

Market Monitor Report

MC Webinar

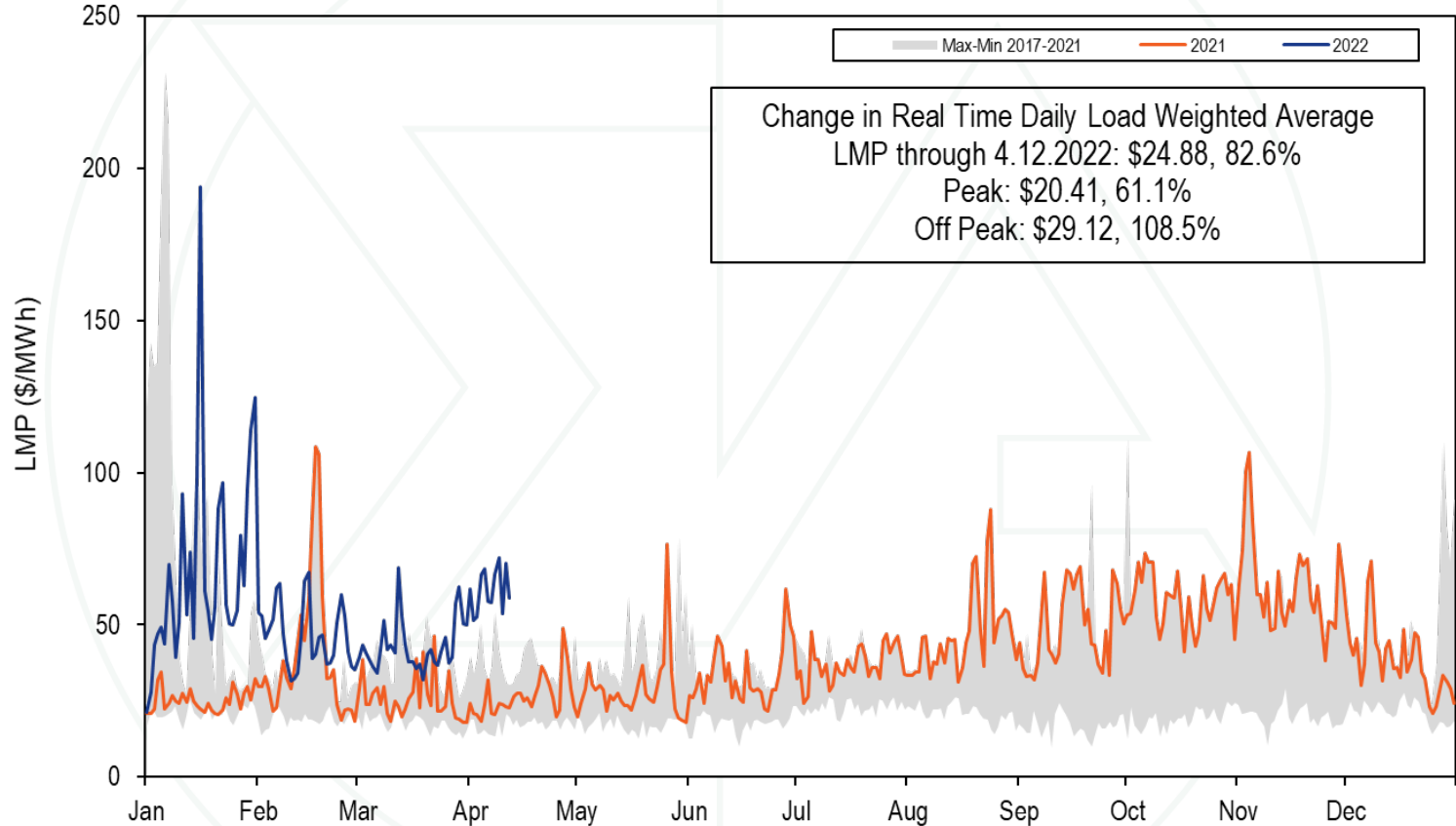
April 25, 2022

IMM

