Evolving Perspectives for Reliability Planning

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Outline

Introduction

Background on Implications of Regional Generation Transition

Sub-Hourly Flexibility Modeling with Stochastic Uncertainty – Considerations and Analytical Approaches

Other Technical Reliability Measures – Considerations and Analytical Approaches

Reliability Planning is Evolving

Traditional resource adequacy accounting is evolving due to growth in intermittent renewables and storage. Planners will increasingly need to consider new approaches for assessing reliability across multiple dimensions.

Context

- The ongoing **energy transition is transforming the way that resource planners need to think about reliability**, and a power market with more intermittent resources will require ongoing enhancements to modeling approaches and new performance metrics for portfolio evaluation

- Utilities need to evaluate their resource attributes in the context of regional markets

Evolution in Planning Approaches

Planning Reserves
- Planning reserve margins require seasonal evaluation
- Capacity contribution of renewables and storage resources (ELCC) over time is dynamic

Flexibility and Operating Reserves
- Stochastic-based risk analysis to assess market exposure and net load ramping needs
- Sub-hourly modeling to test flexibility adequacy and ancillary services value

Integrated T&D Planning
- G&T scenario assumptions consistency
- Power flow and locational impacts
- Integration of DERs

Essential Reliability Services
- Short-circuit strength, frequency, inertia, blackstart considerations

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MISO’s RIIA Provides a Framework for Three Key Focus Areas for Reliability

MISO’s Renewable Integration Impact Assessment (RIIA) provides a framework for evaluating reliability across more dimensions than typical summer reserve margin planning

	Resource Adequacy	Energy Adequacy	Operating Reliability
Definition:	Having sufficient resources to reliably serve demand	Ability to provide energy in all operating hours continuously throughout the year	Ability to withstand unanticipated component losses or disturbances
Planning Considerations:	Ability to meet **reserve margins in all seasons**	Sufficient **flexible / dispatchable capacity** to meet emerging challenges with intermittent resources	Able to provide **short-circuit strength, frequency control, inertial response, blackstart service**, etc.

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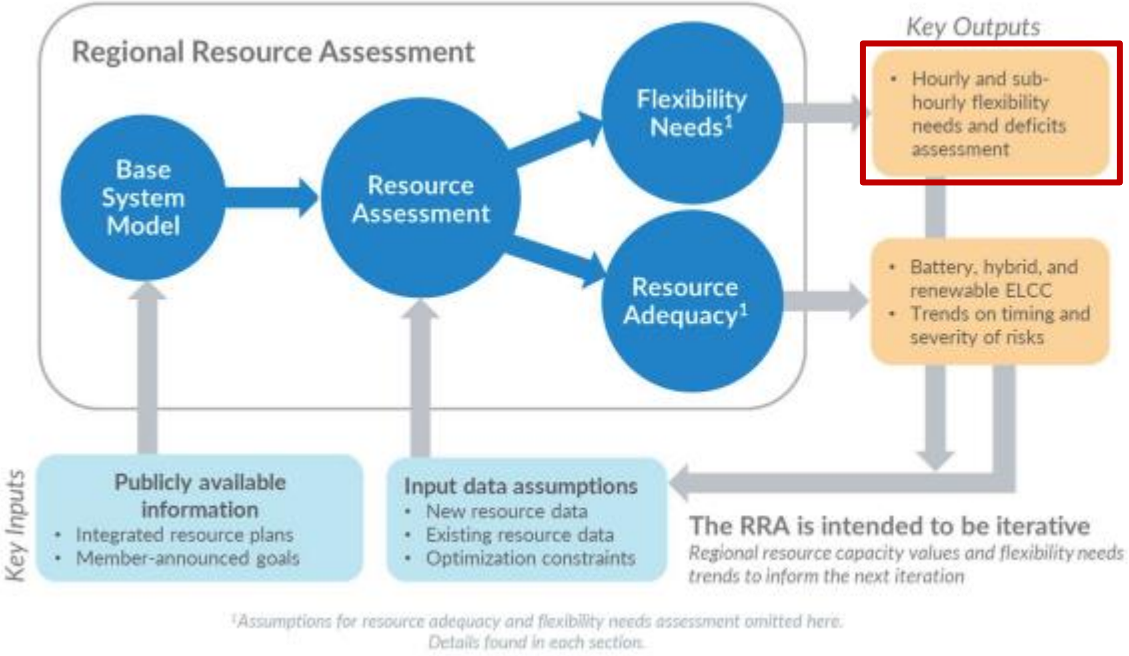
Resource Adequacy – MISO Seasonal Construct

- On August 31, FERC **approved** MISO's seasonal construct
  - Four seasonal planning reserve margin requirements
  - Seasonal capacity accreditation based on ELCC or availability during peak hours
  - Single auction, with requirements cleared for each season
  - Implementation will begin in the 2023/24 planning year
- Initial indications are that winter planning reserve margin requirements will be significantly higher than summer

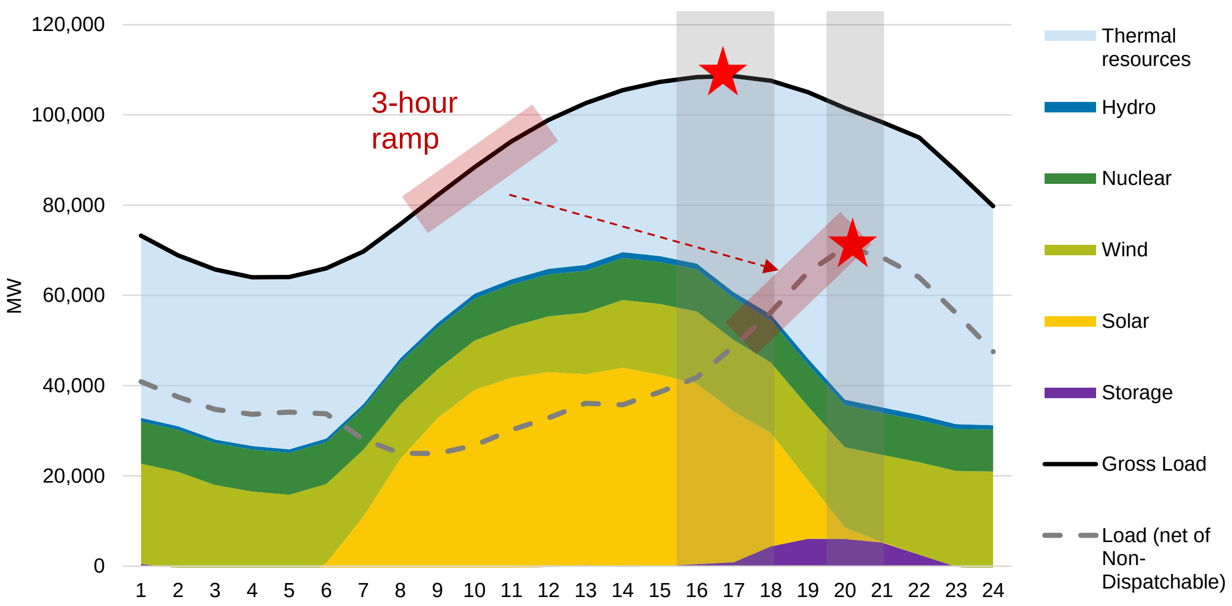
Energy Adequacy

MISO's Regional Resource Assessment is now highly focused on studying system flexibility needs and energy adequacy requirements



