Multi-Faceted Solution for Managing Flexibility with High Penetration of Renewable Resources

FERC Technical Conference

Increasing RT & DA Market Efficiency Through Improved Software

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MISO

Outline

- Impacts of Variable Generation on Ancillary Services
- Dispatchable Intermittent Resources
- Proposed Ramp Products
- Cost / Benefit Analysis
- Questions

Impacts of Variable Generation on Ancillary Services

Regulation

- MISO Peak Load: 100 GW
- Wind generation Installed Capacity over 12 GW
- MISO Regulation Requirements
  - MISO requirement is a bidirectional value varying between 300 MW to 500 MW depending on load level and time of the day
- Impact of Variable Generation
  - In general is little to none
  - Wind Generation can impact the net load variability and uncertainty
    - One minute wind generation variation has very little impact on net load one minute variability
    - Standard deviation of Short-term wind generation forecast error is approximately 1% of wind generation capacity
    - The impact of short-term wind forecast error in net load uncertainty is low

Contingency Reserve(s)

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- **MISO Contingency Reserve Requirement**
  - Criterion: largest generation unit / unit + transmission corridor
  - It is set to 2000 MW
  - Approx. 50% is set as spinning reserve
  - The rest is the supplement reserve
  - Provided by on-line and off-line resources including Demand Response Resources
  - Due to the deliverability issues there are zonal requirements
  - Main Characteristics of the Contingency Event
    - Occur very quickly (seconds)
    - Needs to be compensated in 10 minutes
  - Current RTO / ISO practice does not use the contingency reserve for other shortages in the system

Contingency Reserve(s) – Cont'd

- **Impact of Variable Generation**
  - None. Unless a single wind farm is exceeding the current 2000 MW (system wide) or zonal requirement
  - Utilizing Regulation or CR for renewable generation one should check
    - How fast the variability happens
    - How fast we are learning about it
    - How fast we need to respond to it
  - Forecasted wind generation (and / or actual wind generation) variability has its own latency much longer than a contingency event
    - MISO has experienced loosing wind generation in the magnitude of 6000 to 7000 MW in about 8 hours (majority of these drops were forecasted) – In opposite direction to the load variation
    - Wind generation variation of +/- 2000 MW in 20 minutes (rare events)

Impacts of Variable Generation

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- **No need to increase conventional reserves' requirements in current operations**
  - Size of footprint
  - VG increases the magnitude of current levels of variability and uncertainty not solely causing it
  - Aggregation helps to reduce the negative impacts in the system level
- **One of the main contribution of renewable generation is reduction in energy prices**
  - Adding conventional reserves' requirements will increase the generation cost negating the benefits of renewable generation

Fundamental Issue

- **What is the most challenging issue in the day to day operation?**
  - *Ramping Capability*
    - Keeping enough rampable capacity in the system to go after the net load variability and uncertainty
  - Current Operational Practices
    - Enforcing system wide Ramp Up and Down capacity constraints in the Day Ahead process (partly covering intra-hour ramp requirements)
    - Intra Day RAC process updates commitment of the generation resources to make sure upon changes in the system conditions there is enough headroom in the system
    - Following the ramp needs close to the real-time and committing fast start up units if needed
    - Enforcing an offset value in the dispatch function partly to enforce specific positioning of the units

