Gaps in Current Reserve Pricing Methodology

Lisa Morelli
Manager, Real-Time Market Operations
Energy Price Formation Senior Task Force
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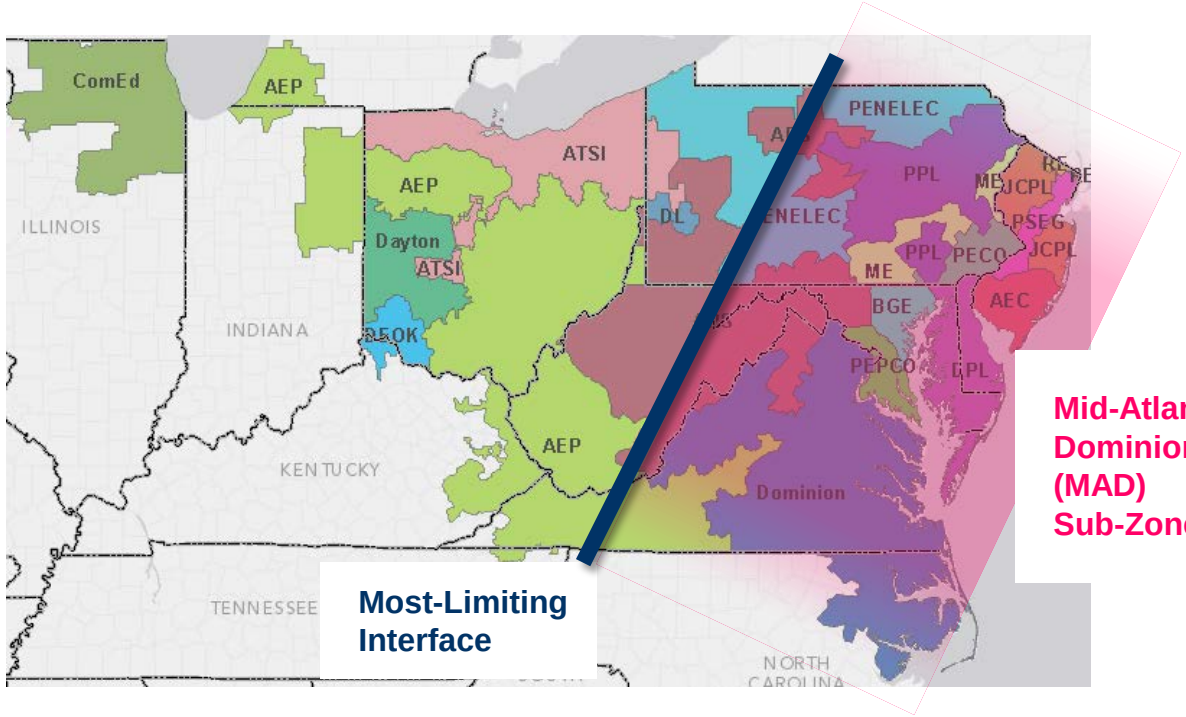
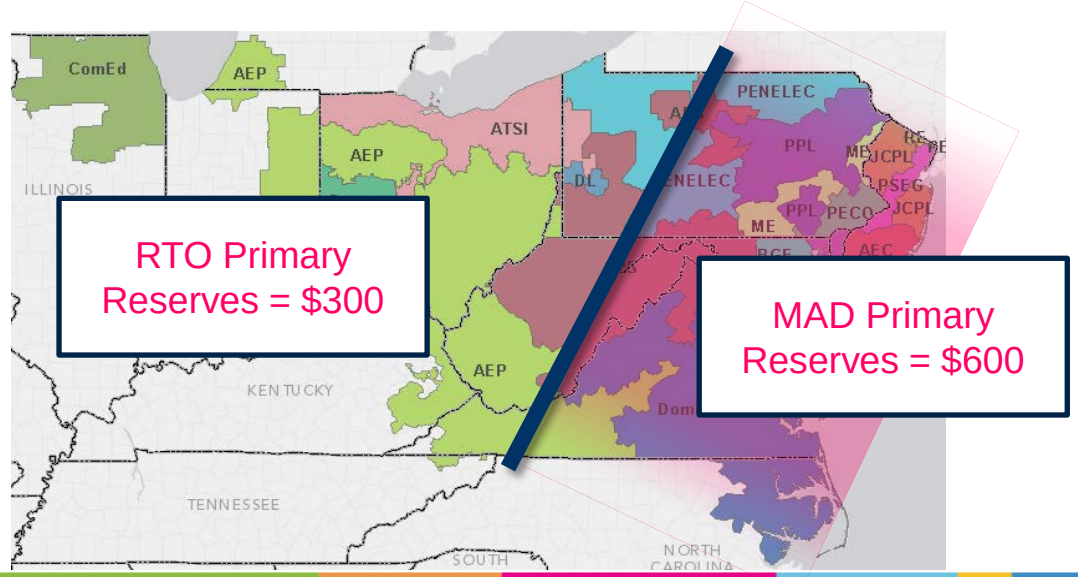
Gap 1: Reserve Zone Modeling

