Evolving the well-established

Requirements for a CO_2 infrastructure in Germany and Europe

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Climate neutral process technologies

Exchange with NL and Delta-Rhine-Corridor Project

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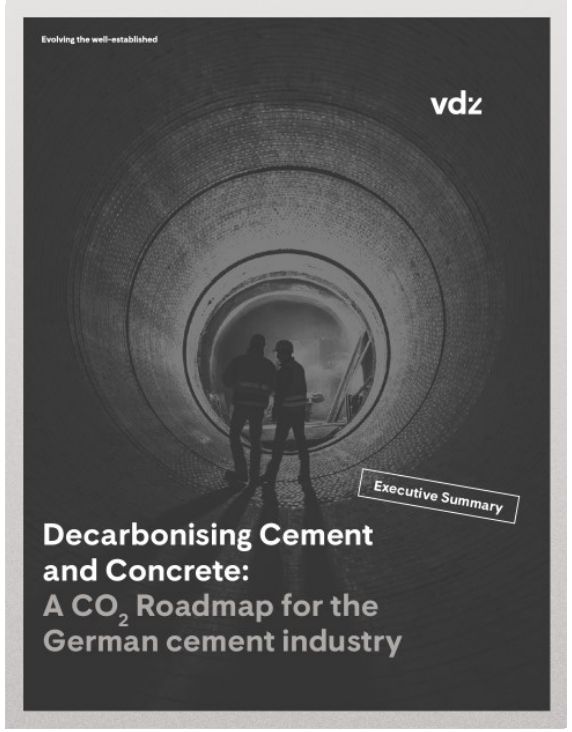
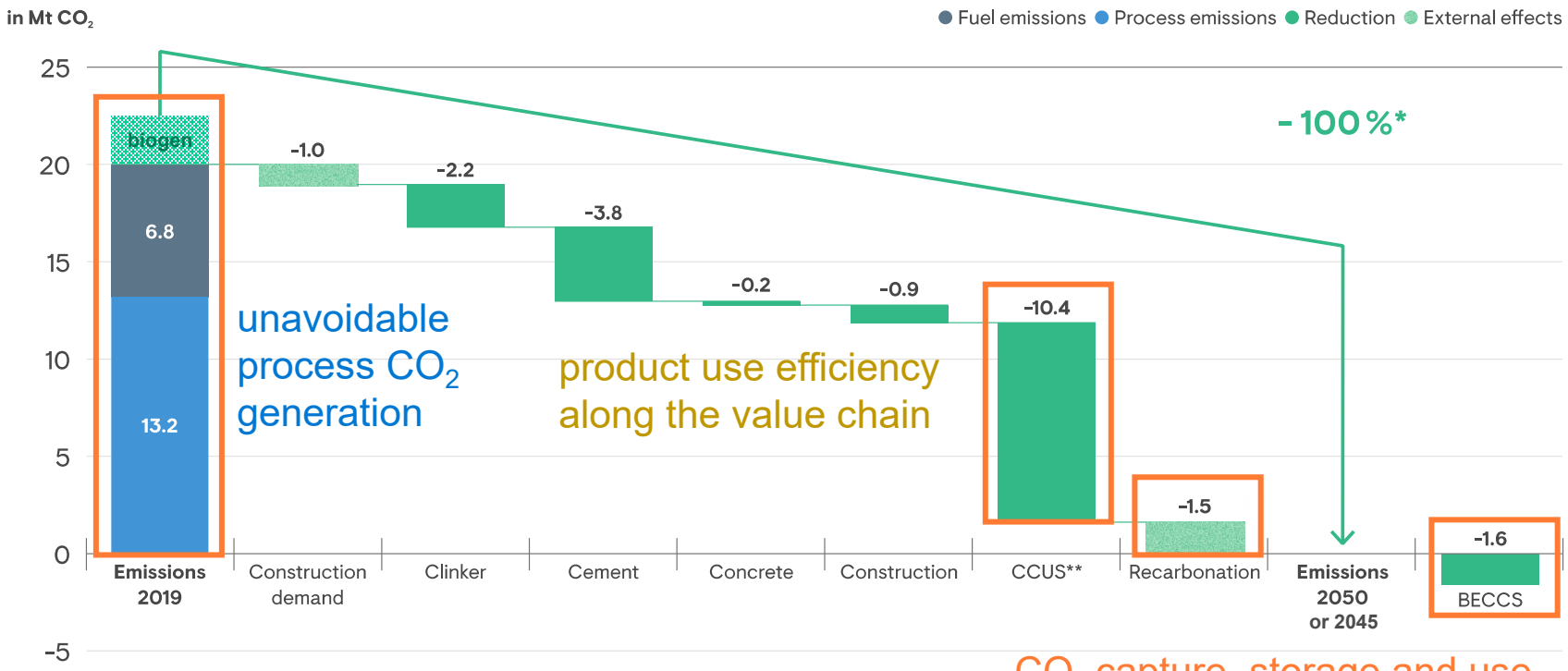
CO_2 for CCS and CCU from the cement industry

