High Pen PV Project – Implementation of the SAM SDK

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Outline

As part of a larger DOE project NREL was tasked with providing guidance to a utility on estimating PV power from existing weather station data and implementing it into their visualization platform.

The quickest solution was use of the SAM SDK.

Background on SAM SDK Task

Develop SAM SDK Interface

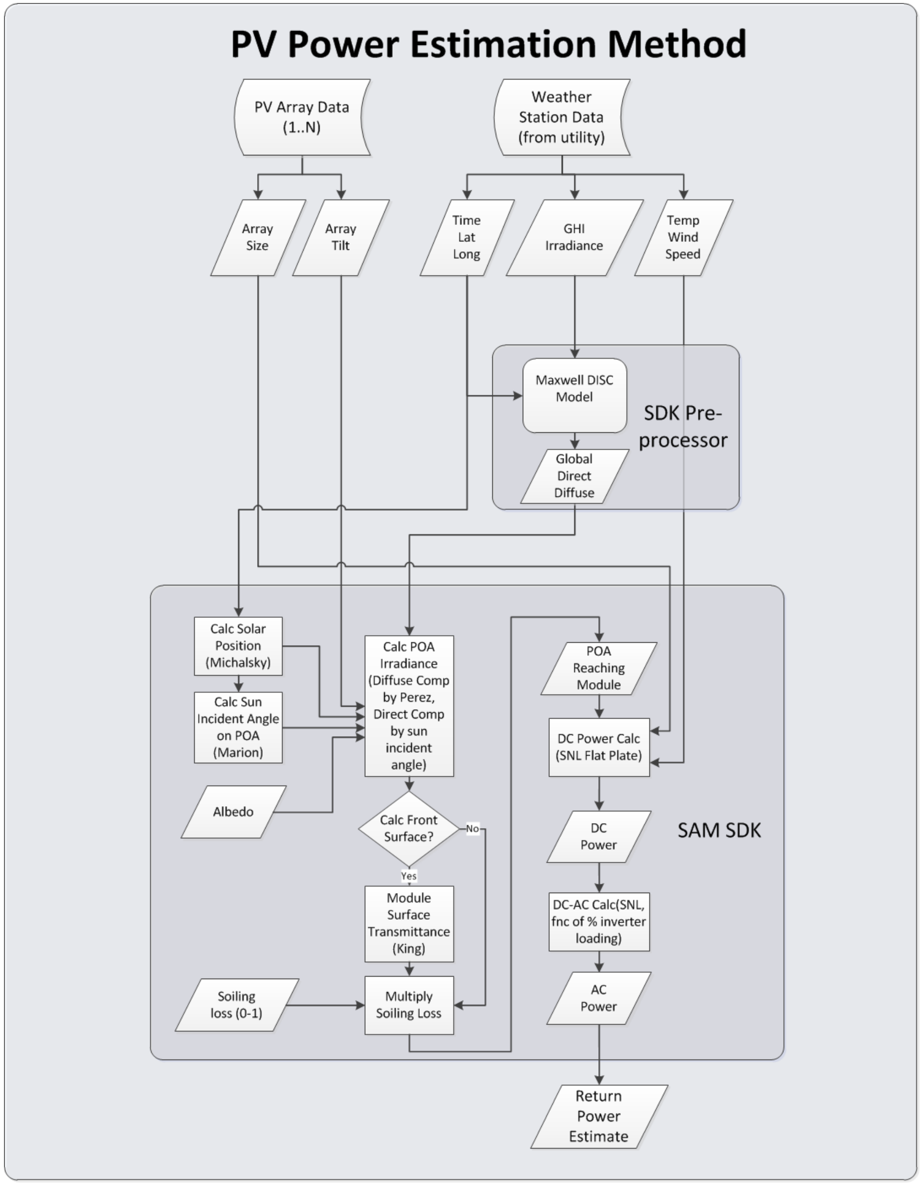
Work with and provide guidance to the utility to develop C# interfaces between NREL's System Advisor Model (SAM) Software Development Kit (SDK) and their existing visualization programs.

