Meeting the Modern Resource Adequacy Challenge:

A Case for Flexible Technology

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Agenda

- Executive summary
- The path to 100% clean grid
- Role of flexibility: Evolving reality of resource adequacy needs in the US
- Value of flexibility: Cost-effective solution to address RA challenges

Executive Summary

- Flexible resources can replace the aging thermal fleet, support renewable growth and are future proof to run on sustainable fuels

- The new era of resource adequacy means changing system risk profiles and calls for resources with flexible attributes

- Flexible technology is well positioned to maximize values from the evolving energy and capacity market structures

The path to a clean grid of the future requires multiple forms of flexibility

1

Adding more renewables into the power mix.

5

A 100% renewable energy future is here

It is based on renewables, energy storage, and balancing engine power plants running on sustainable fuels.

The path to a clean grid of the future requires multiple forms of flexibility

1

Adding more renewables into the power mix.

Decrease running hours of inflexible power plants.

2

Adding flexible engine power plants & storage to balance the intermittency of renewables.

Continue adding renewables supported by flexibility.

3

Phasing out inflexible power plants running on coal.

Sustainable fuel options become widely available.

4

Accessing sustainable fuels and converting all remaining power plants to run on them.

5

A 100% renewable energy future is here

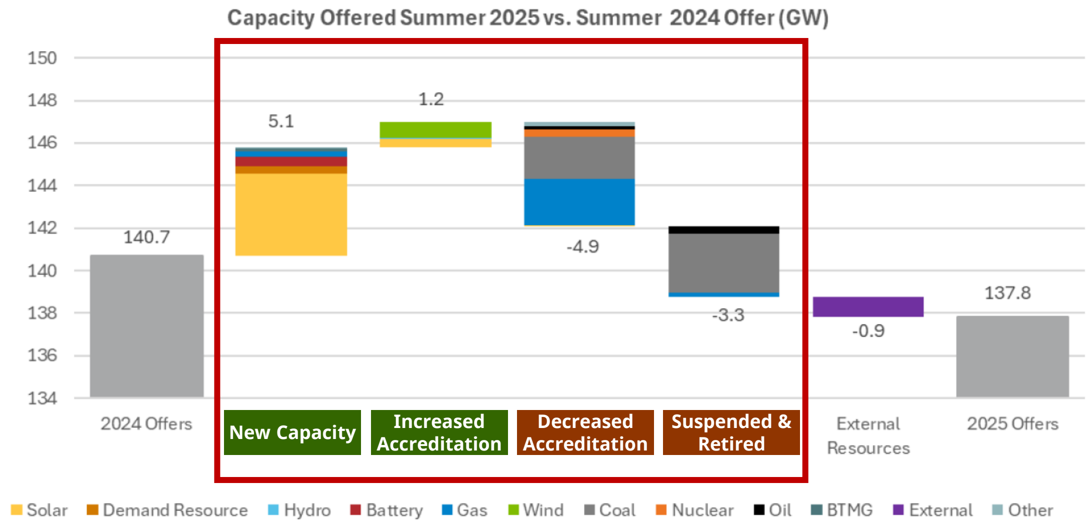
It is based on renewables, energy storage, and balancing engine power plants running on sustainable fuels.

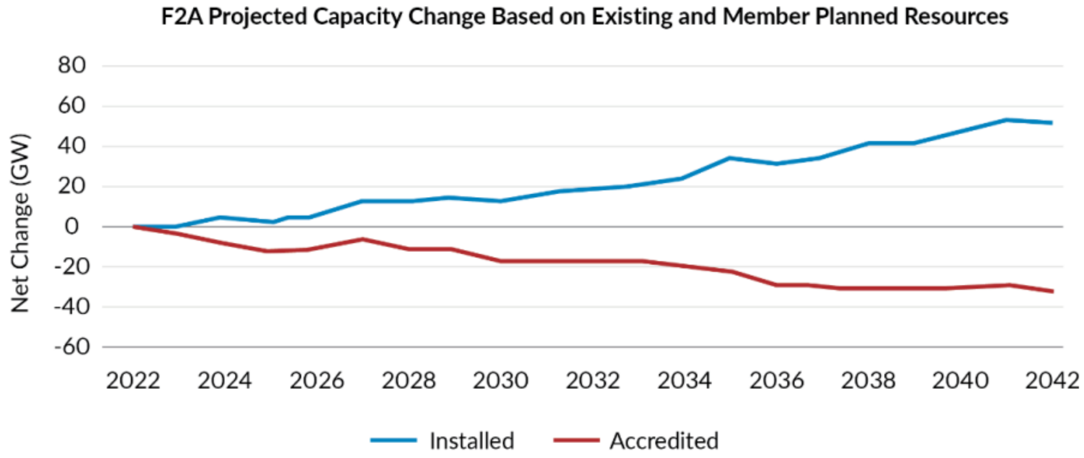
System margins are tightening despite increasing ICAPs

