Materials Supply Chains in the UK :-

Fossil Fired Power Plant

Derek Allen, Alstom Power

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• The Global Challenge
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Market drivers

- Markets & Drivers
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Drivers

GDP Growth

Installed Base Growth ~ linked to GDP

Installed Base ~ 3% pa

World Real GDP ~ 3% pa

Trillion 2000 USD

0 5 10 15

GW

500 1000 1500 2000 2500 3000 3500 4000 4500

85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 '00 '01 '02 '03 '04

Ageing Fleet

66% of +30 year fleet is fossil

Old Fleet >30y: 1224 GW

Age (yrs)

GW/yr

0 50 100 150

Forecast

US Boom

China Boom

Others

Hydro

Nuclear

Conventional steam

Gas Plant (GT & CC)

Environment

66% of +30 year fleet is fossil

Market Forces

Power Systems

ALSTOM
Climate Change remains a key driver

- Emissions remain a key driver and future technologies must address this.
- China has already overtaken USA as world's major CO2 emitter.
Market driver: Environment
Power generation industry: a major contributor to CO₂ emissions

CO₂ emissions from fossil fuel combustion (reference scenario)

Source: IEA

* Includes agriculture and public sector
** Includes international marine bunkers, other transformation and non-energy use
Global Market Growth

• Electricity Generation is predicted to grow globally in excess of 85% by 2030

• Fossil will remain dominant

Source: IEA
• In 2006, electricity generation from fossil fuel combustion made up more than 75% of the UK’s electricity supply, with gas-fired power stations providing 36% and coal-fired power stations providing 37.5%.
Fossil fuelled power plant will continue to be the main source of electricity generation for foreseeable future in the UK.
The UK market drivers

- security of supply
- climate change
- low cost electricity

Substantial Investment in Capacity Needed in the UK to Replace Shut-Downs and Meet Rising Demand (I)

35GW of new plant over the next 20 years
- mainly met by new fossil & renewables
- impact of new nuclear by 2020 likely to be small

Source: RWE
The Global Challenge

• Market Drivers

• The Global Challenge for the supply chain

• Materials Supply Chain
  – Key Components & Supply chain challenges

• Future Challenges

• Conclusions
The China factor— the no. 1 global consumer of natural resources

Chinese demand as a share of global consumption in 2006
(world ranking in brackets)

(1) (1) (1) (1) (1) (2)

Iron ore, Coal, Steel, Aluminium, Copper, Nickel, Oil

(Source IEA, BP)
...and how demand is predicted to grow

(Source IEA, BP)
Chinese stainless steel production and nickel demand explodes

Supply and demand......
The price explosion

4x demand in China 2000-06

~4x increase in price 2000-06

Source: INSG, CRU, CSBC, Macquarie Research, May 2007
The Materials Supply Chain

- Market Drivers
- The Global Challenge
- Materials Supply Chain
  - Key Components & Supply chain challenges
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For fossil (and nuclear) power plant, the main supply chain risk is that of availability of global processing and manufacturing facilities and capabilities....
The Materials Supply Chain
- Steam Turbine & Gas Turbine....key components

Most issues revolve around the ability to source the larger components
• Forgings-rotors, discs
• Castings-casings
The Materials Supply Chain
-GT26 Gas Turbine materials

Supply Chain includes;
• Raw materials
• Cast blades SX/DS, casings to large steel forgings
• Heat treatment
• Machining
• Coatings

Ni-base alloy
Ni-base alloy/ MCrAlY / TBC
Ferritic Steel
Austenitic Steel
SX Alloy / MCrAlY / TBC
DS Alloy / MCrAlY
Rotor ferritic steel
Ni-base Alloy / Chromizing

• 360 single crystal components
• 86 DS components
• over 1000 precision cast parts
The Materials Supply Chain
- Overcoming challenges by design

Welded rotor

Technology/know how
Available since 1929

Advantages:
- controlled material properties
- designed for low internal stresses
- flexibility in materials supplier and reduced lead time
The Materials Supply Chain
-Overcoming challenges by design

Submerged arc welding (SAW)

Automatic SAW-Tandem Welding process

Submerged arc welding Unit 1 + 2
Future Challenges

- Market Drivers
- The Global Challenge
- Materials Supply Chain
  - Key Components & Supply chain issues
- Future Challenges
- Conclusions
Future Challenges
Fossil power plant - Striving for Zero

- TWIN-TRACK APPROACH
- Carbon Reduction
  - +90%

- Time
  - Near-term
  - Mid-term
  - Long-term

- Efficiency + CCS
- £COST
- Improved efficiency
Future Challenges
- Coal can be clean

NOW

Installed base
- Improve efficiency
- Integrated retrofits
- Conventional emissions reductions to 95-99%

New base

TOMORROW

- Post combustion CO₂ scrubbing to achieve emission reduction

- Post-combustion capture
- Oxyfiring
- Pre-combustion capture?

Clean Power = limiting emissions while maintaining plant economics
Future Challenges
- Steam power plant trends

<table>
<thead>
<tr>
<th>Temp</th>
<th>Pressure</th>
<th>Efficiency</th>
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<tbody>
<tr>
<td>&lt;600 C</td>
<td>240 bar</td>
<td>50%</td>
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<tr>
<td>540 C</td>
<td>180 bar</td>
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<td>600-650 C</td>
<td>240-300 bar</td>
<td>55%</td>
</tr>
<tr>
<td>&gt;700 C</td>
<td>&gt;300 bar</td>
<td>55%</td>
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Conventional plant

Current advanced plant

EU programmes

AD700

EU programmes AD700

Low alloy steels

9-12%Cr steels

Nickel alloys

Improved materials

New designs

POWER SYSTEMS

ALSTOM
The new advanced technologies for GT & ST plant will generally:
• Higher temperatures
• Higher stresses
• Harsher environments

- Supply of large steel forgings and castings will continue to be crucial
- Large Ni forgings and castings are potentially needed should the demonstration of 700C steam plant be successful
- Welding/joining technologies for dissimilar metals
- Coatings technologies/surface engineering
- NDT/inspection methods
Future Challenges
-Skills

Skills

Engineering Construction Industry Training Board (ECITB) Review

- In order to stand still in the power sector, ~700 people are needed annually and a further 600 to meet expansion at 5% per annum, giving a total of 1,300 annually across the skills mix.
Conclusions

- Markets & Drivers
- The Global Challenge for the Supply Chain
- Materials Resources
  - Materials at risk?
  - Key Components & Supply chain issues
- Future Challenges
- Conclusions
Conclusions

• The Energy/Power generation market is buoyant and growing. Major opportunities exist in conventional fossil and in Carbon Capture & Storage

• Fossil energy will remain major UK & global source for foreseeable future

• Raw materials supply is not seen as the major risk in fossil plant
  − However, lack of sufficient world-class processing and manufacturing facilities is a major issue

• Large components (forgings and castings) are currently the main bottleneck

• Future technologies may potentially include large Ni base castings and forgings

• Operating conditions will only get more arduous, hence new technologies in
  − Coatings, modelling, lifetime prediction & NDE