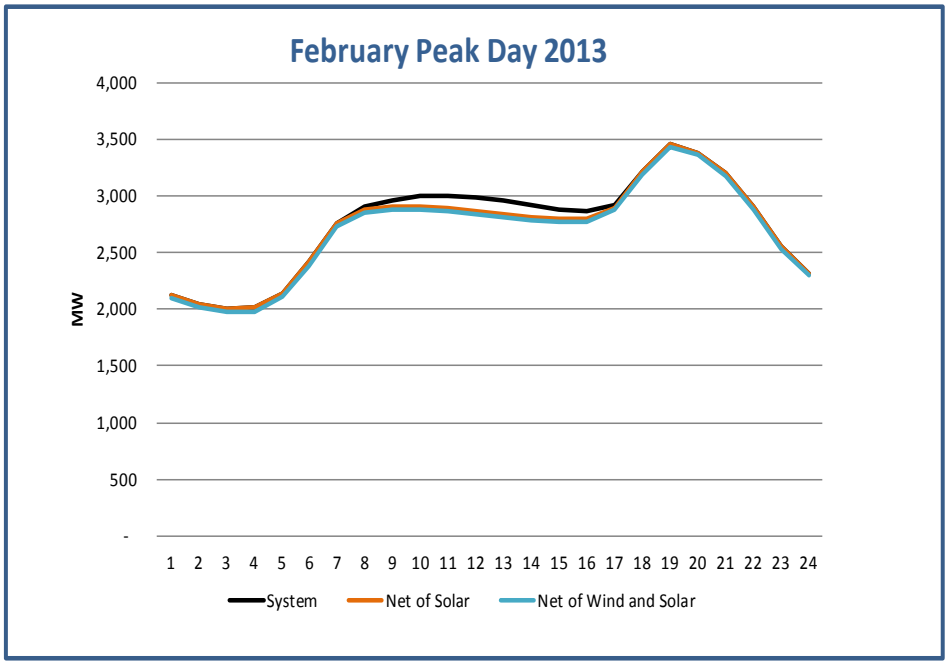
Thomas Bialek, PhD PE

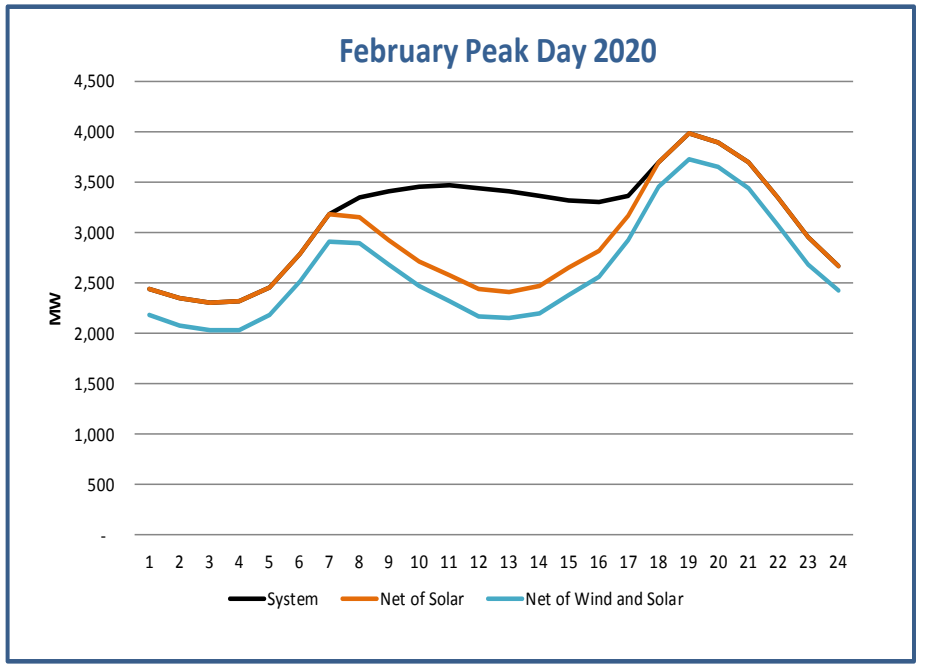
Chief Engineer – Smart Grid

Renewable Impact on Electric Planning

System Planning

Net Impact of Solar & Wind on Peak Load





2013

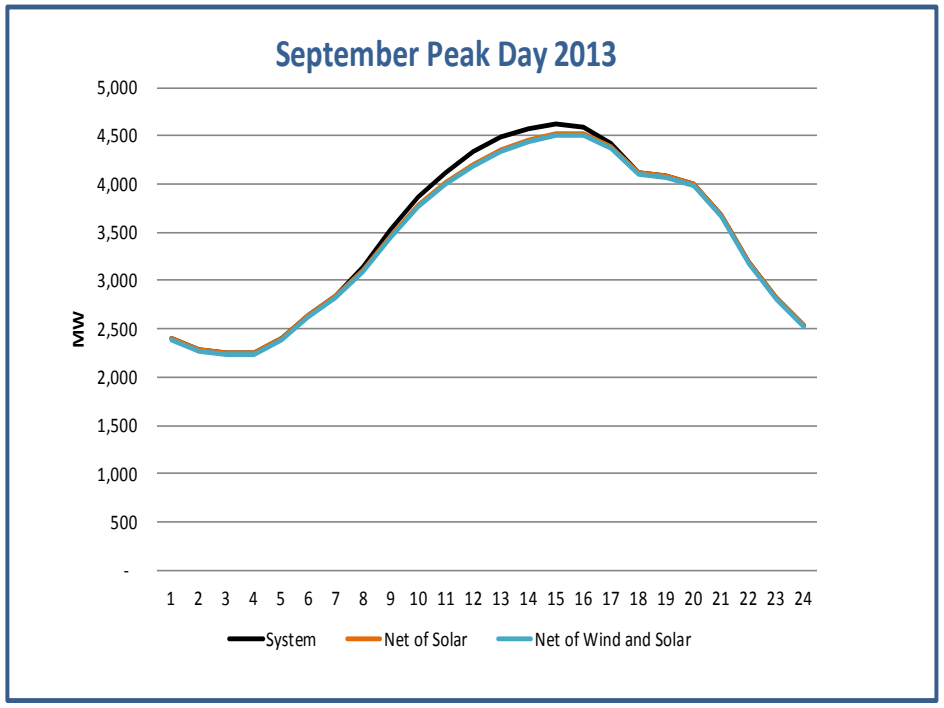
MONTH	SOLAR DG (MW)	SOLAR Central (MW)	WIND (MW)
Feb	150	25	50

