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IEA SHC TASK 46

SOLAR RESOURCE ASSESSMENT AND FORECASTING

Annual Report 2012

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ABSTRACT

IEA SHC Task 46 „Solar Resource Assessment and Forecasting“ is the follow-up of the Task 36, which ended in 2011. From Switzerland University of Geneva and Meteotest are taking part. The goal of IEA Task 46 is to provide the solar energy industry, the electricity sector, governments, and renewable energy organizations and institutions with the means to understand the “bankability” of data sets provided by public and private sectors.

A major component of the task is to provide this sector with information on how accurately solar resources can be forecasted in the near future (sub-hourly, 1-6 hours, and 1-3 days) so that utilities can plan for the operation of large-scale solar systems operating within their systems. Another major component of the task is understanding short-term (1-minute or less) resource variability associated with cloud passages that cause power “ramps”, an important concern of utility operators with large penetrations of solar technologies in their system.

Within this first annual report the goals and the subtasks are defined. Three examples of ongoing work are presented: For activity B1 (“measurement best practices”) a comparison of direct normal irradiance instruments which is going on in Payerne is shortly described. For activity C1 “Short-term forecasting” the current work on the PV power forecast model of University of Oldenburg and the shortest term forecast model developed at Meteotest are shown.

Introduction / project goals

The goal of IEA Task 46 "Solar Resource Assessment and Forecasting" is to provide the solar energy industry, the electricity sector, governments, and renewable energy organizations and institutions with the means to understand the “bankability” of data sets provided by public and private sectors. A major component of the task is to provide this sector with information on how accurately solar resources can be forecasted in the near future (sub-hourly, 1-6 hours, and 1-3 days) so that utilities can plan for the operation of large-scale solar systems operating within their systems. Another major component of the task is understanding short-term (1-minute or less) resource variability associated with cloud passages that cause power “ramps”, an important concern of utility operators with large penetrations of solar technologies in their system.

Based on the outcomes of precedent Task 36, the objectives of Task 46 are to:

- Evaluate solar resource variability that impacts large penetrations of solar technologies
- Develop standardized and integrating procedures for data bankability
- Improve procedures for short-term solar resource forecasting
- Advance solar resource modeling procedures based on physical principles

Achieving these objectives would reduce the cost of planning and deploying solar energy systems, improve efficiency of solar energy systems through more accurate and complete solar resource information, and increase the value of the solar energy produced by solar technologies.

Task 46 focuses on

1) the development, validation, and access to solar resource information derived from surface-based observations, satellite-based platforms, and numerical weather prediction (NWP) models
2) solar resource variability and forecasting issues pertinent to grid-tied or large-scale penetrations of solar technologies into a national energy system
3) data bankability issues, especially those related to solar resource measurement practices and merging of measured and modeled data sets
4) exploring means by which to improve the modeling of the solar resource using satellite-based platforms or other weather observations

As with Task 36 the audience for the results of the Task includes the technical laboratories, research institutions and universities involved in developing solar resource data products. More importantly, data users, such as energy planners, solar project developers, architects, engineers, energy consultants, product manufacturers, and building and system owners and managers, and utility organizations, are the ultimate beneficiaries of the research, and will be informed through targeted reports, presentations, workshops and journal articles. Key results of this task will be posted to the IEA SHC Task 46 Publications web site.

Task definition

SUBTASK A: SOLAR RESOURCE APPLICATIONS FOR HIGH PENETRATIONS OF SOLAR TECHNOLOGIES

This Subtask will develop the necessary data sets to allow system planners and utility operators to understand short-term resource variability characteristics, in particular up and down ramp rates, to better manage large penetrations of solar technologies in the grid system. Although this work is primarily focused toward PV systems, which react almost instantaneously to cloud passages over individual panels, the information is also useful for solar thermal and CSP systems where intermittency due to variable solar resources can impact their ability to meet load demands. Subtask A consists of three main activities:

- Activity A1: Short-Term Variability
- Activity A2: Integration of solar with other RE
- Activity A3: Spatial and Temporal Balancing Studies of the Solar and Wind Energy Resource

SUBTASK B: STANDARDIZATION AND INTEGRATION PROCEDURES FOR DATA BANKABILITY

This task addresses data quality and bankability issues related to both measurement practices and use of modeled data. Subtask activities are:

