USAID
FROM THE AMERICAN PEOPLE

Wind Projects: Optimizing Site Selection

ECOWAS Regional Workshop on Wind Energy

Babul Patel, Principal
Alain Rosier, Vice President
Nexant, Inc.

Praia, Cape Verde
November 4-5, 2013

Basic Criteria for Wind Project Site Selection and Optimization

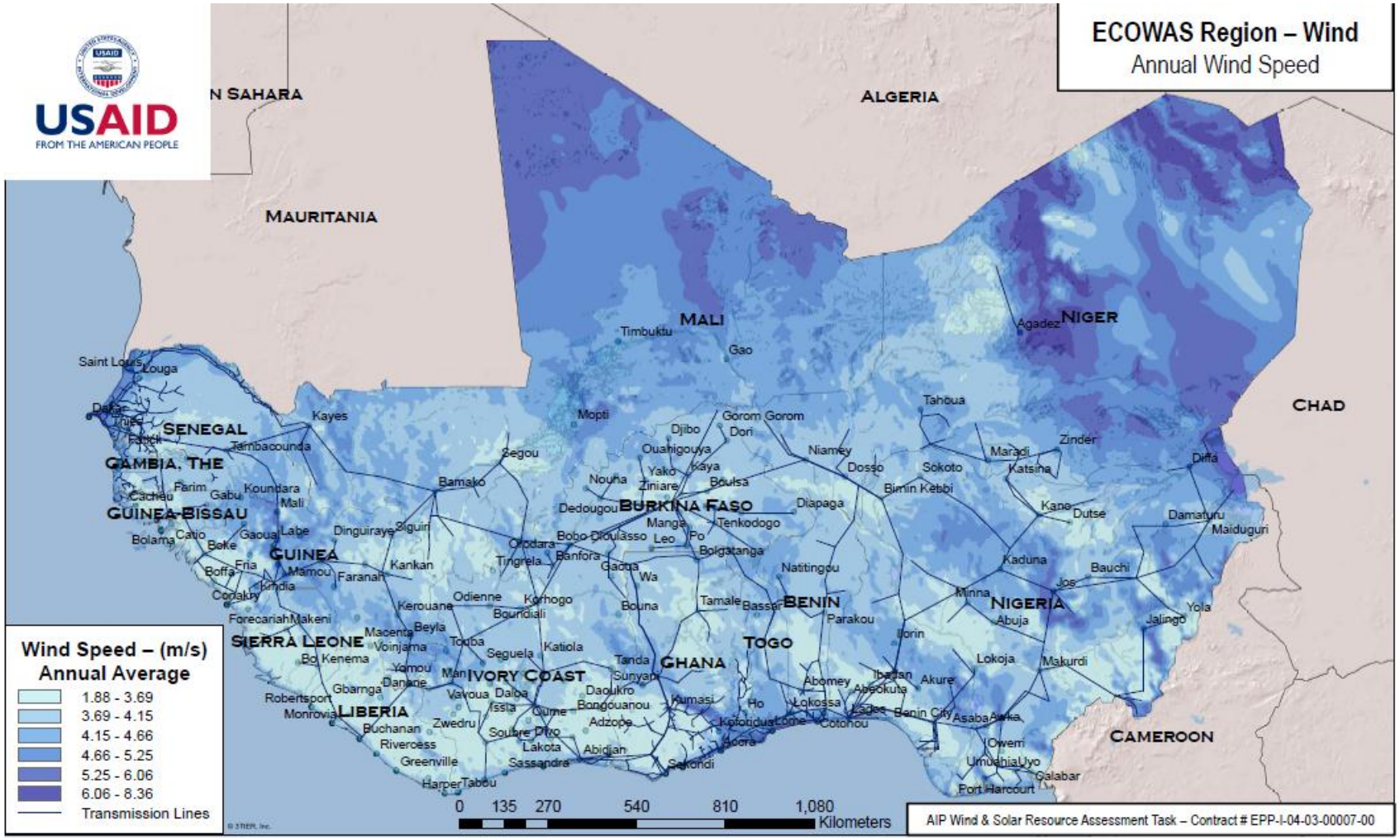
- Wind Resources
- Site Access
- Site Terrain
- Environmental Impact
- Grid Interconnection

