

Machine Learning Proves Value at 740 MW CCGT Merchant Plant

Presented May 23, 2022

at
PowerGen International

by
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Primex Process Specialists, Inc.

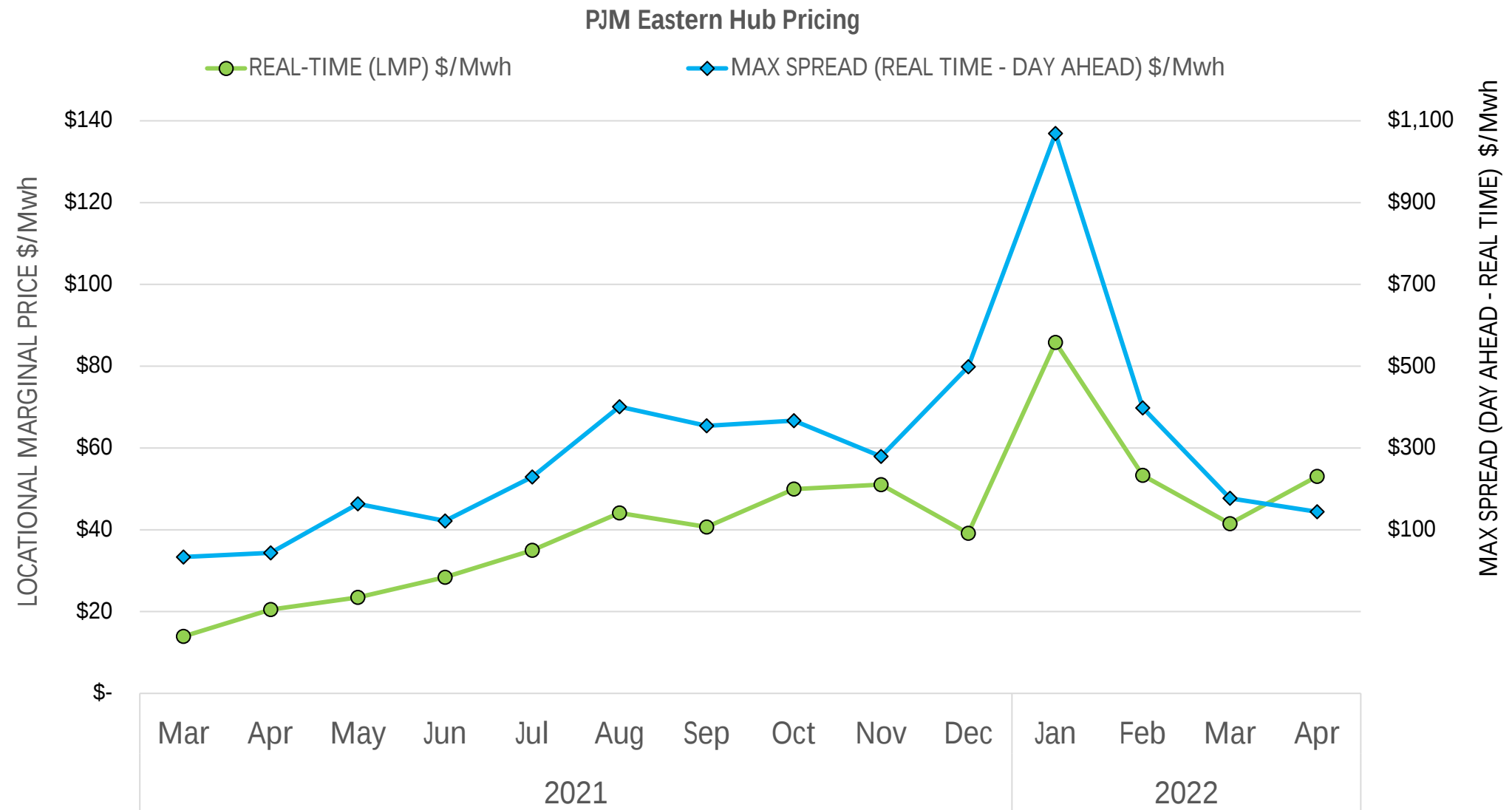
GENERATE BETTER PERFORMANCE

primex 

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

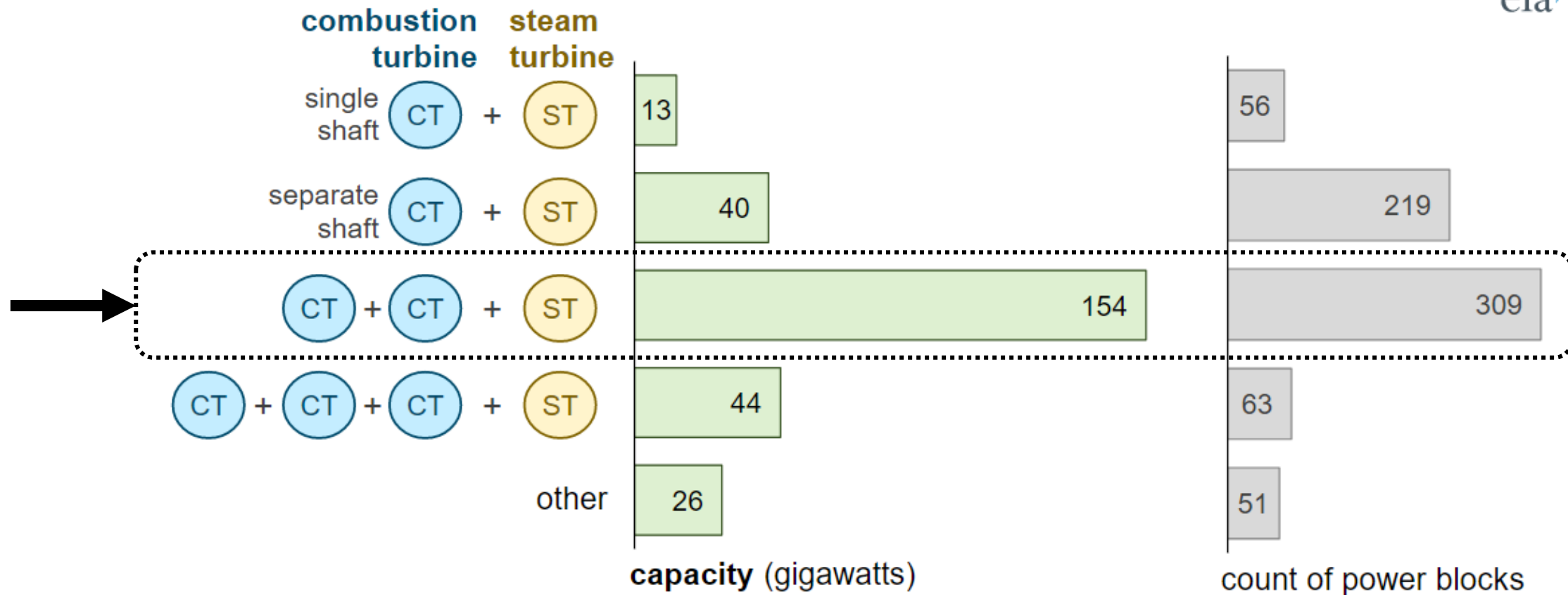


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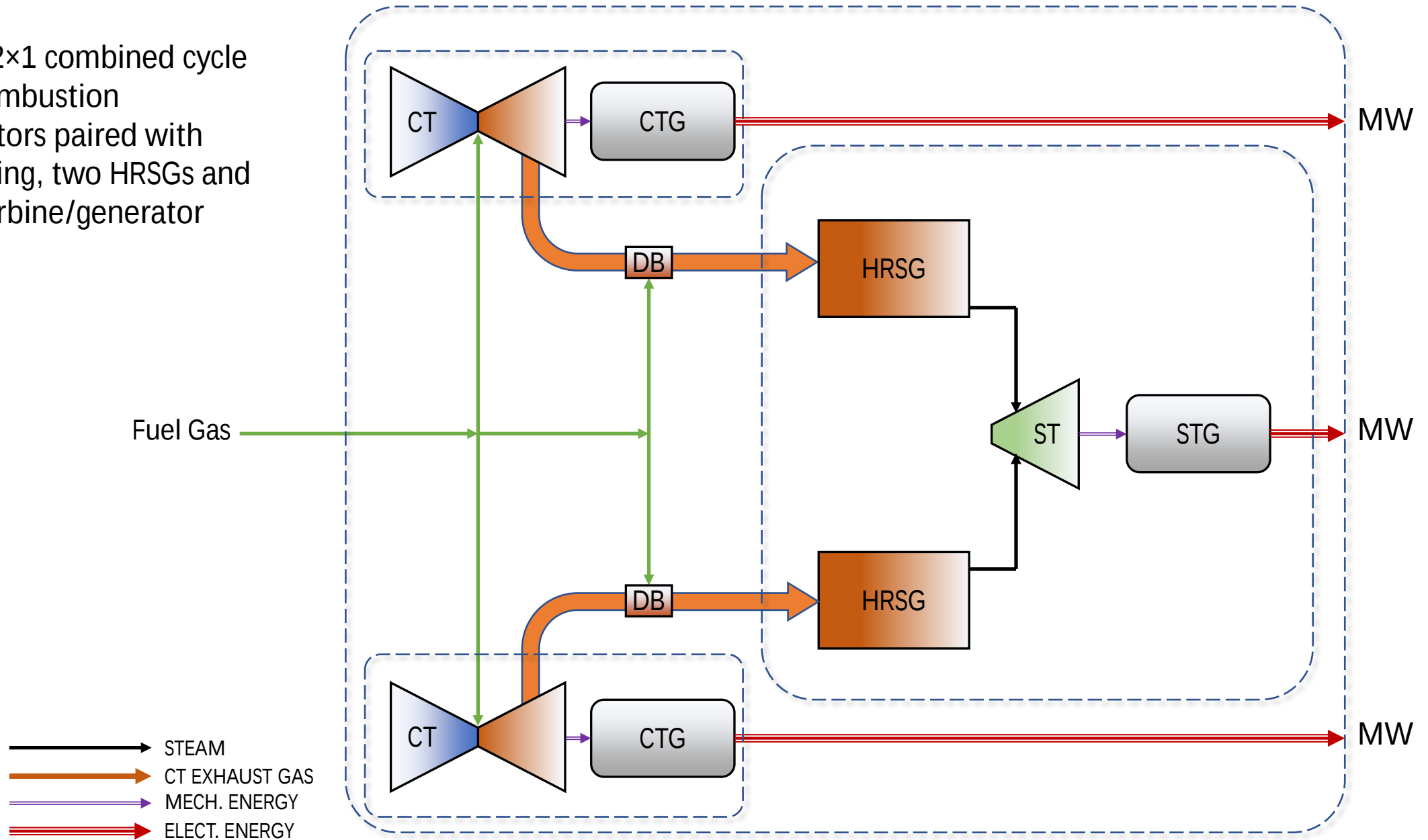
- Ø Market pricing, volatility and competition mean generating companies need better ways to optimize the present and predict the future.
- Ø In what may be an industry first, machine learning applied at a 740 MW CCGT merchant plant shows significant value by detecting/quantifying performance anomalies and improving capacity forecasts.
- Ø In this case at current PJM market pricing of \$40-\$60/Mwh, estimated combined cost savings are ~\$500k-\$1M/year
- Ø Machine Learning is a tool that is necessary but not sufficient to achieve these results; human knowledge & experience are also needed!
- Ø This experience points to greater opportunities in wind, solar and energy storage

