

Generation Asset Performance Assurance and Forecasting

Changing the Game with Machine Learning

Presented February 21, 2023

at

PowerGen International

Orlando, FL



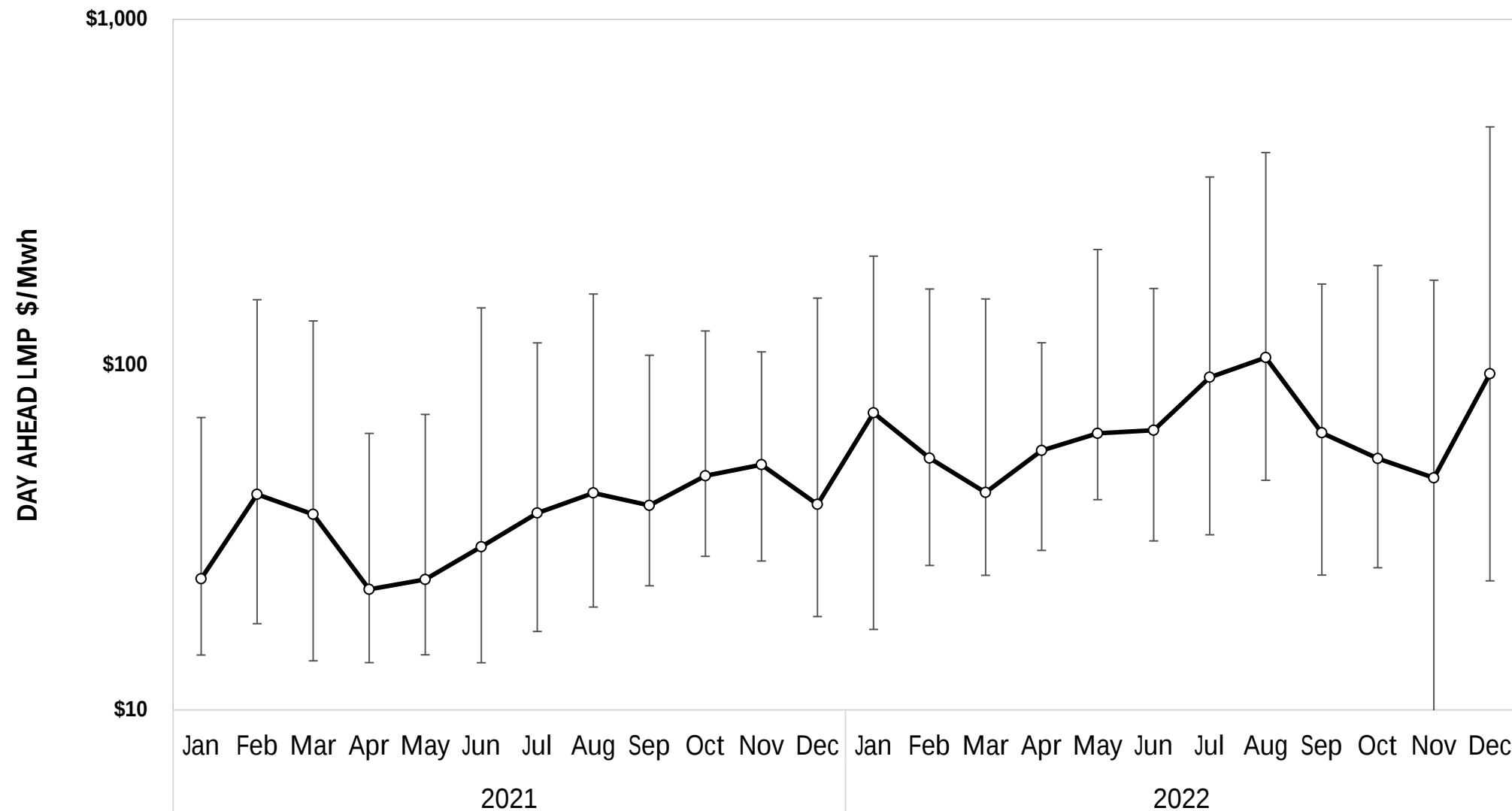
GENERATE BETTER PERFORMANCE



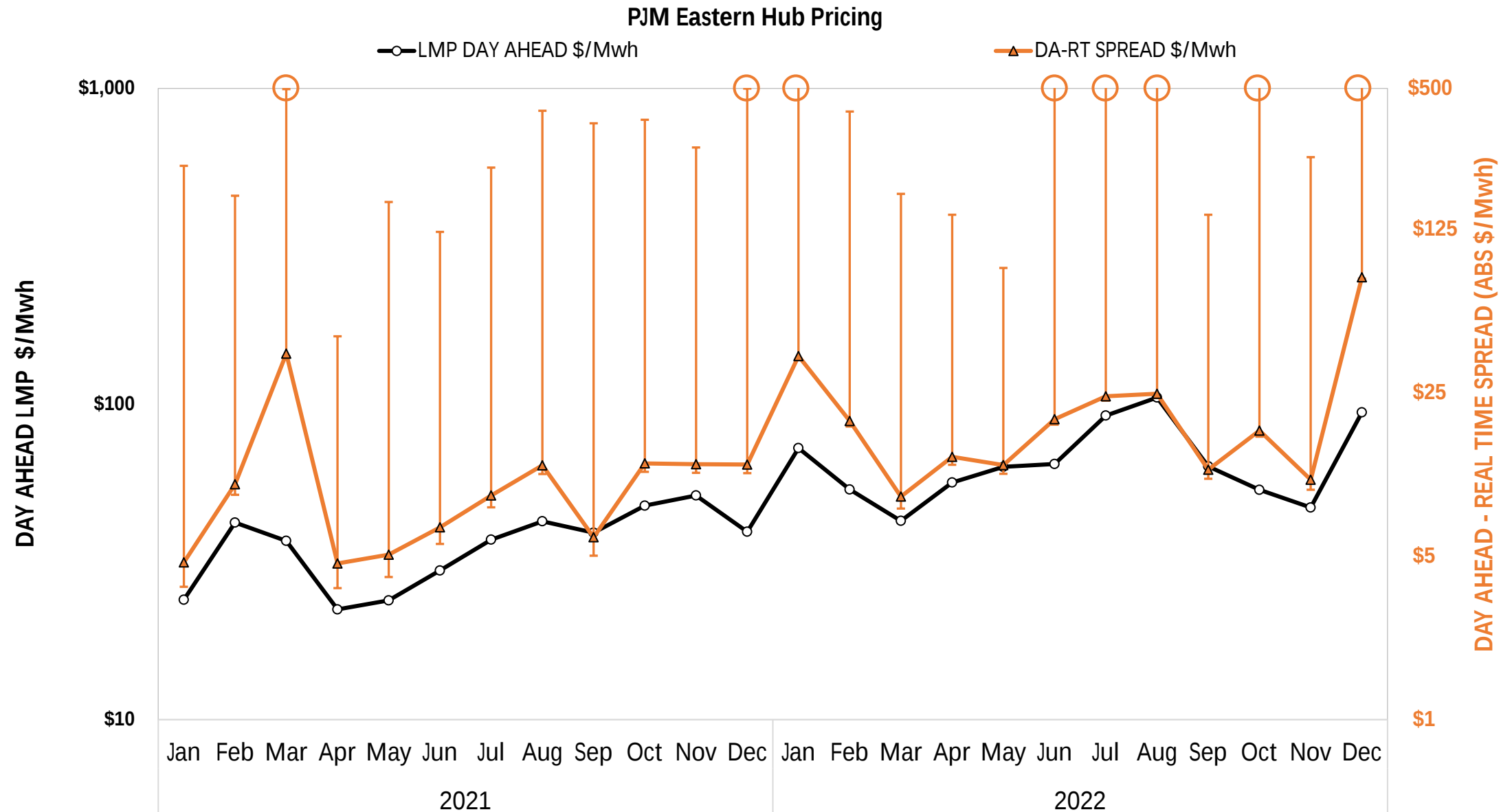
- Ø Market pricing, volatility and competition mean generating companies need better ways to optimize the present and predict the future.
- Ø Efficiency gain or loss of 1 Mw was worth ~\$500k in the 2022 PJM market and 1% change in heat rate was worth ~\$3.5M in earnings at a 740 Mw CCGT plant.
- Ø Compared to conventional methods, machine-learning (ML) technology makes it possible to recognize and realize improvement opportunities sooner, with more precision and greater confidence.
- Ø Machine Learning is a tool that is necessary but not sufficient to understand the present and predict the future; knowledge and experience is also needed!
- Ø Primex's Performance Assurance V2 services (GMD, CFF and PGV) leverage ML technology to change the game for key decision-makers in asset management and operations roles.

