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Carbon Dioxide Capture and Storage (CCS) in Germany

A Technology Assessment in Consideration of Environmental, Economic and Social Aspects

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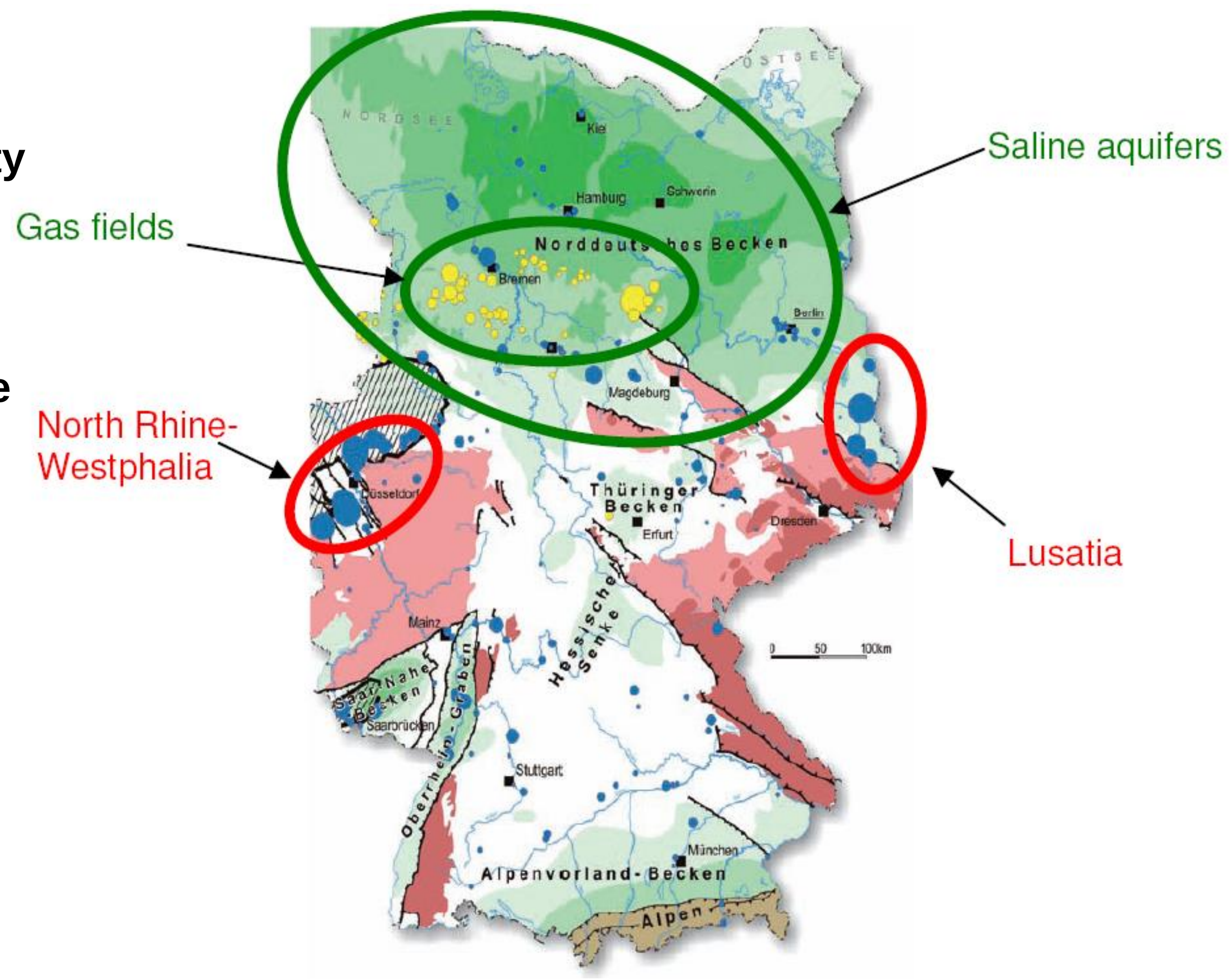
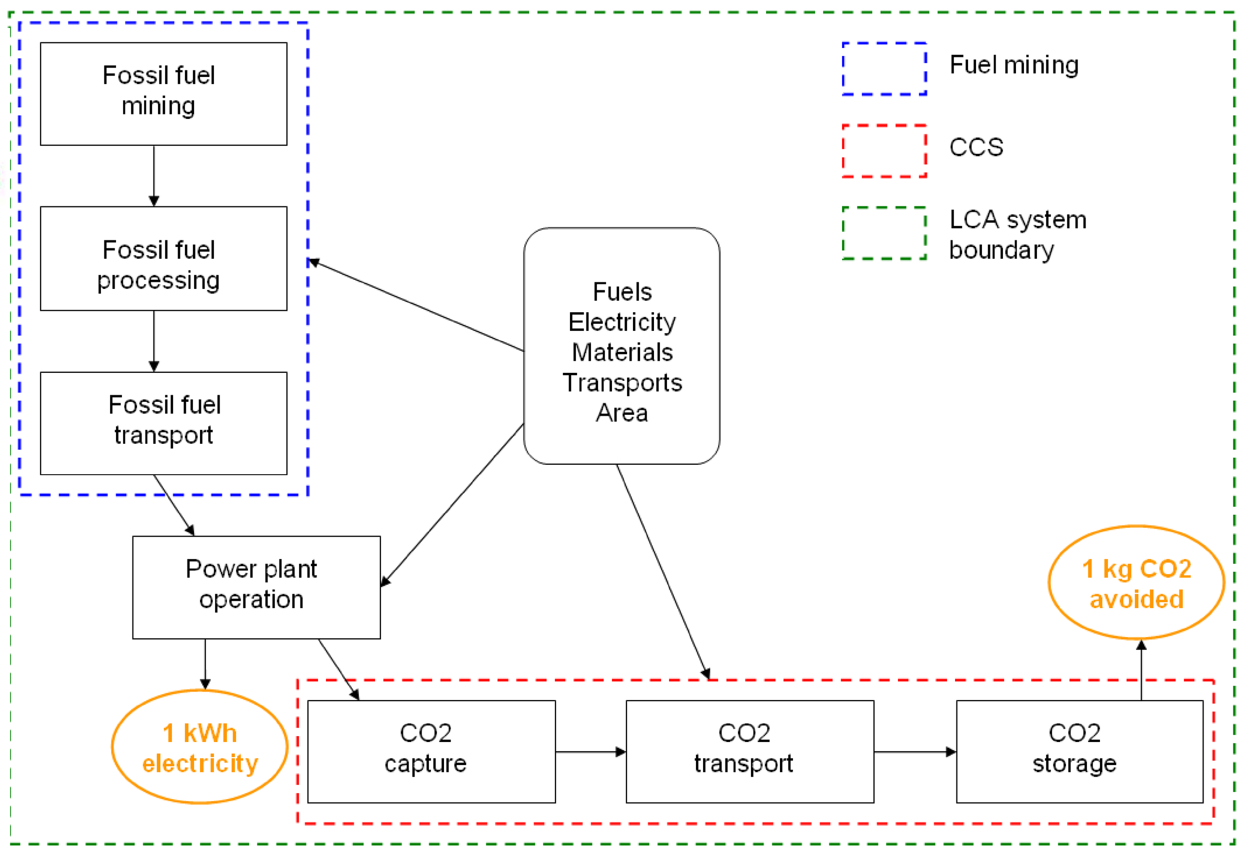
INTRODUCTION

