Optimization of PV Assets: How to Increase the Return of PV Assets Sustainably

greentech is an Independent and Specialized PV Service Provider
Our Company in a Nutshell

✓ Core business and focus: O&M and Asset Management for PV power plants
✓ greentech offers a modular and comprehensive service portfolio
✓ High degree of innovation, processual and IT-driven business
✓ Currently more than 600 MWp under management
✓ greentech today is active in 11 countries
✓ Biggest German independent PV O&M and asset management service provider*
✓ greentech is independent of any EPC, manufacturer or project developer
✓ Recently acquired O&M provider Conergy Services GmbH

Investors Focus More on the Operational Phase of PV-Systems
Typical Questions We Are Being Asked

Motivation O&M Provider
What keeps my O&M provider motivated to deliver high performance every day?

Incident Management
Will all defects be identified immediately and repaired properly?

O&M Contracts
Is my O&M contract fair and is my service provider fulfilling the contractual obligations?

Competence O&M Provider
Are there alternative or more innovative ways to repair or improve my PV-system?

Operating Liability
Who cares about identifying and mitigating my operational risks?

Independence
Does my O&M provider act independently without any conflict of interest?
Still, the Financial Return is the Central Topic
Most Important Question We Are Being Asked

Asset Owner
System Performance

How can I increase the Financial Return of my PV project?

Answer

1. Reduce Costs
2. Increase Performance

Execution

Sustainable execution is challenging
- Reliable analysis to be performed
- Technical and commercial aspects and interdependencies to be considered
- Complex processes to be managed
Benchmarking Is a Useful Starting Point for Cost Reduction
Case Study Benchmarking Project

Project

- Customer: Insurance company as asset owner
- Scope: Commercial and technical audit of five PV-plants, 35 MW
- Duration: June – August 2015

Target

- Transparency about cost structure
- Analysis of service specific prices
- Assessment of price-performance ratio
- Identification of fields for improvement

Project Plan

Pre-Assessment

- Plausibility check
- First review
- Simple cost benchmark

Detailed Assessment

- Detailed assessment of identified areas
- Identification of optimisation potentials
- Identification of focus points and further investigations

Results / Measures

- Measures for price-performance improvements
- Transparency about costs and services
- Further areas of improvement
- Project plan for execution

The iterative approach allows a focused and cost efficient project realisation.
The First Step Is a Simple Cost Benchmarking
As-is Costs in Relation to the greentech Benchmark

<table>
<thead>
<tr>
<th>Cost Items [€/kWp/a]</th>
<th>As-is costs</th>
<th>Out of Benchmark</th>
<th>Benchmark (5MW, yoc 2011)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical O&amp;M</td>
<td>5,30</td>
<td>9,00</td>
<td>11,50</td>
</tr>
<tr>
<td>Commercial asset management</td>
<td>2,00</td>
<td>3,20</td>
<td>3,80</td>
</tr>
<tr>
<td>Power purchase</td>
<td>0,50</td>
<td>1,30</td>
<td>3,00</td>
</tr>
<tr>
<td>Landscape management</td>
<td>0,70</td>
<td>2,20</td>
<td>2,50</td>
</tr>
<tr>
<td>Insurance</td>
<td>2,00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other costs e.g. lease, security, consultancy, lawyers</td>
<td>2,10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall costs</td>
<td>15,60</td>
<td>31,80</td>
<td>35,40</td>
</tr>
</tbody>
</table>

**Approach**
- Identification of all cost items
- Extraction of current costs
- Applying the greentech benchmarks for the individual segment

**Result**
- First impression of cost items and overall costs
- Identification of potential focus points and areas of improvement
- The portfolio is significantly above benchmark
- Further investigation required
**Case Study**
- cost reduction -

**The Second Step Is an In-depth Performance Analysis (1/2)**
Assessment of Technical O&M

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**Technical O&M: Contracted Services**

**Monitoring**
- Hours of operation
- Reaction time

**Reporting**
- Frequency
- Scope

**Inspection / maintenance**
- Frequency
- Scope

**Corrective maintenance**
- Included items (e.g. full maintenance)
- Specific costs

**greentech benchmarking result**

<table>
<thead>
<tr>
<th></th>
<th>Benchmark (5MW, yoc 2011)</th>
<th>Out of Benchmark</th>
<th>As-Is costs</th>
<th>Fair costs for contracted services</th>
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</thead>
<tbody>
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<td>Year high</td>
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<td>Month low</td>
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<tr>
<td>Year high</td>
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<tr>
<td>Corrective maintenance</td>
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<td>none high</td>
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<td>low high</td>
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<tr>
<td>greentech benchmarking result</td>
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<td>5,30</td>
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<td>7,45</td>
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<td>9,00</td>
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<td>11,50</td>
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</tr>
</tbody>
</table>

