Market Design Evolution for High Share of Renewables

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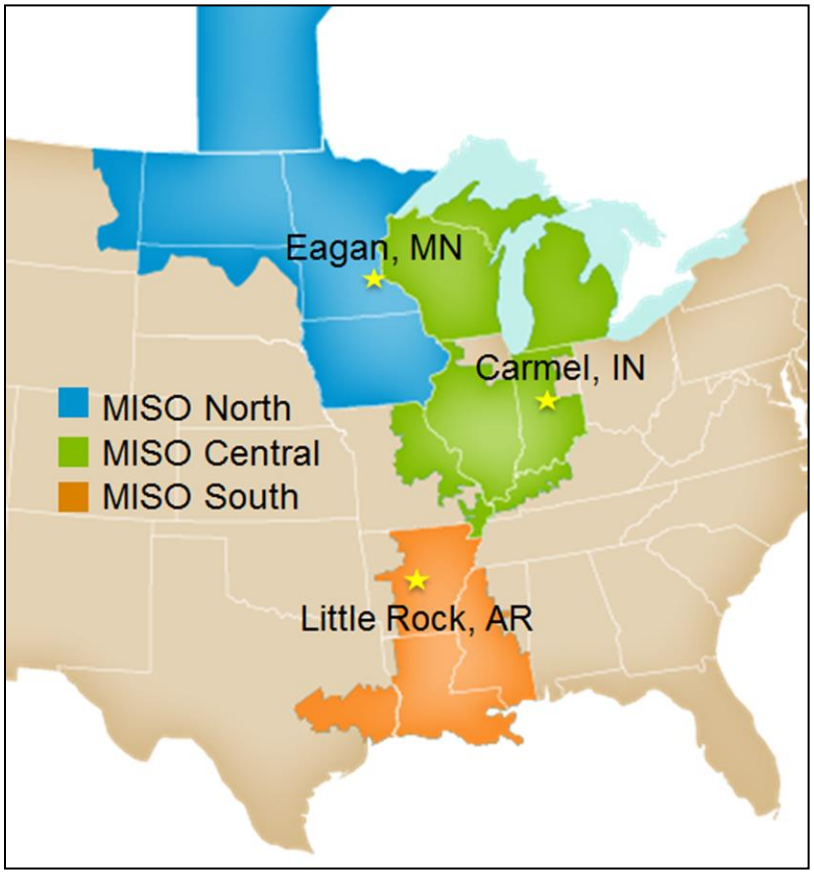
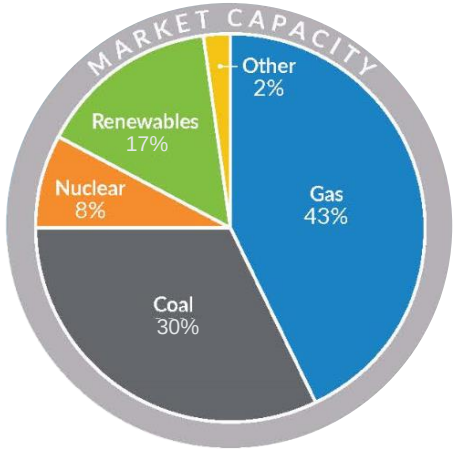
April 9, 2020

MISO drives value creation through efficient and reliable markets, operations and planning

