The Potential for Carbon Dioxide based Industries in Trinidad and Tobago

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Conclusions

- Trinidad and Tobago’s energy sector can realise three significant benefits from carbon capture:
  1. Reversing the current decline in oil production through carbon dioxide enhanced oil recovery (CO$_2$EOR).
  2. Reducing the country’s net carbon dioxide (CO$_2$) emissions.
  3. Creating new industries
Natural Gas Development

1960s-1985
Way marks

- South Chamber of Commerce
- Establishment of Point Lisas Industrial Estate
- Trans-island pipeline - NGC
- Liquefied Natural Gas
<table>
<thead>
<tr>
<th>Company</th>
<th>State Ownership (%)</th>
<th>Start-up Year</th>
<th>Cost (MMUS$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Iron &amp; Steel Company of T&amp;T</td>
<td>100</td>
<td>1981</td>
<td>500.0</td>
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<tr>
<td>TRINGEN 1</td>
<td>51</td>
<td>1977</td>
<td>111.4</td>
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<tr>
<td>Fertilizers of Trinidad and Tobago (FERTRIN 1&amp;2)</td>
<td>51</td>
<td>1982</td>
<td>350.0</td>
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<tr>
<td>Trinidad and Tobago Methanol Company (TTMC)</td>
<td>100</td>
<td>1984</td>
<td>179.2</td>
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<tr>
<td>Trinidad and Tobago Urea Company (TTUC)</td>
<td>100</td>
<td>1984</td>
<td>117.1</td>
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<tr>
<td>Plant</td>
<td>Ownership</td>
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<tr>
<td>1 TTMC I</td>
<td>CL Financial Group (56%), Consolidated Energy Limited (44%)</td>
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<tr>
<td>2 TTMC II</td>
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<td>3 CMC</td>
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<td>4 Methanol IV</td>
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<td>5 M5000</td>
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<tr>
<td>6 Methanex (Titan)</td>
<td>Methanex Corporation (100%)</td>
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<td>7 Atlas Methanol</td>
<td>Joint-venture with Methanex Corporation (63.1%) and bpTT (36.9%)</td>
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<tr>
<td>1 Yara</td>
<td>Yara Caribbean (100%) through Yara (Trinidad) Ltd</td>
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<tr>
<td>2 Tringen I</td>
<td>Yara Caribbean (49%) and GORTT (51%)</td>
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<tr>
<td>3 Tringen II</td>
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<tr>
<td>4 PCS Nitrogen I</td>
<td>Potash Corp Saskatchewan (100%) through PCS Nitrogen Inc</td>
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<td>5 PCS Nitrogen II</td>
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<tr>
<td>6 PCS Nitrogen III</td>
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<tr>
<td>7 PCS Nitrogen IV</td>
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<tr>
<td>8 Pt. Lisas Nitrogen</td>
<td>Koch Nitrogen Industries (50%), Terra Industries (50%)</td>
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<td>9 Caribbean Nitrogen Company</td>
<td>Process Energy/Clico Energy Ltd (30%)</td>
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<tr>
<td>10 Nitrogen 2000</td>
<td>Consolidated Energy Limited /FS Petrochemicals (30%)</td>
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<tr>
<td>11 AUM Ammonia Plant</td>
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<td>1 AUM Urea Plant</td>
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<td>1 AUM Nitric Acid Plant</td>
<td>CL Financial Group (56%), Consolidated Energy Limited (44%)</td>
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<tr>
<td>1 AUM Ammonium Nitrate Plant</td>
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<td>1 AUM UAN Mixing Plant</td>
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<td>1 AUM Melamine Plants (x 2)</td>
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<tr>
<td>2 PCS Nitrogen</td>
<td>Potash Corp Saskatchewan (100%) through PCS Nitrogen Inc</td>
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<tr>
<td>1 Phoenix Park Gas Processors</td>
<td>NGC (51%), Conoco Phillips (39%), and Pan West (10%)</td>
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<tr>
<td>1 Nu Iron Unlimited</td>
<td>NUCOR Corporation</td>
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<tr>
<td>2 Mittal Steel Company</td>
<td>Arcelor Mittal Trinidad Ltd</td>
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<tr>
<td>1 Methanol-to-Power</td>
<td>MHTL &amp; UTT</td>
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</tbody>
</table>

Source: Ministry of Energy and Energy Affairs
Way marks

- South Chamber of Commerce
- Establishment of Point Lisas Industrial Estate
- Trans-island pipeline - NGC
  - (TT$4.6 Billion post-tax profit)
- Liquefied Natural Gas

1960s to 2000s

Source: Ministry of Energy and Energy Affairs
National Energy Commission Focus

- Petrochemicals
- Alternative Energy
- Inorganic Chemicals
- Biochemical and Agro-based products
- Plastics
- Metals

“to develop and manage suitable infrastructure in order to facilitate and promote the various activities relevant and appropriate to natural gas-related operations.”

