Measurement and Standards: The Role of NIST

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NIST Mission

To promote U.S. innovation and industrial competitiveness by advancing

- measurement science,
- standards, and
- technology

in ways that enhance economic security and improve our quality of life.

NIST was founded in 1901 as the National Bureau of Standards and became the National Institute of Standards and Technology to recognize NIST’s broader mission.
NIST at a Glance

Major Assets

- ~2,800 employees
- ~2600 associates and facilities users
- ~1,600 field staff in partner organizations
- ~400 NIST staff serving on 1,000 national and international standards committees

Major Programs

- NIST Laboratories
- Baldrige National Quality Program
- Manufacturing Extension Partnership
- Technology Innovation Program
NIST Laboratories

- Manufacturing Engineering
- Physics
- Nanoscale Science and Technology
- Neutron Research
- Technology Services
- Electronics and Electrical Engineering
- Information Technology
- Materials Science and Engineering
- Chemical Science and Technology
- Building and Fire Research
Why Do Measurements Matter?

Consider Solar Module Ratings

**Issue:** International round robin showed significant variation in basic measurements such as peak power

“Results from the Second International Module Inter-Comparison”, Rummel S., Emey, K, King, D., et al., 2006
NIST Activities:
Measurement Traceability

As the National Metrology Institute, NIST is charged with providing measurement traceability to the SI

- provide the traceability that underpins comparison across companies, labs, and nations

- provide measurement services for optical quantities (power, spectral responsivity, optical thermometry, etc.) and electrical quantities (power, voltage, current, waveform, etc.)

- provide international coordination of units
  - CIPM Consultative Committee for Thermometry (Radiation Thermometry)
  - CIPM Consultative Committee for Photometry and Radiometry

Primary Optical Watt Radiometer
Trap transfer detectors
NIST Activities: Solar Module Ratings

NIST is improving measurement techniques to reduce overall uncertainty by:

- developing high-speed radiometry to eliminate need for reference modules
- developing rating methods directly traceable to SI units
- developing energy production rating methodologies in lieu of power under ideal conditions
NIST Activities: Simulation Tools and Validation Data

**Issue**: PV simulations do not accurately predict energy production under various field conditions.

**Solution**: NIST collected performance data for PV model validation under a wide-range of conditions:

- various geographical locations
- building orientations
- mounting techniques
- photovoltaic cell technologies

The test facility enables a side-by-side comparison of various mounting techniques as well as provide data on performance of various photovoltaic cell technologies.
NIST Activities:

**Power Conditioning Systems**

**Issue:** DC solar energy requires integration with household AC systems & utility DER (Distributed Energy Resource) programs

**Solution:** NIST measurements to support development of power conditioning electronics that convert the unregulated DC power to (and from) 60 Hz AC power

- Perform measurements & develops test methods for high power PCSs
- Created “de facto standard” model used to enable development of IGBT power devices and systems used in PV systems
- NIST leads the interagency group that coordinates federal programs and information exchange for power conditioning devices
NIST Activities: Photovoltaic service life

**Issue:** How can we estimate service lifetime, and is there a way to simulate aging for rapid testing?

**Solution:** Methodologies and metrologies are needed to rapidly assess PV long-term performance/reliability and characterize aging mechanisms in PV systems and component materials.

**NIST Accelerated Weathering Device**

- Simulated Photodegradation via High Energy Radiant Exposure (SPHERE)
- 8400 W UV ≈ 22 “SUNS”
- 95% exposure uniformity
- Precise control of temperature and relative humidity around specimens
NIST Activities: Semiconductor Device Metrology

**Issue:** interface defect generation decreases PV efficiency and causes degradation

Generated defects at the SiO2/Si interface increase carrier recombination

**Solution:** Research in CMOS device reliability is identifying key issues and promising directions:

- NIST research revealed that mechanism for interface defect generation by above bandgap photons in PVs solar is similar to electrical stress as well as Negative-Bias-Temperature-Instability in MOSFET.

...what about lifetime of supporting electronics in PV systems?
Future NIST Activities: Measurements to Enable Next-Generation Photovoltaics

**Issue:** New measurement tools are critical to the development of the next generation of photovoltaic materials.

**Solution:** NIST is working to develop necessary measurement science by developing techniques to measure:

- carrier generation at wavelength (and subwavelength) scales
- carrier transport (mobility, recombination, lifetime) with at microscale (and nanoscale) resolution
- electron and hole concentration in individual 3D nanoscale structures and in nanostructured arrays
NIST Standards Activities:

**Solar-Related Documentary Standards**

**Issue:** Gaps exist in the portfolio of PV-related measurement and documentary standards.

**Solution:**

NIST researchers participate on various standards committees related to solar energy:

- ASTM E44 - Committee on Solar, Geothermal and other Alternative Energy Sources
- ASTM E44.09 - Committee on Photovoltaic Electric Power Conversion

NIST is planning to conduct a documentary standards gap analysis for the PV/solar energy technology sector.
NIST Standards Activities:

**Smart Grid Documentary Standards and Solar**

**Issue:** Renewable energy sources need to be integrated into the proposed Smart Grid.

**Solution:** NIST Smart Grid Interoperability Standards efforts supports increased use of renewable energy sources.

- NIST Roadmap effort is identifying additional work for standards to support integration of PV (solar) and other renewable energy sources
- Relevant standards:
  - IEEE 1547-3,4,6
  - IEC 61850-7-420 (for PV Inverters)
  - Zigbee Smart Energy Profile (Home Area Network)
  - PV Inverter Communication Project
Collaborations

DOE

Energy Efficiency and Renewable Energy (EERE Solar Energy Technologies Program)

Office of Electricity

National Renewable Energy Laboratory (NREL)

Federal Energy Regulatory Commission (FERC)

IEEE, ASTM & various standards groups

BIPM/CIPM

Inter-agency Advanced Power Group, Electrical Systems Working Group (ESWG) chair