Optimized Integration of PV with Battery Storage: A Real World Success Story

AUGUST 2016

Jon Hawkins
Manager, Advanced Technology and Strategy
PNM PROSPERITY ENERGY STORAGE

Project Description

• First of 16 DOE Smart Grid Storage Demonstration Projects to go on line – Sept 2011
• Designed to both smooth PV intermittency and shift PV energy for on-peak delivery
• Successfully demonstrating Storage/PV integration to Utility operations

Equipment

• 500 kW PV (fixed C-Si panels) – not DOE funded
• Ecoult/East Penn - Advanced Lead Acid Battery system for “shifting” – 1MWh
• Ecoult/East Penn - “Ultra” Battery system for “smoothing - 500kW

Cyber Secure, High Resolution Data Acquisition and Control System 1 second and 30 samples per second data capture
PROJECT GOALS

- Demonstrate simultaneous mitigation of voltage-level fluctuations and enable energy shifting
- Combine PV and storage at a substation targeting 15% peak-load reduction
- Create a dispatchable, renewables-based peaking resource
- Develop power system models (baseline and projected), and cost/benefit economic models
- Generate, collect, analyze and share resultant data – Strong public outreach
- Successfully demonstrate PV and storage integration into utility operations
REGULATION - PV SMOOTHING DEMONSTRATION

4/17-4/19/12
2 Clear Days & 1 Cloudy Day

4/19/12
Cloudy Day

4/19/12
4 Hour Window

4/19/12
15 Minute Window

Key:
- Yellow = Battery Output
- Red = System Output
- Blue = PV Output
SMOOTHING ALGORITHM IMPLEMENTATION

- Developed by Sandia National Laboratories, Implemented by Ecoult
  - Baseline algorithm to respond to the changes in solar output.
- Dynamic
  - Ability to optimize with different control source inputs.
  - Ability to be tuned by changing input parameter and gains within the equation
- Allowed investigation of optimization PV smoothing with energy storage
- Question: How much smoothing is enough?
FEEDER MODELING AND ANALYSIS

- Used to do analysis on feeders involved to determine effects from PV
- Supported analysis of the amount of regulation provided by substation tap changers (number of tap changes) under various conditions
  - Clear vs. Cloudy days
  - Central utility storage and customer sited
- Model was compared with some field testing. Showed some benefits to reduce number of tap changes, although did not match the model well.
ENERGY SHIFTING/DISPATCHING STORED ENERGY
Internal Optimization Required

- Prioritization of Applications
- Reliability is top Priority - Peak Shaving
- Further Optimization Determines value of Firming vs Peak Shaving vs Arbitrage
- Life of battery and energy throughput also a consideration

Peak Shaving – Achieved 15%

Firm dispatch – with weather prediction

Price arbitrage using CAISO pricing
MULTIPLE APPLICATION DEMONSTRATION

Charge due to RT price
Emergency Peak Shaving
Charge due to State of Charge
Winter Evening Firming
SIMULTANEOUS REGULATION AND DISPATCH

Simultaneous PV Shifting and Smoothing - 01/14/2013

Entire day of cloudy PV production needed to charge battery for evening peak Firming

Key:
- Blue = PV Output
- Yellow = Battery Output
- Red = System Output
Utilizing set thresholds
System optimizes functionality based on priorities to perform:

- Emergency peak shaving
- Peak shaving
- Arbitrage (wind and PV)
- PV Firming
- All while simultaneously smoothing PV and optimizing for battery life

NWS Next day Weather Forecast
% Cloud Cover
Temperature

228 Available Points from Prosperity site
Met Data
System Data
Meter Data

SCADA Data – Currently Monitoring 3 Feeders ~ 6 sec poll rate

Market Pricing
Currently using CAISO
Real time price (SP15)
LMP Forecast price (SP15)
COST/BENEFIT ECONOMIC MODELS

- Modeled both in EPRI’s Energy Storage Valuation Tool (ESVT) and a cross check was done with the DOE Energy Storage Computational Tool (ESCT)
- Modeled peak shaving, arbitrage, and firming both individually and in combination.
- Smoothing was modeled separately and added
- PV Smoothing provided only nominal benefits
- Energy applications showed approximately a $625k benefit stream
- Break even analysis showed that capital cost would have to drop to approximately $450k to get a cost benefit of 1.
Approximately 1.7 miles between projects “as the crow flies"

Approximately 2.5 circuit miles

1.7 miles
COORDINATED, DISTRIBUTED PV SMOOTHING

BEMS calculates the genset setpoint to achieve PV smoothing.

BESS calculates the battery setpoint to achieve PV smoothing incorporating $P_{GE}$.
INTEGRATION WITH AREA “SMART GRID” SYSTEMS

• Objective: Reduce battery operation in PV-smoothing systems by novel control schemes.

• Smoothing PV power with a coordinated battery and gas genset reduces the required battery capacity and increases battery life, HOWEVER not by as much as predicted in modeling.

Research Partners:

Special Thanks: Abraham Ellis¹,
Atsushi Denda², Kimio Morino²,
Jon Hawkins³, Brian Arellano³,
Takao Ogata⁴, Takao Shinji⁴, and Masayuki Tadokoro⁴

¹Sandia National Laboratories
²Shimizu Corporation
³Public Service Company of New Mexico (PNM)
⁴Tokyo Gas Co., Ltd.

Acknowledgment of support to Dr. Imre Gyuk, Electricity Storage Program Manager, DOE Office of Electricity

Slide adapted from content provided by: Jay Johnson, Sandia National Laboratory
OUTREACH AND REPORTING

- Over 25 publications (IEEE, World Renewable Energy Forum, ASES, EESAT, Sandia Reports, EPRI Reports)

- Over 30 presentations in various forums (Distributech, IEEE, EPRI, DOE, ESA, local outreach, others) including 40+ site tours

- DOE Technical Progress Reports

- Android app developed for access to the Project website – available on GooglePlay:

- DOE/EPRI Energy Storage Handbook, featuring the Prosperity Project and a variety of input from PNM:

- Coordination of Utility Scale Storage and microgrid documented in Sandia Report
GOALS

- Demonstrate simultaneous mitigation of voltage-level fluctuations and enable energy shifting
- Combine PV and storage at a substation targeting 15% peak-load reduction
- Create a dispatchable, renewables-based peaking resource
- Develop power system models (baseline and projected), and cost/benefit economic models
- Generate, collect, analyze and share resultant data — Strong public outreach
- Successfully demonstrate PV and storage integration into utility operations

- Investigation and optimization of regulating PV output with various inputs, approaches, and intensity
- Optimization of energy dispatch with weather prediction
- Demonstrate Energy Arbitrage
- Integration and coordination with local intelligent resources
Thank you