Navigating the Roadmap for Clean, Secure and Efficient Energy Innovation

SET-Nav
Strategic Energy Roadmap

The role of CCS

Carbon Capture, Transport and Storage in the future electricity and industry?

Franziska Holz

Joint work with T. Scherwath (DIW Berlin), C. Skar (NTNU), Andres Ramos, Luis Olmos, Q. Ploussard, S. Lumbreras (Comillas), and A. Herbst, Frank Senssfuss, Christiane Bernath (Fh ISI)

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CCS in an Infrastructure Case Study and the Pathways

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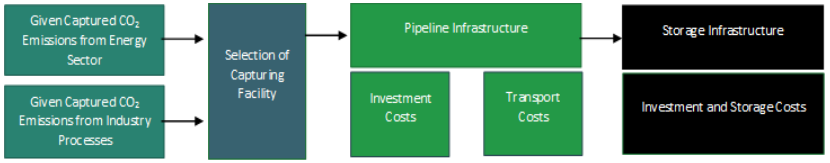
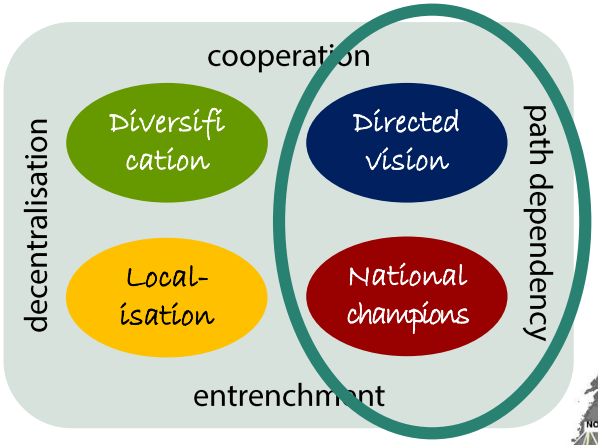
CASE STUDY CCTS INFRASTRUCTURE



Climate policy intensity	Optimistic	Pessimistic	No CCTS
Pathway I *Business as Usual (BAU)*	**Scenario 1:** High profit from CO_2-EOR; High efficiency gains in capturing technology; No CCTS in industry	**Scenario 2:** No profit from CO_2-EOR; Low CCTS efficiency gains and cost reduction; No CCTS in industry	**Scenario 5:** No CCTS technology available
Pathway II *Decarbonisation (DEC)*	**Scenario 3:** Same as scenario 1 + CCTS used in industry	**Scenario 4:** Same as scenario 2 + CCTS used in industry	**Scenario 6:** No CCTS technology available

PATHWAY ANALYSIS



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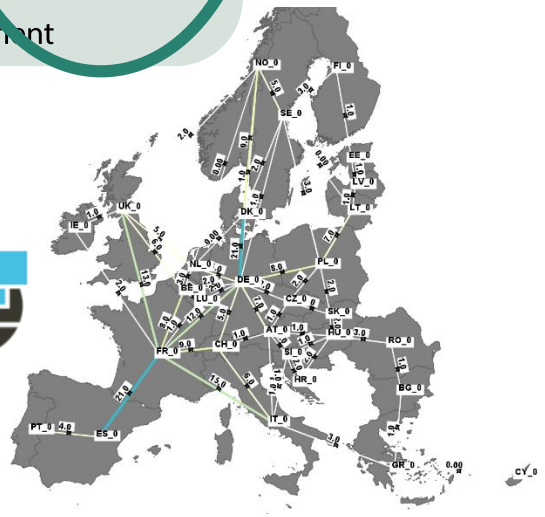

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Main Messages

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1. **Model linking** can improve the data input of the models but it is a challenging effort.
2. CCS can only be envisaged under certain circumstances and their realization is **uncertain**.
3. **CO_2-EOR** can help kick-start the development of a CCS value chain in Europe.
4. Large-scale use of CCS requires the deployment of a **CO_2 pipeline network** which benefits from **economies of scale** when jointly used for CO_2 emissions from the power sector and industry.

