Gaps in Current Pricing Methodology

Adam Keech
Executive Director, Market Operations
PJM
Energy Price Formation Senior Task Force
February 15, 2018

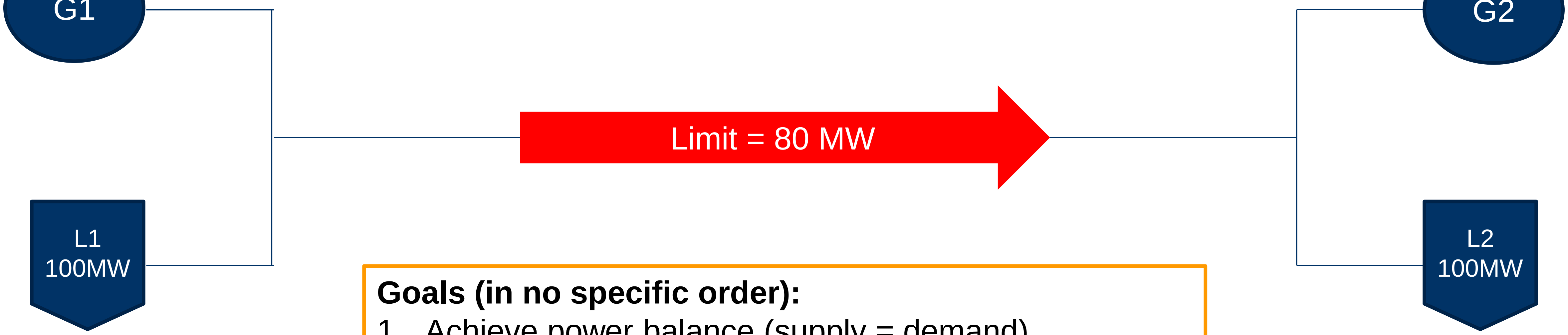
Missing Information in Prices

- There are times when the LMP is unable to send market signals that support the efficient commitment and dispatch of the system
- When this occurs, market participants may have the incentive to deviate from PJM’s instructions
- We use uplift (make whole and LOC) to remove the incentive for generation resources to deviate from dispatch
- PJM believes all known pricing methods require some level of uplift to support commitment and dispatch instructions

Example: Unit Commitment Process

EcoMax = 300 MW
EcoMin = 50 MW
Offer = $50/MWh
Startup Cost = $0
No-Load = $200/hr
Sched. Rate (EcoMax) = $50.67/MWh

EcoMax = 200 MW
EcoMin = 50 MW
Offer = $80/MWh
Startup Cost = $100
No-Load = $200/hr
Sched. Rate (EcoMax) = $81.50/MWh



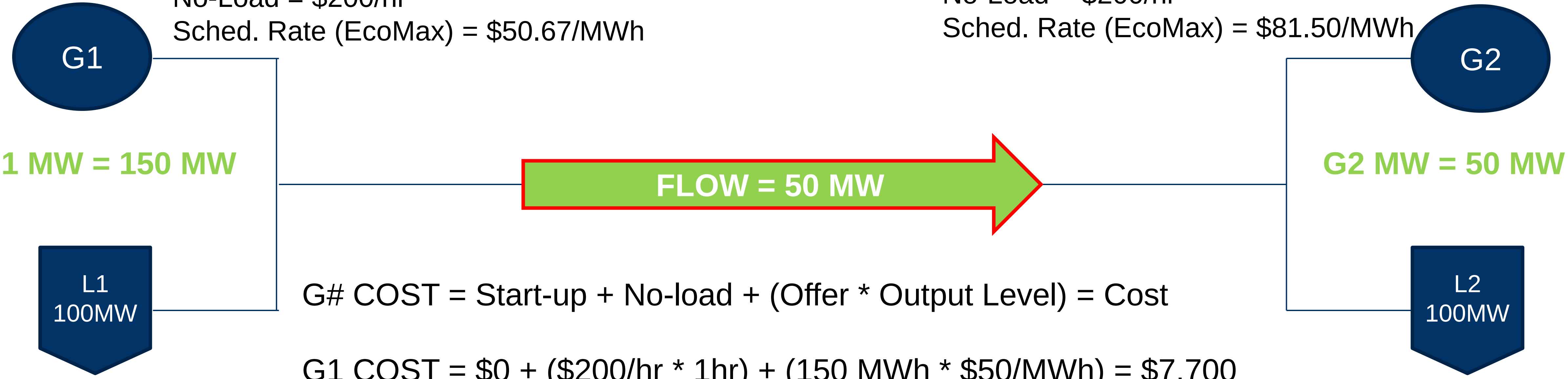
Goals (in no specific order):