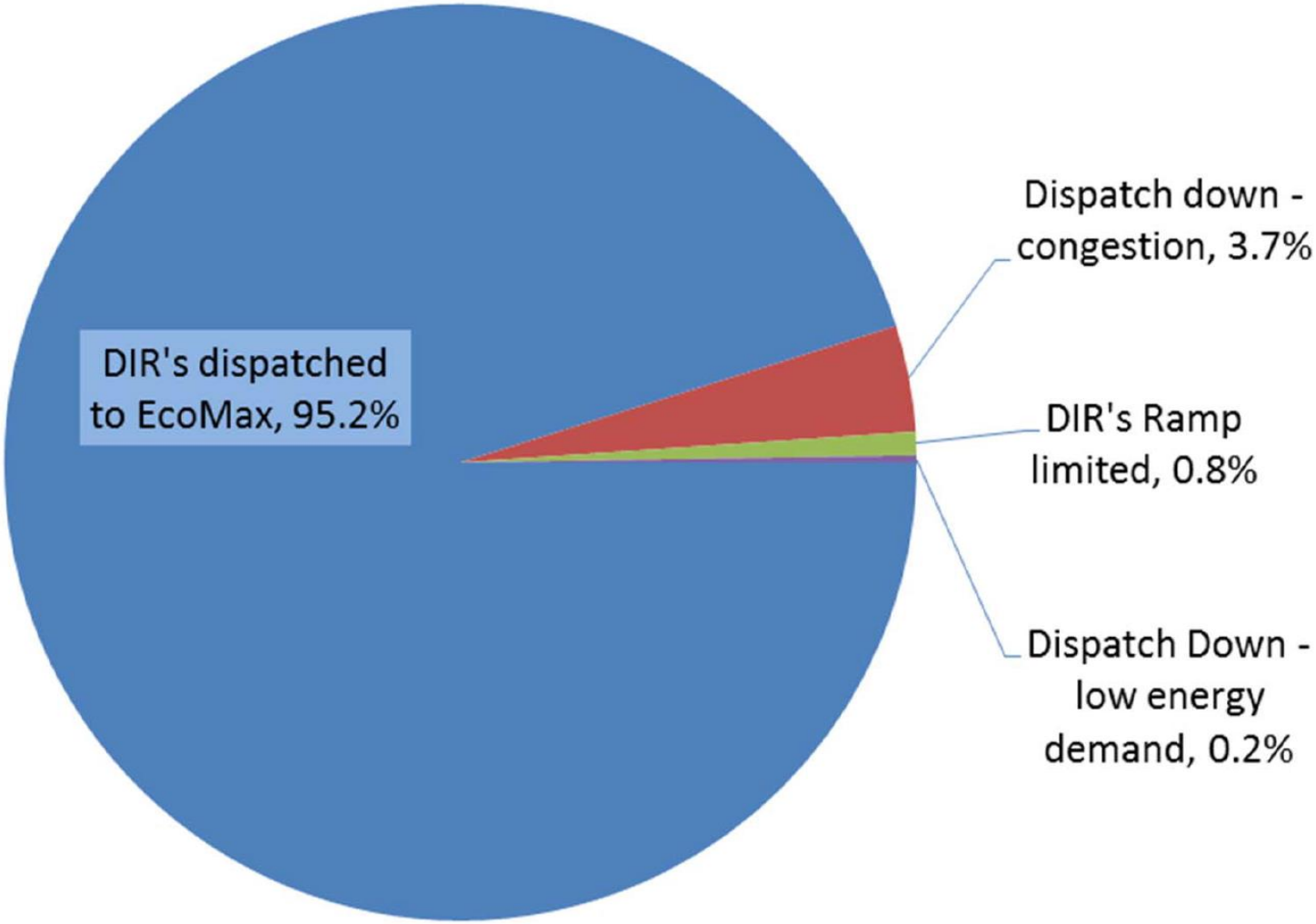
Dispatchable Intermittent Resources

Dispatchable Intermittent Resources (DIR)

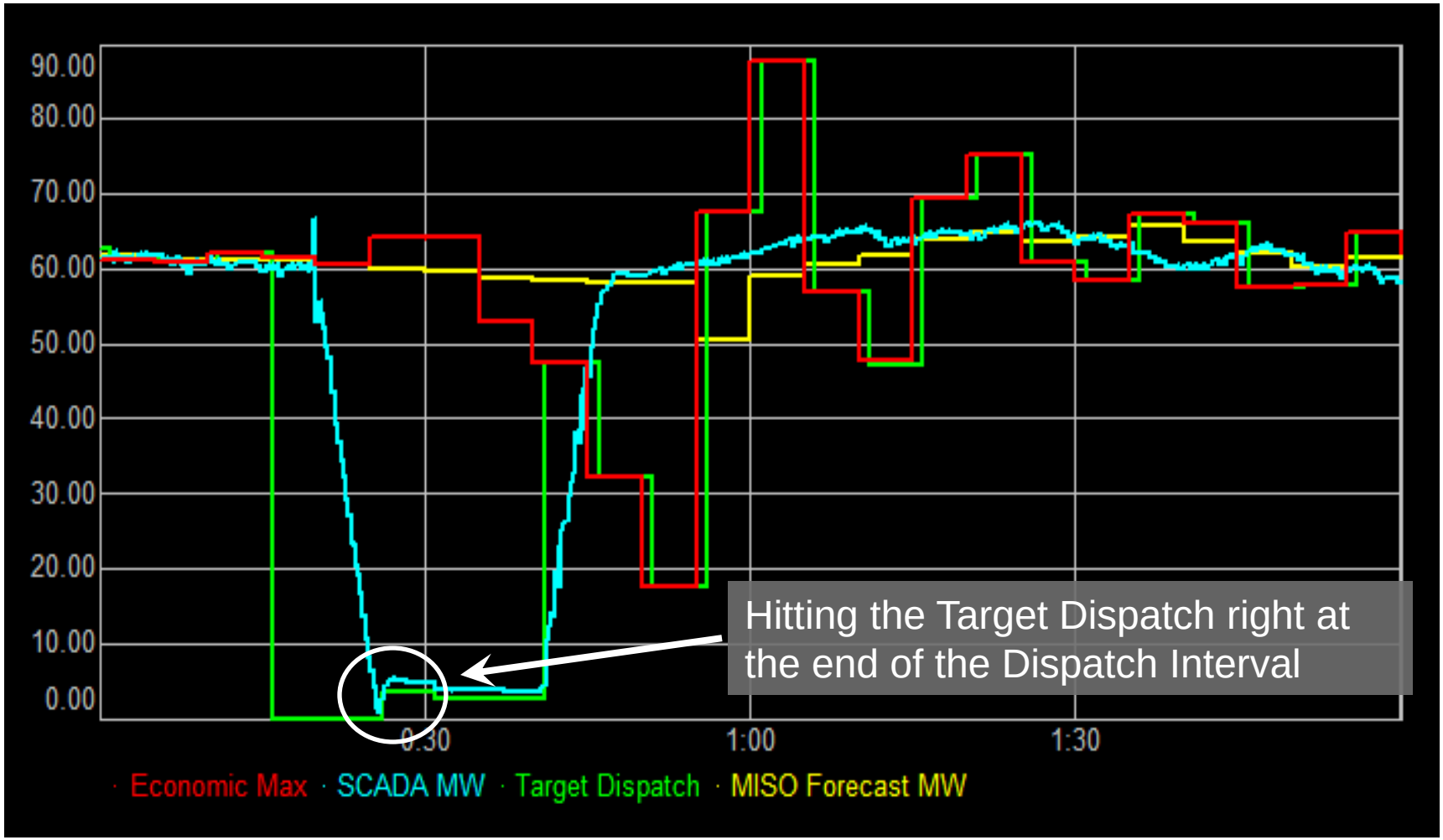
- A new class of generation resources
- Market and settlement treatment very close to conventional generators
- Utilize Forecast Maximum Limit to allow full market participation
- DIR registration required for Resources with “Intermittent” Market Registration
- Same setpoint tolerance as generation resources
- All Resources with “Intermittent” Market Registration subject to RSG for *positive and negative differences* between DA schedules and RT capability

