Module Quality Assurance: Risk Mitigation and Safeguarding Project Value

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CEA is a solar PV advisory firm that is able to provide unrivaled insight into the manufacturing process to ensure the success of solar energy projects worldwide.

- More than 60 employees
- Over 35 engineers
- A presence in 8 countries
- Over 8 years of history
- Certified by ISO 9001:2008
- Proud member of SEIA
- Audited 125+ solar factories worldwide
- Client engagements in 27 countries
Since 2008, CEA has successful client engagements in 27 countries and has employees present in 8 countries.
CEA’s service offerings are focused on three key areas, with a 8 year track record in over 8GW across a broad services portfolio in 27 countries.
Technical Advisors in the past have overemphasized downstream quality without looking as closely on the product in more detail.
CEA’s Quality Assurance Program (CQAP) prevents risk and ensures that downstream project stakeholders maximize the output of their system.

**Pre-Production**
- Supplier’s certification

**Production Monitoring**
- Input material monitoring
- Production environmental control; monitoring of inventory storage and manufacturing workshop
- Production process control; monitoring of equipment calibration, stringing, lay-out, lamination, curing and framing
- Bill of Materials (BOM) inspection data review

**Pre-Shipment**
- Product Inspection
  - Visual inspection
  - Functional test
    - EL test
    - IV test
- ISO 2859 Sample rule
- QC standard
- AQL rule

**Container Loading**
- Proper Packing
  - Container type
  - Container number
  - Seal number
  - Shipment plan
  - Content Listing
  - Packing list
  - Inspection certificate
Typical PV Module Production Process Flowchart: every step is a quality risk
Common Production Defects

Micro crack caused risk is difficult to mitigate without the proper equipment (Electroluminescence – EL imaging) and the right standards, enforced by an independent and accredited QA third party.

Summary

Module power decreased by **20W**
Within 5 years, this rate may increase to **8-15W**

EL testing utilizes special electromagnetic technology to identify defects hidden from the naked eye.

Serious cracks

These are examples of the most serious types of cracks that a defective module may have, designated by the shaded areas. The size of the shaded areas typically corresponds to the degree of capacity lost. These three cells with large cracks correspond to approximately 4 W of capacity loss.

Minor cracks

These minor cracks currently do not result in capacity loss – however, such cracks may deepen or become “contagious” and affect nearby cells. In a worst case scenario, a crack like this could lead to a loss of 1 W of capacity.

“Broken fingers”

About 0.2 W loss

Long cracks across whole cell

These long cracks are slightly more severe and may result in slightly lower cell efficiencies. However, if such cracks deepen, a cell could potentially lose one-third of its capacity. Nearby cells affected may cause further losses in capacity. For each of these cells, we can expect a 1.2 W loss in capacity.

Source: CEA Internal Quality Control Findings
Cells with cold soldering

Summary
This cold soldering is caused by process instability, and lack of training and proper quality control.

If these strings were to be laminated into the module, this issue could elude detection, but will seriously deteriorate the performance of solar module over time.

Source: CEA Internal Quality Control Findings
Summary
Soldering residue between cells can act as an electrical conductor.

This may lead to short circuiting amongst cells, a potential electrical safety risk.

Source: CEA Internal Quality Control Findings
Fire and Electrical Safety Risk From Defective String Layup

**Summary**
Human error during the layup or lamination process can lead to narrow gaps between cells.

Narrow cell spacing can lead to short circuiting amongst cells.

<table>
<thead>
<tr>
<th>Cause</th>
<th>Consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incorrect laminating, poor EVA material</td>
<td>Insufficient space between cells</td>
</tr>
<tr>
<td>Short circuiting between cells</td>
<td></td>
</tr>
</tbody>
</table>

Seriousness: Medium
Time Frame: 10 Years

In this example cell spacing is less than the required 2mm

Source: CEA Internal Quality Control Findings
Summary
Human error committed during the soldering process can lead to improper sealing of the junction box.

Insufficient sealing can lead to electrical fires as well.

Source: CEA Internal Quality Control Findings
**Summary**
During the backsheet measuring and cutting phase, workers must be careful to line up the backsheet with the edge of the module, or else water leakage may occur, forcing module replacement.

**Causes and Consequences**
- **Errors during backsheet cutting**
- **Insufficient backsheet length**
- **Water leakage**

**Seriousness and Time Frame**
- **Seriousness**: High
- **Time Frame**: 3-5 Years

Source: CEA Internal Quality Control Findings
CQAP has been performed in various facilities of Tier 1 manufacturers and the distribution of defect rates has showed surprising results.
Scattered defect distribution show that even on the same production lines as module assembly processes are not stable.
Example of calculated NPVs for 2 100 MWp projects, produced with and without Quality Assurance program, using three scenarios

Quality Assurance done: NPV has its maximum value, as only standard warranted degradation (~0.7%/pa) is assumed

Good scenario: manufacturer shows a small drop in quality w/o QA program (2 x 1% defect loss, or 2% in excess of warranty in project midlife)

Medium scenario: manufacturer shows a medium drop in quality w/o QA program (3 x 1% defect loss, or 3% in excess of warranty in project midlife)

Bad scenario: manufacturer shows a big drop in quality w/o QA program (4 x 1% defect loss, or 4% in excess of warranty in project midlife)
NPV loss in $/W for the 2 projects, without applying Module Quality Assurance Programs, using three scenarios

Good scenario: manufacturer shows a small drop in quality w/o QA program (2 x 1% defect loss, or 2% in excess of warranty in project midlife)
Medium scenario: manufacturer shows a medium drop in quality w/o QA program (3 x 1% defect loss, or 3% in excess of warranty in project midlife)
Bad scenario: manufacturer shows a big drop in quality w/o QA program (4 x 1% defect loss, or 4% in excess of warranty in project midlife)