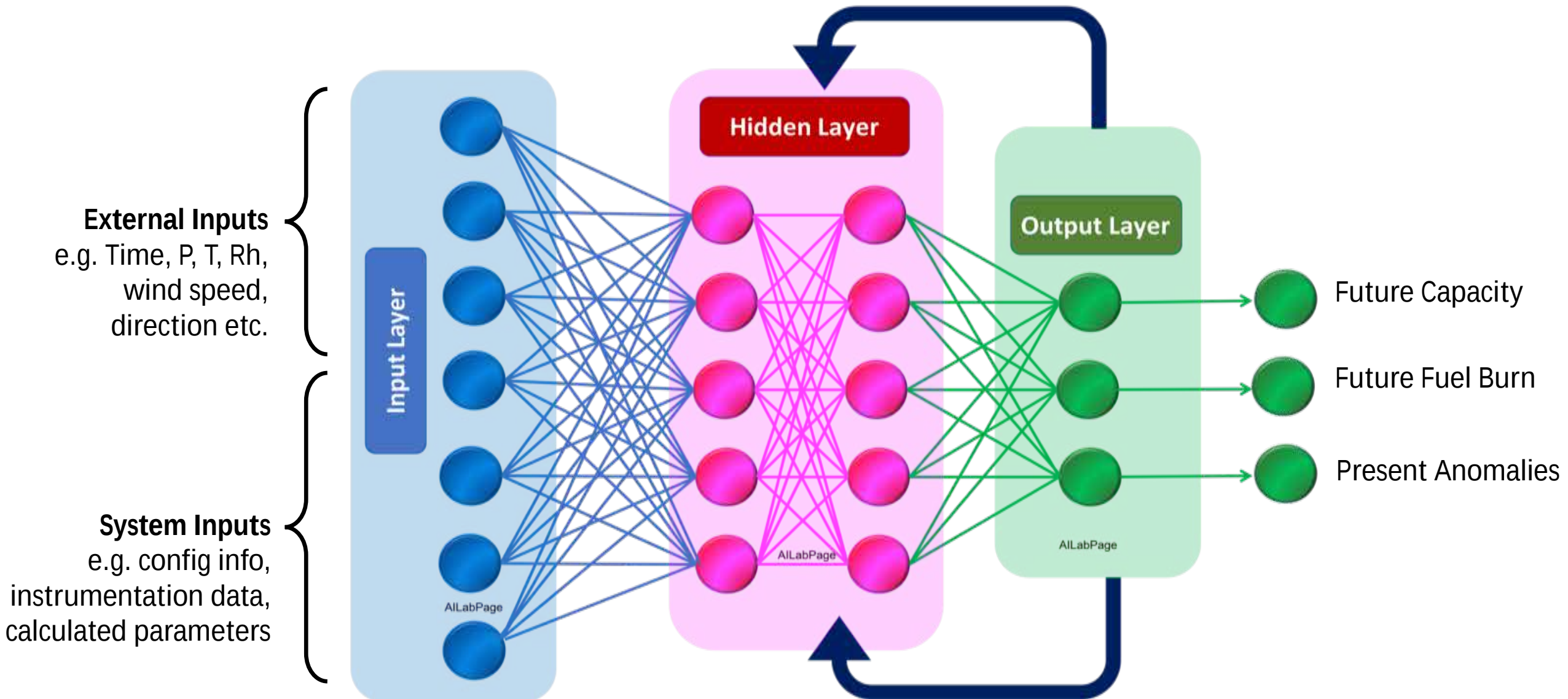
Natural gas combined-cycle capacity and count by configuration (2020)



