NATIONAL RENEWABLE ENERGY LABORATORY

Welcome!

NREL Pyrheliometer Comparisons 2014

NPC-2014

22 September – 3 October

NPC-2013 Participants

15013 Denver West Parkway
Golden, CO 80401
Phone 303-275-3000

NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy
Operated by the Alliance for Sustainable Energy, LLC

Radiometers at the Solar Radiation Research Laboratory (SRRL)

Welcome to the 18th NREL Pyrheliometer Comparisons NPC-2014

22 September – 3 October 2014
Solar Radiation Research Laboratory
Golden, Colorado

The purpose of this NPC is to provide participants with current World Radiometric Reference (WRR) reduction factors for their absolute cavity radiometers and other reference pyrheliometers based on results from the 11th International Pyrheliometer Comparisons (IPC-XI) conducted 27 September – 15 October 2010 at the Physikalisch-Meteorologisches Observatorium Davos/World Radiation Center (PMOD/WRC). Information about IPC-XI is available from: **www.pmodwrc.ch/pmod.php?topic=ipcxi**

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SRRL Staff

Quality Management Systems & Assurance Office
National Center for Photovoltaics - Solar Resources & Forecasting Group

Afshin Andreas	Computer Issues, NREL Cavity Operations
Linda Crow	Host (Security, Logistics, Food)
Mike Dooraghi	Solar Trackers, Tools, Electronics and Hardware
Aron Habte	General Assistance, Data collection and compilation
Mark Kutchenreiter	Electrical Power, Tools, Electronics and Hardware
Preston Morse	NREL Cavity Setup and Operations
Martina Newman	Host (Security, Logistics, Food, Wireless Access)
Ibrahim Reda	NREL Cavity Operations, NPC Data Collection & Processing, General Cavity Assistance
Manajit Sengupta	General Assistance

SRRL Location

Solar Radiation Research Laboratory
(SRRL)

Latitude:	39.742 N
Longitude:	105.18 W
Elevation:	1828.8 m AMSL
Mean Station Pressure:	820 mBar
Time Zone:	(GMT – 7.0)
Phone:	303-384-6326
Emergency Phone:	1234 (on-site)

Telephone Numbers:

EMERGENCY = 303-384-6811

Or

1 2 3 4 (From ***any*** NREL Desk Phone)

SRRL = 303-384-6326

NREL Pyrheliometer Comparisons
NPC-2014

Safety

Emergency Phone: **RED BOX** UNDER INSTRUMENT DECK
OR Press **1 2 3 4** from any NREL extension

Evacuation Assembly Area: Northeast Corner of Parking Area

Security

Phone: 303-384-6811 or Press 6811 from any NREL extension

NREL *Visitor Badges* issued on first day of NPC at the Visitor Center. If you are NOT a U.S. Citizen, then please present the same documentation (Passport, Visa, etc.) you used on the NREL Foreign National Data Card (FNDC). Please wear your badge at all times at SRRL.

Communications

SRRL Phone: 303-384-6326 (also rings outside)

Local (Long Distance): Press **9** – (1) Area Code – Number

Wireless available at SRRL – ***Please see Martina for details***

Food & Beverages

Lunch Menu will be circulated daily by 9:30 MDT

Non-alcoholic Beverages and snacks provided

Equipment Storage

Please use ***designated areas*** in SRRL staging areas.