- Activity B1: Measurement best practices
- Activity B2: Gap-Filling, QC, Flagging, Data Formatting
- Activity B3: Integration of data sources
- Activity B4: Evaluation of Meteorological Products
- Activity B5: Data Uncertainties over Various Temporal and Spatial Resolutions

SUBTASK C: SOLAR IRRADIANCE FORECASTING

Solar irradiance forecasting provides the basis for energy management and operations strategies for many solar energy applications. Depending on the application and its corresponding time scales different forecasting approaches are appropriate. In this subtask forecasting methods covering timescale from several minutes up to seven days ahead will be developed, tested and compared in benchmarking studies. The use of solar irradiance forecasting approaches in different fields will be investigated, including PV and CSP power forecasting for plant operators and utility companies as also irradiance forecasting for heating and cooling of buildings or districts. Subtask activities are:

- Activity C1: Short-term forecasting (up to 7 days ahead)
- Activity C2: Integration of solar forecasts into operations

SUBTASK D: ADVANCED RESOURCE MODELING

Although most of the work in Task 36 involved the testing and evaluation of existing solar resource methodologies, some specific new methodologies have been identified that could be developed within a new task. These methodologies are driven by specific information requests from energy developers and planners. They can include new data sets required for the control and heating and cooling in buildings, solar resource forecasting for CSP plant operations, and the impact of climate change on solar resources, both from an historical perspective as well as estimates of future impacts. Subtask activities are:

- Activity D1: Improvements to existing solar radiation retrieval methods
- Activity D2: Development of global solar resource data sets for integrated assessment of global and regional RE scenarios modeling, with a special focus on CSP and solar heating technologies
- Activity D3: Long term analysis and forecasting of solar resource trends and variability

The team has started the work in autumn 2011. In 2012 one project meeting was held in Golden CO (USA) at the National Renewable Energy Laboratory (NREL).

The team has been growing since the preceding task (Tab.1).

Table 1: Active members of the task.

Country	Teams
Australia (new)	Bureau of Meteorology Research Centre, University of South Australia, CSIRO
Austria	Austria Solar Innovation Center, Blue Sky Wetteranalysen
Canada (new)	Green Power Labs
Denmark (new)	Danish Meteorological Institute (DMI), Technical University of Denmark (DTU)
European Commission	JRC
France	ARMINES, Mines ParisTech, Laboratoire PIMENT, Université la Réunion
Germany	DLR, University of Oldenburg, Suntrace GmbH, University of Ulm, CSPS GmbH
Norway	University of Agder
Slovakia	GeoModel Solar s.r.o.
Spain	CIEMAT, CENER, Public University of Navarra, University of Jaen, ir-SOLaV
Switzerland	Meteotest, UNIGE
USA (partly new)	Department of Energy/National Renewable Energy Laboratory, NASA State University of New York at Albany, University of California San Diego, Irradiance, University of Oregon, Augustyn and Co.

Work done and results

Three examples of ongoing work are described from activity B1 and C1.

ACTIVITY B1

DLR and others

Currently MeteoSwiss is performing intercomparisons of three different rotating shadowband radiometers (RSI) and various Delta-T SPN1 in Payerne, Switzerland, in the framework of the COST Action ES1002 WIRE [1]. The investigated RSIs are the RSR2 (Irradiance), the RSP (Solar Millennium/Reichert GmbH) and the Twin RSI (CSP Services) (Figure 1). Final results are expected for 2013. The comparison campaign represents an important step towards the qualification of the performance of RSIs and the Delta-T SPN1. The data from the collocated MeteoSwiss Baseline Surface Radiation Network (BSRN) station are used as reference for the intercomparison.

In the framework of the intercomparisons and the COST Action, a workshop focusing on the first results and the instrumentation was held September 20th - 21st 2012 at Payerne, Switzerland. The participation of the Delta-T instrument and the corresponding presentations will also allow its inclusion in the future versions of the measurement manual. Other presentations at the workshop also addressed important topics for the uncertainty analysis of RSIs. All original presentations are available upon demand on the restricted part of the COST Action website (www.wire1002.ch).

A new measurand for resource assessment that is investigated in B1 is the sunshape and the circumsolar radiation. The replication of a newly developed measurement system is presented in [2].