- New capacity additions do not keep pace with decreased accreditation, retirements and external resources

- MISO met PY 25/26 RA requirements; but surplus is reducing across regions and in question longer term

MISO PY 2025/26 PRA Results





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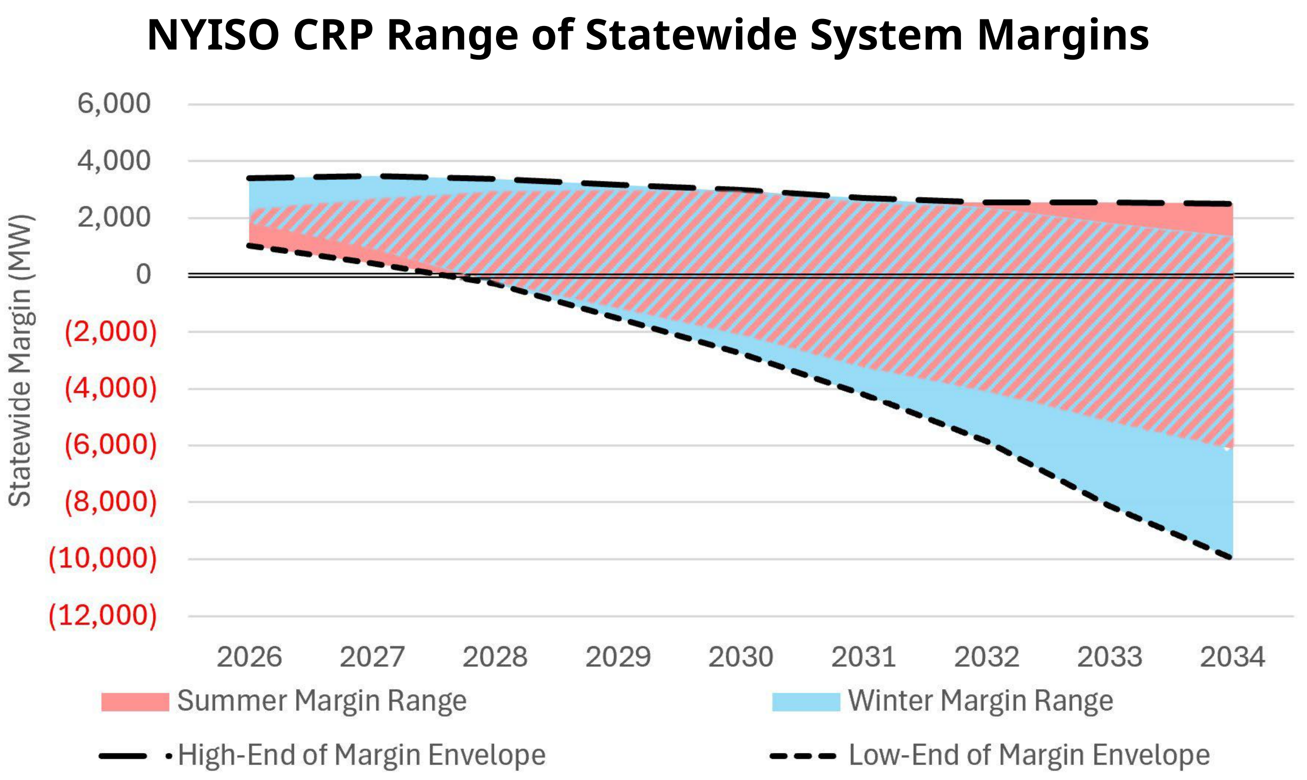
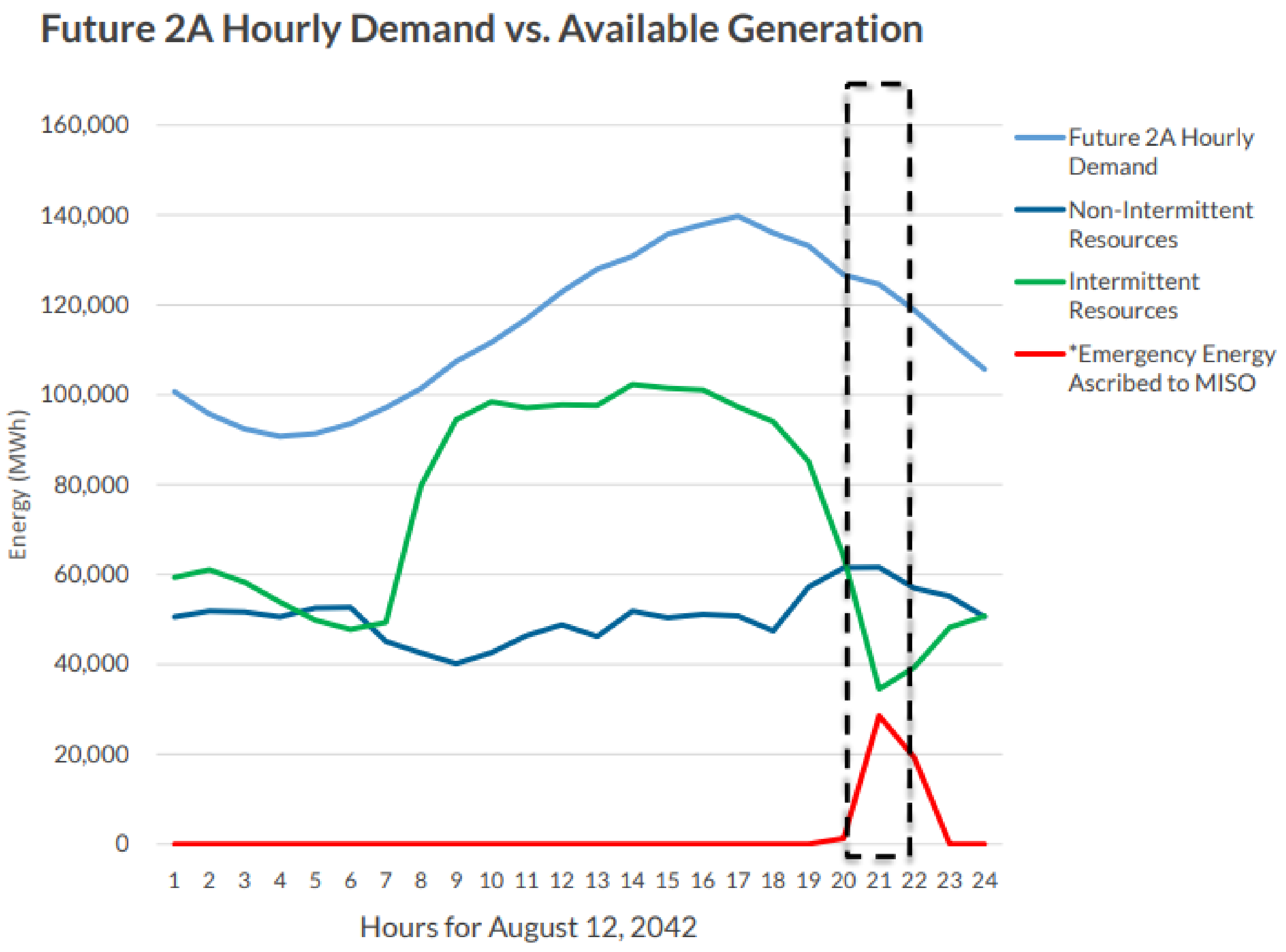


