

Cost Estimation of Fossil Power Plants with Carbon Dioxide Capture and Storage

Cost Estimation of Fossil Power Plants with CCS
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Agenda



- Introducing EnBW
- Carbon Capture and Storage (CCS) as a pathway towards a sustainable and responsible energy supply?
- Techno-economic maturity and other challenges of CCS
- Cost estimation of fossil power plants with CCS
- Economical feasibility of CCS - When and how?

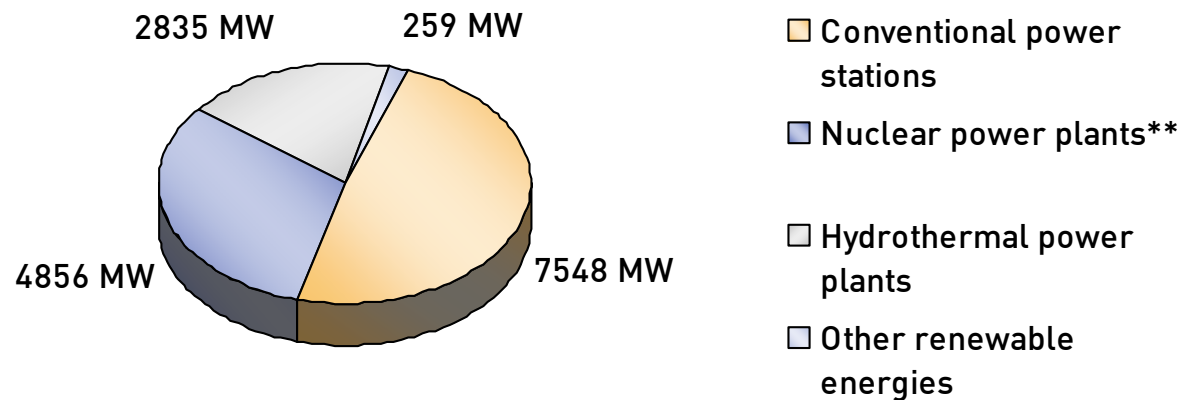
Introducing EnBW - At a glance -



| EnBW group | | 2010 |
|----------------------------|--------|----------|
| External sales | m € | 17,509.0 |
| Employees (annual average) | | 20,450 |
| Customers | in m | ~ 6 |
| Unit sales electricity | bn kWh | 146.9 |
| Unit sales gas | bn kWh | 53.6 |



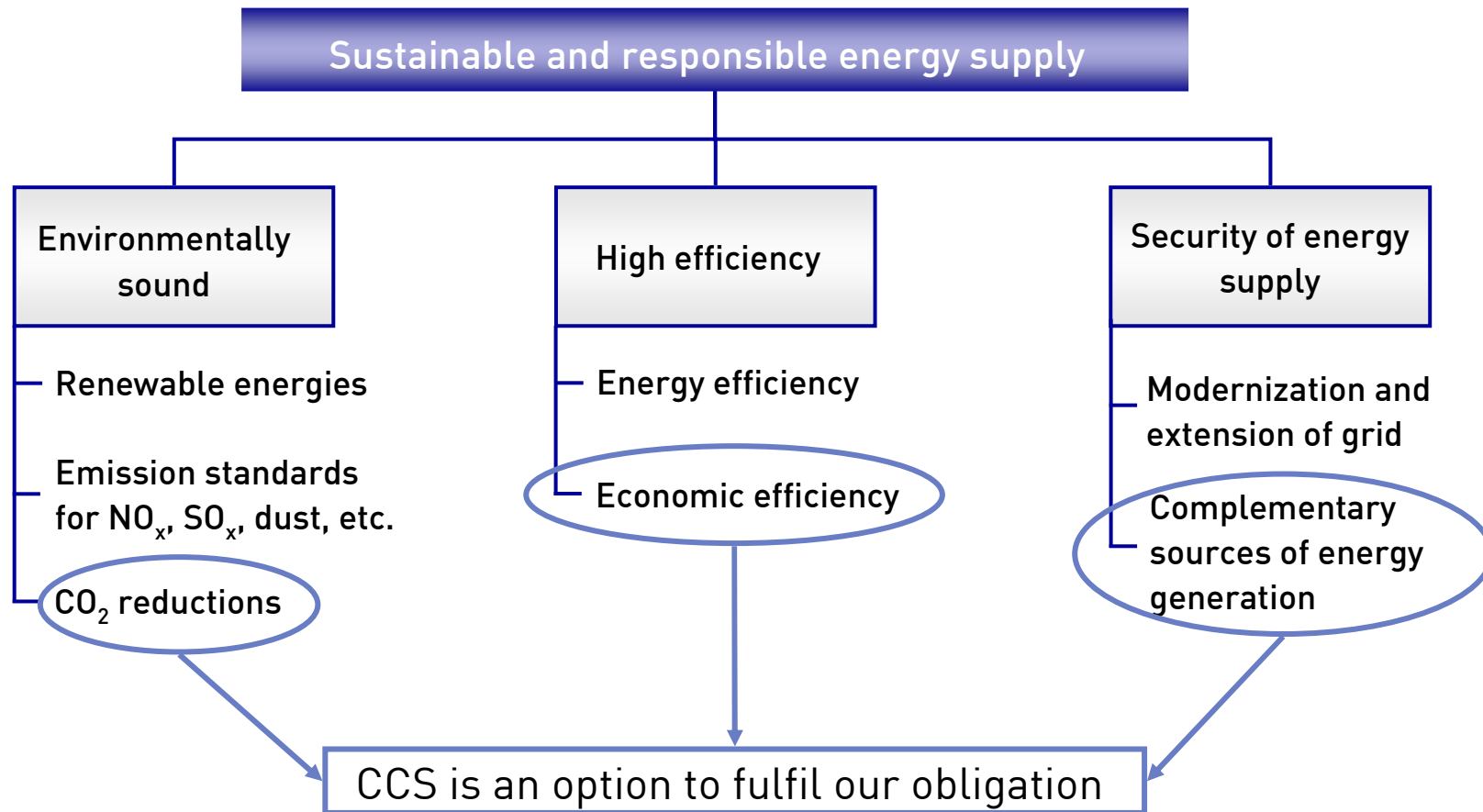
Introducing EnBW - EnBW's generation mix*-



