SOLAR SPECTRUM

Newsletter of the Resource Applications Division

Volume 18, Issue 1 – June 2005 of the American Solar Energy Society®

SATELLITE-BASED SOLAR RESOURCE ASSESSMENT:

SOCIAL, ECONOMIC AND CULTURAL CHALLENGES AND BARRIERS, TECHNOLOGICAL GAPS

by Richard Perez—ASRC, The University of Albany

ABSTRACT

Access to comprehensive solar resource information opens door to a solid analysis capability which often opens door to new solutions, better planning, better targeted R&D, and faster, more intelligent, development of solar energy. This pointed is articulated through two examples identifying overlooked solar energy development potential with appropriate solar resource information.

DEFINING THE ISSUE

Solar resource information is a broad term that encompasses all the data and parameters which characterize the radiation that drives solar energy systems.

The information may be as simple as an annual average gauging a local climate, or as detailed as a next-day forecasts for direct normal irradiance to manage and market the output of a solar thermal power plant. Likewise, prospective users of this information have a wide range of needs depending on their interests and objectives. Let's look at specific examples:

1. <u>Estimating the economic feasibility of a grid-connected residential PV or domestic hot water (DHW) system</u>: In most cases the solar resource information already published under the form of Typical Meteorological Years (TMY) or even climatological monthly averages, even with the current level of accuracy and/or limited geographical coverage, should be more than adequate to make

(Continued on page 8)

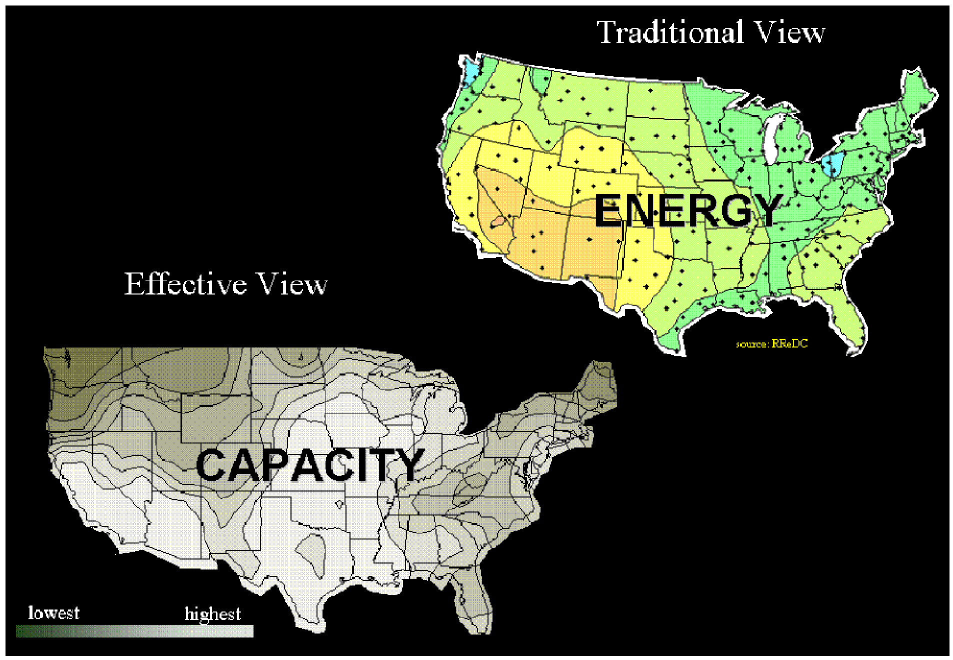

Fig. 1: Comparing climatic solar energy resource map (top right) and effective load carrying capability maps of the United Sates

Inside This Issue

Solar Spectrum is the newsletter from the Resource Applications Division of the American Solar Energy Society and is published on a semi-annual basis. The purpose of this newsletter is to inform division members of events in the resource assessment field and activities of the division and its members.

Success of the newsletter depends on your contributions.

You are encouraged to send comments, letters, or short articles to the Editor:

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email: fev@uoregon.edu

I would like to thank Chris Gueymard, Richard Perez and Gary Vliet for their contributions to this newsletter.

Deadline for contributions to the next newsletter is October 1, 2005.

Frank Vignola

Resource Applications Division Officers

Gary Viet, Chair
Jim Bing, Vice Chair
Jim Augustyn, Secretary

Upcoming Events

ISES World Congress
Bringing Water to the World
Aug 14-19, 2005

Orlando, Florida
Kenneth Sheinkopf
Information: Florida Solar Energy Center, of the University of Central Florida,
1679 Clearlake Road
Cocoa, Florida 32922
Tel 321-638-1007
Email: Sheinkopf@fsec.ucf.edu
http://www.swc2005.org

There will be a lot of activities in Davos next Fall: the 10th IPC, the 2nd sunphotometer intercomparison, the 9th NEWRAD conference, and a UV workshop.

http://www.pmodwrc.ch/ipcx/

http://www.pmodwrc.ch/newrad2005/

http://www.pmodwrc.ch/pmod.php?topic=events

RAD Division Officers and Board—In transition

The Resource Applications Division of ASES in undergoing re-organization. The makeup of the division and its board will be discussed at the next RAD division meeting at Solar 2005.