Today and perspective for climate neutrality in Germany



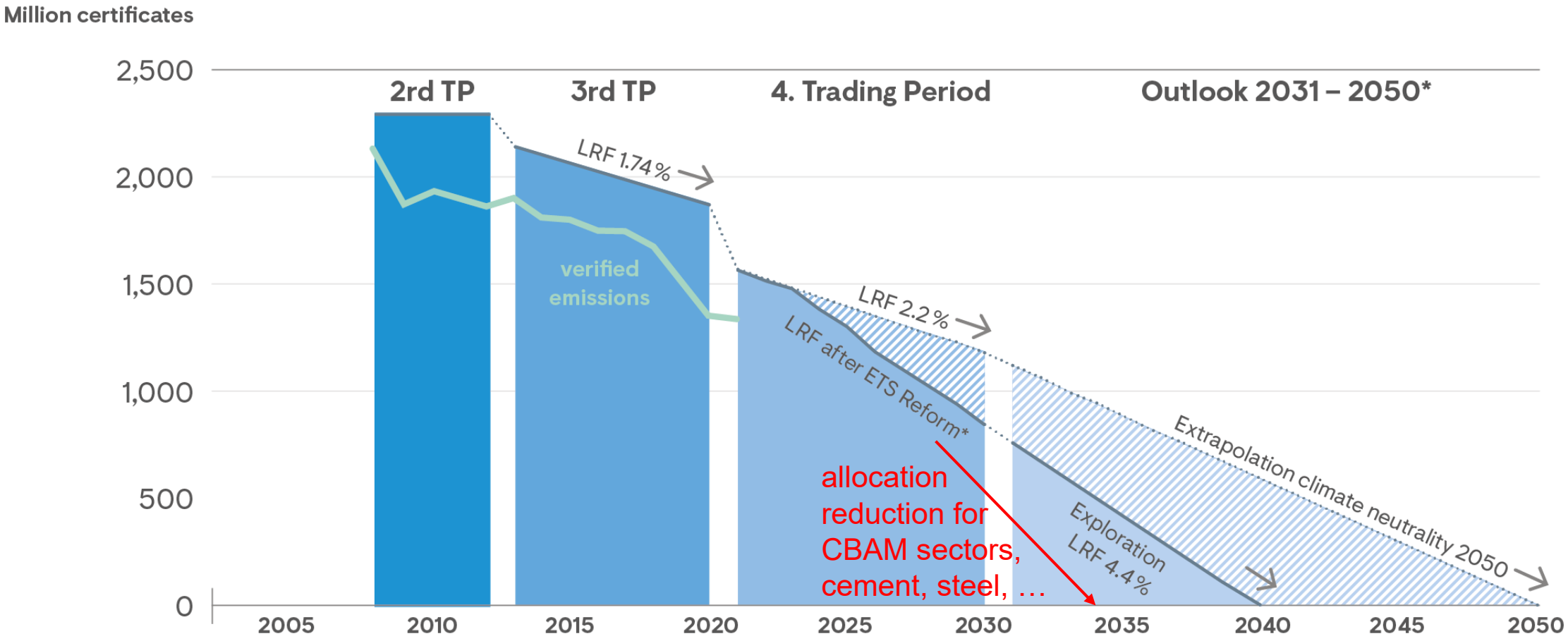


CO_2 capture, storage and use
12 – 14 Mt CO_2/year

Source: VDZ, https://www.vdz-online.de/en/cement-industry/climate-protection-1

Carbon Management – Time is pressing

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

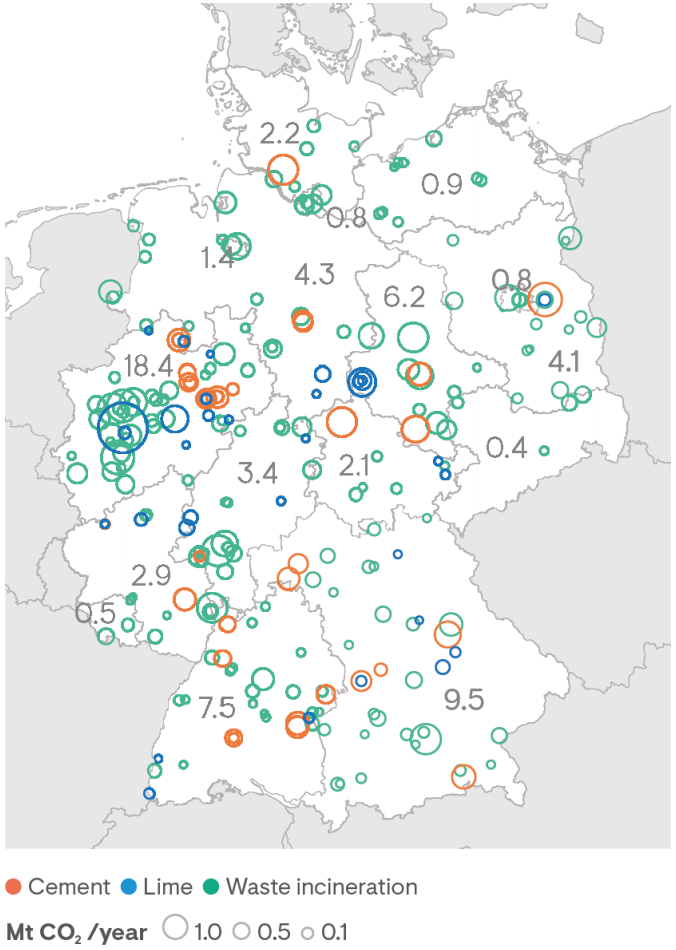


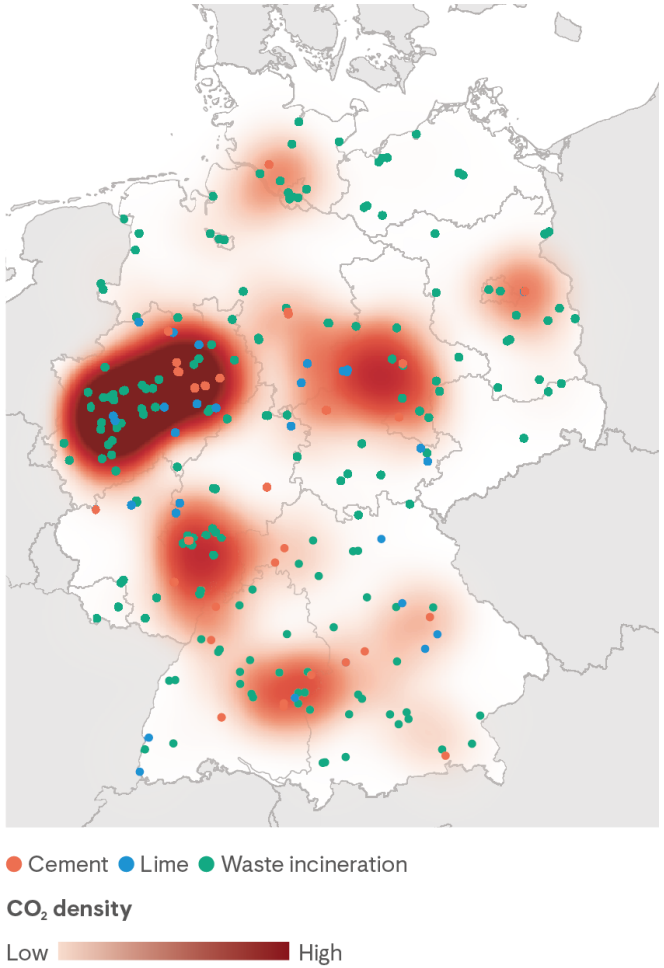
Sources: VDZ based on Federal Environment Agency, EU Commission, EU ETS Directive

* 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

Geographical distribution of CO_2 emissions and clusters

In the cement, lime and waste incineration sectors (today)

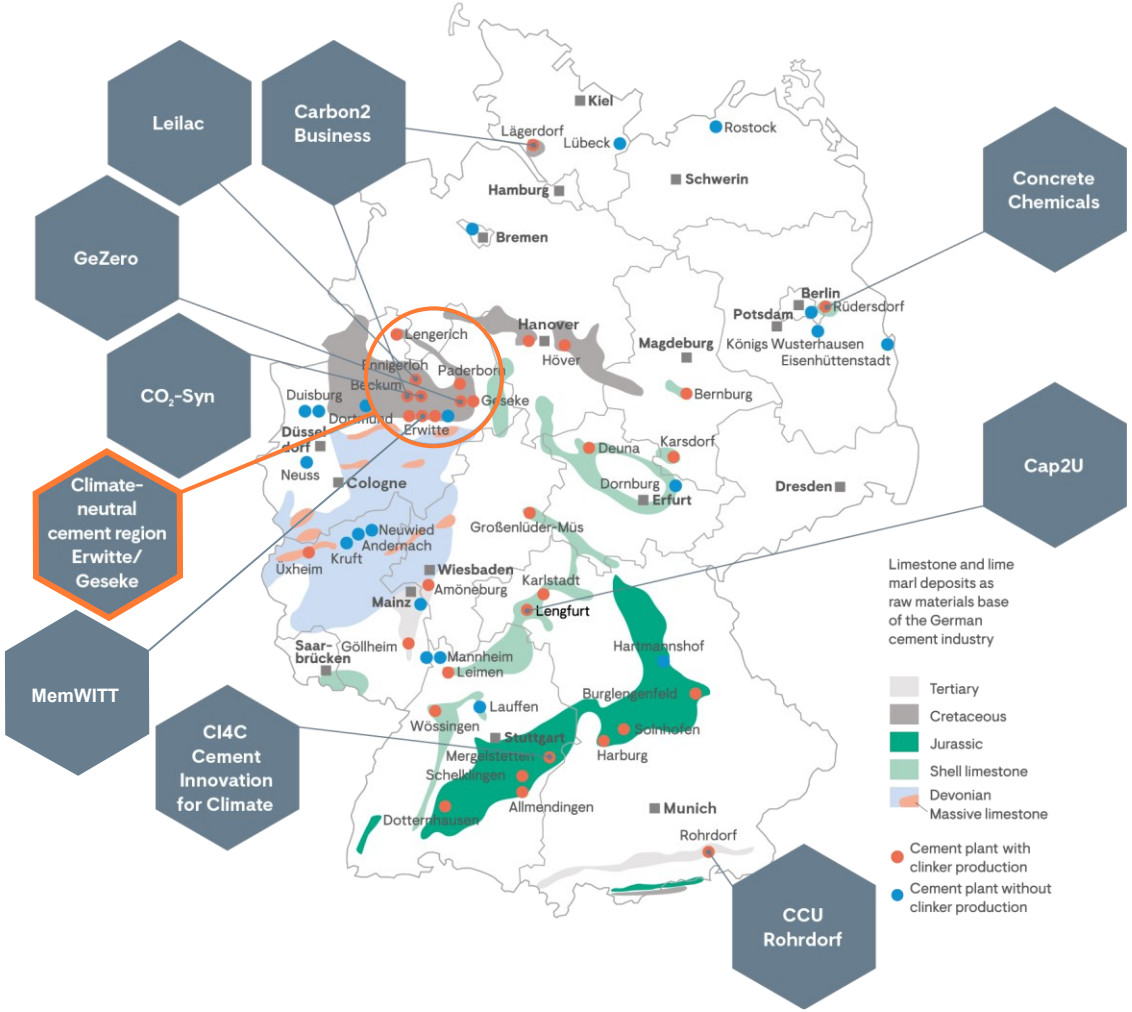




Sources: VDZ, VDZ CO_2 Roadmap, EU-ETS, E-PRTR, BV Kalk, ITAD
Notes: Figures = amount of CO_2 per federal state in Mt

