DECEMBER 5, 2018 | WESTBOROUGH, MA

Day-Ahead Enhancements

Technical Session 1

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Format of These Sessions

- This is NOT a Markets Committee meeting and will not follow normal MC rules (posting, interactive WebEx, etc.)
- Sessions are meant to help the ISO frame the problem and potential solution set. ALL input is welcome and essential
- We will end the session summarizing the planned items for the next session

Important Note on Today's Session

- This session will answer two broad questions
  - How does the ISO meet its next-day Operating Plan reliability requirements?
  - How and why does the current day-ahead market fulfill some, but not all, of these requirements?
- This session <u>will not discuss</u> winter energy security or current ISO proposals on that topic
  - Specifically, it will not address winter energy inventory concepts or multiple day-ahead markets

This Session

- Day-ahead processes and reliability requirements
- Current reliability tools used by the ISO to meet these reliability requirements
  - Description
  - Example
  - Analysis: Focus on market implications
- Key takeaways

DAY-AHEAD PROCESSES AND RELIABILITY REQUIREMENTS

Day-Ahead (DA) Obligations of the ISO

- ISO New England is the Reliability Coordinator for the New England bulk power system
- In this capacity, it must have a next-day Operating Plan that satisfies several reliability requirements
- Some of the requirements are satisfied in the DA market, others are not satisfied until RAA
  - This may not be the most effective approach

DA Reliability Requirements

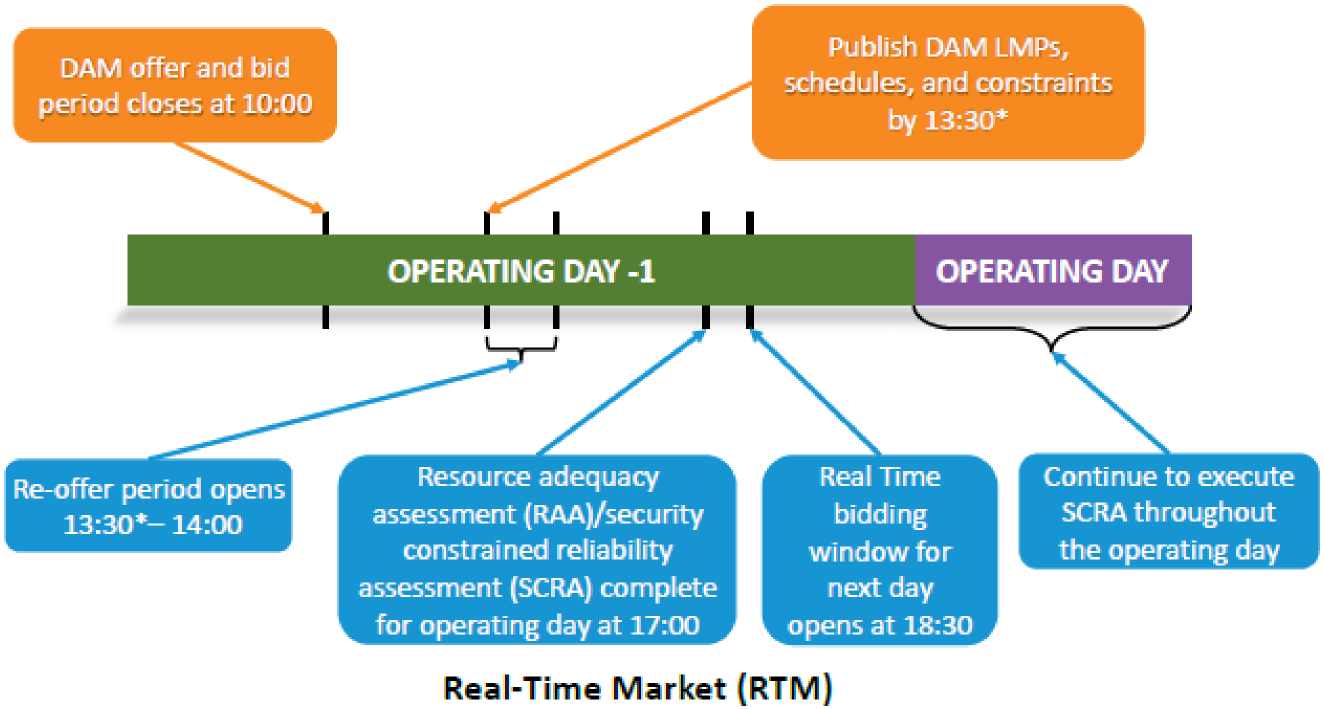
- ISO New England's next-day Operating Plan considers the following uncertainties
  - N – 1 transmission contingencies (NERC FAC-011-3)
  - N – 1 generation contingencies (NERC FAC-011-3)
  - N – 1 – 1 contingencies (NERC IRO-009-2 *and* ISO-NE MLCC-15)
    - Line-line, gen-line, or gen-gen
    - 30-minute recovery time
  - Load forecast balance (NERC TOP-002-4)

Day-Ahead Processes

1. DA Market (DAM)
   - Solve commitment, dispatch, and pricing based on **bid-in load**
   - Output includes
     - Financially binding quantities and prices
     - Planned next-day commitments for non-fast start (non-FS) generators
2. Reserve Adequacy Analysis (RAA)*
   - Respecting planned commitments from the DAM, solve supplemental commitment and dispatch based on **forecasted load**
   - Output includes
     - Additional planned next-day commitments for non-FS generators

* Also known as Resource Adequacy Assessment

Timeline



See WEM101: Day-Ahead Energy Markets

Two purposes of DA Processes

1. Provide an opportunity to hedge against RT price volatility
   - DA prices should be less volatile than RT prices
   - Can benefit both buyers and sellers

2. Ensure a reliable next-day Operating Plan
   - ISO-NE's obligation as Transmission Operator and Reliability Coordinator for the region

Evaluation Principles

- DA reliability requirements are satisfied with a variety of tools
- How should these tools be evaluated?
  1) **E**fficiency
  2) **T**ransparency
  3) **S**implicity

Evaluation Principles

1) **E**fficiency

   a. In general, the DA processes should maximize social surplus/minimize production cost

   b. This presentation focuses more narrowly on the optimality of the final (post-RAA) next-day planned commitments*

      - This definition is based on RT production cost minimization, which requires the optimal set of non-FS commitments from the DA processes

* The effects of virtual bidding will be explicitly considered in a future presentation

Evaluation Principles

2) **T**ransparency

   a. Cost of satisfying the reliability requirement is reflected in an observable market price

   b. DA prices cover incremental costs

Evaluation Principles

3) Simplicity

a. Uniform market prices by location and time

b. Easy-to-understand logic

Motivating Question

- Can the ISO satisfy its DA reliability requirements with market products that more fully satisfy ETS principles?

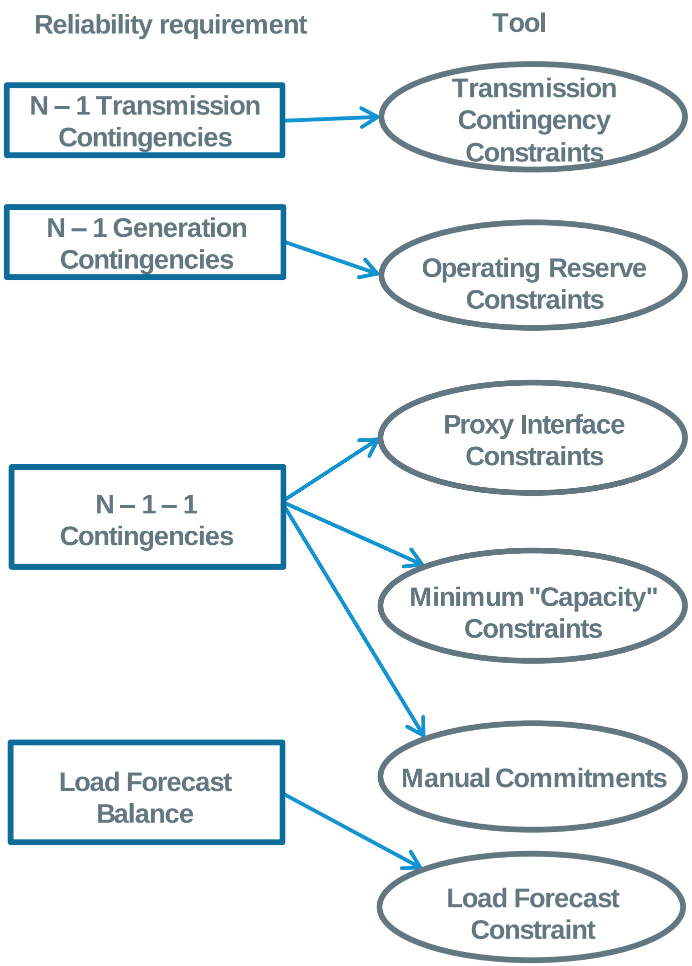
CURRENT RELIABILITY TOOLS

Current methods to satisfy DA reliability requirements

Reliability Tools

- ISO New England currently uses six DA reliability tools
  - Contingency constraints
  - Operating reserve constraints
  - Proxy interface constraints
  - Minimum “capacity” constraints
  - Manual commitments
  - Load forecast constraint
- Each tool can satisfy at least one reliability requirement

