IEA PVPS Task 16

Solar resource for high penetration and large scale applications

1st International Conference on Large-Scale Grid Integration of Renewable Energy in India, September 6-8 2017

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• **Background: Meteotest & IEA**

• **Results of IEA SHC Task 46**
  – Forecast benchmark & variability model

• **Workplan of IEA PVPS Task 16 (focus: forecasts)**
  – Metrics
  – Value of forecast, probabilistic forecasts, regional upscaling
Meteotest

- Founded in 1981, independent company
- Bern, Switzerland
- Staff: 35
- Provider of meteo services (resources & forecasts)
  www.meteonorm.com & solarwebservices.ch
International Energy Agency (IEA)

- International Energy Agency, Paris
  - Founded 1973 by OECD countries
  - Historically known as source for optimistic oil reserves and pessimistic renewable potentials

- 39 Technology Collaboration Programmes
  - International exchange of state of the art knowledge

- Three solar programs:
  - Solar Heating and Cooling (SHC)
  - PV power systems (PVPS)
  - SolarPACES (solar chemistry and concentrating solar power)
IEA SHC Task 36/46

- 2005 – 2016, lead by Dave Renne (NREL, ISES)
  http://www.nrel.gov/docs/fy15osti/63112.pdf
  - Update 2017 (in preparation)
- Benchmarks:
  - Satellite resources
  - Solar forecasts
- Modelling (two examples):
  - Definition of circumsolar radiation and DNI
  - Integration of ground measurements with model derived data
IEA SHC Task 46: benchmark

Forecast error (rel. RMSE) in dependence of forecast horizons for single site predictions (left) and regional forecasts (right).

Elke Lorenz et al, Uni Ol/Fraunhofer ISE // DOI: 10.1002/pip.2799
IEA SHC Task 46: benchmark

- Point forecasts Germany, day ahead: RMSE: 30-40%
- Regional forecasts: 50% lower uncertainty (20%)
- Model ranks (based on RMSE!):
  - Multi model MOS (UOL_Combi)
  - Cosmo/IFS/satellite CMV
  - Model including current data (MT_GFS-MOS)
    - Hourly updated (based on ground measurements)
  - Regional models: show higher rmse values:
    - Hirlam, Cosmo (WRF)
  - Not yet benchmarked:
    - Statistical methods (e.g. ann or svr)

http://doi.org/10.1016/j.solener.2016.05.051
Meteotest forecast – tested and current

- **2015:**
  - Model: GFS
  - Statistics: MOS (multiple linear regressions)
  - Hourly updates based on SYNOP measurements
  - 3 MOS sites in India

- **2017 / September:**
  - Models: GFS, IFS, (Hirlam)
  - Statistics: MOS (multiple linear regressions)
  - Hourly updates based on SYNOP measurements
  - 86 MOS sites in India

https://solarwebservices.ch/
IEA SHC Task 46: variability model

Figure 3.6: Site-pair correlation as a function of distance for daily and weekly time periods. Station pairs are selected to have a predominantly east–west orientation [Perez and Fthenakis, 2015].

Area of India: only 3 h-1d variations visible


\[ \rho = \frac{1}{1 + \frac{d}{(\Delta t)(V)}} \]

\( \rho \) = correlation coeff. of ramps
\( d \) = distance
\( t \) = time resolution
\( V \) = cloud speed

Richard Perez, SUNY
DOI:10.1561/2700000006
Why a new Task?

