Fast Start Pricing in PJM

CAISO Price Formation Enhancements: Phase 2 Working Group

January 16, 2025

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PJM IMM

Monitoring Analytics

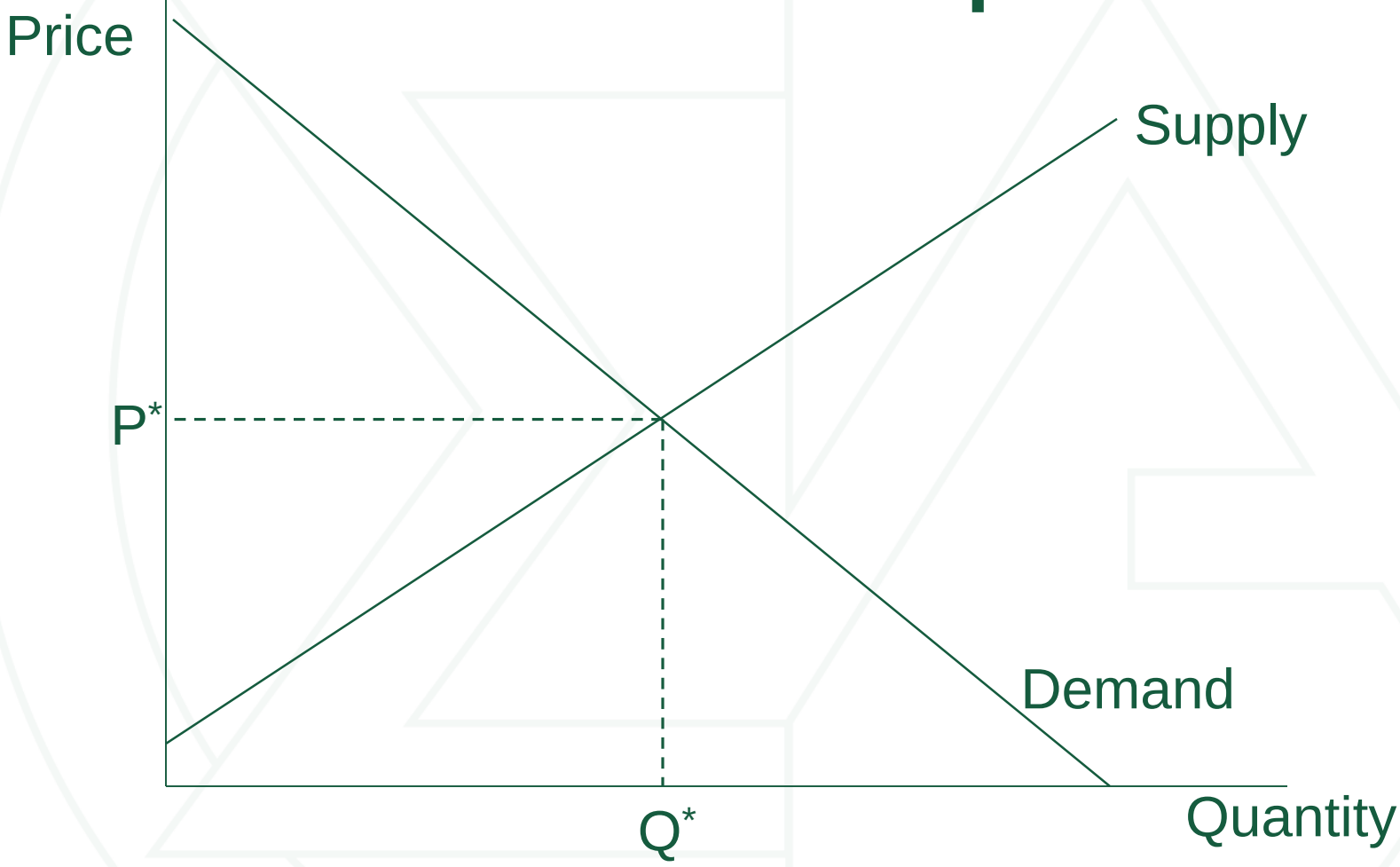
THEORY

Efficient Market Pricing Principles

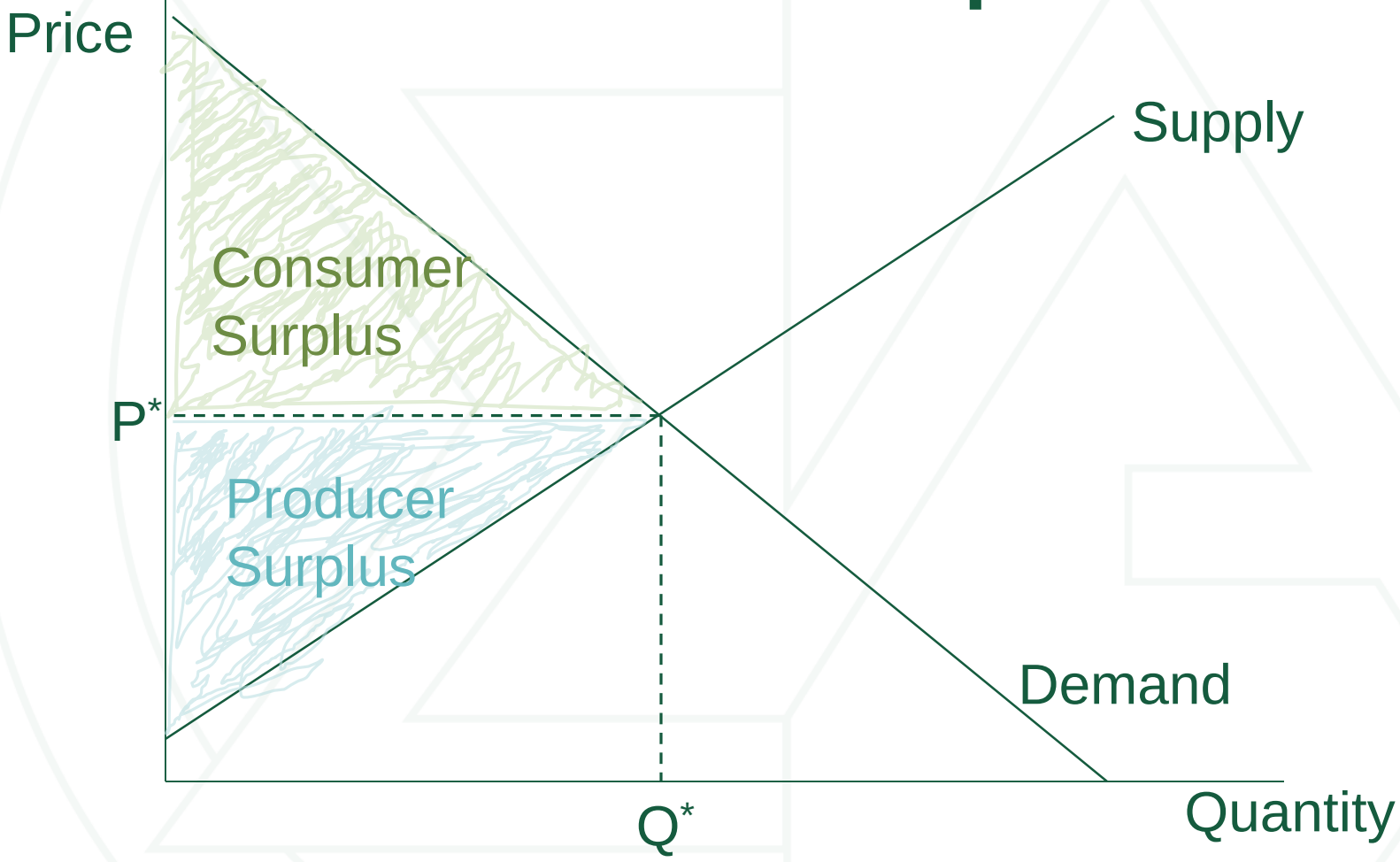
- **A market is a set of interactions between buyers and sellers.**
- **Market prices are determined by the buyers' valuations and sellers' costs.**
- **Competitive market prices are determined on the margin. Price = short run marginal cost.**
- **Sellers who cannot supply at the price determined on the margin, do not sell.**
- **Buyers whose value of the product is less than the market price, do not purchase.**

- **Repricing the market with fast start pricing removes these efficient market outcomes.**

