New Mexico Chapter
Association of Energy Engineers

Renewable Energy and the Need for Energy Storage

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PNM

Renewable Energy and the Need for Energy Storage

- Rules for operating the grid- what utilities have to do to keep the grid operating in the face of increasing renewables
- Impacts of Renewables
- Need for Storage
- Solutions - What's available - Whats being done

Rules of the Game – Accommodating Renewables is not easy

- Resources have to match load – always (24/7/365/525600/31536000/1892160000) - down to 60Hz
  - Transmission Level – High Voltage – Federal (NERC) Jurisdiction
  - Mistakes can cascade and cause very big problems – refer to the interconnected Transmission Network
  - Straying from this invokes serious penalties ($M enforced by Federal Regulators)'
- Customer Loads are very sensitive (and growing more sensitive) and have to be served with quality power
  - Distribution Level – Lower Voltages - NMPRC Jurisdiction polices
  - Voltage variances directly affect customer loads/equipment

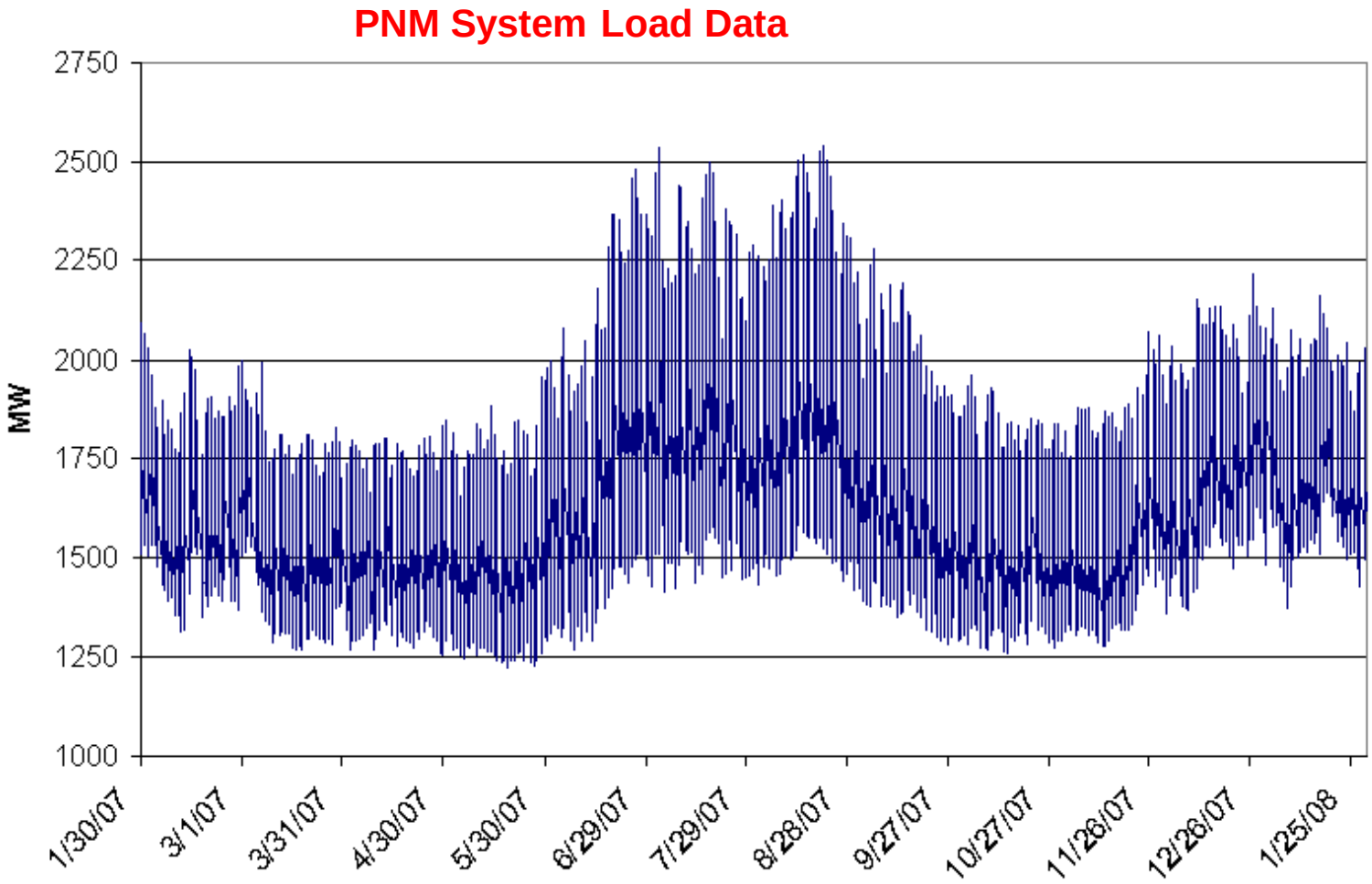
Current Net Electricity Generation by Energy

Energy Source	Net Electricity Generation (GWh)	Percent of Total Net Generation
Coal	2,000,000	48.5
Petroleum liquids[a]	31,200	0.8
Petroleum coke	14,200	0.4
Natural gas	877,000	21.3
Other gases[b]	11,600	0.3
Nuclear	806,000	19.6
Hydroelectric	248,000	6.0
Other renewables[c]	124,000	3.0