Source: MISO's Regional Resource Assessment, Nov, 2021

Sample Hourly Energy Profile with High Renewable Penetration



Source: CRA analysis

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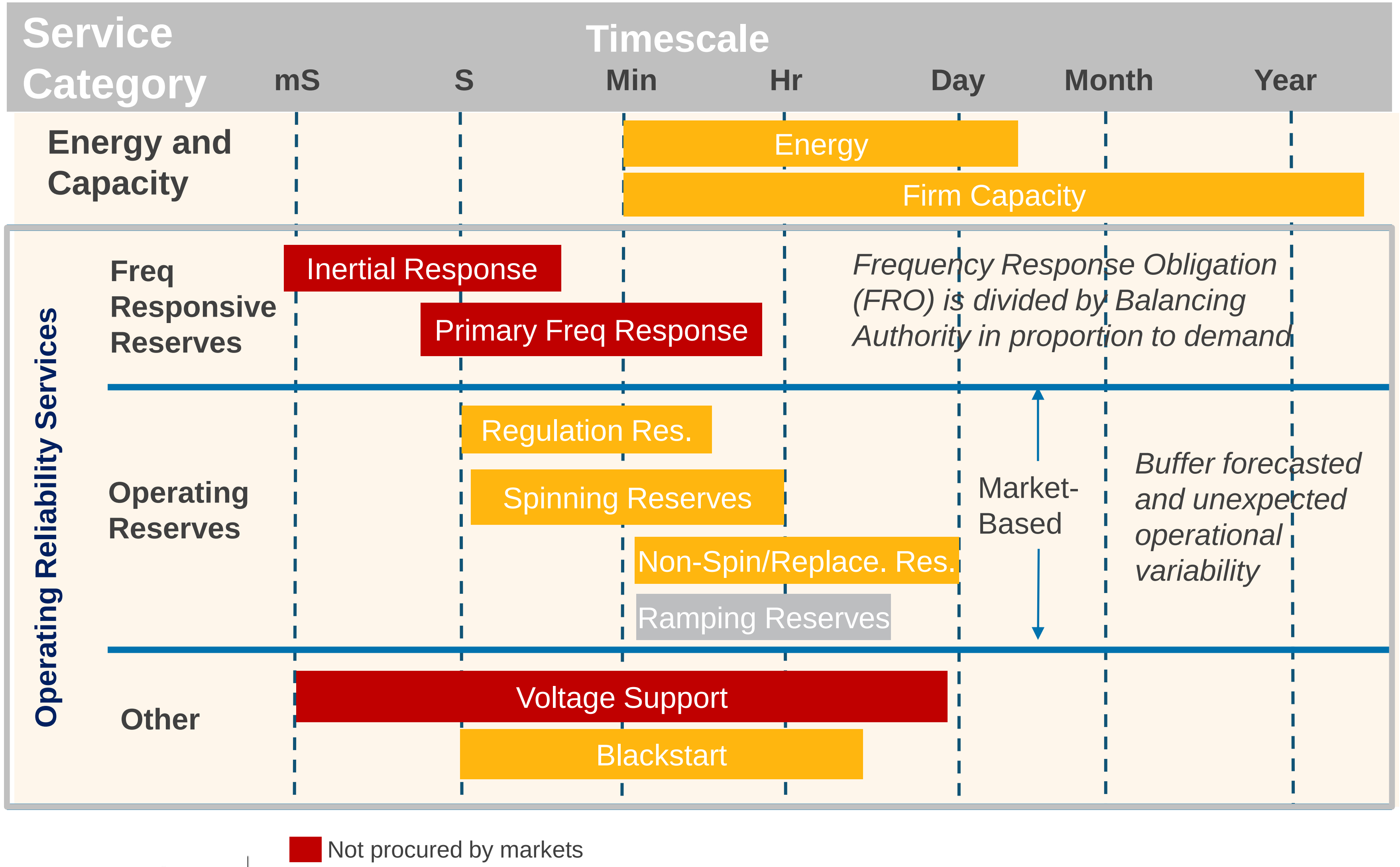
Operating Reliability



- **Market-Procured Reliability Services**
  Some reliability services are typically procured competitively by the RTO or the ISO such as reserves.

- **Portfolio-Supplied Reliability Services**
  Some reliability services are assumed to be innately supplied by the resource portfolio such as inertial and primary frequency response and voltage support

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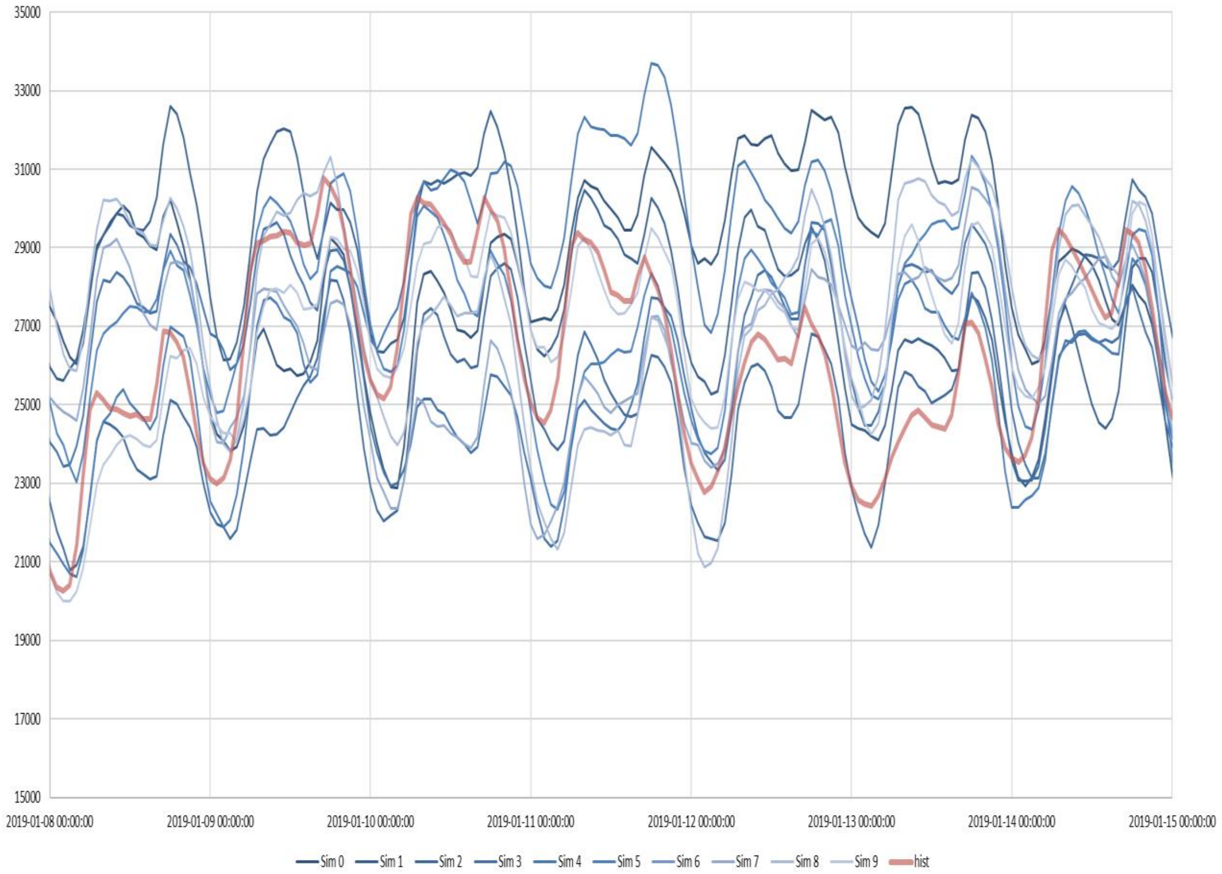
Energy Adequacy Analytical Framework – Sub-Hourly Flexibility Analysis