- **CCS is seen as one of the options to reduce the greenhouse gas (GHG) emissions of the electricity sector in order to mitigate climate change.**
- **Germany's electricity sector heavily relies on fossil fuels (25% lignite, 18% hard coal and 13% natural gas in 2009). It is therefore suitable for the introduction of CCS.**
- **Saline aquifers and gas fields in Northern Germany could be used for carbon dioxide (CO_2) storage.**





METHODOLOGY

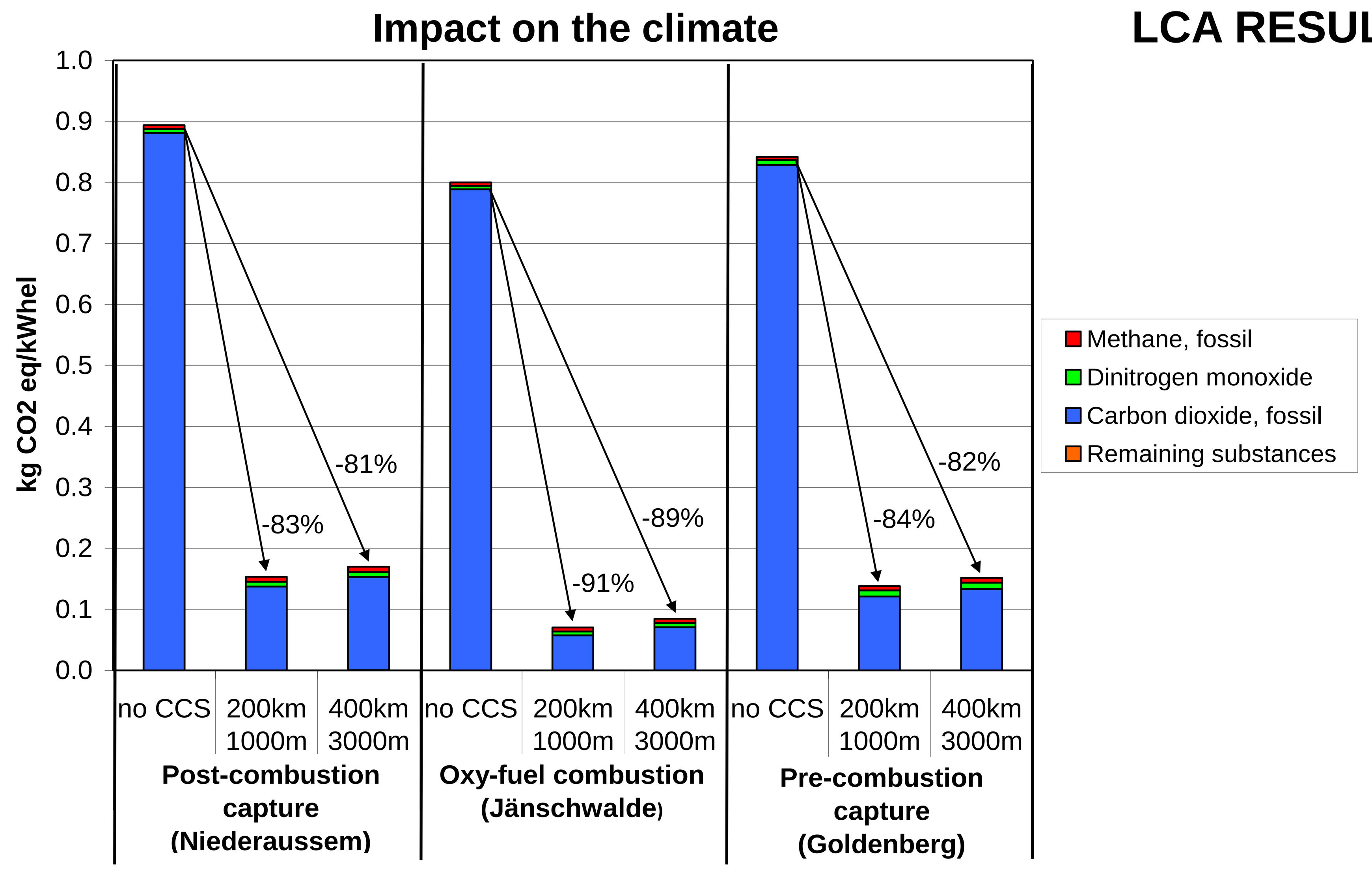
Environmental Assessment using Life Cycle Analysis (LCA) for three case studies:

