Inverter Performance Certification: 
*Does it make sense?*

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Endecon Engineering  

DOE High-Tech Inverter Workshop  
Baltimore, MD  
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Certification...

...is not a four-letter word
Types of Certification

- Safety
- Consumer Confidence
- Reliability
- Performance
Formal Product Certification

Certifying Body

Certified Program

Consensus Test Procedures

Accredited Laboratory
Why Do We Need Another Certification?

- To establish/verify key product characteristics
- UL (ETL, others) do just that for product safety—“May not work, but it’s safe”
- PowerMark certifies PV Modules, but not inverters... yet.
- Do you know how each mfg measures and specifies inverter performance? Do you trust their numbers?
- Do you want to compare the performance of different inverters?
- Do you need an accurate estimate of how your system will perform?
"THAT'S OK....I CAN HOOK IT UP MYSELF!"
It’s on the Internet. It **MUST** be true!
What is Your Inverter Efficiency?

Efficiency vs. Percent of Rated Power graph

- 80%
- 85%
- 90%
- 95%
- 100%

Percent of Rated Power

BEW Engineering, Inc.
Concerns about Instituting Another Product Certification

- Added cost
  - May disproportionately impact small manufacturers
- Delayed product introduction
- Delayed minor product improvements
- Restricted innovation/flexibility/customization
- Problems exacerbated by multiple jurisdictions with different requirements
- Problems relieved by more self-certification, less third-party
Who Requires, Who Pays?

• Who Requires:
  - Large purchasers
    • Historically: DOE, PVUSA, TEAM-UP, etc.
    • Currently: CE(?)
    • Soon: California implementing efficiency and power measurement requirements for CEC rebate program
  - Local Codes/Legislation
    • California Title 24 (Building Energy Efficiency) considering a section on PV

• Who Pays:
  - Tax Payers (when Govt’ funded)
  - Utility Rate Payers
  - Consumers
Who Certifies?

- **Certifying Body**
  - UL, PowerMark, PV Gap, CSA

- **Laboratory Accreditation**
  - OSHA, American Assoc for Laboratory Accreditation (A2LA), National Voluntary Laboratory Accreditation Program (NVLAP; through NIST)

- **Testing Laboratory/Agency**
  - Nationally Recognized Testing Laboratory (OSHA or otherwise), other 3rd party testing agency, manufacturer, owner/installer
Who Tests?

- **Manufacturer**
  - Preferred: least cost
  - Done as part of development/ongoing QC
  - Can be witnessed

- **Owner/Installer**
  - Larger systems
  - Usually limited to field tests
  - More “system”, less “component”

- **3rd Party Testing Laboratory/Agency**
  - When results are contentious
  - When results are critical
  - When mfg data is suspect
  - When owner/installer is unable or unwilling
  - When required by contract or legislation
  - Should be minimized for cost reasons
What Tests?

• For example, one or more of the tests from...
Proposed Performance Test Procedure

Sandia Performance Test Protocol for Evaluating Inverters Used in Grid-Connected Photovoltaic Systems

Ward Bower
Chuck Whitaker
Bill Erdman
Mike Behnke

www.endecon.com click on Sandia PV Inverter Performance Test Procedure DRAFT

BEW Engineering, Inc.
Performance Test Protocol:
Outline

• General Requirements
• Test Equipment Requirements
• DC Input Characterization
• **Maximum Continuous Output Power**
• Inverter Efficiency
• Maximum Power Point Tracking Accuracy
• Tare Losses (nighttime)
• Power Foldback
• Inverter Performance Factors
## Performance Test Protocol: Test Equipment Requirements

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Allowable Maximum Uncertainty</th>
<th>Preferred Maximum Uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC Voltage</td>
<td>± 1% of reading</td>
<td>± 0.25% of reading</td>
</tr>
<tr>
<td>AC Voltage</td>
<td>± 1% of reading</td>
<td>± 0.25% of reading</td>
</tr>
<tr>
<td>DC Current</td>
<td>± 1% of reading</td>
<td>± 0.5% of reading</td>
</tr>
<tr>
<td>AC Current</td>
<td>± 1% of reading</td>
<td>± 0.5% of reading</td>
</tr>
<tr>
<td>DC Power</td>
<td>± 1% of reading</td>
<td>± 0.5% of reading</td>
</tr>
<tr>
<td>AC Power</td>
<td>± 1% of reading</td>
<td>± 0.5% of reading</td>
</tr>
<tr>
<td>AC Frequency</td>
<td>± 0.05 Hz</td>
<td>± 0.01 Hz</td>
</tr>
<tr>
<td>Temperature</td>
<td>±1°C</td>
<td>±0.5°C</td>
</tr>
</tbody>
</table>
Performance Test Protocol: DC Input Characterization

- Define operating voltage and current ranges
- Max Vop is limited by inverter max system voltage, array Vop/Voc (typically <0.8)
  - For Vsys, max = 600Vdc, Max Vop = 480Vdc
Performance Test Protocol: 
Maximum Continuous Output Power

- Measure Output Power
  - 3 hours @ “rated” output
    - After thermal stabilization
  - Maximum rated ambient temperature
    - Additional testing may be done at lower temperatures
  - Various Input/Output Voltages (5 conditions)
Performance Test Protocol: Efficiency

• Measure efficiency over ranges of relevant conditions:
  - Power Level (~7 conditions)
  - Input Voltage (3 conditions)
  - Output Voltage (3 conditions)
  - Ambient Temperature (2 conditions)
Performance Test Protocol: Efficiency Measurement Issues

• Issues
  – Power Level
    • Maximum Rated Power needs to be strictly defined
  – Input/Output Voltage
    • Performance at extremes (Vdc, Vac) is of interest for modeling; help bound performance characteristics
    • How many test points are enough/too many?
  – Ambient Temperature
    • Passively cooled units can be sensitive to forced convection
  – Ancillary equipment: What should be included?
    • External transformers, fans, displays, etc.
Performance Test Protocol: Maximum Power Point Tracking Accuracy

- Most Problematic Test
- Static and Dynamic Tests Defined
- Using PV
  - Standardized/Characterized PV array or Intermittent IV curves
  - Measurement uncertainty exceeds expected MPPT accuracy—good for finding gross errors
  - Limited configurations, characteristics
  - Time consuming
- Using PV Simulator
  - Wide range of characteristics and programmable control
  - Good repeatability
  - Few suppliers, custom equipment, nearly as expensive as PV
  - Unknown uncertainty, unknown response characteristics (how “PV-like” is it?)
Performance Test Protocol: Tare Losses

- Losses related to startup/standby/shutdown operation
  - Control power
  - Transformer magnetization power

- Magnitude and duration are both important
Performance Test Protocol: Foldback

- Reduction in output power due to over-power/over-temperature conditions
- How does unit respond to high input power conditions (e.g., extreme irradiance conditions)
- What conditions lead to thermal foldback, and what is the response
Arco Solar 5.2 MWac
Carrisa Plains
Next Steps

Now:
• Continue to Obtain Industry and User Input and Feedback
• Refine Information Needs and Test Procedures
• Publish Sandia Report
• Submit to IEEE/IEC for Adoption as a Standard

Later:
• Identify Certifying Body
• Develop Certification Requirements
• Define Lab Accreditation Requirements
Conclusion

- Certification Program must be
  - Standardized
  - Cost Effective
  - Flexible
  - Valuable to the Consumer

- These are achievable goals