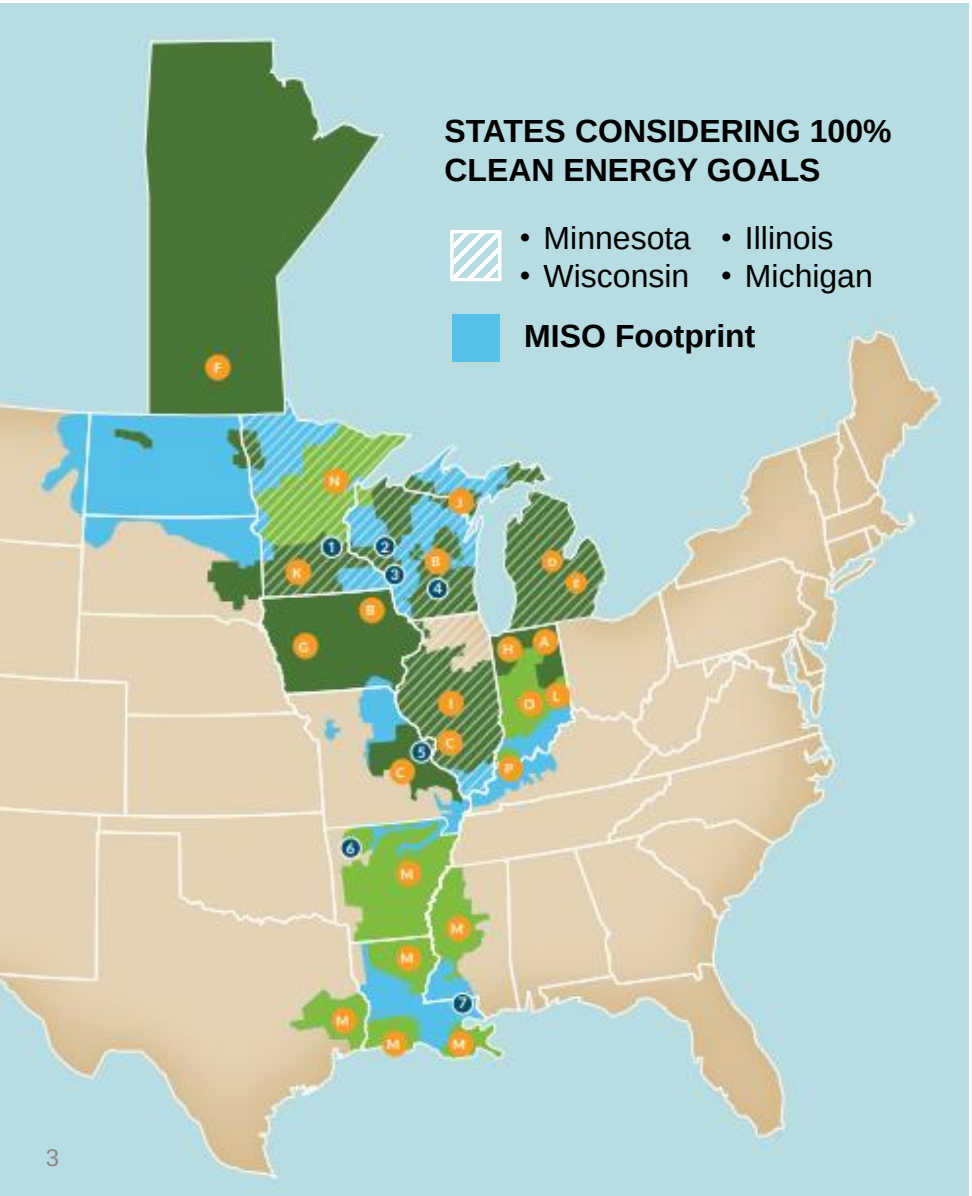
MISO's vision: Be the most reliable, value-creating RTO



MISO by-the-numbers	
Transmission	71,800 miles
Generation Capacity	177,760 MW
Peak Summer System Demand	127,125 MW
Customers Served	42 Million



Large portions of the MISO footprint have set high decarbonization or clean energy goals



MISO States, Cities and Utilities with Decarbonization or Clean Energy Goals

CITIES WITH 100% CLEAN ENERGY GOALS

1. Minneapolis, Minn.
   St. Paul, Minn.
2. Eau Claire, Wis.
3. La Crosse, Wis.
4. Madison, Wis.
5. St. Louis, Mo.
6. Fayetteville, Ark.
7. Abita Springs, La.