PJM Eastern Hub Pricing

—○— LMP DAY AHEAD \$/Mwh

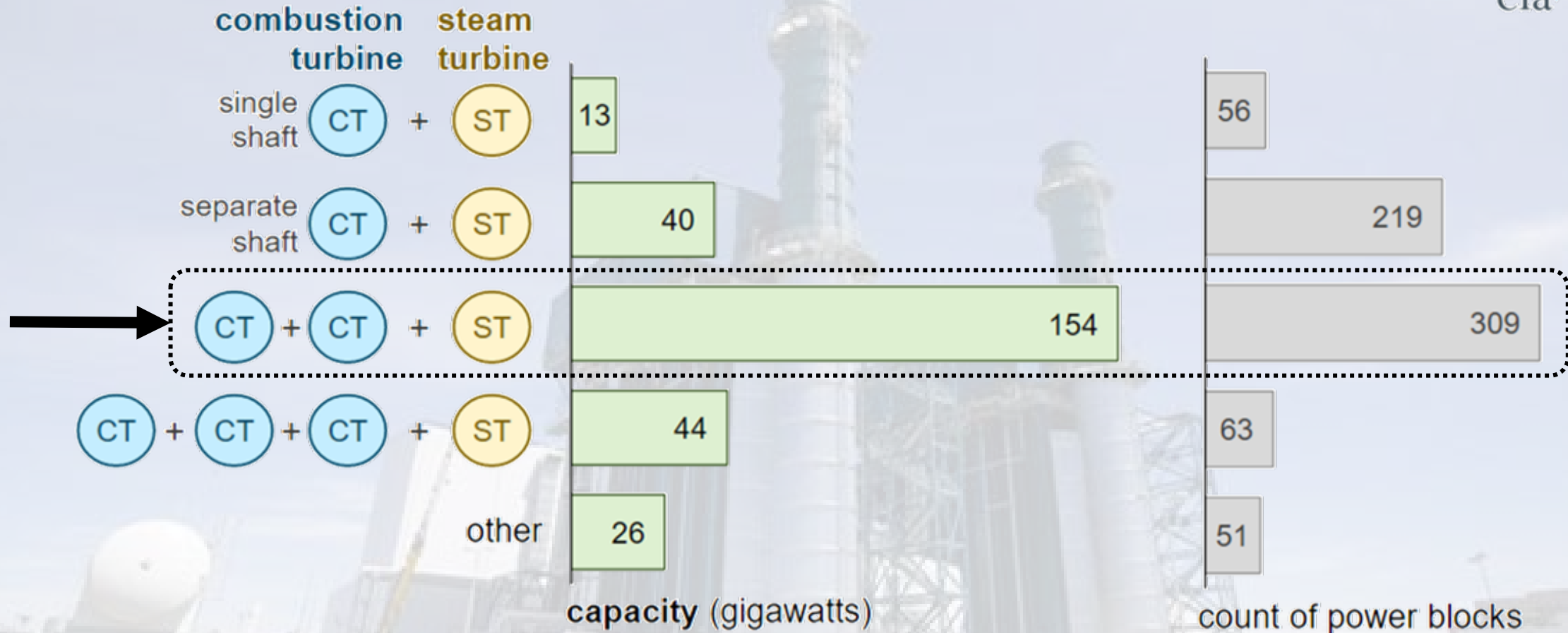


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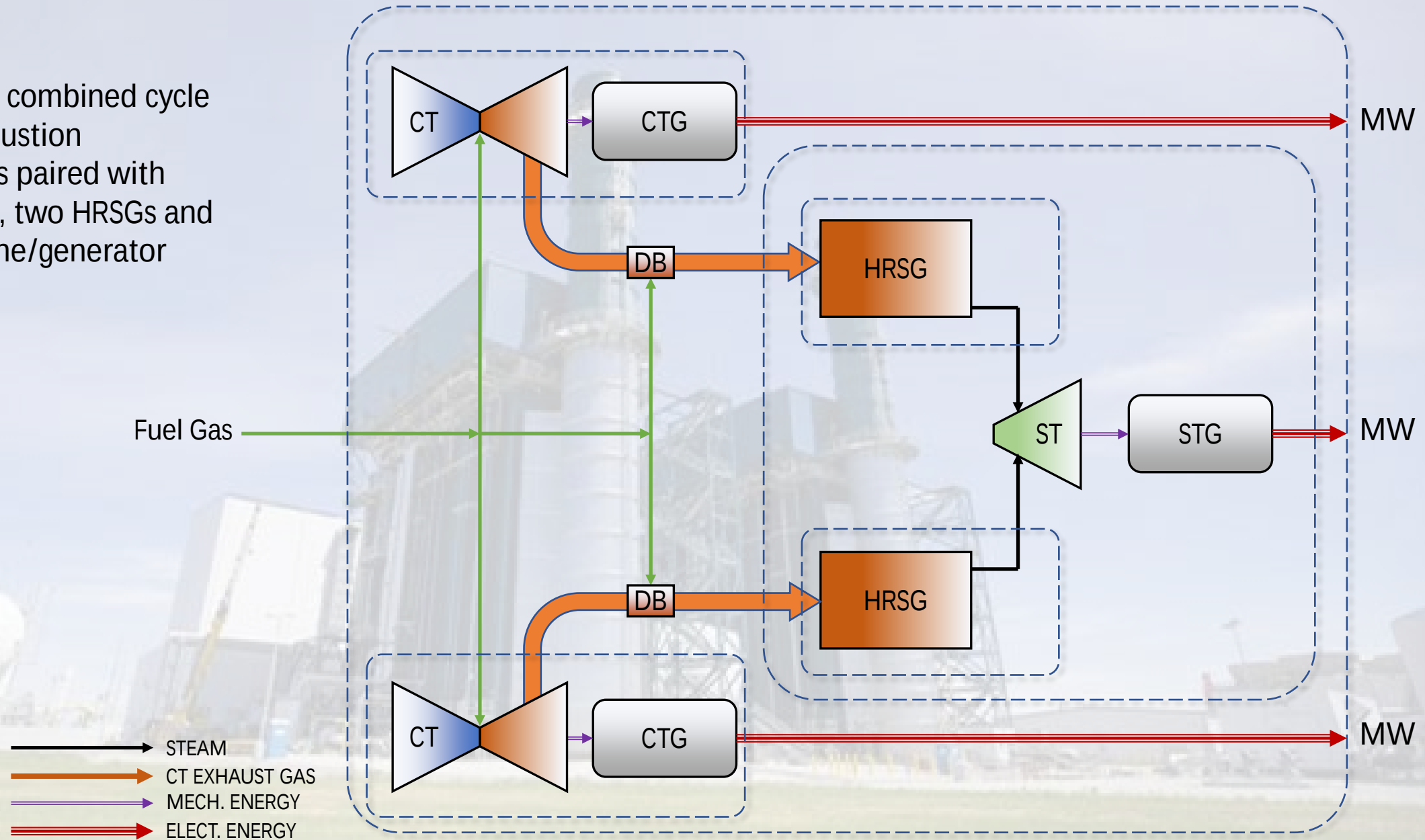
Natural gas combined-cycle capacity and count by configuration (2020)

