WHEN TRUST MATTERS

A closer look at energy assessment accuracy of wind and solar hybrid projects

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The rise of hybrid power

Hybrid power plants are becoming increasingly popular as they:

- Optimize the use of the electricity networks by installing additional capacity from a different complementary technology
- Reduce energy production costs by sharing land, infrastructure or O&M costs
- Improve operation flexibility and reduce investment uncertainties.

Favourable Regulation

has been published in different countries

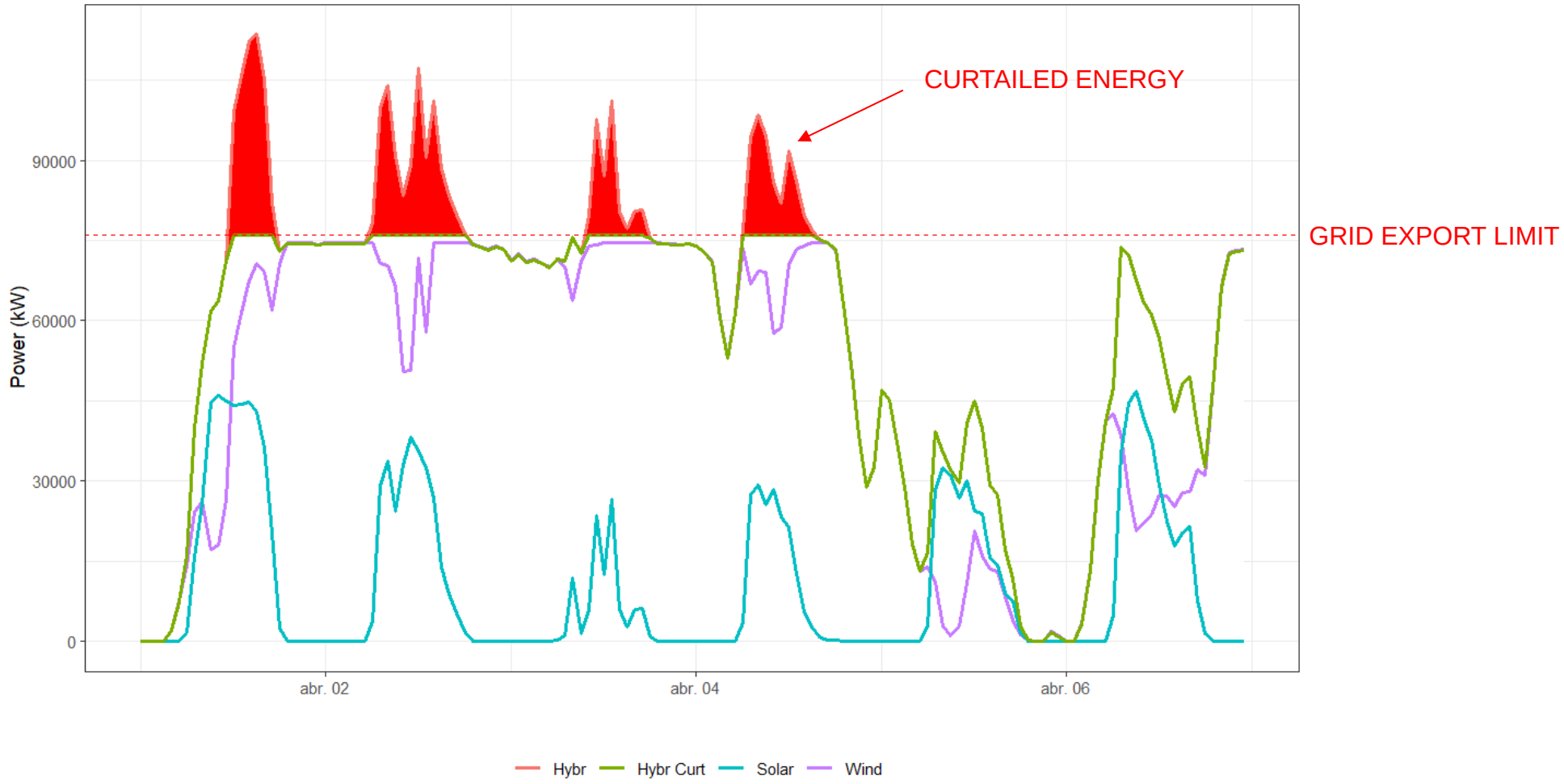
- Allow Plant Overcapacity
- Simplified Permitting
- Reduced Connection costs & Guarantees

Outline

- Hybrid Energy Assessments: a curtailment calculation
- Which factors drive energy curtailment in a Hybrid Plant
- Test case results: Accuracy in Curtailment Estimation
  - Energy Modelling
  - Time Resolution
- Conclusions

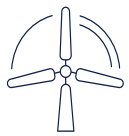
What is a hybrid energy assessment?