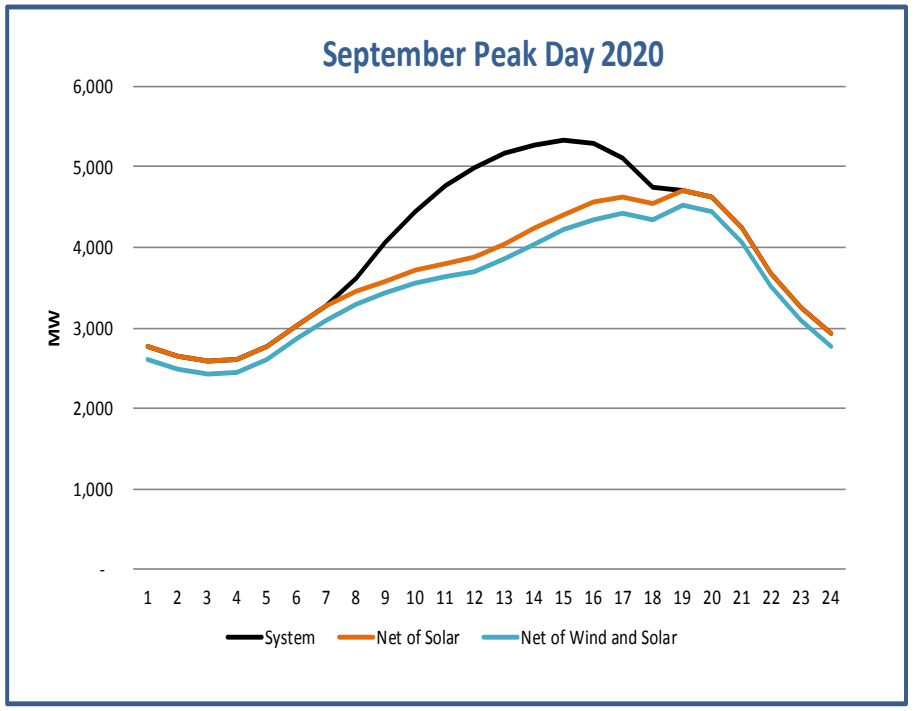
2020

MONTH	SOLAR DG (MW)	SOLAR Central (MW)	WIND (MW)
Feb	273	1000	500

System Planning

Net Impact of Solar & Wind on Peak Load





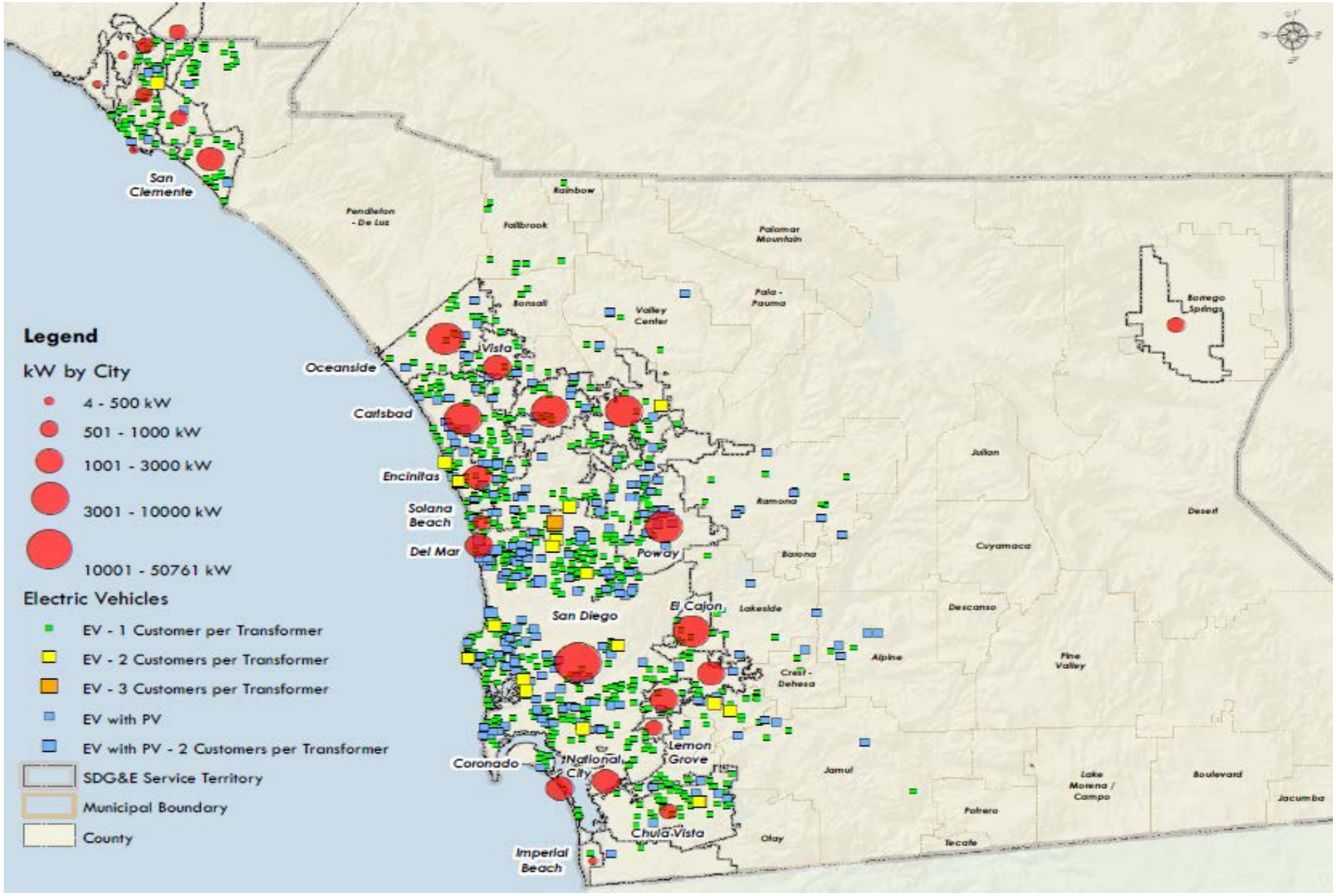
2013

MONTH	SOLAR DG (MW)	SOLAR Central (MW)	WIND (MW)
Sep	150	25	50

2020

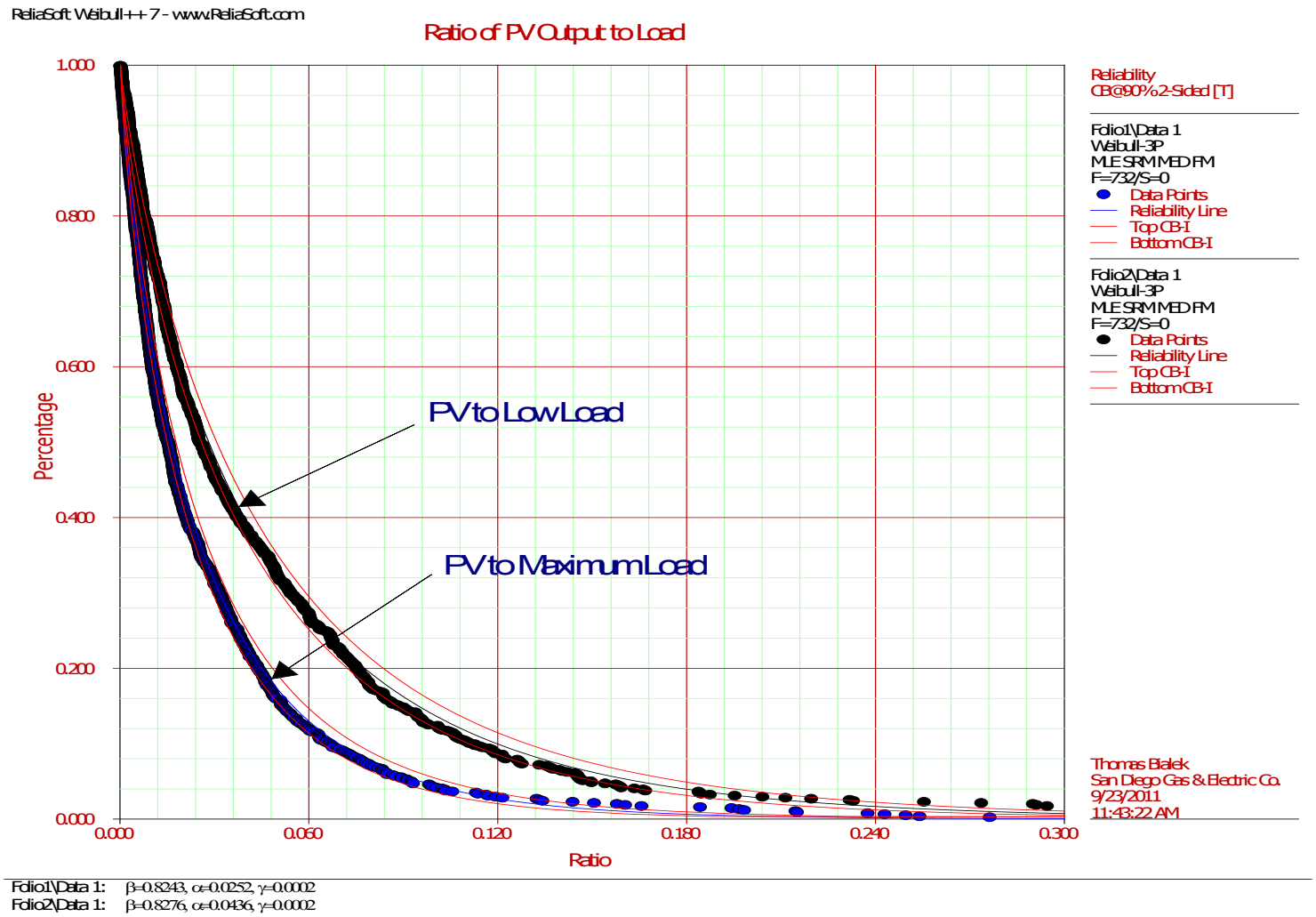
MONTH	SOLAR DG (MW)	SOLAR Central (MW)	WIND (MW)
Sep	273	1000	500