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Model Linking: Data Improvement vs. Compatibility

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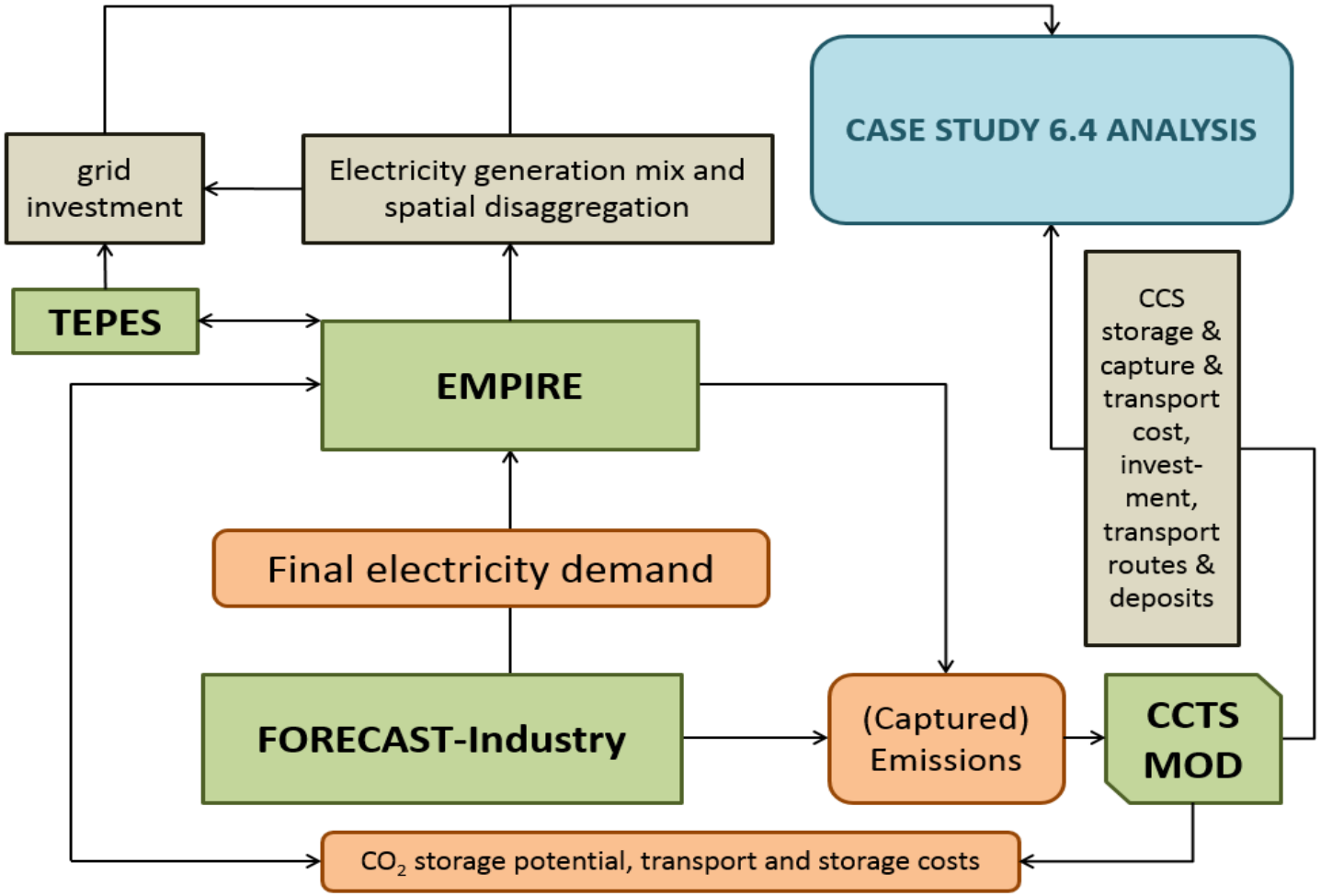

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Strong and Uncertain Assumptions

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Application	Power plant type	Efficiency	CO_2 capture rate	Investment costs in €/kW
EMPIRE (Case study)	Coal with CCS	39-43%	80-90%	2150-2500
	Gas with CCS	52-60%	80-90%	1250-1350
	Lignite with CCS	37-43%	80-90%	2250-2600
ENERTILE Directed Vision Pathway	Coal with CCS	38%	93%	3000-3400
	Gas with CCS (CCGT)	54%	95%	1200-1500
	Lignite with CCS	37%	92%	3400-3800
ENERTILE National Champions Pathway	Coal with CCS	38%	93%	3600-4080
	Gas with CCS (CCGT)	54%	95%	1440-1800
	Lignite with CCS	37%	92%	4080-4560
Global CCS Institute (2017) estimates	Coal with CCS	28-33%	90%-94%	3870-4651
	Gas with CCS	46%	90%	1701
		Short-/Mid-term capture cost	**Long-term capture cost**	**Reference plant scale (annual production in t)**
FORECAST-Industry	Cement production	65-135 €/tCO_2	25-55 €/tCO_2	1 Mt. clinker
	Steel production	25-65 €/tCO_2	0-55 €/tCO_2	4 Mt hot rolled coil
	Refineries and petrochemicals	50-120 €/tCO2	>30€/tCO_2	1-2 $GtCO_2$