- The overall purpose is to use the SAM SDK to estimate near real time power production from small, distributed PV inverters using existing weather station data on a test feeder to:
    - Visualize PV power production
    - Give indication to utility when power production does not match predicted (e.g., from PV inverters not operating properly)
    - Provide offline data for input to electrical models

Weather Station to Power Translation

- Estimated PV power based on nearest weather station GHI data (4 Wx stations within 2 miles of 17 instrumented residential PV arrays)
- PVWattsFunc single step function was used
- PVWatss SDK requires at least two irradiance components thus data preprocessing was required - Direct estimated using Maxwell DISC model
- “derate” value was **computed** based on available power measurements

Flow-Diagram of Power Estimation Method



PVWattsFunc Concept Validation

- 1 Week of 1 second historical weather station and 1 minute power data provided to NREL for proving the concept was valid
- Estimated PV power based on nearest weather station GHI data (Each of 17 instrumented residential PV arrays assigned to weather data from one of 4 Wx stations)
- C# wrapper was written to read weather data and PV array configuration from csv files, preprocess to compute DNI from GHI and execute the SDK to compute AC power

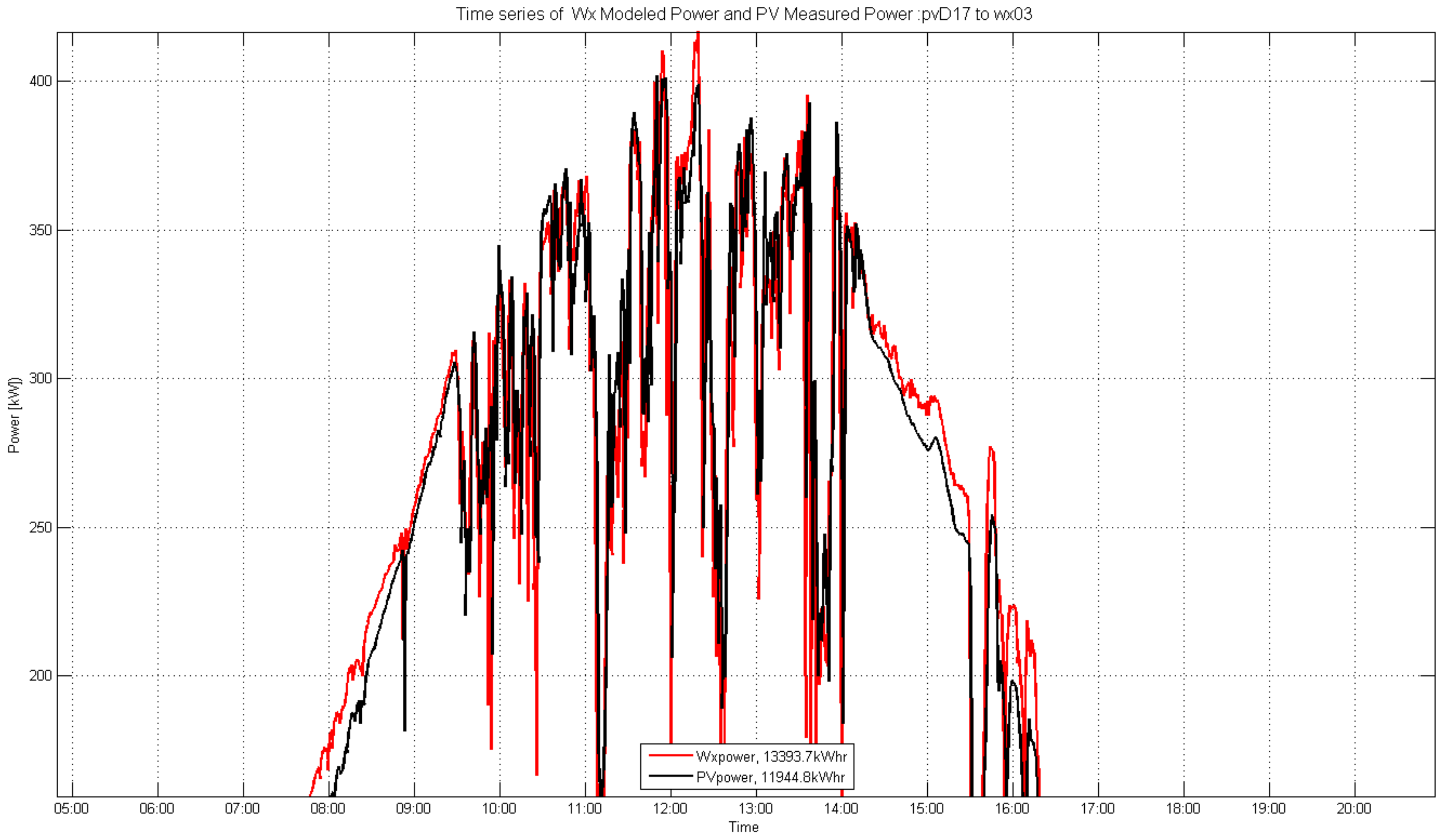
APS.kml | TestSSCAPIForm.Designer.cs | Program.cs | RunSSCAPIForm.cs

```
    {
        sscData.SetNumber("azimuth", Convert.ToSingle(words[13+i])); // azimuth angle 0=north, 90=east, 180=south, 270=west
        sscData.SetNumber("tilt", Convert.ToSingle(words[9+i])); // tilt angle from horizontal 0=flat, 90=vertical

        if (sscModule.Exec(sscData)) // execute pvwattsfunc with the data contained in sscData
        {
            float azimuth = sscData.GetNumber("azimuth");
            float tilt = sscData.GetNumber("tilt");
            float poa = sscData.GetNumber("poa");
            tiltpoa[i] = poa;
            tiltTcell[i] = sscData.GetNumber("tcell");
            tiltDC[i] = sscData.GetNumber("dc");
            tiltAC[i] = sscData.GetNumber("ac");

            txtData.AppendText("i: " + i + "  azimuth: " + azimuth + "  tilt: " + tilt + " poa: " + poa + "W/m2  \n");
            txtData.AppendText("tcell: " + tiltTcell[i] + "  DC: " + tiltDC[i] + " AC: " + "ac: " + tiltAC[i] + " \n");
        }
        else
        {
            txtData.AppendText("Exec(sscData) failed on i = " + i + "\n");
        }
    }
    // write CSV output
```

