Order 841: Electric Storage Participation Model
DA and RT Example for ESRs

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• November, 2016: FERC Notice of Proposed Rulemaking on Energy Storage and Distributed Energy Resources.

• February, 2018: FERC final rule on storage …


Purpose of this presentation is to show an example of how a resource in the ESR Model *could* operate in Day Ahead and Real-Time Energy Markets.

PJM does not recommend or inform how units should be offered into markets, there are multiple ways that an ESR owner could offer and operate.
• Simplified Assumptions for example:
  – 10 MW, 10MWh battery
  – Perfectly efficient electric storage resource (100%)
  – Min/Max state of charge being self-managed by Max Charge/Discharge MW = 9MW
  – DA and RT LMP from 10/10/2018
  – No Make Whole or Lost Opportunity Cost
  – No Ancillary Services
ESR Market Based Offer Curve

ESR Example Market Based Offer Curve

<table>
<thead>
<tr>
<th>MW</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>-10</td>
<td>$15.00</td>
</tr>
<tr>
<td>-5</td>
<td>$21.00</td>
</tr>
<tr>
<td>0</td>
<td>$55.00</td>
</tr>
<tr>
<td>5</td>
<td>$65.00</td>
</tr>
<tr>
<td>10</td>
<td>$120.00</td>
</tr>
</tbody>
</table>
• Unit is Self-Scheduling in DA with Maximum Charge/Discharge at 1MW
• Unit is charging from HE3 –HE5 discharging from HE14- HE20
• Day Ahead Revenue (MW*DA LMP) = $372.61
Day Ahead Scheduling – Other Options

- Unavailable
- Self-Schedule in Charge and/or Discharge with or without a dispatchable range mode
- Self Schedule with a dispatchable range
- With a dispatchable range an ESR:
  - Could receive a DA schedule that cannot be followed in real-time
  - Could receive a DA schedule that does not maximize revenues
  - Could update offer per intra-day offer rules
Real-Time Operations

- Real-Time Dispatch based on Bid Curve
- Blue Circle shows area where unit would run out of charge and resource will need to manage via MG updates
- Balancing Credits (RTMW-DAMW)
  *RTLMP = $502.55
• When ESR energy manager sees resource approaching max SoC they are controlling to they have the opportunity to update parameters in MG to not get an infeasible RT dispatch
  – Blue dotted line is where PJM would have dispatched the unit absent MG update. Green line is where PJM would dispatch the unit with MG update
Real-Time Operations – Other Options

- Operate in charge and/or discharge mode
- Change bid curve (decrease costs) to operate in additional hours
  - Must opt-in for Intra-day offers
- Self-Schedule non dispatchable to better control charge/discharge or block load unit
- Continually update maximum and minimum limits
Example Settlements

- Day Ahead Revenue = $372.61
- Balancing Credits = $502.55
- **Net Daily Energy Revenue = $875.16**

- Could have additional deviation charges for not following dispatch
- Could have additional revenue for ancillary services
Questions or Feedback?

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