

# International Standards for Renewable Energy Sources

---



**A. Hunter Fanney**

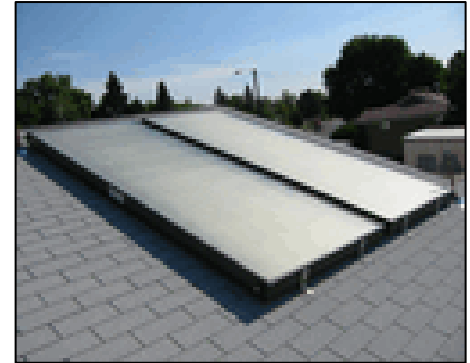
**National Institute of Standards and Technology**

**November 12, 2007**

# Presentation Overview

---

- The Need for Renewable Energy
- The Case for Renewable Energy Standards
- Early Attempts/Challenges (U.S. Perspective)
- A Success Story in Renewable Energy Standards
- A Current Testing Challenge – PV Module Ratings



# Primary Energy Consumption

## Millions of Tonnes of Oil Equivalent (Data from BP Corporation)

Region	2001	2002	2003	2004	Average Increase/Year	2004 Change Over 2003
North America including USA	2,681.5	2,721.1	2,741.3	2,784.4	1.3%	1.6%
USA	2,256.3	2,289.1	2,298.7	2,331.6	1.1%	1.4%
South And Central America	452.0	454.4	460.2	483.1	2.2%	5.0%
Europe and Euro-Asia	2,855.5	2,851.5	2,908.0	2,964.0	1.3%	1.9%
Middle East	413.2	438.7	454.2	481.9	5.3%	6.1%
Africa	280.0	287.2	300.1	312.1	3.7%	4.0%
Asia Pacific	2,497.0	2,734.9	2,937.0	3,198.8	8.6%	8.9%
World	9,179.3	9,487.9	9,800.8	10,224.4	3.7%	4.3%

*\*This data does not include traditional Biomass which was 2,229 MTOE in 2002 according to IEA data*

**2001-2004 Increase 3.7% (Asia Pacific 8.6%)**

**2003-2004 Increase 4.3% (Asia Pacific 8.9%)**

# The Need for Renewable Energy

---

## Future Energy Projections

Average annual growth rate of 2%(low estimate) will result in primary energy demand