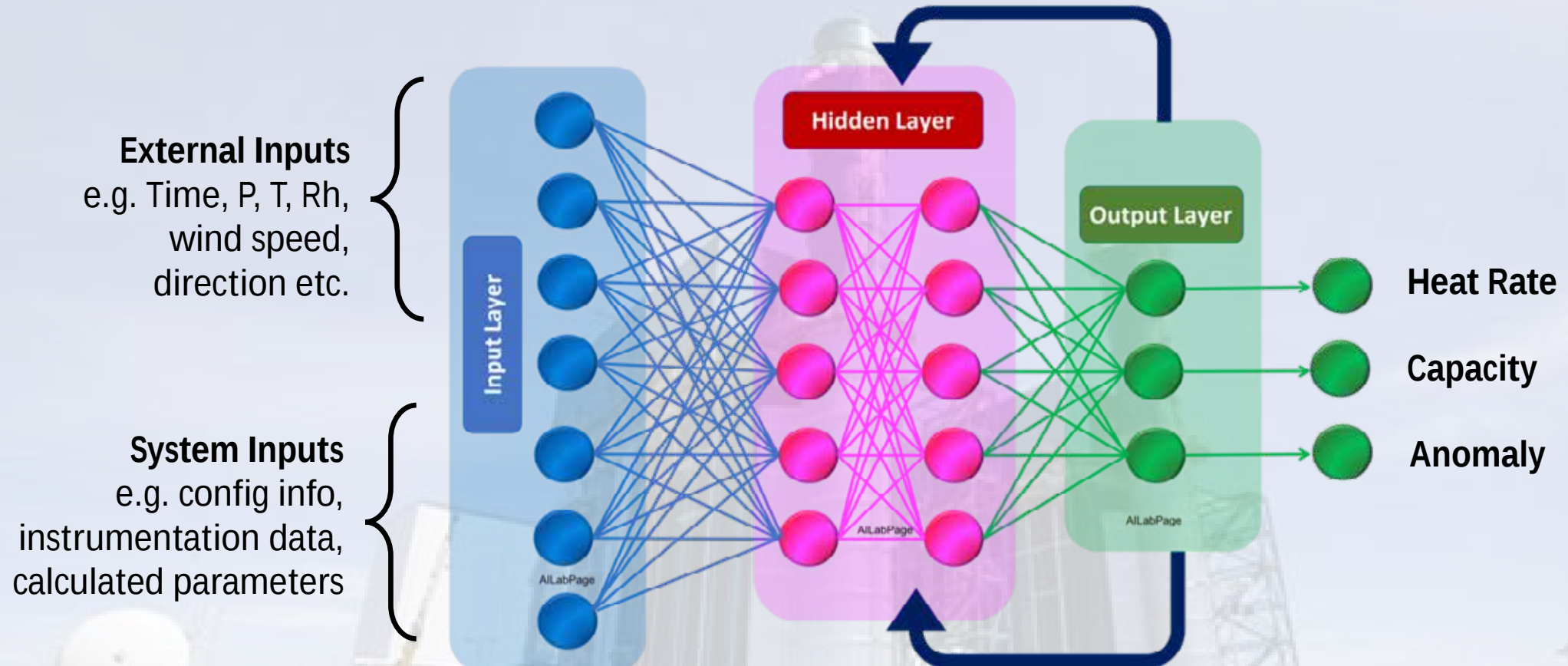


Source: U.S. Energy Information Administration, [Electric Power Annual](#)

Case Study

740 MW (net) 2×1 combined cycle utilizing two combustion turbine/generators paired with parallel duct firing, two HRSGs and single steam turbine/generator

