Automatic Generation Control (AGC) Enhancement for Fast Ramping Resources

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Purpose & Key Takeaways

Purpose:

This paper presents recent MISO development and implementation on AGC enhancement for resources with fast ramping capabilities

Key Takeaways:

- MISO design considers characteristics of both traditional slow and new fast ramping resources
- MISO design takes possible opportunities to move energy limited resources back to neutral zone of Start of Charge

Background

- MISO is registered under NERC as a Balancing Authority (BA) and performs Balancing Authority functions guided by [NERC BAL standards](#)

- AGC enhance after FERC order 755, regulation mileage

- MISO sends 4 second control signals to generation fleets and maintains ACE within range.

- MISO AGC enhancement goal need strike a balance between Reliability, Efficiency and Flexliblity.

Design Principles

1. Maintain system reliability before meeting individual unit needs.

2. Avoid fast/slow competing against each other

3. Keep in mind slow resource capability

4. Avoid charging fast regulation resources with slow regulation resources

5. Avoid fix signal duration to attract various technologies for reliability and market efficiency.

Fast and slow signal

MISO developed a new logic to deploy and un-deploy fast resource first. It lets fast resources to respond to the instant changes of total ACE correction need.

$$R_{fast}'(t) = [R_{total}(t) - R_{total}(t-1)] + R_{fast}(t-1)$$

Where

$R_{total}(t)$ — AGC deployed total regulating reserve for MISO at time slot t

$R_{fast}(t)$ — AGC deployed regulating reserve on fast-ramp resources at time slot t

$R_{fast}'(t)$ — The term of fast signal responding to changes of total deployment

As slow response resources ramp, the fast response resources will adjust according to the total need. The rate, at which fast-ramp resources adjust, is determined by ε . This would result in greater movement of fast ramping resources, and the ability to use slow ramping resources for persistent signals as needed.

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$$R_{fast}'(t) = [R_{total}(t) - R_{total}(t-1)] + R_{fast}(t-1)$$

$$R_{fast}(t) = R_{fast}'(t) + \varepsilon * \{sign(R_{total}(t)) * max[|R_{total}(t)| - RClr_{slow}(t), 0] - R_{fast}'(t)\}$$

Where

$RClr_{slow}(t)$ — UDS cleared regulating reserve MW on slow-ramping resources at time slot t

ε — Damping factor, which is a positive value and less than one

$R_{slow}(t) = R_{total}(t) - R_{fast}(t)$ — The slow signal is created by subtracting the fast signal from the total deployment.

$R_{slow}(t)$ — AGC deployed regulating reserve on slow-ramping resources at time slot t

Fast & slow signal considerations

Fixed Duration
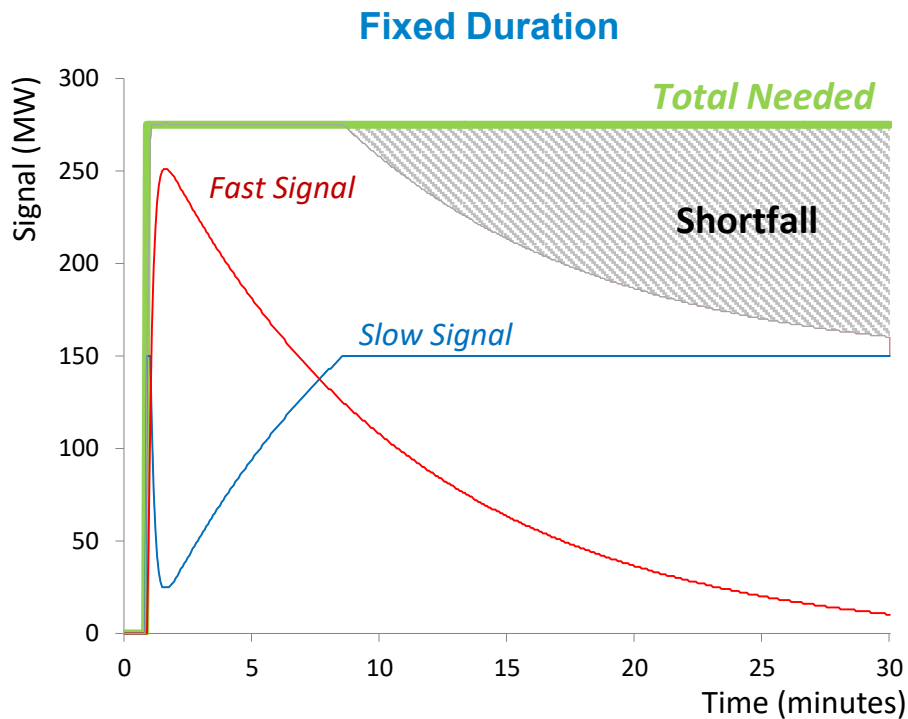
Shortfall created as fast signal pulls back & slow resources cannot meet need.

