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Supercritical Coal Fired Power Plant Dynamic Responses and Grid Code Compliance

- UK-China Collaboration Research on Cleaner Coal Technology

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Outline of the presentation

1. Project background
2. Grid Code study
3. Dynamic responses and control
4. Future work

1. Project background

Supercritical coal fired power plants

	Subcritical (conventional)	Supercritical	Ultra supercritical
Temperature (° C)	500 – 550	500 – 600	550 – 600, (600 – 700)*
Pressure (MPa)	16 – 17	24 – 26	27 – 32, (40 – 42)*
Features	Drum: single reheat	Once through: single reheat	Once through: double reheat
Efficiency cycle (%)	33 - 35	42	42 – 47, (50 – 55)*

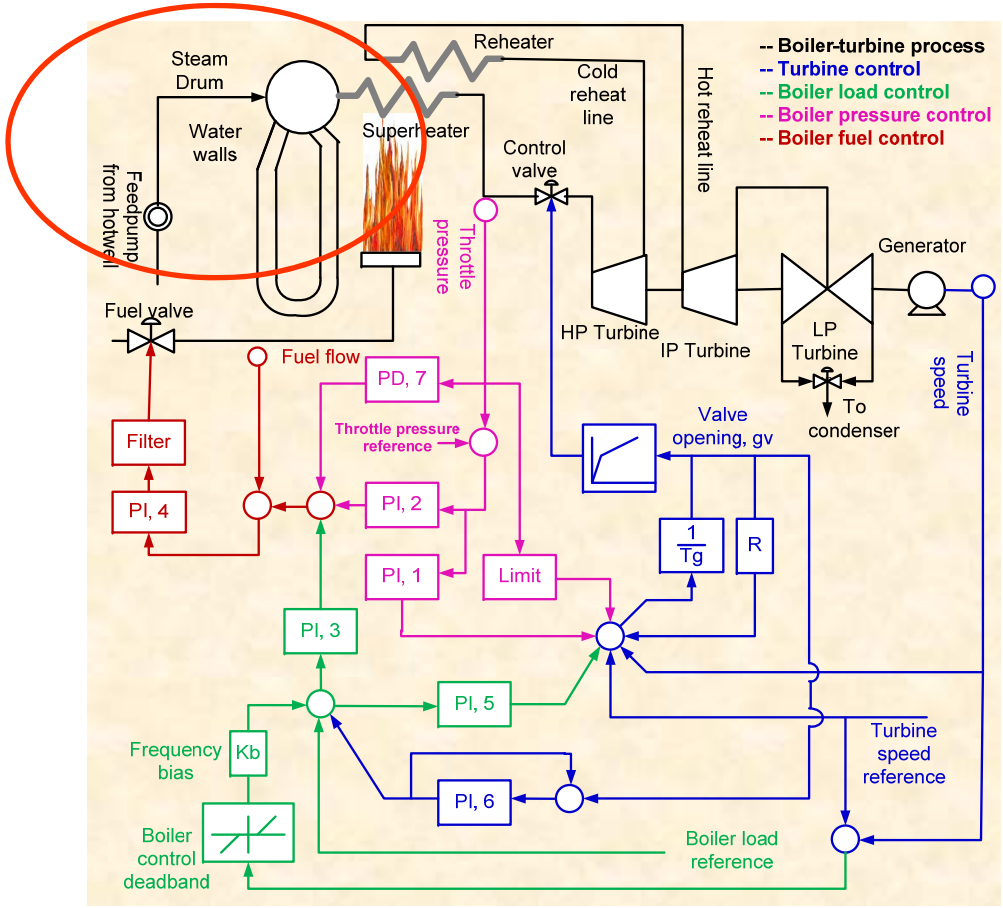
1. Project background

WHY SUPERCRITICAL?

- More efficient: fuel combustion under supercritical conditions is much more efficient, leading to higher fuel conversion towards gas. Lower grade fuels are usable too.
- Fuel consumption savings and reduced flue gas emissions/MW.
- This technology is compatible with some CO_2 capture technologies, which are under development.

1. Project background

Challenge?



1. Project background

Study of supercritical coal fired power plant mathematical modelling and simulation.

