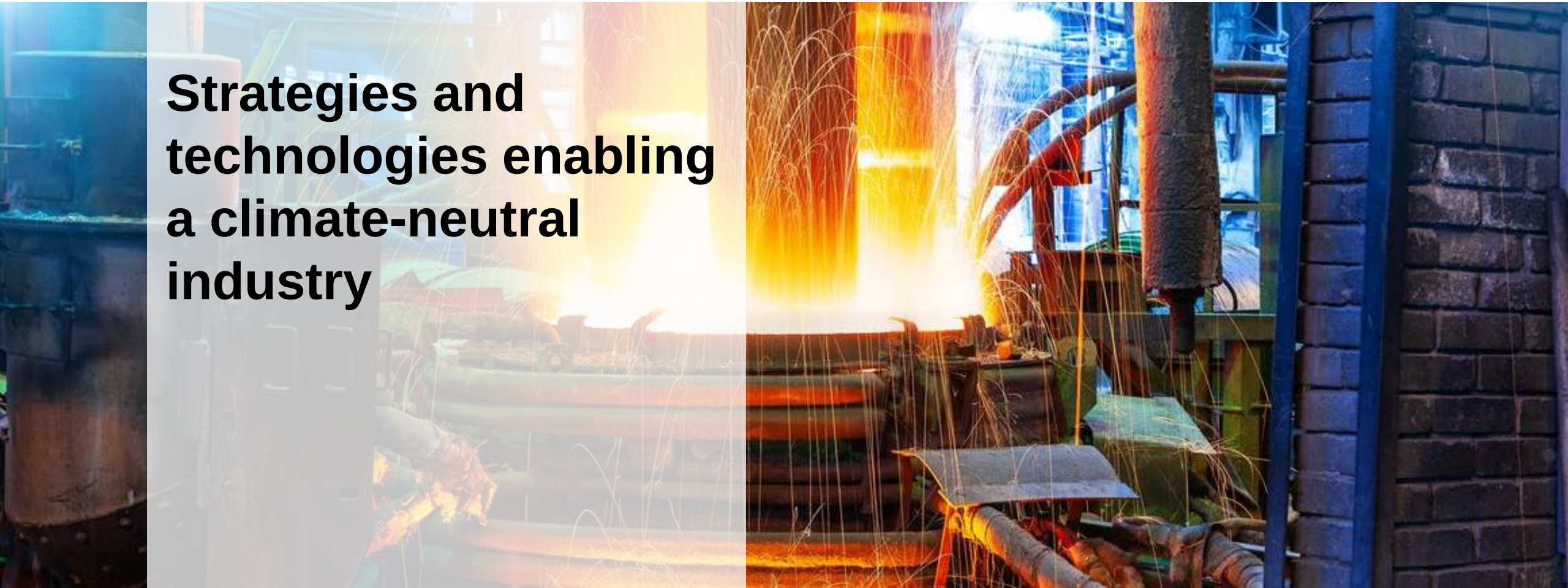
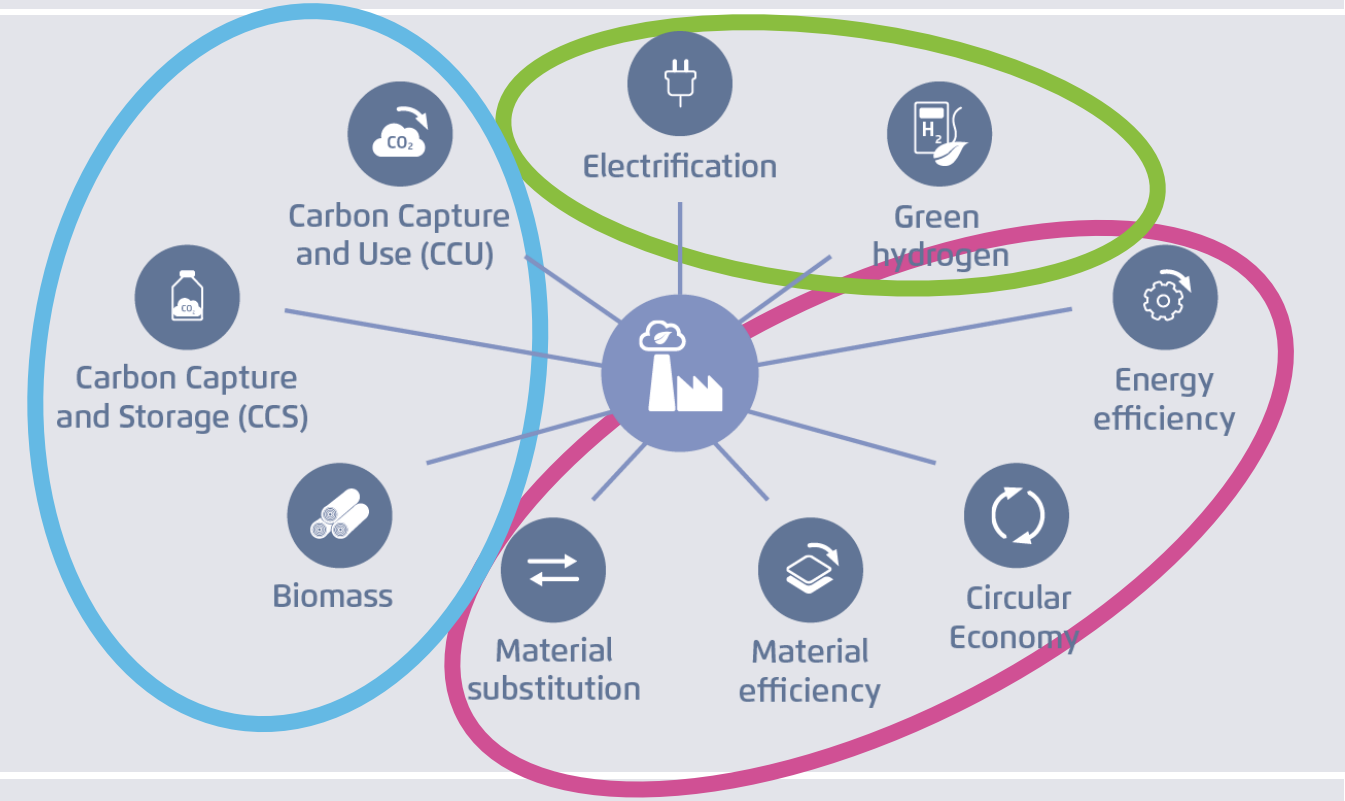
Strategies and technologies enabling a climate-neutral industry