There is an ongoing discussion The division meeting has tentatively been scheduled for Monday, Thursday August 11, 2005 from 12:30-1:30 pm. This is a chance to help shape the future of the RAD division.

Currently the RAD division activities are mainly associated with the annual conference. In the past the division has put together forum or workshops, helped select reviews for the review of papers, and suggested members of the conference technical review committee. The division also helps in the nominations of the division member to the ASES board.

Email Addresses for Resource Applications Division Members

In order to open communications between RAD division members, the following members circulated their Email address at the RAD division annual meeting. If you are not on this list and would like to add your name to the list, contact Solar Spectrum's editor and your Email address will be added to the list and published in the next newsletter.

Please notify the editor of changes.

Augustyn & Company .. jimaugustyn@solarcat.com
Ray Bahm....................... r.bahm@ieee.org
Bruce Bailey................... awssci@delphi.com
John Dunlop................... JRDunlop@IGC.org
Eppley Laboratory Inc ... info@eppleylab.com
Tracy Gardner.................tgardner@nrel.nrel.gov
Jack Garrison.........................jgarriso@sciences.sdsu.edu
Chris Gueymard Chris@SolarConsultingServices.com
Bill Marion .... bill_marion@nrel.gov
Ken Miller.....................ecskamil@aol.com
Ross McCluney................RMcCluney@fsec.ucf.edu
Rob Nelson ....rnelson@heliakos.com
Richard Perez.....Perez@asrc.albany.edu
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Lorin Vant-Hull..... vanthull@uh.edu
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Cecile Warner .... cecile@nrel.nrel.gov

Resource Application Division Meeting Minutes At ASES 2004, Portland, Oregon

July 13, 2004

by Gary Vliet

Location: Three Sisters room, Doubletree Hotel, Portland, Oregon, 2004

Time: Monday, July 13th, 5:30 – 6:30 PM

Attendees: See end of minutes for names and emails. Those present introduced themselves and gave brief statement of their interests/activities.

Election/Appointment of officers:

Jim Bing agreed to serve as Chair-elect

Jim Augustyn will be contacted by Gary Vliet about serving as secretary. (Jim has agreed to serve.)

Division Name:

At the 2003 division meeting in Austin it was decided, after lengthy discussion, to change our division name to the 'Resource Applications Division'. However, we note that ASES still designates us as the 'Resource Assessment Division'. This needs to be changed.

ISES '05 World Solar Congress,

Aug. 6-12, 2005.

Discussion of abstract/paper review procedures for ISES '05, and solicitation of leaders for 'tracks' and reviewers for abstract/papers

Dave Renne and Richard Perez agreed to serve as co-leaders for the Resource Assessment Track.

The following persons agreed to serve as reviewers for the sub-tracks indicated:

C. Gueymard – 8a, 8b
J. Bing – 8b
S. Wilcox – 8a
D. Wichert – 8d
P. Stackhouse – 8a, 8b, 8c
S. Baker – 8a, 8b
R. Perez – 8a, 8b, 8c
F. Vignola – general
G. Vliet – 5a and 8a

Suggested Forums and Workshops:

Forum - Solar and Wind energy Assessment (Renne)

Forum – New NSRDB (Wilcox)

Forum – Commercial Potential for Renewables (D. Wichert)

Workshop – Solar Spectral Data/Resources (Gueymard & Myers)

Workshop – Fund. of Solar Meas. (Vignola, Vliet & Wilcox)

Mission Statement
Needs review.

G. Vliet, F. Vignola and incoming chair will work on this.

Newsletter:

Vignola agreed to continue to develop the newsletter. Steve Baker agreed to assist Frank in this endeavor. There was discussion about also having e-notes, but no action was taken.

Meeting was adjourned at 6:30 pm.

Attendees:

David Renné – david_renne@nrel.gov

Frank Vignola – fev@uoregon.edu

James Bing – jbing@newenergyoptions.com

Paul Stackhouse – Paul.W.Stackhouse@nasa.gov

Chris Gueymard – chris@solarconsultingservices.com

Cecile Warner – Cecile_warner@nrel.gov

Daryl Myers – daryl_myers@nrel.gov

Steve Wilcox – stephen_wilcox@nrel.gov

Bill Chandler – w.s.chandler@larc.nasa.gov

Jack Garrison – j.garrison@mail.sdsu.edu

Richard Perez – perez@asrc.cestm.albany.edu

Don Wichert – donw@weccusa.org

Steven Baker – msbaker@cs.uoregon.edu

Gary Vliet— gvliet@mail.utexas.edu

To: Resource Applications Division Membership

from: Gary Vliet, 2004-2005 Chair

Subject: Division and Business Meetings at the 2005 Solar World Congress of the American Solar Energy Society in August in Orlando, Florida.

This is a reminder to you of the ASES/ISES meeting and of the meeting time for the Resource Applications division meeting.

Now it is time to make meeting, travel and lodging reservations.

You should have already received general information for this important conference from Becky Campbell-Howe. The information is also on-line at: http://www.swc2005.org

Please note that the Resource Applications Division Business meeting is set for Thursday, August 11, 12:30 to 1:30 pm.