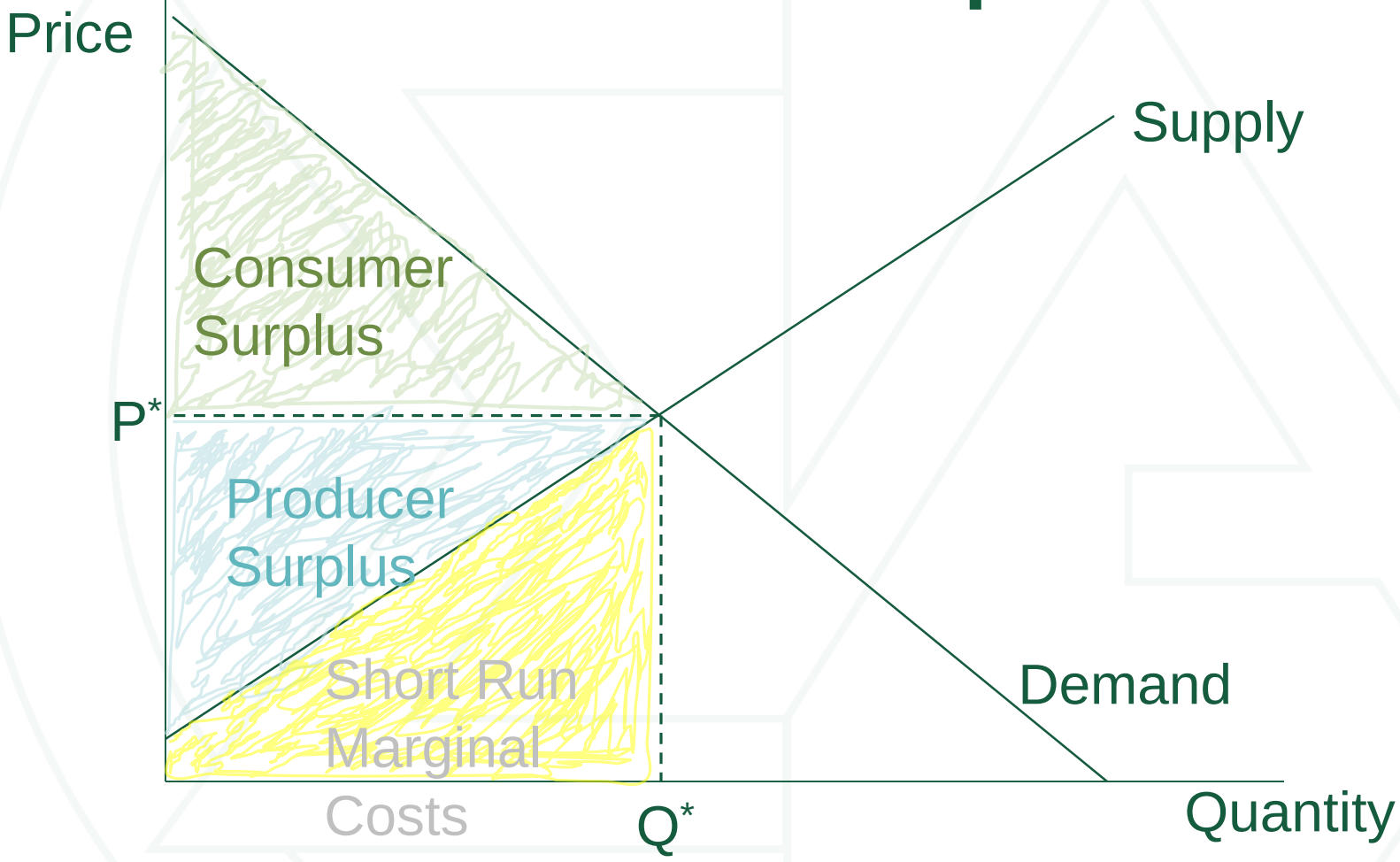
Short Run Market Equilibrium



Short Run Market Equilibrium



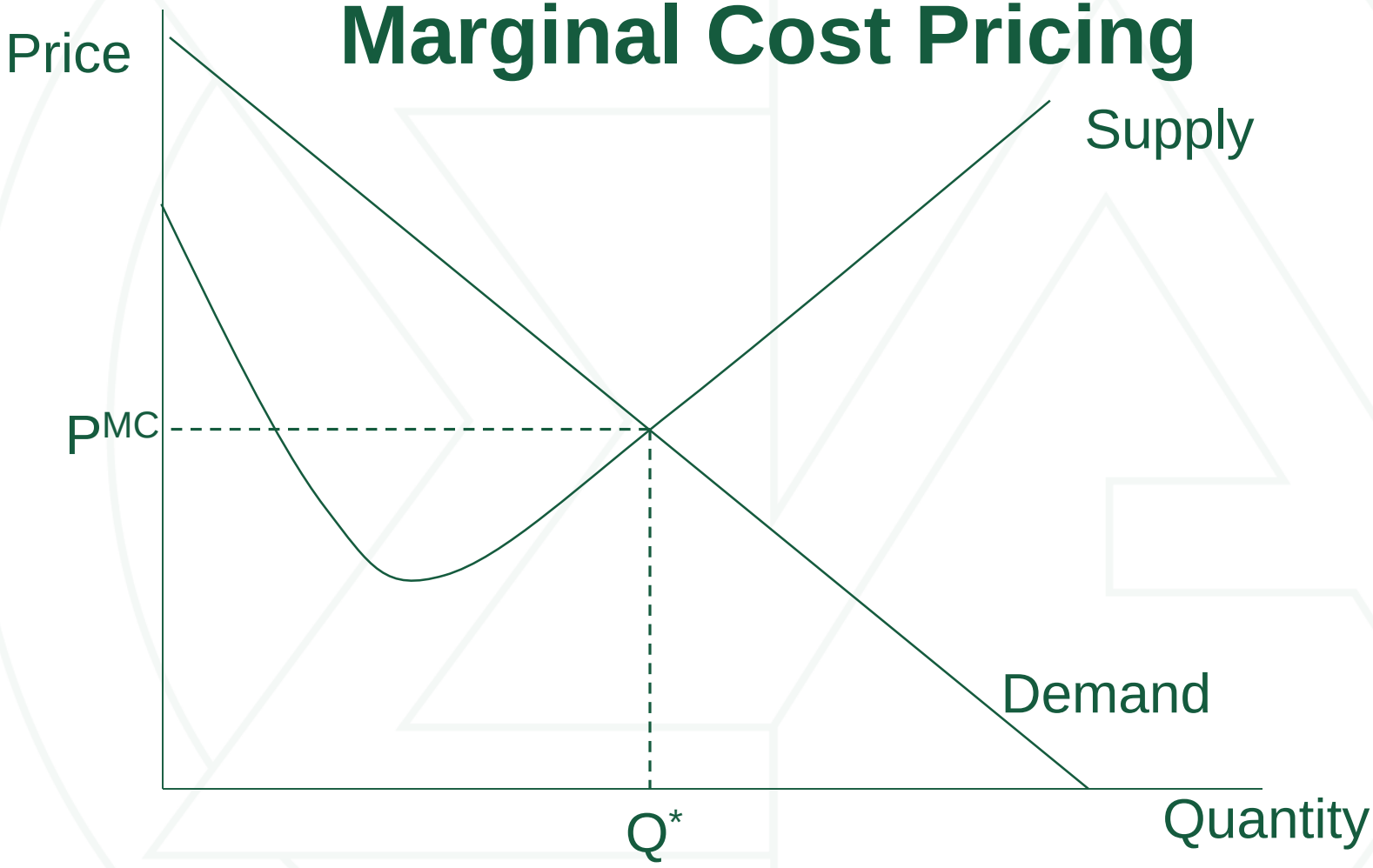
Short Run Market Equilibrium



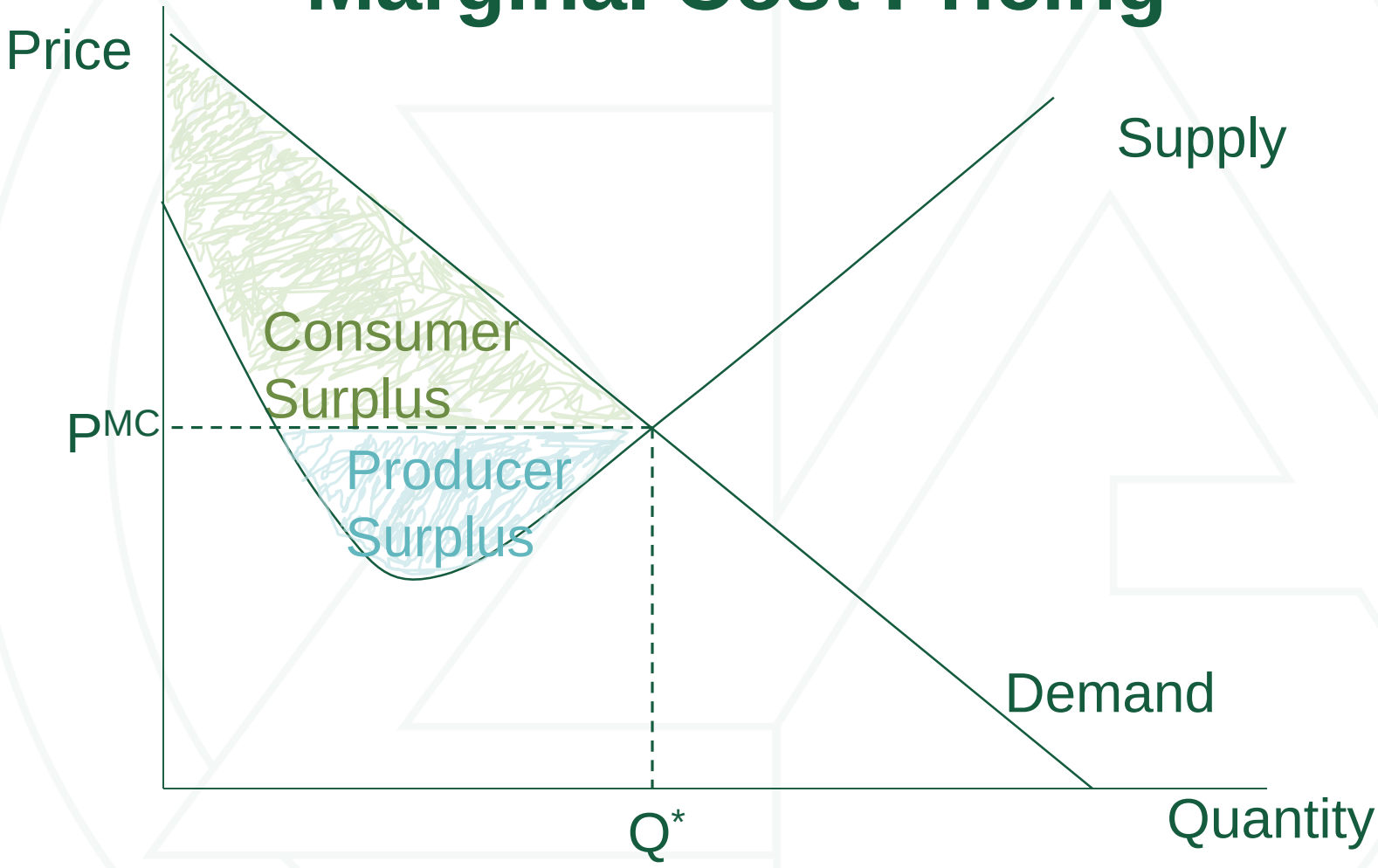
Supply Curve Convexity

- **Efficient means both**
  - **Cost minimizing**
  - **Consumer and producer surplus maximizing**
  - **The standard efficient market outcome requires convex costs.**
- **Short run marginal costs for power production**
  - **Fuel, emissions costs, opportunity costs**
  - **Not convex due to commitment costs**
- **Achieving the efficient market outcome requires coordinated intervention due to the nonconvex costs.**
  - **Uplift payments perform the role of coordination.**
  - **Marginal cost pricing with the correct amount of uplift results in efficient market outcomes.**
  - **The use of uplift is not a market inefficiency, though overpayment has been a common problem in RTO rules.**

