

# Simulating impacts of power plant flexibility on CCS Chains with gCCS

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# Energy Technologies Institute (ETI)

Public-private partnership between global industries and the UK Government set up with the objectives of

- ensuring clean, secure and affordable energy supplies are available to power everyday living and business
- reducing greenhouse gas emissions to tackle the effects of climate change

The ETI makes targeted investments in key technologies that will help the UK meet its legally binding 2050 targets

## ETI members

### Corporate



Rolls-Royce



e-on



CATERPILLAR

### Public institutions

Technology Strategy Board  
Driving Innovation

EPSRC  
Engineering and Physical Sciences  
Research Council



BIS | Department for Business  
Innovation & Skills

e-on

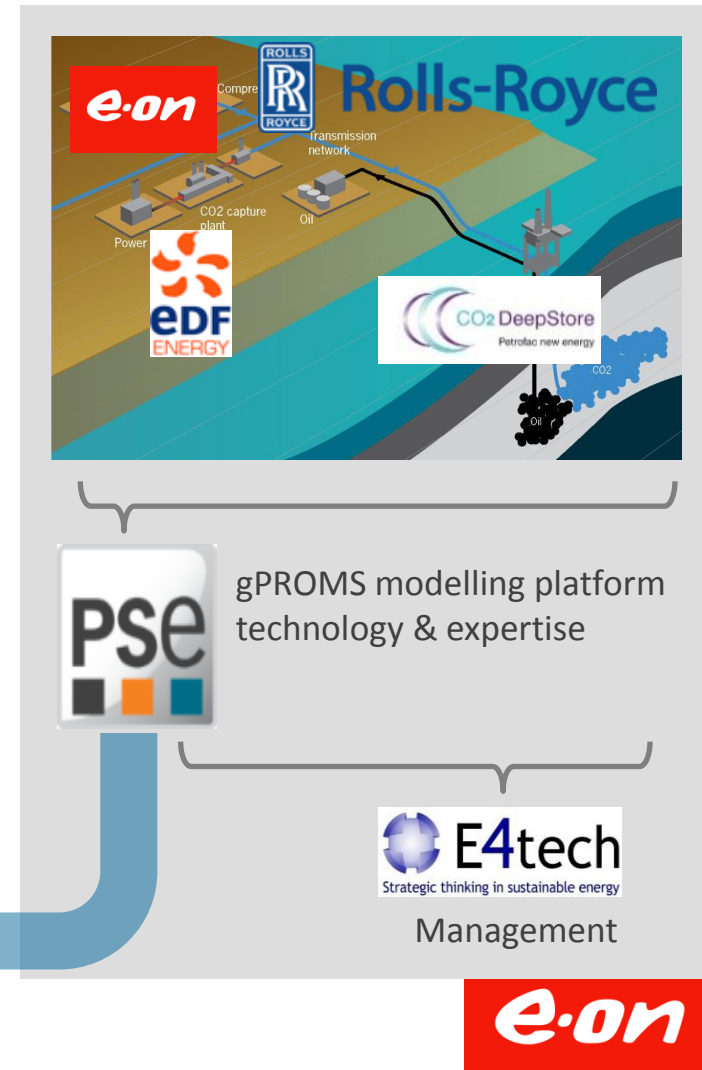
# System-wide modelling: high-level requirements

## CCS System Modelling Tool-kit Project

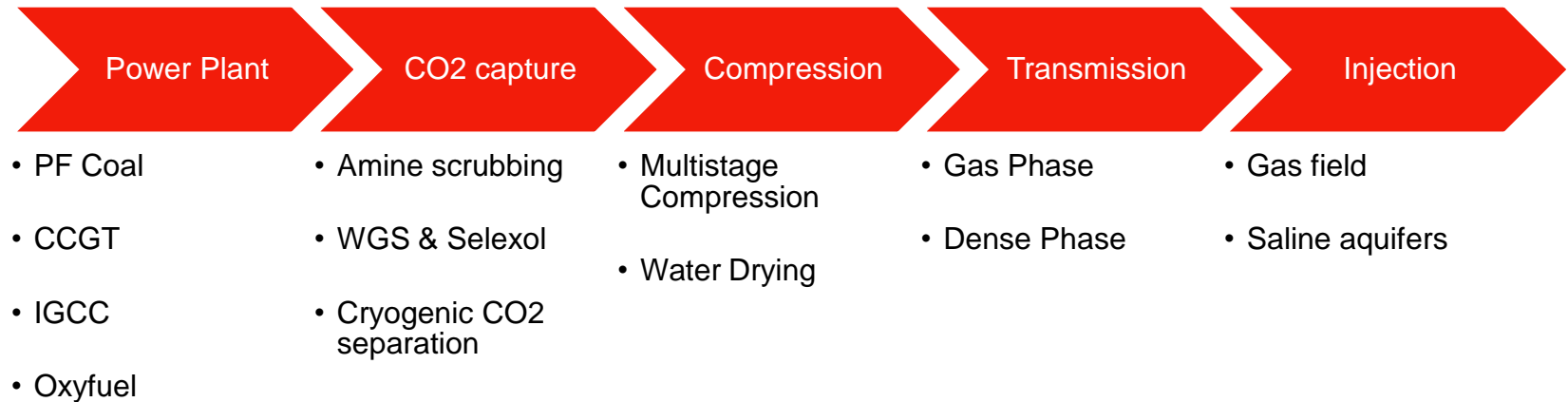
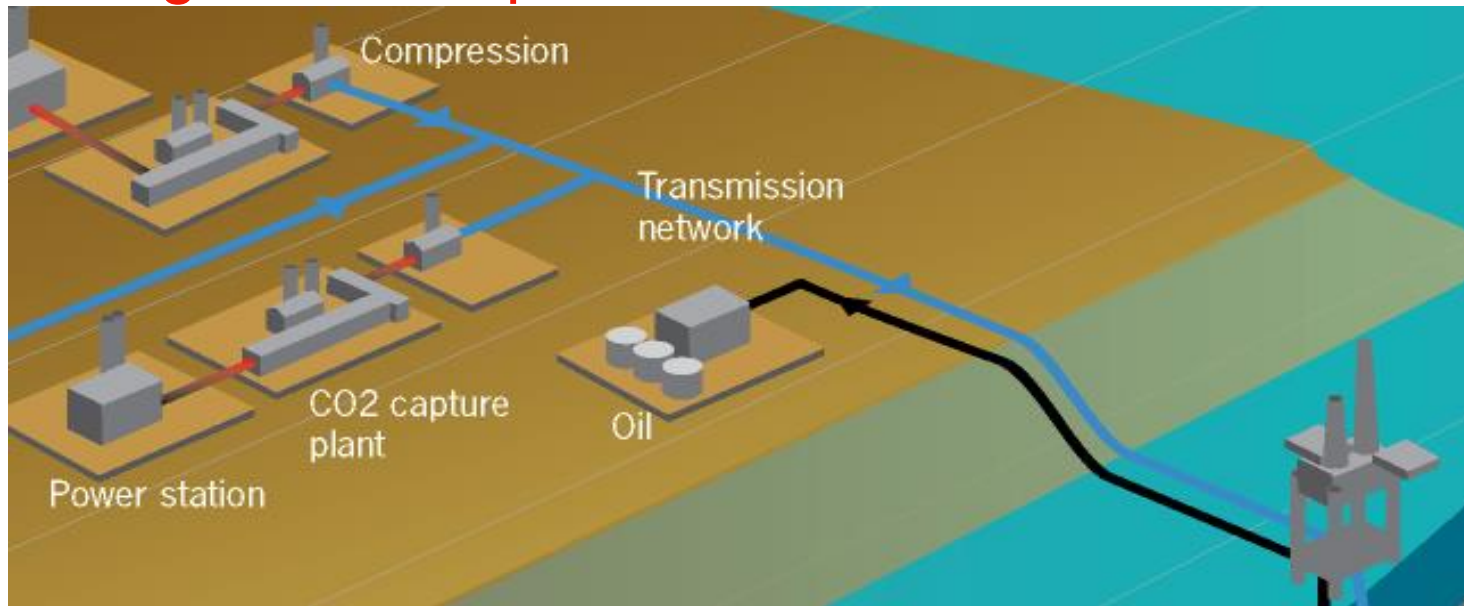
- Energy Technologies Institute (ETI) commissioned £3m (\$5m) project
- E.ON, EDF, Rolls-Royce, Petrofac/CO2DeepStore, PSE, E4tech
- September 2011- Spring 2014

