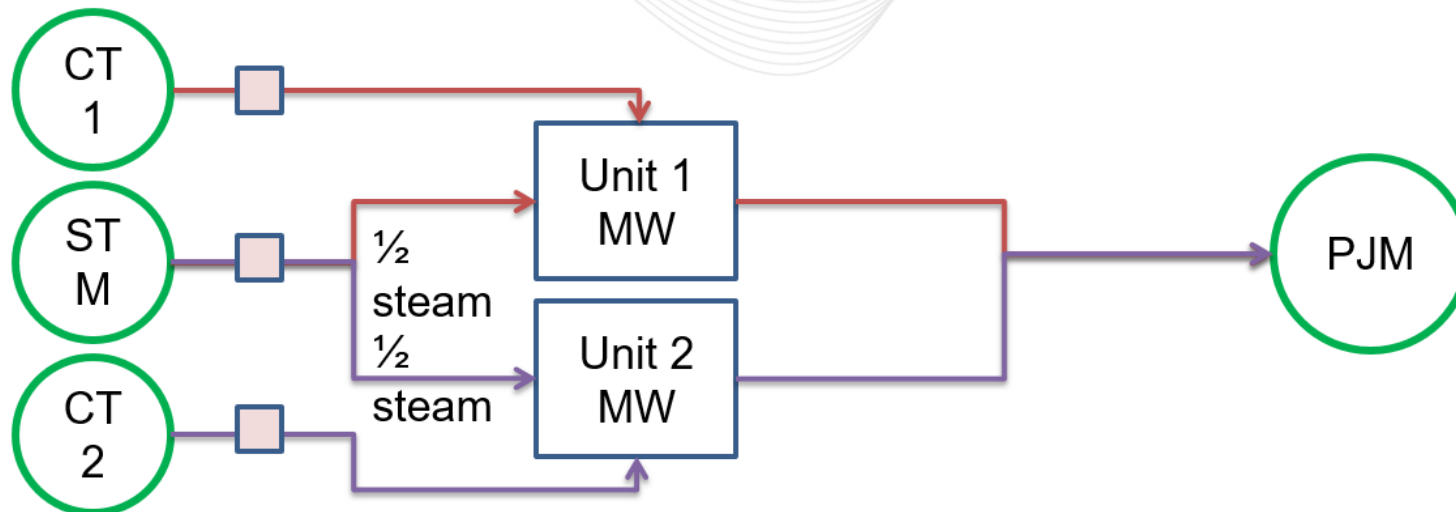


Virtual Combined Cycle Units in Regulation

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- Combine cycles can be modeled as a single market unit or split into multiple pseudo market units



- Need to qualify each individual unit for regulation (M12.4.5)
- Once qualified - Units will be offered individually and dispatched individually based on market results

- Because the plant is modeled in multiple parts, there is a possibility for unbalanced or unequal awards to each “unit”



Alignment of Offers between Pseudo Units

- To minimize the frequency of unbalanced regulation market awards:
 - Market Sellers may self-schedule their units to ensure equal awards
 - Market Sellers may submit identical MW and price offers in both the regulation and energy markets.
 - These will align the energy dispatch MW as well as the regulation adjusted total offer cost.

$$\begin{aligned}
 \text{Adjusted Total Offer Cost (\$)} &= \text{Adjusted Capability Cost (\$)} + \text{Adjusted Performance Cost (\$)} + \text{Adjusted Lost Opportunity Cost (\$)} \\
 &\rightarrow \text{Adjusted Lost Opportunity Cost (\$)} = \frac{\text{Lost Opportunity Cost (\$/MW)}}{\text{Benefits Factor of Offered Resource}} * \frac{\text{Capability (MW)}}{\text{Historic Performance Score}}
 \end{aligned}$$

- Simplified RegLOC formula

$$|LMP - MC| * GENOFF$$

Where:

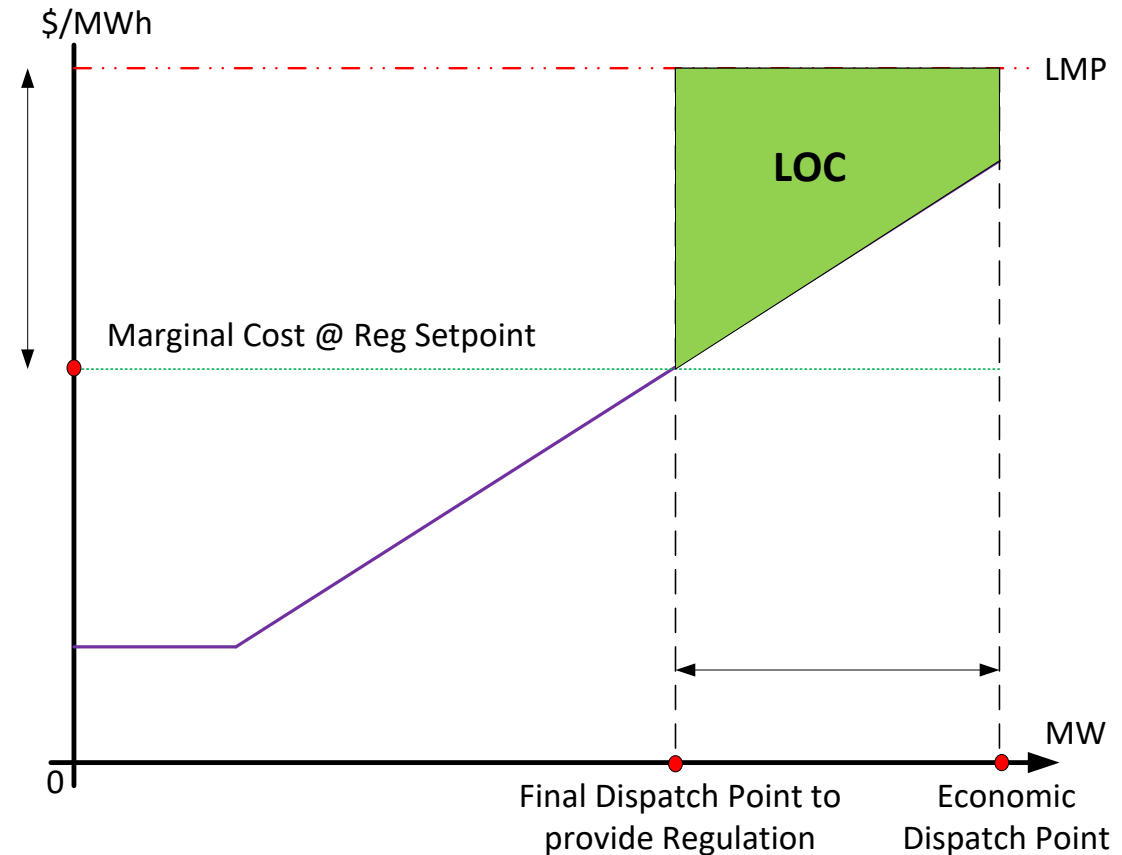
LMP – is the LMP at the resource bus;

