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WEATHER SERVICES

Importance of Telemetry Data to Solar Forecast

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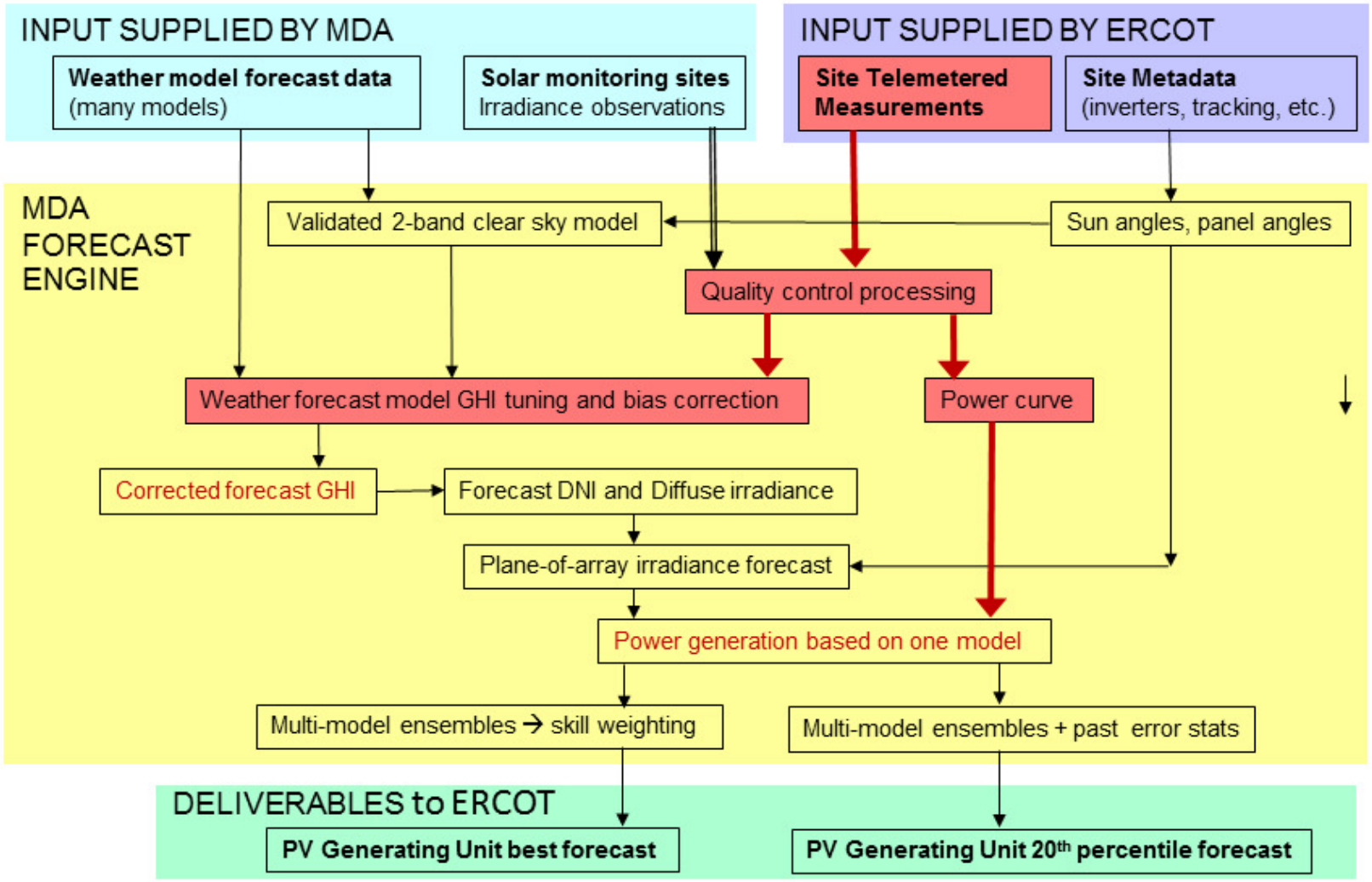
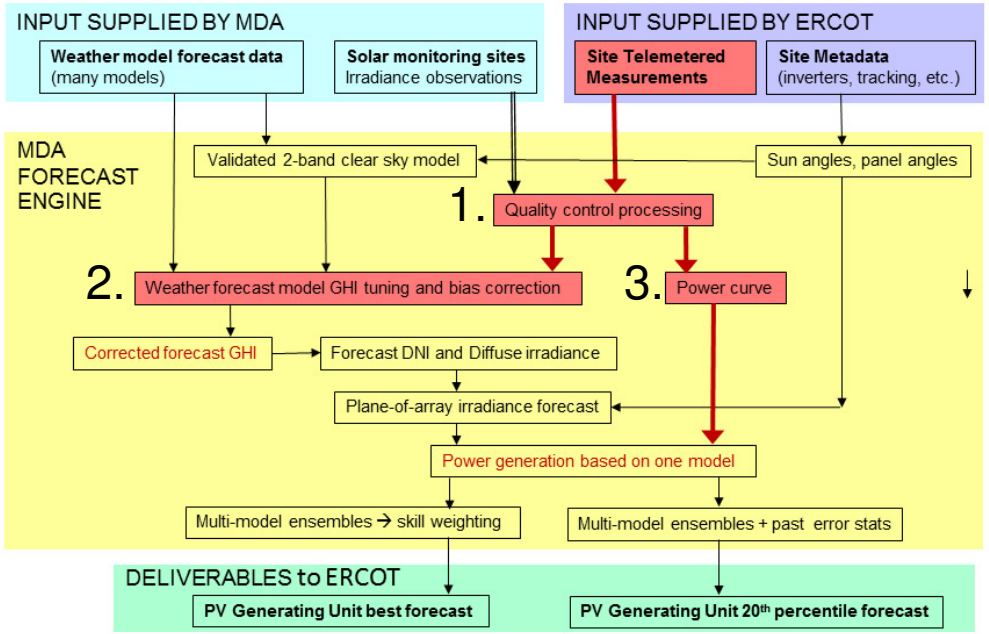
How MDA Makes Solar Forecasts (simplified version)



