Projetos ligados à rede: Estudos de caso na CEDEAO

Grid-connected projects: case studies in the ECOWAS region

Eder Semedo
ECREEE
Status of Utility Scale RE Capacity in the region

Total installed grid-connected RE capacity stands at **5,779.05 MW** (incl. medium and large hydro)

- 5,505.88 MW Hydro
  - (221.44 MW small hydro)
- 228.52 MW Solar PV
- 27.05 MW Wind
- 16.04 MW Biomass

- **493.05 MW** total RE capacity excl. medium and large hydro
Status of Utility Scale RE Capacity in the region

Total Installed RE Capacity per Country

- Benin
- Burkina Faso
- Cabo Verde
- Côte d'Ivoire
- The Gambia
- Ghana
- Guinea
- Guinea Bissau
- Liberia
- Mali
- Niger
- Nigeria
- Senegal
- Sierra Leone
- Togo

Installed Capacity (MW)

- Large Hydro
- Medium Hydro
- Small Hydro
- Biomass
- Wind
- Solar PV
Status of Utility Scale RE Capacity in the region

Total Installed RE Capacity per Country (excl. medium and large hydro)

ECOWAS Member States

- Small Hydro
- Biomass
- Wind
- Solar PV
ECREEE activities on Grid-connected RE

• Support the development of grid-connected RE projects with the potential of becoming important projects through technical assistance (TA)

• *Document and disseminate the experiences with grid-connected RE flagship projects in West Africa*

• Supporting the creation of an enabling environment for public and private investments in RE

Case studies documented by ECREEE

- Cabeólica wind project in Cabo Verde
- Electric Wind project in Cabo Verde
- Santiago and Sal solar PV plants in Cabo Verde
- Navrongo Solar PV project in Ghana
- Solar PV IPP projects in Senegal

http://www.ecreee.org/page/grid-connected-renewable-energy-flagship-projects
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Grid integration of the ELECTRIC WIND project in Cabo Verde

- **Key facts**

<table>
<thead>
<tr>
<th>Site</th>
<th>Aguada de Janela, Paúl, Santo Antão island</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology</td>
<td>Wind generators (refurbished)</td>
</tr>
<tr>
<td>Capacity</td>
<td>0.5 MW (2x 250 kW)</td>
</tr>
<tr>
<td>Developer</td>
<td>Electric Wind, S.A.</td>
</tr>
<tr>
<td>Operator</td>
<td>Electric Wind, S.A.</td>
</tr>
<tr>
<td>Commissioning</td>
<td>April 2011</td>
</tr>
<tr>
<td>Investment cost</td>
<td>900,000 EUR</td>
</tr>
<tr>
<td>Financing</td>
<td>Equity, shareholder loans, grant</td>
</tr>
</tbody>
</table>
Grid integration of the ELECTRIC WIND project in Cabo Verde

- **Key facts**

<table>
<thead>
<tr>
<th>Timeline</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007 - December</td>
<td>Signature of grant agreement with the Dutch government</td>
</tr>
<tr>
<td>2008 - July</td>
<td>Formation and registration of joint venture</td>
</tr>
<tr>
<td>2008 - November</td>
<td>Certification of foreign investor status, power production license and signature of PPA</td>
</tr>
<tr>
<td>2010 - March</td>
<td>Bankruptcy of Main Wind BV</td>
</tr>
<tr>
<td>2010 - November</td>
<td>Replacement of Main Wind BV by Green Energy Services</td>
</tr>
<tr>
<td>2011 - April</td>
<td>Commissioning</td>
</tr>
</tbody>
</table>
Grid integration of the ELECTRIC WIND project in Cabo Verde

• Cabo Verdean developer Electric, SA targeting smaller islands with lower peak loads.
  • Santo Antão: approx. 40,000 inhabitants (12,000 clients); 9.8 MW installed capacity (thermal); 3 MW peak load; 1.5 MW base load

• Co-financed in the framework of a program from the Dutch government (PSOM/PSI)

• New company Electric Wind, SA created with a Dutch shareholder

• IPP license; 20-year PPA with the utility

• Corporate tax exemption (first 5 years of operation)

• Wind turbines manufactured in 1993, operated for 14 years in the Netherlands, reinstalled in Cabo Verde.
Grid integration of the ELECTRIC WIND project in Cabo Verde

Operational availability: 2012-2016
Grid integration of the ELECTRIC WIND project in Cabo Verde

