Electricity Generation Options considered by Eskom

Presentation at the Energy Planning Colloquium

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30 March 2012
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## Current Eskom generating capacity

<table>
<thead>
<tr>
<th>Type</th>
<th>Number of stations</th>
<th>Number of units</th>
<th>Net maximum capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal-fired</td>
<td>13</td>
<td>79</td>
<td>34 772 MW</td>
</tr>
<tr>
<td><strong>Coal-fired (return to service)</strong></td>
<td></td>
<td>8</td>
<td>949 MW</td>
</tr>
<tr>
<td>Hydroelectric</td>
<td>2</td>
<td>6</td>
<td>600 MW</td>
</tr>
<tr>
<td>Pumped storage</td>
<td>2</td>
<td>6</td>
<td>1 400 MW</td>
</tr>
<tr>
<td>Nuclear</td>
<td>1</td>
<td>2</td>
<td>1 800 MW</td>
</tr>
<tr>
<td>Wind</td>
<td>1</td>
<td>3</td>
<td>3.2 MW</td>
</tr>
<tr>
<td>Open Cycle Gas Turbine (OCGT) (Liquid fuel)</td>
<td>4</td>
<td>20</td>
<td>2 409 MW</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>23</td>
<td>124</td>
<td>41 933.2 MW</td>
</tr>
</tbody>
</table>

The Net Maximum Capacity reflects the MW that the station can supply to the grid after taking out the capacity used for auxiliaries (plant)
Eskom’s + imports energy mix (2010)

- Coal: 88%
- Nuclear: 5%
- Imports: 6%
- Hydro: 1%
- Energy from Open Cycle Gas Turbines (OCGTs): <1%

Imports are a significant contribution
Comparison of annual CO₂ emissions by country in 2009

<table>
<thead>
<tr>
<th>Rank</th>
<th>Country</th>
<th>Annual CO₂ emissions (Mt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>World</td>
<td>30,398</td>
</tr>
<tr>
<td>1</td>
<td>China</td>
<td>7,711</td>
</tr>
<tr>
<td>2</td>
<td>United States</td>
<td>5,425</td>
</tr>
<tr>
<td>3</td>
<td>EU</td>
<td>4,310</td>
</tr>
<tr>
<td>3</td>
<td>India</td>
<td>1,602</td>
</tr>
<tr>
<td>4</td>
<td>Russia</td>
<td>1,572</td>
</tr>
<tr>
<td>5</td>
<td>Japan</td>
<td>1,097</td>
</tr>
<tr>
<td>6</td>
<td>Germany</td>
<td>766</td>
</tr>
<tr>
<td>7</td>
<td>Canada</td>
<td>541</td>
</tr>
<tr>
<td>8</td>
<td>South Korea</td>
<td>528</td>
</tr>
<tr>
<td>12</td>
<td>South Africa</td>
<td>450</td>
</tr>
<tr>
<td>27</td>
<td>Egypt</td>
<td>192</td>
</tr>
<tr>
<td>36</td>
<td>Algeria</td>
<td>114</td>
</tr>
</tbody>
</table>

Highest CO₂ emitting power companies in the world

<table>
<thead>
<tr>
<th>Rank</th>
<th>Company</th>
<th>Annual CO₂ emissions (in Mt)</th>
<th>MWh Energy (in M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Huaneng Power International</td>
<td>285</td>
<td>260</td>
</tr>
<tr>
<td>2</td>
<td>Eskom</td>
<td>210</td>
<td>208</td>
</tr>
<tr>
<td>3</td>
<td>China Huadian Group</td>
<td>207</td>
<td>195</td>
</tr>
<tr>
<td>4</td>
<td>Southern Co</td>
<td>206</td>
<td>279</td>
</tr>
<tr>
<td>5</td>
<td>NTPC Ltd</td>
<td>186</td>
<td>182</td>
</tr>
</tbody>
</table>

If Eskom was a country, it would rank 26th globally with its emission, higher than any other African country.

Source: EIA International Energy Statistics
Eskom’s climate change strategy

- The climate change agenda is real and it is here
- Medium to long-term plans aligned to Government plans to mitigate and reduce relative emissions by 2025 and thereafter will see real reduction
- We must change our CO$_2$ footprint
- We will diversify our plant mix to reflect our climate change mitigation

- **Diversification** of the generation mix to lower carbon emitting technologies
- **Energy efficiency** measures to reduce demand and greenhouse gas and other emissions
- **Innovation** through research, demonstration and development
Technology Considerations

**Natural Gas Technologies**
- Limited local resources; lower efficient when dry-cooled/high altitude
- Short lead time; technically suited to low load factors; easier to site and therefore closer to load centres

**Clean Coal Technologies**
- Higher efficiency reduces CO$_2$ emissions
- Reduced efficiency (dry cooling/CO$_2$ capture); flue gas desulphurisation uses water
- Energy security; local resource;

**Nuclear Technologies**
- Require a higher assurance water supply; more suited to coastal sites; avoids the use of fresh water
- Perceptions around nuclear proliferation; longevity of radioactive waste material

**Renewable Technologies**
- Possible high price; intermittency; storage technology
- Low energy density; high volume of land use
Medupi is the first coal-generating plant in Africa to use supercritical power generation technology.