Carbon Capture in the German cement industry

Project examples in Germany as a starting point for modelling



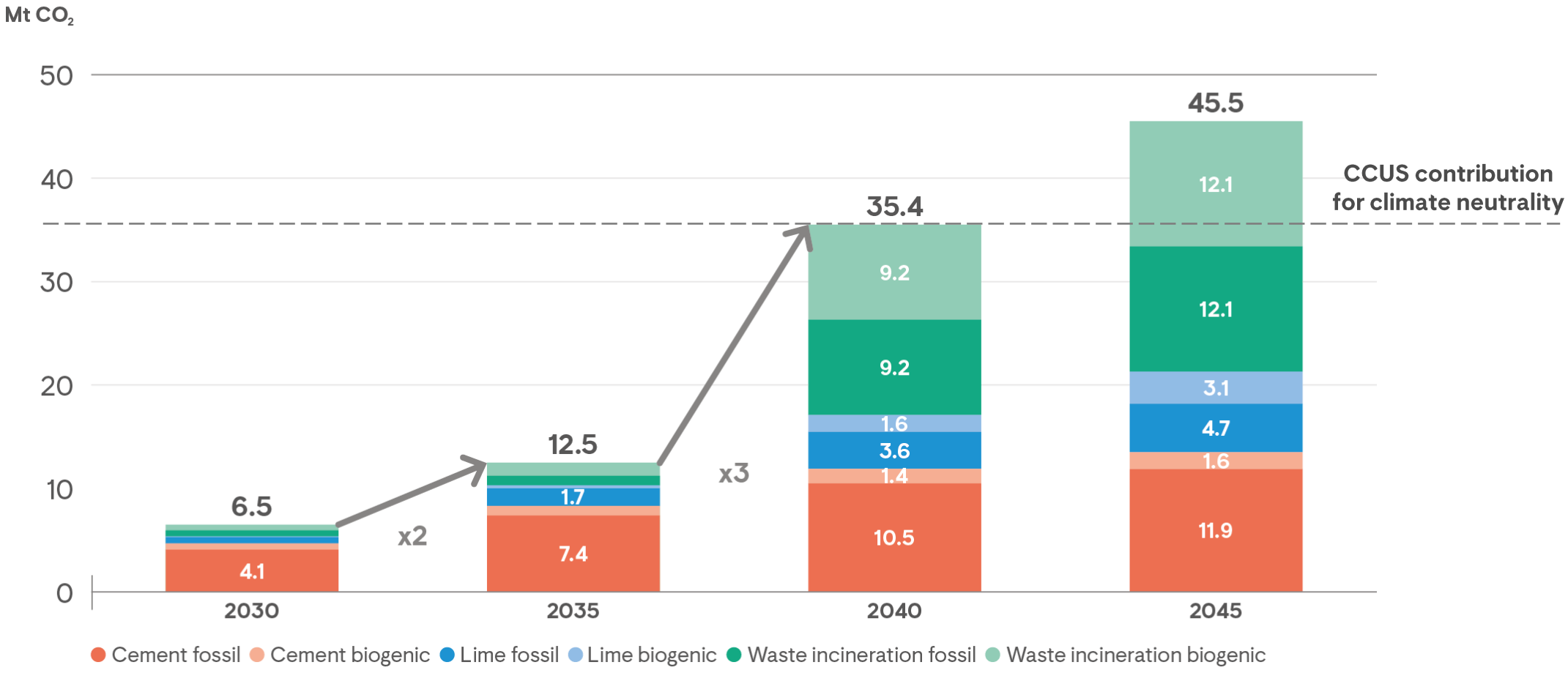
- 10 cement plants
- 1 regional initiative

- 4 lime plants
- 9 waste incineration plants

Sources: VDZ, GCCA
Note: A further 34 pilot projects in the area of waste incineration have been announced, but could not be quantified for the modelling

Fast ramp up of CO_2 capture and transport demand

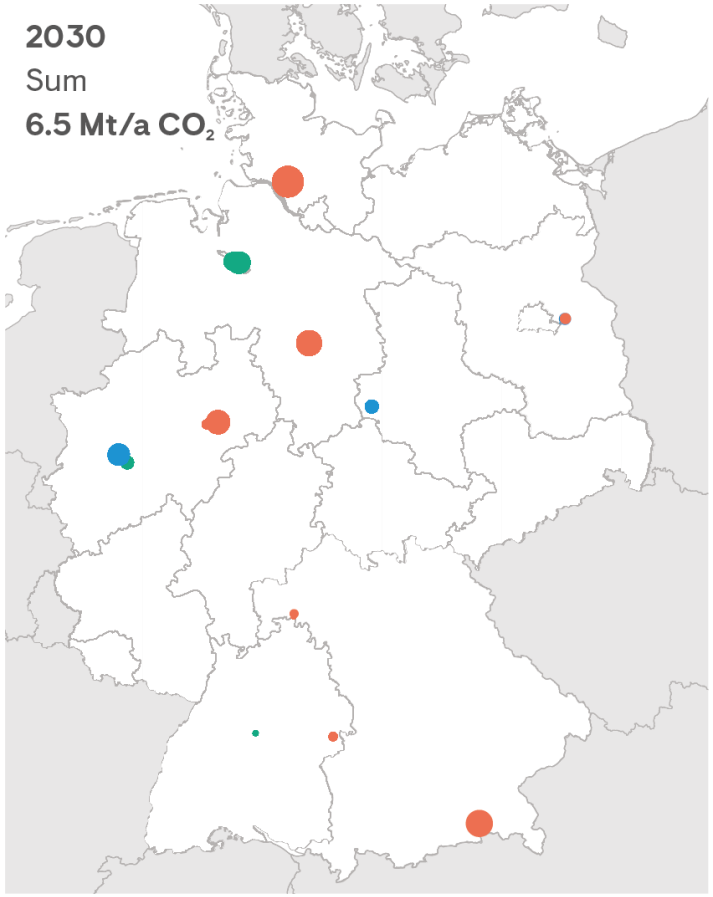
Cement, lime, waste incineration / Climate neutrality scenario 2040

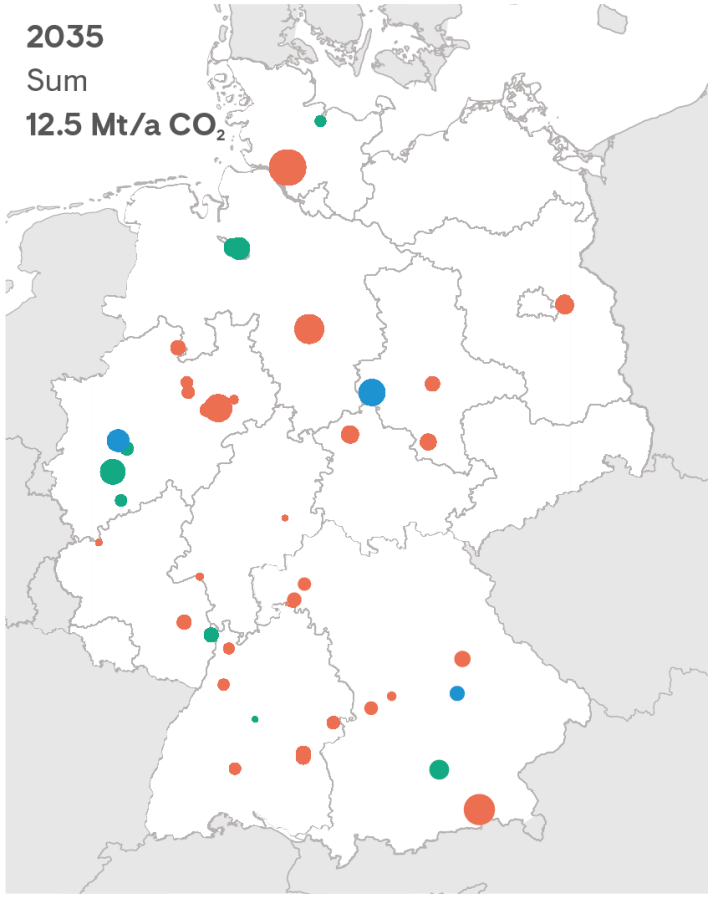


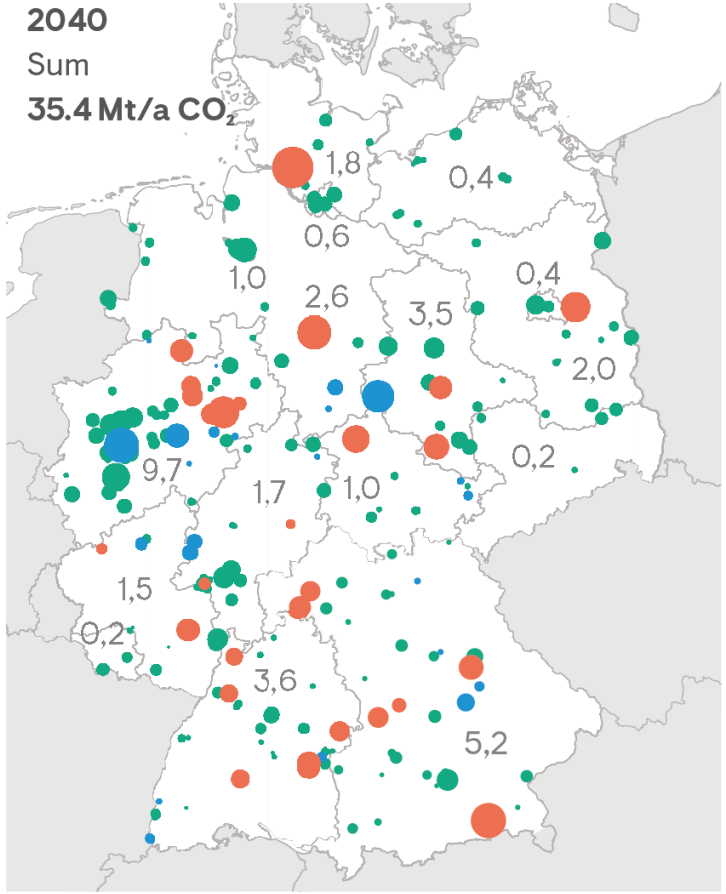
Sources: VDZ, EU ETS, E-PRTR, BV Kalk, ITAD
Note: All unavoidable CO_2 in cement and lime will be captured by 2045 (fossil/biogenic). At waste incineration plants, only 2/3 of the sites with CC, climate neutrality as a sector will still be achieved.