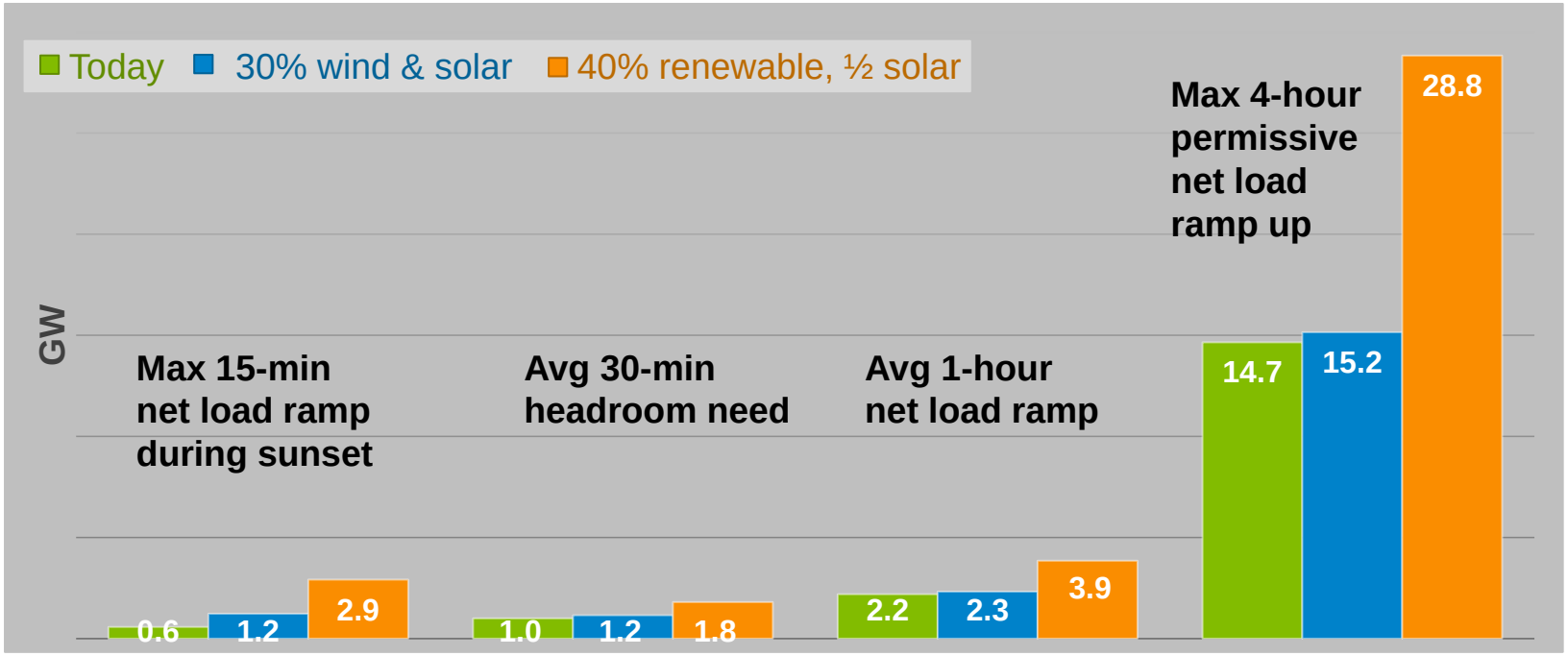
UTILITIES WITH 80%+ TARGETS

A. AEP
B. Alliant
C. Ameren
D. Consumers
E. DTE
F. Manitoba Hydro (achieved, not a target)
G. MidAmerican
H. Northern Indiana Public Service
I. Vistra
J. WEC Energy Group
K. Xcel