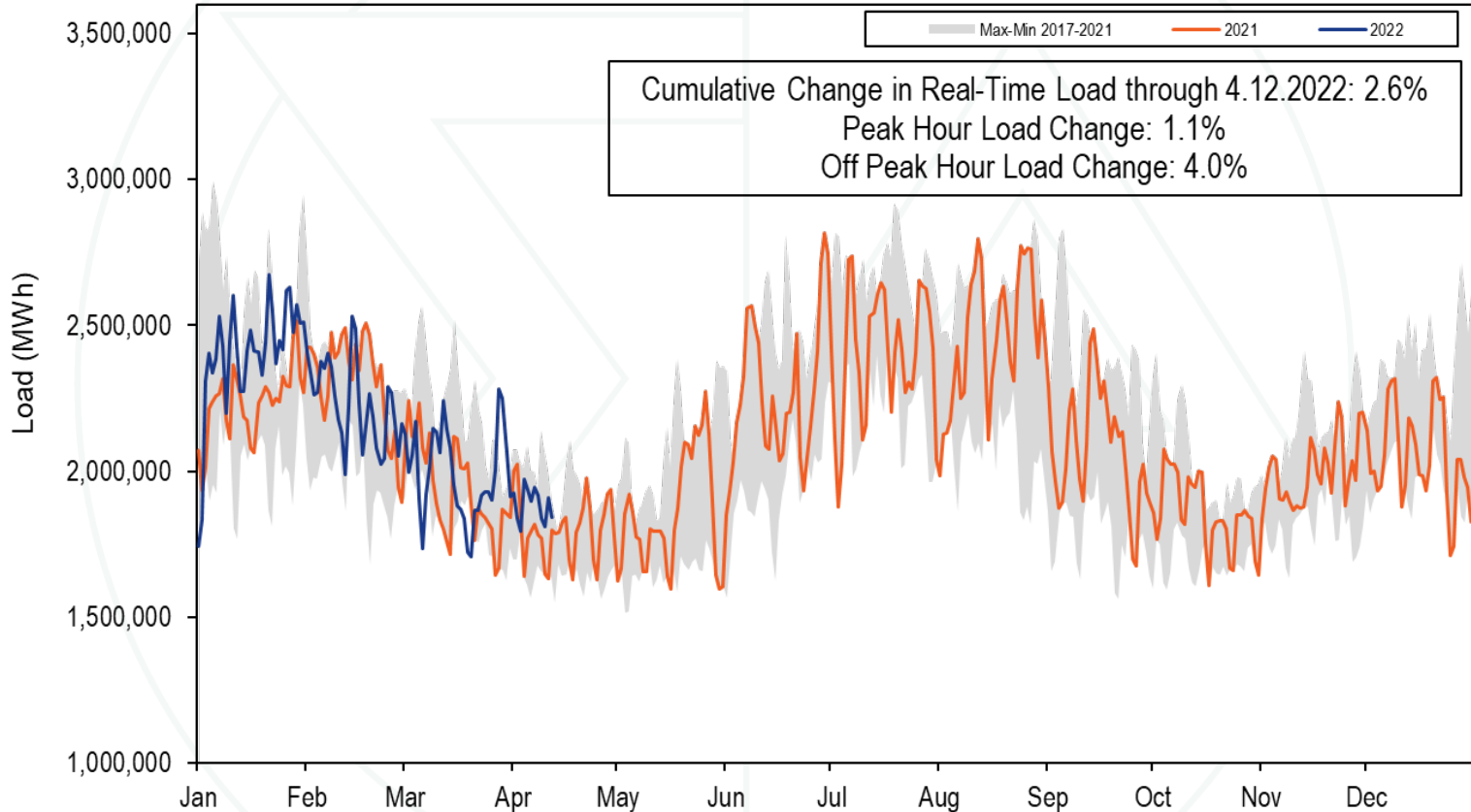


Monitoring Analytics

2022 YTD PJM Real-Time LMP



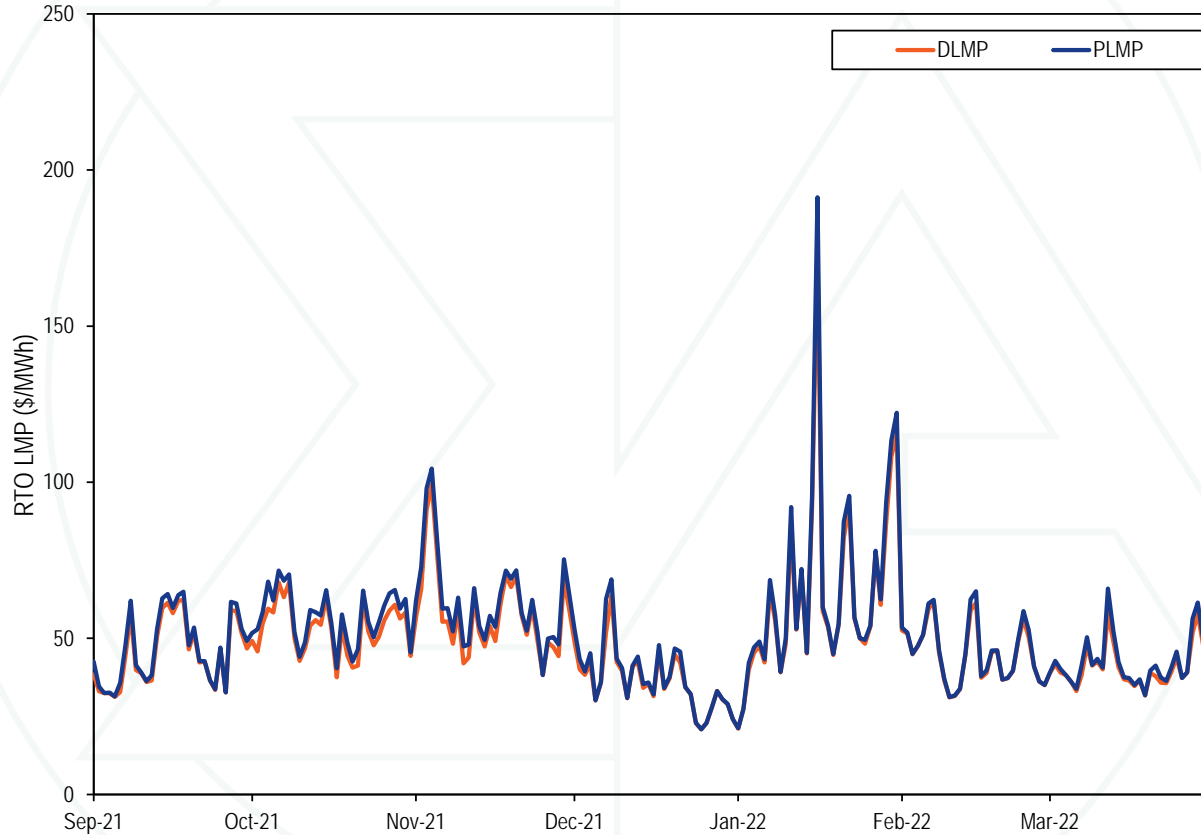