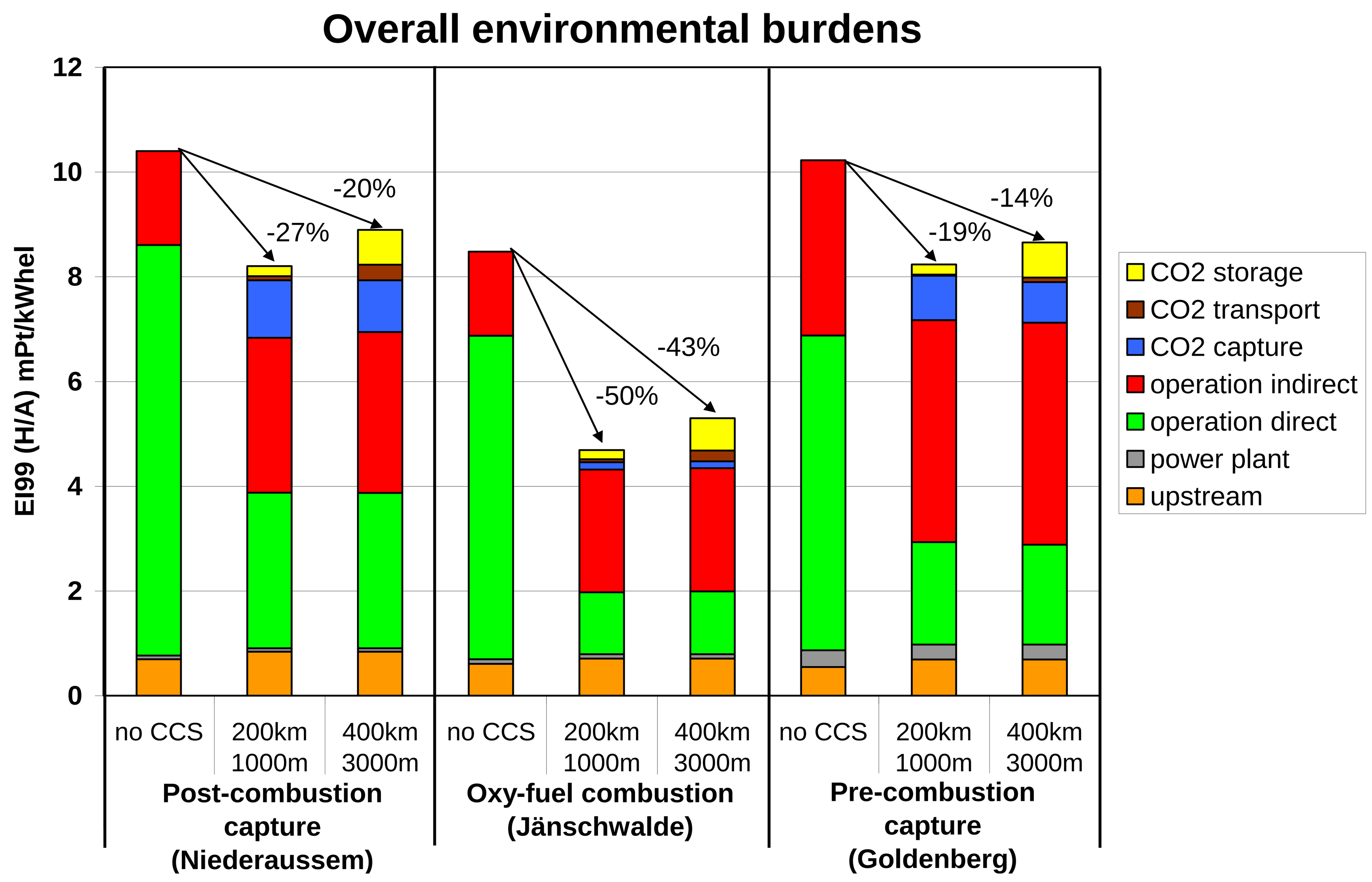
- **Lignite power plants: post-combustion capture / oxyfuel combustion / pre-combustion capture**
- **Pipeline transport: 200 km / 400 km length**
- **Storage in saline aquifers and depleted gas fields: 1000m / 3000m depth**

- **Economic assessment using literature values:**
  - **Lignite, hard coal, natural gas**
  - **Today, 2025 and 2050**
  - **Internal and external costs**