### → Create a commercially available product

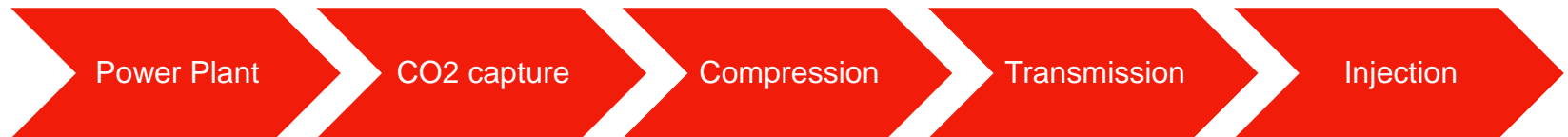
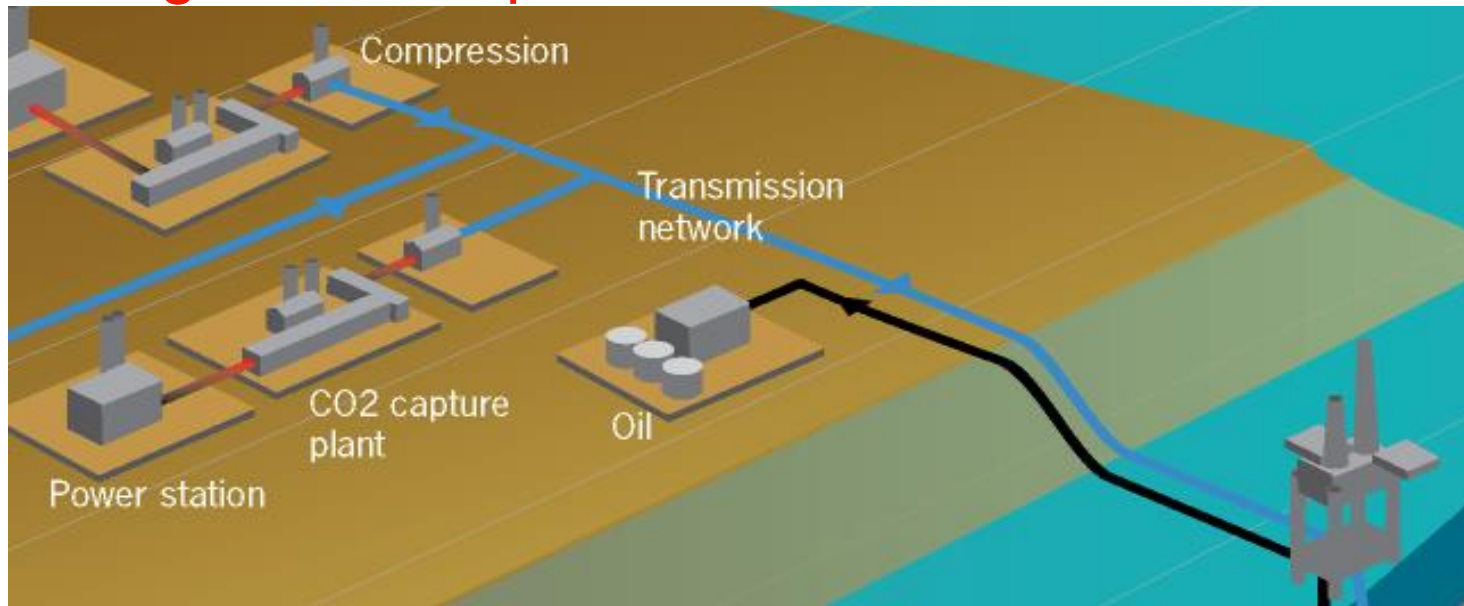
- built on PSE's gPROMS platform
- High-fidelity system-wide CCS modelling
- Toolbox and ecosystem