Coordinated
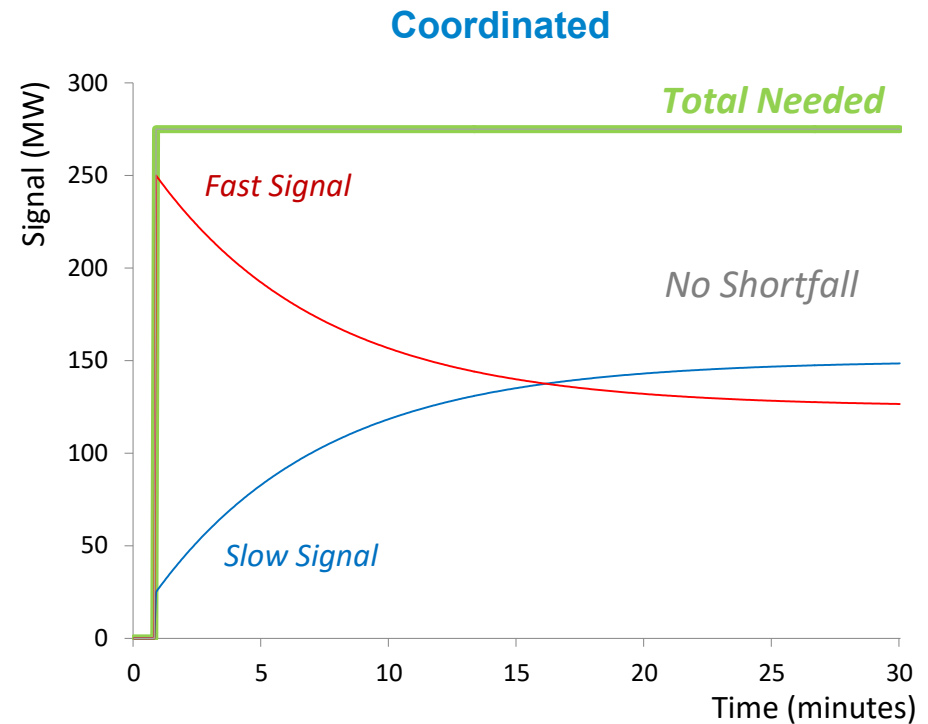
Slow resource signal grows while fast one reduces contribution based on need.
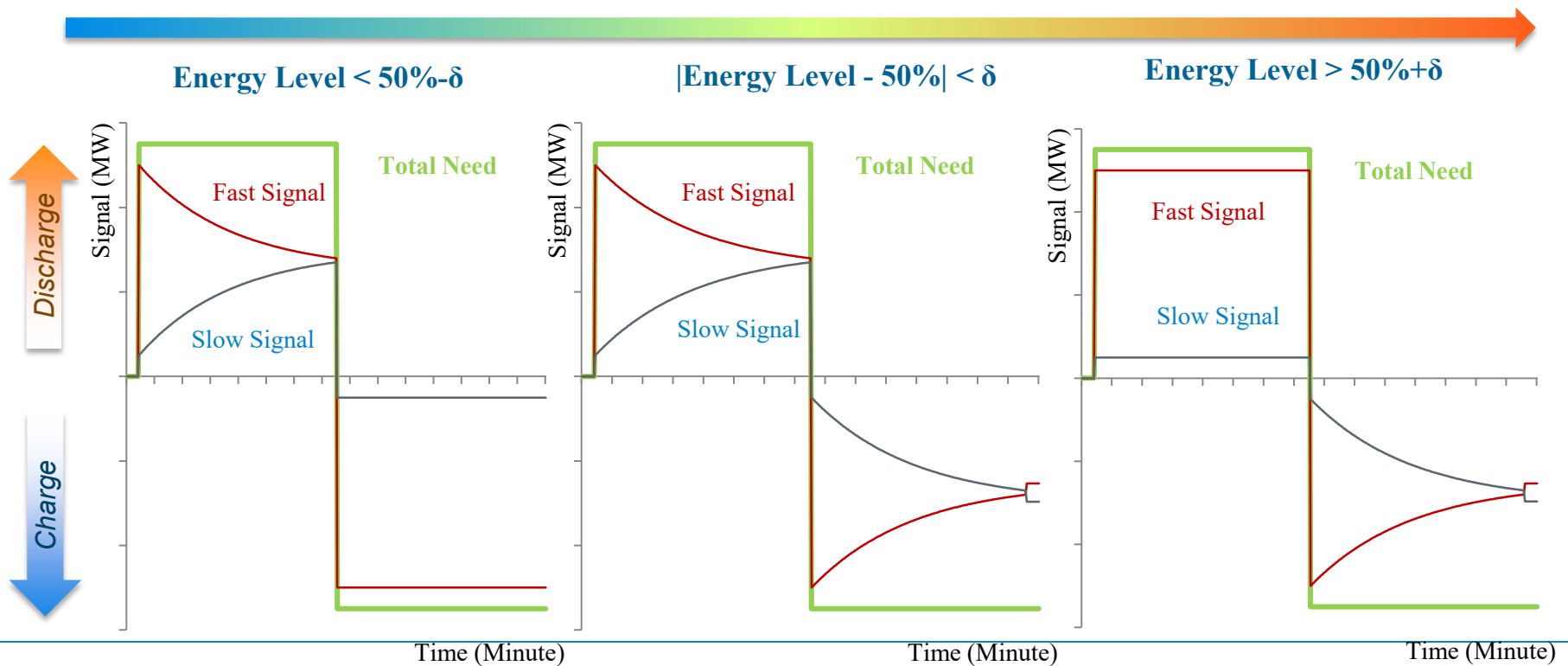
Assumptions: Total Deployed = *275* MW, Fast cleared = *250* MW, Slow cleared = *150* MW