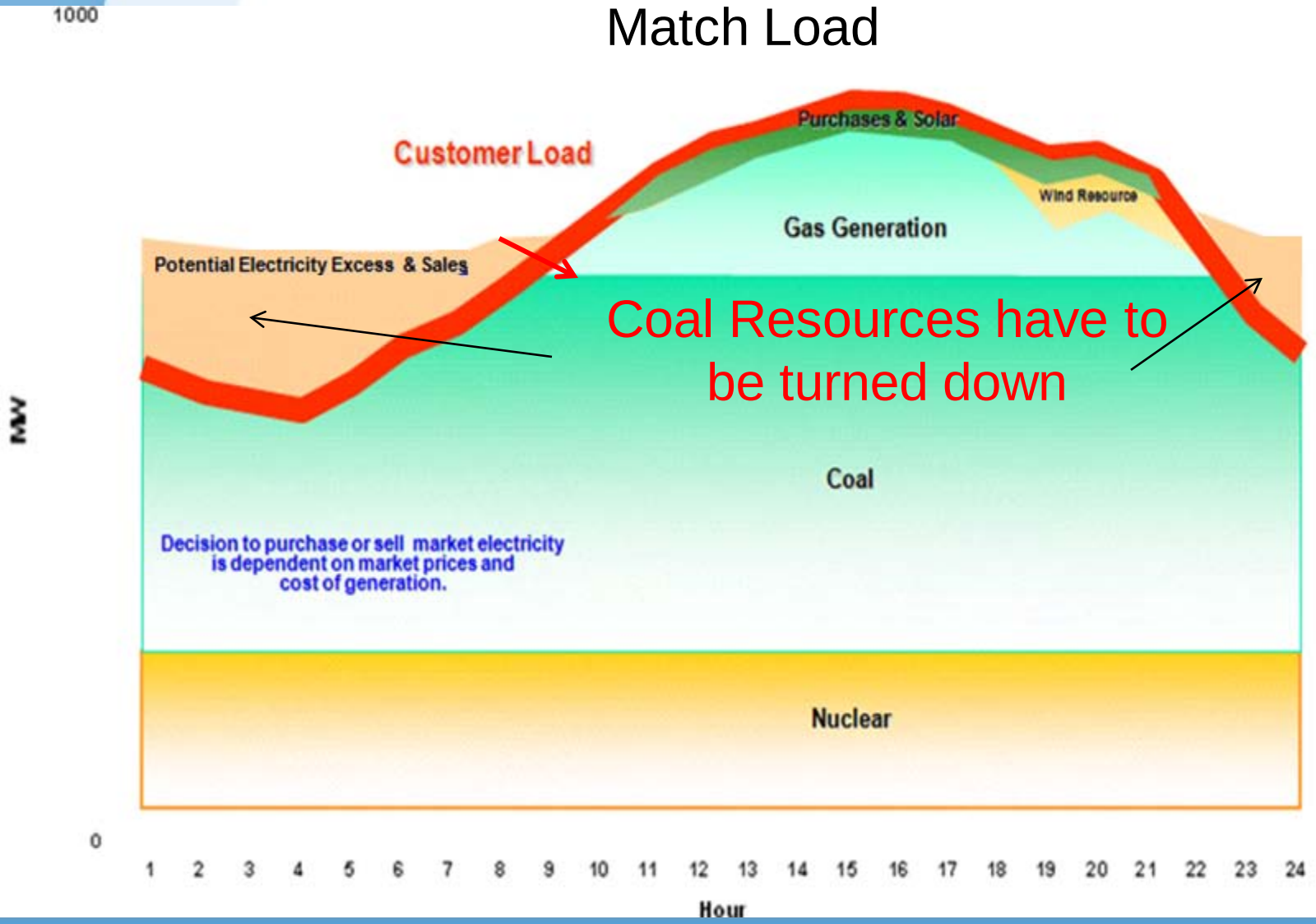
In a general sense this has to change to 20% by 2020

Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use (2010), National Academies Press

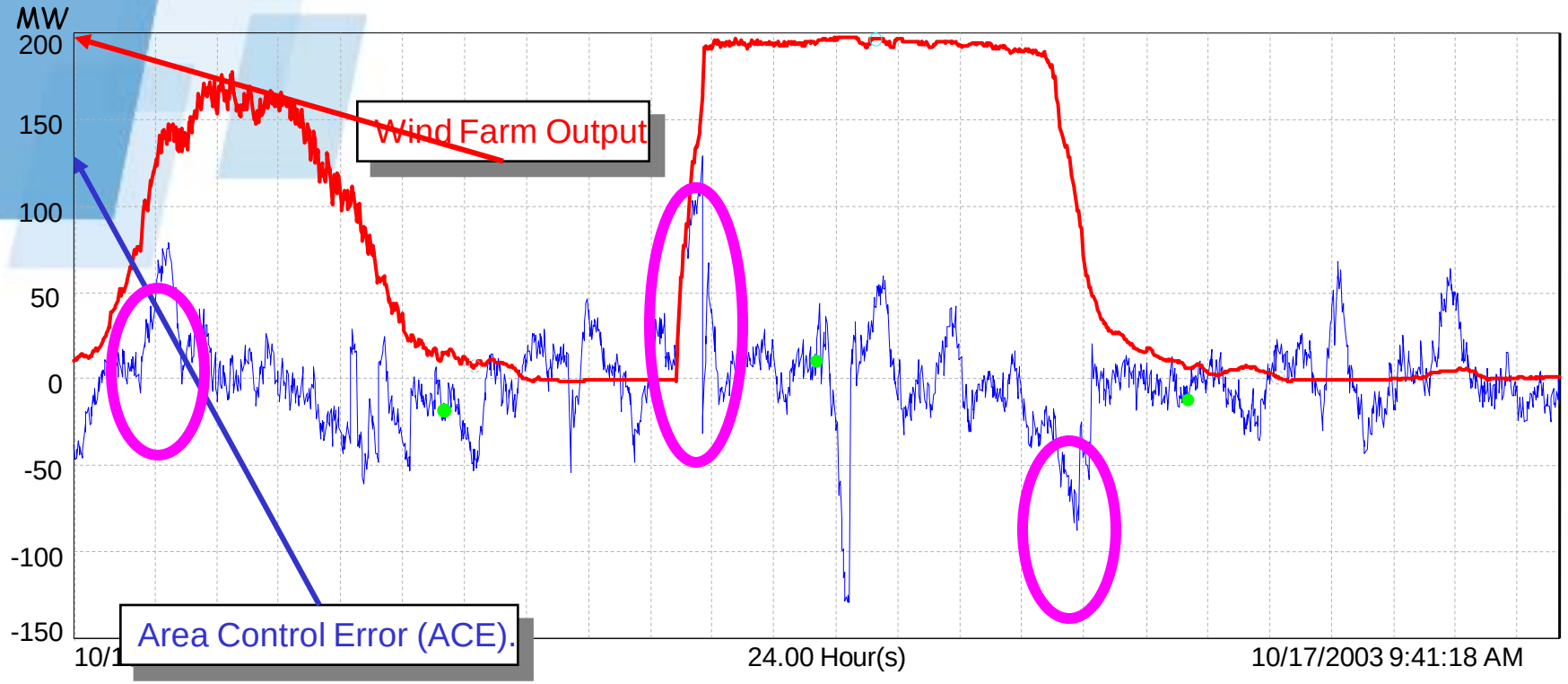
Key Rule – **Load must match output of generation resources – always**