Objectives:

- to understand the dynamic responses of supercritical power plants
- to investigate the possible strategies for improvement

1. Project background

Project Title:
Supercritical Coal Fired Power Plant Dynamic Responses and Grid Code Compliance - UK-China Collaboration Research on Cleaner Coal Technology

Project Ref: EP/G062889/1

Investigators:

Dr Jihong Wang
School of Electronic, Electrical and Computer Engineering
Dr Bushra Al-Duri
School of Chemical Engineering

Start Date: 1st December 2009

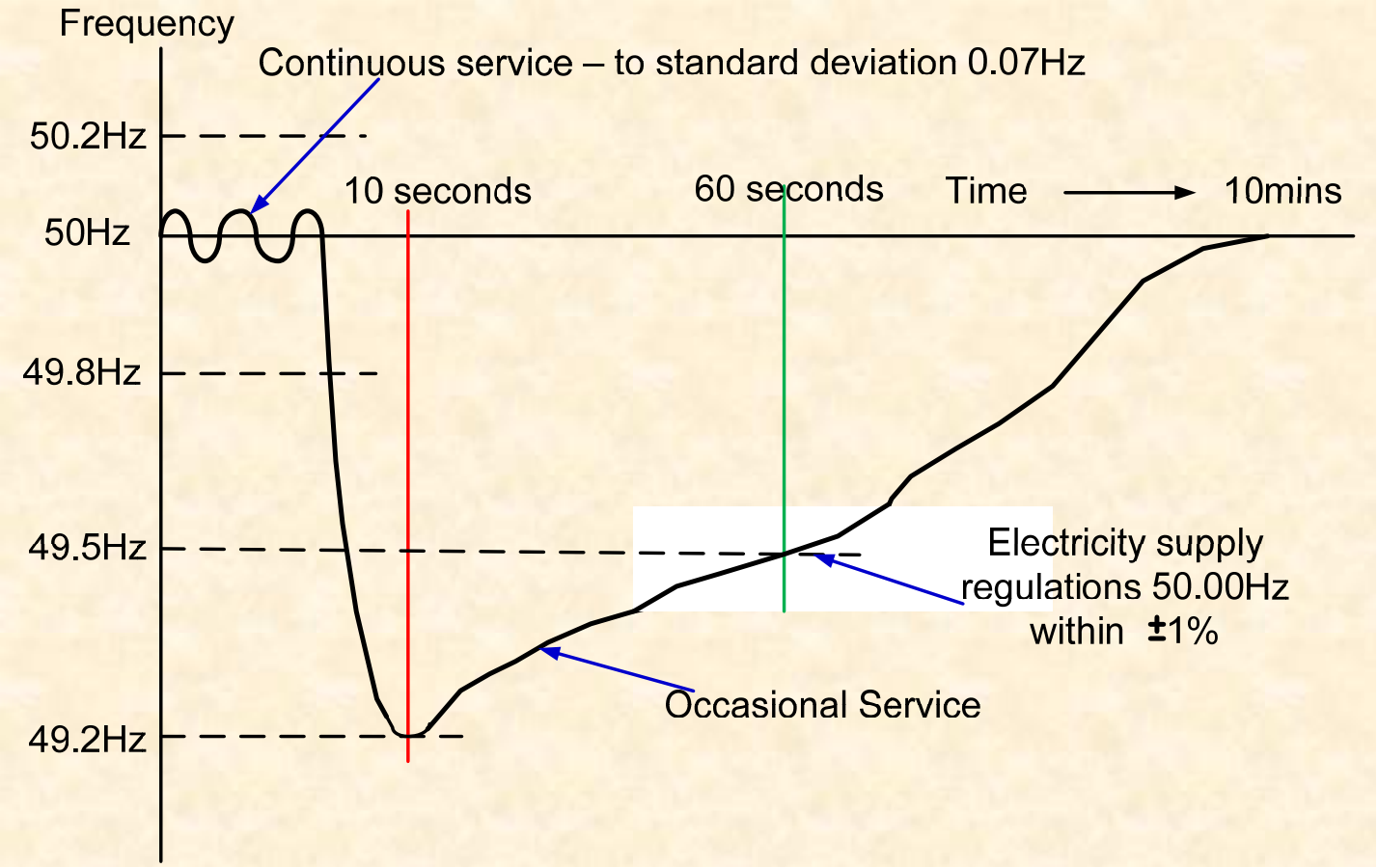
2. Grid Code Study

UK grid code requirement:

System **frequency** is a continuously changing variable that is determined and controlled by the careful balance between system demand and total generation.

If demand is greater than generation, the frequency falls while if generation is greater than demand, the frequency rises.

2. Grid Code Study



2. Grid Code Study

For frequency control, each generating unit must satisfy the following minimum requirements:

- fast acting proportional speed governor to provide continuous, automatic and stable responseacross its entir operating range;
- speed governor capable of being set to a droop of 3~5%;
- minimum speed governor deadband no greater than 0.03 Hz (i.e. ±0.015Hz)
- load control capability with target frequency setting of 50±0.1Hz either continuously or in 0.05Hz steps;
- capability to control frequency to below 52Hz in island operation;
- if operating at full load, capability to maintain power output; if frequency falls to 49.5Hz, thereafter a reduction in power output no more than pro-rota with frequency downto 47 Hz.