As for Resource technical sessions, there are the following will be held (please look up their scheduling in the conference program, available at the address above):

Oral Sessions:

1. Resource Assessment Fundamentals
2. Satellite-based Solar Resource Models and Data
3. Solar Resource Models and Data

Poster Presentations:

1. Modeling and Estimation Satellite-based Resource Assessment
2. Solar Radiation Measurement
3. Wind, Hydro, Biomass and Ocean Resources.

Important actions we must take at our Division meeting are:

1. to provide a list of reviewers for Next Year's conference papers,
2. to provide a representative to travel to the meeting of select reviewers to handle the final selection and placing of papers,
3. to elect a new slate of officers (Chair Elect, Secretary, Treasurer, and Newsletter Editor) for the division, as all officers terms end at the beginning of the business meeting, with the Chair Elect taking over as Chair.

Our Chair Elect is Jim Bing.

To efficiently achieve these ends, please email me your nominations for reviewers, traveling reviewer, and officers. Don't be shy: include yourself wherever you are willing to serve! For the reviewers, it will be helpful to include a few keywords with each name suggesting of their areas of competence.

Nominations will also be accepted from the floor at our business meeting, but we really need a wider set of candidates than can be provided by those fortunate enough to be able to attend our meeting.

Many of you are also interested in other Divisions, and the times for other division meetings are indicated. These meetings are spread out to minimize conflicts, so try to attend the Division business meetings of which you are a member and/or are interested!

Division Chairs Committee
Chair: Dave Renné
Monday, August 8, 7:00 - 8:00am

Sustainability
Chair: Paulette Middleton
Monday, August 8, 5:45 – 6:45pm

Solar Electricity
Chair: Lorin Vant-Hull
Monday, August 8, 5:45 – 6:45pm

Renewable Fuels and Transportation
Chair: Paul Notari
Tuesday, August 9, 12:30 – 1:30pm

Solar Thermal
Chair: Joe O'Gallagher
Tuesday, August 9, 12:30 – 1:30pm

Solar Buildings
Chair: Harvey Bryan
Tuesday, August 9, 5:45 – 6:45pm

Resource Applications
Chair: Gary Vliet
Thursday, August 11, 12:30 – 1:30pm

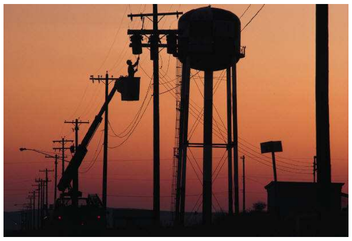
Hope to see you at the Orlando meeting in a few months!

Regards,

Gary Vliet,

Chair, Resource Applications

gvliet@mail.utexas.edu



SOLAR 2005 Workshop

SMARTS Terrestrial Solar Spectral Model Workshop—Introduction and Applications

W07 SMARTS Terrestrial Solar Spectral Model—

Introduction and Applications

Saturday, August 6

1:30 pm – 5:30 pm

Registration Price: $75

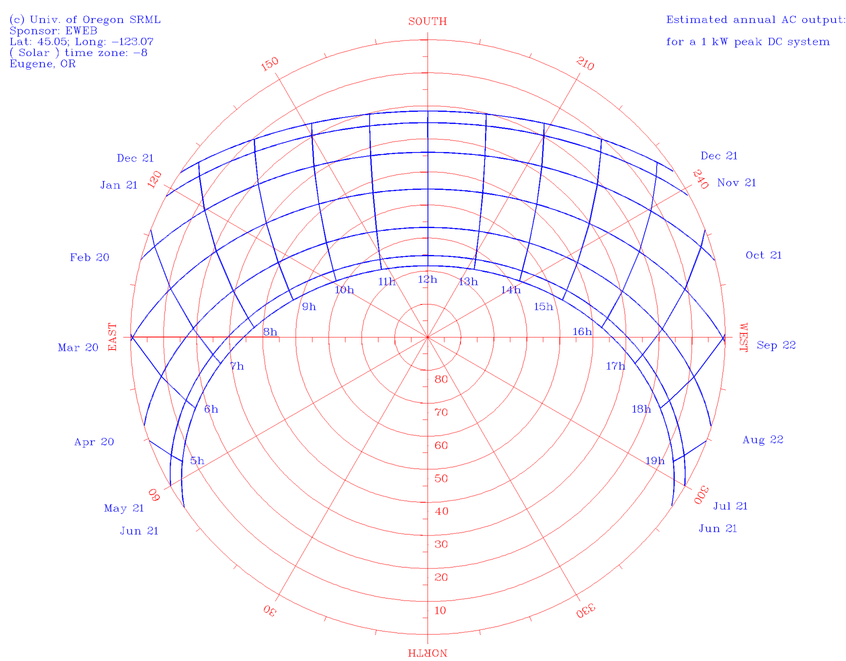
Presented by: Dr. Christian A. Gueymard, Solar Consulting Services, USA and Daryl R. Myers, National Renewable Energy Laboratory, USA

This workshop will introduce researchers and system designers to the importance of solar spectral distributions in the arena of photovoltaic device design and performance, daylighting, materials research, and solar radiation modeling. Attendees will gain a working knowledge of the SMARTS (Simple Model for Atmospheric Radiative Transfer of Sunshine) spectral distribution model and its various applications, using real-world examples. Will also provide venue for SMARTS users to describe applications and pose questions of concern for their application to the model's development team.