An extension to meteorological stations with solar trackers called “TraCS” has been tested and validated at PSA in collaboration with the University of Oujda, Morocco. Its purpose is the routine measurement of soiling levels of solar test mirrors additionally to the standard irradiance measurements performed at the stations.

Figure 1: Test instruments during the measurement campaign in Payerne (Photo: MeteoSwiss).

ACTIVITY C1

University of Oldenburg

University of Oldenburg is investigating an approach based on linear regression to combine forecasts based on cloud motion vectors from satellite images and forecast data of two Numerical Weather Prediction (NWP) models [3]. The used NWP model data are operational forecasts of the integrated forecast system (IFS) run by the European Centre for Medium-Range Weather Forecasts (ECMWF) and the COSMO-EU model, operated by the German Weather Service DWD. There is a strong potential for improving the forecast performance by combining different models. The combined forecasts outperform the single model forecasts for all forecast horizons investigated. For regional day-ahead predictions an improvement of 10% compared to the ECWMF based forecasts is found, when combining the two NWP model forecasts. For intra-day predictions with additional integration of satellite based CMV forecasts, the benefit is even much larger (Fig. 2)

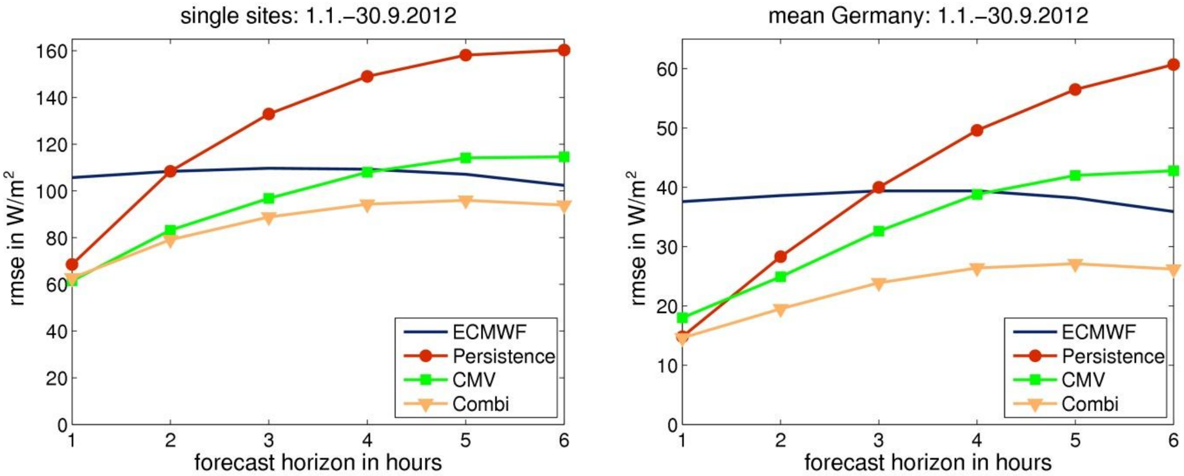

Figure 2: RMSE of ECMWF based, CMV and combined forecasts in comparison to persistence in dependence on the forecast horizon. For the ECMWF based forecast, the 12:00 UTC run of the previous day is evaluated independent of the forecast horizon and variations of the RMSE with the forecast horizon are due to the horizon dependent data sets Left: single sites, right: German mean.

Meteotest

Prediction models for solar power have usually a forecast horizon of 12 to 72 hours (for example COSMO-EU model). However for this time scales the spatiotemporal evolution of the cloud is difficult to predict and is uncertain with increasingly longer time scales. A shortened forecast horizon (1 - 6 hours) leads to a significant improvement in prediction accuracy [4].

During partly overcast conditions high and low radiation levels can alternate within a very short time. In our project such short-term fluctuations are predicted with the following approach:

The shortest-term forecast model is based on a combination of satellite images and numerical weather model WRF to determine the motion of the clouds, as well as the clear sky radiation model for calculating the radiation on the surface. From the satellite images (Meteosat Second Generation, 3 km resolution) the current cloud cover index is determined.

With the help of the wind field from the numerical weather model WRF trajectories in the clouds for a determined length of 6 hours with a time resolution of 15 minutes are calculated. The global radiation is forecasted with help of the clear sky model and the calculated future position of the clouds (Fig 3).

