SUB AND SUPERCRITICAL EXPERIENCE ON ESKOM COAL-FLEET

Centre for Science and Environment Conference

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CONTENTS

- Eskom Overview
- Coal New Build Technology
- Technology Selection and Criteria
- Lessons Learnt
ESKOM AT A GLANCE

- Strategic 100% state-owned electricity utility, strongly supported by the government
- Supplies approximately 95% of South Africa’s electricity
- Performed 201,788 household electrification connections during the year, the highest in a single year since 2002
- As at 31 March 2014:
  - 5.2 million customers (2013: 5.0 million)
  - Net maximum generating capacity of 42.0GW (2013: 41.9GW)
  - 17.4GW of new generation capacity being built, of which 6.1GW already commissioned
  - Approximately 359,337km of cables and power lines
  - 46,919 employees, inclusive of fixed-term contractors, in the group (2013: 47,295)
- Moody’s and S&P stand-alone credit ratings: b1 and b- respectively with a negative outlook

**Number of electrification connections**

<table>
<thead>
<tr>
<th></th>
<th>Mar-12</th>
<th>Mar-13</th>
<th>Mar-14</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>154,250</td>
<td>139,881</td>
<td>201,788</td>
</tr>
</tbody>
</table>

**Generation capacity – 30 September 2014**

- Coal: 85.1% of nominal capacity
- Hydro: 17.4%
- Pumped Storage: 3.4%
- Gas: 4.4%
- Nuclear: 5.7%
ESKOM’S PURPOSE, VALUES AND STRATEGIC OBJECTIVES

Our purpose
To provide sustainable electricity solutions to grow the economy and improve the quality of life of people in South Africa and the region

- Leading and partnering to keep the lights on
- Reducing Eskom’s environmental footprint and pursuing low-carbon growth
- Securing future resource requirements
- Implementing coal haulage and the road-to-rail migration plan
- Pursuing private-sector participation

Transformation (including the business productivity programme)
Ensuring Eskom’s financial sustainability
Becoming a high-performance organisation

ZIISCE: Zero harm, Integrity, Innovation, Sinobuntu, Customer satisfaction, Excellence

Foundation: Long-term nation-building – Electricity for all – Triple bottom line
POWER STATION MAP

South African grid map
The map indicates the South African power network

Key
- Existing grid system
- Possible future grid system
- Future hydroelectric power station
- Future thermal power station
- Future interconnection substation
- Town

- Future renewables
- Renewables
- Thermal power station
- Nuclear power station
- Future gas station
- Gas power station
In order to accelerate progress on the Medupi Power Station Project, additional shifts were introduced, 24 hours a day, seven days week. Unit 6 reached its full load of 794MW on 26 May 2015
# ESKOM DESIGN UNIT EFFICIENCY BASED GROSS OUTPUT

<table>
<thead>
<tr>
<th>POWER STATION</th>
<th>EFFICIENCY (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arnot</td>
<td>37.7</td>
</tr>
<tr>
<td>Camden</td>
<td>33.3</td>
</tr>
<tr>
<td>Duhva</td>
<td>37.6</td>
</tr>
<tr>
<td>Grootvlei</td>
<td>32.2</td>
</tr>
<tr>
<td>Hendrina</td>
<td>34.5</td>
</tr>
<tr>
<td>Kendal</td>
<td>36.6</td>
</tr>
<tr>
<td>Komati</td>
<td>29.3</td>
</tr>
<tr>
<td>Kriel</td>
<td>36.8</td>
</tr>
<tr>
<td>Kusile*</td>
<td>41.9</td>
</tr>
<tr>
<td>Lethabó</td>
<td>38.7</td>
</tr>
<tr>
<td>Majuba</td>
<td>38.5</td>
</tr>
<tr>
<td>Matimba</td>
<td>36.4</td>
</tr>
<tr>
<td>Matla</td>
<td>37.6</td>
</tr>
<tr>
<td>Medupi*</td>
<td>41.4</td>
</tr>
<tr>
<td>Tutuka</td>
<td>36.4</td>
</tr>
</tbody>
</table>

Based on Indicative average efficiencies across Plants / *Denotes Supercritical Plants
The feasibility phase of the project considered both sub- and super-critical pulverized fuel technologies for implementation.

Through the technical and financial evaluation processes followed during the feasibility phase, it emerged that the super-critical option is the preferred technology solution.

The term “super-critical” refers to the critical transition point of water to steam at pressures over 22 mega Pascal (MPa). Super-critical units typically refer to main steam conditions of 24 to 30 MPa and 538 to 600 degrees Celsius (°C), with a single reheat stage at 566 to 600°C.

