Options for gas to power in South Africa

STIAS Workshop, March 2013

Investment and technology choices in the SA power sector: Economic, social and environmental trade-offs

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### guide to today’s presentation

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an overview of gas to power technology options

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<tr>
<th>Open cycle (LHV basis)</th>
<th>Turbines</th>
<th>Engines</th>
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<tr>
<td>Output (MW)</td>
<td>375</td>
<td>18.3</td>
</tr>
<tr>
<td>Heat rate (kJ/kWh)</td>
<td>9000</td>
<td>7411</td>
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<tr>
<td>Efficiency (%)</td>
<td>40</td>
<td>48</td>
</tr>
<tr>
<td>Weight (t)</td>
<td>440</td>
<td>360</td>
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<tr>
<td>Exhaust temp (°C)</td>
<td>625</td>
<td>&lt;450</td>
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- Gas engines are reciprocating machines with typically higher simple cycle efficiencies than gas turbines
- Largest gas engines are around 18MW each whereas turbines can be >375MW (open cycle)
- With high exhaust temperatures turbines can have very high combined cycle efficiencies – 60%
  - Siemens SGT5-8000H CCGT ~ 570MW

Note: (Wärtsila 50SG gas engine) (Siemens SGT5-8000H gas turbine)

Siemens 8000H (Siemens)  GE-9H gas turbine prepared for testing (GE power systems)
### Value Proposition of Natural Gas in Electricity Generation

#### Technology
- Well proven
- Very high combined cycle efficiency (60% or more)
- Modular (easily scalable)
- Multiple experienced equipment vendors

#### Constructability
- Short construction periods (18 months from FID for gas engines, 24 – 30 months for gas turbine packages)
- Standardised packages available

#### Operation
- Dispatchable power – quick ramp-up rates
- Load following

#### Reduced CO₂
- Less than half the CO₂ emissions compared to coal-fired generation (emission factor of about 0.4 tCO₂/MWh compared to Eskom grid factor of ~0.98 tCO₂/MWh)
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### Some Useful Conversion Factors and Issues to Note

#### Details Matter
- Most countries sell gas on higher heating value basis (HHV)
- Most OEMs specify machines on lower heating value (LHV)
- HHV/LHV difference for natural gas is typically ~10%
- 55% on LHV is around 50% on HHV – be careful

#### Definitions Differ
- Gas heat content should be specified in MJ (megaJoule)
- Electricity energy is specified in kWh (kilowatt hour)
- Pipeline gas flows are typically in scf/h or scf/d (standard cubic foot per hour or day) – needs a heat content to convert to energy

#### Some Factors

**General approximate natural gas flows**
- 80mmscf/d ~ 30PJ/a ~ 0.8tcf over 25 years
- 30PJ/a will support about 550MW for 8000 h/a

**General approximate LNG conversion factors**
- 1 tonne LNG ~ 2.5m$^3$ LNG ~ 48.6 GJ
- 900MW (@58% LHV eff) needs about 1Mt/a LNG or ~ 50PJ gas (for 8000h/a)
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conventional gas opportunities in South Africa
West coast opportunities

Orange Basin:
Best estimate **Prospective Resource** gas in place = 22.5 Tcf
(based on geological modeling)

Source: Petroleum Agency South Africa
conventional gas opportunities in South Africa

Source: Petroleum Agency South Africa
Comprising the Bredasdorp, Pletmos, Gamtoos, Algoa and Southern Quteniqua sub-basins:
Best estimate for **Prospective Resources** gas in place = 19.4 Tcf
conventional gas opportunities in South Africa

Source: Petroleum Agency South Africa
east coast gas landscape

Durban and Zululand basins
Prospective P50 estimated resources gas in place = 4 Tcf

Source: Petroleum Agency South Africa
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Coalbed methane reserves in South Africa

- Lephalale/Waterberg: ~1 Tcf
- Springbok Flats: ~ 5 Tcf GIP prospective resources
- Tuli & Soutpansberg sub-basins
- Northern coalfields

