Inverter Performance Certification:
Does it make sense?

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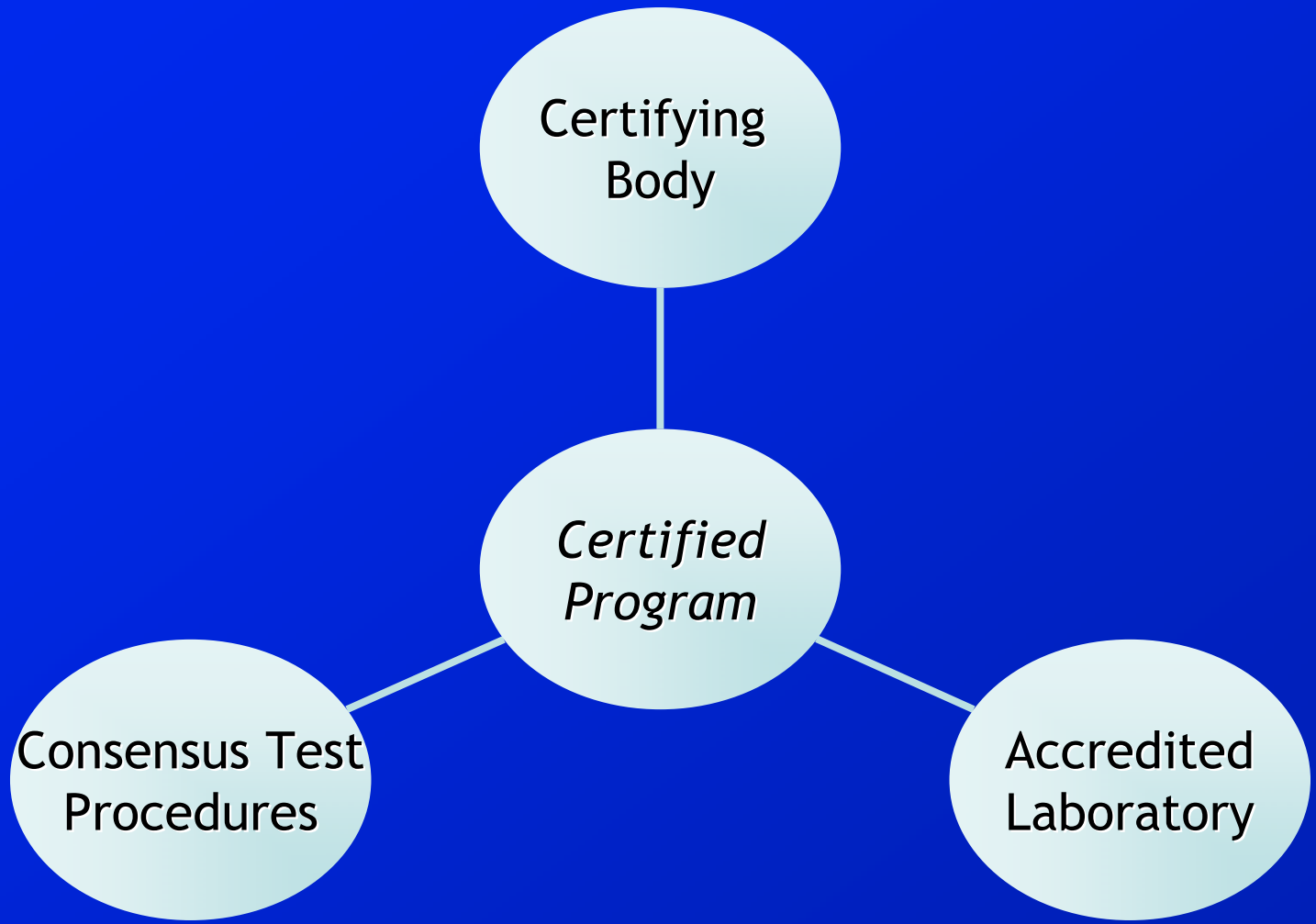
Certification...

