FUTURE CONVENTIONAL POWER

EPSRC
Engineering and Physical Sciences Research Council

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

UNIVERSITY OF CAMBRIDGE
Durham University
THE UNIVERSITY OF EDINBURGH
UNIVERSITY OF LEEDS
UNIVERSITY OF OXFORD

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Things are Changing.

- Overall Context

Past-Current

Current-Future

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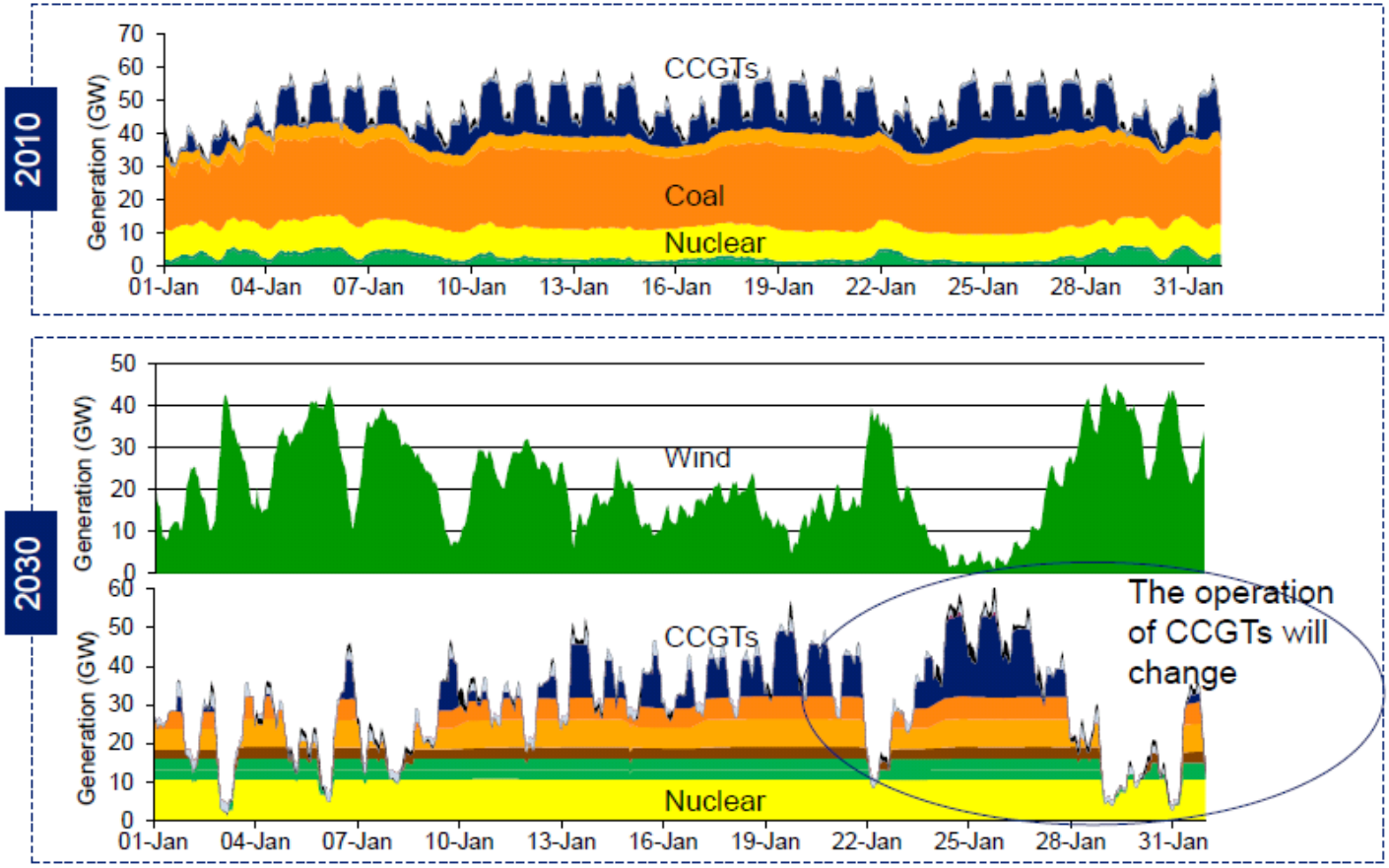
Future Energy Scenarios – The Need for Flexibile Operation on UK Grid.



