PRESENTATION BY SOREN KROHN

WIND POWER CONSULTANT

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TECHNICAL DUE DILIGENCE FOR WIND ENERGY PROJECTS




Perspective of Presentation

KEY VANTAGE POINTS:

- Point of view of financiers and equity investors

- Key technical/procurement/liability pitfalls
- Risk and risk mitigation measures
- What happens if one or more risk-prone events occur?

- About Independent Power Producer projects (IPP/BOO)…

Technical Due Diligence for Wind Energy Projects

STEPS IN THE PROCESS FOR A TYPICAL PROJECT

- Examine project development model and the sponsors in the particular national context
- Understand contract structure
- Lenders' independent engineer report (basic document)
- Site conditions
- Infrastructure, geotechnical issues, electrical grid
- EPC contract
- Turbine supply agreement
- Operation and maintenance agreement
- Wind turbine technology review
- Expected project performance

Project Development Model in National Context

SOME OVERLAP WITH OTHER ELEMENTS OF DUE DILIGENCE

- Understand business model & motivation of sponsors
- Who does what?
  Active leadership, passive participation, economic stake, time horizon for participation, suppliers, conflicts of interest, competitive procurement?
- Track record in planning, construction and operation
- Local knowledge and experience
- Active staff characteristics, advisors, consultants
- Division of labor internally and with grid operator
- Track record of grid operator and financial issues

Understanding the Project Contract Structure

APPLIES TO TYPICAL PROJECT, THERE MAY BE VARIATIONS…

- Turbine Supply Agreement
- Turnkey EPC Contract
- Comprehensive Operation & Maintenance Contract
- (Umbrella Agreement)
- Subcontracting issues
- Land Lease Agreements etc.

- Concession Agreement, Licenses
- Power Purchasing Agreement (PPA), (Implementation Agreement), Tripartite Agreement
- Interconnection Agreement

Lenders' Independent Engineer Technical Report

MOST IMPORTANT BASIC DOCUMENT FOR FINANCIERS' TECHNICAL DUE DILIGENCE

- Review of:
  Site
  Turbine
  Site Suitability
  Contracts for EPC, Turbine Supply and O&M
  PPA, Concession, Interconnection Contracts
  Operation and Maintenance Plans and Track Record
  Foundation Design
  Electrical System Design
  Remote Monitoring and Communications (SCADA)
  Project Costs
  Financial Model
  Project Schedule
  Permits and Licenses