- At low levels of renewable energy penetration, flexible resource attributes (fast ramping and load following capabilities) are not often of primary concern, since load ramps are low and more predictable
- However, proliferation of renewable resources will dramatically increase the ramping and load following requirements across the markets
- A sub-hourly flexibility study can be used better understand and anticipate portfolio and system energy adequacy requirements as the share of intermittent, renewable generation grows.

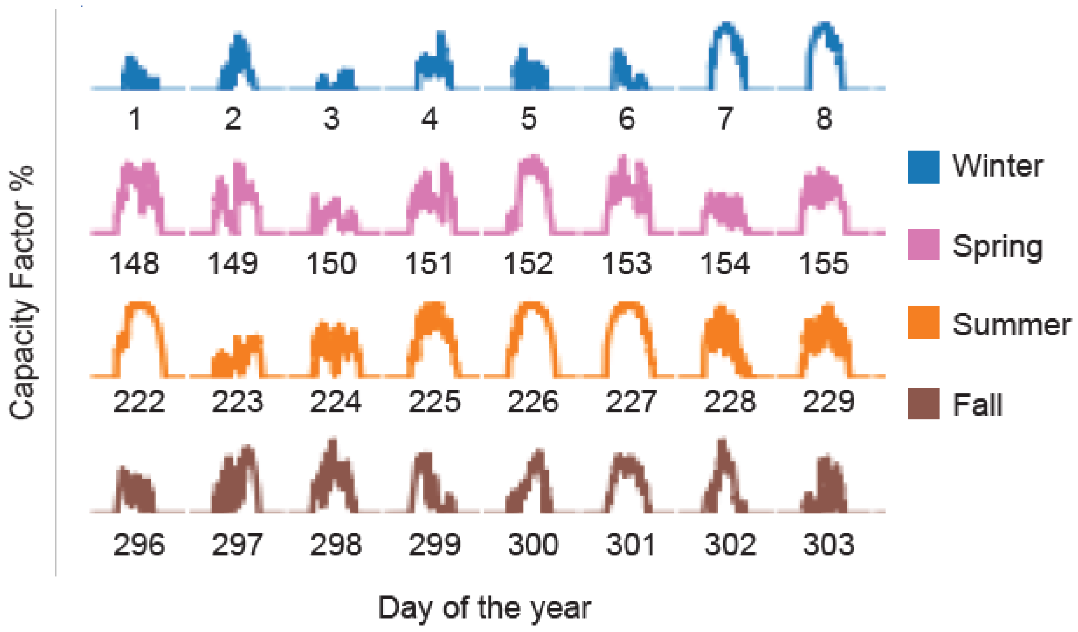
Key Input Development

Simulation techniques for load and renewable output can be used to develop sub-hourly data sets for use in flexibility simulations

Load Samples (sample weekly iterations)



Sub-hourly renewable output simulations (solar example)



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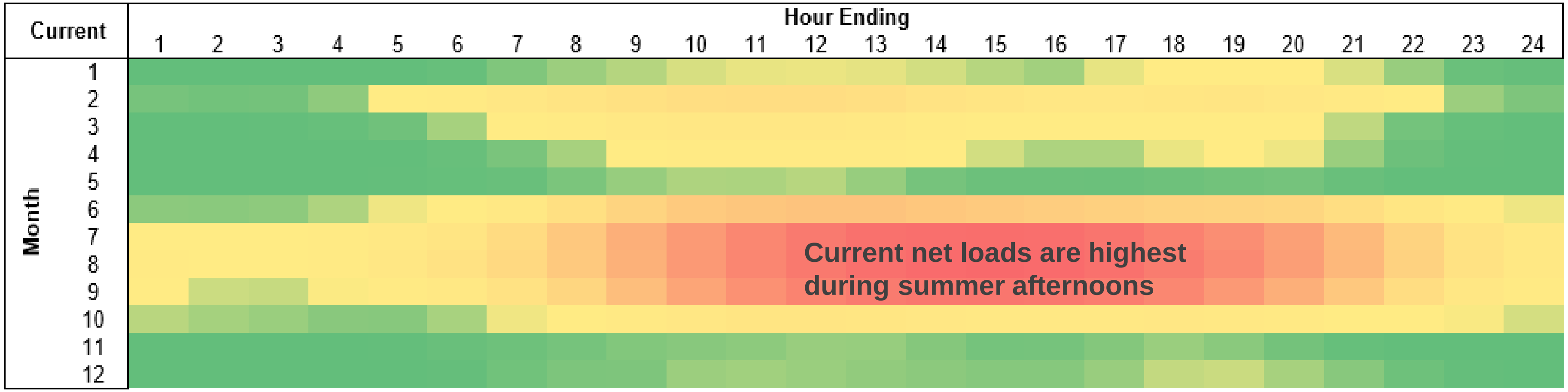
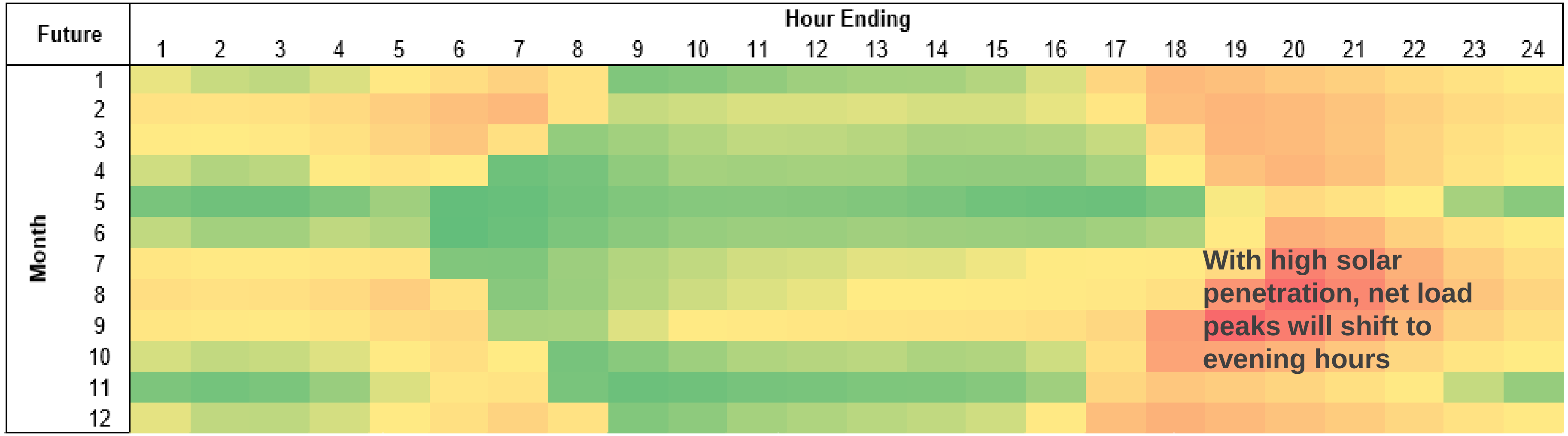
Key Output Considerations – Net Load