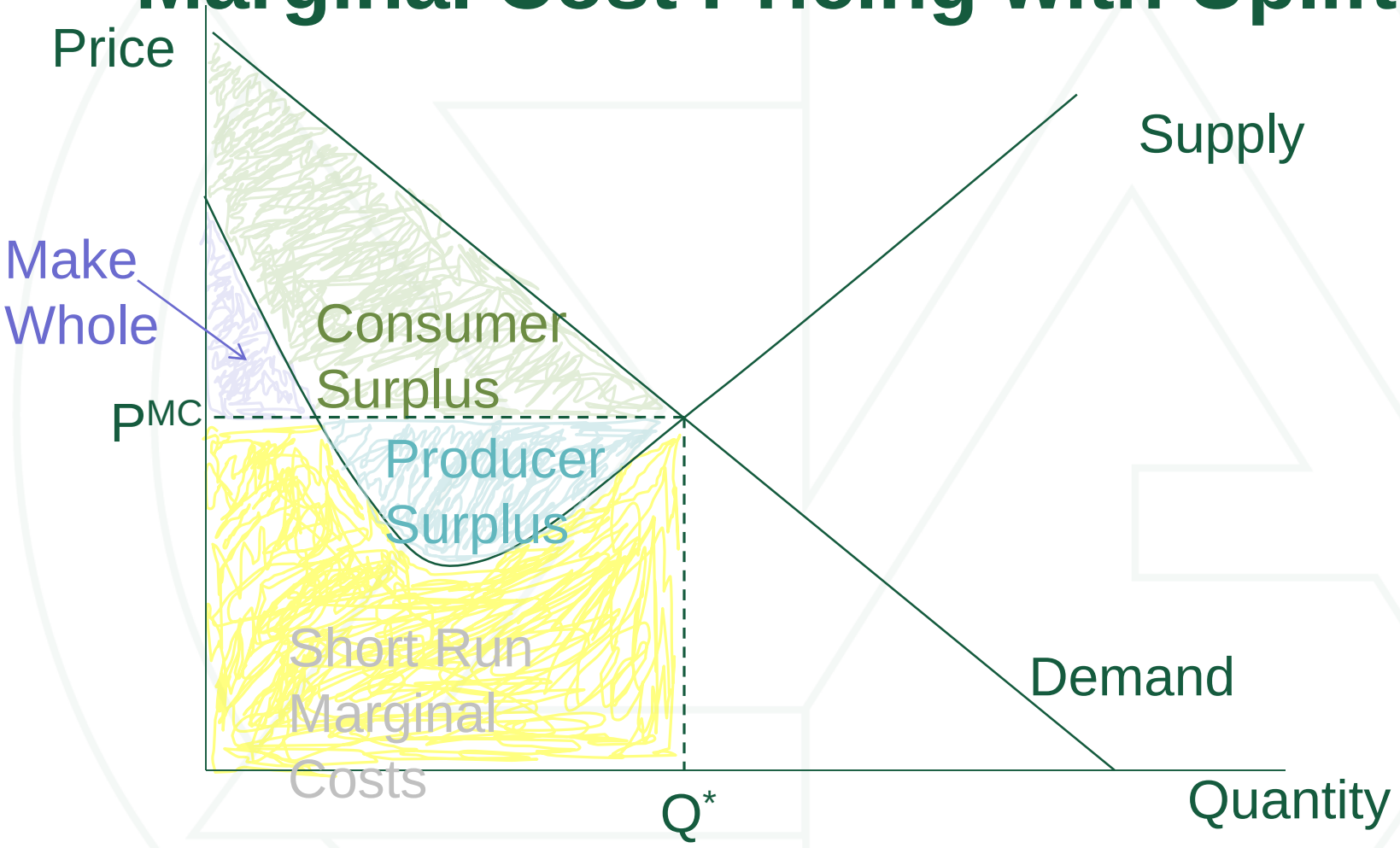
Marginal Cost Pricing



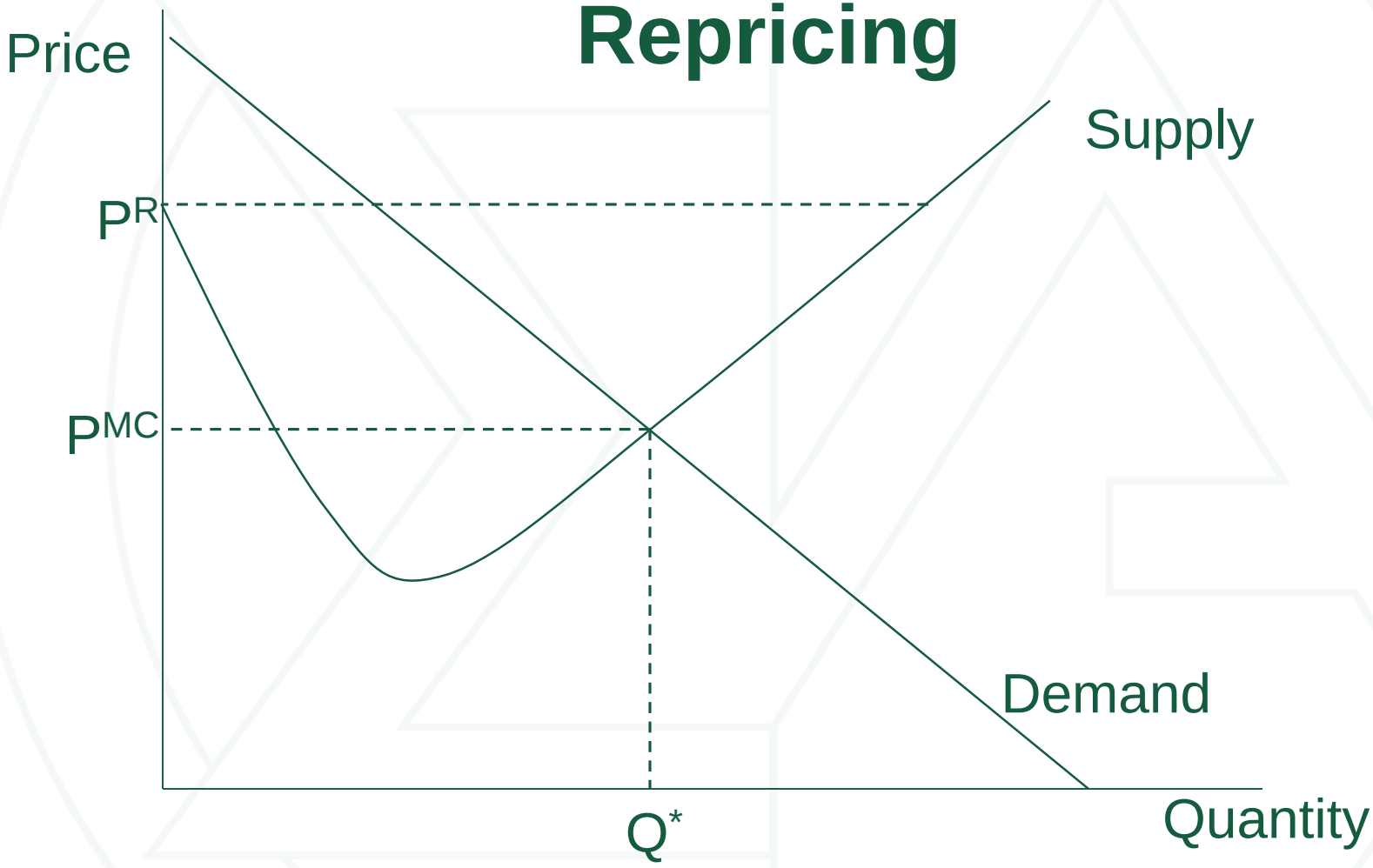
Marginal Cost Pricing



Marginal Cost Pricing with Uplift



Repricing



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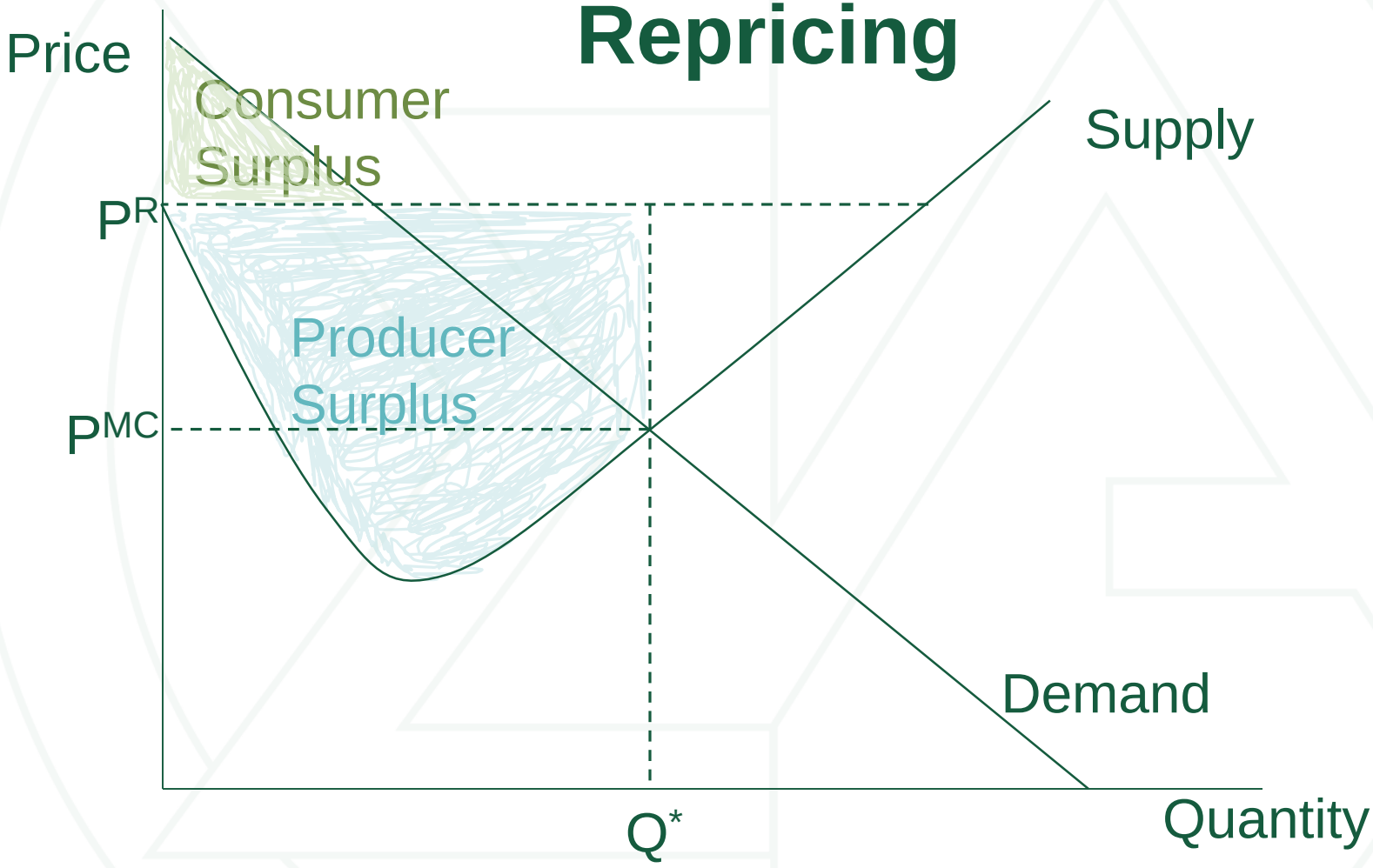
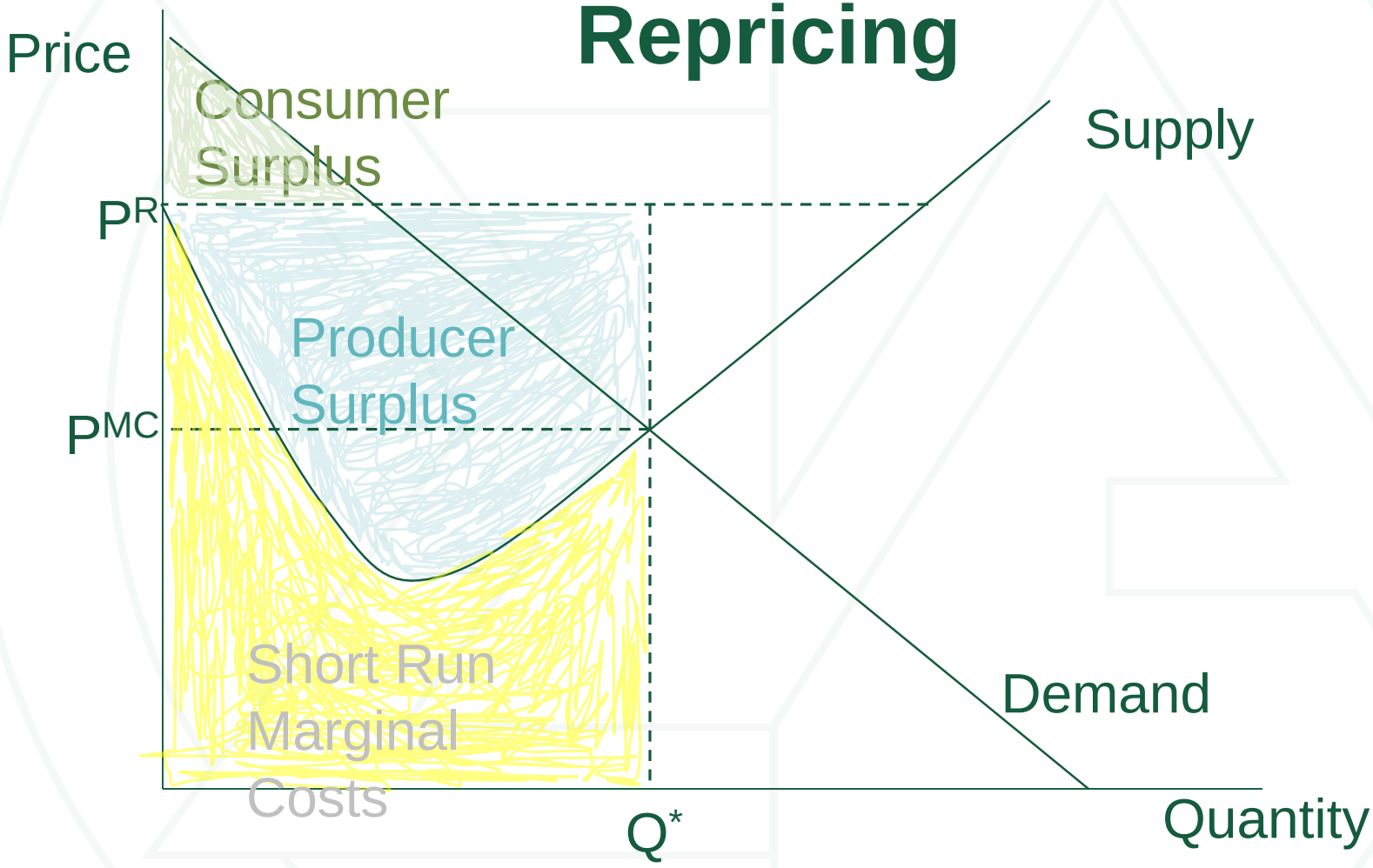
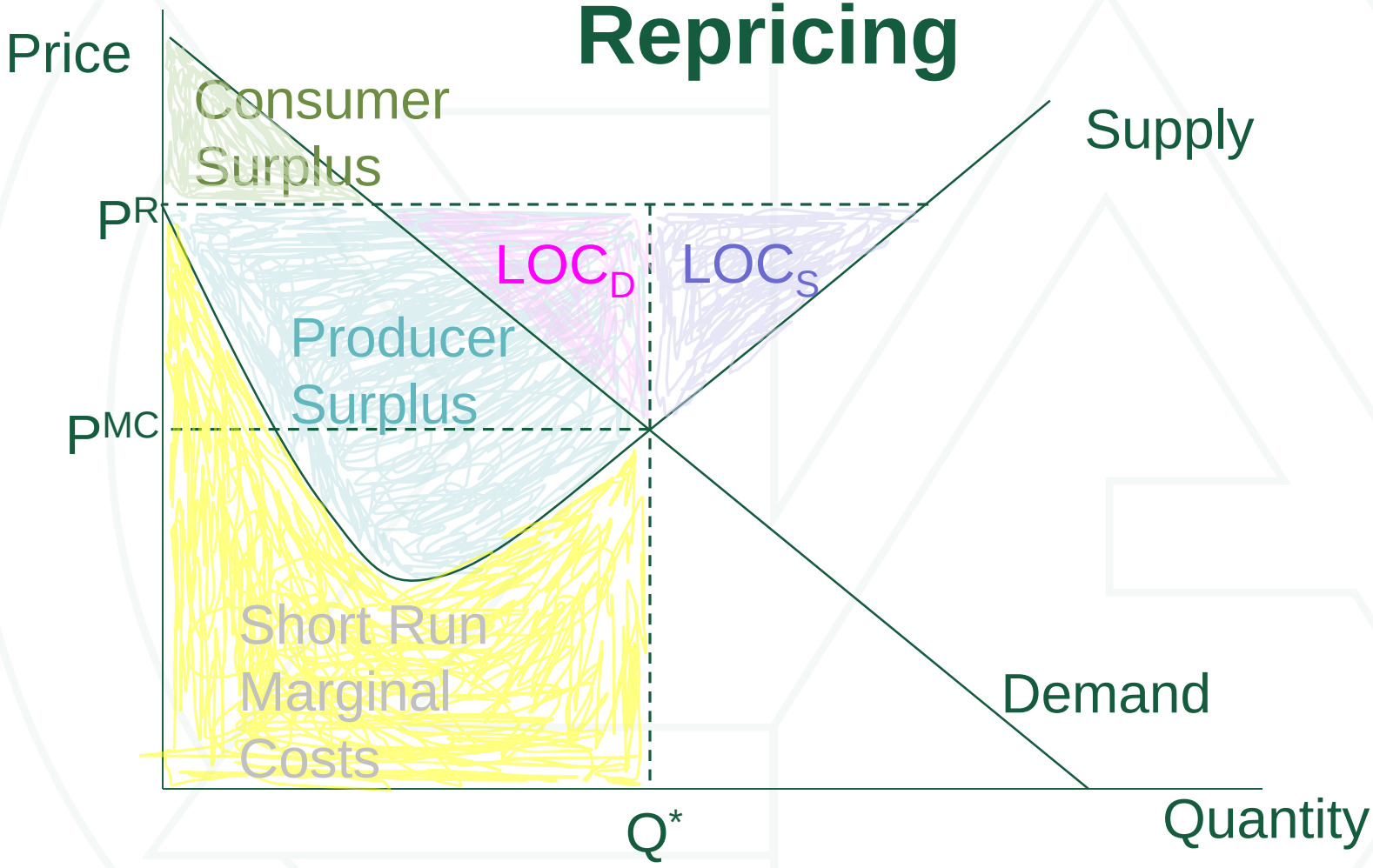
Repricing