Mapping: Reliability Requirement → Tool



Transmission Contingency Constraints

- Post-contingency transmission limits that ensure feasible power flows after a transmission element failure

$$\text{Post-contingency flow} \leq \text{Post-contingency limit}$$

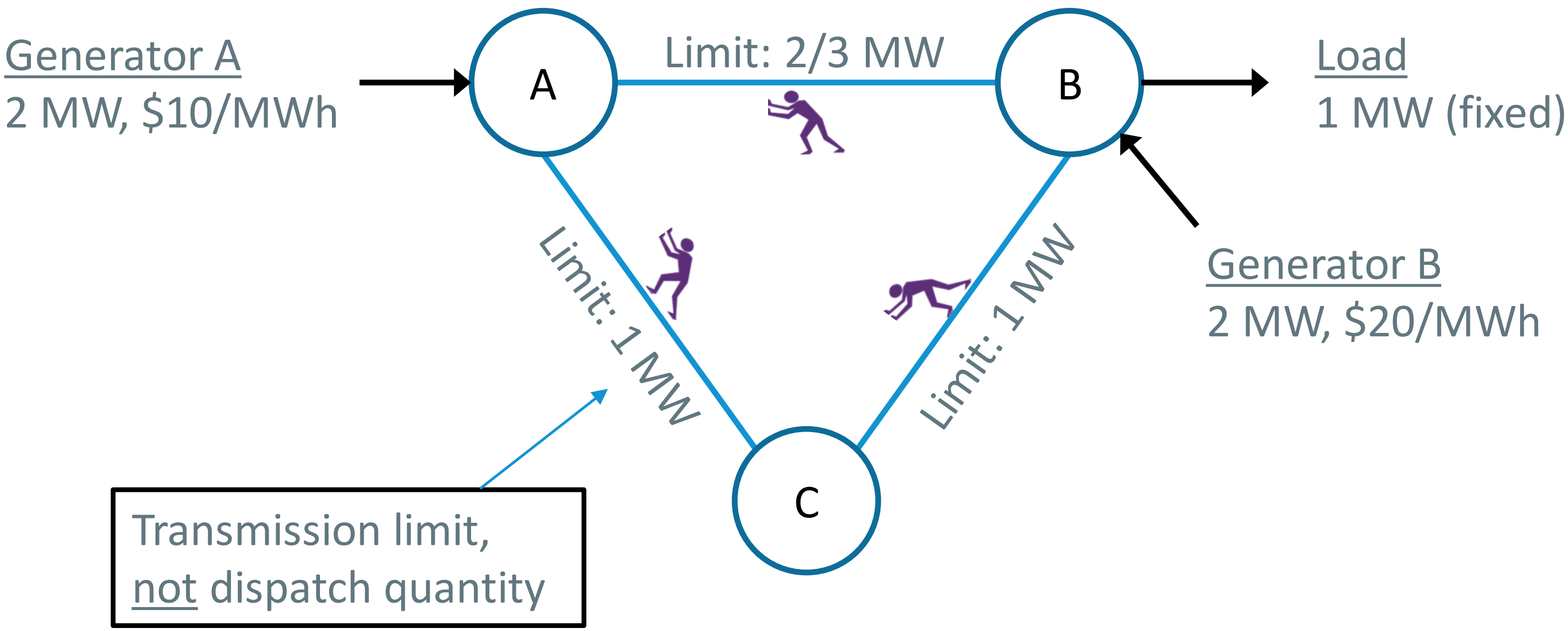
- Post-contingency limit: Long-term emergency (LTE) limit of the transmission element
  - Refer to ISO New England Operating Procedure No. 19
- Implemented in **DAM** and **RAA**

Transmission Contingency Constraints: Example

- The following example illustrates
  - The effect of a transmission contingency constraint on the ISO's DA dispatch solution
  - DA prices that cover incremental costs

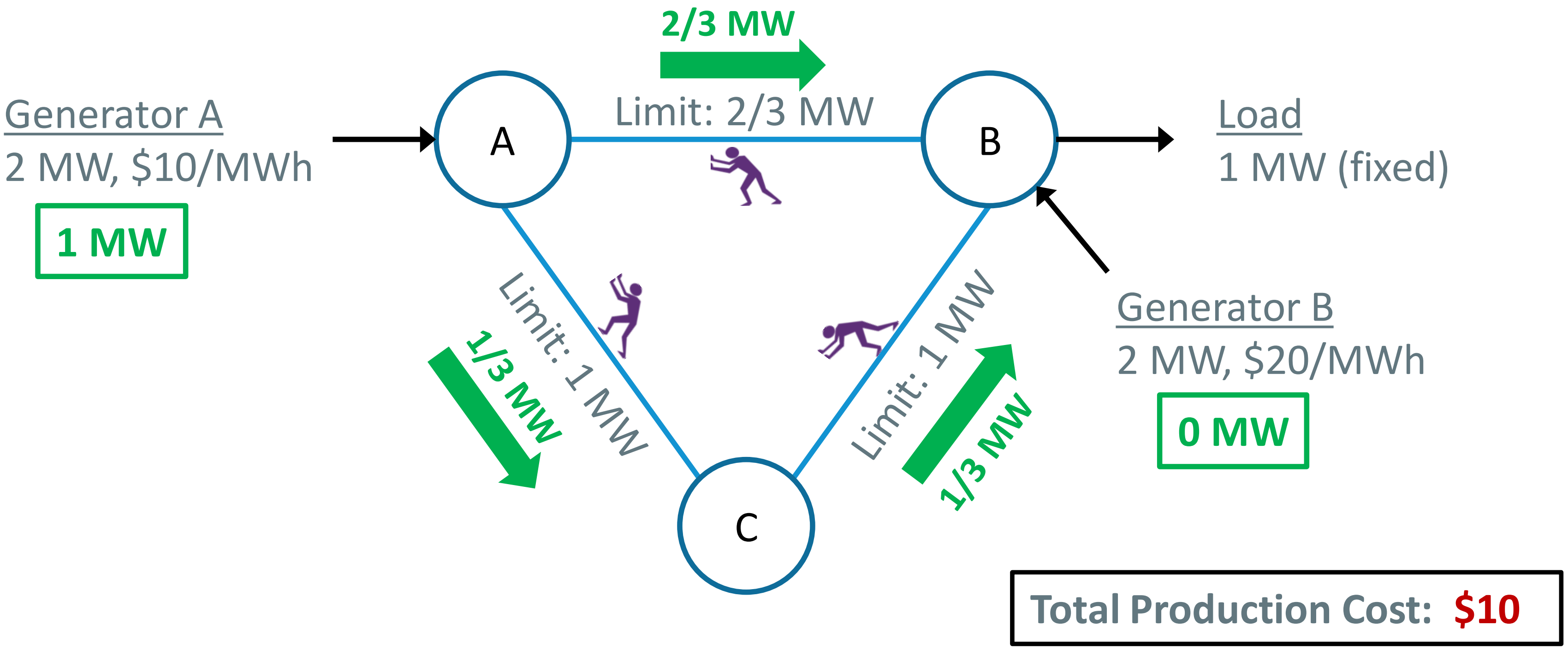
Transmission Contingency Constraints: Example

- Consider the following dispatch problem
  - All lines have the same impedance ( )
  - For simplicity, assume normal and LTE transmission limits are same



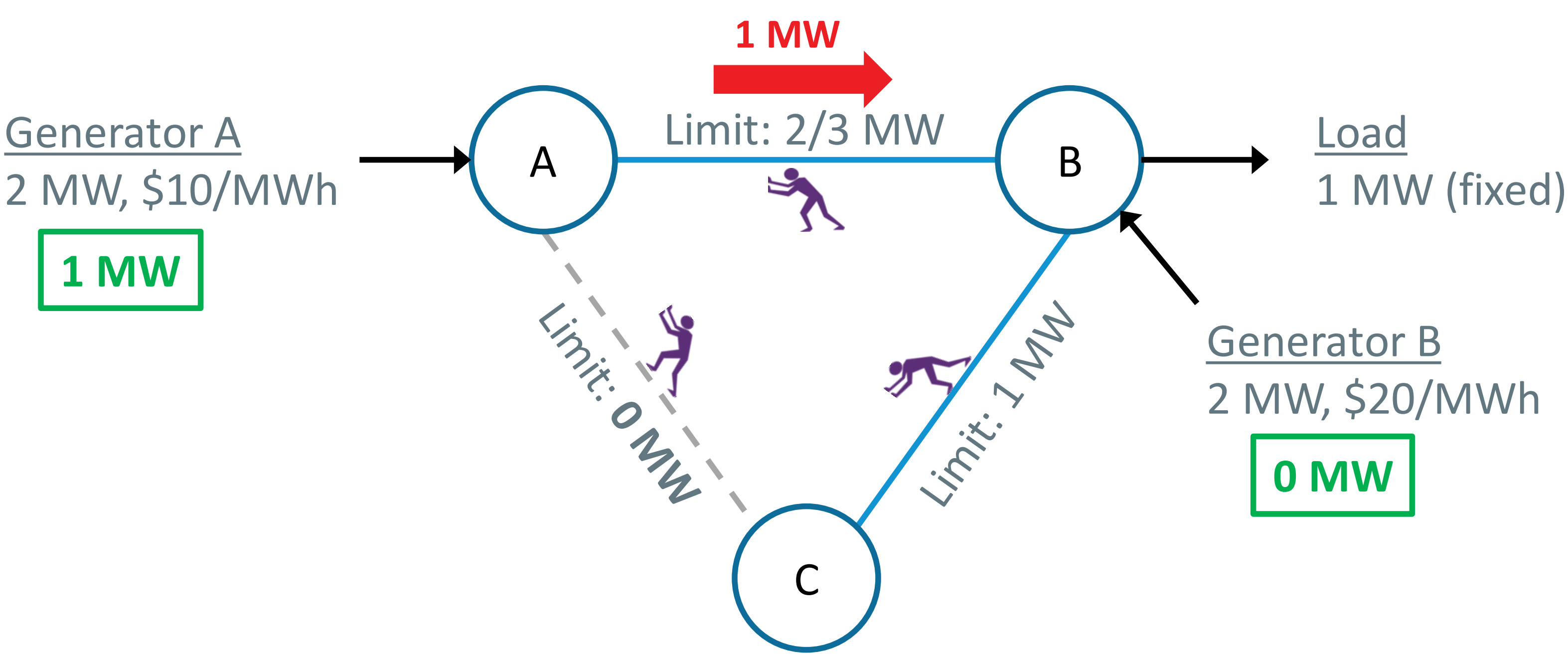
Transmission Contingency Constraints: Example

- Without contingency constraints, the optimal (least-cost) dispatch solution uses only Generator A



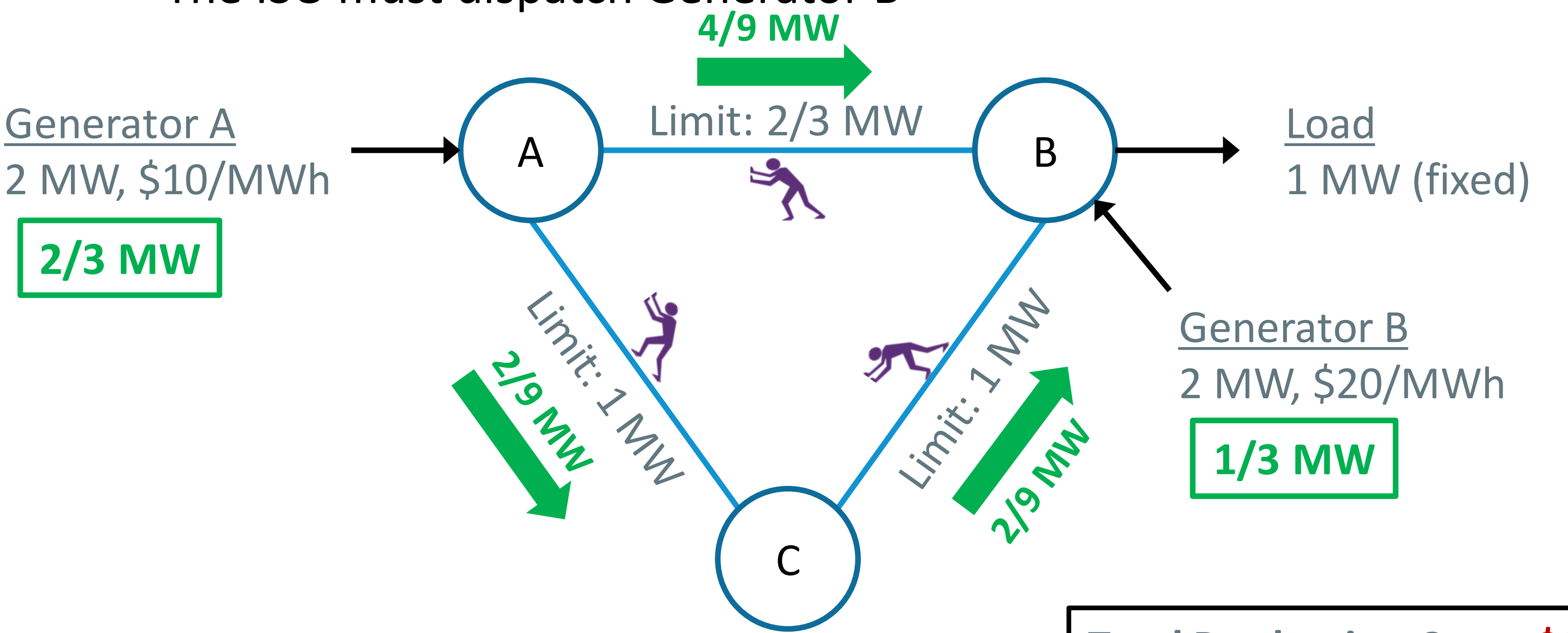
Transmission Contingency Constraints: Example