1. Achieve power balance (supply = demand)
2. Adhere to all limitations (ecomin/max, transmission limits, etc.)
3. Minimize bid production cost (BPC) in the process

Example 1: Commitment and Dispatch Solution

EcoMax = 300 MW
EcoMin = 50 MW
Offer = $50/MWh
Startup Cost = $0
No-Load = $200/hr
Sched. Rate (EcoMax) = $50.67/MWh

EcoMax = 200 MW
EcoMin = 50 MW
Offer = $80/MWh
Startup Cost = $100
No-Load = $200/hr
Sched. Rate (EcoMax) = $81.50/MWh



G# COST = Start-up + No-load + (Offer * Output Level) = Cost

G1 COST = $0 + ($200/hr * 1hr) + (150 MWh * $50/MWh) = $7,700

G2 COST = $100 + ($200/hr * 1hr) + (50 MWh * $80/MWh) = $4,300

BPC = G1 COST + G2 COST = $12,000

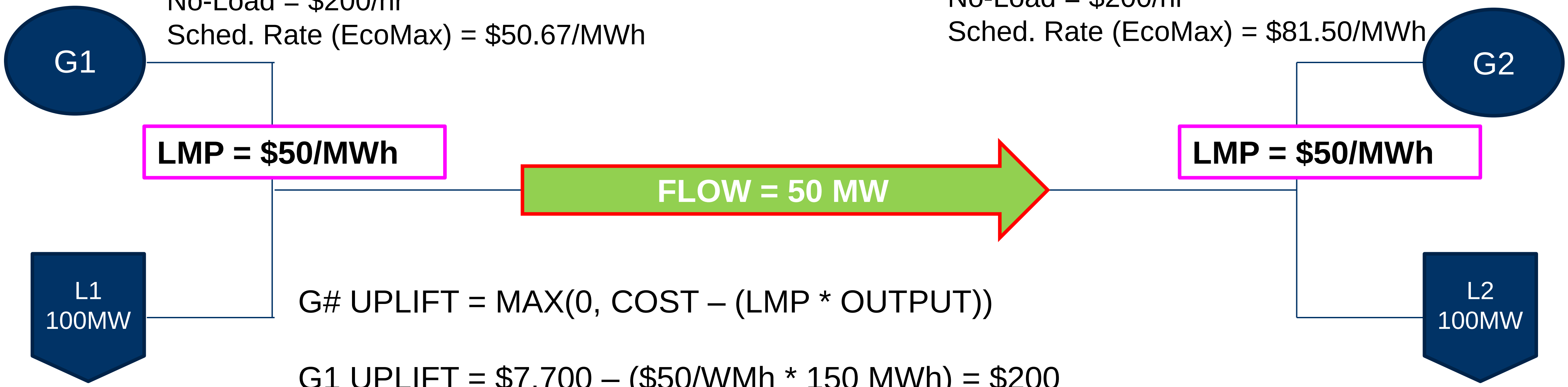
Example 1: Commitment and Dispatch Solution

- If the limit on the line were 100 MW or greater only G1 would be needed to serve all load
  - LMP = $50/MWh across the system
- G2 has an EcoMin = 50 MW which must be adhered to in the commitment/dispatch process
- Because G2 is committed at 50 MW, G1's output is reduced to 150 MW to maintain power balance

Example 1: Current LMP Calculation

EcoMax = 300 MW
EcoMin = 50 MW
Offer = $50/MWh
Startup Cost = $0
No-Load = $200/hr
Sched. Rate (EcoMax) = $50.67/MWh

EcoMax = 200 MW
EcoMin = 50 MW
Offer = $80/MWh
Startup Cost = $100
No-Load = $200/hr
Sched. Rate (EcoMax) = $81.50/MWh