**Description**

**Approach**
- Qualitative contract review
- Applying greentech costing tool
- Analysis of results
  - Target price for contractual scope
  - Suggestion for optimized scope (including target costs)

**Result**
- Transparency about current price-performance ratio
- Basis for optimization
- The costs for technical O&M are too high in comparison to the contracted services
- Renegotiation of price or increase of service level and included services

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Feb-17
Case Study - cost reduction -

The Third Step Shows the Improvement Potential in All Areas
Results and Definition of Measures

- Optimisation-Potential

<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approach</td>
</tr>
<tr>
<td>- Presentation of price-performance analysis</td>
</tr>
<tr>
<td>- Definition of preferred risk profile and scope of services</td>
</tr>
<tr>
<td>- Definition of target prices and changes on scope of services</td>
</tr>
<tr>
<td>Result</td>
</tr>
<tr>
<td>- Costs can be reduced by 22% which is 8€/kWp/a at the same service level</td>
</tr>
<tr>
<td>- This leads to an increased IRR of 0,7%</td>
</tr>
<tr>
<td>- Solid basis for negotiation towards a better cost performance ratio</td>
</tr>
</tbody>
</table>

In conjunction with the plant owner, all findings are being prioritized and approached.
Financial Return Can Be Improved by Performance Increase as Well
Most Important Question We Are Being Asked

Answer

1. Reduce Costs
2. Increase Performance

Execution
Sustainable execution is challenging
- Reliable analysis to be performed
- Technical and commercial aspects and interdependencies to be considered
- Complex processes to be managed

How can I increase the Financial Return of my PV project?

Asset Owner
System Performance
Repowering Is a Common Way To Increase Revenue Streams

greentech Repowering Approach

Market Situation
- Repowering is mainly technical driven
- No focus on commercial aspects
- Interdependencies and influencing factors often unknown

Repowering Requirements
- Well defined and structured process with clear decision points
- Commercial transparency along all project stages
- Sensitivities of main drivers for identifying most beneficial solution

Repowering Process
- Analysis
- Concept
- Implementation
- Monitoring

Repowering Toolset: Examples
- Exchange of low performing panels
- Exchange of low performing inverters
- Reengineering (string configuration, DC/AC ratio)
- Electronic components upgrade
- Optimization of panel performance
greentech Repowering-Tool Provides a Reliable Decision Basis

Function and Features of the Repowering-Tool

Input Parameter

- **Plant data**
  - Remaining FIT period
  - Tariff, other incomes

- **Technical data**
  - Performance data
  - Degradation
  - Specific yield

- **Repowering costs**
  - Fixed and variable re-investment costs

- **Financial data**
  - Capital structure
  - Target IRR and interest rate

Additional Yield

Assessment of additional yield through comparison of As-is and To-be scenarios

Re-Investment Case

Calculation of economic indicators, such as IRR, net present value and break even time

Sensitivity

Representation of interdependencies of most relevant factors and parameters
### General Plant and Repowering Data

**General Plant Data:**

- **Type:** Free field
- **Location:** Germany, Bavaria
- **Rated Power:** 4 MWp
- **Modules:** 58000 thin film modules
- **Year of construction:** 2008
- **Inverter type:** Central inverter

**Repowering Data:**

- **Replaced rated power:** 990 kWp
- **Average degradation:** 23.8% (measured before repowering)
- **Feed-in tariff:** 0.3549 €/kWh
- **Investment period:** 13 years
- **Total Costs:** 683,100 €
Analysis of Profitability Indicates High Repowering Potential
Calculation with Planned Values as Input Parameters

**Outcome Pre Analysis**

**Approach:**
- Detailed planning of repowering concept
- Technical, legal and commercial analysis
- Profitability assessment with identified parameters

**Results:**
- **Additional Yield:** 3,184,029 kWh
- **IRR:** 8%
- **NPV:** 133,185 €
- **Amortization after 10 years**
- Small chances in parameters do not endanger profitability

**Decision:**
- Repowering concept will be implemented
Assessment of Repowering Implementation Confirms High Profitability
Calculation with Actual Values as Input Parameters

**Outcome post analysis**

**Description**

**Approach:**
- Review of repowering implementation
- Technical review and measurements on-site
- Commercial assessment
- Post analysis with actual values to determine profitability of implementation