- Problem: This solution is not reliable if Line A-C fails



Transmission Contingency Constraints: Example

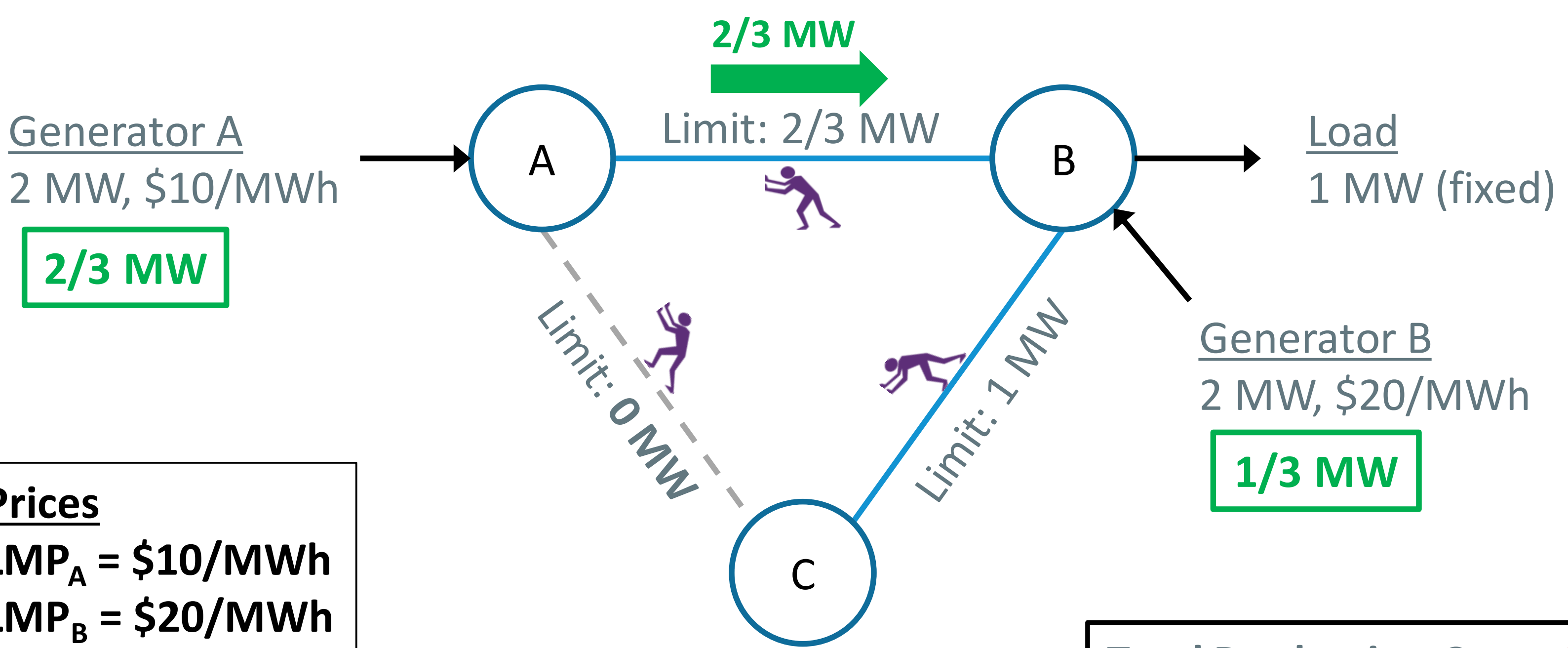
- The transmission contingency constraint limits Generator A's output to 2/3 MW
  - The ISO must dispatch Generator B



Total Production Cost: **$13.33**

Transmission Contingency Constraints: Example

- This solution is reliable if Line A-C fails
- The LMPs reflect the cost of this reliability



Prices
LMP_A = $10/MWh
LMP_B = $20/MWh
LMP_C = $20/MWh

Total Production Cost: $13.33

Transmission Contingency Constraints: Analysis

1) Efficient
   – Because DA commitment and RAA use the same transmission contingency constraints, the sequential DAM-RAA process should not commit inefficient generators

2) Transparent
   – Constraints affect DA prices (LMP congestion components)
   – DA prices cover incremental costs

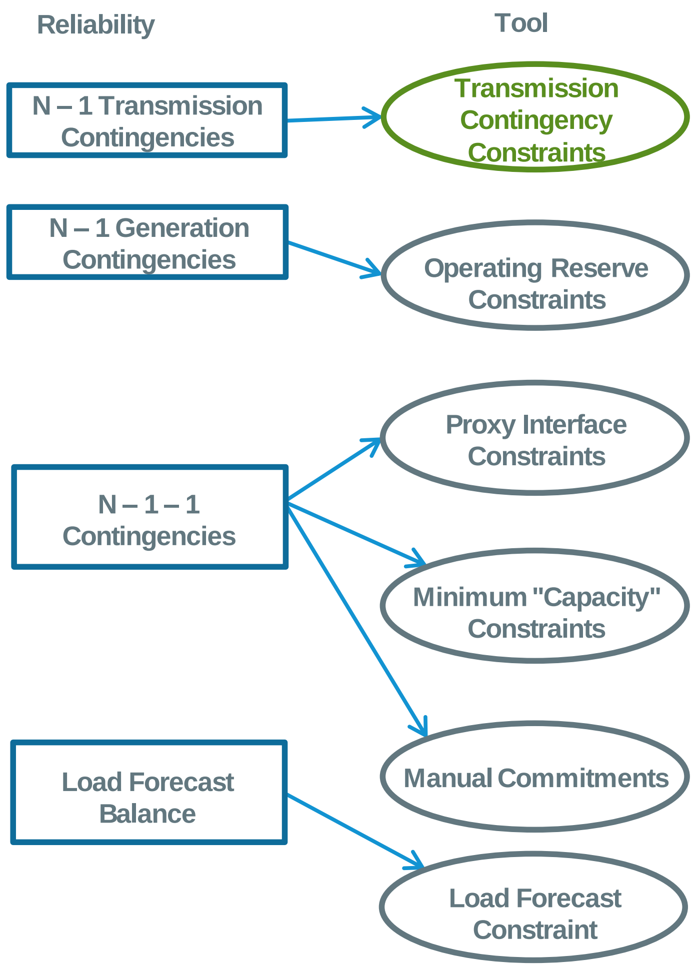
3) Simple
   – Same constraint model as the real-time market

Transmission Contingency Constraints: Summary

- Post-contingency transmission limits in DAM and RAA
- Satisfies ETS principles

- Conclusion: No reason to change DA modeling of transmission contingency constraints

Mapping: Reliability Requirement → Tool



ETS principles satisfied

Operating Reserve Constraints

- Operating reserve requirements that ensure generation recovery within a specified time of a generator failure

$$\Sigma(\text{Operating reserve designations}) \geq \text{Requirement}$$

- Requirement: Largest potential supply losses
- ISO-NE implementation depends on the problem
  - **DA commitment:** TMSR, Total-10, and Total-30 (System)
  - **DA dispatch and pricing**: None
  - **RAA:** TMSR, Total-10, and Total-30 (System and Local)
- Operating reserves in the DA timeframe are <u>not</u> priced products in ISO New England markets

Operating Reserve Constraints: Example

- The following example illustrates
  - The effect of an operating reserve constraint on the ISO's DA commitment and dispatch solutions
  - DA prices that do not cover incremental costs
- For concreteness, it can be assumed that this example studies a Total-10 constraint
  - Requirement = 120% of expected largest supply