SA CBM Prospective Resources gas in place (P50) estimated more than 5 Tcf

Need to understand more about costs & availability

Source: Petroleum Agency South Africa
New coal technologies could present other supply options

A promising mining method with the potential to unlock strategic coal resources in a future carbon constrained world

Underground Coal Gasification

• Low-quality deep coal can be put to productive use
• Produce fuel gas for power or steam generation and syngas
• Smaller environmental footprint than conventional mining and gasification
  • Minimal waste
  • Low dust, noise and visual impact
  • Lower water consumption

Need to understand costs & other impacts
domestic shale gas – many unknowns

- What is the extent of the reserves, and can they be extracted?
- What is the cost of production?
- What are the water and other environmental issues?
- When will enough be known about these issues so that their potential for large scale power generation can be assessed? When can we bank on this option?
southern Mozambique gas reserves – some already commercialised & piped to South Africa

An extensive drilling campaign conducted by Sasol in 2003 which included exploration and production wells in the Pande/Temane Block allowed the expansion of gas reserves and the discovery of Inhassoro Gas Field, making total of 5.504 trillion cubic feet (tcf).

Source: Instituto Nacional de Petróleo, Mozambique
Large discoveries in northern Mozambique
– not yet developed

5 discoveries in area 1:
30 – 50 tcf
(Anadarko 36.5%, Mitsui 20%, Bharat 10%, Videocon 10%, Cove 8.5% and ENH 15%)

2 discoveries in area 4:
30 tcf
(ENI 70%, Kogas 10%, GALP 10%, and ENH 15%)

Source: Instituto Nacional de Petróleo, Mozambique
Recent discoveries of large gas reserves in northern Mozambique - far from South Africa

- Large gas finds off Northern Mozambique and southern Tanzanian coastline in excess of 30tcf
- Pipeline from source to demand:
  - Distance of more than 2,000km from northern Mozambique to Gauteng
  - Rough terrain including river crossings and flood plains
  - Cost ~ $5-$10 billion?
    - Upper estimate based on $5 million/km (costs of recent international pipelines)
    - can vary depending on terrain, compression required and pipeline configuration.
- Challenge to achieve sufficient utilisation in early years to justify investment?
Importing LNG could be an option for South Africa

- Importing LNG removes the reserve and related risks associated with the other gas sources
- Building an LNG terminal can provide flexibility for South Africa
  - An import terminal will cost much less than a pipeline from northern Mozambique
  - Import capacity can be increased over time as power demand increases
- LNG imports will require long-term contractual commitments
  - LNG producers need firm offtake to reward large upstream & liquefaction plant capital investments
  - LNG is priced in dollars and linked to other gas prices
- Power generation could provide an anchor offtake to justify initial LNG investment
The LNG global trade is increasing

Going swimmingly
LNG imports, bn cubic metres

Source: The Economist, July 2012

Major gas trade movements 2011
Trade flows worldwide (million tonnes)

Source: BP Statistical Review of World Energy 2012
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The impact of future GW-scale gas-to-power on the electrical grid also needs to be considered.
Could gas provide a large proportion of SA’s power needs in future?

• Advantages of gas for power generation in South Africa
  • Relatively quick power project implementation rates using off the shelf technology
  • Flexible generation possible to complement intermittent renewables
  • Lower GHG emissions than coal-fired power [but higher than nuclear & renewables]

• Several options could have potential to supply GW-scale power, but with different risks and implications for South Africa

• Need to balance issues such as
  • reserve risk and time to commercialisation
  • infrastructure costs & initial utilisation rates
  • gas prices and linkages
  • etc
  • security of supply
  • lock-in versus longer-term flexibility
  • impact on economy

• Most likely GW-scale options appear to be
  • Domestic shale gas
  • Pipeline imports from northern Mozambique
  • LNG imports

• All have different risks & implications