Role of Telemetered Data in MDA Solar Forecast

1. Quality control of observations
2. Calibration of Numerical Weather Prediction forecasts of GHI
3. Power curve to convert MDA irradiance forecast to electric generation by the individual PV generating unit
4. (not in flow chart) Real-time data are used to modify the first few hours of the forecast



1. Quality Control of Observations

Ground measurements form the underlying basis for calibrating physical models and developing empirical relationships between predicted parameters and power generation by the PV generating unit

Accurate measurements are required.
Erroneous data need to be detected, then corrected if possible or eliminated

Erroneous data has many sources, including:

- Instrument failure (usually obvious)
- Irradiance monitor in deep shadow (often obvious) or partial shadow (difficult)
- Recorder stuck briefly (same values repeat) –
  - can be stable condition (correct) or malfunction (difficult to detect)
- Recorder stuck for prolonged period (usually obvious)
- Instrument calibration drift evolves over time such as irradiance monitor soiled
- Instrument not properly calibrated
- Power is misattributed among generating units at a multi-unit farm

Observations of multiple related parameters improves error detection and data use

1. Quality Control of Observations, example

Site (not in ERCOT) reported GHI and Plane of Array (POA) irradiance every 1 minute

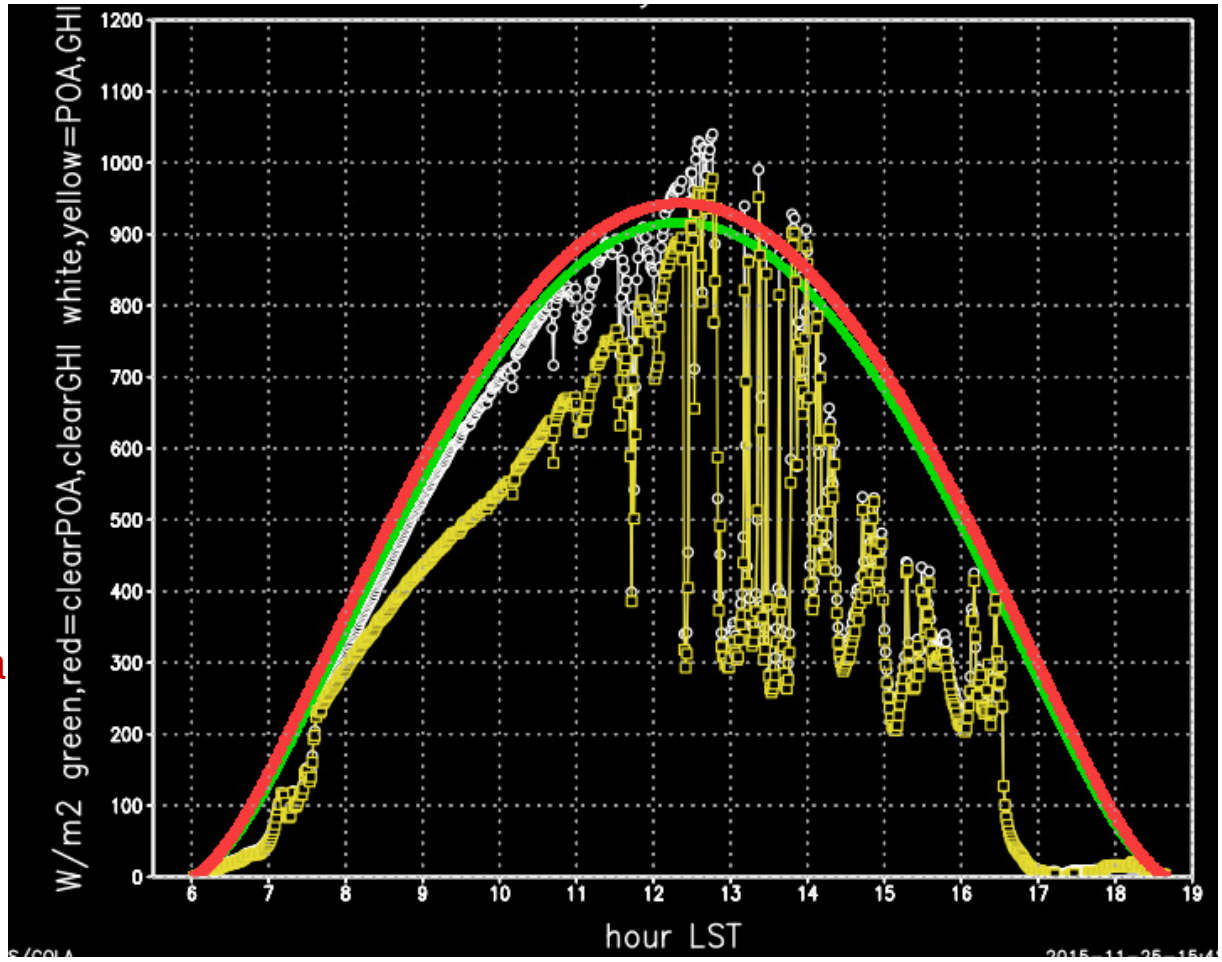
8am-noon on this day:
POA (white) matched
clear sky POA (green)