MC – is the resource cost at the regulation set point;

GENOFF – is the MW deviation from the economic dispatch and the regulation set point

Note:

- In the clearing process, forecasted LMP is used
- In the pricing, Real-Time LMP is used
- RegLOC is further adjusted by:
 - Resource Historic Performance Score and
 - Resource Benefits Factor (if RegD)



- Because of the potential differences in performance scores between the individual pseudo modeled units,
 - PJM suggests setting up and utilizing the performance group functionality (Manual 12, Section 4.5.7)
 - All resources within the group that have been awarded MWs for any one given hour will be awarded the same score
 - If each unit within the performance group has the same scores across hours
 - This will align the 100 hour rolling score (i.e. same 100 hours to average) that is used to calculate the adjusted regulation offers

MWs Cleared	Unit 1	Unit 2
HE1	10	0
HE2	10	10
HE3	10	5
HE4	10	10

Performance Group Scores	Unit 1	Unit 2
HE1	93%	N/A
HE2	95%	95%
HE3	92%	92%
HE4	91%	91%

Key Takeaways:

- Same score for all resources in group given an award in one hour
- Differing assignments will not cause differing performance scores between units
- If units do not receive an assignment – they will not receive a score for that hour
 - This will alter the 100 hour rolling score between the units within the performance group (one unit with an extra score to average)
 - Ultimately causing misalignment of offers in the regulation market

- It is possible after each of these precautions that one pseudo unit will clear and other pseudo may not
 - Market Sellers should:
 - Contact PJM dispatch to decommit the resource for the hour. PJM practice is to decommit the regulation assignment for the committed pseudo unit.
- Another possibility is unbalanced awards across pseudo units.
 - Market Sellers should:
 - Contact PJM dispatch to lower the awards to be equal across all pseudo units or to a level that the plant can safely perform to.
- **Dispatch will not split awarded MWs across pseudo units.**



Regulation Clearing Example

- Scenario 1

Requirement = 50 MW

Offer Prices assumed \$0

Resource	Energy MW	LOC = Rank	Reg MW Award
A	300	4	10
B	150	5	15
C	0	0	5
U1	215	7.2	0
U2	205	7	20

U1 did not get Reg award because the energy output caused a higher RegLOC

- Scenario 2

Requirement = 50 MW

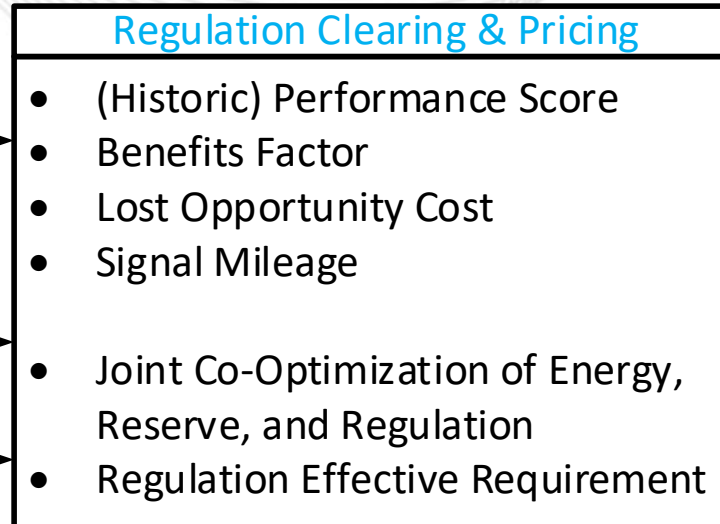
All resources self-scheduled

Resource	Performance Score	Reg MW Award
A	0.921	10
B	0.955	15
C	0.968	5
U1	0.915	20
U2	0.908	0

U2 did not get Reg award because of its performance score

Input:

- Resource Energy Offers & Schedules →
- Resource Regulation Offers & Limits →
- ... →



Output:

- Resources with award (Least Cost Set)
- Resources with no award (more expensive)
- Market Clearing Prices

Key Takeaways:

- Virtual CC units may not clear equally if their parameters are not exactly the same;
- The software clears the least cost set to satisfy the regulation requirement MW;
- Splitting award with another unit that did not clear (out-of-market action) could potentially inflate the market clearing price. No award splitting.

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Regulation for Virtual Units



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