How the Match is Made – Resources Used to Match Load



Wind Variability – Transmission and Generation Level Impacts

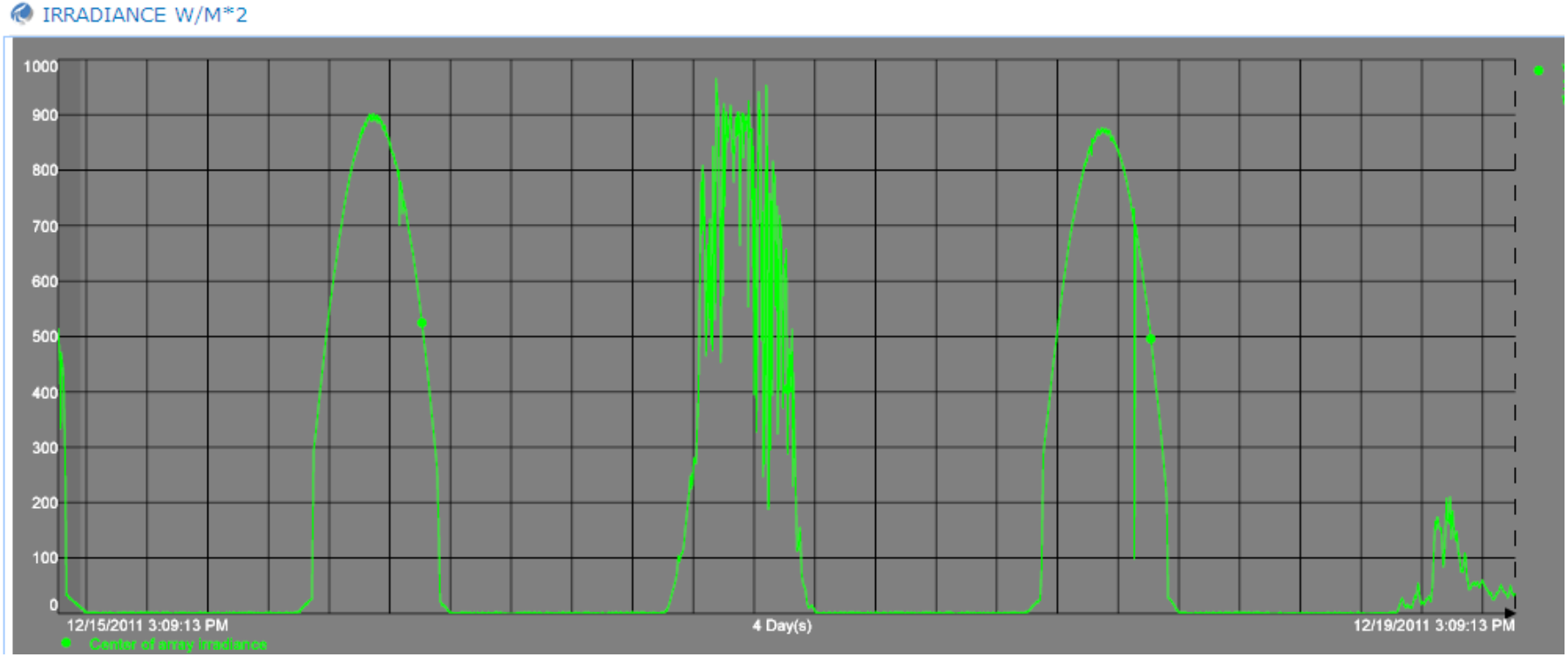


- NERC CPS-2: The average ACE for at least 90% of a clock-ten-minute periods during a calendar month must be within a specific limit. *PNM's current limit is ± 38 MW.*

- ACE deviates by more than 40 MW as a result of rapid changes in wind power output, affecting CPS-2 for this sample month (average CPS-2 was still above 90%)

Solar PV Variability - Distribution Level Impacts Prosperity Energy Storage 12/16 -19/2011

1 second interval PV output data from PNM Prosperity Energy Storage Site



Potential Solutions to Renewable Intermittency

- Energy vs. Power
  - Power – fast acting (seconds to minutes) – Regulation
  - Energy – slower (minutes to hours)
- Shape the Load to Resource
  - Load Modification - Invoke Real Time Pricing (Smart Grid)
  - Load Reduction
- Shape the Resource to the Load
  - Curtail Renewables
  - Energy Storage