Materials provided will include a CD-ROM with the SMARTS spectral model, including source and executable FORTRAN code, ancillary files, Excel-based user interface, user manuals and reference documents in PDF format. In addition, a hardcopy notebook including the manuals for reference in the workshop, and print versions of the main points in the worked examples will be provided.

Minimum registrants needed: 7

Polar Sun Path Charts Available Soon on the Web



Under contract with the Energy Trust of Oregon, the University of Oregon Solar Radiation Monitoring Laboratory is creating a Web based program to produce sun path charts in polar coordinates. Test plots can be made by going to http://solardata.uoregon.edu/PolarSunChartProgram.html.

Resource Application Sessions at 2005 ISES Solar World Congress

The following are Oral and poster sessions being presented at the 2005 Solar World Congress. Updated information can be found on their Website at http://www.swc2005.org/.

Tuesday, August 9

2:00PM to 3:30PM

Resource Assessment Fundamentals

Session Chair: TBD

1. *The Assessment of Four Different Correction Methods Applied to the Diffuse Radiation Measured in Jerusalem, Israel*
   Kudish and T. Rahima, Ben-Gurion University of the Negev, Israel
2. *Can Present Global Climate Change Models Provide Climatological Sound Solar Radiation Data for Solar Energy Design?*
   J. Page, University of Sheffield, UK
3. *Trends in Direct Normal Solar Irradiance in Oregon from 1979-2003*
   L. Rihiimaki and F. Vignola, University of Oregon, USA
4. *Comparing Several Proceedings of Estimating the Available Solar Radiation, with Data Measured in the University of Vigo Radiometric Station*
   M. Vazquez, J. Santos, M. Prado and D. Vazquez, University of Vigo, Spain
5. *Time Delay Neural Networks (TDNN) Applied to a Weather Data Generator Based on Typical Meteorological Sequence Analysis*
   M. David, L. Adelard, P. Lauret and E. Fock, University of La Reunion, France
   Determining Wind Resources as a Function of Surface Roughness and Height from NASA Global Assimilation Analysis
   W. Chandler and C. Whitlock, SAIC and P. Stackhouse, Jr., NASA Langley Research Center, USA

Wednesday, August 10

10:30AM to NOON

Solar Resource Models and Data

Session Chair: Frank Vignola, University of Oregon Solar Radiation Monitoring Lab, USA

1. *Results of Solar Resource Assessments in the UNEP/SWERA Project*
   D. Renné, R. George and B. Marion, National Renewable Energy Laboratory, USA; R. Perez, ASRC - State University of New York at Albany, USA; C. Schillings, F. Trieb and R. Meyer, German Aerospace Center (DLR), Germany; E. Pereira et.al.
2. *A New Business Model for Grid-Connected Solar Generation in Restructured Electricity Markets*
   J. Bing, New Energy Options Inc., USA
3. *Forecasting Solar Radiation -- Preliminary Evaluation of an Approach Based Upon the National Forecast Database*
   R. Perez, ASRC, The University at Albany, USA; S. Wilcox and D. Renné, National Renewable Energy Laboratory, USA; K. Moore, IED, USA and A. Zelenka, Meteosuisse, Switzerland
4. *Broadband Model Performance for an Updated National Solar Radiation Data Base in the United States of America*
   D. Myers, S. Wilcox, W. Marion, R. George and M. Anderberg, National Renewable Energy Laboratory, USA
5. *Validation of DNI Estimations in Brazil Using Brazil-SR Model*
   F. Martins and E. Pereira, Brazilian Institute of Space Research and S. Abreu, University of Santa Catarina, Brazil
6. *Renewable Energy Resources in Brazil - SWERA Products*
   F. Martins and E. Pereira, Brazilian Institute of Space Research and S. Abreu and S. Colle, Solar Energy Laboratory - University of Santa Catarina, Brazil
7. *Bayesian and Sensitivity Analysis Approaches to Modelling the Direct Solar Irradiance*
   P. Lauret, M. David, E. Fock and L. Adelard, University of La Reunion, Reunion

Wednesday, August 10

Poster Technical Presentations

12:30PM to 1:30PM

Modeling and Estimation

1. *Improvement in Estimation of Hourly Solar Diffuse Irradiance*
   S. Munawwar and T. Muneer, Napier University, Scotland, UK
2. *Sequential Properties and Modeling of Daily Global Horizontal Solar Radiation, in Tropical Climates*
   Siqueira and C. Tiba, Universidade Federal de

(Continued on page 7)

Resource Application Sessions at Solar 2005

(Continued from page 6)

Pernambuco, Brazil

3. *Experimental and Theoretical Evaluation of the Solar Energy Collection by Tracking and Non-Tracking Photovoltaic Panel*
   Y. Vorobiev, P. Vorobiev and P. Horley CINVESTAV-Querétaro and J. González-Hernández, CIMAV, Mexico
4. *Solar Horizontal Irradiance: Data Quality Control and Modeling*
   S. Younes and T. Muneer, Napier University, Scotland, UK
5. *Night Length Duration and Public Illumination*
   F. Martins and E. Pereira, Brazilian Institute of Space Research, Brazil

Satellite-based Resource Assessment

1. *Solar Radiation Climate in Korea*
   Y. Chil Park, Seoul National University of Technology; D. Ki Jo and Y. Heack Kang, Korea Institute of Energy Research, Korea (South)