PÖYRY **Example for GB**

Taken from Poyry presentation at Gas to Power Conference, 2012

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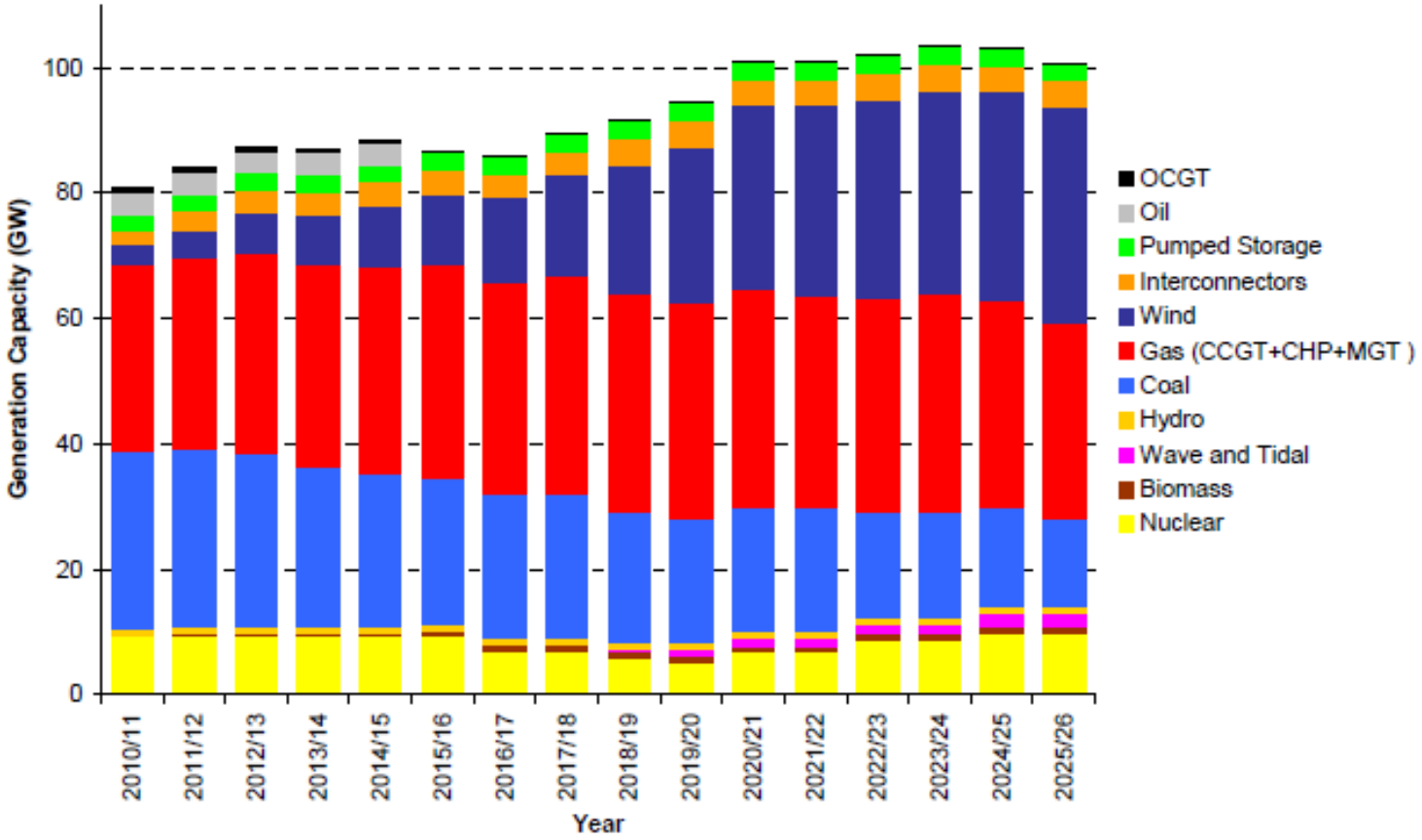
Current and Predicted Future Power Mix in UK.



