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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$^5$P CFD calculation)
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: WASP + 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
  - ...
Thank You.

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