Sasol Technology R&D
Coal and Gas Processing

A DIAMOND IN THE GLOBAL WORLD OF CARBON

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Chief Scientist and Technical Specialist
Sasol Technology (Pty) Ltd
The road ahead in the next 30 minutes…..

1. South-Africa

2. SASOL

3. Sasol Technology C&GPT

4. C&GPT Technical focus areas

5. Coal has a future....
Population statistics

Population: 49,991,300 (July 2010 est.)
Growth rate: -0.051%
Birth rate: 19.61 births/1,000 population (2010 est.)
Death rate: 16.99 deaths/1,000 population (2010 est.)
Life expectancy: 49.2 years (2010 est.)
  – male: 50.08 years (2010 est.)
  – female: 48.29 years (2010 est.)
Fertility rate: 2.33 children born/woman (2010 est.)
Infant mortality rate: 43.78 deaths/1,000

Age structure

0-14 years: 28.9% (male 7,093,328/female 7,061,579)
15-64 years: 65.8% (male 16,275,424/female 15,984,181)
65-over: 5.4% (male 1,075,117/female 1,562,860) (2010 est.)

http://en.wikipedia.org/wiki/Demographics_of_South_Africa
South Africa occupies 4% of the continent's total landmass, covering an area of 1,221,040 square kilometres. The country is five times larger than Great Britain and three times the size of Texas.

http://www.edusouthafrica.com/south-africa.html
The road ahead in the next 25 minutes.....

1. South-Africa

2. SASOL

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Sasol’s global presence (updated end 2011)
Sasol in South-Africa?
Birth of Sasol

South African Government investigated the production of oil from coal.

Decided to form a state-owned company

Sasol incorporated as a state owned company

South Africa has very little crude oil and gas reserves but large coal reserves

1950 Sasol’s first board of directors

Government support was essential for the establishment of a Synfuels Industry
Construction of the first Sasol plant in Sasolburg completed at a cost of USD 132 million of the day

First petrol delivered to the market

Sasol became cash positive

First profit

1954 1955 1958 1960

Initial Facility Profitable within 5 years of start-up
1974: Sasol Two announced

1973: October War
Crude oil prices peaked at > USD40/bbl in today’s money

1979: Iranian Revolution
Crude oil prices peaked at about USD80/bbl in today’s money

1979: Sasol Three announced

High oil prices precipitated the establishment of a Large Scale Synfuels Industry

The location of Sasol’s huge new factory, Secunda, is announced
1980: Completed construction of Sasol II at a cost of USD 3200 million of the day

1984: Completed construction of Sasol III at a cost of USD 2520 million of the day

1989: PetroSA GTL facility (Mossgas) using Sasol technology
Since inception, produced more than 1.6 billion barrels of high quality fuels from coal and gas. More than 20 million gasifier operating hours. More than 1 billion tons of coal processed at Sasol Synfuels.
Sasol’s largest commercial facilities is the Sasol Synfuels operations in Secunda in South Africa.

The Secunda plant is an equivalent of 160,000 bbd refinery.

Coal is first gasified in the Sasol® FBDB™ Gasification Process to produce synthesis gas.

The synthesis gas is then converted into hydrocarbons and other chemicals utilizing Sasol’s proprietary Hydrocarbon Synthesis technologies.

Some Synfuels Facts from a Gasification Perspective:
- In excess of 1 billion tons of coal has been gasified.
- Total coal mined per year >41 million tons; 26 million tons to gasification.
- 6 Coal Sources: 5 Sasol Mines + 1 mine as contracted coal supplier (High ash yield 25-35+ % AD).
- 84 Mk IV™ Sasol® Fixed Bed Dry Bottom™ Gasifiers producing > 3 million m³/h.
**SA energy drives growth in group profitability**

<table>
<thead>
<tr>
<th></th>
<th>2012</th>
<th>2011</th>
<th>% Δ</th>
</tr>
</thead>
<tbody>
<tr>
<td>SA Energy</td>
<td>29,0</td>
<td>19,9</td>
<td>▲ 45</td>
</tr>
<tr>
<td>International Energy</td>
<td>(0,1)</td>
<td>1,6</td>
<td>▼ 103</td>
</tr>
<tr>
<td>Chemicals</td>
<td>6,5</td>
<td>8,7</td>
<td>▼ 25</td>
</tr>
<tr>
<td>Other</td>
<td>1,4</td>
<td>(0,3)</td>
<td></td>
</tr>
<tr>
<td>Operating profit (Rbn)</td>
<td>36,8</td>
<td>29,9</td>
<td>▲ 23</td>
</tr>
<tr>
<td>Operating margin (%)</td>
<td>21,7</td>
<td>21,0</td>
<td>▲ 1</td>
</tr>
<tr>
<td>Earnings per share (R)</td>
<td>39,10</td>
<td>32,97</td>
<td>▲ 19</td>
</tr>
<tr>
<td>Dividend per share (R)</td>
<td>17,50</td>
<td>13,00</td>
<td>▲ 35</td>
</tr>
<tr>
<td>Cash generated by operations (Rbn)</td>
<td>47,9</td>
<td>38,6</td>
<td>▲ 24</td>
</tr>
</tbody>
</table>