- **doubling by 2037**
- **tripling by 2057**

# The Need for Renewable Energy

---

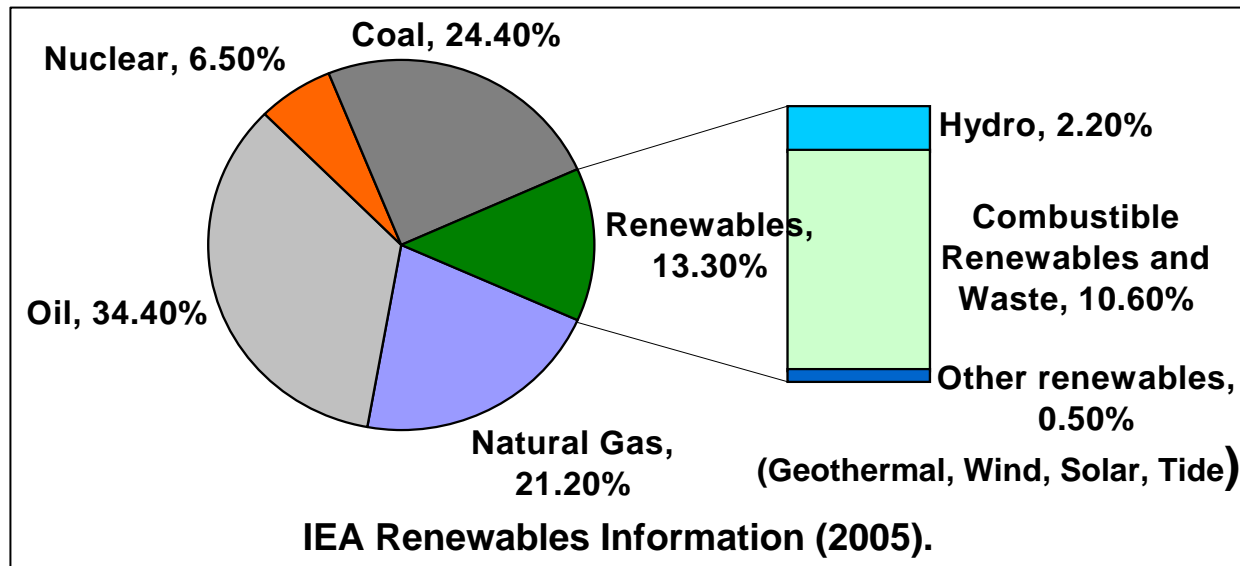
## Projected Depletion of Current Fuels

Oil Reserves – 41 Years

Natural Gas – 40 Years

Coal – 164 Years

## 2003 Fuel Shares in World Total Primary Energy Supply



# Renewable Energy

## Direct and Indirect Forms of Solar Energy



**Renewable Resources will have to provide at least 50% of the world's energy by 2050**



# International Renewable Energy Standards – The Need

---

- Overcome technical barriers in the international commerce of renewable energy products
- Provides the tools/metrics to assess energy savings potential
- Meet the testing/certification needs of the growing international renewable energy market
- Reduce trade barriers resulting from different countries adopting varying standards
- Provides assurance that existing/emerging renewable products meet expectations



# Challenges to the Development of Performance Measurement Standards for Solar Hot Water Systems (Circa 1977- 1984)

---

## Outdoor Testing

- Time Consuming
- Difficult to repeat due to variable weather conditions
- Resulting performance indicative of prevailing weather conditions



# Challenges to the Development of Performance Measurement Standards for Solar Hot Water Systems – (Circa 1977-1984)

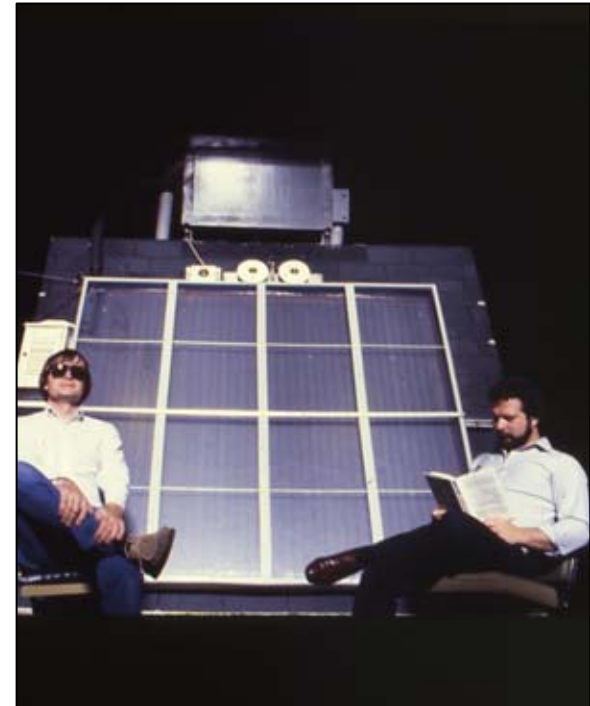
---

## Indoor Testing Using Solar Simulator

- Expensive
- Applicable to all system types
- Resulting performance indicative of simulated conditions
- Lacked ability to predict annual performance



*Refrigerant Charged Solar Hot Water System Evaluated Outdoors at NBS and Indoors at National Solar Test Facility in Canada*