G# UPLIFT = MAX(0, COST – (LMP * OUTPUT))

G1 UPLIFT = $7,700 – ($50/WMh * 150 MWh) = $200

G2 UPLIFT = $4,300 – ($50/MWh * 50 MWh) = $1,800

TOTAL UPLIFT = $2,000

Example 1: Missing Information in Prices

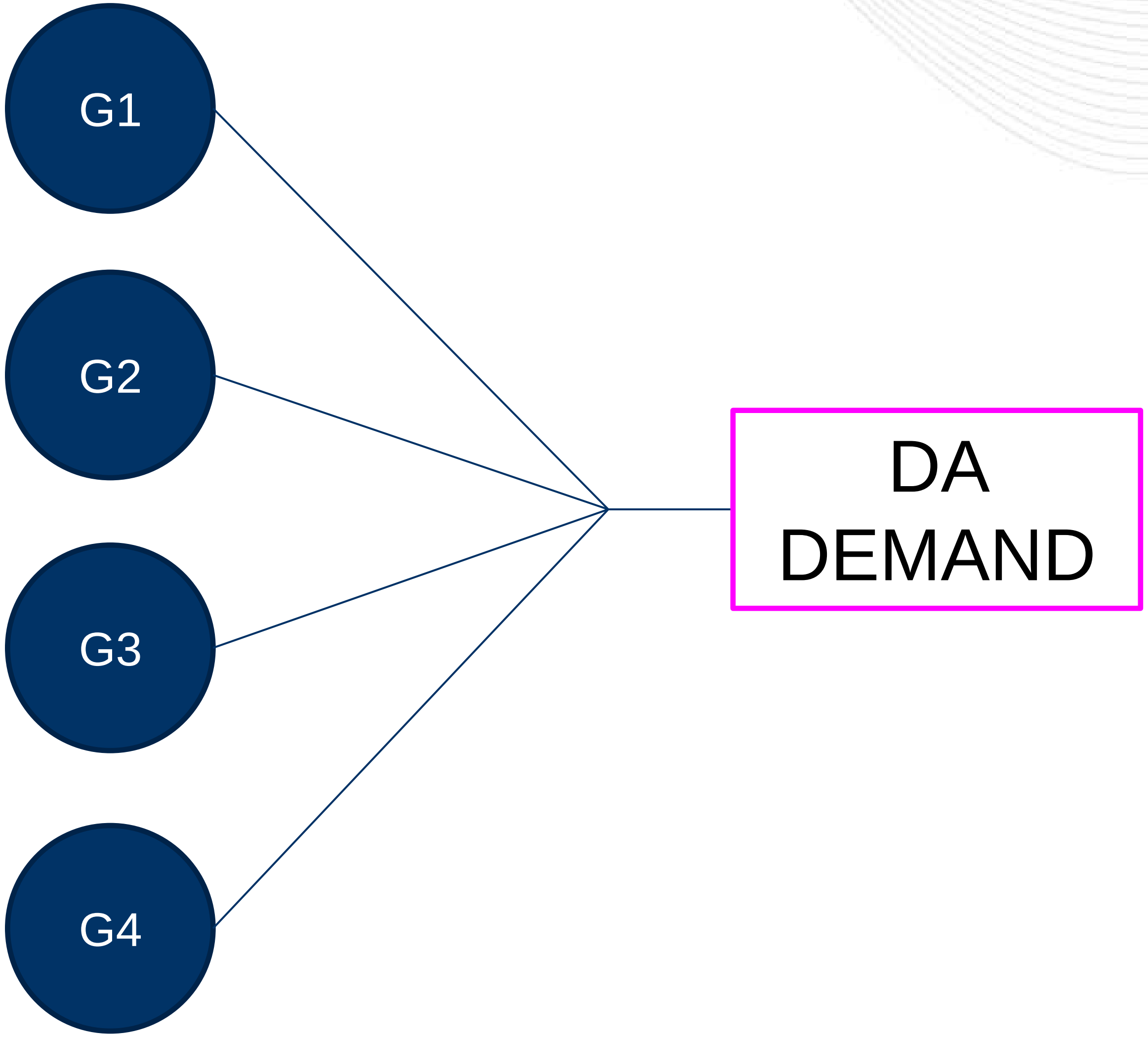
- The next MW of load would be serve by G1 thus the LMP = $50/MWh
- The transmission constraint is not binding so prices are uniform across the system