2. Grid Code Study

The Primary Response capability (P) of a Generating Unit or a CCGT Module or Power Park Module or DC Converter is the minimum increase in Active Power output between 10 and 30 seconds after the start of the ramp injection. This increase in Active Power output should be released increasingly with time over the period 0 to 10 seconds from the time of the start of the Frequency.

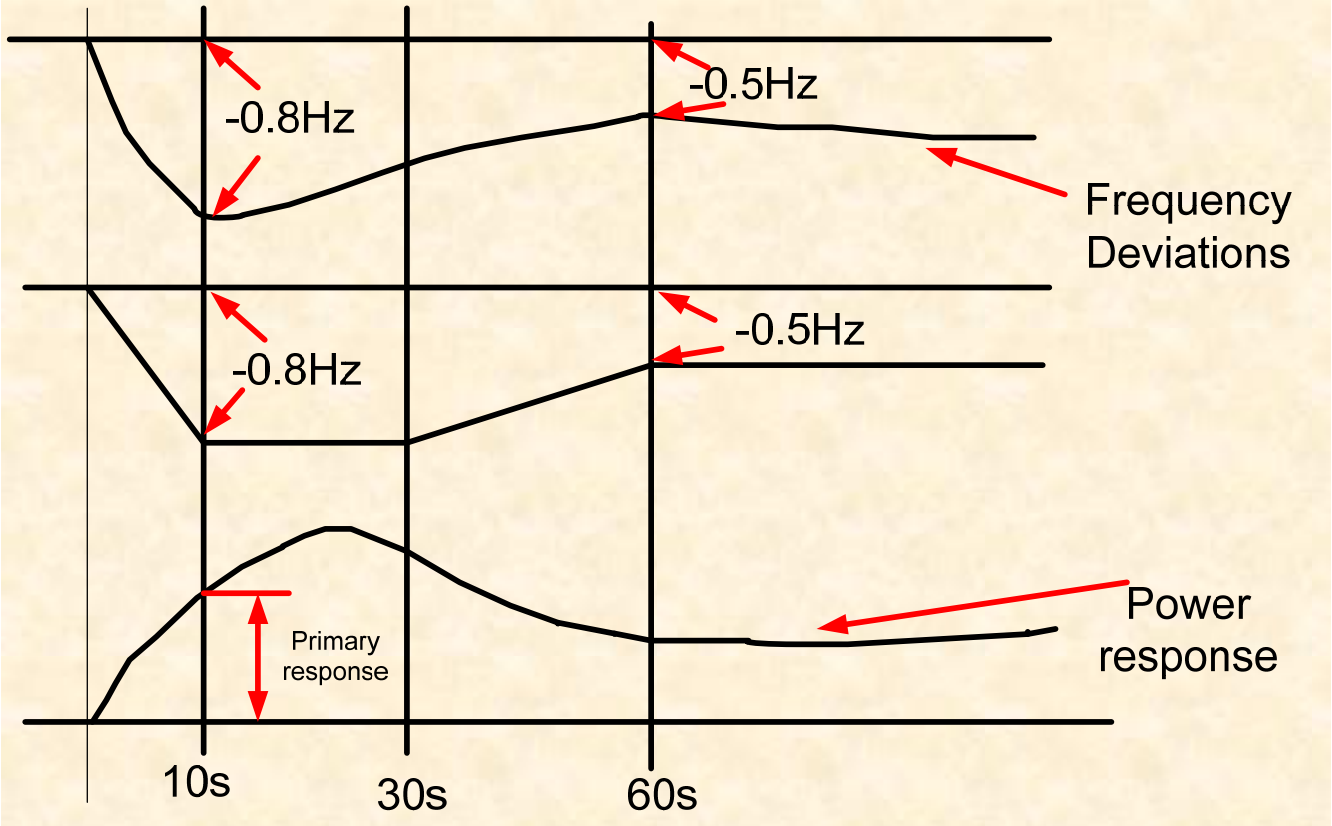
The Secondary Response capability (S) is the minimum increase in Active Power output between 30 seconds and 30 minutes after the start of the ramp injection.

