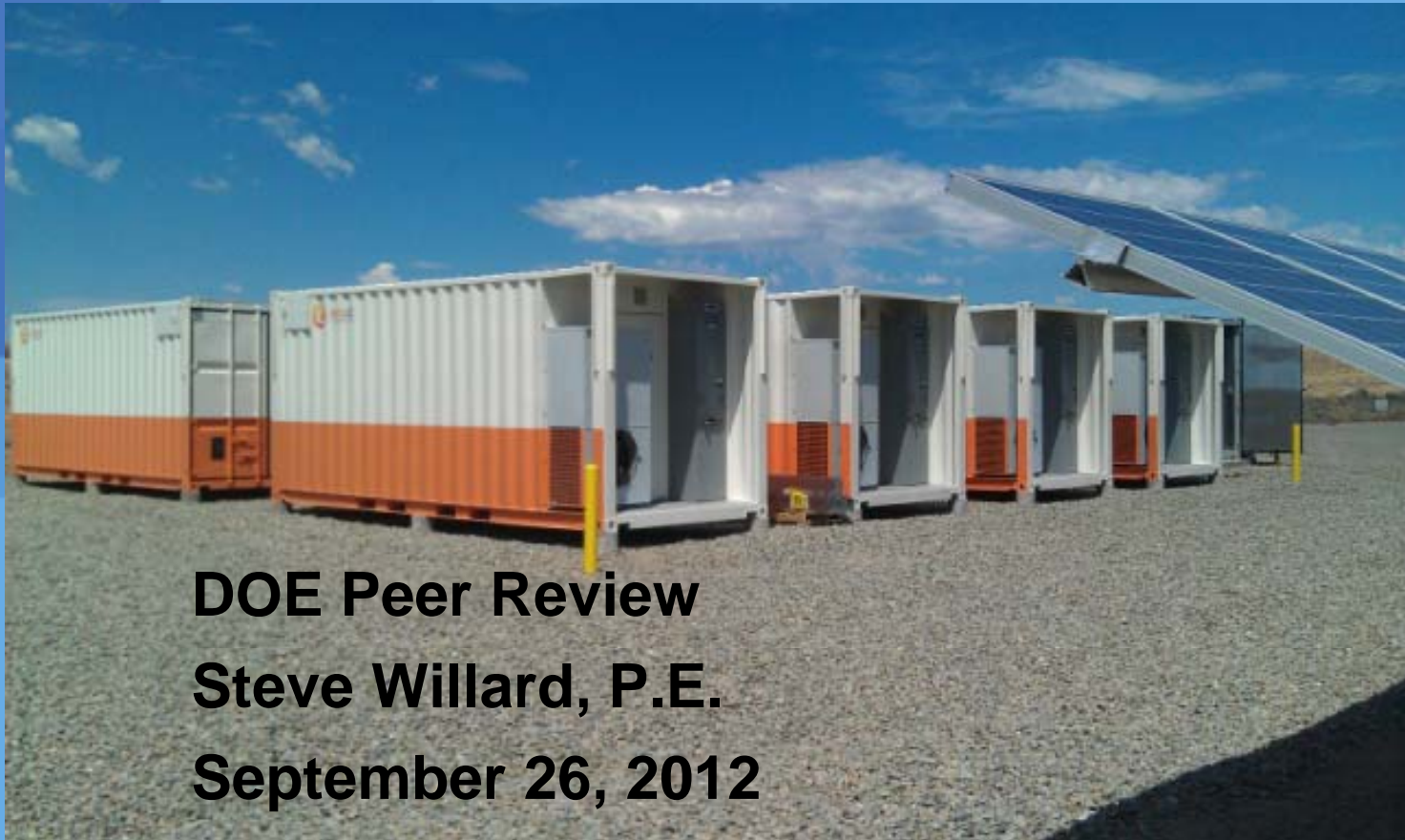


Public Service Co. of New Mexico (PNM) - PV Plus Storage for Simultaneous Voltage Smoothing and Peak Shifting



DOE Peer Review
Steve Willard, P.E.
September 26, 2012

Project Goals – Develop an even more Beneficial Renewable Resource – Transferable Nationwide