Net load = Load net of solar and wind generation. Net load can be negative if renewable generation exceeds load





- In a high solar penetration scenario, net loads tend to be higher overnight relative to the middle of the day
- Net load requirements ultimately drive ELCC and reserve requirement calculations

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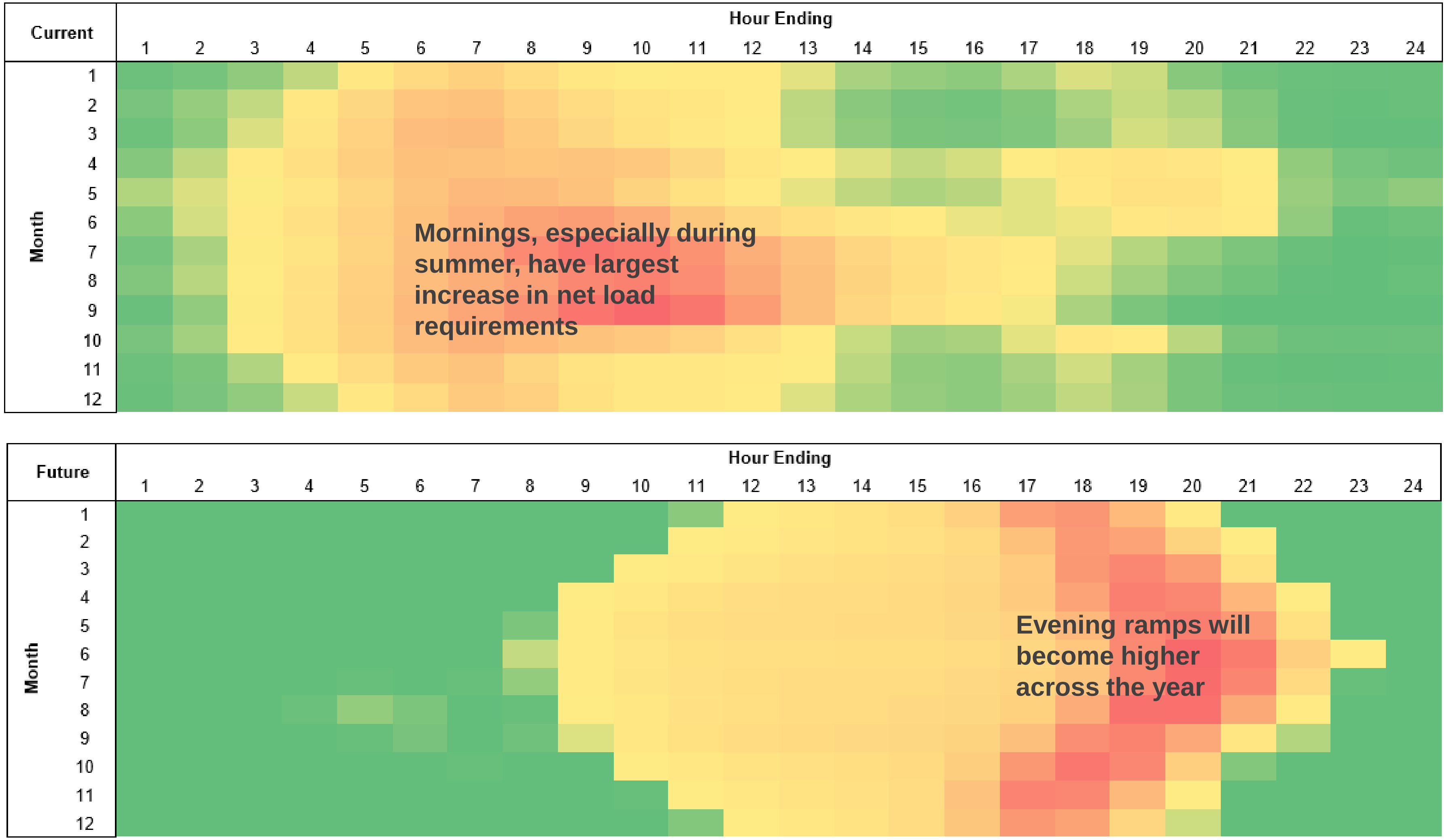
Key Output Considerations – 3-Hour Ramps

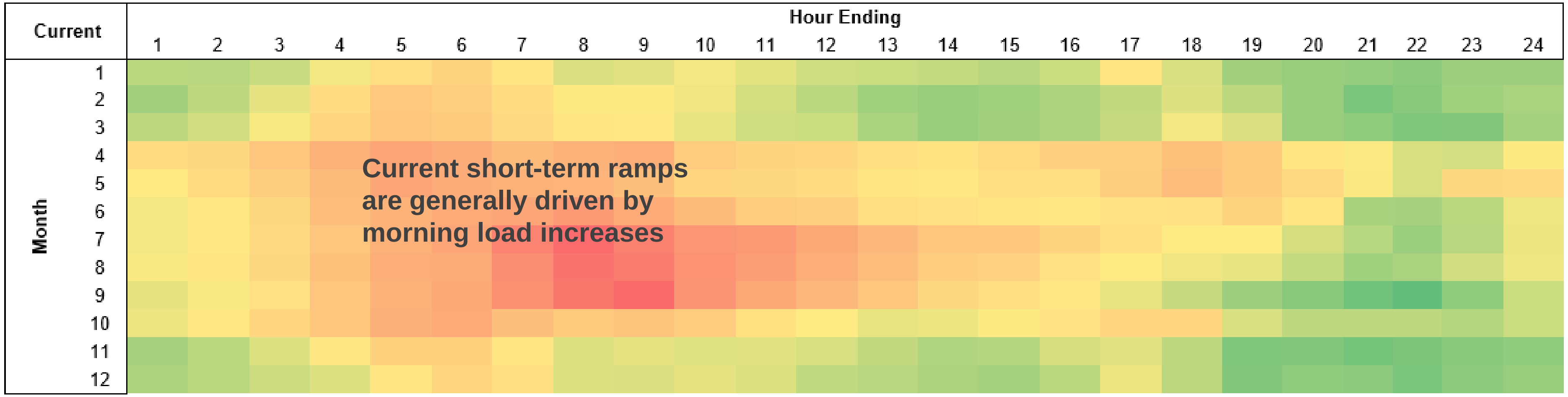
3-Hour Ramp = Increase in net load over a 3-hour period