Repricing


Price
Consumer Surplus
Supply
P^R
Producer Surplus
P^{MC}
Short Run Marginal Costs
Demand
Q^*
Quantity

Repricing



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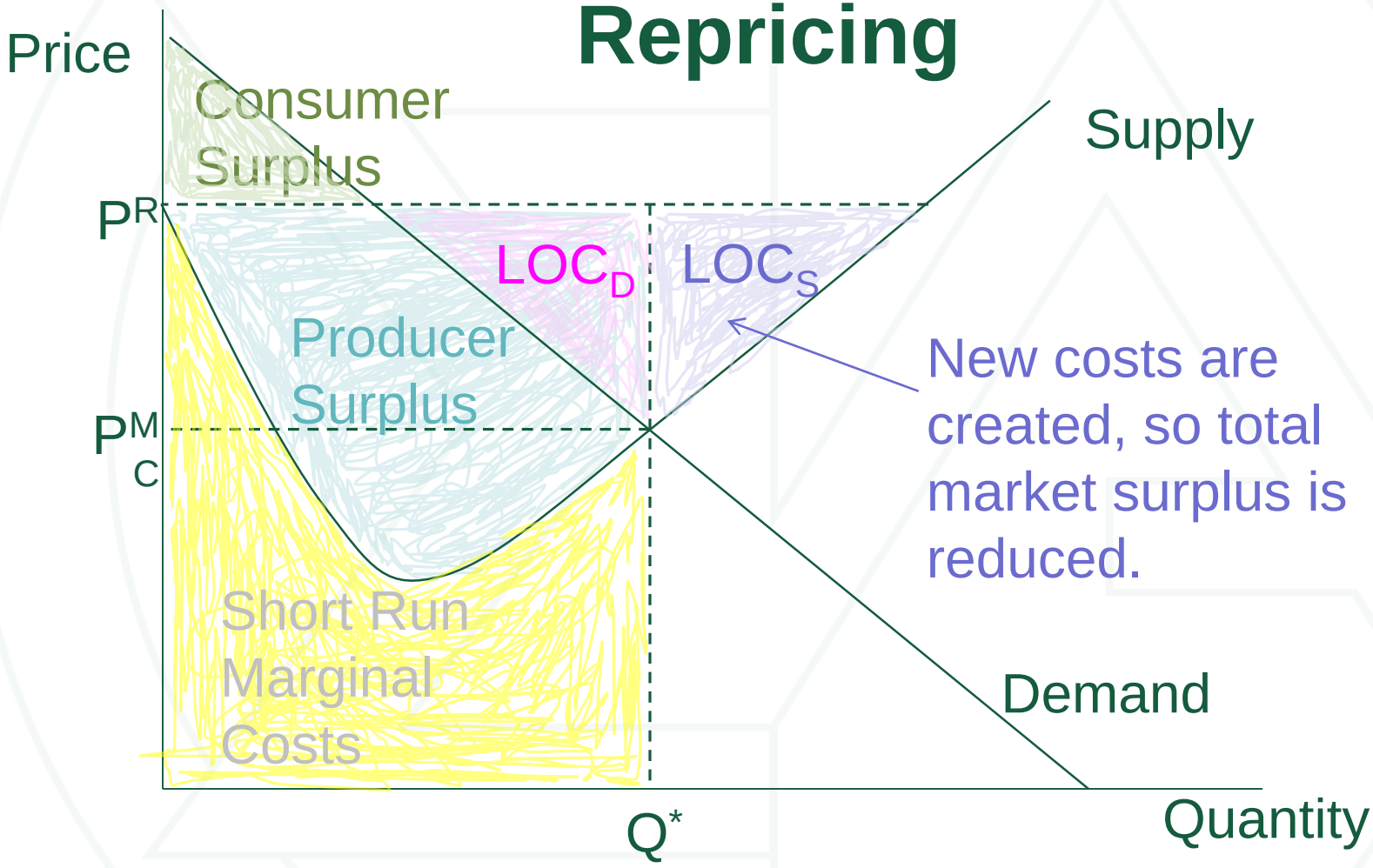
Repricing



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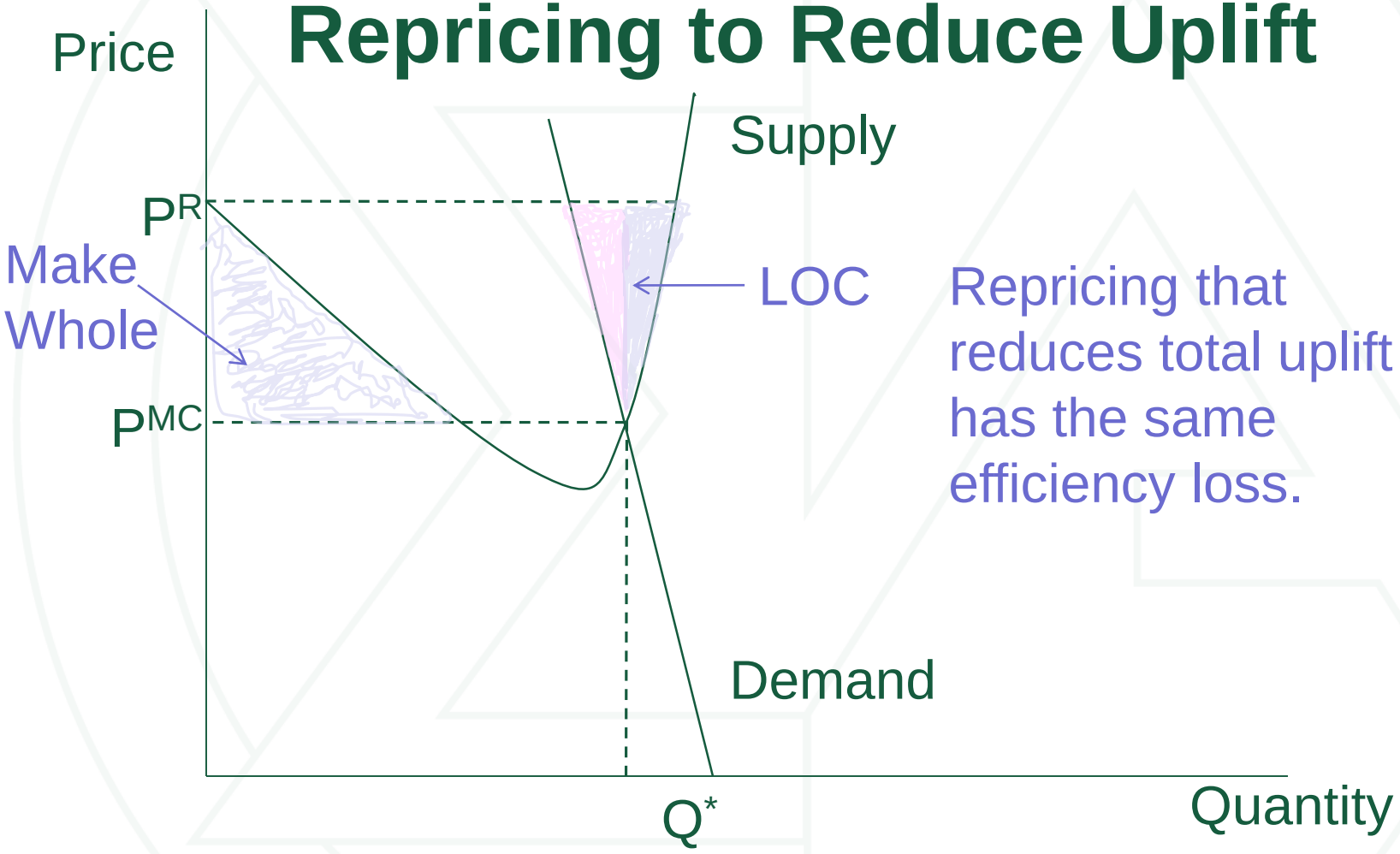
Repricing to Reduce Uplift



Repricing that reduces total uplift has the same efficiency loss.