General DIR Market Rules

- DIRs are eligible to supply Energy, but not Operating Reserves (Regulating, Spinning, or Supplemental)
- DIRs and traditional generation have same market behavior in Day-Ahead Market (DA)
- Primary difference between DIRs and traditional generation in RT is source of Maximum Limit
  - Participants submitted short term Forecast value
  - MISO generated short term Forecast value
  - Sate Estimator
- DIRs can Self-Schedule Energy (self-schedule will be reduced if greater than RT capability)


DIR's dispatched to EcoMax, 95.2%
Dispatch down - congestion, 3.7%
DIR's Ramp limited, 0.8%
Dispatch Down - low energy demand, 0.2%

Example – (Single DIR – Correct Initial Response)



Proposed Ramp Products

The Ramp Problem

- Maintaining sufficient ramp capability is a significant challenge in operating the MISO system
- Ramp shortages are the most common cause of scarcity
  - Due to the hierarchy of the products Ancillary Services will be sacrificed to keep system balance
  - Scarcity reflects reduction of real-time robustness / reliability
  - Scarcity pricing has big market impact for short-term ramp issues
- These scarcity conditions are short lived (few intervals) and before resources react to it will disappear
  - Not a suitable (or actionable) market signal

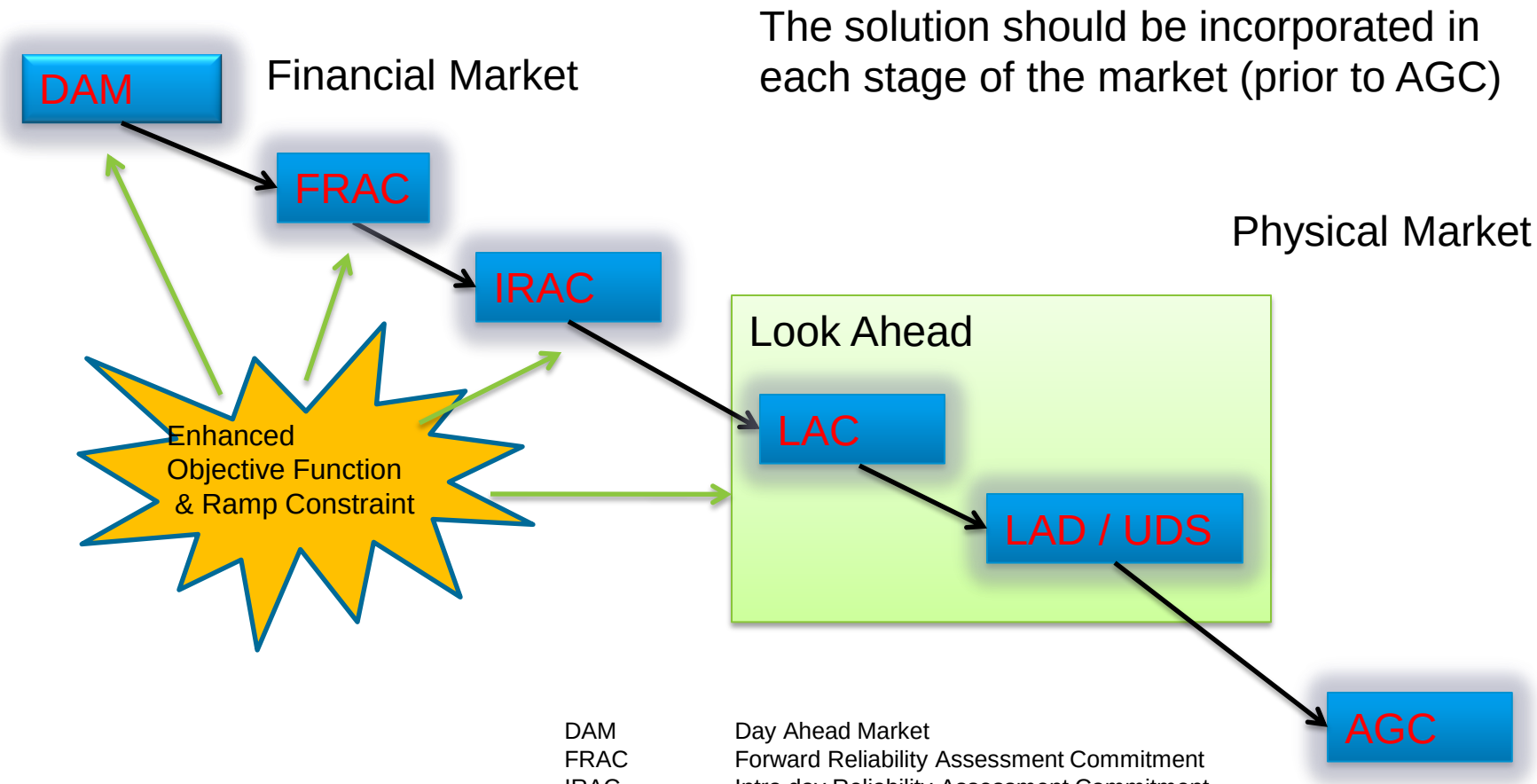
What are the proposed Ramp Products?