A combination of different strategies enables a climate-neutral industry – the less emphasis is placed on electrification, the more ‘circular economy’ and CCS are required

Strategies that enable a climate-neutral industry



Source: Agora Energiewende, 2019

1. **Strategy: Direct and indirect use of renewable electricity**
   - → Direct use of green electricity
   - → Indirect use of green electricity through green hydrogen
2. **Strategy: Resource efficiency and the circular economy (‘Kreislaufwirtschaft’)**
   - → Circular Economy
   - → Energy efficiency
   - → Material efficiency
   - → Material substitution
3. **Strategy: Closing the carbon cycle**
   - → Carbon Capture and Storage (CCS)
   - → Carbon Capture and Use (CCU)
   - → Biomass

Key technologies for steel: Hydrogen will play a central role
Key technologies for cement: Alternative binders and CCS are needed

Overview of possible key technologies for a (largely) greenhouse gas neutral steel and cement sector

Steel	Key technology	Earliest possible market readiness
	Direct reduction with hydrogen and smelting in the electric arc furnace	2025 – 2030 (phase-in with natural gas)
	Alcaline iron electrolysis	likely after 2050
	HIsarna® process in combination with CO_2 capture and storage	2035 – 2040
	CO_2 capture and utilization of waste gases from integrated blast furnaces	2025 – 2030