NPC-2014 Protocol Summary

Ibrahim Reda

1. Schedule

DAY # 1 September 22nd

a. Visitor check-in at NREL Site Entrance Building,
15013 Denver West Parkway, Golden, CO 80401.
Please plan to arrive at NREL between 07:30 and 08:30 MDT.
b. Drive to SRRL – Call 303-384-6326 to open gate
Locate your equipment and review seating charts
c. 09:00 MDT - Safety and SRRL orientation briefing for all participants.
Review of NPC Protocol
d. 09:30 MDT - Equipment Installation & tests:
Dry Weather - See the ***seating diagram*** on page 9 for your workstation.
Wet Weather – Assemble and bench test your equipment inside SRRL.
e. 12:00 MDT - Conclude equipment tests as needed.
f. Review measurement protocol and procedures.
g. 13:00 to Sunset - Practice and/or NPC measurements (weather permitting)

DAYS #2-12: 23 September through 03 October (*Daily*, including the weekend):

a. Clear sky = Take Measurements!
-Arrive at SRRL by 08:00 MDT
-Equipment warm-up for at least 30-minutes
-First Cavity Calibration at 08:55 MDT
-Begin comparison "Runs" by 09:00 MDT (08:00 MST)
-Continue measurements until sundown or the clouds interfere.

b. Cloudy sky = No Measurements, but optionally...
-Review of previous day's data analyses
-Technical Briefings on Radiometry, Measurement Network Operations, etc.
-Equipment Tests
-NREL Tours
-Office Time (wireless available)

c. We will determine the need for continued measurements at the end of each day.

2. SRRL Coordinates

Program your solar tracker using:

LAT = 39.7425º North
LON = 105.1778º West
ELEV = 1828.8 m above Mean Sea Level (6,000 ft)
BARO = 820 mBar (average station pressure)

3. Time Keeping

-Wim Zaaiman will again be our timekeeper (as long as his voice holds out!)
-***All time records will be Mountain Standard Time (MST)***
-Outdoor time display is available for guidance ***(Wim's time is the Reference Time!)***
-The NIST atomic clock is a local call: 9-303-499-7111.
-We need to keep all PC clocks in agreement to better than 2 sec.
-***Set your system clock at the daily start-up*** or as often as needed to keep 2-second accuracy. Check personal computer clocks during the day.

4. Minimum Data Set

Our goal for a minimum data set for these comparisons is to measure irradiance during three different days (all day or portion). Historically, we have acquired more 3,000 data values for each participating cavity radiometer. At least 300 data values are needed to provide a valid transfer of the WRR to the participating radiometers.

5. Measurements

- Do NOT apply any previous **WRR** correction factors to your measurements.
- Use only the **factory calibration factor** to adjust your data beyond any other adjustments you feel are needed to correct your data (e.g., pre- and post-calibration drifts in sensitivity are OK). As in the past, we will use the following terms:

"Calibrate" = Perform electrical calibration and wait for next measurement period to begin

"Read" = A measurement of direct irradiance within 1 sec of announcement at 20-sec intervals.

"Run" = Collection of 37 readings taken in sequence (also called a *Series*).

The *Timekeeper* will make the following announcements for each Run:

Next Run Begins at HH:MM (MST) [HH:MM (MDT)]
T minus 6 minutes. BEGIN CALIBRATION
T minus 3 minutes
T minus 2 minutes
T minus 1 minute
T minus 30 sec
T minus 10 sec
T minus 5 - 4 - 3 - 2 - 1 - READ!

Continued countdowns at 20 sec intervals until 37 readings have completed a "Run"

6. Data Transfer

The following *standard data format* will be used by each participant to improve our data processing efficiency. Please see Reda if you have any questions about the data format.

a. Single instrument per file:

YYYYMMDD,HH:MM:SS,NNNNN,XXXX.XX

b. Multiple instruments per file:

YYYYMMDD,HH:MM:SS,NNNNN,XXXX.XX,NNNNN,XXXX.XX,...

Where, for each RUN of 37 measurements:

YYYY	=	Year
MM	=	Month
DD	=	Day of Month
HH	=	Hour (Mountain Standard Time) of RUN Start
MM	=	Minute " " " "
SS	=	Second " " " "
NNNNN	=	Radiometer Serial Number (not limited to 5 figures)
XXXX.XX	=	Irradiance (Watts per square meter)

After the last daily RUN, and ***before*** equipment tear-down, place your *USB Flash Drive* in the "IN BOX" or e-mail message with your corrected irradiance data. Cavity calibration files are not needed.

