East Africa - Major Gas Projects
Development Plans and Costs

Mike Wood - GCA
Gas Discoveries - Mozambique and Tanzania

Source: PetroView
Mozambique LNG – Onshore Site Plan – Palma Bay

Source: Anadarko
Tanzania

- Plans for developments to be integrated with major pipeline project
- Domestic demand for power and fertilisers
- Government demands onshore LNG plants
- Several onshore sites under consideration
- Fields are typically 100 km from shore
- Current plans for 4 x 5 MMtpa trains, fed by several operators/discoveries

Source: TPDC
Tanzania - LNG Project Potential

- Several discoveries
- Similar development considerations as Mozambique
- Statoil has stated potential for FLNG – up to 3.5 MMtpa

Source: Statoil
Mozambique LNG Project Summary

- Major integrated upstream/downstream project incorporating a multi-train onshore liquefaction facility to monetize significant gas discoveries from, initially, two offshore concessions in the Rovuma Basin, northeast Mozambique
- CAPEX: estimated by one sponsor a few years ago at up to US$16 Bn for initial two-train (10 MMtpa) development
- Natural gas production: initially 1,500 MMscfd for 2 trains from fields in Offshore Areas 1 & 4; 1,500 m water depth; gas is dry so liquids expected to be minimal
- Plant location determined: Afungi LNG Park, Palma Bay, Cabo Delgado Province, northern Mozambique; in vicinity of Offshore Areas 1 & 4
- LNG Plant Capacity: initially 10.0 MMtpa via 2 trains; with a notional 50 MMtpa in total
- Plans for 2 further Onshore trains
- Anadarko and ENI reported to be considering FLNG for future trains, and to develop other smaller discoveries in the Blocks - expected to be in the order of 2.5 MMtpa
- View is that FLNG has lower CAPEX !! Reported to be 30% lower costs for Australian Browse Basin projects
Mozambique LNG - Project Development

- Deepwater, close to shore
- Dry gas – initially, limited flow assurance concerns
- Very prolific wells, - 100 MMscfd per well expected
- Remote region, no infrastructure
- All major hardware logistics likely to be by sea
- Site for onshore plant selected – appears to have reasonable ground conditions
- Camp – up to 10,000 workers for construction of 2 trains, airstrip, power plant required
- Construction efficiency uncertain
- Extended jetties, dredging required
- Late life water production may require future modification to subsea system & pipeline
Onshore LNG Development Costs

- Much publicised benchmark rates – now reported to be approaching $2,000 per tpa, (as high as $3,000 per tpa for Gorgon)
- Apparent rapid growth in recent years
- But – no clarity in what is included in the cost:
  - Offshore development costs, platforms, pipelines to shore??
  - Gas pre-treatment - sweetening, LPG recovery??
- Actual liquefaction costs, including storage and export jetties costs are probably nearer to $1,500 per tpa
- Still major uncertainties however, relating to location, site conditions, access, infrastructure, labour efficiency and costs
- Wheatstone LNG site preparation costs (levelling and grading, roads, dredging) reported to be $3 Bn !!
- Labour/construction costs in Australia are dominant factor
## Cost Estimate 5 MMtpa Onshore Plant – (750 MMscfd)

<table>
<thead>
<tr>
<th>Project Component</th>
<th>Equipment &amp; Materials $ MM</th>
<th>Construction $ MM</th>
<th>Eng. / Mgt. &amp; Owners $ MM</th>
<th>Total Cost $ MM</th>
<th>Basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development Wells (15)</td>
<td>150</td>
<td>1,250</td>
<td>400</td>
<td>1,800</td>
<td>Standard, deepwater subsea wells.</td>
</tr>
<tr>
<td>Subsea Facilities</td>
<td>300</td>
<td>200</td>
<td>150</td>
<td>650</td>
<td>Standard configuration, current technology.</td>
</tr>
<tr>
<td>Pipeline to Shore</td>
<td>100</td>
<td>150</td>
<td>50</td>
<td>300</td>
<td>Close to beach, limited flow assurance risk.</td>
</tr>
<tr>
<td>Gas pre-treatment, condensate stabilisation, water handling</td>
<td>250</td>
<td>250</td>
<td>150</td>
<td>650</td>
<td>Sweet, lean gas, low condensate rates.</td>
</tr>
<tr>
<td>LNG Facilities</td>
<td>2,500</td>
<td>2,300</td>
<td>1200</td>
<td>6,000</td>
<td>Standard configuration, remote, poor infrastructure, but good ground conditions.</td>
</tr>
<tr>
<td>Storage, Marine Facilities, Dredging</td>
<td>500</td>
<td>700</td>
<td>400</td>
<td>1,600</td>
<td>Dredging required for LNG tanker access / turning</td>
</tr>
<tr>
<td><strong>Total $ MM per 5 MMtpa</strong></td>
<td><strong>3,800</strong></td>
<td><strong>4,850</strong></td>
<td><strong>2,350</strong></td>
<td><strong>11,000</strong></td>
<td></td>
</tr>
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</table>

GCA estimate
The 5.5 MMtpa, $10 billion Angola LNG plant shipped its first cargo in Mid 2013 after an 18-month delay.