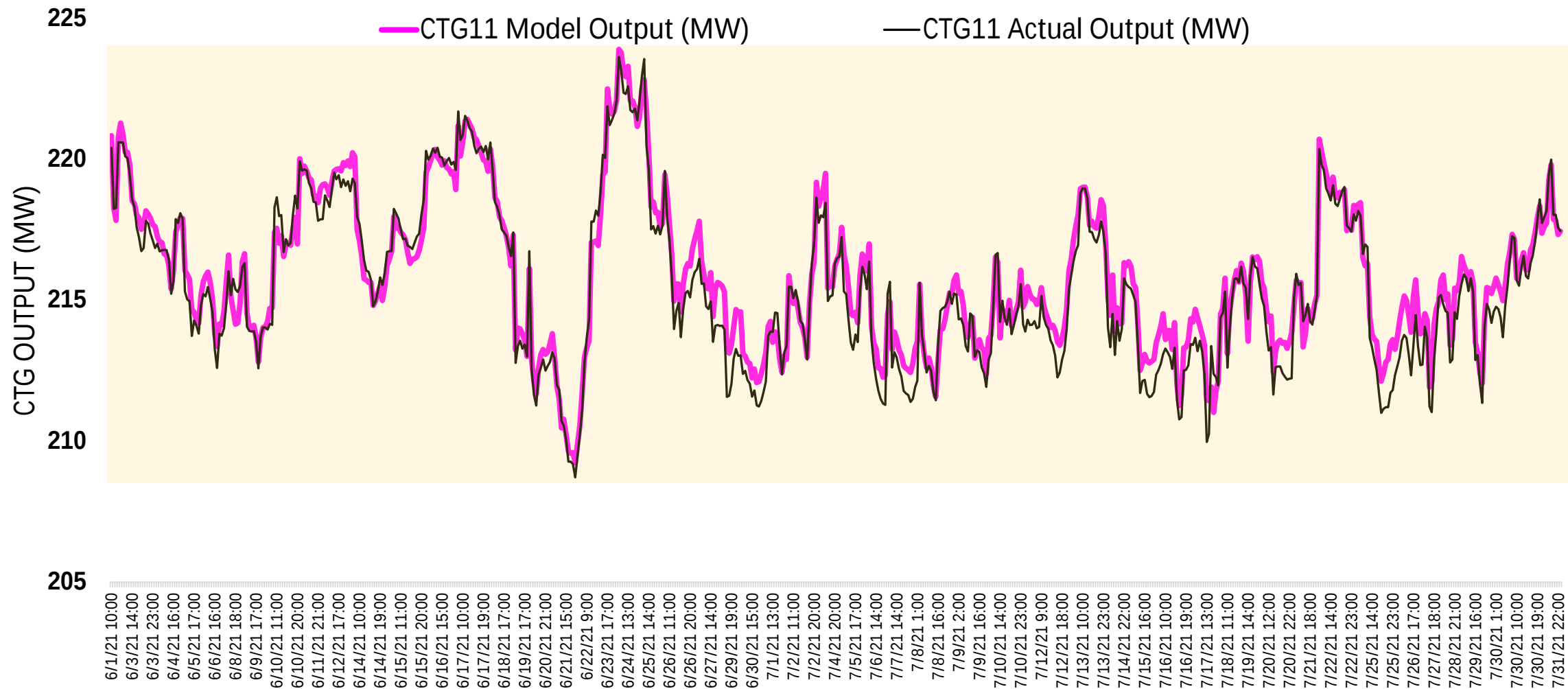
Source: U.S. Energy Information Administration, *Electric Power Annual*

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





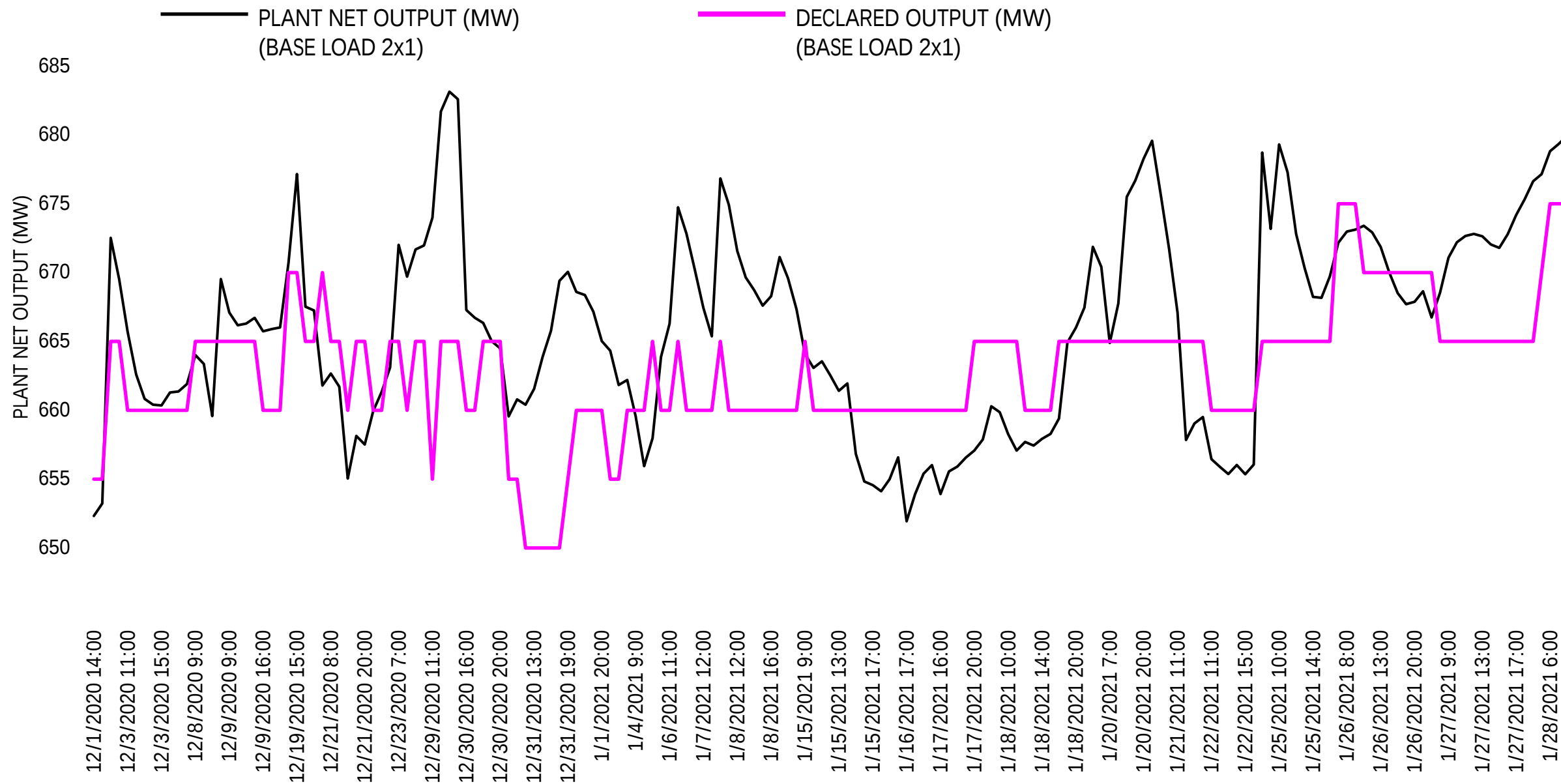
CTG Output – Actual vs. Model at Base Load (IGV Open)

