Public Service Co. of New Mexico
Batteries & Energy Storage: Values for Electric Utilities

IEEE/PES LUNCHEON AND DISCUSSION

Santa Fe, NM
June 25th, 2019
Public Service Co. of New Mexico (PNM)

- Only NYSE traded company headquartered in NM
- 1,500 employees
- Serving 525,000 customers (40 communities)
- 15,000 miles of transmission and distribution line
- 2,700 MW generation capacity
- Top quartile for affordability in the west and reliability in the nation.
- Top companies in the nation for diversity
BATTERY SERVICE ATTRIBUTES FOR ELECTRIC UTILITY APPLICATIONS

- Grid Regulation
  - Frequency
  - Voltage
- Energy Price Arbitrage
- Peak load capacity contribution
- Operating Reserves
  - Spinning
  - Contingent
- Quick start
- Black start
- Transmission & distribution investment deferral
FACTORS COMPELLING PNM TO EXAMINE ENERGY STORAGE

- Anticipated shutdown of San Juan Generating Station; coal plant and mine in NW New Mexico
  - Scheduled close June 2022;
  - 1,700 MW prior to 2018; PNM owns 562 MW

- Energy Transition Act; 2019 legislation
  - Dramatically increases renewable energy requirements for NM utilities
  - Carbon emissions to be eliminated for NM electricity production by 2045
BATTERY PRICE CURVE FORECAST

FIGURE 11
Battery Cost Trajectory

$ / kWh

Source: BNEF, Barclays Research
PNM WAS AN EARLY INVESTIGATOR OF PV WITH STORAGE

Project Description

• DOE Smart Grid Storage Demonstration Project – Sept 2011
• Designed to shape PV output both by smoothing PV intermittency as well as shift PV energy for various applications

Equipment

• 500 kW PV (fixed C-Si panels)
• Ecoult/East Penn - Advanced Lead Acid Battery system for “shifting” – 1MWh
• Ecoult/East Penn - “Ultra” Battery system for “smoothing - 500kW
Utilizing set thresholds, the 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

Other data certainly will be needed.
## RENEWABLE/CARBON FREE PENETRATION RATES

<table>
<thead>
<tr>
<th>Year</th>
<th>RPS Target</th>
<th>Total Renewables</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>15%</td>
<td>13%</td>
<td>Old rules with exceptions</td>
</tr>
<tr>
<td>2020</td>
<td>20%</td>
<td>16%</td>
<td>Old rules with exceptions</td>
</tr>
<tr>
<td>2020</td>
<td>20%</td>
<td>20%</td>
<td>ETA rules</td>
</tr>
<tr>
<td>2025</td>
<td>40%</td>
<td>40%</td>
<td>ETA rules</td>
</tr>
<tr>
<td>2030</td>
<td>50%</td>
<td>50%</td>
<td>ETA rules</td>
</tr>
<tr>
<td>2040</td>
<td>80%</td>
<td>80%</td>
<td>Allowance for Palo Verde</td>
</tr>
<tr>
<td>2045</td>
<td>Carbon Free</td>
<td>Carbon Free</td>
<td></td>
</tr>
</tbody>
</table>
MANY FACTORS INFLUENCE PROVIDING POWER

• The utility must have adequate resources to meet the power demands of its customers
  • Adequate defined by regulators based on probabilistic loads and probabilistic supply
  • In stress, we can call on support from the grid, but we must also be prepared to support our neighbors
• We must meet the peak load and have a plan to meet future peak with resource additions
• We must be able to follow the swings in load; not falling short or oversupplying
DEFINING CHARACTERISTICS OF LOAD FOR PLANNING

- Annual peak demand
- Daily 24-hour (diurnal) load pattern
- Total energy demand
- Short-term variation
- Uncertainty of future demands (short term and long term)
PNM PEAK SUMMER DAY - DEMAND CURVE - 2008 VS 2018
PNM PEAK WINTER DAY - DEMAND CURVE - 2008 VS 2018
WEEKLY CHARACTERISTICS OF RENEWABLE RESOURCES

![Graph showing weekly characteristics of renewable resources with data points for Palo Verde, Wind, and Solar.]
SUMMER & SPRING DAYS: LOADS AND MUST TAKE RESOURCES