Integration of DER
Solar & Electric Vehicle Customers

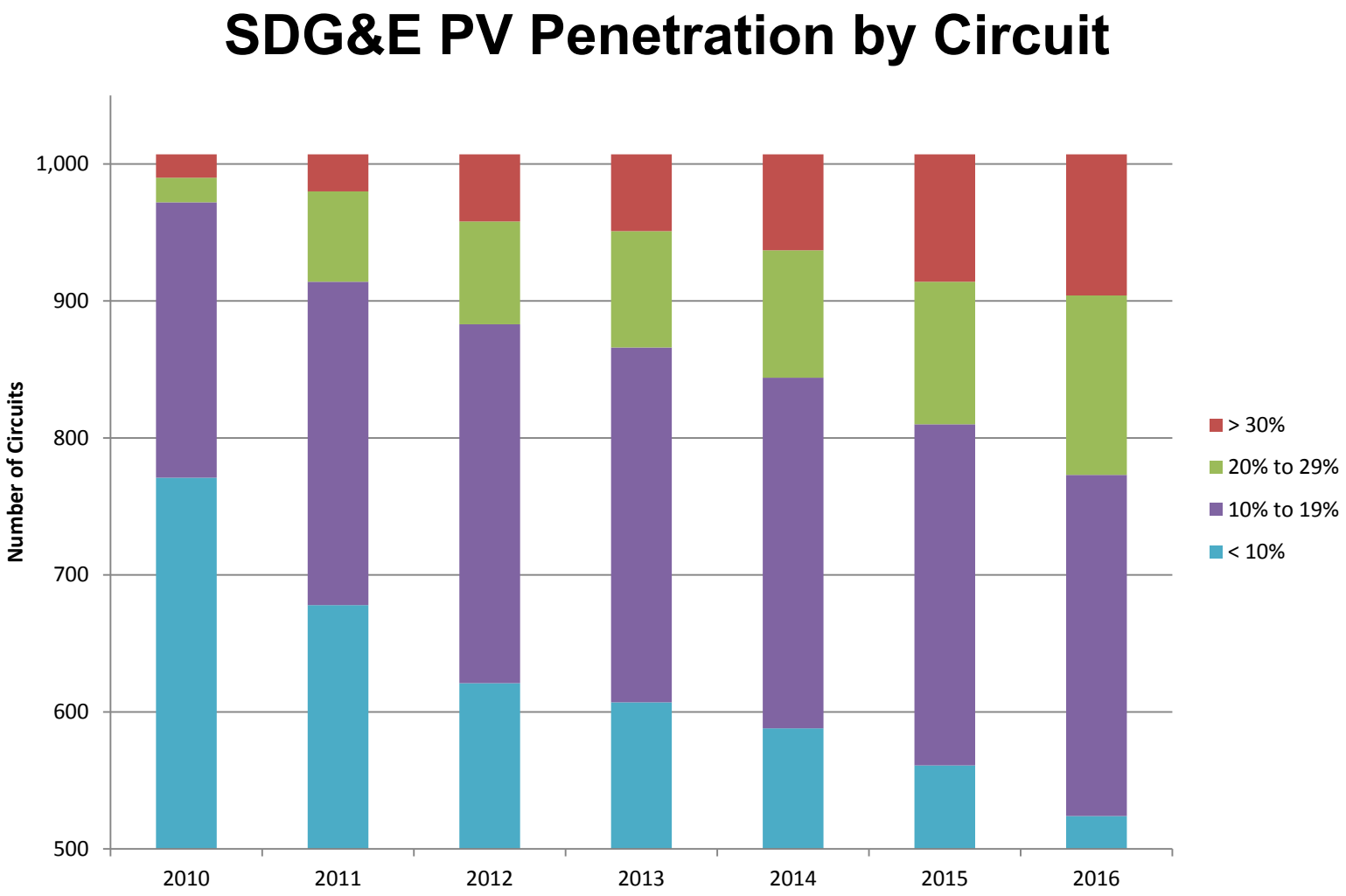


INTEGRATION OF DER

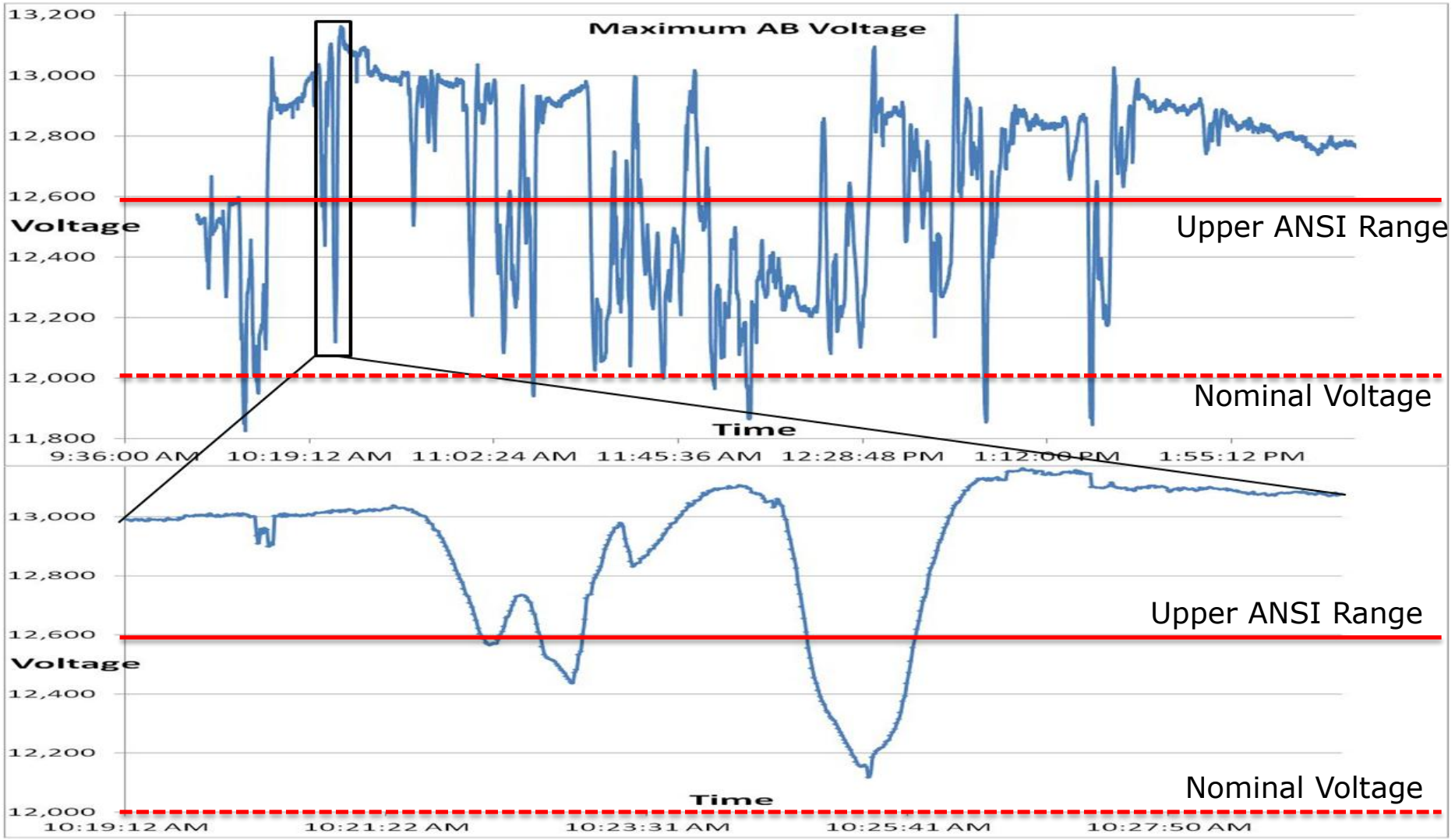
PV Penetration Threshold