The new era of resource adequacy and reliability needs

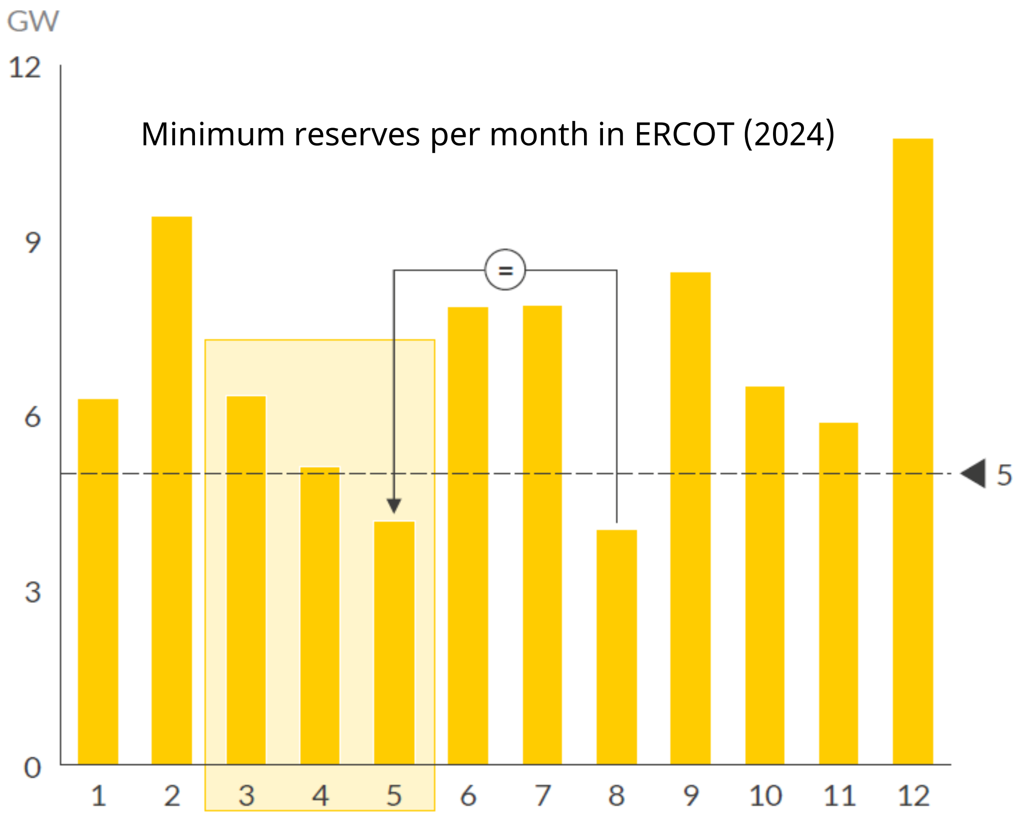


Source: MISO Futures Design Workshop

Twilight hour risks require the addition of flexible generation when intermittent resources are unavailable and traditional dispatchable generation cannot meet the fast net load ramping.

The new era of resource adequacy and reliability needs

Combined thermal outages and weather volatility pushed shoulder-month reserves as low as summer levels



Source: Aurora Public Report 6/12/2025
The US Reliability Challenge and the Value of Flexibility

System risks and reliability concerns become a year-round challenge.

High-load events during the shoulder months become more common when planned maintenance removes critical thermal generation, compounded by increasing weather volatility during the spring and fall.

Not all dispatchable resources are created equal. With the evolving system risk profiles, resources with flexible attributes are better positioned to provide support

Cost effective

Flexible operation

Heat rate/Efficiency

Weather tolerant

Low emissions

Modular design

Revenue competitive

Commercially ready

Sustainable fuel

Attributes that allow flexible engine power plants to show up when and where needed

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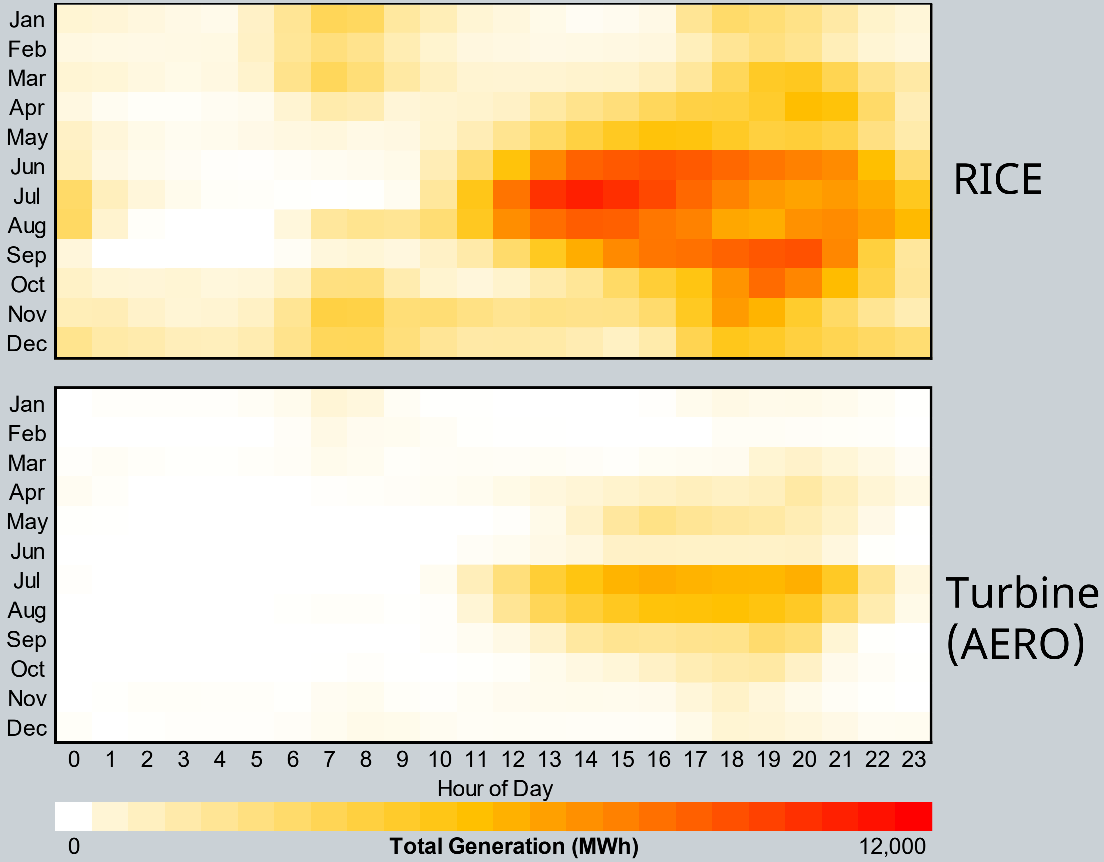
Balancing vs. Peaking