- New products to explicitly manage the ramp available from the controllable generation thru market incentives
- Up and down ramp products reserve a specified level of resource ramp capability to meet RT dispatch variability
  - Ramp requirements vary to support different operating conditions, forecasts, uncertainties, time of day and / or year
  - Ramp products reserve exclusive resource capacity and are co-optimized with energy and Ancillary Service products
  - Cleared ramp for future variations is automatically reduced when ramp capacity is needed to meet requirements in the current RT dispatch interval
  - Ramp product prices determined by resource opportunity cost
    - Ramp prices are expected to frequently be zero when ramp availability is not constrained **(Pay As Needed Basis)**

What are the proposed Ramp Products? (p.2)

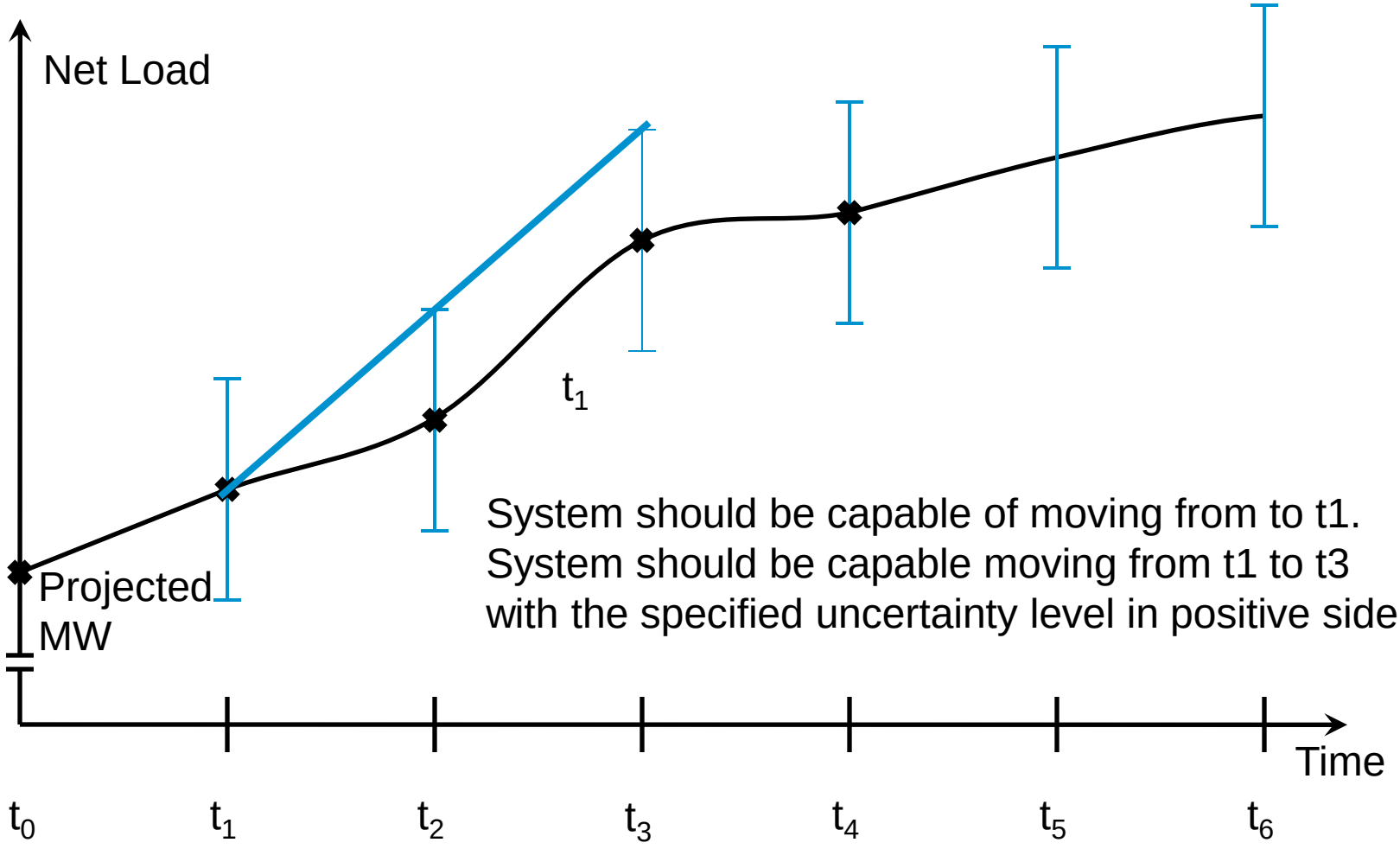
- Ramp products in Commit & Dispatch for DA, RAC, RT
  - Redispatch can create operational ramp cushion reducing the need for real-time commitments
  - Ramp pricing and settlement for transparent market incentives
- Current markets will be extended with minimal impact
  - Existing energy and AS products are not changed (although the interaction of pricing and dispatch may change clearing results)
  - Versatile ramp product formulation is compatible with current markets and future changes such as ELMP and Look Ahead Dispatch (LAD)