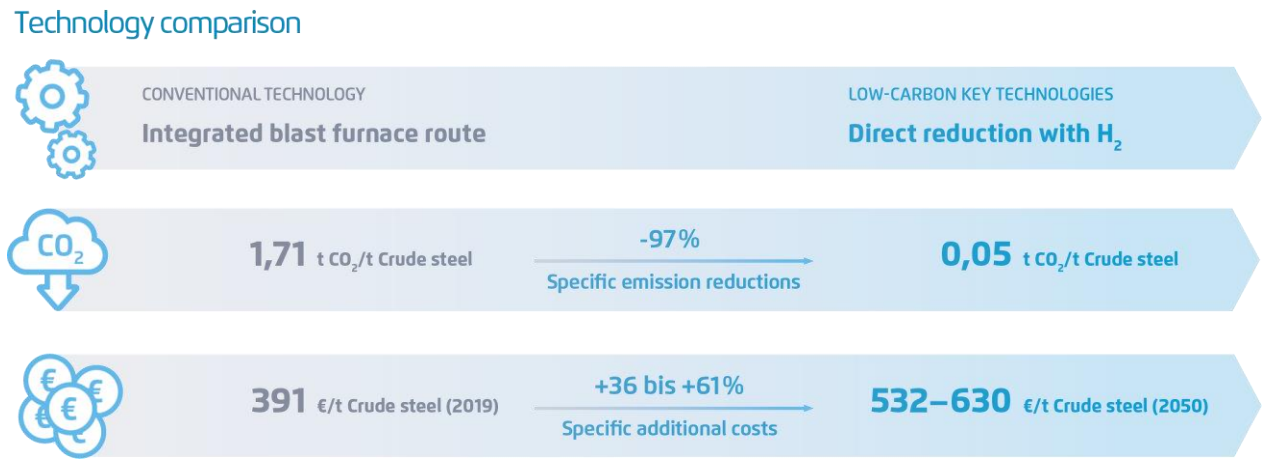
Cement	Key technology	Earliest possible market readiness
	CO_2 capture with oxyfuel process (CCS)	2025 – 2030
	CO_2 capture in combination with electrification of the high temperature heat at the calciner	2030 – 2035
	Alternative binders	2020 – 2030 (depending on product)

- Direct and indirect use of green electricity
- Closing the carbon cycle
- Resource efficiency and Circular Economy

Sources: Agora Energiewende/Wuppertal Institut, 2019

The promising low- and zero-carbon technologies identified in the study have different CO_2 reduction potentials, costs and technological maturity levels