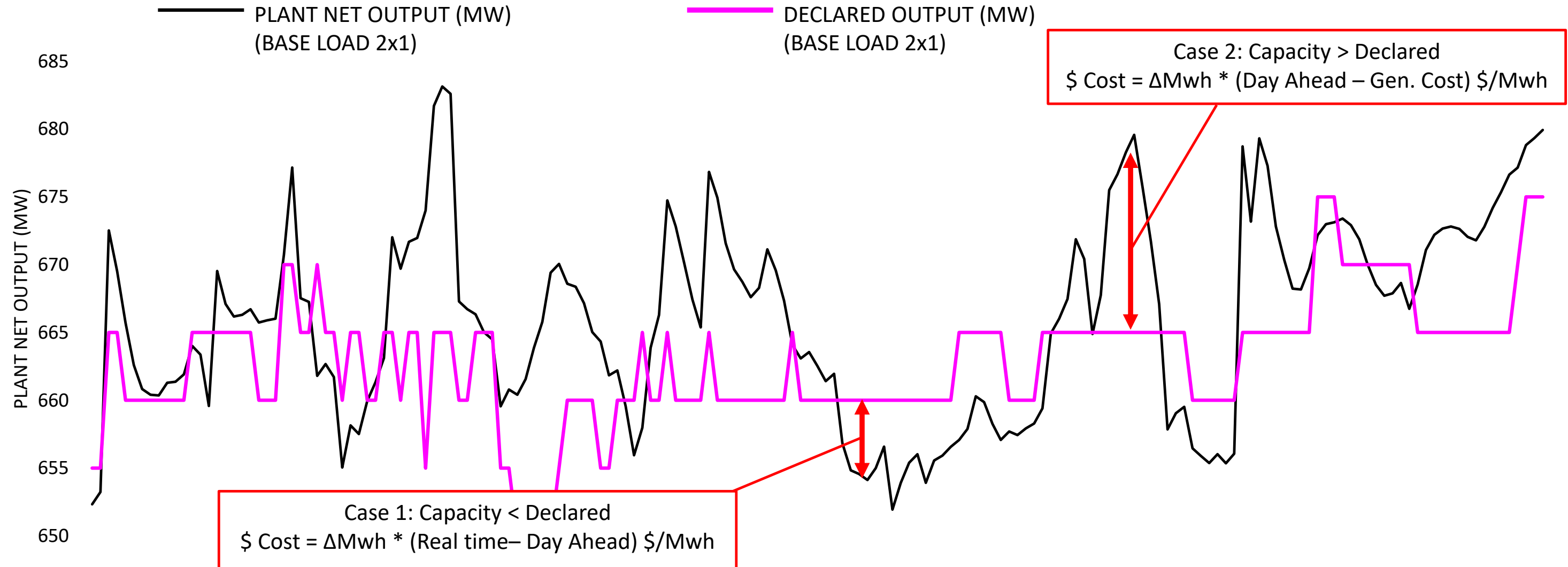


Solution: Primex ML technology enables real-time anomaly detection > 2MW within 1 hour and precision forecasting for daily declarations