# Challenges to the Development of Performance Measurement Standards for Solar Hot Water Systems – (Circa 1977-1984)

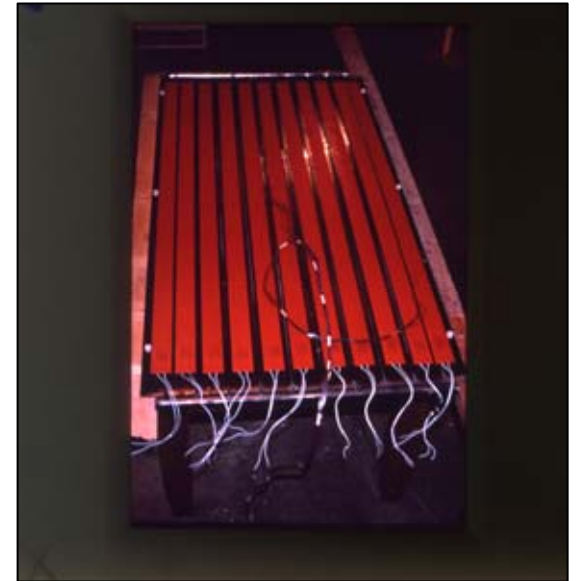
---

## Indoor Testing Using Electric Strip Heaters

- Not Applicable to all system types (example – evacuated tubular solar collectors)
- System integrity compromised
- Resulting performance indicative of simulated conditions
- Lacked ability to simulate annual performance



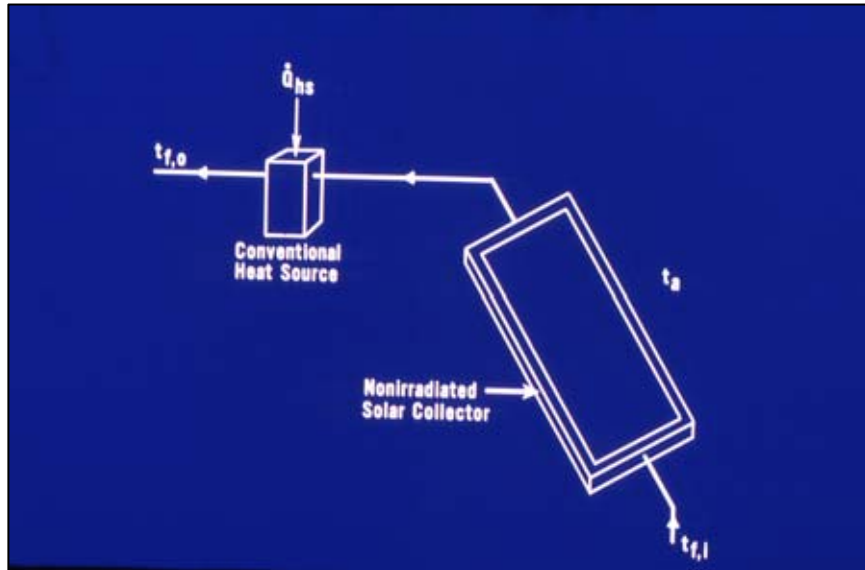
*Power Input to Electric Strip Heaters Manually Adjusted to Replicate Absorbed Solar irradiance – NBS 1981*



# Challenges to the Development of Performance Measurement Standards for Solar Hot Water Systems – (Circa 1977-1984)

## Indoor Testing Using Non irradiated Collectors + Heat Source

- Not applicable to all system types (thermosyphon and integrated collector storage)
- Resulting performance indicative of simulated conditions
- Lacked ability to simulate annual performance



Electric Conventional Heat Source and Vacuum Insulated Enclosure

*Power Input to Conventional Heat Source Adjusted Such That Combination of Heat Source and Non-irradiated Collector Array Replicated Thermal Output of Irradiated Solar Collector Array*