Permissive Charging

- Fast-first signal assists energy limited fast resources back to neutral when situation permits.

Need Charge → Need Discharge

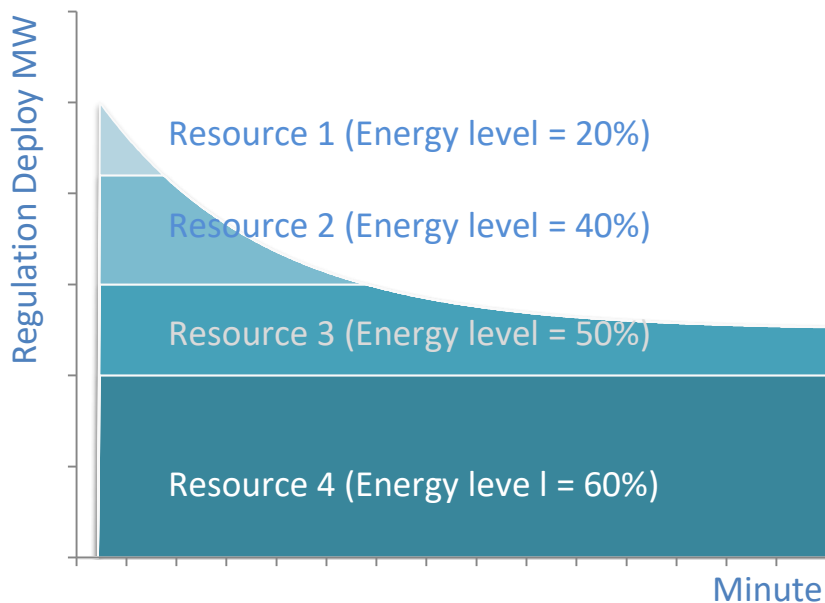Energy Level < 50%-δ | |Energy Level - 50%| < δ | Energy Level > 50%+δ