Market Coverage

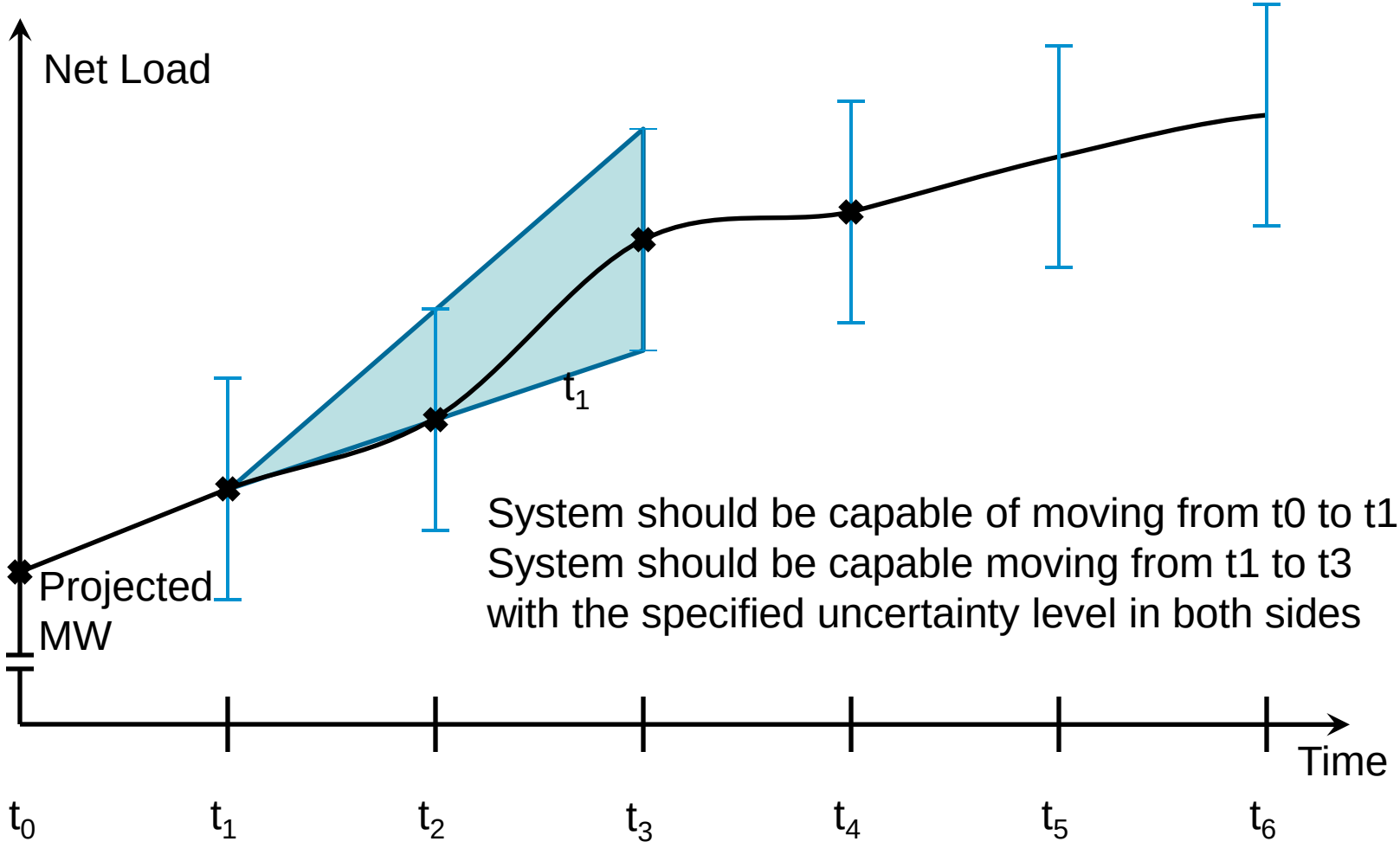


DAM	Day Ahead Market
FRAC	Forward Reliability Assessment Commitment
IRAC	Intra day Reliability Assessment Commitment
LAC	Look Ahead Commitment
LAD	Look Ahead Dispatch (Currently UDS)
AGC	Automatic Generation Control