Wind Resource is most important criteria

- Wind resources are classified based on annual mean wind speed

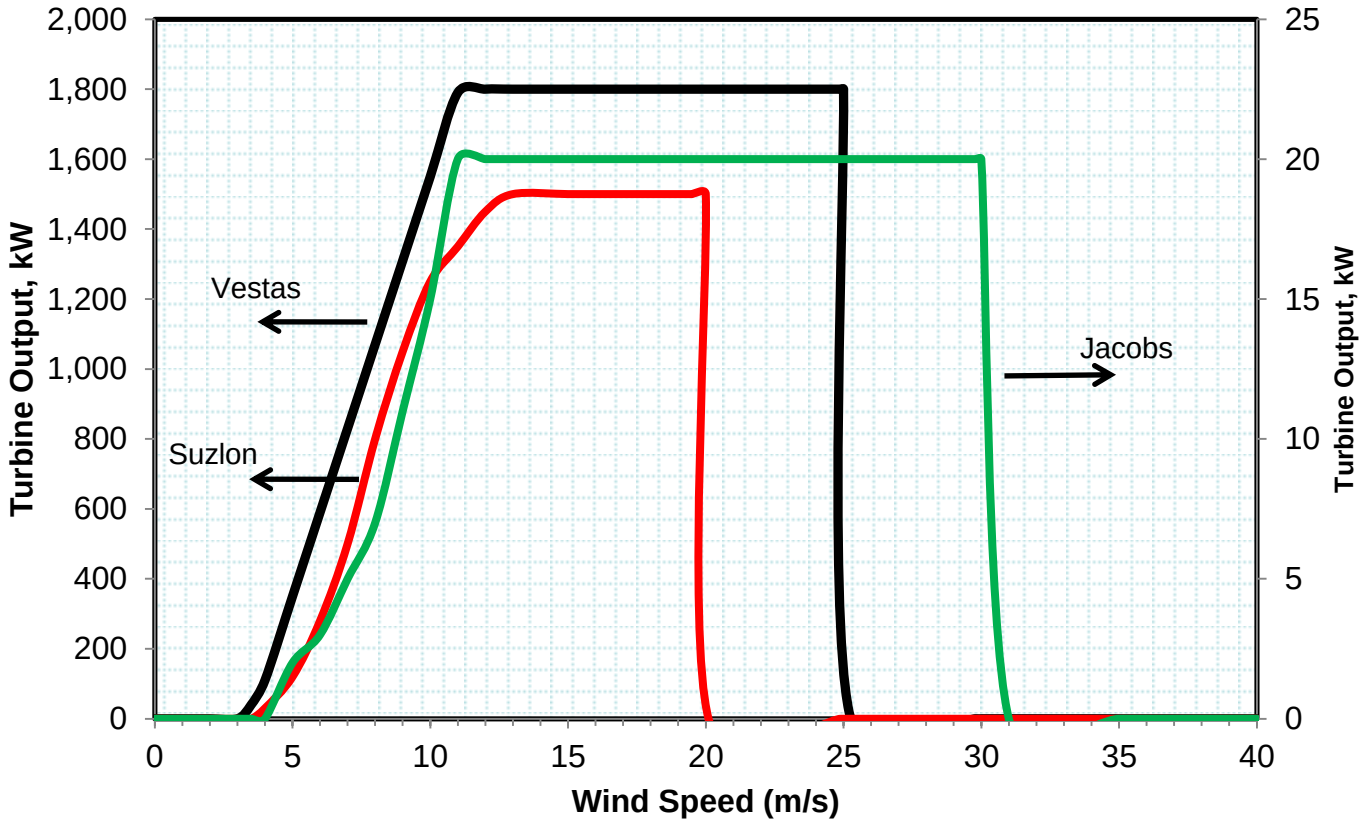
Wind Power Class		Wind Speed m/s	Wind Power Density W/m2	Resource Potential
	1	<4	0-100	Poor
	2	4. -6.4	100-300	poor
	3	6.4 - 7.0	300-400	Fair
	4	7.0-7.5	400-500	Good
	5	7.5 - 8.0	500-600	Excellent
	6	8.0 -9.8	600 - 800	Outstandig
	7	8.8 - 11.1	800-1000	Superb

