



CCS Costs and Economics

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Overview

- Cost methodologies
- Overview of costs of CO₂ capture
 - Power plants
 - Capital costs (1st/Nth of a kind plants)
 - Thermal efficiencies and operating costs
 - Costs of electricity and CO₂ abatement
 - Costs at non-power industrial plants



Cost Methodologies



- There are many differences in the costing methods and assumptions used by different organisations
 - Many of these differences are not readily apparent
- Such differences contribute to misunderstanding of CCS costs especially among audiences unfamiliar with details of CCS costing



CCS Cost Methodologies Task Force Report



- Task Force set up to harmonise methodologies and reporting of CCS cost estimates
- Representative of IEAGHG, EPRI, USDOE, GCCSI, IEA, Vattenfall/ZEP, MIT, Carnegie Mellon University
- Report is freely available



TOWARD A COMMON
METHOD OF COST
ESTIMATION FOR CO₂
CAPTURE AND STORAGE
AT FOSSIL FUEL POWER
PLANTS

Report: 2013/TR2

March 2013



Common Measures of CCS Costs



- Increased capital cost (\$/kW)
- Increased cost of electricity (\$/MWh)
- Cost of CO₂ avoided (\$/tonne CO₂)
- Cost of CO₂ captured (\$/tonne CO₂)

- *Costs should include CO₂ transport and storage (but often do not)*
- *All measures are relative to a baseline plant*





Cost of CO₂ Avoided

- Cost of CO₂ avoided (\$/tonne CO₂)

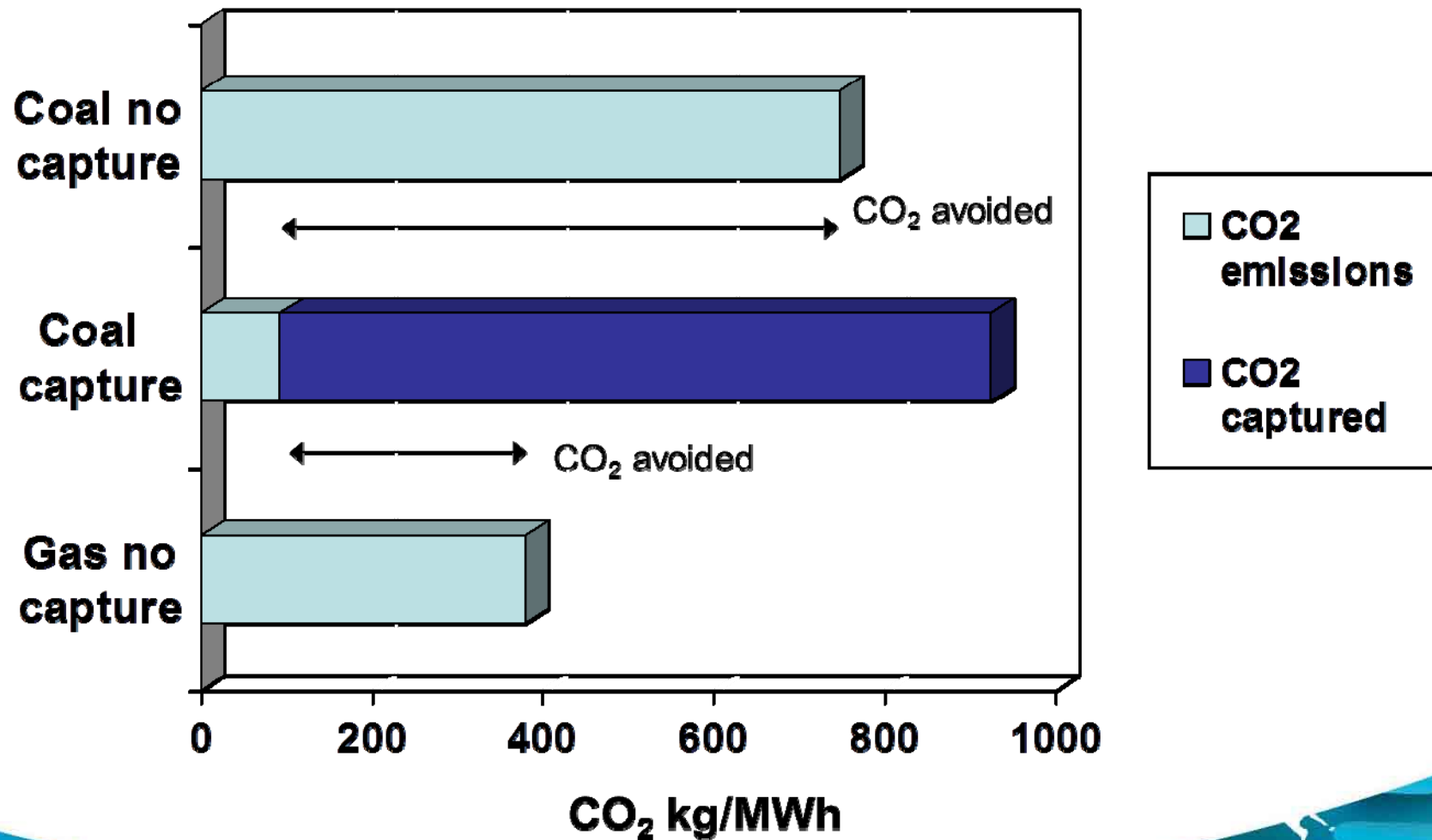
$$\frac{\text{COE}_{\text{CCS}} - \text{COE}_{\text{baseline}}}{t\text{CO}_2/\text{MWh}_{\text{baseline}} - t\text{CO}_2/\text{MWh}_{\text{CCS}}}$$