Temporal and geographical development of CO_2 volumes

Scenario CN2040





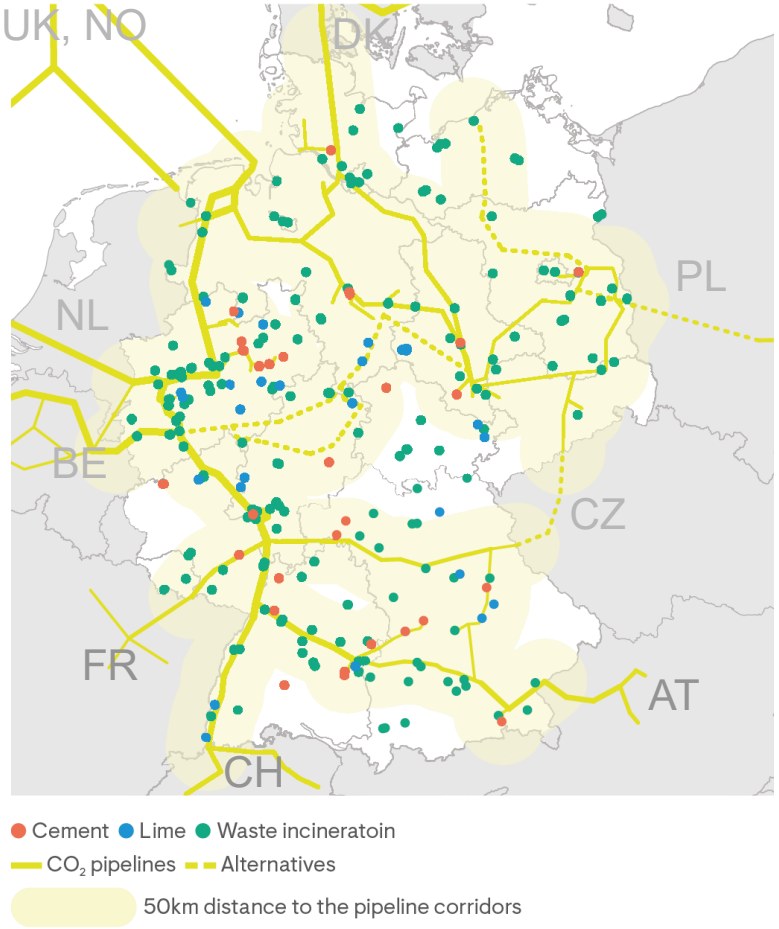


Source: VDZ

A CO_2 network for Germany

Pipeline connection of a large proportion of CO_2 sources possible and necessary

- Almost all cement and lime plants as well as many waste incineration plants at a distance of approx. 50 km from planned corridors
- Plant site-specific assessment of a connection required
- CO_2 network with a length of ~ 4,800 km required
- Construction by 2035 at the latest
  - Partly parallel to hydrogen network
  - Natural gas pipelines generally cannot be used for technical reasons
- Transit from Austria, Switzerland, East France needed



Sources: VDZ, BV Kalk, ITAD, OGE, bayernets, CapTransCO_2

CO_2 transport requirements for pipeline, rail and ship

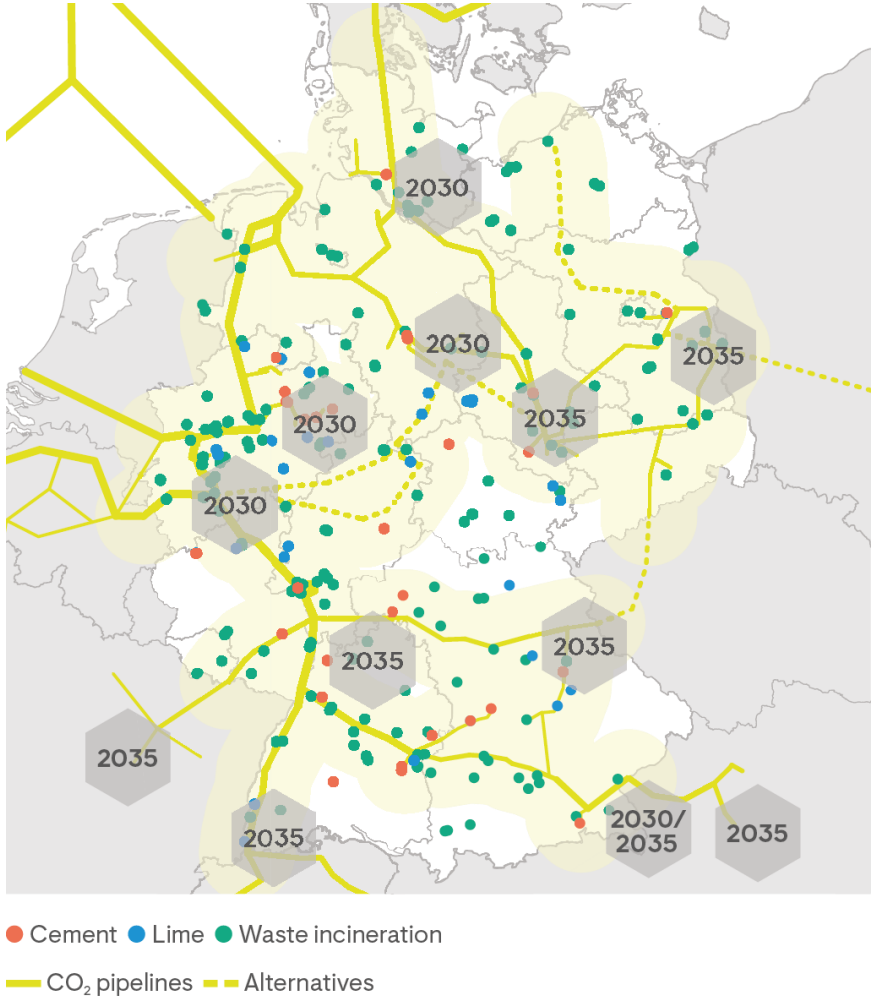
Pipeline network transports most of the CO_2, supporting role for rail and ship transport

Source: VDZ

CO_2 infrastructure requirements and investments

Rapid development of the pipeline network is essential

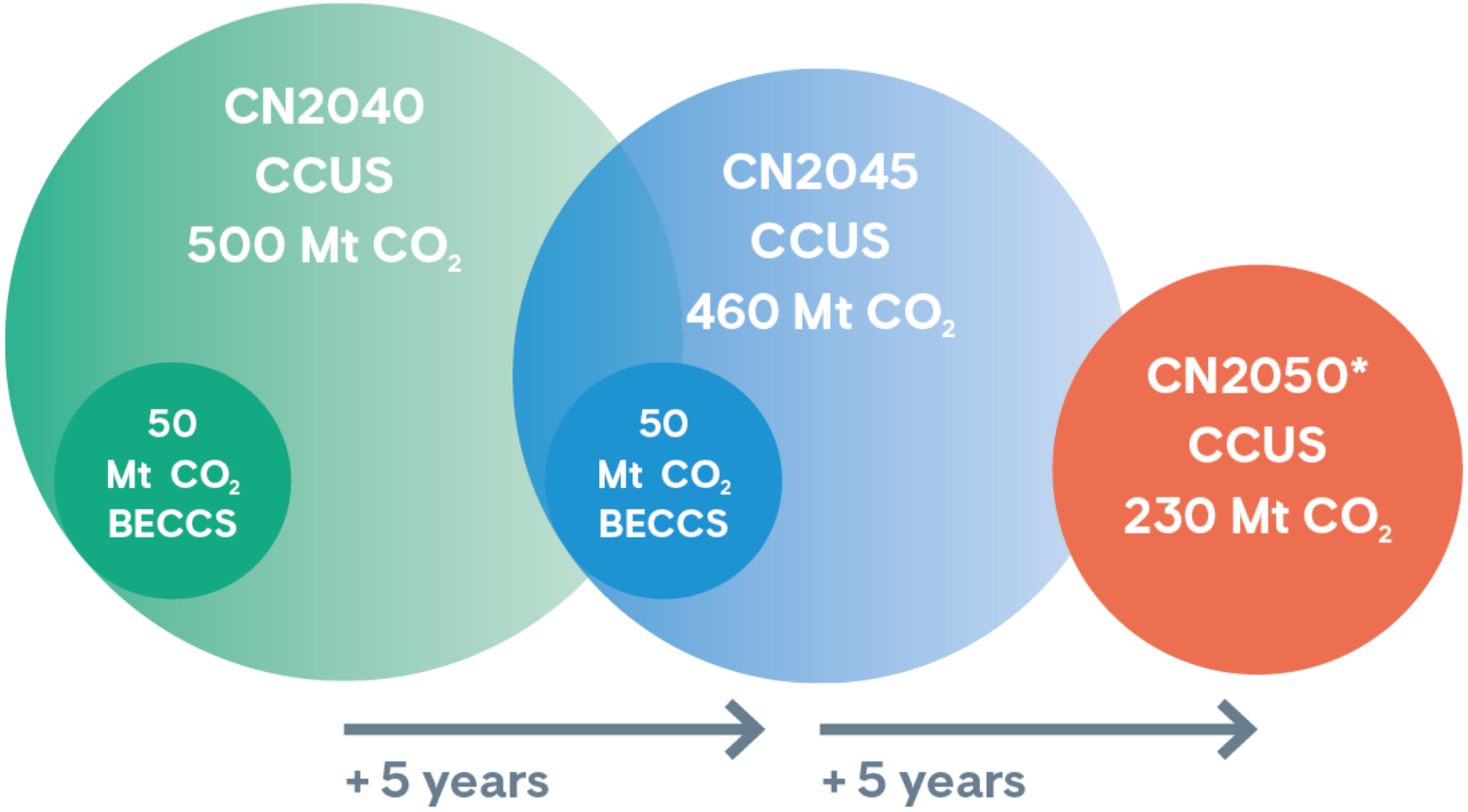
- Construction of the CO_2 long-distance pipeline network by 2035 in parallel across all regions
  - 4,800 km long with an investment requirement of around 14 bn euros
  - around 25 to 35 Euro / t CO_2 with or without transit volumes
- Train transport up to 5 to 9 Mt CO_2/a with stable transport volumes
  - 2 to 4 % of today's freight transport capacities
  - around 35 to 60 Euro / t CO_2