2. Grid Code Study

UK grid code requirement:

The High Frequency Response capability (H) of a Generating Unit or a CCGT Module or Power Park Module or DC Converter is the decrease in Active Power output provided 10 seconds after the start of the ramp injection and sustained thereafter. This reduction in Active Power output should be released increasingly with time over the period 0 to 10 seconds from the time of the start of the Frequency rise.

2. Grid Code Study



2. Grid Code Study

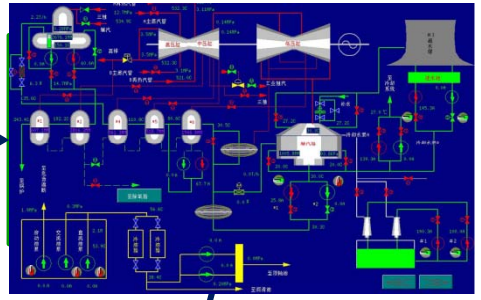
The GB Grid Code has more demanding requirements for frequency response than have previously been applied to this type of plants.

Will the supercritical generation meet the requirement of the grid code?

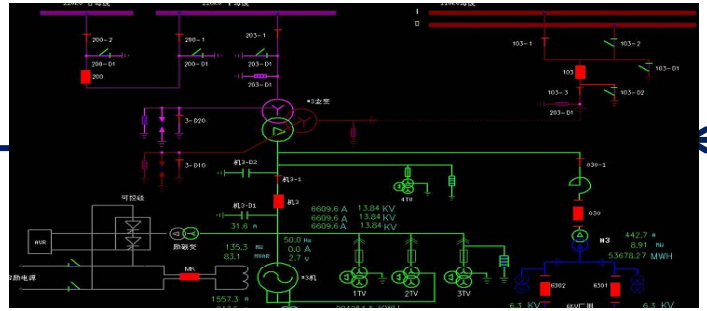
Increasing penetration of renewable energy
→ more demand on dynamic responses to thermal power plants