- Costs and CO₂ emissions are sensitive to the choice of baseline plant

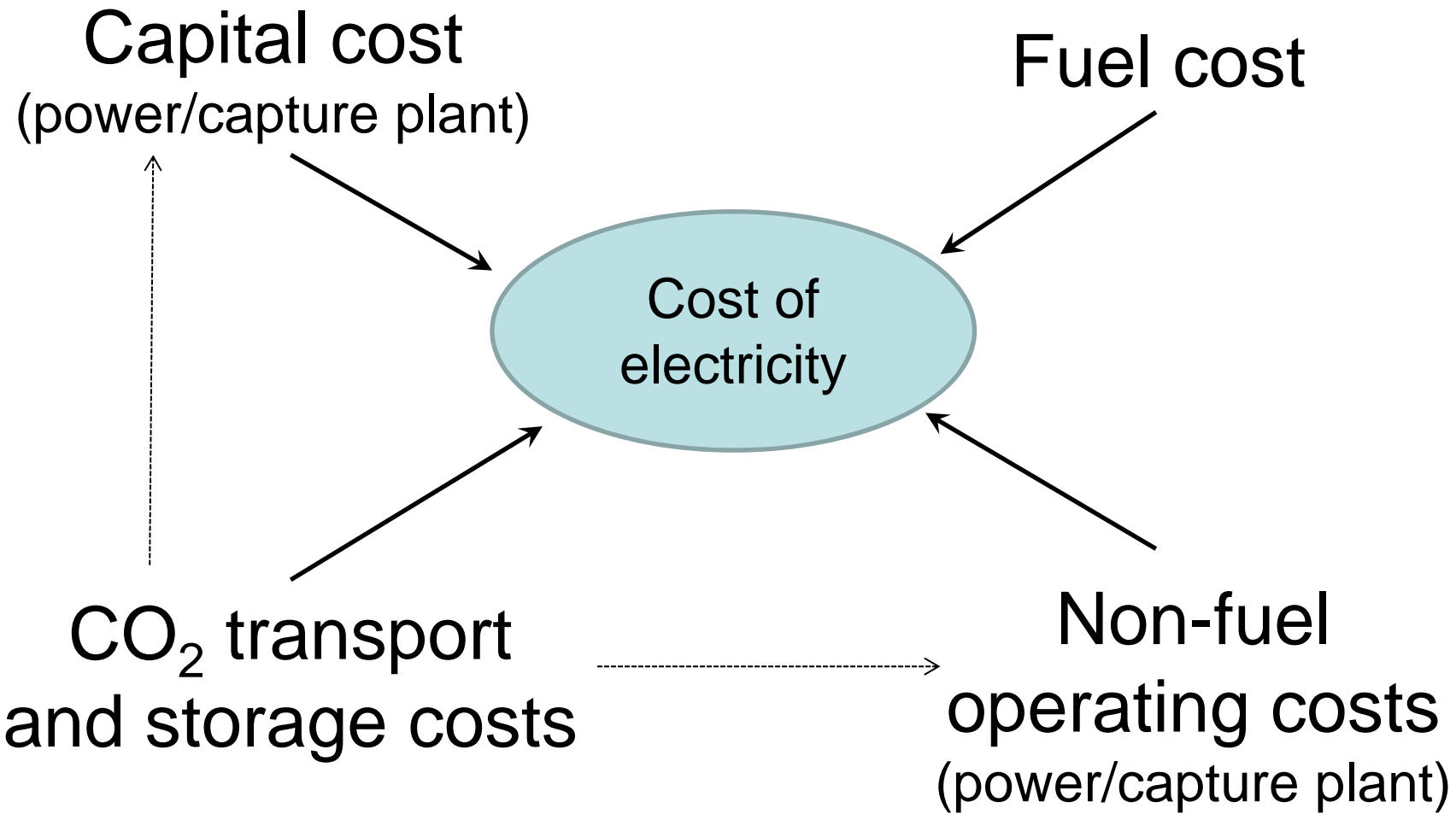


Importance of Baselines

CO₂ captured and emissions avoided



Cost of Electricity with CCS



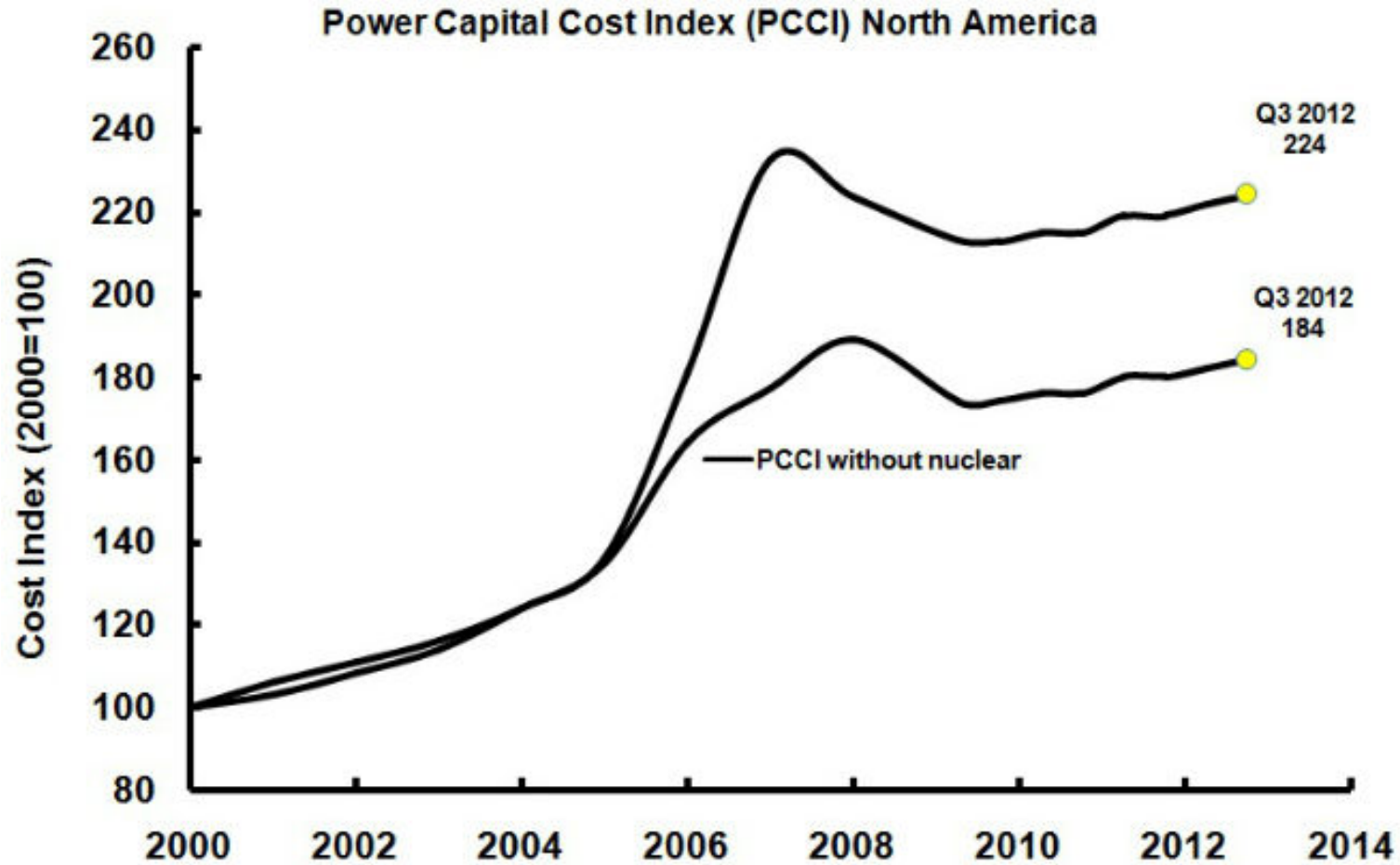
Capital Cost



- What is included?
 - No consistent definition
- Total Plant Cost (EPC Cost)
 - Normally includes contingencies
- Total Capital Requirement
 - EPC cost
 - Owner's costs – different definitions of what is included
 - Interest during construction
 - Working capital and start-up costs
- Is capital cost of transport and storage included?
- Current \$ values or actual \$ with inflation?