A **hybrid energy assessment** is essentially a **time-series**-based wind/solar energy assessment + a **curtailment** calculation



What does the production hybrid wind-solar system subject to a power limitation depend on?

The production of a hybrid system depends on the specific realization of synchronized (sub) hourly power time series for both technologies.



Wind/Solar Energy Production

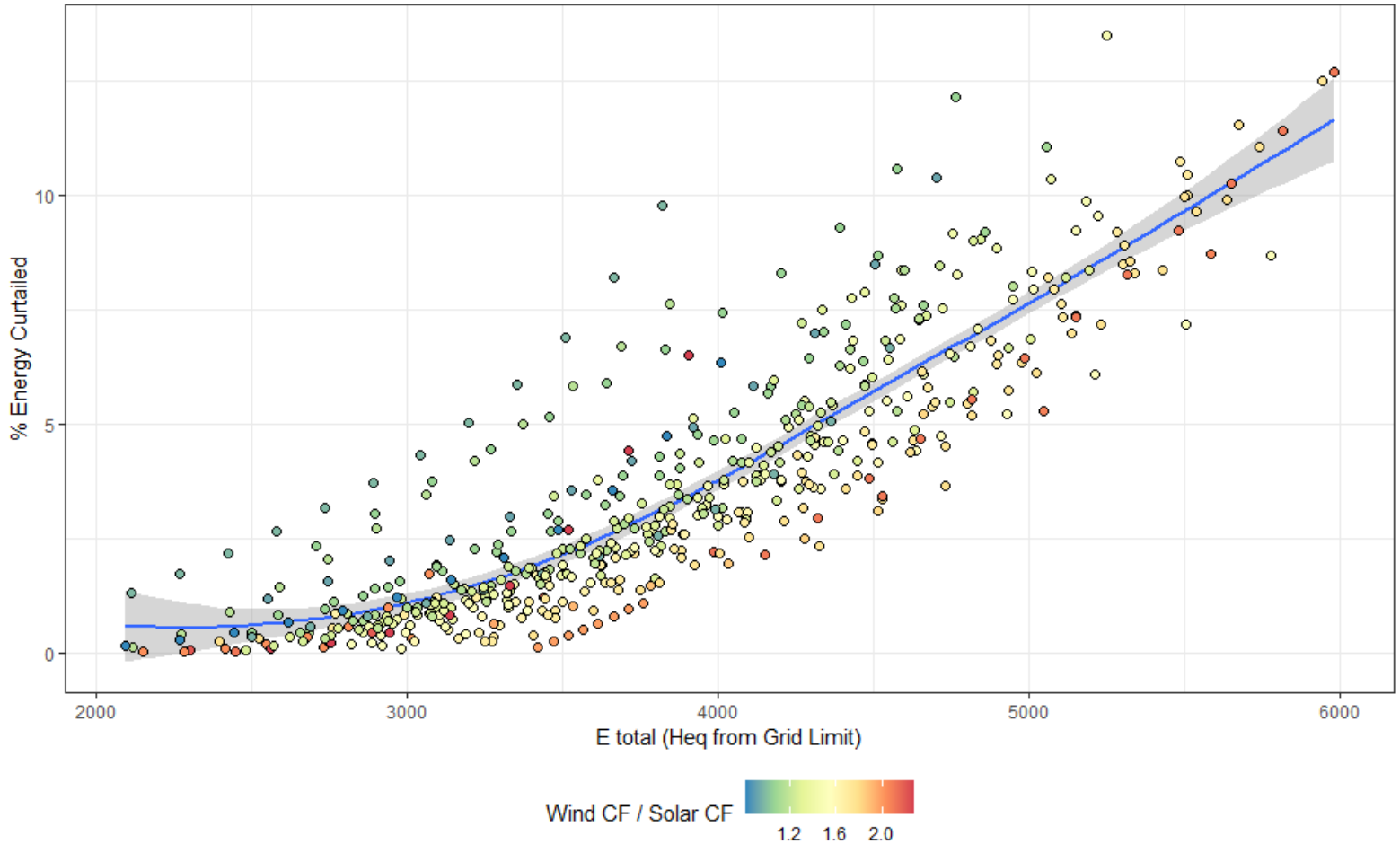
- Total wind + solar energy production
- Power distribution shapes
- Wind/Solar capacity factor ratio