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Fast Start Pricing Discussion

- **Fast start changes prices from the efficient level**
  - **Market participants will have an incentive to change their behavior due to setting a different price.**
  - **But the efficient market solution is for participants to follow the efficient market clearing in the short run.**
- **Fast start uses uplift payments to correct the incentive to deviate from the efficient market solution.**
  - **Uplift payments do not provide the same quality signal for efficient behavior on the margin as prices.**
- **Repricing presents a tradeoff between the reduction in uplift and efficient price signals.**
- **The PJM IMM does not agree that it is worth the loss of efficient pricing to achieve other goals, like the reduction of uplift.**

PJM Fast Start Implementation

- **One hour start time is not fast.**
  - **These resources are not eligible to provide reserves.**
  - **These resources are not committed from an offline state by the real time market clearing process.**
- **Some resources are considered eligible for fast start treatment but do not actually offer commitment costs that would be used in fast start pricing.**
- **Fast start is applied in both the day-ahead and real-time markets, but it has only a small effect on the day-ahead market.**
- **PJM uses the pricing run to implement other market administrative differences from the dispatch run, like price capping and transmission constraint penalty factors.**

DATA FROM THE PJM MARKET

Dispatch Run and Pricing Run

- **DLMP**
  - **Dispatch run LMP.**
  - **This is the price consistent with PJM's pricing calculation prior to fast start pricing.**
  - **The DLMP is the price that is consistent with the market clearing MW.**
- **PLMP**
  - **Pricing run LMP.**
  - **This is the price that results from applying the fast start logic, also called integer relaxation.**
  - **The PLMP results from the fast start (integer relaxation) clearing. It is not based on the physical capabilities of the operating resources.**
  - **The PLMP is not consistent with incentives to follow the market clearing dispatch instructions.**

Pricing Differences at PJM Hubs

Hub	2024 (Jan-Sep) Day-Ahead Average DLMP	Day-Ahead Average PLMP	Day-Ahead Difference	Day-Ahead Percent Difference	Real-Time Average DLMP	Real-Time Average PLMP	Real-Time Difference	Real-Time Percent Difference
AEP GEN HUB	$29.10	$29.13	$0.03	0.1%	$27.37	$29.74	$2.37	8.7%
AEP-DAYTON HUB	$30.12	$30.15	$0.03	0.1%	$28.19	$30.60	$2.42	8.6%
ATSI GEN HUB	$30.56	$30.57	$0.01	0.0%	$28.42	$30.75	$2.33	8.2%
CHICAGO GEN HUB	$25.11	$25.21	$0.10	0.4%	$23.09	$25.16	$2.07	8.9%
CHICAGO HUB	$26.09	$26.10	$0.01	0.0%	$24.25	$26.34	$2.10	8.7%
DOMINION HUB	$33.68	$33.71	$0.03	0.1%	$31.17	$33.84	$2.66	8.5%
EASTERN HUB	$30.74	$30.78	$0.04	0.1%	$28.15	$30.74	$2.59	9.2%
N ILLINOIS HUB	$25.61	$25.74	$0.12	0.5%	$24.00	$26.08	$2.08	8.7%
NEW JERSEY HUB	$27.02	$27.04	$0.02	0.1%	$25.81	$27.55	$1.74	6.7%
OHIO HUB	$30.11	$30.14	$0.03	0.1%	$28.16	$30.57	$2.41	8.6%
WEST INT HUB	$31.58	$31.58	$0.01	0.0%	$29.53	$32.00	$2.47	8.3%
WESTERN HUB	$33.51	$33.53	$0.02	0.1%	$30.82	$33.36	$2.54	8.2%

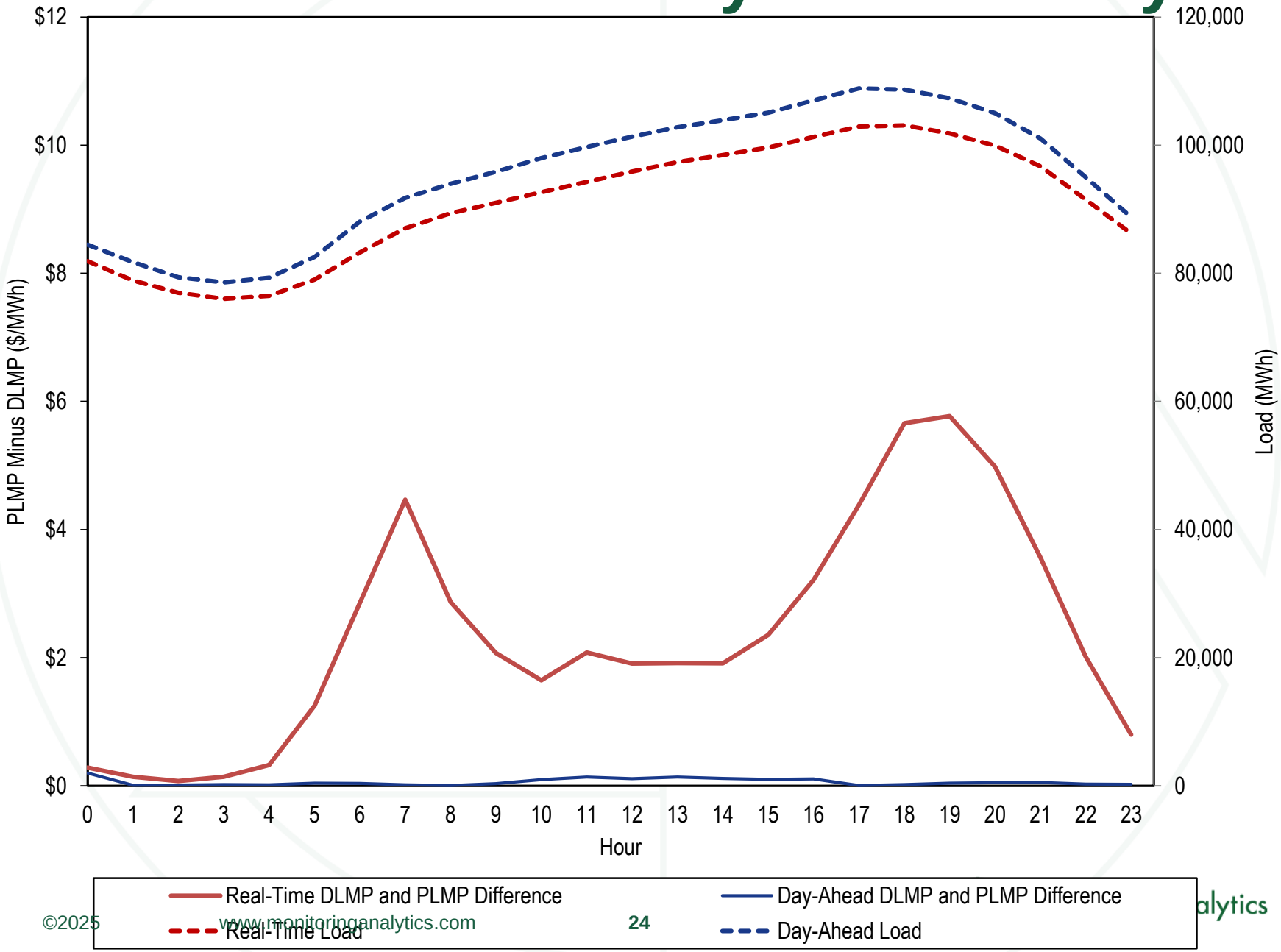
Monthly Average Price Differences

		Day-Ahead Load-Weighted Average				Real-Time Load-Weighted Average			
Year	Month	DLMP	PLMP	Difference	Percent Difference	DLMP	PLMP	Difference	Percent Difference
2023	Jan	$36.53	$36.58	$0.05	0.1%	$34.66	$35.75	$1.09	3.1%
2023	Feb	$31.16	$31.22	$0.06	0.2%	$25.47	$26.04	$0.57	2.2%
2023	Mar	$28.39	$28.41	$0.02	0.1%	$27.58	$28.42	$0.85	3.1%
2023	Apr	$29.81	$29.81	($0.00)	(0.0%)	$27.09	$29.32	$2.22	8.2%
2023	May	$28.86	$28.80	($0.05)	(0.2%)	$25.91	$28.44	$2.53	9.7%
2023	Jun	$27.82	$27.82	($0.00)	(0.0%)	$25.69	$27.29	$1.60	6.2%
2023	Jul	$40.46	$40.56	$0.10	0.3%	$34.34	$37.21	$2.87	8.4%
2023	Aug	$30.49	$30.54	$0.05	0.2%	$29.77	$31.33	$1.55	5.2%
2023	Sep	$30.82	$30.91	$0.09	0.3%	$29.33	$31.55	$2.22	7.6%
2023	Oct	$35.15	$35.17	$0.02	0.1%	$30.61	$34.77	$4.16	13.6%
2023	Nov	$33.32	$33.40	$0.08	0.2%	$30.40	$32.94	$2.54	8.3%
2023	Dec	$27.97	$28.00	$0.03	0.1%	$26.37	$27.97	$1.59	6.0%
2023	Jan - Sep	$31.59	$31.63	$0.03	0.1%	$28.87	$30.59	$1.72	6.0%
2023		$31.89	$31.93	$0.04	0.1%	$29.11	$31.08	$1.97	6.8%
2024	Jan	$48.45	$48.65	$0.20	0.4%	$40.82	$42.78	$1.95	4.8%
2024	Feb	$23.67	$23.70	$0.03	0.1%	$23.20	$24.86	$1.66	7.2%
2024	Mar	$21.89	$21.93	$0.04	0.2%	$20.30	$23.15	$2.85	14.0%
2024	Apr	$26.73	$26.75	$0.02	0.1%	$23.29	$27.17	$3.87	16.6%
2024	May	$32.92	$32.90	($0.02)	(0.1%)	$31.70	$36.16	$4.46	14.1%
2024	Jun	$32.59	$32.62	$0.03	0.1%	$31.95	$33.35	$1.40	4.4%
2024	Jul	$44.51	$44.69	$0.18	0.4%	$44.12	$47.17	$3.04	6.9%
2024	Aug	$36.34	$36.31	($0.03)	(0.1%)	$34.37	$36.29	$1.92	5.6%
2024	Sep	$30.63	$30.77	$0.14	0.4%	$29.32	$31.81	$2.48	8.5%
2024	Jan - Sep	$33.78	$33.85	$0.07	0.2%	$31.73	$34.31	$2.58	8.1%

Frequency of Real Time Marginal Fast Start Units by Unit Type

		Dispatch Run				Pricing Run			
Year	Month	CT	Diesel	Wind	All Fast Start Units	CT	Diesel	Wind	All Fast Start Units
2023	Jan	1.6%	0.5%	0.1%	2.1%	6.2%	2.8%	0.0%	9.0%
2023	Feb	0.9%	0.2%	0.0%	1.1%	3.1%	0.6%	0.0%	3.7%
2023	Mar	0.8%	0.4%	0.1%	1.2%	3.0%	0.7%	0.1%	3.8%
2023	Apr	2.5%	0.4%	0.2%	3.2%	8.1%	0.8%	0.2%	9.1%
2023	May	1.0%	0.3%	0.1%	1.3%	4.8%	0.7%	0.1%	5.6%
2023	Jun	0.5%	0.2%	0.0%	0.7%	2.5%	0.5%	0.0%	3.0%
2023	Jul	1.4%	0.9%	0.0%	2.4%	8.6%	1.6%	0.0%	10.3%
2023	Aug	0.9%	1.5%	0.0%	2.4%	5.1%	2.3%	0.0%	7.4%
2023	Sep	0.4%	0.8%	0.1%	1.3%	5.1%	1.4%	0.1%	6.6%
2023	Oct	1.4%	0.3%	0.0%	1.7%	6.9%	0.8%	0.0%	7.7%
2023	Nov	4.0%	0.6%	0.0%	4.5%	11.4%	1.4%	0.0%	12.8%
2023	Dec	1.4%	0.7%	0.0%	2.2%	7.2%	2.0%	0.0%	9.3%
2023	Jan - Sep	1.1%	0.6%	0.1%	1.7%	5.2%	1.3%	0.1%	6.5%
2024	Jan	0.7%	0.6%	0.0%	1.3%	3.5%	1.1%	0.0%	4.7%
2024	Feb	0.4%	0.1%	0.1%	0.5%	2.2%	0.1%	0.1%	2.4%
2024	Mar	0.7%	0.2%	1.2%	2.1%	4.1%	0.8%	1.3%	6.2%
2024	Apr	1.5%	0.2%	0.2%	1.9%	6.5%	0.7%	0.1%	7.3%
2024	May	0.6%	0.2%	0.1%	1.0%	5.1%	0.6%	0.1%	5.8%
2024	Jun	0.5%	0.3%	0.1%	0.8%	3.5%	0.4%	0.1%	4.0%
2024	Jul	0.8%	0.5%	0.0%	1.4%	7.4%	1.0%	0.0%	8.5%
2024	Aug	0.6%	0.5%	0.0%	1.1%	5.0%	1.0%	0.0%	6.0%
2024	Sep	1.0%	0.1%	0.0%	1.1%	7.1%	0.4%	0.0%	7.6%
2024	Jan - Sep	0.8%	0.3%	0.2%	1.3%	4.9%	0.7%	0.2%	5.8%