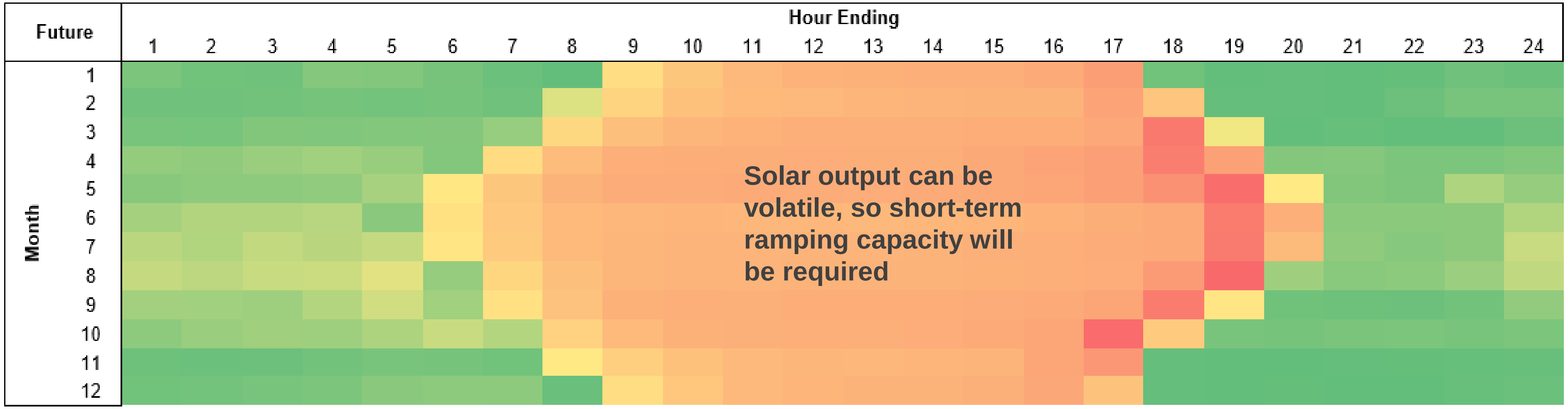


- Evening ramp requirements are likely to increase in magnitude in high solar penetration scenarios relative to current morning ramp needs
- Evening ramp magnitudes can be compared with flexible capacity able to meet the requirement

Key Output Considerations – 3-Hour Ramps

10-Minute Ramp = Increase in net load over a 10-minute period





- Sufficient fast responding capacity is needed throughout the day, largely to cover growing solar uncertainty

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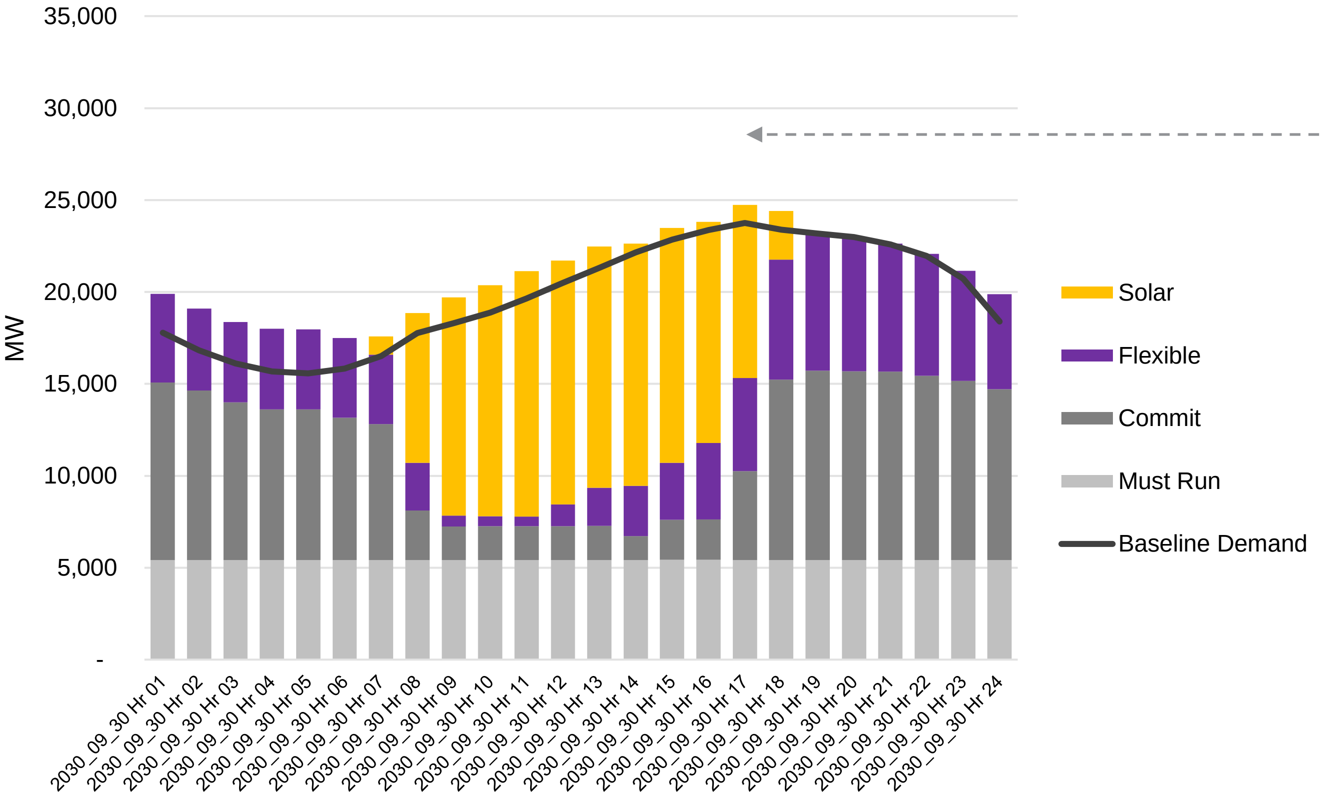
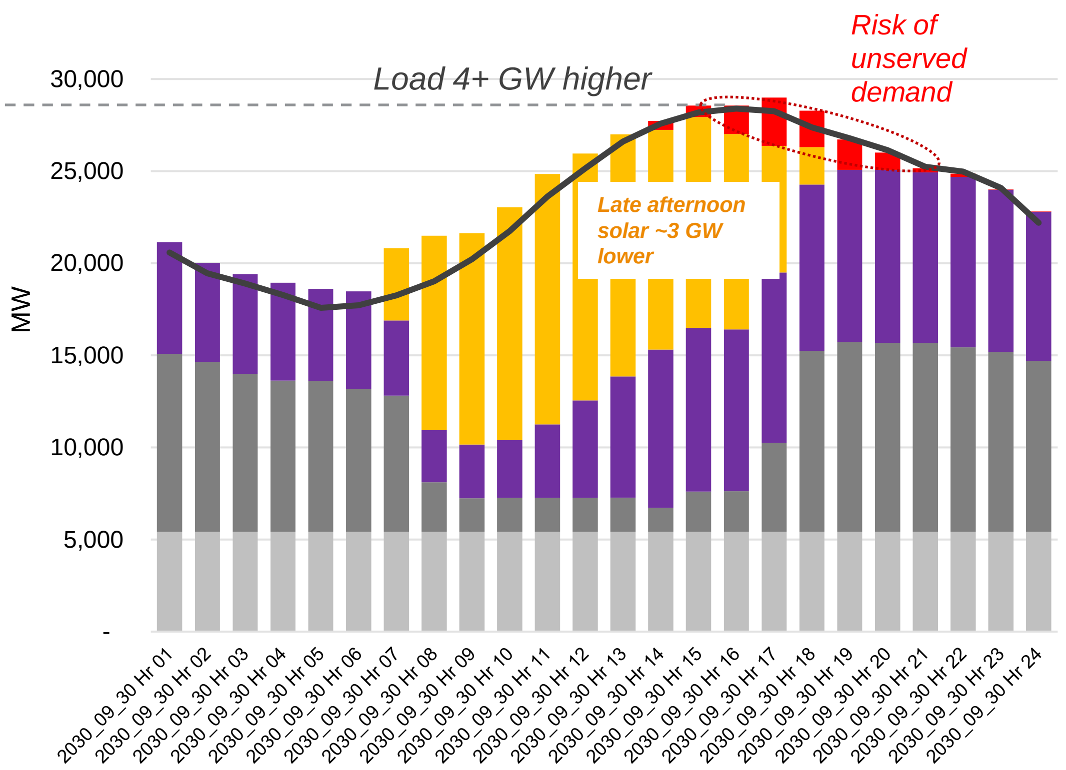
Key Output Considerations – 3-Hour Ramps