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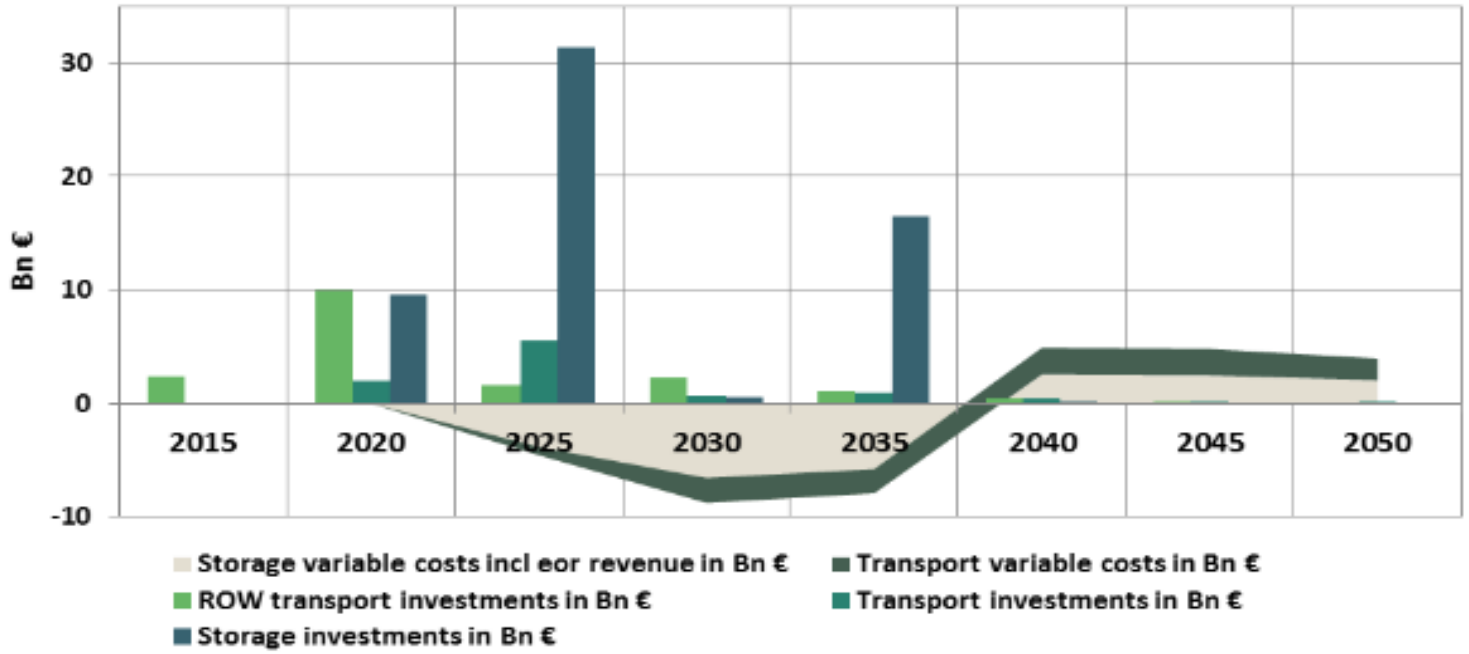
CCS Storage: CO_2-EOR in early Periods

- EOR brings down average variable storage costs to negative values (i.e. there is an economic benefit of storing CO_2)
- Investment expenditures are highest for CO_2 storage because new facilities have to be constantly put into operation (small size of facilities)



High CCS scenario (Scenario III in the Case Study)

Joint Infrastructure Use by Industrial and Electricity CO_2 creates Economies of Scale