Solar Radiation Measurement

1. *Preliminary Study of One Minute Solar Radiation Measurements*
   T. Soubdhan and T. Feuillard, Universite Antilles Guyane (UAG-GRER), France
2. *Sky Clearness Index for Iranian cities*
   M. Bahadori and S. Mirhosseini, Sharif University of Technology, Iran
3. *General Characterisation of the Solar Radiation Components in Mozambique*
   B. Cuamba, M. Chenene and G. Mahumane, Eduardo Mondlane University, Mozambique; D. Quissico and E. Vasco, National Institute of Meteorology, Mozambique; P. O'Keefe, University of Northumbria at Newcastle, UK and J. Lovseth, Trondheim University of Science and Technology
4. *Outdoor Uncertainty on Heat Flux Measurement*
   C. Pérez-Rabago and C. Estrada, Universidad Nacional Autónoma de México, Mexico and M. Marcos, J. Ballestrín and M. Rodriguez, CIEMAT - Plataforma Solar de Almería, Spain

Oral Technical Presentations

4:00PM to 5:30PM

Satellite-based Solar Resource Models and Data

Session Chair: David Renné National Renewable Energy Laboratory, USA

1. *Parameters for Designing Back-Up Equipment for Solar Energy Systems*
   C. Whitlock, W. Chandler and J. Hoell, Science Applications International Corporation; T. Zhang, Analytical Services and Materials, Inc. and P. Stackhouse, NASA Langley Research Center, USA
2. *Progress on an Updated National Solar Radiation Data Base for the United States*
   S. Wilcox, National Renewable Energy Laboratory; R. Perez, State University of New York at Albany; R. George, W. Marion, D. Meyers and D. Renné, National Renewable Energy Laboratory; A. DeGaetano, Northeast Regional Climate Center; C; Gueymard, Solar Consulting Services; et.al.
3. *Use of Long-Term Solar Irradiance Products Derived from Satellite for Solar Power Project Development*
   R. Meyer and S. Lohmann, DLR Institut für Physik der Atmosphäre; C. Hoyer and C. Schillings, DLR Institut für Technische Thermodynamik and E. Diedrich and M. Schroedter-Homscheidt, DLR Deutsches Fernerkundungs-Datenzentrum, Germany
4. *Analysis of Satellite Derived Beam and Global Solar Radiation*
   F. Vignola and P. Harlan, University of Oregon and R. Perez and M. Kmiecik, ASRC the University of Albany, USA
5. *Gridded Aerosol Optical Depth Climatological Datasets over Continents for Solar Radiation Modeling*
   C. Gueymard, Solar Consulting Services and R. George, National Renewable Energy Laboratory, USA
6. *Estimation and Contour Mapping of Global Solar Radiation under Tropical Climate of Southern Thailand*
   S. Phethuayluk, Renewable Energy System Research and Demonstration Center (RESRDeC); J. Weawsak, ISES and RESRDeC and J. Keaw-On RESRDeC, Thaksin University, Thailand

SATELLITE-BASED SOLAR RESOURCE ASSESSMENT: SOCIAL, ECONOMIC AND CULTURAL CHALLENGES AND BARRIERS, TECHNOLOGICAL GAPS

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sensible decisions.

2. Siting of a multi MW solar thermal facility: These capital-intensive systems rely on direct normal irradiance (DNI) which is noticeably more variable than the global irradiance driving flat plate systems. Given the € millions at play, microclimatic optimization is a prime concern. This can only be achieved with access to high-resolution mapped solar resource information -- not yet universally available.

3. Investigation of PV grid-support capability: It has been shown that under certain circumstances, the deployment of dispersed PV installations can strengthened the reliability of the power grid by providing peak output during times of high demand and grid stress. The solar resource information needed to investigate this question consists of site/time-specific irradiance time series (hourly or less) necessary to simulate the production of PV arrays coincident with actual electrical demand.

4. Management of a large dispersed PV resource: The deployment of dispersed PV installations throughout regional power grids will affect the management of power flows on these grids as soon as the penetration of PV installations reaches a few percent. The solar resource information required to properly manage that flow will consist of recent, real-time, and forecasted site-specific irradiances.

5. Engaging in sensible socio-economic planning concerning the development of solar energy: Intelligent decisions concerning the future of solar energy require a complete understanding of the technology's scope and of its capabilities. Too often, as will be illustrated below, an incomplete understanding of the solar resource will lead to missed opportunities and misguided planning. Therefore, it is important that socio-economic decision makers, including governments, regulators, businesses and financiers have access to as complete a solar resource characterization as possible, implying, high resolution, time/site-specificity, passed and future. The point is that solar resource does not only consist of maps or atlases but is a complex *multi-facetted* set of information required to address complex, *multi-facetted* issues.