Comparison of direct reduction with hydrogen with the blast furnace route

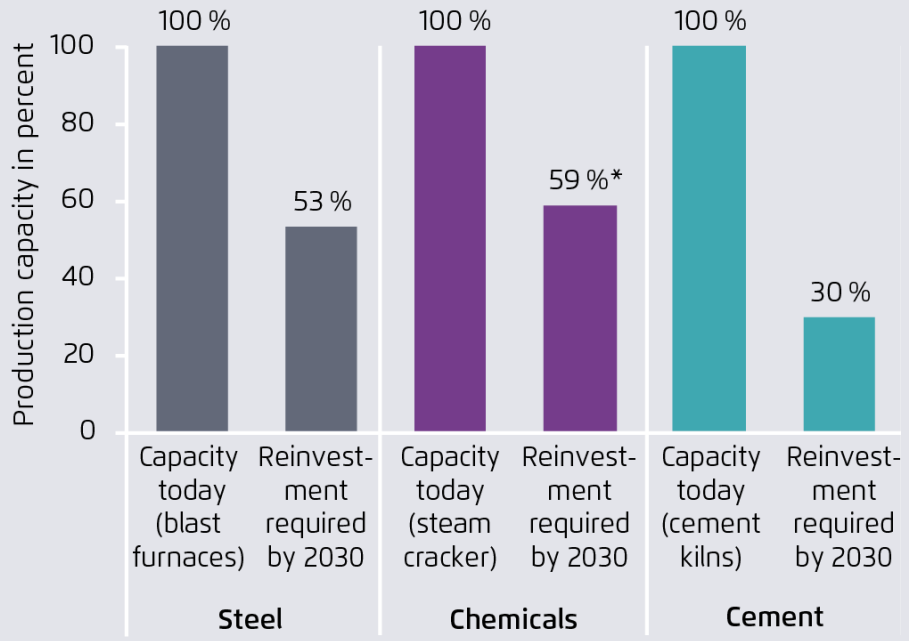


Source: Wuppertal Institut, 2019

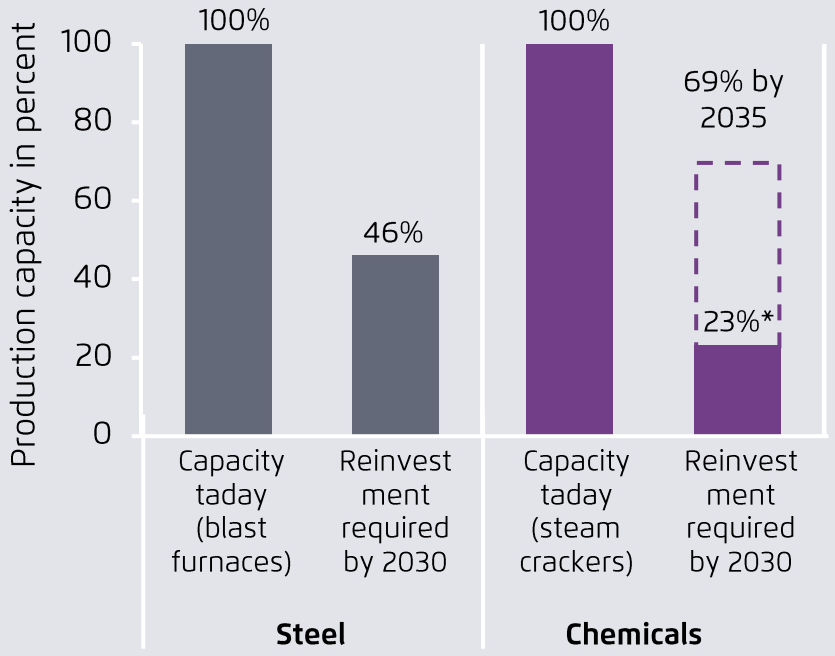
- Agora Energiewende and the Wuppertal Institute have developed brief fact sheets for 13 promising key technologies in the fields of steel, chemistry and cement that are potentially CO_2-free/low CO_2
- Information provided in the fact sheets includes: CO_2 abatement costs, CO_2 abatement potential, technology-specific additional costs, existing pilot projects, reinvestment cycles and technology readiness.
- Interim results were provided to and consulted with industry associations and companies

The reinvestment needs in Germany's energy-intensive industry until 2030 are high – many jobs are affected

Reinvestment needs in the German (left) and French (right) industry until 2030 (primary production capacity)



