CAISO Contingency Modeling Alternative:
Regional Flexibility Markets

March 2014
Southern California Edison
Outline

- Concerns with the CAISO’s N-1-1 proposal
- Alternative approach: Regional Flexibility Markets
  - Concept
  - Key considerations
  - Formulation
  - Payment structure
  - Illustrative examples
Concerns with CAISO’s N-1-1 Proposal

- The CAISO proposal may ultimately be the best approach, however

- Proposal is complex and results in largely incomprehensible/inexplicable price formation
  - Introduces a nodal capacity product and impacts energy LMPs based on the cost of temporal restoration
  - No other ISO’s have a nodal capacity payment; now the CAISO wants two nodal capacity products (RUC and SOL-1 relief)

- No real-world demonstration of its merit/viability
  - Market power mitigation not addressed

- False precision: Relies on a host of assumptions in the DA market that will not materialize in real-time; thus DA “solution” may not solve the problems real-time
  - Too much uncertainty between DA and RT to attempt a single “optimal” solution in DA
  - Improper treatment of Virtual bids in the solution
  - Improper treatment of transmission emergency limits available for true N-1-1 restoration

- Cost: Spend money in DA with no guarantee that it works in real-time. Uses the DA market to “address” transmission problems that only require resolution in real-time

- Potential under-utilization of Transmission

- Unreasonably excludes Flexi-ramp and Regulation as part of the solution
  - Improper treatment of RA resources

- Given concerns, it is appropriate to explore alternatives
Regional Flexibility Markets: Concept

- Flexibility regions can be created to address regional and sub-regional capacity needs including Ancillary Services, flexi-ramp and N-1 SOL capacity
  - The CAISO does offline studies to determine regional flexibility needs

For each AS region:
AS Capacity >= AS Req.

For CAISO System:
Flexi-Ramp Award >= FlexiRamp Req.

For each Flexibility Region:
Flexibility in the region >= Flexibility Requirement in the region

A/S Regions

- NP26
- SP26

Flexi-Ramp Constraint Region

CAISO

Regional Flexibility Markets

- NP26
- Flexibility Region 1
- Flexibility Region 2
- Flexibility Region 3
- ...
Regional Flexibility Markets

**Proposed solution: Regional Flexibility Markets**

- Create regions or sub-regions to provide more targeted and more locational Ancillary Services and Flexibility Capacity Procurement in the Day-ahead and Real-time markets
  - Without going to the nodal level
  - No new products (current Flexible Ramping proposal will require modifications)
  - A/S and Flexible Ramping will receive a Regional price “adder” when regional flexibility constraints bind
- Use off-line studies to determine typical flexibility needs given expected conditions
  - More reasonable than “flow based” approach for Day-ahead market (e.g. no flows from Virtual Bids)
- Energy and capacity are co-optimized as today, but procurement will have more regional targets
  - Relatively minor change from status quo (just more regions and price adders)
  - Robust solution to deal with uncertainty from VERs, load, and other sources
- Similar to A/S, procure all needs in the DA market and only do additional procurement in RT if resources become unavailable or under material system condition changes

**A regional approach will ensure**

- Under an N-1 event, generation capacity will be used when they are needed
  - It will not restrict Operators in what capacity can be used to restore the flow
- Addresses locational A/S needs and locational flexibility needs
- Reduces unnecessary EDs on normal days
- Address the failure of the CAISO “system-wide” Flexi Ramp Constraint design
Aside: Flexi Ramp Refinements to Integrate with SOL Issues

- The Flexi-Ramp Constraint was implemented in Dec 2011

- The current Flexi-Ramp design lacks regional procurement
  - Neither the flexi-ramp constraint or the flexi-ramp product considers regional procurement

- Without refinement, this design shortcoming will continue to cause problems such as those emphasized by stakeholders and FERC
  - FERC concluded the failure of the flexi-ramp in its 2012 State of the Markets Report:
    "… CAISO implemented the constraint for the ISO as a whole, rather than for specified locations. This failed to prevent insufficient ramp capability to meet load ramping needs around San Diego in summer 2012."
  - CAISO DMM also noted this problem in its 2012 Annual Report:
    "… around 56 percent of the capacity procured for the flexible ramping constraint was in the Pacific Gas and Electric area. Because flexible capacity is deployed during tight system-wide conditions, the majority of this capacity cannot be used when there is congestion in the southern part of the state, which occurred more frequently in 2012"