2022 YTD PJM Real-Time Daily Load



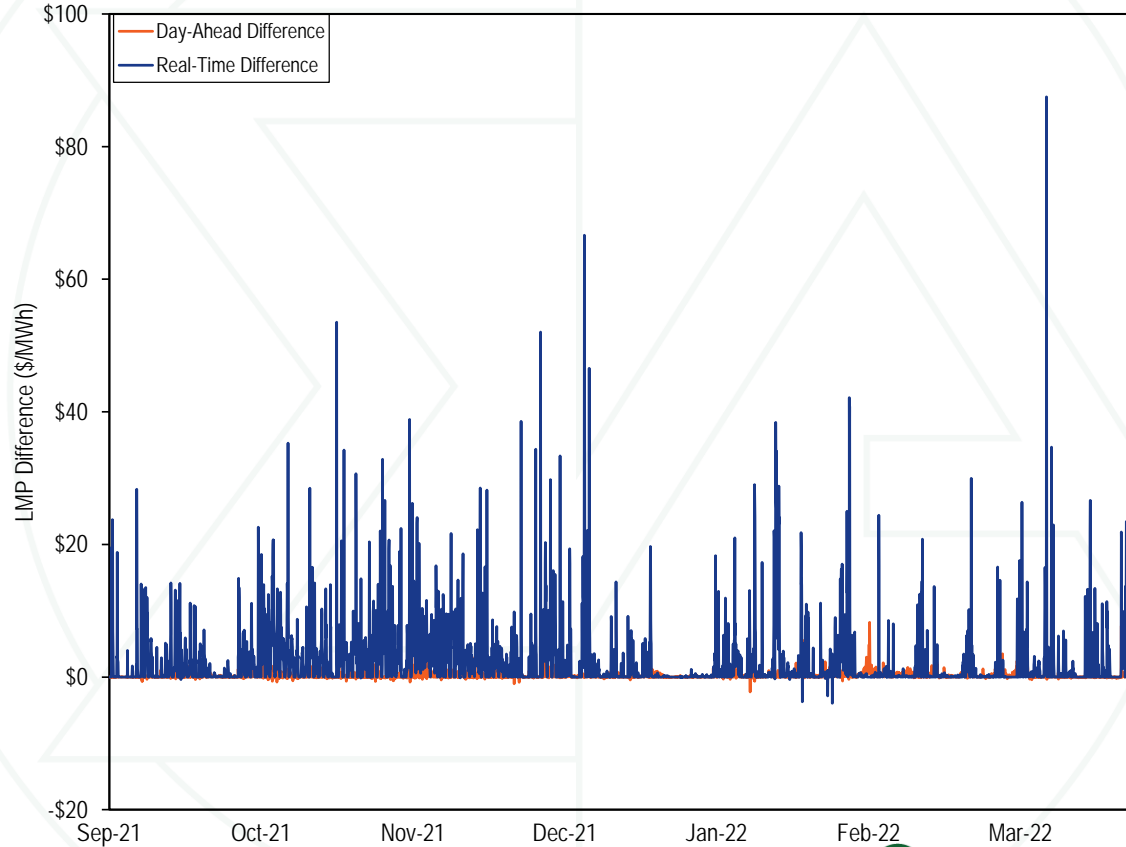
Monthly Average Load-Weighted DLMP and PLMP

