TIRDO’s Role in Development of Sustainable Energy Technologies for Supporting the Industrialization Process in Tanzania

by Lugano Wilson & Hossen Iddi

Day 2 Paper

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“Making industrialization work for socio-economic transformation”

TIRDO Role in Development of Sustainable Energy Technologies for Supporting the Industrialization Process in Tanzania

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1: INTRODUCTION

1.1 Energy is prerequisite for development

A correlation between per capita energy use and real per capita income throughout the world economies

- Higher use implies higher income and vice versa
- Low per capita energy consumption in the developing countries is negatively affecting economic opportunities, and the provision of social services like health, education, and safe water.
... / Energy is prerequisite for development

Best case future scenario
India and China 2060

India and China 2060
This scenario may require two resource worlds

Earth I   Earth II

TZ 100    EU    USA    UAE

Annual per capita electricity use (kWh)
1.2 Challenges of development

Various, which may base on:

- Low technological skills
- Low technological capacity
- Governance-based
- Mindset-based
- Resources-based

- Tanzania has abundant energy resources are to include hydro, biomass, natural gas, coal, uranium, solar, wind and geothermal
- Sustainable industrialization calls for an effective harnessing to these energy resources.
2. TANZANIA ENERGY RESOURCES

2.1 Hydropower

- The macro hydro potential is about 4.7GW
  - Only 565MW have been developed
- Micro hydro potential of about 350 MW
  - About 63.54 MW developed
TPDC has discovered five offshore natural gas reserves (Songo Songo, Mnazi Bay, Mkuranga, Kiliwani and Ntorya) and eight deep sea discoveries (Chaza, Jodari, Zafarani, Pweza, Mzia, Chewa, Papa 1 and Lavani) - southeastern Tanzania

- Total natural gas reserve is 55.08 trillion cubic feet (TCF)
- 1.142 TCF is proven at Songo Songo and Mnazi Bay
- 20.68% of the proven natural gas reserve has been harnessed
... / Natural gas
2.3 Coal reserve

- Coal reserves is about 1,500 million tons of which 496.11 million tons are proven.
- Majority coal resource is within the Ruhuhu coalfield that contains reserves at Mhuhuru, Katewaka-Mchuchuma and Ngaka that contains almost 700 million tons of coal.
- Other deposit is the Songwe-Kiwira coalfield.
- Recent discoveries of deposits in the southwest part of Tanzania.
- The level of utilization is still low (0.51%) through one power plant and thermal applications.
Estimated at 1,500 mill. tons; 304 mil. tons proven

Ruhuhu (Mhuhuru, Katewaka-Mchuchuma and Ngaka) has 700 mil. tons

1. Namwele-Nkomolo coa, Muze coalfield
2. Galula coalfield
3. Songwe-Kiwire coalfield
4. Ruhuhu basin
5. Katewaka/Mchuchuma coalfield
6. Njiga coalfield
7. Mhukuru coalfield
8. Mbamba Bay coalfield
Tanzania coal reserve has received spatial assessment (Mpanju et al. 1991; Mbede, 1991; Cairncross, 2001; Semkiwa et al., 2003; Wilson and Iddi, 2014)

- It is bituminous
- Reported ash of up to 25%
- Calorific value of between 15 and 35 MJ/kg
- Potential applications include:
  - Thermal processes
  - Low temperature carbonization
  - Hydrogenation
  - Blending for iron and steel industry
### 2.4 Biomass energy potential

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural waste (tons)</td>
<td>12,000,000</td>
</tr>
<tr>
<td>Forestry waste ($m^3$)</td>
<td>205,400</td>
</tr>
<tr>
<td>Forestry waste (tons)</td>
<td>143,780</td>
</tr>
<tr>
<td>Potential energy forest land (ha)</td>
<td>19,000,000</td>
</tr>
<tr>
<td>Yield ($m^3$/ha - yr.)</td>
<td>10.4</td>
</tr>
<tr>
<td>Potential forest biomass ($m^3$)</td>
<td>197,600,000</td>
</tr>
<tr>
<td>Potential forest biomass (tons)</td>
<td>138,320,000</td>
</tr>
<tr>
<td><strong>Total potential biomass resource (tons)</strong></td>
<td><strong>150,463,780</strong></td>
</tr>
<tr>
<td>Taking 1 kg biomass = 0.43 kg oil equivalent</td>
<td></td>
</tr>
<tr>
<td>Gross energy potential (TOE)</td>
<td>64,699,425</td>
</tr>
<tr>
<td>Net energy in liquid or gaseous form</td>
<td></td>
</tr>
<tr>
<td>at 75% conversion efficiency (TOE)</td>
<td>48,524,569</td>
</tr>
<tr>
<td><strong>At 25% realistic proven potential (TOE)</strong></td>
<td><strong>12,131,142</strong></td>
</tr>
</tbody>
</table>
Commercial biomass energy production