# A Success Story In Renewable Energy Standards

---

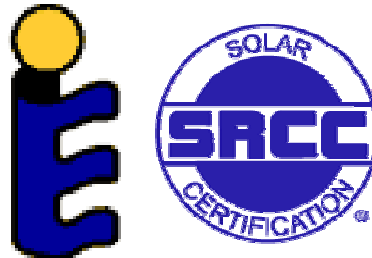
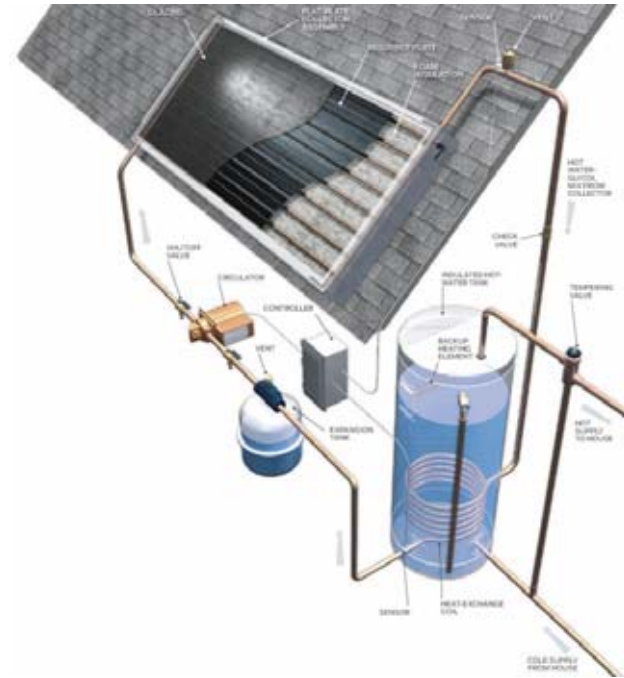
## Testing and Rating Methods for Solar Hot Water Systems

### Performance Test Methods

- Five ISO Standards produced
  - ISO 9459-1,-2,-3,-4,-5
- European National Standards
  - EN 12976-2, ENV 129777-2
- U.S. Standards
  - ASHRAE 95, SRCC TM-1/OG300

### Certification Bodies

- Solar Keymark (Europe)
- SRCC (US)



# A Success Story In Renewable Energy Standards

## Testing and Rating Methods for Solar Hot Water Systems

ISO has produced five international standards on SDHW testing

- ISO 9459-1 (USA)
  - Uses solar simulator or thermal simulator
  - Permits comparisons of solar systems under identical conditions
  - Based on ASHRAE Standard 95 – Standard day, not annual, performance
- ISO 9459-2 (China, Japan, Korea, Taiwan)
  - Solar only systems, no auxiliary heaters
  - Produces “input-output” characteristics for a system
  - Results combined with daily mean values of solar irradiance, ambient temperature, and inlet water temperature to predict annual performance
- ISO 9459-3
  - Solar plus supplemental systems
  - Uses “black box” procedure to correlate data collected during outdoor testing
  - Correlation coefficients used to predict annual performance
  - Requires same load pattern in “actual use” to load pattern used during testing



# A Success Story In Renewable Energy Standards

## Testing and Rating Methods for Solar Hot Water Systems

---

- ISO 9459-4 (Australia, USA)

- Solar only systems
- Combines component tests with simulation tools
- Results in “input-output” characteristics of solar system
- Predicts annual system performance
- Solar only (no auxiliary) systems

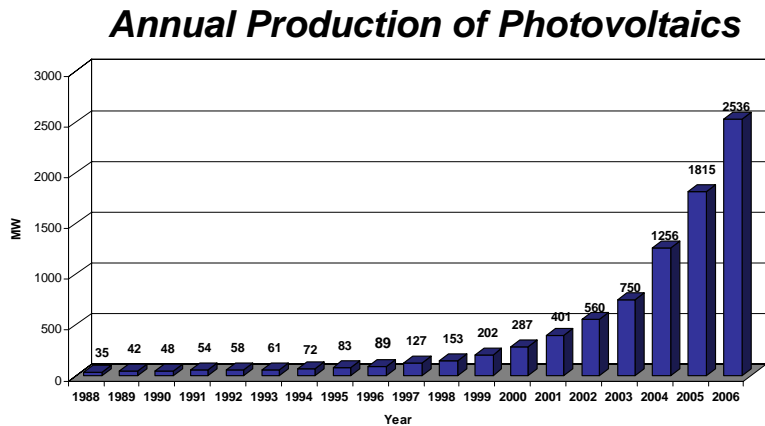


- ISO 9459-5 (Europe)