- Created a dispatchable, renewables-based peaking resource
- Combined PV and storage at a substation targeting 15% peak-load reduction
- Demonstrating a combination that can simultaneously mitigate voltage-level fluctuations as well as enable load shifting
- Developed power system models (baseline and projected), and cost/benefit economic models
- Generating, collecting, analyzing and sharing resultant data
- Enabling distributed solutions that reduce GHG emissions through the expanded use of renewables

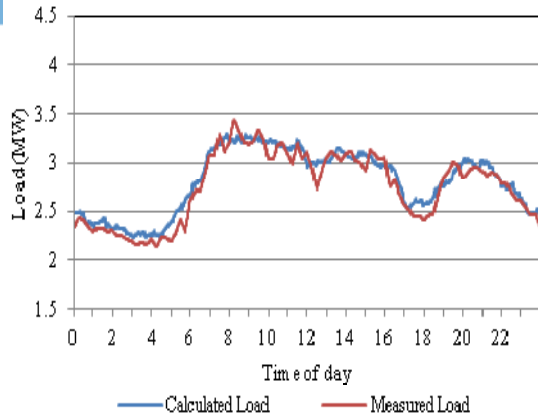
Project Partners

- Sandia National Labs: assistance in battery control algorithm development**
- Northern New Mexico College: field data acquisition, manipulation and analysis**
- University of New Mexico: grid modeling, development of control schemes**
- Ecoults/East Penn Manufacturing: advanced lead acid battery vendor**

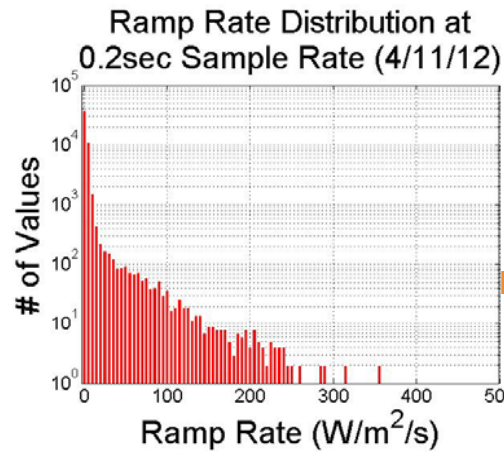
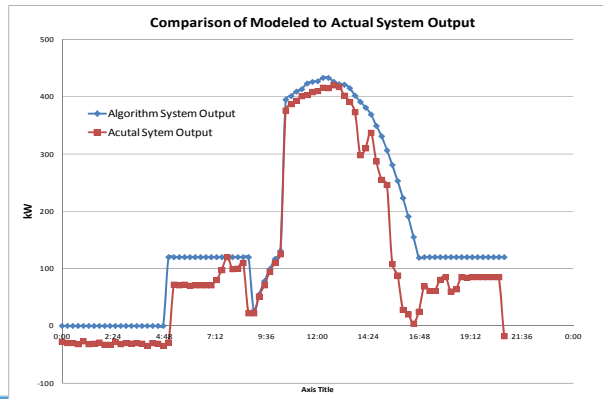
Project Schedule Update

- Five of six major milestones have been achieved on time and on budget.
 1. Negotiate Final Award (completed 10/2010)
 2. Revise PMP (completed 11/2010)
 3. Manufacture Battery System (completed 05/2011)
 4. Create system computer models and calibrate (Completed 05/2011)
 5. Install and commission system (completed 09/2011)
 6. Demonstration of the system is on track for early 2014 completion
 - 5 Test Plans Total
 - Test Plan 1 (smoothing) underway
 - Test Plan 2 (shifting) underway
 - Test Plan 3 – SCADA data porting effort underway – effort to start in Oct.