Complementarity of resources

- Pearson/Spearman correlation coefficient is a good (but not perfect) metric

Energy curtailment % for different projects and capacities

Data from 63 hybrid projects

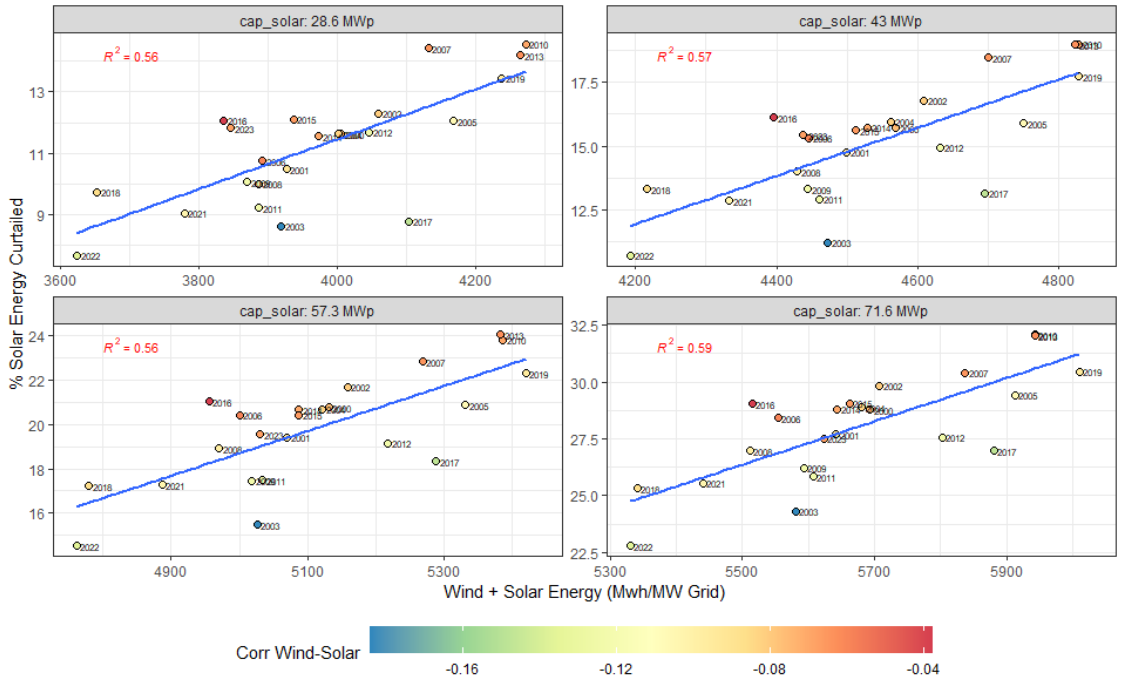


Regardless of the particularities of each site, plant capacities, or power limits, curtailment rate clearly depends on:

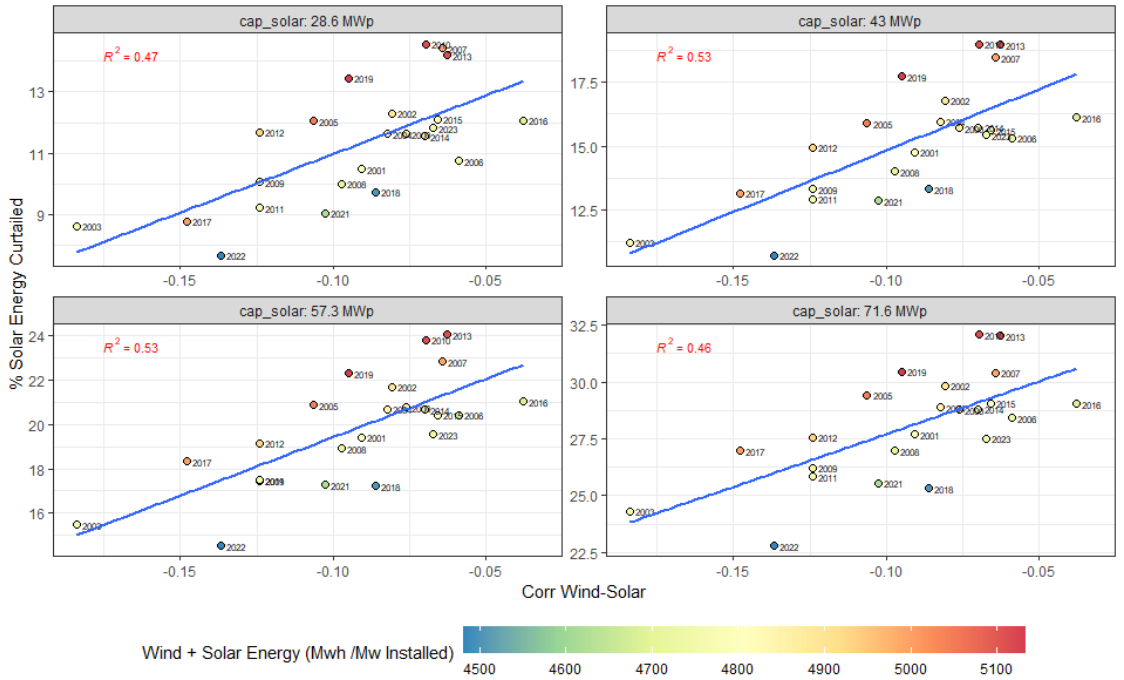
- Wind + Solar Energy Production (referenced to Grid Power Limit)
- Correlation coefficient between Wind and Solar Production
- Wind Capacity Factor to Solar Capacity Factor Ratio

One Project: Curtailment Annual Variability

Wind + Solar Annual Energy



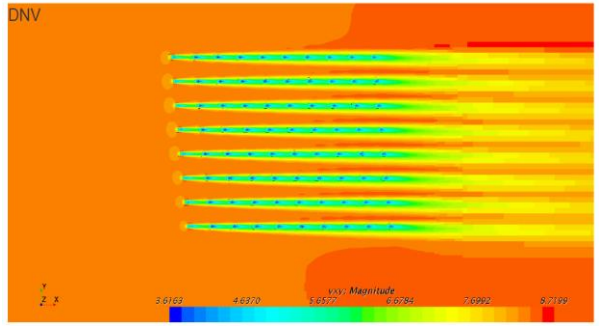
Complementarity



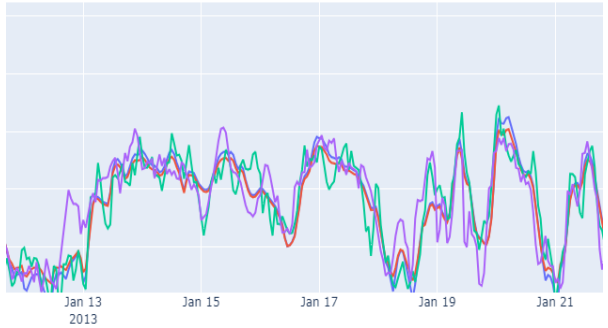
Year to Year we observe the same dependence of Curtailment with Annual Wind+Solar Energy Production and Correlation between Wind and Solar Power Series

Time series Modelling is the crucial step

Which assumptions and ways to do it



- How do you scale different capacities in the modelling ?
  - Performance adjustments per capacity: Wakes, wind flow, shadings, …



- How long should it be ?
  - The longer the better to explore different energy/complementarity combinations
  - Long-term power time series synthesis
  - Risk using Typical Meteorological Years (TMYs)
- Which time resolution ?
  - The higher the better
  - How to synthetize? Reference data in sub-hourly resolution?