Includes 20% non-performance adjustment

Operating Reserve Constraints: Example

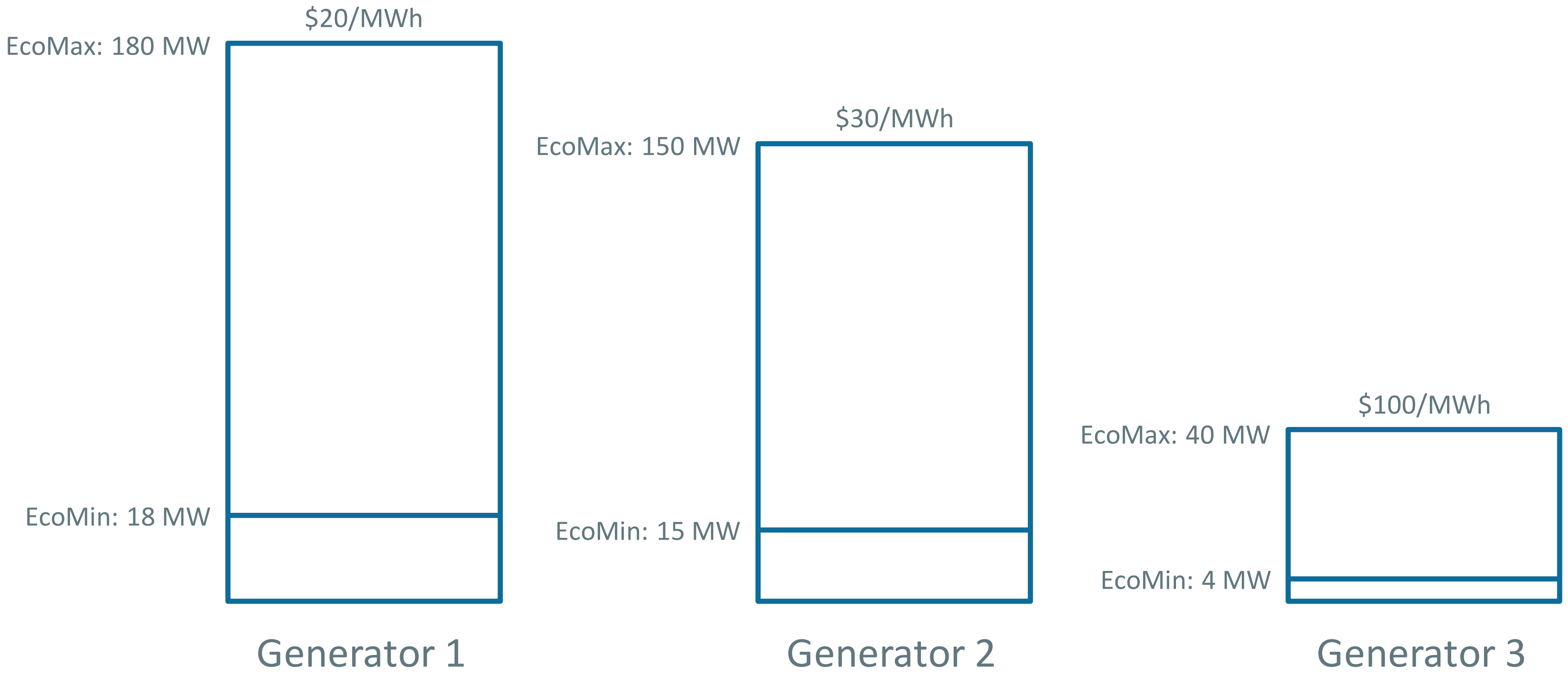
- Consider the following DAM problem
  - Bid-in load = 175 MW
  - Operating reserve requirement = 30 MW

	EcoMin (MW)	EcoMax (MW)	Incremental cost ($/MWh)	Start-up fee ($)	Max online operating reserve capability (MW)	Offline operating reserve capability (MW)
Generator 1*	18	180	20	1800	20	0
Generator 2	15	150	30	1500	20	0
Generator 3	4	40	100	100	20	0

* Generator 1 can be thought of as a group of generators, the largest of which is 25 MW (sets the operating reserve requirement at 30 MW)

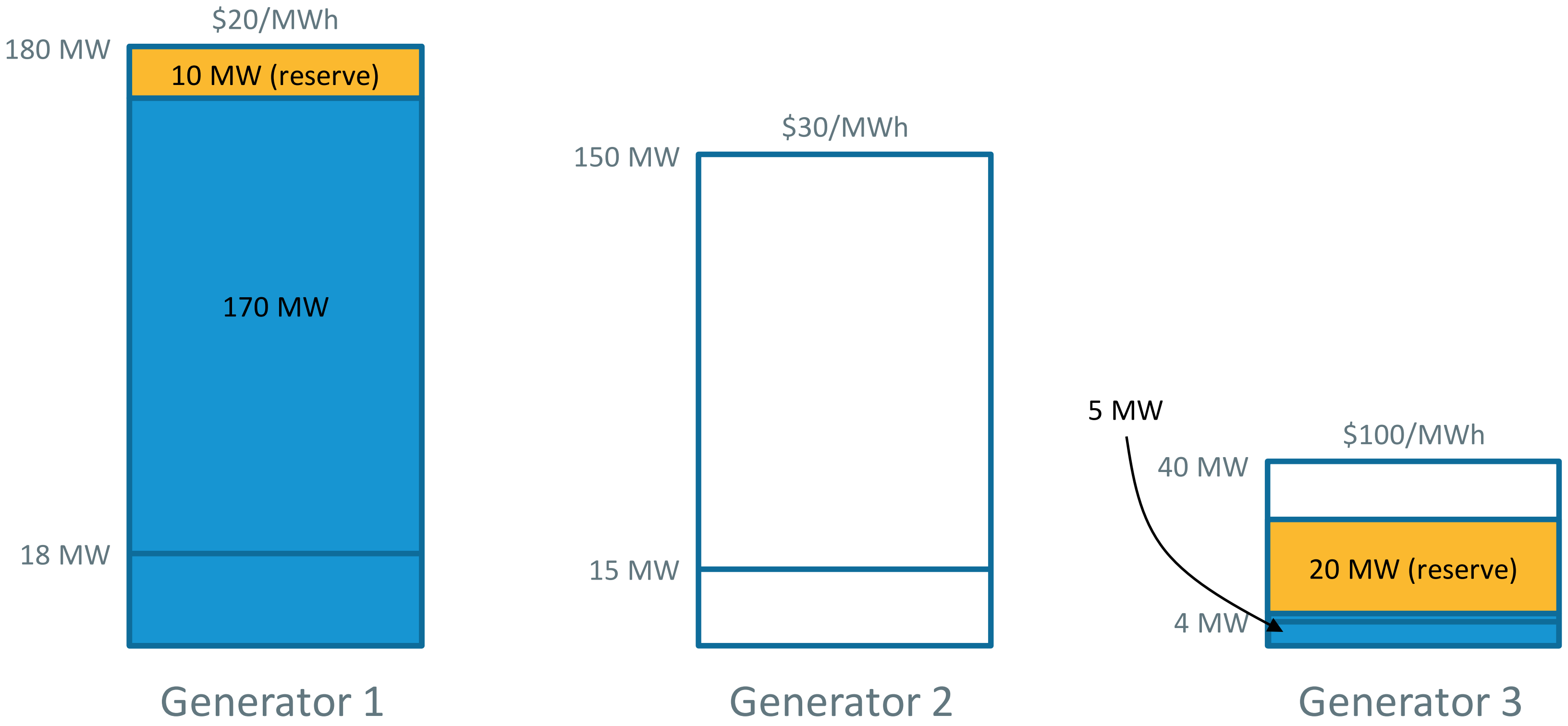
Operating Reserve Constraints: Example

- Consider the following DAM problem
  - Bid-in load = 175 MW
  - Operating reserve requirement = 30 MW



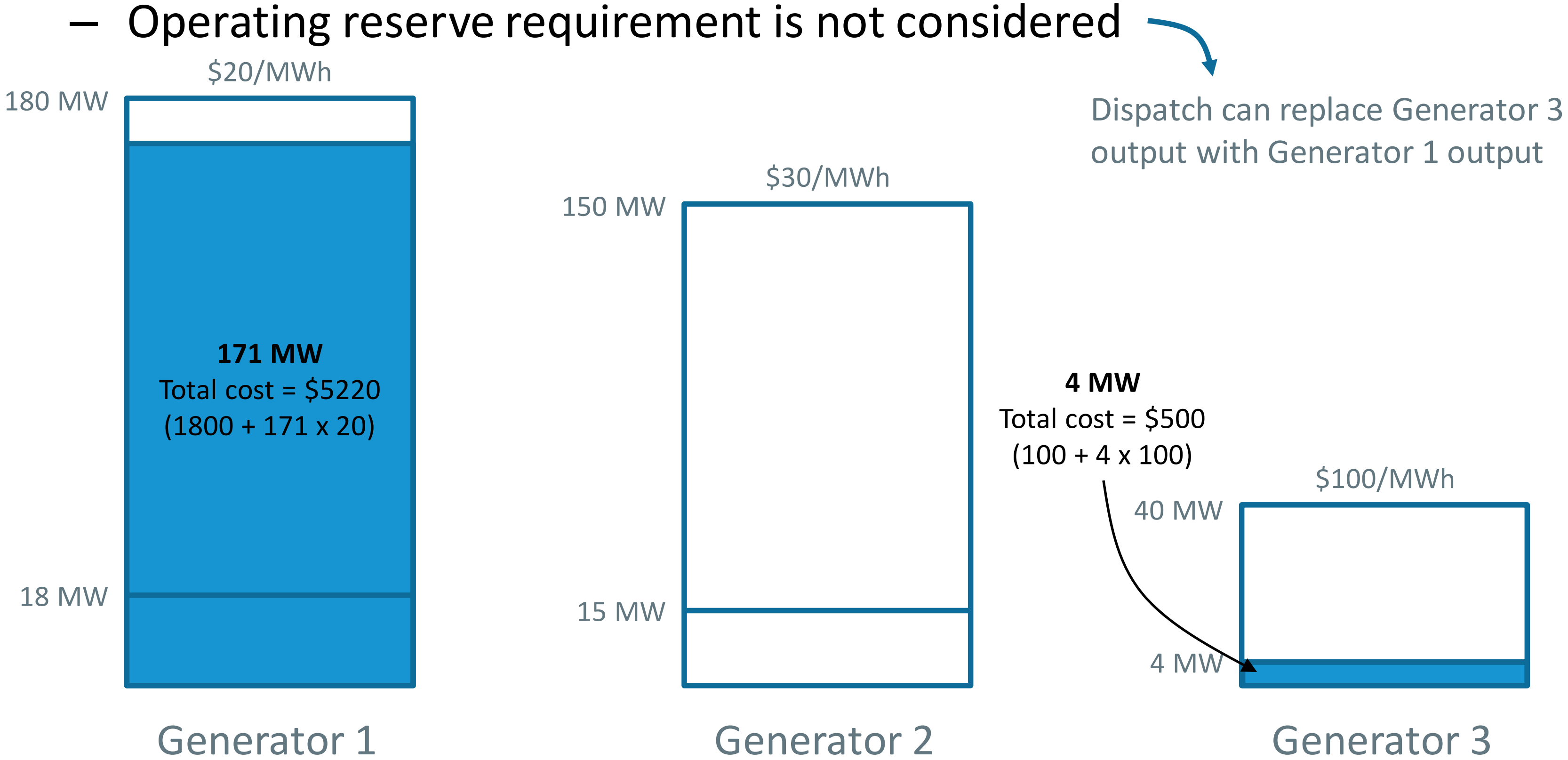
Operating Reserve Constraints: Example

- DA commitment solution
  - Operating reserve requirement → 2 generators must be committed
  - The least-cost solution commits Generators 1 and 3



Operating Reserve Constraints: Example

- DA dispatch solution
  - Generators 1 and 3 are online
  - Operating reserve requirement is not considered



Operating Reserve Constraints: Example

- In DA dispatch problem, how much would the optimal production cost change due to the next MW of load?
  - DA LMP = $20/MWh
- In the DA dispatch problem, there is no operating reserve requirement and (therefore) no operating reserve price
- The DA LMP does not cover incremental costs
  - Generator 1 incremental cost = $20/MWh = DA LMP
  - Generator 3 incremental cost = $100/MWh > DA LMP

Operating Reserve Constraints: Example

- RAA solution
  - Operating reserve requirement is considered again
  - No additional commitments are needed if load forecast ≤ 190 MW