- Dynamic performance measurement and parameter identification procedure
- Performance data captured frequently (2 minutes) and system parameters computed that produce closest match to measured performance
- Parameters in conjunction with hourly values of solar radiation, ambient air, and cold water inlet used to predict annual performance

# Current Challenge in Renewable Energy Testing/Standards PV Module Power Rating

- Significant Uncertainty (+/- 6%) Present in Photovoltaic Power Rating



- Photovoltaic Modules Compete on Dollars Per Watt

• Examples:

• \$4.31 per watt at SRC for Multicrystalline Module (05/17/07)

• \$3.00 per watt at SRC for Thin Film Module (05/17/07)

- Module rating uncertainty can result in significant loss/gain of revenue

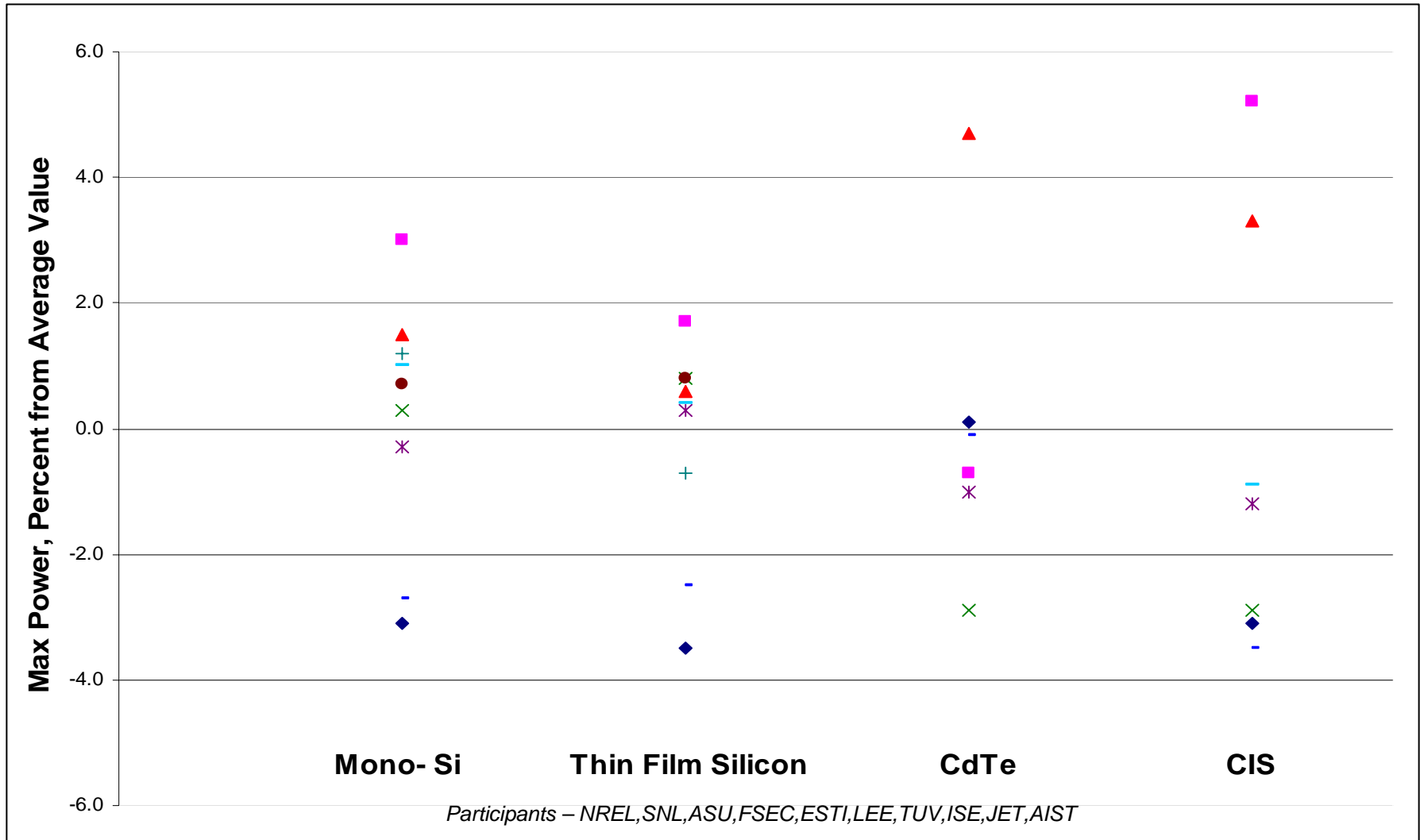
• Example – 5 percent uncertainty in module power rating