- **Prices do not reflect G2 as being needed**
- **The need for G2 is reflected through uplift payments which are not transparent and shift costs**

Example 1: Uplift Allocation

- Assume this scenario occurs in the Day-ahead Market
  - DA Uplift is allocated to all withdrawal transactions on a pro-rata basis
    - Cleared DA demand, DECs, price-sensitive demand, exports
  - L1 and L2 will both be allocated a pro-rata share of the cost to make units G1 and G2 whole ($1,000 each)
  - L1 and L2 pay the same price despite the fact that G2 is needed to serve load at L2 and not L1

Example 2: Impacts on Balancing Settlement



- Units G1-G4 able to be scheduled to serve load in the DAM
- DA Demand = 550 MW
- G1 and G2 are flexible
- G3 and G4 are inflexible

Example 2: Generator Offer Data

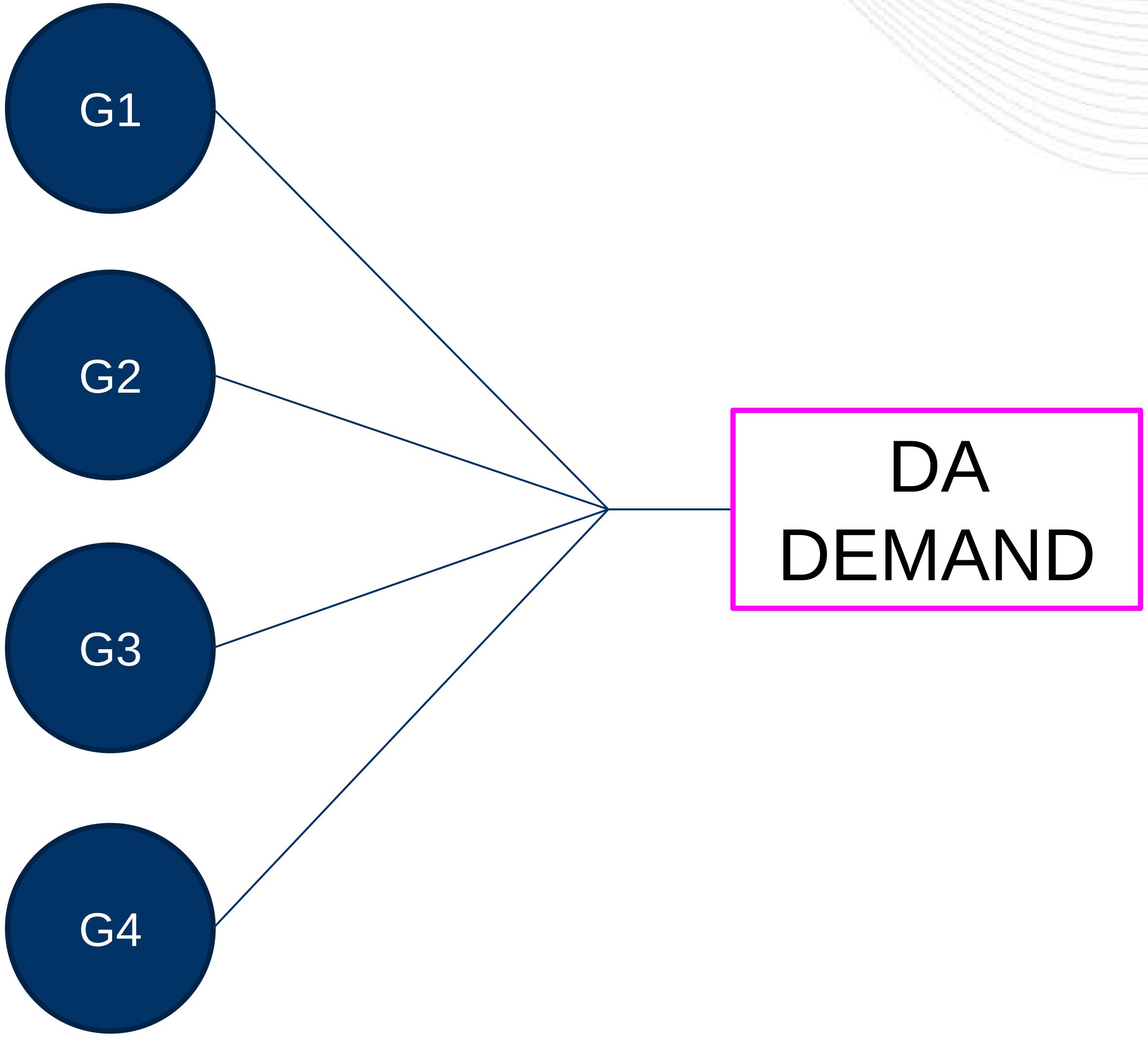
G1 Unit Parameters
EcoMax = 300 MW
EcoMin = 100 MW
Offer @ EcoMax = $60/MWh
Offer @ EcoMin = $40/MWh
Startup Cost = $0
No-Load = $200/hr