- Required major land reclamation/dredging effort
- Remote location
- Dedicated tankers included in costs??

Source: Bechtel
## Cost Uncertainties

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<th>Cost Drivers</th>
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<td>Development Wells</td>
<td>150</td>
<td>1,250</td>
<td>400</td>
<td>1,800</td>
<td>Well productivity, Water depth. Rig Rates</td>
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<tr>
<td>Subsea Facilities</td>
<td>300</td>
<td>200</td>
<td>150</td>
<td>650</td>
<td>Gas Composition.</td>
</tr>
<tr>
<td>Pipeline to Shore</td>
<td>100</td>
<td>150</td>
<td>50</td>
<td>300</td>
<td>Distance to shore, flow assurance</td>
</tr>
<tr>
<td>Gas separation, pre-treatment, condensate stabilisation, water handling</td>
<td>250</td>
<td>250</td>
<td>150</td>
<td>650</td>
<td>Gas Composition</td>
</tr>
<tr>
<td>LNG Facilities, gas conditioning liquefaction, utilities, power</td>
<td>2,500</td>
<td>2,300</td>
<td>1200</td>
<td>6,000</td>
<td>Site and soil conditions, labour rates, access, logistics, regulatory compliance, local content</td>
</tr>
<tr>
<td>LNG Storage, Marine Facilities, Dredging</td>
<td>500</td>
<td>700</td>
<td>400</td>
<td>1,600</td>
<td>Water depth, soil conditions, storage capacity</td>
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<td>Total $ MM per 5 MMtpa</td>
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FLNG Costs

- Reported to be in the order of $2,000 per tpa for the FLNG vessel; including gas pre-treatment, but excluding subsea and well costs
- Reduced uncertainty – fabricated in shipyard – therefore independent of site conditions
- However as yet – unproven
- FLNG promoters claiming costs below $1,000 per tpa – what is included in this?
- Prelude FLNG costs are reported to be in the order of $3,000 per tpa of LNG (3.6 MMtpa) – but this also included costs for production of Condensate and LPG (1.7 MMtpa), - nearer $2,000 per tpa of liquids
- Potential cost savings in offshore infrastructure if fields are located distant from shore – eliminates pipeline costs
- Peak production capacity?
- Constraints on storage capacity?
- Availability uncertain?
Prelude FLNG

Source: Shell
Prelude

- 5.3 MMtpa of total liquids: including 3.6 MMtpa LNG, 1.3 MMtpa of condensate and 0.4 MMtpa of LPG
- Storage in the hull of the vessel
- Reported CAPEX of $10 Bn to 12 Bn
- Similar CAPEX indicated for 6 MMtpa dry gas case
- Remains higher than equivalent onshore LNG plant
- Bur valid for remote offshore fields
- Perceived reduced cost risk??

Source: Shell
Other Contenders - FLEX LNG

Classification
DNV @1A1, Floating Offshore LNG Liquefaction Terminal

Maintenance
20 years on-station maintenance

Turret
Internal Submerged Turret Production system (STP) from APL

Accommodation
150 POB (regular + temporary)

Liquefaction Capacity:
1.7-2.0 mtpa LNG

Overall (riser to offloading) Fuel Shrinkage: Approx. 10%

LNG Storage Capacity: Up to 185,000 m³
Condensate/LPG Storage: Up to 50,000 m³

Feed Gas: Approx. 250 – 300 mmscf/day

Source: FLEX LNG
Managing Uncertainty – a Hybrid Approach ??

Transport of Snohvit LNG Liquefaction /
Utilities Barge from Spain to Norway

Source: Iberdrola / Statoil
Snohvit LNG – Uncertainty Management

- Capacity 4.4 MMtpa LNG
- CAPEX reported to be $7.5 Bn (in 2006)
- Extensive subsea investment ~150 km multphase tie back
- Use of prefabricated LNG process module/barge, floated into position on the island
- Similar concept used for Sakhalin 1 Central Production Facility, and proposed for southern US liquefaction plants

Source: Statoil
FLNG

- Appears to offer a cost benefit in some locations, where it can offset costs for major offshore facilities or pipelines
- Similar cost levels to traditional onshore LNG
- Can offset construction cost uncertainty in difficult/remote locations
- Potentially reusable
- As yet unproven – both in terms of development costs and operability
- The “Snohvit” hybrid development, with process equipment pre-fabricated on a barge, could be attractive for near-to-shore fields, with a challenging onshore construction environment