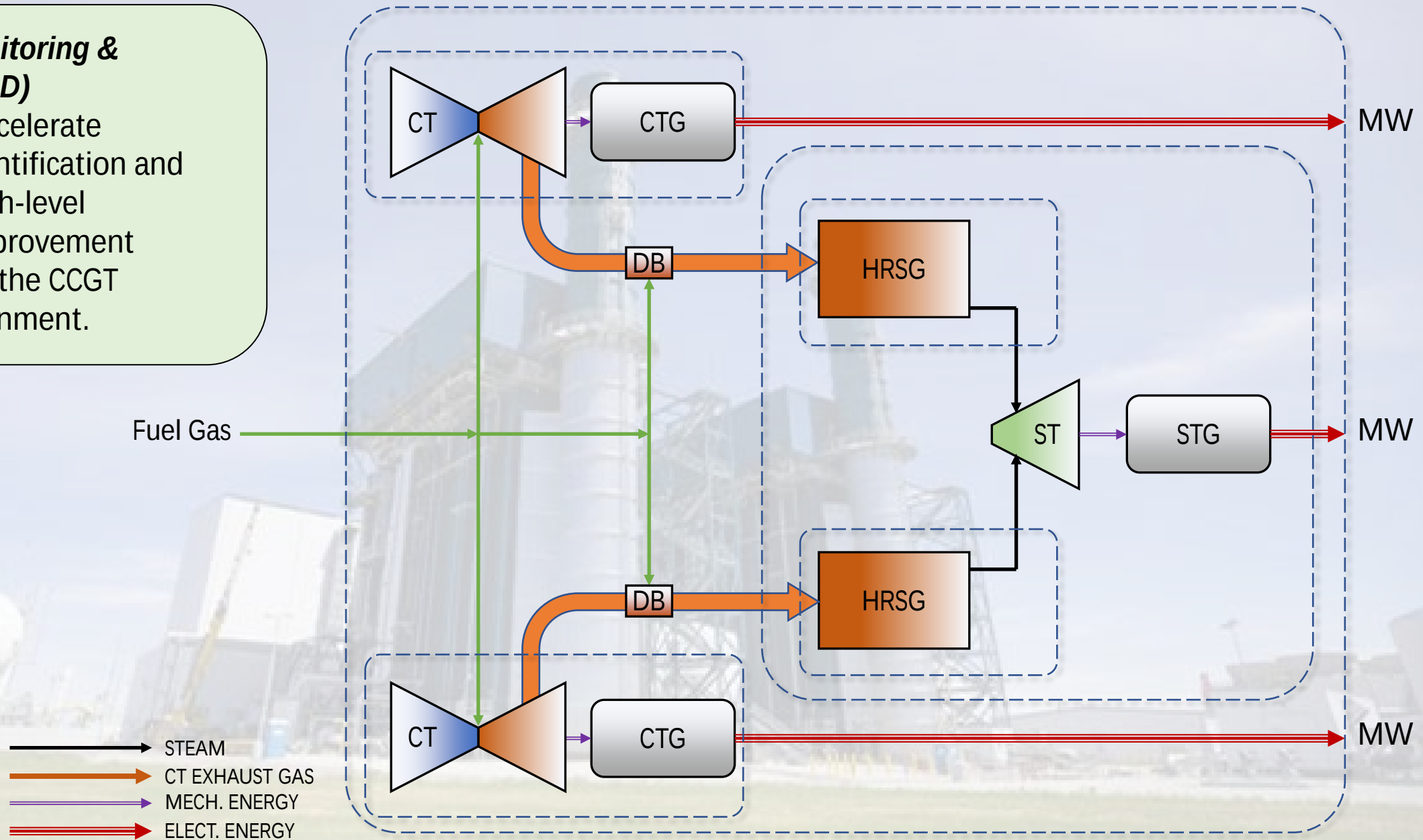


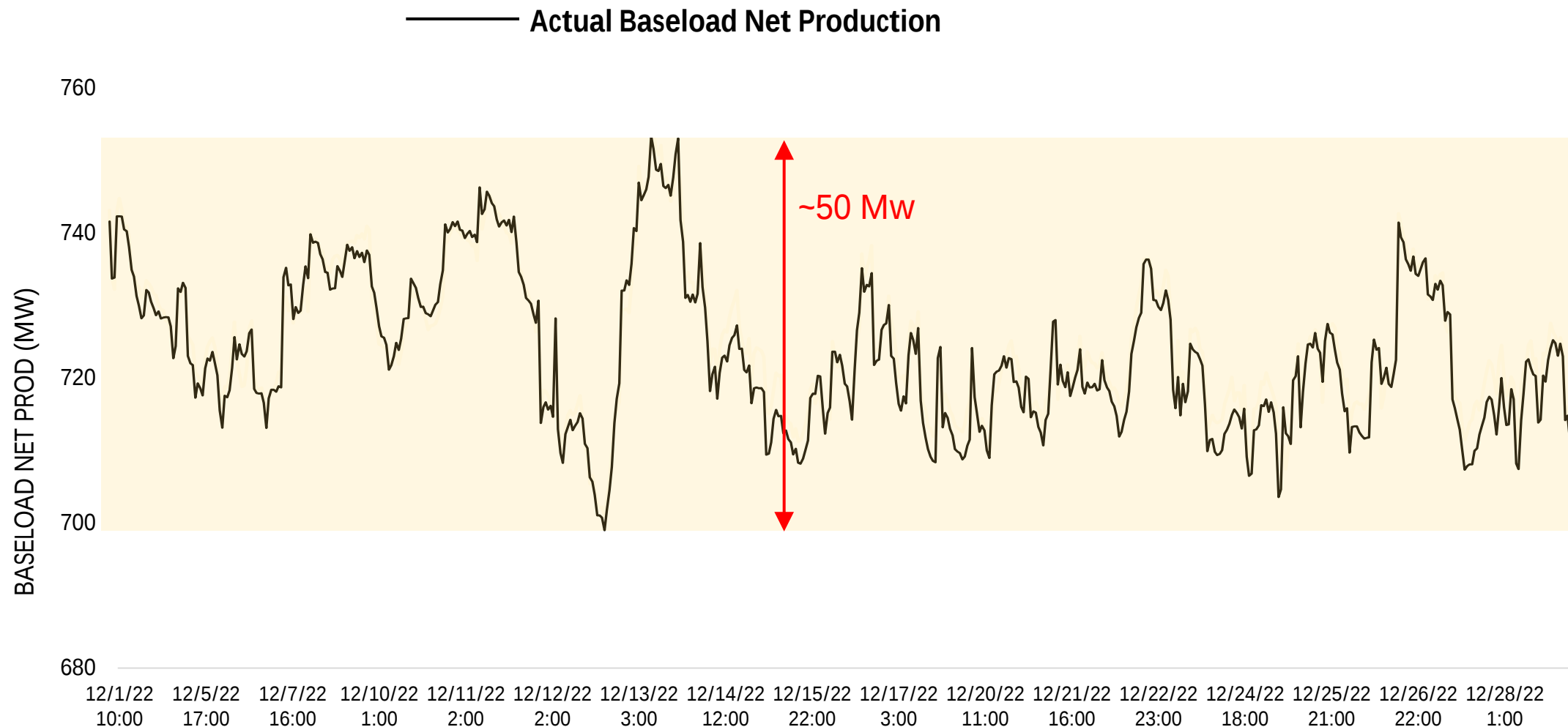


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Generation Monitoring & Diagnostics (GMD)

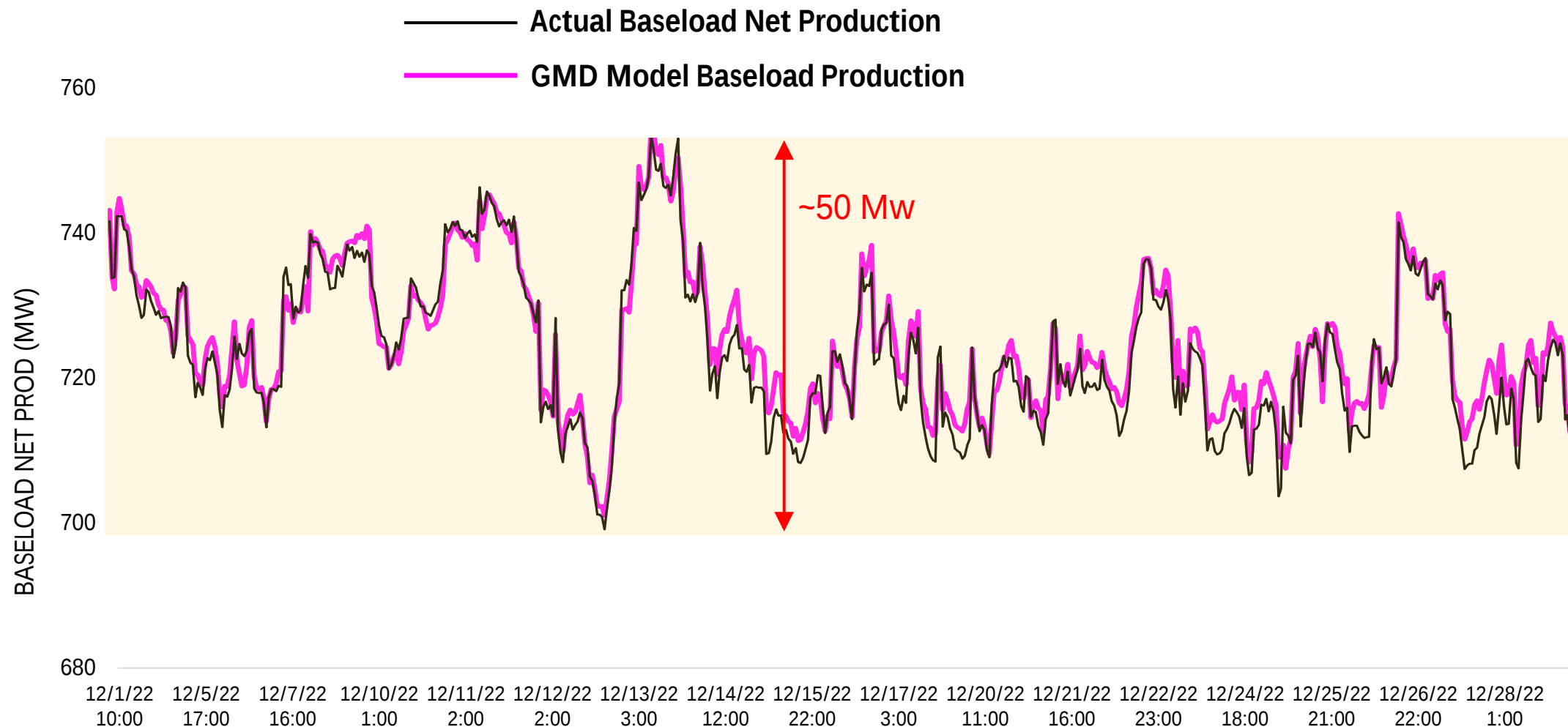
GMD services accelerate recognition, quantification and realization of high-level performance improvement opportunities in the CCGT operating environment.