Sufficient flexible capacity will be needed to respond to significant deviations in load and renewable forecasts in real time

Day Ahead



Real Time



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Reliability Concerns for Inverter-Based Resource-Dominated Portfolios

Planning
- Energy Adequacy
- Resource Adequacy
- Short Circuit Strength
- Reactive Deliverability
- Power Quality
- Blackstart
- Evacuation Paths

Operations
- Dispatchability
- Predictability
- Firmness
- Power Ramping
- Frequency Response

Protection
- Low Short Circuit Currents
- Sequence Currents
- Source Impedance
- Low Inertia
- Inverter Models

Interconnection Standards

Synchronous Condensers

Energy Storage Duration

Grid Forming Inverters

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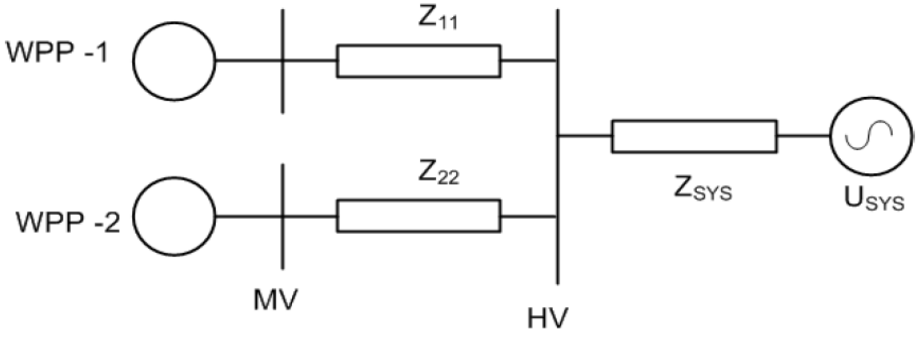
Short-Circuit Strength



Bus #	IBR (MW)	SCMVA	SCR	ESCR	ESCR with SC
237	30	343	11.5	2.1	3.2
59200	32	369	11.5	2.3	3.7
59100	32	600	18.7	2.5	4.0
238	23	206	8.9	2.2	4.2
1813	10	605	60.0	2.6	4.2
99000	20	481	24.0	2.6	4.2
119	29	311	10.8	3.0	4.2
56	29	343	12.0	2.2	4.3
94	28	1092	39.0	2.7	4.6
59400	23	736	32.0	3.1	4.8
2803	28	548	19.8	3.0	4.9

SCR is not a good indicator under high IBR penetration
Synchronous Condensers (SC) can increase short circuit strength

- Short Circuit MVA (SCMVA) is a measure of the strength of a bus in a system. The larger SCMVA, the stronger the bus.
- When conventional power plants with synchronous generators are retired and/or the system tie-lines are severed, the short circuit currents will dramatically decline. IBRs are not a substitute because their short circuit contribution is limited, and also the phase of their current (real) is not aligned with typical short circuit currents (reactive).
- Declining SCMVA and increasing IBRs will eventually violate the ESCR limits, requiring either a prohibition on additional IBR interconnections, or provisioning additional mitigation measures.
- Mitigations can come in the form of optimal placement of IBRs to avoid clustering them in a manner that violates the ESCR limits, provisioning synchronous condensers, or requiring inverters to have grid-forming (GFM) capability.