Taken from Generating Capacity 'Gone Green', Operating the Electricity Transmission Networks in 2020, Initial Consultation, National Grid, June 2009

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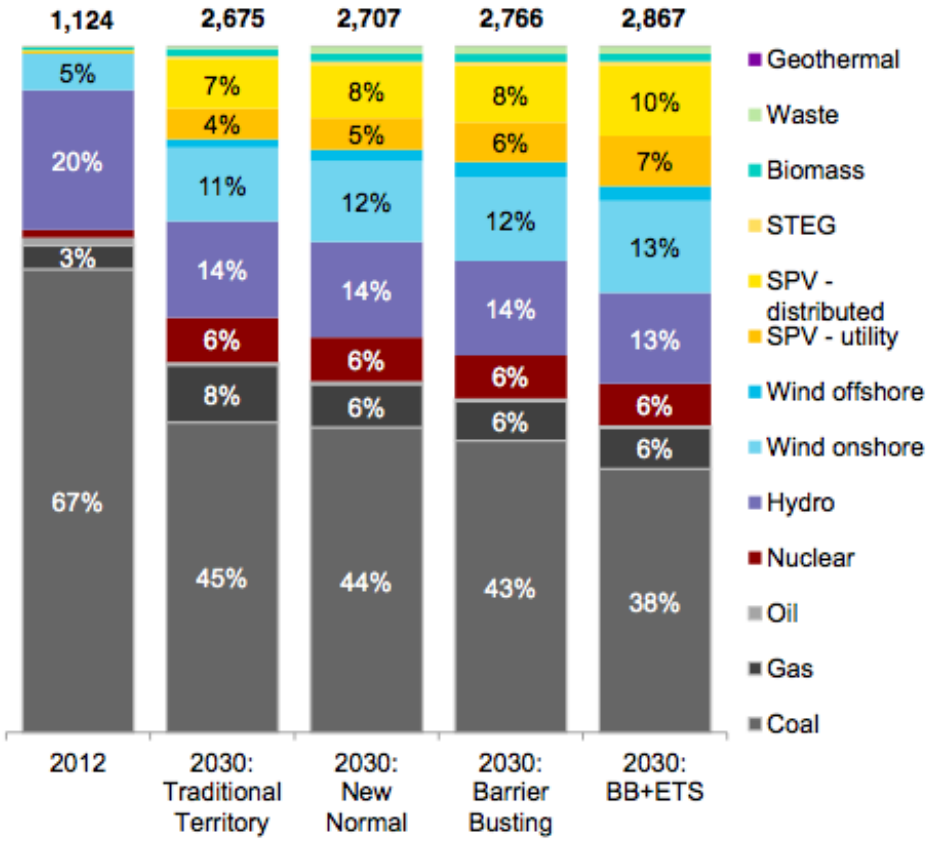
Current and Predicted Future Power Mix in China.

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



Source: Bloomberg New Energy Finance. Note: Pumped hydro excluded.

