The value of solar forecasting for energy-related applications

a treasure box of literature yet to be opened

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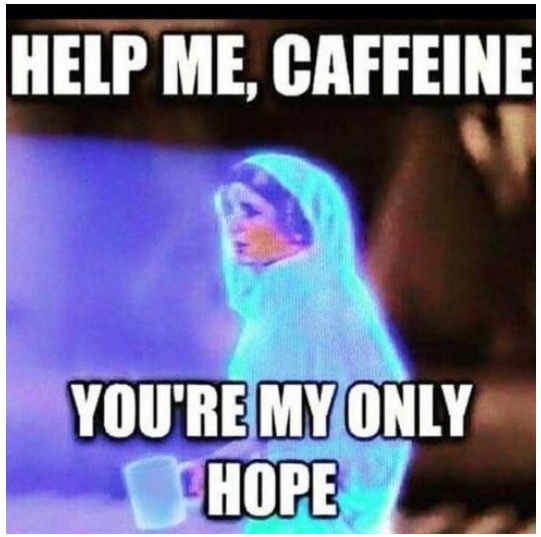
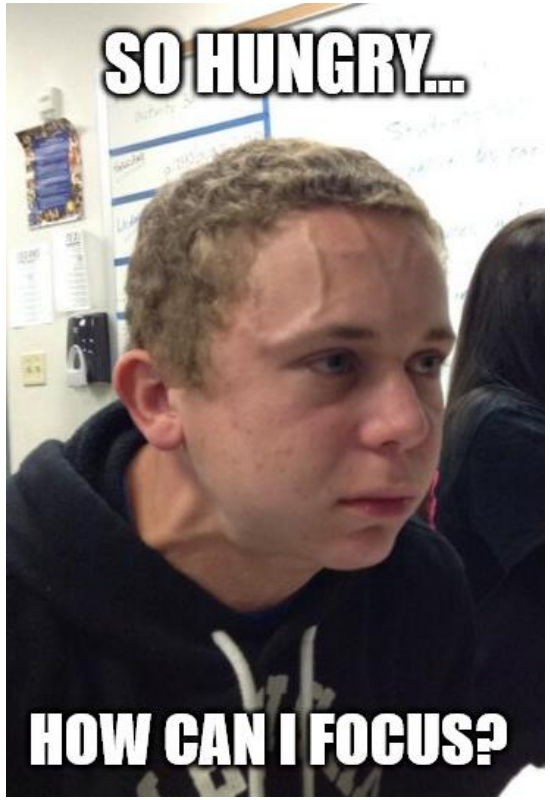
Expectations for the audience





Starting with some **context**

High expectations for solar power

source: CarbonBrief

Solar the energy workhorse in latest gloomy IPCC verdict

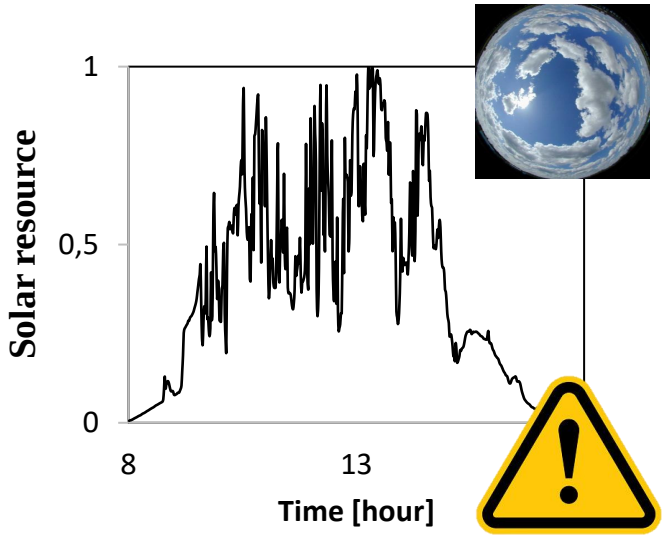
APRIL 5, 2022 MAX HALL

source: pv-magazine

Suggested reading: IPCC, 2022. Working Group III contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (Summary for Policymakers)

However, first rule of power grids

At every instant
At all times



Left figure adapted from ERSE - Entidade Reguladora dos Serviços Energéticos
Figures done using global horizontal irradiance records provided by the University of Lisbon

