Insurability, Bankability, Investability

Dr. Edward Hsi
Swiss Re’s Solar Panel Code of Practice
Acknowledgements

The research we present herein draws extensively on the work of and/or discussions with many reputable institutions and individuals. In particular, we would like to acknowledge the following for their contributions to the advancement of PV reliability and/or this research:

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- Telecom Technology Center Green Communications Laboratory (TTC) – Dr. M. H. Wang, Risen Chu, Christine Chang, Taco Wang
- PVsyst – Dr. Jay Um

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Jay is Head of Engineering, China and a Level 4 (top level) senior manager of Global Engineering, Swiss Re. Jay has extensive engineering and hands-on risk management experience in various industries and has been a key contributor to international risk management best practice on Renewable Energies (PV and Offshore Wind) and Underground Mining. Jay has a Bachelor of Science Degree in Mechanical Engineering and is also an MBA.

Edward Hei, Senior Consultant, Swiss Re

Dr. Hei has worked for Swiss Re for over 20 years in different roles including Senior Consultant, Global Chief Engineer, China and Japan Underwriting Manager, Portfolio Manager and more. He has co-authored papers on Reliability papers (with NREL, LLNL, EIJRC, FGST, and Veolia Energy) at ISES PVSC, and Renewable Power, and has a regular reviewer for IEEE Transactions on Smart Grid, Power System and Power Delivery. He has a PhD in Electrical Engineering and is also a Chartered Financial Analyst (CFA).
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- PVGuider – Dr. Jay Lin
About Swiss Re
This is Swiss Re – RE100 Cofounder, 2014

https://www.ekoenergy.org/buying-100-renewable-energy-is-becoming-the-new-normal/
This is Swiss Re
June, 2017, NY’s largest solar array

World’s Top 20 Reinsurance by Net Written Prem

<table>
<thead>
<tr>
<th>Ranking</th>
<th>Company Name</th>
<th>Life &amp; Non-Life</th>
<th>Non-Life Only</th>
<th>Total Shareholders</th>
<th>Loss</th>
<th>Expense</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Swiss Re Ltd.</td>
<td>36,406</td>
<td>34,042</td>
<td>20,864</td>
<td>20,220</td>
<td>28,727</td>
<td>74.2</td>
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<tr>
<td>2</td>
<td>Munich Reinsurance Company</td>
<td>35,814</td>
<td>34,515</td>
<td>23,395</td>
<td>22,570</td>
<td>30,336</td>
<td>65.2</td>
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<tr>
<td>3</td>
<td>Hannover Rück SE</td>
<td>21,952</td>
<td>19,791</td>
<td>13,709</td>
<td>12,368</td>
<td>10,923</td>
<td>66.9</td>
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<tr>
<td>4</td>
<td>SCOR S.E.</td>
<td>17,466</td>
<td>15,773</td>
<td>7,069</td>
<td>6,115</td>
<td>6,672</td>
<td>66.5</td>
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<td>5</td>
<td>Berkshire Hathaway Inc.</td>
<td>15,376</td>
<td>15,376</td>
<td>9,930</td>
<td>9,930</td>
<td>352,500</td>
<td>88.6</td>
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<tr>
<td>6</td>
<td>Lloyd’s</td>
<td>14,064</td>
<td>9,926</td>
<td>14,064</td>
<td>9,926</td>
<td>34,846</td>
<td>72.2</td>
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<tr>
<td>7</td>
<td>China Reinsurance (Group) Corporation</td>
<td>11,564</td>
<td>10,681</td>
<td>3,942</td>
<td>3,809</td>
<td>12,689</td>
<td>58.0</td>
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<tr>
<td>8</td>
<td>Reinsurance Group of America Inc.</td>
<td>11,341</td>
<td>10,544</td>
<td>N/A</td>
<td>N/A</td>
<td>8,451</td>
<td>N/A</td>
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<td>9</td>
<td>Great West Lifeco</td>
<td>7,737</td>
<td>7,647</td>
<td>N/A</td>
<td>N/A</td>
<td>20,096</td>
<td>N/A</td>
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<tr>
<td>10</td>
<td>Korean Reinsurance Company</td>
<td>6,803</td>
<td>4,786</td>
<td>5,972</td>
<td>4,058</td>
<td>2,014</td>
<td>83.7</td>
</tr>
</tbody>
</table>

Source: AMBest
Insurability, Bankability, and Investability
The Stakeholders

Sponsors

Lenders

Equipment Provider

Connection

Civil Works

Project Co.