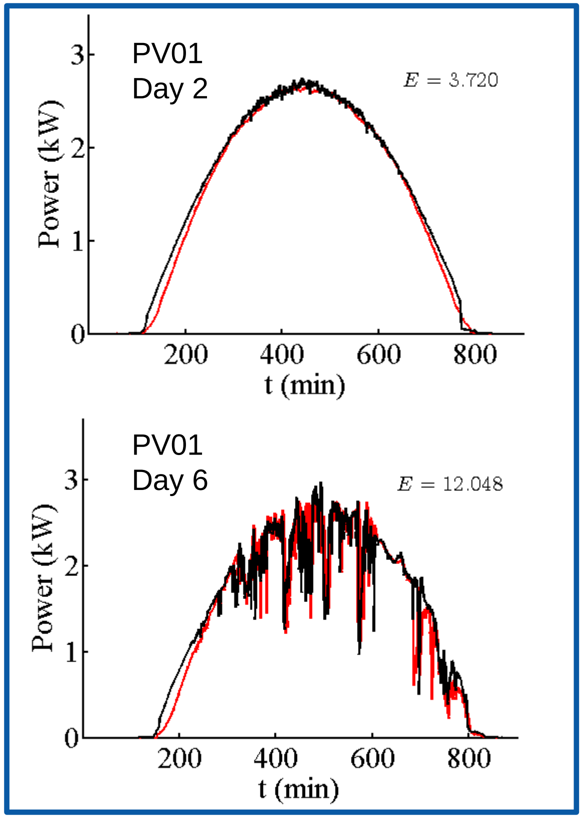
SDK PVWattsFunc Results

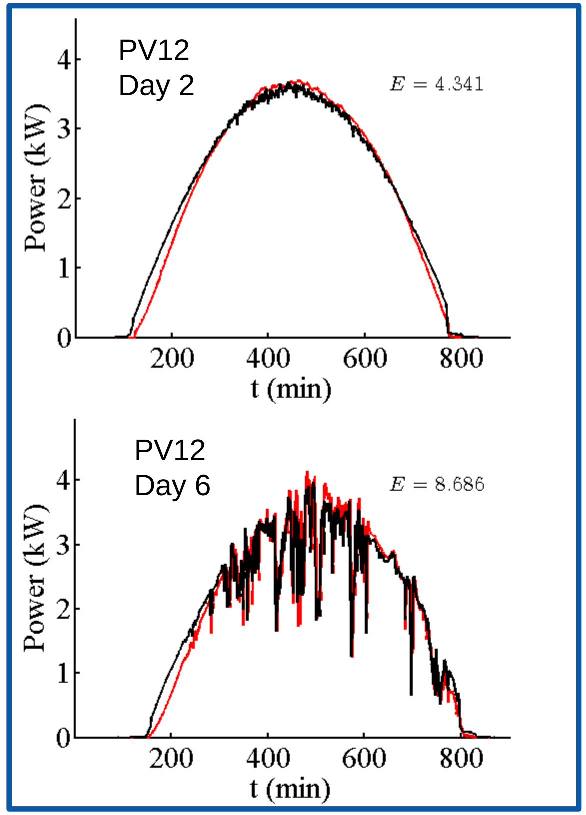
Power Estimation at Co-located Site

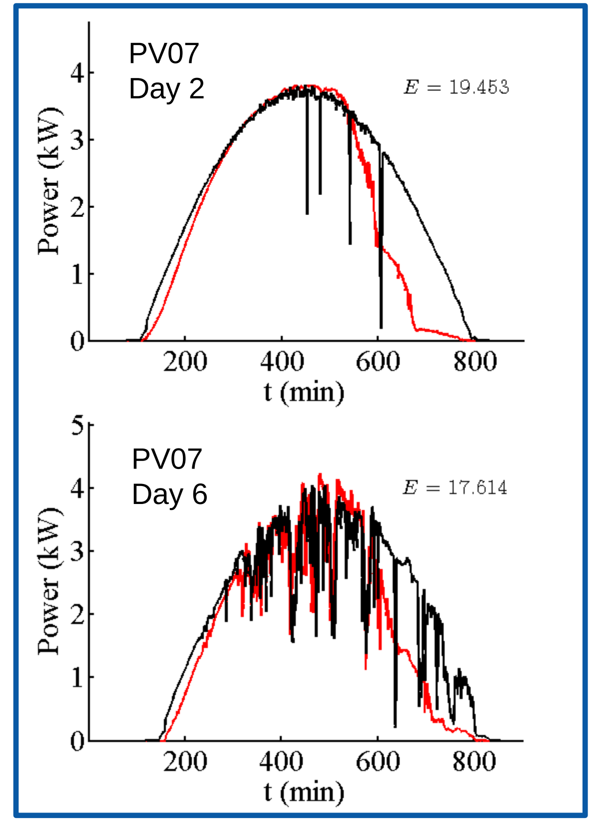
GHI to Power Validation
(Best case of co-located Wx station)