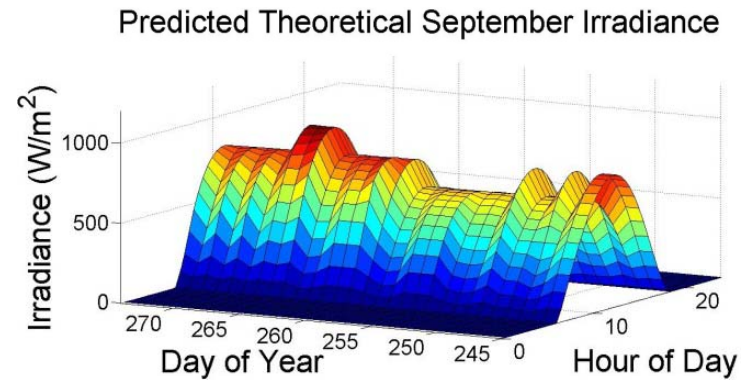
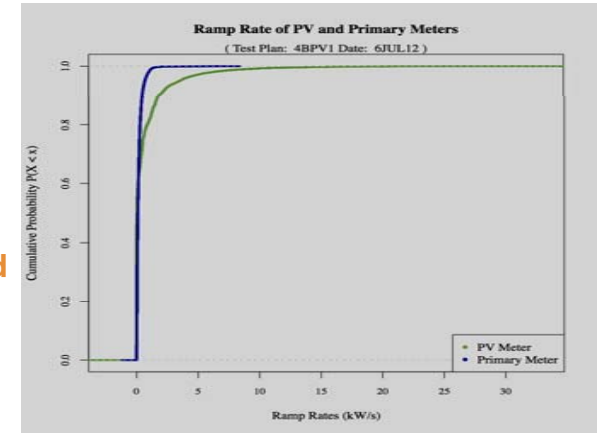
Many Types of Models Developed to Support Project



Grid Models (OpenDSS, GridLAB-D™) Built and calibrated to system meter data



Ramp Rate Statistical Analysis - Numerical Methods and Filters Established



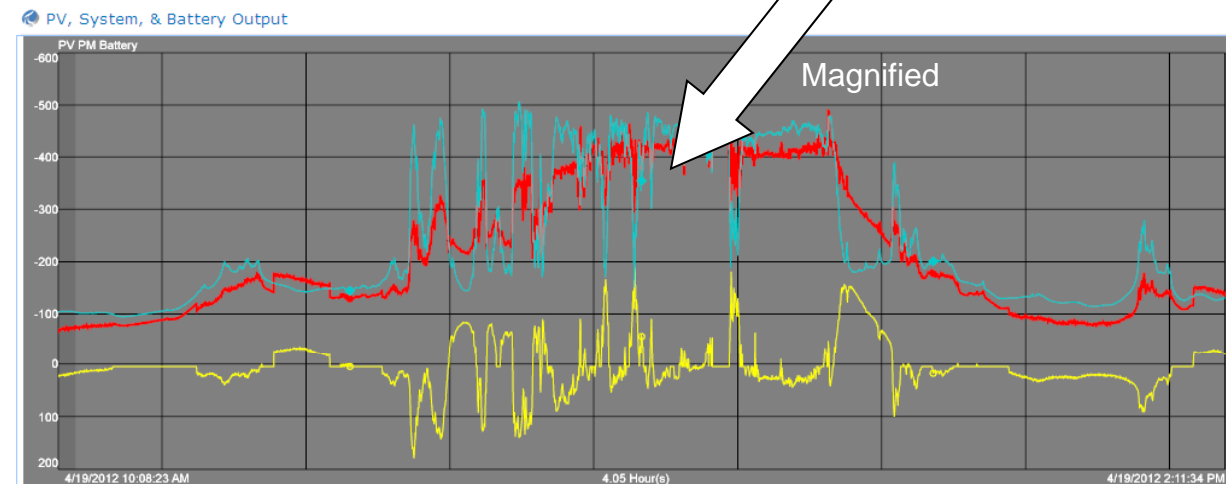
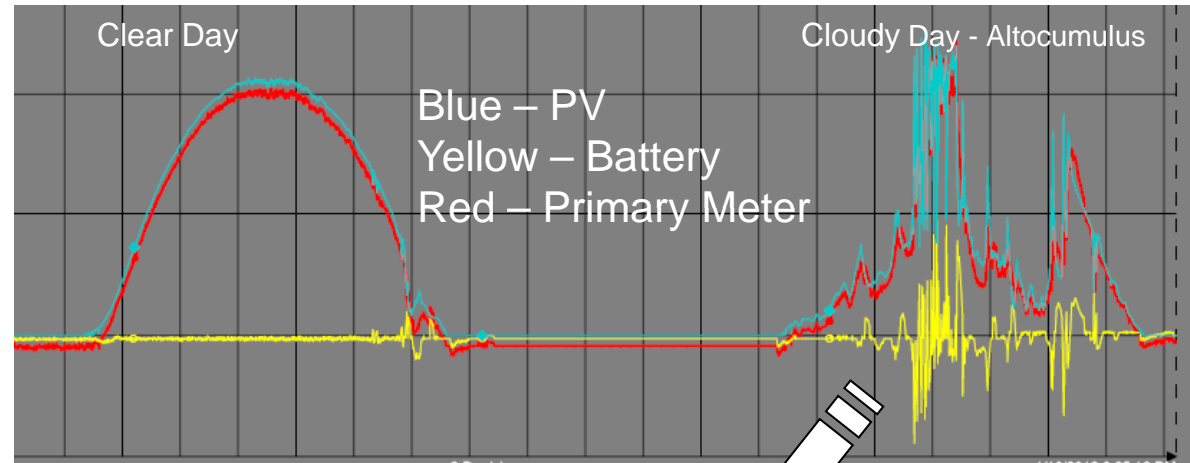
Shifting operation - MATLAB models - refined in VB and transitioned to PI ACE