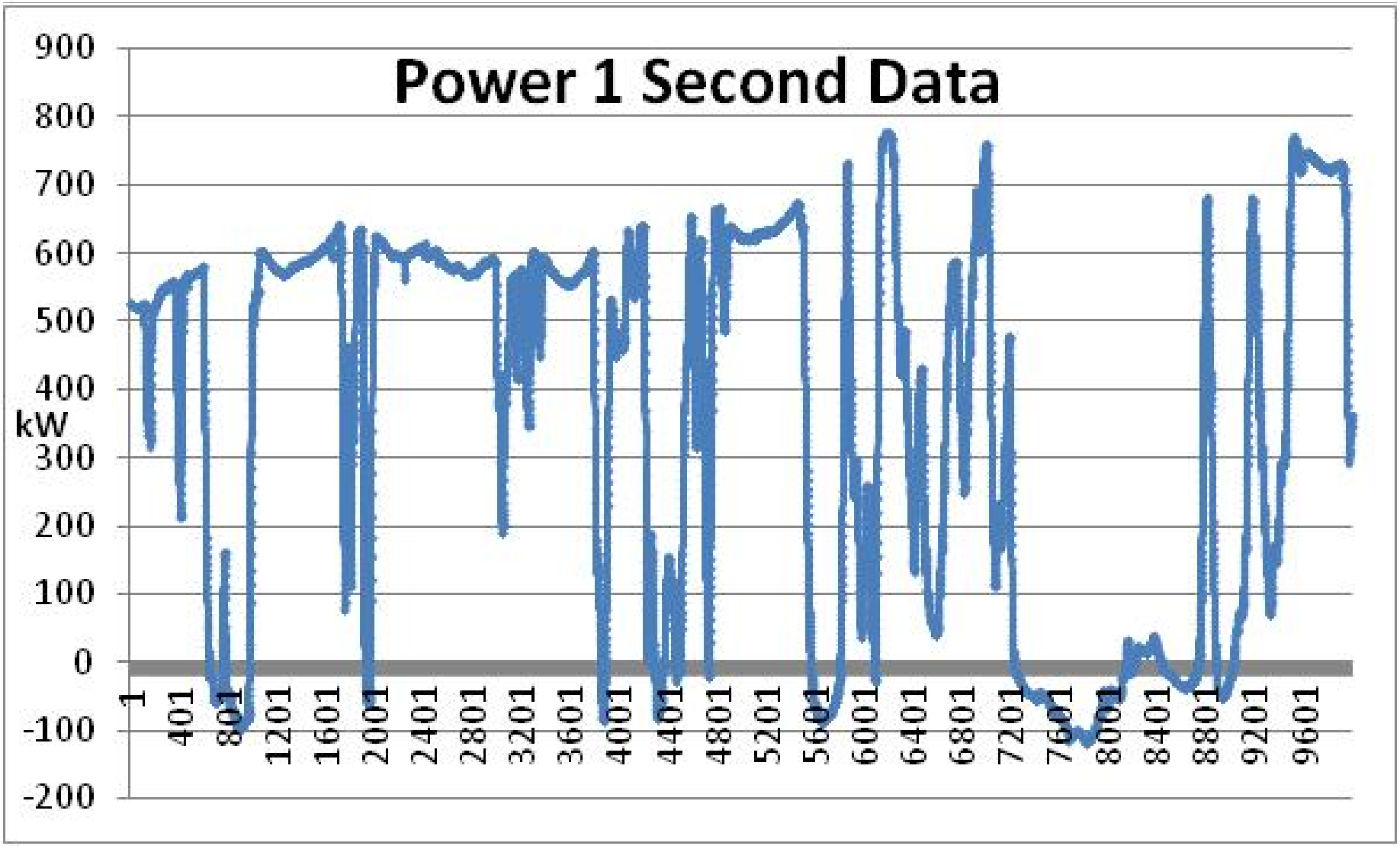
Rooftop PV Generation



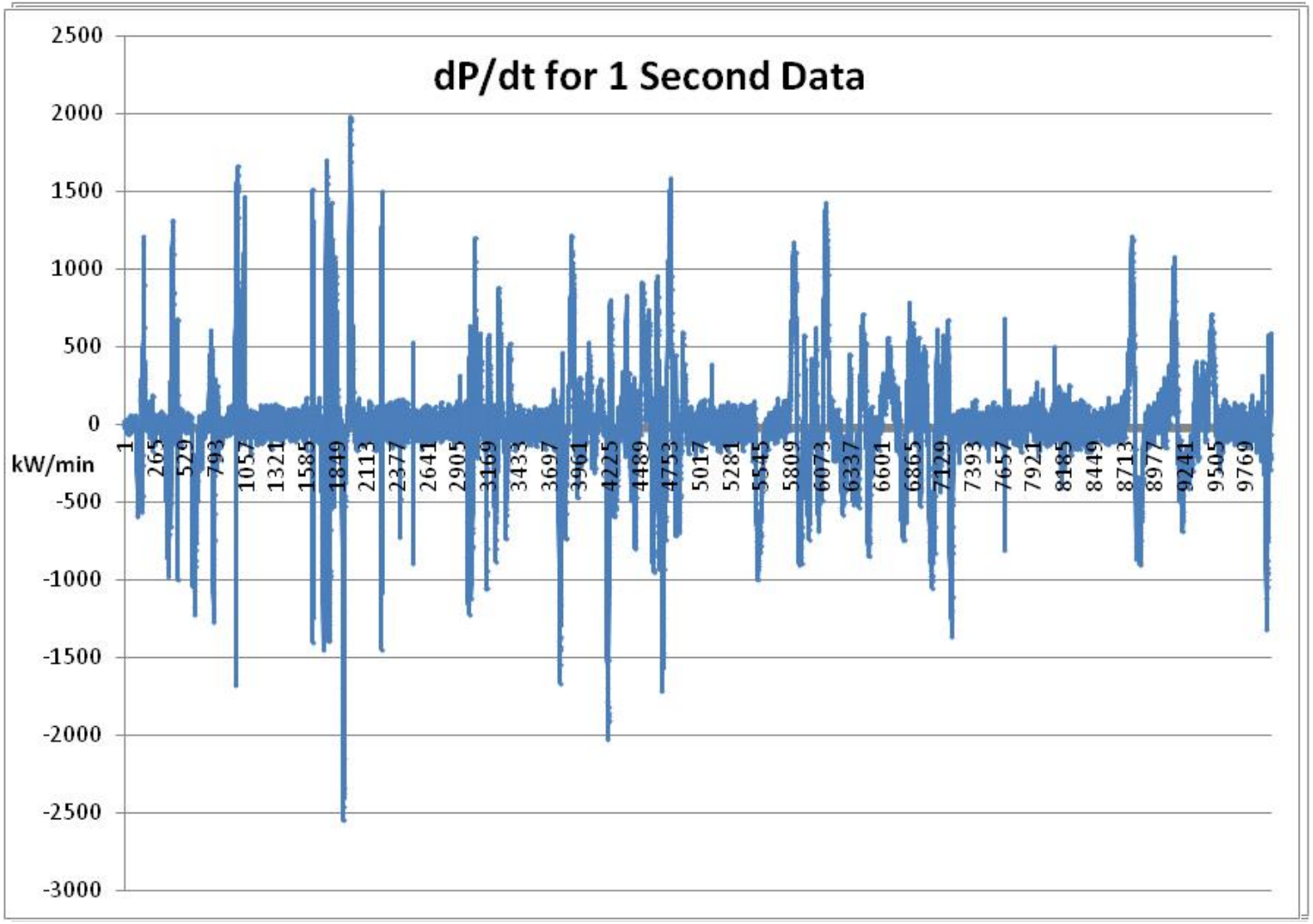
PV Issues - Intermittency



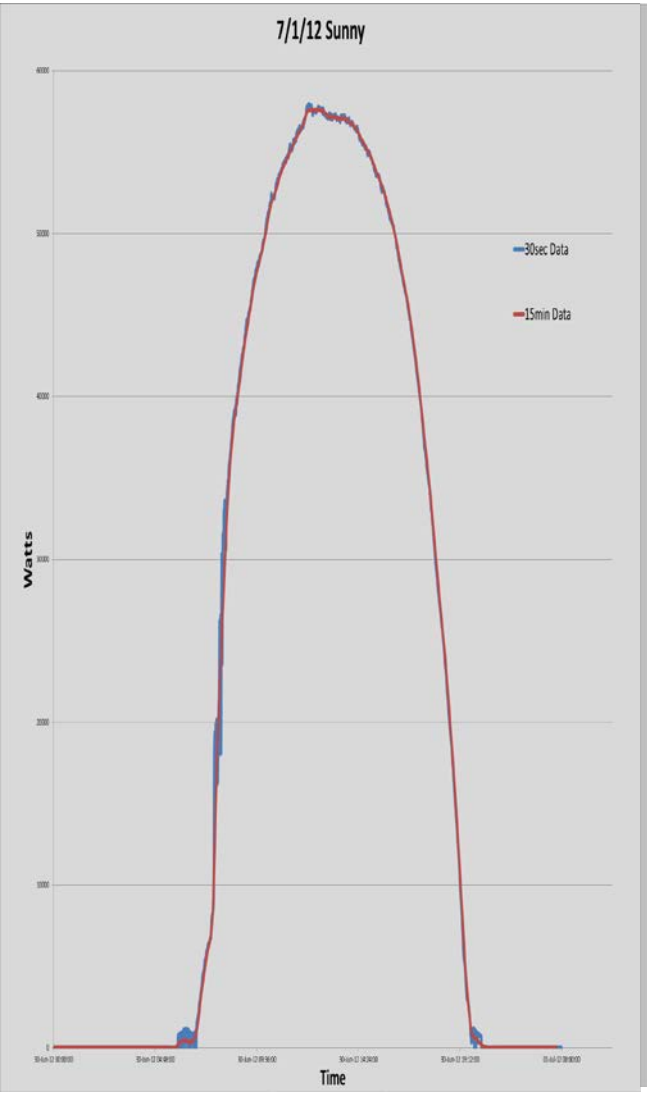