Operating Reserve Constraints: Analysis

1) Efficient*
   – Because DA commitment and RAA use the same operating reserve constraints, the sequential DAM-RAA process should not commit inefficient generators

2) Not transparent
   – Constraints do not directly affect DA prices
   – DA prices may not cover incremental costs

3) Simple

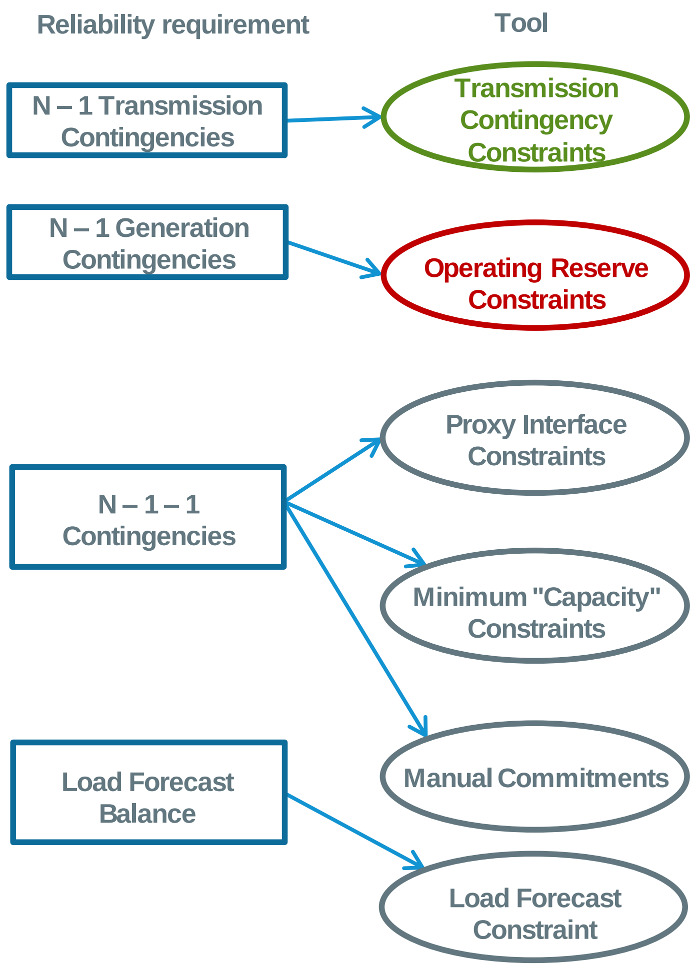
* The lack of zonal reserves in DA commitment is being ignored (they are usually irrelevant)

Operating Reserve Constraints: Summary

- Operating reserve requirements in DA commitment and RAA
- Does not satisfy ETS principles

- Conclusion: Possible improvement opportunity
  - Other ISOs clear and price DA reserve products to address this concern
  - To be discussed in a future session

Mapping: Reliability Requirement → Tool



ETS principles not satisfied

Proxy Interface Constraints

- Idea: Limit power flow over a transmission interface (typically for a major load pocket)
- Two different purposes
  1. **N – 1 – 1 security:** Ensure ability to recover from an N – 1 contingency within 30 minutes
     - ISO considers line-line, gen-line, and gen-gen losses
  2. **Voltage or stability limits:** Ensure ability to satisfy voltage or stability requirements
     - Will not be discussed here (the mathematical complexity of these limit calculations makes improvement unlikely at this time)

Proxy Interface Constraints for N – 1 – 1 Security

- Pre-contingency transmission limits across interfaces that ensure acceptable system conditions after N – 1 – 1 contingencies

  Interface pre-contingency flow ≤ Proxy interface limit

- Proxy interface limit: Offline transmission system studies
- Implemented in **DAM** and **RAA**
- In the DAM, effect is similar to contingency constraints for N – 1 transmission contingencies
  - Satisfies ETS principles

Proxy Interface Constraints

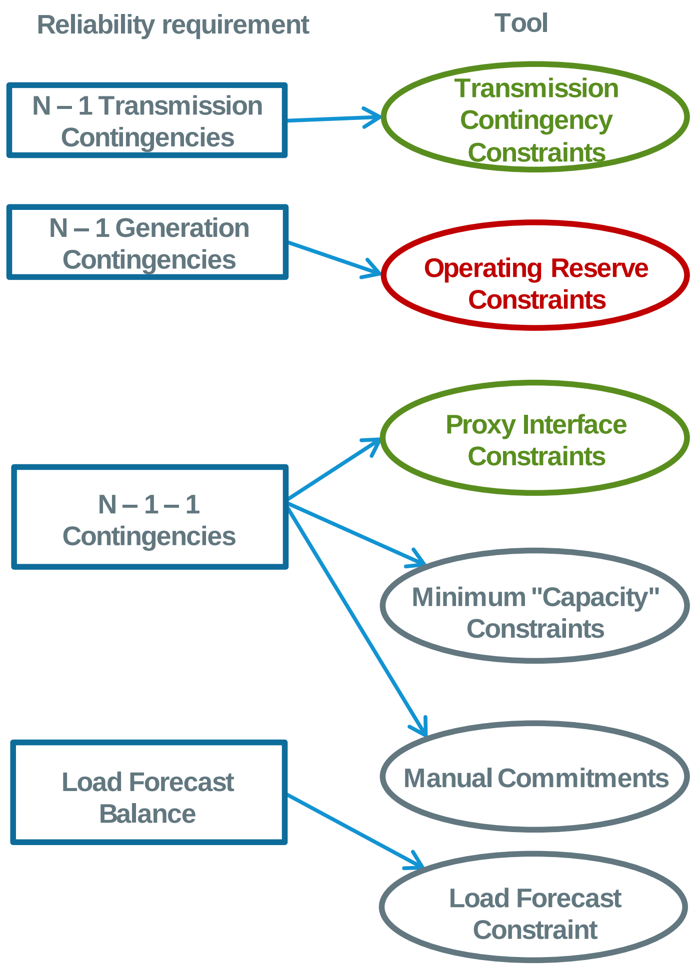
- Caveat: Cleared virtual transactions affect interface flow in the DAM solution
  - Implication: DAM interface flows may incorrectly appear OK because of virtual transactions
  - The ISO uses other reliability tools when this situation is observed
- Conclusion: Proxy interface constraints satisfy the ETS principles but cannot always guarantee a reliable next-day Operating Plan

Proxy Interface Constraints: Summary

- Pre-contingency transmission limits across interfaces in DAM and RAA
- Satisfies ETS principles when they work

- Conclusion: No reason to change DA modeling of proxy interface constraints

Mapping: Reliability Requirement → Tool



ETS principles satisfied

Minimum "Capacity" Constraints

- Idea: Require a minimum amount of physical generation within a local area (typically a major load pocket)
  - This constraint is not directly related to EcoMax values, hence “capacity”
- Two different purposes
  1. **N – 1 – 1 security:** Ensure ability to recover from an N – 1 contingency within 30 minutes
     - ISO considers line-line, gen-line, and gen-gen losses
  2. **Voltage or stability limits:** Ensure ability to satisfy voltage or stability requirements
     - Will not be discussed here (the mathematical complexity of these limit calculations makes improvement unlikely at this time)
- In general, these constraints are used when proxy interface constraints do not work

Minimum "Capacity" Constraints

- Local area dispatch requirements that ensure acceptable system conditions after N – 1 – 1 contingencies

  $$\Sigma(\text{DDPs of physical units in local area}) \geq \text{Requirement}$$

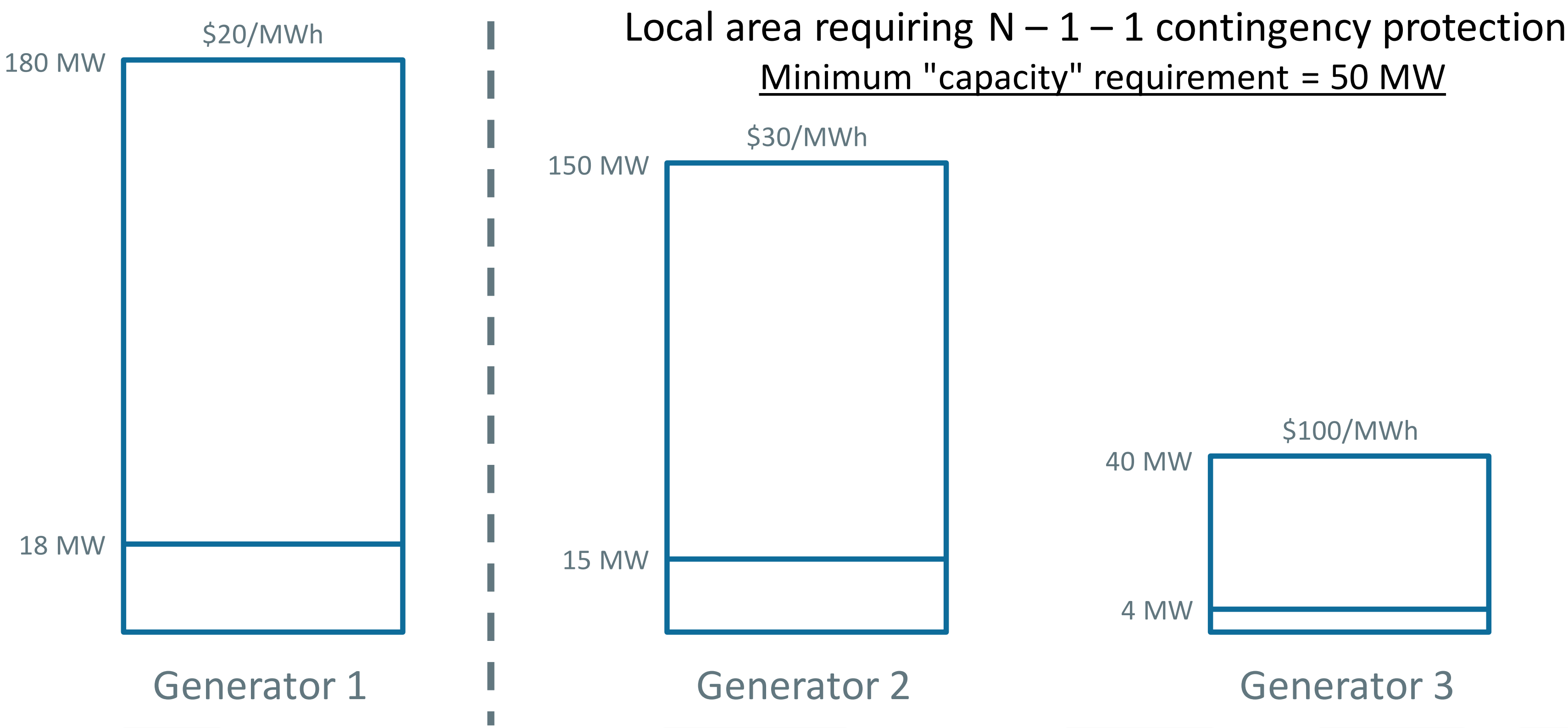
- Requirement: Area load forecast – Proxy interface limit
- Implemented in **DA commitment**
  - The physical nature of this constraint in DA commitment implies that it is not needed in **RAA**