Sources: VDZ, BV Kalk, ITAD, OGE, bayernets, CapTransCO_2

Contribution of CO_2 infrastructure to climate protection

Cumulative CO_2 savings of 500 Mt possible with rapid implementation

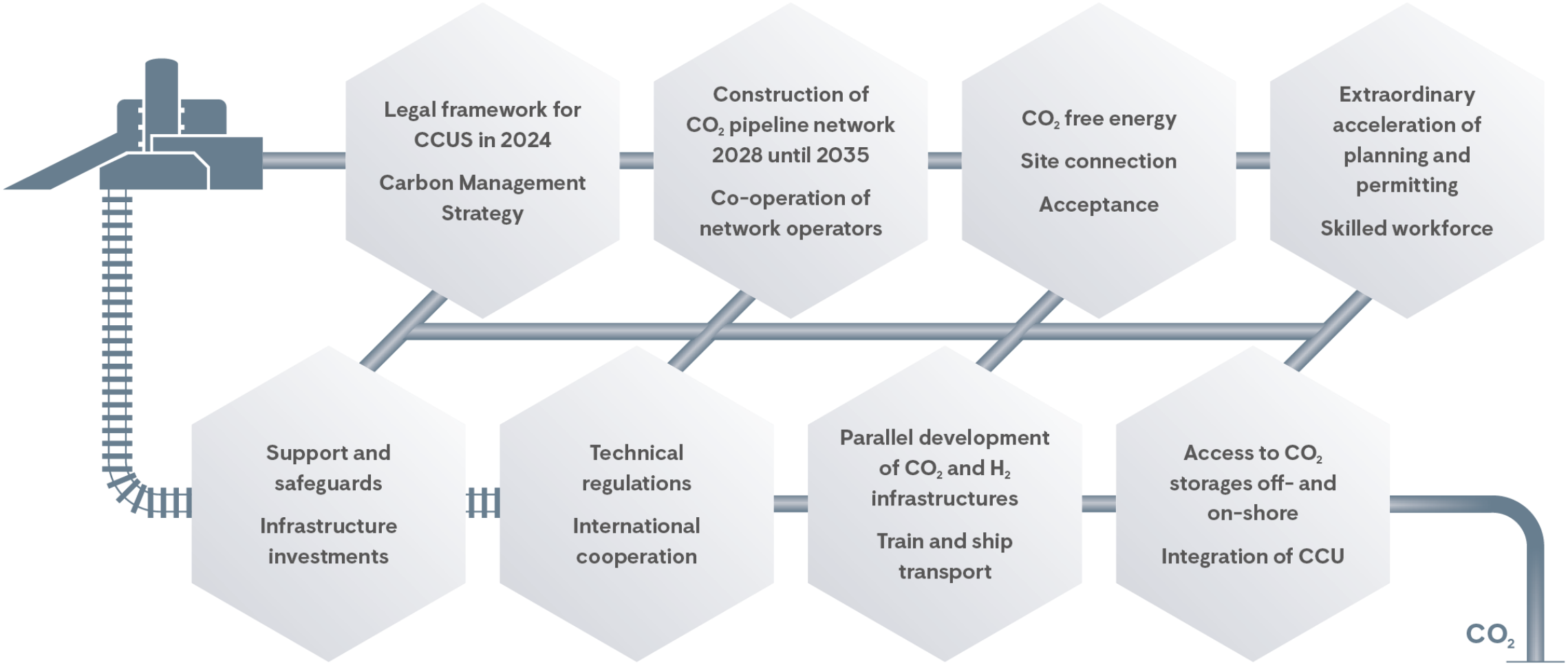


Pipeline connection: from 2028 → + 5 years → + 5 years (after 2033)

Source: VDZ / Note: CN2050 = Climate neutrality will not be achieved until 2050. This analysis is not a separate scenario. It merely estimates the impact of a further delay in pipeline expansion on the climate protection contribution of the CO_2 infrastructure network.

Requirements and fields of action

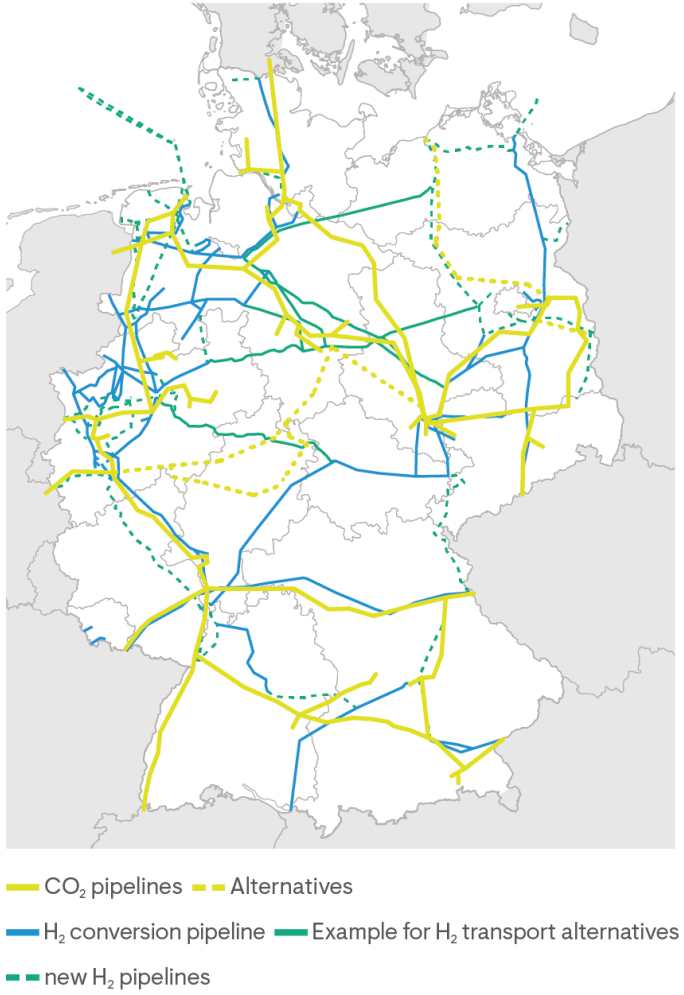
For the ramp-up of CO_2 capture and transport



