POTENTIAL FOR REGIONAL USE OF EAST AFRICA’S NATURAL GAS

Prof. Vijay Modi
Columbia University

Addis Ababa, June 2nd, 2014

Authors: Jonathan Demierre, Morgan Bazilian, Jonathan Carbajal, Shaky Sherpa, Vijay Modi
MOTIVATION

• Longer term view
• Substantial fuel needs in cooking, transport, fertilizer prod, industry, power
• Same time, large gas finds
• Also working on synergy with renewables
• Benefits from similar integration in power
• Shared prosperity: meeting domestic needs in parallel with export incomes
Projection of Primary Energy Demand

- **CAGR = 5.4%**
  - Total pop. = 1.24 Billion

- **CAGR = 6.1%**
  - Total pop. = 1.35 Billion

- **CAGR = 5.9%**
  - Total pop. = 2.0 Billion

* *Natural gas equivalent*

**Year**


**Total primary energy consumption [tcf]**

0 20 40 60 80 100 120 140 160

**Sources:**
- China's and India's consumption: EIA 2014
- Sub-Saharan Africa's projection: own calculations

*CAGR = Compound Annual Growth Rate*
Urbanizing World: 45% of total by 2050
Eastern Africa (UN DESA definition)

- Urban Population [Millions]
- Year

Sub-Saharan Africa
- CAGR = 3.2%
- 56% of total pop.

Eastern Africa
- CAGR = 3.9%
- 23% of total pop.

- CAGR = Compound Annual Growth Rate
Major Urban Centers of the Region

In 2050

- 6 Cities with more than 12 million
- 16 Cities with more than 4 million

Projected Population of Major Urban Centers in 2050 (millions):

- 1 - 2
- 2 - 4
- 4 - 8
- 8 - 12
- 12 - 20

Addis Ababa 14.7 million
Kampala 13.1 million
Nairobi 15.2 million
Dar es Salaam 18.3 million
Maputo – Matola 7.7 million
Pretoria – Johannesburg 14.0 million
Potential City Gas Demand in the Region

- Addis Ababa: 203 Bcf/year
- Kampala: 208 Bcf/year
- Nairobi: 280 Bcf/year
- Dar es Salaam: 313 Bcf/year
- Maputo – Matola: 100 Bcf/year
- Pretoria – Johannesburg: 745 Bcf/year

Potential Natural Gas Demand of Major Urban Centers in 2050 (Bcf/year)

- 20 - 50
- 50 - 100
- 100 - 200
- 200 - 500
- 500 - 1000
# Natural Gas: Which Uses and at What Price?

<table>
<thead>
<tr>
<th></th>
<th>Est. Max Price at City Gate* [$/MMBtu]</th>
<th>Alternatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooking</td>
<td>10 - 20</td>
<td>Retail Wood, Charcoal, Kerosene, LPG</td>
</tr>
<tr>
<td>Power generation</td>
<td>12 - 48</td>
<td>Existing dispatchable generation (from gas to diesel)</td>
</tr>
<tr>
<td>Transportation</td>
<td>25 - 52</td>
<td>Diesel, Gasoline</td>
</tr>
<tr>
<td>Fertilizer Production</td>
<td>14 - 24</td>
<td>Retail imported Price</td>
</tr>
</tbody>
</table>

* Maximum natural gas price at city gate to compete with existing alternatives. An additional $5/MMBtu is taken into account for distribution within the city (cooking) and an additional 25% is considered for CNG at refueling stations (transportation).

→ **A price at city gate < $10-15/MMBtu may allow a large penetration of natural gas**
Transmission Network: Baseline Scenario

- Production cost: $3/MMBtu
- Max citygate cost ≤ $10/MMBtu
- Pipeline trans network: $57 B
- Supply: 4.2 tcf/yr
- Avg City Gate cost: $5.2/MMBtu

Year 2050

Exports to South Africa: 1.3 tcf/year
Transmission Network: High-Cost Scenario

Gas Cost at Citygate ($ / MMBTU)
- 3 - 5
- 5 - 7
- 7 - 9
- 9 - 12
- 12 - 15

Gas Flow (Bcf / Year)
- 0 - 20
- 20 - 50
- 50 - 100
- 100 - 500
- 500 - 1000
- 1000 - 2000

Year 2050

Avg at City Gate: $10.3/MMBtu

- Ethiopia, Rwanda, and Burundi not connected

Exports to South Africa: 0.8 tcf/year
Delivered Gas Cost for the Major Cities

- Bujumbura, Addis Ababa, and Kigali not connected in the high-cost scenario (delivered cost > $15/MMBtu)

Assumed production cost: $3/MMBtu

Gas Cost at City Gate [$/MMBtu]

<table>
<thead>
<tr>
<th>City</th>
<th>Baseline</th>
<th>High-Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bujumbura</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Addis Ababa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kigali</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kampala</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nairobi</td>
<td></td>
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<tr>
<td>Maputo</td>
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<tr>
<td>Lilongwe</td>
<td></td>
<td></td>
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<tr>
<td>Mombasa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dar es Salaam</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Population Benefitting in 2050 (baseline scenario)
National-level population: 614 Million (urban+rural)

_Countries:_ Mozambique, Malawi, Tanzania, Kenya, Uganda, Burundi, Rwanda and Ethiopia

<table>
<thead>
<tr>
<th>Population Impacted</th>
<th>Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power</td>
<td>75% access to electric grid 25% of electricity from gas</td>
</tr>
<tr>
<td>N Fertilizer needs</td>
<td>100% of urban + rural needs</td>
</tr>
</tbody>
</table>
### Population Benefitting in 2050 (baseline scenario)
Urban population supplied by gas: 185 Million