NWS Cloud Cover Prediction analyzed vs actual irradiance

Smoothing Results

Test Plan 1

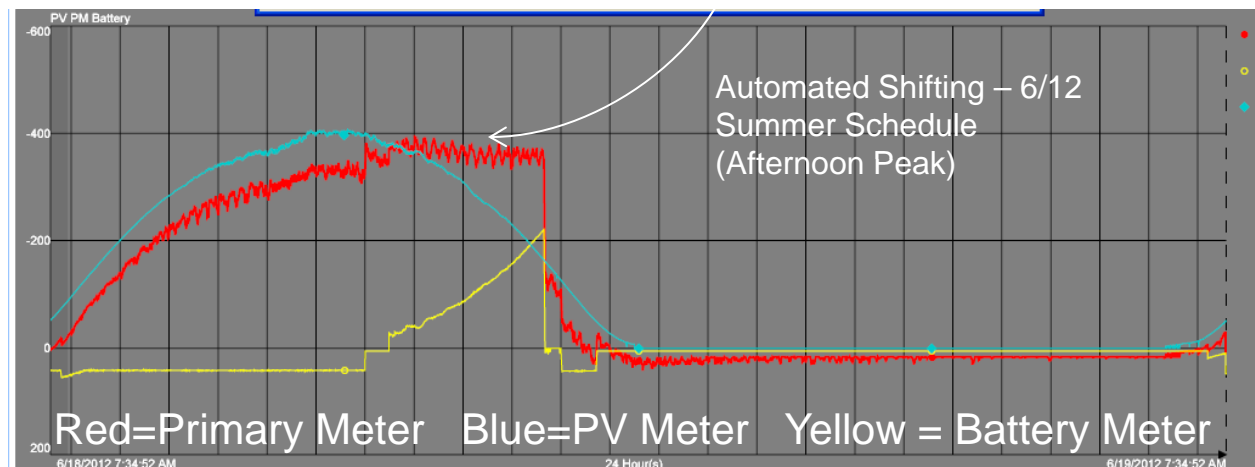
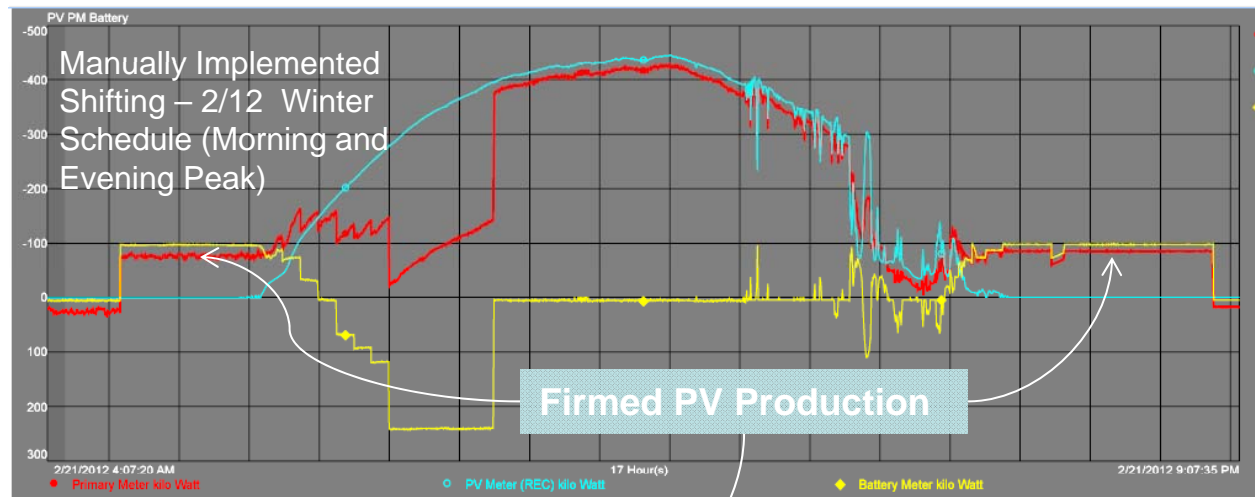
- Variety of control inputs
- Variety of gains on input – tests different capacities of battery use
- Question is: how much smoothing is enough?