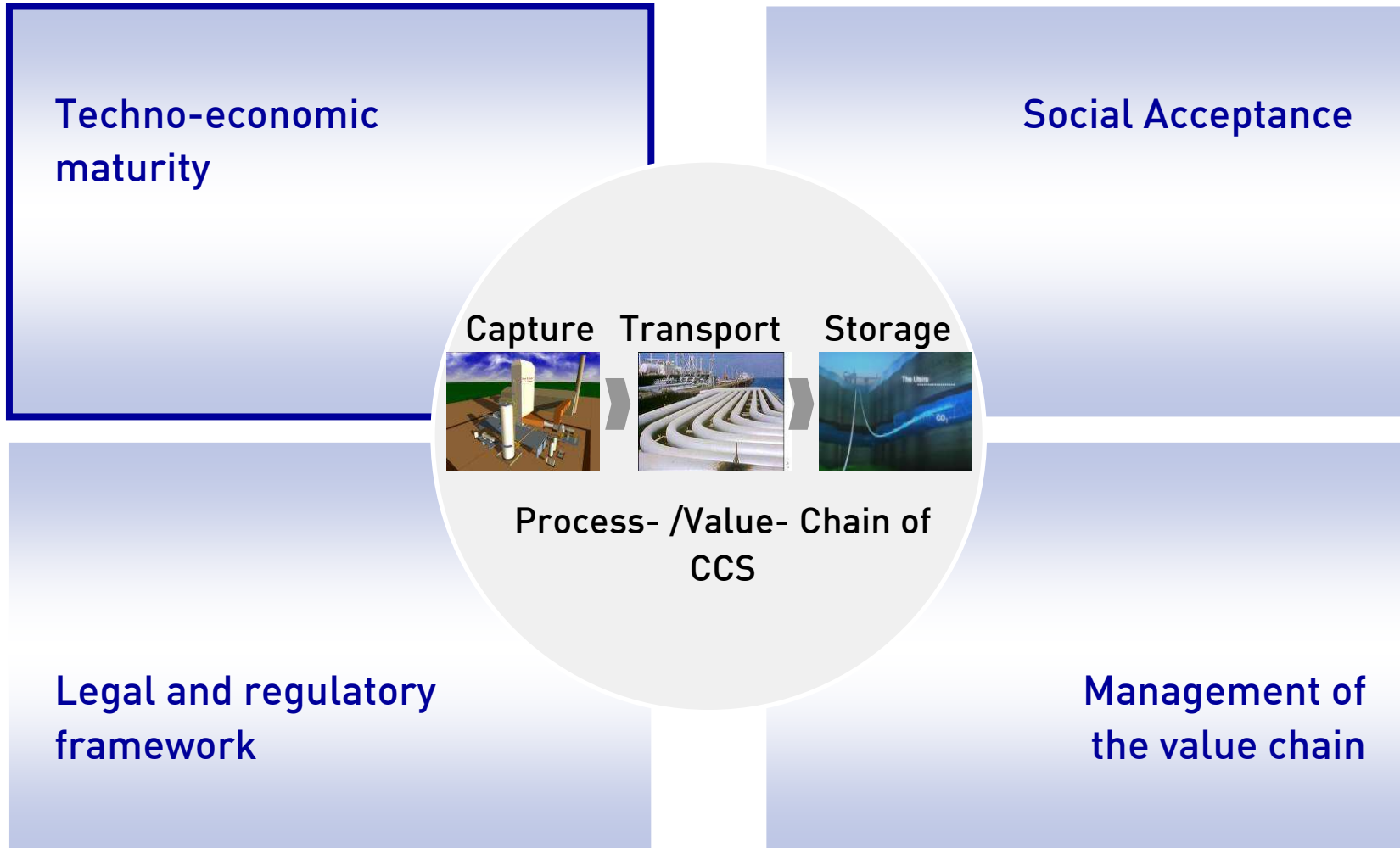
EnBW generation portfolio electrical output

- As Germany's third-largest energy company we take sustainable and responsible action for both the company and the society as a whole.