Year	Month	Day-Ahead Load-Weighted Average				Real-Time Load-Weighted Average			
		DLMP	PLMP	Difference	Percent Difference	DLMP	PLMP	Difference	Percent Difference
2021	Sep	\$46.00	\$46.14	\$0.13	0.3%	\$47.73	\$49.63	\$1.90	4.0%
2021	Oct	\$57.86	\$57.98	\$0.12	0.2%	\$54.53	\$58.42	\$3.89	7.1%
2021	Nov	\$60.76	\$61.00	\$0.24	0.4%	\$59.27	\$63.01	\$3.74	6.3%
2021	Dec	\$37.74	\$37.85	\$0.11	0.3%	\$37.37	\$38.92	\$1.55	4.2%
2021	Sep - Dec	\$50.30	\$50.46	\$0.15	0.3%	\$49.47	\$52.20	\$2.73	5.5%
2022	Jan	\$63.93	\$64.15	\$0.22	0.3%	\$66.43	\$69.06	\$2.64	4.0%
2022	Feb	\$49.75	\$50.13	\$0.39	0.8%	\$45.93	\$46.76	\$0.83	1.8%
2022	Mar	\$45.15	\$45.40	\$0.25	0.6%	\$41.83	\$43.56	\$1.73	4.1%
2022	Jan - Mar	\$53.61	\$53.89	\$0.28	0.5%	\$52.34	\$54.13	\$1.79	3.4%

Daily Average Real-Time DLMP and PLMP



Hourly Difference: PLMP – DLMP



Fast Start Units as a Percent of Marginal Units

Year	Month	Dispatch Run				Pricing Run			
		CT	Diesel	Wind	All Fast Start Units	CT	Diesel	Wind	All Fast Start Units
2021	Sep	2.2%	0.8%	0.0%	3.0%	6.7%	1.3%	0.0%	8.1%
2021	Oct	3.2%	1.4%	0.0%	4.6%	11.1%	2.1%	0.0%	13.3%
2021	Nov	3.2%	0.3%	0.0%	3.5%	11.3%	0.6%	0.0%	11.9%
2021	Dec	1.4%	0.3%	0.2%	1.8%	4.4%	0.6%	0.1%	5.2%
2022	Jan	1.3%	0.3%	0.2%	1.8%	5.0%	0.9%	0.2%	6.2%
2022	Feb	0.6%	0.2%	0.3%	1.2%	3.3%	0.5%	0.3%	4.0%
2022	Mar	0.5%	0.2%	0.4%	1.1%	3.5%	0.5%	0.4%	4.4%



Fast Start Impacts: Zonal Average Differences

Zone	2022 (Jan-Mar)							
	Day-Ahead				Real-Time			
	Average DLMP	Average PLMP	Difference	Percent Difference	Average DLMP	Average PLMP	Difference	Percent Difference
ACEC	\$44.75	\$44.89	\$0.15	0.3%	\$45.77	\$47.72	\$1.95	4.3%
AEP	\$50.73	\$50.93	\$0.20	0.4%	\$49.18	\$51.50	\$2.32	4.7%
APS	\$52.99	\$53.20	\$0.21	0.4%	\$51.75	\$54.20	\$2.45	4.7%
ATSI	\$50.59	\$50.79	\$0.20	0.4%	\$48.43	\$50.64	\$2.21	4.6%
BGE	\$59.83	\$60.04	\$0.21	0.4%	\$58.50	\$61.57	\$3.06	5.2%
COMED	\$42.51	\$42.70	\$0.19	0.4%	\$40.64	\$43.10	\$2.45	6.0%
DAY	\$52.91	\$53.12	\$0.21	0.4%	\$51.17	\$53.51	\$2.34	4.6%
DUKE	\$51.63	\$51.83	\$0.20	0.4%	\$49.32	\$51.57	\$2.25	4.6%
DOM	\$58.10	\$58.30	\$0.19	0.3%	\$58.48	\$61.25	\$2.77	4.7%
DPL	\$51.40	\$51.62	\$0.22	0.4%	\$51.81	\$54.87	\$3.06	5.9%
DUQ	\$49.54	\$49.74	\$0.20	0.4%	\$47.57	\$49.74	\$2.17	4.6%
EKPC	\$51.74	\$51.94	\$0.20	0.4%	\$49.88	\$52.16	\$2.27	4.6%
JCPLC	\$47.01	\$47.17	\$0.16	0.3%	\$47.85	\$50.14	\$2.29	4.8%
MEC	\$55.27	\$55.44	\$0.16	0.3%	\$54.21	\$56.84	\$2.63	4.9%
OVEC	\$50.14	\$50.34	\$0.20	0.4%	\$48.38	\$50.59	\$2.21	4.6%
PECO	\$45.09	\$45.23	\$0.14	0.3%	\$46.03	\$48.11	\$2.08	4.5%
PE	\$52.93	\$53.13	\$0.20	0.4%	\$50.32	\$52.45	\$2.13	4.2%
PEPCO	\$58.58	\$58.79	\$0.21	0.4%	\$58.43	\$61.50	\$3.07	5.2%
PPL	\$49.65	\$49.81	\$0.16	0.3%	\$48.38	\$50.61	\$2.23	4.6%
PSEG	\$48.52	\$48.67	\$0.15	0.3%	\$49.98	\$52.26	\$2.28	4.6%
REC	\$51.37	\$51.52	\$0.15	0.3%	\$52.84	\$55.14	\$2.30	4.3%

