Case Study of a 20 MW PV Power Plant in El Salvador

Methodology

Techno-Economic Feasibility Study

Methodology

Technical Assessment
- Site Assessment
  - Geotechnical-
  - Environmental-
  - Social-
  - Climatic aspects

- Technology Assessment
  - PV Module Selection
  - Inverter Concepts
  - O&M Requirements

- Permitting process
  - Validation of grid connection
  - Legal Framework Report

Technical Design

Yield Verification

Financial Implications
- Evaluation of CDM Revenues
  - Evaluation revenue and operating expenditures
    - Feed-in tariff analysis
    - Demand analysis

- Assessment capital expenditures
  - Investment costs incl. decommissioning

- Financing Plan and Structure
  - Co-operation with international financing Institutions
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Technical Assessment

- Site Assessment

Objective Site Assessment

• Evaluation of the site suitability based on:

  1. Meteorological data
  2. Terrain usability
  3. Area accessibility
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Technical Assessment

- Irradiation El Salvador
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Technical Assessment

- Site Evaluation

**Resulting area 15 de Septiembre**

**Resulting area Guajoyo**
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Technical Assessment

- **Environmental and Social Evaluation**

  **Objective**

  - Identification of sensitive environmental and social features
  - Consideration of impacts
    - Site preparation
    - Construction
    - Operation
    - De-commissioning
  - Development of mitigation measures

  **Result**

  - Both sites are feasible for development of a PV plant
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Technical Assessment

Technology Selection

Objective of Technology Assessment

- **Identification** of potential technological solutions

- **Evaluation** of the following technical components:
  1. PV Modules
  2. Mounting Structure and Foundations
  3. Inverter Concept
## Case Study of a 20 MW PV Power Plant in El Salvador

### Technical Assessment

#### Module Selection

<table>
<thead>
<tr>
<th>Description</th>
<th>Thin Film Technology</th>
<th>Crystalline Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Amorphous Silicon a-Si</td>
<td>Cadmium Telluride CdTe</td>
</tr>
<tr>
<td>Total Number of Modules / MW</td>
<td>10,020</td>
<td>12,528</td>
</tr>
<tr>
<td>Module Area / MW</td>
<td>14,329 m²</td>
<td>9,020 m²</td>
</tr>
<tr>
<td>Total Area</td>
<td>1.9 ha - 3.1 ha</td>
<td>1.3 ha - 2.2 ha</td>
</tr>
<tr>
<td>Max Power El Salvador / ha</td>
<td>0.5 MW</td>
<td>0.75 MW</td>
</tr>
<tr>
<td>Yield / Year</td>
<td>****</td>
<td>1,528 kWh/kW</td>
</tr>
<tr>
<td>PR</td>
<td>****</td>
<td>79.8 %</td>
</tr>
<tr>
<td>Turnkey Price in Euro per kW</td>
<td>2,300 € - 2,600 €</td>
<td>2,300 € - 2,600 €</td>
</tr>
</tbody>
</table>

**Result:** Poly-crystalline
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Technical Assessment

Technology Selection

2. Objective Mounting Structure

- Elaboration of cost and time efficient adequate mounting structure
- Identification of geological requirements

Results

- 15 de Septiembre:
  - Pile driven foundations sometimes pre-drilling required
- Guajoyo:
  - Pile driven foundations often pre-drilling required
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Technical Assessment

- **Technology Selection**

  3. **Objective Inverter Concept**

  • **Elaboration** of adequate inverter technology based on availability of maintenance and cost-efficiency
  
  • **Identification** of costs and service availability

- **Results**

  **String inverter concept**
  
  → No on-site maintenance services required
  
  → Maintenance for central inverter concept are not available in El Salvador
  
  → Less operation costs
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Technical Assessment

- **Operation & Maintenance**

  **Status Operation & Maintenance**

  - Extremely low O&M
  - No rotating equipment

  **Results**

  ➔ O&M Concept

  - 24 h security service
  - Cleaning of modules
  - Maintenance main components
  - Maintenance low and medium voltage system
  - Visual inspection
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Technical Assessment