Pathways towards a sustainable and responsible energy supply

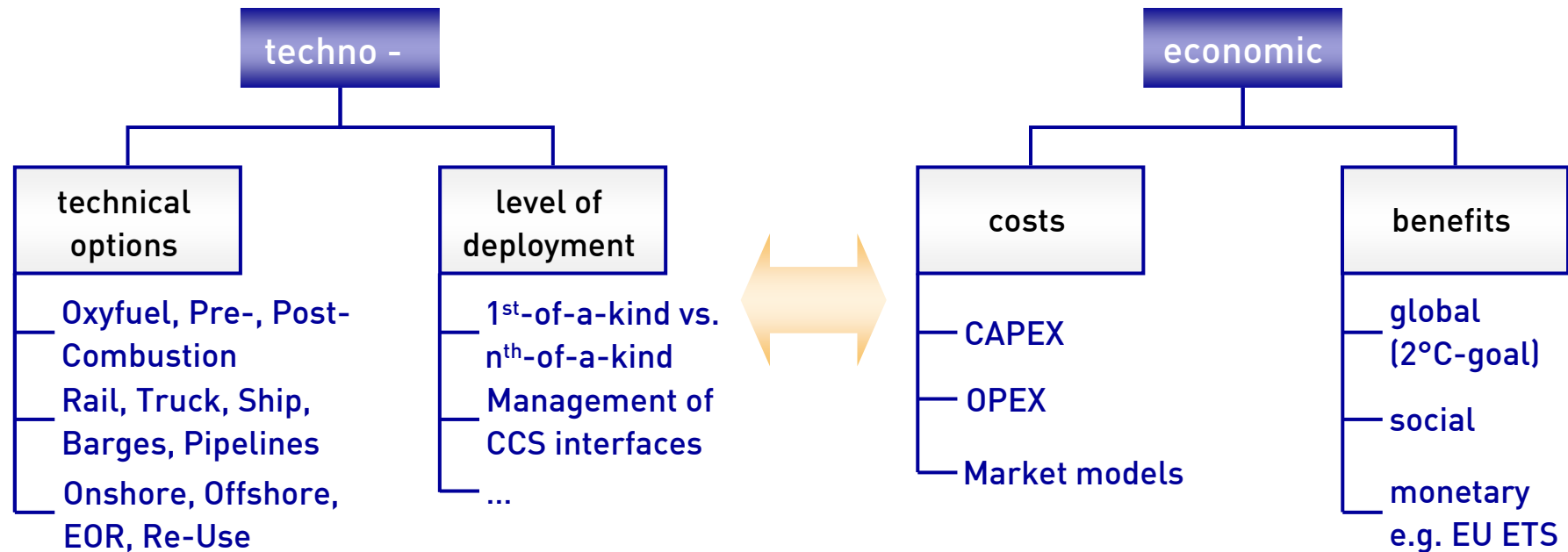


Challenges of CCS by means of commercial deployment



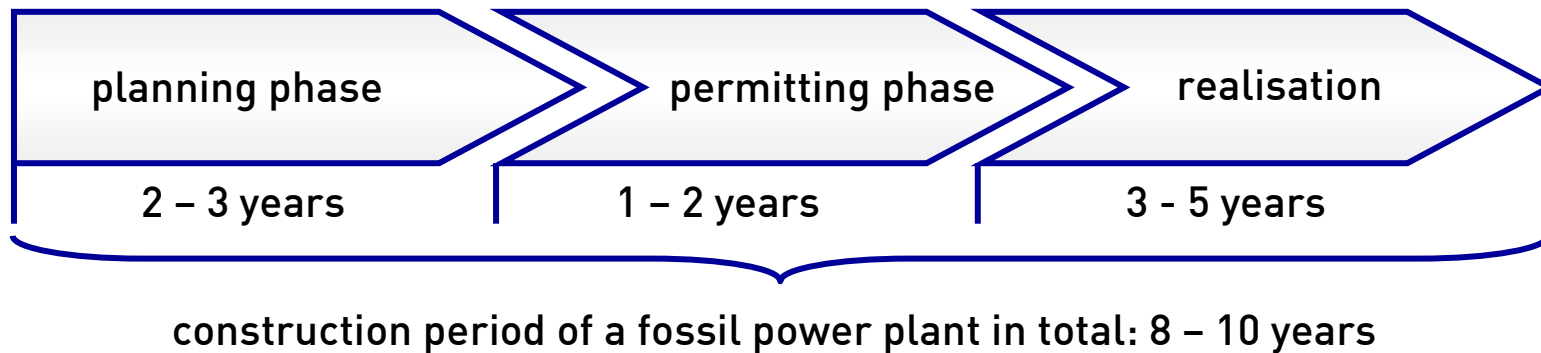
Techno-economic maturity: A challenge?!