PV Intermittency – Time Views

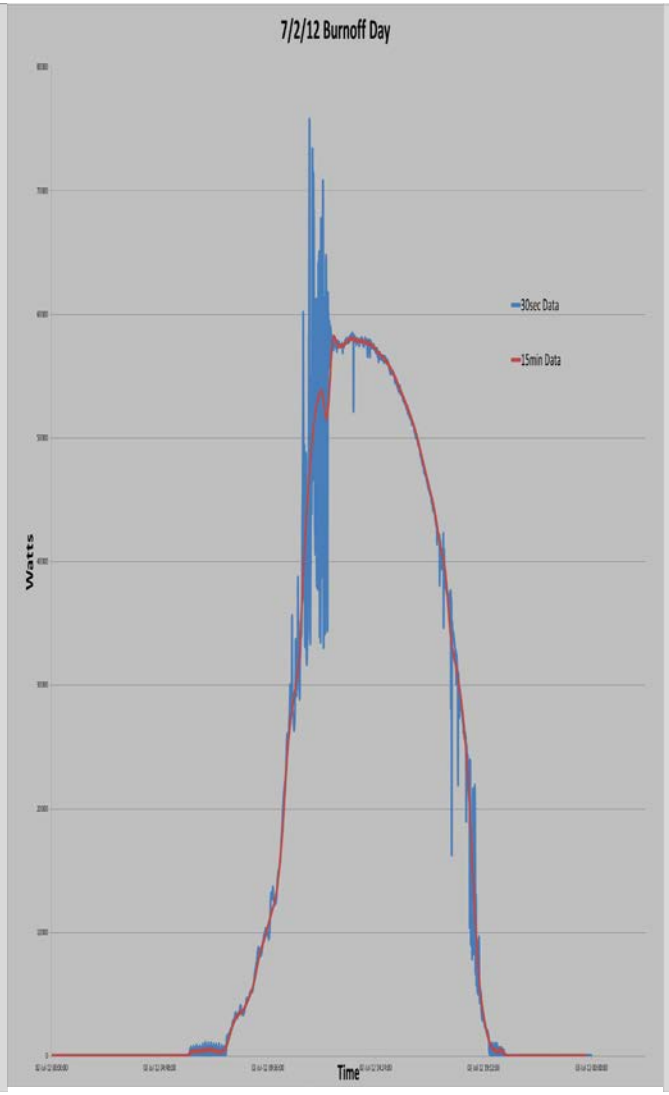


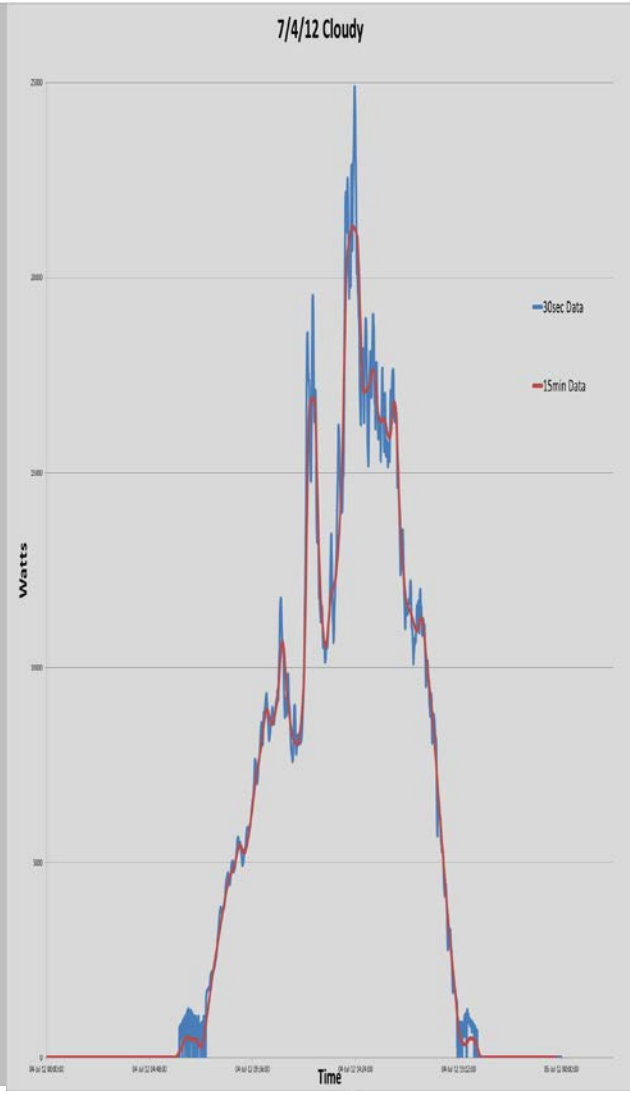
PV Intermittency – Time Views



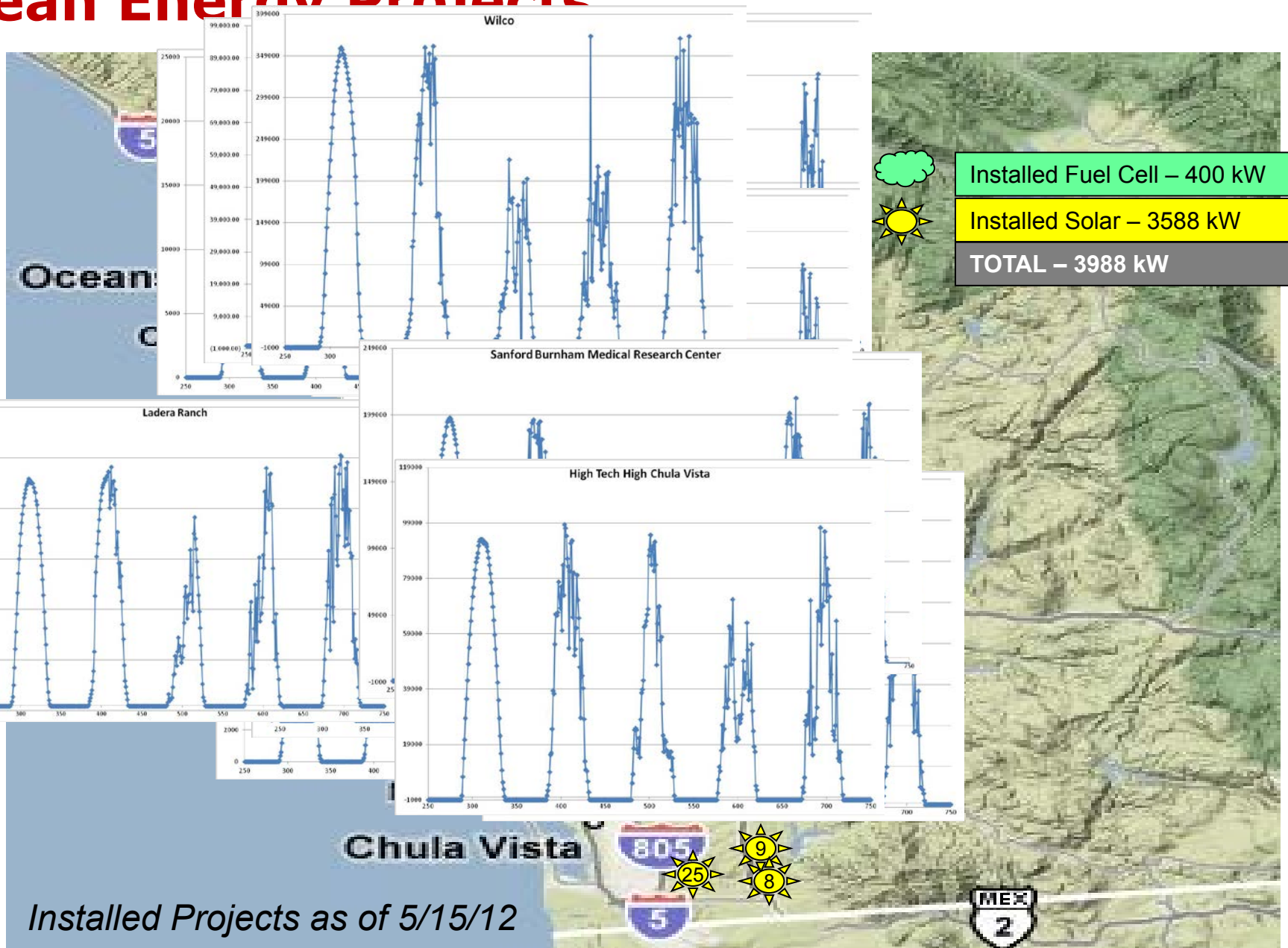