Solar: variability & uncertainty

Clouds

Day/Night

Seasons

How much and how fast it changes

How well and how far ahead we can predict it

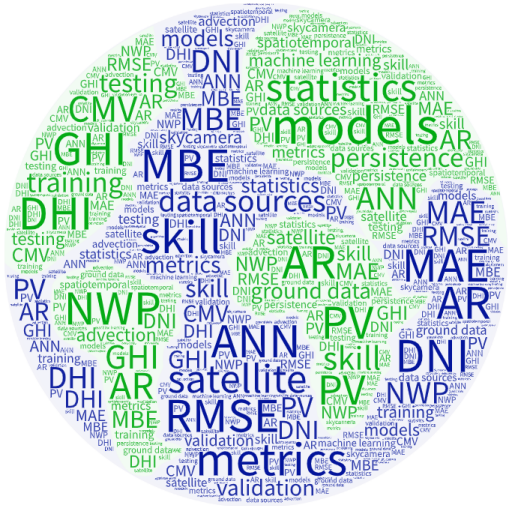
Suggested reading: Ela et al. (2013), NREL Technical Report NREL/TP-5500-58274

Let’s talk about **value**

Literature shows some disconnection

Reviews are mostly focused on

- Models
- Performance metrics (statistical ones)
- Data sources



Applications and **practical value**…

- barely discussed (5-10% of references in two major reviews)
- we end up having to search for scattered references

Figure created in wordart.com

Solar forecasting is effectively a business

Arbitrary order, chosen by PowerPoint itself ☺

Various applications

Market bidding[1] Handling extreme events[2]

Ramp-rate compliance[3] Battery scheduling[4]

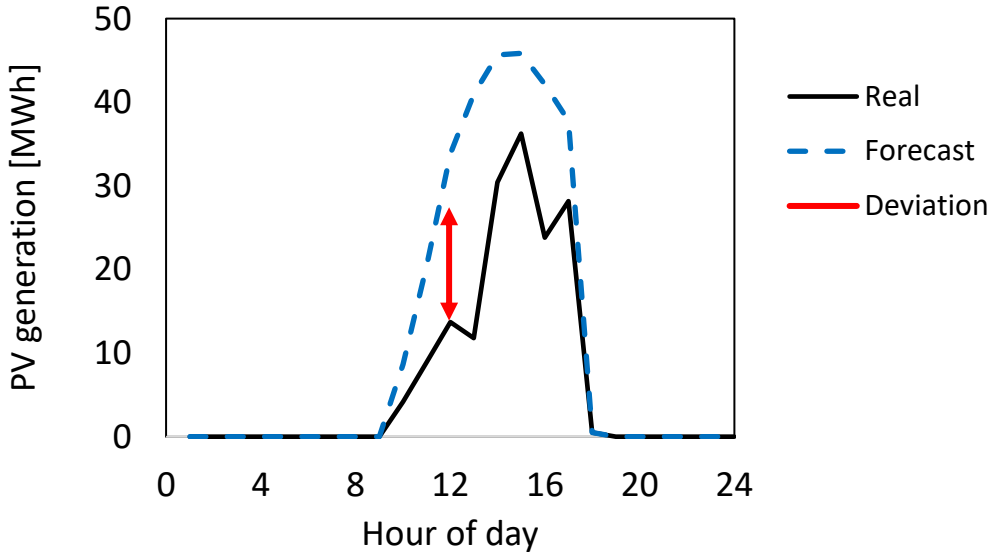
Demand response[5] Maintenance scheduling

1 – Visser et al. (2022), 10.1016/j.renene.2021.10.102 | 2 – Saint-Drenan et al. (2016), Report IEA-PVPS T14-06:2016
3 – Cirés et al. (2019), 10.1016/j.energy.2019.116053 | 4 – Moshövel et al. (2015), 10.1016/j.apenergy.2014.07.021
5 – Masa-Bote et al. (2014), 10.1016/j.apenergy.2014.03.045

One example - Electricity market bidding

<u>Power plant operators must forecast their generation</u>

- Forecast horizon & penalty mechanism depend on given market
- **Penalties** applied to forecast deviations (**typically non-linear***)