# Modelling Toolkit Capabilities



# Modelling Toolkit Capabilities

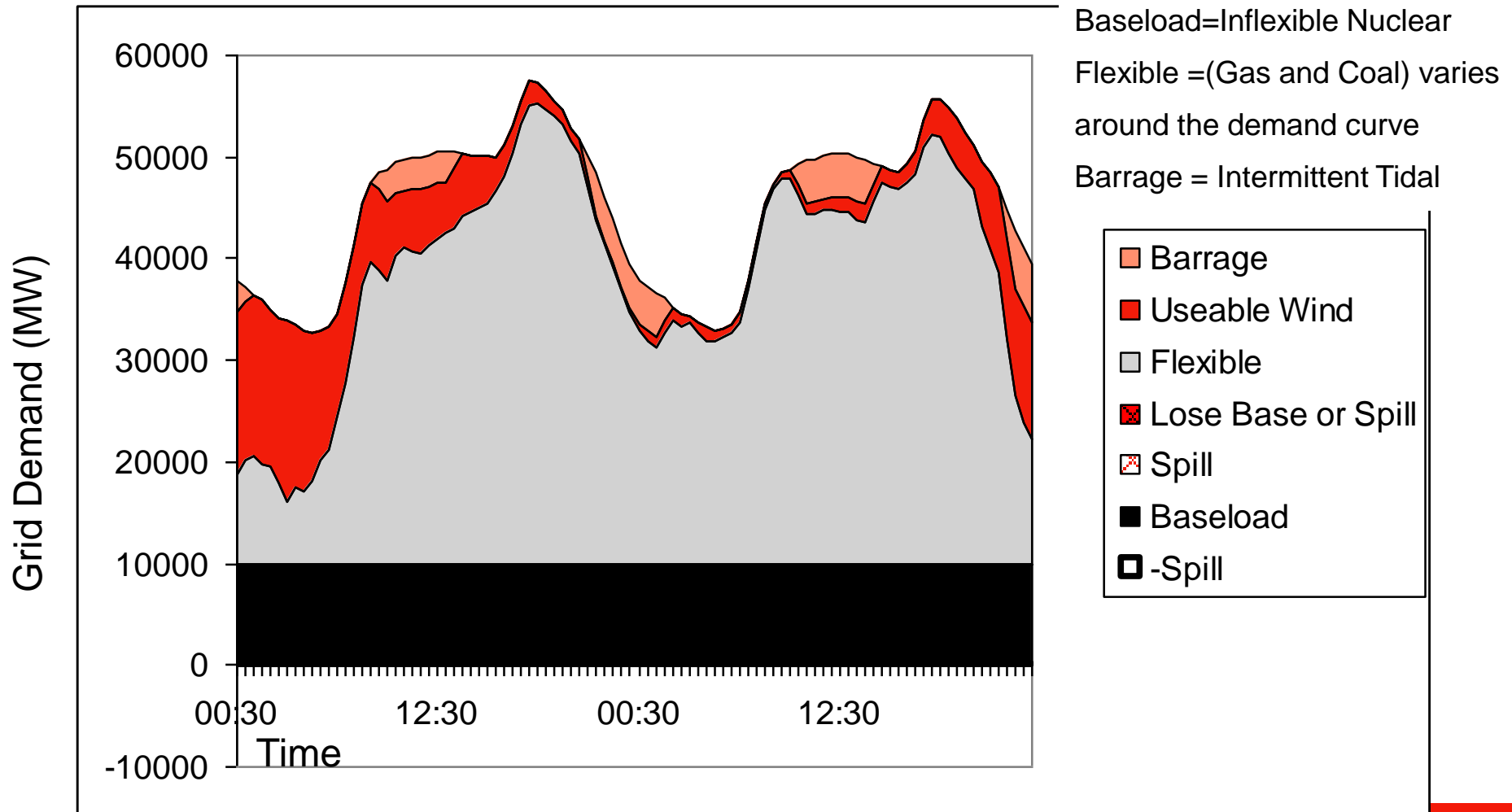


Steady State	Medium	High	Medium – High	High	Medium
Dynamic	Low	High	Low	High	Low

# Why is dynamic simulation of CCS important?

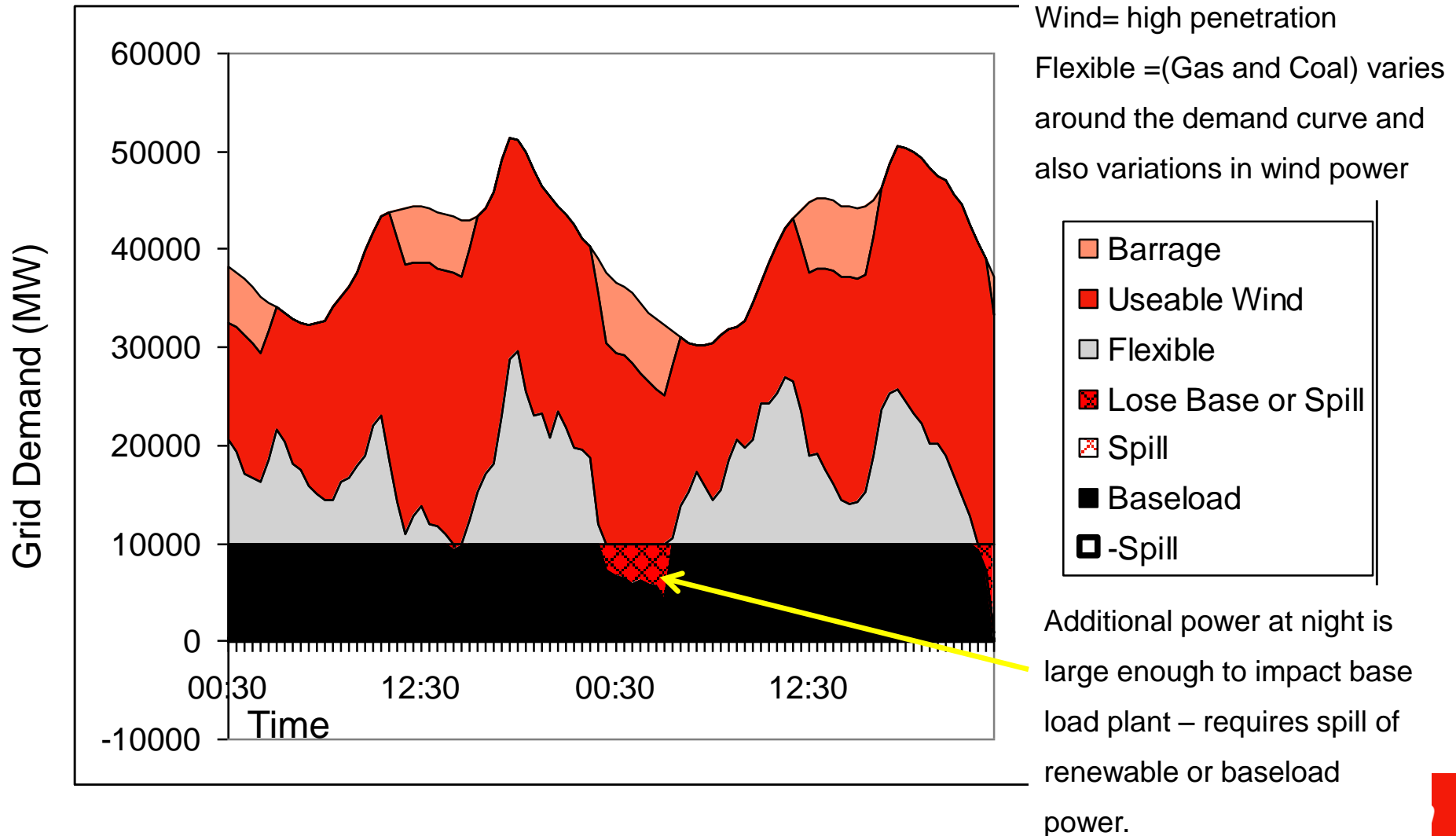
- To achieve carbon reduction targets in the UK, electricity must be effectively decarbonised by ~2030
- Therefore to meet these targets fossil plants must have CO<sub>2</sub> capture and sequestration to eliminate their emissions.
- Fossil plant currently provides the on-demand flexible generation to meet changes in demand over the day.
- In-flexible intermittent generation(e.g. wind & solar) means fossil plant will be required to change load around less predictable changes in green supply.