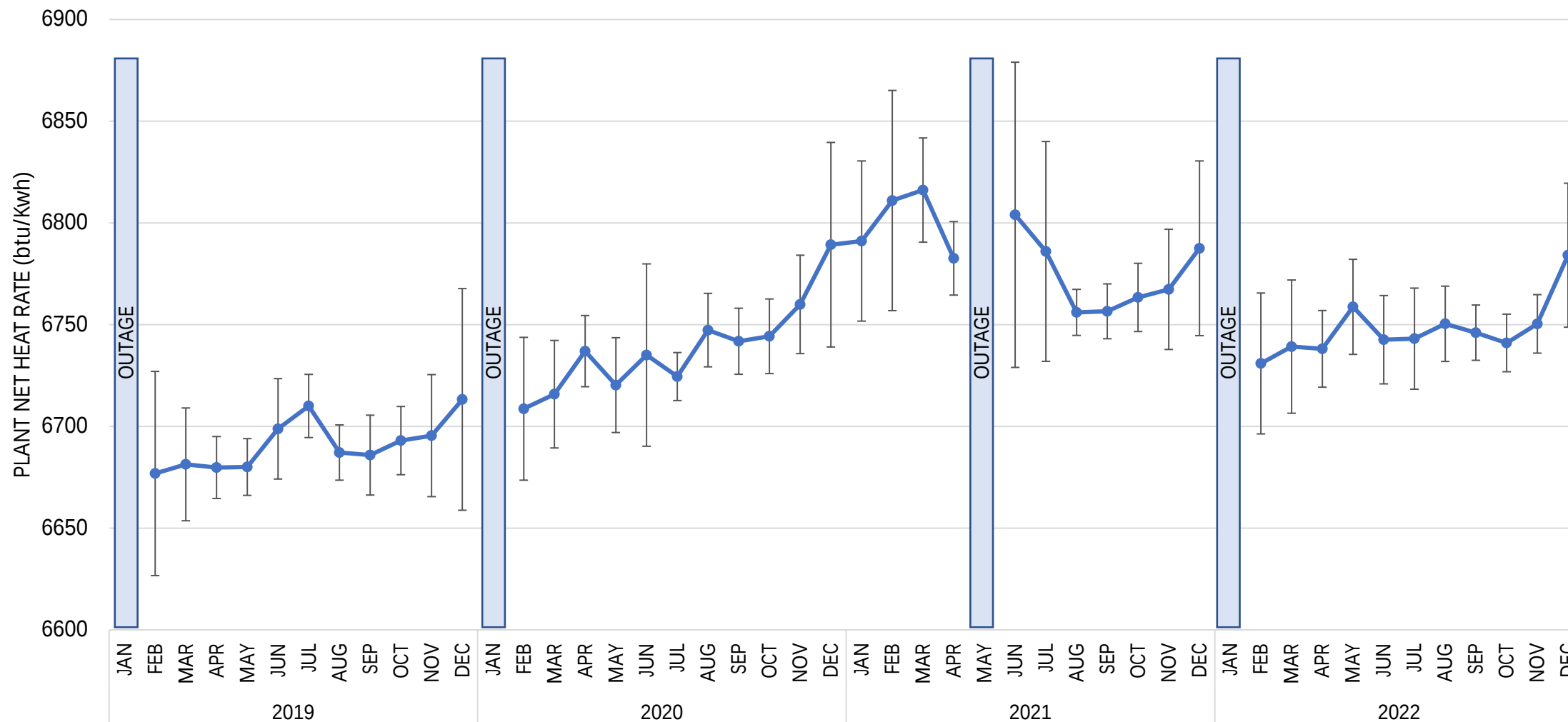
Ø Efficiency gain or loss of 1 Mw in the 2022 PJM market was **worth ~\$500k in earnings**

Ø Baseload capacity varies continuously. How are we supposed to know when 1 Mw is gained or lost?



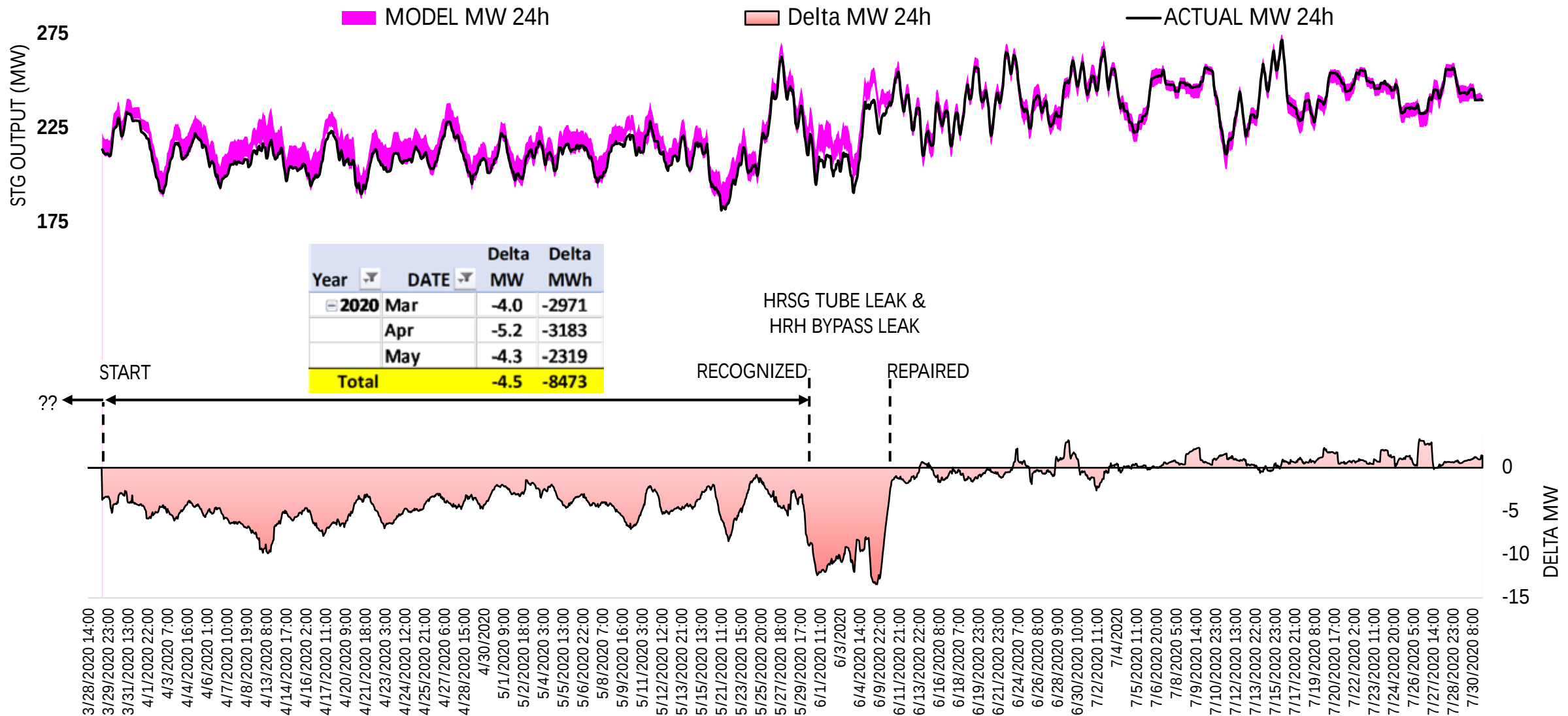
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Plant Net Heat Rate 2019-2022 Monthly Average, Baseload Only



Ø 1% change in heat rate was **worth ~\$3.5M in earnings** at a 740 Mw CCGT plant in 2022

Ø Heat rate varies continuously. How are we supposed to know when 1% is gained or lost?