7. Data Processing

-Reda has developed an Excel spreadsheet system for reducing the data.

8. Data Reporting

-Our goal is to provide each participant with next-day analyses.
-NPC WRR Reduction Factors will be sent to the participants within one month of the comparisons.
-A final report will be published by NREL within six months of the comparisons.

9. Equipment Storage

-Each participant will be given space to store systems at SRRL.
-Please let us know if you wish to have any electronics connected to AC power while in storage.

10. Courtesies

-Please get permission before touching someone else's equipment (turning off power strips, adjusting trackers, etc.) to prevent inadvertent data loss.
-Please return borrowed tools to owner.

11. Dinner on Wednesday (September 24th)

Please join us for the NPC Dinner!

Dinner will be at a local restaurant and bar called the Rock Rest Lodge. Dinner will be BBQ and will be served buffet style. We will meet for dinner between 6:30 and 7:00 PM.

Schedule of Events (overview)

Monday, 22 Sept 2014

Obtain your NREL ***Site-Access Badge*** at the Site Entrance Building
Your host will meet you in the Research Support Facility:

1. Drive in LEFT lane to Site Entrance Building
2. Tell the attendant you are here for "NPC-2014" (You may need to show your passport/visa)
3. Receive a visitor parking card for your car and drive to covered parking lot immediately on the RIGHT.
4. Walk to the main entrance to the Research Support Facility (RSF).
5. Your host will greet you at the RSF reception desk where you will be issued your visitor badge
6. Drive to the *Mesa Top Facilities* to access SRRL
7. Call 303-384-6326 if you need the entrance gate opened.

Participants unpack and install equipment for testing
(Please use ***Seating Chart*** on next page)

Security will review ***important Safety, Security, & logistics*** information.

Clear Sky?	Take Solar Irradiance Measurements!
Cloudy, but no precipitation?	Take Practice Data

23 September through 03 October:

SRRL will be OPEN DAILY from 07:30 MDT to at least 17:00 MDT

Clear Sky?	Arrive SRRL by 08:00 MDT Install Equipment and allow electronics to warm up Prepare to TAKE DATA by 09:00 MDT!
Cloudy Sky?	Arrive SRRL by 09:00 MDT Technical Presentations RSF Conference Rooms

NREL Pyrheliometer Comparisons 2014
Seating Diagram

South

NREL Pyrheliometer Comparisons 2014
Seating Diagram

Tracker Info
Organizational Name
Participant Names

Providing own tracker	Providing own tracker
Kipp & Zonen USA, Inc	Sandia National Laboratories
Victor Cassella	Bill Boyson
Joop Mes	Charles Robinson
	Craig Carmignani

Bench # 1: Breaker # 2S

Providing own tracker	NREL Brusag (Spare)	Providing own tracker
DLR	PMOD	Black Photon Instruments
Stefan Wilbert	Nathan Mingard	Joachim Jaus

Bench # 2: Breaker # 4N

ARM-Brusag 1	ARM-Brusag 2
DOE Atmospheric Radiation Measurement (ARM) Program	European Commission Directorate General JRC
Craig Webb	Wim Zaaiman

Bench # 3: Breaker # 6S

Providing own tracker	NREL-SMT-3
The Eppley Laboratory, Inc	National Oceanic & Atmospheric Administration
Tom Kirk	Jim Wendell
John R. Hickey	Emiel Hall

Bench # 4 East: Breaker # 10

Bench # 4 West: Breaker # 8

Providing own tracker	Providing own tracker	Providing own tracker
Science Systems & Applications, Inc.	EKO Instruments USA, Inc	Atlas Weathering Services Group
Fred Denn	Tsukasa Kobashi	Erik Naranen
	Akihito Akiyama	
	Bill Dokos	