Daily Declaration Sheet

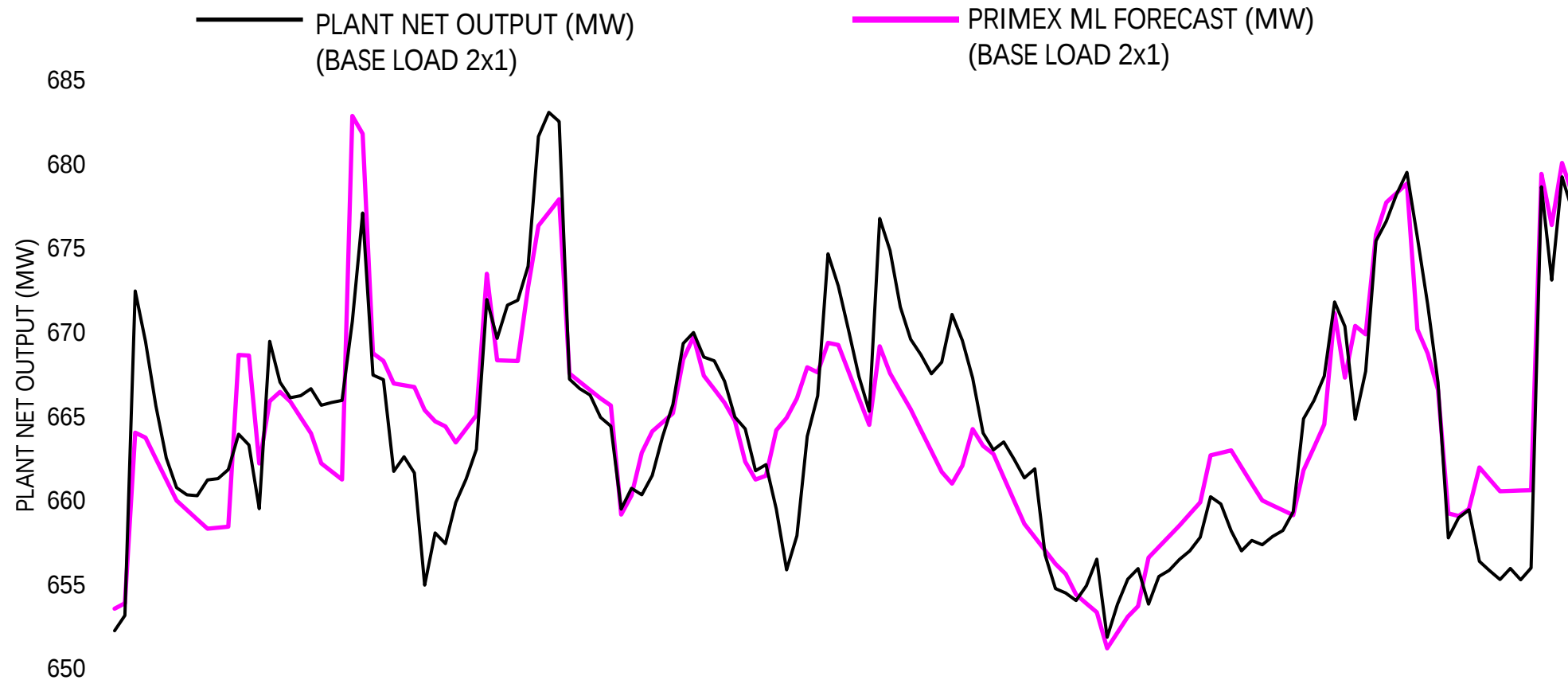
Today's Date	9/29/2020									
For Operating Day	9/30/2020							20200930		
Hour Ending	Ambient Forecast (degrees F)	Emergency Minimum (MW)	Economic Minimum (MW)	Economic Maximum (MW)	Economic Maximum with Duct Fire (MW)	Emergency Maximum (MW)	Unit Status	Duct Firing Available? (Yes / No)	AR 2x1 Min	AR Offer MW
100	69	140	300	650	700	705	2x1 Available	Yes	300	173
200	69	140	300	650	700	705	2x1 Available	Yes	300	173
300	68	140	300	650	700	705	2x1 Available	Yes	300	172
400	68	140	300	650	700	705	2x1 Available	Yes	300	172
500	67	140	300	650	700	705	2x1 Available	Yes	300	172
600	65	140	300	650	700	705	2x1 Available	Yes	300	171
700	63	140	300	650	700	705	2x1 Available	Yes	300	172
800	63	140	300	650	700	705	2x1 Available	Yes	300	172
900	62	140	300	650	700	705	2x1 Available	Yes	300	174
1000	63	# 140	300	650	700	705	2x1 Available	Yes	300	173
1100	64	140	300	650	700	705	2x1 Available	Yes	300	173
1200	66	140	300	650	700	705	2x1 Available	Yes	300	174
1300	69	140	300	650	700	705	2x1 Available	Yes	300	176
1400	71	140	300	650	700	705	2x1 Available	Yes	300	178
1500	72	140	300	650	700	705	2x1 Available	Yes	300	179
1600	72	140	300	650	700	705	2x1 Available	Yes	300	179
1700	71	140	300	650	700	705	2x1 Available	Yes	300	178
1800	69	140	300	650	700	705	2x1 Available	Yes	300	177
1900	67	140	300	650	700	705	2x1 Available	Yes	300	176
2000	64	140	300	655	705	705	2x1 Available	Yes	300	175
2100	63	140	300	655	705	705	2x1 Available	Yes	300	175
2200	62	140	300	655	705	705	2x1 Available	Yes	300	176
2300	60	140	300	655	705	705	2x1 Available	Yes	300	177
2400	59	140	300	655	705	705	2x1 Available	Yes	300	178





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

Original Capacity Forecasting: Annual Error ~16,000 Mwh, Opportunity Cost ~\$230k