Storage Types

Batteries - Power and Energy

Multiple types of chemistries

Thermal - Energy

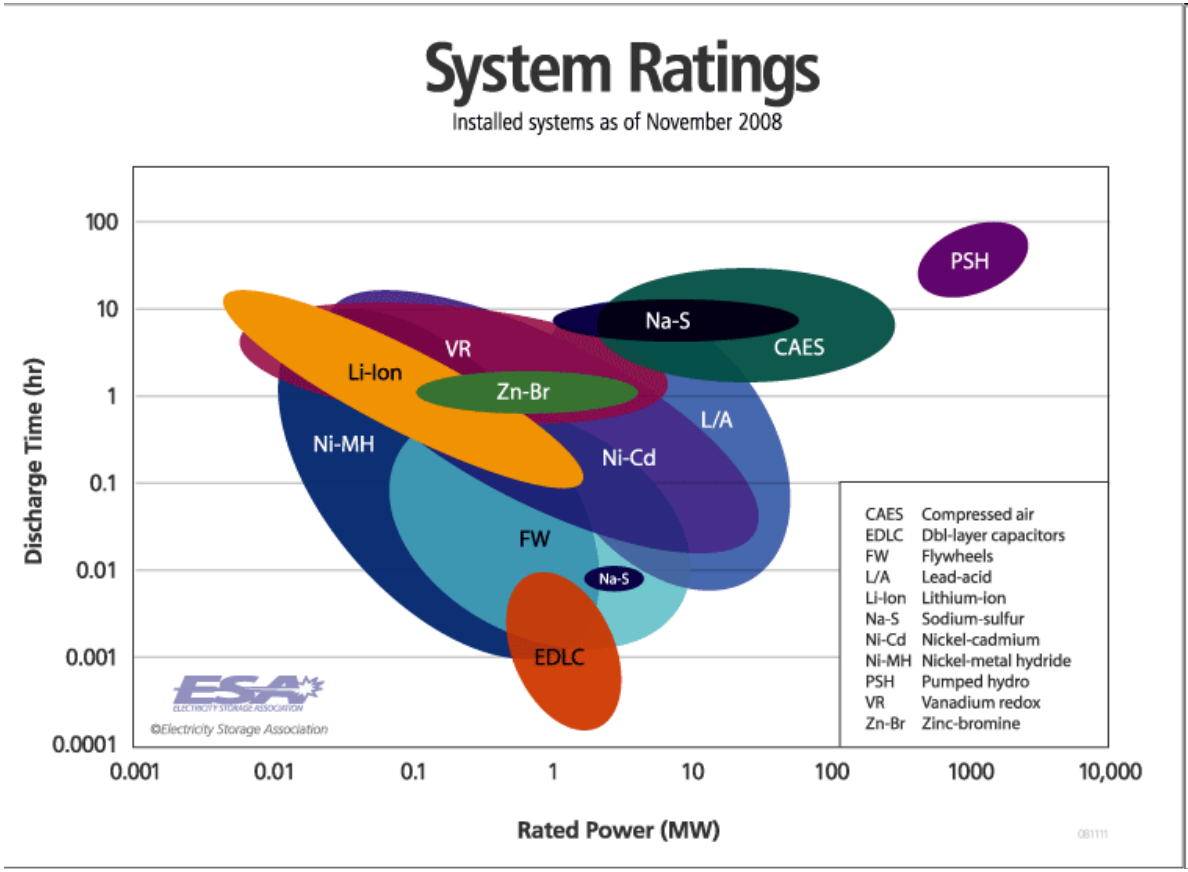
Flywheels - Power

Supercapacitors/ Ultracapacitors - Power

Compressed Air Energy

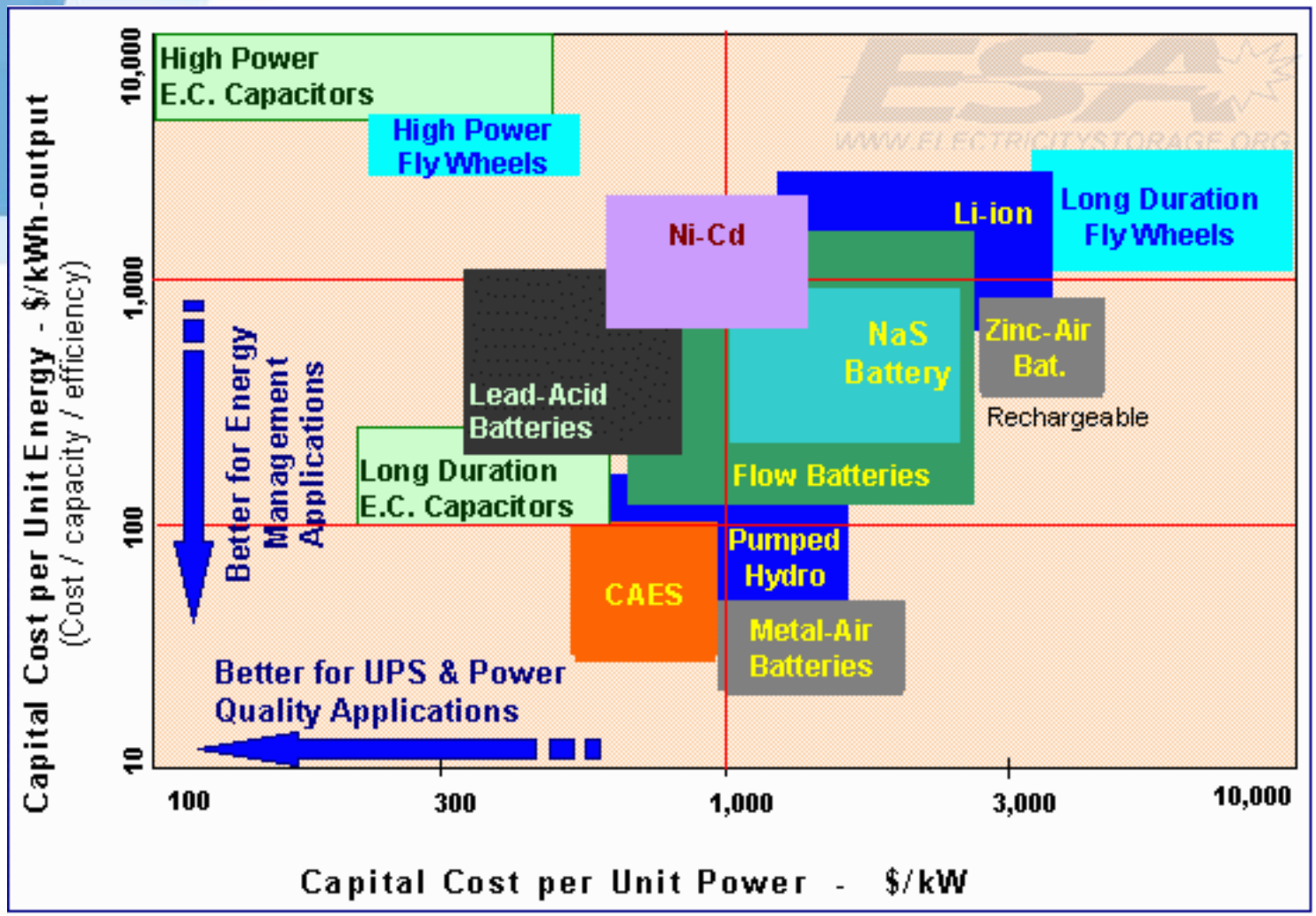
Storage (CAES) _ Energy

Pumped Hydro – Energy



See Electricity Storage Association

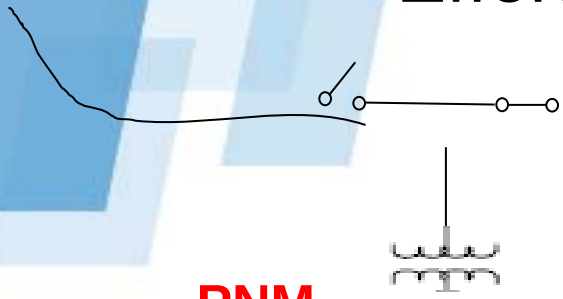
Storage Costs



What's being done?

- PNM/EPRI Smart Grid Demo
  - Feeder Modeling
  - Communication/control system architecture development
  - Started 2008
- PNM/DOE – Prosperity Energy Storage
  - Utility side Project
  - One of 16 DOE Smart Grid Storage Demonstration Projects
  - First to come on-line on budget on-time
- NEDO/Mesa del Sol Project –
  - Implementing various customer side technologies
- NIST Cybersecurity
  - PNM actively participating in Stakeholder Process

Collaboration with Numerous Proximate Efforts



PNM installed PV + Battery Storage

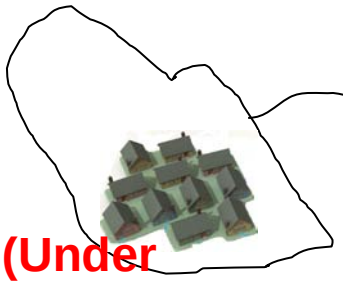
Switchgear

To Studio Substation- Feeder 14

Studio Substation – Feeder 14

Fraunhoffer Solar Test Facility

Phase 1 Residential



Residential (Under Construction)

Albuquerque Studios

Town Center

Site for MdS/NEDO commercial Energy Efficient building

PNM/DOE Smart Grid Storage Demonstration Objectives

Prove a battery system can achieve multiple Benefits – simultaneous Smoothing and Shifting (Power and Energy)

Create a dispatchable, renewables-based peaking resource

Combine PV and storage at a substation to achieve a minimum of 15% peak-load reduction on an associated distribution feeder

Demonstrate that this combination can mitigate voltage-level fluctuations as well as enable load shifting

Quantify and refine the associated performance requirements, operating practices, and cost:benefit, particularly for regions well-suited for distributed generation

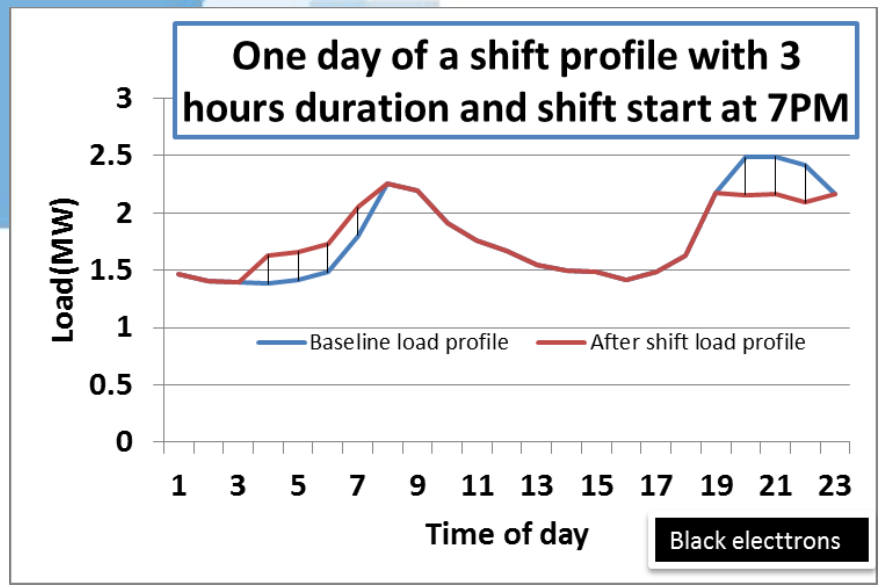
Generate, collect, analyze and share resultant data