- Which losses to model and how ?
  - Time dependent modelling: availability, electric efficiency, ice, ..
  - Other losses applied as wind speed loss

Accuracy in Hybrid Energy Assessments

Test Case

Operating Wind Farm (50 MW rated power) and **50 MW Grid Export Capacity**

Wind Farm:

- 3 years of Wind operation data: Hourly Meter data / 10-minute SCADA data
- 4.5 years of Wind Met-Mast measured data and Pre-Constructive Modelling
- Long Term:
  - Pre-Constructive Power Time Series ERA-5 Synthesis
  - Operational Data Resampled to Long-Term using ERA-5 reanalysis as reference

PV Plant:

- Pre-Constructive Solar Energy Assessment based in 15-minute Satellite Data
- Different solar capacities have been simulated and curtailed energy due to the grid limitation has been calculated

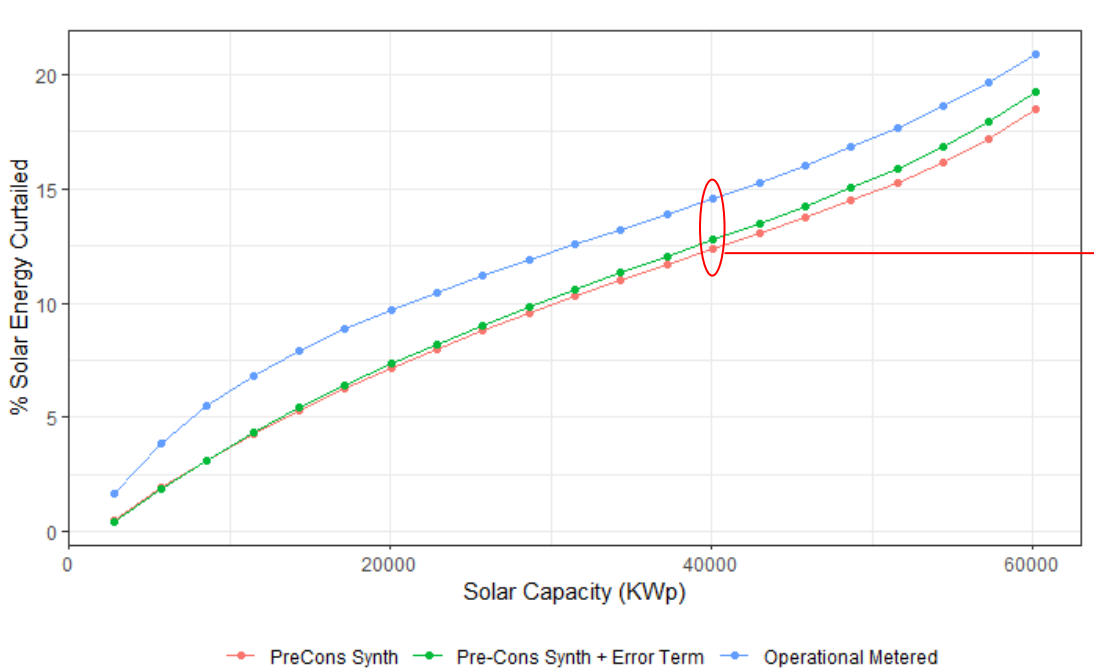
OBJECTIVE: Compare curtailment rates obtained using different series modelling (synthesis, TMY, etc), pre-constructive or operation data and different time resolutions