Cost Escalation

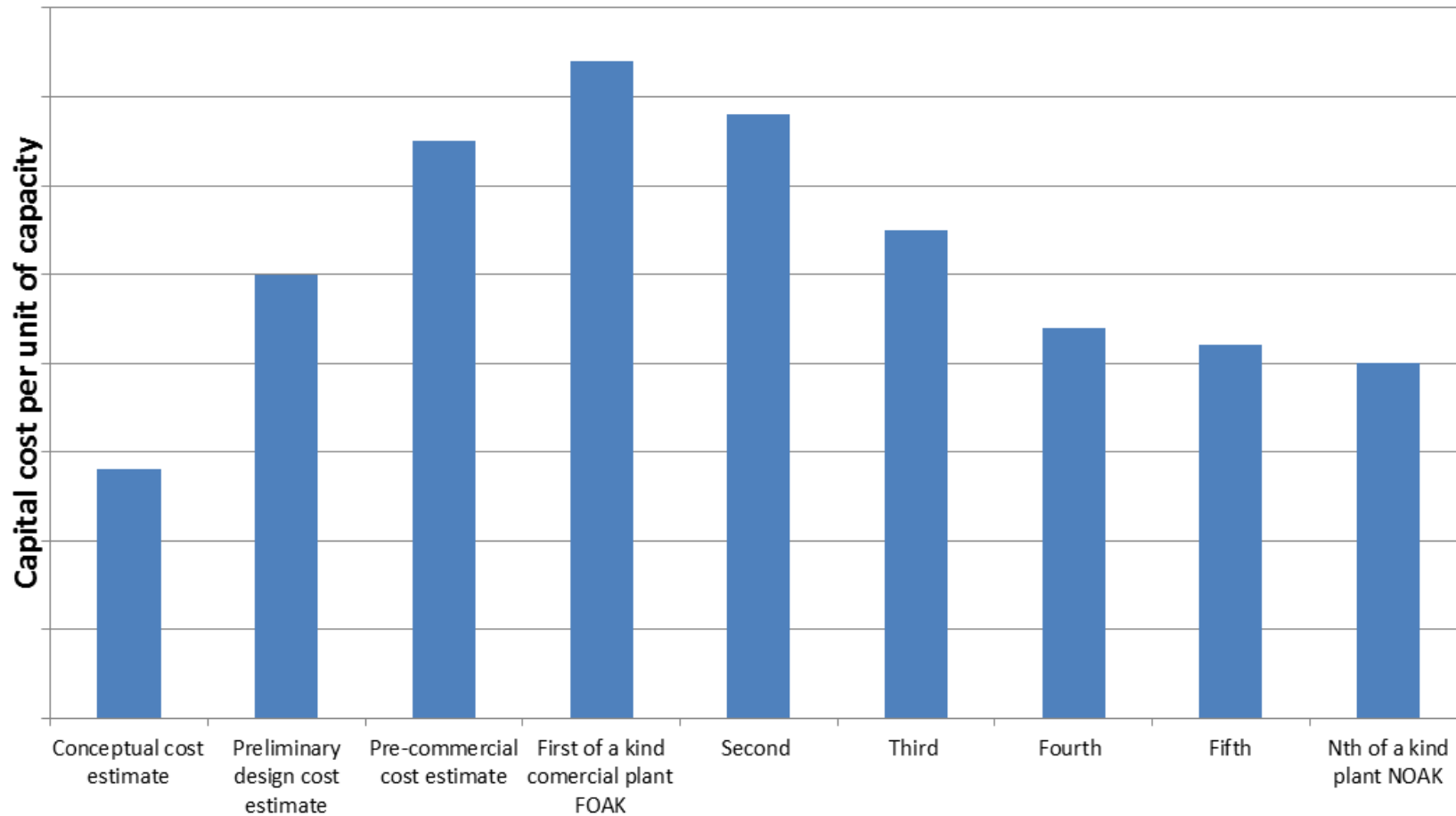


IHS CERA Power Plant Cost Index

Costs of New Technologies



Beware of the optimism of early stage cost estimates

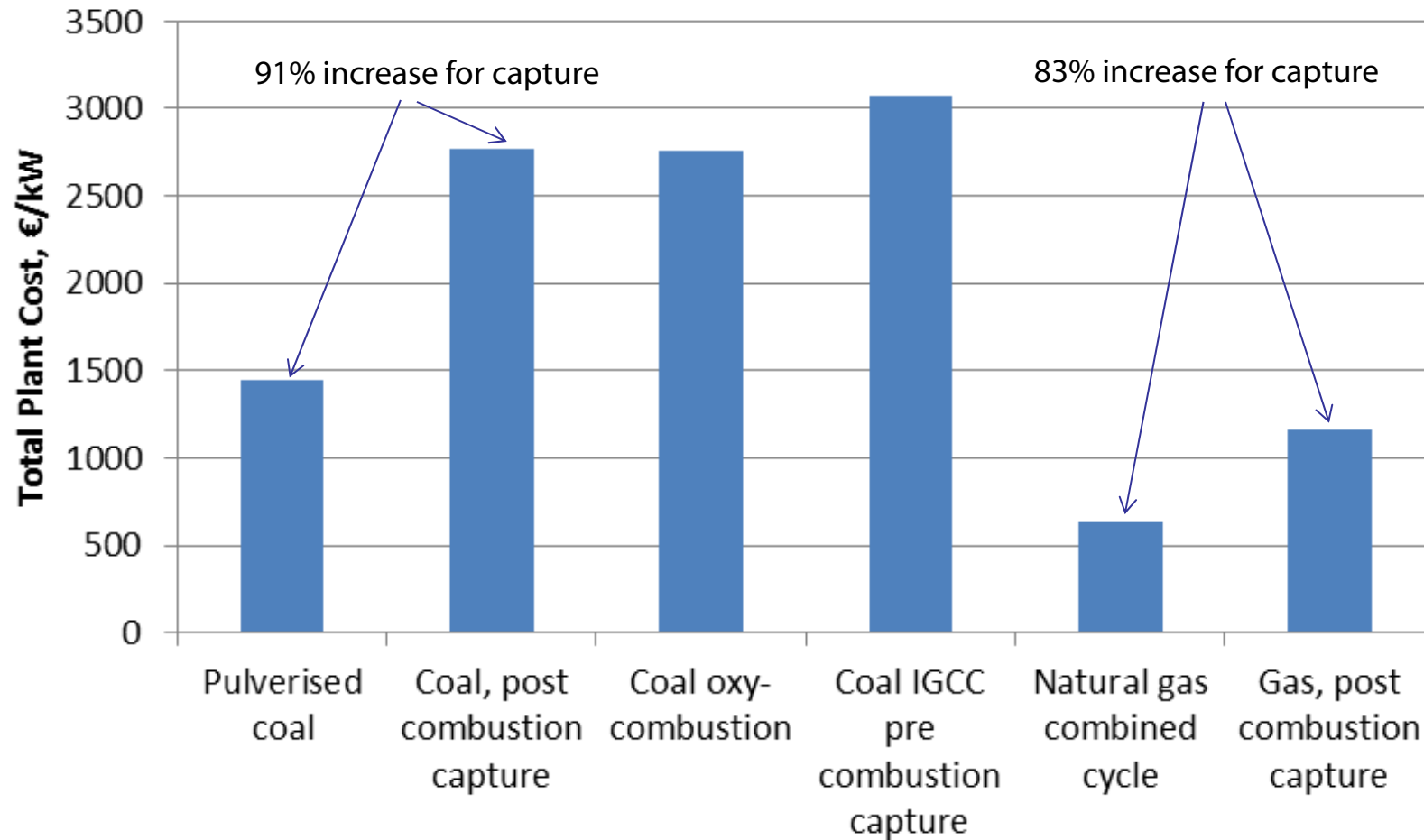


Nth Plant Cost Reductions



- CCS First-of-a-Kind (FOAK) demonstration plants have relatively high costs
 - Conservative design – to make sure it works
 - High design and owner's costs
 - High costs of CO₂ transport and storage for small projects
 - High capital return required – perceived high risk
- Costs will reduce for Nth-of-a-Kind plants
 - Elimination of FOAK cost factors
 - Learning by doing