Operational availability: 2012-2016
Grid integration of the ELECTRIC WIND project in Cabo Verde

Production & Capacity Factor

MWh

- Prod.
- CF

- 2011: Prod. = 862 MWh, CF = 26%
- 2012: Prod. = 1381 MWh, CF = 32%
- 2013: Prod. = 1527 MWh, CF = 35%
- 2014: Prod. = 1842 MWh, CF = 42%
- 2015: Prod. = 1687 MWh, CF = 39%
- 2016: Prod. = 1446 MWh, CF = 33%
Grid integration of the ELECTRIC WIND project in Cabo Verde

Yearly average wind penetration in the electrical system
Grid integration of the ELECTRIC WIND project in Cabo Verde

Grid Integration Challenges

• Significant reduction of errors from 2012 to 2016: improved technical performance

• No capability to control the active power production; sudden wind variations dramatically shifts production values

• Connected with a small grid whose control and regulation systems of frequency was not efficient enough
Grid integration of the ELECTRIC WIND project in Cabo Verde

Financial Viability - Tariffs

<table>
<thead>
<tr>
<th>Year</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average fuel cost on the island of Santo Antão (c€/kWh)</td>
<td>0.29</td>
<td>0.24</td>
<td>0.25</td>
<td>0.18</td>
<td>0.14</td>
</tr>
<tr>
<td>Wind power tariff (c€/kWh)</td>
<td>0.15</td>
<td>0.13</td>
<td>0.13</td>
<td>0.13</td>
<td>0.13</td>
</tr>
</tbody>
</table>
## Grid integration of the ELECTRIC WIND project in Cabo Verde

### Financial Viability – Fuel Savings

<table>
<thead>
<tr>
<th>Year</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production (kWh)</td>
<td>861,759</td>
<td>1,381,310</td>
<td>1,527,097</td>
<td>1,841,690</td>
<td>1,687,104</td>
<td>1,445,758</td>
<td>8,744,718</td>
</tr>
<tr>
<td>Fuel savings (liter)</td>
<td>237,049</td>
<td>389,223</td>
<td>434,277</td>
<td>560,857</td>
<td>477,867</td>
<td>384,006</td>
<td>2,483,279</td>
</tr>
<tr>
<td>Foreign currency savings (€)</td>
<td>203,827</td>
<td>326,714</td>
<td>286,426</td>
<td>345,663</td>
<td>213,117</td>
<td>127,873</td>
<td>1,503,621</td>
</tr>
<tr>
<td>Avoided greenhouse gas emissions (ton CO₂ eq.)</td>
<td>612</td>
<td>981</td>
<td>1,084</td>
<td>1,308</td>
<td>1,198</td>
<td>1,026</td>
<td>6,209</td>
</tr>
</tbody>
</table>
Case studies documented by ECREEE

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- *Electric Wind project in Cabo Verde*
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First 3 Solar PV IPP in Senegal

• Situation in Senegal:
  • Reforms in the energy sector since 2010
  • Promotion of Renewable Energy

• Setting objectives
  • Increasing the installed renewable energy capacity to 20% of the total installed capacity by 2017
  • Reducing the cost of generation and the electricity tariff for households and companies
  • Increasing the share of renewables in the energy mix in order to improve the energy independence of the country

• In a short period of time Senegal reached 124 MW of installed Solar PV at a competitive starting price of 0.10 EUR/kWh... How?
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First 3 Solar PV IPP in Senegal

Program Milestones

• 2011: over 100 spontaneous applications for renewable energy IPPs (mainly solar) had been received by the Ministry of Energy – transition period

• June 2012: Selection committee is established. 72 IPPs are shortlisted based on a first appraisal.

• 31st December 2013: Deadline to submit bids with a fixed PPA price of FCFA 65 / EUR 0.10 per kWh.

