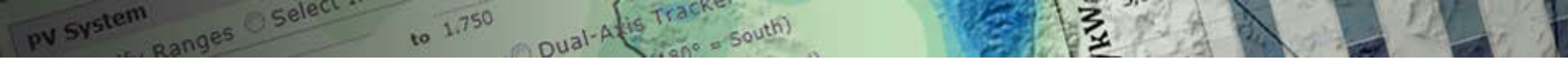
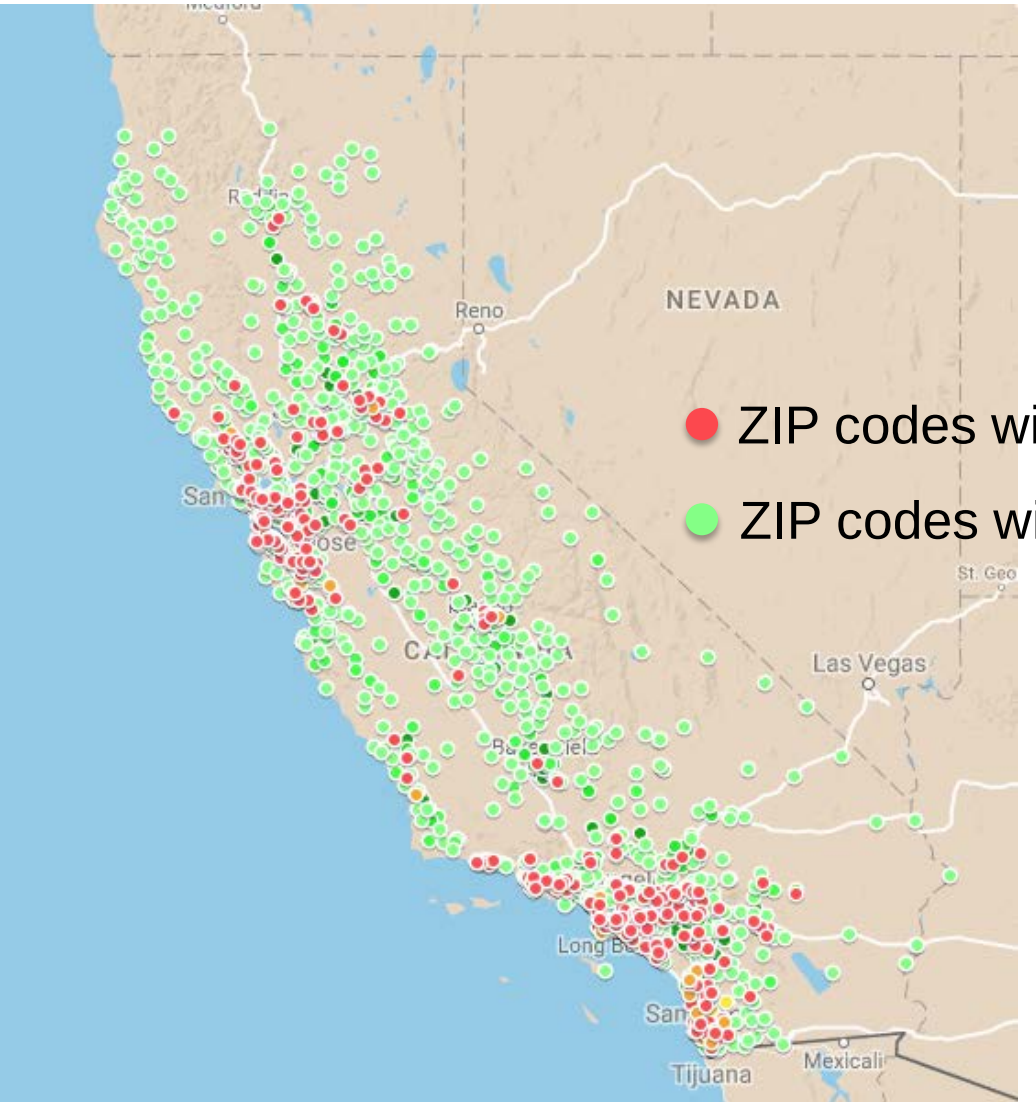


Task 4: Develop DER Production Database

- Create database of aggregated BTM PV production by zip code
  - Based on 15-minute interval data from 504 Itron meters since 2010
- Improve database using simulated data
  - Use CSI reported system specifications
  - Use CPR's "*Inference Engine*" to obtain system specifications
  - Validate using error analysis (simulated versus measured production)
- Normalize data for easier scaling
- Refine growth projections for PV adoption in the DRPs

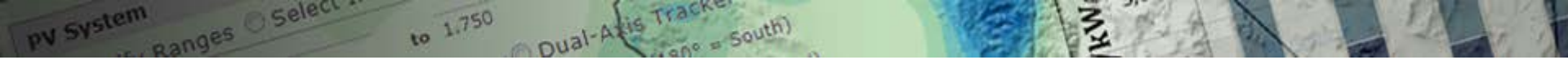
System Locations



414 sites in 292 different ZIP codes (California has approximately 2,589 ZIP codes)

- ZIP codes with measured data sites
- ZIP codes with PV Systems[1]

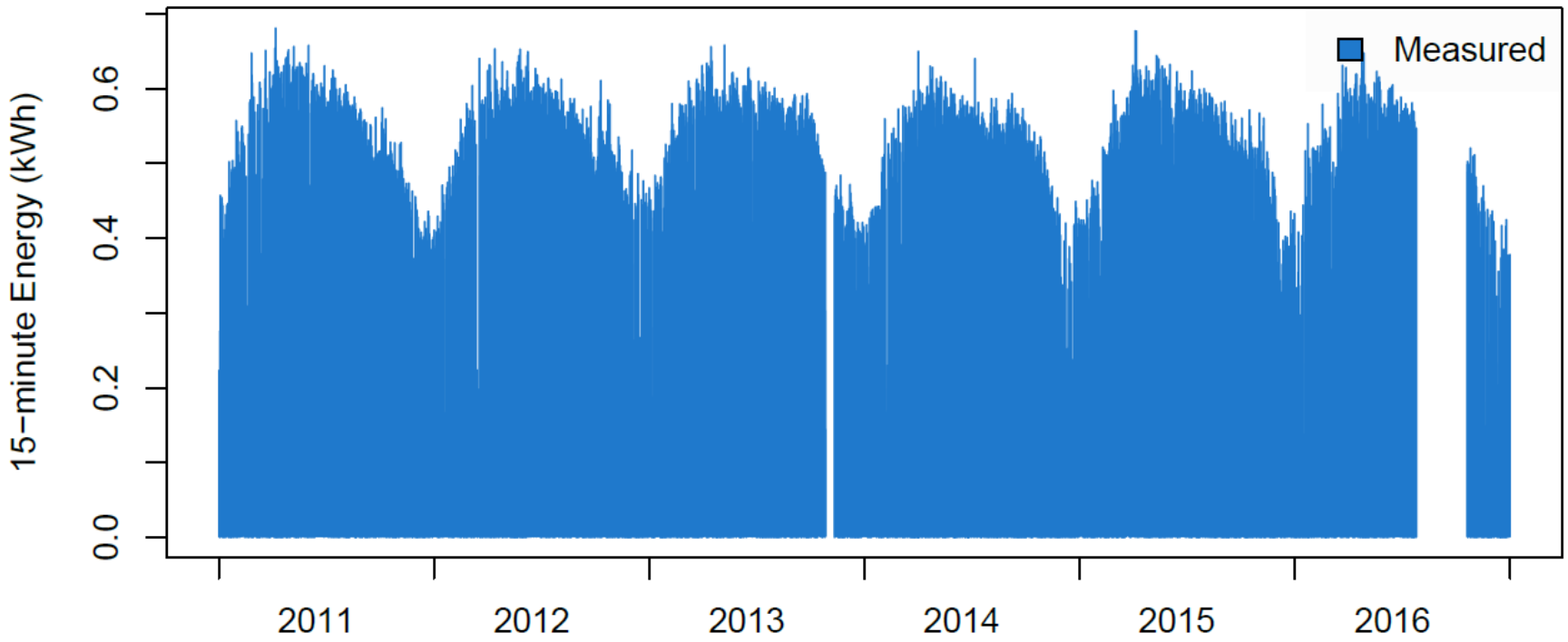
[1] NEM Currently Interconnected Data Set, https://www.californiadgstats.ca.gov



Inference Engine: “Reverse Engineer” PV Specs from Measured Time-Series Data

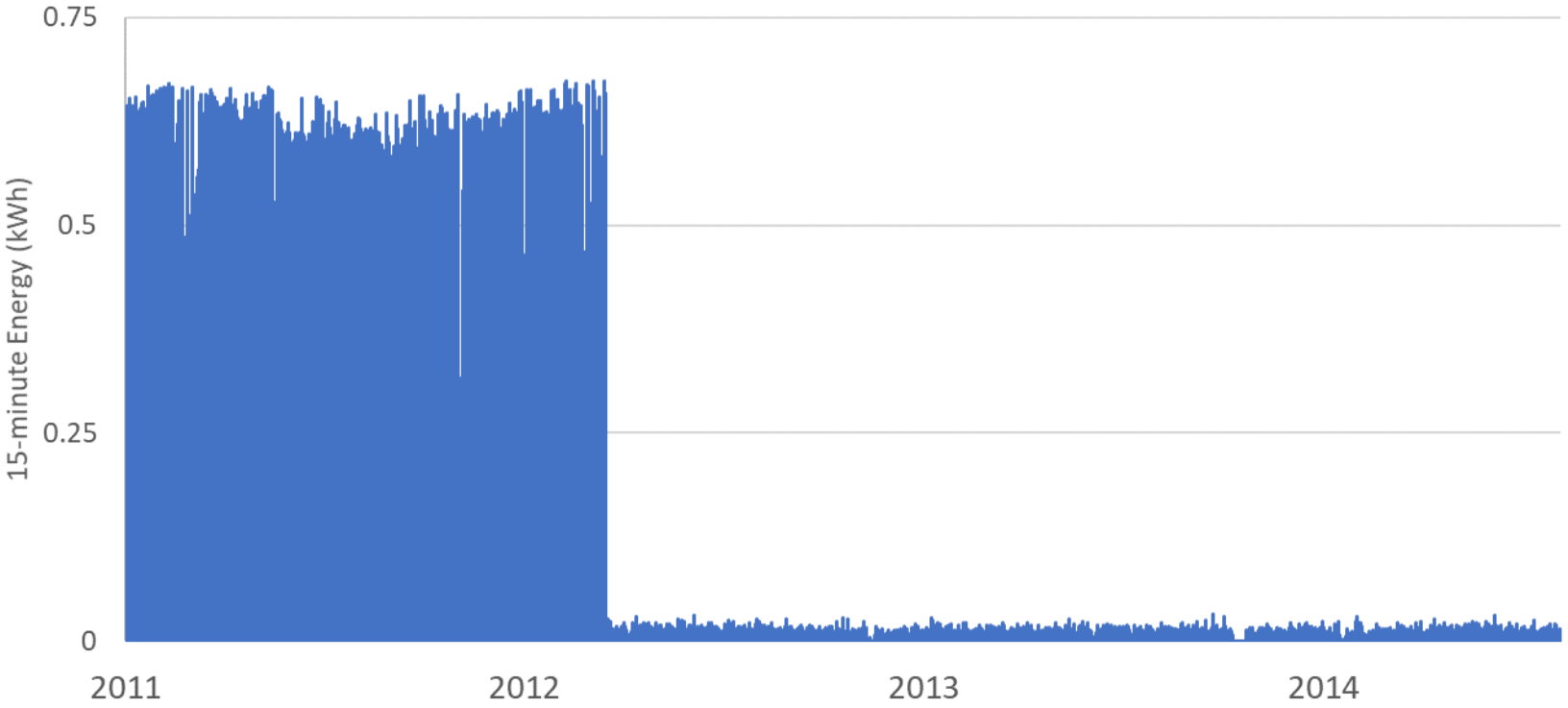
- PV rating
- Azimuth angle
- Tilt angle
- Obstruction elevation angles in multiple azimuth directions
- PV power temperature coefficient
- Inverter maximum power rating
- System PTC rating
- Fixed mount, single-axis or dual axis tracking