Anomaly detectable using GMD >2 months earlier: $8400 \text{ Mwh} * \$67/\text{Mwh} = \560k

Generation Monitoring & Diagnostics (GMD)

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Week Ending 2022-10-03 00:00:00+00:00

System	Heat Rate / Efficiency		Capacity	
Plant Net	G	-0.3% +/-0.2%	G	-0.2% +/-0.2%
CTG11	G	-0.3% +/-0.2%	G	-0.4% +/-0.2%
CTG12	G	0.2% +/-0.1%	G	0.3% +/-0.1%
STG	G	NC +/-0.3%	G	NC +/-0.3%
HRSR 11	R	-0.7% +/-0.3%		
HRSR 12	G	-0.4% +/-0.2%		

GMD Benefits

- Increase performance confidence:** ML-generated performance metrics provide precise, real-time understanding of current asset performance relative to baseline.
- Accelerate quality decision making:** Performance opportunities are identified in near real-time to accelerate quality decision-making and reduce both response time and cost.
- Accelerate diagnostics and problem solving:** Immediately tap into Primex’s expert diagnostic resources to reduce problem duration, severity and cost.

Generation Monitoring & Diagnostics (GMD)

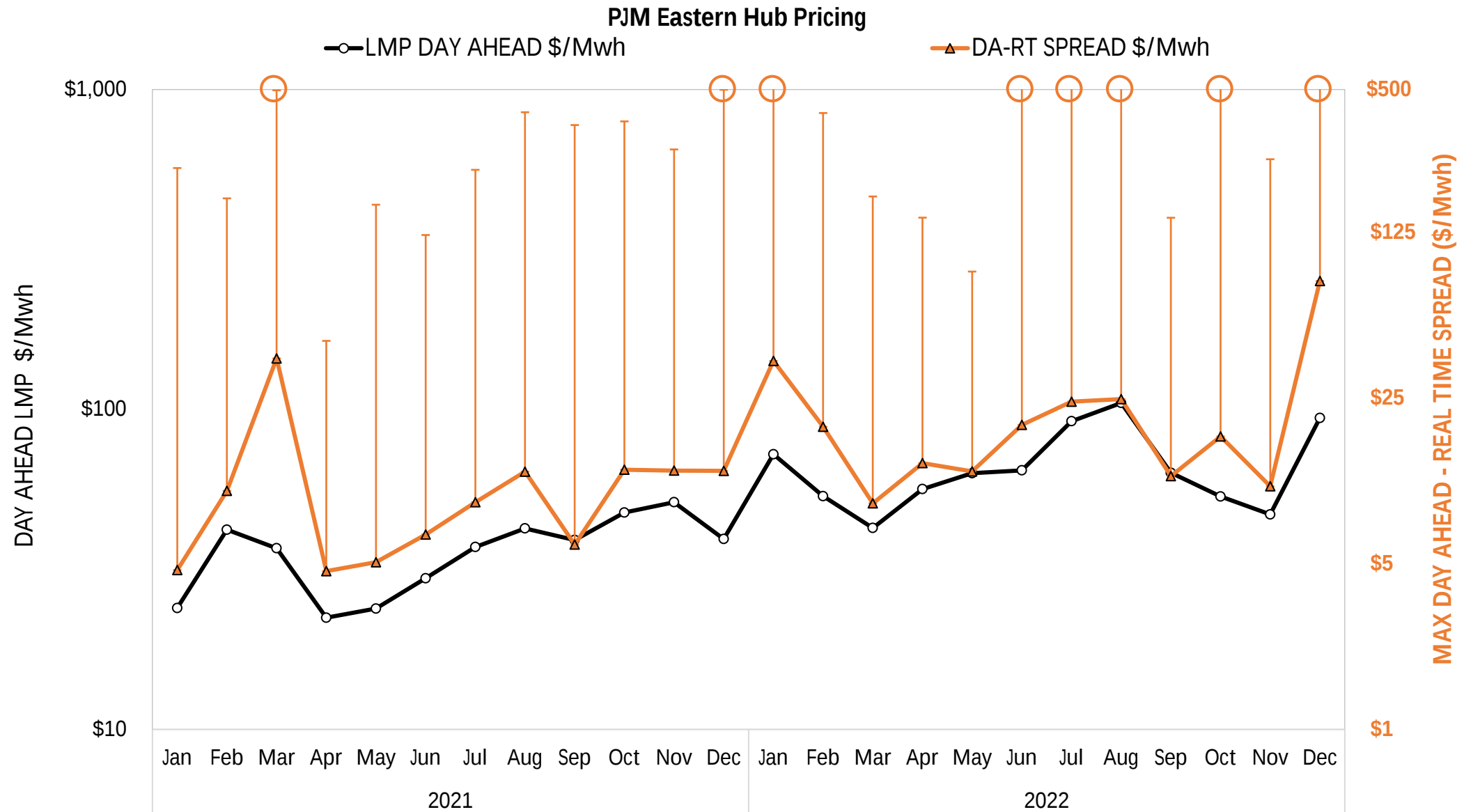
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Capacity and Fuel Demand Forecasting (CFF)

