An perspective from Eskom Research

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Corporate Services Division
Introduction

- Research assists Eskom to fulfil its commitments to South Africa. Eskom Research and Innovation is driven by the Sustainability and Innovation business unit within the Eskom Corporate Services Division.
- It plays an integral role in the pursuit of company objectives and strategic imperatives.
- The department provides a variety of services to the Eskom organisation including scientific and technical advice, research and consulting, analysis, detailed design as well as providing strategic technical planning services and direction.
- The research is focussed on the needs of the line Divisions within Eskom – they are the core business and recipient of the majority of outputs. Their needs drive the research agenda and they determine value add. Thus, the focus is predominantly on applied, not pure research and the research outputs are focussed on the strategic and operational needs of Eskom.
- In order to remain relevant however, a portion of research resources is allocated to technology innovation and emerging technology options.
- Research underpins the technology vision and direction of Eskom and ensures the sustainability of the business through balanced financial, social and environmental decision making whilst at the same time building and sustaining Eskom’s skills and core competencies.
- This presentation gives an overview of both the RESEARCH as well as DEMONSTRATION programmes at Eskom.
Research Strategic Direction – Governance

Research Advisory Council (RAC) (2 x year)
Strategy
Internal (Executive)

Tactical, Operational

Working Groups (Driven by activity leaders. As and when required)
Tasks and Outputs

18 Steering Committees (2 x year)

SAPURAB (2 x year)

Strategy External

Demonstration and Pilots Committee (4 x year)
<table>
<thead>
<tr>
<th>Project Names</th>
<th>2010 Forecast</th>
<th>2011 Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leveraging Research Memberships, Technical networks and partnerships</td>
<td>28 060</td>
<td>33 267</td>
</tr>
<tr>
<td>Generation Plant Availability &amp; Performance Enhancement</td>
<td>22 086</td>
<td>23 762</td>
</tr>
<tr>
<td>Transmission Technology and Resilience</td>
<td>17 669</td>
<td>19 010</td>
</tr>
<tr>
<td>Distribution Technology and System Performance</td>
<td>17 669</td>
<td>19 010</td>
</tr>
<tr>
<td>Demand Side Management, Energy Efficiency and Customer Research</td>
<td>13 252</td>
<td>14 257</td>
</tr>
<tr>
<td>Understanding and Managing Environmental Aspects</td>
<td>15 460</td>
<td>16 633</td>
</tr>
<tr>
<td>Implementing Asset Management Principles</td>
<td>11 043</td>
<td>11 881</td>
</tr>
<tr>
<td>Enhancing Human Performance and Facilitating Knowledge Creation</td>
<td>8 834</td>
<td>9 505</td>
</tr>
<tr>
<td>Future Strategic Technologies (% of budget)</td>
<td>11 043</td>
<td>11 881</td>
</tr>
<tr>
<td>Power System Operation and Control</td>
<td>11 043</td>
<td>11 881</td>
</tr>
<tr>
<td>Primary Energy Resources and Utilisation Technologies</td>
<td>13 252</td>
<td>14 257</td>
</tr>
<tr>
<td>Renewable Energy, Energy Storage and Integrated Distributed Energy</td>
<td>11 043</td>
<td>11 881</td>
</tr>
<tr>
<td>Applied Information Communications Technology</td>
<td>6 626</td>
<td>7 129</td>
</tr>
<tr>
<td>Energy Economics and Statistics</td>
<td>6 626</td>
<td>7 129</td>
</tr>
<tr>
<td>Safety, Health and Socio-Economic Aspects</td>
<td>6 626</td>
<td>7 129</td>
</tr>
<tr>
<td>Slowing and Adapting to Climate Change</td>
<td>6 626</td>
<td>7 129</td>
</tr>
<tr>
<td>Energy Markets and Regulation</td>
<td>4 417</td>
<td>4 752</td>
</tr>
<tr>
<td>Promoting a culture of innovation</td>
<td>6 626</td>
<td>7 129</td>
</tr>
<tr>
<td><strong>Fin Plan (R’000)</strong></td>
<td><strong>218 000</strong></td>
<td><strong>237 620</strong></td>
</tr>
</tbody>
</table>
We are in the midst of an energy technology revolution…

December 1903
Range 36.5m (in 12 seconds)
Top Speed 10km/h

November 1904
2 ¾ miles in 5m04s
4430m @ 52.5km/h

1 year

April 2005
Range 15200km
Top Speed 990 km/h (0.89 Mach)

