Evolving the well-established

Requirements for a CO_2 infrastructure in Europe and Germany

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Key questions of the VDZ study

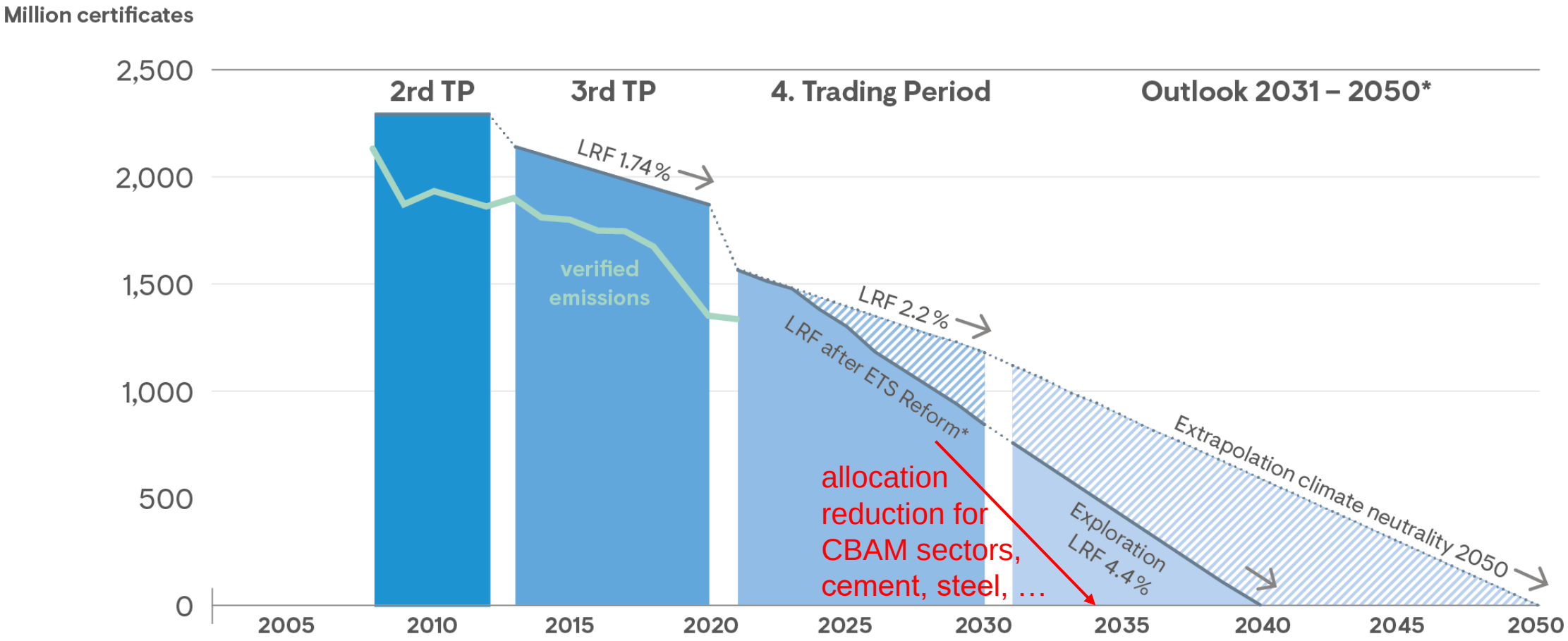
- How will the unavoidable CO_2 emissions develop?
- How must CO_2 capture develop in terms of time and geography?
- What infrastructure requirements does this result in for CO_2 transport?
- What requirements must be met for the CO_2 infrastructure to be set up quickly?

- Executive Summary in English, full study in German language
  - www.vdz-online.de/en/cement-industry/climate-protection/co2-infrastructure
  - www.vdz-online.de/co2-infrastruktur