Price Differences by Time of Day



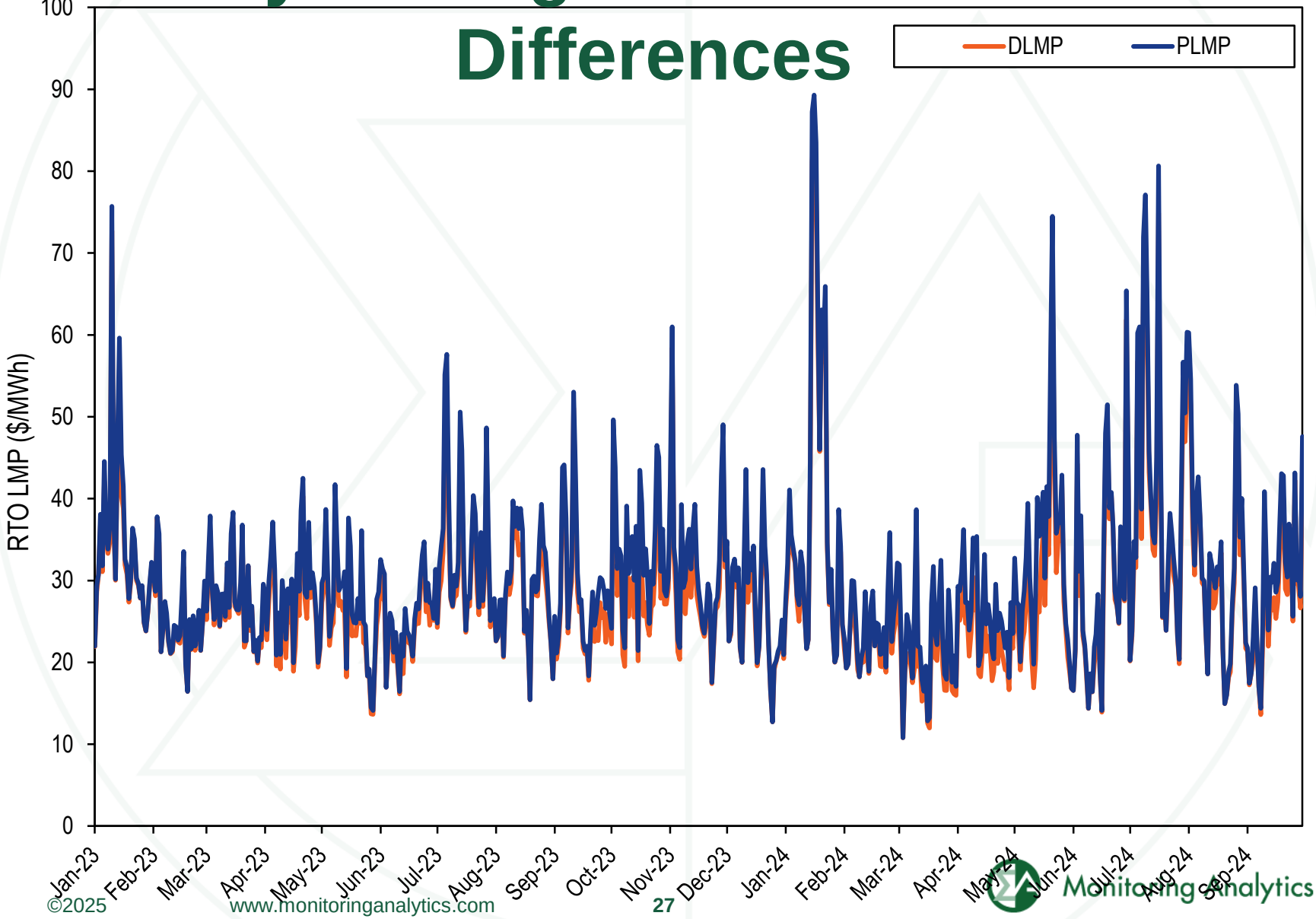
Price Differences by Zone

	2024 (Jan-Sep)							
	Day-Ahead				Real-Time			
Zone	Average DLMP	Average PLMP	Difference	Percent Difference	Average DLMP	Average PLMP	Difference	Percent Difference
ACEC	$26.96	$27.01	$0.05	0.2%	$25.67	$27.34	$1.68	6.5%
AEP	$30.54	$30.60	$0.06	0.2%	$28.83	$31.29	$2.45	8.5%
APS	$31.72	$31.78	$0.06	0.2%	$29.47	$31.98	$2.51	8.5%
ATSI	$30.90	$30.90	($0.01)	(0.0%)	$29.04	$31.41	$2.37	8.2%
BGE	$40.25	$40.32	$0.08	0.2%	$37.44	$40.58	$3.14	8.4%
COMED	$25.80	$25.88	$0.08	0.3%	$24.05	$26.14	$2.09	8.7%
DAY	$32.01	$32.07	$0.07	0.2%	$30.02	$32.62	$2.61	8.7%
DUKE	$30.76	$30.83	$0.06	0.2%	$28.70	$31.16	$2.46	8.6%
DOM	$36.65	$36.72	$0.06	0.2%	$33.73	$36.51	$2.78	8.2%
DPL	$30.88	$30.96	$0.09	0.3%	$28.39	$31.02	$2.63	9.3%
DUQ	$30.50	$30.54	$0.04	0.1%	$29.03	$31.35	$2.32	8.0%
EKPC	$30.02	$30.08	$0.06	0.2%	$28.42	$30.85	$2.42	8.5%
JCPLC	$26.88	$26.94	$0.06	0.2%	$25.70	$27.43	$1.73	6.7%
MEC	$28.41	$28.46	$0.06	0.2%	$26.17	$28.17	$2.00	7.6%
OVEC	$29.17	$29.23	$0.06	0.2%	$27.32	$29.64	$2.33	8.5%
PECO	$26.67	$26.72	$0.05	0.2%	$25.40	$27.01	$1.61	6.3%
PE	$31.33	$31.37	$0.04	0.1%	$29.00	$31.27	$2.26	7.8%
PEPCO	$37.90	$37.97	$0.07	0.2%	$34.93	$37.85	$2.92	8.3%
PPL	$26.54	$26.60	$0.06	0.2%	$24.76	$26.57	$1.81	7.3%
PSEG	$27.11	$27.16	$0.05	0.2%	$26.02	$27.77	$1.75	6.7%
REC	$29.11	$29.16	$0.05	0.2%	$27.71	$29.56	$1.85	6.7%

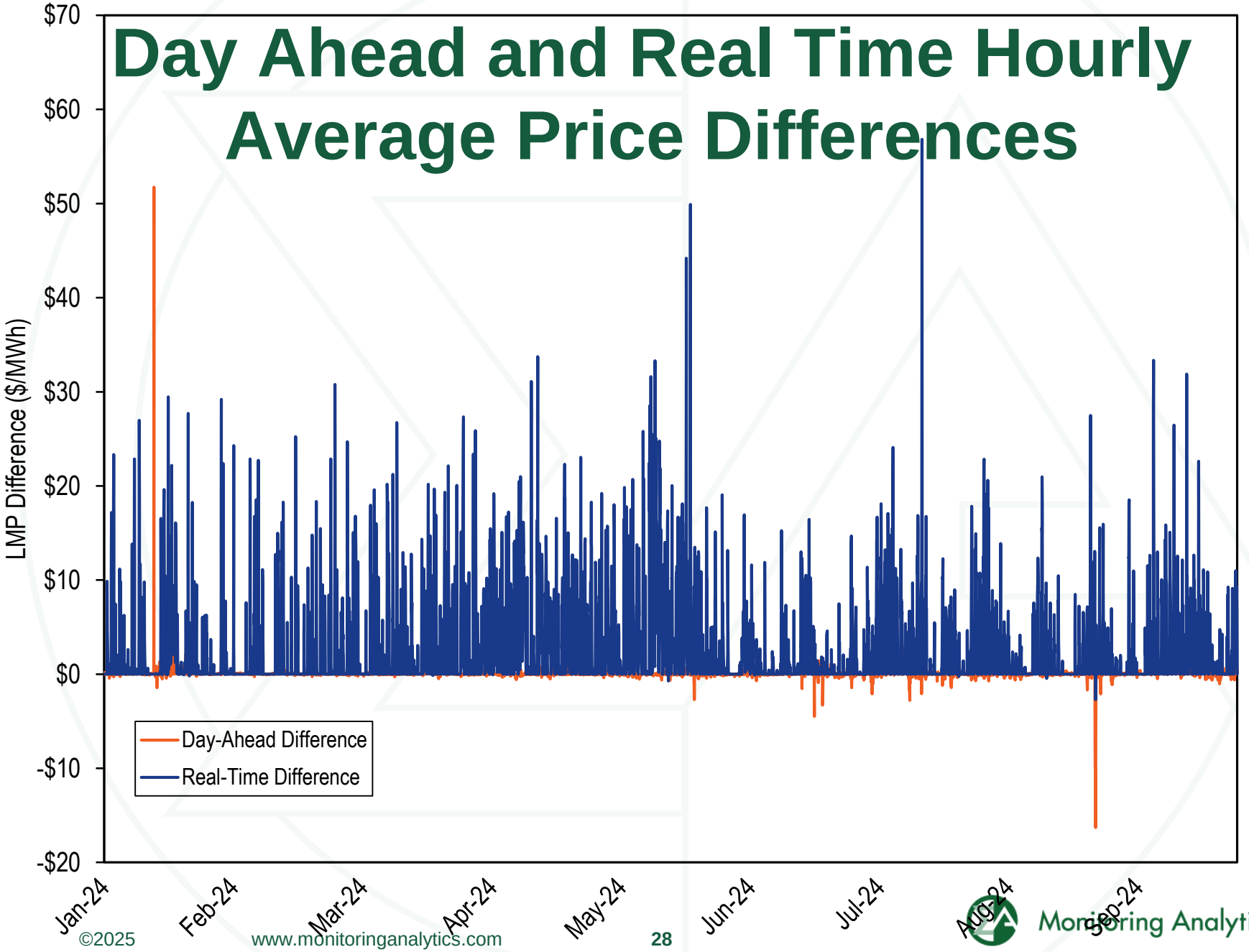
Frequency of Real-Time Five Minute Price Differences by Zone