- Flexi-ramp should support N-1 SOL restoration
  - To align with operational reality of how the grid operators respond to N-1 events
Regional Flexibility Markets: Benefits

- Benefits of Regional Flexibility Markets*

1. Provides a framework for regional Flexibility procurement
2. Procurement based on “study conditions”, rather an “optimization” based on false precision/inaccurate DA forecasts
3. Avoids co-mingling of financial (e.g. virtual bids) and physical flows to address a reliability requirement
4. Allows Flexi-ramp and demand response to address N-1 SOL issues
5. Regional price formation/better price transparency and mitigation of market power
6. Avoid potential under-utilization of transmission under normal system conditions and better recognize transmission flexibility during N-1 conditions
7. Potential to reduce both SOL-related EDs and other EDs (MOCs?)
8. Resources selling “Flexibility” in a binding region will receive a locational premium

*: Compared to the current CAISO proposal which is Prevent-Corrective Constraint Approach
Market Design & Analysis

Formulation in IFM & RTM

Flexibility Constraint for Region $\alpha$ (15-min basis)*:

$$w_r \cdot \text{Reg}_\alpha + w_{ns} \cdot \text{NS}_\alpha + w_s \cdot \text{S}_\alpha + w_{fr} \cdot \text{FR}_\alpha \geq 50\% \cdot T_\alpha$$  \hspace{1cm} (Eq. 1)

Where

- $T_\alpha = T_{\alpha 0} - \text{DR}_\alpha - \text{Other Allowable Non-Market Actions} - \text{Transf}_\text{Cap}$
- $T_{\alpha 0}$ = Flexibility Requirement for Region $\alpha$
- Transf_Cap = Transfer Capability from neighboring regions to $T_\alpha$
- w's = Weights

Payment Structure:

Any existing product in Region $\alpha$ will be paid:

Existing product price + Flexibility Constraint shadow price in Region $\alpha$

Example:

For Spinning and Non-Spinning, the existing product prices will be determined through:

- $\text{Reg Award} \geq \text{Reg Target}$
- $\text{Reg + Spin} \geq \text{Reg Target} + \text{Spin Target}$
- $\text{Reg + Spin + Non-Spin} \geq \text{Reg Target} + \text{Spin Target} + \text{Non-Spin Target}$  \hspace{1cm} (Eq. 2-4)

Assume Eq. 2-4 set $P_S$ (price for Spin) and $P_{NS}$ (price for non-Spin) system-wide.

Assume the shadow price of Eq. 1 is $P_\alpha$, then the prices for Region $\alpha$ will be

- $P_S + P_\alpha$ for Spin in Region $\alpha$
- $P_{NS} + P_\alpha$ for Non-Spin in Region $\alpha$

Same price adder $P_\alpha$ applies to FR in Region $\alpha$.

*: Roughly 50% in 15 minutes. It can be more or less than 50% in reality

Notation:

Reg: Regulation
NS: Non-spinning
S: Spinning
DR: Demand Response, including emergency programs
FR: Flexi Ramp
Constraint/Product

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Formulation in RUC

**Flexibility Constraint for Region $\alpha$ (30-min basis):**

$$w_r \cdot \text{Reg}_\alpha + w_{ns} \cdot \text{NS}_\alpha + w_s \cdot \text{S}_\alpha + w_{fr} \cdot \text{FR}_\alpha +$$

$$\text{Avail.Cap}_\alpha + \text{Transf.Cap} \geq T_\alpha$$

(Eq. 1)

Where

- $\text{Avail.Cap}_\alpha = \text{QS}_{\text{RA}\alpha} + \text{QS}_{\text{NRA}\alpha} + \text{ULC}_\alpha$
- $\text{Transf.Cap} = \text{Transfer Capability from neighboring regions to } T_\alpha$
- $T_\alpha = T_\alpha^0 - \text{DR}_\alpha - \text{Other Allowable Non-Market Actions}$
- $T_\alpha^0 = \text{Flexibility Requirement for Region } \alpha$
- $w's = \text{Weights}$