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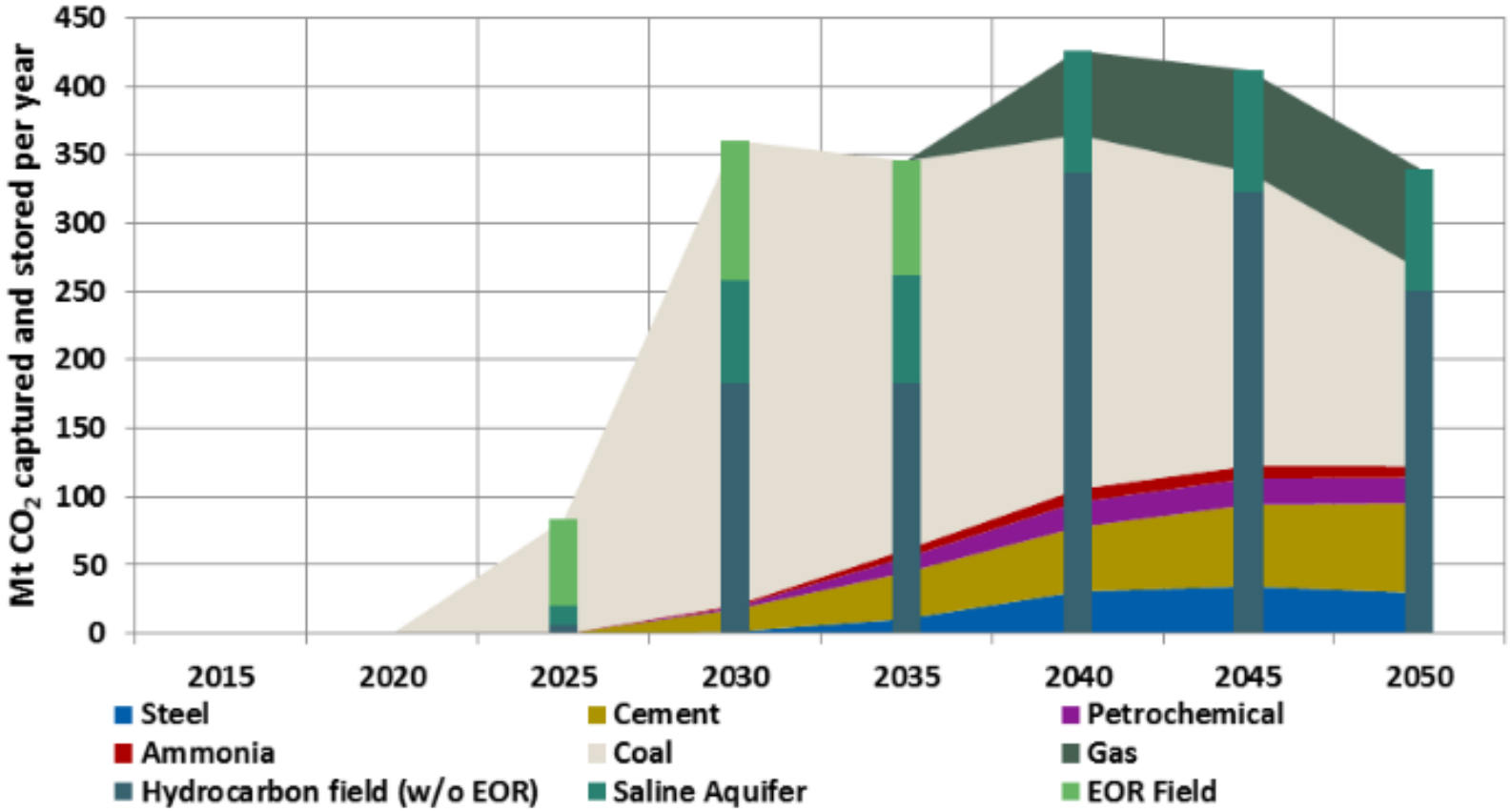

High CCS scenario (Scenario III in the Case Study)

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CO_2 Infrastructure Deployment: Economies of Scale