Example of “Good” Measured Data



PGE-CSI-00213

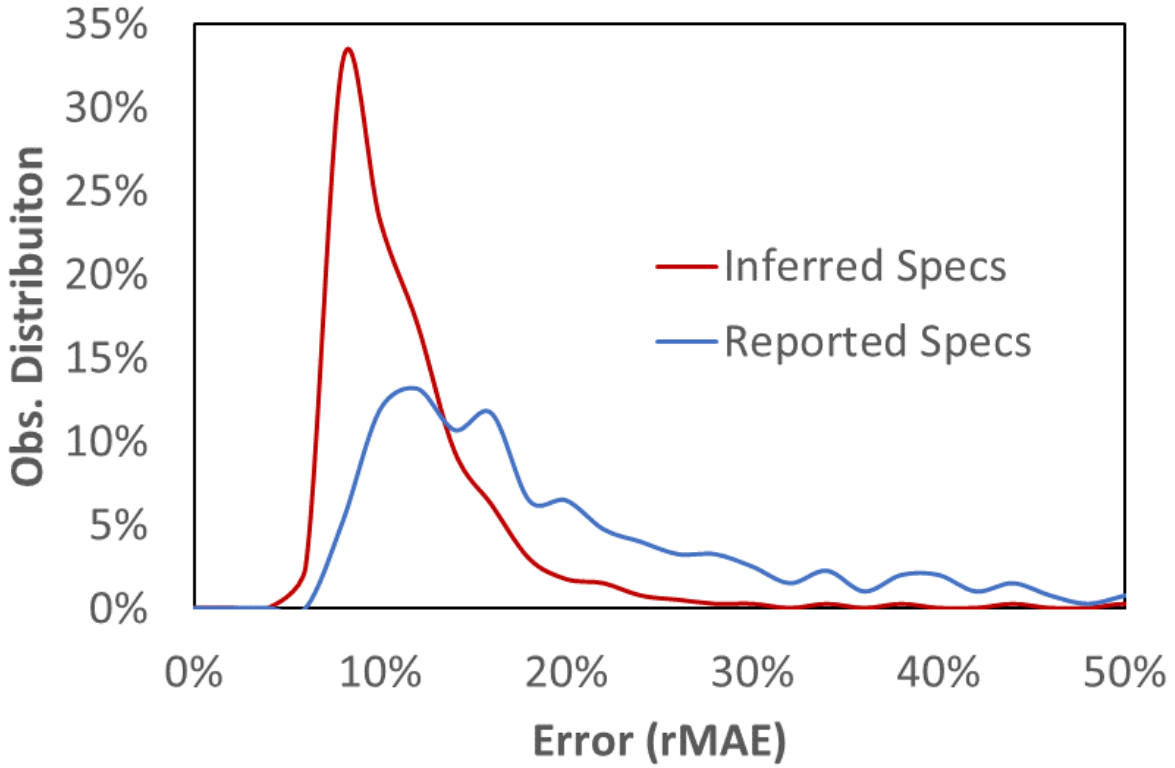
Example of Data Quality Issues



PGE-CSI-10404

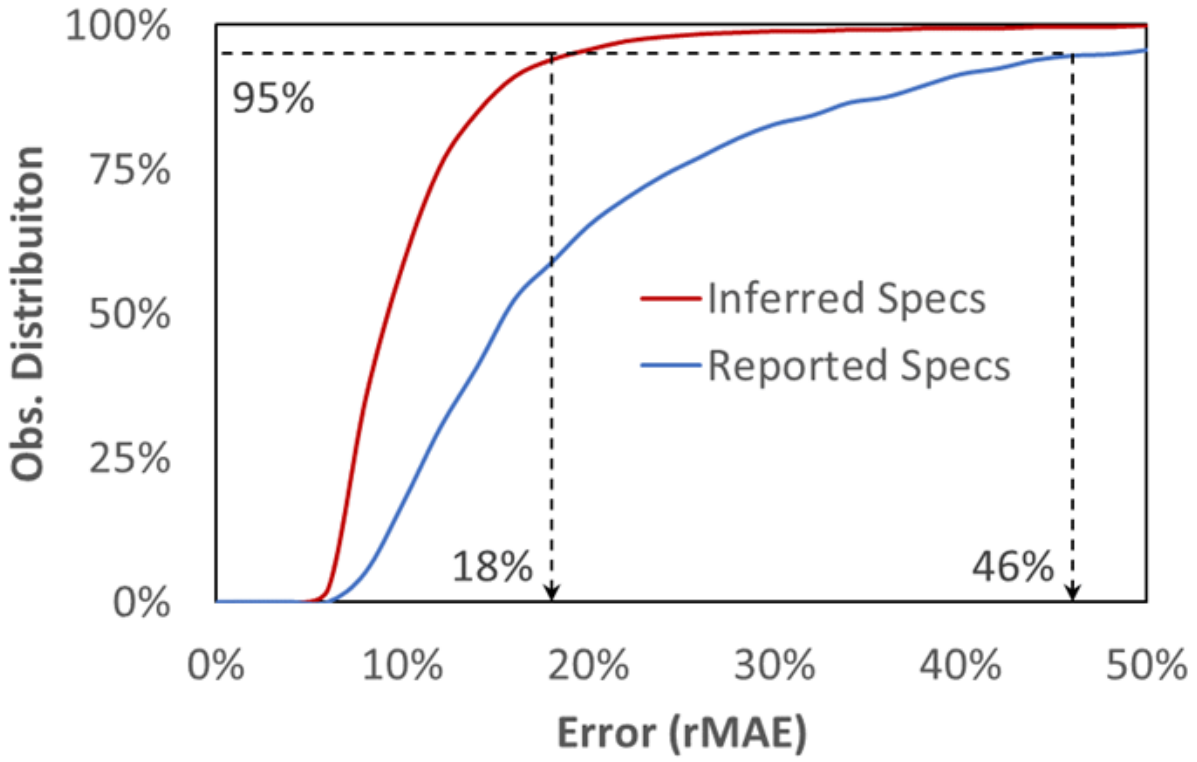
Error in Measured vs. Simulated

Compared to measured data, simulations using system specs inferred from measured data had lower error than simulations that used the specs reported by installers.



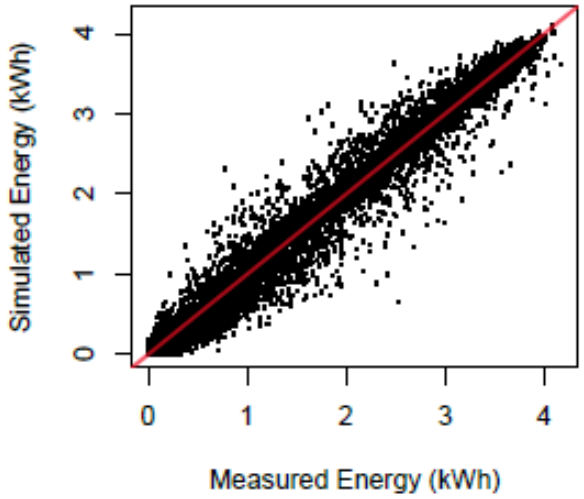
Error in Measured vs. Simulated

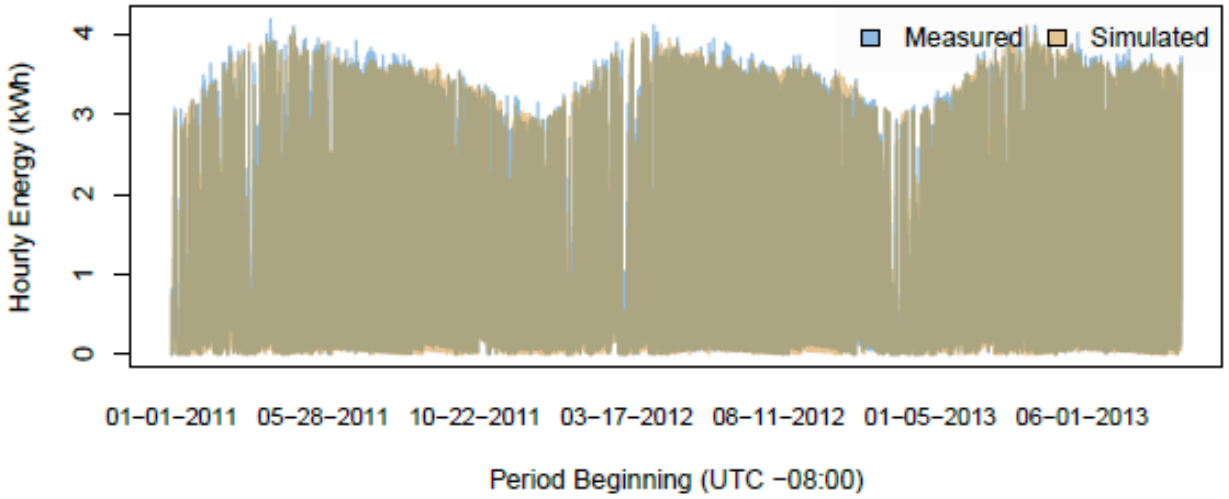
95% of the systems using the inferred specs approach have less than 18% error, while 95% of the systems using the reported specs have less than 46% error.