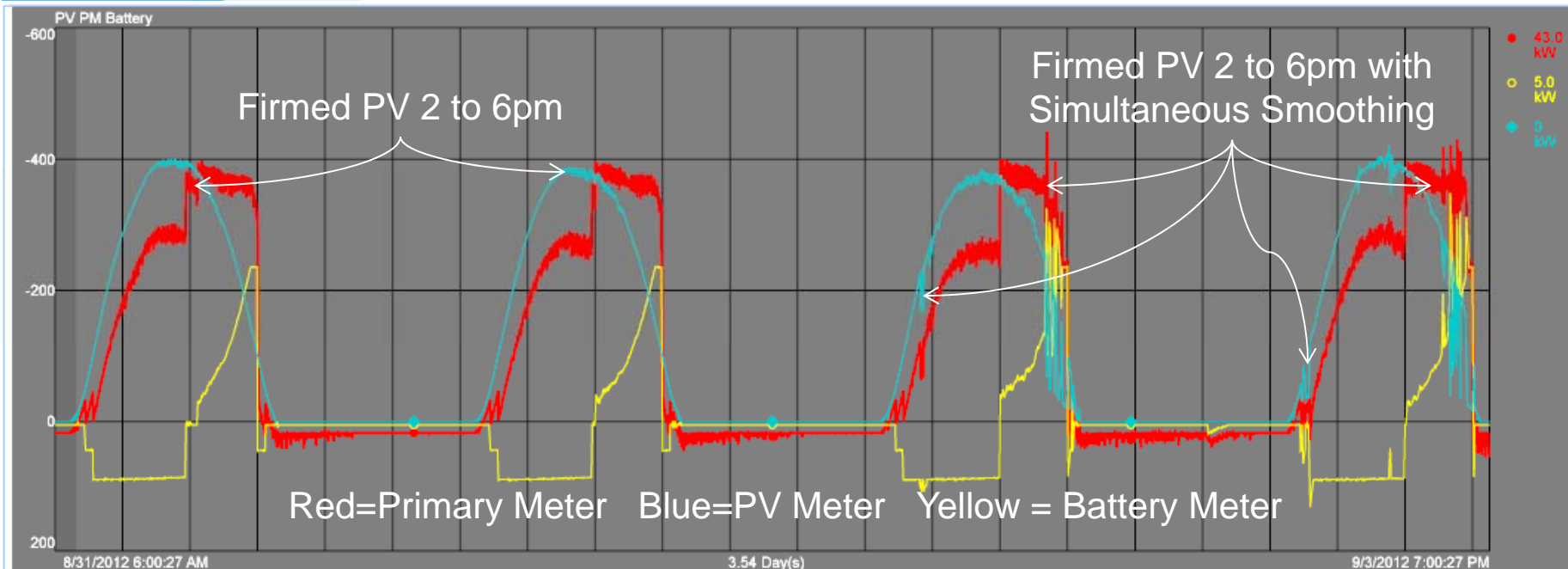
Shifting Results

Test Plan 2

- Advancing Automation and Sophistication
- Automated cloud forecast retrieval
- Automated PV energy calculation
- Algorithm will get more and more complex



Simultaneous Smoothing and Shifting Results



Both storage systems interact well – some tuning remaining on the Smoothing side to optimize spiking during cloudy periods

Key Findings

- **Dead Band Implemented in Shifting Algorithm**
 - Eliminated spikes induced by algorithm looking at SoC too quickly
- **Firming with Clouds - Simultaneous Smoothing and Shifting**
 - Tuning needed on smoothing to prevent spikes during shifting discharge
- **Ramp Rate Analysis - HVAC Noise Filtering Need**
 - May be impacting ramp rate statistical analysis - HVAC meter signal available if needed to be introduced to smoothing algorithm
- **Ramp Rates Definition and Mitigation Analysis**
 - No clear definition (until now) on how to treat non uniform time stamped data - on line real time Savitsky Golay filter will be utilized
- **Smoothing Adequacy – How much is enough?**
 - Optimization analysis will be needed to determine best amount of smoothing vis-a-vis status quo solutions (i.e., what are we preventing and what's the lowest cost way to prevent it?)