- Techno-economic maturity can only be achieved if the following aspects and their interactions are well-balanced



Cost-estimation of fossil power plants with CCS

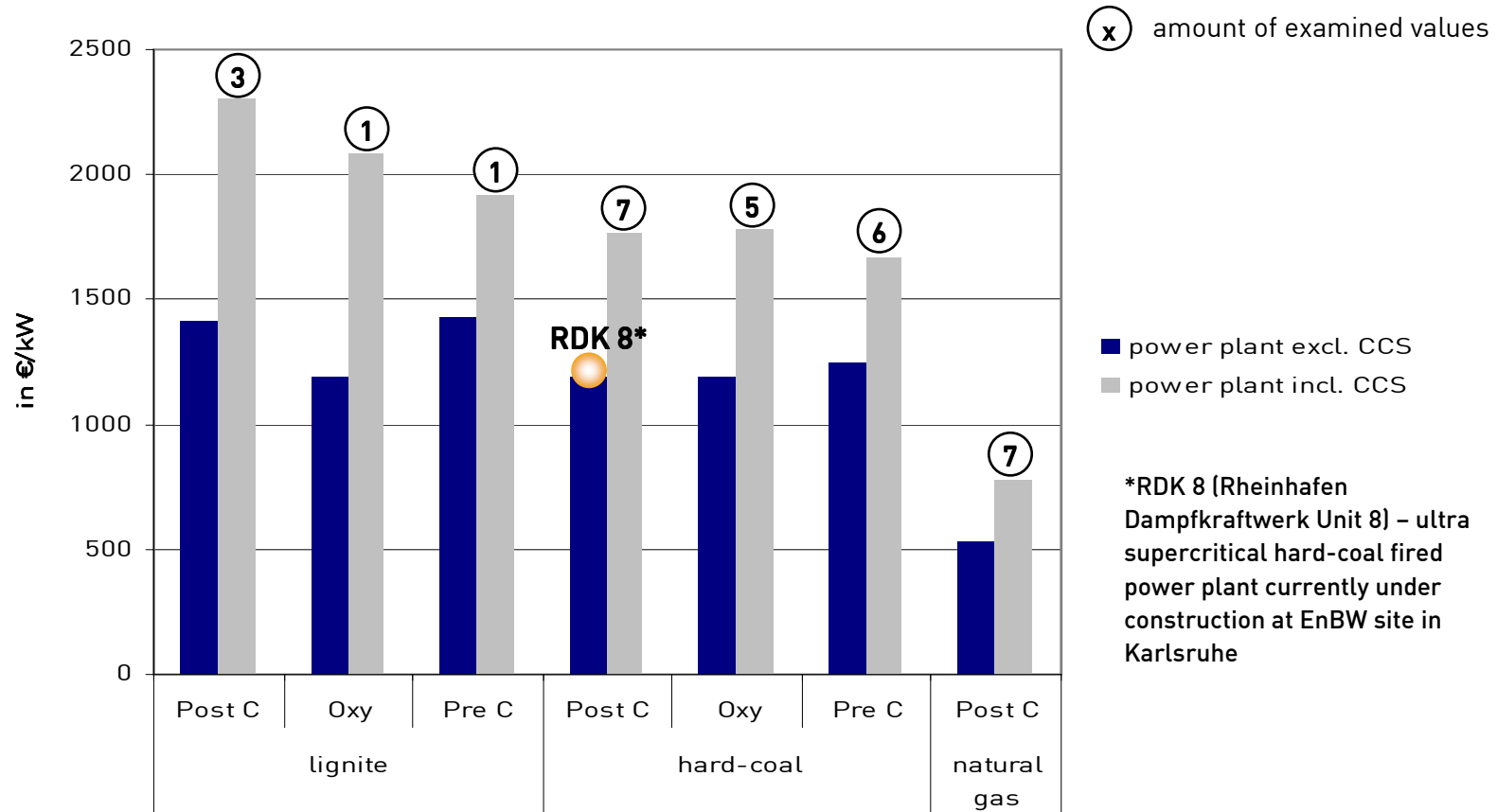
- For energy utilities it is essential to know the costs of fossil power plants with CCS, as...
 - Considerations on mid- and long-term power generation start nowadays and costs are a main driver to estimate the future competitive position of fuels within a generation mix