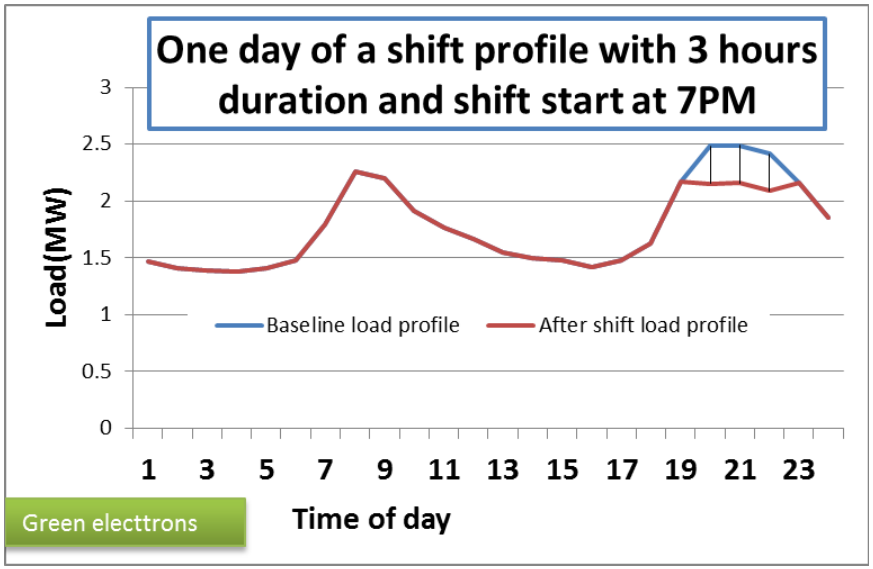
Enable distributed solutions that reduce GHG emissions through the expanded use of renewables

Modeling – Key to Field Success

- UNM Based Effort
- Utilizing Leading Edge Distribution System Models
  - OpenDSS (EPRI)
  - GRIDLAB-D (PNNL)
- Allows understanding and quick development of control methodologies
- Allows system wide assessment of benefits
- Allows results to be transferable to the Utility Industry

Modeling: Shifting algorithm





- Previous models incapable of modeling storage
- Current Models calibrated to PNM feeder data
- Currently testing algorithm effectiveness for both Shifting and Smoothing

Prosperity Energy Storage Project Features

Prosperity Energy Storage Project Hi Value Renewable Intermittency - Utility Scale Storage

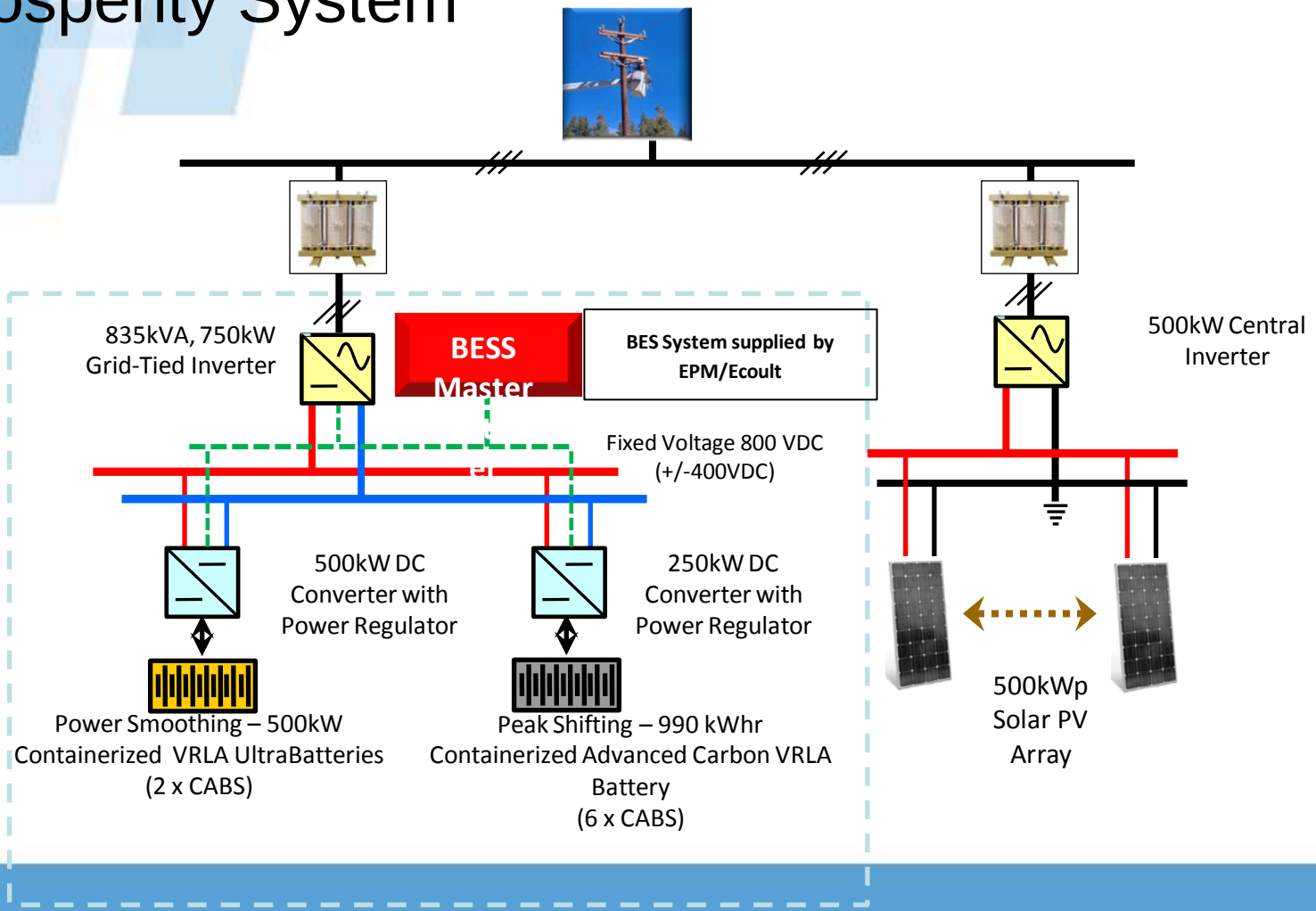
Project

- Is designed to both smooth intermittency and store energy for later usage
- Development of control algorithms is key to this project