102 years

Driven by…?
Some of the exciting new technologies that can contribute to this transformation have not yet been commercialised, but most have. **Windows** are now available with three times the insulation value of their predecessors. Modern gas and oil furnaces have attained 95% efficiency. Efficient **air conditioners** use 30 to 40% less energy than the models of ten years ago. District heating, heat pumps and solar energy can all save energy. **Improved lighting** could yield cost-effective savings of 30 to 60%. Major improvements have been made in refrigerators, water heaters, washing machines and dishwashers. Stand-by power (leaking electricity) absorbs about 10% of residential electricity in IEA countries, but technologies exist that can substantially reduce this consumption.

**New technologies such as “smart” metering, micro combined-heat-and-power generation, fuel cells and solar photovoltaics are opening up new ways to provide energy services.**
DR-Ready Appliance Designation

Data Needs

- Use cases
  *What would a...*
  AC/HP; water heater; pool pump; clothes washer; dishwasher; refrigerator; etc.

  *Need to do in order for your company to consider it “DR-Ready”*

- Interviews and survey responses

Issues/Challenges

- No standard communications protocol (yet); physical vs. application-layer
- Definitional variations by utility as function of Smart Grid strategy
- Does a consumer-oriented designation like ENERGY-STAR make sense for DR?
PV Plant

Nellis Air Force Base US largest PV 15 MW

Canada 97 MW
When will PV reach the “ignition” cost point? Sooner or later utility industry will need to be proactive on PV opportunities, and to avoid risk of losing market share.
Cell Efficiency Improving

3rd Generation
Solar Subdivision (SMUD)
Direct Carbon Fuel Cell

- Direct conversion of carbon-based fuel to electricity (no combustion)
- Very high efficiency
- Fuel flexibility (coal, natural gas, biomass)

Source: EPRI/SRI
PHEV Batteries in Secondary Use

Many questions about secondary use:

• What performance can we expect from a secondary use battery?

• What applications are they suitable for?

• What cost discount will there be?

• What will the cost be for refurbishment?

Need for Utility-Automotive-Battery Industry Collaboration to Answer These Questions
Dynamic Systems Infrastructure

Utility Communications

Efficient Building Systems

Renewables

Internet

PV

Control Interface

Consumer Portal & Building EMS

Advanced Metering

Plug-In Hybrids

Smart End-Use Devices

Dynamic Systems Control

Data Management

Distribution Operations

Distributed Generation & Storage
Renewable Technology
CLIMATE CHANGE/RENEWABLE RESEARCH

- Cofiring of Biomass (Wood, Grass, Crop residues) in PF Stations
- Municipal Solid Waste
- Continued support for SWH and Wind

- Research into off-grid or stand alone options is acceptable in support of national objectives, though implementation will be done by other parties.
- Wind and Solar Resource Assessment will be site specific.
- Combine with CSP with UCG in Eskom/SASOL strategic partnership for Hybrid PS

FUTURE

- Retrofit Solar Hybrid to PF Stations
- Hybrid UCG Gas, CSP combined cycle PS
- Biomass Co-fire
- UCG Co-firing

[Map of South Africa with various energy sources shown]
Molten Salt Power Tower Technology

- Cold Salt
- Hot Salt

Conventional EPGS

Steam Generator

285 °C

565 °C
The Future?
Hydro? Grand Inga
Clean (er) Coal Technologies
**Carbon Capture and Storage**

1. Conventional coal-fired power plants release CO₂ directly into the atmosphere. Plants equipped with CCS will capture much of the CO₂ instead.

2. Liquid CO₂ can be transported by pipeline or truck.

3. CO₂ can be injected and stored deep underground.

Depleted oil or gas reservoirs

Alternative possible locations for CO₂ storage

Unmineable coal beds

Deep saline aquifer

Groundwater

Seal rock

Seal rock
Ranges from $23.1 to $70.3 per ton of CO$_2$ ~ 15c-50c/kWh
## CO₂ Storage Potential