Fast Start Impacts: Hub Average Differences

2022 (Jan-Mar)

Hub	Day-Ahead				Real-Time			
	Average DLMP	Average PLMP	Difference	Percent Difference	Average DLMP	Average PLMP	Difference	Percent Difference
AEP GEN HUB	\$49.55	\$49.75	\$0.20	0.4%	\$47.61	\$49.41	\$1.80	3.8%
AEP-DAYTON HUB	\$49.93	\$50.13	\$0.20	0.4%	\$47.96	\$49.84	\$1.88	3.9%
ATSI GEN HUB	\$49.66	\$49.86	\$0.20	0.4%	\$47.30	\$49.09	\$1.80	3.8%
CHICAGO GEN HUB	\$41.81	\$41.99	\$0.19	0.4%	\$39.67	\$41.67	\$2.00	5.0%
CHICAGO HUB	\$42.77	\$42.97	\$0.19	0.4%	\$40.89	\$42.95	\$2.06	5.0%
DOMINION HUB	\$57.01	\$57.21	\$0.19	0.3%	\$57.20	\$59.40	\$2.21	3.9%
EASTERN HUB	\$50.35	\$50.57	\$0.22	0.4%	\$50.61	\$53.35	\$2.74	5.4%
N ILLINOIS HUB	\$42.44	\$42.63	\$0.19	0.5%	\$40.55	\$42.58	\$2.03	5.0%
NEW JERSEY HUB	\$47.37	\$47.52	\$0.15	0.3%	\$48.53	\$50.43	\$1.90	3.9%
OHIO HUB	\$49.62	\$49.82	\$0.20	0.4%	\$47.49	\$49.39	\$1.91	4.0%
WEST INT HUB	\$51.81	\$52.00	\$0.20	0.4%	\$50.50	\$52.44	\$1.95	3.9%
WESTERN HUB	\$54.64	\$54.85	\$0.21	0.4%	\$52.55	\$54.56	\$2.01	3.8%

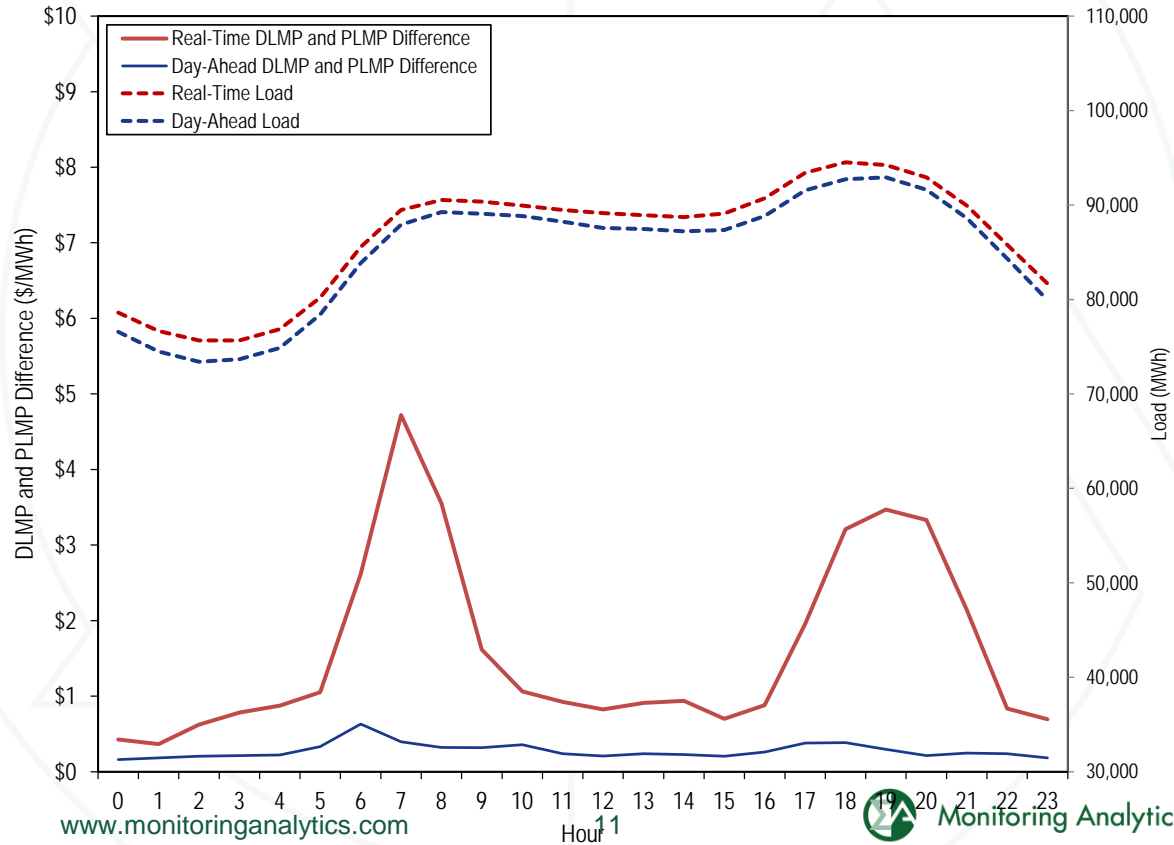


Zonal PLMP-DLMP Difference Frequency

2022 (Jan-Mar)