![Graph showing the variation of loads and must take resources over the course of a day with different energy sources like wind, solar, and load data from March 2017 and July 2018.](image)
The best solar production occurs ~ 2 to 8 hours prior to:
when the most power is needed on the system
NEED FOR FLEXIBILITY

Growing need for flexibility starting 2015
IMPACT of INCREASING SOLAR PENETRATION ON PEAK SHIFTING

Figure 3. Load and net load profiles for California under increased penetration of PV for three representative days of peak demand in the summer

CHALLENGES FOR RELIANCE ON WIND ENERGY

- Seasonal energy issues
  - 2018 NMWEC energy in April = 56,866 MWh
  - 2018 NMWEC energy in July = 16,027 MWh
- Peak load versus wind capacity availability
  - NM’s hottest days are summertime high pressure system weather patterns
  - Wind is often nearly still at those times
- Ramping of production levels
  - Change in output levels can be rapid; up and down with passing of weather fronts, local wind patterns
  - Just like load following, we need to be able to follow these changes
UTILITY ELECTRICAL SYSTEM REQUIREMENTS

Balancing Authority/Reliability Requirements

- Capacity
- Reserves
  - Operating Reserves
  - Spinning Reserves
- Load Following Capability
- Voltage Support
- Frequency Control
DIMINISHING RETURNS

• The more batteries we have installed on our system, the less valuable the next battery will be.
• The first tier of battery capacity installed captures most regulation opportunities.
• As more battery capacity shaves our peak load, pond size/duration raises the cost of further shaving.
• Other applications face similar diminishing returns.

• But also, the more inflexible generation we have, the more valuable batteries become.
FIGURE 37
Cost of Utility-Scale Solar versus Residential Solar – NREL

2017 USD per Watt DC

Source: NREL, Barclays Research
BATTERY PRICE CURVE FORECAST

Source: BNEF, Barclays Research
NATURAL GAS COSTS DECLINE DUE TO FRACKING

PNM's Average Annual Cost of Natural Gas
PEAK CAPACITY CONTRIBUTION; DURATION CHALLENGE

Credit: Fluence, National Renewable Energy Laboratory
HOW DOES IT COMPARE – STORAGE VS. COMBUSTION TURBINE (FLEXIBILITY)

50 MW Storage Unit

Flexible operating range of 40 MW

50 MW Gas Peaker

50 MW

Flexible operating range of 100 MW

30 MW Set point

10 MW Min Output
## HOW DOES IT COMPARE – STORAGE VS. COMBUSTION TURBINE

<table>
<thead>
<tr>
<th>Energy Storage</th>
<th>Combustion Turbine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours at rated capacity: 4 to 6 hours typical (round trip efficiency ~ 85%-90%)</td>
<td>Hours at rated capacity: 24 (CPP limitations may apply)</td>
</tr>
<tr>
<td>Fuel cost - off peak power prices approximately ~ $20 /MWh</td>
<td>30.00 $/MWh</td>
</tr>
<tr>
<td>Startup time – nearly instantaneous</td>
<td>Startup time ~ 10 minutes</td>
</tr>
<tr>
<td>Full up/down ramp in a second or less</td>
<td>~15 to 50 MW/min</td>
</tr>
<tr>
<td>Control Center Integration – not well defined yet</td>
<td>Control Center Integration – Generation and Energy Management Systems well known</td>
</tr>
<tr>
<td>Capital cost battery storage (Li Ion) ~ $3000/kW</td>
<td>Capital cost ~ 1000 $/kW</td>
</tr>
<tr>
<td>OpEX – today is still pretty unknown and will mature based early project experience</td>
<td>OpEX ~ 29 $/kWyr</td>
</tr>
</tbody>
</table>
VALUE OF STORAGE

• While stacking the monetary benefits is illustrative, it is very difficult to do in practice. Once the battery is used for one application, the state of charge remaining would determine if it can perform others and for how long before needing a charge again.

• Value of each application can vary depending location:
  • Assembling benefits may be easier in a vertically integrated utility (e.g. in NM may be more easily deployed and valued)
  • Some markets we don’t even know who can own it (e.g. TX)
  • Some markets it is difficult to access (e.g. premium product in PJM)