 - Greater number of suppliers and more competition
 - Lower rates of return
 - New capture technologies – potential for large reductions

Power Plants with Capture



Nth-of-a-Kind EPC costs, IEAGHG studies 2011-13
Excluding owner's costs and interest during construction



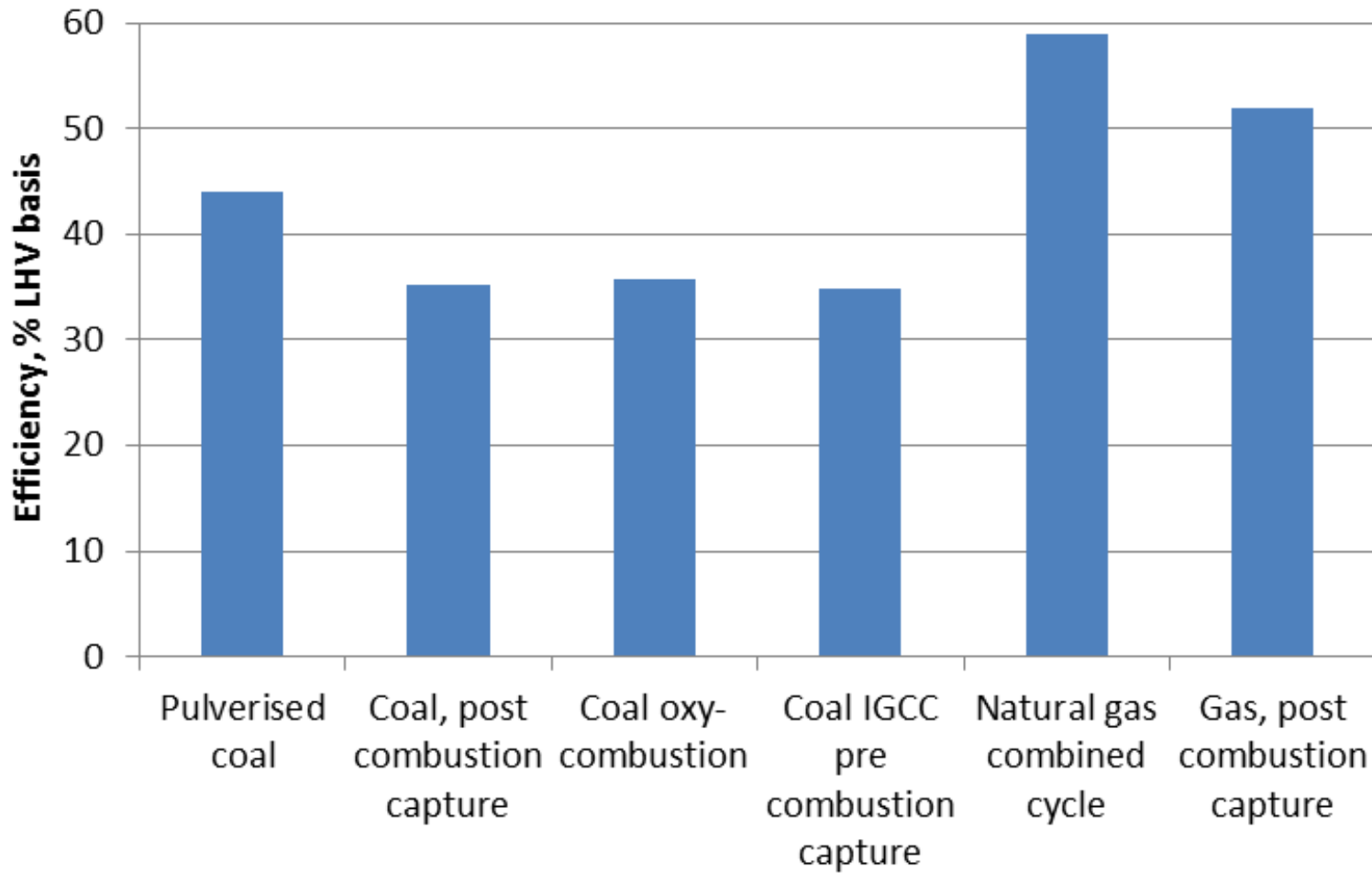
Operating Costs



- Fuel price
 - Large regional differences
 - Future fuel prices are highly uncertain
- Non-fuel operating costs
 - Maintenance is the largest cost
 - Operating labour
 - Chemicals, catalysts etc (e.g. capture solvent)
 - Waste disposal / by-product revenue
 - Overhead costs
 - Insurance
 - Local taxes
 - CO₂ emissions cost