Source: Wuppertal Institute, 2019

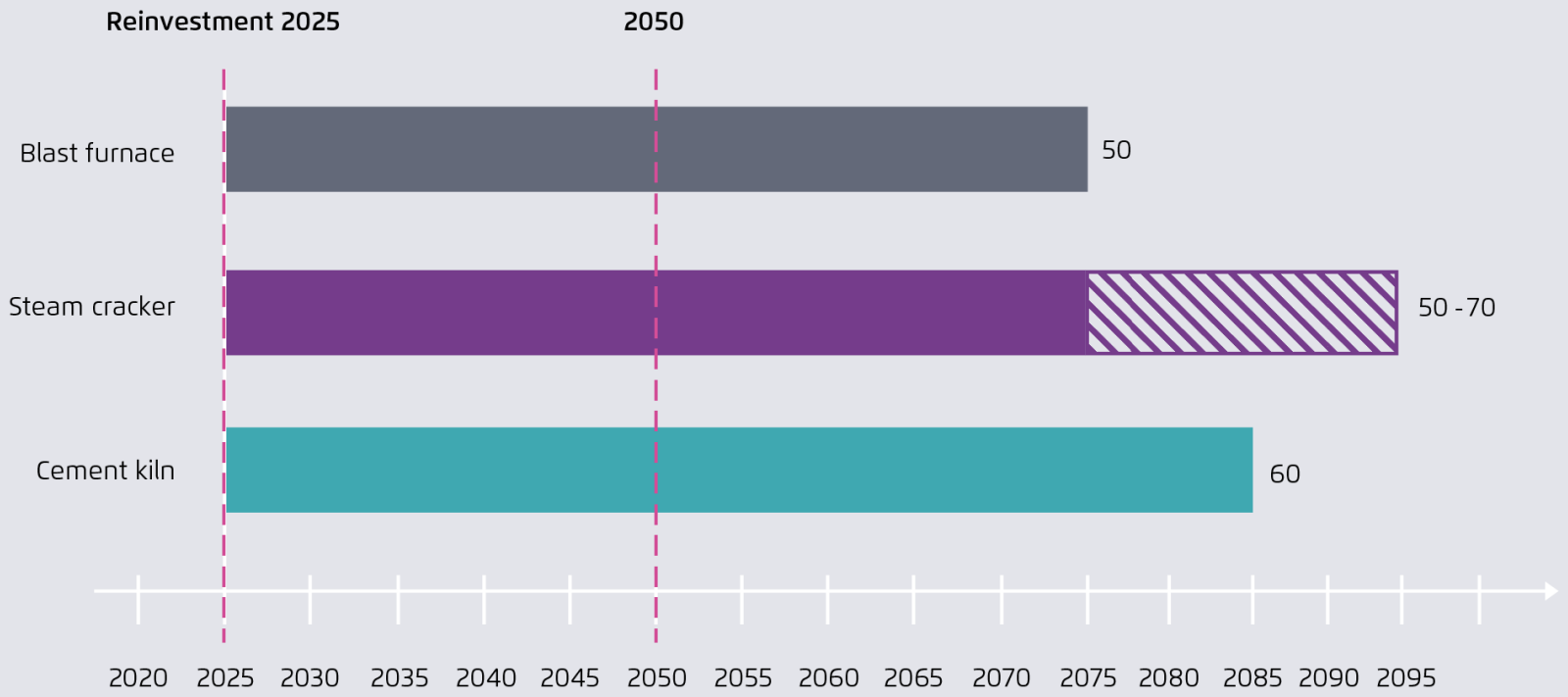


Source: Wuppertal Institute, 2020 – work in progess

* Steam crackers are normally maintained and modernised continuously so that they are not completely replaced at one time. However, the need for reinvestment gives a rough impression of the need to modernise existing facilities.

All plants built today will still exist in 2050 – any future investment must therefore be climate-neutral