	2024 (Jan-Sep)									
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%	0.8%	53.3%	38.6%	4.9%	2.2%	0.1%	0.0%	0.0%
AECO	0.0%	0.0%	4.7%	53.6%	36.8%	3.2%	1.6%	0.1%	0.0%	0.0%
AEP	0.0%	0.0%	1.5%	53.5%	37.3%	5.1%	2.5%	0.1%	0.0%	0.0%
APS	0.0%	0.0%	1.1%	53.4%	37.6%	5.0%	2.7%	0.1%	0.0%	0.0%
ATSI	0.0%	0.1%	1.9%	53.4%	37.3%	4.8%	2.4%	0.1%	0.0%	0.0%
BGE	0.0%	0.1%	2.6%	53.3%	34.0%	5.8%	3.8%	0.4%	0.1%	0.0%
COMED	0.0%	0.1%	3.4%	54.1%	35.9%	4.3%	2.0%	0.1%	0.0%	0.0%
DAY	0.0%	0.0%	1.5%	53.5%	36.7%	5.3%	2.8%	0.2%	0.0%	0.0%
DEOK	0.0%	0.0%	1.6%	53.5%	37.2%	5.0%	2.5%	0.1%	0.0%	0.0%
DOM	0.0%	0.1%	1.8%	53.4%	35.9%	5.3%	3.1%	0.3%	0.0%	0.0%
DPL	0.0%	0.2%	6.9%	53.6%	33.0%	3.0%	2.4%	0.5%	0.4%	0.0%
DUQ	0.0%	0.0%	1.7%	53.4%	37.6%	4.7%	2.4%	0.1%	0.0%	0.0%
EKPC	0.0%	0.0%	1.5%	53.5%	37.5%	5.0%	2.4%	0.1%	0.0%	0.0%
JCPL	0.0%	0.0%	2.3%	53.6%	39.3%	3.2%	1.6%	0.1%	0.0%	0.0%
METED	0.0%	0.1%	3.5%	53.4%	36.9%	4.0%	1.9%	0.1%	0.0%	0.0%
OVEC	0.0%	0.1%	1.8%	53.5%	37.2%	4.8%	2.3%	0.1%	0.0%	0.0%
PECO	0.0%	0.1%	6.3%	53.5%	35.2%	3.1%	1.6%	0.1%	0.0%	0.0%
PENELEC	0.0%	0.1%	1.5%	53.3%	38.3%	4.6%	2.1%	0.1%	0.0%	0.0%
PEPCO	0.0%	0.1%	2.2%	53.4%	35.0%	5.6%	3.4%	0.3%	0.0%	0.0%
PPL	0.0%	0.1%	3.1%	53.4%	38.3%	3.5%	1.6%	0.1%	0.0%	0.0%
PSEG	0.0%	0.0%	2.2%	53.5%	39.3%	3.2%	1.6%	0.1%	0.0%	0.0%
RECO	0.0%	0.1%	2.1%	53.3%	39.3%	3.3%	1.7%	0.1%	0.0%	0.0%

Daily Average Real Time Price Differences



Day Ahead and Real Time Hourly Average Price Differences



Monitoring Analytics

Difference in Components of LMP

Element	Dispatch Contribution to LMP	Dispatch Percent	Pricing Contribution to LMP	Pricing Percent	Change in Percent
Gas	$12.09	38.1%	$13.00	37.9%	(0.2%)
Coal	$4.46	14.1%	$4.17	12.1%	(1.9%)
Positive Markup	$3.41	10.7%	$3.94	11.5%	0.7%
Variable Maintenance	$2.27	7.2%	$3.28	9.6%	2.4%
Transmission Constraint Penalty Factor	$3.16	10.0%	$3.23	9.4%	(0.5%)
Ten Percent Adder	$1.85	5.8%	$1.99	5.8%	(0.0%)
CO_2 Cost	$1.94	6.1%	$1.91	5.6%	(0.6%)
Variable Operations	$1.41	4.5%	$1.46	4.3%	(0.2%)
Ancillary Service Redispatch Cost	$0.84	2.7%	$1.41	4.1%	1.5%
Opportunity Cost Adder	$1.23	3.9%	$1.37	4.0%	0.1%
Oil	$1.08	3.4%	$1.08	3.1%	(0.3%)
Market-to-Market	$0.52	1.7%	$0.30	0.9%	(0.8%)
Increase Generation Differential	$0.17	0.5%	$0.24	0.7%	0.2%
LPA Rounding Difference	$0.32	1.0%	$0.20	0.6%	(0.4%)
Scarcity	$0.23	0.7%	$0.18	0.5%	(0.2%)
NO_x Cost	$0.10	0.3%	$0.11	0.3%	0.0%
NA	$0.12	0.4%	$0.11	0.3%	(0.1%)
Landfill Gas	$0.06	0.2%	$0.05	0.1%	(0.0%)
Other	$0.02	0.1%	$0.02	0.1%	(0.0%)
SO_2 Cost	$0.00	0.0%	$0.00	0.0%	(0.0%)
LPA-SCED Differential	$0.01	0.0%	($0.00)	(0.0%)	(0.0%)
Renewable Energy Credits	($0.07)	(0.2%)	($0.05)	(0.1%)	0.1%
Decrease Generation Differential	($0.02)	(0.1%)	($0.05)	(0.1%)	(0.1%)
Negative Markup	($3.49)	(11.0%)	($3.64)	(10.6%)	0.4%
Total	$31.73	100.0%	$34.31	100.0%	0.0%

Commitment Cost Components of PLMP

	Start Cost Components		No Load Components		Other Components		Total	
Element	Contribution to LMP	Percent	Contribution to LMP	Percent	Contribution to LMP	Percent	Contribution to LMP	Percent
Gas	$0.00	0.0%	$0.38	1.1%	$12.62	36.8%	$13.00	37.9%
Coal	$0.00	0.0%	$0.00	0.0%	$4.17	12.1%	$4.17	12.1%
Postive Markup	$0.02	0.1%	$0.00	0.0%	$3.92	11.4%	$3.94	11.5%
Variable Maintenance	$0.16	0.5%	$0.02	0.1%	$3.11	9.1%	$3.28	9.6%
Transmission Constraint Penalty Factor	$0.00	0.0%	$0.00	0.0%	$3.23	9.4%	$3.23	9.4%
Ten Percent Adder	$0.01	0.0%	$0.03	0.1%	$1.94	5.7%	$1.99	5.8%
CO_2 Cost	$0.00	0.0%	$0.02	0.1%	$1.89	5.5%	$1.91	5.6%
Variable Operations	$0.00	0.0%	$0.00	0.0%	$1.46	4.3%	$1.46	4.3%
Ancillary Service Redispatch Cost	$0.00	0.0%	$0.00	0.0%	$1.41	4.1%	$1.41	4.1%
Opportunity Cost Adder	$0.00	0.0%	$0.00	0.0%	$1.37	4.0%	$1.37	4.0%
Oil	$0.00	0.0%	$0.03	0.1%	$1.05	3.1%	$1.08	3.1%
Market-to-Market	$0.00	0.0%	$0.00	0.0%	$0.30	0.9%	$0.30	0.9%
Increase Generation Differential	$0.00	0.0%	$0.00	0.0%	$0.24	0.7%	$0.24	0.7%
LPA Rounding Difference	$0.00	0.0%	$0.00	0.0%	$0.20	0.6%	$0.20	0.6%
Scarcity	$0.00	0.0%	$0.00	0.0%	$0.18	0.5%	$0.18	0.5%
NO_x Cost	$0.00	0.0%	$0.00	0.0%	$0.11	0.3%	$0.11	0.3%
NA	$0.00	0.0%	$0.00	0.0%	$0.11	0.3%	$0.11	0.3%
Landfill Gas	$0.00	0.0%	$0.00	0.0%	$0.05	0.1%	$0.05	0.1%
Other	$0.00	0.0%	$0.00	0.0%	$0.02	0.1%	$0.02	0.1%
SO_2 Cost	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%
LPA-SCED Differential	$0.00	0.0%	$0.00	0.0%	($0.00)	(0.0%)	($0.00)	(0.0%)
Renewable Energy Credits	$0.00	0.0%	$0.00	0.0%	($0.05)	(0.1%)	($0.05)	(0.1%)
Decrease Generation Differential	$0.00	0.0%	$0.00	0.0%	($0.05)	(0.1%)	($0.05)	(0.1%)
Negative Markup	($0.00)	(0.0%)	($0.04)	(0.1%)	($3.60)	(10.5%)	($3.64)	(10.6%)
Total	$0.19	0.6%	$0.44	1.3%	$33.68	98.2%	$34.31	100.0%

Fast Start Eligible Units

- One suggestion by proponents of fast start pricing is that it creates incentives for entry of more fast start units.
- The evidence in PJM does not support this. The number of fast start CTs and diesels has fallen.
- New fast start eligible units have been batteries and renewables, which do not actually use fast start pricing, because they do not have commitment costs.

Average Number of Fast Start Eligible Units by Year

Year	Total	BATTERY	CT	DIESEL	HYDRO	SOLAR	WIND
2021	662	28	214	79	0	240	101
2022	679	27	216	77	0	256	103
2023	778	30	194	74	76	296	108
2024	836	32	195	67	79	354	109

Fast Start and Uplift

- Fast start pricing is intended to reduce uplift,
  - Specifically to reduce balancing generator payments.
- Fast start pricing also creates new forms of uplift,
  - Called dispatch differential lost opportunity cost.
- The net change in uplift is an empirical question.
- The net change in uplift depends on many factors:
  - The fast start qualifying resource definition (time to start, min run time)
  - The number of fast start qualifying resources
  - The pattern of use of fast start resources by operators
  - Fuel costs, emissions costs, and maintenance costs

PJM Uplift History

Year (Jan - Sep)	Day Ahead Generators	Balancing Generators	Balancing LOC	Dispatch Diff LOC	Total
2015	$86.7	$106.6	$75.1		$284.3
2016	$40.8	$44.2	$16.3		$102.7
2017	$17.0	$42.7	$9.9		$84.6
2018	$31.9	$76.5	$47.8		$176.9
2019	$13.9	$40.7	$12.5		$70.5
2020	$7.0	$31.8	$17.1		$58.6
2021	$10.8	$97.1	$17.5	$0.1	$131.1
2022	$35.3	$113.4	$25.4	$3.6	$180.5
2023	$42.8	$54.8	$17.9	$0.5	$117.4
2024	$93.7	$95.0	$25.5	$1.6	$218.5

PJM Uplift Summary

Category	Type	(Jan - Sep) 2023 Credits (Millions)	(Jan - Sep) 2024 Credits (Millions)	Change	Percent Change	2023 Share	2024 Share
Day-Ahead	Generators	$42.8	$93.7	$50.9	119.1%	36.4%	42.9%
	Imports	$0.0	$0.0	($0.0)	(97.4%)	0.0%	0.0%
	Load Response	$0.0	$0.0	$0.0	139,950.0%	0.0%	0.0%
Balancing	Canceled Resources	$0.1	$0.1	$0.0	41.5%	0.0%	0.0%
	Generators	$54.8	$95.0	$40.2	73.4%	46.7%	43.5%
	Imports	$0.0	$0.0	$0.0	NA	0.0%	0.0%
	Load Response	$0.0	$0.0	$0.0	NA	0.0%	0.0%
	Local Constraints Control	$0.6	$1.3	$0.7	121.4%	0.5%	0.6%
	Lost Opportunity Cost	$17.9	$25.5	$7.6	42.6%	15.2%	11.7%
	Dispatch Differential Lost Opportunity Cost	$0.5	$1.6	$1.1	207.9%	0.4%	0.7%
Reactive Services	Day-Ahead	$0.5	$0.1	($0.4)	(86.2%)	0.4%	0.0%
	Local Constraints Control	$0.0	$0.0	$0.0	NA	0.0%	0.0%
	Lost Opportunity Cost	$0.0	$0.0	$0.0	228,133.7%	0.0%	0.0%
	Reactive Services	$0.0	$0.9	$0.9	9,724.4%	0.0%	0.4%
	Synchronous Condensing	$0.0	$0.0	$0.0	NA	0.0%	0.0%
Synchronous Condensing		$0.0	$0.0	$0.0	NA	0.0%	0.0%
Black Start Services	Day-Ahead	$0.0	$0.0	$0.0	NA	0.0%	0.0%
	Balancing	$0.0	$0.3	$0.3	NA	0.0%	0.1%
	Testing	$0.3	$0.0	($0.3)	(100.0%)	0.2%	0.0%
Total		$117.4	$218.5	$101.1	86.2%	100.0%	100.0%

Uplift Share by Unit Type (Jan – Sept 2024)