Zone	< (\$50)	(\$50) to (\$10)	(\$10) to \$0	\$0	\$0 to \$10	\$10 to \$20	\$20 to \$50	\$50 to \$100	\$100 to \$200	>= \$200
PJM-RTO	0.0%	0.0%	0.0%	1.0%	58.2%	36.5%	2.3%	1.7%	0.2%	0.1%
ACEC	0.0%	0.0%	0.4%	5.4%	58.5%	31.1%	2.0%	1.7%	0.6%	0.3%
AEP	0.0%	0.0%	0.0%	1.4%	58.3%	37.1%	1.9%	1.0%	0.1%	0.1%
APS	0.0%	0.0%	0.0%	1.1%	58.3%	36.7%	2.0%	1.5%	0.2%	0.1%
ATSI	0.0%	0.0%	0.0%	1.9%	58.3%	37.0%	1.7%	0.9%	0.1%	0.1%
BGE	0.0%	0.0%	0.1%	3.1%	58.3%	33.8%	2.2%	1.8%	0.6%	0.1%
COMED	0.0%	0.0%	0.0%	2.7%	58.6%	36.2%	1.6%	0.8%	0.1%	0.1%
DAY	0.0%	0.0%	0.0%	1.4%	58.4%	37.2%	1.8%	1.0%	0.2%	0.1%
DUKE	0.0%	0.0%	0.0%	1.6%	58.3%	37.2%	1.7%	0.9%	0.1%	0.1%
DOM	0.0%	0.0%	0.1%	2.5%	58.4%	34.5%	2.0%	1.9%	0.5%	0.1%
DPL	0.0%	0.0%	0.1%	6.2%	58.4%	29.6%	1.9%	1.7%	1.1%	0.9%
DUQ	0.0%	0.0%	0.0%	2.2%	58.3%	36.8%	1.6%	0.8%	0.1%	0.1%
EKPC	0.0%	0.0%	0.0%	1.6%	58.3%	37.0%	1.8%	1.0%	0.1%	0.1%
JCPLC	0.0%	0.0%	0.2%	3.9%	58.6%	32.6%	2.0%	1.8%	0.7%	0.2%
MEC	0.0%	0.0%	0.2%	3.0%	58.3%	33.8%	2.1%	1.7%	0.6%	0.2%
OVEC	0.0%	0.0%	0.0%	1.7%	58.4%	37.0%	1.7%	0.9%	0.1%	0.1%
PECO	0.0%	0.0%	0.1%	6.1%	58.4%	30.7%	2.1%	1.7%	0.6%	0.2%
PE	0.0%	0.0%	0.1%	1.5%	58.1%	36.2%	2.6%	1.3%	0.1%	0.1%
PEPCO	0.0%	0.0%	0.1%	3.2%	58.4%	33.7%	2.1%	1.9%	0.6%	0.1%
PPL	0.0%	0.0%	0.1%	3.2%	58.3%	34.1%	2.1%	1.5%	0.5%	0.1%
PSEG	0.0%	0.0%	0.1%	2.8%	58.5%	33.2%	2.4%	2.0%	0.7%	0.2%
REC	0.0%	0.1%	0.1%	2.4%	58.3%	33.4%	2.4%	2.4%	0.8%	0.2%

Hourly Average Load and LMP Difference: Jan through Mar 2022



Real-Time Monthly On Peak and Off Peak Load-Weighted LMP

	2021				2022			
	Off Peak	On Peak	Difference	Percent Difference	Off Peak	On Peak	Difference	Percent Difference
Jan	\$23.53	\$27.45	\$3.91	16.6%	\$74.99	\$62.54	(\$12.46)	(16.6%)
Feb	\$35.40	\$46.40	\$11.01	31.1%	\$45.70	\$47.86	\$2.16	4.7%
Mar	\$23.98	\$28.43	\$4.45	18.6%	\$41.58	\$45.41	\$3.83	9.2%
Apr	\$22.60	\$30.45	\$7.86	34.8%				
May	\$22.58	\$36.80	\$14.23	63.0%				
Jun	\$27.50	\$39.88	\$12.38	45.0%				
Jul	\$31.52	\$42.83	\$11.31	35.9%				
Aug	\$36.74	\$56.71	\$19.97	54.4%				
Sep	\$39.47	\$59.03	\$19.56	49.6%				
Oct	\$49.53	\$67.34	\$17.81	36.0%				
Nov	\$55.73	\$70.49	\$14.76	26.5%				
Dec	\$34.83	\$42.56	\$7.73	22.2%				

ICAP Definition

- **ICAP is the summer capacity units can achieve under rated conditions.**
- **The rated conditions are the average conditions at the site (or local weather station) during the last 15 PJM summer peaks. Can be as long as 20 years prior.**
- **Units are tested within a defined threshold from the rated conditions:**
 - **Cooling body water temperature within 5°F.**
 - **Wet bulb temperature within 10°F.**
 - **Dry bulb temperature within 20°F.**
- **Values are interpolated to the exact rated conditions.**

Average Peak Load Ambient Conditions

- Average among ORD, BWI, EWR, PHL, PIT, RIC.