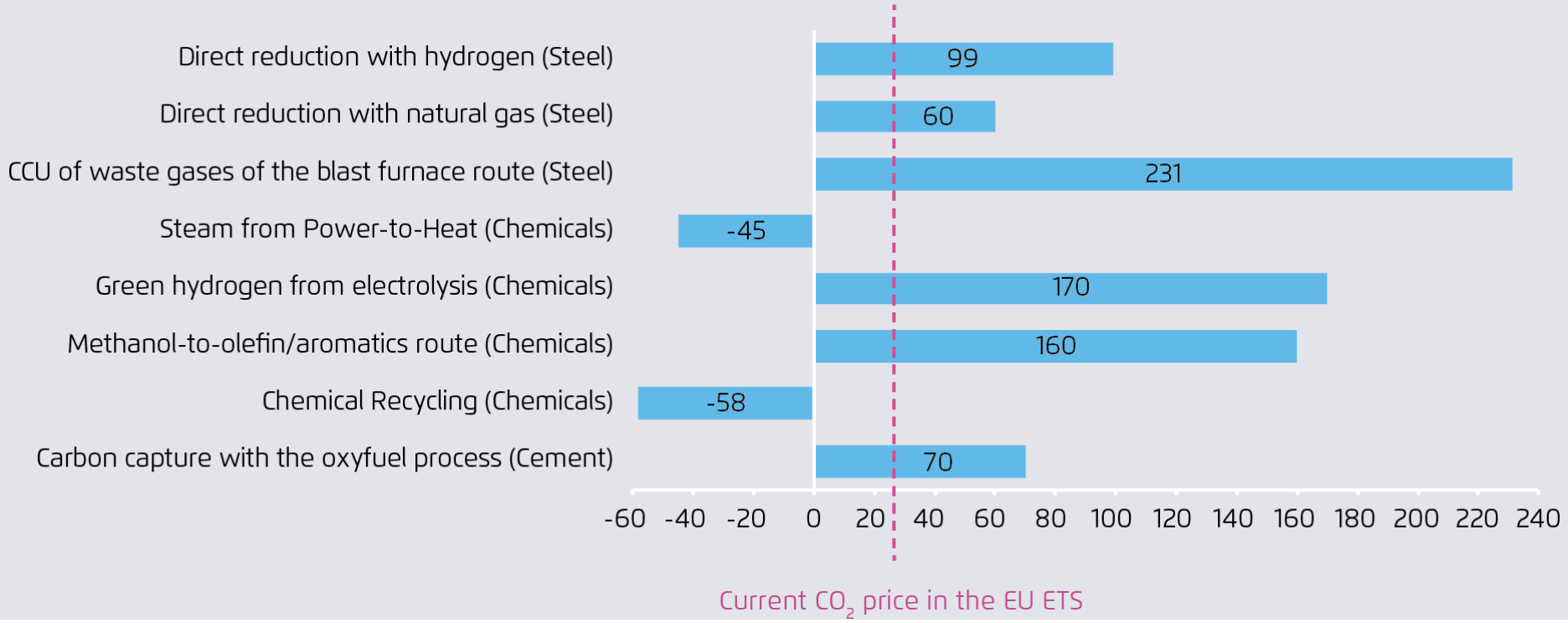
Technical lifetime of primary production plants in the steel, chemical and cement sectors with reinvestment in 2025



Sources: Agora Energiewende/Wuppertal Institute, 2019

The marginal abatement costs of breakthrough innovations are in most cases significantly higher than current and anticipated EU ETS-prices

Marginal abatement costs of new technologies in industry 2030, lower range, in Euro/t CO_2



Sources: Wuppertal Institute/Agora, 2019

Green energy and raw materials (Upstream)

- Internationally competitive prices for green electricity
- Green hydrogen quota *
- Development of the required infrastructure

Green electricity

Green hydrogen and feedstock

High-quality raw materials from recycling (steel scrap, carbon, concrete)

Climate-friendly production processes (Midstream)

- Minimum CO_2 price in the EU ETS *
- *Carbon Contract for Difference* *
- Green financing instruments*

Basic materials industry

Climate-friendly end products (Downstream)

- Quota for low-carbon materials*

Consumer

Production of end products

- Consumption charge on end products*
- Carbon price on final products*
- Standards for recyclable products*
- Changes of construction and product standards*

State

- Green public procurement *

End-of-Life (Recycling)

Steel scrap, old plastic, demolition of buildings

*More detailed explanation in policy instrument fact sheets in Part D

Conclusion

1. The sector targets for 2030 and 2050 for the industry are ambitious – given expected continued economic growth, it will be difficult to achieve the targets through efficiency improvements alone. Fundamentally new processes and production methods are needed to achieve climate-neutrality.
2. The available strategies and technologies for a climate-neutral, energy-intensive industry are well known. It is critical to anticipate the re-investment needs, so that upcoming re-investments go into future-proof technologies.
3. Research and innovation funding is helping to bring technologies into the pilot and demonstration phase. However, appropriate policy instruments and framework conditions to enable commercialization and industrial-scale investment are still needed:
   - develop clean energy and raw materials for the industry (upstream) – e.g. green H2 quota
   - support the deployment of new climate-neutral production technologies (midstream) – e.g. CCFD
   - shift the market towards climate-friendly products (downstream) – e.g. green public procurement

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Questions or Comments? Feel free to contact me:

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