MANAGING RISK FOR PV PLANT CONSTRUCTION AND COMMISSIONING

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Presenters

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More than 10 years of experience in the
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a consultant working basically for the
Spanish and LATAM markets
100+ Country locations of UL renewable energy customers

55+ Years of combined experience in the renewable energy industry

Independent / Owner’s Engineer on 450+ wind & solar projects*

ADVISED 90% of the wind and solar industry’s top PROJECT DEVELOPERS and PLANT OWNERS

500+ UL Renewable Energy Experts

200,000+ MW Total renewable energy megawatts (MW) assessed

FORECAST PROVIDER for 72+ GW of installed renewable energy projects

*since 2012
International Presence

44 Countries with UL offices
159 UL sites (offices, labs)
500+ Renewable Energy Experts
UL DRIVES TRUST IN RENEWABLES
UL SERVICES FOR SOLAR

DEVELOPER / EPC / FINANCIER / INSURER

<table>
<thead>
<tr>
<th>6 - 18 months</th>
<th>4 - 24 months</th>
<th>&gt; 25 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLANNING, DESIGN &amp; ENGINEERING</td>
<td>CONSTRUCTION &amp; COMMISSION</td>
<td>OPERATIONS &amp; MAINTENANCE</td>
</tr>
</tbody>
</table>

UL SERVICE ENGAGEMENT

UL SERVICE ALIGNMENT

<table>
<thead>
<tr>
<th>DESIGN REVIEW</th>
<th>ONSITE VERIFICATION</th>
<th>PLANT CERTIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>TECHNICAL DUE DILIGENCE</td>
<td>YIELD ASSESSMENT/ANALYSIS</td>
<td>FAILURE ANALYSIS</td>
</tr>
<tr>
<td>BANKABILITY</td>
<td>PERIODIC INSPECTION/MEASUREMENT</td>
<td></td>
</tr>
</tbody>
</table>

KNOWLEDGE ACCESS THROUGH UL
1. Risk Categorization
2. Main Risks during construction
3. Importance of Commissioning
RISK EVALUATION

Risks are the potential consequences of the outcome of a decision being different from that expected by the decision maker.

In a Project, the possible consequences are established in three dimensions: **TIME**, **COST** and **QUALITY**.

Risk cannot be avoided and is present in all aspects of life and Projects.
RESPONSE TO RISKS

Once the risks have been identified, analyzed and classified, the following are all the possible responses that can be adopted:

✓ Delete it
✓ Reduce it as much as possible
✓ Live with it and observe
✓ Transfer it to someone else
✓ Negotiate it
✓ Ignore It
PV PROJECTS AND RISKS ASSOCIATED

POSSIBLE ISSUES DURING A PV PROJECT LIFECYCLE

FINANCING

DEVELOPMENT

CONSTRUCTION

OPERATION

EXPERIENCE / SOLVENCY
TECHNICAL / ECONOMIC
Manufacturer, Supplier,
Constructor, Operator, etc.

PLANNING
Permits, documents, administrative
and contractual procedures (land,
connection, authorizations, ...).

FEASIBILITY
Previous considerations.
Measurements and initial design.
Initial production estimates.
Specific studies (topographic,
geotechnical, seismic, transport,
etc.).

LOGISTICS
Shipments of large components and
access to the site.
Damage, theft, etc. during shipping and/
or installation.

DELAYS
Equipment delivery, environmental,
administrative, third parties, force
majeure, tests, etc.

SCOPE CONTRACT EXECUTION
Requirements (PPA and connection).
Scope not considered (EPC).

CONSTRUCTION MONITORING
Periodic reports to certify work done and
payment milestones.

PRODUCTION BELOW EXPECTATION
Low irradiation: Study resource and/or incorrect campaign.
Poor contracts: EPC, O&M (scope, guarantees, etc.)
High losses: monitoring, regulation, breaks, electrical, environmental, force
majeure, inverter stops, etc.

HIGH EXPENSES (Above expected)
Abusive contracts / permits: land, administrative, O&M ...
Inadequate insurance: transport, force majeure, theft, etc.