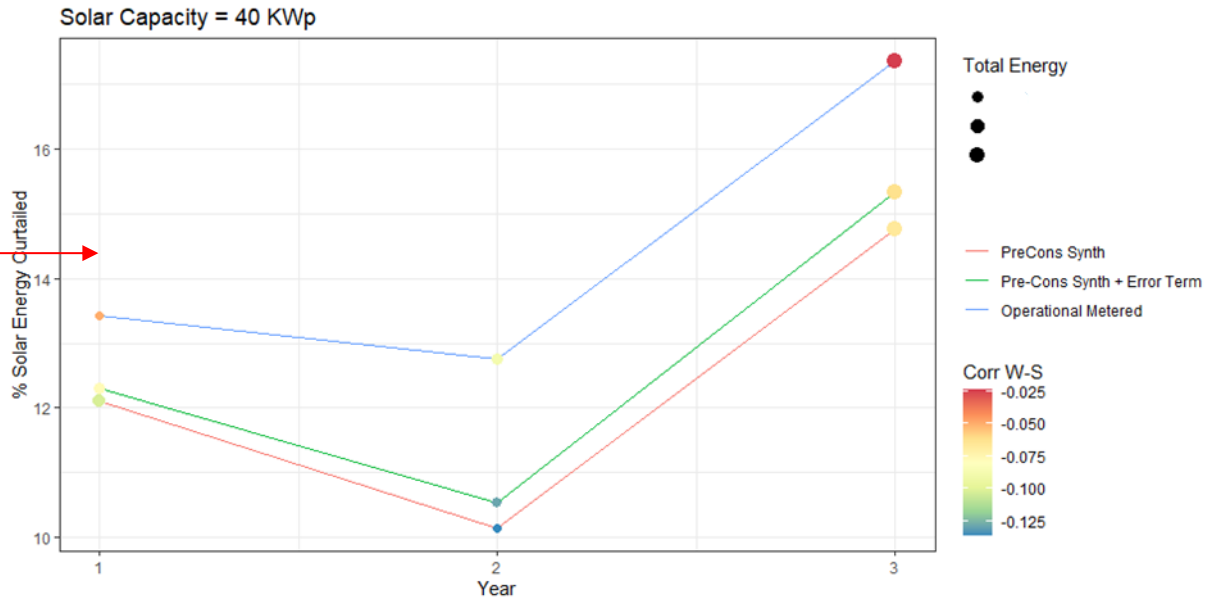
Results in Operational Metered Period (Hourly)

Pre- Constructive vs Operational Data

Long-Term period

Operational period





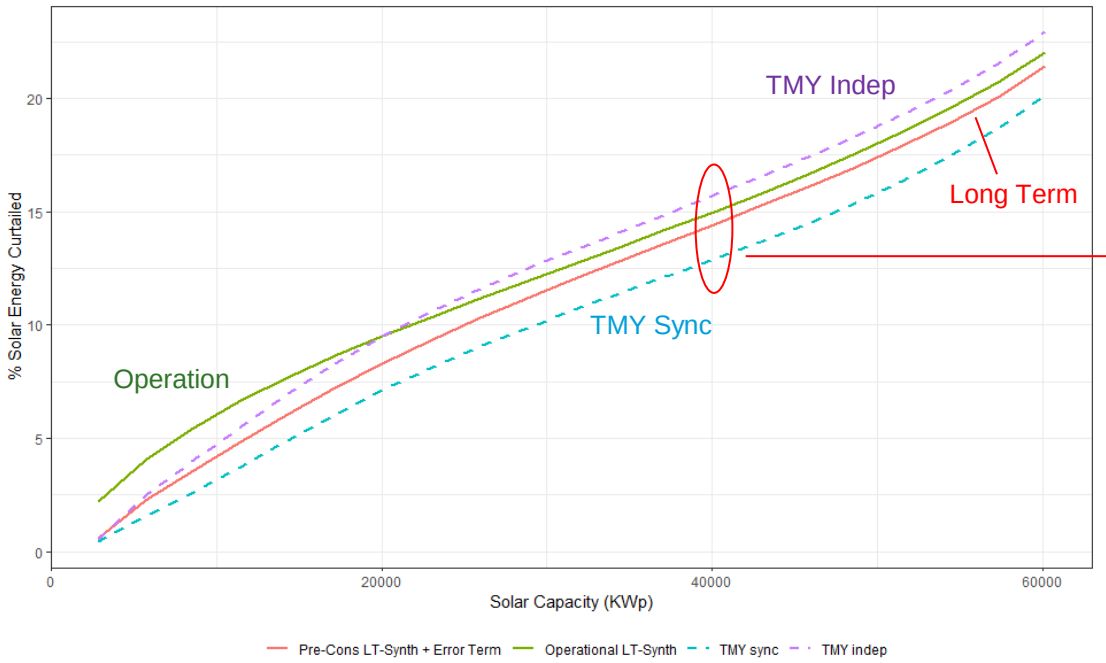
Pre-constructive Modelling is underestimating curtailment around 25 % on average in metered period