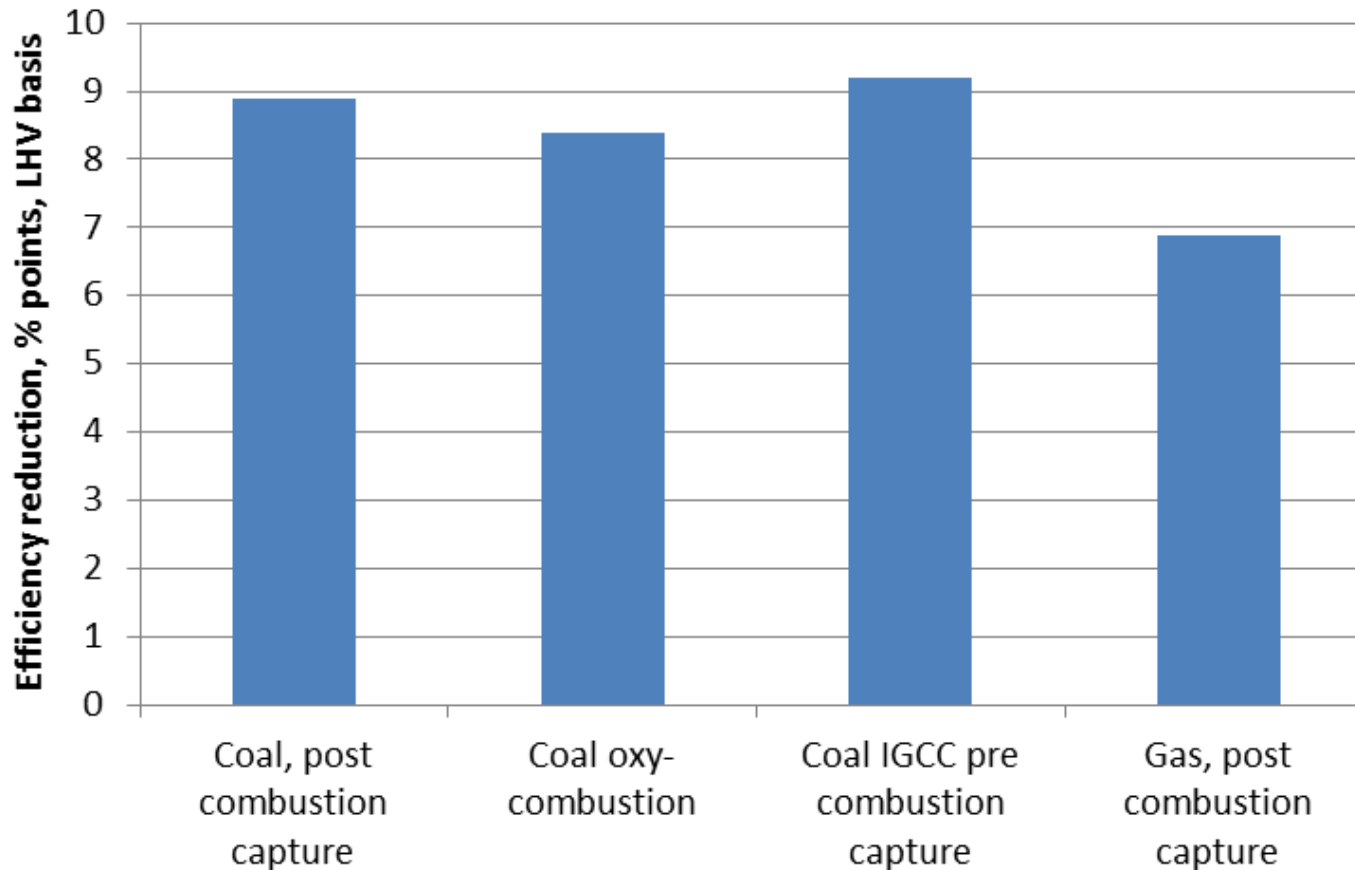


Thermal Efficiencies



Source: IEAGHG studies

Efficiency Reduction for Capture



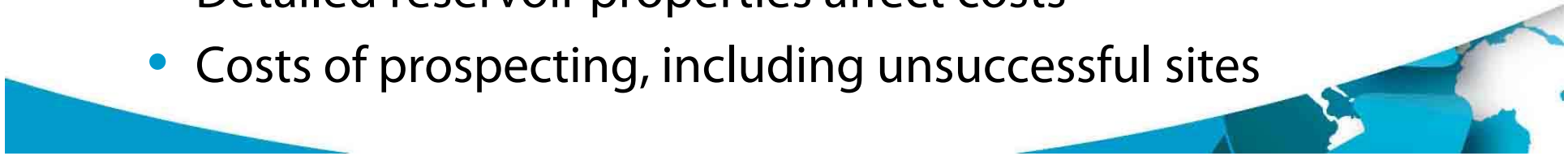
Coal plants compared to a pulverised coal baseline
Gas plant compared to a gas combined cycle baseline