System with Lowest Error (Best Result)

PGE-CSI-24017

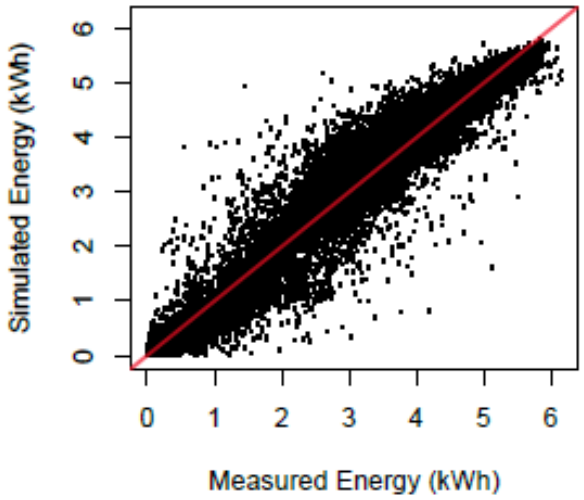


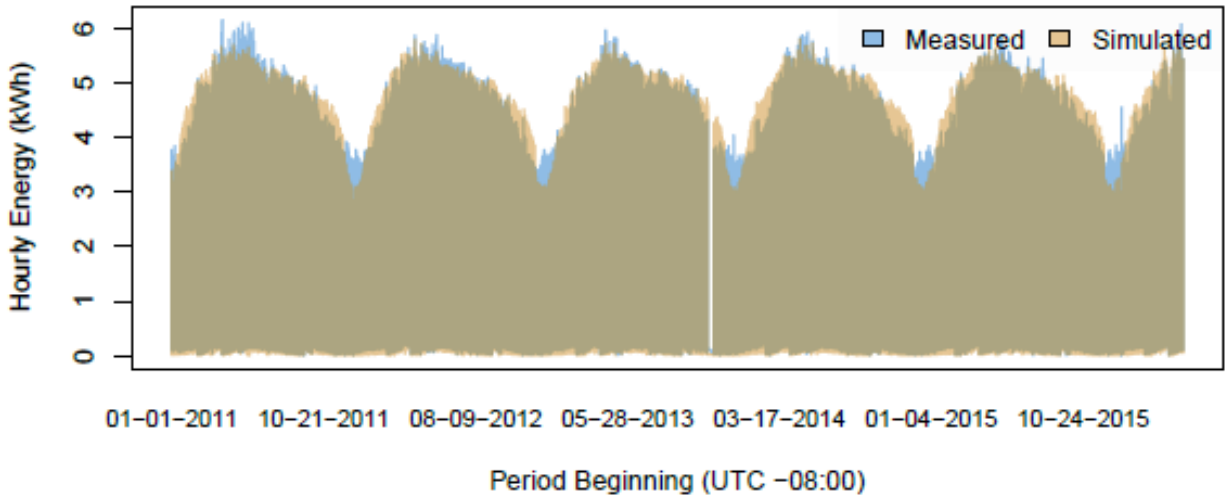


Simulated output using inferred specs, 6.3% hourly rMAE

System with Typical Error

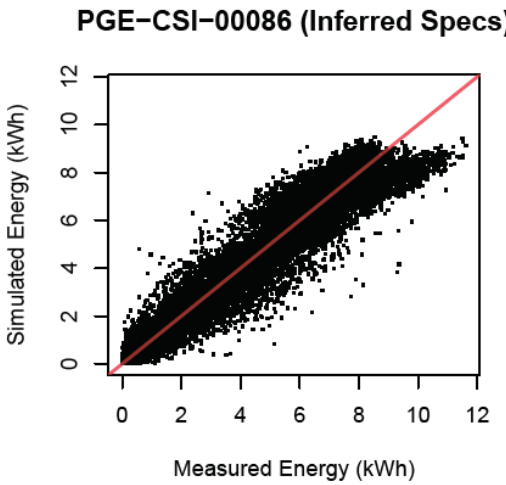
SCE-CSI-13299

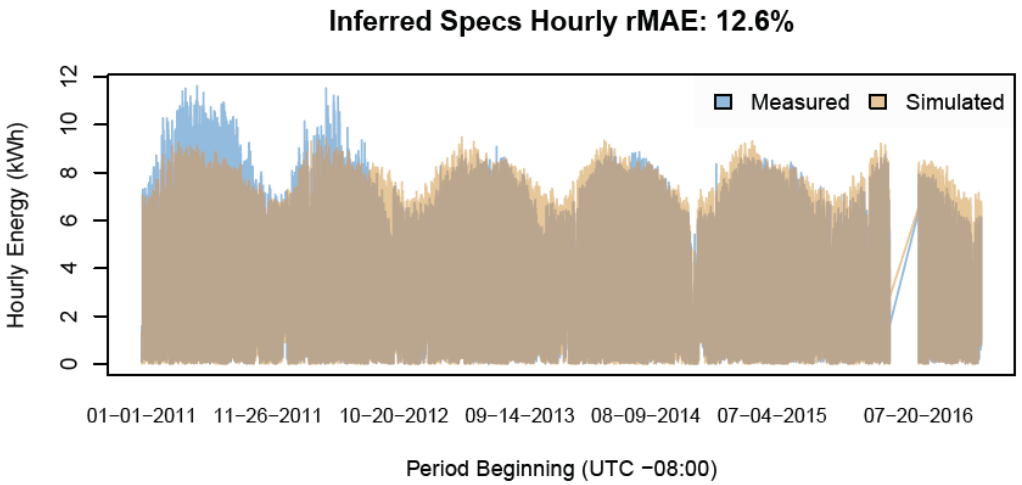


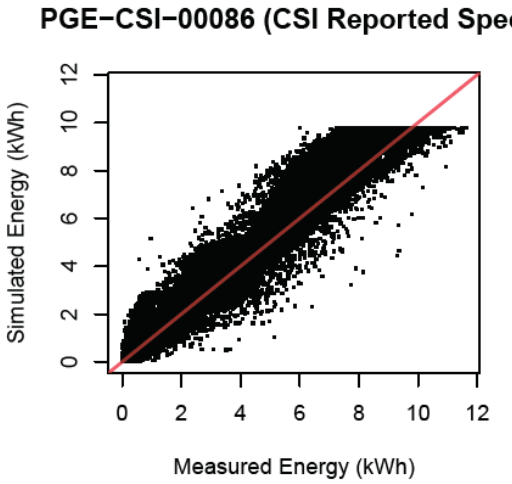


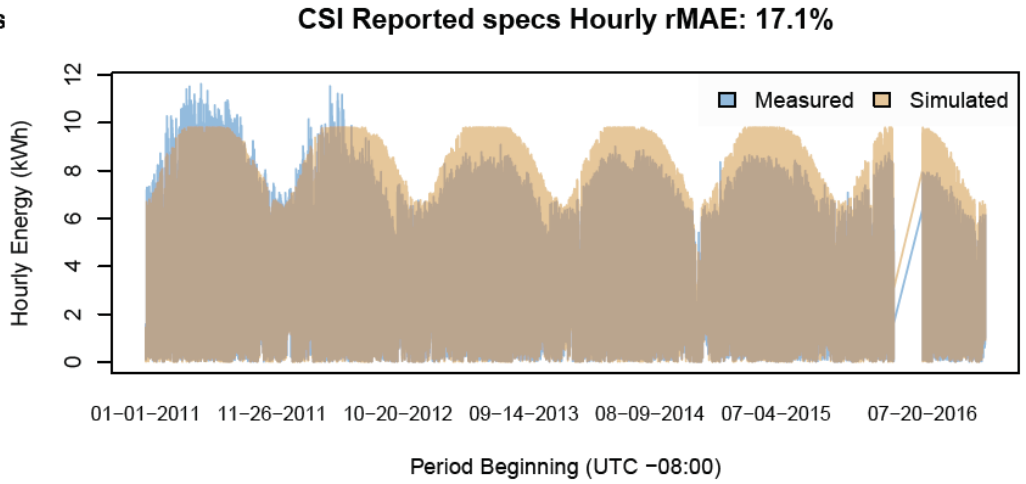
Simulated output using inferred specs, system with median error, 10.1% hourly rMAE