G2 Unit Parameters
EcoMax = 400 MW
EcoMin = 200 MW
Offer @ EcoMax = $40/MWh
Offer @ EcoMin = $20/MWh
Startup Cost = $0
No-Load = $200/hr

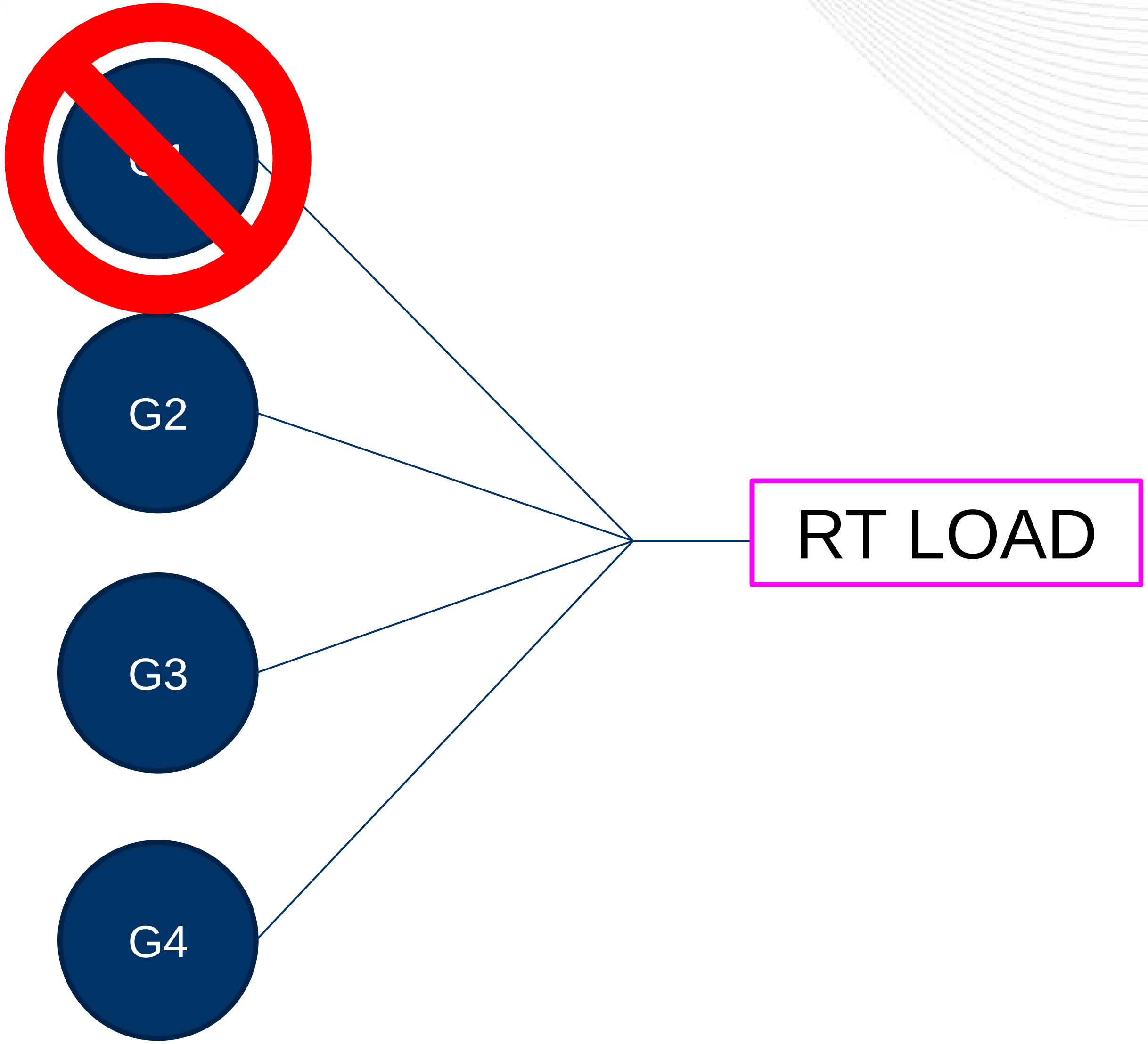
G3 Unit Parameters
EcoMin = EcoMax = 100 MW
Offer = $70/MWh
Startup Cost = $300
No-Load = $0/hr