INSUFFICIENT INCOME (LESS THAN EXPECTED)
Regulatory framework (PPA and connection): terms, conditions, etc.
Incomplete / Inadequate Financial Model

STRUCTURAL DAMAGE
Tracker or structural design not fitting site conditions.
Incorrect foundation design for the Project structures and shelters
Inadequate civil works infrastructure (drainage)
HIDDEN ISSUES

Thorough Analysis → Risk Detection → Mitigation

“FULL SCOPE!!”

“TURN KEY!!”
CONTRACTS – RENEWABLE PROJECTS

- PPA
- Project
- IA
- O&M
- EPC

Responsibility Lagoons
LD interactions Deficits
Requirements Discrepancies
Schedule Misalignments
Financial Model Effects
## PPA – GENERAL ASPECTS

<table>
<thead>
<tr>
<th>Item</th>
<th>Standards</th>
<th>Bad Practices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guaranteed Dates</td>
<td>Parent Warrantys, Market Registration, COD.</td>
<td>COD’s with unrealistic timeframe</td>
</tr>
<tr>
<td>Term</td>
<td>12 months to 20 years</td>
<td>Short Terms or too long terms</td>
</tr>
<tr>
<td>Capacity</td>
<td>Should be in line with Projects desing capacity</td>
<td>Capacities Below the Interconnection Agreement or Design</td>
</tr>
<tr>
<td>Contracted Products</td>
<td>Energy, CELs, Power Amounts</td>
<td>Unrealistic Quantities Above P50 values (Guaranteed amounts)</td>
</tr>
<tr>
<td>Payment Rate</td>
<td>Strong currency based or Local currencies based with exchange to strong currency indexation (monthly)</td>
<td>Local currencies with no strong currency indexation</td>
</tr>
<tr>
<td>Point of Interconnection</td>
<td>Same as Interconnection Agreement POI</td>
<td>Different tan the IA POI and desing</td>
</tr>
<tr>
<td>Operational Requirements</td>
<td>Forecasting, registration, transmission fees,</td>
<td>Operational Data not included in Asset Management or O&amp;M contracts</td>
</tr>
<tr>
<td>EoD Termination</td>
<td>Typical Force Majeure, Bankruptcy, Failing to comply with requirements</td>
<td>Delivery Products - Delivery</td>
</tr>
</tbody>
</table>
# INTERCONNECTION AGREEMENT – GENERAL ASPECTS

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<tr>
<th>Item</th>
<th>Standards</th>
<th>Bad Practices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Description</td>
<td>In accordance to Design and other contracts</td>
<td>Differences</td>
</tr>
<tr>
<td>Facilities and Network Upgrades</td>
<td>New Bay or Maneuver (Components in adjacent SS)</td>
<td>“Carte Blanche”</td>
</tr>
<tr>
<td>Guaranted Dates</td>
<td>Energization, Testing periods, COD.</td>
<td>Unrealistic timefranes</td>
</tr>
<tr>
<td>Term</td>
<td>30 years</td>
<td>Short term</td>
</tr>
<tr>
<td>Curtailment</td>
<td>Not curtailment or limited</td>
<td>No restrictions on curtailment, subjected to generation in the area</td>
</tr>
<tr>
<td>EoD Termination</td>
<td>Typical Force Majeure, Bankruptcy, Failing to comply with requirements</td>
<td>Agressive timeframes</td>
</tr>
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</table>
EPC CONTRACTS – SCOPE OF WORKS

PV modules – number, manufacturer, model, string connection.
   Is there a requirement for the modules to have a valid IEC Certificate?
   Are there any FAT and SAT defined in the contract?
   Are long-term warranties (PV modules, inverters, trackers) clearly defined.
   Is a passthrough on Provisional Acceptance?

Monitoring system and communications. What is the scope?
   Does it include monitoring of the substation?
   String inverter is included?

Initial Stock of Spares. Including key components (at least 0.2% of the total nº Modules)
EPC CONTRACTS – SCOPE OF WORKS

Interconnection and Site Substation.

In cases those are part of a separate contract
 Are the schedules aligned?
 Responsibilities are clearly defined?

Monitoring system and communications. What is the scope?