Minimum "Capacity" Constraints: Example

- The following example illustrates
  - The effect of a minimum “capacity” constraint on the ISO’s DA commitment and dispatch solutions
  - DA prices that do not cover incremental costs

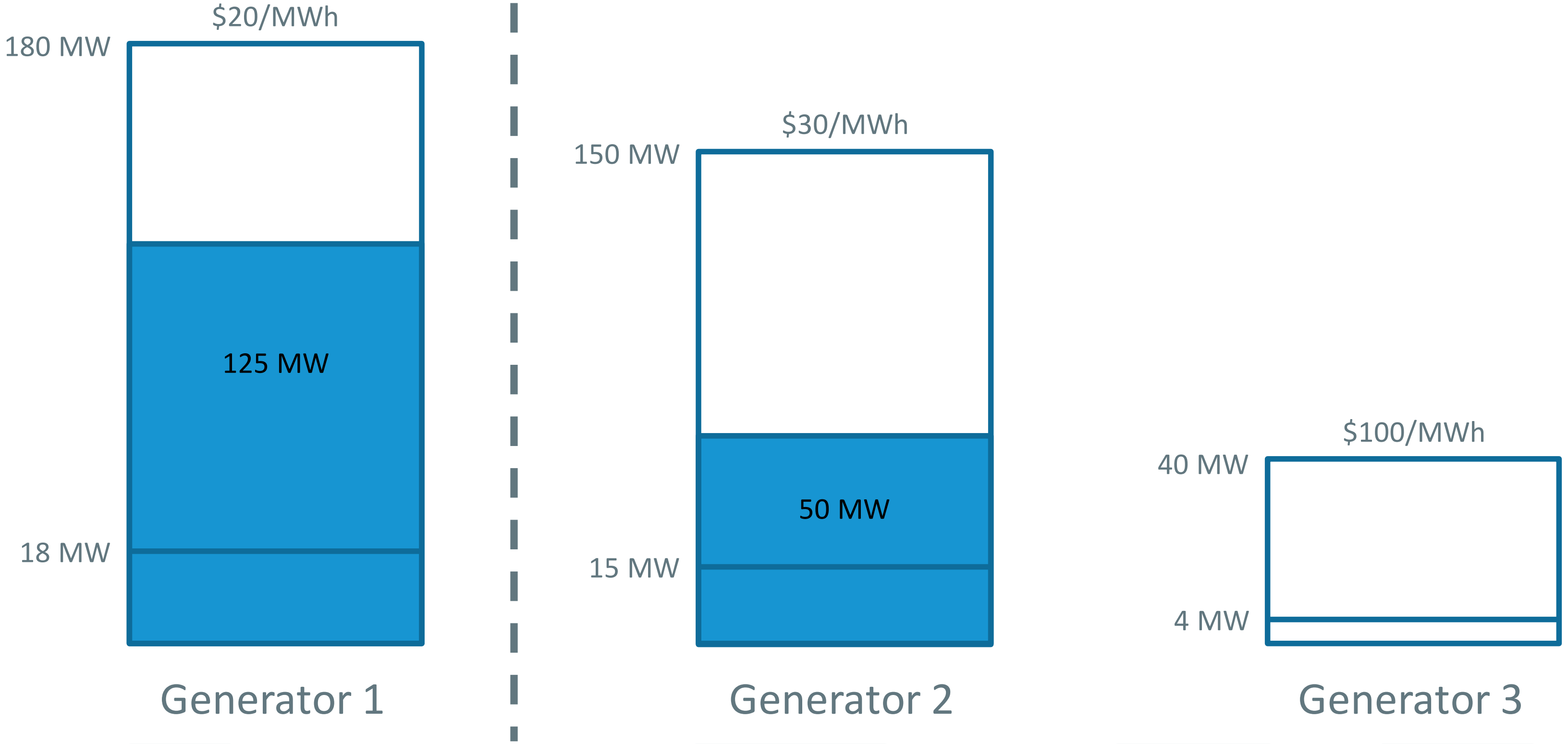
Minimum "Capacity" Constraints: Example

- Consider the following DAM problem
  - Bid-in load = 175 MW



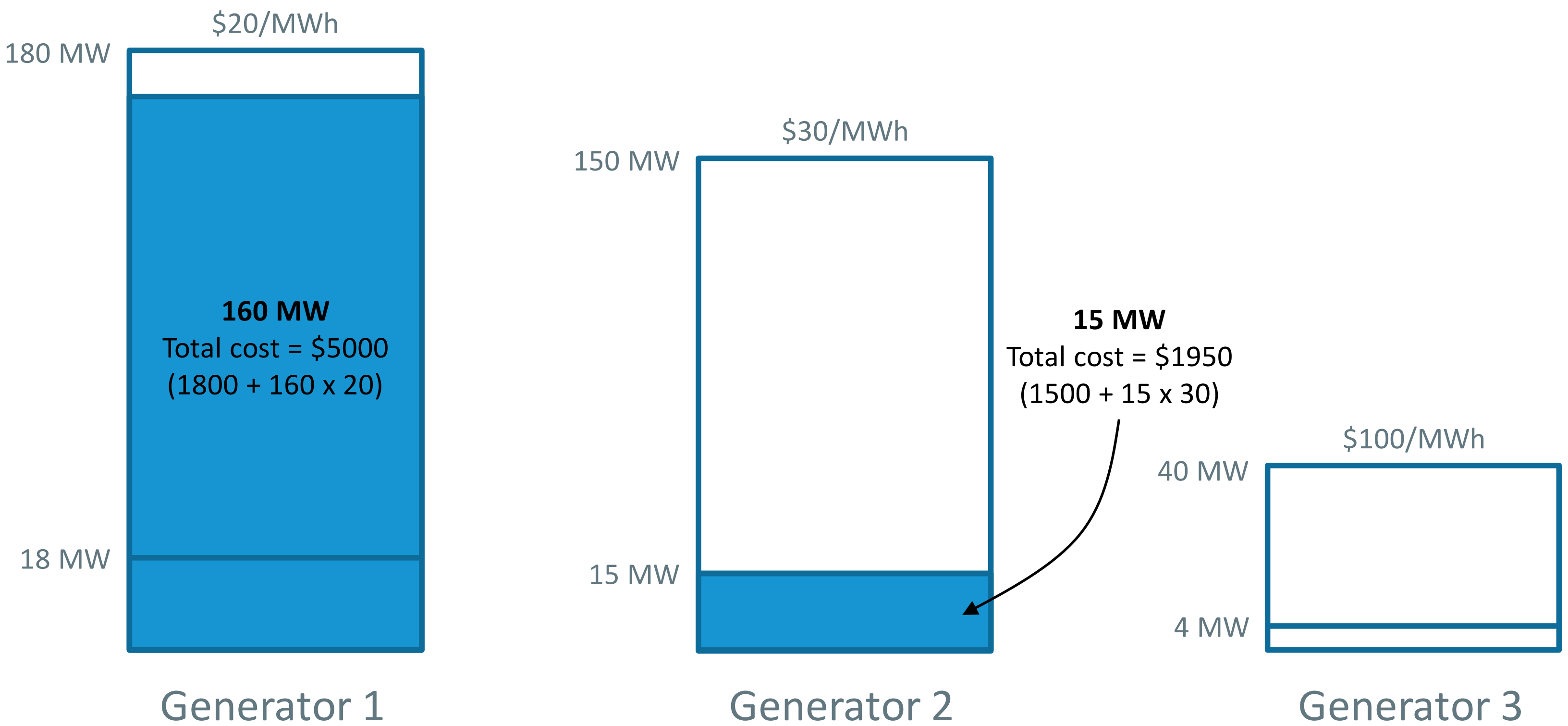
Minimum "Capacity" Constraints: Example

- DA commitment solution
  - ISO must commit either Generator 2 or Generators 2 and 3
  - The least-cost solution commits Generators 1 and 2



Minimum "Capacity" Constraints: Example

- DA dispatch solution
  - Generators 1 and 2 are online
  - No minimum "capacity" requirement



Minimum "Capacity" Constraints: Example

- In DA dispatch problem, how much would the optimal production cost change due to the next MW of load?
  - DA LMP = $20/MWh

- The DA LMP does not cover incremental costs
  - Generator 1 incremental cost = $20/MWh = DA LMP
  - Generator 2 incremental cost = $30/MWh > DA LMP

Minimum "Capacity" Constraints: Analysis

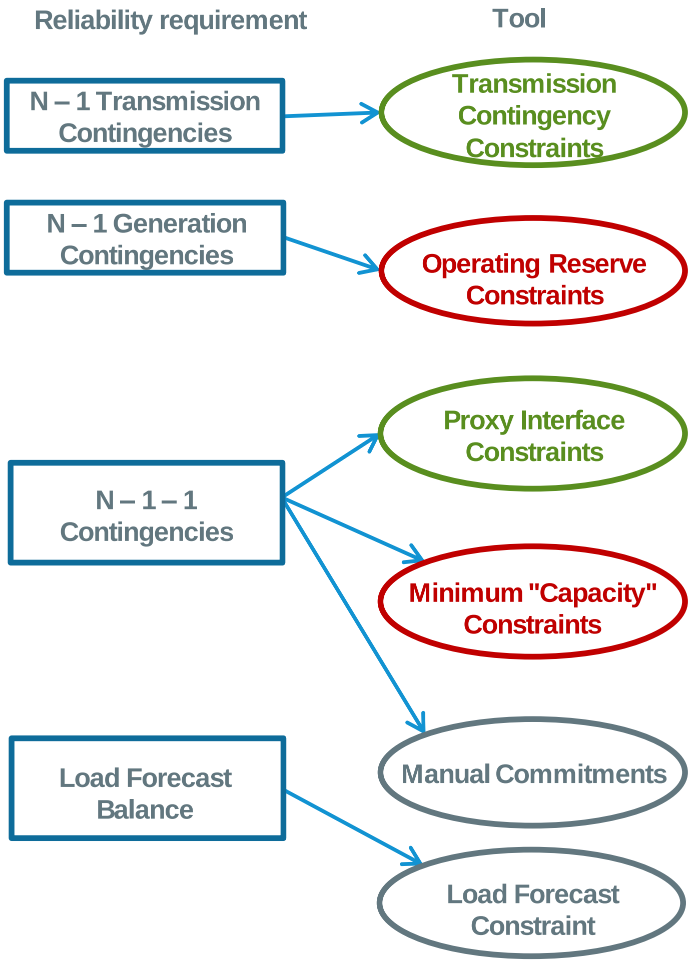
1) Efficient
   – Because minimum "capacity" constraints are for physical generation in DA commitment, the sequential DAM-RAA process should not commit inefficient generators
2) Not transparent
   – Constraints do not directly affect DA prices
   – DA prices may not cover incremental costs
3) Not simple
   – Requires area load forecast