Source: VDZ

Carbon Management – Time is pressing

Reduction path of EU emissions trading requires "net zero" by 2040

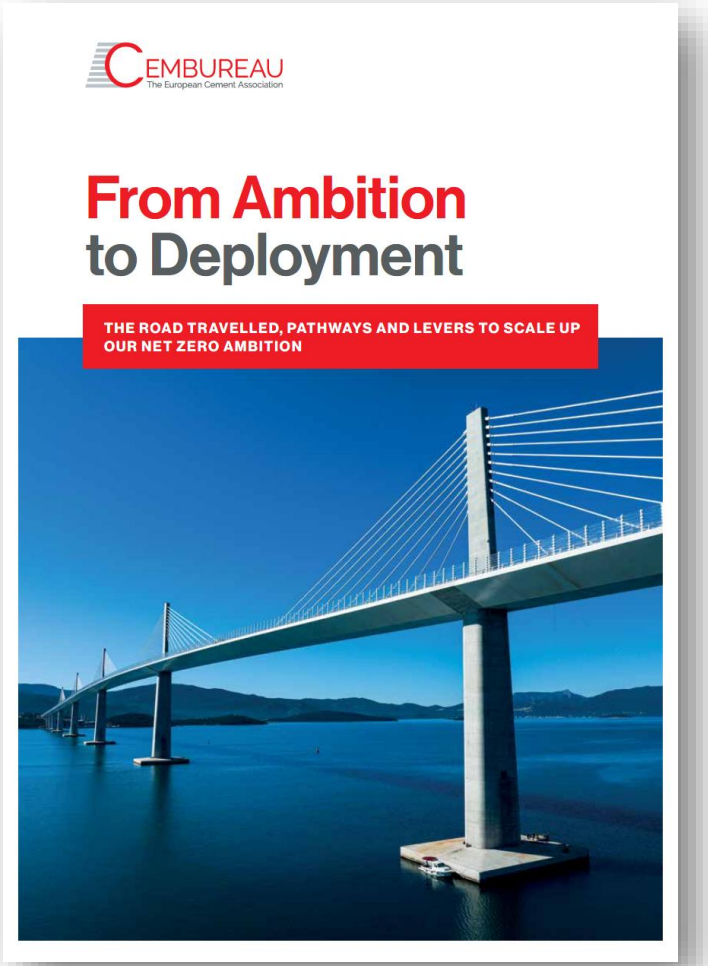


Sources: VDZ based on Federal Environment Agency, EU Commission, EU ETS Directive

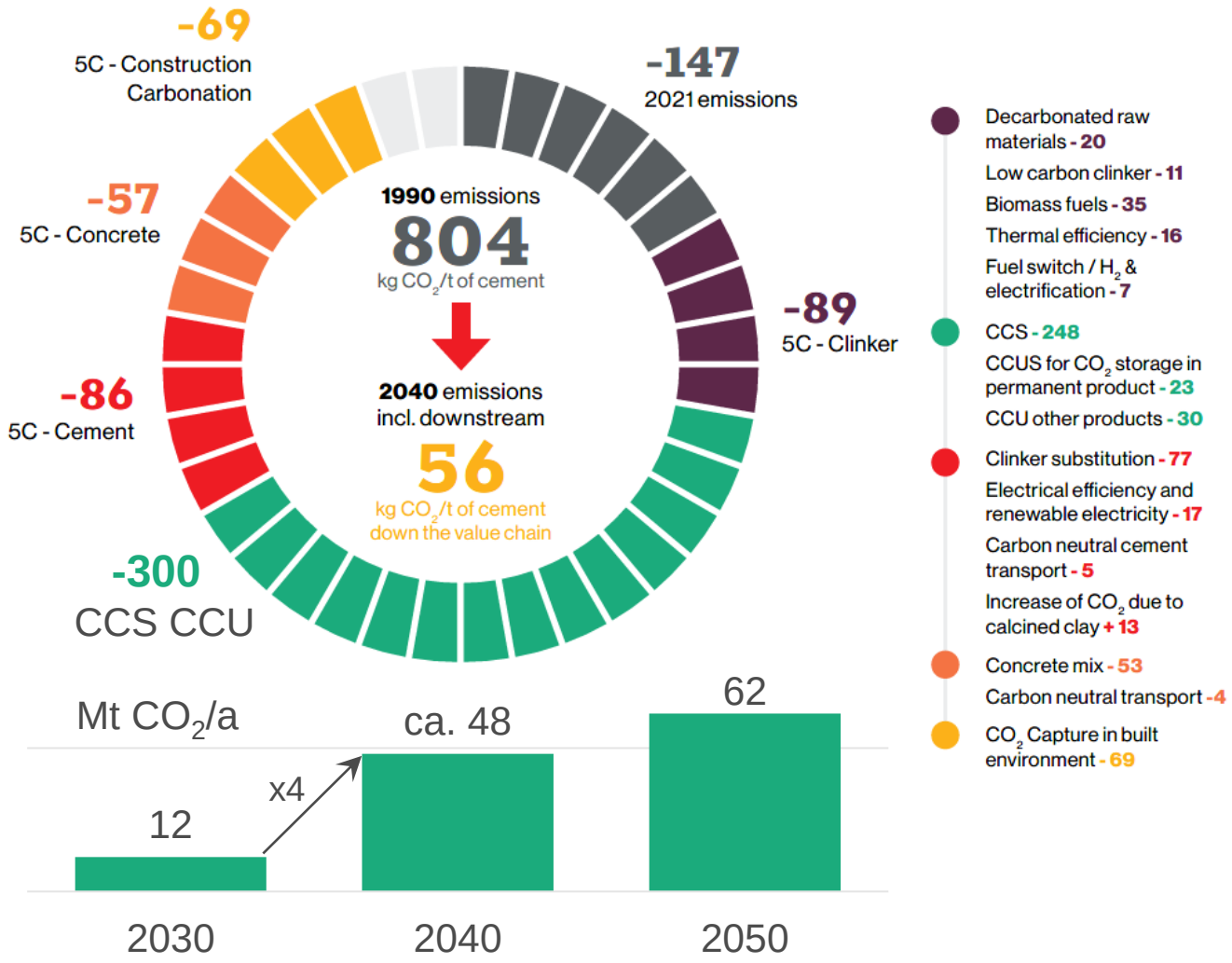
* Assumptions for projection: Update of the original reduction path (linear reduction factor LRF 2.2 % p.a.) with climate neutrality in the EU ETS by 2050; update of the current reduction path in the EU ETS (LRF 4.3 % from 2024 and 4.4 % p.a. from 2028) leads to climate neutrality around 2040. Effects not taken into account: Market stability reserve, inclusion of waste incineration plants from 2028 onwards, possible inclusion of ETS 2 (transport, buildings, other industrial plants); possible offsetting of negative emissions