PV Intermittency - EIC



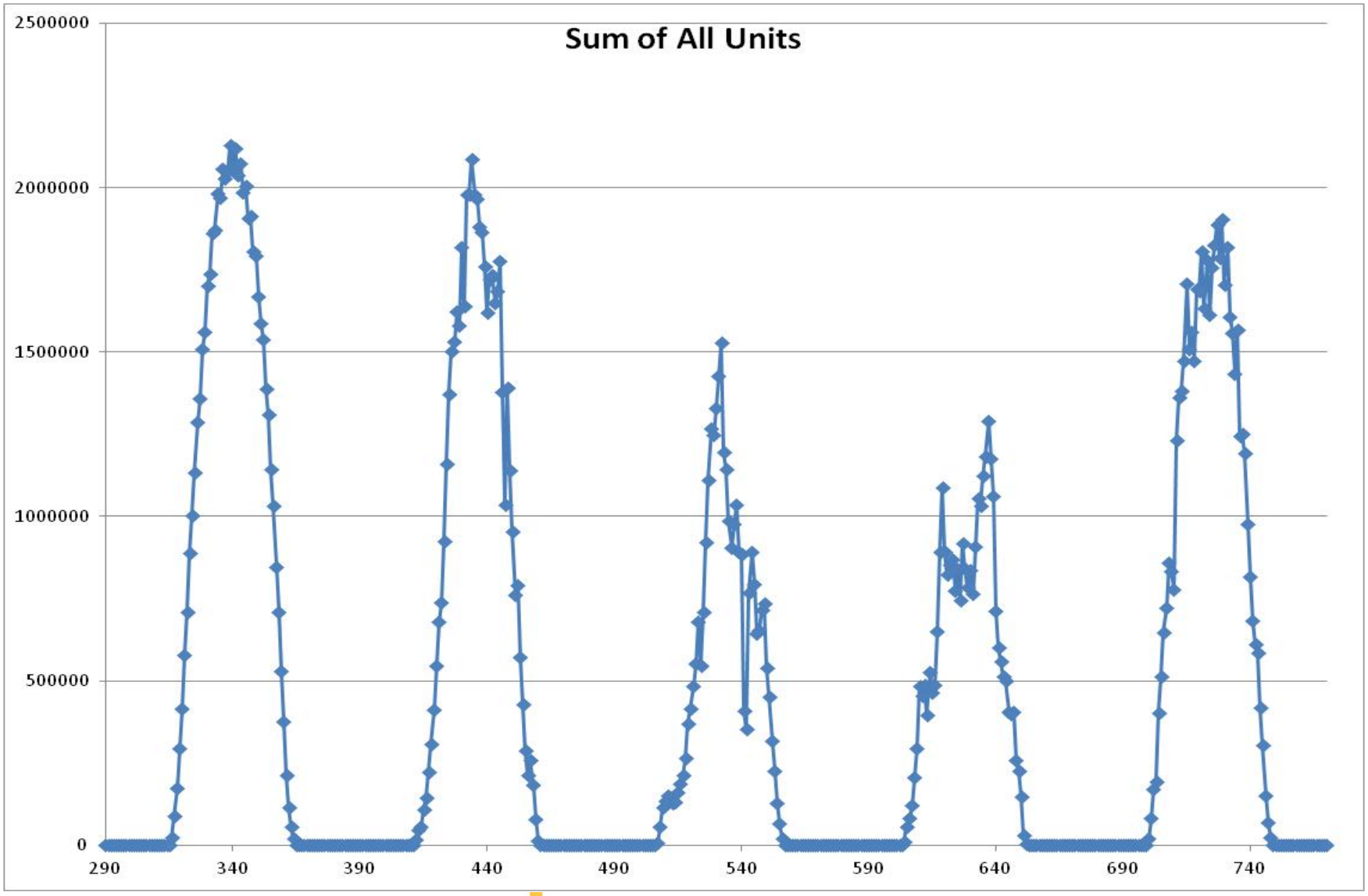




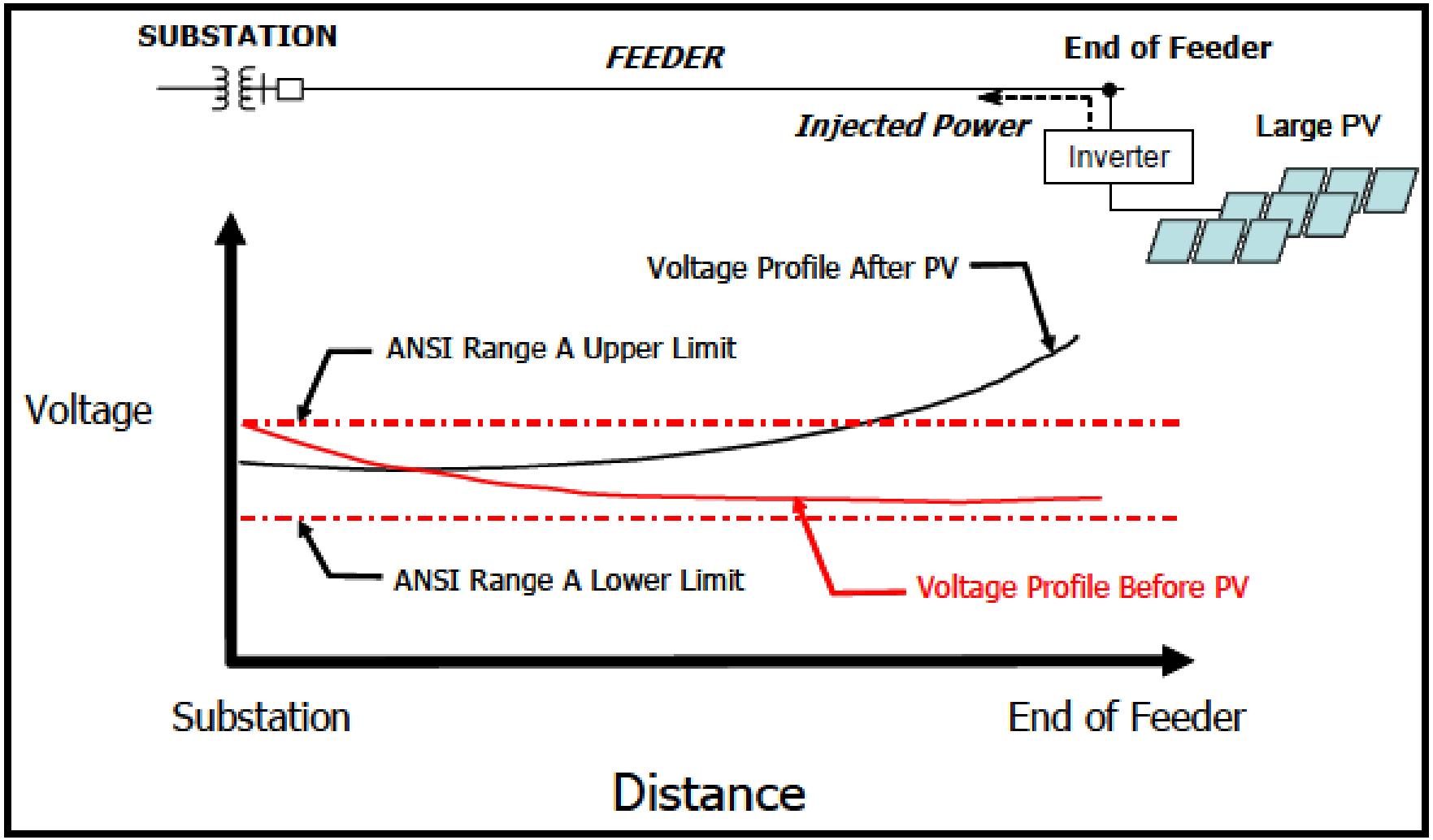
Sustainable Communities
Clean Energy Projects