IDENTIFYING OPPORTUNITIES WITH THE APPROPRIATE SOLAR RESOURCE INFORMATION

Two investigations recently completed in the USA have uncovered opportunities for PV deployment that were not entirely intuitive, and that could not have been identified by relying solely on "traditional" solar resource information, such as typical data time series or atlas maps. A brief synopsis of these investigations is presented:

Identification of high PV effective capacity in the northeastern USA: The north-central/eastern portion of the United States had not been considered as one of the leading prospective markets for PV. Indeed, a quick look at the US solar radiation atlas (Fig. 1, top right) indicates that the solar resource is more abundant in the south and the west of the country. However the value produced by a power plant does not depends only on its energy yield, but also on its ability to provide added capacity to a local grid, a transmission and distribution (T&D) system, or a utility customer. As a non-controllable, non-dispatchable resource, PV generation was, until recently, assigned a zero capacity credit by utility planners, particularly in region with moderate solar resource, such as the northeastern US.

A more detailed look at the resource – its ability to match demand – through the analysis of time/site specific solar resource data and coincident utility/regional loads revealed that, in some cases the capacity credit of PV installations greatly exceeds their capacity factor (ratio of average output to rating). The author and his colleagues analyzed 100+ utility load-years through the USA and derived a capacity credit map of the United States that is considerably different from the climatic map (Fig. 1, lower left) (see perez et al., 1995, 1996).

In insight, the results are logical, because they show that, where peak loads are indirectly driven by solar gain, through heat waves and commercial air-conditioning demand, the effective capacity of PV is the most significant. This is the case for the large urban-suburban region extending

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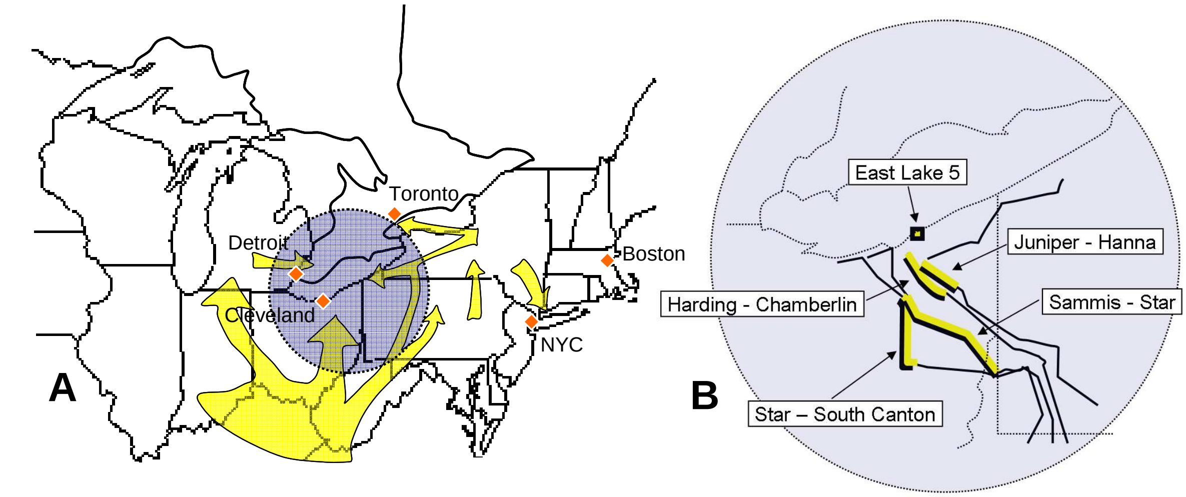

	Before 1:31 PM	1:31 PM	3:05 PM	3:32 PM	3:41 PM	4:05 PM	Cause
East Lake 5 Plant	100% (600MW)	Failed	Failed	Failed	Failed	Failed	Exceeding MVAR limit
Harding-Chamberlain	35% (400MW)	45% (500MW)	Failed	Failed	Failed	Failed	Tree Contact
Juniper-Hanna	55% (800MW)	70% (1 GW)	80% (1.2 GW)	Failed	Failed	Failed	Tree Contact
Star-South Canton	65% (650MW)	80% (800MW)	90% (900MW)	120% (1.2 GW)	Failed	Failed	Overaload
Star-Sammis	55% (650MW)	60% (700MW)	65% (800MW)	85% (1 GW)	120% (1.4 GW)	Failed	Overaload

Fig. 2: Regional power transfers in the afternoon of 8/14 (A). Much of this power flowed through 345kV lines in eastern Ohio (B). The loss of the East Lake generating facility and of the power lines compounded by the lack of situational awareness from the grid operators forced the power flows into alternate paths and precipitated the outage (source US-Canada Task Force, 2003)

(Continued from page 8)

from Washington to Boston where "9-to-5" commercial A/C loads are very large. By contrast "sunny" Florida, which sometimes experiences early morning winter demand peaks from electric heating is characterized by a much smaller PV effective capacity despite a larger climatic solar resource. Although they are logical, these attributes would have been overlooked without access to a proper characterization of solar resources: time/site-specific irradiances at arbitrary locations.

<u>Dispersed PV as an outage-preventive power generation base</u>: The largest blackout in the United States and Canada occurred over a matter of hours on August 14, 2003. The total regional cost of the outage has been estimated at upward of $8 billion.