Key Findings

- **Lack of Correlation with Current Forecast Used for Shifting**
 - % cloud cover prediction doesn't work well on cloudy days No surprise as % cloud cover is not tuned to PV, may try forward forecasts or persistence forecasting
- **Need for Hour Ahead PV forecasts**
 - Required for forward forecasting/smoothing – may come through parallel efforts – could incorporate a simple smart camera – key to forward moving average approach
- **Need for Day or 2 Day Ahead Accurate Cloud Forecast**
 - Required for optimized shifting – may come through parallel efforts
- **PV Meter vs Irradiance Sensor**
 - Irradiance sensor can mislead smoothing batteries because of no upper limit – PV meter is upward bounded by inverter size – also MPPT is ignored.
- **Latency Issues in Smoothing response – 3 computers involved that have to react sub second - pretty much solved**
- **Sensitivity of PV System - Ramp Rates Measured**
 - 500kW PolySi Field is extremely sensitive – ramp of 135kW/sec measured

Next Steps - Continue Test Plans Implementation

- **Algorithm Development**

- Smoothing–will continue to test various inputs and filters throughout test period
 - Forward Moving Average (with forecast)
 - Low Pass Filter instead of Moving Average
 - Adding other external signals (adjacent PV farm, PNM ACE)
- Shifting – data structure assembled to align next day forecast with historical load/price history
 - Adding price forecast (ICE – Palo Verde) combined with hourly price shaping model
 - Peak Shaving to commence when SCADA signal import is completed to PI

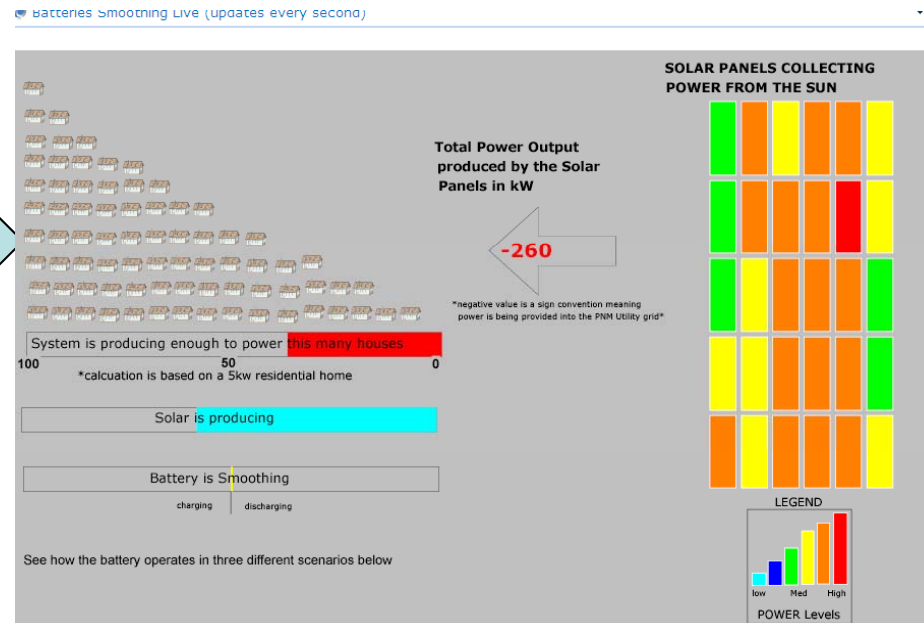
- **First of five test plans being initiated**

- Smoothing – Oct through Dec 2013
- Peak Shaving – winter and summer peaking period 2012-2013
- Firming – summer 2012 on going
- Arbitrage – Shoulder periods throughout test period
- All of the above – summer 2013

PNM Prosperity Energy Storage Online



- Real Time Data Presentation
- Project Description
- Publications/Press
- Education & Outreach Focus – being embedded in College Curriculum at UNM and NNMC as well as local high schools



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