System Degradation

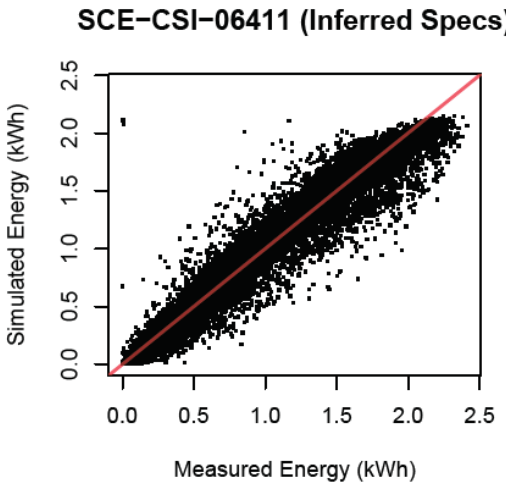


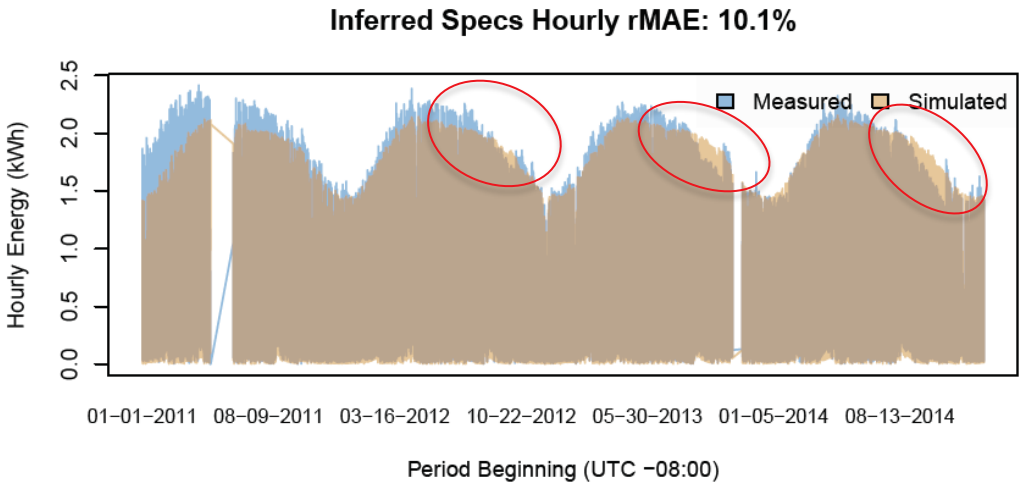


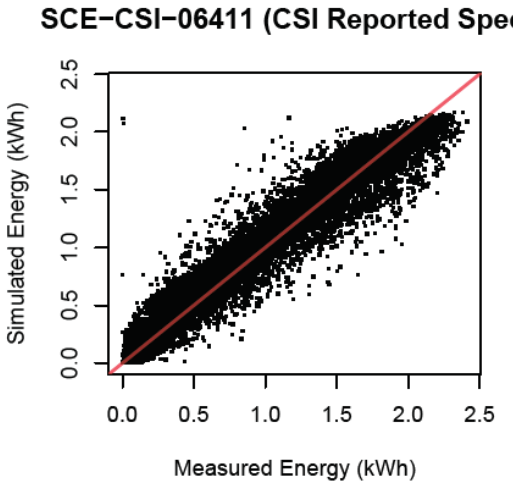


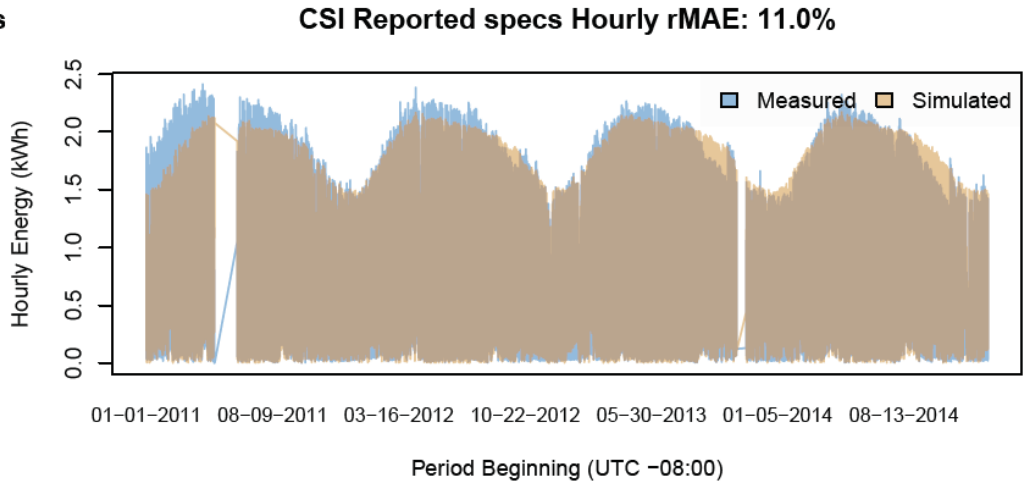


Soiling and Precipitation?