The super-critical boiler is a once through design which (with sliding pressure) means that heating, evaporating, and superheating of the incoming feed water are completed within a single pass through the evaporator tubes and therefore does not require the use of a steam drum to separate and re-circulate water during normal operation.

This technology provides improved cycle efficiency and hence improved environmental performance.
The benefits of super-critical technology are:

- Increased gross efficiencies. This increase in efficiency results in a reduction in coal consumption of approximately 5%.

- A reduction in emissions in the order of 5%.

- Super-critical plant performance in terms of availability indicators is comparable to that of current Eskom plant performance according to a VGB report "Availability of Thermal Power Plants" for the operation period from 1995-2004.
<table>
<thead>
<tr>
<th><strong>Plant type</strong></th>
<th>Super critical pressure with reheat</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Boiler type</strong></td>
<td>Once-through sliding pressure, tower type</td>
</tr>
<tr>
<td><strong>Fuel</strong></td>
<td>Hard coal (HHV 18.7 MJ/kg)</td>
</tr>
<tr>
<td><strong>Plant output</strong></td>
<td>6 × 800 MW&lt;sub&gt;e&lt;/sub&gt; (4,800 MW&lt;sub&gt;e&lt;/sub&gt;)</td>
</tr>
<tr>
<td><strong>Turbine type</strong></td>
<td>Single reheat condensing</td>
</tr>
<tr>
<td><strong>Steam condition</strong></td>
<td>241 bar/560 °C/570 °C</td>
</tr>
<tr>
<td><strong>Condenser</strong></td>
<td>Air-cooled condenser</td>
</tr>
<tr>
<td><strong>Condenser pressure</strong></td>
<td>141 mbar at 23.7 °C ambient</td>
</tr>
<tr>
<td><strong>Generator</strong></td>
<td>GIGATOP 2 poles, power factor = 0.9, 50 Hz</td>
</tr>
</tbody>
</table>

MATERIAL DESIGN CONVECTIVE PATH: MEDUPI & KUSILE

Morris Moraga, Corporate Consultant, Eskom, Publication African Fusion, 2010
Lessons Learnt
During post-production and in some cases during installation, it was discovered that certain welding procedures where incorrectly approved.

These procedures needed to be re-approved using actual production parameters. Of the over 200 procedures requiring re-approval, 4 procedures on thick-walled components affecting X10Cr-MoVNb9-1 and 10CrMo9-10 material did not pass.

This resulted in components already installed on Medupi Unit 6 and Kusile Unit 1 requiring in-situ repairs or additional post-weld heat treatment.

Components affected included P91 circular weld on headers, separator vessels (eventually all four replaced on Medupi Unit 6) and the start-up vessel.
Heat treatment charts were produced without heat treatment or incorrect heat treatment. Over 9,000 welds which were potentially affected had to be verified to establish whether post-weld heat treatment (PWHT) was performed.

This resulted in more than 400 welds with wall thickness $\leq 10$ millimeters (mm) being cut out and replaced and more than 400 welds with wall thickness $> 10$ mm being heat-treated.

Areas cut and re-welded included the inlet and outlet connecting tubes of super heater 3 and re-heater 2.
During the review of databooks for final approval, it was discovered that there were additional welding procedures not appropriately qualified thus requiring re-qualification.

Welder qualifications and re-testing documentation was missing and PWHT charts showed deviations from procedures.

A significant amount of work had to be done post-fabrication and installation to close out the databooks prior to pressure test.
SOUTH AFRICA – SUPERCRITICAL FUTURE?

Samcheok 4 x 550 MWe Supercritical CFB Boiler

<table>
<thead>
<tr>
<th>Each Unit</th>
<th>English</th>
<th>Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam Capacity</td>
<td>550 MWe</td>
<td>1,600 MWth</td>
</tr>
<tr>
<td>Unit Steam Flow</td>
<td>3,461 / 2,820 kpph</td>
<td>437 / 354 kg/s</td>
</tr>
<tr>
<td>SH/RH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main Steam Pressure</td>
<td>3,728 / 783 psi</td>
<td>257/53 bar (a)</td>
</tr>
<tr>
<td>SH/RH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main Steam Temp.</td>
<td>1,117 / 1,117 °F</td>
<td>603 / 603 °C</td>
</tr>
</tbody>
</table>

Full Load Emissions
- SOx < 50 mg/Nm³
- NOx < 50 mg/Nm³

Fuel : Coal
- Moisture: 20-43%
- Ash in dry fuel: 1.5-17.0%
- Sulfur in dry fuel: 0.1-1.0%
- Biomass co-firing
Thank you

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