Transient Behavior of Post Combustion CO_2 Capture Process

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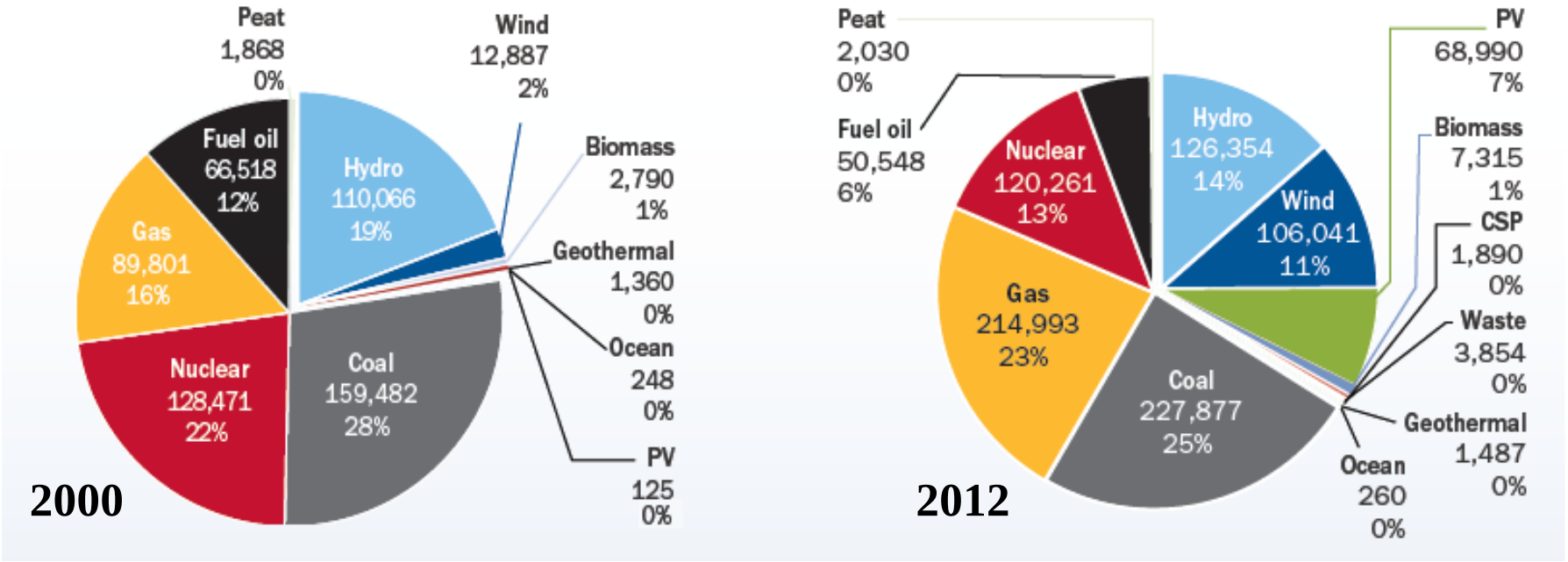
Background

- Increased capacity of intermittent energy sources in the electricity mix
  - Demand for load flexibility in base load power plants increases
- Effects on downstream CO_2 capture systems
  - Dynamic analysis is needed