On the afternoon of August 14, loads and power transfers through the northeastern US were high. The region was experiencing large power transfers (~5 GW) from the south-central US to the north. Much of that power transited through northern Ohio on its way to the major load centers of Detroit, Cleveland and Toronto, where local energy production was insufficient. A series of precursor events took place near Cleveland, where large (345 kV) power lines were carrying much of the south-to-north power flow (see Figure 2). At 1:31 PM a local power plant, attempting to meet voltages depressed by high demand, failed, leading to the loss of 600 MW. At 3:05 a 345 kV power line failed due to tree contact, losing another 500 MW. The lost power had to be carried by neighboring lines. At 3:32 another 345 kV power line, which had absorbed part of the above losses failed, also due to tree contact resulting in the rerouting of the1200 MW it carried to other neighboring paths, including the Star-South Canton 345 kV power line which failed at 3:41 PM due to overload. Two aggravating factors in this series of events were the inadequate situational awareness of the local utility, and the failure of the concerned reliability coordinator organizations to provide effective problem diagnostics. The precursor events were thus left to evolve without effective interventions

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SATELLITE-BASED SOLAR RESOURCE ASSESSMENT: SOCIAL, ECONOMIC AND CULTURAL CHALLENGES AND BARRIERS, TECHNOLOGICAL GAPS

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from grid operators – utilizing such mitigating efforts as targeted rolling blackouts. When the Star-South Canton line failed, much of the power found its way on secondary power lines (138 kV) that overloaded one after the other, and on the only remaining local 345 kV line: Sammis-Star which, overloaded at 4:05 PM, marking the beginning of the massive outage.

The north-south power flow in eastern Ohio got pushed on other paths to the east and west toward the load centers. These massive power flow reroutings resulted in line failure at an exponentially increasing rate, as the flow was redistributed into fewer and fewer paths. Within four minutes, all of the south-to-north paths had been severed. The northeastern corner of North America became and electrical island where demand exceeded generation (see fig. 3). The resulting depressed voltages and frequencies caused the line trips and generation failure cascade to continue within the electrical island, creating several sub-islands. Sub-islands where local generation was sufficient to meet demand (New England, Quebec, Upstate New York) stabilized and remained online. The other sub-islands (including New York City, Toronto, Detroit and Cleveland), blacked out. The US-Canada Task Force (2003) identified three main causes for the outage: (1) inadequate situational awareness from the local utility; (2) inadequate tree trimming; (3) inadequate diagnostic support from reliability coordinators. The task force thus concluded that the outage was preventable and that better, enforceable controls and regulations should take care of future similar contingencies. However, above and beyond these "official" causes, the analysis of events clearly suggests that, had regional power transfers to meet localized energy demands not been as high, the probability of each contingency – even unattended – leading to the next, and finally into cascade would have been much lower.

As was discussed above, one of the well documented attributes of PV generation is its high Effective Load Carrying Capability when loads are driven by air-conditioning (A/C) demand. Conditions on August 14th 2003, although not extreme, represented a "textbook example" of high regional A/C demand creating high power transfers and stress on the grid. Therefore it was no coincidence that the solar resource – indirectly driving demand – was plentiful – see Fig. 4 and 5.

Using two independent methods based on (1) avoiding each precursor contingencies and (2) reducing regional power transfers by 10%, a recent study by the author and his colleagues (Perez and Collins, 2004, Perez et al., 2004) showed that at most a few hundred PV MW located in and around each major concerned metropolitan area would have provided an insurance against the unfortunate contingencies of 8/14 compounded by the shortcomings of the concerned utilities and grid reliability coordinators.

This analysis and its

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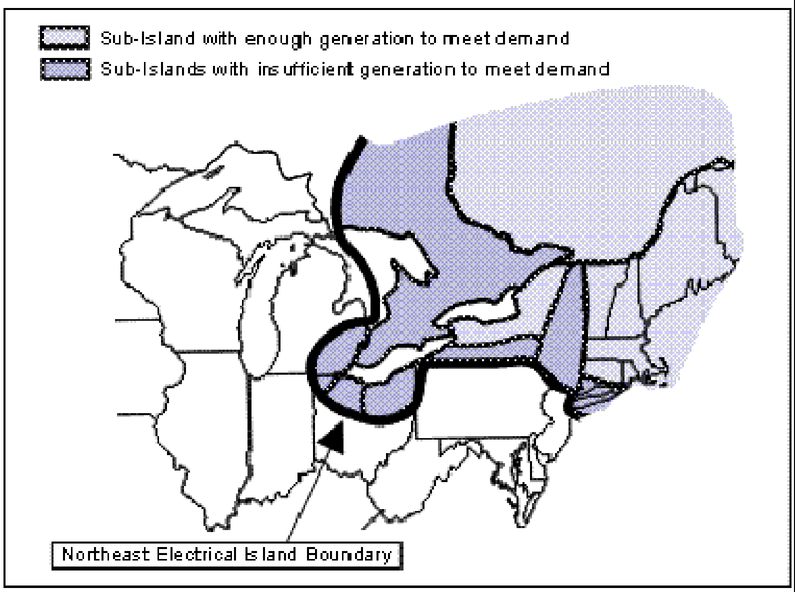

Fig. 3: Within 7 minutes of the Sammis-Star trip, all paths wheeling power from south to north were severed resulting in a large power deficient island (source US-Canada Task Force, 2003)