- Significant improvements in production performance in 2H12
- Operating profit negatively impacted by once-off charges of R2,1bn (FY11: R1,1bn)
- Robust performance from SA Energy
- International energy impacted by Canada non-cash costs
- Chemicals negatively impacted by lower demand and margin squeeze

**Operating profit split**

- SA Energy: 79%
- Intl Energy: 4%
- Chemicals: 17%
- Other: 4%

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The road ahead in the next 20 minutes.....

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Sasol Technology R&D

• Corporate R&D located mostly in Sasolburg (590)
• Also centers in Secunda (30); Netherlands (9); Scotland (22)
• Extensive R&D Infrastructure
• Laboratories & Pilot Plants
• Design; Construction; Commissioning & Operation
• Main R&D Focus Areas

  **Coal & Gas Processing Technologies**
  Fischer Tropsch
  Chemicals
  Environment
  Refinery Technologies
  New Energy

**Disciplines**
- Scientists
- Engineers
- Administration
- Process Controllers
- Technologists
- Lab Assistants

**Qualifications**
- PhD
- MSC
- 4 Year Degree
- B Tech
- Diploma
- MBA
2011 / 2012 Budget

- Operating budget R 785 million (US$112M)

Facilities in Sasolburg
- Laboratories
- Analytical equipment
- Pilot Plants
- Library
- Maintenance workshops

External Liaison
- Local Universities
- Foreign Universities
- Various Research Institutes
The road ahead in the next 15 minutes.....

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Coal & Gas Processing Technologies - Value Chains

- **Underground Coal Gasification**
  - Solids Conversion
    - High Temperature Gasification
      - Sasol® FBDB™ Gasification
  - Sasol® Phenosolvan™
  - Sasol® CLL™
  - Coal Tar Filtration
  - Co-Product Recovery
- **Coal Mining**
- **Coal Preparation / Beneficiation**
- **Coal Conveyance & Distribution**
- **Ash Disposal**
- **Ash Processing**
- **Condensate Processing**
  - Condensate Treatment
    - Sasol® Gas Liquor Separation™
  - Co-Product Recovery
    - Sasol® Phenosolvan™
    - Sasol® CLL™
    - Coal Tar Filtration
- **Hydrocarbon Synthesis**
- **Sulphur Recovery**
- **Benfield Reforming**
- **Crude Gas Cooling Shift**
  - Acid Gas Removal
- **Syngas Processing**
  - Condensate Processing
  - Cryselic Acids
  - Nitrogen Based Business
  - Effluent Treatment

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Coal & Gas Processing Technologies R&D

Coal Characterisation & Processing

- Physical and chemical properties
- Coal processing and beneficiation
- Coal agglomeration

Gasification Technologies

- Sasol® Fixed Bed Dry Bottom™ Technology
- Underground Coal Gasification
- High Temperature Gasification
- Fluidized Bed Gasification

Synthesis Gas Treatment

- Gas Cooling, Cleaning & Conditioning
Co-product Processing

- Sasol® Gas Liquor Separation™
- Sasol® Phenosolvan™
- Sasol® CLL™ Ammonia Recovery
- Coal Tar Filtration

Supporting

- Direct Coal Liquefaction
- Pyrolysis
- Coal Combustion
- Process Modeling
Some Facts about C&GPT Team

Qualifications
PhD = 16
MSc=9
BSc (4yrs)= 2
BSc (3yrs) = 1
Diploma = 2
Matric and below = 5

Years with Sasol

- < 2: 9
- 2 to 5: 4
- 5 to 10: 11
- 10 to 15: 8
- > 15: 3

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Specialized skills tools to assist R&D programs

- Discreet element modelling (DEM)

- Lab scale atmospheric reactor s(i.e. pipe reactor)

- Sasol Proprietary Pyrolyzer (Koekebakker™)
Specialized skills tools to assist R&D programs

- Inorganic simulation of mineral matter

- HT-XRD – mineral characterization

- Spectroscopy lab
Typical C&GPT programs Team

Coal Supply Value Chain
• On-line Coal Quality Measurements & Gasifier Performance Monitoring
• Particle Size Distribution Optimization
• Coal Characterization
• Mineral Transformation
• Coal Agglomeration

Coal Conversion
• Intensification of Sasol® FBDB™ Process
• Optimization of mass flow behaviour
• Reactor Development
• Alternative Gasification Technologies
• Underground Coal Gasification