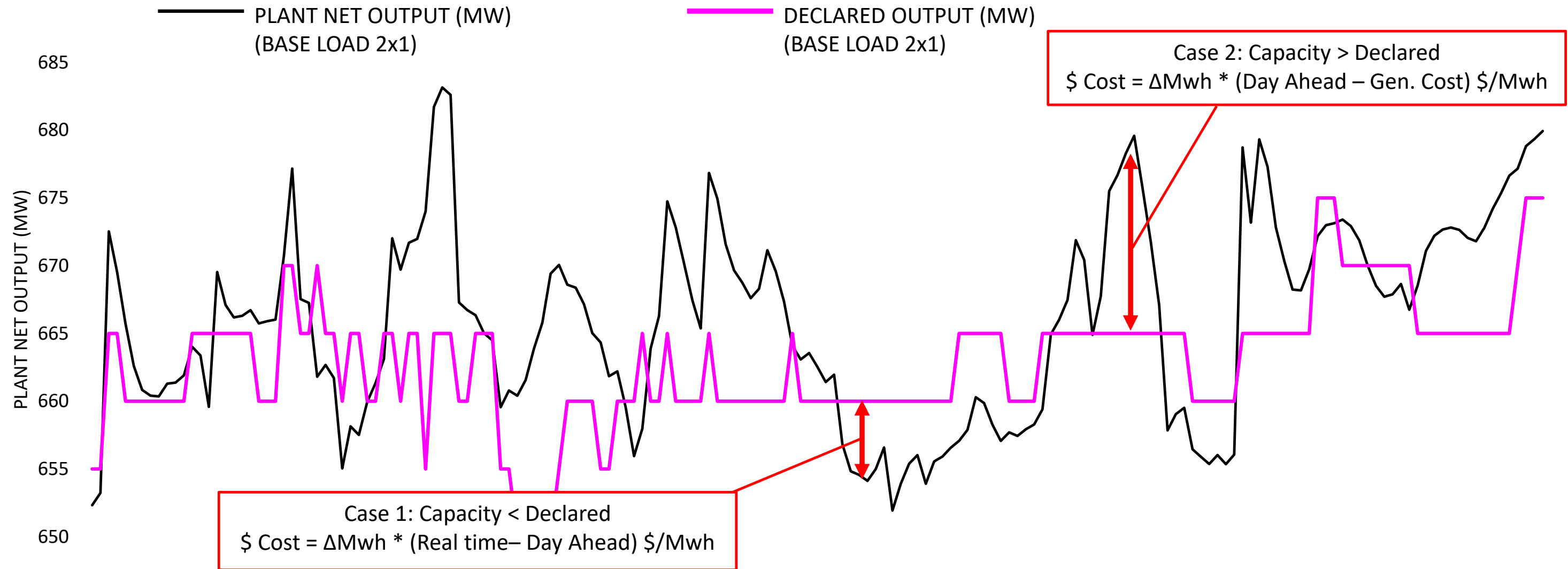
CFF services produce highly accurate capacity and fuel demand forecasts that enhance the value of CCGT assets operating in day-ahead merchant markets.

Changing the Game with Performance Assurance V2

Designed for key decision-makers in CCGT generation asset management and operations roles, Primex PAV2 services enable precise forecasting, validation, recognition and realization of high-level performance improvement opportunities in the CCGT operating environment.

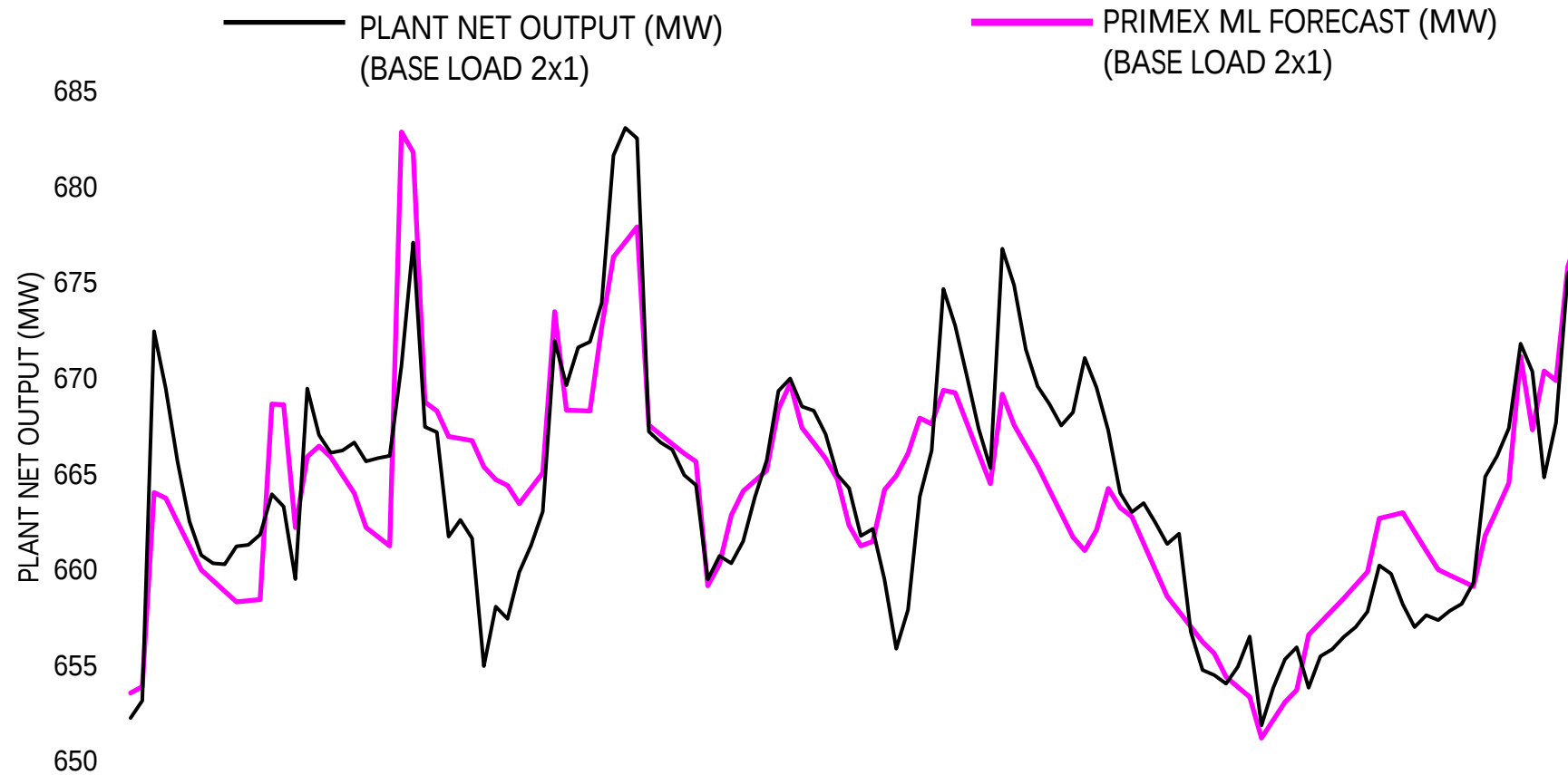


Ø Market pricing, volatility and competition mean generating companies need better ways to optimize the present and predict the future.



Actual Base Load Capacity <> Declared (Cases 1 & 2)
Partial DB operation to achieve declared MW
Throttle CT Output to achieve declared MW

