Valuing Storage in RPM

Planning Committee
July 2, 2014
Our Members:
Energy Storage

- **Duration**: variety of technologies operate wide range of hours
  - Energy storage is not a fixed duration resource
  - Storage best characterized by energy (MWh), not power (MW) or time
  - Most storage technologies can deliver their rated MWh over time periods from less than an hour to many hours or days

- **Dispatchable**: 24/7 365 days per year
  - Field experience confirms 24/7/365 operation

- **Dedicated**: grid-connected resources fully under PJM control

- **Improve Utilization**: Ability to optimize efficiency of the grid
  - Value to PJM planning, operations, and markets
Capacity Value of Energy Storage

- Storage should earn an RPM capacity that reflects its contribution to reliability.
- The tariff does not have a general definition of capacity.
- Our working definition is:

  One MW of UCAP allows the addition of $\frac{1}{1+IRM}$MW of peak load with no increase in LOLE.

- This presentation suggests a quantitative approach to valuing storage, grounded in reliability benefits.
Peaky Loads Cause Utilization Issues for Electric Systems

- Not just generation, but the entire T&D delivery system
- Storage could shift load from off-peak to on-peak load periods to avoid additional peak generation and T&D delivery system

Approximately 1/3 of capacity rarely used
Energy Storage Can Help

- Not just generation, but the entire T&D delivery system
- Storage could shift load from off-peak to on-peak load periods to avoid additional peak generation and T&D delivery system

Required Peak Generation and T&D capacity

Less Peak Capacity Required…

With a Higher Utilization.

This is a High Value Service for Storage.
Cost-effective Peak Capacity

Storage has the unique ability to provide peak power using lower cost off-peak power.
Applying to PJM Planning Analysis

- Goal is to determine increase in load carrying capacity of PJM system with addition of storage.
- Should be consistent with other PJM planning procedures
- Approach:
  - 7 years of hourly load data was obtained from PJM website.
  - To account for growth of PJM, years prior to DY2013 scaled up so each year’s annual average load equal to average load in DY2013.
  - Assume addition of 10,000MWh of storage.
  - Storage was modeled with simple “charge during valleys, discharge during peaks” strategy.
Value on Summer Days

Required Generation (000 MW)

Benefit of 10GWh storage (MW)

<table>
<thead>
<tr>
<th></th>
<th>Best 10% of days</th>
<th>Avg.</th>
<th>90% of days</th>
</tr>
</thead>
<tbody>
<tr>
<td>MW Peak Load Served</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CP20 Days</td>
<td>3,996</td>
<td>3,509</td>
<td>&gt;3,015</td>
</tr>
<tr>
<td>Summer Weekdays</td>
<td>4,112</td>
<td>3,399</td>
<td>&gt;2,477</td>
</tr>
</tbody>
</table>

Legend:
- Storage CP20 Days
- CP20 Days
- Storage Summer Weekdays
- Summer Weekdays
Fixed Duration Reduces Benefits

- Requiring set output durations is equivalent to lowering maximum output

- Reduces the load carrying benefits
- Shifts capacity from when needed to when it's not
- For maximum benefit, storage often needs to be able to deliver 25% or more of its total energy during the peak hour of the day.
- A resource rated for high power can reduce output if needed, but the reverse is not true
- Developers will build to market requirements.
- If power is limited to 1/6\textsuperscript{th} of energy, storage loses more than half its load carrying value. If power is limited to 1/10\textsuperscript{th} of energy, only one quarter of load carrying value remains.
Reliability on Non-Peak Days
Reliability on Non-Peak Days

- Meeting peak loads is only one aspect of reliability
- Recent risky days seem to not have been on system peak days
- Over the last 7 years, there have been 54 emergency days
  - Defined as any day with Load Management, Max Emergency Gen, Primary Reserve Alert, Voltage Reduction Alert, Voltage Reduction, Load Dump Warning, or Load Dump Action.
  - 59% of these days were in the CP20 for their year
  - Almost half of emergency days were not in the top 20 high load days of their year
  - Almost a quarter of emergency days were not in the top 50 high load days of their year
  - Storage has many unique benefits that go far beyond meeting peaks
## Benefits of Storage