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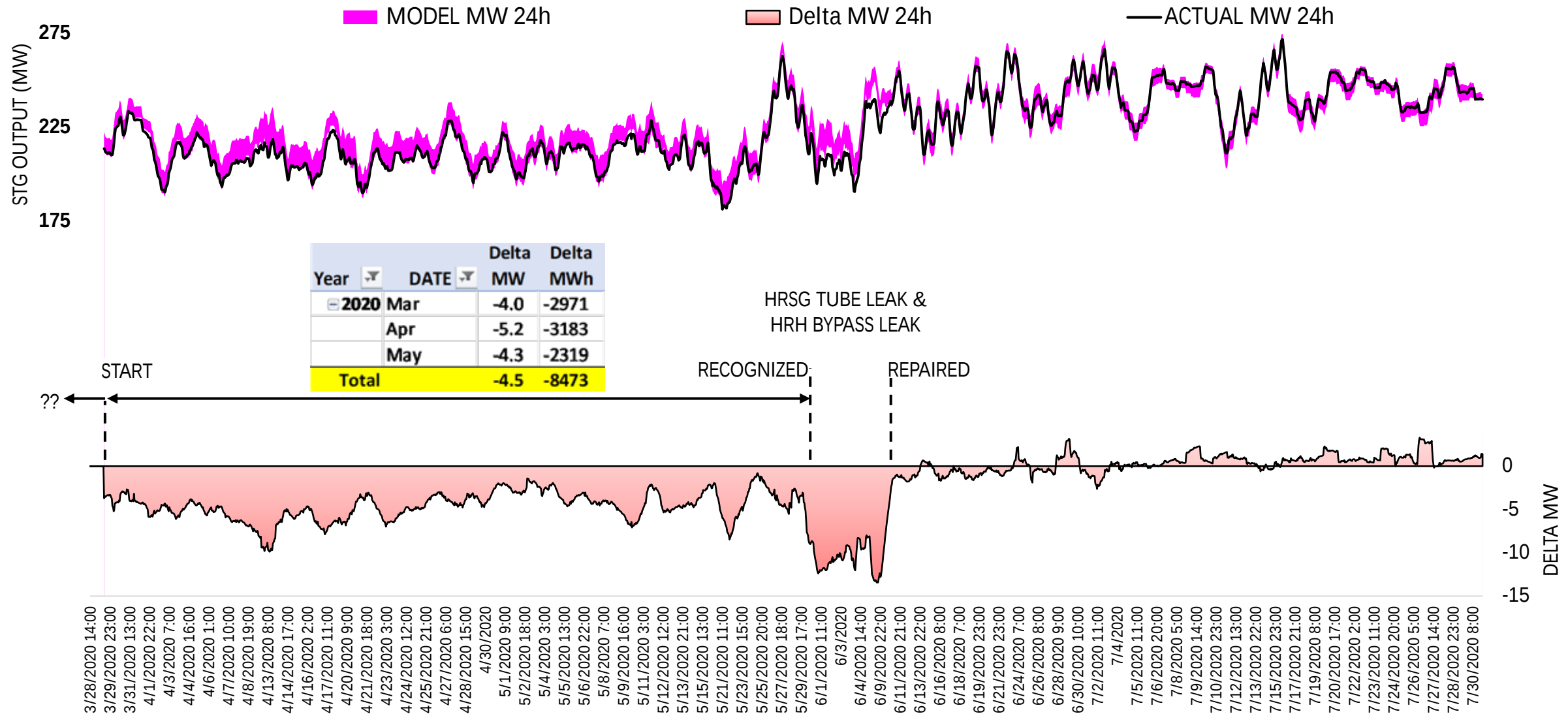
Original Capacity Forecasting: Annual Error ~16,000 Mwh, Opportunity Cost ~\$230k

Primex ML Capacity Forecasting: Annual Error ~8,000 Mwh, Opportunity Cost ~\$50k

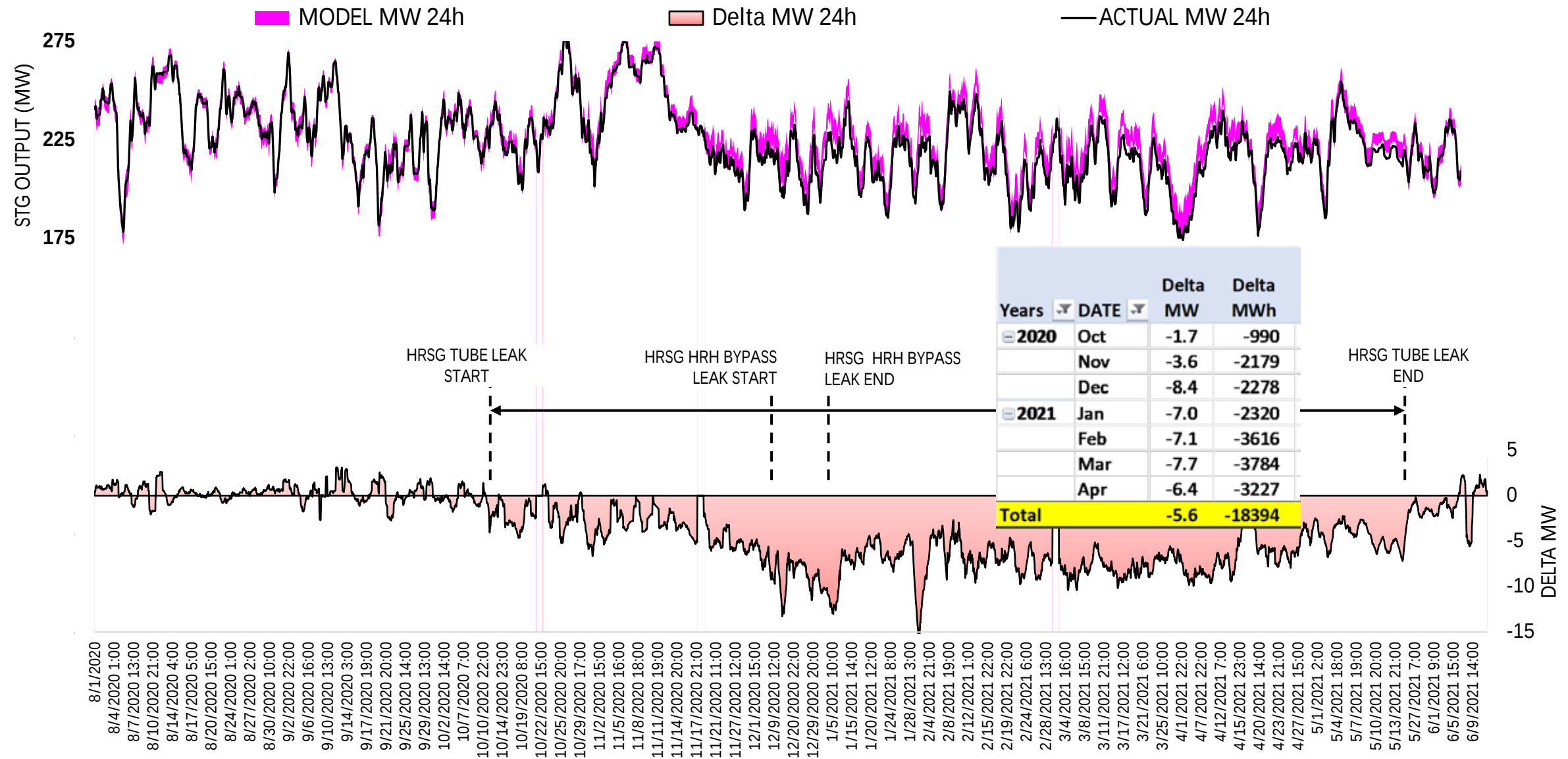
Incremental Earnings: ~\$180k (at \$15-\$30/Mwh)