UTILITIES WITH 50%+ TARGETS

L. Duke
M. Entergy
N. Great River Energy
O. Indianapolis Power and Light
P. Vectren/SIGE

Flexibility needs across and within hours will grow with these changes

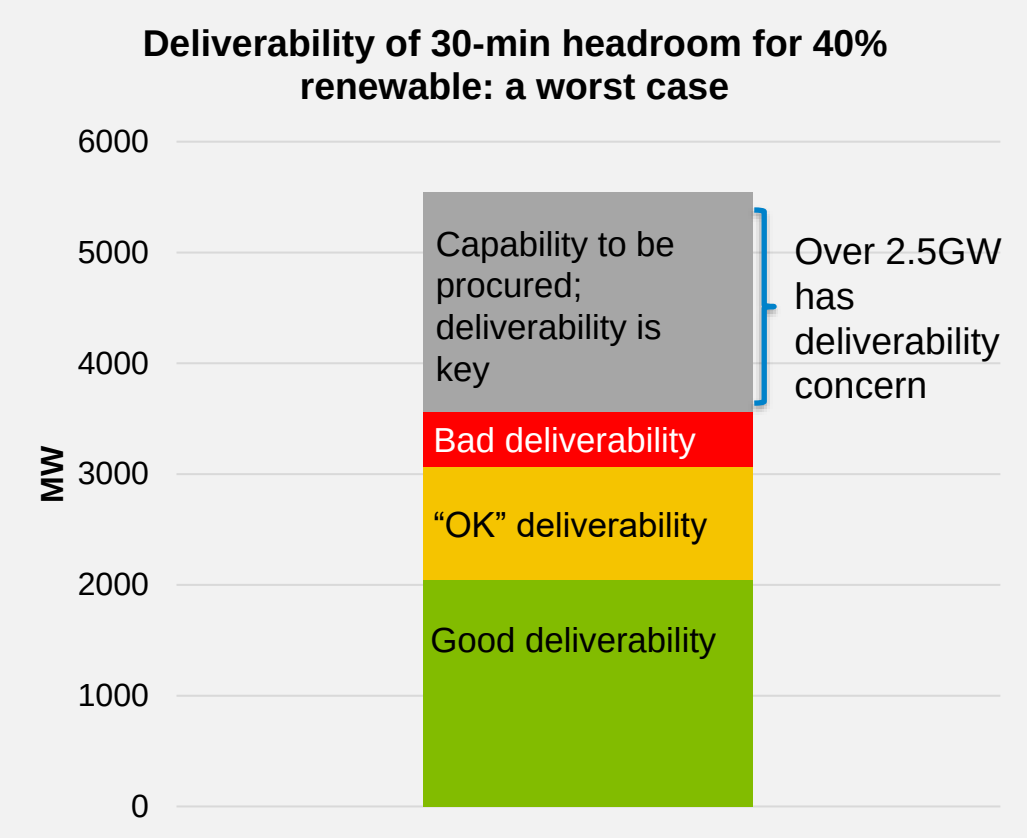


- Wind and solar increase hourly and multi-hour flexibility needs.
- Solar growth increases intra-hour needs due to its diurnal patterns and intra-hour profiles.

Note: Sample simulated days

Deliverability needs will grow without transmission adaptation to the new resource mix

- Flexibility needs will grow in future with deliverability issue becoming more crucial.
- Transmission builds, flexible transmission management, and market enhancements could improve deliverability outcomes.
- Short-term reserves is a start.

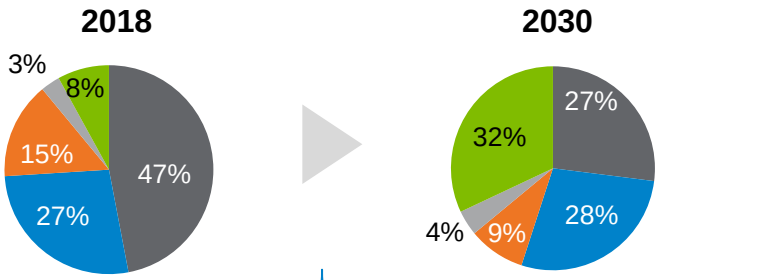


Notes:
Sample simulated days.
Deliverability is indicated by the marginal congestion component of locational marginal price

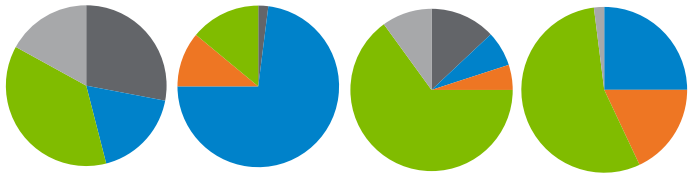
Industry trends create a reliability imperative to address needs for Availability, Flexibility and Visibility

TRENDS

MISO Region Generation Portfolio Evolution (% of Energy)



Announced 2030 Members' Generation Mix (% of Energy)



Renewables | Other | Nuclear | Gas | Coal

RAN 2020 Focus

Identify Reliability Needs

- Develop analytic methods to define reliability criteria, and identify needed attributes in additional to peak hour MWs

Planning Horizon

- Define planning constructs that complement state and member roles in resource Adequacy
  - Develop sub-annual planning + PRA reform
  - Enhance resource accreditation

Operating Horizon

- Ensure market prices reflect underlying system conditions
  - Propose scarcity pricing reforms

2030 Energy projections (MWh) compiled from IRPs, investor reports and other sources

Day Ahead and Real Time: MISO has been developing its markets in light of changing needs

Price Formation. Reflect system conditions and needs.

- Emergency and scarcity pricing
- Extended locational marginal pricing

Ancillary Services. Identify needs & compensate services.