Source: IEAGHG studies

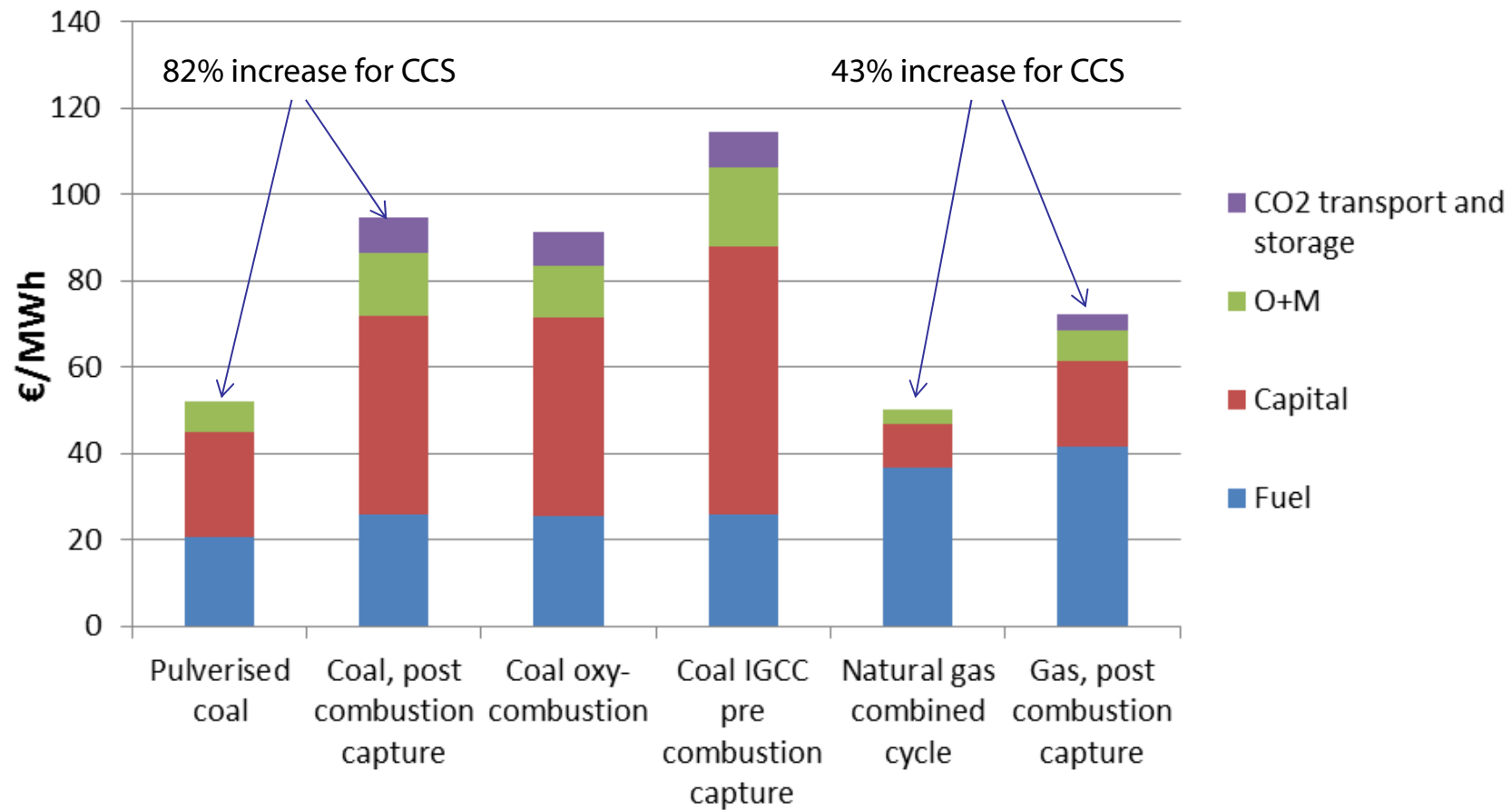
CO₂ Transport and Storage



- Highly site specific costs
- CO₂ Transport
 - Transport distance
 - Onshore / off-shore
 - Pipeline or ship
 - Large economies of scale - advantage of networks
- CO₂ Storage
 - EOR, depleted oil and gas or saline reservoir
 - Credit for EOR oil production
 - Onshore or offshore
 - Detailed reservoir properties affect costs
 - Costs of prospecting, including unsuccessful sites



Levelised Cost of Electricity



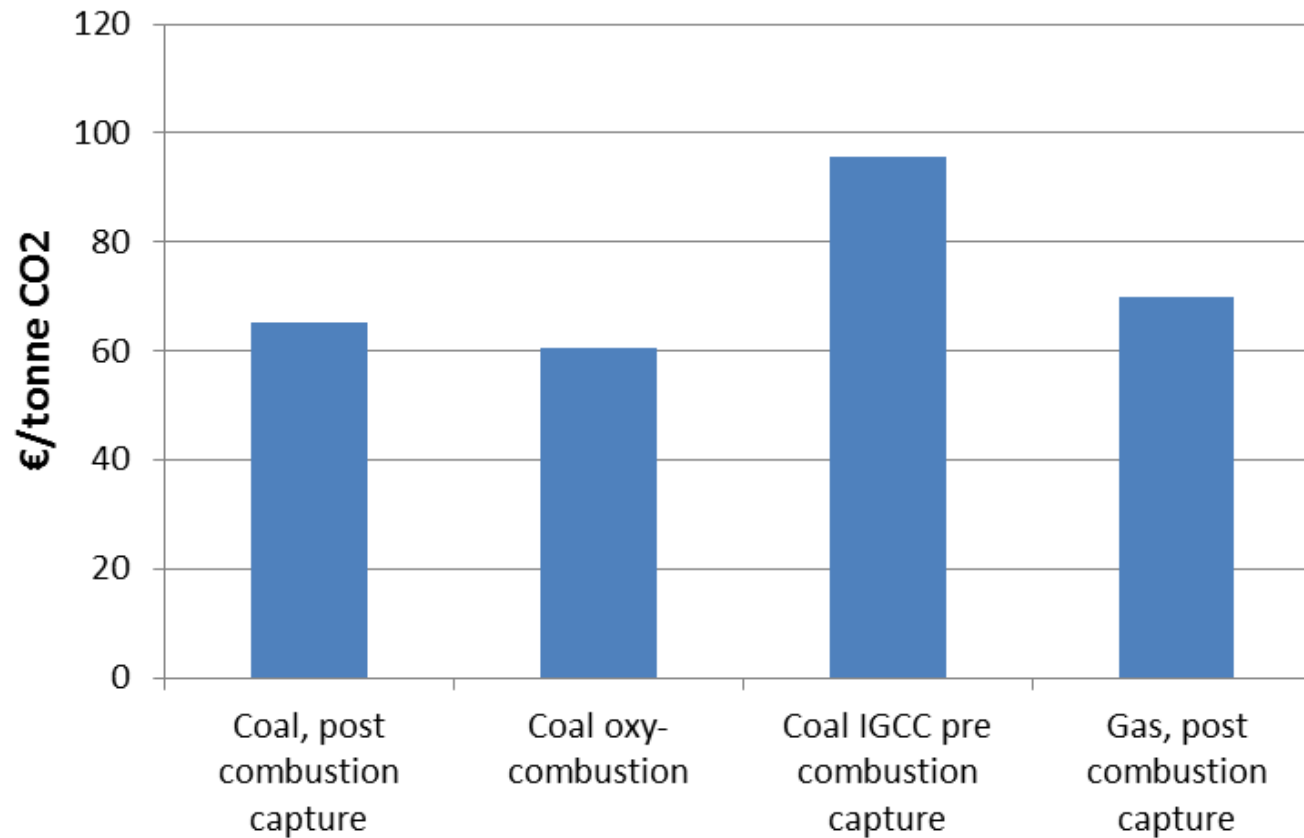
NOAK 2011-13 costs (IEAGHG)
 8% discount rate
 25 year plant life
 Base load operation