Does it include monitoring of the substation?
 String inverter is included?
 How many stations are available? What is the setup for bifacial projects?
EPC CONTRACT WARRANTIES

Typical warranties include:

- Milestone completion dates. At least Provisional Acceptance is guaranteed. Some contract also warrant partial milestones
- PR Test as part of the PAC (duration between 10-15 days)
- Final Completion (2 years from PAC)

Non compliance with those implies LDs that should be sized to compensate the loss of income and other project related or financing costs.
Overall EPC contract works have at least 2 years warranty starting on Provisional Acceptance of the Plant.

Equipment warranties with a longer term should be clearly transferred to the Plant owner on PAC. Those may include:

*PV modules, inverters and trackers, cables and transformers*

Typically the warranty term starts on PAC and continues for two years until FAC. Normally, during this period the EPC Contractor is responsible for the maintenance of the plant.
Provisional Acceptance Tests

Should certify that:

• Commissioning is completed
• The plant is mechanical and electrically complete
• Punch list items do not include elements that would require energy loss or plant disconnection for repair.
• An initial Performance (PR) test has been conducted and successfully passed.
Draft standard of IEC 61724-1 Ed2.
Photovoltaic system performance - Part 1: Monitoring

Defines a procedure for PR calculation for Bifacial systems

\[
PR'_{\text{annual -eq,bi}} = \left( \sum_k P_{\text{out},k} \times \tau_k \right) \bigg/ \left( \sum_k \frac{C_k \times P_0 \times G_{i,k} \times BIF_k \times \tau_k}{G_{i,\text{ref}}} \right)
\]
Risk Mitigation Construction Phase
RISKS DURING CONSTRUCTION OF A PV PLANT

ACCESS
GEOLOGIC
HYDRO
TECHNOLOGY
ARCHAEOLOGIC
SOCIAL
LOGISTICS
CIVIL / ELECTRICAL
TECHNICAL RISK ASSESSMENT FOR MODULES

Long term durability
- Laboratory Tests, IEC and UL tests
- Field tests
- Component lifespan (backsheets, connectors, wires etc.)

Long term performance
- Long term degradation rates
- System performance monitoring

Warranties and replacement
- Warranty claims, testing, availability of replacement modules, MLPE
LOCATION AND ACCESS: SOLAR

Generally, solar projects will be located in rural places and away from major urban centers.

PV Plant in Chile (left)  PV Plant in Brazil (right)
HYDROLOGICAL RISK

Civil infrastructure and drainage requirements should be designed considering the right return and all climatological aspects of the area.

Classifying soils at runoff level, identifying the outlets or natural water inlets to the site and justifying the passage works on channels and drains in roads and areas adjacent to the draft.

It provides vital information for calculating the height of the embankments of roads and platforms required to avoid floods.
HYDROLOGICAL RISK

Flood risk areas identified at the design phase
Flood risk areas identified at the construction phase
HYDROLOGICAL RISK
GEOTECHNICAL RISK
LOGISTIC RISKS

The logistics strategy to follow for the construction of the project should be defined beforehand.

We have to consider available ports and roads, but also the machinery capacity of the project region (driving piles).

Important to consider complications in mounting with high-power and bifacial modules.
CONSTRUCTION AND O&M RISK

Construction risks that eventually begin to impact the operation of a project are many and strictly depend on the quality once the implementation, design and subsequent construction stage is completed.

Vegetation, soiling, cleaning
MANAGING RISK FOR PV PLANT CONSTRUCTION AND COMMISSIONING

• Early identification of risks is essential for implementing the right mitigation with the lowest impact on costs and delays on the Project. The sooner, the better, the easier, the cheapest.

• A proper contractual definition of the Project is required with the right level of coverage for the construction and O&M contracts and properly aligned with other key contracts for the Project.

• Independent verification of contract clauses (technical and legal) would add value on minimizing risks.

• Thorough supervision during construction from a third party will ensure that quality is not compromised and that construction risks are properly identified and mitigated.

• Definition of the right KPIs tasks and activities is key to remove any risk at Project completion, to make sure that the Plant will be handed to the Owner in perfect shape for Operation.
THANK YOU !

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