- Fossil power plants have life-cycles of up to 40 years

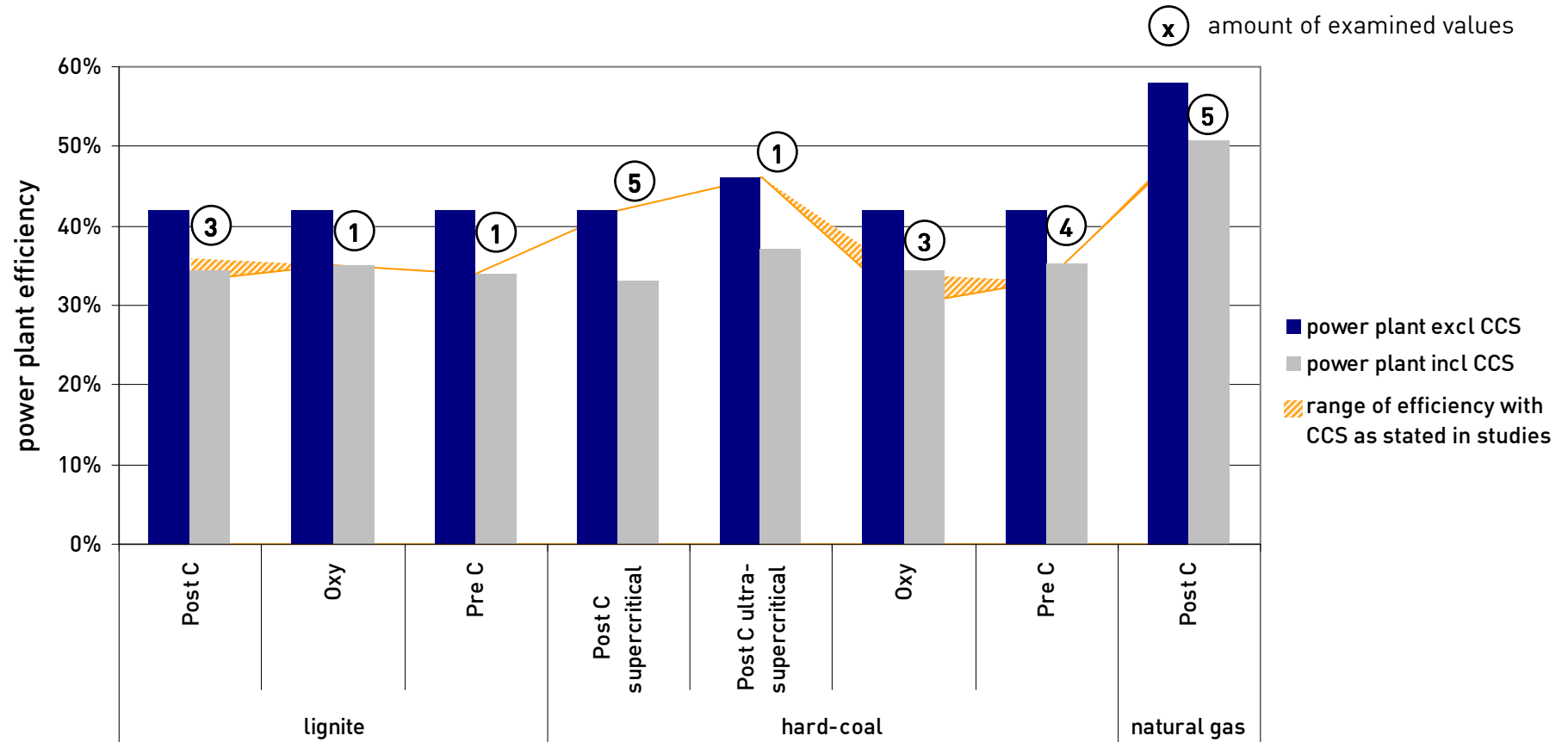
- Major challenges are:
 - Acquiring the necessary data
 - A multitude of studies exist, which have been investigating the CCS technology concerning its future potential, costs, technological options and acceptance based on interviews with technology providers, power generators, institutes etc.
 - Studies differ with respect to country, currency, publishing year and technologies
 - „Harmonization“ of costs has been executed through converting them to a defined base year 2009 also considering inflation and development of national industries (e.g. plant capital cost index, chemical engineering plant cost index)
 - Noticeable variations between primary offers and / or first cost estimates and costs at execution of projects
 - Additional charges for risks, profit etc.
 - Reliability of numbers in early stages, but also for a more mature situation

Increase of specific costs of fossil power plants due to the application of CO₂-Capture



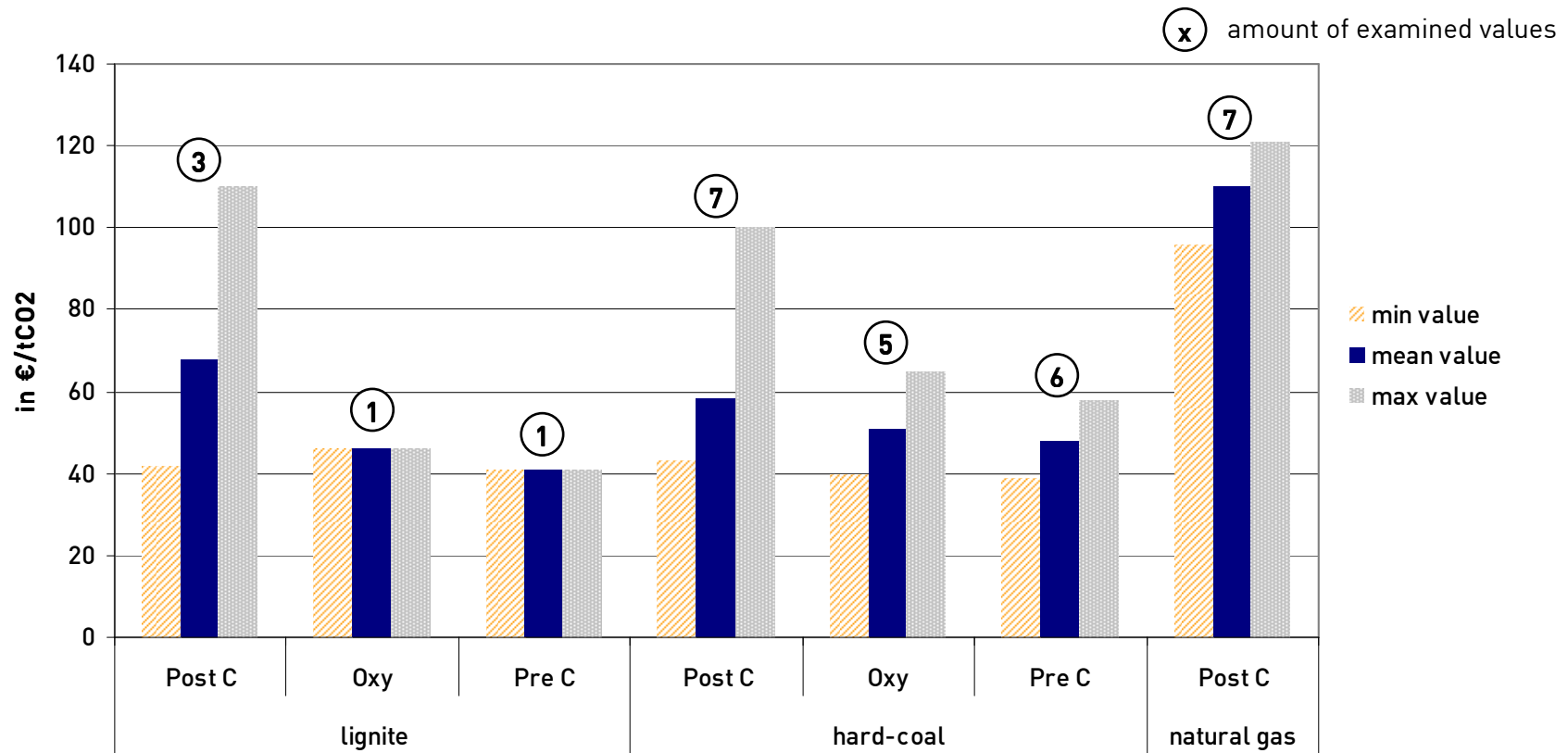
Significant increase of CAPEX ranging from + 30 % to + 75 % only through application of CO₂-Capture – costs of transport and storage add even further up