- Solar resources are the fuel of PV
- Uncertainty in solar belt still high
- Big PV and high penetration need high quality of meteorological information
  - Finer spatial and temporal resolution of data
- Added values
  - Independent benchmarks (never trust non independent validations)
  - State of the art descriptions
  - Lower uncertainties lead to lower costs of implementation and to more PV
Participation

15 IEA PVPS members + SGP

Potential partners: China, Japan and Mexico
51 institutions

Science (labs and universities)

Met Services
Utilities

Data providers
Subtask 1: Resources

- Evaluation of current and emerging resource assessment methodologies:
  - Ground based methods (instruments, soiling)
  - Numerical weather models (NWP)
  - Satellite-based methods (uncertainties, modelling)
  - Benchmarking framework
Subtask 2: Bankability

- **Enhanced data & bankable products:**
  - Data quality & format
  - Merging of satellite, NWP and ground data
  - Spatio-temporal high variability
  - Long-term inter-annual variability
  - Products for the end-users
ST 2: Metrics

- What is the best metric to choose?
- RMSE isn’t the best in all cases:

Fig. 1. Examples of two different methods (left: CMV based 15-min ahead solar forecast, right: ECMWF day-ahead solar forecast resampled at 15-min) giving the same score of RMSE on the same day but with different behavior.
ST 2: Metrics

- „TDM“, „TDI“, ramp scores, ...
  - To be discussed (complexity vs. adequacy)

Mines Paristech,
Loic Vallance

Fig. 11. Global performance of the 15-min persistence forecast, the CMV method based on HelioClim maps and the 15-min interpolated ECMWF forecast before (a) and after (b) aligning the forecast series.
Subtask 3: Forecasting

- Evaluation of current and emerging solar forecasting techniques:
  - Value of solar power forecasts
  - Regional solar power forecasting
  - Variability forecasting and probabilistic forecasting

E.g. Benchmark of «All sky cameras» planned
ST 3: Value of forecasts

Forecasts get better (state of the art: multi model MOS with current measurements / satellite data):

SA = solar anywhere

SA = solar anywhere

SUNY, CPR
Richard Perez
ST 3: Value of forecasts

What’s the value of better forecasts?

Fig. 10. Variable electricity generation cost savings from solar power forecasting improvement. Region: ISO-NE, USA

Figure 5: Battery capex per PV kW sufficient to deliver 100% accurate 24 hour-ahead forecasts as a function of the linear dimension of a PV fleet’s footprint.

Assumed battery costs: 300 USD/kWh

NREL, Carlo Brancucci et al. 10.1016/j.solener.2016.01.049

SUNY, Clean Power Research
Richard Perez
ST 3: Probabilistic forecasts e.g. Analog model

Analog model:

• Search for similar situation in history and use it for forecast

• Ideal settings for search:
  – number of prev. days 20-180
  – number of sites: 1-66
  – ensemble members 20-100
  – pattern for similar forecasts
    • clear sky index

Fraunhofer ISE, Elke Lorenz
NCAR, Della Monache
http://www.wemcouncil.org/ICEMs/ICEM2017_PRES/ICEM_20170629_1200_Sala_3_DelleMonache.pdf
ST 3: Regional Upscaling

Many open issues:

- Brute force: model and sum up all plants
- Smart: use distribution of plants, model only few
- Methods: parametric or statistical?
  - Directly on sum or for each plant?

Rafael Fritz, Fraunhofer IWES
Yves-Marie Saint-Drenan, MPT

Da Silva Fonseca J, Univ. Tokyo
10.1016/j.renene.2014.02.018
Subtask 4: Dissemination

- Dissemination and Outreach:
  - Task Brochure & Newsletters
  - Conference and Journal papers
  - Webinars and/or conference presentations → connection to ISES
  - Workshops (at major conferences)
  - Reports
  - July 2017 - June 2020

Update of the solar resource handbook (NREL)
Take home messages

• T16: Solar resources and forecasts for all solar applications
  – Trust machine for solar resources and forecasts
  – Guidelines for measurements, forecasts and benchmarks

• Best forecast method:
  – Multi model MOS including current data

• Attention:
  – Metrics, time periods and location define accuracy

• Best overview:
  – Renewable Energy Forecasting
    https://www.elsevier.com/books/renewable-energy-forecasting/kariniotakis/978-0-08-100504-0
Questions & Discussion

Thank you for your attention!