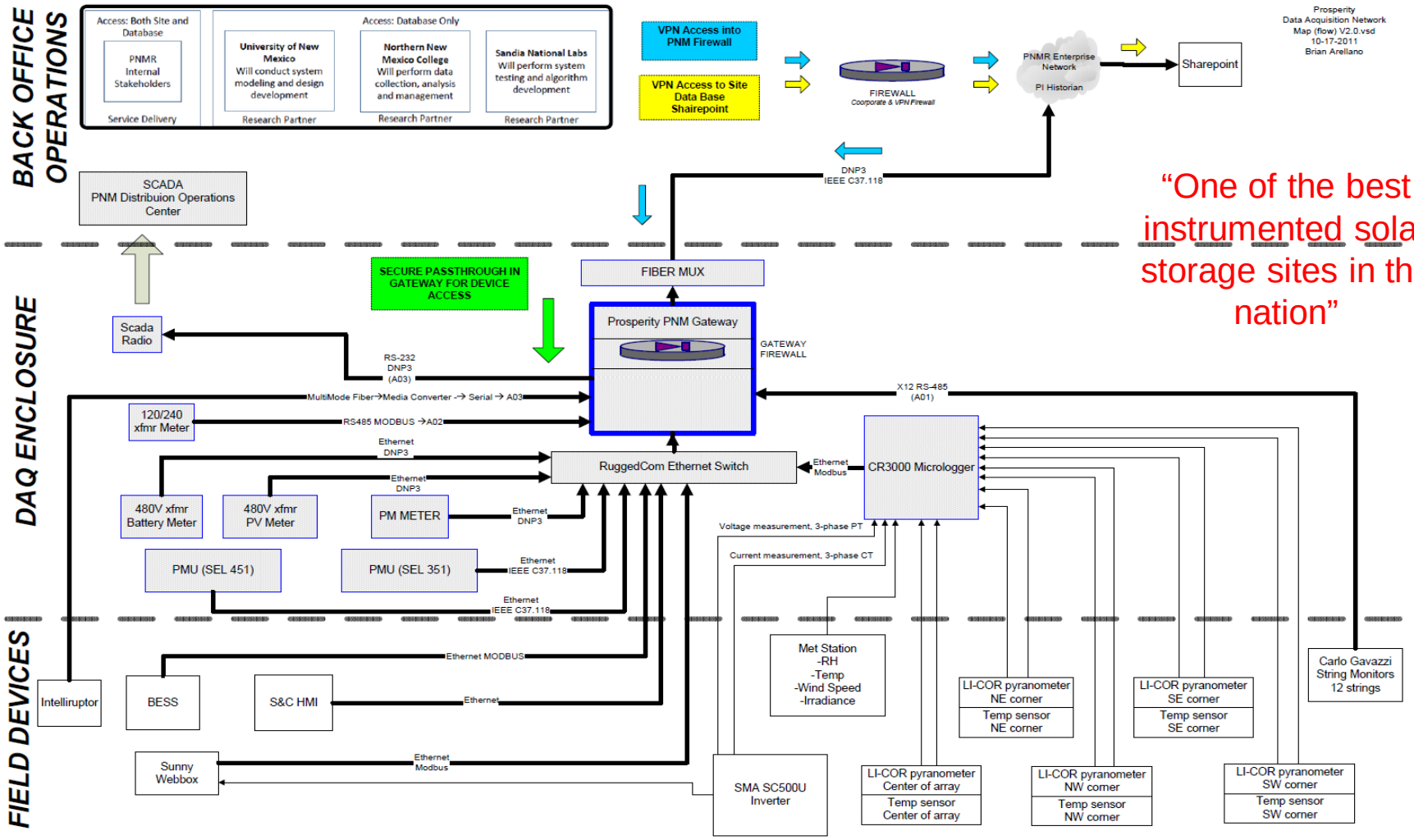
Equipment

- 500 kW PV (energy for about 100 homes)
- Battery system for “shifting”
- Battery system for “smoothing”
- Cyber Secure , High Resolution Data Acquisition

Schematic of the Prosperity System



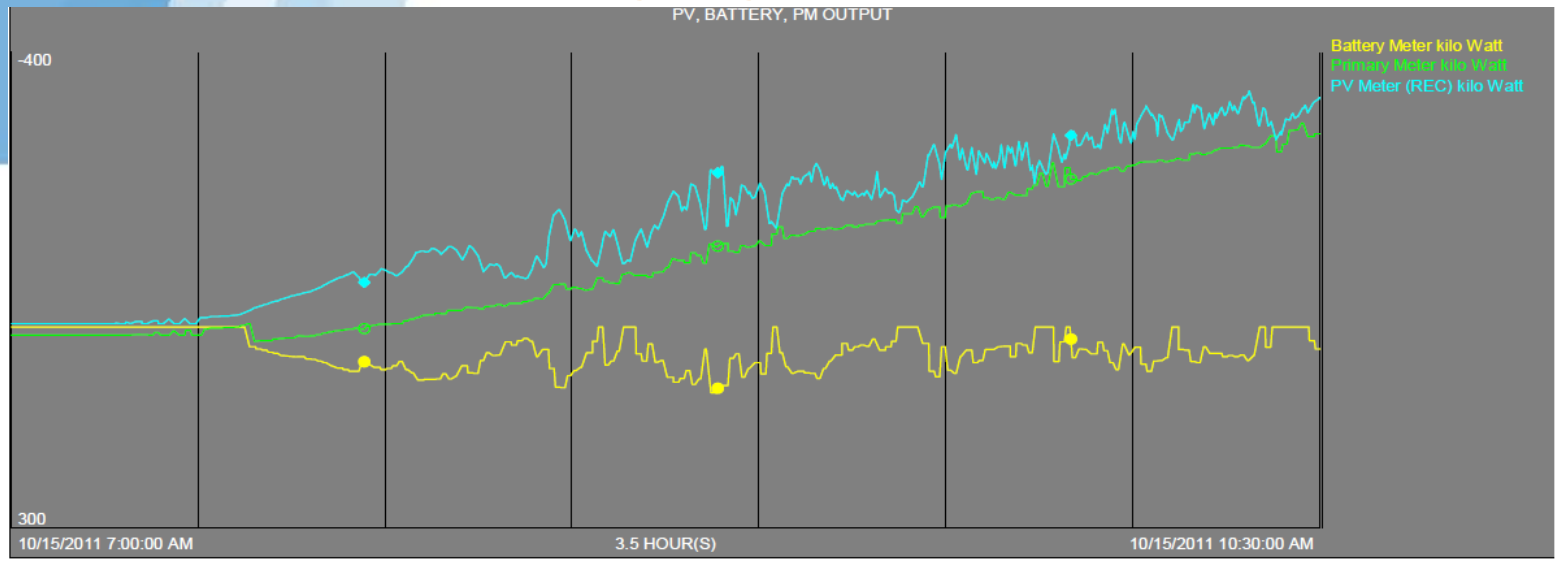
Details – Data Acquisition System Specification/Engineering Architecture Diagram