Wind Farm Site Conditions

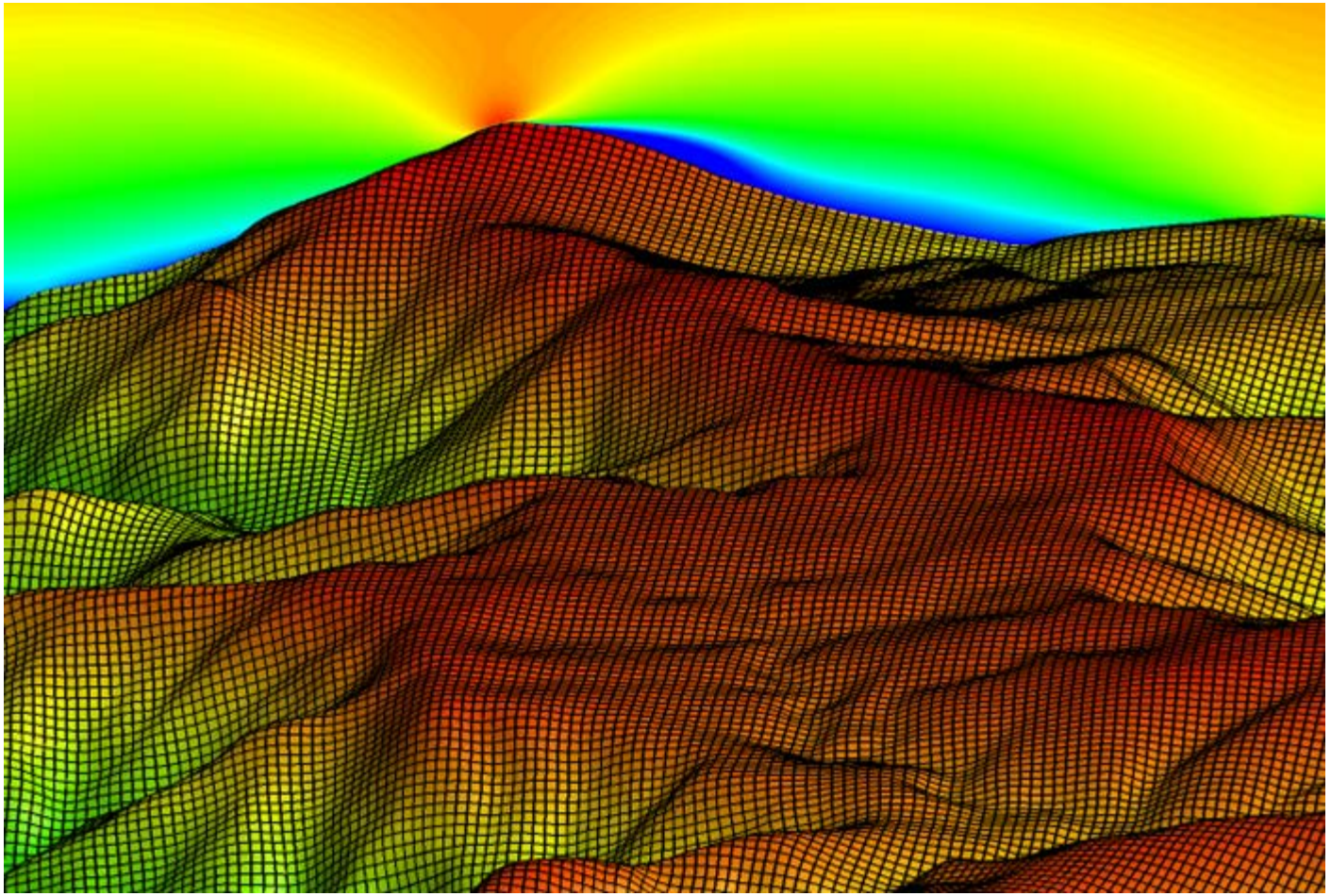
CLIMATE, ENVIRONMENT AND TOPOGRAPHY - IMPORTANT FOR ENERGY PRODUCTION

- Examine site maps and do a site (and area) inspection
- Topography and climate:
  Turbulence intensity, extreme wind speeds, wind inflow angles, wind shear, site complexity, atmospheric stability
- Turbine suitability, IEC turbine class I,II, III, A or B
- Present and future neighboring wind farms, forestry, construction, ESIA concerns: neighbors, land use
- Tropical hurricane or tornado risks
- Extreme temperatures
- Low air density (aerodynamics, electrical design)
- Icing, dust, sand, insects (aerodynamics)
- Corrosion risks

Wind Farm Site Conditions

CLIMATE, ENVIRONMENT AND TOPOGRAPHY - IMPORTANT FOR ENERGY PRODUCTION

- Wind resources in complex terrain (WA^{S}P CFD calculation)



Infrastructure, Geotechnical Issues, Electrical Grid

Necessary prerequisites to build a wind farm on the site

- Land acquisition, compensation
- Land registry issues, right of way, social issues
- Construction permitting, environmental permitting
- Geotechnical investigations for foundations and roads
- Earthquake risks, erosion issues
- Logistical studies (road curvature, bridges, wires, signs)
- Grid code compliance
- Interconnection studies, system stability studies (if any)
- Agreement and licenses for transmission line, interconnection agreement, right of way issues

EPC Contract

UNCOVERING THE RISKS IN THE CONTRACT

- Contract scope, pricing conditionality
- Completion definition and conditions for take over
- EPC pricing
- Risk of cost overruns
- Project time schedule
- Remedies, liquidated damages, damage caps, guarantees

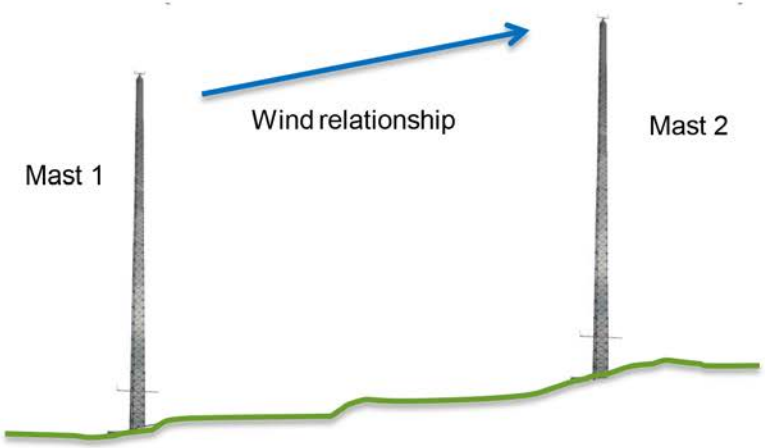
Turbine Supply Agreement

UNCOVERING THE RISKS IN THE CONTRACT

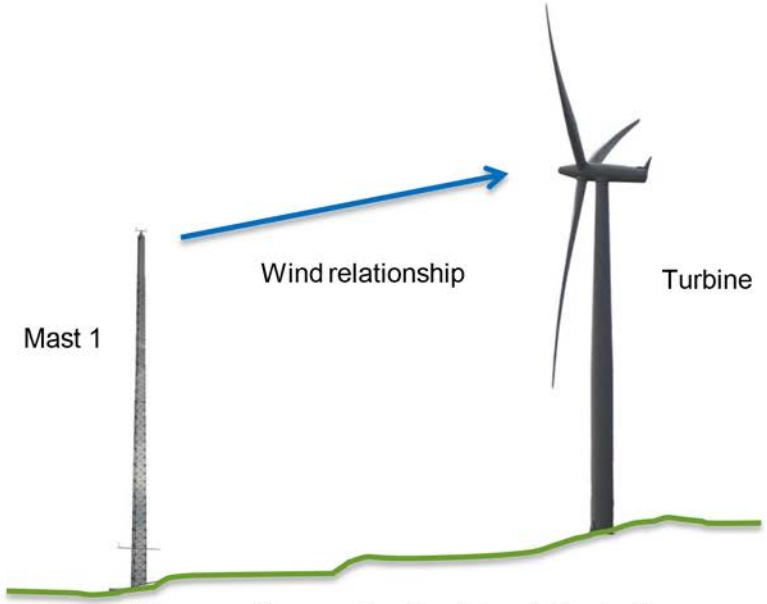
- Warranties (in line with market):
- Quality warranty (replace/repair)
- Power curve warranty (typically 100% - uncertainty)
- Sound level warranty (compensation mechanism)
- Certify suitability of site (for IEC turbine class)
- Pricing in line with market
- Site calibration for power curve warranty test in complex terrain [next slide]
- Remedies, liquidated damages, damage caps, guarantees

