Wind Projects: Optimizing Site Selection

ECOWAS Regional Workshop on Wind Energy

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Basic Criteria for Wind Project Site Selection and Optimization

- Wind Resources
- Site Access
- Site Terrain
- Environmental Impact
- Grid Interconnection
Wind Resource is most important criteria

- Wind resources are classified based on annual mean wind speed

<table>
<thead>
<tr>
<th>Wind Power Class</th>
<th>Wind Speed m/s</th>
<th>Wind Power Density W/m²</th>
<th>Resource Potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&lt;4</td>
<td>0-100</td>
<td>Poor</td>
</tr>
<tr>
<td>2</td>
<td>4.0 - 6.4</td>
<td>100-300</td>
<td>poor</td>
</tr>
<tr>
<td>3</td>
<td>6.4 - 7.0</td>
<td>300-400</td>
<td>Fair</td>
</tr>
<tr>
<td>4</td>
<td>7.0 - 7.5</td>
<td>400-500</td>
<td>Good</td>
</tr>
<tr>
<td>5</td>
<td>7.5 - 8.0</td>
<td>500-600</td>
<td>Excellent</td>
</tr>
<tr>
<td>6</td>
<td>8.0 - 9.8</td>
<td>600 - 800</td>
<td>Outstanding</td>
</tr>
<tr>
<td>7</td>
<td>8.8 - 11.1</td>
<td>800-1000</td>
<td>Superb</td>
</tr>
</tbody>
</table>
ECOWAS Wind Resources

ECOWAS Region – Wind
Annual Wind Speed

Wind Speed – (m/s)
Annual Average

- 1.68 - 3.99
- 3.69 - 4.15
- 4.15 - 4.66
- 4.66 - 5.25
- 5.25 - 6.06
- 6.00 - 6.35
- Transmission Lines

AIP Wind & Solar Resource Assessment Task – Contract # EPP-04-03-00007-00
Wind Turbine Output Curves vs. Wind Speed

Vestas V90-1.8MW, Rotor 90m; Suzlon S82 – 1.5 MW, Rotor 82m; Jacobs 20 kW, Rotor 9.4m
Site Access Considerations

- Site access will determine size of turbine that can be deployed
  - Wind Turbine blades are from 5 m to 80 m in length
  - Wind Turbine Rotors, Nacelle, etc. can weigh 5 tons to 100 tons
- Current land based wind turbines are 5 kW to 2 MW
  Offshore wind turbines are >2.5 MW
Wind Turbine Transportation Logistics
83 m Rotor blade transported to Scotland
Site Terrain Considerations

- Special consideration to terrain surrounding the site that features:
  - Significant variations in topography and terrain obstacles that may cause flow distortion
  - Complex terrain will have wakes or flow separation, flow channeling, flow accelerations over the crest of terrain, augmentation of turbulent intensity, distortion of vertical wind profiles, etc.
  - Nonlinear phenomena caused by terrain may result in errors in predicting Annual Energy Production (AEP) and errors in selecting the wind class of the turbine
Site Terrain Considerations (contd.)

- It is difficult to accurately predict the performance of wind farms in complex terrain.
- Many wind farms constructed in complex terrain reached only 60% of expected electricity production.
- Conventional models developed for simple terrain will predict over production.
- No standard for wind resource assessment and energy production estimation in complex terrain.
- Risk is on wind farm developers for wind resource assessment and wind farm design in complex terrain.
Example Wind Resource Map on Varying Terrain

The colors denote the energy content of the wind.
- Red high energy
- Blue low energy
Optimized Site Layout for a Wind Farm

- Road
- Field track
- Site border
- Commercial area
- Residential area
- Wind energy converter
- Access track
- Internal power line
- Transformer and switches
- 20 kV power line

Prevailing Wind

0 600m
Examples of Wind Farm Site Layouts

Single String Layout

Multiple String Layout
Examples of Wind Farm Site Layouts (contd.)

Multiple String Layout

Cluster Configuration
Environmental Impact

- Typical Land Area Requirement for Wind Farm
  - The overall average direct or permanent impact area is $0.3 \pm 0.3$ Ha/MW
  - Temporary or indirect surface area disruption is $0.7 \pm 0.6$ Ha/MW
  - Total surface area disruption is about $1.0 \pm 0.7$ Ha/MW.

- A 10 MW Wind Farm will impact 10 – 17 Ha
Transmission Grid Connection Considerations

- Following is rule of thumb guidelines
  - <10 MW Wind projects can be connected to 33 kV or 66 kV distribution lines
  - >10 MW Wind projects require 120 kV or larger transmission system
- Due to variable nature of wind power, detailed grid impact study will be required
- Cost of construction HV transmission line can be significant
- Transmission line also requires right of way considerations
Wind Project SWOT ANALYSIS

- Strength, weakness, Opportunity, and Threat (SWOT) analysis
- Score assigned to each category
- Weighting factor assigned to each category
- Weighted average score is used to rank sites
Wind Resource Estimation

- For Feasibility Study
  - From NASA, DLR, NREL and other weather services mostly free
  - From Commercial data provider – 3Tier, Garrad Hassan, etc. for a fee

- For Commercial Development and Loan Guarantees
  - Field Measurements for
    - 50 m or 80 m tower with wind measurements at minimum 2 or 3 elevations
    - At least one year of data
    - Data recorded over minimum 10 min averages
Site Terrain

- For Feasibility Study:
  - From Google Earth
  - ESRI – Arc GIS Mapping

- For Engineering Design and Project Permitting:
  - Physical Site Survey
Site Access

- From Google Earth
- Local Maps with Infrastructure Overlay
- Sea Port Information for Imported Turbine Parts
- Bridge and Overpass/Underpass Information
- Highway and Local Roads Weight Limit
- Road Width Information
Transmission and Distribution

- Local Utility Transmission Maps
- Local distribution maps
- Line capacity
- Nodal analysis of existing generating units (type and size)
Environmental Impact

- Land area requirements
- Local wild life consideration
- Local and migratory bird species
- Site runoff
- Impact of site grading on terrain and runoffs
- Noise level at site boundary, nearest habited location
- EMF signal interference
- Visual impact
Thank You
Questions and Comments?

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