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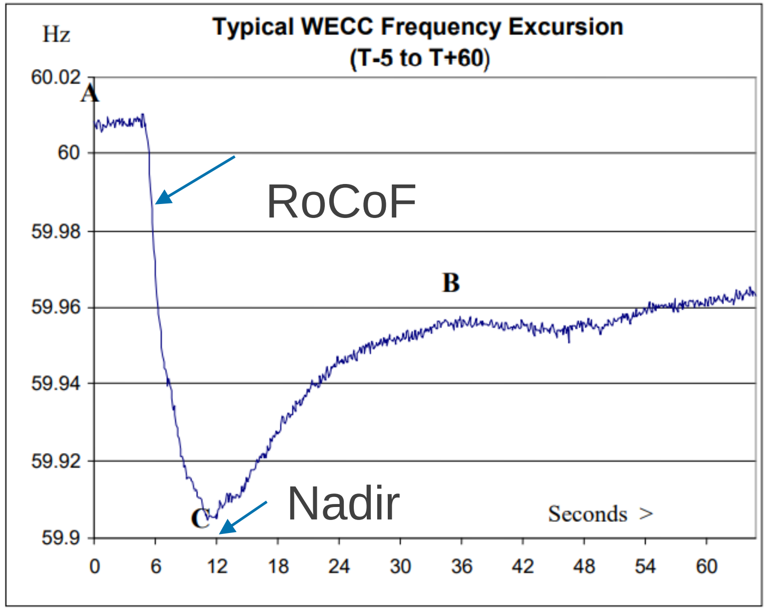
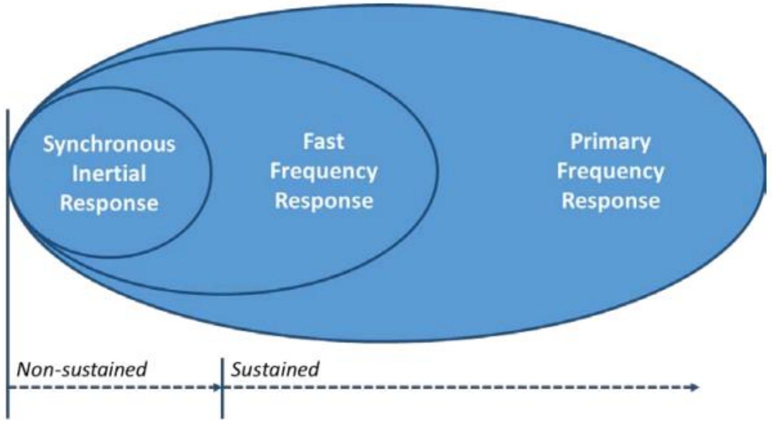
Frequency Control

- Power systems are designed and operated in conformance with NERC standards to maintain system frequency within acceptable limits under all conditions including:
  - Blue-Sky Operation (normal condition, interconnected system)
  - Black-Sky Events (catastrophic events that severely disrupt multiple infrastructures)
- The control of frequency requires multiple capabilities:
  - Inertial Response and Fast Frequency Response (FFR)
  - Primary Frequency Response (PFR)
  - Secondary Response (Regulation)
  - Tertiary Response (Imbalance and Reserves)
- Inverter-Based Resources impact frequency control significantly:
  - Low Inertia
  - Fast Response
- A fundamental responsibility of the Balancing Authority (BA) is to ensure that adequate amounts of frequency responsive reserves (including sufficiently fast frequency response) are available to reliably respond to frequency excursion events and ensure UFLS is not triggered for the largest credible contingency.





Control	Ancillary Service/IOS	Timeframe	NERC Standard
Primary Control	Frequency Response	10-60 Seconds	FRS-CPS1
Secondary Control	Regulation	1-10 Minutes	CPS1– CPS2 – DCS - BAAL
Tertiary Control	Imbalance/Reserves	10 Minutes - Hours	BAAL - DCS
Time Control	Time Error Correction	Hours	TEC

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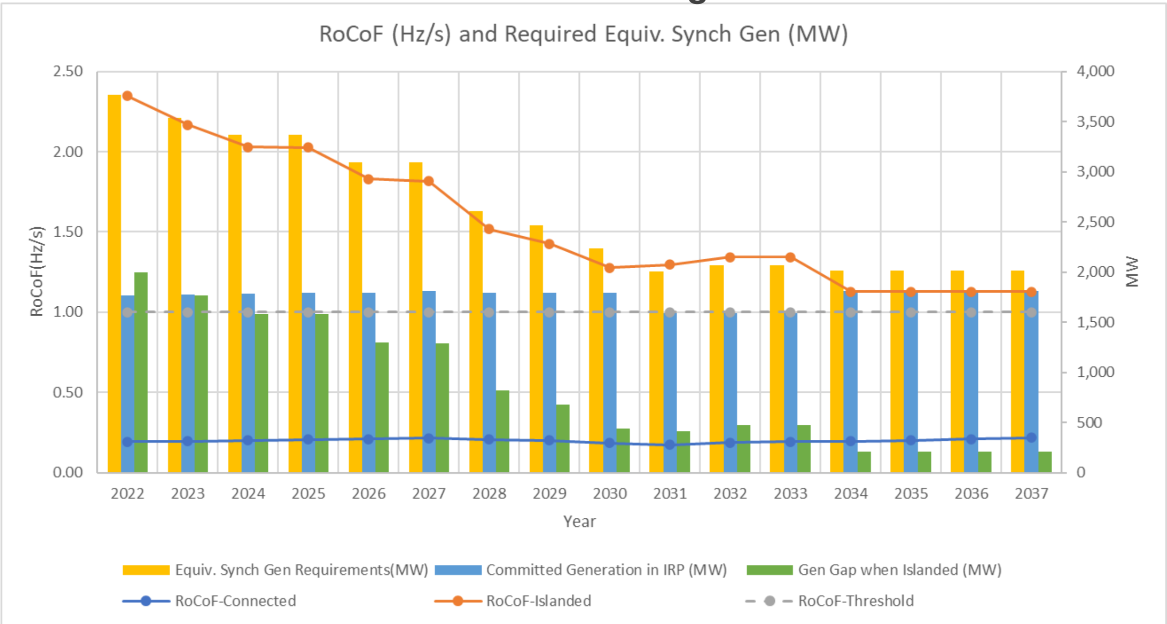
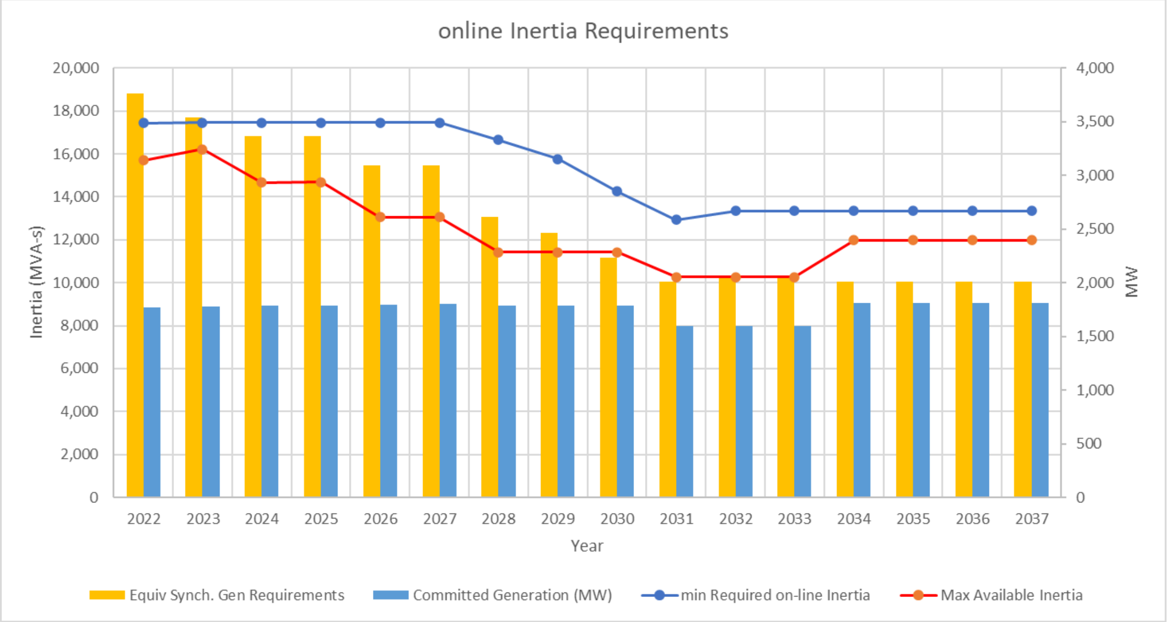
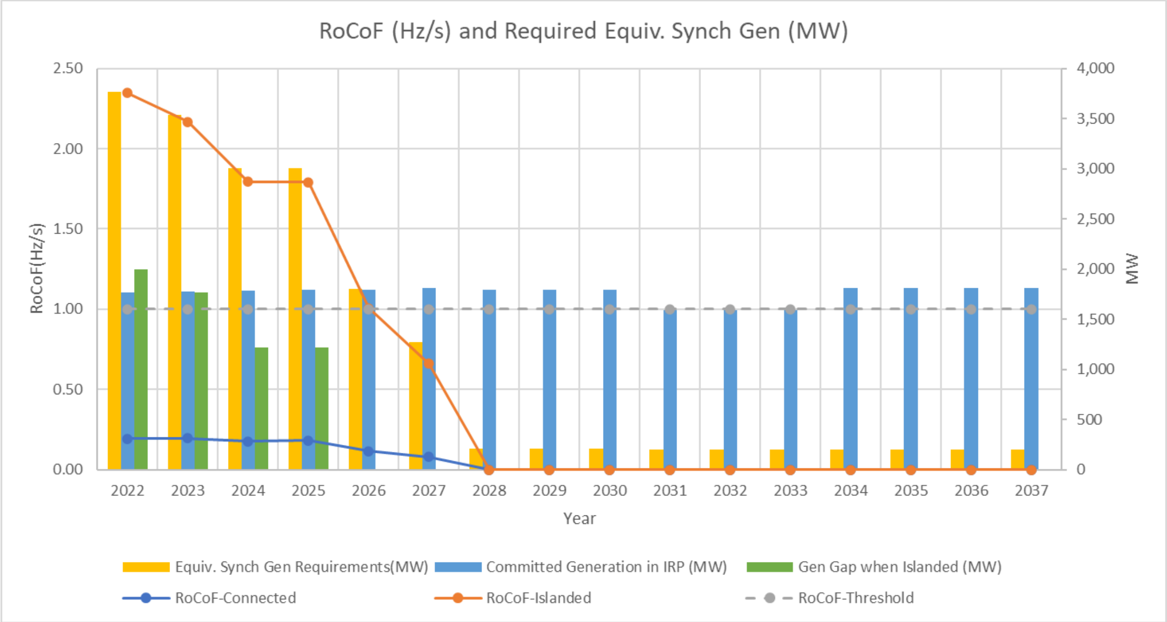
Inertial Response – Illustrative Example