Range of power plant efficiency with and without CO₂-Capture



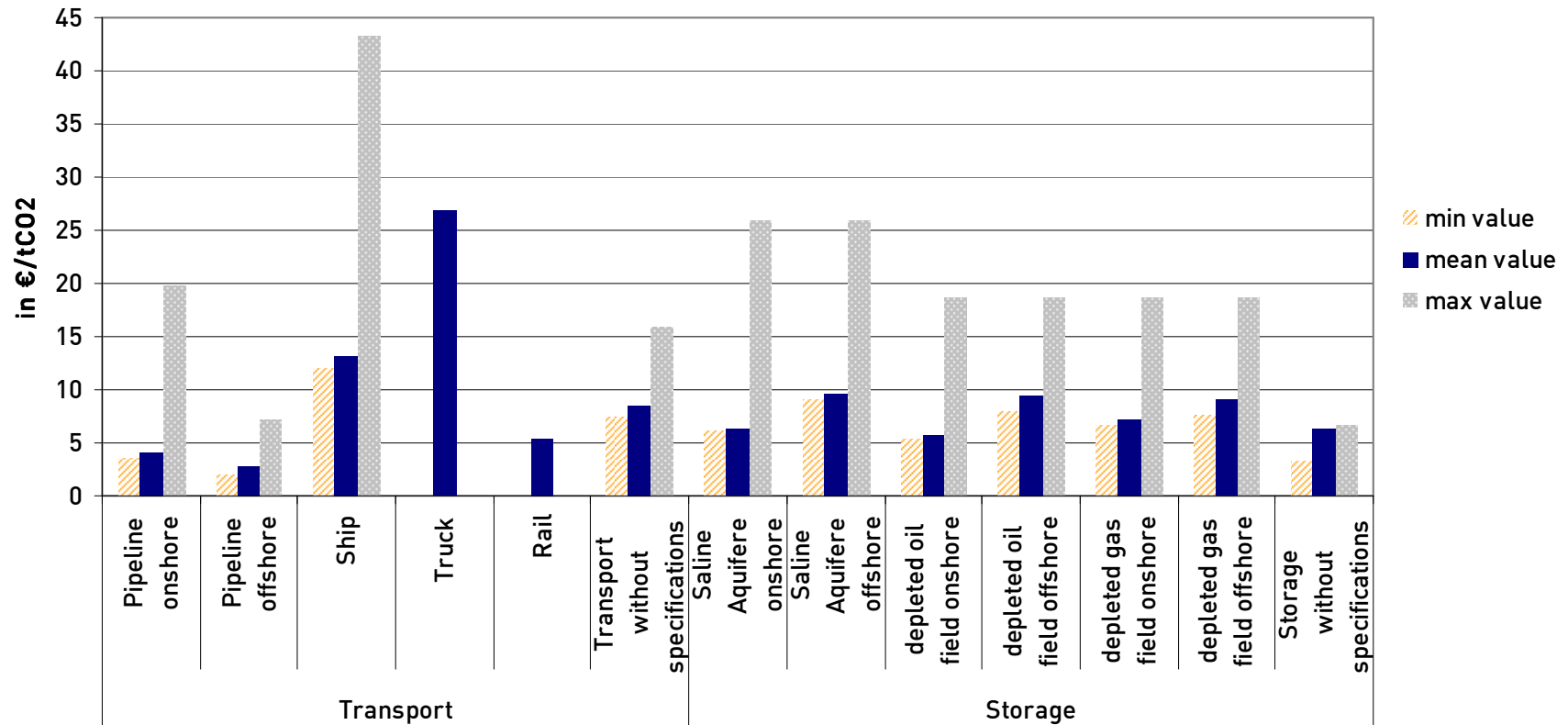
Considerable loss of efficiency due to the application of CCS – efficiency loses ranging from 4 to 12 %-points leading to efficiencies that have been state-of-the art in the 1970s