# Typical day in 2010



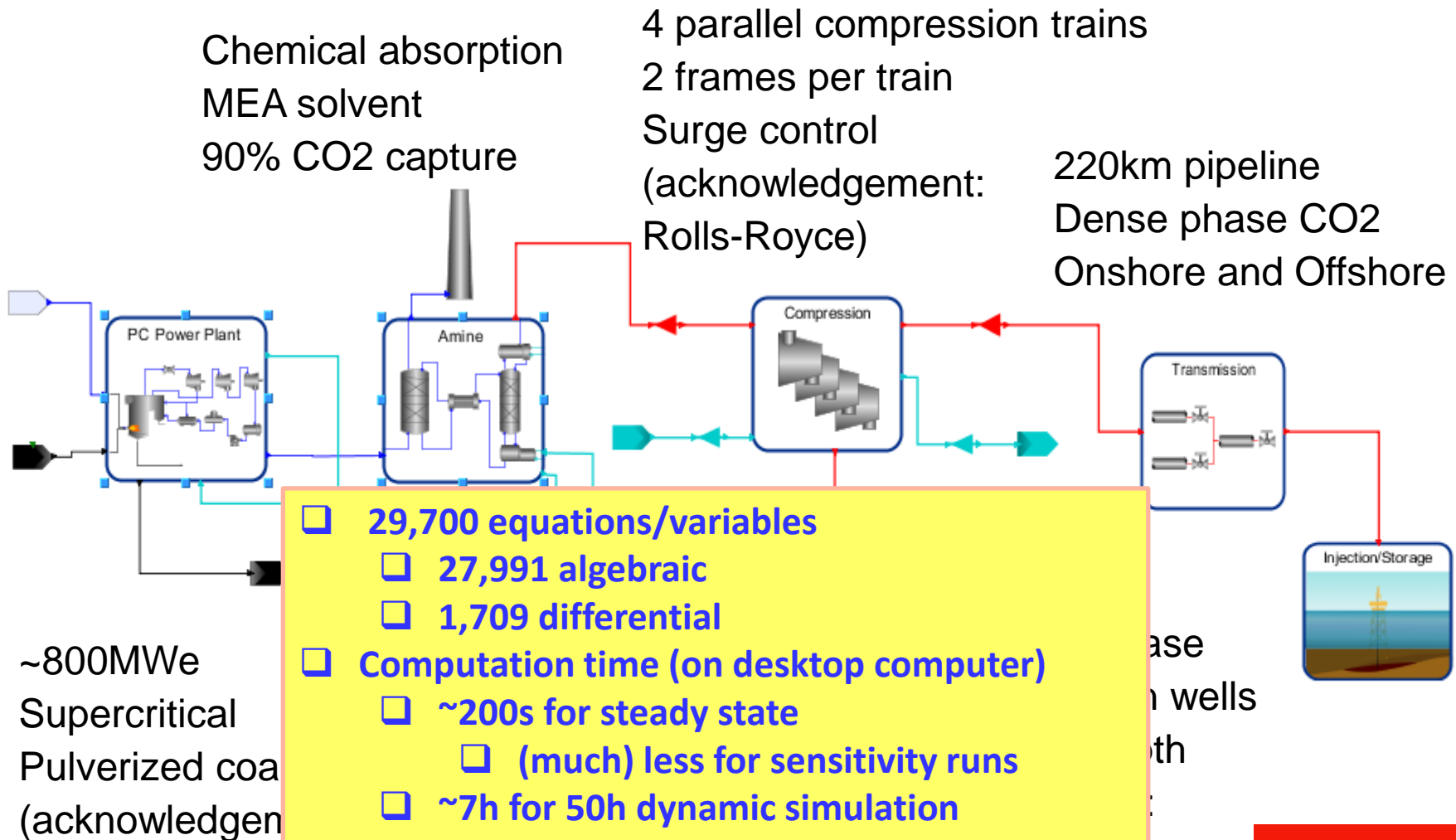


## Windy day in 2030 with high wind penetration



## Case Study: dynamic analysis

# System overview

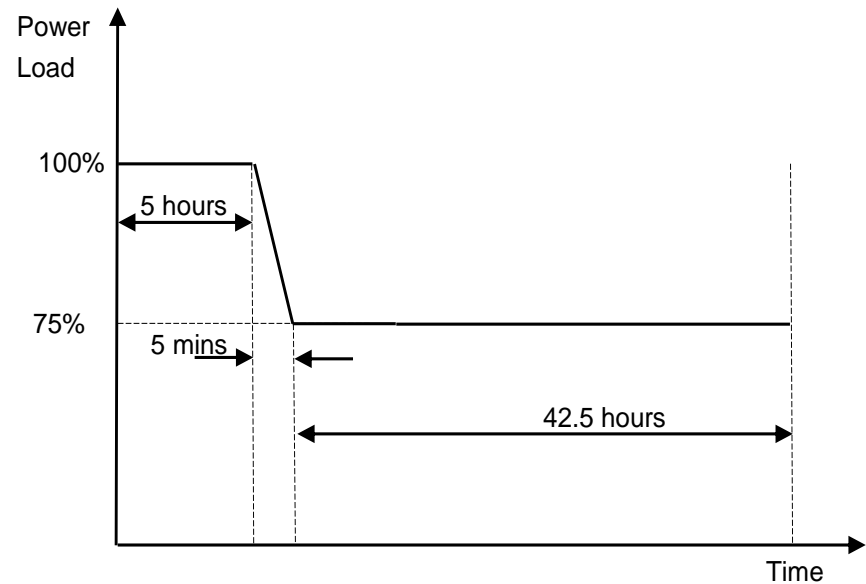
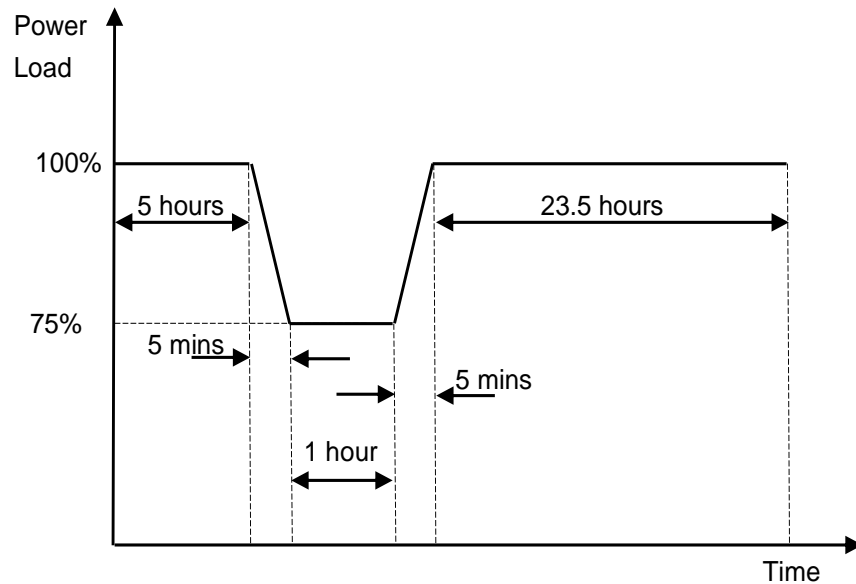


# Dynamic analysis

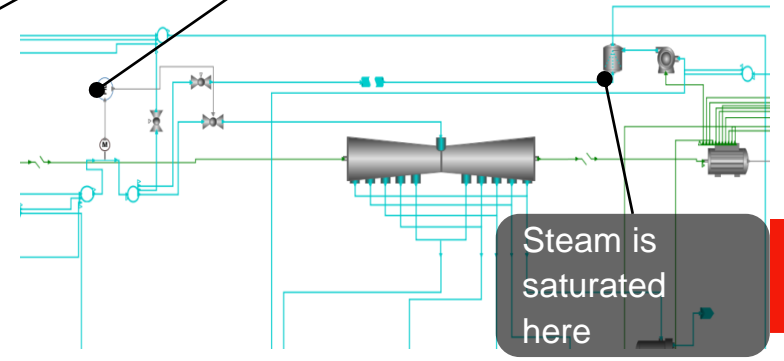
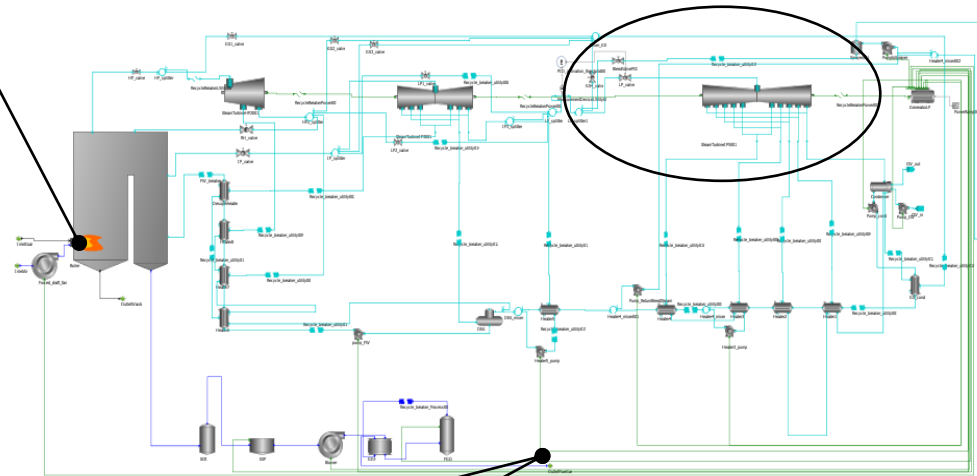
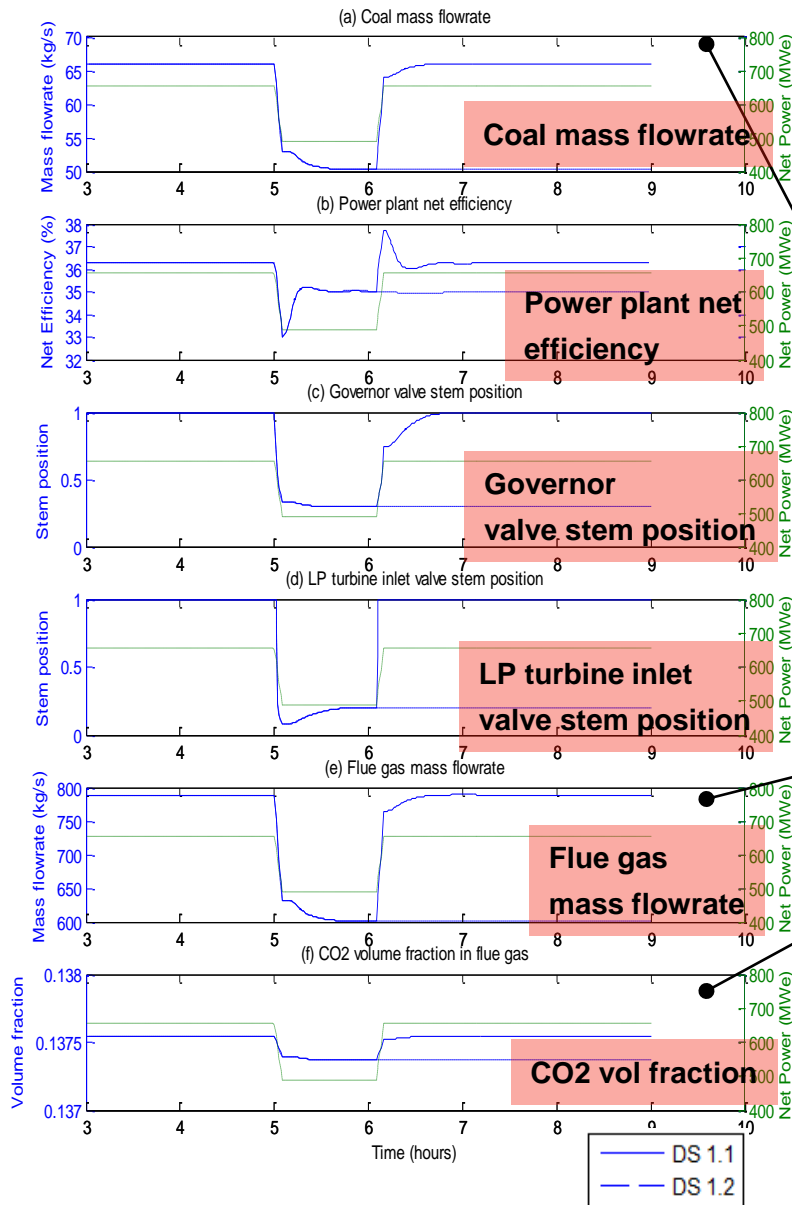
## Scheduled changes in power plant load