**Results:**
- Additional Yield: 3,288,191 kWh
- IRR: 10%
- NPV: 192,760 €
- Amortization after 9 years
- Finding after implementation outperforms first indication
- Higher profitability caused by lower costs and better performance
The Project IRR Can Be Increased in Many Cases
Summary and Considerations for Return Driven O&M

Cost Reduction
- Cost reduction: Potential in almost every project without reducing service level
- Customer perspective: Preferred cost-performance-level and risk profile
- Data basis: Knowledge about market prices and benchmarks

Performance Increase
- Technical approach: Important but not sufficient
- Economic Transparency: Basis for an educated decision along all process steps
- Sensitivity: Knowledge about interdependencies and influencing parameters
Do not hesitate to contact us.
Besides the Classic Disciplines, Additional Services Gain Importance

Three Main Columns of Service

### Technical Operation
- Keeping a continuous eye on the system performance
- Maintaining the technical status of components and systems
- Identifying yield losses and improving the performance

### Commercial Operation
- Generating full transparency on liquidity, profitability and incidents
- Managing all stakeholder involved in the PV plant
- Guaranteeing compliance of accounts and files

### Additional Services
- Auditing the performance of external PV assets and providers
- Consulting in all relevant technical areas, e.g. repowering
- Covering all commercial concerns, e.g. benchmarking and cost reduction programs
# Case Study - cost reduction -

## The Second Step Is an In-depth Performance Analysis (2/2)

**Assessment of Other Items**

### Power purchase

- **Power costs (Ct/kWh)**
  - Benchmark (5MW, yoc 2011): 5.00
  - Out of Benchmark: 8.20
  - As-Is costs: 13.50
- **Power consumption (MWh)**
  - Benchmark (5MW, yoc 2011): 20
  - Out of Benchmark: 60
  - As-Is costs: 111

**greentech benchmarking result**

### Electronic & interruption insurance

- **Excess**
  - Benchmark (5MW, yoc 2011): none
  - Out of Benchmark: 2.000 €
- **Security measures**
  - Benchmark (5MW, yoc 2011): CCTV
  - Out of Benchmark: none
- **Liability insurance**
  - **Personal / material damage**
    - Benchmark (5MW, yoc 2011): 2,5 M€
    - Out of Benchmark: none
  - **Property loss**
    - Benchmark (5MW, yoc 2011): 50 k€
    - Out of Benchmark: none

**greentech benchmarking result**

### Approach

- Qualitative contract review
- Applying greentech costing tool
- Analysis of results
  - Target price for contractual scope
  - Suggestion for optimized scope (including target costs)

### Result

- Transparency about current price-performance ratio
- Basis for optimization
- Costs for power purchase are too high, especially the specific costs, this needs to be renegotiated
- Insurance terms are even below benchmark, no action required
Optimization of Plant Performance by Replacement of Inverters

General Plant and Repowering Data

<table>
<thead>
<tr>
<th>General Plant Data:</th>
<th>Repowering Data:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type:</td>
<td>Rated power: 1,1 MWp</td>
</tr>
<tr>
<td>Location:</td>
<td>Actual inverter efficiency: 92,71%</td>
</tr>
<tr>
<td>Rated Power:</td>
<td>(measured before repowering)</td>
</tr>
<tr>
<td>Modules:</td>
<td>Feed-in tariff: 0,2111 €/kWh</td>
</tr>
<tr>
<td>Year of construction:</td>
<td>Investment period: 16 years</td>
</tr>
<tr>
<td>Inverter type:</td>
<td>Total costs: 116,622,00 €</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Free field</td>
</tr>
<tr>
<td></td>
<td>Germany, Saxony</td>
</tr>
<tr>
<td></td>
<td>20 MWp</td>
</tr>
<tr>
<td></td>
<td>87,000 modules</td>
</tr>
<tr>
<td></td>
<td>2011</td>
</tr>
<tr>
<td></td>
<td>Central inverter</td>
</tr>
</tbody>
</table>
Analysis of Profitability Indicates Low Internal Rate of Return Calculation with Planned Values as Input Parameters

Outcome Pre Analysis

Approach:
- Detailed planning of repowering concept
- Technical, legal and commercial analysis
- Profitability assessment with identified parameters

Results:
- Additional Yield: 847,772 kWh
- IRR: 5.6%
- NPV: 1.627 €
- Amortization after 16 years
- Small chances in parameters endanger profitability

Decision:
- Expected IRR too low, Repowering concept will not be implemented
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