**Payment Structure:**

- For RA resources, none
- For non-RA resources, paid at the RUC price

**Notation:**

- Reg: Regulation
- NS: Non-spinning
- S: Spinning
- DR: Demand Response, including emergency programs
- FR: Flexi Ramp Constraint/Product
- Avail.Cap: available capacity in a region
- QS: Quick Start resources
- QSRA: Quick Start RA resources
- QSNRA: Quick Start non-RA resources
- ULC: Unloaded Capacity
- $T_\alpha$: Flexibility Target in Region $\alpha$
Flexibility Modeling Example 1: Locational Flexibility can meet both Locational A/S and N-1 SOL needs

**Setup**
For simplicity, consider only Non-Spin (NS) is available to provide flexibility

<table>
<thead>
<tr>
<th>Requirement</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>NS in SP26</td>
<td>1100 MW</td>
</tr>
<tr>
<td>Flexibility in Region (\alpha)</td>
<td>500 MW</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bids</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>U1 (outside (\alpha))</td>
<td>NS: 1100MW @$1</td>
</tr>
<tr>
<td>U2 (inside (\alpha))</td>
<td>NS: 700MW @$2</td>
</tr>
</tbody>
</table>

**Results**

### Without regional flexibility requirement

<table>
<thead>
<tr>
<th></th>
<th>Dispatch</th>
<th>Paid Price</th>
<th>Payment</th>
</tr>
</thead>
<tbody>
<tr>
<td>U1 (outside (\alpha))</td>
<td>1100MW</td>
<td>$1/MW</td>
<td>$1100</td>
</tr>
<tr>
<td>U2 (inside (\alpha))</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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</tbody>
</table>

### With regional flexibility requirement

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<td>600MW</td>
<td>$1/MW</td>
<td>$600</td>
</tr>
<tr>
<td>U2 (inside (\alpha))</td>
<td>500MW</td>
<td>$2/MW</td>
<td>$1000</td>
</tr>
</tbody>
</table>

- The 500MW U2 NS award can serve both locational A/S need and N-1 SOL need
- U2 is compensated for the service
- NS Price for U2 in Region \(\alpha\):
  \[SP26 \text{ A/S price} + \text{Flexibility Constraint Price} = $1/MW + $1/MW^*\]

*: The optimization will calculate the shadow price as the marginal saving of reducing the flexibility constraint regional flexibility requirement by 1MW, which can be achieved by reducing U2 award by 1MW with increasing U1 award by 1MW. The saving is $2 - $1 = $1/MW
**Flexibility Modeling Example 2: locational flexibility can meet both locational flexi-ramp and N-1 SOL needs**

**Setup**
For simplicity, assume only flexi-ramp is available to provide flexibility needed for N-1 SOL relief

**Requirement**
- Flexi-Ramp System-wide: 1000 MW
- Flexibility in Region $\alpha$: 500 MW

**Flexi-Ramp cost**
- U1 in NP26: 1100MW @$1
- U2 (SP26 inside $\alpha$): 700MW @$2

**Results**

**Without regional flexibility requirement**

<table>
<thead>
<tr>
<th>Dispatch (Flexi-Ramp)</th>
<th>Paid Price</th>
<th>Payment</th>
</tr>
</thead>
<tbody>
<tr>
<td>U1 (outside $\alpha$)</td>
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<tr>
<td>U2 (inside $\alpha$)</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

- The 1000MW of ramp in NP26 can't address a problem in SP26 if there is congestion
  - This issues is noted by FERC and CAISO stakeholders
  - Load pays the main cost of having U1 Ramp for nothing

**With regional flexibility requirement**

<table>
<thead>
<tr>
<th>Dispatch (Flexi-Ramp)</th>
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<th>Payment</th>
</tr>
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<tr>
<td>U1 (outside $\alpha$)</td>
<td>500MW</td>
<td>$1/MW</td>
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<tr>
<td>U2 (inside $\alpha$)</td>
<td>500MW</td>
<td>$2/MW</td>
</tr>
</tbody>
</table>

- The 500MW U2 flexi-ramp award can serve both locational Flexi-Ramp need and N-1 SOL need
- U2 is compensated for the service
Summary

- The Regional Flexibility approach has many potential benefits when compared to the CAISO approach.
- The Regional Flexibility approach addresses one of the core problems with the current Flexi-ramp design – a locational component.
- We feel strongly that alternatives, including the Regional Flexibility Markets, should be evaluated along with the CAISO proposal before deciding on a final design.
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