Abatement costs of CO₂-Capture



Estimations of abatement costs differ considerably, even if examined per fuel: lignite 41 €/t_{CO₂} - 110 €/t_{CO₂}; hard-coal 39 €/t_{CO₂} - 100 €/t_{CO₂}; natural gas 96 €/t_{CO₂} - 121 €/t_{CO₂}

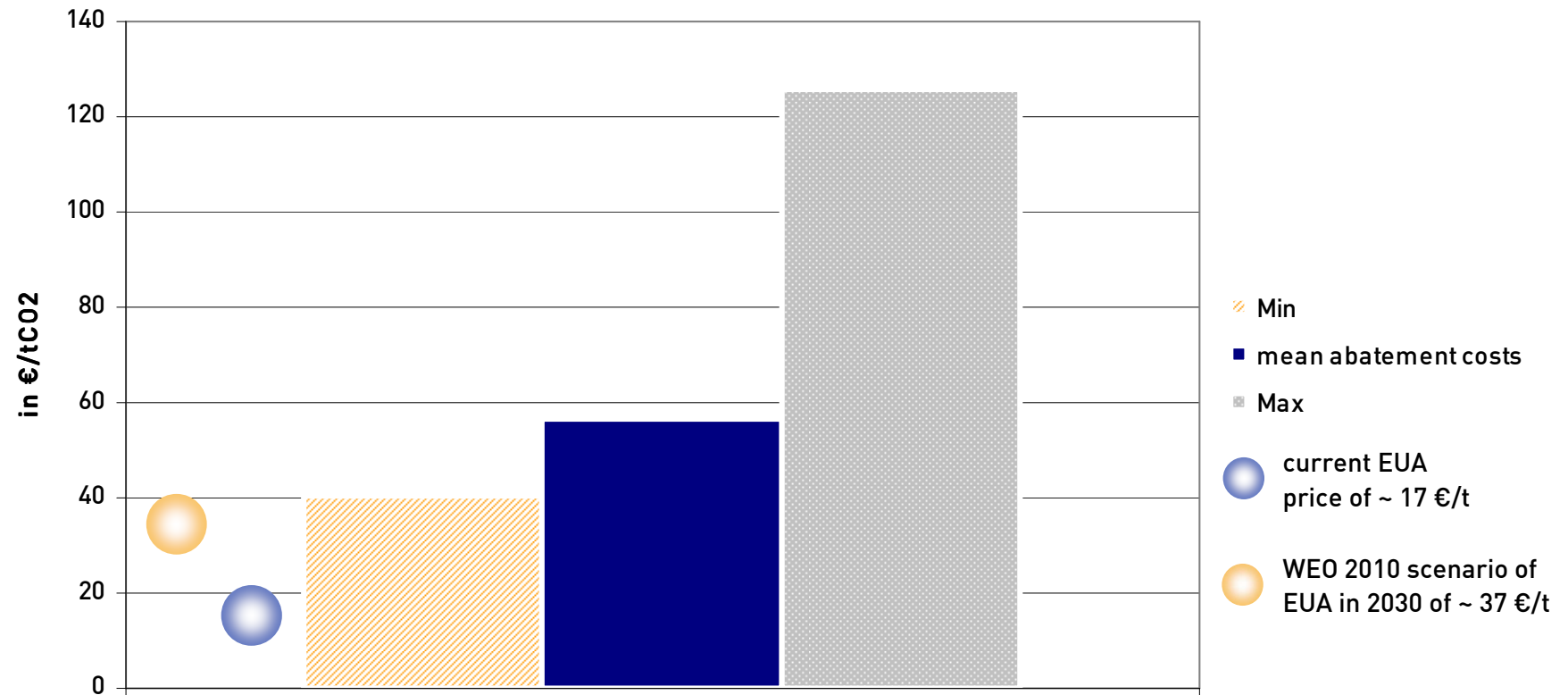
Range of costs of CO₂-transport and -storage