Allocation within fast group

1. Response rate priority group based on ramp rate availability for regulation
2. Proportionally distribute based on cleared regulation MW
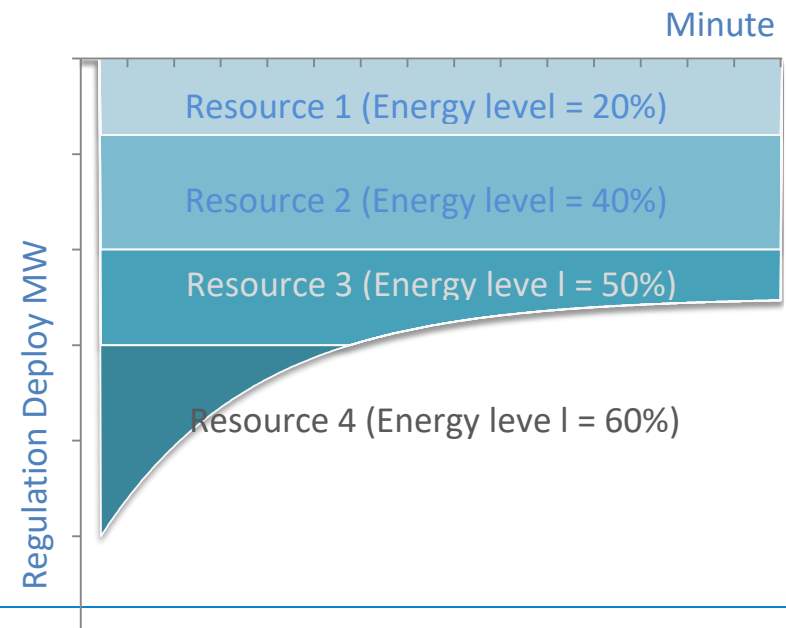3. Energy level deviation from neutral state

Example of #3: Total fast signal allocates to individual resources based on their energy level distance to neutrality.

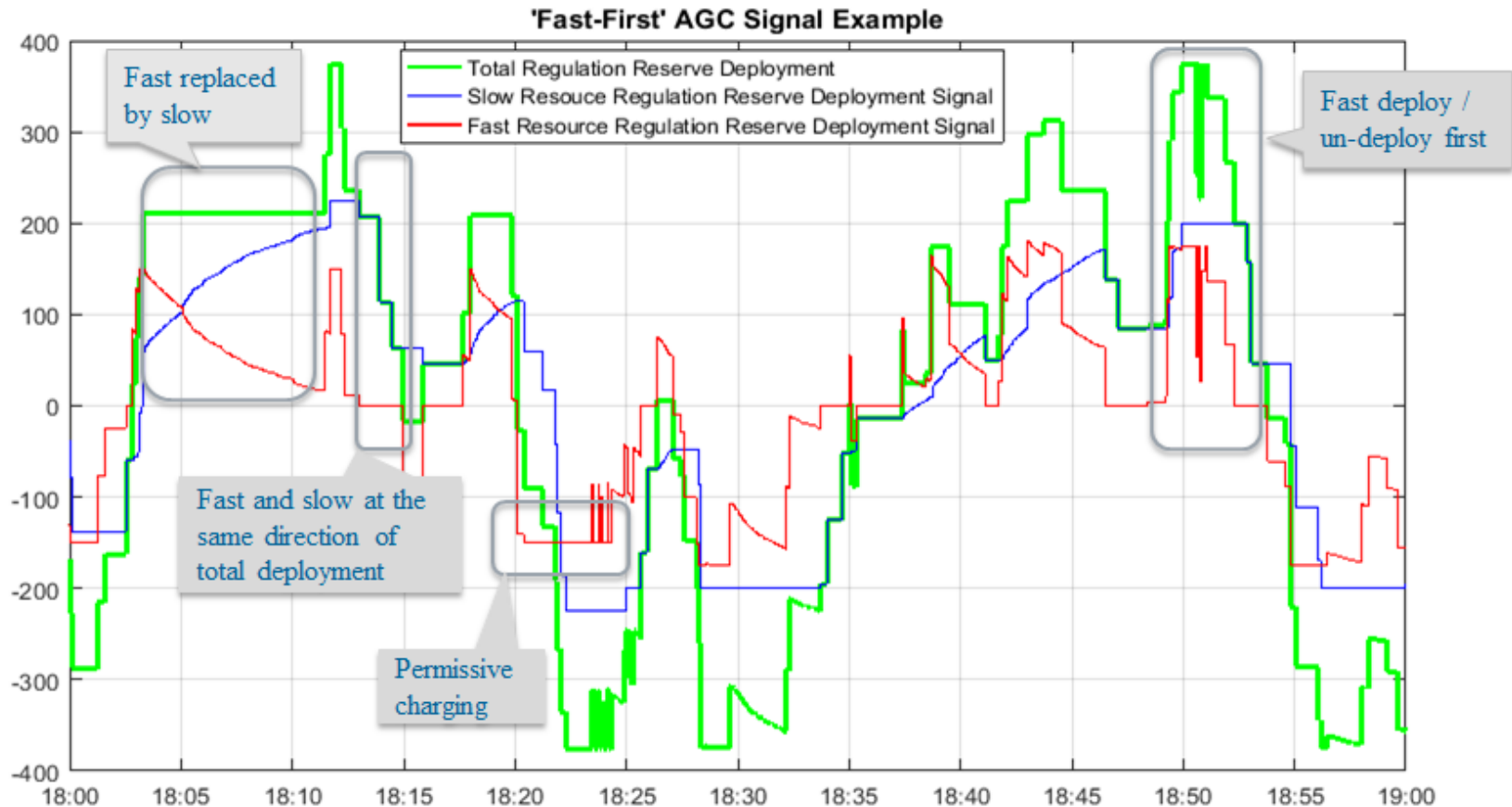- Fast resource without energy limitation will be considered as always neutral :Energy level = 50%