### Scenario DS1.1

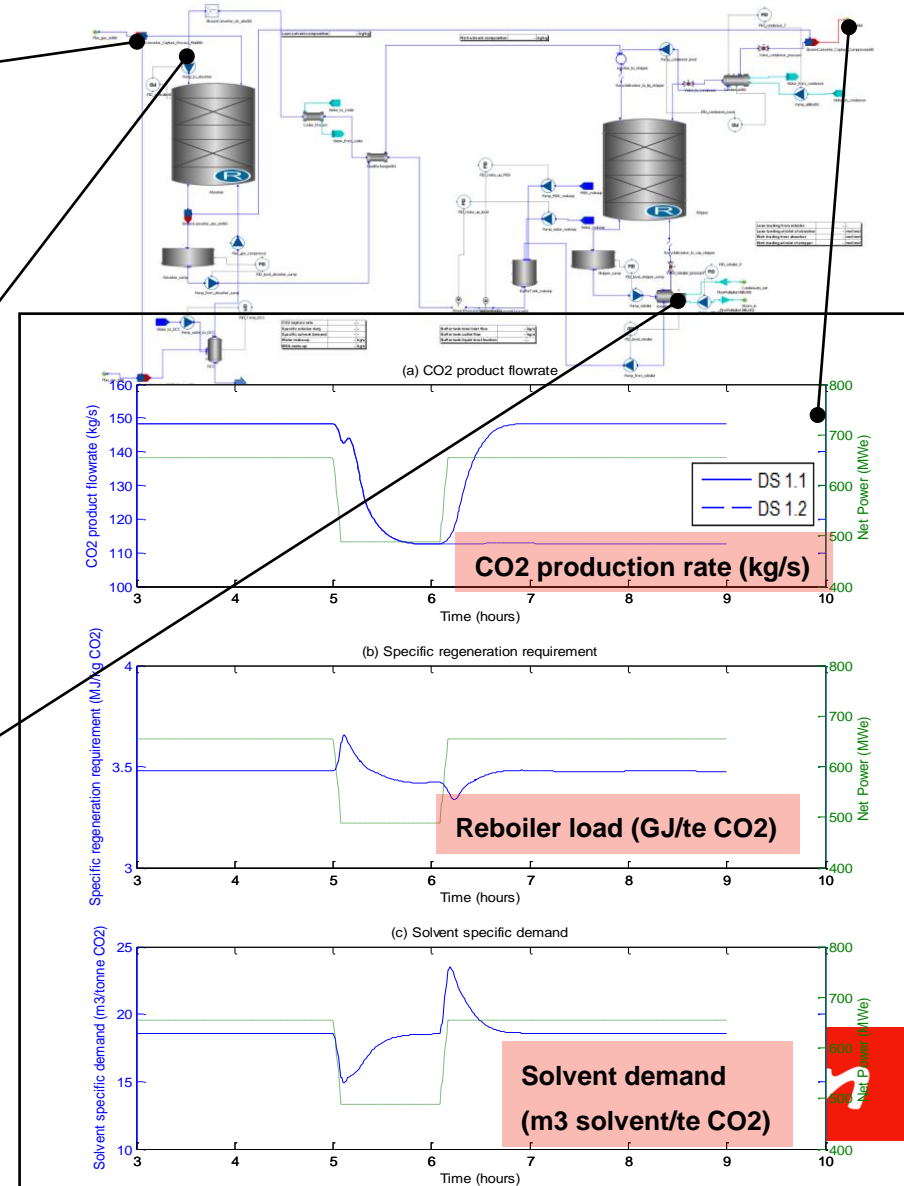
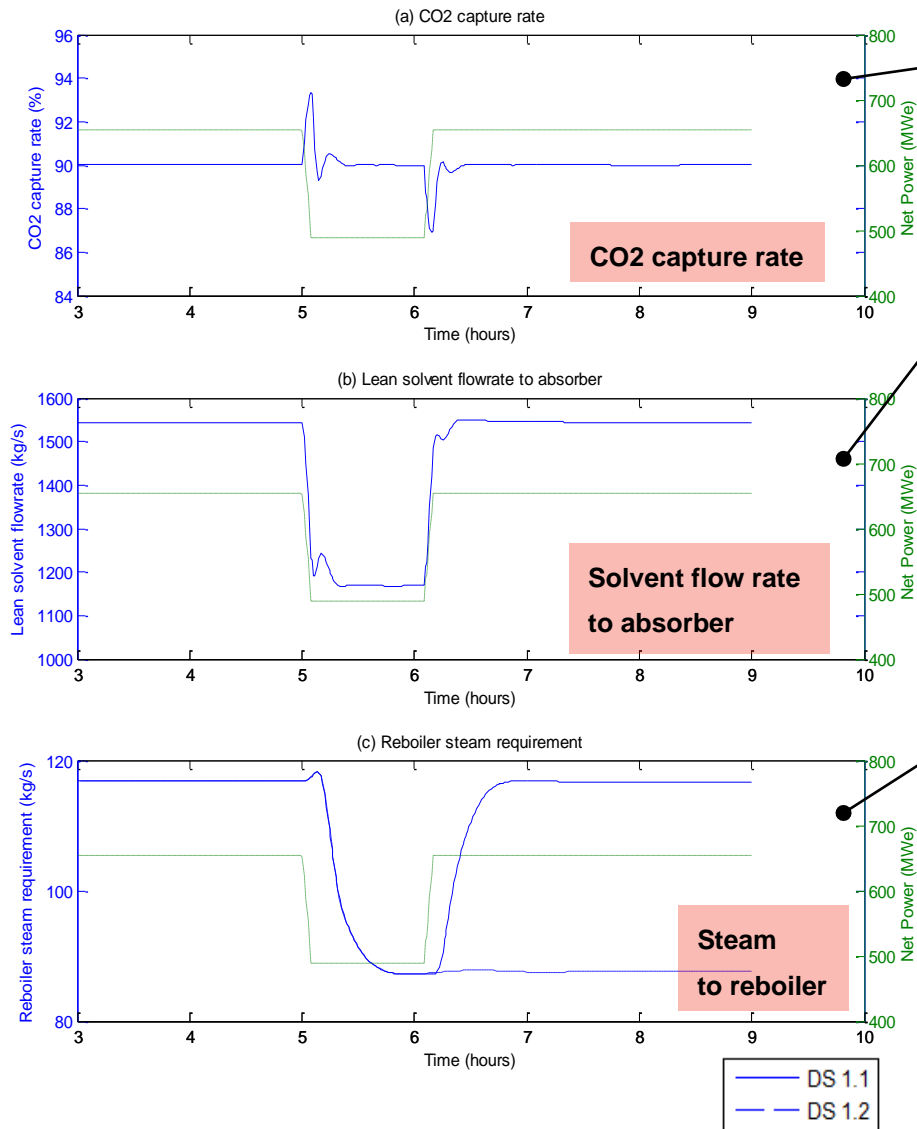
### Scenario DS1.2



