Potential for integration of small wind turbines in mini-grids in East Africa

Paper by:
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Small wind turbines for mini-grids

Background

• Need for quick upscaling to reach universal access
• Need for local jobs in production and maintenance of energy systems
• Hybrid systems with PV and batteries are becoming mainstream
• However, we believe that using the latest knowledge from a large wind turbine manufacturer, it is possible to develop a wind turbine (5-20 kW), which is
  – technologically advanced,
  – low cost, easy to maintain,
  – partly locally produced
  – and competitive to PV and batteries

Objective

What is the potential market for small wind turbines in Kenya and Tanzania?
  – What is the existing and future 'market' for mini-grids?
  – What is the wind-potential at existing and potential mini-grid sites?
How to assess avr. wind speed in 250 localities

Global Wind Atlas

- Global Wind Atlas (globalwindatlas.info)
- Aggregated wind data around the world
- Resolution of 250 Meter
- Wind information of 50, 100 and 200 meters

Algorithm

- Wind turbine height at 20 meter
- Wind speed calculated at each 250 meter grid point in a circle with 2.5 km radius
- Wind speed for the location in estimated as average of top 10 sites (out of app.300) in the circle.
Status Kenya

Business models

• Public model (27+26)
  – REA own, KPLC operate, uniform tariff
• Private model (42)
  – Privately owned, cost reflective tariffs, negotiations on donor funding and/or cross subsidies
• Public Private Partnership model (124)
  – K-OSAP, auction model, cost reflective tariff to owner and operator, uniform tariff to consumer, cross subsidy
• Community based model (11)
  – few examples under the radar without concessions

Policy framework

• Government agreement on universal access by 2020
• Energy Act, 2015 to be approved
• Regulations on private concession model to be finalised
• Rural electrification strategy to be finalised (Jan. 2017)
• K-OSAP sites to be tendered to private companies
## Existing and planned minigrids

<table>
<thead>
<tr>
<th>Size (kW)</th>
<th>Public model</th>
<th>Private</th>
<th>PPP</th>
<th>Community</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>KPLC</td>
<td>REA</td>
<td>K-OSAP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;50</td>
<td>34</td>
<td>124</td>
<td>10</td>
<td>168</td>
<td></td>
</tr>
<tr>
<td>50-100</td>
<td>5</td>
<td>0</td>
<td>1</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>100-150</td>
<td>1</td>
<td>25</td>
<td>0</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>&gt;150</td>
<td>26</td>
<td>1</td>
<td>3</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>27</td>
<td>26</td>
<td>42</td>
<td>124</td>
<td>11</td>
</tr>
</tbody>
</table>

450 trading centres under the radar

155 sites < 150 kW
184 sites with UTM coordinates
### Number of sites per windspeed category

<table>
<thead>
<tr>
<th>Wind speed (m/s)</th>
<th>K-OSAP</th>
<th>REA</th>
<th>All other</th>
<th>All sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.0 - 4.5</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>20</td>
</tr>
<tr>
<td>4.5 - 5.0</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>5.0 - 5.5</td>
<td>8</td>
<td>2</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td>5.5 - 6.0</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>6.0 - 6.5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>6.5 - 7.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>7.0 - 7.5</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>7.5 - 8.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>8.0 - 8.5</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>8.5 - 9.0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>&gt;9.0</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>27</td>
<td>8</td>
<td>18</td>
<td>53</td>
</tr>
<tr>
<td><strong>&gt; 4 m/s</strong></td>
<td>32 %</td>
<td>32 %</td>
<td>44 %</td>
<td>34 %</td>
</tr>
</tbody>
</table>
Position of all sites (155) below 150 kW
Status Tanzania

Business models

- Public model (24)
  - TANESCO own and operate, uniform tariff
- Private concession model (37)
  - Privately owned, cost reflective tariffs, negotiations on donor funding and/or cross subsidies
- Missions (28)
  - Privately owned but charity based with lower (subsidized) tariffs. Established years back, mostly hydropower,
- Community based model (18)
  - No need for concessions, including a number of multifunctional platforms

Policy framework

- Three generations of policy frameworks, 2008, 2015, 2017
  - More clarity on procedures when grid meets the mini-grid
  - Simplified licensing
  - No licence and tariff approval requirements for mini-grids below 100 kW
  - Output based subsidies, 180 USD/connection
- National Rural Electrification Program (NREP), 2014
- Rural Energy Master Plan (REMP) to be finalised September 2018
# Potential mini-grids in Tanzania

<table>
<thead>
<tr>
<th>Category</th>
<th>Total</th>
<th>Population Millions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural settlements</td>
<td>12,248</td>
<td></td>
</tr>
<tr>
<td>Non electrified settlements by 2022</td>
<td>3,400</td>
<td>10.5</td>
</tr>
<tr>
<td>Included in 10 km buffer zone from grid in 2022</td>
<td>1,950</td>
<td>5.5</td>
</tr>
<tr>
<td>Deep rural areas</td>
<td>1,450</td>
<td>5.1</td>
</tr>
<tr>
<td>Deep rural &gt; 2000</td>
<td>416</td>
<td>1.4</td>
</tr>
</tbody>
</table>

154 mini-grids planned before 2020
Wind speeds for existing grids below 150 KW (60)

<table>
<thead>
<tr>
<th>Wind speed (m/s)</th>
<th>Community</th>
<th>Mission</th>
<th>Private</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.0-4.5</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>4.5-5.0</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>5.0-5.5</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>5.5-6.0</td>
<td>1</td>
<td>3</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>6.0-6.5</td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
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<tr>
<td>6.5-7.0</td>
<td>2</td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8</strong></td>
<td><strong>9</strong></td>
<td><strong>6</strong></td>
<td><strong>23</strong></td>
</tr>
</tbody>
</table>

38 % have windspeeds above 4 m/sec.
Wind speeds for existing grids below 150 KW (60)
Overview of mini-grid sites

Kenya
- About 200 existing and planned sites below 150 kW
- 450 trading centres below the radar
- 34% wind speed above 4 m/s

Tanzania
- About 60 existing sites below 150 kW
- 154 planned sites
- 3400 settlements without electricity in 2022
- 1450 in 'deep rural areas'
- 38% above 4 m/s
Next steps

- Feasibility studies for integration of wind in 5 existing mini-grids in Kenya
  - diurnal and seasonal variation in wind speed
  - practical tool assessing value of wind-integration
  - options for productive use
- Demonstration of integration of 6 kW turbine in PV mini-grid in Kenya
- Development of new design for low cost, easy to maintain and partly locally produced wind turbine in Kenya
- Facilitating increased productive use of electricity in the communities
- Providing input to the regulatory framework for mini-grids and wind turbine integration in Kenya

http://www.unepdtu.org/newsbase/nyhed?id=32280351-0516-471F-9CFB-C221B796E1A8