RICE experiences no to minimal derating due to high ambient temperature

Cost effective

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Low emissions

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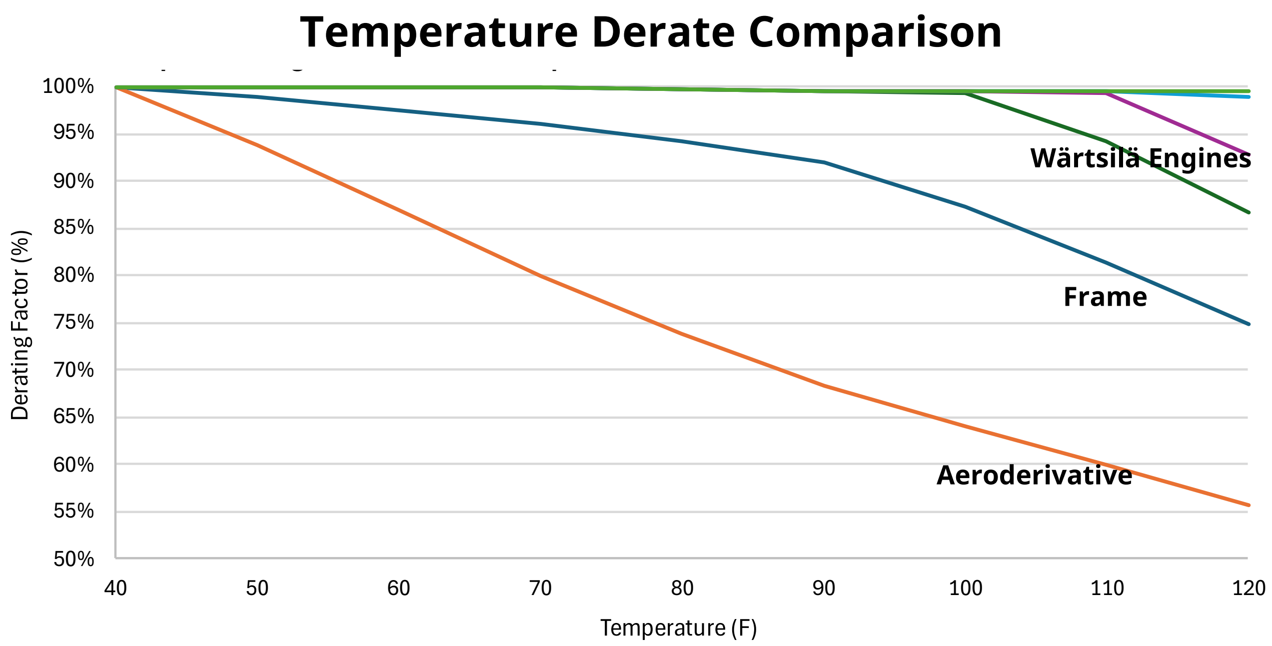
Commercially ready

Sustainable fuel



-Elevation 0 ft / 0 m
-Relative Humidity 60%
-GE LM6000PC/7F.05 – no inlet conditioning
Source: GTPro, PerfPro

RICE are designed to endure cold temperatures as low as -40°F

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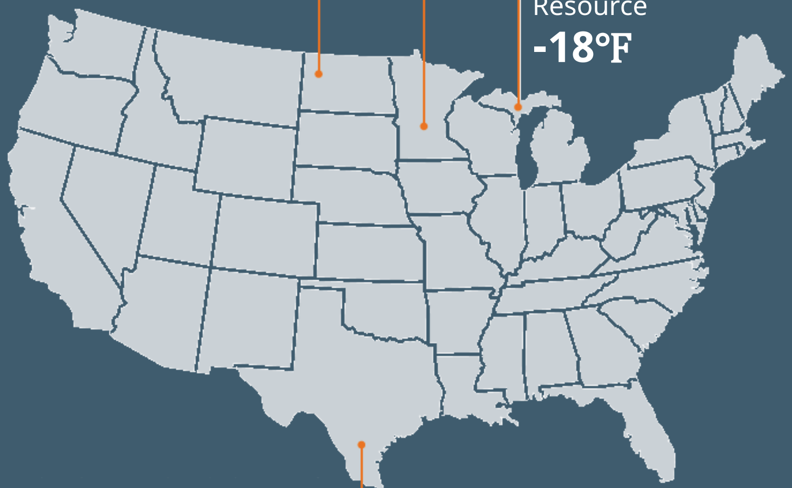

Wärtsilä engine power plants performed through record low temperatures during Winter Storm Uri in February 2021

Investment in new resources is complicated by myriad of new phenomena and needs all-around cost benefit analyses