Energy Efficiency, Energy Services, Common Utilities
CO$_2$ Development
Motivation

- Climate Change Issues
  - Global Warming
  - Increasing concentration of greenhouse gases (mainly CO$_2$)
    - Flooding
    - Stronger and more frequent hurricanes
    - Sea level rising
    - Disease
    - Displacement
- Large CO$_2$ emissions
- Signatory to the Kyoto Protocol
Motivation

Contributions of the Various Sectors to CO$_2$ Emissions in T&T (2009)

- Power Generation: 17%
- LNG: 13%
- Transport: 8%
- Residential: 1%
- Manufacturing: 3%
- Ammonia: 76%
- Methanol: 1%
- Urea: 1%
- Natural Gas Processing: 4%
- Iron and Steel: 14%
- Oil Production and Refining: 4%

Source: Boodlal et al (2009)

Trinidad & Tobago CO$_2$ Emissions

Breakdown of the Petrochemical Sector (2009)

- Petrochemical: 56%
- Flaring: 3%
- LNG: 13%

Source: Boodlal et al (2009)
Carbon Storage

CO₂ Enhanced Oil Recovery
Heavy Oil in Trinidad and Tobago

- **Reserves**
  - 2 billion barrels
  - 8-3,500 cp at reservoir conditions

- **Production**
  - 20,000 bbl/day
  - 30% of total oil production

- **Primary recovery**
  - 5-20%

- **Potential Revenue**
  - US$40/tCO₂

Source: Mohammed- Singh and Singhal, 2005
Hosein et al, 2011
CCS

Carbon Capture and Storage

- Subsurface CO₂ storage
  - Increase oil recovery
  - Can attract international funding and investment
  - Established technology
  - Revenue generating activity

Reproduced from Blunt, 2010
Carbon Reuse Technologies

Everything is doable...at a price
Concrete Curing
• Reduce cost of process
• Increase safety of process
• Can use CO$_2$ from the process

• Technology being developed for commercial use
Algae Cultivation
Can produce biodiesel
Can be blended in petroleum refineries
Does not compete with arable land
Reduce demand for petroleum derived fuels

Technology being developed for commercial use
Large land space needed
Liquid Fuel production
Biofuels for transportation market
Reduce use of petroleum derived fuels
Electric vehicles may be more competitive

• Technology being developed for commercial use
• High capital cost
• Low thermal efficiency
Plastics
Reduce demand for petroleum derived fuels

Technology being developed for commercial production
CO₂ Development
Will History repeat itself?

Initiative, Investment, Incentives, Innovation

Who is going to pay?

Everything is doable...at a price
Who should pay for CCS?

- Government: 48%
- Oil and Gas Companies: 24%
- Industry: 12%
- Uncertain: 14%
- End use consumers: 2%

Source: Alexander, Boodlal and Bryant, 2011
Cost

- Research
- Proprietary technology
- Pilot projects
  - Feasibility studies
- Infrastructure
- Land
## Funding & Incentives

<table>
<thead>
<tr>
<th>Government</th>
<th>Private Investors</th>
<th>International Organisations</th>
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</thead>
<tbody>
<tr>
<td>• Incentives and disincentives</td>
<td>• Carbon market</td>
<td>• UNFCCC</td>
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<tr>
<td>• Carbon tax</td>
<td>• Low or Carbon neutral manufacturing</td>
<td>• UNDP</td>
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<tr>
<td>• Natural gas pricing</td>
<td>• Environmentally friendly products</td>
<td>• IEAGHG</td>
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<tr>
<td>• Regulate &amp; Facilitate</td>
<td>• Possible low cost alternative to petroleum derived products</td>
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<tr>
<td>• Policy</td>
<td></td>
<td></td>
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<tr>
<td>• Regulations</td>
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</table>

- Possible low cost alternative to petroleum derived products
Everything is doable...at a price

CO₂ Development