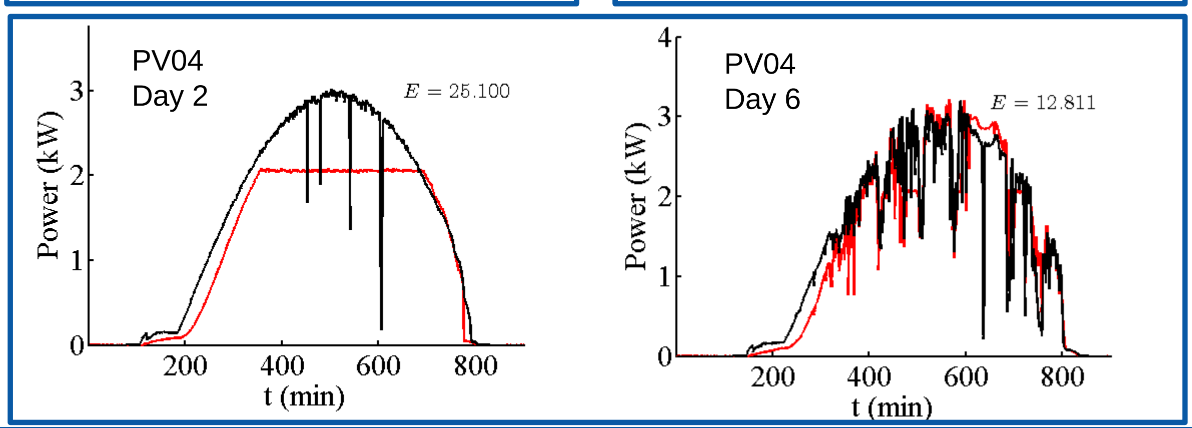


Power Estimation at Nearest PV Sites





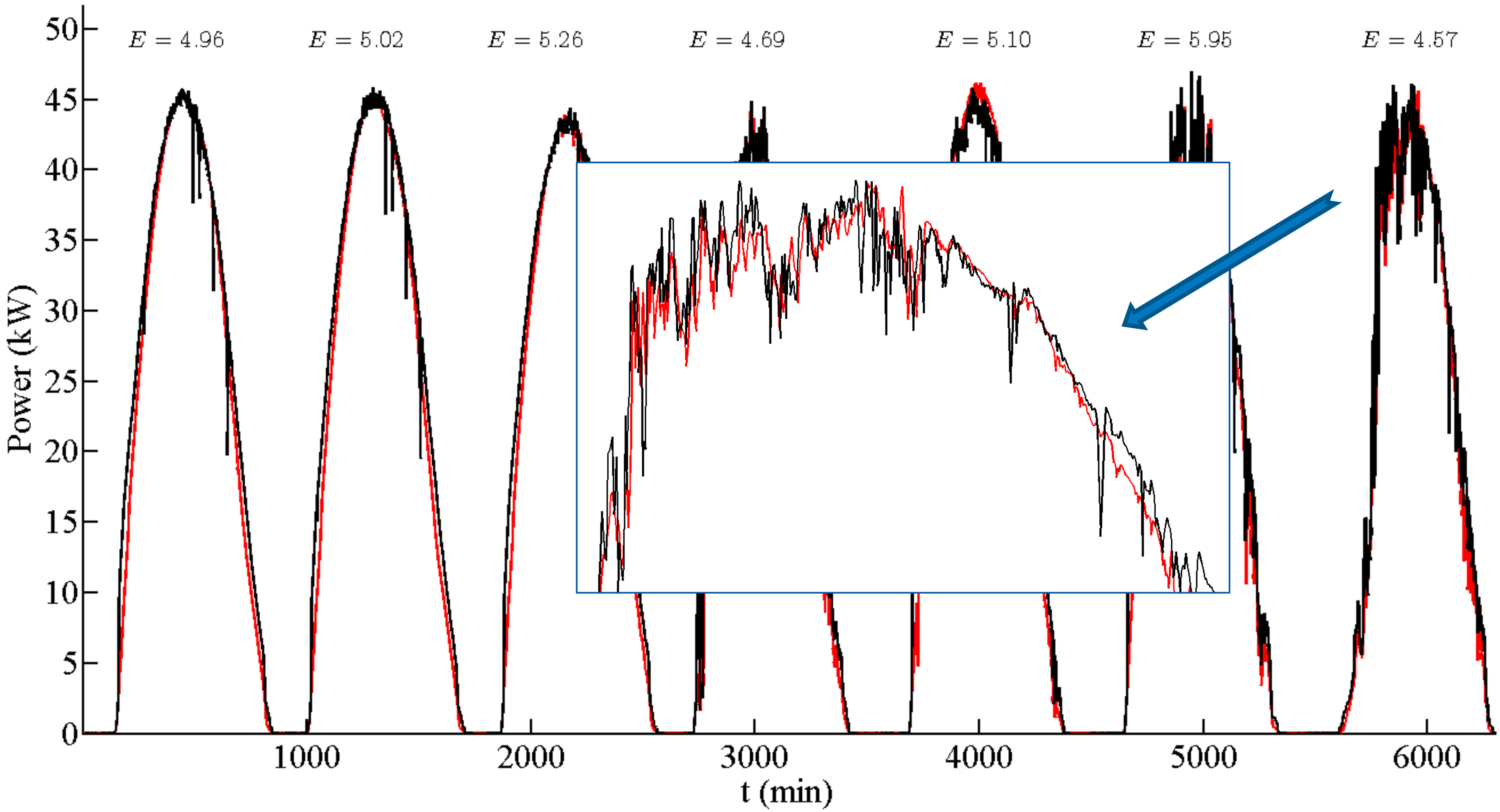




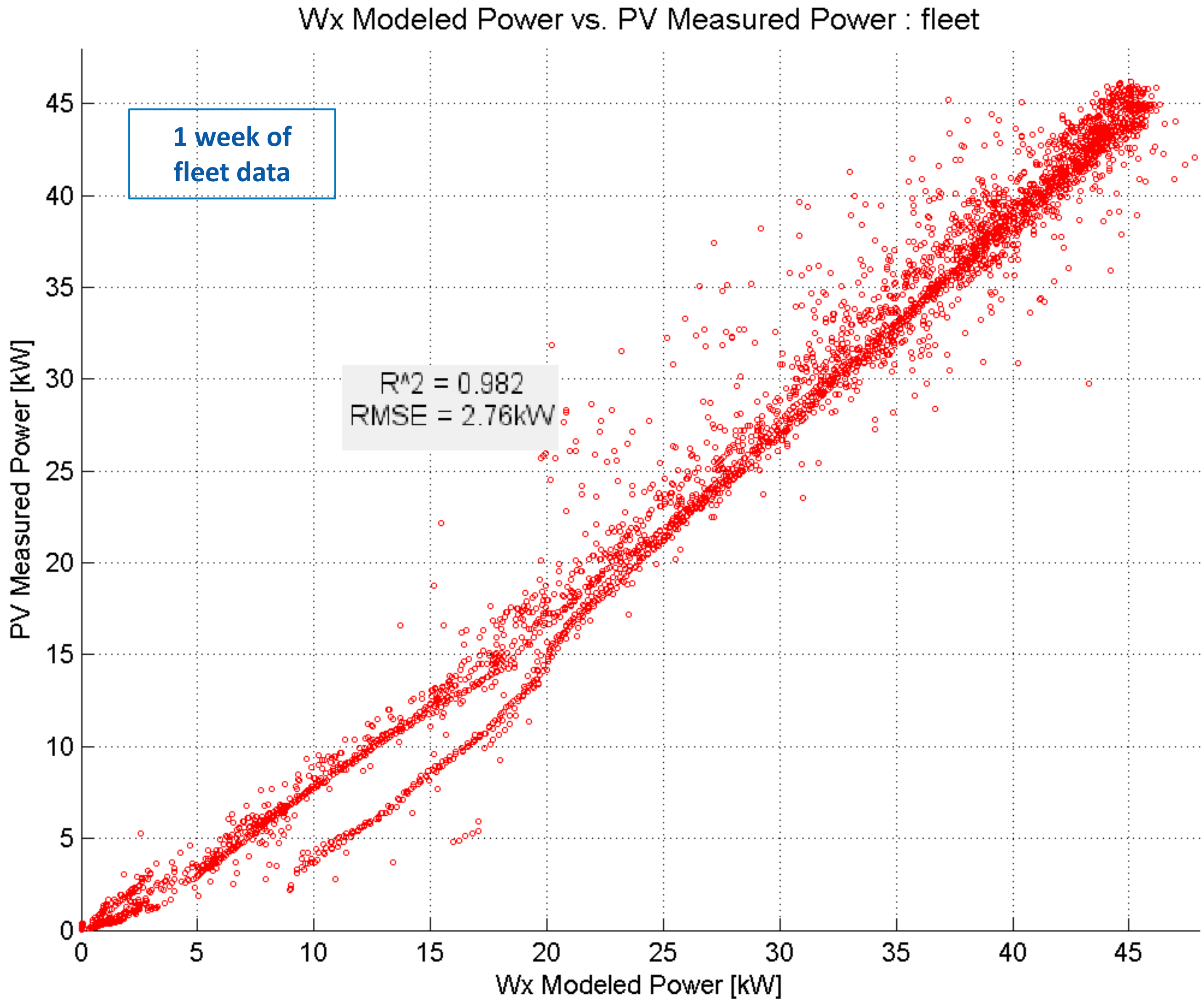
Red = Measured
Black = Simulated

$$E = \frac{100}{\max(P_m)}\sqrt{\frac{1}{N}\sum_{j=1}^{N}\left(\boldsymbol{P}_{m,j} - \boldsymbol{P}_{s,j}\right)^2}$$

Power Estimation of Fleet



Power Estimation of Fleet



Summary on Weather to Power Translation

Advantages

- Doesn't require AMI (only weather station data)
- Captures PV power based on orientation, time, date, temperature, wind-speed, etc.
- Captures irradiance variability at the same rate as input data. Power and weather data was available at 1 second and 1 minute rates.
- A satellite feed or forecasted irradiance could also be used as input

Disadvantages

- Neglects any spatial or temporal decorrelation between irradiance at weather station and PV arrays
- Preprocessing calculations for direct and diffuse irradiance introduce additional error (DISC model worked well for the arid environment in this project)
- (SDK) "derate" parameter remains a rather nebulous quantity without access to additional SAM inverter and module libraries and models

Next Steps (NREL):

- NREL DESI group continues to provide guidance for real time implementation of C# interface into utility visualization platform

Contact for Questions:

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