<table>
<thead>
<tr>
<th>Potential sink</th>
<th>Tonnage (million ton/year)</th>
<th>Duration (years)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afforestation Reduced tillage</td>
<td>3.9</td>
<td>20</td>
<td>An effort is required to store CO₂ in “perpetuity”</td>
</tr>
<tr>
<td>Savanne thickening</td>
<td>0.4</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7.9</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Gas reservoirs</td>
<td>1</td>
<td>Very long</td>
<td>There may be enhanced gas recovery</td>
</tr>
<tr>
<td>Mines</td>
<td>10</td>
<td>Site specific</td>
<td>More study is required</td>
</tr>
<tr>
<td>Vryheid formation</td>
<td>18375 million total</td>
<td>Very long</td>
<td>Relatively poor porosity and permeability, more study is required</td>
</tr>
<tr>
<td>Katberg formation</td>
<td>1600 million total</td>
<td>Very long</td>
<td></td>
</tr>
<tr>
<td>Coalbed methane</td>
<td>Small</td>
<td>Long</td>
<td>It may enhance methane recovery</td>
</tr>
<tr>
<td>Chemical capture</td>
<td>1 – 5 /year</td>
<td>Indefinite</td>
<td>Large volume of “reactive material” required</td>
</tr>
<tr>
<td>Deep ocean</td>
<td>Nearly unlimited</td>
<td>Several hundred years</td>
<td>Deep ocean ecosystems poorly understood</td>
</tr>
<tr>
<td>Ocean fertilisation</td>
<td>Not known</td>
<td>Not known</td>
<td>Study required, but not by South Africa</td>
</tr>
</tbody>
</table>

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**Simplified Geology**

South Africa, Lesotho and Swaziland

Image credits: CSIR, CSIR Manufacturing and Materials Technology

**Contract Report**

The potential for sequestration of carbon dioxide in South Africa

86D1D / HT339
UCG is a process where air is injected into the cavity, water enters from surrounding strata, and partial combustion and gasification takes place at the coal face after ignition. The resulting high-pressure syngas stream is returned to the surface, where the gas is cleaned and then combusted in a high-efficiency gas & steam turbine combined cycle plant to generate electricity.

UCG commercially proven in Former Soviet Union (FSU) – Eskom is demonstrating in RSA

Co-firing – Pipeline to Power Station

UCG pipeline between the UCG mine and Majuba power station

600mm NB pipeline for transporting UCG gas to Majuba power station
UCG gas burners at Majuba power station

© Eskom
Cleaner Option for Eskom

The only cleaner coal-based technology is ultra-supercritical PF

Data Reference: Australian ACARP Life Cycle Assessment (LCA) study, Case Study B20, June 2002
27 Potential Sites

- RSA coal resources quoted at 194.4 Bt (1998, DME Bulletin 113)

- Eskom geological records for coal offers received but considered unminable = 45 Bt
  
  = potential for 350 GWe

  = 8 x present Eskom total capacity

- The remaining:

  194.4 Bt – mined – minable = 100 Bt ?
How far forward should we look?
Algae as a CO2 sink?

algae@work
A2BE Carbon Capture, LLC
www.algaeatwork.com
Solar Chimneys
Some Breakthroughs required…

- Higher **efficiency** renewable technology (PV, wind etc.)
- Energy **storage** options
- **Nuclear waste** processing
- **CO2 storage** locations

Also consider……

- Medical breakthroughs – life span to 125
- Desalination
- Hydrogen
- Etc….
Plot the technologies that will have strategic impact

Impact on Eskom

- Less than 2 years
  - Advanced Metering Infrastructure
  - High eff. lighting
  - Emissions Technologies
  - Biomass Gasifier
  - Traffic Lights
  - RFID
- 2 to 5 years
  - High eff. heating
  - UCG
  - Condition Monitoring
  - Online Coal Quality
  - Opensource
  - Intelli subs
- 5 to 10 years
  - Advanced Energy Storage
  - Distributed Generation
  - Home energy storage
  - Ocean Current
  - Large CSP
- > 10 years
  - CO\textsubscript{2} Storage
  - CO\textsubscript{2} Capture
  - Fusion
  - Geothermal Gen
  - Hydrogen Economy
  - High temp Supercond.

Impact on Eskom

- Low
  - Small Hydro
  - Compact AC lines
- Moderate
  - Innovation Circuit
  - Knowledge Mgmt.
  - High eff. water
- High
  - CHP
  - Micro Gen
  - Biofuels
  - Plug in EV
  - CO\textsubscript{2} Storage
- Transformational
  - CCT - IGCC
  - CCT - USC
  - CCT - Scrubbing
  - CCT - Oxyfuel
  - CCT
  - Fluid Bed
  - uWave space power
  - PBMR
  - UHV DC
  - Fusion
  - Fusion
  - Fusion

Suggested Roll Out
- Will Happen
- Probable
- Likely
- Rare