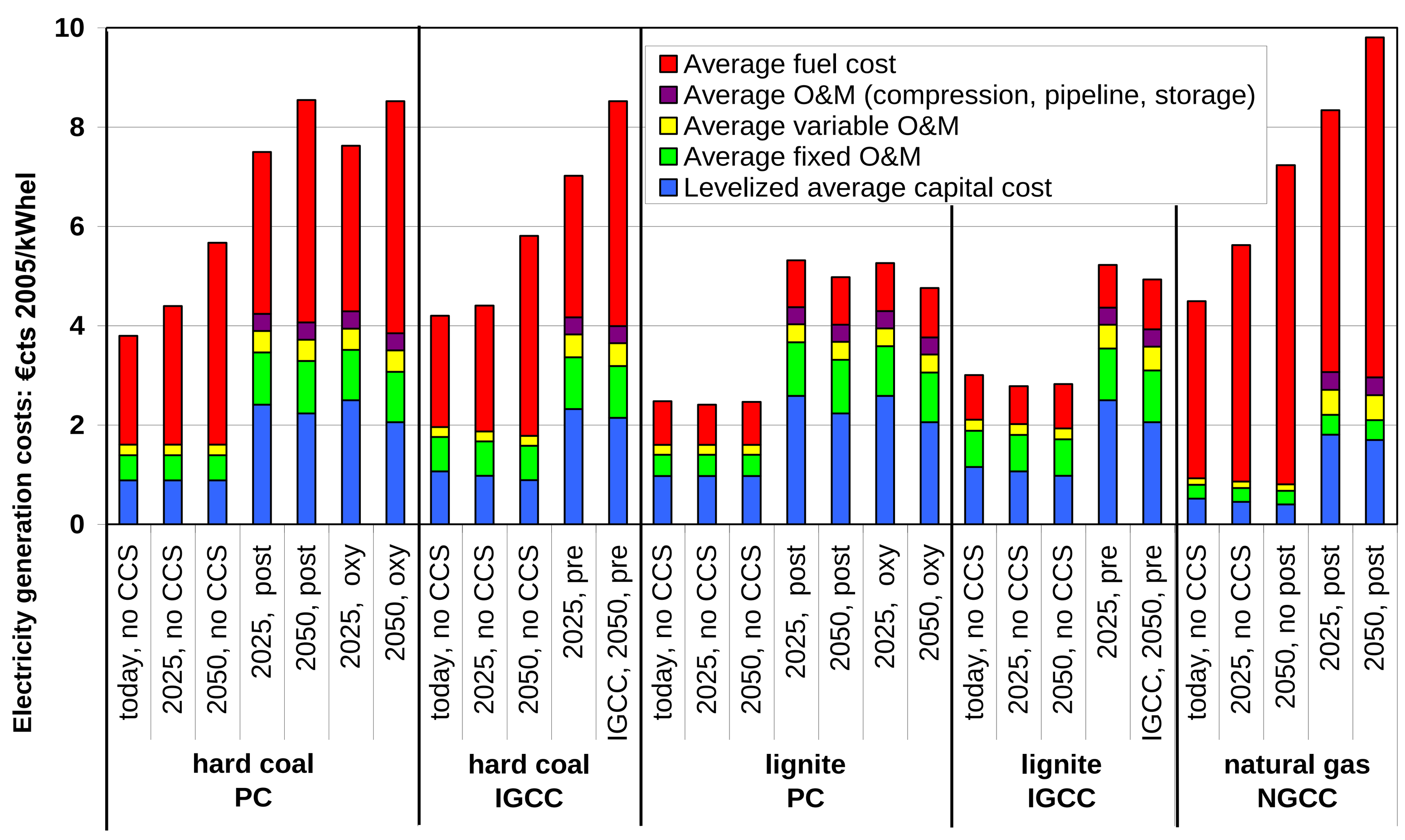
	Post-combustion	Oxyfuel combustion	Pre-combustion capture
Lower heating value lignite	8.48 MJ/kg	8.65 MJ/kg	10 MJ/kg
Efficiency without capture	45%	50.5%	48.5%
Efficiency with capture	35%	41.8%	34%
Capture rate	90%	96%	92%
Solvent	MEA 30%	-	Methanol 100%

LCA RESULTS





COST RESULTS



- **The inclusion of the external costs of electricity production can increase the competitiveness of CCS power plants. The external costs largely depend on the valuation of the costs of climate change.**

ENVIRONMENTAL CONCLUSIONS

- **Applying CCS at lignite power plants reduces the life cycle GHG emissions by around 80-90% and the life cycle environmental impacts by 14-50% with the assessment method chosen. The reduction of the overall impact is dominated by reduced CO_2 emissions at power plant operation, whereas contributions from other life cycle phases may increase.**
- **The oxyfuel technology offers the largest life cycle GHG emission reduction potential due to the high CO_2 capture rate; the relatively high efficiency; the lack of solvents in the capture process.**
- **Compared to renewable and nuclear electricity production the life cycle GHG emissions and environmental impacts of CCS power plants are still high.**

ECONOMIC CONCLUSIONS

- **Implementation of CCS significantly increases electricity generation costs. Fuel costs dominate the production cost for natural gas, whereas capital costs are more important for coal.**
- **Lignite power plants offer low generation costs as well as low avoidance costs and should therefore be targeted for CCS application first.**
- **The price of CO_2 must significantly increase to allow for economically competitive power generation with CCS power plants.**

The Technology assessment group at the PSI is continuing to broaden the scope of the comparison of CCS technologies. Other aspects currently under analysis include a case study for CCS in Switzerland and CCS at natural gas power plants.
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The Laboratory for Energy Systems Analysis (LEA) is leading sub-project 1 within CARMA, which is a Swiss research project that aims at exploring the potential and feasibility of CCS systems deployment in Switzerland, within the framework of future energy scenarios.
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