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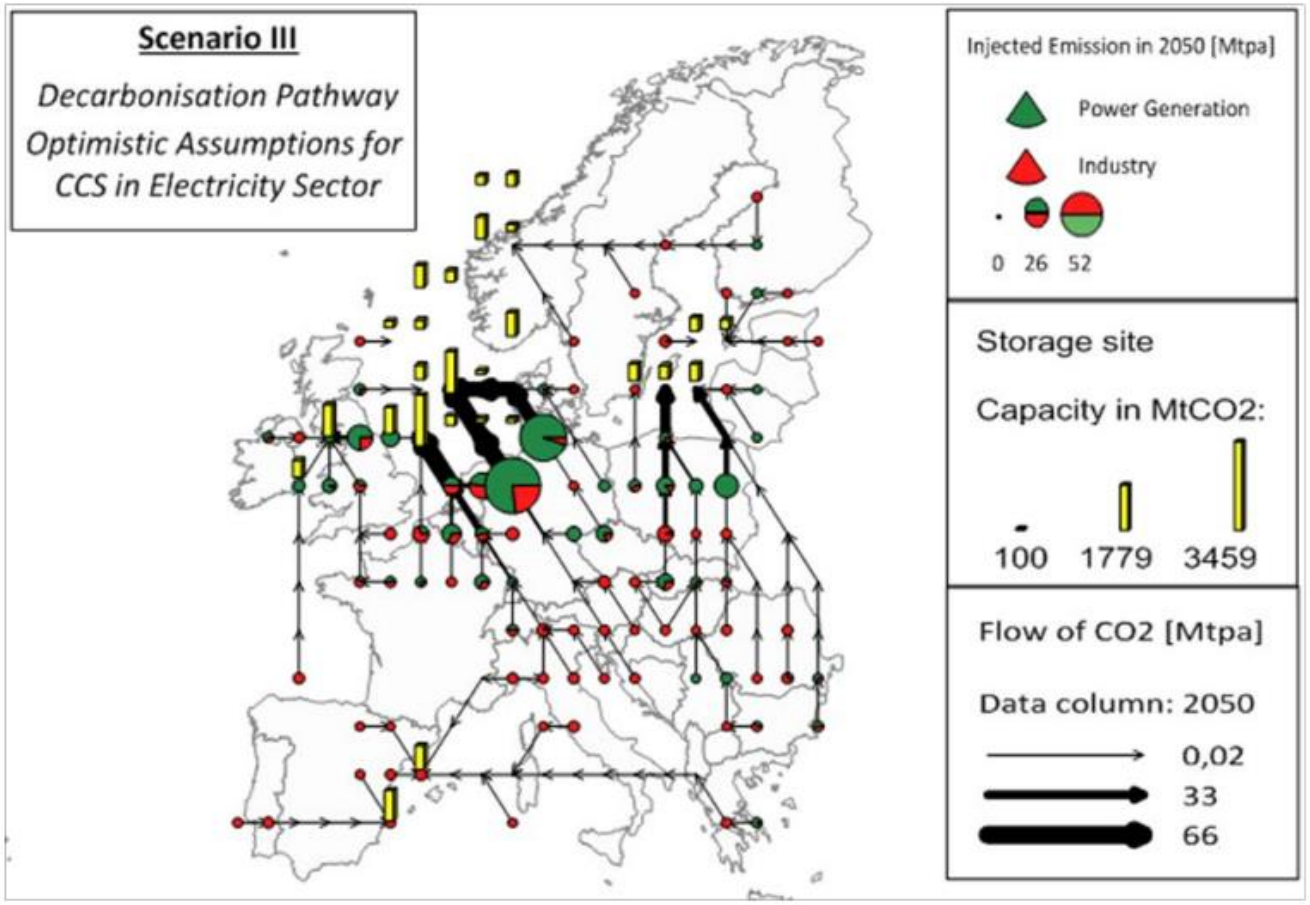

Economies of scale in CO_2 pipeline infrastructure also make capturing far away from the (North Sea) shore an economically feasible option

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Thank you!

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Electricity Mix in Scenario III (Case Study)

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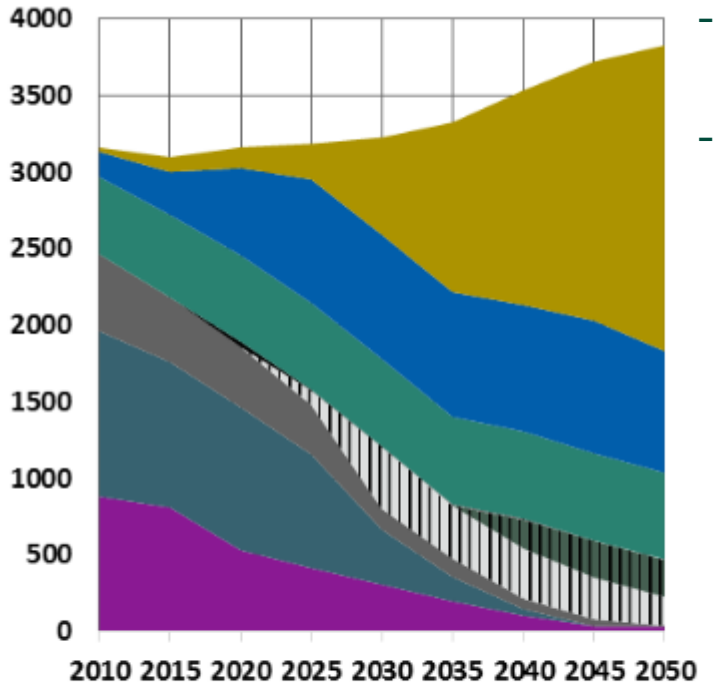