- Ramp Product
- Automatic Generation Control (AGC) Enhancement for Fast-Ramping Resources
- Exploring others

Resource Models. Reflect resource capabilities, constraints and costs.

- Enhanced Combined Cycle
- Energy storage
- Hybrid plants

AGC Enhancement Example: The approach leverages resource capabilities for system benefit

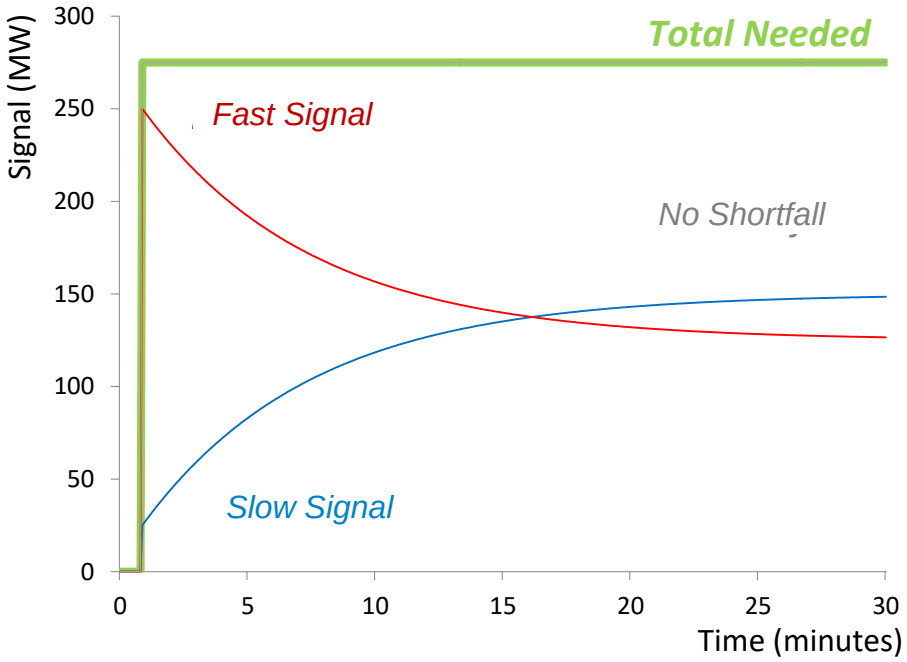
MISO implemented an enhancement in AGC for Fast Ramping Resources effective in RT Markets February 26, 2020.

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.

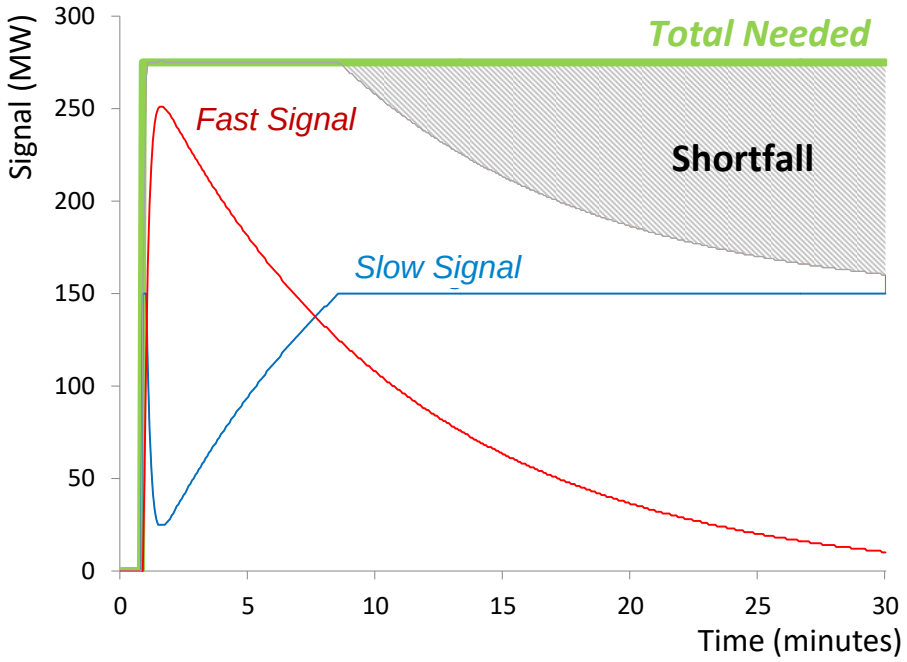
The new logic moves fast resources first and organizes responses according to system need

Coordinated



Slow resource signal grows while fast one reduces contribution based on need.