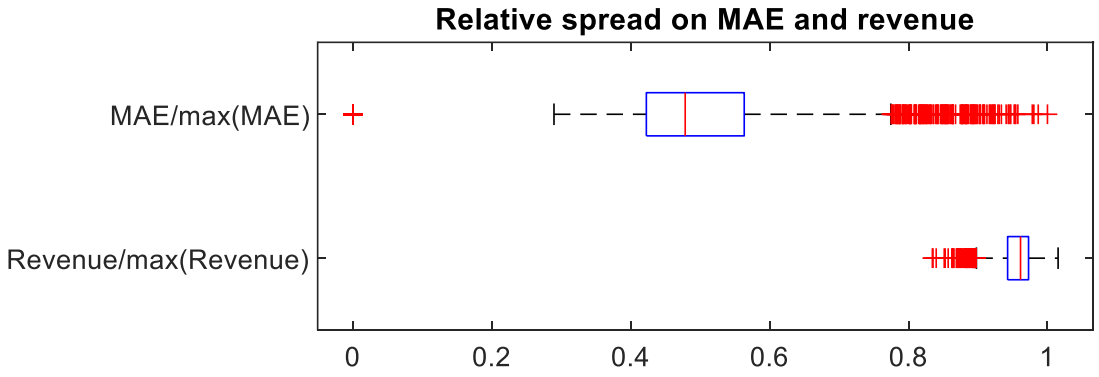


*For example, there may be no penalty if your forecast error ends up helping the system as a whole (e.g., underestimating generation forecast for a period where the system ended up underestimating the expected demand)

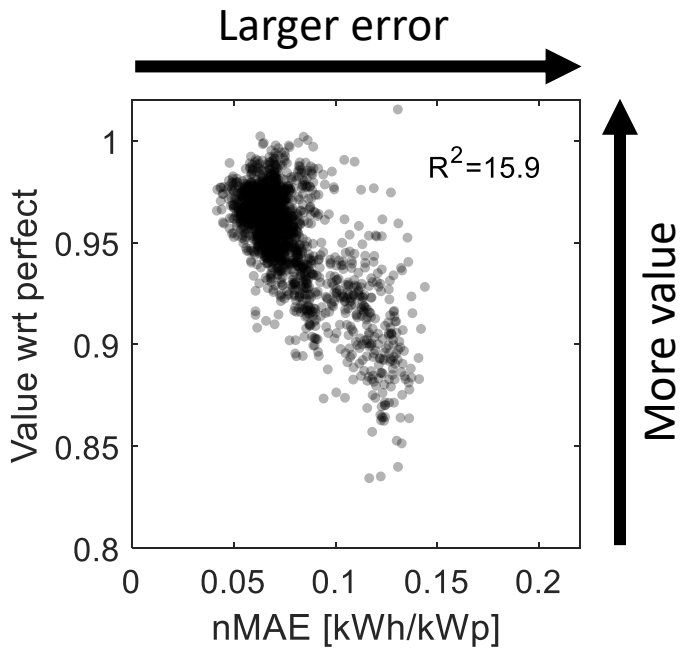
One example - Electricity market bidding

Visser et al. (2022)

- 152 PV systems in Netherlands / day-ahead market
- Tested several forecasting models



Spread in MAE >> Spread in value



nMAE not a good predictor of value

Visser et al. (2022), 10.1016/j.renene.2021.10.102

Figures created based on data from original reference, courtesy of Lennard Visser

Next steps

Close to 100 references identified on the topic

Working on a review, addressing:

- What are the applications?
- How much is the value?
- How is this estimated?

Two colleagues from France & Netherlands likely to join ☺

Call to action

Renewable and Sustainable Energy Reviews 161 (2022) 112348

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

A review of solar forecasting, its dependence on atmospheric sciences and implications for grid integration: Towards carbon neutrality

Dazhi Yang [a,*], Wenting Wang [a], Christian A. Gueymard [b], Tao Hong [c], Jan Kleissl [d], Jing Huang [e], Marc J. Perez [f], Richard Perez [g], Jamie M. Bright [h], Xiang'ao Xia [i], Dennis van der Meer [j], Ian Marius Peters [k]

doi: 10.1016/j.rser.2022.112348

ALCOR-SYSTEM website, ALPHEA all-sky camera

This demands for multidisciplinary collaboration!

Extra slide

There are interesting insights to be found

Forecast is seen as a cheap solution, fast to develop/implement

- Tuohy et al. (2015)
- Notton et al. (2018)
- Hodge et al. (2020)

Grab the Low-hanging Fruit: Use Solar Forecasting Before Storage to Stabilize the Grid

October 14, 2014

By Steven E. Letendre, Contributor
Profesor

DOI: 10.1109/MPE.2015.2461351; DOI: 10.1016/j.rser.2018.02.007; DOI: 10.1002/wene.376