- Current modeling of Mid-Atlantic Dominion (MAD) reserve sub-zone may result in overly conservative procurement of reserves in MAD
  - Forces set amount of reserves to be procured in MAD
  - Main goal in procuring locational reserves is to not overload critical constraints when reserves are deployed



Gap 1: Reserve Zone Modeling

- Reactive Transfer Interfaces used to define the MAD sub-zone are not always the constraints that dispatch is most concerned with overloading
  - Results in reserves being procured in areas where they can exacerbate these constraints upon deployment
  - Leads to MAD reserve prices that are misaligned with the reliability value of reserves in MAD
- September 2017 shortage event
  - System was constrained East to West
  - Most of MAD reserves would aggravate the constraints if deployed
    - MAD reserves valued at 2x non-MAD reserves



Synchronized Reserves Background

Tier 1	Online units that are following economic dispatch and are only partially loaded, and therefore are able to increase output within 10 minutes following PJM dispatcher request Paid: • Synch Reserve Market Clearing Price (SRMCP) when Non-Synch Market Clearing Price (NSRMCP) > $0 • Synchronized Reserve Premium Price for event response
Tier 2	Resources that have offered into the Synchronized Reserve Market and cleared • Condensers (CTs and hydro) transition to online Tier 2 condense mode • CTs online at min – operating at a point that deviates from economic dispatch • Steam reduced to provide Tier 2 MW • Demand response that can drop load Paid: • SRMCP for any assigned MW (made whole to offer if necessary)

Gap 2: Tier 1 Estimation

- Use of Tier 1 can lead to inaccurate accounting of reserve capability
  - Tier 1 has no obligation to respond
  - Resources don't explicitly offer Tier 1 and therefore may not be aware they are being relied upon
  - Additional Tier 1 specific data that is not always kept up-to-date is used in the calculation of Tier 1 MW estimates
    - Synch Reserve Maximum MW
    - Synch Reserve Ramp Rate

Tier 1 Event Response

Event	Date	Start Time	End Time	Duration	Region	Tier 1 Estimate (MW)	Tier 1 Response (MW)
1	01/01/2018	02:41	02:48	00:07	RTO	1135.7	668.4
2	01/03/2018	03:00	03:13	00:13	RTO	1896.7	509.9
3	01/07/2018	14:15	14:24	00:09	RTO	2513.1	850.5

- Poor response attributed to
  - Lack of Synch Reserve Maximum MW updates
  - Inaccurate Synchronized Reserve Ramp Rates
  - Communication from MOC to Generator

Impacts of Data Quality

- Data quality directly affect Tier 1 estimates
  - Impact to Shortage Pricing
    - Creates the potential to over or under estimate available synchronized reserves
      - Poses a challenge to creating a price signal that is consistent with system conditions
  - Operator decisions and actions
    - Disconnect between Economic Dispatch and Energy Management System (EMS) actual reserves
    - Use of Tier 1 biasing and additional Tier 2 commitments

Gap 3: Tier 1 Valuation and Compensation

- Tier 1 is compensated (when NSRMCP > $0) without an obligation to respond. Obligations and compensation are misaligned.
- Tier 1 is assumed to be free. If we can meet the entire reserve requirement with Tier 1, the price of reserves is $0. This price does not align with the value of synchronized reserves.
  - Tier 1 MW could be considered the most valuable synchronized reserves
    - Most economic
    - Less delivery risk than some Tier 2 resources because they're already online and generating energy
  - Tier 1 is currently treated as perfectly substitutable for Tier 2 reserves, yet not valued comparably

Gap 4: 30-Minute Reserves

- PJM schedules 30-minute reserves in the Day-ahead Market
- PJM does not maintain a 30-minute reserve requirement in real-time
- No compensation in real-time suggests this capability has no operational value or cost
  - Market prices do not reflect the cost of resources needed to reliably serve system needs
- Value and potential use of 30-minute reserves:
  - Respond to unforeseen system occurrences like under forecasted load
  - Back-filling 10-minute reserves
  - Meeting large interchange exports
  - Responding to gas contingencies

Gap 4: 30-Minute Reserves & Shortage Pricing

- A real-time 30-minute reserve market could also trigger shortage pricing earlier than today
  - Currently shortage pricing is triggered when the system does not have enough 10-minute reserves, which is a severely degraded operating state
- Adding a real-time 30-minute reserve market would help change shortage pricing into a tool to avoid operating emergencies rather than an indication that we are in one (proactive vs. reactive)