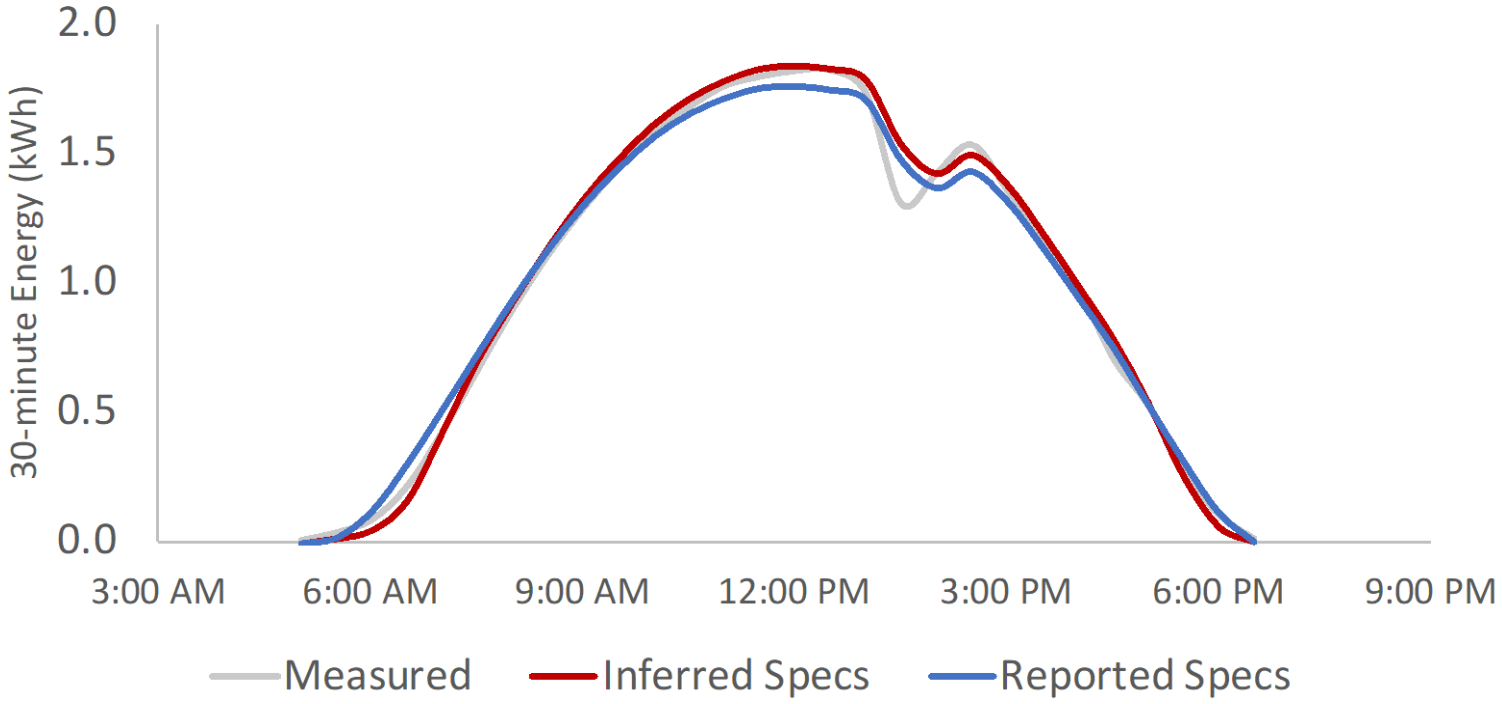






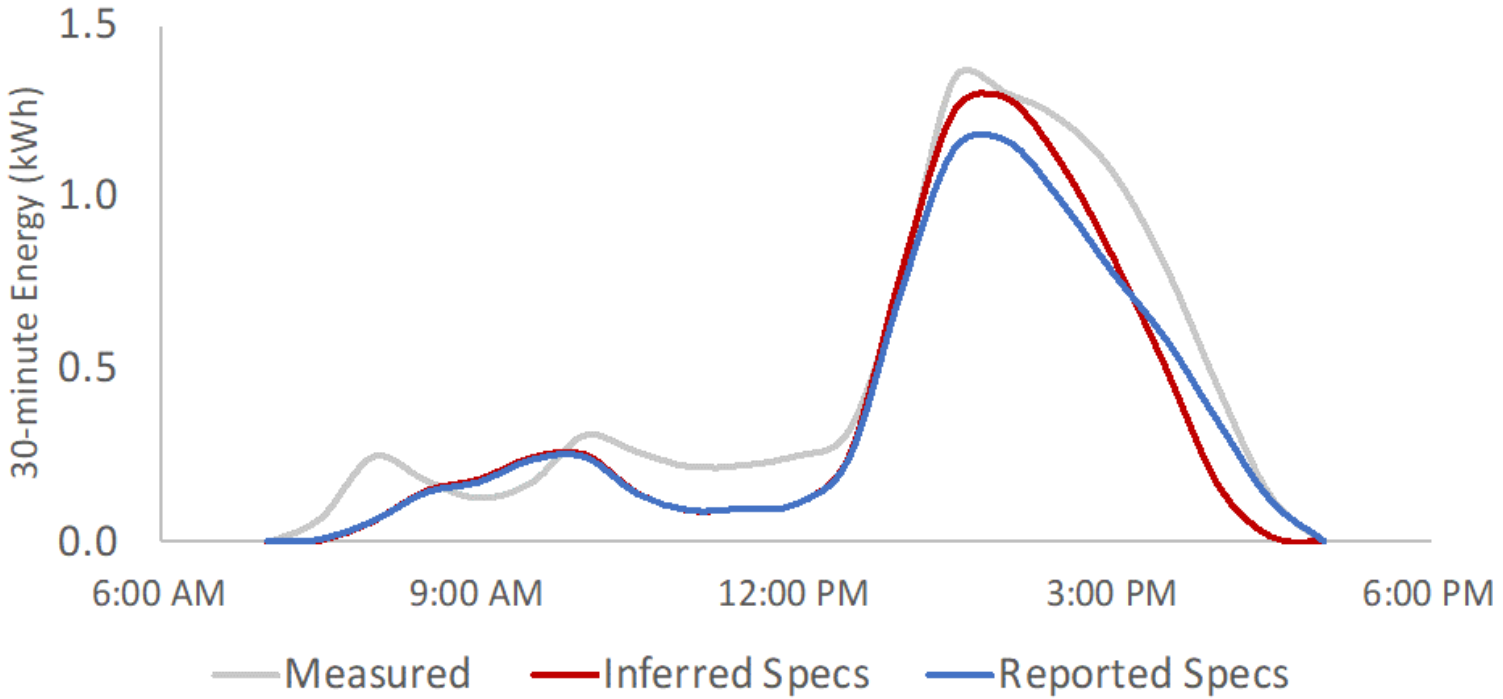


Single System, Single Day Production



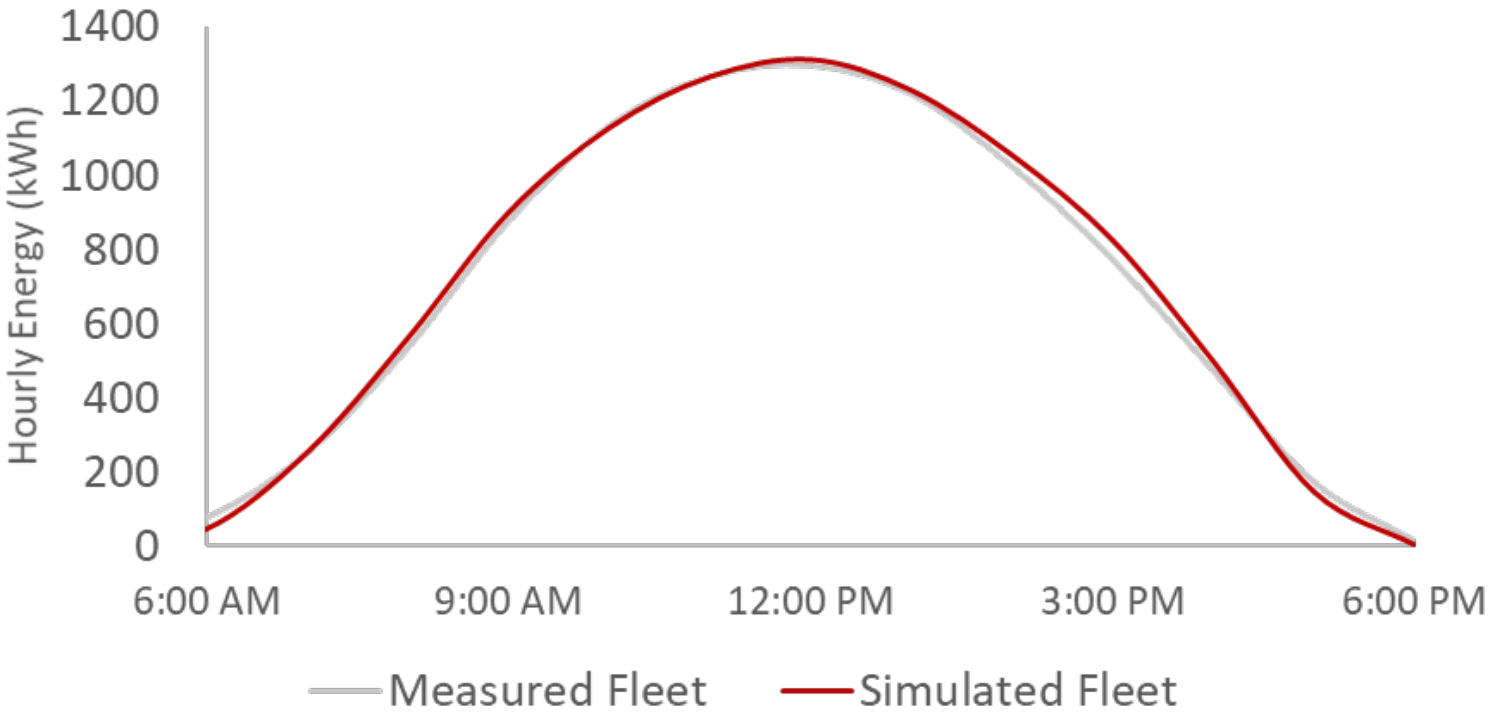
PGE-CSI-24017 production comparison for May 5, 2011

Single System, Single Day Production



PGE-CSI-24017 production comparison for January 19, 2011

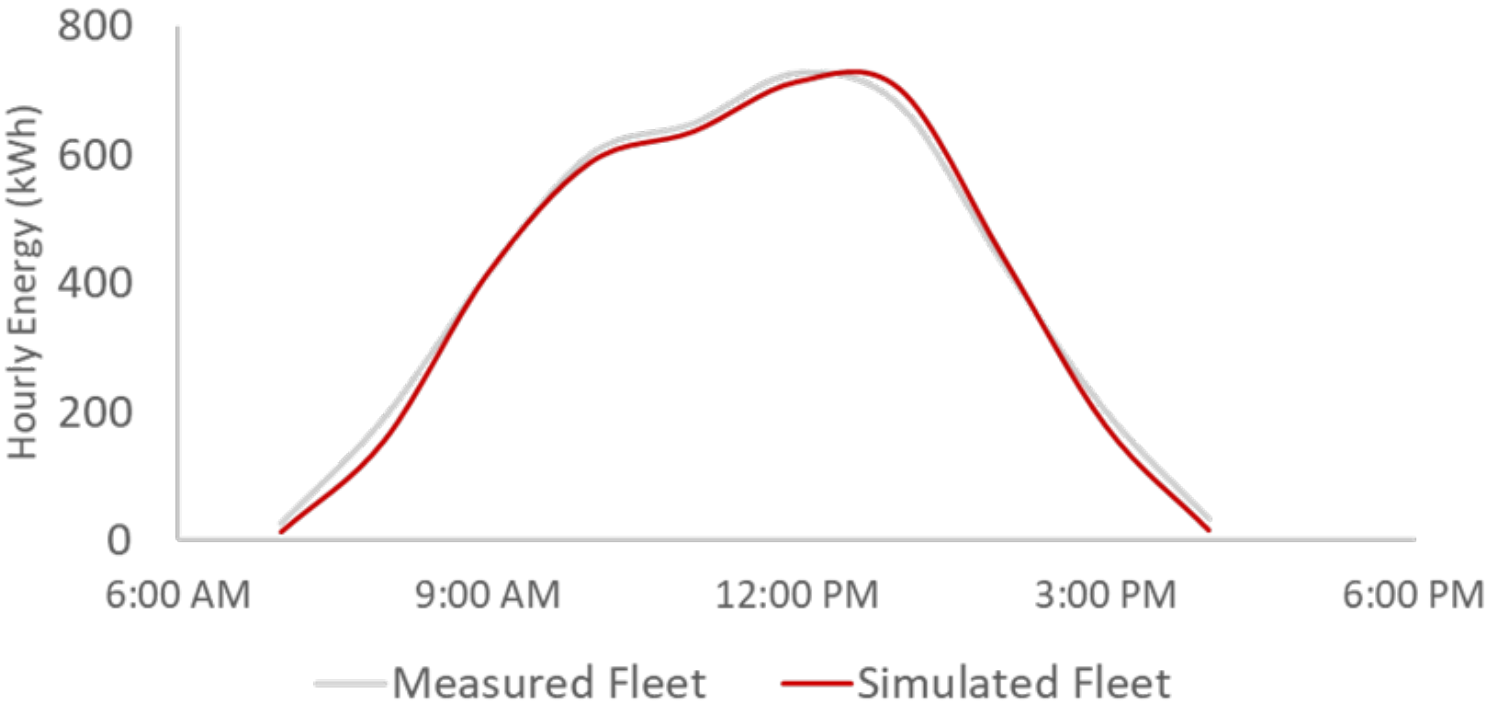
All Systems, Single Day



Fleet Production August 23, 2015

All Systems, Single Day

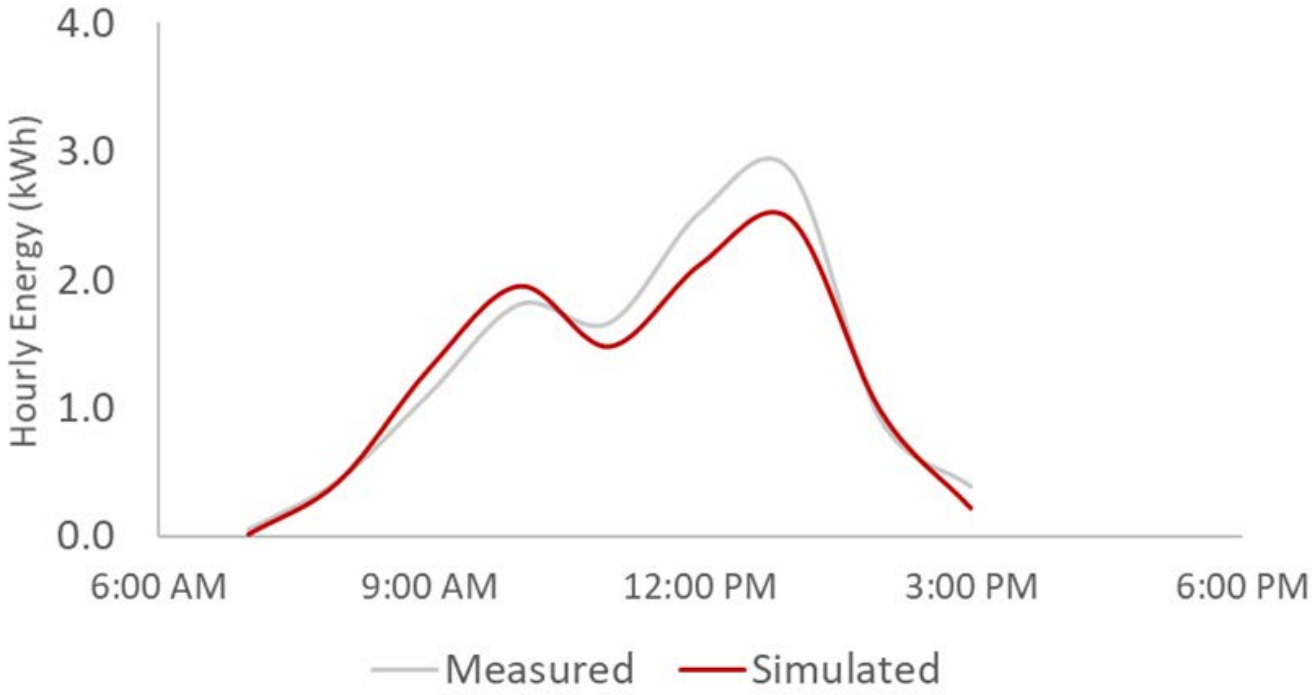
Fleet output on a day with variable cloudiness