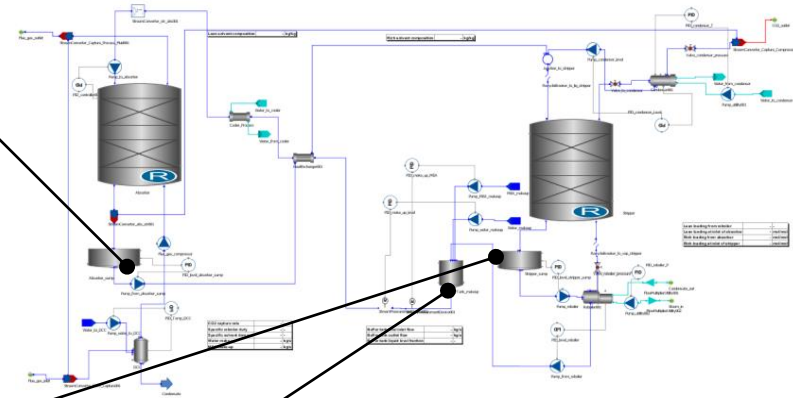
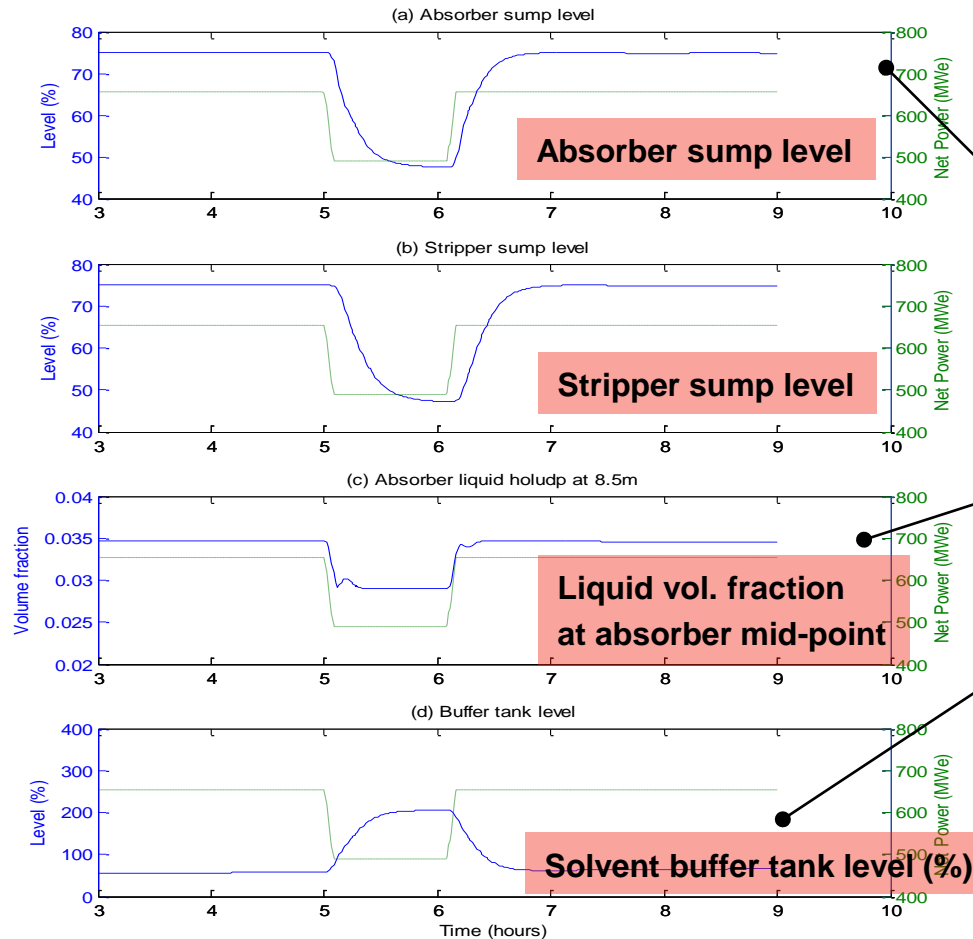
# Dynamic analysis - Power plant



# Dynamic analysis - CO<sub>2</sub> capture plant

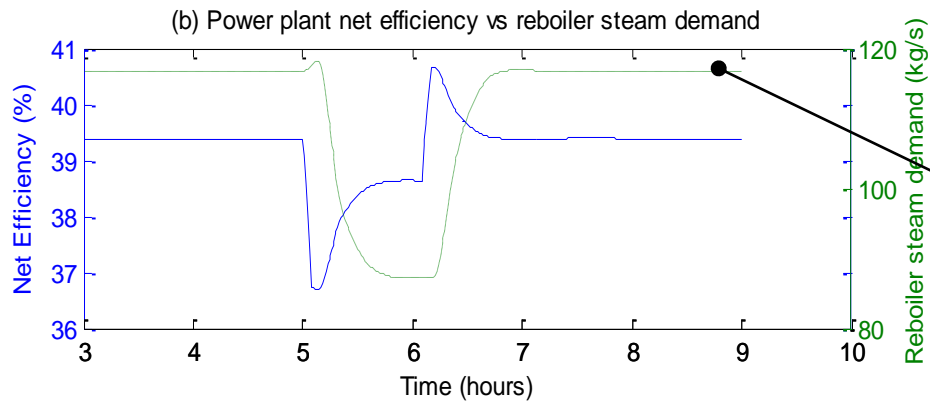
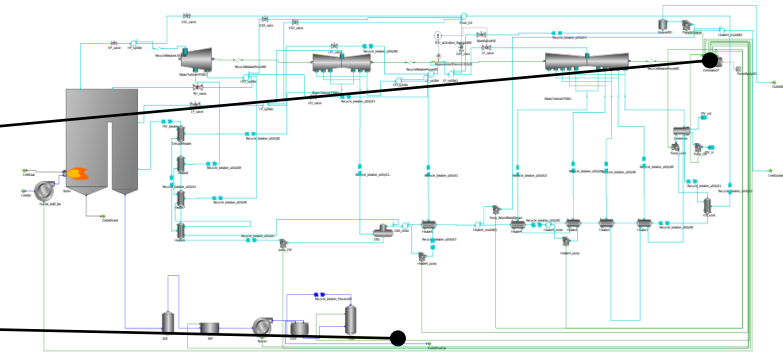
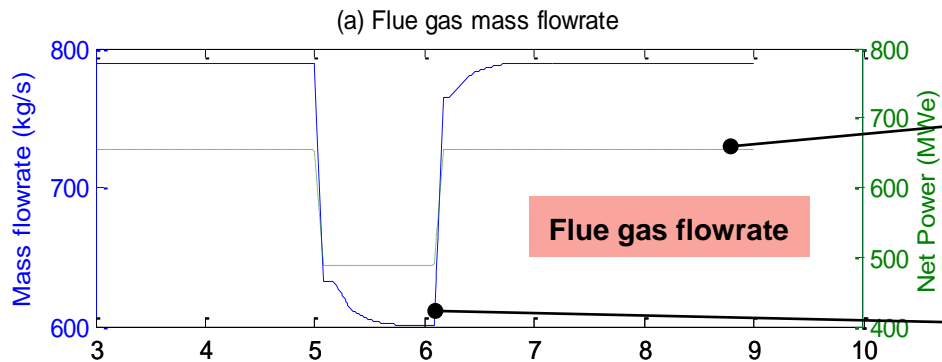