EU power mix

Source: ewea.org

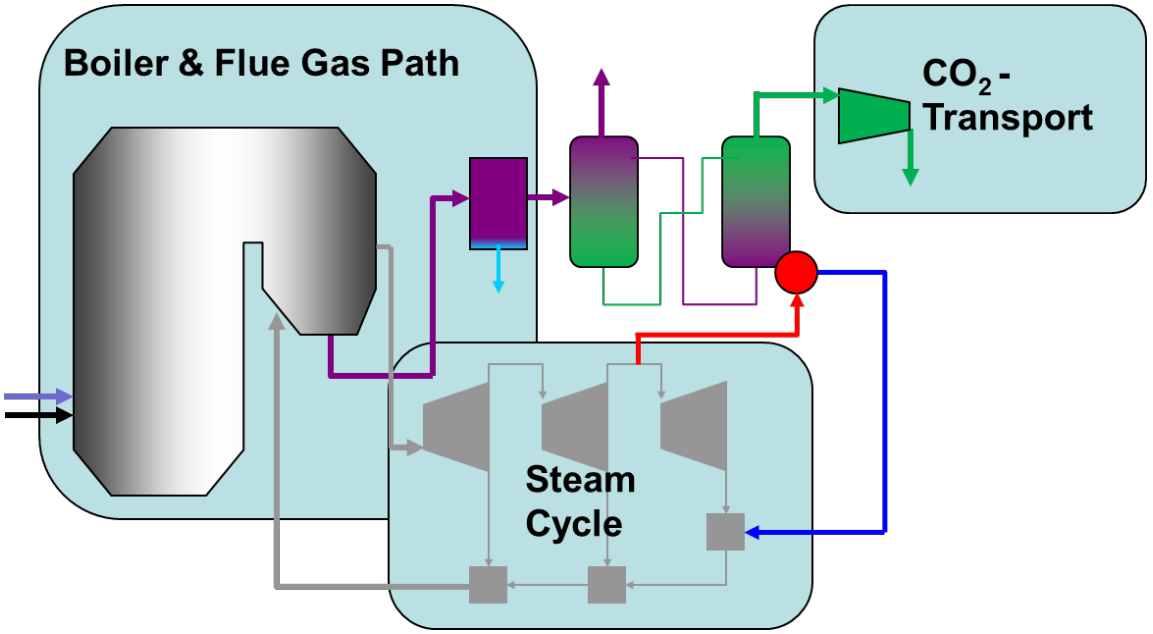
Aim

- Evaluate transient behavior of the capture system with respect to a typical load-change ramp rate in modern coal power plants
  - Discuss connections for the steam cycle and CO_2 transportation network

- Evaluate steady state effects on power plant performance at different load conditions

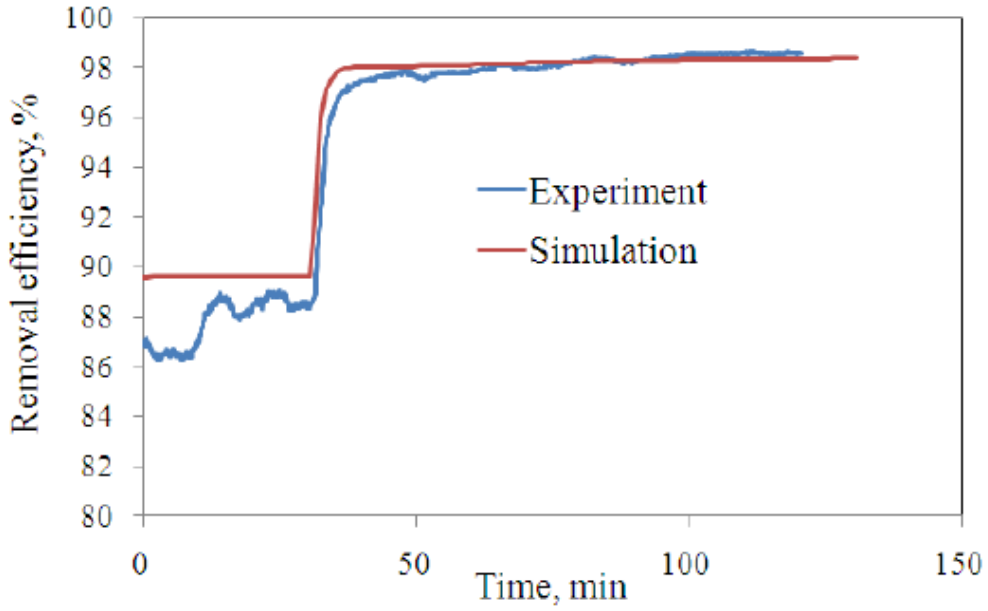
The model

- 30 wt% MEA-based absorption model constructed in Dymola (Åkesson et al. 2012)
- Rate-based model
- Chemical equilibrium assumed in model parts



Evaluation of absorption model

- Experimental results from step response tests conducted at DONG Energy coal fired power station in Denmark
- Experimental data from two operating points
  - Both steady-state and dynamic operation