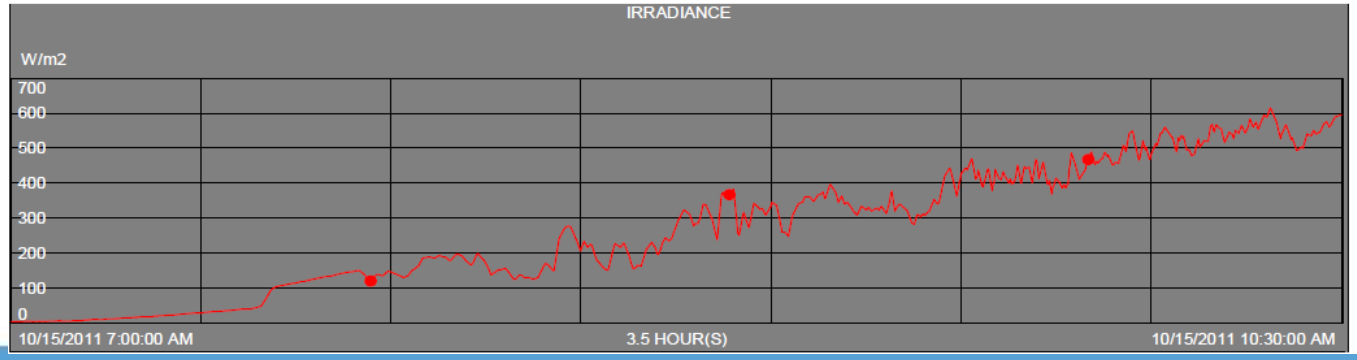


"One of the best instrumented solar storage sites in the nation"

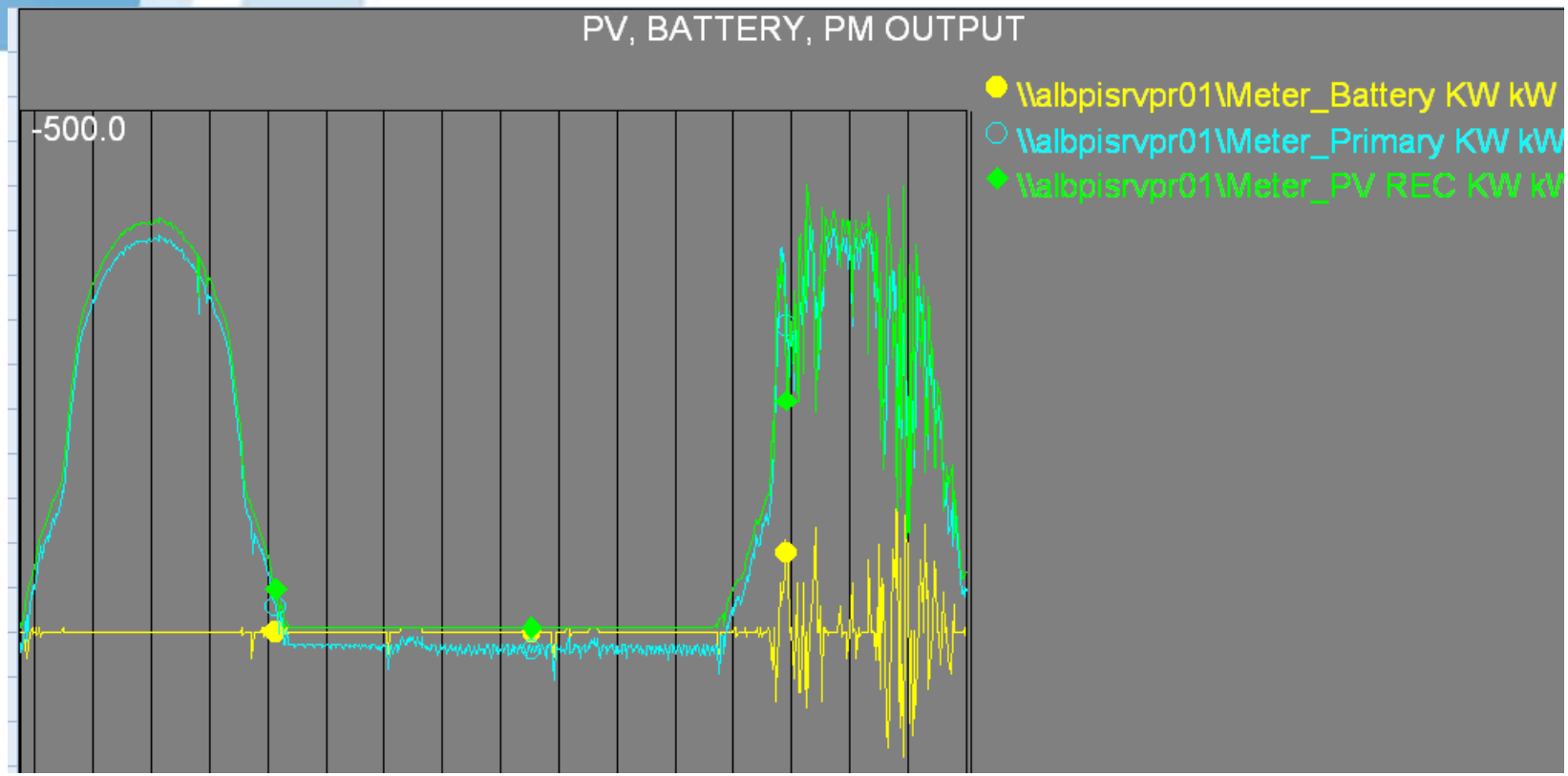
Applying Storage – Commissioning Data

Shifting and Smoothing Batteries Commissioned and dispatching to grid - data from Saturday 10/15/11