European Cement Industry Climate Neutrality Roadmap

CO_2 saving by efficiency along the entire value chain (5C), plus CCS at significant scale in 2040



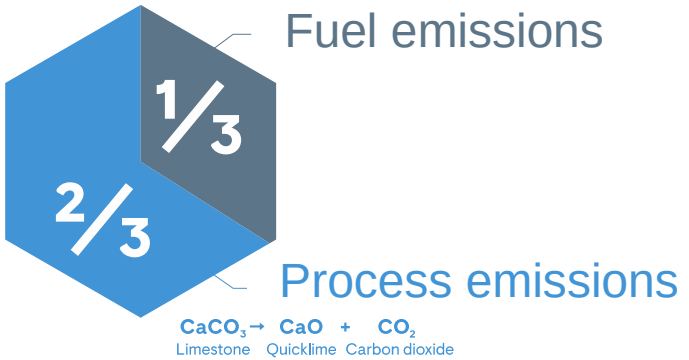
https://cembureau.eu/library/reports/cembureau-s-net-zero-roadmap/



Cement CO_2 sources distributed across all of Europe

Source: VDZ, OSM

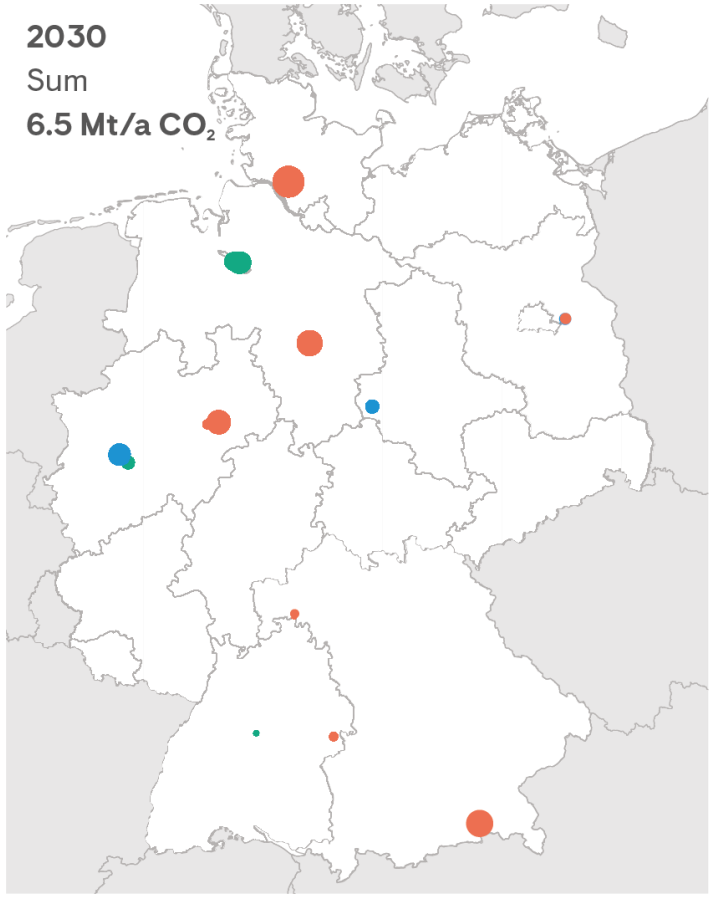
- Cement clinker production uses local geological resources of limestone