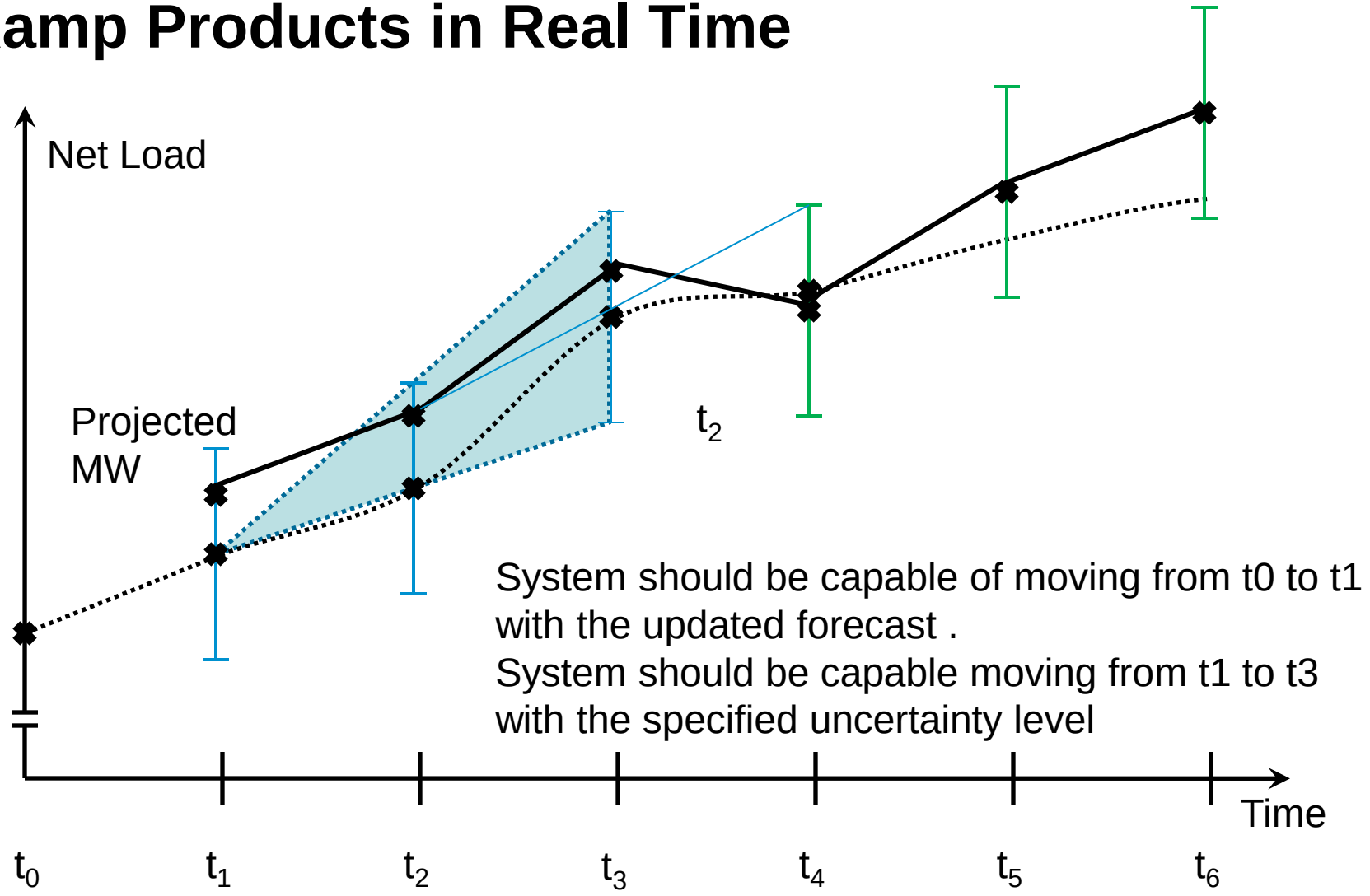
Ramp Products in Real Time



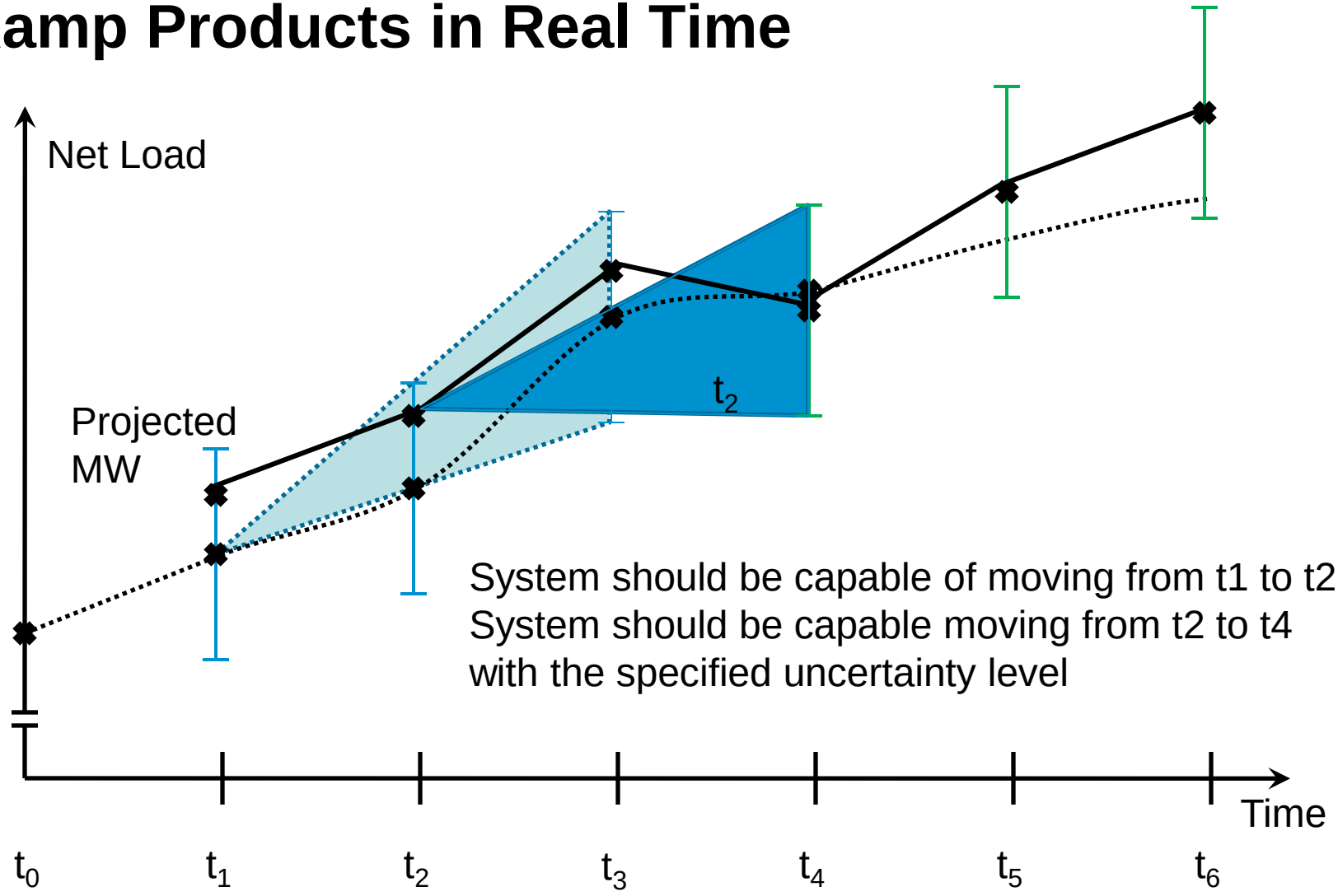
Ramp Products in Real Time



Ramp Products in Real Time

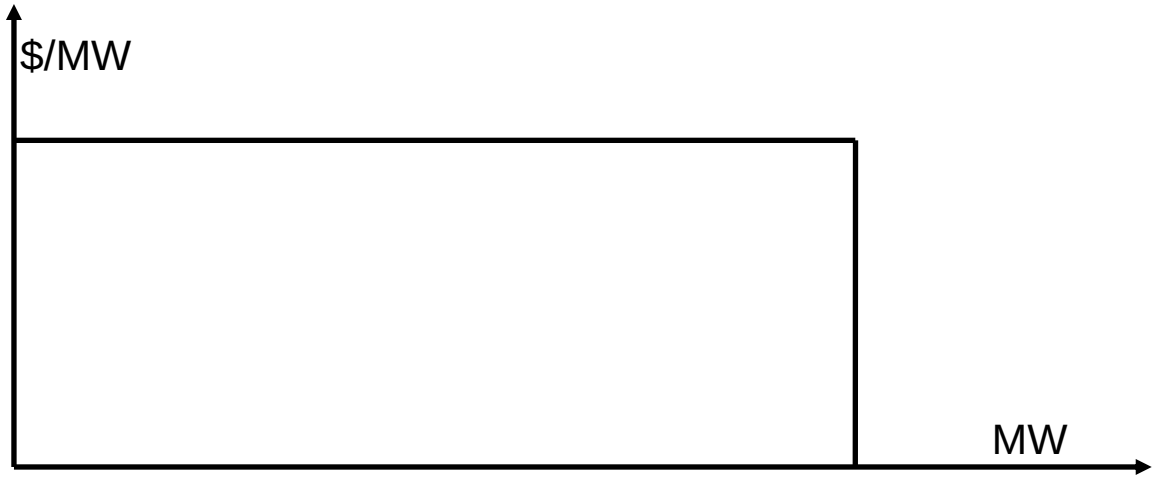


Ramp Products in Real Time



Ramp Product Demand Curves

- Ramp capability acts as a buffer to absorb forecasted and unexpected operational variability
  - Ramp retained in a previous dispatch is available for energy dispatch in the current RT dispatch
- Demand curve pricing allows automatic tradeoff between reserving ramp capacity for a future interval and using the ramp to meet current system needs



Ramp Capability Payments & Charges

- Awarded Ramp Capability is paid product clearing price
  - Subject to real-time performance monitoring of allowable deviation
  - Revenues from Ramp Capability included in make whole payment calculation
- Charges for Ramp Capability products are similar to other ancillary services
  - Load charges are increased to compensate for ramp capability payments to resources, however reduced scarcity pricing, CT commitment, etc. decreases load payments (*causing an overall production cost saving*)

Cost / Benefit Analysis

Simulation Results of Ramp Products

- The Up Ramp Capability (URC) and Down Ramp Capability (DRC) requirements are simulated based on the actual net load variation and an uncertainty level

$$[R^u(t):R^d(t)] = \hat{p}^D(t+t_0 \mid t) - p^D(t) \pm a\sigma$$

- where $\hat{p}^D(t+t_0 \mid t)$ is the net load for $(t + t_0)$ forecasted at t, and σ is the standard deviation of the uncertain net load