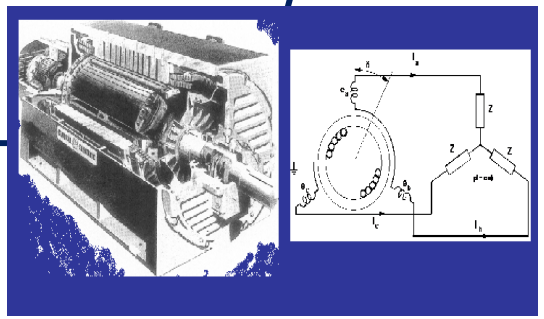
3. Dynamic responses and control

Supercritical
-boiler



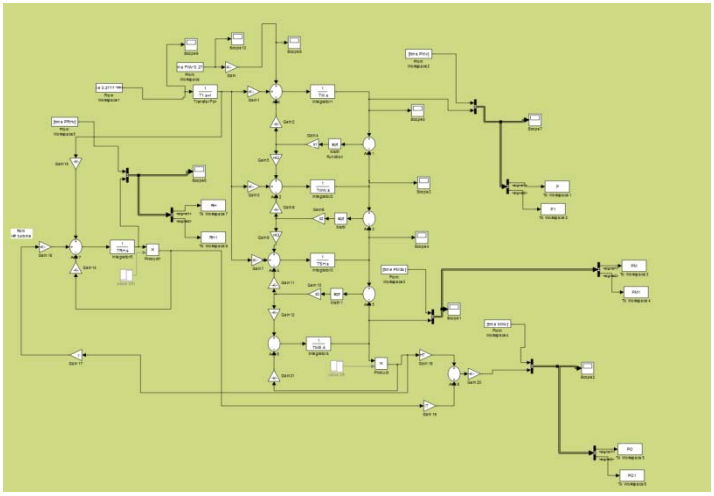
To network

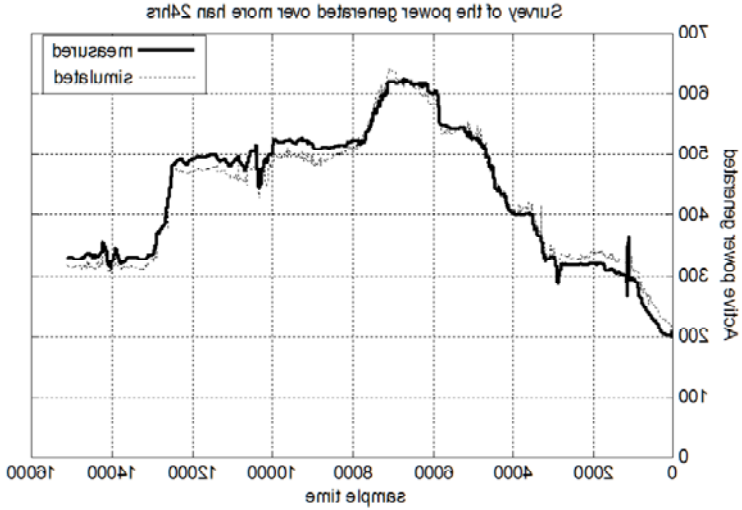




3. Dynamic responses and control

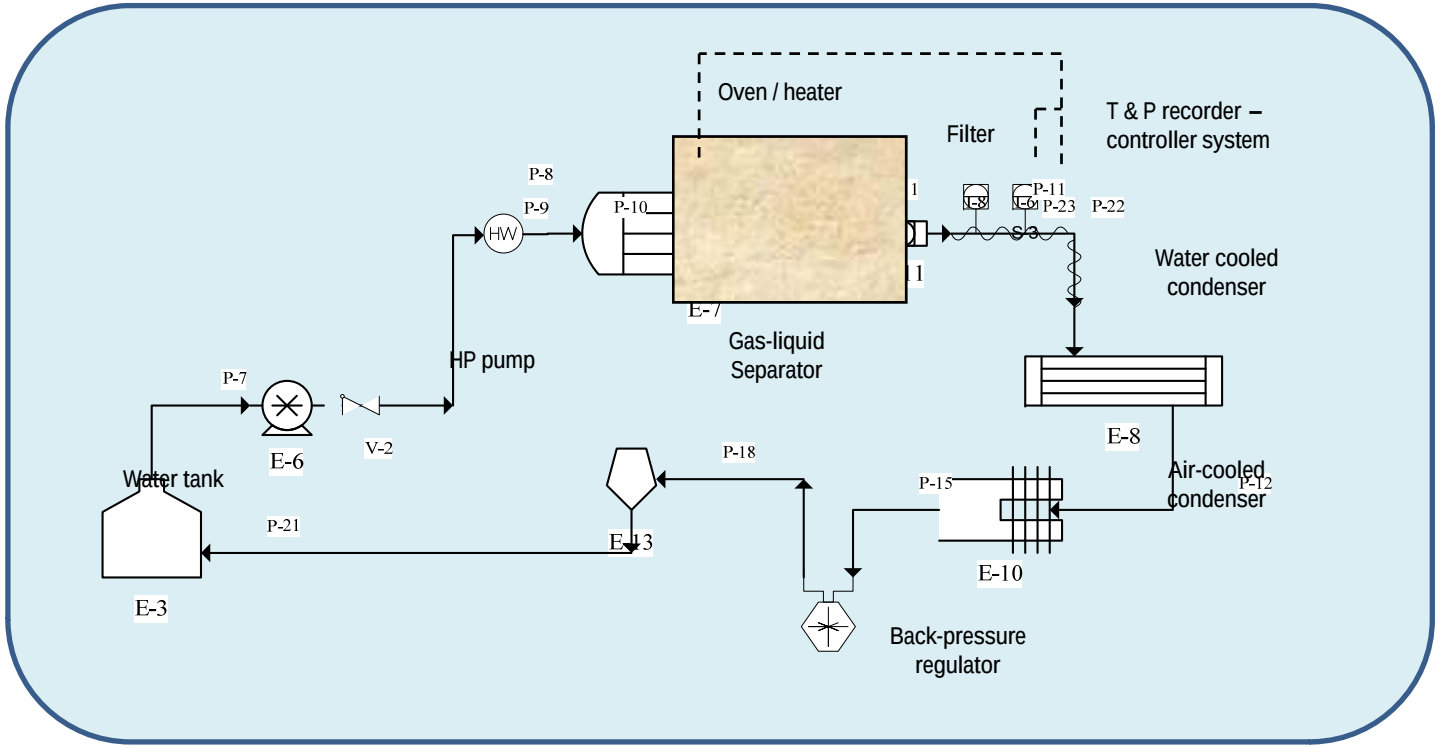
Initial work on mathematical modelling





3. Dynamic responses and control

Laboratory Test



4. Summary

What has been done?

- Recruiting research staff and research students for the project;
- Initial visiting to Chinese partners in September;
- Comparison study of Grid Code of UK, China and Australia, which is essential for on-site data collection and analysis;
- With permission, the Chinese partners have provided us with the first set of plant data;
- A student started working on plant modelling and the data are used for parameters identification;
- Kick-off meeting was scheduled for 10th December 2009 at the University of Birmingham. On the same day, we will organise a UK-China workshop. 4 speakers from China and 4 Speakers from the UK have been confirmed for the day.