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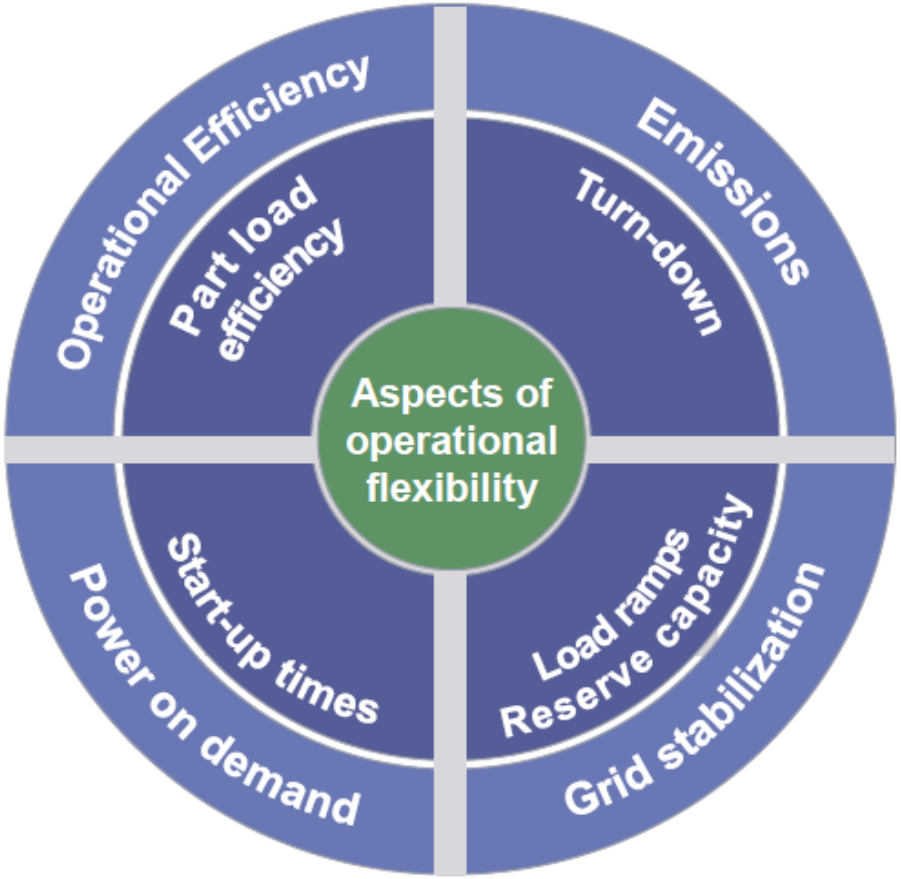
Operational Flexibility – Aspects & Drivers.