Sum of All Units

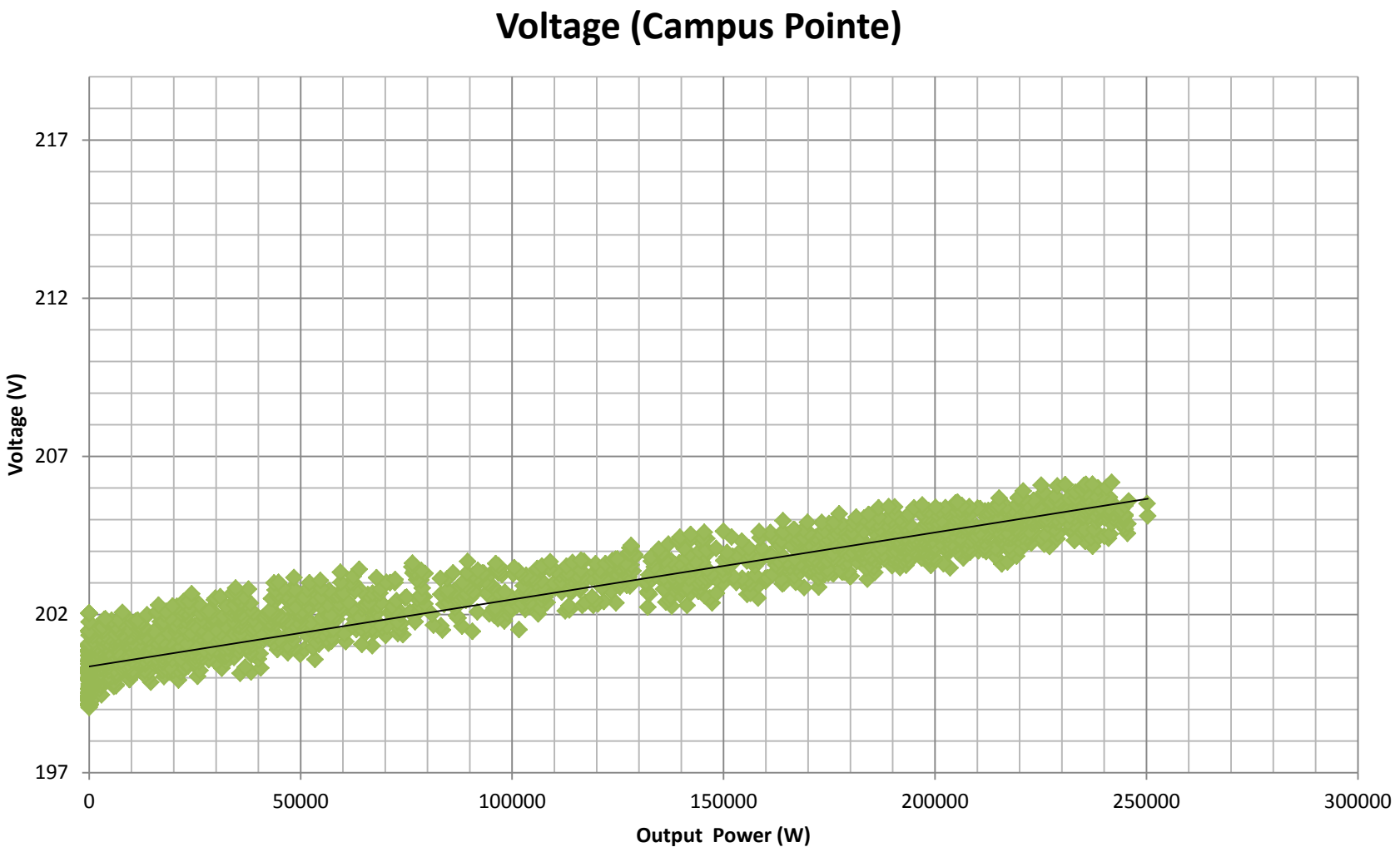


PV Issues – Voltage Regulation



Sandia National Labs – Solar Energy Grid Integration Systems – Program Concept Paper October 2007

Voltage Impact of PV



INTEGRATION OF DER

Factors Determining Impact

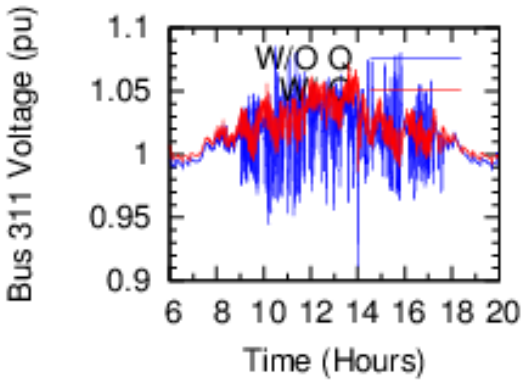
- **Location on the Circuit**
  - Near Substation vs End of Circuit
  - Near equivalent load
- **Circuit Rating**
  - 4 kV vs 12 kV
- **Type of Circuit**
  - Urban vs Rural
- **Circuit minimum loading**
  - High vs Low
- **Circuit X/R ratio at location**
  - High vs Low
- **Aggregate DG capacity**
- **Voltage Regulation Equipment**

INTEGRATION OF DER

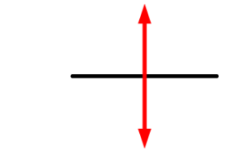
Solutions?

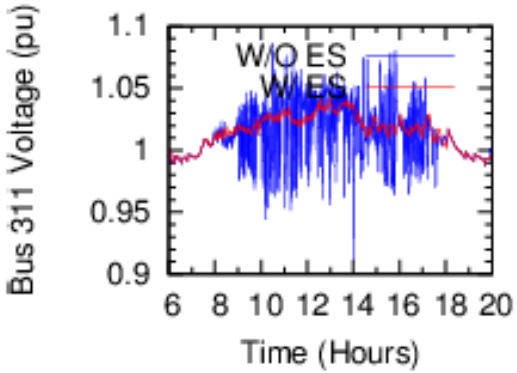
- **Circuit modifications**
  - Monitoring and ensuring resource adequacy
  - Frequency regulation
- **Demand response**
  - Slower dP/dt events?
- **4 quadrant control**
  - Utility dynamic VAR devices
  - Utility storage
  - Customers inverters/storage
- **Regulatory/Standards Changes**
  - Existing rules require modification to accommodate high PV penetration
    - Draft IEEE 1547.8, IEC 61850 can be utilized today
      - Similar to German Grid Code