# Dynamic analysis - CO<sub>2</sub> capture plant

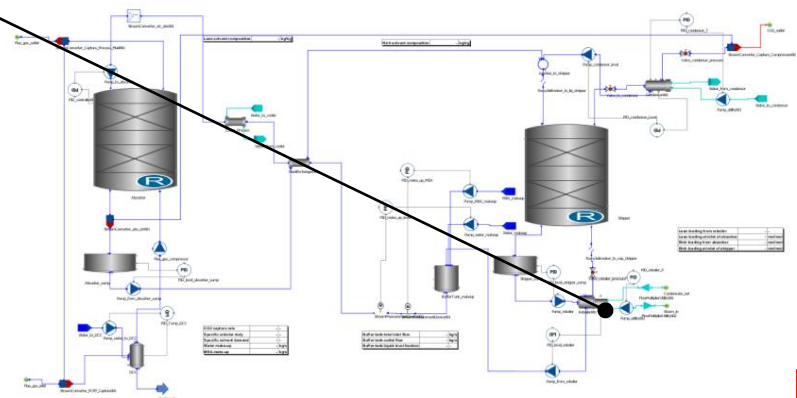


# Dynamic analysis

## Power/CO<sub>2</sub> capture two-way coupling

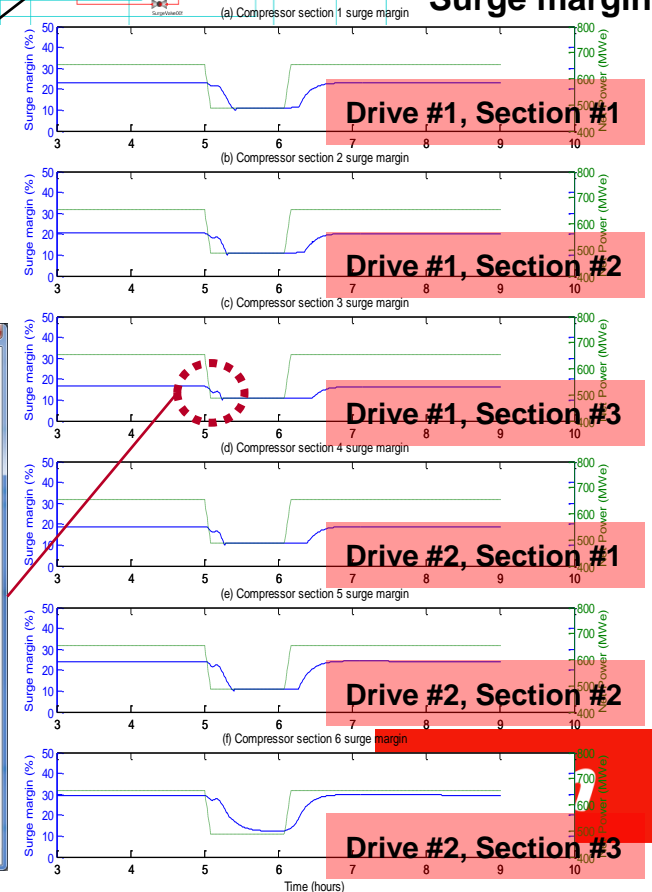
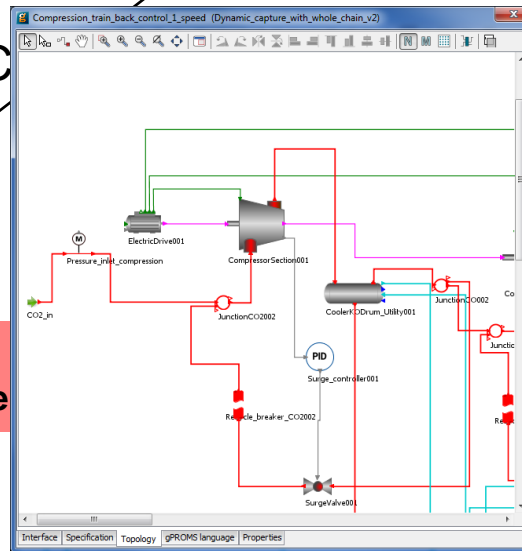
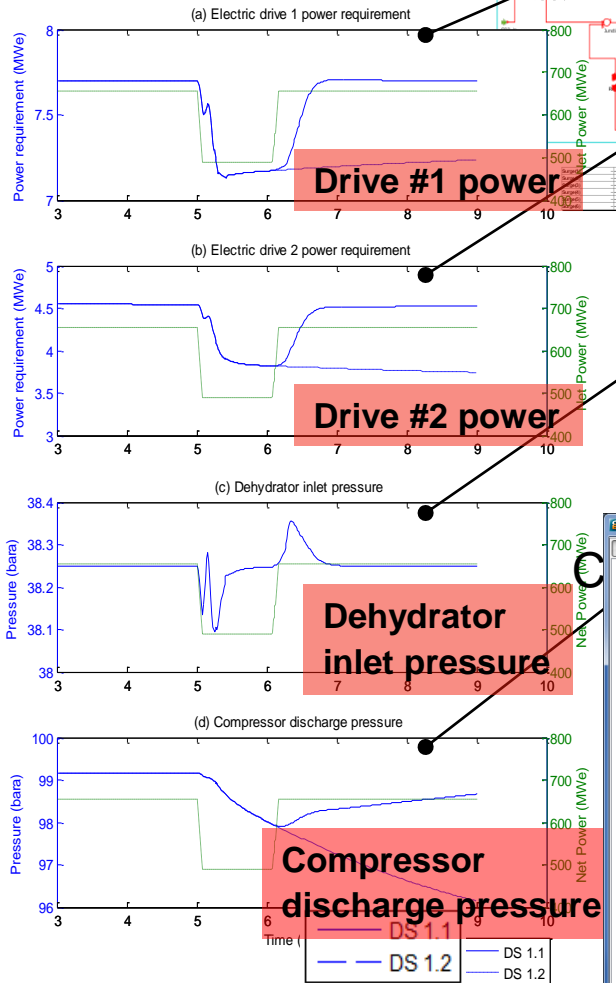


Power plant net efficiency  
vs. reboiler steam demand



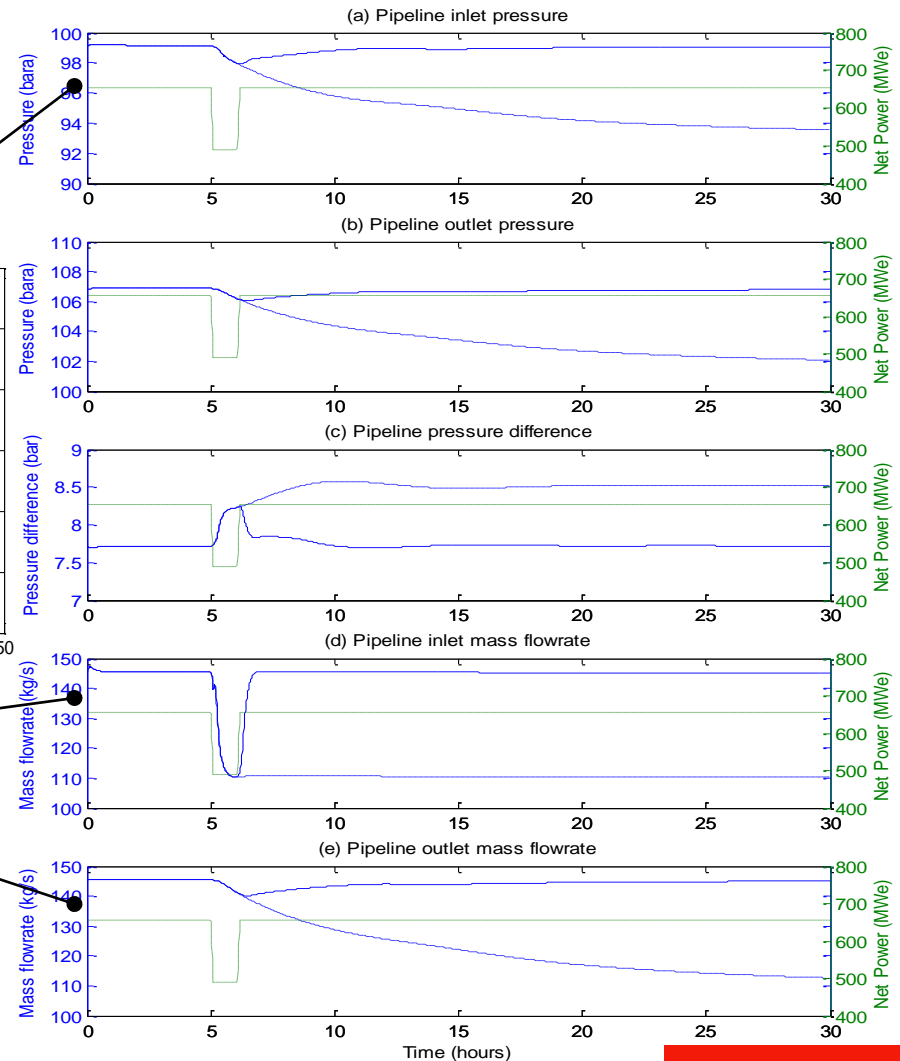
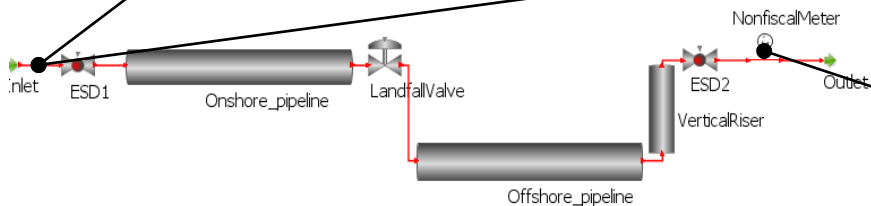
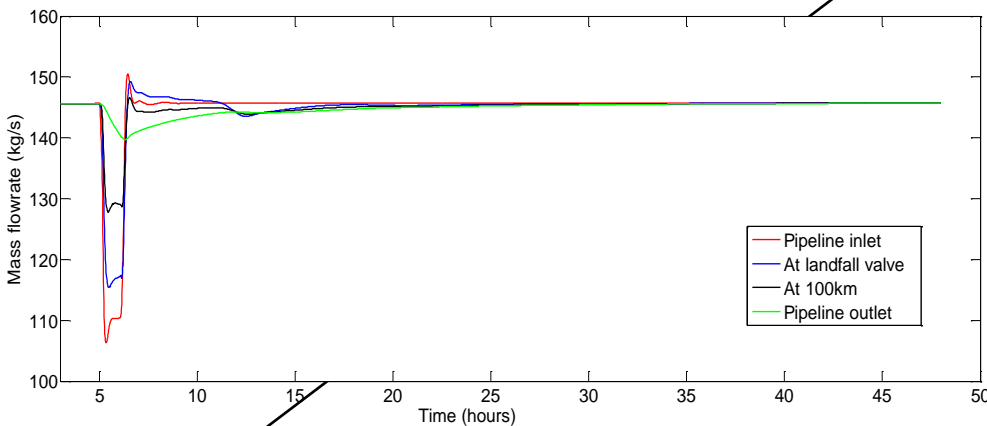