1. **Capacity Forecasting**, 2x1 Eco Max and Eco Max with Duct Firing
 - ü Incremental Earnings ~\$180k at \$15-\$30/Mwh
 - ü Daily remodeling adapts quickly to changing characteristics
 - ü Fully automated daily declaration in 2x1 and 1x1 configurations
 - ü Human resources applied daily to forecasting can pursue other valuable tasks

2. **Anomaly Detection**



Anomaly detectable using ML Technology >2 months earlier: $8400 \text{ Mwh} * \$50/\text{Mwh} = \420k



Anomaly quantifiable using ML Technology: $18400 \text{ Mwh} * \$50/\text{Mwh} = \$920k$

Process	Event	Anomaly Start Date		Anomaly End Date		Verification Comments	Potential Value
		Reported	Verified	Reported	Verified		
CTG	Offline water wash	10/4/20 0:00	10/4/20 0:00	undefined	No gain detected	<u>No gain detected</u>	\$Med Evaluate Actual vs. Expected
CTG	Offline water wash	5/15/20 0:00	5/15/20 0:00	undefined	No gain detected	<u>No gain detected</u>	\$Med Evaluate Actual vs. Expected
CTG	Firing curve change and adjusted IGV max angle	7/6/20 0:00	2/24/20 18:00	undefined	7/6/20 19:00	Verified.	\$Med Evaluate Actual vs. Expected
CTG	Unit 12 inlet bleed heat stuck open.	11/1/20 13:00	11/1/20 17:00	11/1/20 18:00	11/1/20 18:00	Verified.	\$Low Evaluate Actual Cost
CTG	Lost a controller and had firing curve constants revert back to old values.	3/30/21 12:00	3/25/21	4/19/21 13:00	4/21/21	Verified.	\$Low Evaluate Actual vs. Expected
CTG	Firing curve change	4/19/21 13:00	4/19/21	4/23/21 14:00	4/23/21	All Verified.	\$Med Evaluate Actual vs. Expected
STG10	Suspected tube leak in HRSH 11. 4-5MW loss. Repaired in outage that ended 10/26/2018	7/27/18 0:00	n/a	10/26/18 0:00	n/a	Not examined (before data period) but highly likely to be detectable	\$High Inc. Fuel & Capacity Cost
STG10	Arch binding on last stage of LP buckets discovered during outage. LP rotor removed, blades replaced, and packing leaks repaired.	Unknown	n/a	Jan 2020 Outage	n/a	Not examined (before data period) but likely to be detectable	\$High Inc. Fuel & Capacity Cost
STG10	HRSG 12 tube leak and HRH bypass crack. Outage taken June 6 to June 9 to repair.	late May/Early June 2020	3/28/20 or earlier	6/9/20 0:00	6/9/20	Verified.	\$High Inc. Fuel & Capacity Cost > 3 Mos. Early Detection
STG10	Suspected HRSG 11 tube leak – verified leak in reheater header #2.	10/19/20 0:00	10/1/20	May '21 Outage	May '21 Outage	Verified.	\$High Inc. Fuel & Capacity Cost >6 mos after Detection
STG10	Air in leakage found in unit 12 HRH bypass. Backpressure on ST was affected. Outage taken 1/9 to 1/15 to repair cracks in the line.	Early January 2021	12/29/20?	1/15/21 0:00	1/15/21	Verified.	\$High Inc. Fuel & Capacity Cost 2-3 wks earlier detection

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2. **Anomaly Detection** 24/7 hourly CTG and STG output
 - ü Earlier detection (one case in 2020 potentially > 3 months) value ~\$420k at \$50/Mwh
 - ü Concurrent detection quantified and trended capacity and cost effects ~\$920k at \$50/Mwh
 - ü Accelerate/optimize decisions & response planning
 - ü Daily declarations adjusted to account for anomaly capacity deficits

Forecasting

Fuel Consumption
Extended look-ahead
Wind, Solar & Storage Assets

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Anomaly Detection

HRSO, ST, Condenser etc.
Diagnostics
Wind, Solar & Storage Assets



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Our Services

Capacity Forecasting

Anomaly Detection

Performance Optimization

Analytical Services

Training & Education

Our Clients



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