GHI (yellow) much lower
than clear sky GHI (red)

MDA calculated
clear sky GHI and POA

Result: we deduce that GHI
sensor is partly shadowed
at these times=bad GHI data

If this site reported only GHI,
more difficult to distinguish
between clouds and shadow



2. Calibration of Numerical Weather Prediction Forecasts

Numerical Weather Prediction forecasts of GHI have biases

- Some bias even under clear skies (model and observations both show clear)
- Bias as a function of various parameters including sun angle
- Bias can vary locally, regionally, and seasonally due to variations in aerosol effects and other influences imperfectly accounted for by the model
- Biases are different for each numerical weather prediction model

Solar generation forecasts are improved by correcting for these complex biases.

Correction is performed through statistical relationships between recent model forecasts, various parameters, and quality-controlled observations

NOAA, Department of Energy, and others have scattered sites with GHI measurements. Quality varies widely by site and network.
Good quality observations at the PV generating unit location help most
Good quality observations within ~100 km (or possibly further) of the generating unit help more than lesser quality observations at the generating unit
Irradiance monitor needs to be well-calibrated and well-maintained

3. Power Curve (converting irradiance to generation)

The irradiance falling on the PV array (plane of array [POA]) is converted by the PV panels into DC current and through the inverters to the AC stepped up to the transmission feed.

This conversion POA → AC output is modeled statistically and applied to the forecast POA to yield a forecast of the PV power generation.

A key factor influencing this conversion is the back panel temperature.
(Assuming back panel temperature varies little between panels across the solar farm except when a cloud shadows only part of the farm, only one good measurement per farm is needed, two is better to help with quality control)

The statistical model works best when good quality measurements of power and POA are available for the same time periods (such as 1-minute or 5-minute averages for both). Temperature and wind measurements help define a relationship between forecast parameters and back panel temperature. Number of inverters online is needed so that the POA-power relationship can be properly scaled for each data pair of POA and power.

4. Real-time Adjustment of Short-term Forecast

Real-time measurements of good quality help identify when the model-based forecast is on the wrong track and can be statistically corrected based on persistence (adjusted for the diurnal curve) and trends over the most recent minutes or hours

Power and irradiance are the key observations
Quality is paramount – bad observations can cause the forecast to be pushed in the wrong direction

Some data quality control steps require "future" data (e.g., did the logger get stuck in the last few minutes) → quality control is less robust in real time
Therefore, a high quality of the measured real-time data is crucial
→ maintaining the instruments and loggers etc. well is very important

5. Additional Considerations

Correct PV panel angles for the solar installation are required to properly predict Plane of Array irradiance. This requires accurate tracking information for 1-axis and 2-axis trackers.

MDA has inferred the tracking angles from available site observations of irradiance and power, but there is some error associated with these estimates. The panels are typically rested horizontally overnight and can take up to 2 hours to reach the optimal standard configuration. Additionally, our calculations reveal that the panels typically tilt more vertically at the appropriate times of morning and evening than the manufacturer specifications for the trackers list as the peak tilt (typically listed as 45 degrees, depending on the tracker). Also, one site either has some rows at fixed tilt or has for a long time had failure of the tracking mechanism for some rows. Forecast accuracy would be improved if the forecast vendor would be provided:

- Tracking angles as part of the real-time data feed
- Fraction of the generating unit that is online but not currently tracking and the angles of those panels

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Thank you

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