- CCS plays a complementary role to renewables
- Conventional thermal power plants with CCS serve as „balancing" capacity for intermittent renewables

Nuclear
Unabated Coal
Unabated Gas
Coal CCS
Gas CCS
Bio
Hydro/Geo/Ocean
Wind
Solar PV

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Captured Emissions in Industry (Case Study: Decarbonization)

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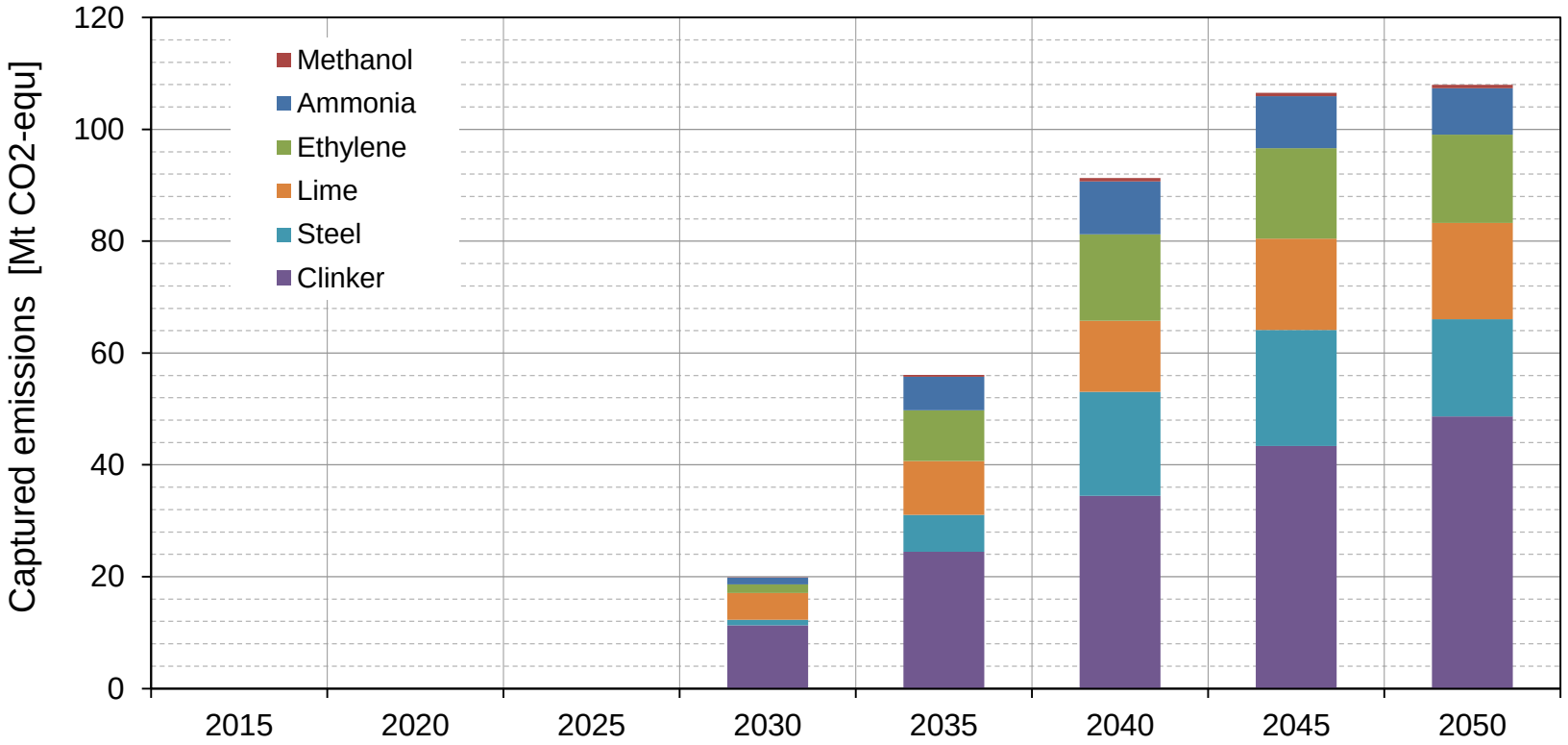

