The EPSRC Future Conventional Power Research Consortium.

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‘Combustion for Low Carbon Power Generation’
The Coal Research Forum 25th Annual Meeting
University of Warwick - 8th April 2014
Things are Changing.

- **Overall Context**

  Past-Current

  Current-Future
Future Energy Scenarios – The Need for Flexible Operation on UK Grid.

Example for GB
Taken from Poyry presentation at Gas to Power Conference, 2012
Current and Predicted Future Power Mix in UK.

Taken from Generating Capacity ‘Gone Green’, Operating the Electricity Transmission Networks in 2020, Initial Consultation, National Grid, June 2009
Current and Predicted Future Power Mix in China.

Figure 1: Power generation capacity mix under different scenarios, 2012 vs. 2030e (%, GW)

Source: Bloomberg New Energy Finance. Note: Pumped hydro excluded.
Operational Flexibility – Aspects & Drivers.

Aspects of operational flexibility:
- Operational Efficiency
- Part load efficiency
- Start-up times
- Power on demand
- Emissions
- Turn-down
- Load ramps
- Reserve capacity
- Grid stabilization

Taken from ‘The Future Role of Fossil Power Generation’, 2011, Siemens AG
Tension between Efficiency and Flexibility.

Efficiency:
- low pressure
- high temperature
- thin casings to avoid thermal stress
- thick casings

Flexibility:
- fast starts
- slow starts
- fast ramp rates
- slow ramp rates to avoid transient thermal stress

Courtesy of ALSTOM Power
The Partners & Principal Contacts

Project Launched 10\textsuperscript{th} Sept 2013

- Prof John Young
- Dr Alex White

- Prof Janusz Bialek
- Dr Chris Dent
- Dr Simon Hogg
- Dr Grant Ingram

- Prof Jon Gibbins
- Dr Hannah Chalmers

- Prof Jenny Jones
- Prof M. Pourkashanian
- Prof Alan Williams

- Prof Li He
- Dr Budimir Rosic

- Michael Sell
- John Seaton
- Dave Waldron

- Rufus Ford
- Ricky Chaggar

- Chris Carey
- Stephen McCormick

- Leon Walker

- Paul Van Lieshout
- Steve Buckley
The Themes

- Plant Efficiency
- Plant Flexibility
- Fuel Flexibility
- Sustainability
Impact - What will be possible at the end of the Programme that is not possible now?

The principal outputs to help to reduce carbon emissions & increase flexibility of conventional fossil fuelled power plant will be:

- **Plant Flexibility** — A validated dynamic power plant simulation tool, allowing operators to assess scenarios for more flexible plant operation.

- **Plant Efficiency** — Better clearance control (heat transfer methods and new seal technology) and wetness methods under part-load conditions, allowing designers to produce turbines capable of more flexible operation.

- **Fuel Flexibility** — More efficient and cleaner combustion of different biomass and biomass/coal blends in conventional plant, with reduced rates of deposition.

- **Sustainability** — Robust messages delivered to the power industry concerning the impact of wind penetration on the need for flexible capacity investment under different socio-economic energy scenarios.
Project Activity 1: Lower Thermal Stresses & Improving Axial Clearance Control.

Aerothermal challenge: huge solid-fluid length scale disparity.

- Very active research area at present.
- Need to identify & understand the limiting factors in steam turbine aerothermal behaviour during cooling-down and start-up.
- Develop new advanced computer modelling techniques and use these to design new reduced order models (ROM) to achieve high fidelity results at low fidelity effort.
Improved Sealing – more compliant alternatives to conventional labyrinth seals are being developed.

- Brush Seals, Leaf Seals, Finger Seals, Fluidic Seals.
- Active Clearance Control.
Erosion from droplets in wet steam is a major issue in fossil LP’s and LWR Nuclear HP’s and LP’s.