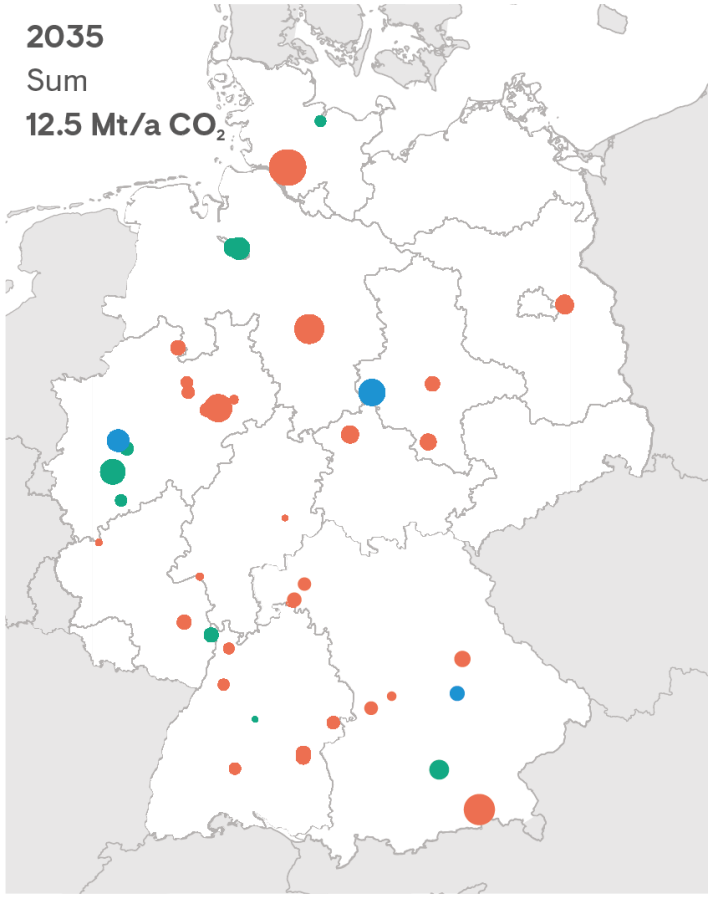


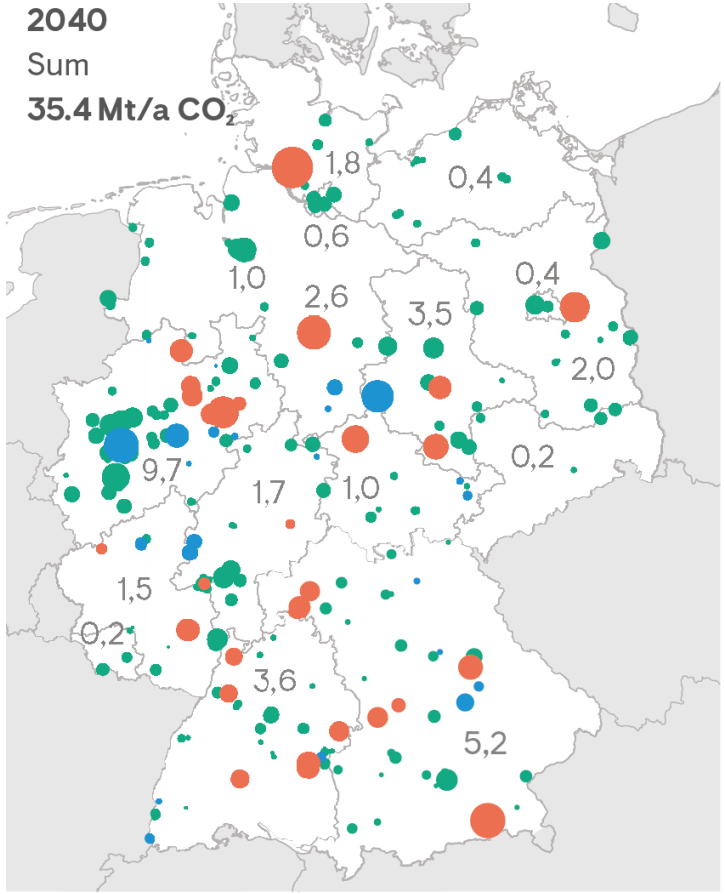
- Cement plants serve the regional building product demand and markets
- Efficient and circular use of material and products will decrease total CO_2 volumes
- Regional supply, demand and European distribution of production sites will remain!