G4 Unit Parameters
EcoMin = EcoMax = 100 MW
Offer = $75/MWh
Startup Cost = $300
No-Load = $0/hr

Example 2: DA Commitment



- At 550 MW of load
  - G1 = 150 MW
  - G2 = 400 MW
  - G3 = 0 MW
  - G4 = 0 MW
- G1 is marginal
  - LMP = $45.10/MWh



- G1 trips in real-time
- Load is still 550 MW
  - G1 = 0 MW
  - G2 = 350 MW
  - G3 = 100 MW
  - G4 = 100 MW

- G2 is marginal
  - LMP = $35.10/MWh

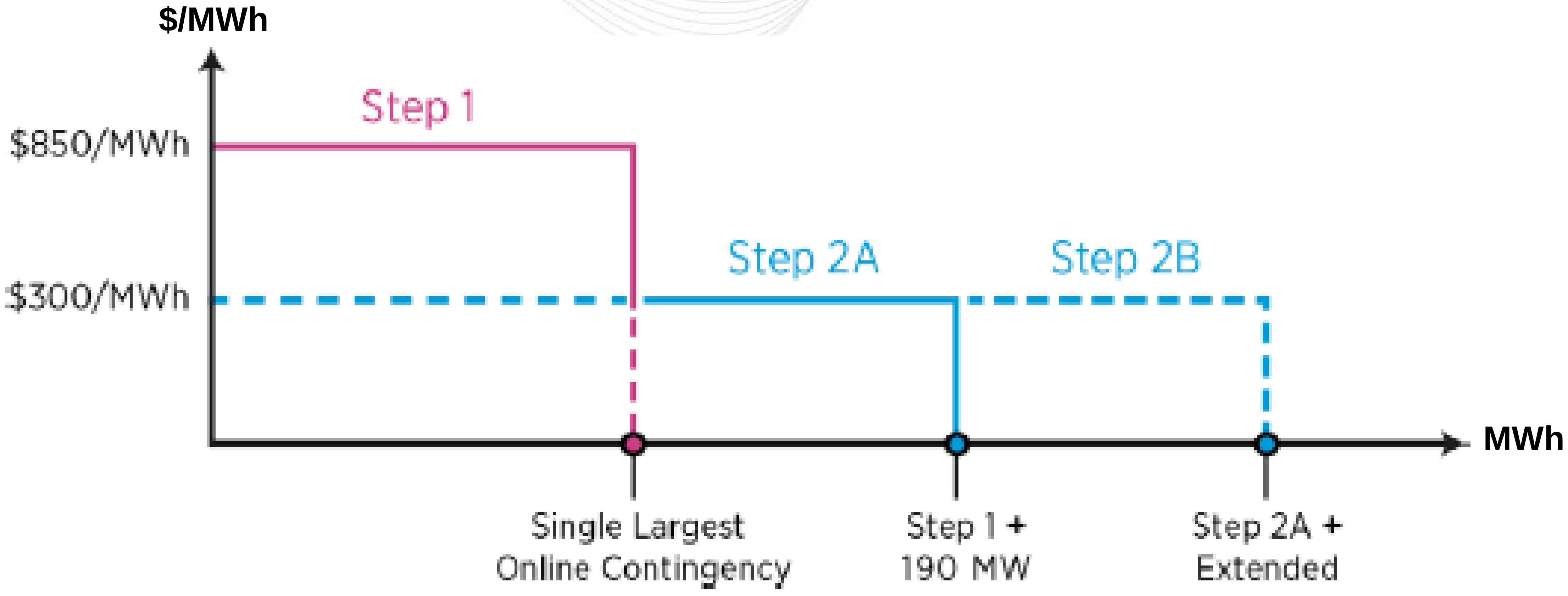
Example 2: Real-time

- G1 has tripped
- The real-time LMP is set by G2 as it is the only dispatchable unit on the system
  - LMP is set consistent with the cost of the next MW at $35.10/MWh
- G1 must purchase out of its DA commitment at the RT LMP
  - This nets a margin of $10/MWh
- The uplift costs to G3 and G4 (~$8,080) are allocated to deviations between DA and RT
  - Assuming G3 and G4 are not for conservative operations