Minimum "Capacity" Constraints: Summary

- Local area dispatch requirements in DA commitment and RAA
- Does not satisfy ETS principles

- Conclusion: Possible improvement opportunity
  - Dynamic local reserve zones may help address this concern
  - To be discussed in a future session

Mapping: Reliability Requirement → Tool



ETS principles not satisfied

Manual Commitments

- Unit-specific commitments to address DA reliability requirements, particularly when other tools either:
  - Do not offer any advantage (*next slide*), or
  - Cannot solve a reliability concern
- Can be made either before or after DAM
  - If made prior to DAM, respected in **DAM** and **RAA**
  - If made after DAM, respected in **RAA**

Manual Commitments

- N – 1 – 1 contingency or voltage/stability
  - Sometimes, only one generator can satisfy the reliability requirement
    - No benefit from proxy interface constraint or minimum "capacity" constraint
      - No DA pricing benefit
      - No efficiency loss

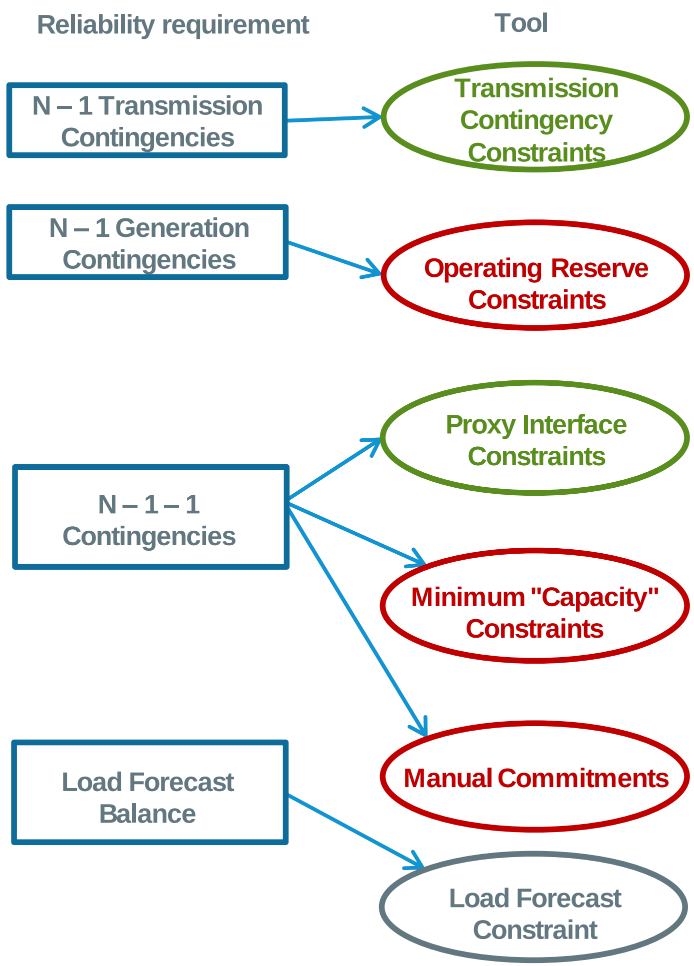
Manual Commitments: Analysis

1) Possibly inefficient
   - Depending on when the manual commitment is made, the sequential DAM-RAA process may commit inefficient generators
2) Not transparent
   - Constraints do not directly affect DA prices
   - DA prices may not cover incremental costs
3) Simple

Manual Commitments: Summary

- Unit-specific commitments in RAA and possibly DAM (depending on creation time)
- Does not satisfy ETS principles
- Conclusions: No practical way to change DA modeling of manual commitments
  - Manual commitments cannot be completely eliminated

Mapping: Reliability Requirement → Tool



ETS principles not satisfied

Load Forecast Constraint

- Requirement that DA load forecast can be satisfied by committed generators

$$\Sigma(\text{DDPs}) = \text{Load forecast}$$

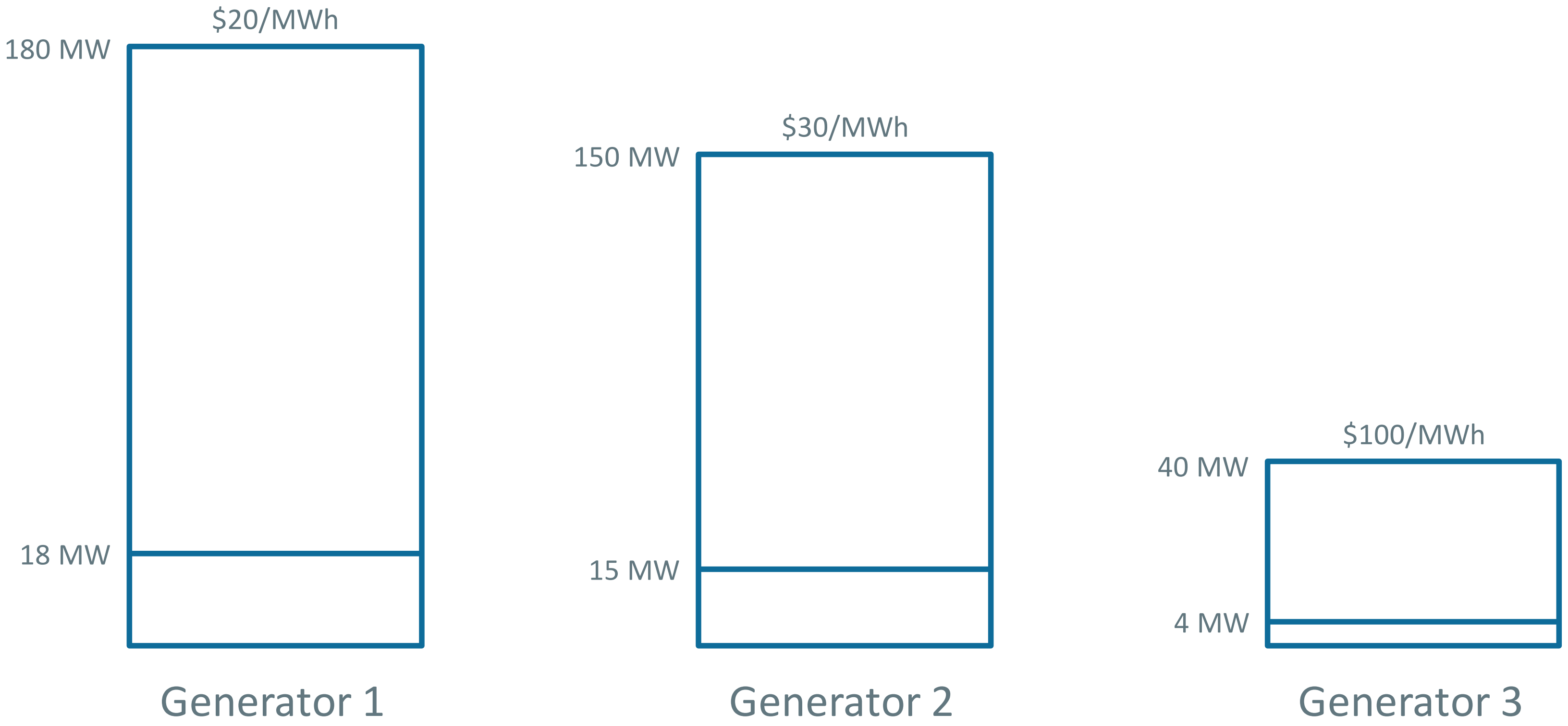
- NERC TOP-002-4 explicitly requires this property for the next-day Operating Plan
- Implemented in **RAA**

Load Forecast Constraint: Example

- The following example illustrates
  - The effect of a load forecast balance constraint on the ISO’s DAM and RAA solutions
  - The absence of DA reimbursement for RAA-committed generators

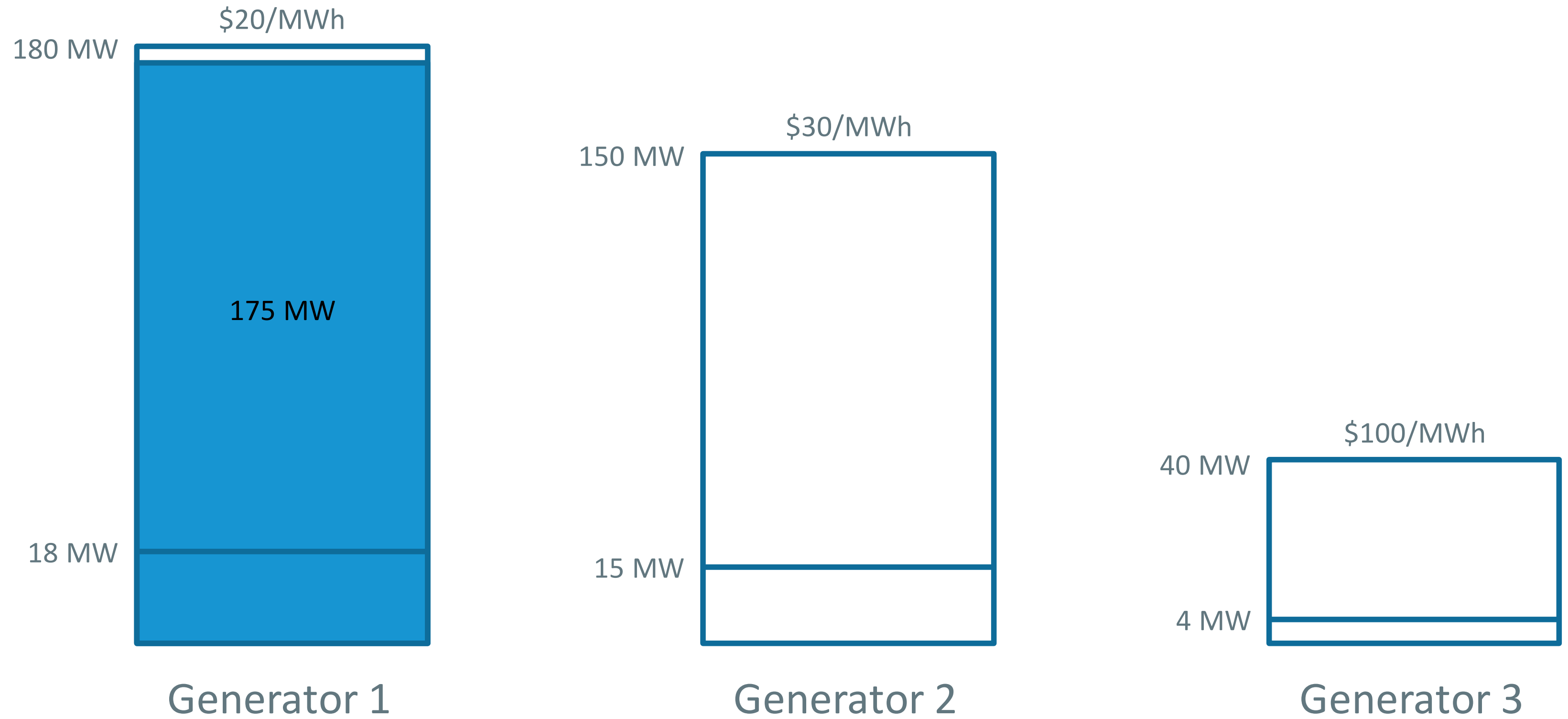
Load Forecast Constraint: Example

- Consider the following DAM problem
  - Bid-in load = 175 MW
  - DA load forecast = 182.5 MW