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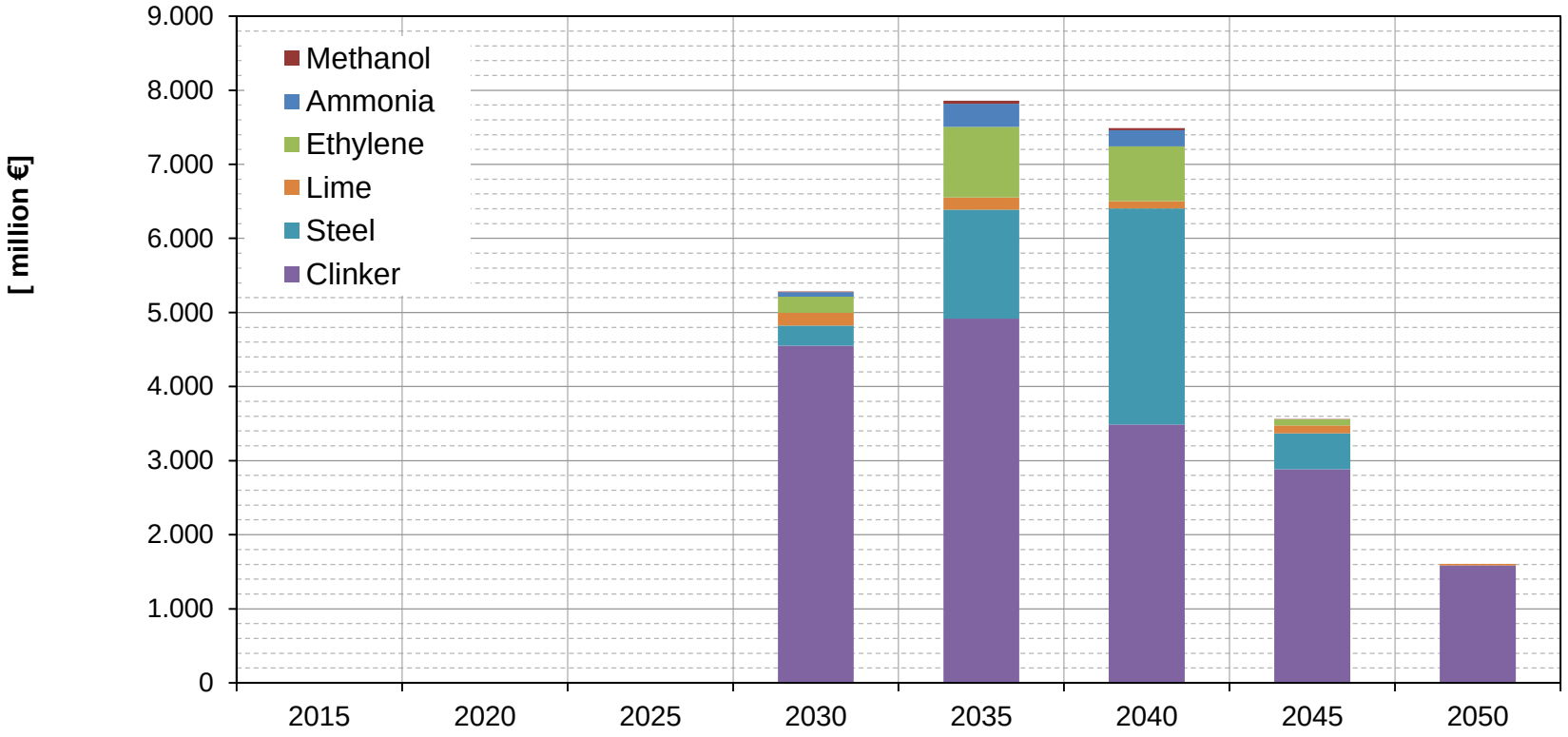
CCS in Industry: High Additional Capital Costs

- Hardly any alternative decarbonization option are available for these sectors / processes



Total Discounted Electricity System Costs (Case Study)

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Table 12: Total discounted electricity system costs in bnEUR2015 for 2015 - 2055

	Optimistic	Pessimistic	No CCTS
Pathway I *Business as Usual (BAU)*	**Scenario 1** 10370 (-2%)	**Scenario 2** 10584 (0%)	**Scenario 5** 10584
Pathway II *Decarbonisation (DEC)*	**Scenario 3** 10485 (-4%)	**Scenario 4** 10925 (0%)	**Scenario 6** 10921

Note: In parentheses, deviations from the No CCTS scenario in each pathway.