Year	Temperature (F)	Relative Humidity (%)	Heat Index
2004	83	68	88
2005	90	46	95
2006	96	42	102
2007	92	51	96
2008	90	42	92
2009	91	47	95
2010	97	36	99
2011	98	42	106
2012	97	33	100
2013	94	49	101
2014	90	45	93
2015	89	49	91
2016	93	50	101
2017	90	49	94
2018	91	53	98
2019	92	56	102
2020	93	42	97
2021	90	47	94
Total	92	47	97

- Heat index reference:

https://www.wpc.ncep.noaa.gov/html/heatindex_equation.shtml

Ambient Derates

- **Units should take forced outages for reduced MW when ambient conditions at a site mean that the ICAP under rated conditions cannot be reached.**
- **Ambient conditions that require derates are expected to occur every year, given that the rated conditions are an average.**

GE 7FA Temperature Curve Example

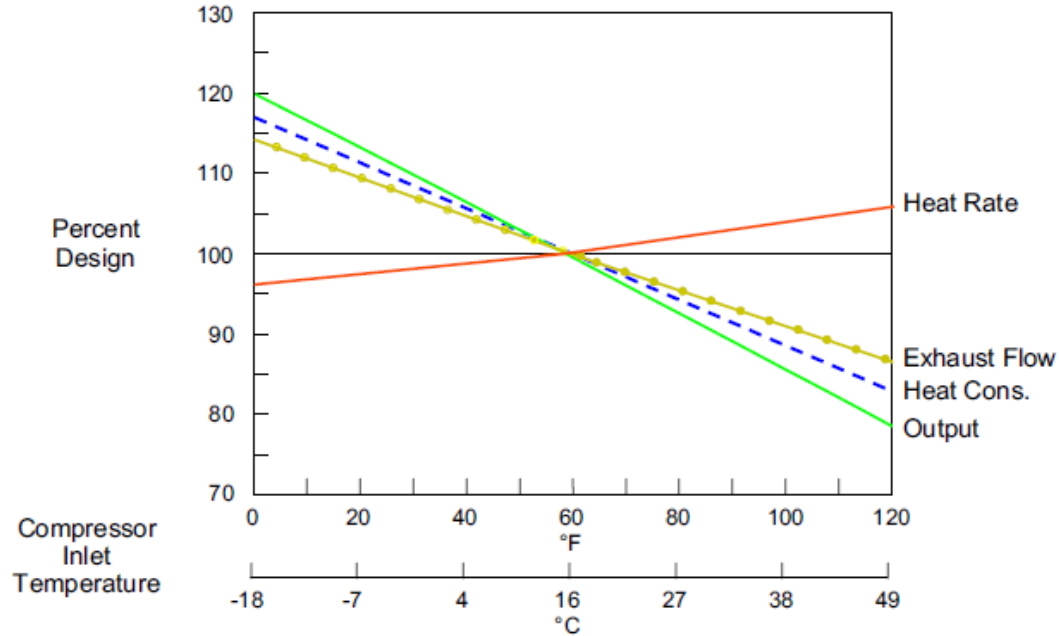


Figure 9. Effect of ambient temperature

Source: https://www.ge.com/content/dam/gepower-new/global/en_US/downloads/gas-new-site/resources/reference/ger-3567h-ge-gas-turbine-performance-characteristics.pdf