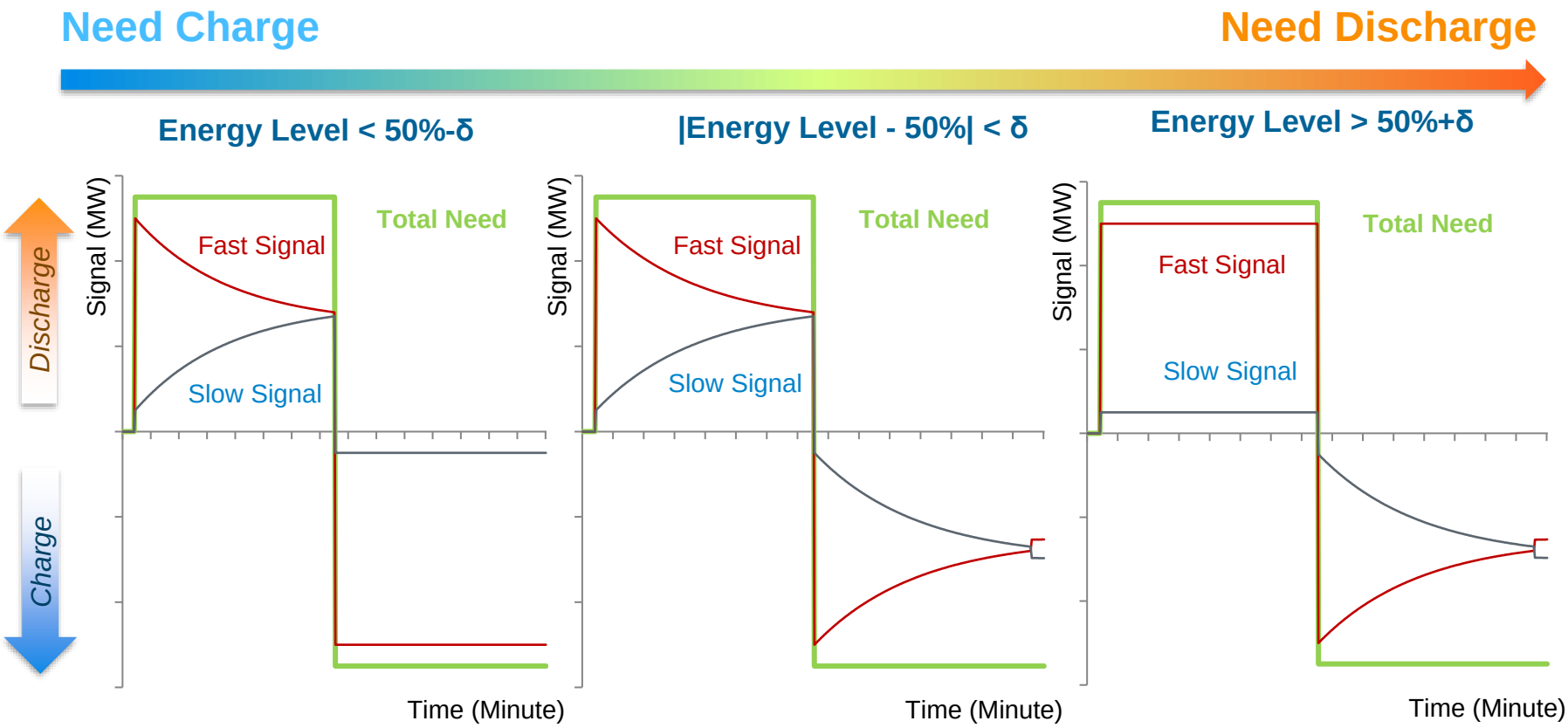
Fixed Duration



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

Assumptions: Total Deployed = *275* MW, Fast cleared = *250* MW, Slow cleared = *150* MW

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



The enhancement has the potential to more efficiently utilize AGC resources in the aggregate

MISO simulation indicates that

1. Fast ramping resources can help enhance system reliability at various penetration levels.
2. Fast ramping resources potentially could reduce regulation reserve requirements.