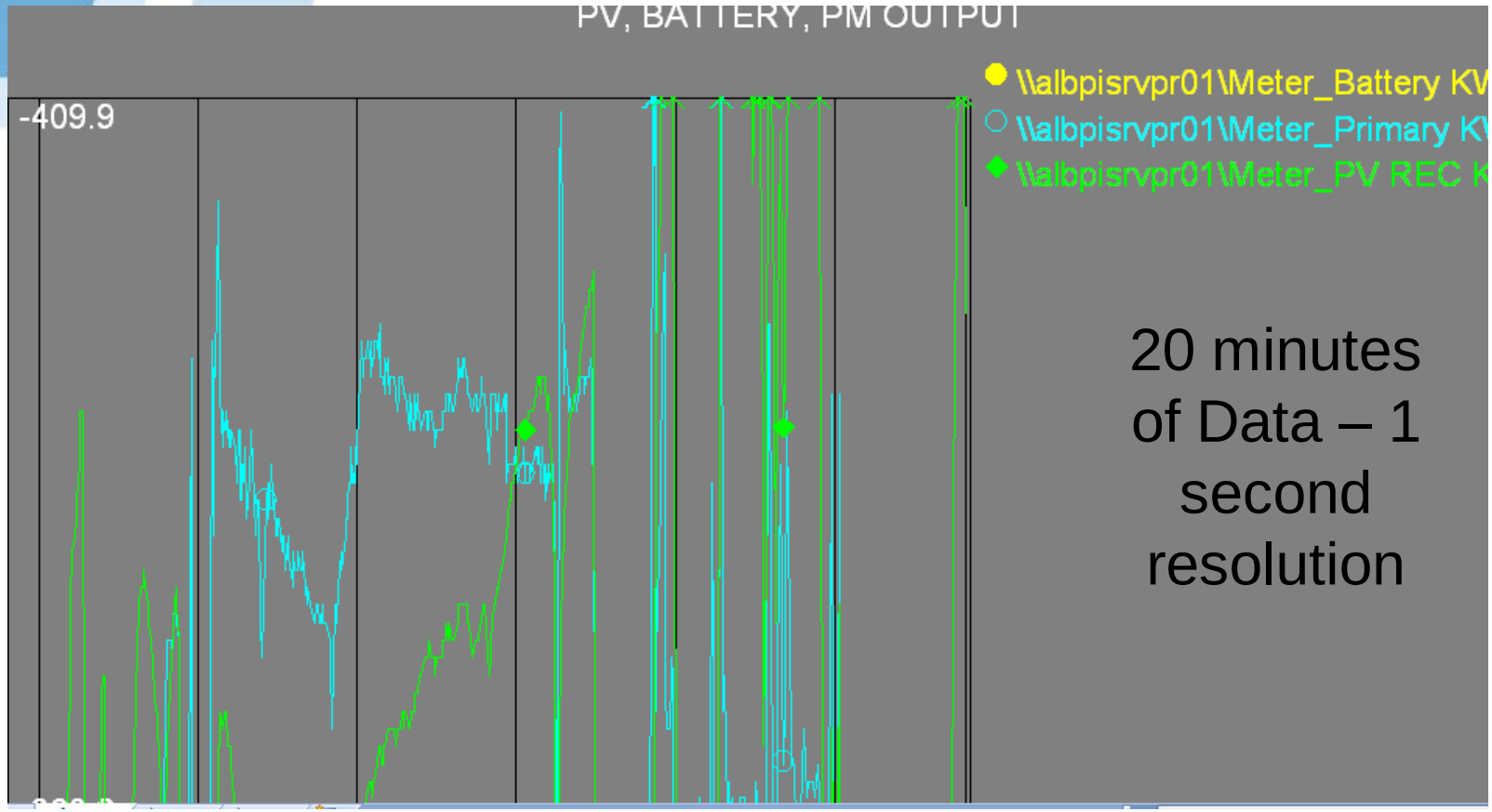




Smoothing Results 12/16/11

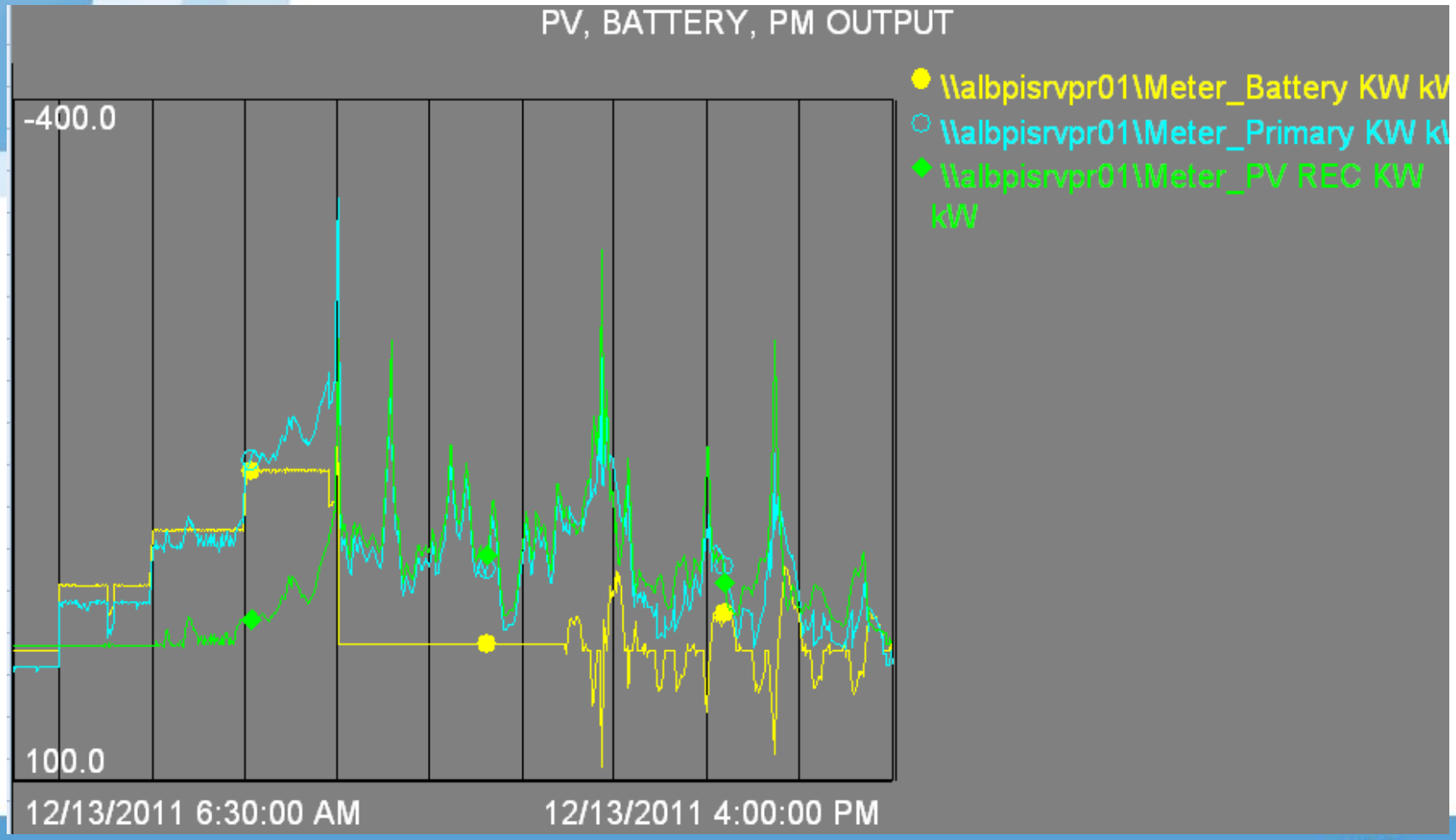


Granular Look at Smoothing 12/17/2011 – Configuration at 70% of ramp rate input into algorithm



20 minutes of Data – 1 second resolution

Smoothing Data 12/13/2011



Next Steps - Implementing Test Plans

- Algorithm Development
  - Shifting – coded V1 in place – will test various inputs and filters throughout test period
  - Smoothing – data structure assembled to align next day forecast with historical load/price history
    - extensive data correlation of historical price/load history completed
    - Result forecasted to be multi-variant /optimization based algorithm – extensive effort – start simple and grow in complexity
- Test Plans Aligned to seasonal load and PV output
- First of five test plans being initiated
  - Smoothing – Oct through Dec 2013
  - Peak Shaving – winter and summer peaking period 2012-2013
  - Firming – winter and summer 2012
  - Arbitrage – Shoulder periods throughout test period
  - All of the above – summer 2013