Taken from 'The Future Role of Fossil Power Generation', 2011, Siemens AG

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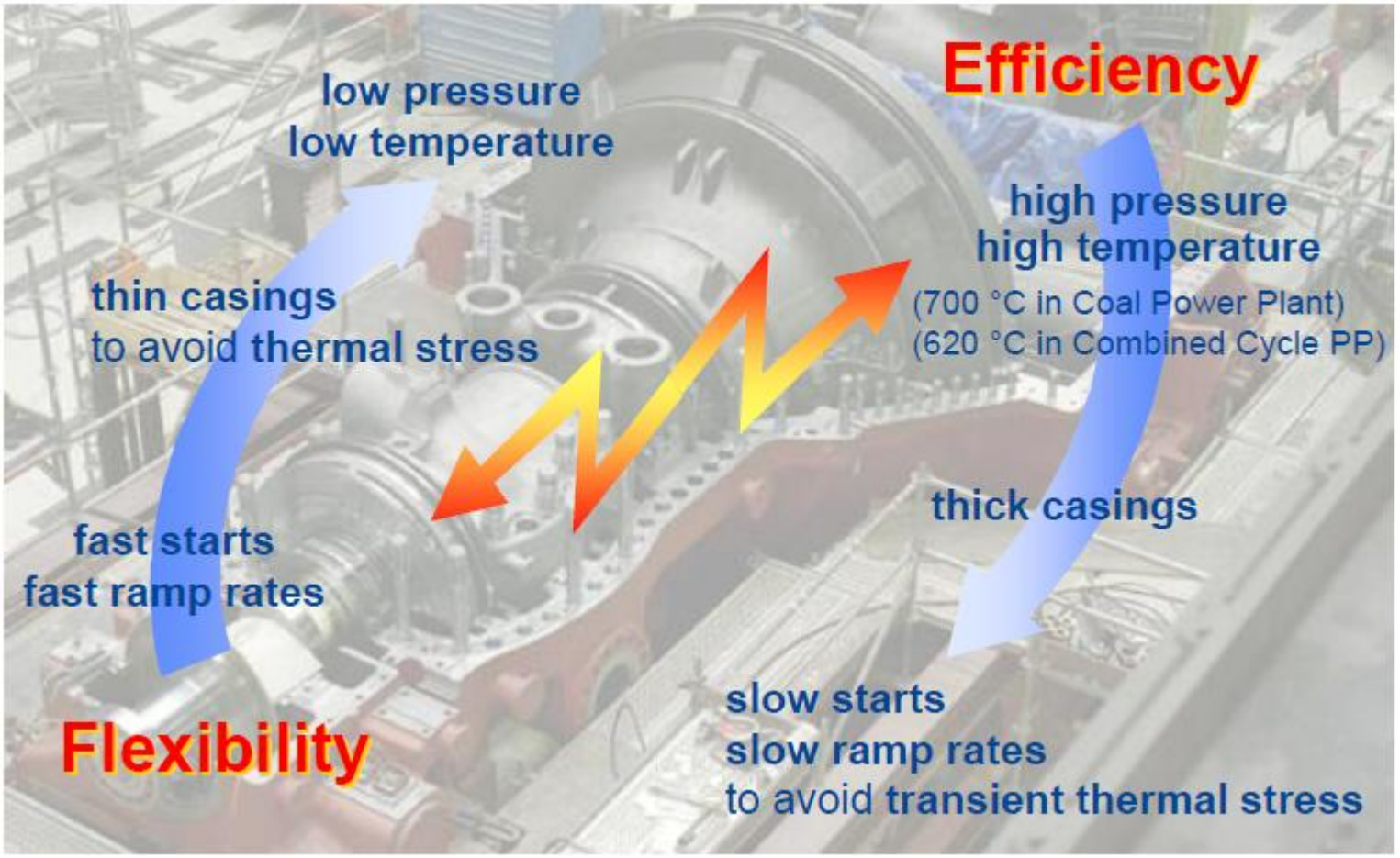
Tension between Efficiency and Flexibility.



Courtesy of ALSTOM Power

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The Partners & Principal Contacts

Project Launched 10th Sept 2013

UNIVERSITY OF CAMBRIDGE	Prof John Young Dr Alex White
Durham University	Prof Janusz Bialek Dr Chris Dent Dr Simon Hogg Dr Grant Ingram
THE UNIVERSITY OF EDINBURGH	Prof Jon Gibbins Dr Hannah Chalmers
UNIVERSITY OF LEEDS	Prof Jenny Jones Prof M. Pourkashanian Prof Alan Williams
UNIVERSITY OF OXFORD	Prof Li He Dr Budimir Rosic
ALSTOM	Michael Sell John Seaton Dave Waldron
SSE	Rufus Ford Ricky Chaggar
ANSYS	Chris Carey Stephen McCormick
nationalgrid	Leon Walker
SINCLAIR KNIGHT MERZ SKM	Paul Van Lieshout Steve Buckley

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The Themes

- Plant Efficiency

- Plant Flexibility

- Fuel Flexibility

- Sustainability

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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.