Temporal and geographical development of CO_2 capture

VDZ Scenario Climate Neutrality 2040 (CN2040): Cement, lime, waste incineration with unavoidable CO_2





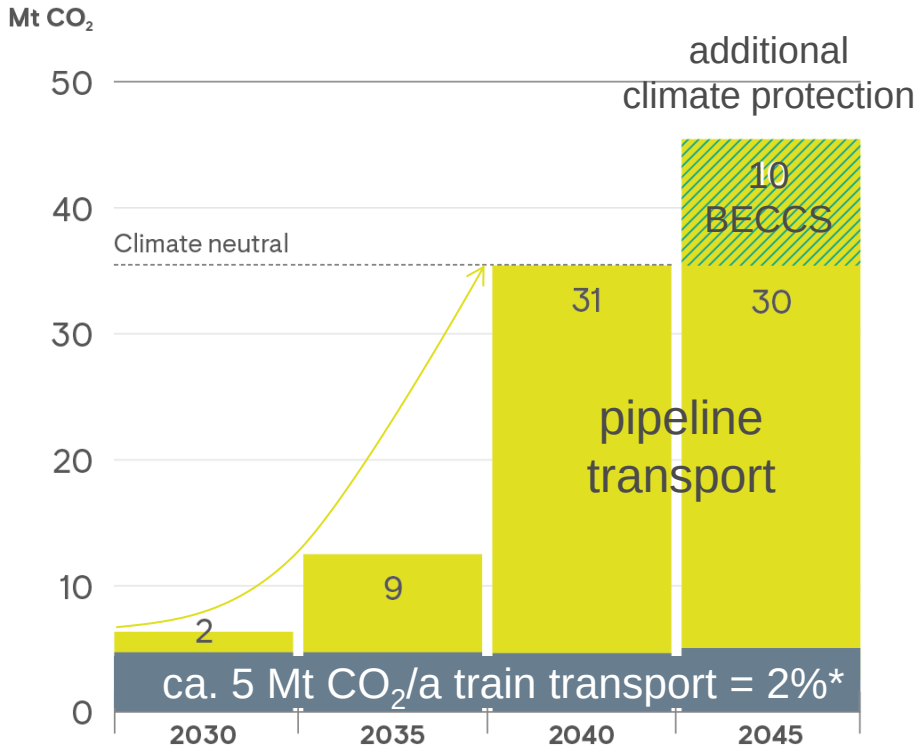


Source: VDZ

CO_2 infrastructure requirements and pan-European network

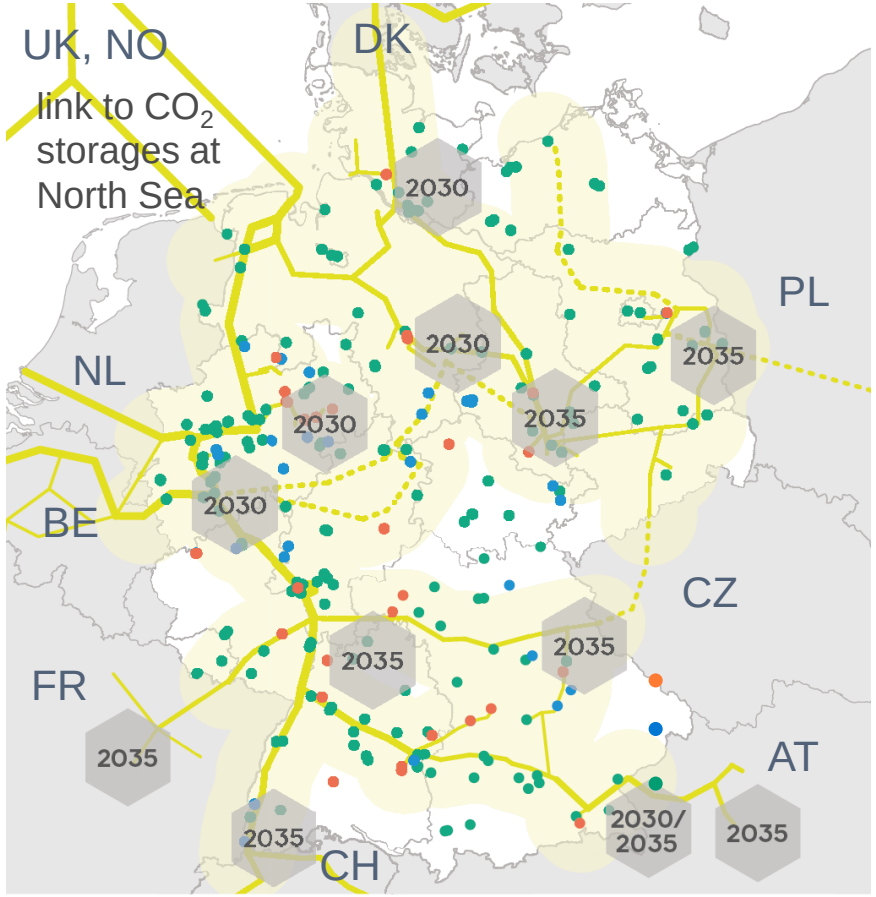
Rapidly progressing expansion of the CO_2 pipeline network by 2035 across all regions in parallel