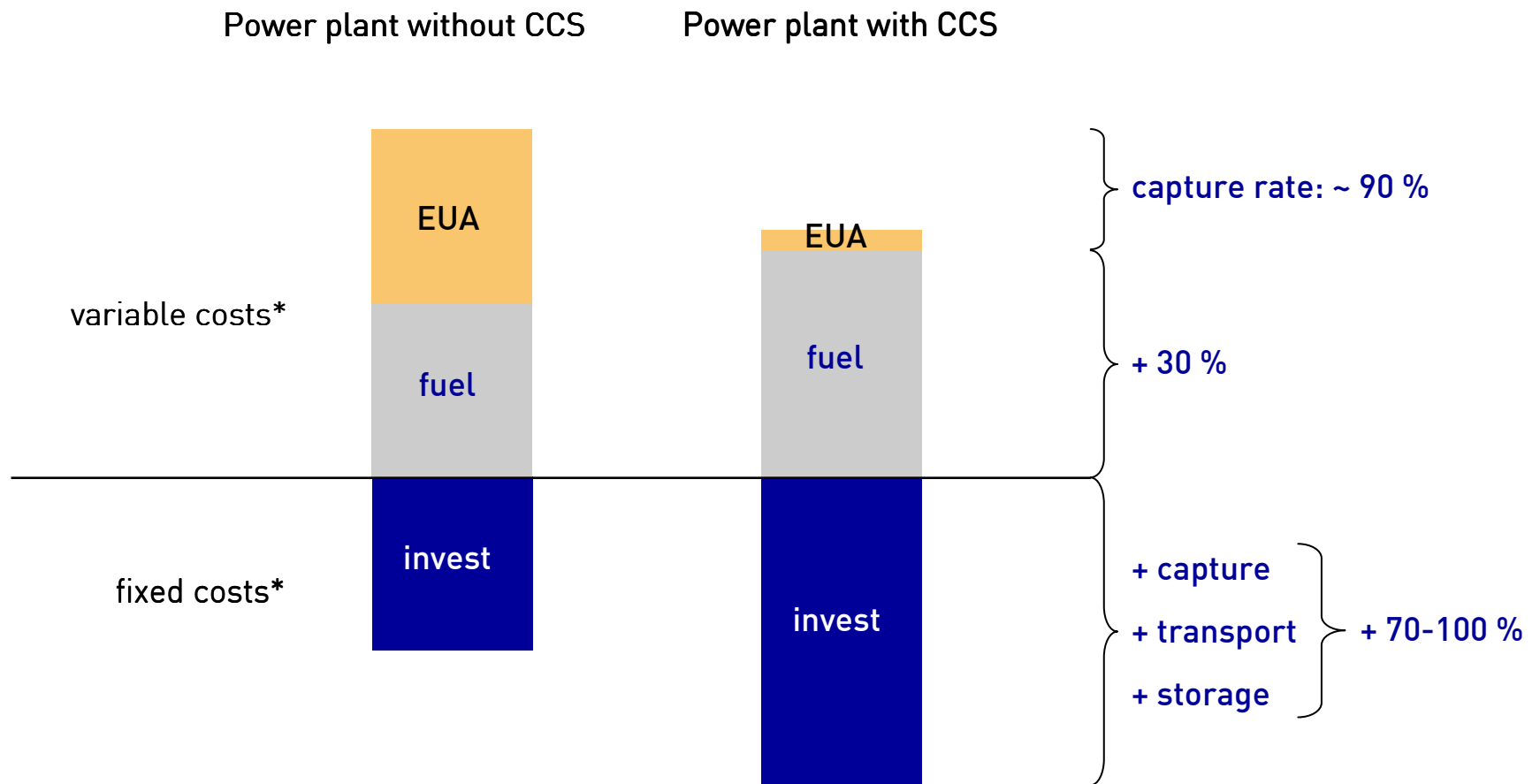
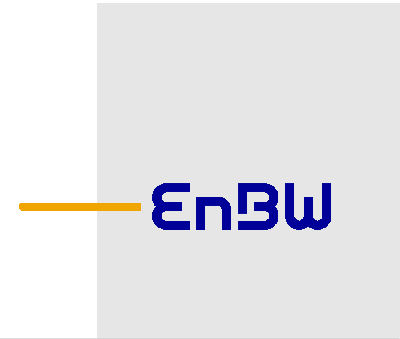
The cost of transport and storage vary in accordance to the used transport (2 €/t_{CO2} - 43 €/t_{CO2}) and/or storage option (5 €/t_{CO2} - 26 €/t_{CO2})

Example of CO₂ abatement costs based on the application of CCS at a hard-coal fired power plant

- Further assumptions: Post-Combustion Capture
Transport via pipeline
Offshore storage in depleted gas field



Comparison of a power plant with CCS and one without, assuming the same net power



Economical feasibility of CCS – when and how? (1)



- More investigation necessary regarding costs of retrofitting power plants with CCS
 - The majority of studies only covers new build
 - Calculation of general economics of retrofit is challenging since in those cases the conditions / cost are very dependent on the location
- Power plant with CCS likely to be more cost-intensive concerning CAPEX though less cost-intensive concerning variable operating costs (fuel + CO₂) than power plants without CCS
 - Is current market model suitable for a fossil power generation with CCS?
 - EU ETS: EUA prices need to be high enough to cover increased OPEX (fuel costs through decrease of efficiency + operating costs capture) plus be able to cover CAPEX long-term

Economical feasibility of CCS – when and how? (2)

- Further costs will add up:
 - e.g. risk of insurability (especially storage)
 - any public dues that might or probably will be levied (see German draft §42: dues can be levied by federal states)
 - contribution for maintenance of storage sites after closure (see German draft §32: 3 % of EUA price for stored tonnes of CO₂ per year)



Thank you for your attention!
Any further questions?