<table>
<thead>
<tr>
<th>SNO.</th>
<th>STATION</th>
<th>INSTALLED CAPACITY (MW)</th>
<th>FUEL TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tanganyika Planting Corporation Ltd-TPC</td>
<td>17</td>
<td>Bagasse</td>
</tr>
<tr>
<td>2</td>
<td>Tanganyika Wattle co Ltd-TANWAT</td>
<td>2.7</td>
<td>Biomass</td>
</tr>
<tr>
<td>3</td>
<td>Kilombero Sugar Company Ltd</td>
<td>10.6</td>
<td>Bagasse</td>
</tr>
<tr>
<td>4</td>
<td>Mtibwa Sugar Estate Ltd</td>
<td>13</td>
<td>Bagasse</td>
</tr>
<tr>
<td>5</td>
<td>Tanzania Sisal Board, Tanga</td>
<td>0.5</td>
<td>Biomass</td>
</tr>
<tr>
<td></td>
<td><strong>Subtotal:</strong></td>
<td><strong>43.8</strong></td>
<td><strong>Biomass</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SNO.</th>
<th>STATION</th>
<th>INSTALLED CAPACITY (MW)</th>
<th>FUEL TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ngombeni Power Ltd, Mafia</td>
<td>2.5</td>
<td>Biomass</td>
</tr>
<tr>
<td>2</td>
<td>Kagera Sugar Estate Ltd</td>
<td>5</td>
<td>Bagasse</td>
</tr>
<tr>
<td>3</td>
<td>Saohill Saw Mills, Mafinga</td>
<td>15</td>
<td>Bio-mass</td>
</tr>
<tr>
<td>4</td>
<td>Symbion-KMRI, Tunduru</td>
<td>0.3</td>
<td>Bio-mass</td>
</tr>
<tr>
<td>5</td>
<td>Symbion-Kigoma</td>
<td>3.3</td>
<td>Bio-mass</td>
</tr>
<tr>
<td></td>
<td><strong>Subtotal:</strong></td>
<td><strong>25.1</strong></td>
<td><strong>Biomass</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Total biomass:</strong></td>
<td><strong>69.9</strong></td>
<td><strong>Biomass</strong></td>
</tr>
</tbody>
</table>
Tanzania lies between 10° and 11° South of the Equator, with long sunshine hours of between 2800 and 3500 hours per year.

The average potential of solar energy in the country is approximated to be 187 Wm$^{-2}$.

- This is an opportunity for installing solar photovoltaic (PV) and solar thermal energy systems.
- To date there is a limited harnessing of the solar resource as only about 6 MWp of PV.
### 2.6 Wind energy potential

<table>
<thead>
<tr>
<th>SITE</th>
<th>10 m WIND SPEED m/s</th>
<th>30 m WIND SPEED m/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Makambako</td>
<td>7.6</td>
<td>8.7</td>
</tr>
<tr>
<td>Singida</td>
<td>8.2</td>
<td>9.4</td>
</tr>
<tr>
<td>Karatu (Arusha)</td>
<td>4.9</td>
<td>5.5</td>
</tr>
<tr>
<td>Mkumbara (Tanga)</td>
<td>4.14</td>
<td>4.9</td>
</tr>
<tr>
<td>Gomvu (Kigamboni)</td>
<td>3.56</td>
<td>4.28</td>
</tr>
<tr>
<td>Litembe (Mtwara)</td>
<td>3.21</td>
<td>4.47</td>
</tr>
</tbody>
</table>

No commercial wind farm
2.7 Geothermal potential

- existing geothermal potential is 650 MW.
- No commercial harnessing
Eastern Tanzania is a 1,424 km coastal strip along the Indian Ocean. This strip including those along the Zanzibar and Mafia Islands constitute a potential energy source for tidal, wave, and ocean thermal energy conversion (OTEC) technologies.