Germany, cement, lime, waste incineration, CN2040



5 years delay in pipeline availability will double need for train/barge transport to 9 Mt CO_2/a

Source: VDZ, *share of current train transport of goods in Germany



Sources: VDZ, BV Kalk, ITAD, OGE, bayernets, CapTransCO2

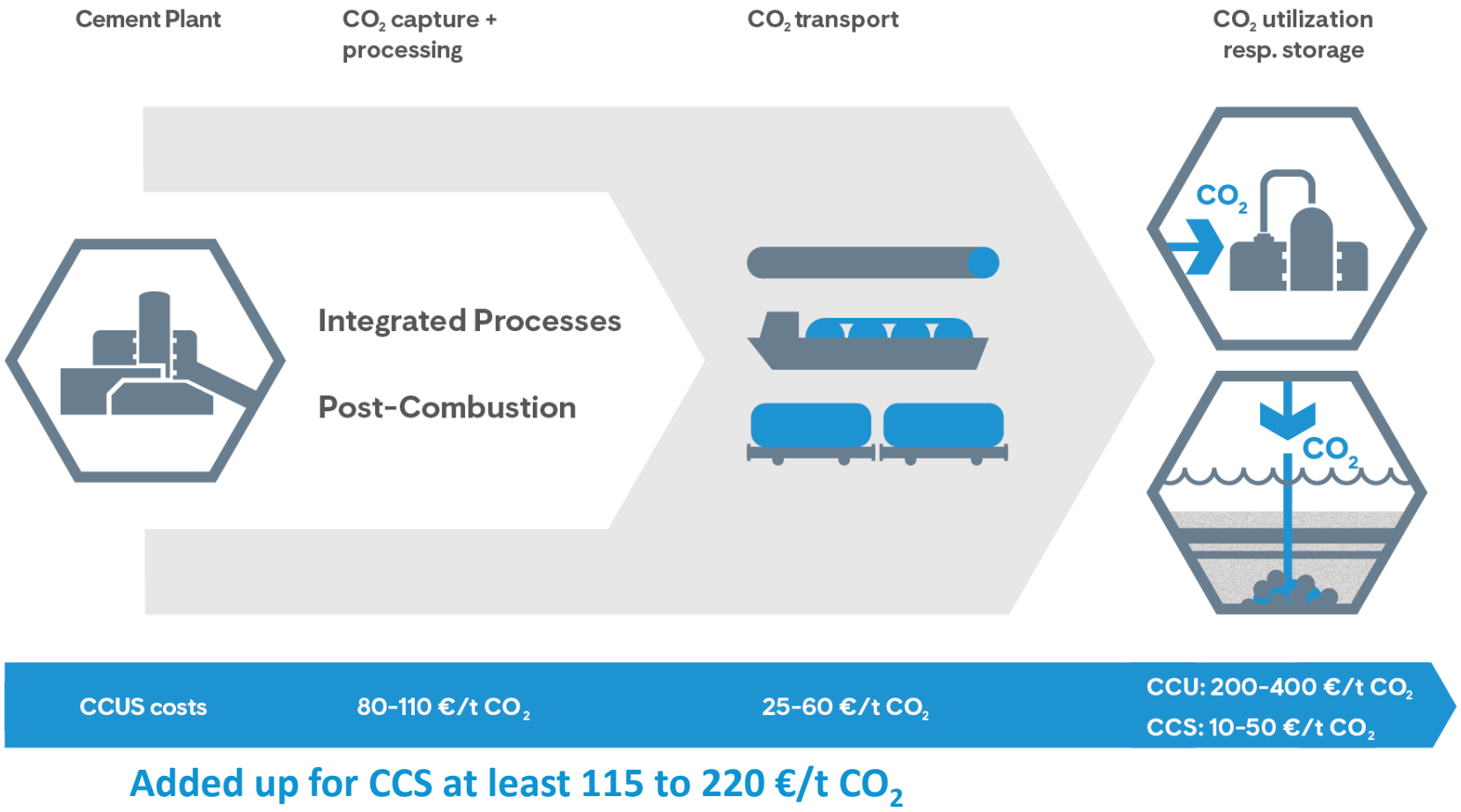
Investment and possible costs of the CCUS value chain