- Monte- Carlo simulations used to maximize the "Production Cost Savings"
  - The aim is to eliminate the ramp induced price spikes as much as economically is viable
- Actual MISO production data for 4 days of operation are used

Production Cost Savings by Spike / Non-Spike

Date	Spike Comb. Cost Savings	Spike Count	Spike Intervals	Non-Spike Comb. Cost Savings
$5 Demand Curve and 2.5 standard deviations				
06-Jul	18651	8	106	2257.0
28-Jul	10685	5	18	593.0
15-Sep	-64	5	20	325.3
14-Oct	80	10	56	77.6
Annual (Count)	1773703	1692		296834
Annual (Intervals)	873958		5955	296834
$10 Demand Curve and 2.5 standard deviations				
06-Jul	23514	8	106	1568
28-Jul	13505	5	18	30
15-Sep	-64	5	20	325
14-Oct	80	10	56	20
Annual (Count)	2238006	1692		177375
Annual (Intervals)	1102734		5955	177375

Estimated Annual Production Cost Savings (p.3)

- To emulate the tangible production cost savings for the entire process from DA to RT these components are considered:
  - Simulation results for savings in RT dispatch
  - Estimates for additional reductions in scarcity conditions by adding URC / DRC to the DA process
  - Estimates for reduction in CT commitments

	Annual Comb. Cost Savings
Impact of URC / DRC in RT with Original Commitment	$1.2 - 2.4 M
Add. Reduction of Scarcity Conditions by Including URC / DRC in DA	$0.6 – 1.0 M
Reduction in CT Commitment	$2.0 M
Total (DA to RT)	**$3.8 – 5.4 M**

- The annual cost of URC / DRC will be in the range of $2 – 4M
  - Included in the annual Combined cost savings
  - Binding in 10% of the intervals in RT