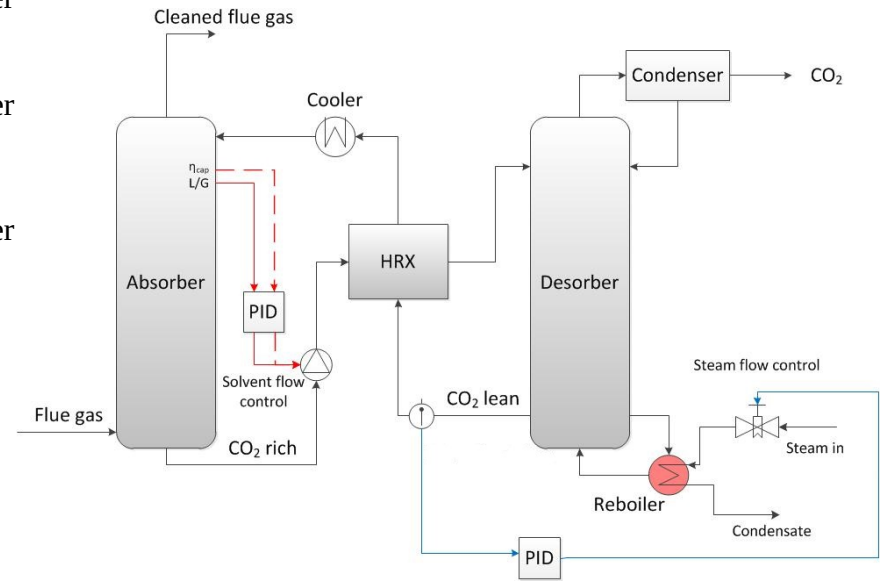


Source: Åkesson et al., 2012

The model applied I

- Capture system dynamics
  - Dynamic sensitivity analysis
  - Effects of different control strategies

Control strategy	Controlled variable	Varied variable
No control	Lean solvent loading	Steam flow to reboiler
Capture efficiency	Capture efficiency + Lean solvent loading	Solvent flow rate + Steam flow to reboiler
L/G	L/G ratio + Lean solvent loading	Solvent flow rate + Steam flow to reboiler



Method

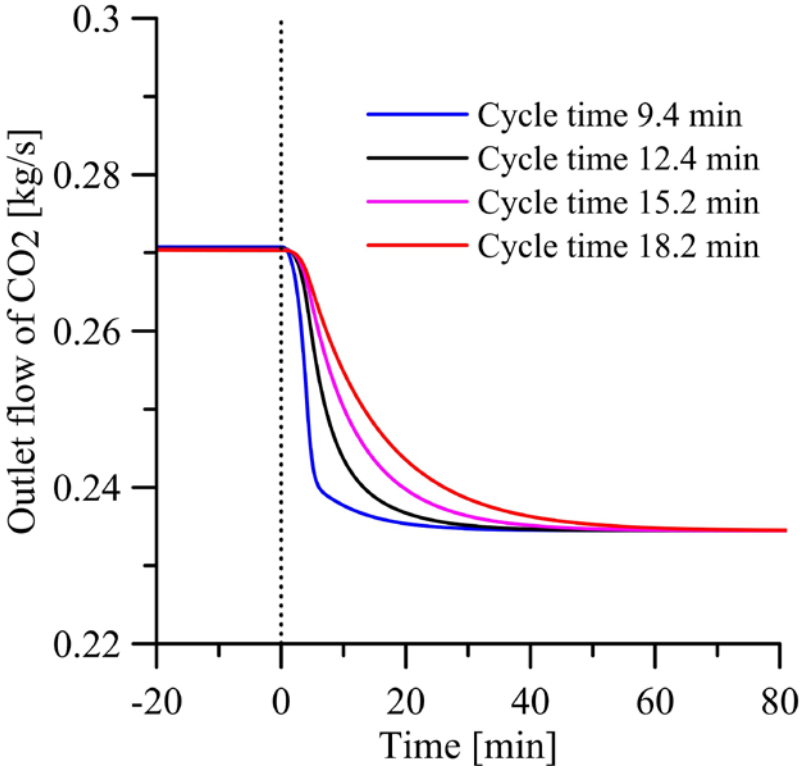
The model applied II

- Power plant application
  - Steady state evaluation of power plant performance during full load and part load
  - Effects of controllers on power plant performance