Site Calibration

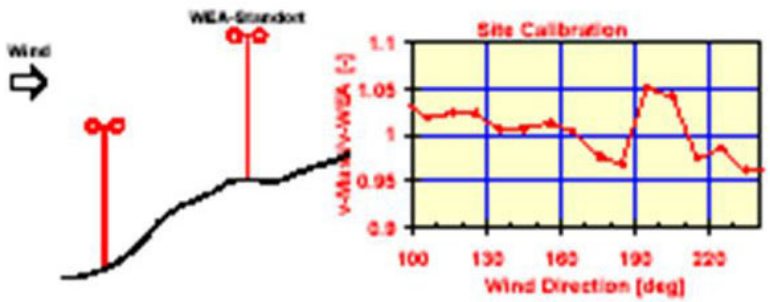
UNCOVERING THE RISKS

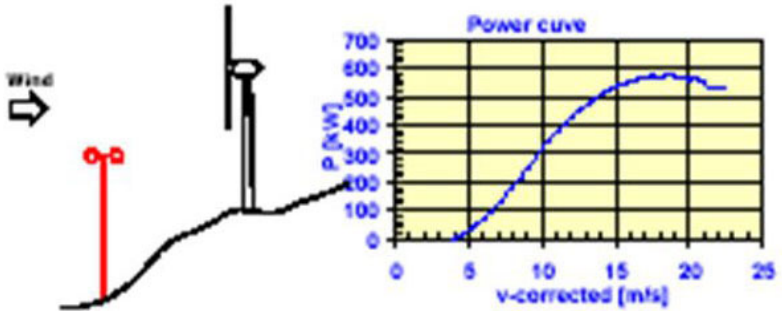


*Site Calibration – **Pre** Install*



*Power Curve test – **Post** Install*





Operation and Maintenance Agreement

UNCOVERING THE RISKS IN THE CONTRACT

- Contract term (e.g. 15 years post 2-5yr guarantee period)
- Inclusiveness of contract (e.g. spare parts), exclusions
- Manufacturer-executed O&M?
- Warranties in line with market:
  Availability warranty (typically 95% initially - 97% later)
- Spare part and crane availability on site or in the region
- Staff on site or nearby, response time
- Remote and on-site surveillance
- Pricing, all-inclusiveness in line with market
- Duration, price escalation clauses
- Remedies, liquidated damages, damage caps, guarantees

Wind Turbine Technology Review

PROVEN TECHNOLOGY SUITABLE FOR SITE – POSSIBLY NEED FOR EXTENDED WARRANTIES

- Turbine manufacturer background and track record
- Financial strength of turbine manufacturer
- Product program and track record
- Technical assessment of turbine
- IEC 61400-1 turbine certification status for class
- Turbine historical performance (or for variants thereof)
- Remedies, supplementary third party certification, extended warranties

Expected Project Performance

POOR WIND MEASUREMENTS OR POOR DOCUMENTATION ARE A COMMON PROBLEM

- Review of site measurement program:
  - Locations, no. and height of masts (given terrain complexity)
  - Instrument quality, mounting clearances, boom orientation
  - Data recovery rates, period of simultaneous measurement
  - Correlation with nearby long-term reference measurements
  - Quality of documentation and traceability for auditing

  Please, do require IEC 61400-12 standard compliance & first class MEASNET calibrated instruments on tall masts.
  - ESMAP has best practice requirements std. for bankability
- Energy modeling: WA^{S}P + CFD needed? – topo map quality
- Loss estimates including array effects, grid availability (+PPA)
- Uncertainty estimates
- Comparison with performance of similar projects
- Financing is on the basis of P_{90} or P_{95}, not P_{50} production

Financial Modeling of Risks

DEPENDS ON RISKS DETERMINED DURING THE REVIEW

- Examples:
  - Delays in commissioning
  - Series failure of turbine model
  - Failure of turbines exposed to steep wind inflow angles
  - Poor maintenance work
  - …

SOREN KROHN, WIND POWER CONSULTANT

SK@SKPOWER.NET

+1-202-468-2902

Thank You.

The World Bank | 1818 H Street, NW | Washington DC, USA
www.esmap.com | esmap@worldbank.org