# Dynamic analysis CO<sub>2</sub> compression plant



# Dynamic analysis CO<sub>2</sub> transmission pipelines

- Buffer potential for flexible operation?

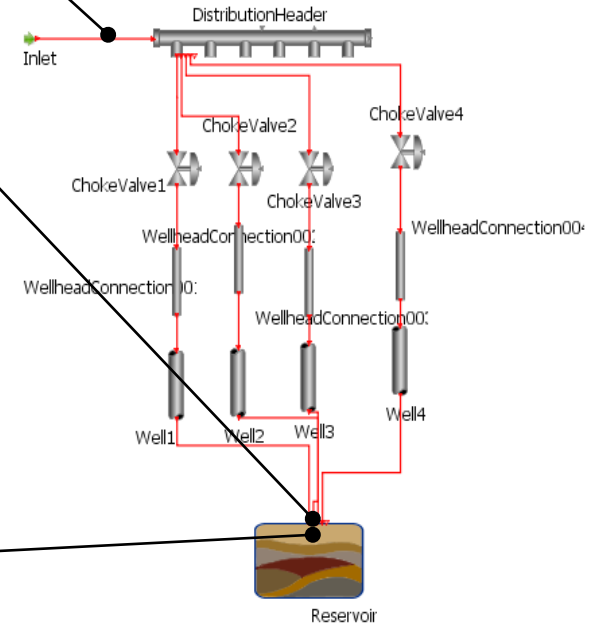
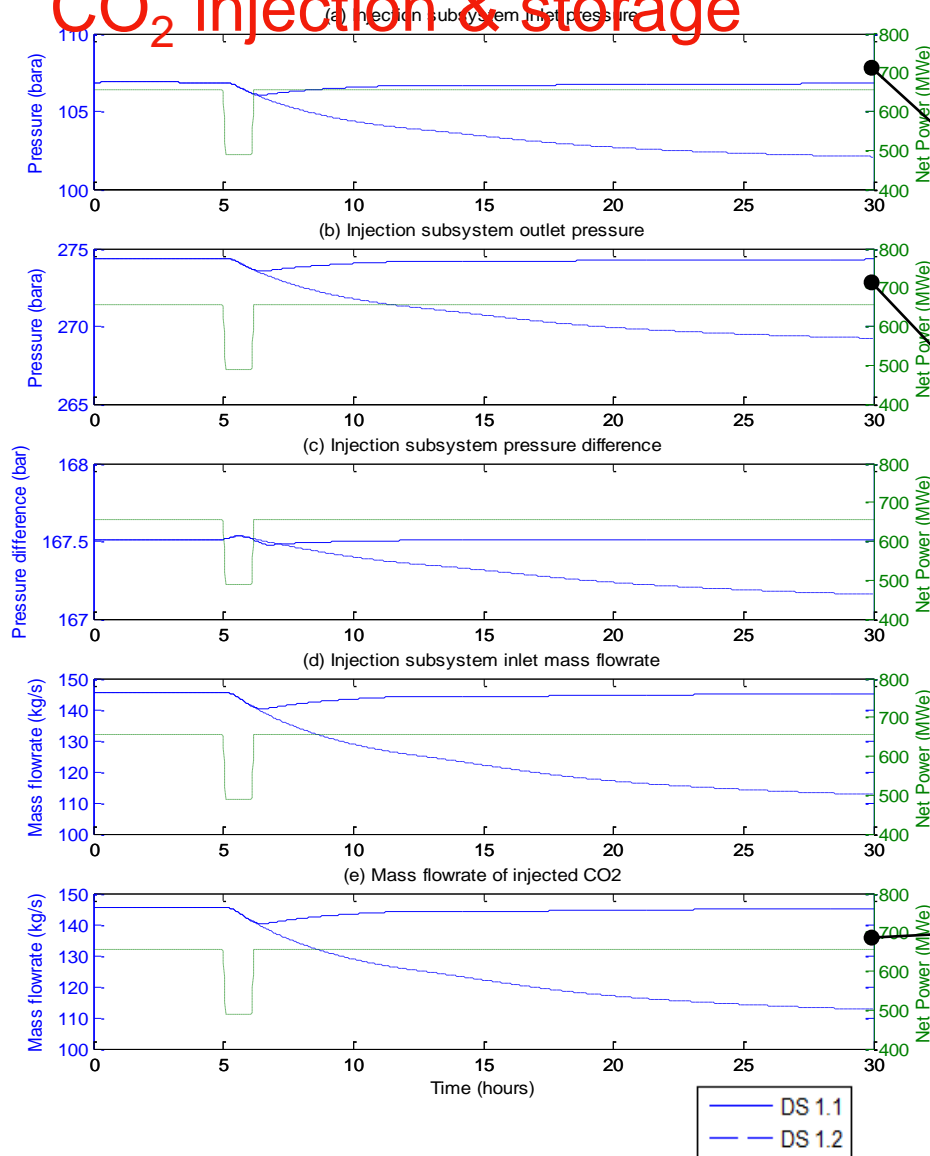


DS 1.1  
DS 1.2

e-on

# Dynamic analysis

## CO<sub>2</sub> injection & storage



## Final remarks

- A dynamic simulation of a full scale CCS chain has been completed in a single model using gCCS
- gCCS can be used to identify key areas of interest for components across the CCS chain based on their response to dynamic operation.
- gCCS can be used to inform and aid the design of safe control systems and operating procedures
- The dynamic performance can still be improved – the real test will be using these tools “in anger” against operating plant data.

# Thank you for your attention

Acknowledgement to ETI Modelling toolkit project team:

- Andrew Green (ETI)
- Thierry Moes (Rolls-Royce)
- Bhavesh Limani (EdF Energy)
- Luca Bertuccioli(E4Tech)
- Ian Phillips(CO2 DeepStore)
- Alfredo Ramos and team (PSE)