Operational Benefits of Ramp Products

- Reduced instances of short-term ramp-induced scarcity
  - Improved operational reliability
  - Reduce dependence on ad hoc operator actions to manage short-term variations in net load by using ramp products as operational shock absorbers
    - Reduce frequency CTs are started to meet ramp needs
    - Reduce need for RT UDS delta MW offsets
- Market transparency providing economic incentives for resources to provide additional ramp capability
  - Resources are paid opportunity cost so would not make more money by providing a different product
  - Improved long-term incentives for resources to offer and develop improved resource flexibility

Operational Benefits of Ramp Products (p.2)

- Maintenance of operational flexibility needed to manage increasing penetration of variable energy resources
  - Less expensive and effective alternative to increasing regulation and / or CR requirements
  - Maximize ramp capability available from current on-line fleet
  - Cost benefit analysis is based on current level of net load variability, prospective increases in intermittent resource output may lead to greater variability and greater benefits
- Adding URC / DRC provided
  - Production cost savings (less than 1%)
  - Actual Load Payment (approximated around 5%)

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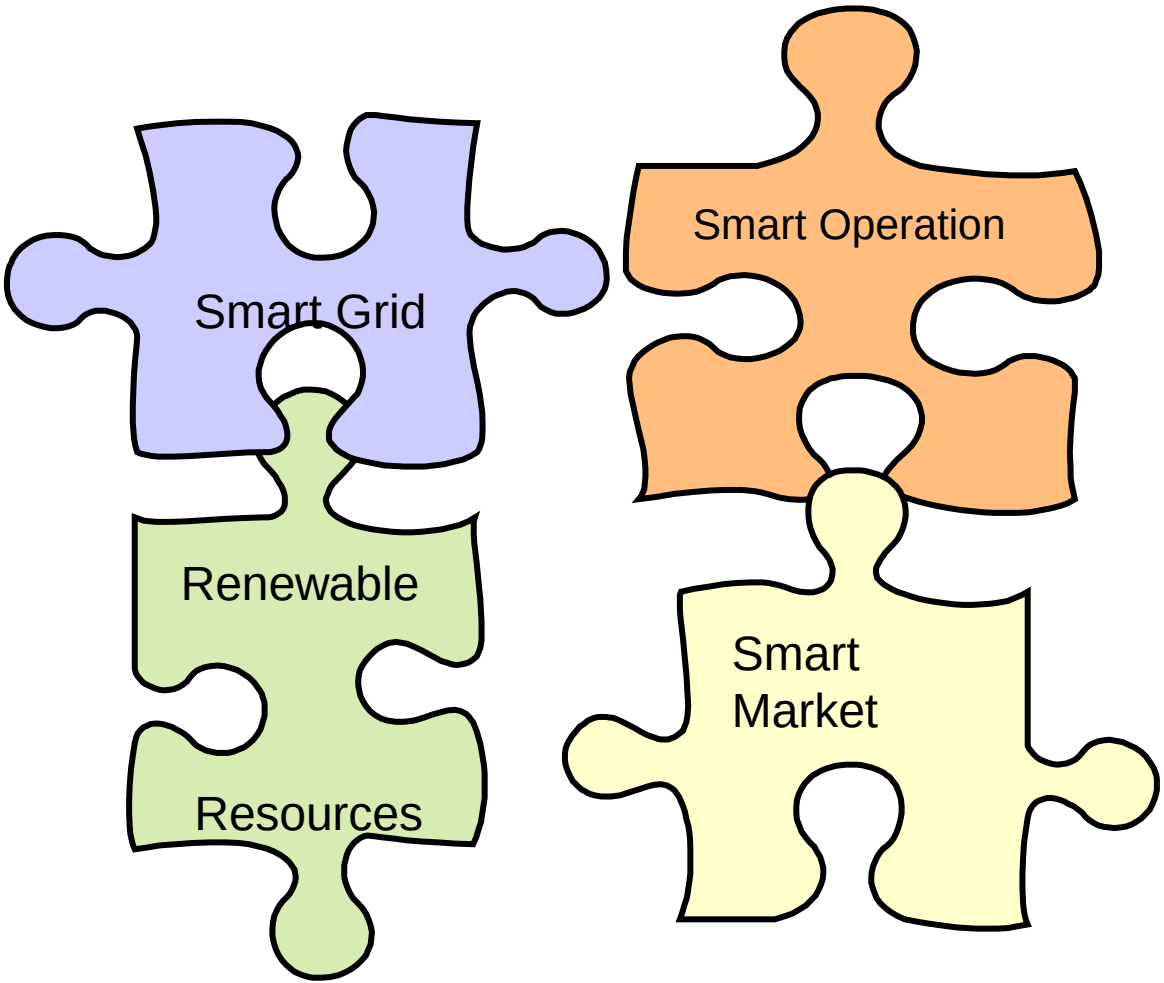
Operational Benefits of Ramp Products (p.3)

- Maintain ramp flexibility when resource mix changes
  - Changes in relative fuel prices and/or environmental laws can cause changes in operational resource mix (e.g., more gas generation online and priced to be loaded at max)
  - Ramp products bias market commitment toward a more flexible resource available at slightly higher cost
  - Dispatch to maintain ramp capability on fast responding resources when more ramp is needed

What Can We Achieve?

- SMART GRID Needs SMART Operation and SMART Market
  - We can operate the system with high level penetration of Renewable resources without adding any new cost to it



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Questions

- MISO Web Page for Ramp Management
  - www.misoenergy.org/WhatWeDo/StrategicInitiatives/Pages/RampManagement.aspx