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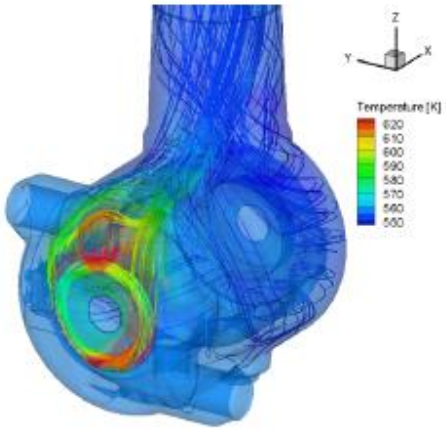
Project Activity 1: Lower Thermal Stresses & Improving Axial Clearance Control.

Aerothermal challenge: huge solid-fluid length scale disparity.

- Method/modelling challenge: coupled conjugate heat transfer calculations.
- 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.



Carefully understanding of heat transfer coefficients (particularly at low flow)

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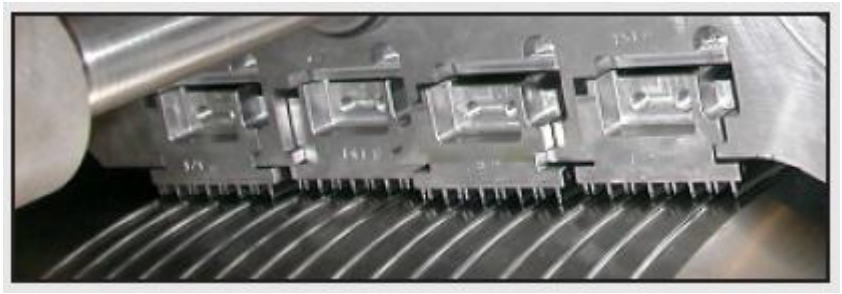
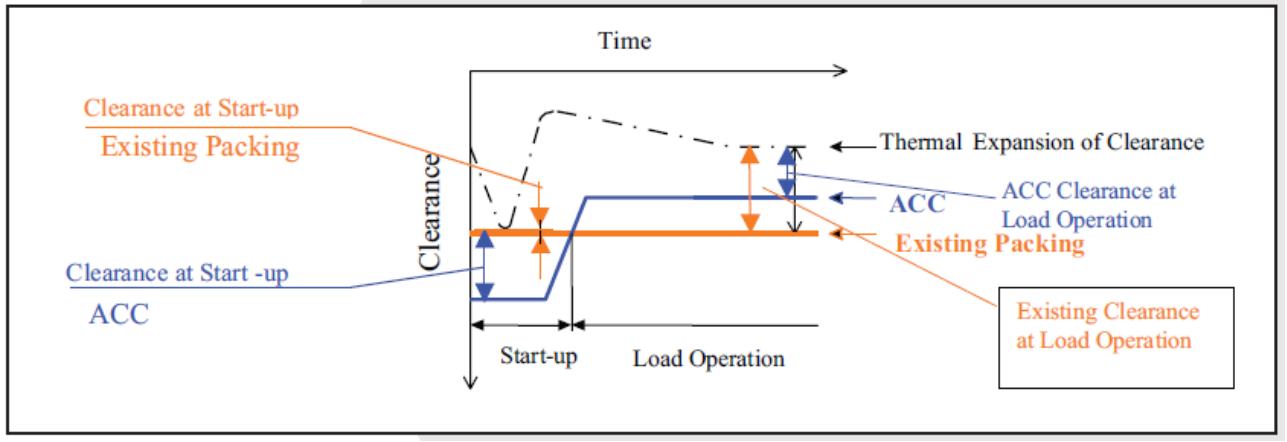
Project Activity 2: Improving Radial Clearance Control.

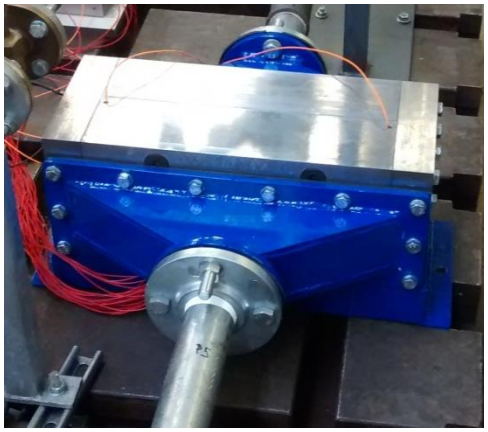
Improved Sealing – more compliant alternatives to conventional labyrinth seals are being developed.