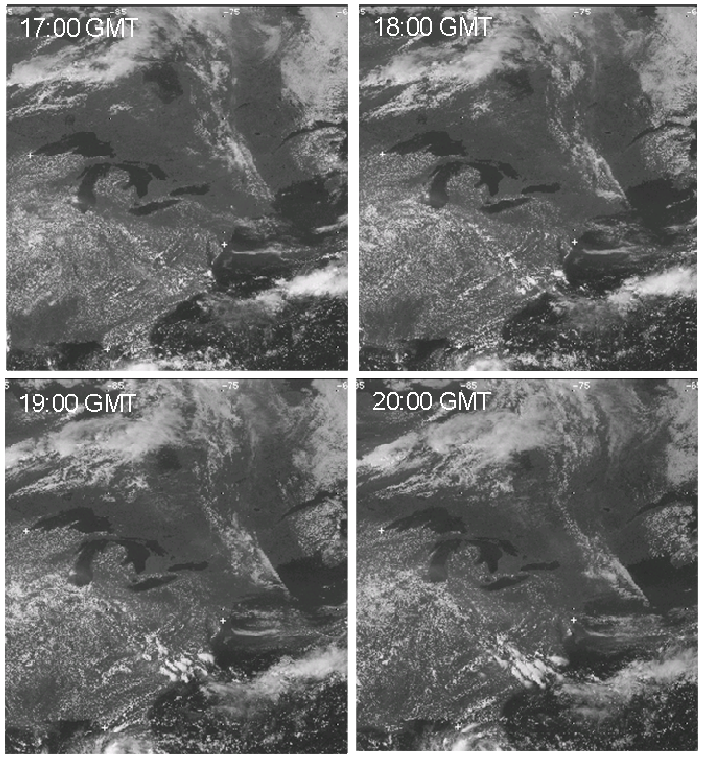

Fig. 4: Cloud cover distribution in eastern North America on 8/14/03 -- note that the area affected by the outage is almost cloud-free. 20:00 GMT20:GMT19:00 GMT18:00 GMT18:GMT17:00 GMT

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development of solar energy.

Therefore developing a comprehensive, multi facetted solar resource information base – including better models, validations, production of data, worldwide coverage, and worldwide access – and making this information available to research and planning communities, are pivotal issue.

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conclusions showing that distributed PV could be one of the solutions to strengthen the reliability of the power grid could not have been undertaken without access to time/site specific maps of the solar resource.

DISCUSSION

The two case studies show that some very important attributes of PV generation affecting its value, market penetration, and design can only be captured with an appropriate form of solar resource information. Some of these results were counter-intuitive and had been overlooked.

Access to comprehensive solar resource information opens door to a solid analysis capability which often opens door to new solutions, better planning, better targeted R&D, and faster, more intelligent,

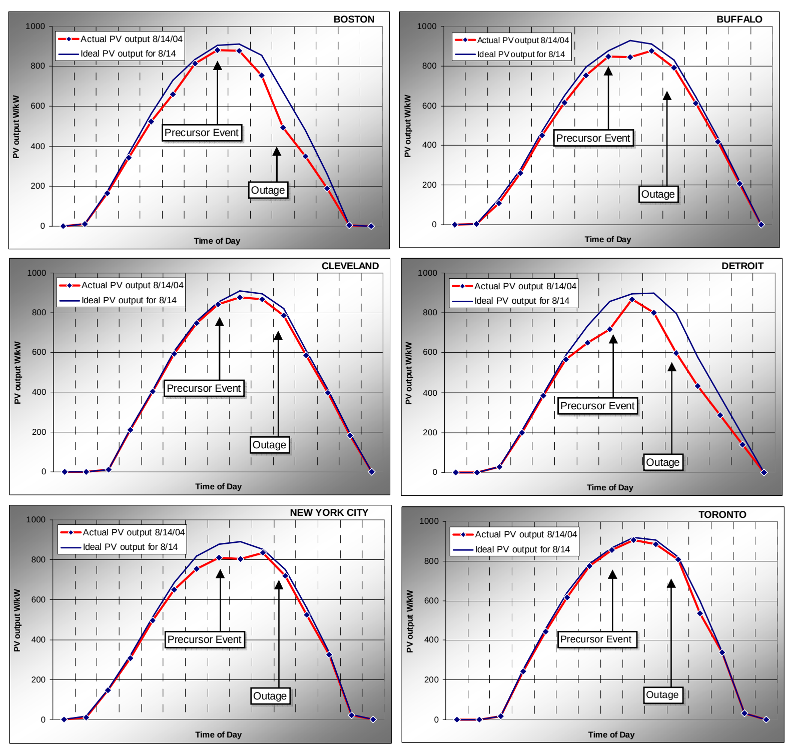

Fig. 5: Actual vs. Ideal simulated output of fixed-optimized PV arrays on 8/14/04 in major eastern American cities.

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Such an effort will require international cooperation, effort continuity, exchange of information between producers of information and users of information, and last but not least, adequate budgeting

Developing the proper resource information is a small investment in light of the formidable development potential of solar energy.

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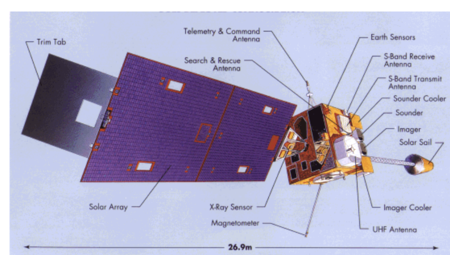

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