Fast Signal Allocation (Discharge)

Regulation Deploy MW

Resource 1 (Energy level = 20%)

Resource 2 (Energy level = 40%)

Resource 3 (Energy level = 50%)

Resource 4 (Energy level = 60%)

Minute

Fast Signal Allocation (Charge)

Minute

Resource 1 (Energy level = 20%)

Resource 2 (Energy level = 40%)

Resource 3 (Energy level = 50%)

Resource 4 (Energy level = 60%)

Regulation Deploy MW

Simulated AGC Signal Example

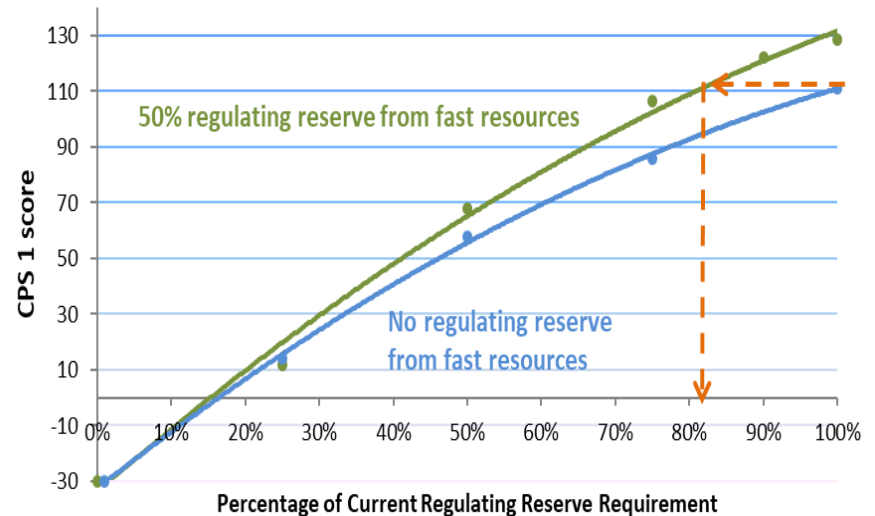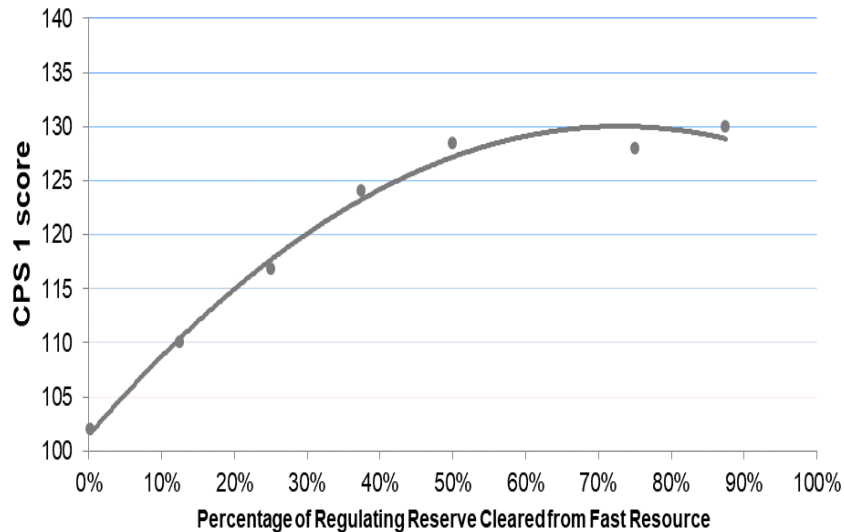'Fast-First' AGC Signal Example

Benefit study

MISO Simulation shows
1. Fast ramping resources help enhancing system reliability in various penetration level.
2. Fast ramping resources potentially could reduce regulation reserve requirements.

Questions

Thank you.

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MISO