€2.5/GJ (LHV) coal price
 €6/GJ (LHV) gas price
 €10/t CO₂ stored
 No emission cost



Cost of CO₂ Abatement

Own technology baseline

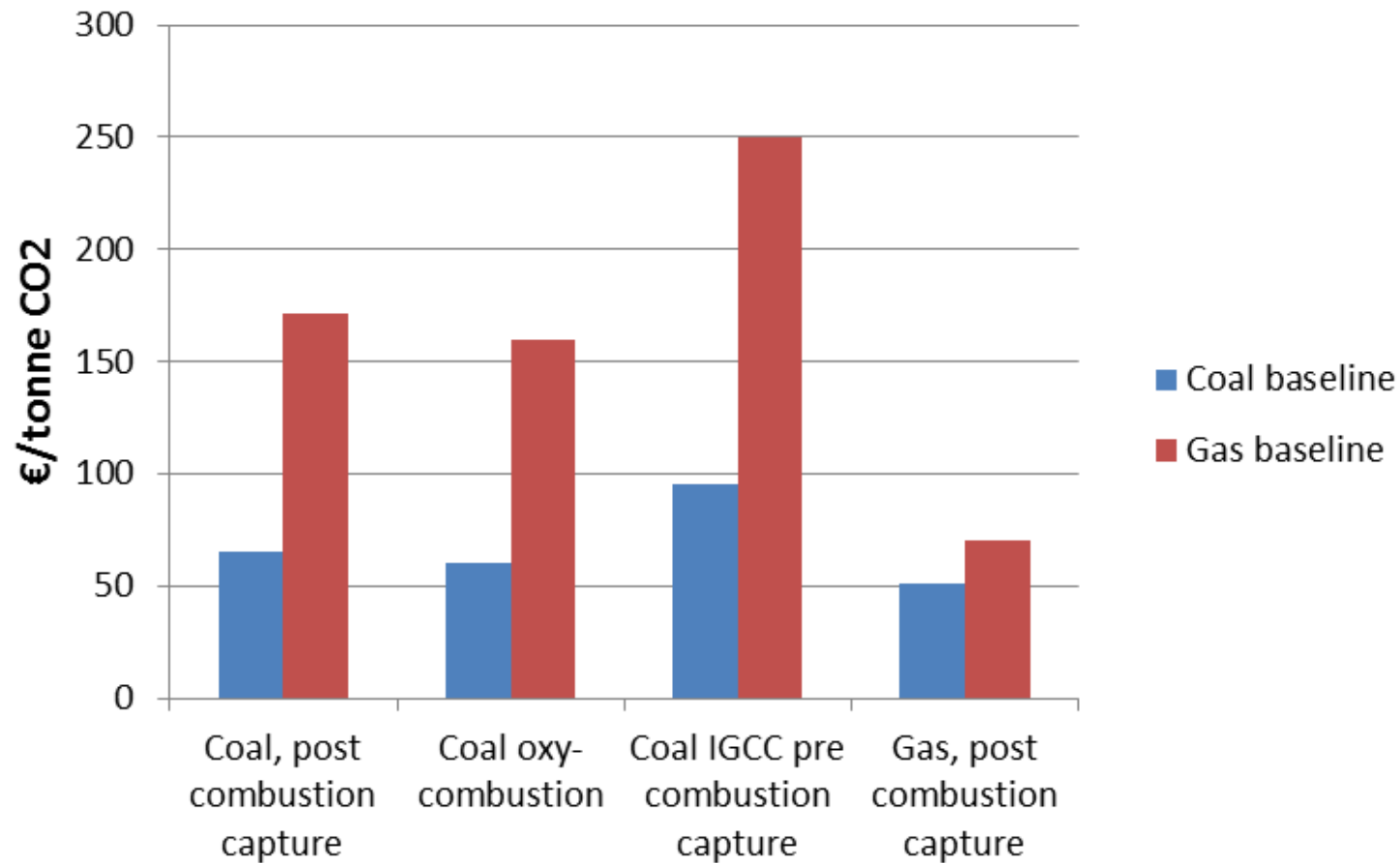


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Cost of CO₂ Abatement

Effect of choice of baseline



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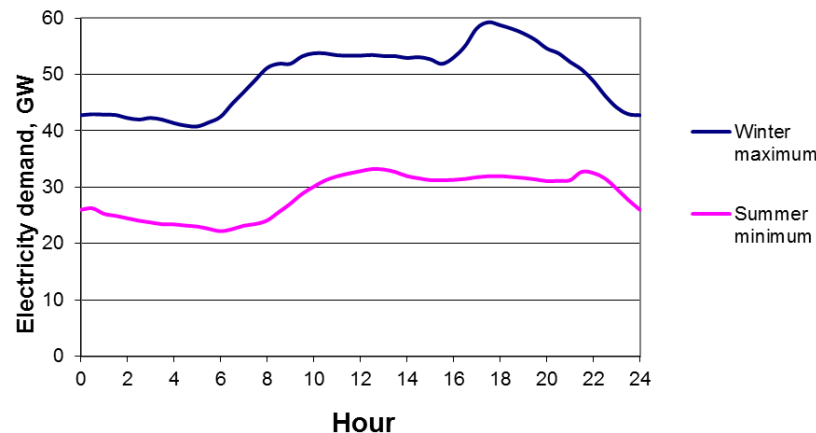
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Operating Capacity Factor