Fleet Production January 8, 2016

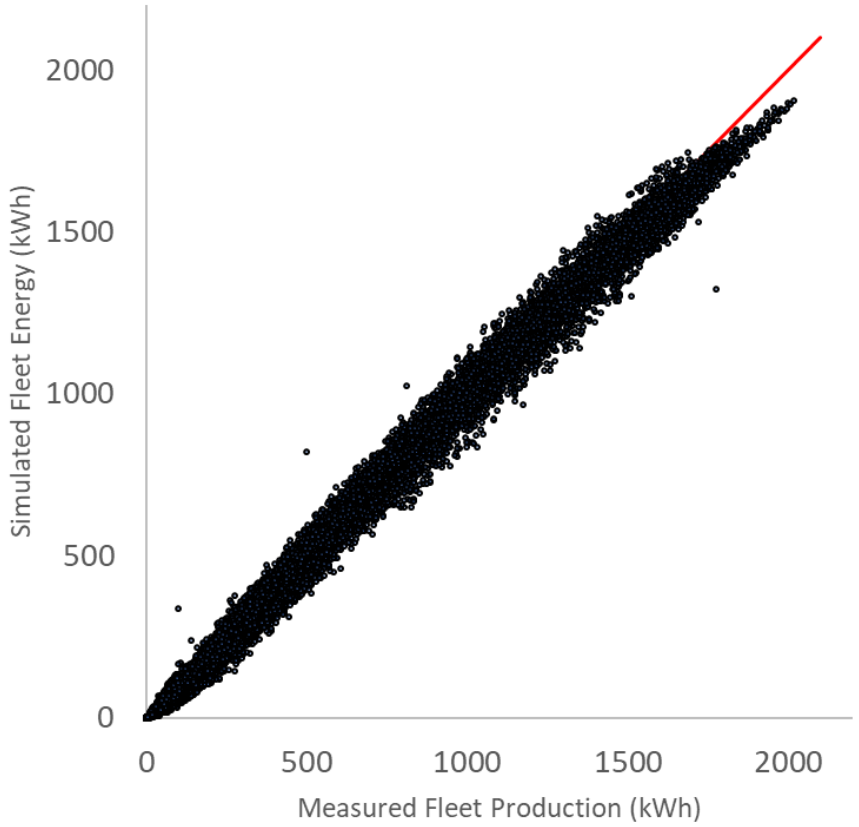
Single System, Single Day Production

Variability in single-system production is greater than fleet variability on the same day

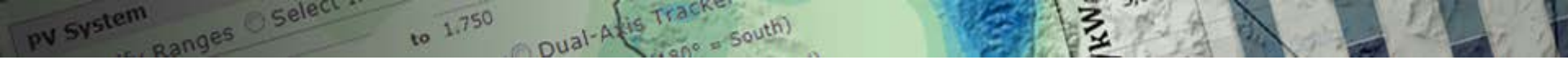


PGE-CSI-00221 Production January 8, 2016

Fleetwide Error



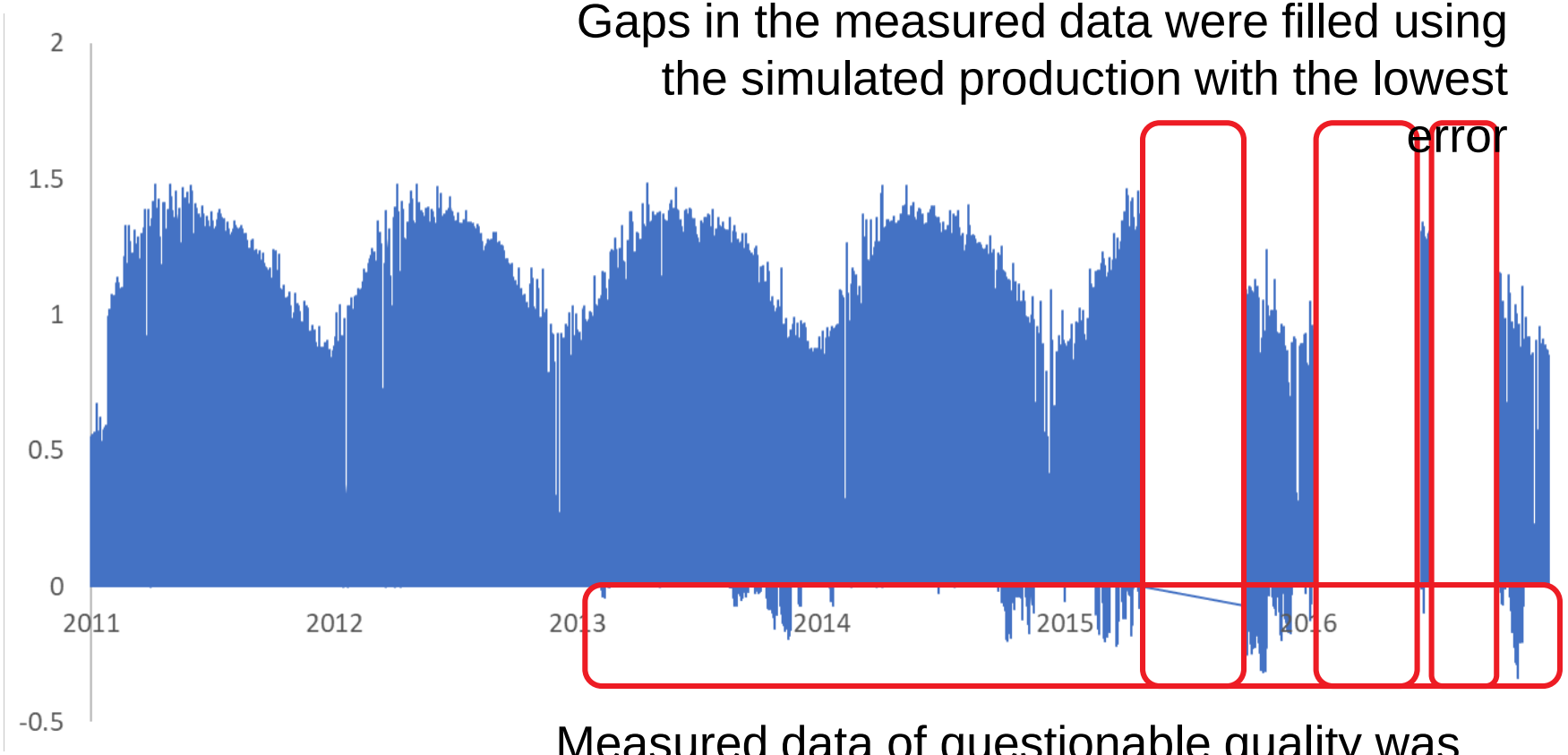
With an hourly rMAE of just 4.3%, the fleet output begins to approach the error in the underlying satellite-derived irradiance data



PV System Specs inferred from Measured Production Data

- All PV production data modeling used SolarAnywhere® satellite-derived irradiance data
- Using system specifications inferred from measured production data resulted in lower error than using reported specifications 96% of the time
- Median hourly relative MAE for individual system data from inferred specs was 10.1% versus 16.7% for reported specs