<table>
<thead>
<tr>
<th>Discharging</th>
<th>Charging</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Ability to rapidly and accurately follow dispatch instructions</td>
<td>• Extends ramp periods</td>
</tr>
<tr>
<td>• Peak shaving, with lower cost energy</td>
<td>• Allows earlier unit start up</td>
</tr>
<tr>
<td>• Reduce thermal unit start/stop costs because the use of “peakers” is reduced</td>
<td>• Allows units with minimum outputs to be run earlier or longer without uplift</td>
</tr>
<tr>
<td>• Granular dispatch - On “high flat peak” days, overcomes the peak shifting and other limits of block-loaded DR</td>
<td>• Absorbs excess interchange</td>
</tr>
<tr>
<td>• Perfect compensation for start failures, unit trips, and other contingencies without calling reserves</td>
<td>• Makes use of otherwise wasted value of block-loaded DR</td>
</tr>
<tr>
<td>• Reacts to import recalls and other issues of external capacity resources and interchange</td>
<td>• Obvious value during Min Gen events</td>
</tr>
<tr>
<td>• Nodal – Can relieve transmission constraints on hot days unlike DR</td>
<td>• Controls voltage excursions after transmission contingencies</td>
</tr>
<tr>
<td>• Moving energy to where it is needed is recognized as having capacity value (e.g, QTUs).</td>
<td>• Reduces costs associated with “must run” minimum generation from thermal units because storage is withdrawing energy during off-peak</td>
</tr>
<tr>
<td></td>
<td>• Reduces renewable energy curtailments or negative pricing because storage is withdrawing energy during off-peak</td>
</tr>
</tbody>
</table>
Energy storage brought online primarily to meet capacity requirements is able to provide value across all hours of the year, unlike new gas-fired peakers which are used in relatively few hours.
Winter Reliability Benefits

• Available in Winter, unlike Limited products

• Allows “early start up” of thermal plants in early morning hours without uplift
  – Annual DR not available until 10 am

• Quickly fill in stack for resources tripping off or failing to start

• Ability to supply during 2 critical peaks
  – Jan/Feb: HE 8-9, HE 19-20

• Potential to absorb wind overnight
  – Avoid Min Gen Issues
Cold Weather: Jan 6, 2014

- Mid-day lull used to get head start on afternoon ramp
- Supply during evening peak
- Supply during morning peak
- Storage provides reserves while charging
- 20 hours+
- Morning ramp extended from 3 to 7 hours – Allows Early Start-up
- 775 MW Shared Reserves
- Voltage Reduction
- 800 MW Shared Reserves

Graph showing required generation (000 MW) and ramp rate (000 MW/hour) for different hours of the day.
Typical Winter Day (Average Jan 21 – 30, 2014)
Hot Weather: ATSI Sept. 11, 2013

Charge by ramping 15 minutes early. This creates ~300MW of reserves for 5.75 hours.

Storage follows load and DR to manage peak. Combined benefit more than the sum of the parts.

Scenario has 850MWh of storage in ATSI.

Peak Reduction
- DR alone: 281MW
- Storage alone: 386MW
- Together: 722MW

13 hours+
Capacity of Value of Storage
### Storage: Comparison to other Resources

<table>
<thead>
<tr>
<th>Storage</th>
<th>Generation</th>
<th>DR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nodally dispatched</td>
<td>Nodally dispatched</td>
<td>At unknown nodes</td>
</tr>
<tr>
<td>24 hour resource with operational parameters •Charge time/rate managed by PJM</td>
<td>24 hour resource with operational parameters •Minimum run time, minimum down time, max starts per day</td>
<td>6 or 10 hour resource Limited calls, times of year and/or times of day</td>
</tr>
<tr>
<td>Must offer requirement</td>
<td>Must offer requirement</td>
<td>None</td>
</tr>
<tr>
<td>Individually dispatched, flexibility throughout entire range, with high accuracy</td>
<td>Individually dispatched, with Pmin and Pmax, ramp times</td>
<td>Dispatched in large, inflexible blocks</td>
</tr>
<tr>
<td>No notification time, “instantaneous”</td>
<td>Start up time varies</td>
<td>30-minute notification (up to 2 hours today)</td>
</tr>
<tr>
<td>Annual – available summer and winter, No fuel risk, No emissions issues</td>
<td>Annual – but fuel availability risk in winter, emissions limitations</td>
<td>Limited – only summer Annual – summer and winter</td>
</tr>
</tbody>
</table>