- Brush Seals, Leaf Seals, Finger Seals, Fluidic Seals.
- Active Clearance Control.





Taken from Mitsubishi Application Data Sheet - MPS 06001



DU Test Rig

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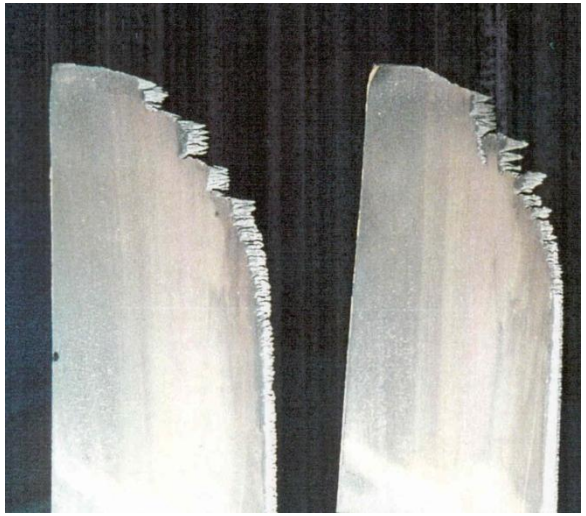
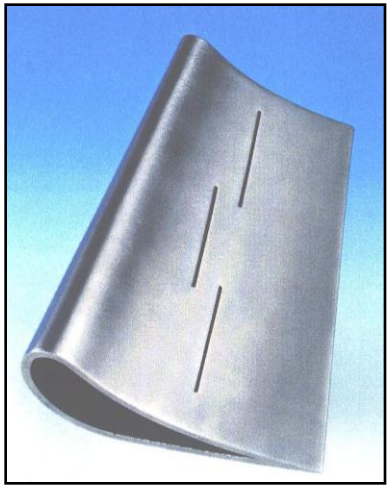
Project Activity 3: Wet Steam Effects.

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.





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Project Activity 4: Biomass/Coal Firing.

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

Feedstock	Quantity burned (tonnes) in 2005	% quantity burned (tonnes) in 2005	Likely country of origin	Mode of transport	Total transport-related emissions (kg CO_2/tonne biomass)
Energy crops (SRC,granulated willow, miscanthus)	4,306	0.3	UK	Road	1.7
Shea residues (meal and pellets)	5,420	0.4	Africa	Ship	55.4
Sunflower pellets	20,331	1.4	Romania	Road & ship	47.1
Sewage sludge and waste derived fuels	49,155	3.5	UK	Road	3.4
Cereal co products and pellets	102,246	7.2	UK	Road	1.7
Tallow	119,828	8.5	UK	Road	1.7
Olive waste (residue and expeller)	283,222	20.1	Greece, Italy Spain	Road & ship	21.2
Wood (sawdust, chips, pellets, tall oil)	377,956	26.8	UK, Canada, Latvia, Scandinavia	Road & ship	1.7 (UK) to 42.9
Palm residues (palm kernel expeller, shell, pellets, oil)	449,657	31.8	Indonesia, Malaysia	Road & ship	106.5 (Indonesia) to 107.4 (Malaysia)
Total mass	1,412,121				
Total energy (PJ)	14.1				

Sources: UK Biomass Strategy, DEFRA, May 2007 & Evaluating the Sustainability of Co-firing in the UK, report to DTI from Themba Technology Ltd, September 2006