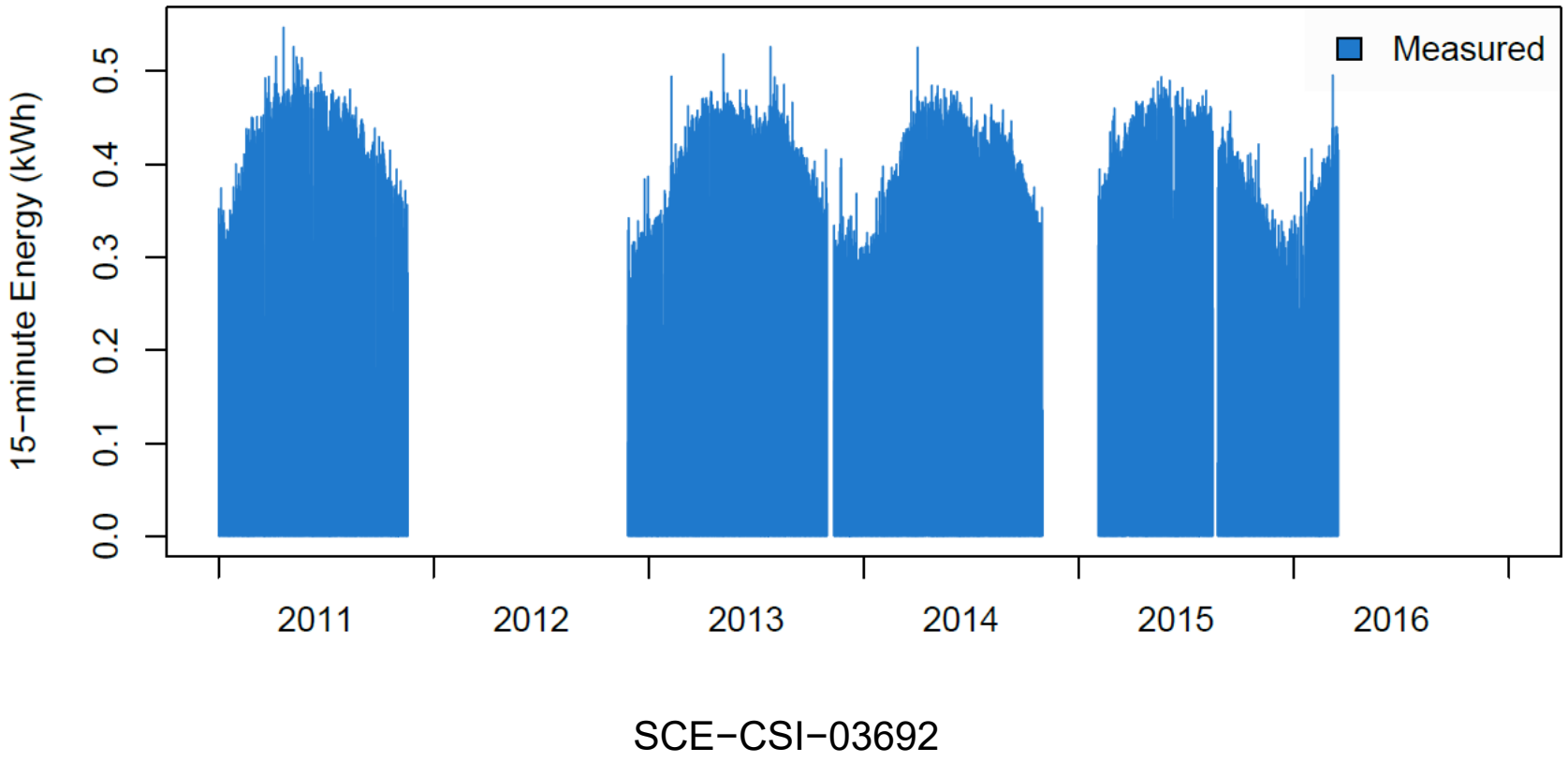
Measured Data Missing or Bad



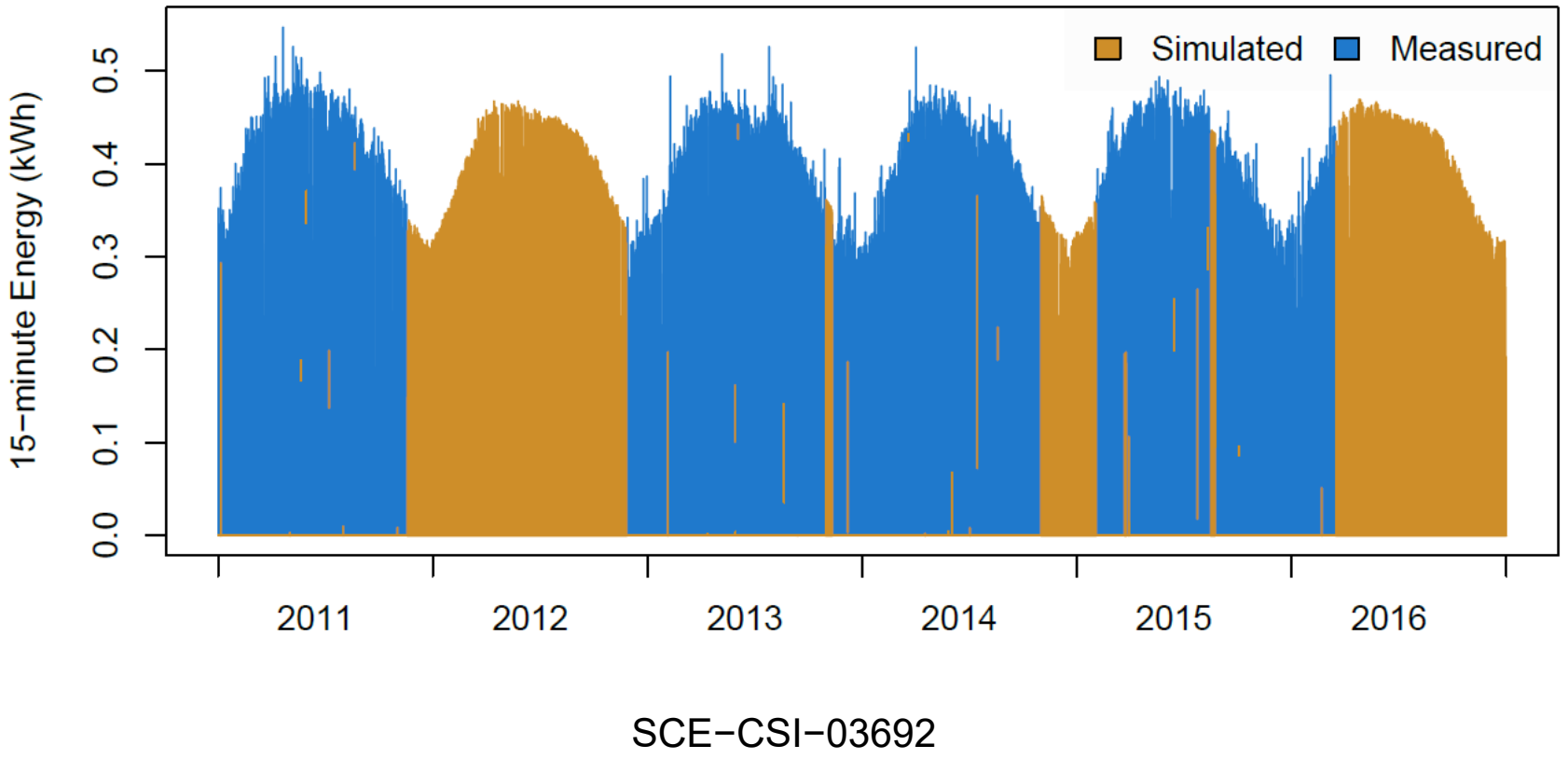
Gaps in the measured data were filled using the simulated production with the lowest error