Source: VDZ

Parallel development of CO_2 and H_2 pipeline network

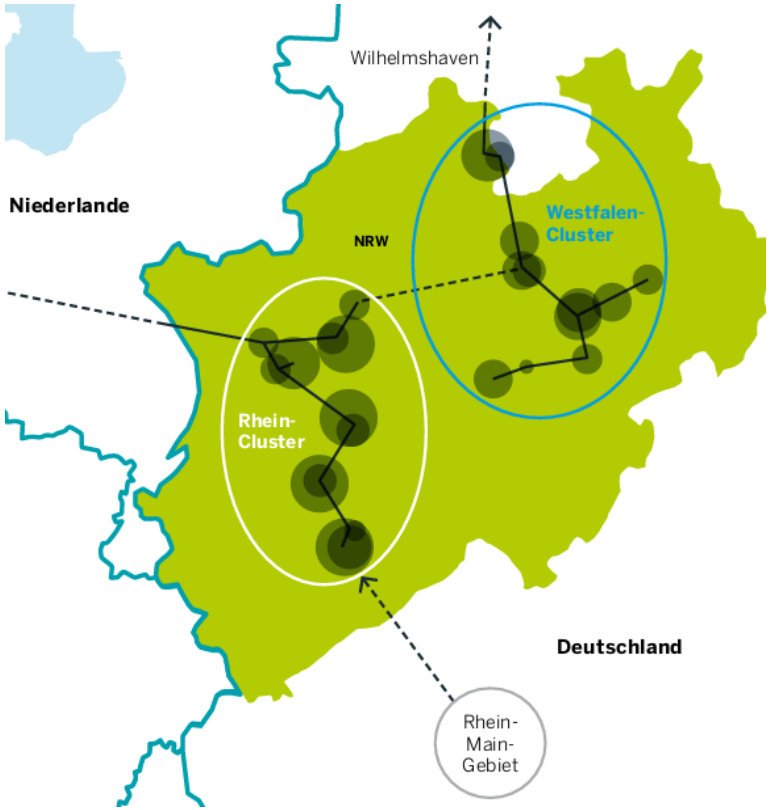
- Increasing parallelisation of CO_2 and H_2 pipeline construction
- Innovative permitting procedures (e.g. bundling of authorisations for corridors for H_2 and CO_2 transport)
- Strategic network planning and financing
- Transfer of acceleration measures from H_2 to CO_2 transport



Sources: VDZ, OGE, bayernets, CapTransCO_2, EHB

Carbon-Management-Strategy, NRW and Germany, BMWK

Carbon management for climate protection, targeting climate neutral industry production in NRW

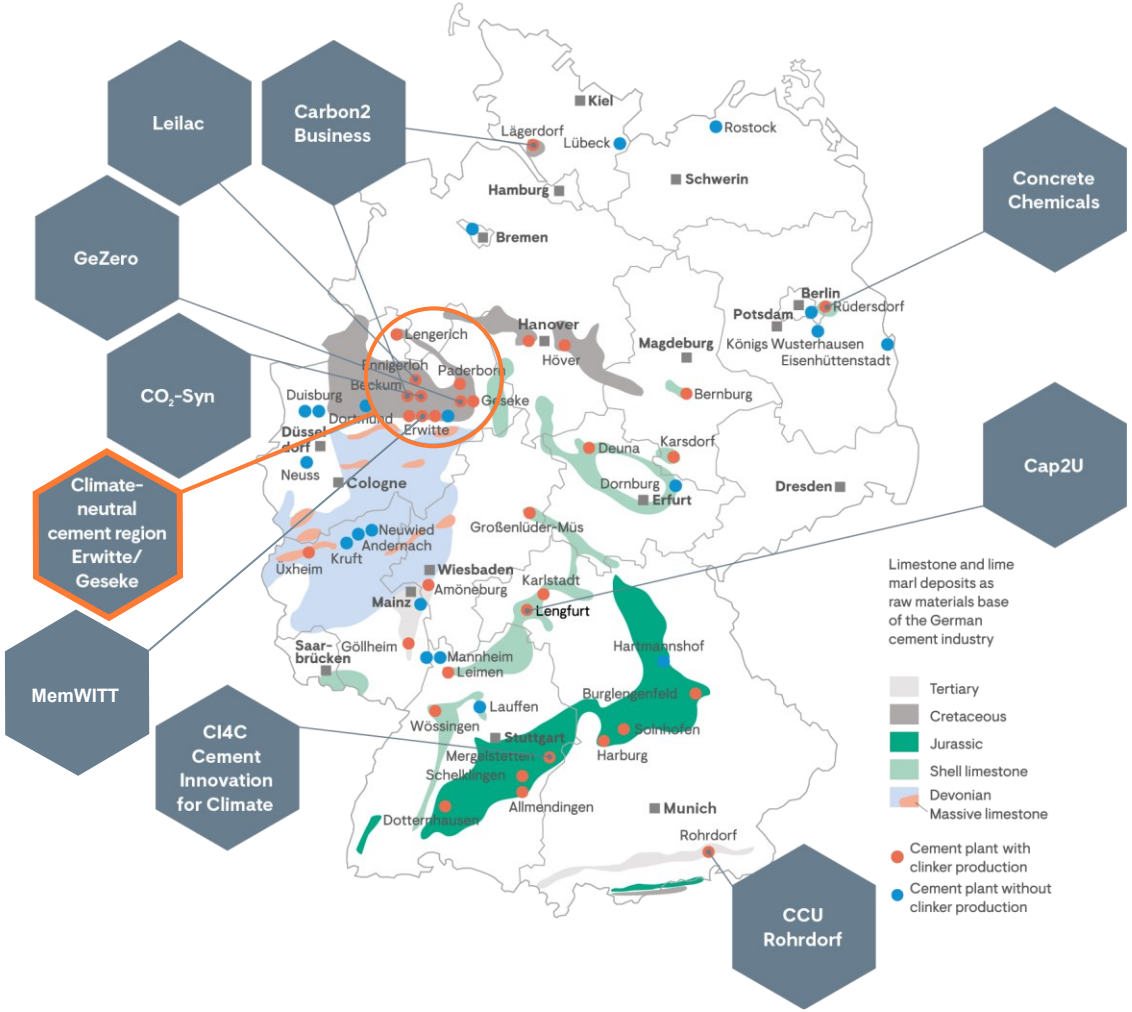


- Reduction of carbon intensity and fossil carbon in industrial processes as far as possible
- Nachhaltige Kohlenstoffnutzung: Sekundärrohstoffe, C-Recycling
- CO_2 Management and Infrastruktur: CCX, CO_2 capture, transport, usage (CCU) and storage (CCS)
- Social discourse and acceptance in society for new technologies

https://www.wirtschaft.nrw/sites/default/files/documents/mwide_br_carbon_management_strategie_summary_eng_bf.pdf
and In4Climate.NRW working group on carbon economy

Carbon Capture in the German cement industry

Project examples in Germany as a starting point for modelling



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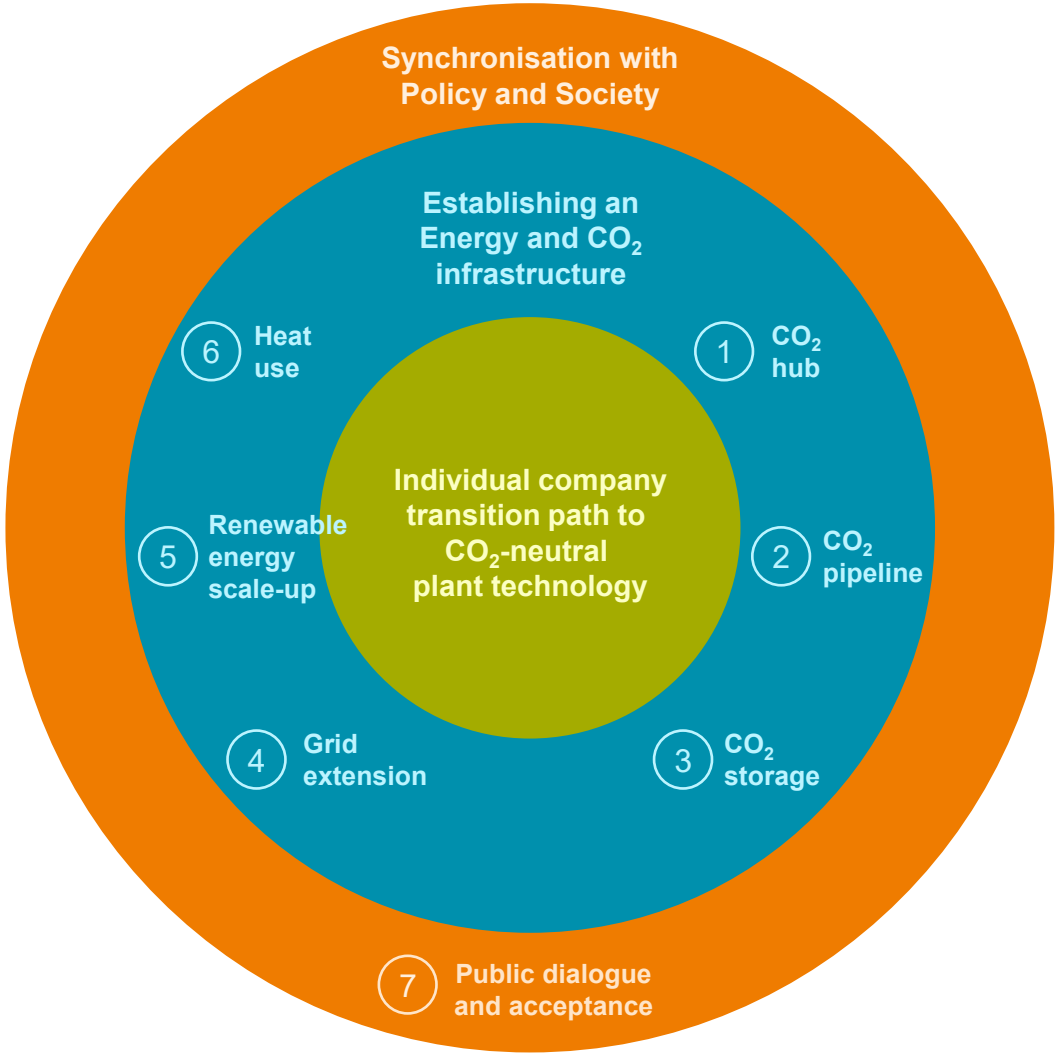
Transformation towards a climate neutral cement region