Capture system dynamics

Dynamic sensitivity analysis

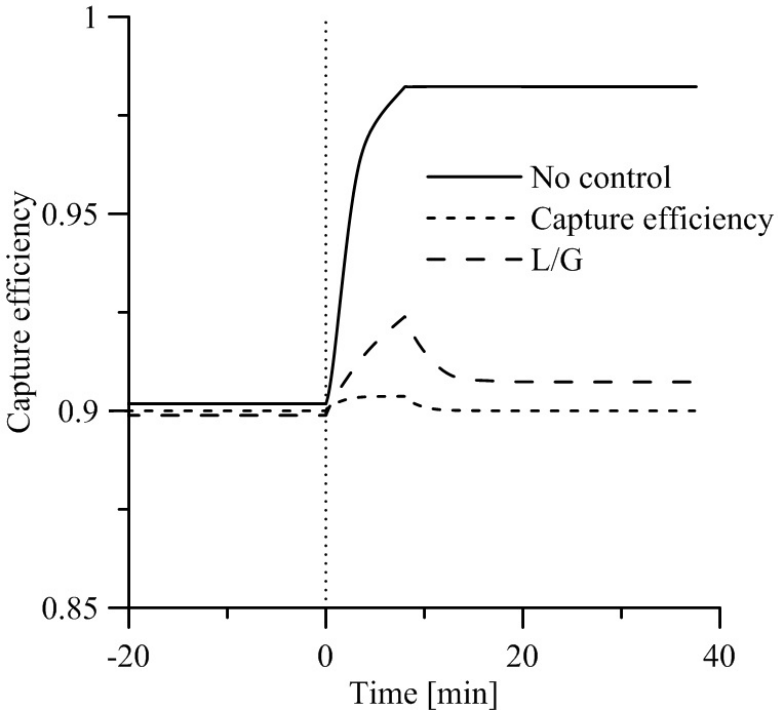
- Amount of liquid in the system varied without varying flow rates or properties of the packed volumes
- Increased liquid mass → slower system dynamics