• 5 kW System (typical residential) - Over/under payment \$1250

• 100 kW Commercial Installation – Over/under payment \$25,000

# Current Challenge in Renewable Energy Testing/Standards

## Measured PV Module Rating – Standard Reporting Conditions



*"Results from the Second International Module Inter-Comparison", Rummel S., Emey K, King, D., et al.*

# Current Challenge in Renewable Energy Testing/Standards Measured PV Module Rating

## *Outdoor Testing Challenges*

- Limited Windows of Opportunity
  - Clear Sky Conditions
  - Low Wind Velocity Conditions
- Outdoor Variable Conditions
  - Solar Irradiance
  - Solar Spectrum
  - Wind Velocity/Direction
  - Cell Temperature
- Requires Translation from Performance Measurements under Outdoor Conditions to Standard Reporting Conditions
- Significant Uncertainty in Solar Radiometric Measurements

### Standard reporting conditions

- Solar Irradiance 1000 W/m<sup>2</sup>
- Module Temperature 25 C
- Incident Angle – 0 Degrees
- Solar Spectrum – ASTM E892/IEC 904-3



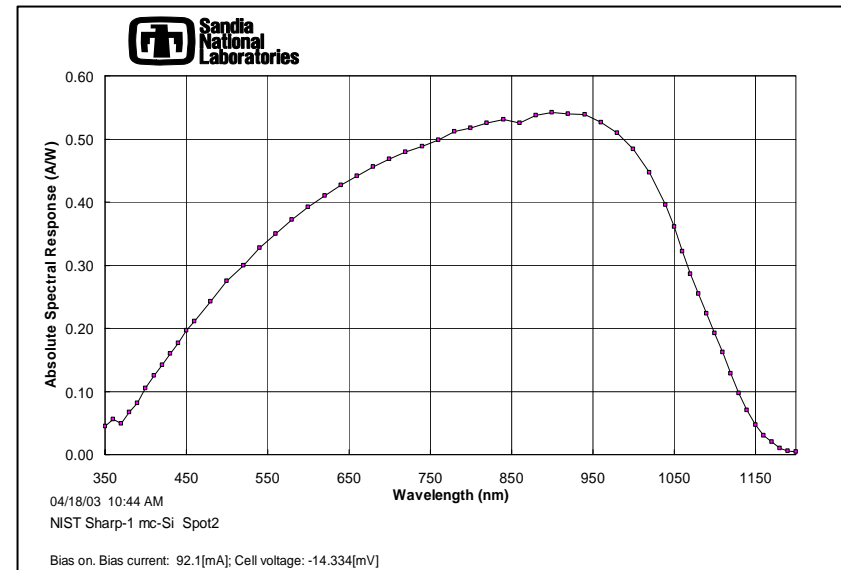
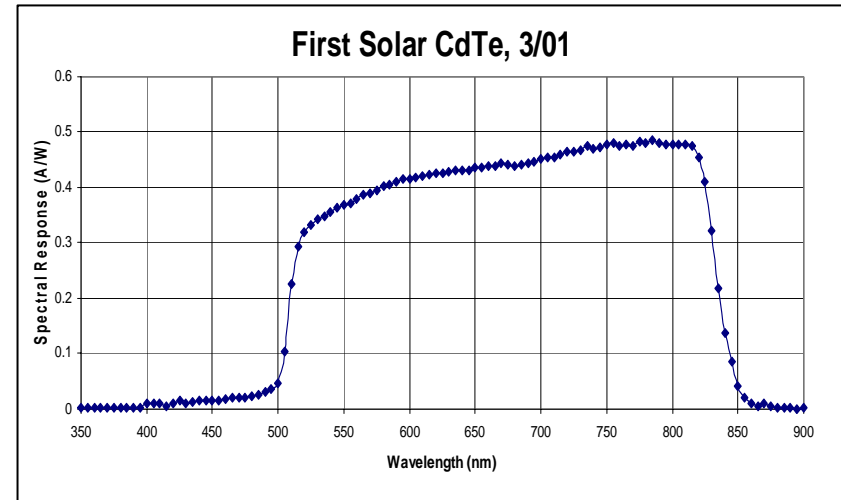
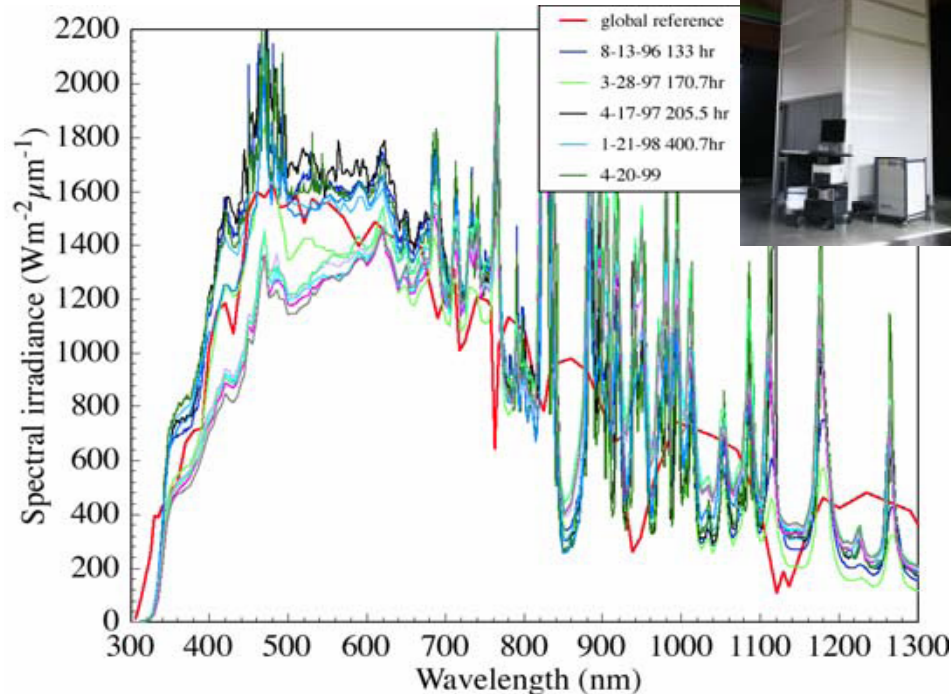
*NIST's Outdoor Solar Test Facility*

# Current Challenge in Renewable Energy Testing/Standards

## Measured PV Module Rating

### Indoor Testing Challenges

- Large Uncertainty in Solar Radiometric Measurements
- Difficult to Replicate Outdoor Solar Spectrum with Simulators
- Solar Simulator Spectrum Varies with Lamp Age/Temperature
- Time response of select PV technologies to flash duration
- PV Cell Performance Function of Spectrum



# Summary

---

- Renewables are needed to address the world's growing energy appetite
- Early struggles to develop solar hot water testing and rating resulted in
  - Widely accepted National/International Standards
  - Renewable energy certifying bodies (Keymark/SRCC)
- Must continue to develop/improve the measurement science, methods of test, and performance metrics associated with renewable energy