- **Real-time prices do not reflect the need or commitment of G3 and G4**
- G1 is not held accountable for this deviation...it actually profits!
  - G1 will receive a pro-rata share of the deviation charges.*
- **This significantly diminishes performance incentives.**

**Due to the simplicity of this example, G1 is the only resource deviating. In reality there are many that will all pay a share of uplift created by G1 in this case.*

Example 3: Reserve Pricing



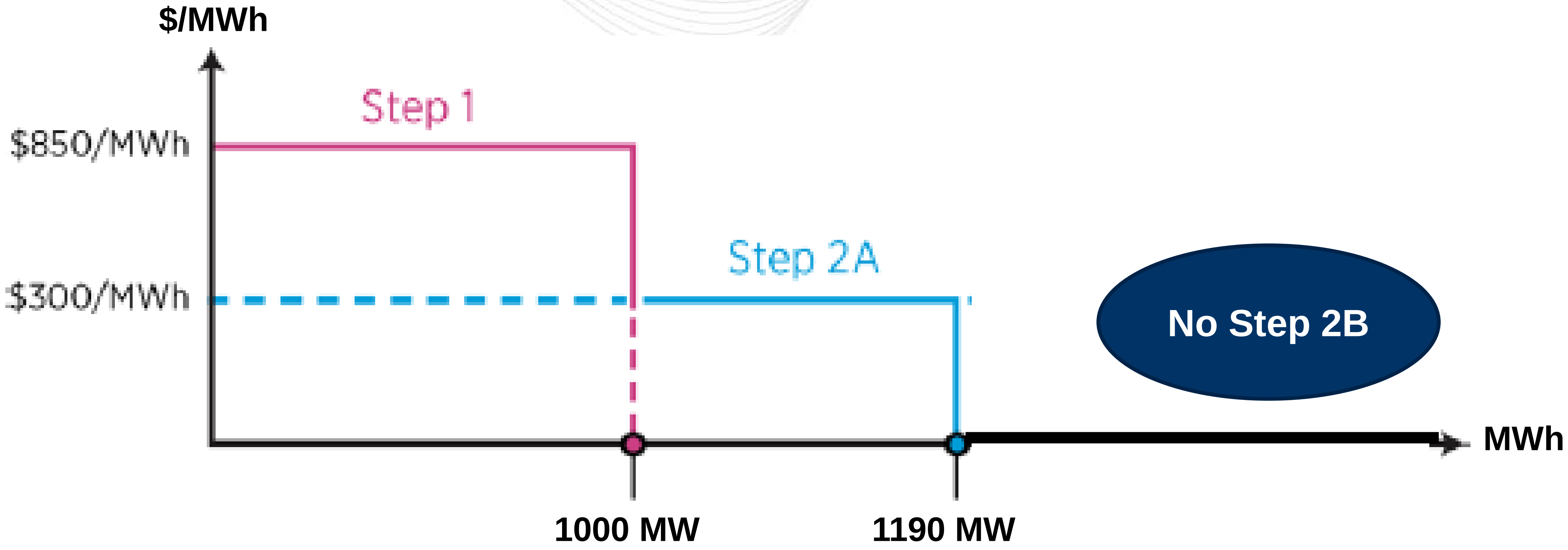
Example 3: Reserve Pricing

- Step 1 - $850/MWh
  - Largest single system contingency
  - Usually the largest unit
- Step 2A - $300/MWh
  - Additional reserves added July 2017
  - Intended to mitigate significant pricing impacts from transient shortages
- Step 2B (optional) - $300/MWh
  - Intended to reflect additional reserves added by operators