Lack of full feasibility assessments and technological capacity has led to the limited deployment.
2.9 Petroleum exploration

Active petroleum system - in deep sea and along Lake Tanganyika
Mkuju River Project (MRP) by Australian company, Mantra Resources Limited

- Results show an average annual production of 3.7 million pounds of uranium grade $\text{U}_3\text{O}_8$ at a minimum initial mine lifetime of twelve years
- Requires more definitive feasibility studies
## 2.11 Harnessing level summary

<table>
<thead>
<tr>
<th>SNO</th>
<th>ENERGY RESOURCE</th>
<th>PROVEN POTENTIAL</th>
<th>RESERVE</th>
<th>UTILIZATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hydropower, MW</td>
<td>5,050</td>
<td>5,050</td>
<td>12.38</td>
</tr>
<tr>
<td>2</td>
<td>Natural gas, BCF</td>
<td>1,142</td>
<td>55,080</td>
<td>20.68</td>
</tr>
<tr>
<td>3</td>
<td>Biomass, '000 TOE</td>
<td>12,131</td>
<td>64,699</td>
<td>0.37</td>
</tr>
<tr>
<td>4</td>
<td>Coal (proven), Mil. Tons</td>
<td>304</td>
<td>1,200</td>
<td>0.57</td>
</tr>
<tr>
<td>5</td>
<td>Solar</td>
<td>Not estimated</td>
<td>Not estimated</td>
<td>Not estimated</td>
</tr>
<tr>
<td>6</td>
<td>Wind</td>
<td>Not estimated</td>
<td>Not estimated</td>
<td>Not estimated</td>
</tr>
<tr>
<td>7</td>
<td>Geothermal, MW</td>
<td>&gt; 650</td>
<td>Not estimated</td>
<td>Not utilized</td>
</tr>
<tr>
<td>8</td>
<td>Tidal and wave</td>
<td>Not estimated</td>
<td>Not estimated</td>
<td>Not estimated</td>
</tr>
<tr>
<td>9</td>
<td>Petroleum</td>
<td>Under exploration</td>
<td>Under exploration</td>
<td>Under exploration</td>
</tr>
<tr>
<td>10</td>
<td>Uranium</td>
<td>Under exploration</td>
<td>Under exploration</td>
<td>Under exploration</td>
</tr>
</tbody>
</table>
3. TIRDO INTERVENTION

Developed coal program aiming at coal characterization and coal technologies development

- Collaborators
  - Government through the Commission of Science and technology (COSTECH)
  - High Commission of India in Tanzania, the program is receiving technical support from the Council of Scientific and Industrial Research (CSIR)

- Coal laboratory at TIRDO is already equipped to undertake coal resource quality assessment
3.1 Coal characterization

characterize coal deposit available in Tanzania for developing coal utilization technologies

Specifically:

- Identify all coal deposit available in Tanzania
- Characterize the coal through chemical and physical analysis to establish proximate, ultimate and coking characteristics
- Ranking the coal
- Provide technical advice on coal utilization technology
- Develop coke for domestic and industrial applications to include SMEs
Coal Characterization
3.2 Development of coal utilization technologies

For supporting

- Iron and steel industry
- Other energy intensive sectors like cement
- Chemical industry
- Households
3.3 Coal Bed Methane Energy Technology Development

Objectives

To develop the coal bed methane (CBM) production technology in Tanzania by undertaking gassing assessment of available coal seams.
Specific objectives

- Mapping selected coal bed methane reservoirs
- Establishing specific factors that influence reservoir heterogeneity and permeability
- Determining hydrological and geological factors that control storage and release of methane in Tanzania coal seams
- Establishing critical reservoir parameters that control production
- Confirming reserves and making long-term production forecasts
- Developing technologies for harnessing the coal bed methane
Outcomes and impacts

- Introduction of coal bed methane power plant(s) and contribute to electrification
- To increase access to indigenous commercial energy by industrialists and households
- Increase coal mining safety
- Add value to Tanzania coal mining operations
- Mitigate greenhouse gases from gassing coal mines
4. CONCLUSION AND RECOMMENDATIONS

Coal is among the abundant energy resources for Tanzania.

Due to its products’ diversity, the sustainable harnessing of this resource has a significant contribution to the country’s industrial development.

- This calls for increasing local capacity in acquiring niche skills in undertaking coal resource quality assessment and in developing coal utilization technologies.
- Benchmarking of coal resource quality is mandatory for supporting the development of coal utilization technologies and in quality assurance of the traded coal.
THANK YOU

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