2020 Forecasting Error: ~23,000 Mwh



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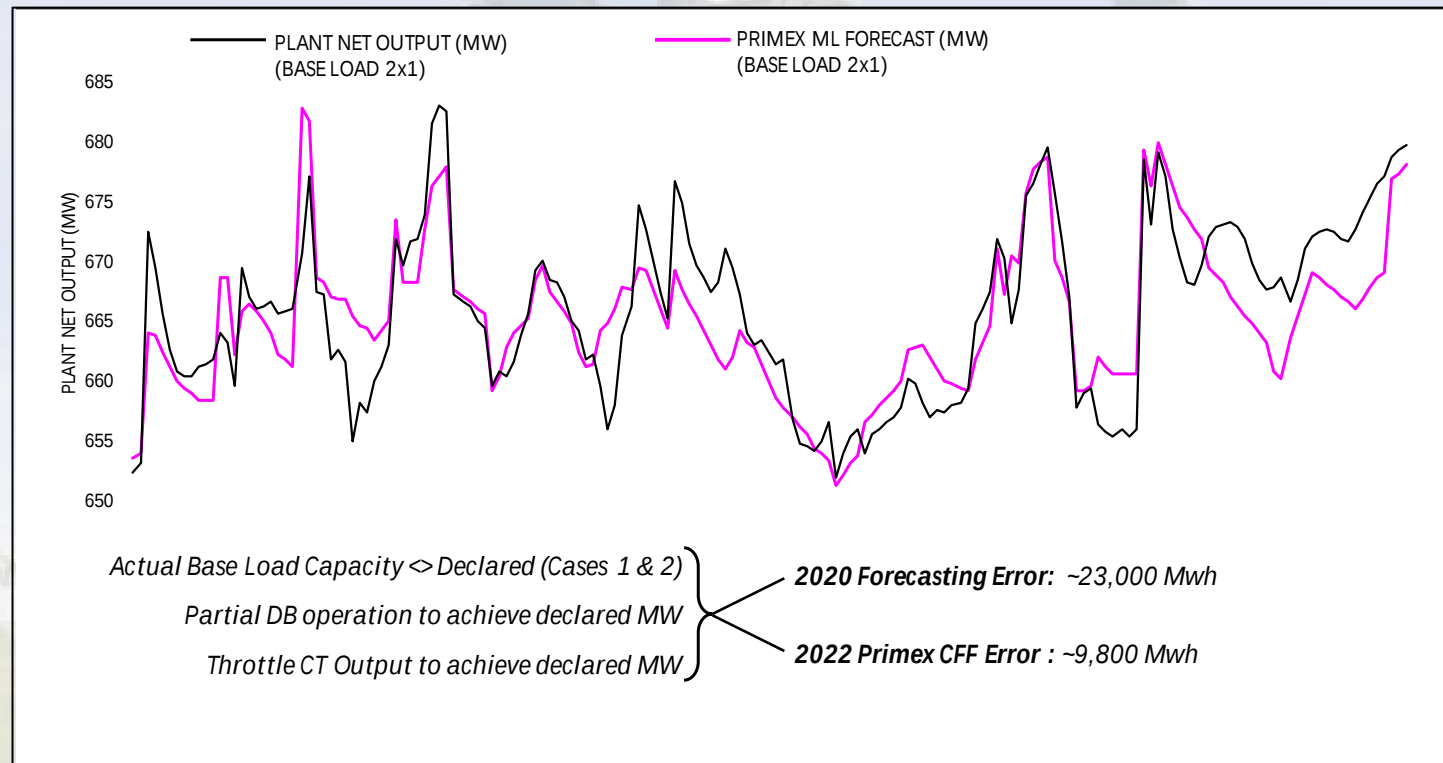
2020 Forecasting Error: ~23,000 Mwh
2022 Primex CFF Error : ~9,800 Mwh

Capacity and Fuel Demand Forecasting (CFF)

CFF services produce highly accurate capacity and fuel demand forecasts that enhance the value of CCGT assets operating in day-ahead merchant markets.

CFF Benefits

- **Reduce losses due to forecast errors** during adverse day-ahead vs. real-time price spreads.
- **Increase accuracy of fuel demand forecasts** to maximize the flexibility and value of energy management decisions.
- **Eliminate manual wrangling** of weather forecasts and other activities to calculate, check, and distribute daily declarations.



Generation Monitoring & Diagnostics (GMD)

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Capacity and Fuel Demand Forecasting (CFF)

CFF services produce highly accurate capacity and fuel demand forecasts that enhance the value of CCGT assets operating in day-ahead merchant markets.

Performance Guarantee Validation (PGV)

Use PGV services to validate performance test results and guarantees relating to major overhauls, upgrades and degradation rates.

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Use PGV services to validate performance test results and guarantees relating to major overhauls, upgrades and degradation rates.

PGV Benefits

- Increase test period flexibility (months vs. hours)
- Decrease result uncertainty / increase confidence
- Independent validation of contract compliance

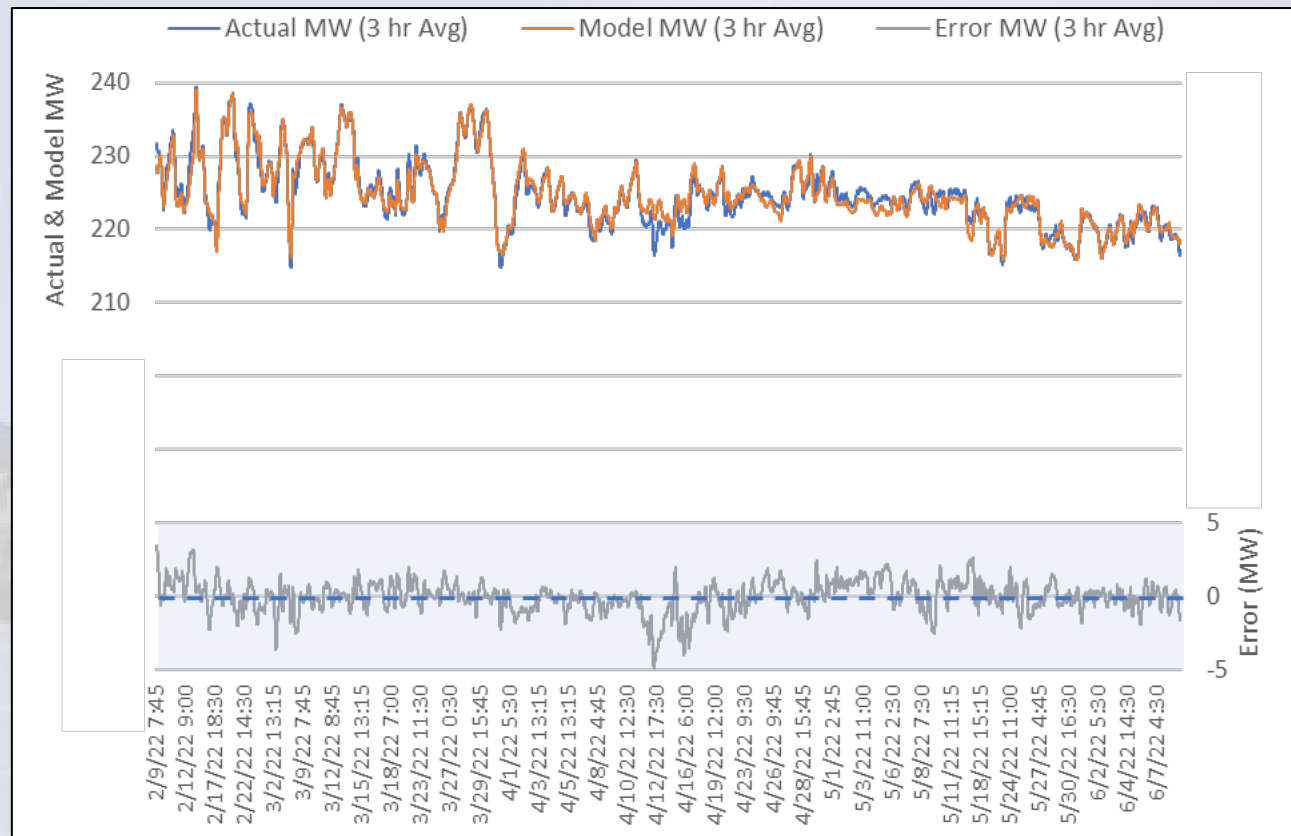


Table 1: Key Statistics

Parameter	Test Year	
	2015	2022
Performance Test Period MAE (MW)	0.5	0.6
120 Day Training Period MAE (MW)	0.6	0.8
CT12 Normalized Output (MW)	213.1	215.7

Comparing the normalized outputs noted above, we estimate normalized CT12 output in 2022 was 2.6 MW higher than in 2015 with uncertainty of +/- 1.0 MW.

Our Services

Generation Monitoring & Diagnostics

Capacity and Fuel Demand Forecasting

Performance Guarantee Validation

Performance Optimization

Knowledge Resources

Our Clients



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