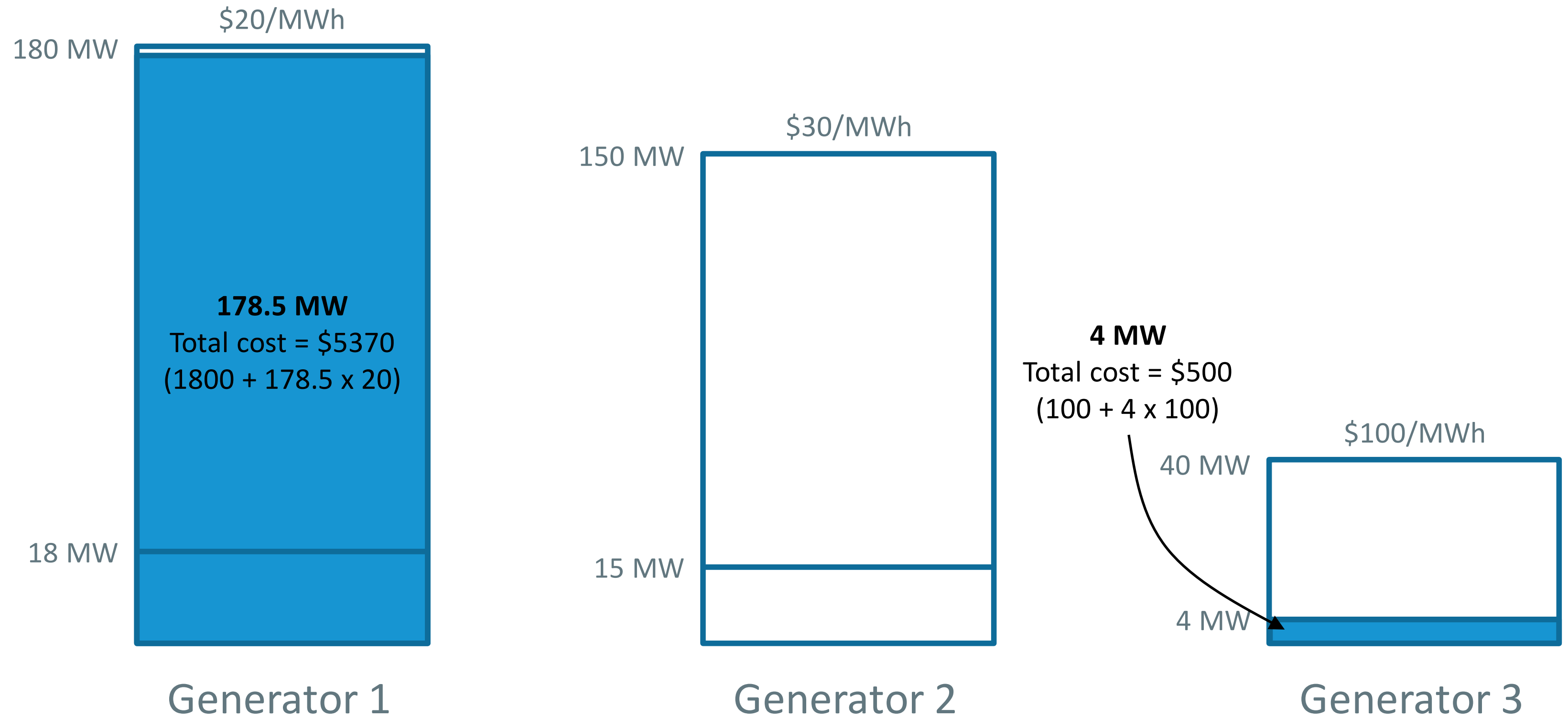
Load Forecast Constraint: Example

- DA commitment and dispatch solution
  - ISO only needs to commit Generator 1 to satisfy bid-in load
  - The LMP is $20/MWh



Load Forecast Constraint: Example

- RAA solution
  - Respect Generator 1 commitment and load forecast constraint
  - The least-cost solution commits Generator 3



Load Forecast Constraint: Example

- Generator 3 is part of the next-day Operating Plan but receives no DA revenue
  - Generator 3 faces real-time price risk
  - Unknown (at the time of commitment) uplift payments

Load Forecast Constraint: Analysis

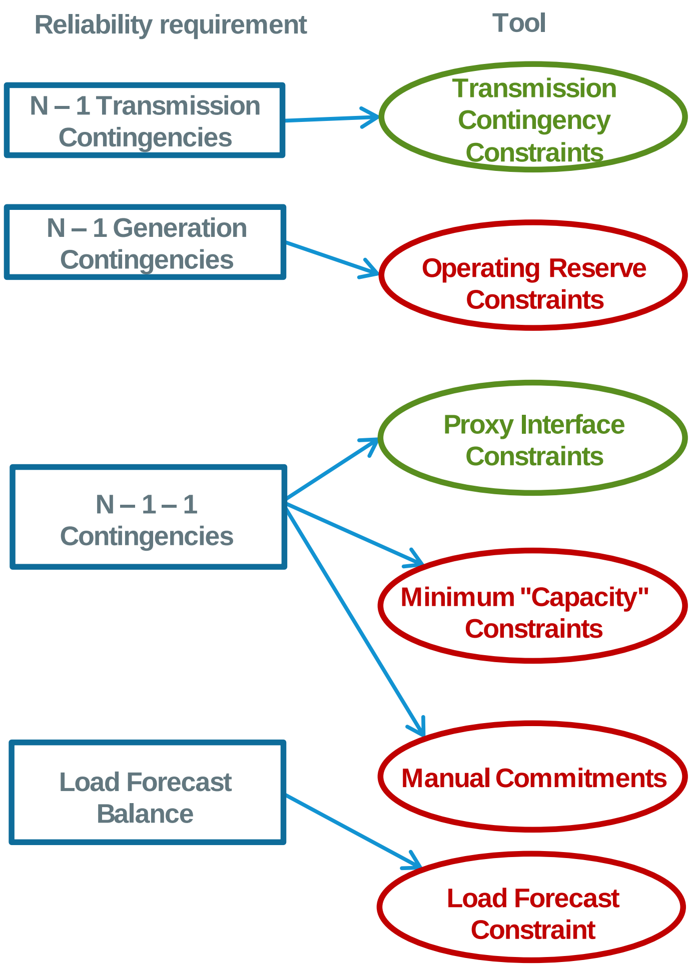
1) Possibly inefficient
   - The sequential DAM-RAA process may commit inefficient generators
2) Not transparent
   - Constraints cannot affect DA prices
   - DA prices may not cover incremental costs
3) Not simple
   - Requires load forecast

Load Forecast Constraint: Summary

- Requirement that RAA satisfies the DA load forecast
- Does not satisfy ETS principles

- Conclusion: Possible improvement opportunity
  - DA products have been proposed by other ISOs to address this concern
  - To be discussed in a future session

Mapping: Reliability Requirement → Tool



ETS principles not satisfied

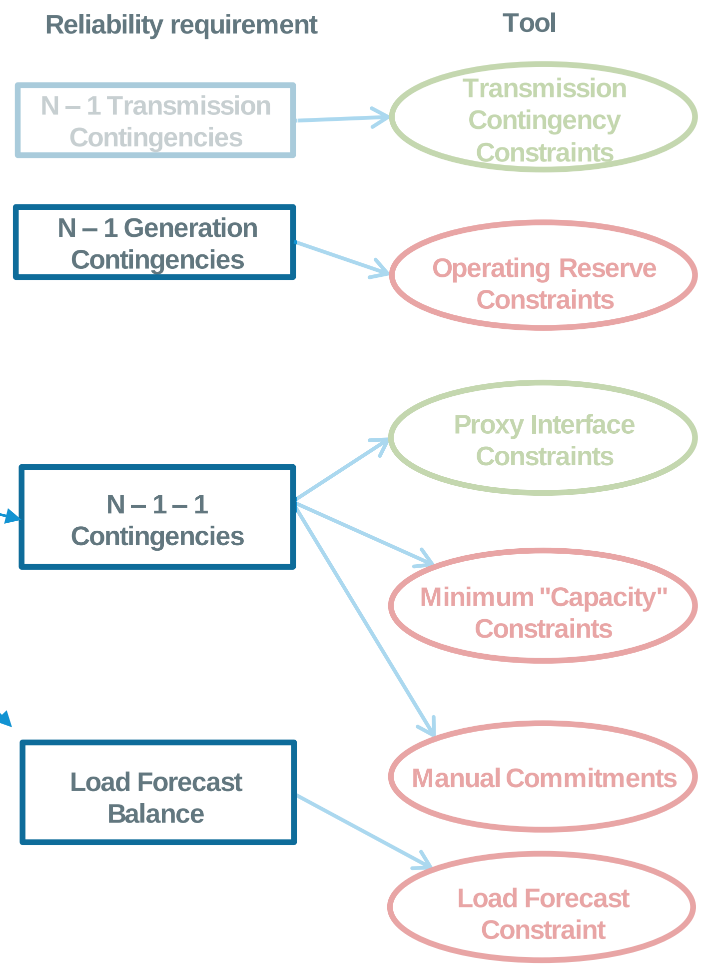
KEY TAKEAWAYS

Key takeaways

- The ISO's next-day Operating Plan must satisfy specific next-day reliability requirements
- Certain reliability tools are not ideal
  - DA products/prices may not reflect actions taken to ensure reliability
- Overcoming the limitations of current reliability tools is neither straightforward nor simple
- Still, some improvements may be possible

Areas of potential improvement

Are there better ways to satisfy these requirements?



Next session

- Study how other ISOs satisfy next-day reliability requirements
- Analyze whether the tools of other ISOs satisfy the ETS principles