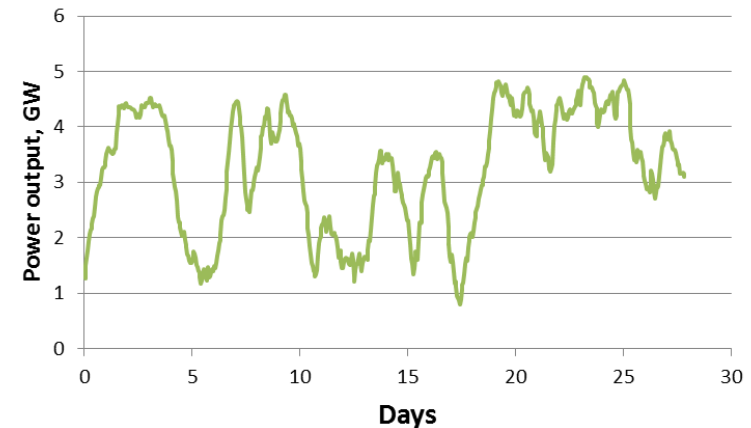


- Power systems need flexible plants to cope with:

Demand variability



Renewables variability



Electricity demand and renewables: UK data

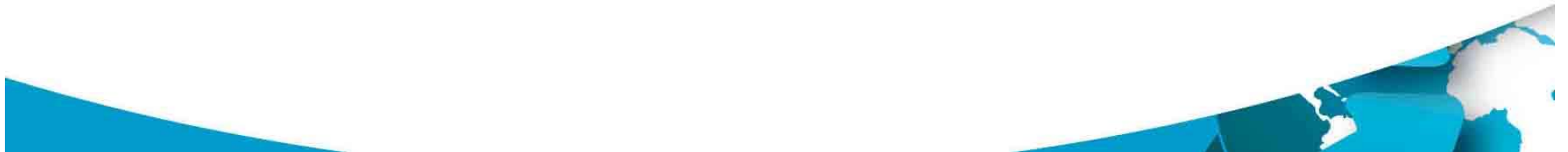
- CCS plants may have to operate at non-base load
 - More likely for gas fired plants – high variable costs
- Generation costs will be higher
- **Revenue per kWh will also be higher**



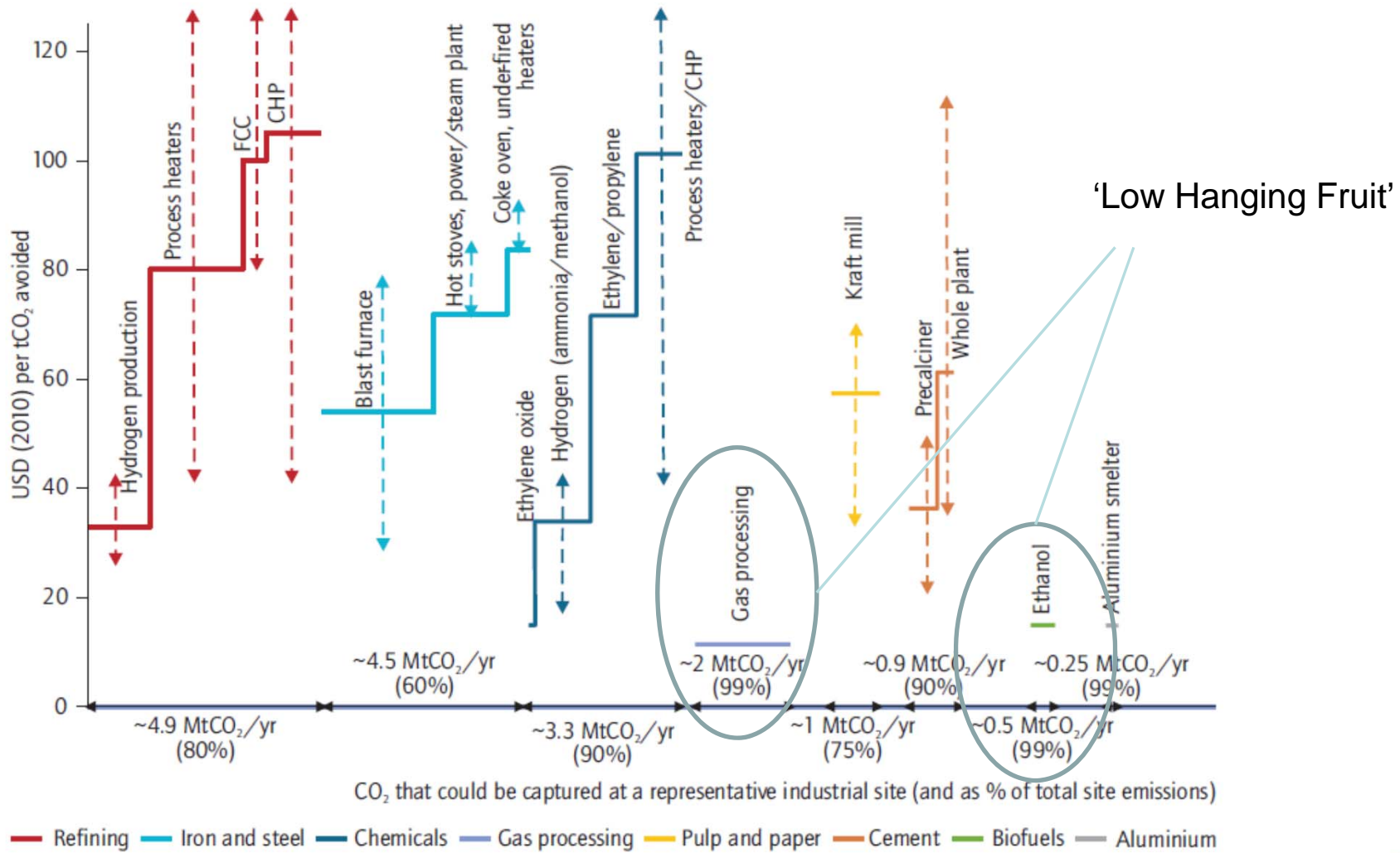
Industrial CCS Costs



- Less CCS cost information is available for non-power industries
- Costs will be different for each CO₂ source at each site
 - Partial capture of CO₂ at a site may be preferred
- Costs differ between sites
- Little information on costs in less developed countries, where most industrial emissions are



Industrial CCS Costs



Note: arrows represent data given by literature data. Dotted lines are ranges from selected studies.

Summary



- CCS is expected to almost double the capital cost of power plants
- Cost of electricity will increase by about 40-80%
- Cost of abatement around €60-100/t CO₂ for base load power plants
- First-of-a-kind CCS plants will be more expensive
- Costs should reduce due to learning-by-doing and new technologies
- Important to look at CCS costs in the context of future energy systems
- Some opportunities for low cost CCS in industry
- Costs of industrial CCS are highly uncertain



Thank you

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