ECOWAS Wind Resources



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



USAID
FROM THE AMERICAN PEOPLE

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

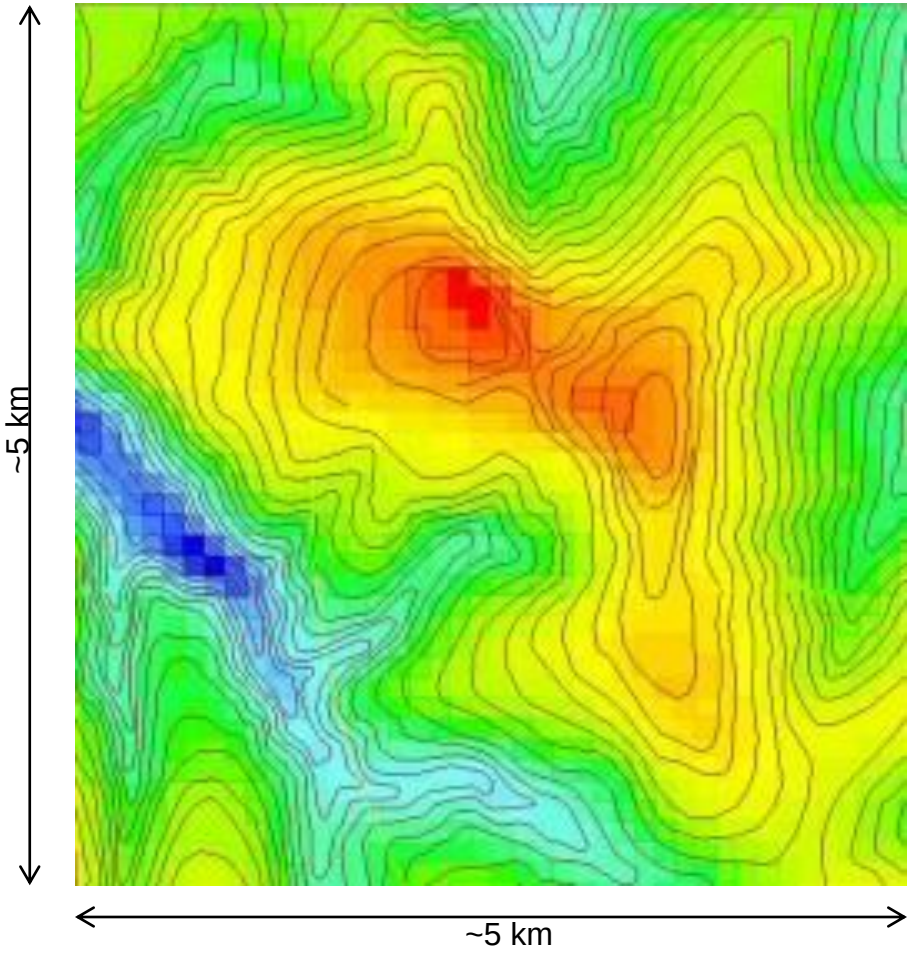
- **Special consideration to terrain surrounding the site that features:**
  - Significant variations in topography and terrain obstacles that may cause flow distortion
  - Complex terrain will have wakes or flow separation, flow channeling, flow accelerations over the crest of terrain, augmentation 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.