Measured data of questionable quality was removed

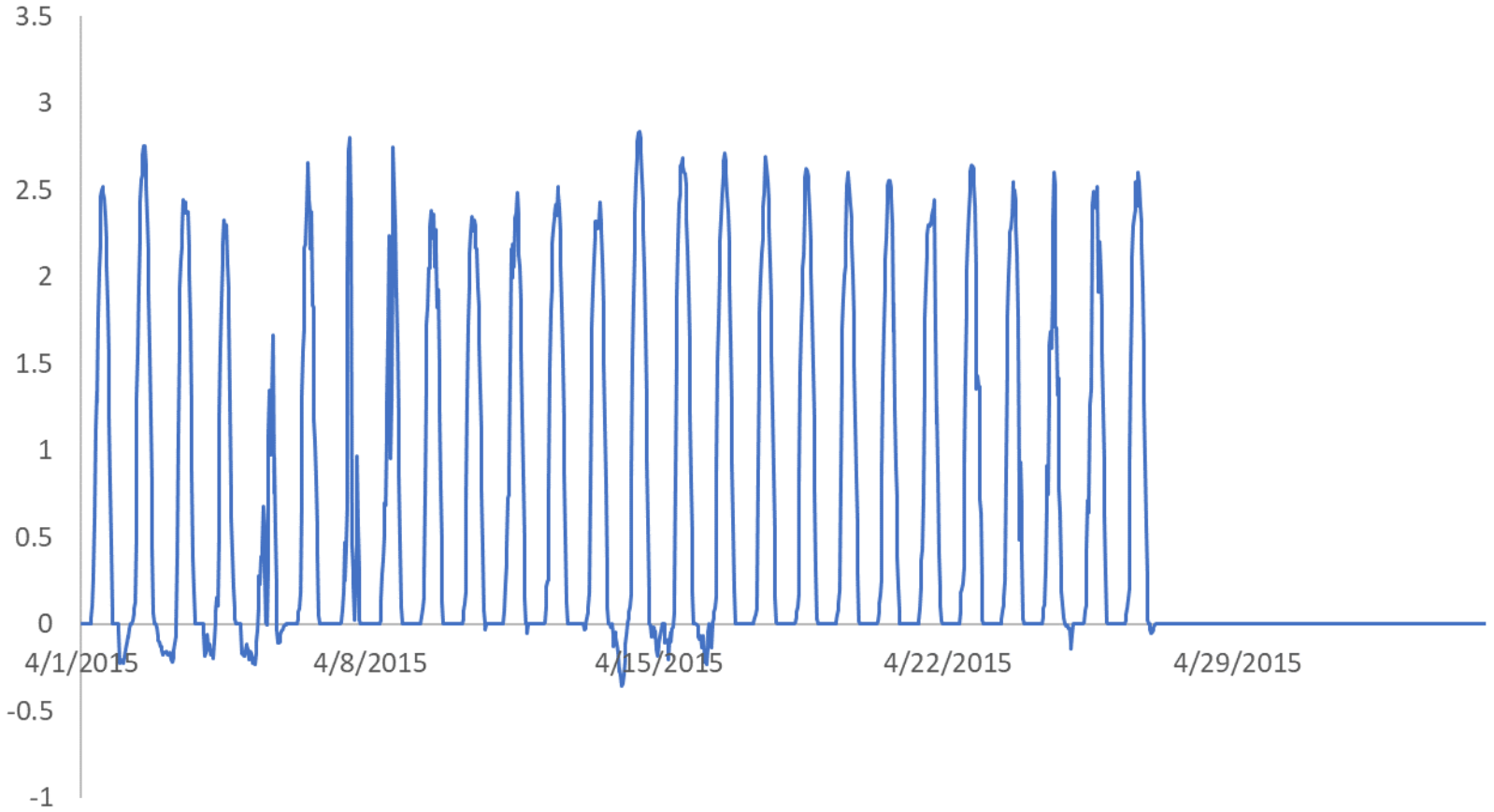
Filtered Measured Data



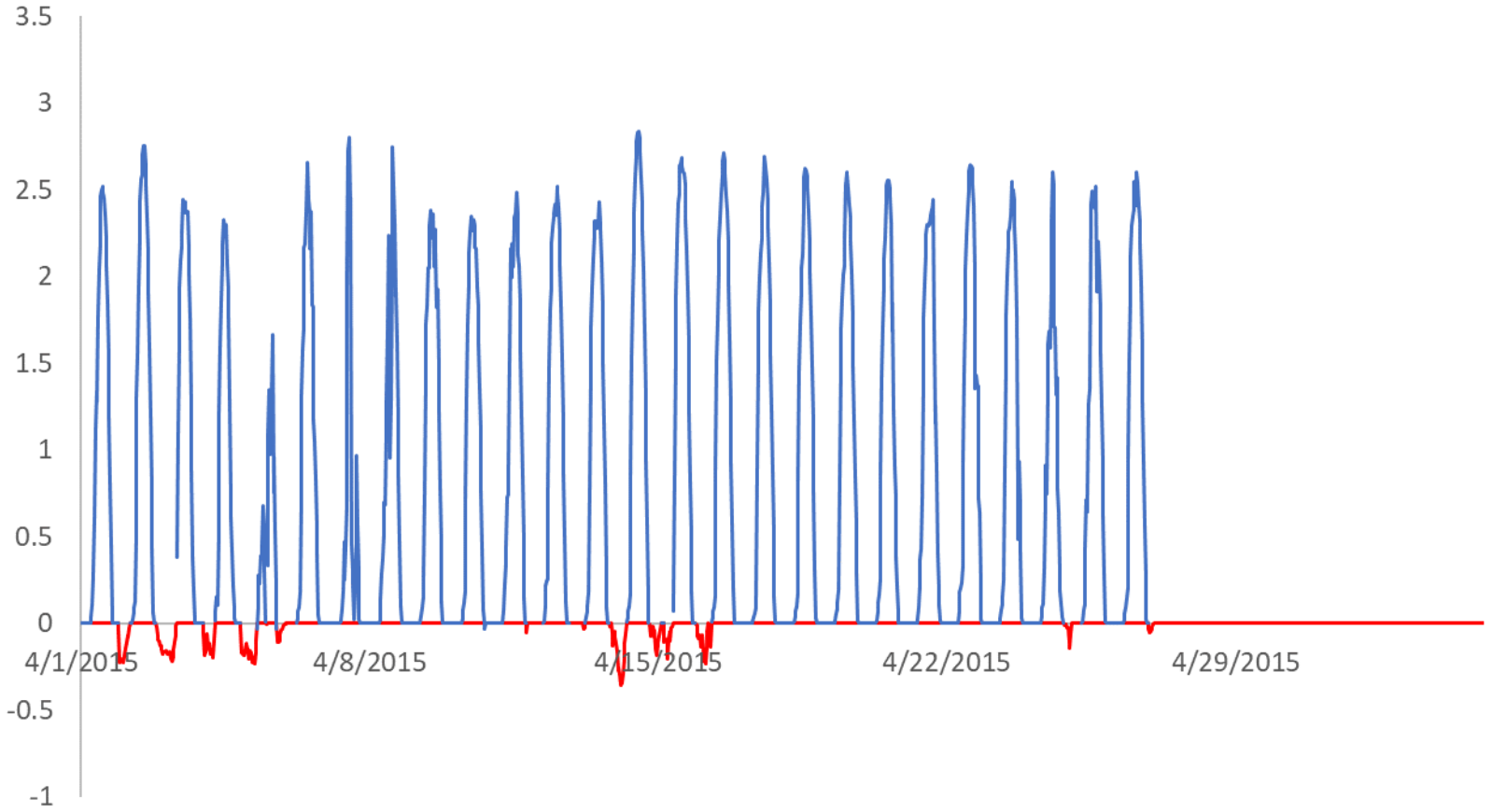
Measured Data Merged with Simulated



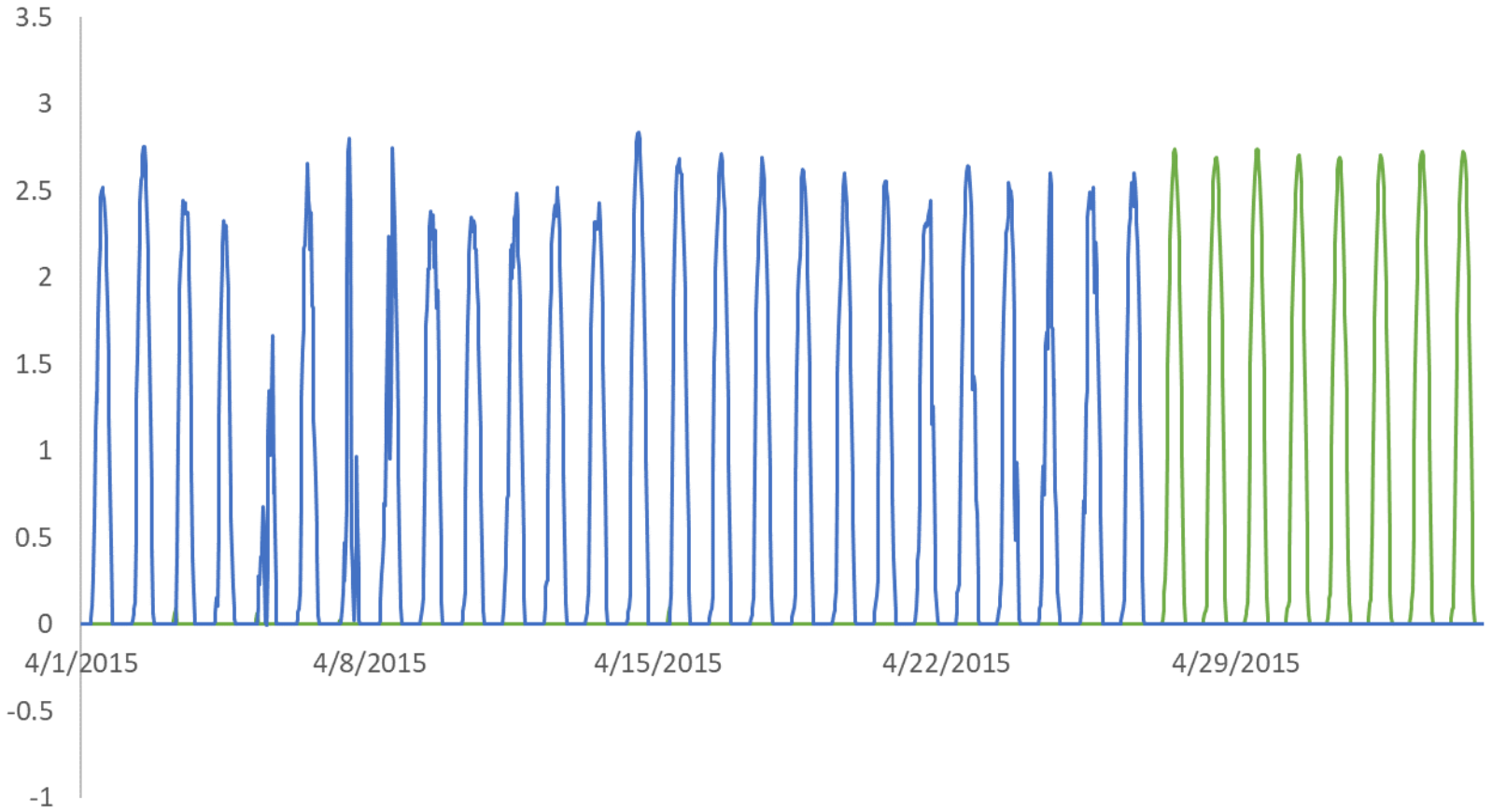
Zooming in…



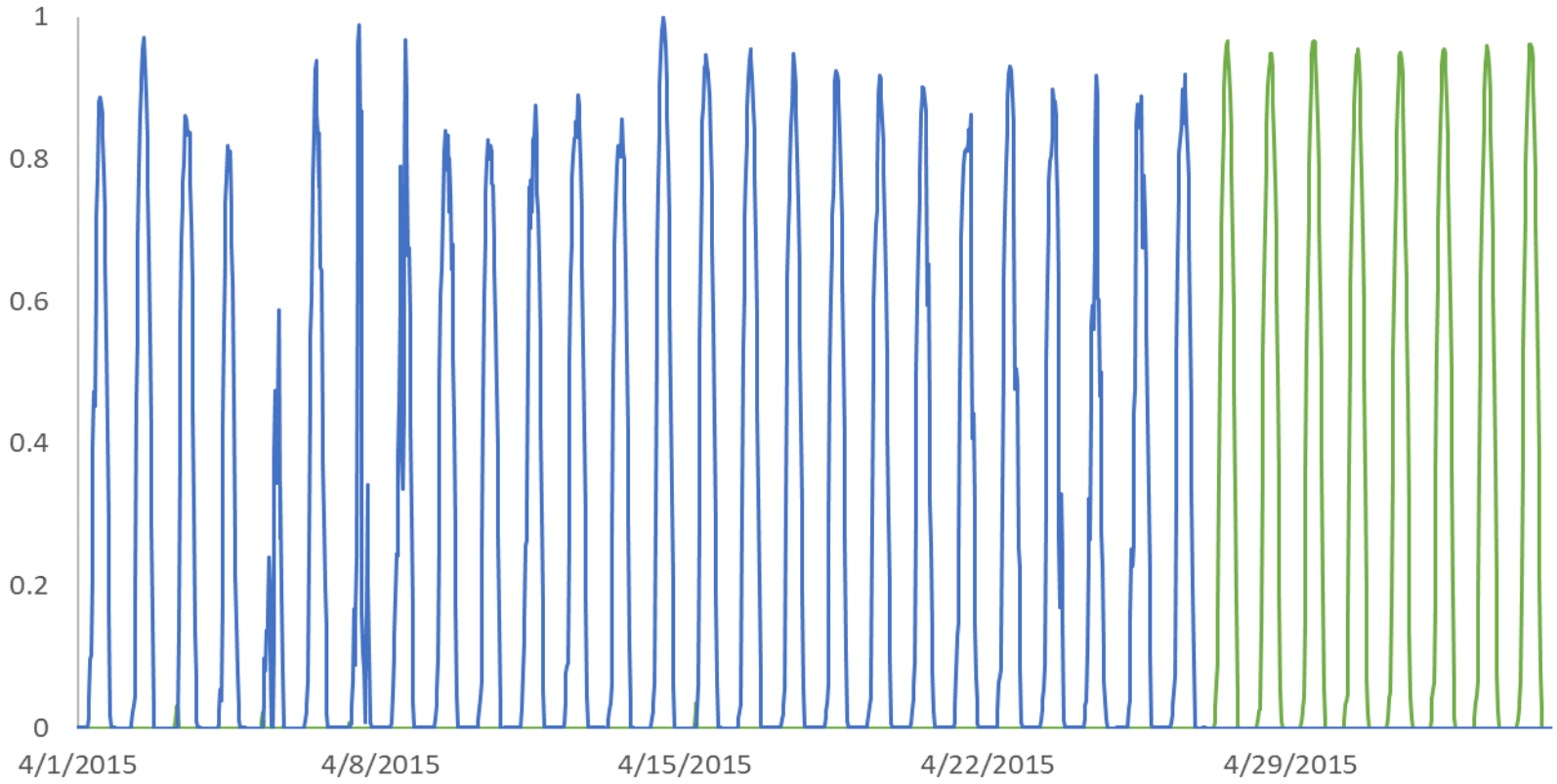
Missing or Bad Data Identified

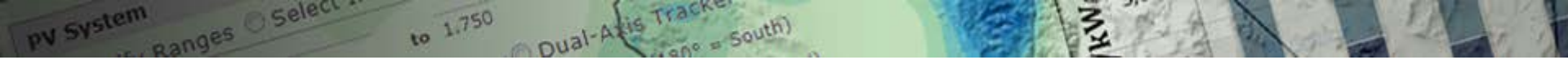


Missing or Bad Data Replaced by Simulated



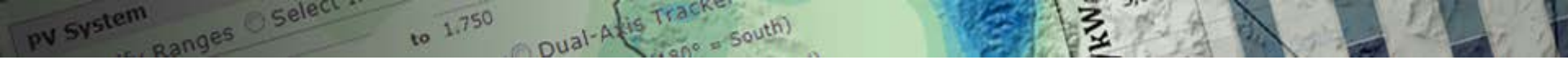
Normalized Data (kWh per kW)





DER Production Database

- Measured 15-minute interval production data from 414 selected PV systems augmented by simulated production data for those same systems
- Individual system production data was aggregated by ZIP code and normalized using AC_{CEC} ratings to produce 292 CSV files
- Most ZIP codes contain only one system
- Fleet production exhibits a significantly different shape with less variability than single-system production
- Production in ZIP code level files is not representative of actual production of all systems in that ZIP code



DRP Mid-Term Growth Projections

- Installed PV capacity growth follows a consistent pattern for all three California IOUs
- This behavior follows a logistic function, sometimes described as the Bass Diffusion Model
- NEM Currently Interconnected Data Set could be used in conjunction with this model to project installed PV capacity

Diffusion Model Fitted to Historical Adoption (CIDS, PV)