**Storage resembles Highly Flexible Generation not Limited or even Annual DR**
California ISO Proposed Storage rules

• “Given the flexibility of many energy storage technologies and the high degree of availability the ISO expects of these resources, the ISO does not need to apply a minimum number of hours a non-generator resource must be available.”

• ISO has not identified any limitation that would preclude storage from being available comparable to conventional thermal resources

• ISO can optimize the dispatch through both the charge and discharge

• Storage that is fully discharged (charged) because of ISO dispatch instructions is available to the ISO but has hit an operational constraint

• No operational or environmental limits appear to justify the ISO classifying a non-generator resource as a use-limited resource

CAISO, Reliability Services Straw Proposal, June 5, 2014
California ISO Proposed Storage rules

The ISO is proposing default qualifying capacity provisions for non-generator resources:

- Default qualifying capacity calculation based on the resource’s discharge capability
- The ISO will provide two different default qualifying capacity provisions:
  - Regulation energy management (REM)
    - Based on their ability to provide energy for 15 minutes
  - Energy and regulation
    - Based on the amount of output the resource can sustain over a four-hour period
- Cannot choose the REM for the default qualifying capacity provisions and the energy option for EFC or vice versa
- Must be a participating generator or a system resource
  - Requires the resource be at least 0.5 MW
Proposed RPM Storage rules

- **Treat as Generation**
  - Similar to pumped hydro storage
  - Clears with other annual resources with no restrictions
  - No change in RPM auction clearing mechanisms
  - Interconnection, metering, and telemetry requirements same as generators

- **Energy Market: 24/7/365 Must Offer**
  - As other Generation Capacity Resources: must submit offer data into the Day-ahead Market and may elect either to Self-Schedule or offer the resource to PJM for scheduling as a PJM RTO-Scheduled Resource. (M11)
  - Offer parameters may include charge rate/time (e.g. pumped hydro)
  - Energy scheduling and dispatch must respect charge state and limits
  - Available 24/7/365 subject to normal forced/planned outages
Determining UCAP Value

• Very few resource types have their UCAP reduced due to parameter limitations.
• Only example suggests UCAP could be set so the resource is parameter limited on no more than 10% of CP20 days.
• Results:
  - On the 140 CP20 days in our sample, 10,000MWh of storage met between 2,791MW and 5,499MW of peak load.
  - On 90% of those days (126 days), the 10,000 MWh storage met 3,015MW or more of peak load.

This suggests 3.3MWh of storage has the equivalent load serving capability of 1MW$_{UCAP}$ of generation.
Proposed RPM Storage rules

Capacity Valuation

- UCAP determined by Nameplate Energy Rating/3.3 * (1-EFORd)
- UCAP also limited to maximum output * (1-EFORd)
  - Example: 3 MW/10 MWh storage resource with 5% EFORd:
    10MWh/3.3 * (1-.05) = 2.88 MW
  - Minimum UCAP 100kW, as other RPM resources.

*Results in storage sized in both power and energy rating to meet peak requirements*
Proposed RPM Storage rules

- **Performance Measurement**
  - All EFORd and EFORp rules apply
  - Annual tests to demonstrate both power and energy
  - Out of charge is not a forced outage, unless due to failure to follow dispatch
- **Annual & initial test to determine capacity value**
- **Must offer requirement in RPM auctions as other generation**
- **Ability to include ACR & EAS offset (per normal generation offers in capacity market)**
  - EAS determined by MMU
  - ACR entered by market participant, including normal maintenance to maintain nameplate capacity value.
  - ACR – EAS offset = Capacity market offer