Coal Derived Condensate & Gas Treatment
Coal Derived Condensate Characterization & Prediction
Alternative Phenol recovery
Sulphur Recovery Optimization
Reduction of Environmental Footprint

Sasol Coal Stirrer-Distributor™ for Caking Coal
Enhanced Mk V™ Gasifier Internals
Advanced Ash Lock & Coal Lock Valve Designs
Effect of mineral matter on slag formation

SLAG FORMATION VERSUS AFT ANALYSIS

Predictions of slag composition

Temperature (°C)
Viscosity (log 10 poise)

Crystalline material
Cooled slag or glas

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Patterns recorded using a Philips X’pert MPD diffractometer equipped with Raytech 12° position sensitive detector and an Anton Paar HTK2000 heating stage.

- Radiation used was Co-Kα2
- Sample placed on Pt-strip
- Recorded X-ray spectra with crystalline phase...50°C and 100°C intervals.
SLAG-LIQUID FORMATION: 100% COAL

Measured flow temperature = 1420

Initial deformation temperature

Softening temperature

Hemisperical temperature

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Equilibrium simulation and Factsage™

Minerals Engineering
Volume 19, Issue 10, August 2006, Pages 1126–1135
Selected papers from Computational Modelling '06, Cape Town, South Africa

Mineral matter transformation during Sasol-Lurgi fixed bed dry bottom gasification – utilization of HT-XRD and FactSage modelling

J.C. van Dyk, S. Melzer, A. Sobiecki
Sasol Technology, R&D Division, Syngas and Coal Technologies, P.O. Box 1, Sasolburg 1947,
Received 24 January 2006. Accepted 15 March 2006. Available online 8 May 2006.
http://dx.doi.org/10.1016/j.mineng.2006.03.008, How to Cite or Link Using DOI
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Fuel
Volume 88, Issue 1, January 2009, Pages 67–74

Viscosity predictions of the slag composition of gasified coal, utilizing FactSage equilibrium modelling

J.C. van Dyk, F.B. Waanders, S.A. Berson, M.L. Laumb, K. Hack
Sasol Technology, R&D Division, Syngas and Coal Technologies, P.O. Box 1, Sasolburg 1947, South Africa
School of Chemical and Minerals Engineering, North West-University, Potchefstroom 2520, South Africa
Microbeem Technologies, Inc., P.O. Box 14758, Grand Forks, ND 58208-4758, USA
GTT-Technologies, Kaiserstrass 100, 52134 Herzogenrath, Germany

Importance of tar

Tar production during low pressure gasification:
- Liquids evolved from the gasifier downstream are tar, oil, gas liquor and naphtha
- Tars and oils are distilled in the tar refinery into various boiling point cuts (light and heavy)
- Heavy cut (pitch) is used as a feed for coal-tar coke production
- Light cuts are hydrogenated for the fuel pool

Importance of tar:
- Light cuts are hydrogenated for the fuel pool
- Direct conversion of coal to liquids
- Downstream products
  - Distillation for fuel
  - Pitch to coke
  - Crude tar acids

Current questions:
- Problematic heteroatoms and phenolics
- Can tar quality and quantity be influenced?
- Can Quantity and Quality be predicted for different coal types?
Web application: Multivariate Statistical Process Evaluation and Monitoring (MSPEM) – Online measurements

This website and methods have been developed by the Industrial Statistics Group, Sasol Technology R&D
For any questions or feedback please contact
Ruan Rossouw or Roelof Coetzee

Coal online XRF analyzer

Coal monitoring and info are coming

CVC Health check

Coal online PSD analyzer

CQI table
The road ahead in the next 5 minutes.....

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   C&GPT
4. C&GPT Technical focus areas
5. Coal has a future....
Coal has a future....!

Sasol R&D has the expertise and capability to support Sasol’s existing and new business ventures.

Cheap source of energy

Widely distributed

Coal also provides a stable source of energy and there is an abundance of supply both in South Africa and around the world.
Coal has a future....!

Coal is nothing more than ancient wood which has been under pressure for millions of years. It is not sinister as you may have been led to believe.

Accelerating technology advancements through focussed R&D ensures continued relevance

<table>
<thead>
<tr>
<th>Number of employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gold</td>
</tr>
<tr>
<td>PGMs</td>
</tr>
<tr>
<td>Iron ore</td>
</tr>
<tr>
<td>Chrome</td>
</tr>
<tr>
<td>Manganese</td>
</tr>
<tr>
<td>Diamonds</td>
</tr>
<tr>
<td>Coal</td>
</tr>
<tr>
<td>Aggregate &amp; sand</td>
</tr>
<tr>
<td>Other mines &amp; quarries</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
</tr>
</tbody>
</table>

Source: DMR

Coal is South-African made. We do not have to import this product into this country.
Coal is (still) the solution....