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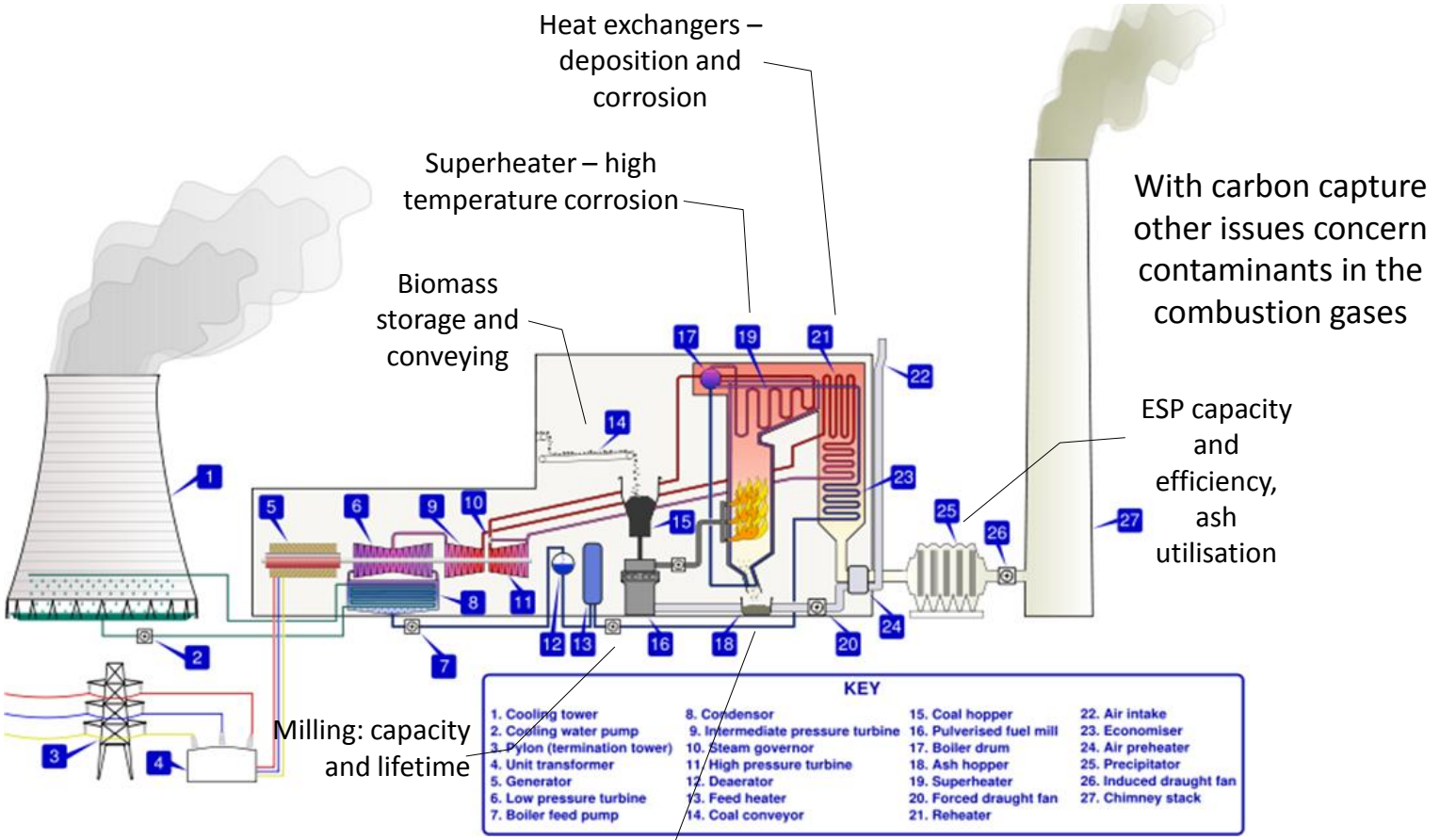
Project Activity 4: Biomass/Coal Firing.



http://electricalandelectronics.org/wp-content/uploads/2008/09/steam-power-plant.png

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.