PV Intermittency Mitigation Based Upon Modeling with Smart Inverters

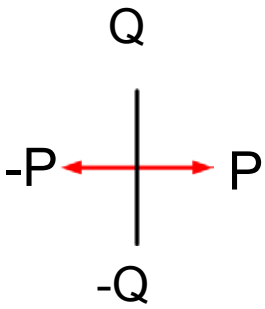


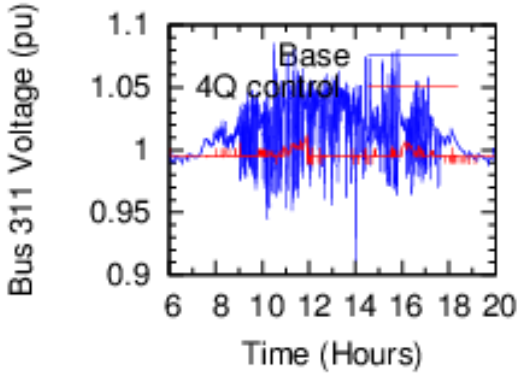
With and without dynamic VAr device



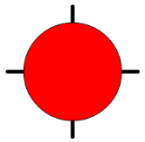


With and without energy storage



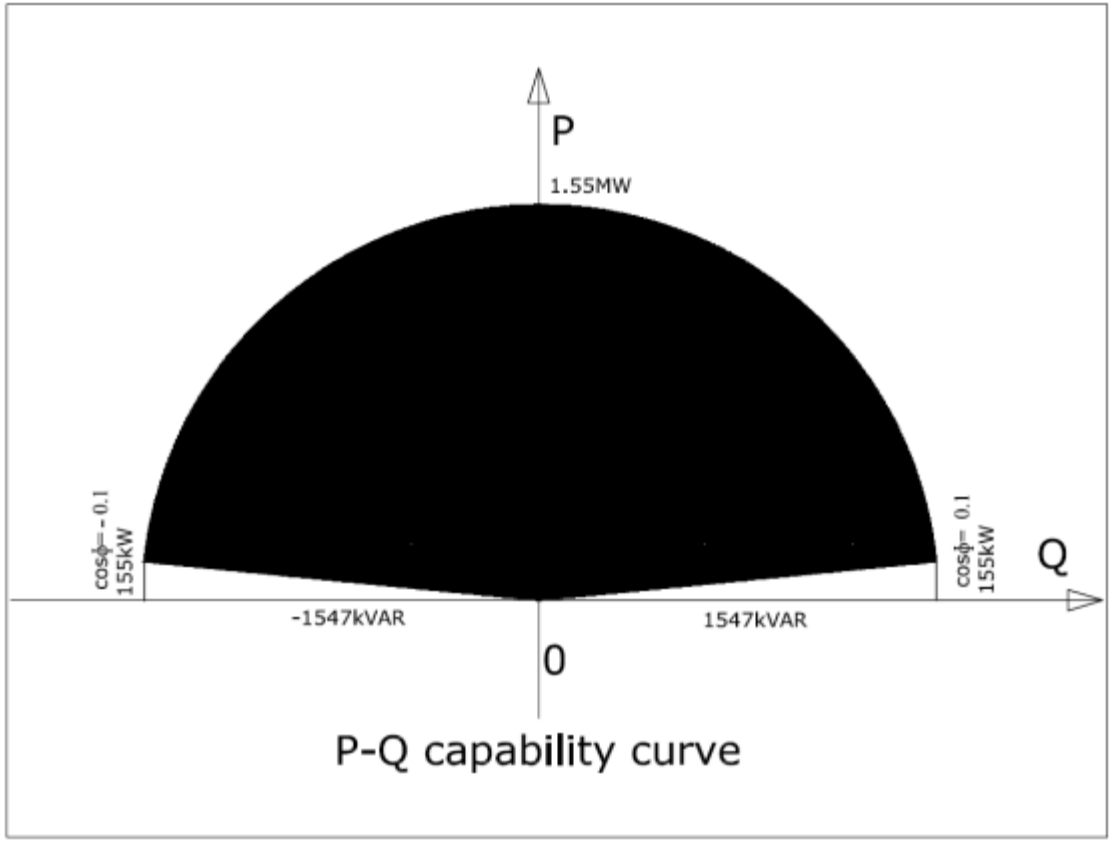


With and without storage and 4 quadrant control



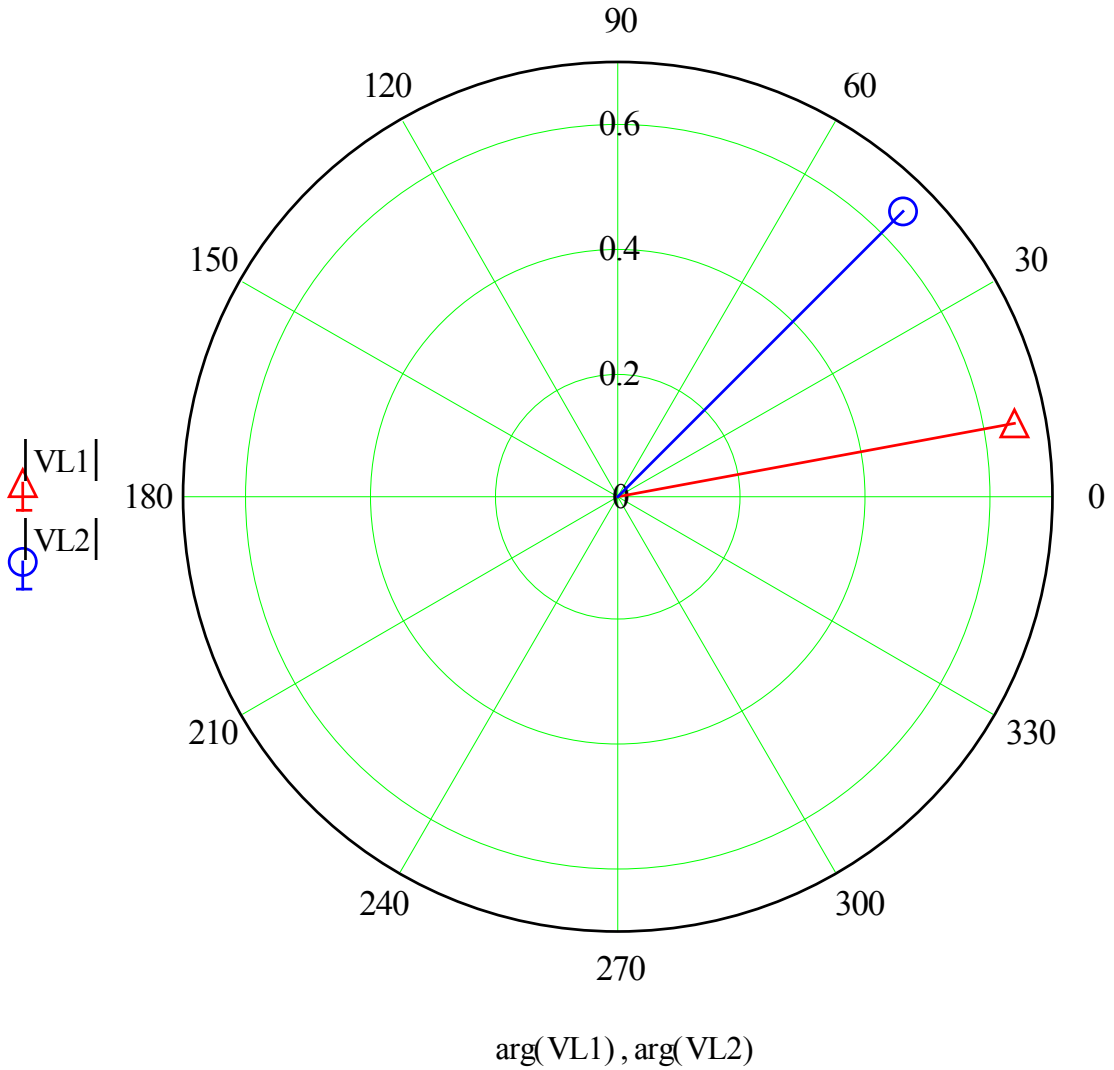
Red = With Blue = Without

PV with Smart Inverter



P-Q capability curve

Voltage Regulation Smart Inverters



- Operating at different power factor affects voltage magnitude
- For an illustrative example operating at a 0.7 power factor can have 2 times the generator rating as one generator operating at unity power factor while maintaining the same voltage
- $1M for 2 MVA dynamic VAr device
- $3M for 500 kW, 1500 kWh battery

Inverter Functions Needed

Desired inverter characteristics:

- Under-frequency trip point
- Low voltage ride through
- Real and reactive power support
- Dynamic VAr injection
- Communications capability

Benefits:

- Operating at various power factor may enable generators to avoid upgrades
- Industry will benefit from improved inverter functionality

Service Standards: Utilities (SDG&E) will develop Service Standards to define interconnection requirements and facilitate interconnection or PV/Wind generators

Summary

- PV and PEV have significant impact on the grid
  - Voltage regulation impacted by loading and DG
  - New approaches are required to mitigate intermittency
    - NEM customers do not pay
  - "Smart" inverters are a necessary tool to traditional alternatives
    - Need to change PUC and Rules
    - Storage provides maximum flexibility
      - Can operate as a generator or a load at any power factor

Questions ?

Thank you.

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www.sdge.com/smartgrid/