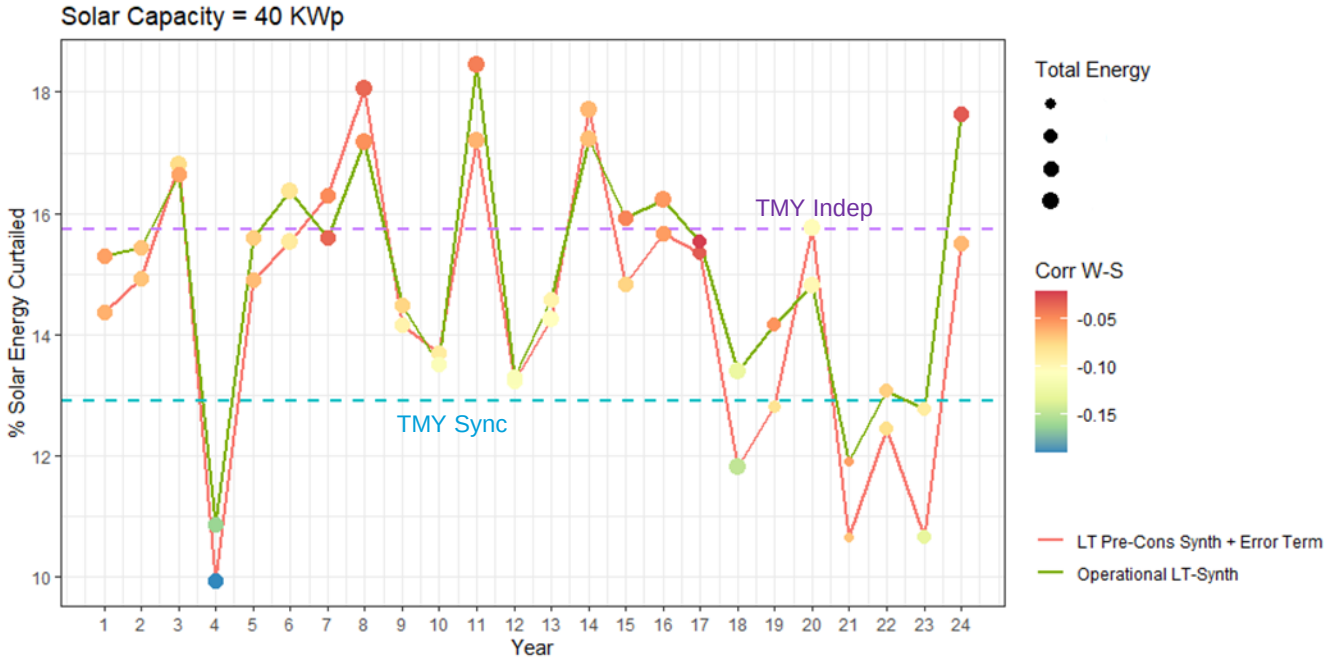
Annual Variability in curtailment is mostly explained from wind solar correlation and total annual energy production

Long-Term Results (Hourly)
Pre- Constructive vs Operational Data

Long-Term period

Operational period





- Pre-constructive and operational difference is smoothed
- TMYs can either under- or over-estimate depending the choice

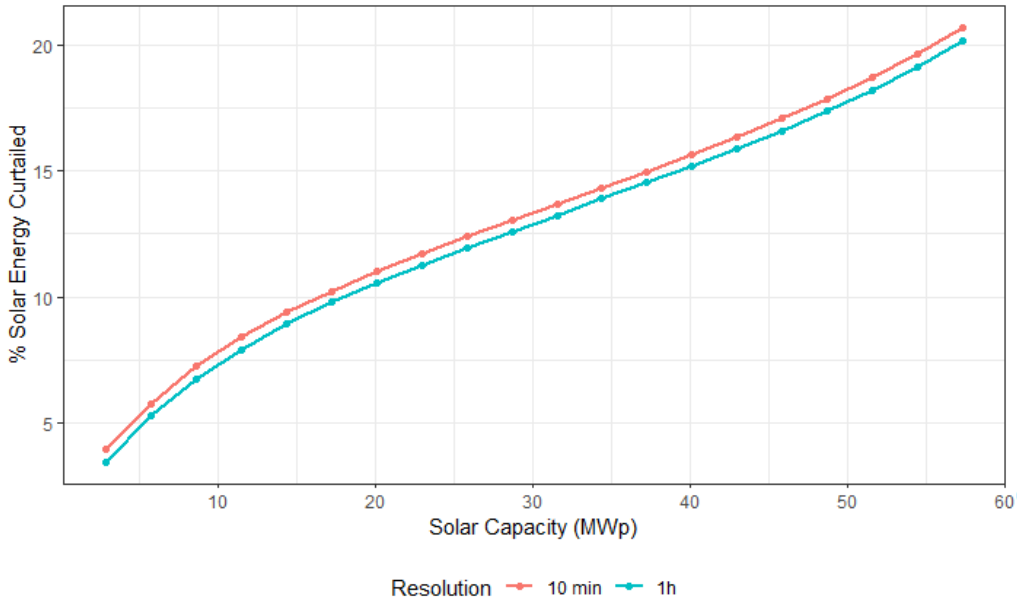
High Annual Variability in Curtailment Rate