**Countries:** Mozambique, Malawi, Tanzania, Kenya, Uganda, Burundi, Rwanda and Ethiopia

<table>
<thead>
<tr>
<th></th>
<th>Population Impacted</th>
<th>Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cooking</strong></td>
<td>185 million</td>
<td>100% of the population in connected cities</td>
</tr>
<tr>
<td><strong>URBAN Passenger transport</strong></td>
<td>185 million</td>
<td>85% of LDV and Public transport in connected cities</td>
</tr>
</tbody>
</table>
Consumption by Sector in 2050

Baseline Scenario
Countries: Mozambique, Malawi, Tanzania, Kenya, Uganda, Burundi, Rwanda and Ethiopia

Pie Chart: 2.4 tcf
Fertilizer, 23%
Other indus/commercial: 0.5 tcf
Exports to South Africa 1.3 tcf
TOTAL: 4.2 tcf/yr
Similar Profits than with LNG exports

- Estimated profit for LNG exports to Japan (medium term): $1-7/MMBtu
- Assuming $5/MMBtu profit for the domestic market, natural gas would still be a very affordable alternative

*Baseline scenario
CAN THE POOR PAY FOR ENERGY SERVICES?
SOLAR MINIGRID DEPLOYMENTS IN UGANDA AND MALI. PAY-AS-YOU-GO SMART MODULAR MINIGRIDS
10 Consumer System: Metering + Communications

Meter Enclosure

Version 1: 40 cm x 30 cm x 20 cm

Version 2: 15 cm x 7 cm x 7 cm
Needed Investment by Sector by 2050

Baseline Scenario
Countries: Mozambique, Malawi, Tanzania, Kenya, Uganda, Burundi, Rwanda and Ethiopia

Needed investments in the 4 main sector to develop the demand in addition to the $57 Billion for the transmission system

<table>
<thead>
<tr>
<th>Sector</th>
<th>Investments [Billion $]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distribution Networks within Urban Centers</td>
<td>13.9</td>
</tr>
<tr>
<td>Power Plants</td>
<td>43.9</td>
</tr>
<tr>
<td>CNG Refueling Stations</td>
<td>9.3</td>
</tr>
<tr>
<td>Fertilizer Plants</td>
<td>33.2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>
GUJARAT, INDIA: A CASE STUDY IN GAS AND GAS INFRASTRUCTURE FOR DOMESTIC GROWTH

Mr. Pandian
Additional Chief Secretary
Sec, Energy and Petrochemicals
CHICKEN AND EGG PROBLEM

- No market demand without infrastructure
- No infrastructure without market demand
- Infrastructure and Market demand useless without assured gas supply!

- Gujarat had domestic gas so a study was carried out to use domestic gas

- Even with R-LNG it is viable today in Gujarat
- Of course with domestic piped gas is much better
STATE GOVT. GROWTH STRATEGY FOR GAS

- Securing Gas Supply
  - Indigenous Gas Sources + LNG Terminals for Import of gas

- Develop Gas Infrastructure
  - Integrated Transmission Gas Grid + City Gas Distribution Networks

- Encourage Gas Demand
  - Gas Power Plants
  - Fertilizer Plants
  - (Anchor Load Projects), State wide City Gas projects, Large and SME industries, CNG, PNG

- Government Act as a Facilitator
  - Government Policy Support
IN WHAT ORDER WAS IT DONE? WITHIN A DECADE

Anchor Loads
- Power (State and Private)
- Fertilizer (State actors to support agriculture)
- Industry (Private, eg ceramic industry)

City Gas Distribution
- Started with CSR demo. near LNG terminal
- Domestic cooking (state and Private)
- Public Transport (state)
GSPL GAS GRID
## CGD COVERAGE IN GUJARAT

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<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>GSPC Gas</td>
<td>1,892</td>
<td>490,000</td>
<td>1,893</td>
<td>159</td>
<td>445</td>
<td>90,000</td>
<td>5.00</td>
</tr>
<tr>
<td>3</td>
<td>GGCL</td>
<td>794</td>
<td>440,000</td>
<td>8,951</td>
<td>57</td>
<td>275</td>
<td>64,000</td>
<td>2.60</td>
</tr>
<tr>
<td>5</td>
<td>Adani Gas</td>
<td>760</td>
<td>190,000</td>
<td>1,460</td>
<td>52</td>
<td>320</td>
<td>62,300</td>
<td>0.88</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>3,789</strong></td>
<td><strong>1.3 Million</strong></td>
<td><strong>15K</strong></td>
<td><strong>331</strong></td>
<td><strong>1200</strong></td>
<td><strong>254K</strong></td>
<td><strong>9.90</strong></td>
</tr>
</tbody>
</table>

**STATE URBAN POPULATION 3 Million HH**

Done in 10 years

**HOW?**
GAS TRANSMISSION NETWORK IN GUJARAT

2174 KMS OPERATIONAL, 500 KMS UNDER PROGRESS

Total CGD Infrastructure – 15000 Kms (Steel & PE)
CITY DISTRIBUTION

• Typical CNG+PNG city network
• Cost Rupees 250-300 crores ($50 million) to supply 1.5 MMSCMD of gas
• $5M/yr for 15 Million MMBTU/yr
• With O&M and profit: $4/MMBTU
• Large cities could be $3.50
ADDED NEW PUBLIC TRANSPORT CAPACITY

CNG BUSES and RICKSHAW ANCHOR PUBLIC DEMAND

Facts File: Ahmedabad BRTS
Operationl Corridor – 63 kms.
Corridor under Implementation – 25 kms.
BRT stations – 104
Buses–127
TODAY:
HH of 5 spends $6/month on cooking

CAN BE DONE
Took Political Will and Administrative skill
Thank you