**Capacity expansion programme**

<table>
<thead>
<tr>
<th>Primary Energy</th>
<th>Generation</th>
<th>Transmission</th>
<th>Distribution &amp; customer service</th>
<th>Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Return-to-service (RTS)</td>
<td>New coal</td>
<td>Peaking &amp; renewables</td>
<td>Mpumalanga refurbishment</td>
<td>Transmission</td>
</tr>
<tr>
<td>Komati (1 000 MW)</td>
<td>Medupi (4 764 MW)</td>
<td>Ankerlig (1 338.3MW)</td>
<td>Arnot capacity increase (300 MW)</td>
<td>765kV projects</td>
</tr>
<tr>
<td>Camden (1 520 MW)</td>
<td>Kusile (4 800 MW)</td>
<td>Gourikwa (746 MW)</td>
<td>Matla refurbishment</td>
<td>Central projects</td>
</tr>
<tr>
<td>Grootvlei (1 180 MW)</td>
<td></td>
<td>Ingula (1 332 MW)</td>
<td>Kriel refurbishment</td>
<td>Northern projects</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sere (100 MW)</td>
<td>Duvha refurbishment</td>
<td>Cape projects</td>
</tr>
</tbody>
</table>

- **3 700 MW**
- **9 564 MW**
- **3 516.3 MW**
- **300 MW**
- **~ 4 700 km**

**Commissions of new stations**

<table>
<thead>
<tr>
<th></th>
<th>First Unit</th>
<th>Last Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medupi</td>
<td>2013</td>
<td>2018</td>
</tr>
<tr>
<td>Kusile</td>
<td>2014</td>
<td>2018</td>
</tr>
<tr>
<td>Ingula</td>
<td>2014</td>
<td>2014</td>
</tr>
</tbody>
</table>

- ~ 17 080 MW of new capacity (5 381 MW installed and commissioned)
- ~ 4 700 km of required transmission network (3 531 km installed)
Renewable Energy
Developing renewable energy in South Africa is important

- Reduce CO₂-emissions
- Mitigate climate change
- Diversify energy sources

Government has taken several important steps to drive renewables deployment

- Large portion of IRP allocated to renewables
- Renewable Energy Purchase programme introduced

South Africa has good resources (especially for solar)

- Average solar radiation of about 2,300 kWh/m²/year
- Large areas in the Cape with average wind speeds of more than 6 m/s
Eskom’s current renewables activities

Sere Wind Farm

Description
- 100 MW Wind farm being constructed in Western Cape region
- 50 turbines of 2 MW each
- Commissioning in 2013

Summary
- Wind is recognised as the most proven renewables technology worldwide
- ~220,000t CO$_2$ saved per year based on 0.9t CO$_2$ /MWh

PV at Eskom sites

Description
- First installation of one hectare per site at two sites adding 2 MWp of capacity
- Installations on buildings. Three systems at MWP.

Summary
- PV is zero emissions technology
- PV does not require water during the power production cycle
- PV is a well-established, safe technology
- PV can be installed quickly at plant site

CSP demo plant

Description
- Studies under way of a 4km$^2$ 100 MWp concentrating solar thermal power station with molten salt energy storage near Upington

Summary
- Plant required to investigate CSP technology in South Africa
- Vital to Eskom’s carbon footprint reduction/ low carbon growth strategy
PV Arrays – Lethabo Power Station
Installations at MWP
Dual Axis Tracking PV Array – Megawatt Park
Parking Canopy Mounted PV Arrays
Megawatt Park
Eskom will build a 100 MWe Central Receiver demonstration plant with molten salt as a heat transfer fluid.

Further plant specifications:
• Capacity factor suited for base load operation (~9 hours storage)
• Two tank storage systems, with molten salt, designed to operate the power plant as a base-load plant and optimised based on Levelised Energy Costs
• The plant will be dry cooled, designed to optimise the water usage
• All auxiliary power will be sourced from the national grid and backup will be sourced from diesel generators
• Life of plant will be a minimum of 25 years
The system makes use of solar energy to create steam.

The advantages are that it will decrease CO$_2$ emissions and decrease the amount of fossil fuel being burnt.

Concerns are that the most intense solar energy generation is only sustained at a maximum output during peak summer hours and is only available during the day.
Solar Augmentation

Source: AREVA
Cleaner Coal
UCG Project Progress

- UCG technology scan - April 2001
- Ergo Exergy Technologies Inc. (Canada) contracted
- Scoping study highlighted potential at Majuba colliery - Nov 2002
- Pre-feasibility study confirmed Majuba potential - Dec 2003
- Site characterisation study confirmed the potential - July 2005
- Commissioned a 3-5000 Nm3/h pilot plant - 20 Jan 2007
- First electricity generated from UCG gas at Majuba - 31 May 2007
Co-firing:

- Commissioned new co-firing gas treatment plant – Jun 2010
- Commissioned new 7km x 600mm NB pipeline to Majuba power station – Jun 2010
- Gas co-fired into Majuba U4 - 28 Oct 2010

UCG-OCGT demo plant:

- Design study underway for a demonstration plant comprising 250,000 Nm$^3$/h gas production and a 100 – 140 MW gas turbine plant
Carbon Sequestration using Algae

- Carbon capture technology are developing rapidly.
- The concern is that South Africa has limited on shore options for geological CO$_2$ storage.
- Storage options, on shore and offshore, are significant distance from current coal-fired power station sites.
- Algae is considered to provide a realistic and technically feasible solution for CCS.
- Positive laboratory results on local algae strains prompted larger scale outdoor assessment.

Source: Net Energy
Looking further ahead
Current considerations for the future…

- Higher efficiency renewable technology (PV, wind etc.)
- Improved energy storage options
- CO₂ storage clarity or alternatives
- Hydrogen economy
- Desalination
Thank You