Investment need CO_2 pipelines

- about 14 bn € estimated for 4800 km in Germany
- Construction by 2035 for climate neutrality 2040
- 25 to 35 €/t CO_2 with/without transit volumes from Austria, Switzerland, East-France to North Sea

Transport by rail

- around 35 to 60 €/t CO_2 ca. 500 km incl. loading

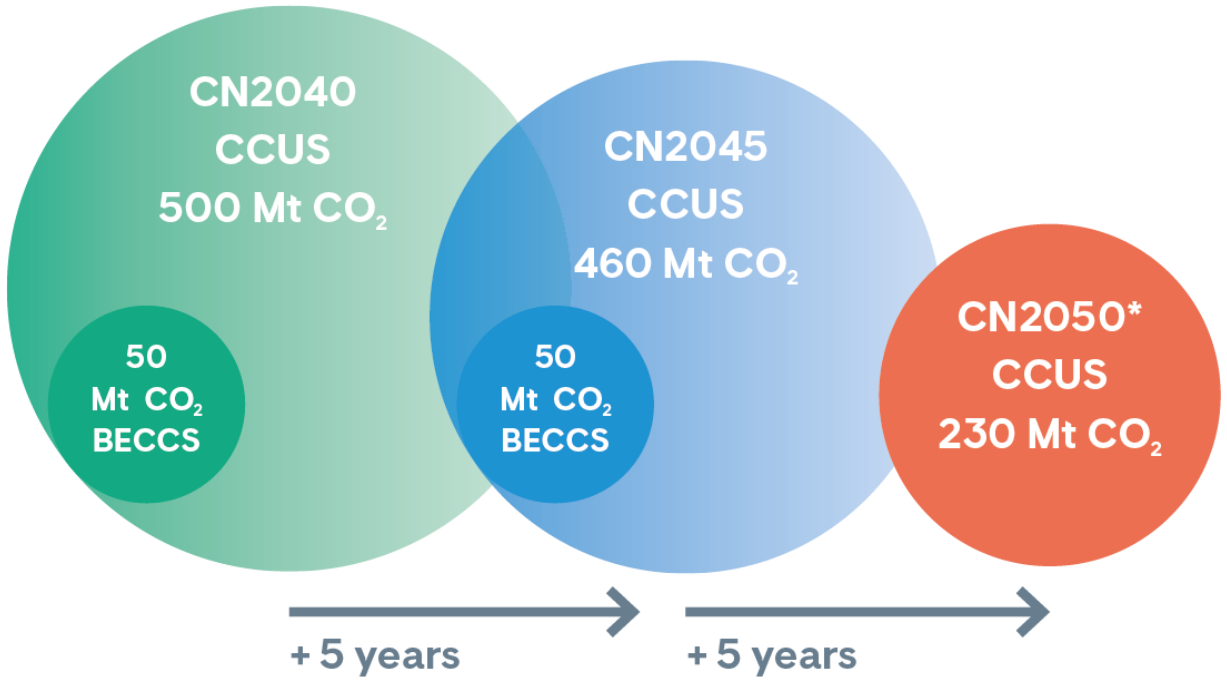


Added up for CCS at least 115 to 220 €/t CO_2

Sources: ECRA, VDZ, expert interviews, CO_2 Value Europe, IOGP / Note: The transport figures refer to a transport distance of approx. 500 km from the plant to the CO_2 export terminal on the coast. The costs for the connection to the pipeline network are not included. Assumptions for CO_2 capture: straight-line amortisation over 20 years; future increase in grid fees due to an increase in the plant's electrical connected load not taken into account.