Example 3: Background and Interpretation

- Step 1
  - Load is not willing to pay more that $850/MWh to maintain the system's largest single contingency in reserves
  - PJM system operators will commit reserves beyond this cost to maintain reliability and compliance
  - **In these cases, the market prices are not reflecting operator actions**
- $850/MWh was determined in 2007 based on the average cost of reserves during shortage events during that time
  - Offer cap was $1,000/MWh at that time
- There are similar interpretations for Steps 2A and 2B

Example 3: Reserve Pricing



Example 3: Alignment with Reliability Value

- PJM estimates the amount of Tier 1 on the system every 5 minutes
- If PJM estimates more than 1190 MW in Tier 1 (even by 1 MW) the price for Synchronized Reserves is $0/MWh
- **This indicates reserves have no value. This is inconsistent with the reliability value in terms reducing the loss of load probability in real-time**
- If PJM cannot meet the requirement at the specified price, even if its by 1 MW, the price goes to the applicable penalty factor

Example 4: Inflexible Reserve Resources and Pricing

- Similar to energy, there are resources in the PJM market that have lumpy reserve capabilities
  - Synchronous condensing resource with a non-zero economic min
  - Fast-start CT with a non-zero economic min
- For the same reason these resources cannot set prices in the energy market, they cannot set price in the reserve markets
- This results in these resources often requiring reserve LOC payments in addition to the market clearing price
- This accounts for about 65% of the total Synchronized Reserve market billing

Example 4: Inflexible Reserve Resources and Pricing

- Reserve Market Clearing:
  - 1 hour ahead commitment of inflexible reserve resources
    - Synchronous condensers
    - Demand response
  - 5 minute co-optimzation of remaining amount of reserves needed
    - Tier 1 estimation
    - Tier 2 assignments on flexible resources
    - Clearing price calculation

Example 4: Generator Offer Data

G1 Unit Parameters
EcoMax = 300 MW
EcoMin = 100 MW
Offer @ EcoMax = $60/MWh
Offer @ EcoMin = $40/MWh
Reserve Offer = $5/MWh
Reserve Capability = 20 MW (flexible)

G2 Unit Parameters
EcoMax = 400 MW
EcoMin = 200 MW
Offer @ EcoMax = $40/MWh
Offer @ EcoMin = $20/MWh
Reserve Offer = $6/MWh
Reserve Capability = 50 MW (flexible)

G3 Unit Parameters
EcoMin = EcoMax = 40 MW
Offer = $70/MWh
Reserve Offer = $4/MWh
Reserve Capability = 40 MW (inflexible)

G4 Unit Parameters
EcoMin = EcoMax = 30 MW
Offer = $75/MWh
Reserve Offer = $5MWh
Reserve Capability = 30 MW (inflexible)

RESERVE REQUIREMENT = 75 MW

Example 4: Inflexible Reserve Resources and Pricing

- LOAD = 600 MW
  - LMP = $50/MWh
  - Reserve Allocations (done based on offer + LOC)
    - G1: 20 MW Tier 1 estimate ($0/MWh assessed offer because it is Tier 1)
    - G2: 0 MW (fully loaded for energy)
    - G3: 40 MW Tier 2 assignment ($4/MWh offer)
    - G4: 30 MW Tier 2 assignment ($5/MWh offer)
  - Total Reserves = 90 MW
    - 20 MW Tier 1
    - 70 MW Tier 2
- **Today's rules produce an SRMCP = $0/MWh despite needing G3 & G4 to avoid a reserve shortage (prices don't reflect operator actions)**
- **This price is not transparent**
  - **Out-of-market LOC payments to G3 & G4 needed due to $0/MWh clearing price**
  - **Increase in energy dispatch of G1 and further tightening of reserve capability would result in $0/MWh SRMCP until the point of shortage**