The forecast is recalculated every 15 minute (the frequency of the satellite images) for 6 hours. With the multi-channel retrieval system of MeteoSwiss (includes visible and long-wave channels) also clouds during the night can be determined what allows forecasting the radiation also during early morning hours.

The forecast data are compared with ground measurements from 12 stations of the SwissMetNet network and with data from 3 test sites. The project is supported by the BKW FMB AG and is going on until spring 2014.

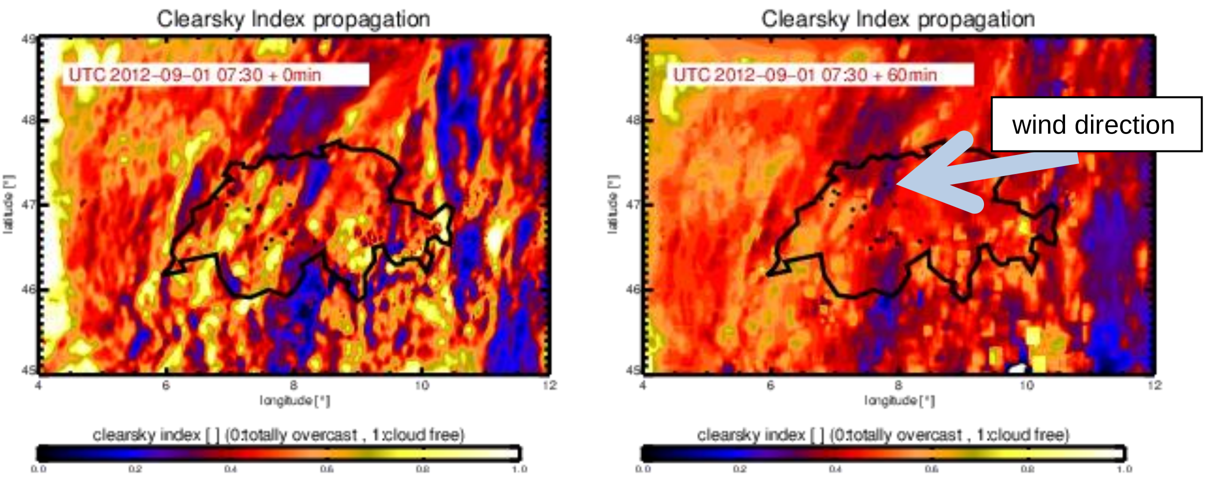

Figure 3: Situation on September 1st, 2012 with easterly winds. Left: cloud conditions based on satellite image. Right: forecasted cloud conditions one hour later.

National / international cooperation

The work was done in the framework of IEA Solar Heating and Cooling task 46. From Switzerland there is also University of Geneva part of the task team. The results are exchanged with IEA PVPS Task 14 (high penetration of PV) and the COST action ES1002 ("wire").

Outlook

The task will go on next year. The team will meet presumably twice with a first meeting in January.

References

[1] Laurent Vuilleumier, Gianluca Paglia, Nicolas Sommer, and Bertrand Calpini; Performance evaluation of radiation sensors for the solar energy sector; 2012; TECO-2012 WMO TECHNICAL CONFERENCE ON METEOROLOGICAL AND ENVI-RONMENTAL INSTRUMENTS AND METHODS OF OBSERVATION; Brussels, Belgium, 16-18 October 2012; available online http://www.wmo.int/pages/prog/www/IMOP/publications/IOM-109_TECO-2012/Session1/P1_25_Vuilleumier_performance_eval_radiation_sensors.pdf (visited 16.11.2012)

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[3] [Lorenz et al, 2012] Lorenz E, Kühnert J, and Heinemann D: Short Term Forecasting of Solar Irradiance by Combining Satellite Data and Numerical Weather Predictions. Proc. of 27th EUPVSEC, p 4401 – 4405, Frankfurt, Germany, 25 – 27 September 2012 and 12th EMS Annual Meeting & 9th European Conference on Applied Climatology (ECAC), Łódź, Poland, 10 – 14 September 2012.

[4] Dierer S., J. Remund, R. Cattin, T. Koller and P. Strasser, 2010: BFE Bericht: Einspeiseprognosen für neue erneuerbare Energien.