Contribution of CO_2 infrastructure to climate protection

CCUS as a prerequisite for achieving Germany's climate targets



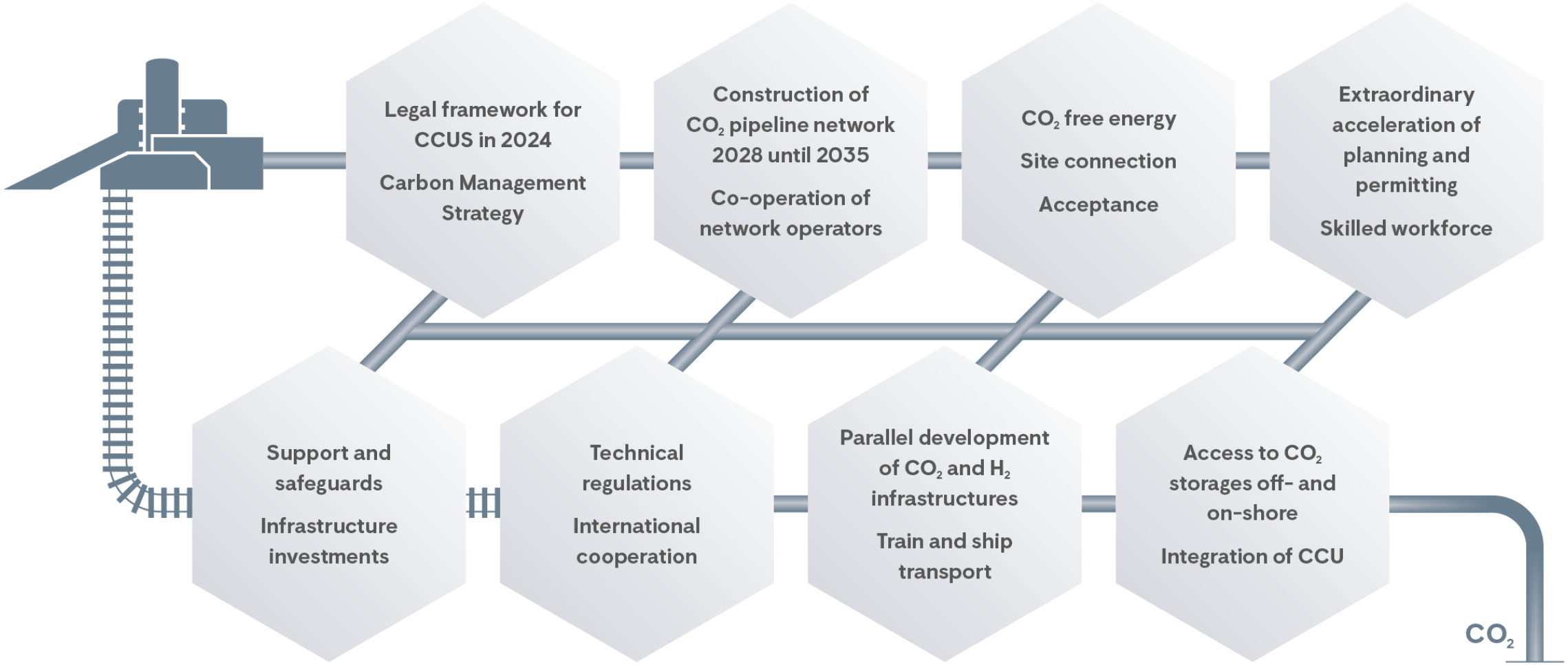
Pipeline connection: from 2028 → + 5 years → + 5 years (after 2033)

- Rapid infrastructure ramp-up enables cumulative CO_2 savings of 500 Mt CO_2
- In case of a significant delay, the infrastructure's contribution to climate protection will be halved (230 Mt CO_2)
- Innovative permitting procedures (e.g. bundling of authorisations for corridors for H_2 and CO_2 transport)
- Strategic network planning and financing
- Fast investment decisions required to maximise the CO_2 infrastructure's contribution to climate protection

Source: VDZ Climate neutrality scenarios CN2040 and 20245. *CN2050 = Climate neutrality will not be achieved until 2050. This analysis estimates the impact of a further delay in pipeline expansion on climate protection contribution of the CO_2 infrastructure network in Germany.

Requirements and fields of action

For the ramp-up of CO_2 capture, transport and storage in Europe



Source: VDZ

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