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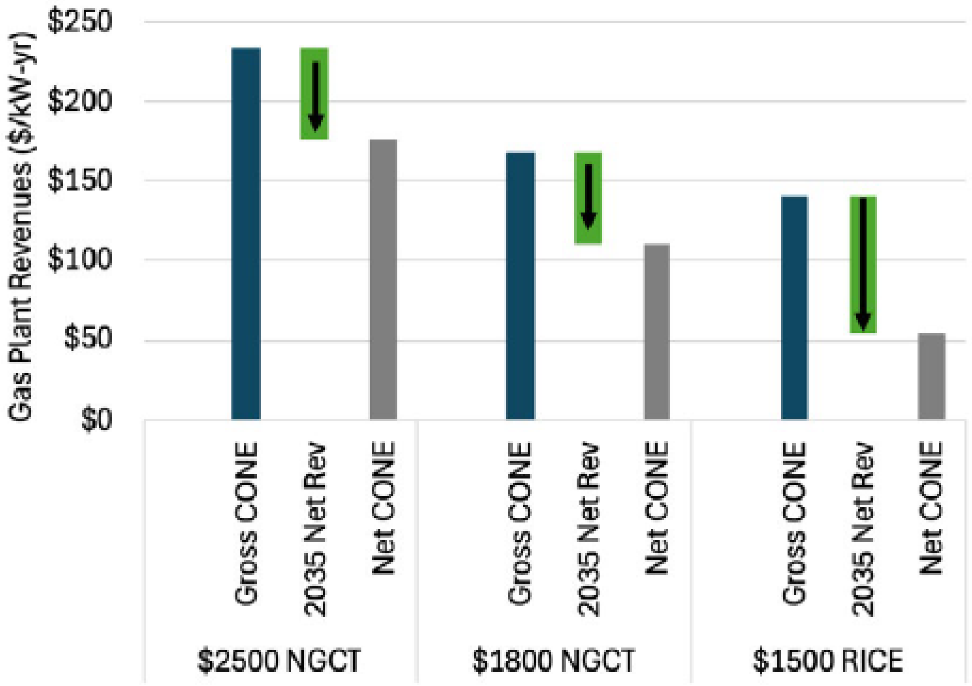

CapEx forecast for selected natural gas plant technologies (nominal $) by online year and impact on revenue required from capacity markets and other capacity incentives[1].

[1] Source: Ascend Analytics
Thermal Generation: The importance of maximizing flexibility and availability in the coming era of high capacity prices and low energy prices

Key Takeaways

We envision a clean grid of the future that has a diverse and balanced supply stack, consisting of renewable, energy storage, and flexible power plants running on sustainable fuels that balances the intermittency of renewables.

Ongoing resource adequacy challenges and reliability concerns are being driven and exacerbated by load growth acceleration, aging and retiring thermal fleet, loss of accredited capacity despite increasing ICAPs and more frequent extreme weather events.

High risk intervals are shifting from load peaks and reliability is becoming a year-round issue. RA means more than having surplus capacity but also having energy assurance. Flexible resources are the more cost-effective solutions in addressing system risks when and where needed.

It is high time to explore multi-metric planning and align planning needs with operational realities. Flexibility is critical to manage system stress at all times and needs to be incentivized accordingly.

Thank you

Kiitos Paljon

Appendix

System margins are tightening despite increasing ICAPs

- New capacity additions do not keep pace with decreased accreditation, retirements and external resources