**Permitting Process**

<table>
<thead>
<tr>
<th>Results of Legal Framework</th>
</tr>
</thead>
<tbody>
<tr>
<td>• <strong>Permits and Authorizations</strong></td>
</tr>
<tr>
<td>– Environmental Permit Process</td>
</tr>
<tr>
<td>– City Hall Permit</td>
</tr>
<tr>
<td>– Working Establishment regulation</td>
</tr>
<tr>
<td>{ Dialogue with Authorities</td>
</tr>
<tr>
<td>• <strong>Connection to Grid</strong></td>
</tr>
<tr>
<td>• <strong>Contract and Pricing</strong></td>
</tr>
<tr>
<td>• <strong>Tax Benefits</strong></td>
</tr>
</tbody>
</table>
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Financial Implications

- Financial Analysis:
  - Irradiation/Net Generation
  - CAPEX/Investment
  - OPEX
  - Electricity Tariff
  - CER Certificates
  - Start of operation
  - Operation period/Project Lifetime
  - Financing/Funding Structure
  - Expansion Plan

- Financial Analysis:
  - Financial Rate of Return
  - Levelized Electricity Cost
  - Debt Service Coverage Ratio
  - Net Present Value
  - Avoided Emissions
**Financial Analysis:**

- **Irradiation/ Net Generation:** 9,878 MWh/a
- **CAPEX/ Investment:** 17,950 TEUR
- **OPEX:** 205,870 TEUR/a
- **Cost-based vs. Market regulated Tariff**
- **CER Certificates:** 12 EUR/t
- **Start of operation:** 2012
- **Operation period:** 25 years
- **KfW Funding/ CEL Equity**
- **Potential Ext. Steps**

**Financial Implications**

- **FIRR:** 7.36%
- **LEC:** 0.13 EUR/KWh
- **DSCR:** 1.60
- **NPV:** 13,836.01 TEUR
- **Avoided Emissions:** 158,494 t
## Cost Estimation

### 15 de Septiembre

<table>
<thead>
<tr>
<th>Description</th>
<th>Initial 6.1 MW</th>
<th>Extension 8.1 MW</th>
<th>Guajoyo 3.6 MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modules</td>
<td>8,612.68</td>
<td>11,485.24</td>
<td>5,169.11</td>
</tr>
<tr>
<td>Inverter</td>
<td>1,375.00</td>
<td>1,825.00</td>
<td>822.50</td>
</tr>
<tr>
<td>Civil material and construction</td>
<td>760.00</td>
<td>207.00</td>
<td>459.75</td>
</tr>
<tr>
<td>Electrical Material</td>
<td>3,894.80</td>
<td>4,832.90</td>
<td>2,394.13</td>
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<tr>
<td>Grid connection</td>
<td>717.50</td>
<td>-</td>
<td>567.50</td>
</tr>
<tr>
<td>Engineering, tendering, site supervision</td>
<td>840.00</td>
<td>655.00</td>
<td>460.00</td>
</tr>
<tr>
<td>Insurances</td>
<td>81.00</td>
<td>95.03</td>
<td>49.36</td>
</tr>
<tr>
<td>Contingencies</td>
<td>1,628.10</td>
<td>1,910.02</td>
<td>992.24</td>
</tr>
</tbody>
</table>

### Specific Investment Costs (EUR/kW)

- **15 de Septiembre**: 2,522 (3,556 USD)
- **Extension**: 2,340 (3,299 USD)
- **Guajoyo**: 2,701 (3,808 USD)
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Conclusions

**Recommendations**

- Communication of PV Technology
  - Presentation Workshop with Local Authorities
  - Project Visualization
- Sourcing Strategy
  - Local Content -> Assessment of Local Capacities
  - Knowledge Transfer -> Training
  - Technology Selection -> Consideration of Local Skills
  - Make projects attractive to int. EPCs
- Reliable Tariff System for RE must be established for project lifecycle
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Visualization
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Thank you for your attention!