Regulatory Authorities

Energy Provider

Lawyers

Brokers

Rating Agency

ICE

IEC

Equity

Dividend

O&M Support

Debt

Debt Svc

Electricity Payment

Electricity Delivery

Construction Contracts

Licenses Certificates

Zoning, Permits, EIA

Source: Modified from IE Business School
Failure Modes – Technical View

Source: IEA 2014
Failure Modes – Underwriting View

1. Failure Mode

2. Failure Consequence

3. Failure Timing

4. Failure Cause

5. Failure Scale

6. If New Failure Mode…

Source: IEA 2014
<table>
<thead>
<tr>
<th>No.</th>
<th>Process Name</th>
<th>Tasks/Items</th>
<th>SOP/SIP</th>
<th>Equipment Management</th>
<th>Equipment</th>
<th>Equipment Calibration Frequency</th>
<th>Quality Characteristics</th>
<th>Spec (Figure for Illustration Purpose Only and Are Intentionally Distorted)</th>
<th>Inspection Tools</th>
<th>Inspection Frequency (Production)</th>
<th>Inspection Frequency (TPC)</th>
<th>Records</th>
<th>Corrective Reaction</th>
</tr>
</thead>
</table>
| 17  | Framing               | Edge Trimming Tape Sealing   | Framing Instruction Manual | Trimming Tool Framing Mach | Per Shift | Per Shift | Edge Condition Tape Overlay Symmetric Frame Work Complete in 25 sec No Gap, No Level Difference Corner Appearance, Parallelism | Visual | 100%                      | Check Record IPQC Audit Record | 5 Pcs/hour | 1. Isolation  
2. Report to Manager  
3. Root Cause Analysis  
4. Improvement Measure  
5. Follow-up |
| 18  | Junction Box Install  | Material Confirmation Adhesion Terminal Insertion Diode Test Potting Appearance Check | J-Box Installation Instruction Manual | Dispenser Diode Tester Caliper Potting Mach | Per Shift | Per Year | Per Shift | BOM Confirmation J-Box Position Silicon Application Terminal Insertion Diode Test Potting Potting Curing Time Appearance | Visual/Tools | 100% | Check Record IPQC Audit Record | 15 Pcs/hour | 1. Isolation  
2. Report to Manager  
3. Root Cause Analysis  
4. Improvement Measure  
5. Follow-up |
| 19  | Testing               | Reference Module Mgm Serial Number Runcard Product Output Test Insulation Resistance Hi-POT Test | Ref Module Management Guidbook Solar Simulator Instruction Manual | Ref Module Solar Simulator HiPOT Tester | Per Month | Per Shift | Per Shift | Reference Module Mgm Bar Code Consistency Apply Parameters Insulation Resistance Hi-POT Test | Solar Simulator | 100% | Check Record IPQC Audit Record | 10 Pcs/hour | 1. Isolation  
2. Report to Manager  
3. Root Cause Analysis  
4. Improvement Measure  
5. Follow-up |
| 20  | EL Test               | In-Line EL Testing Instruction Manual | EL Test Passing Guideline | EL Tester | Per Day | Per EL Test Passing Guideline | EL Tester | 100% | Check Record IPQC Audit Record | 10 Pcs/hour | 1. Isolation  
2. Report to Manager  
3. Root Cause Analysis  
4. Improvement Measure  
5. Follow-up |
| 21  | Final QC Check        | Module Classification Protective Paper Angle Appearance Check | Final QC Check Guidline | Power Classification Output Variability Color Classification Protective Paper Cap Appearance | Visual | 100% | Check Record IPQC Audit Record | 10 Pcs/hour | 1. Isolation  
2. Report to Manager  
3. Root Cause Analysis  
4. Improvement Measure  
5. Follow-up |
| 22  | Packaging             | Package Material Barcode Scan Package Content List Packaging Package Beltd Carton Label Film Coated Package Appearance | Packaging Instruction Manual | Packaging Tool | Per Shift | Per Shift | Packaging Material Package Content Appearance | Visual | 100% | Check Record IPQC Audit Record | 1 time /shift | 1. Isolation  
2. Report to Manager  
3. Root Cause Analysis  
4. Improvement Measure  
5. Follow-up |
| 23  | Outgoing QC           | Inventory Management Sampling Reference Module Mgm Power Output Test Insulation Resistance Hi-POT Test Product Name & Qty Appearance | Outgoing QC Instruction Manual | Ref Module Solar Simulator HiPOT Tester | Per Month | Per Shift | Per Shift | Inventory Management Reference Module Mgm Apply Parameters Insulation Resistance Hi-POT Test | Visual | ISO2859 | Check Record IPQC Audit Record | 1 time /shift | 1. Isolation  
2. Report to Manager  
3. Root Cause Analysis  
4. Improvement Measure  
5. Follow-up |
| 55  | Specialized PVT       | Product Verification Test    | PVT Instruction Manual | Autonomous extended test scope to reconfirm mass-produced module performance particularly after recipe change, material supplier change, equipment change, and/or operation staff change. | Check Record IPQC Audit Record | 1. Isolation  
2. Report to Manager  
3. Root Cause Analysis  
4. Improvement Measure  
5. Follow-up |
Thank You!