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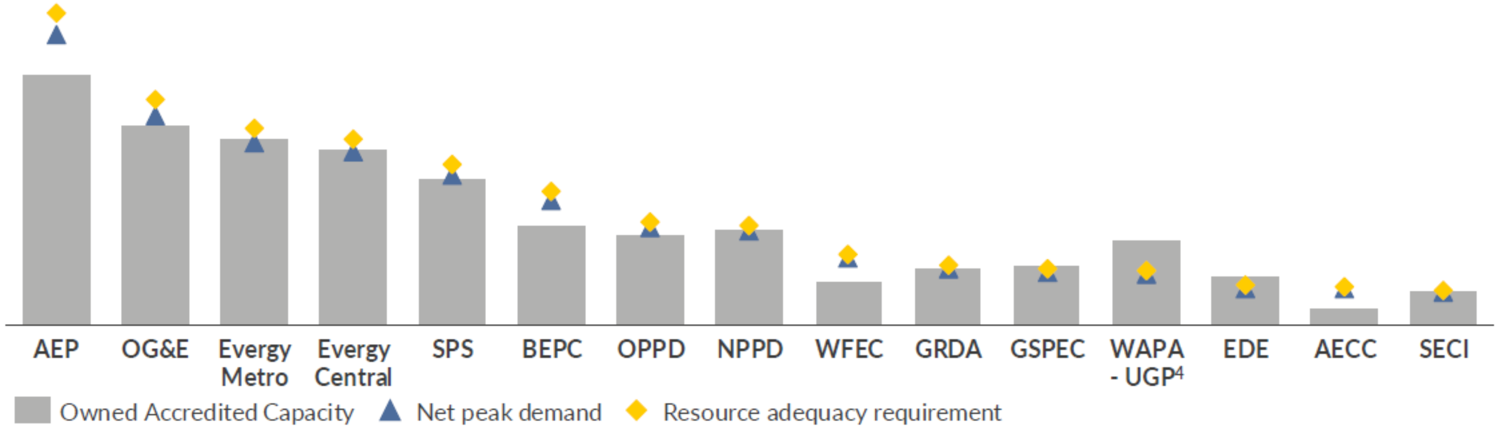
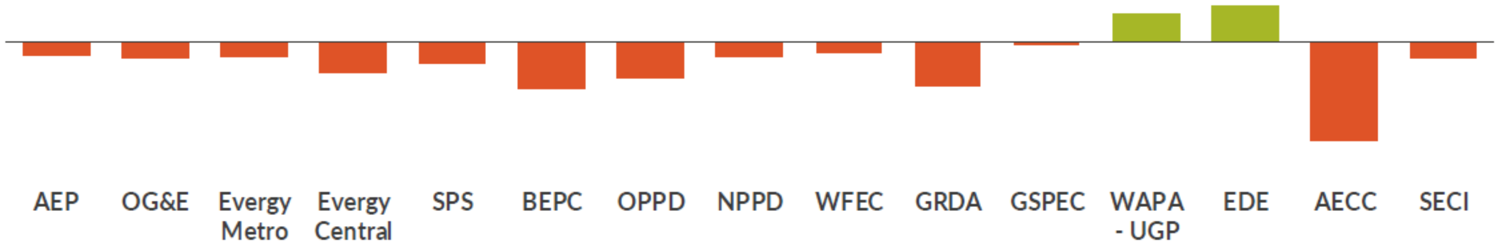
- NYISO draft 2025-2034 Comprehensive Reliability Plan identifies no immediate reliability needs, however the most plausible futures point to significant reliability shortfalls in the coming decade

- SPP is moving to Performance Based Accreditation for conventional resources effective summer 2026, putting downward pressure to their accredited values

SPP LSE 2025 owned accredited capacity, net peak load and resource adequacy requirement (MW) [1]



Change (%) in owned accredited capacity with new summer class average accreditation [1]



[1] Source: Aurora Energy Research
Race to Reform: Resource Adequacy in SPP public webinar

Comparison of typical cost and flexibility characteristics for various NG technologies

	NGCC	NGCT	NGCT-Aero	RICE
CapEx ($/kW)	$2500	$2200	$2500	$1500
Heat Rate (MMBTU/MWh)	5.5-7	8-10	8-10	7-8
Startup Time	1-5h	<1h	<15min	<5min
Minimum On-Time	2-8h	<1h	10-30min	5min
Minimum Generation Level (% of Nameplate)	25-40%	30-50%	10-30%	0%
Ramp Rate (time to full output)	>1h	10-20min	5min	5min
Cold Startup Cost ($/MW)	$80	$50	$20	$0

Sustainable Fuels

1. Wärtsilä Dual-Fuel (DF) Engines
   - Wärtsilä's dual-fuel engines are designed to operate on both liquid fuels (e.g., marine diesel oil, heavy fuel oil) and gaseous fuels (e.g., natural gas, bio-LNG, synthetic methane).
   - Examples of dual-fuel engines:
     - Wärtsilä 31DF, 34DF, 50DF

2. Wärtsilä Pure Gas Engines
   - These engines are optimized for running exclusively on gaseous fuels, including sustainable options like bio-LNG and synthetic methane.
   - Example:
     - Wärtsilä 34SG: A spark-ignited gas engine used in power generation.

4. Wärtsilä Ammonia-Ready Engines
   - Wärtsilä is actively testing and developing engines that can run on ammonia, a zero-carbon fuel.
   - **Current engines, such as the Wärtsilä 31 and Wärtsilä 46, are being adapted to be ammonia-ready**.