Bench # 5: Breaker # 2N

NREL-Solys2	NREL 2AP (Patio)
King Abdullah City of Atomic and Renewable Energy	University of Oregon
Hussain Shibli	Rich Kessler
Yaser Al Jnoobi	Josh Peterson

Bench # 6: Breaker # 7

BORCAL Brusag 1	BORCAL Brusag 1	BORCAL Brusag 1	NREL 2AP (Deck)
GroundWork Renewables Inc.	Brookhaven National Laboratory	Energy Research Institute King Abdulaziz City for Science and Technology	HuksefluxUSA, Inc.
Justin Robinson	Scott Smith	Abdulrahman S. Binsufayran	Jörgen Konings
		Ahmed F. Alghamdi	Robert Dolce
		Ayman K. Sheikho	
# of NIPs 3	**# of NIPs 1**	**# of NIPs 4**	**# of NIPs 0**

On SRRL BMS Platform

BORCAL Brusags
National Renewable Energy Laboratory
Ibrahim Reda
Preston Morse
Afshin andreas
Breaker #1

NREL 2AP (Patio)
Florida Solar Energy Center
Caleb Reninger
Table 1

Total Pyrheliometers needing tracker support	8

Attendees without Instruments	**Attendees without Instruments**
Campbell Scientific Inc.	Solar Resource Solutions, LLC
William Beuttell	Tom Stoffel
Matt Perry	Steve Wilcox

Tracker Not needed
Augustyn + Company
James Augustyn

NPC-2014 Technical Discussions: Candidate Topics

The following are simply suggestions for possible presentations and discussions. The first list is presentations that were offered NPC participants and the second list is topics that you would like to hear about. If there is a topic that someone would like to hear about and you would be willing to present on it, please let Mike know. These topics were taken from the NPC Surveys that you submitted. Also, let Mike know if you would like to add any other topics not listed! Presentations will most likely take place in our conference room at the SRRL.

Presentations offered by attending NPC participants

- Stephan Wilbert – Overview of Circumsolar Radiation
- Stephan Wilbert – RSI Calibration
- Steve Wilcox (with input from Aron and Reda) - Methods to calculate solar measurement uncertainty for field stations to produce values that satisfy the needs of the analysts and financiers.
- Fred Denn – Off-shore light house site
- Fred Denn – Determining AOD with a MFRSR

Presentation that participants said they would like to hear. If you can present on one of these topics, please let me know.

- Each participant group presents briefly (maybe 10 – 15 minutes) on how they use their cavities.
- Discussions about solar variability and methods that can be used to estimate spatial distributions required to properly quantify variability for resource assessment and performance monitoring of +100MW AC.
- Estimating cloud speed from multiple irradiance measurements, available methods and performance evaluation.
- Any information about radiometer working groups actively working on widely accepted method of irradiance measurement uncertainty estimation that includes thermopile and silicon based solar radiation measurement devices.
- Summary of in field performance of available off the shelf irradiance measurement devices (Kipp, Huks, EKO…).
- Comparison of RSR2 data to high quality active tracking thermopile based component sum measurements in various climate regimes.
- Evaluation of RSR2 data against active tracking thermopile based component sum measurements using measured GPS PWV data instead of ground based Temp/RH to drive LI200 corrections developed by Irradiance Inc.
- Uncertainty evaluation of NREL/Kern vs LiCor calibration factors when used in RSR2 (GHI, DNI & DHI) in comparison to active tracking thermopile based component sum across `various climatic regimes. Is the NREL/Kern calibration better, if so how much better, all three components?
- Diffuse measurement, spectral measurements, and how ISO 17025 improves uncertainty. –
- Development and Maintenance of the World Radiometric Reference (WRR)
- Absolute Cavity Radiometer Design and Operational Concepts
- BORCAL Process Overview
- Measurement & Data Aggregation Uncertainty Analysis (Concepts)