System cost advantage of CCS, but small

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Average Cost of Electricity in 2050 (Case Study)

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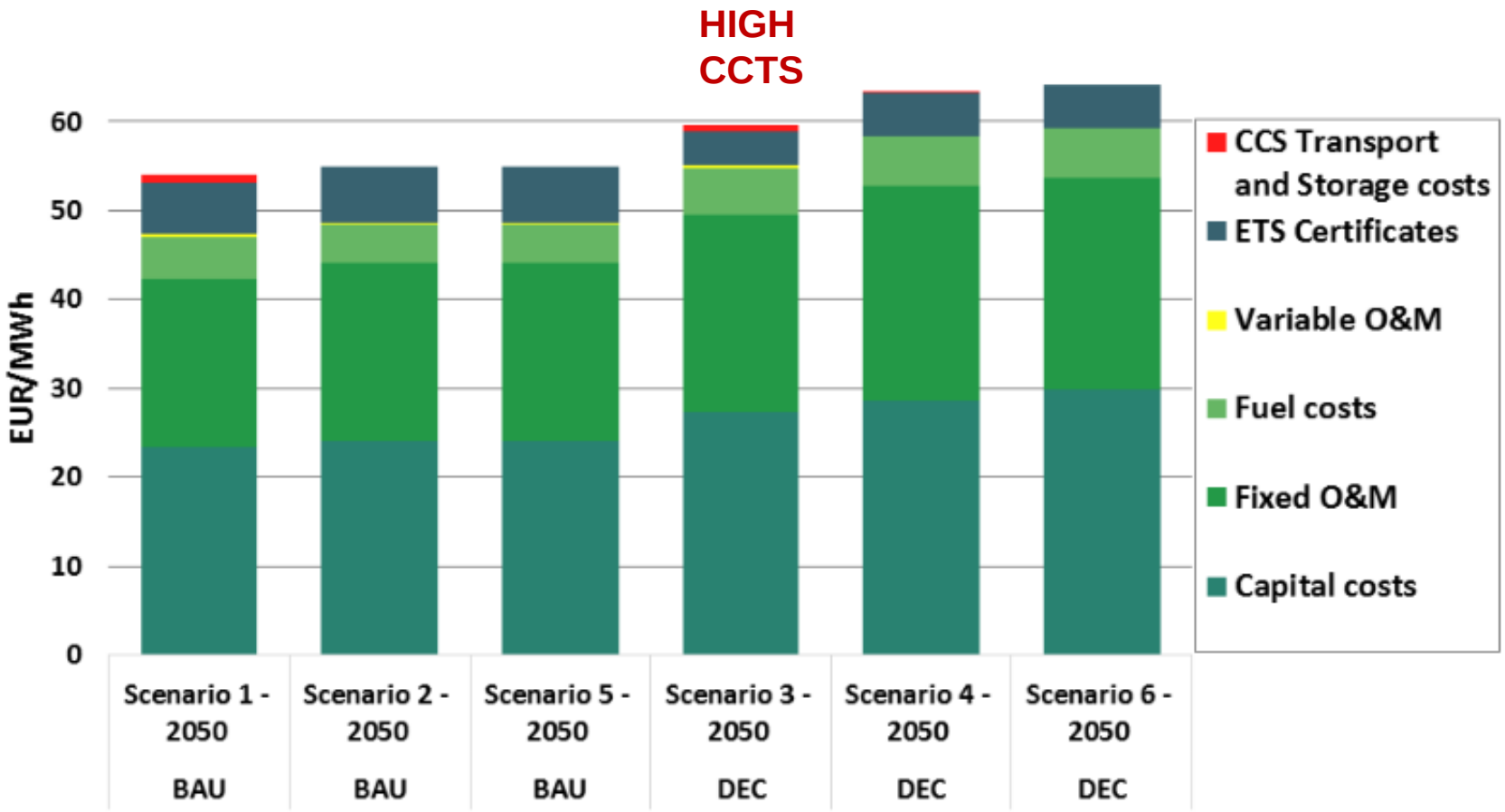

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