USAID
FROM THE AMERICAN PEOPLE

Example Wind Resource Map on Varying Terrain

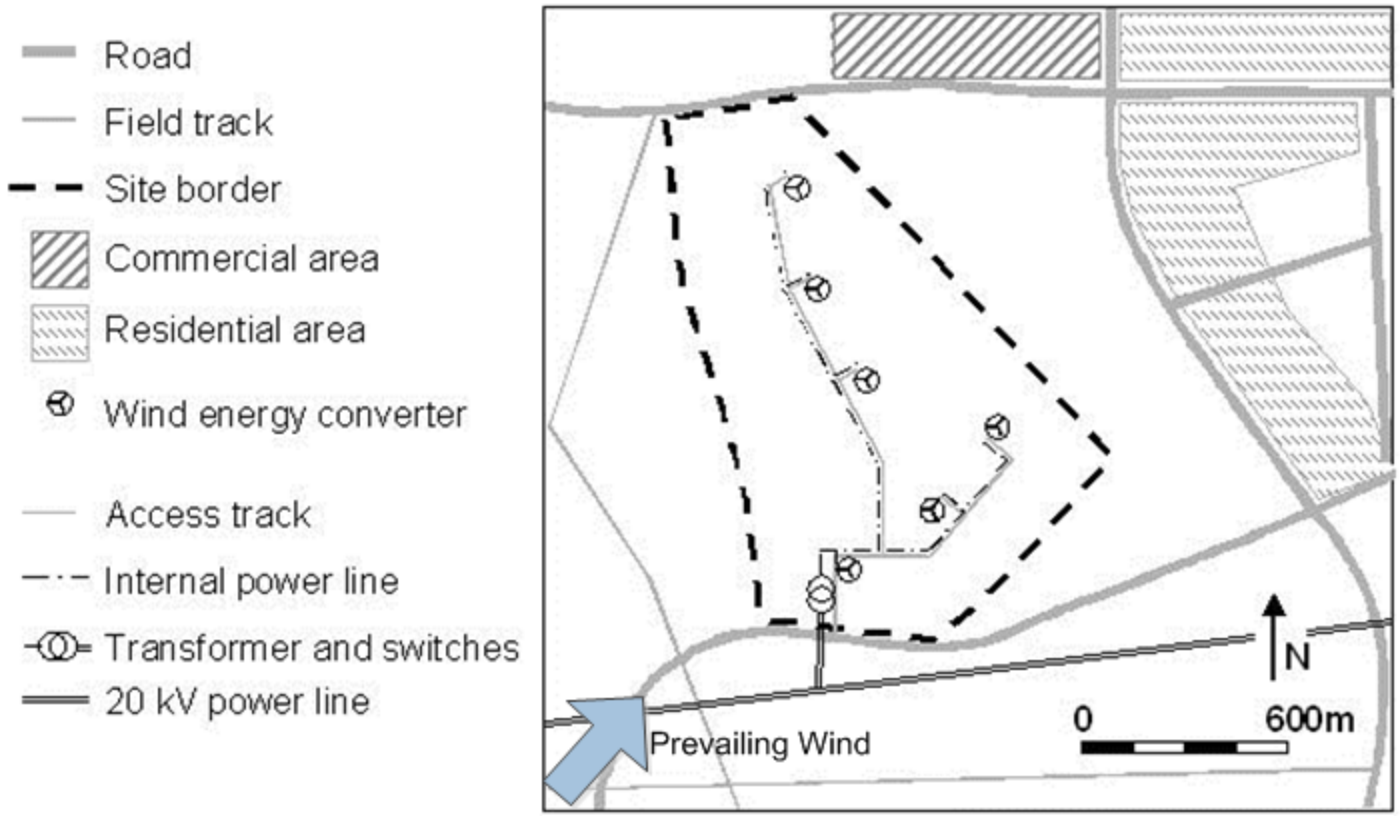


The colors denote the energy content of the wind.