7-point-program for a wholistic feasibility study

http://erwitte.net/wp-content/uploads/2024/02/KNZR_Abschlussbericht_Druckversion.pdf

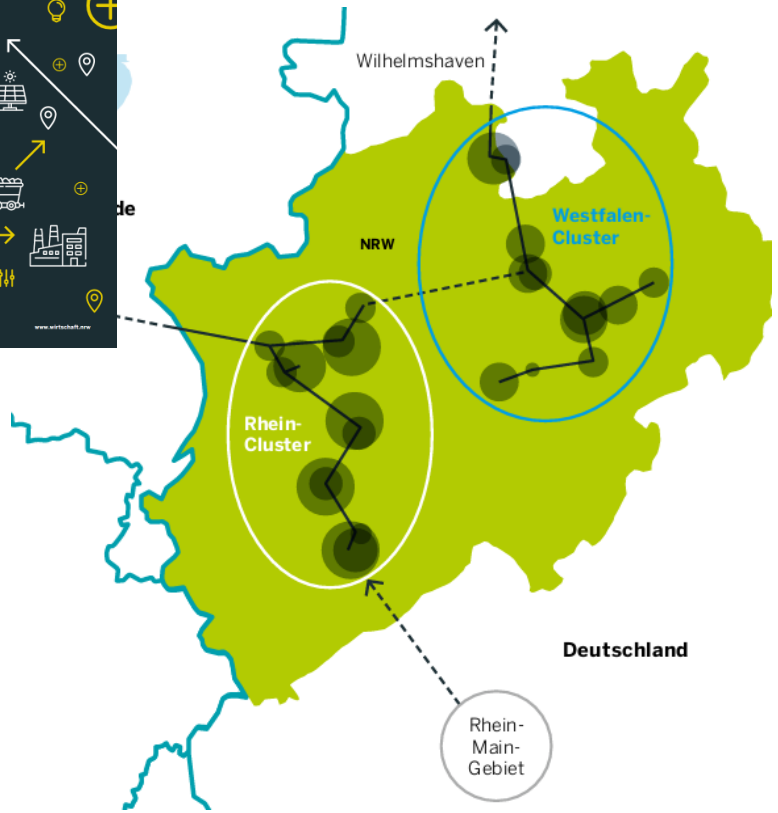
Final presentation of the Initiation Project Climate Neutral Cement Region Erwitte / Geseke



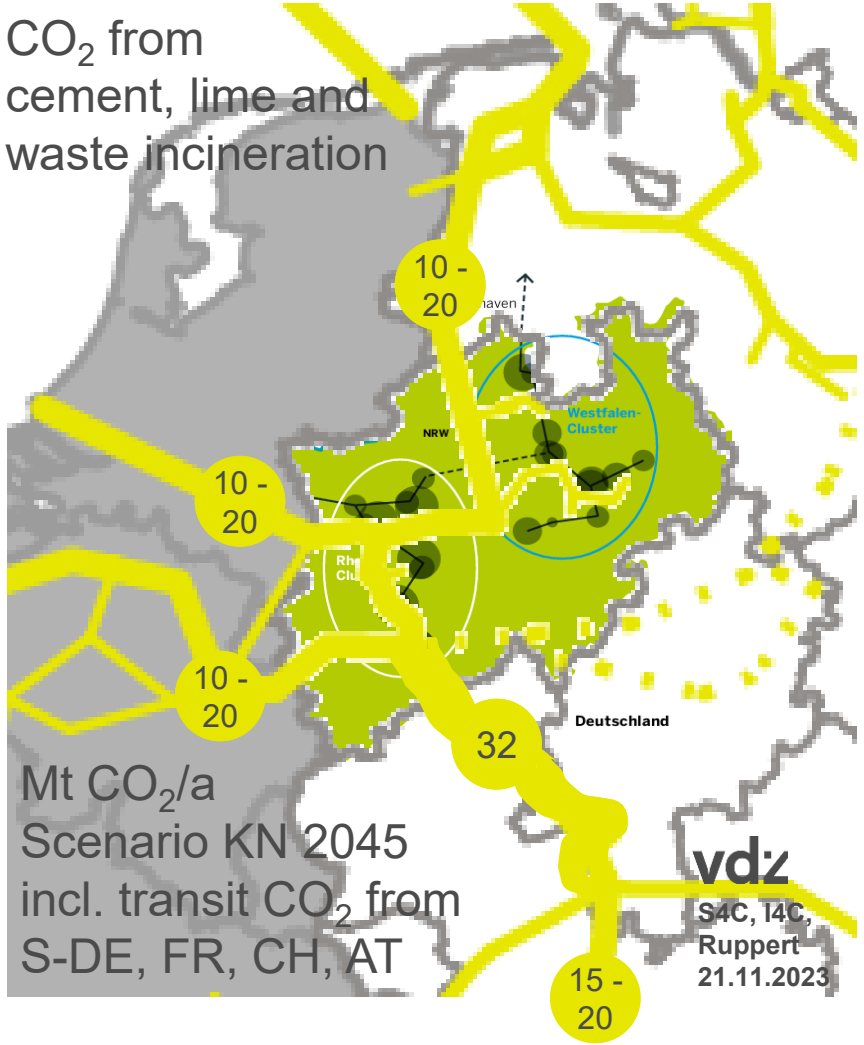
CO_2 infrastructure requirements

Perspectives with NRW detail on pipeline capacity demands

2021



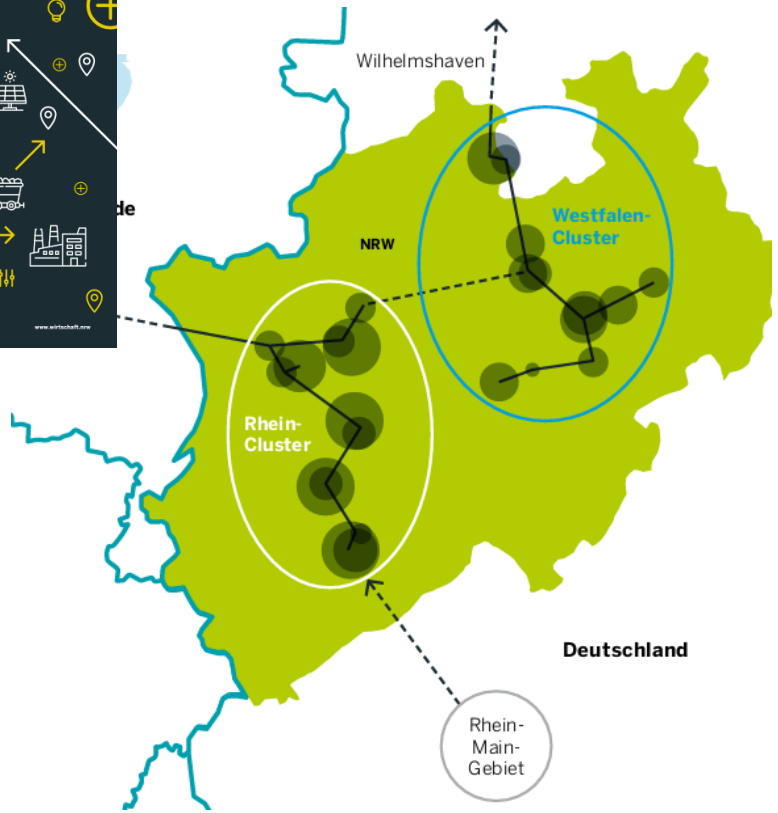
CO_2 from cement, lime and waste incineration