...is not a four-letter word

Types of Certification

Formal Product Certification



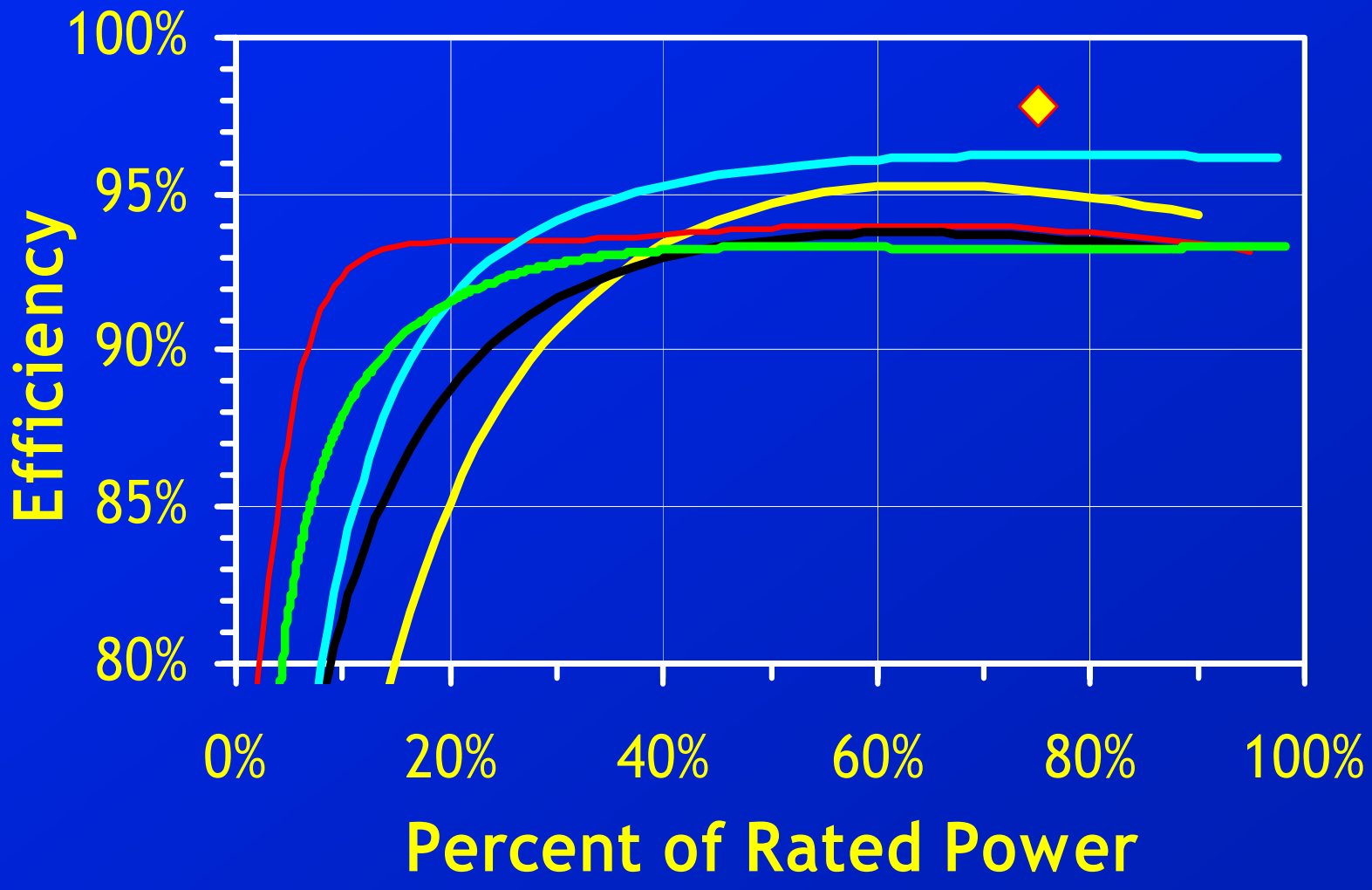
Why Do We Need Another Certification?

- 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!"


003/45/7844
It's on the Internet. It *MUST* be true!
ISAT GeoStar 45
23:15 EST 14 Aug. 2003

What is Your Inverter Efficiency?



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

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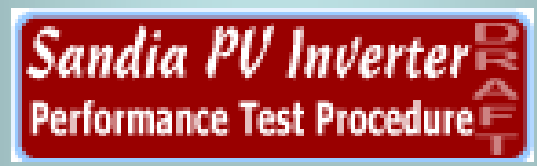
www.endecon.com click on



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

Parameter	Allowable Maximum Uncertainty	Preferred Maximum Uncertainty
DC Voltage	± 1% of reading	± 0.25% of reading
AC Voltage	± 1% of reading	± 0.25% of reading
DC Current	± 1% of reading	± 0.5% of reading
AC Current	± 1% of reading	± 0.5% of reading
DC Power	± 1% of reading	± 0.5% of reading
AC Power	± 1% of reading	± 0.5% of reading
AC Frequency	± 0.05 Hz	± 0.01 Hz
Temperature	±1°C	±0.5°C

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


ASE/Ascension 300W
©New England Electric

Arco Solar 5.2 MWac
Carrisa Plains


DC SOURCE
CIRCUIT ENCLOSURE
DANGER HIGH VOLTAGE


xantrex


Microdine

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