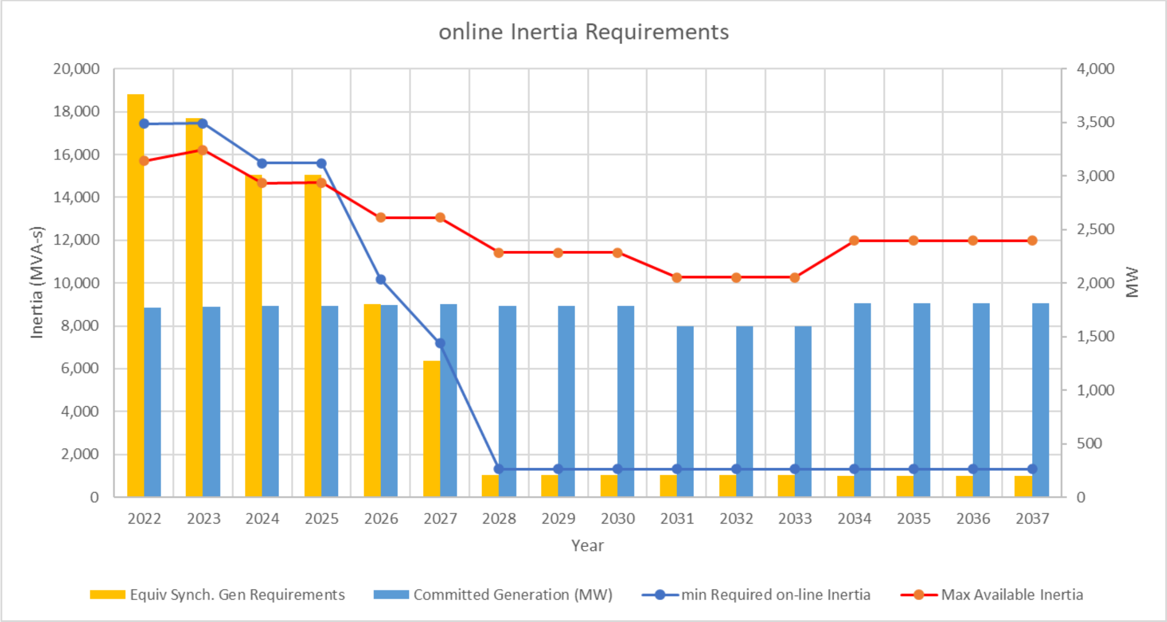
ESS with Grid-Following Inverters





ESS with Grid-Forming Inverters





Black Start Considerations

- Modeling:
  - Sequencing of Essential Motors (Startup and Shutdown)
  - Modeling of Induction Motors (dynamic characteristics)
  - Protection system Modeling
  - Fast bus transfer
  - Battery System
  - Transformers
- Analysis:
  - Transient and steady-state simulations
- Considerations:
  - Inverter short-circuit current limitations
  - Soft-start techniques
  - Dynamic interactions
  - Frequency and Voltage control
  - Protective relay operation in view of limited short circuit currents

- **Results:**
  - Inverter Size (MVA, PF)
  - BESS Size (MW, MWh)
  - BESS control and protection settings
  - Transformer tap settings
  - Protection setting adjustments

- Portfolios without Peaker Plants or Energy Storage equipped with GFM inverters cannot be started.
- Portfolios without peaker plants will have a limited time to energize the system (depending on the state of charge of the batteries). Larger batteries are better. During this period of time, they can attempt to start facilities with solar+storage first, and then solar, and then wind near the major load centers. The synchronous condensers provide the reactive power, and the battery stabilize the frequency.

Questions?

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