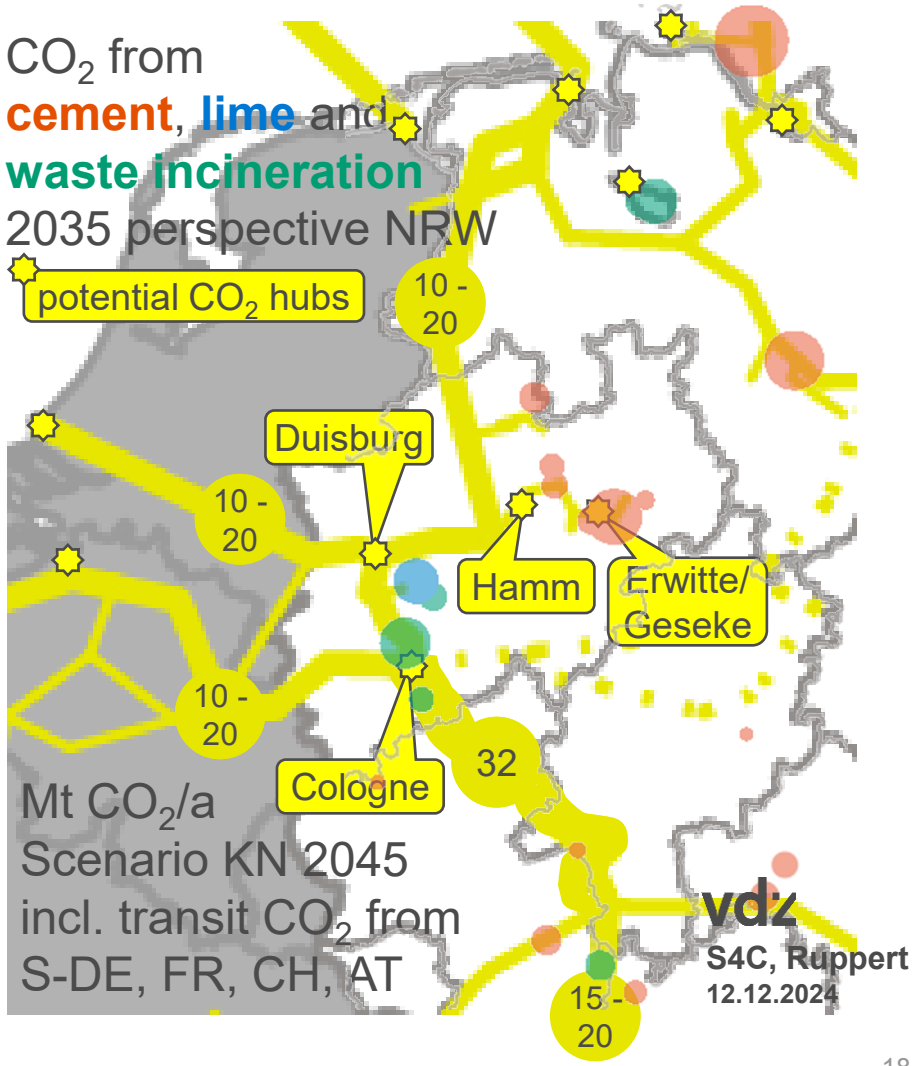


CO_2 infrastructure requirement

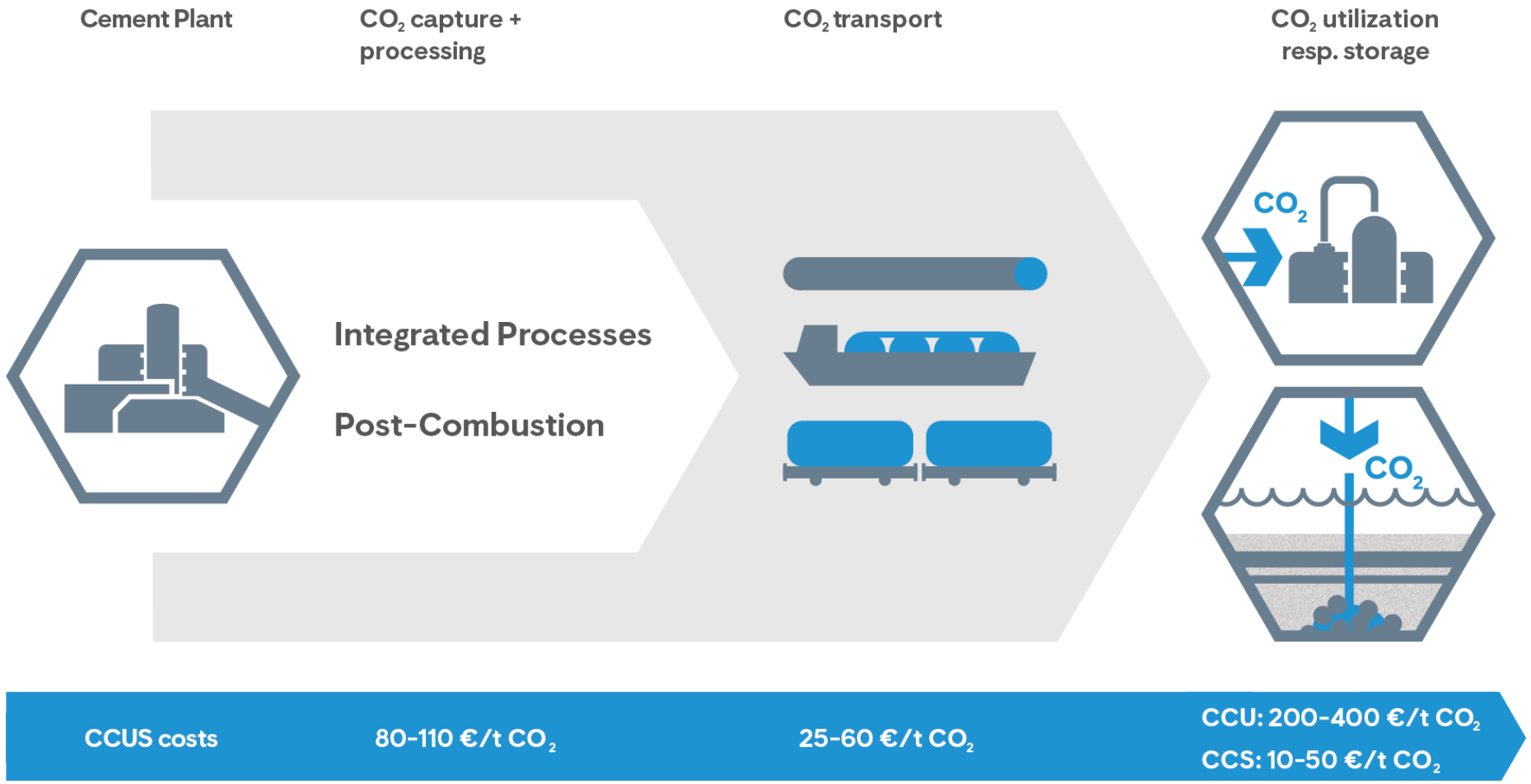
Perspectives with NRW detail on expected CO_2 capture projects 2035 and potential hub locations

2021





Possible costs of the CCUS value chain



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.

Energy requirement for CO_2 capture in 2045

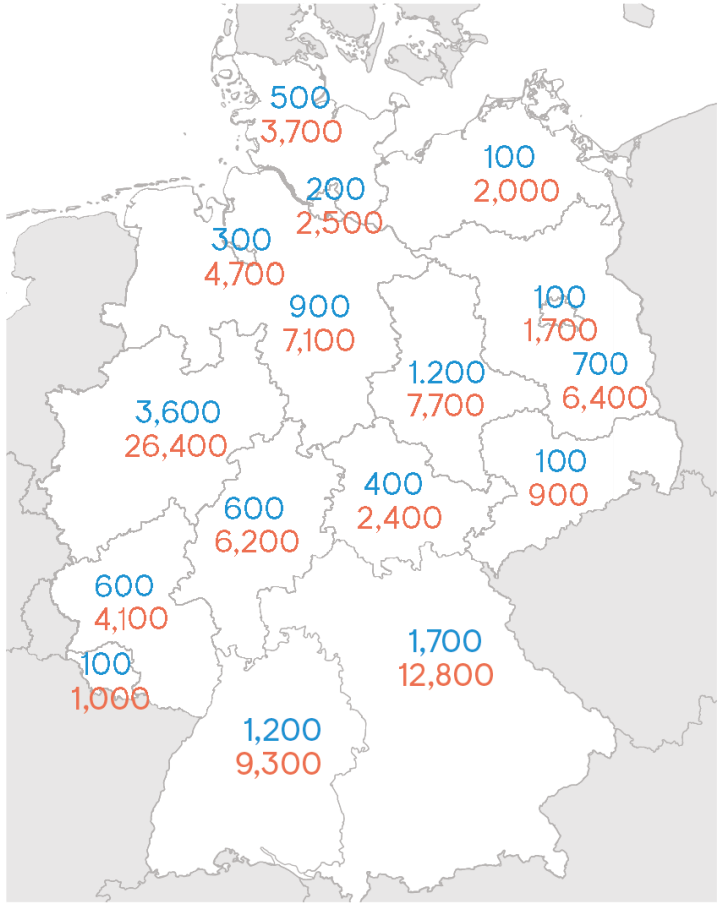
Key building block for climate neutrality in cement, lime and waste incineration

CO_2 free electrical energy demand around 12 TWh/a

- 1/3 of Südlink capacity (35 TWh/a)
- 1,400 wind turbines*
- Quadrupling the current energy demand level of cement and lime production

Thermal energy demand around 100.000 TJ/a

- Around 20 % of today's fuel energy requirements in the cement, lime and waste incineration sectors
- Additional energy requirement ultimately depends on the technology selected for the specific site



Sources: VDZ, ITAD, BV Kalk, Transnet BW, Stromrechner / Anmerkung: *) at approx. 8.8 GWh/a per 5 MW wind turbine

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