• January 2014: Senelec invited ten IPPs to negotiate PPAs (nine solar, one wind)

• August 2015: Creation of Renewable Energy Department at Senelec serving as one-stop-shop for developers (acceleration of process)

• February 2016: Bokhol is the first project to sign PPA

• October 2016: First phase of Malicounda plant commissioned shortly followed by Bokhol plant

• June 2017: Santhiou Mékhé plant commissioned
First 3 Solar PV IPP in Senegal

• Selection committee:
  • Ministry of Energy
  • Senelec
  • ANER
  • ASER
  • National Energy Efficiency Agency
  • CRSE

• Bidding process:
  » Price (1.75% annual indexation)
  » Technical
  » Financial
  » Planning
  » 25 years PPA (take or pay)

• ESIA

• National grid integration study done by Senelec after selection of 10 projects
# First 3 Solar PV IPP in Senegal

<table>
<thead>
<tr>
<th>Key facts</th>
<th>Bokhol</th>
<th>Malicounda</th>
<th>Santhiou Mékhé</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site</td>
<td>20 MWp</td>
<td>22 MWp</td>
<td>30 MWp</td>
</tr>
<tr>
<td>Installed capacity</td>
<td>20 MWp</td>
<td>22 MWp</td>
<td>30 MWp</td>
</tr>
<tr>
<td>Developer</td>
<td>Senergy 2</td>
<td>Solaria Kima</td>
<td>Senergy PV</td>
</tr>
<tr>
<td>EPC Contractor</td>
<td>Omexom (Vinci)</td>
<td>Techno Solaire</td>
<td>Solairedirect (Engie)</td>
</tr>
<tr>
<td>Inauguration</td>
<td>Oct. 2016</td>
<td>Nov. 2016</td>
<td>June 2017</td>
</tr>
<tr>
<td>Investment cost</td>
<td>FCFA 15.7 billion / EUR 23.93 million</td>
<td>FCFA 22 billion / EUR 33.53 million</td>
<td>FCFA 27 billion / EUR 41.15 million</td>
</tr>
<tr>
<td>Financing</td>
<td>75% debt from single European lender</td>
<td>Full equity</td>
<td>75% debt from single European lender</td>
</tr>
</tbody>
</table>
First 3 Solar PV IPP in Senegal

- Bokhol

- CDC
  - 33%

- Private French investors
  - 67%

- GreenWish Africa REN Holding Ltd
  - 82%

- Private Senegalese investors
  - 18%

- GreenWish Africa REN CFA
  - 45% - 55%

- Equity - 25%

- SPV Senergy II

- Debt - 75%

- Green Africa Power (GAP)
First 3 Solar PV IPP in Senegal

- Malicounda

CNG

Chemtech Group

CNGEE Senegal Holding SAS

Chemtech Solar

Malicounda Municipality

Groupe Solaria (originally Solaria Kima Afrique et Associés)

90%

5%

5%
First 3 Solar PV IPP in Senegal

- Santhiou Mékhé

<table>
<thead>
<tr>
<th>Shareholder</th>
<th>Ownership</th>
</tr>
</thead>
<tbody>
<tr>
<td>SENERGY SUARL</td>
<td>15%</td>
</tr>
<tr>
<td>FONSIS</td>
<td>32%</td>
</tr>
<tr>
<td>MERIDIAM + international</td>
<td>53%</td>
</tr>
<tr>
<td>AFD + international</td>
<td>64%</td>
</tr>
<tr>
<td>Other shareholders + international</td>
<td>36%</td>
</tr>
</tbody>
</table>

Equity - 25%

Senergy PV SA

Debt - 75%

Proparco 100%
First 3 Solar PV IPP in Senegal

- Community relations and Socio-economic benefits

<table>
<thead>
<tr>
<th></th>
<th>Bokhol</th>
<th>Malicounda</th>
<th>Santhiou Mékhé</th>
</tr>
</thead>
<tbody>
<tr>
<td>Announced job creation during construction</td>
<td>150</td>
<td>105 in total 59 skilled</td>
<td>350</td>
</tr>
<tr>
<td>Free equity given to the community</td>
<td>2%</td>
<td>5%</td>
<td>4%</td>
</tr>
<tr>
<td>Other community benefits</td>
<td>- Installation of small PV systems, micro grids and street lights - 1 flour mill - 20 ha agricultural project - 1 maternity - Electrification of 22 villages - LV + MV electrical training</td>
<td>- 10 ha agricultural project - 1 maternity - Micro-credit lines for women and youngsters - 1 borehole</td>
<td></td>
</tr>
</tbody>
</table>
First 3 Solar PV IPP in Senegal

Conclusions

- Senegal leading West Africa in non-hydro RE
- Importance of sovereign guarantees provided by the Senegalese government
- Agreed kWh price is similar to variable cost of generation and provides long-term tariff stability
- Two of the plants with significant Senegalese capital
Obrigado
Thank you
Merci

esemedo@ecreee.org