- Designers try to keep steam wetness < 12% and employ other measures (course water extraction) to avoid unacceptable erosion rates.
- Wetness modelling is not well understood and only relatively crude design models/rules exist at present.
- Wetness effects will become even more acute under flexible operating conditions.
- Improved dynamic wetness models are needed – another research topic currently receiving much attention.
### Project Activity 4: Biomass/Coal Firing

Feedstock for co-firing in the UK by type, quantity and source

<table>
<thead>
<tr>
<th>Feedstock</th>
<th>Quantity burned (tonnes) in 2005</th>
<th>% quantity burned (tonnes) in 2005</th>
<th>Likely country of origin</th>
<th>Mode of transport</th>
<th>Total transport-related emissions (kg CO₂/tonne biomass)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy crops (SRC, granulated willow, miscanthus)</td>
<td>4,306</td>
<td>0.3</td>
<td>UK</td>
<td>Road</td>
<td>1.7</td>
</tr>
<tr>
<td>Shea residues (meal and pellets)</td>
<td>5,420</td>
<td>0.4</td>
<td>Africa</td>
<td>Ship</td>
<td>55.4</td>
</tr>
<tr>
<td>Sunflower pellets</td>
<td>20,331</td>
<td>1.4</td>
<td>Romania</td>
<td>Road &amp; ship</td>
<td>47.1</td>
</tr>
<tr>
<td>Sewage sludge and waste derived fuels</td>
<td>49,155</td>
<td>3.5</td>
<td>UK</td>
<td>Road</td>
<td>3.4</td>
</tr>
<tr>
<td>Cereal co products and pellets</td>
<td>102,246</td>
<td>7.2</td>
<td>UK</td>
<td>Road</td>
<td>1.7</td>
</tr>
<tr>
<td>Tallow</td>
<td>119,828</td>
<td>8.5</td>
<td>UK</td>
<td>Road</td>
<td>1.7</td>
</tr>
<tr>
<td>Olive waste (residue and expeller)</td>
<td>283,222</td>
<td>20.1</td>
<td>Greece, Italy, Spain</td>
<td>Road &amp; ship</td>
<td>21.2</td>
</tr>
<tr>
<td>Wood (sawdust, chips, pellets, tall oil)</td>
<td>377,956</td>
<td>26.8</td>
<td>UK, Canada, Latvia, Sweden, Scandinavia</td>
<td>Road &amp; ship</td>
<td>1.7 (UK) to 42.9</td>
</tr>
<tr>
<td>Palm residues (palm kernel expeller, shell, pellets, oil)</td>
<td>449,657</td>
<td>31.8</td>
<td>Indonesia, Malaysia</td>
<td>Road &amp; ship</td>
<td>106.5 (Indonesia) to 107.4 (Malaysia)</td>
</tr>
<tr>
<td><strong>Total mass</strong></td>
<td>1,412,121</td>
<td></td>
<td></td>
<td></td>
<td>14.1</td>
</tr>
</tbody>
</table>

Project Activity 4: Biomass/Coal Firing.

- Biomass storage and conveying
- Milling: capacity and lifetime
- Combustion chamber – flame shape/stability, heat transfer, slagging

Heat exchangers – deposition and corrosion

Superheater – high temperature corrosion

With carbon capture other issues concern contaminants in the combustion gases

ESP capacity and efficiency, ash utilisation

Future Conventional Power Research Consortium - Conclusions.

- Project launched 10th September 2013.
- Academic Partners are Cambridge, Durham, Edinburgh, Leeds & Oxford Universities. ALSTOM, SSE & ANSYS are principal industry partners.
- Consortium project organised around key themes of Plant Flexibility, Plant Efficiency, Fuel Flexibility and Sustainability.
- Compliments Flex-e-Plant Consortium - Opportunities to hold joint training workshops, annual assemblies and other dissemination events.
- Essentially no technical overlap between the two consortium projects.
- Both projects funded for 5 years duration.