- Again, explained by energy production and correlation
- Difference between operational and pre-constructive varies in time

Results for different Time Resolutions

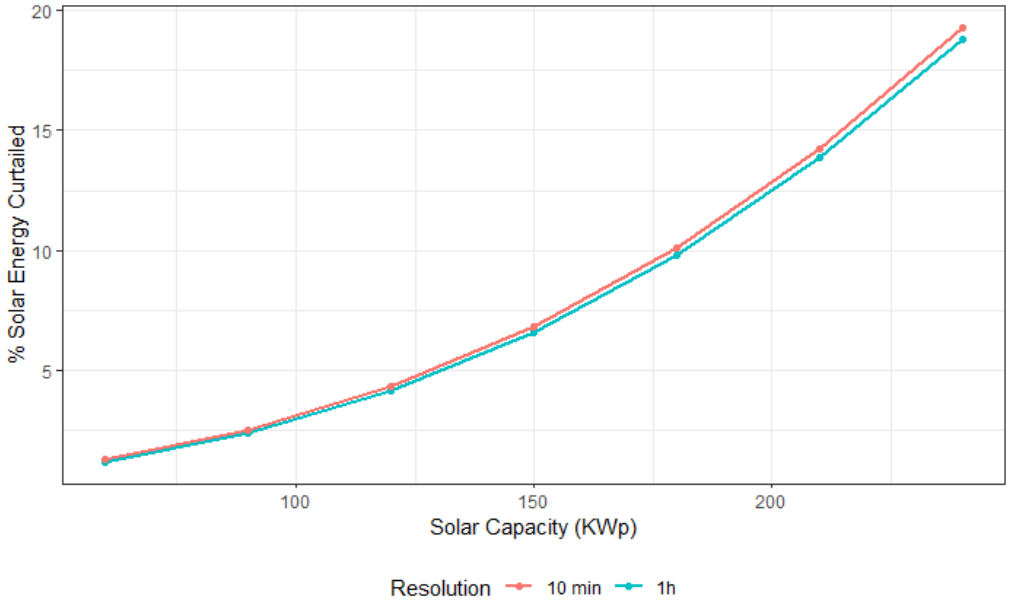
Wind: Operation SCADA Data 10 min

Solar: Pre-Constructive SOLARGIS 15 min Satellite Data



Wind: Pre-Constructive Model + ERA5 Interpolated

Solar: Pre-Constructive SOLARGIS 15 min Satellite Data



The higher the resolution the higher the curtailment

Conclusions

The analysis addresses some of the most common question marks about methodology and assumptions conducted in hybrid projects. Real data have been used to illustrate the following findings:

- Hybrid energy assessment depends strongly on the specific details of wind and solar power distributions and mutual time correlation.
- Different modelling approaches could lead to significantly different results which affects to business decisions. The more relevant are:
  - **Data source**: Pre-constructive (Mesoscale/Mast Measurements) vs Operational → Use operational data if available.
  - **Evaluation period** → The longer the better. Consider synthesis (also of operational data)
  - Use **synchronized** wind and solar periods → Avoid TMYs
  - **Time resolution** → The higher the better (but difficult/uncertain synthesis)
- Therefore, results must be considered with the corresponding degree of uncertainty to take the investment decisions adjusted to the desired risk level

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Thank you for your interest.

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