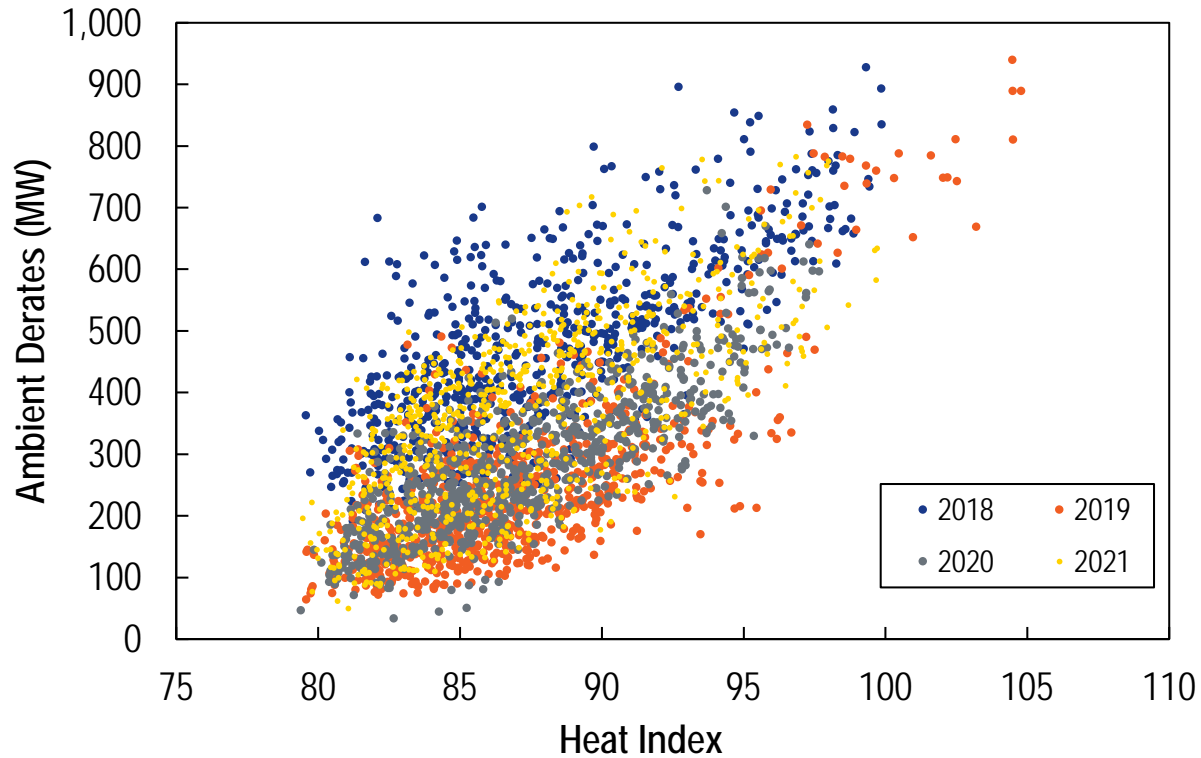
GE 7FA Temperature Curve Example

- Assuming that the rated condition is 90°F, a 100 MW unit's ICAP will be rated at a 94.5 MW.
- At 95°F, the expected full output is 92.4 MW, a 2.2 percent derate from ICAP at 90°F.
- At 100°F, the expected full output is 90.4 MW, a 4.3 percent derate from ICAP at 90°F.
- At 105°F, the expected full output is 88.3 MW, a 6.5 percent derate from ICAP at 90°F.

Historical Ambient Derates

- **The Market Monitor estimated the amount of ambient derates in PJM between 2018 and 2021.**
- **The data were compiled using energy market data and eGADS data. eGADS data was used to exclude derates for non ambient reasons.**
- **The derates were plotted against the heat index.**
- **Heat index is a metric that incorporates temperature and relative humidity.**

Historical Ambient Derates



Historical Ambient Derates

- From 2018 through 2021 there were 175 hours with a heat index between 95 and 100. The average hourly derates were 624 MW.
- There were only 13 hours with a heat index above 100 (all in 2019). The average hourly derates for the 13 hours were 786 MW.
- The heat index values are the simple average of: ORD, BWI, EWR, PHL, PIT, RIC.

Many Units Do Not Reflect Ambient Conditions

- **Not all units update their eco max to reflect ambient conditions.**
 - **Some units update eco max hourly.**
 - **Some units update eco max monthly or seasonally.**
 - **Some units never update. They offer ICAP all the time.**
 - Even during times ICAP cannot be achieved (hot days).
 - Even during times they can exceed ICAP (cold days).

Unit Type	Number of units	Units with fixed Eco Max	Units with monthly/seasonal Eco Max	Total ICAP (MW)	Total ICAP from fixed Eco Max units (MW)	Total ICAP from monthly/seasonal Eco Max units (MW)	Percent of ICAP from fixed/monthly/seasonal Eco Max
CT	414	193	45	28,970	11,454	2,734	49%
CC	117	16	0	53,459	6,834	0	13%
Total	531	209	45	82,429	18,288	2,734	26%



Implications

- **ICAP procurement based on average peak ambient conditions in the last 15-20 years means that ICAP will be overstated when ambient conditions are less favorable than average.**
- **These are exactly the times when accuracy is most important for reliability and for markets.**
- **Failure to update max output in the energy market leads to inefficient dispatch, inefficient pricing, incorrect calculation of reserves, and need for operator manual intervention.**

Conclusion

- **Recommendations:**
 - **Generators should be required to submit accurate hourly max output data, based on expected ambient conditions.**
 - **If ambient adjusted hourly max output is less than ICAP, generators should be required to submit forced outages in eGADS.**
 - **Rated capacity ambient conditions should be updated annually.**
 - **ICAP should be based on the same ambient conditions included in PJM's load forecast used in capacity market, rather than 15 years of history.**
 - **Testing requirements should be strengthened.**

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