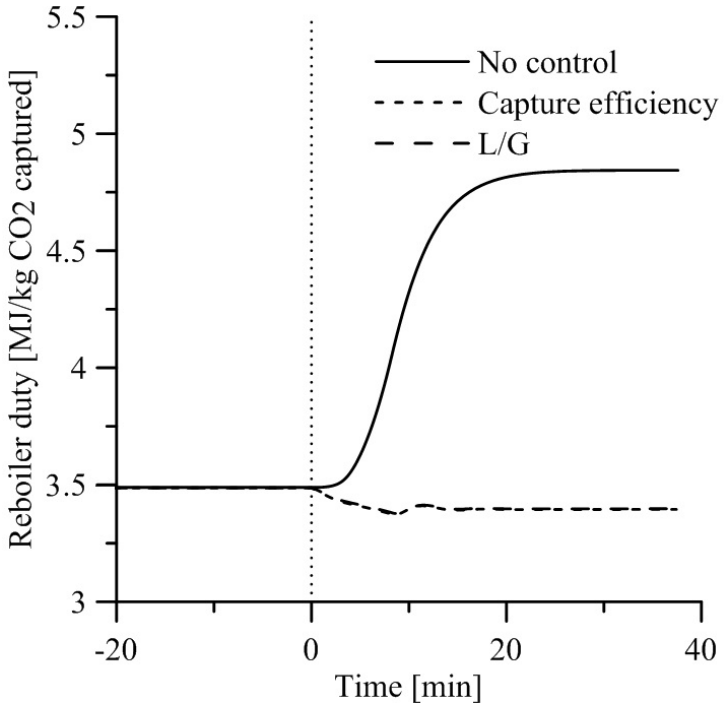


Results

Effects of process control

- Power plant load is ramped down from full load to 60%

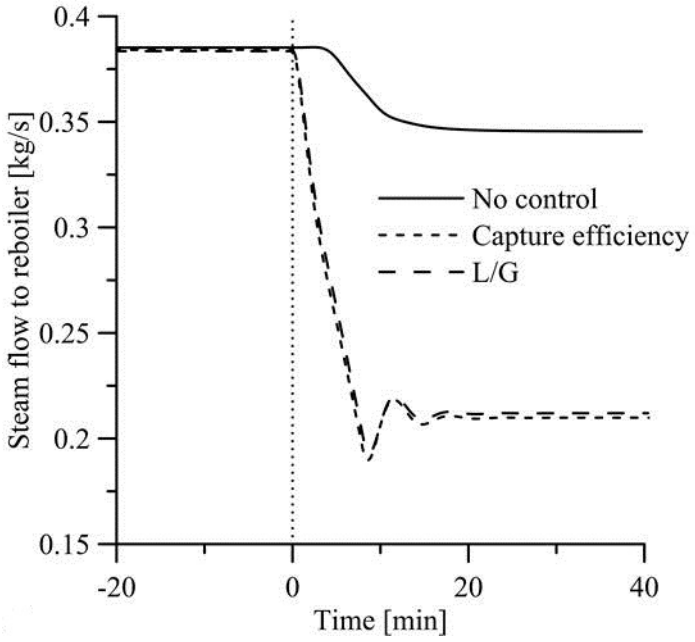




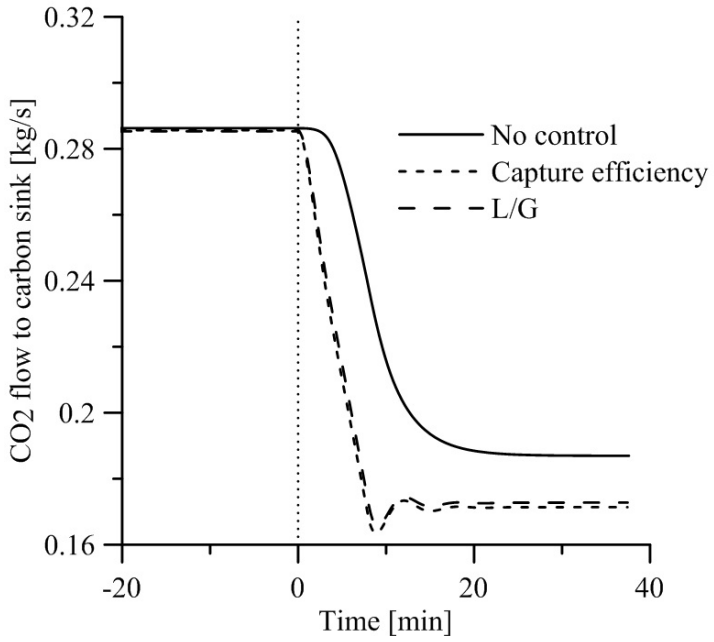
Results

Interaction with connected systems

- Capture system acts like a buffer



Steam flow from power cycle



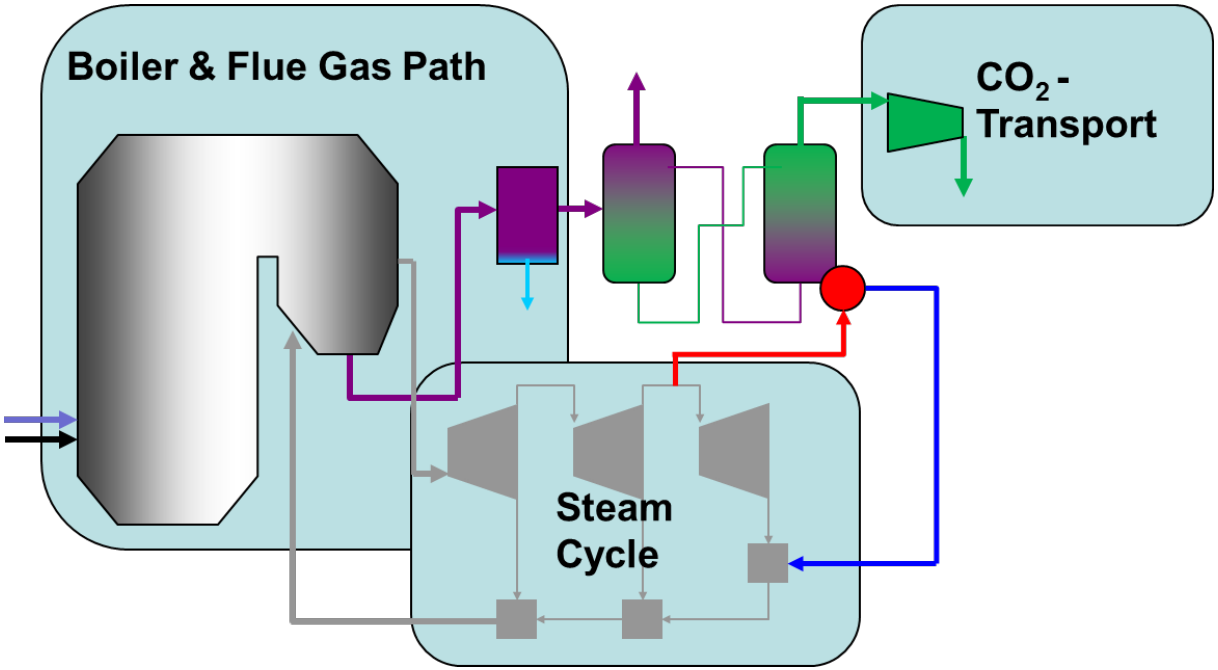
CO_2 flow to pipeline system

Results

Power plant application

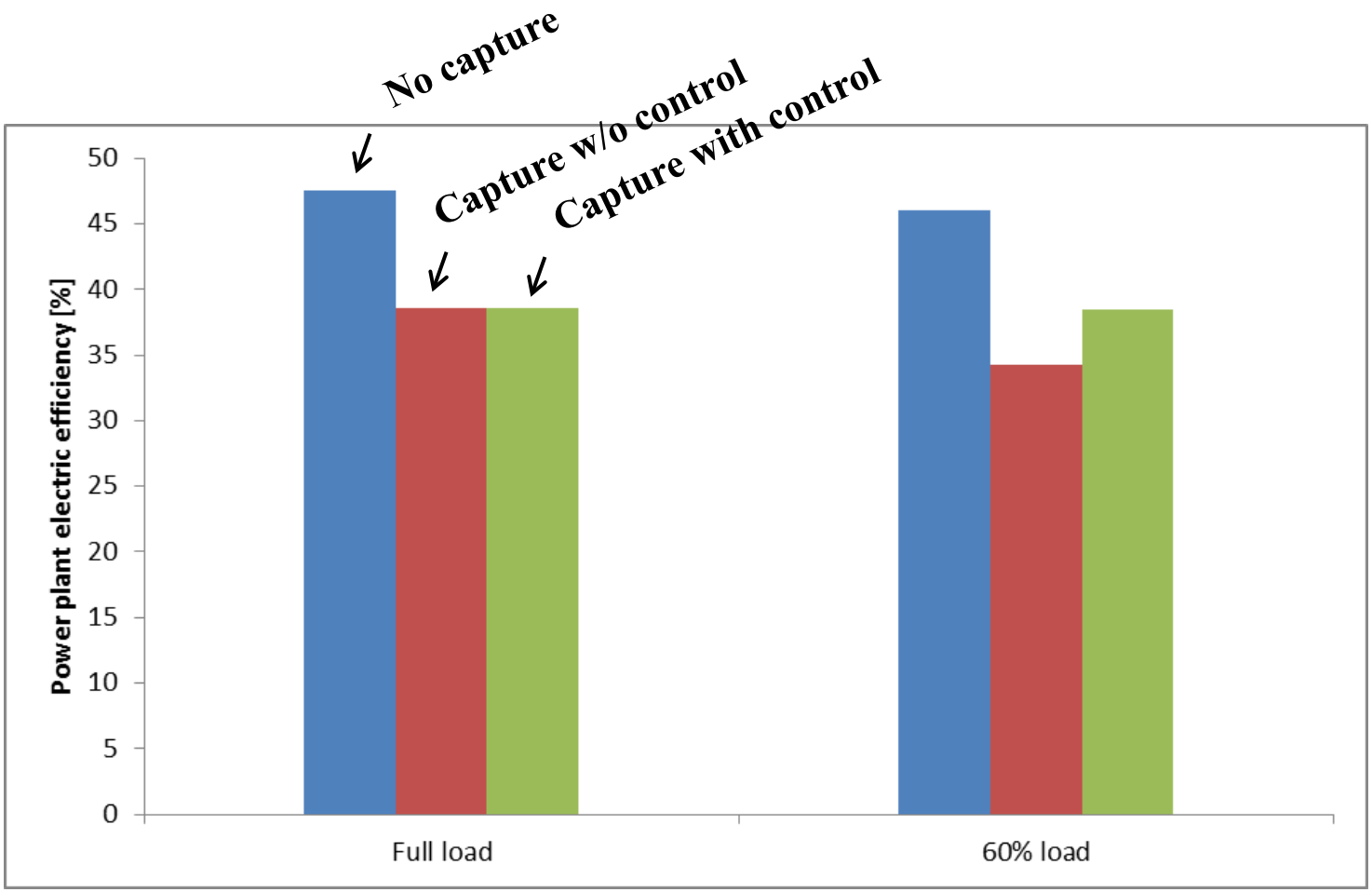
Power plant application

- Evaluation of power plant performance based on steady-state modeling of Nordjyllandsvaerket in Denmark
  - Steam for capture system extracted between two intermediate pressure turbines
  - Full load and part load operation



Method

Effects on power plant



CO_2 compression work and other mechanical work is not included in the power plant efficiency values

Results

Conclusions

- The simulations show that the CO_2 capture process responds to load changes within few minutes
- Implementation of active control strategies improves capture system performance with respect to heat requirement
  - The response time of the system is generally lower in these cases
- Integration with the power plant results in an efficiency decrease in the range of 8-12 percentage points

Thank you for your attention!

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