5. Hydrogen-Ready Engines
   - Wärtsilä is working on engines that can run on hydrogen/hydrogen blends. While **full hydrogen operation is still under development**, some engines can already operate on hydrogen blends.
   - Example:
     - **Wärtsilä 31DF: Can operate on a blend of hydrogen and natural gas.**

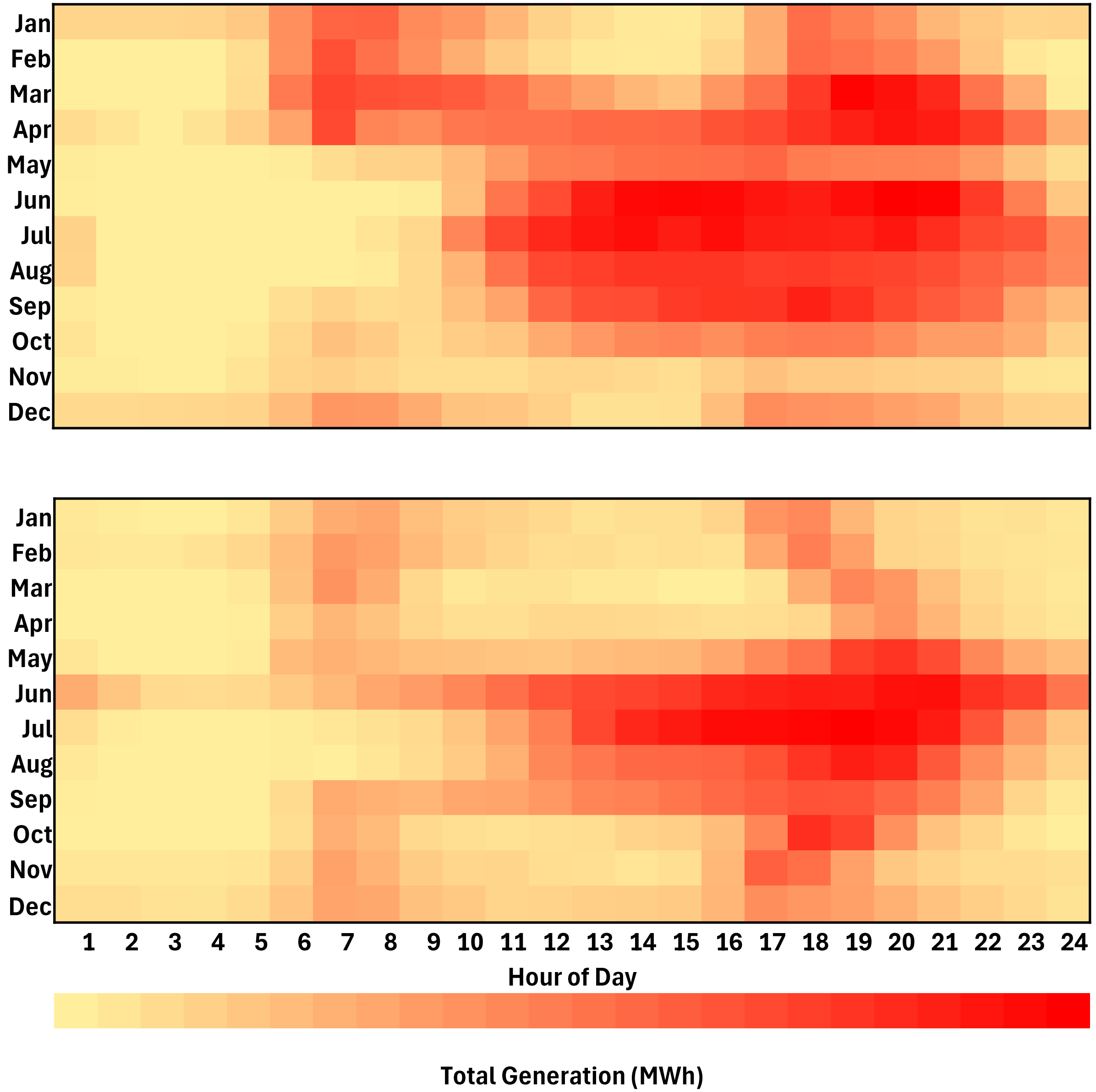
6. Hydrogen Blends
   - Wärtsilä has **conducted successful tests of its engines running on hydrogen blends (up to 25% hydrogen by volume).** While full-scale hydrogen power plants are still in development, some pilot projects are underway.
   - Example: Wärtsilä has partnered with energy companies to test hydrogen blends in power plants, such as in Europe and Asia.

7. Biofuels Compatibility
   - Many Wärtsilä engines can run on biofuels, such as biodiesel or hydrotreated vegetable oil (HVO), with little or no modification.
   - Examples:
     - Wärtsilä 20, 46F

8. Retrofitting for Sustainable Fuels
   - Wärtsilä offers retrofit solutions to modify existing engines to run on sustainable fuels, such as LNG, methanol, or ammonia. This allows customers to transition to cleaner fuels without replacing their entire engine.

RICE demonstrate both Peaking and Balancing Capabilities

Lack of Flexible in Real-Time



Electric Cooperative Heat Map

Utility Customer Heat Map

Balancing Capabilities

RICE plants exhibit a much broader operating profile, with frequent generation across practically all hours of the day in each month.

Dispatch Data for 2024

- **MISO Region**
- **469 / 417 Plant Starts**
- **23% / 22% Capacity Factor**

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