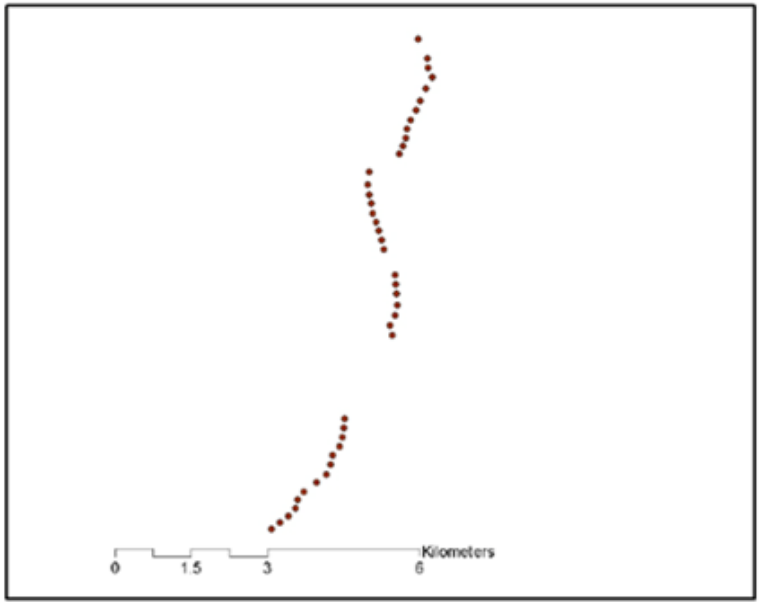
- Red high energy
- Blue low energy

USAID
FROM THE AMERICAN PEOPLE

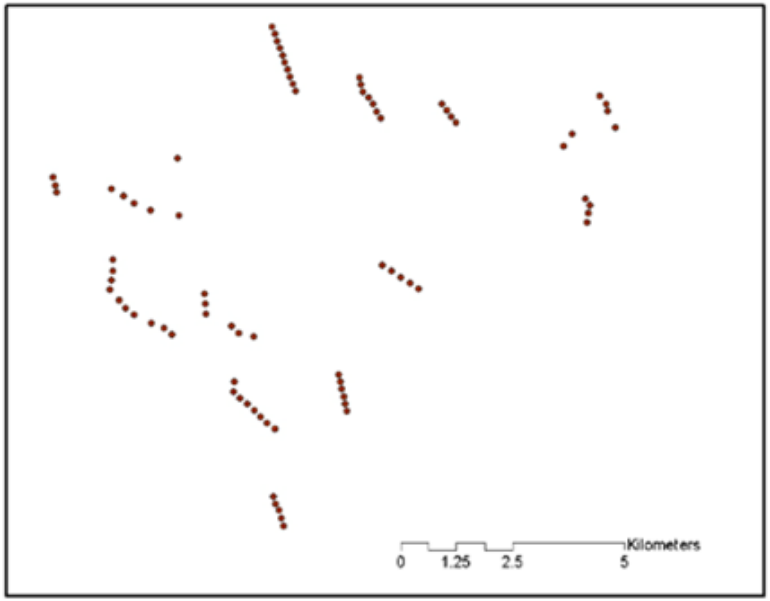
Optimized Site Layout for a Wind Farm



Examples of Wind Farm Site Layouts



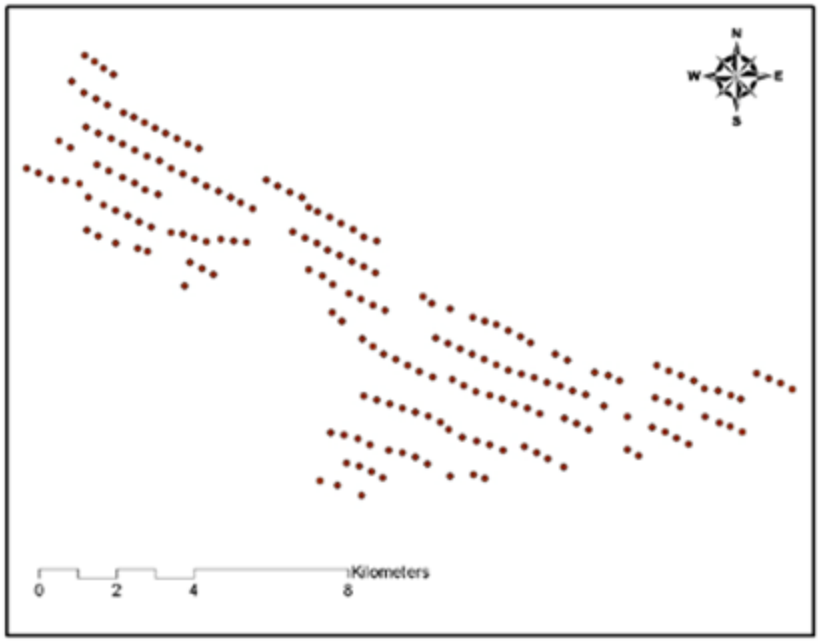
Single String Layout



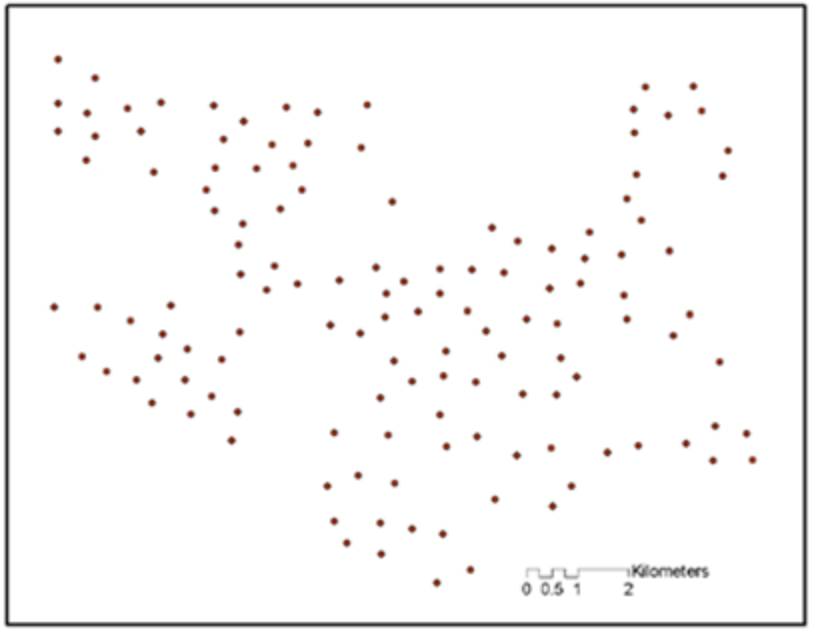
Multiple String Layout

USAID
FROM THE AMERICAN PEOPLE

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 ± 0.3 Ha/MW
  - Temporary or indirect surface area disruption is 0.7 ± 0.6 Ha/MW
  - Total surface area disruption is about 1.0 ± 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

USAID
FROM THE AMERICAN PEOPLE

Thank You
Questions and Comments?

Contact Information:

Mr. Allan Rosier
Vice President
Nexant, Inc.
arosier@nexant.com

Dr. Babul Patel
Principal
Nexant, Inc.
bpatel@nexant.com

www.nexant.com