Unit Type	Day-Ahead Generator	Balancing Generator	Canceled Resources	Local Constraints Control	Lost Opportunity Cost	Reactive Services	Synchronous Condensing	Black Start Services	Dispatch Differential Lost Opportunity Cost
Combined Cycle	2.8%	6.2%	0.0%	0.0%	4.4%	0.4%	0.0%	4.9%	22.4%
Combustion Turbine	1.1%	75.1%	0.0%	90.8%	86.8%	92.2%	0.0%	95.0%	15.8%
Diesel	0.0%	0.9%	0.0%	3.9%	2.1%	2.9%	0.0%	0.1%	0.8%
Hydro	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	52.9%
Nuclear	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Solar	0.0%	0.0%	0.0%	0.0%	0.9%	0.0%	0.0%	0.0%	0.9%
Steam - Coal	39.2%	7.1%	100.0%	4.8%	0.3%	4.6%	0.0%	0.0%	5.2%
Steam - Other	56.8%	10.7%	0.0%	0.0%	0.5%	0.0%	0.0%	0.0%	0.4%
Wind	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total (Millions)	$93.7	$95.0	$0.1	$1.3	$25.5	$1.0	$0.0	$0.3	$1.6

Uplift Concentration (Jan – Sep 2024)

		Top 10 Units		Top 10 Organizations	
Category	Type	Credits (Millions)	Credits Share	Credits (Millions)	Credits Share
Day-Ahead	Generators	$83.8	89.4%	$92.7	99.0%
Balancing	Canceled Resources	$0.1	100.0%	$0.1	100.0%
	Generators	$14.1	14.8%	$68.0	71.5%
	Local Constraints Control	$1.2	88.4%	$1.3	100.0%
	Lost Opportunity Cost	$5.0	19.4%	$17.9	70.0%
	Dispatch Differential Lost Opportunity Cost	$0.9	57.8%	$1.3	84.6%
	Total Balancing	$21.1	17.1%	$88.6	71.7%
Reactive Services		$1.0	97.1%	$1.0	100.0%
Synchronous Condensing		$0.0	NA	$0.0	NA
Black Start Services		$0.2	53.5%	$0.3	96.2%
Total		$94.0	43.0%	$165.4	75.7%

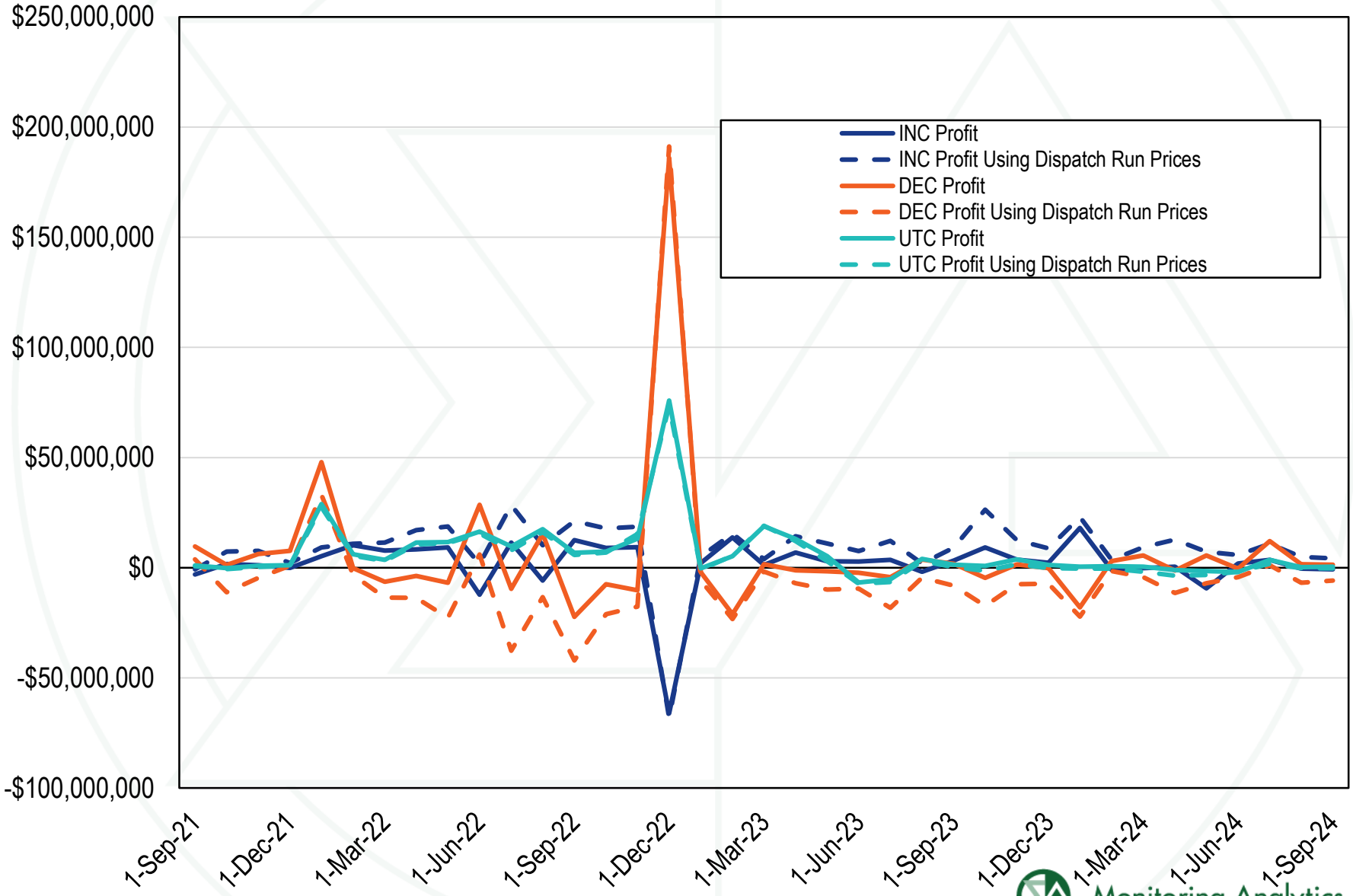
Uplift Concentration (Jan-Sep 2024)

Category	Type	Average	Minimum	Maximum	Highest Market Share (One day)	Highest Market Share (All days)
Day-Ahead	Generators	7738	2023	10000	100.0%	55.7%
	Imports	10000	10000	10000	100.0%	100.0%
	Load Response	10000	10000	10000	100.0%	74.9%
Balancing	Canceled Resources	10000	10000	10000	100.0%	100.0%
	Generators	2522	798	9572	97.8%	12.1%
	Imports	NA	NA	NA	NA	NA
	Load Response	NA	NA	NA	NA	NA
	Lost Opportunity Cost	4782	948	10000	100.0%	14.5%
	Dispatch Differential Lost Opportunity Cost	3340	853	9575	97.8%	27.9%
Reactive Services		9551	5005	10000	100.0%	83.5%
Synchronous Condensing		NA	NA	NA	NA	NA
Black Start Services		9534	5003	10000	100.0%	34.4%
Total		3340	853	9575	97.6%	27.3%

Fast Start and Virtual Transactions

- **Fast start pricing changes the prices paid by and to virtuals from those used to clear the transactions.**
- **Example**
  - **Virtual demand (DEC) bid: $50 per MWh**
  - **DLMP: $45 per MWh**
  - **The DEC will clear because the bid willingness to pay exceeds the DLMP.**
  - **PLMP: $100 per MWh**
  - **The DEC will charged $100 per MWh for the energy purchased, exceeding its $50 per MWh bid.**
- **On average, DECs benefit from fast start pricing because the price increase due to fast start pricing in real time exceeds the price increase paid day ahead.**

Profit Differences for Virtuals



Monitoring Analytics

Fast Start and Shortage Pricing

- **Fast start pricing removes reserves from the market in the pricing run, creating pricing run shortages that do not exist in the actual dispatch.**
- **Fast start pricing removes MW at the top of a fast start resources dispatch range, and creates MW at the bottom of their dispatch range.**
  - **The market clearing engine has to remove as many MW as it creates to maintain power balance.**
  - **No MW created below the minimum dispatch point can clear as reserves.**
  - **Therefore, fast start pricing removes reserves from the pricing run solution.**
- **False shortage pricing is a result.**

Shortage Pricing Differences

	Pricing Run					Dispatch Run				
Interval (EPT)	RTO Extended Primary Reserve Requirement (MW)	Total RTO Primary Reserves (MW)	RTO Primary Reserve Shortage (MW)	Uncapped RTO Primary Reserve Clearing Price ($/MWh)	Capped RTO Primary Reserve Clearing Price ($/MWh)	RTO Extended Primary Reserve Requirement (MW)	Total RTO Primary Reserves (MW)	RTO Primary Reserve Shortage (MW)	Uncapped RTO Primary Reserve Clearing Price ($/MWh)	Capped RTO Primary Reserve Clearing Price ($/MWh)
20-Jan-24 17:40	3,530.3	3,483.9	46.4	$300.00	$300.00	3,530.3	3,483.9	46.4	$300.00	$300.00
20-Jan-24 17:50	3,530.3	3,340.4	190.0	$544.78	$544.78	3,530.3	3,340.4	190.0	$544.78	$544.78
20-Jan-24 17:55	3,530.3	3,340.4	190.0	$544.78	$544.78	3,530.3	3,340.4	190.0	$544.78	$544.78
22-Jan-24 06:45	3,536.2	3,261.3	274.9	$850.00	$850.00	3,536.2	3,261.3	274.9	$850.00	$850.00
22-Jan-24 06:50	3,536.2	3,346.2	190.0	$647.02	$647.02	3,536.2	3,346.2	190.0	$647.02	$647.02
29-Jan-24 12:05	3,507.9	3,226.8	281.1	$850.00	$850.00	3,507.9	3,226.8	281.1	$850.00	$850.00
29-Jan-24 12:10	3,475.2	3,207.1	268.1	$850.00	$850.00	3,475.2	3,207.1	268.1	$850.00	$850.00
10-Mar-24 19:20	3,664.9	3,495.7	169.2	$300.00	$300.00	3,664.9	3,495.7	169.2	$300.00	$300.00
10-Mar-24 19:25	3,664.9	2,912.5	752.4	$850.00	$850.00	3,664.9	2,912.5	752.4	$850.00	$850.00
10-Mar-24 19:30	3,664.9	3,297.6	367.3	$850.00	$850.00	3,664.9	3,297.6	367.3	$850.00	$850.00
10-Mar-24 19:35	3,664.9	2,730.1	934.8	$850.00	$850.00	3,664.9	2,730.1	934.8	$850.00	$850.00
10-Mar-24 19:40	3,664.9	3,103.9	561.0	$850.00	$850.00	3,664.9	3,103.9	561.0	$850.00	$850.00
10-Mar-24 19:45	3,664.9	2,836.3	828.6	$850.00	$850.00	3,664.9	2,836.3	828.6	$850.00	$850.00
10-Mar-24 19:50	3,664.9	3,205.6	459.3	$850.00	$850.00	3,664.9	3,213.6	451.3 ★	$850.00	$850.00
10-Mar-24 19:55	3,664.9	3,343.9	321.0	$850.00	$850.00	3,664.9	3,351.9	313.0 ★	$850.00	$850.00
18-Mar-24 20:00	3,664.9	3,554.0	110.9	$300.00	$300.00	3,664.9	3,554.0	110.9	$300.00	$300.00
14-Apr-24 20:00	2,822.5	2,790.1	32.4	$300.00	$300.00	2,822.5	2,790.1	32.4	$300.00	$300.00
14-Apr-24 20:20	2,822.5	2,785.3	37.2	$300.00	$300.00	2,822.5	2,785.3	37.2	$300.00	$300.00
21-May-24 18:10	3,664.9	3,635.7	29.2	$300.00	$300.00	3,664.9	3,664.9	- ★	$236.45	$236.45
03-Jun-24 18:55	3,695.7	3,249.7	446.0	$850.00	$850.00	3,695.7	3,249.7	446.0	$850.00	$850.00
03-Jun-24 19:00	3,691.4	2,566.8	1,124.6	$850.00	$850.00	3,691.4	2,566.8	1,124.6	$850.00	$850.00

Fast Start and Reserve Pricing

- **Reserve prices are higher in the pricing run than the dispatch run.**
- **This occurs for two reasons:**
  - **The same reason that false shortages occur with fast start pricing, the pricing run removes reserves**
  - **PLMP is higher than DLMP on average, which increases the marginal cost of dispatching any unit in the market down to provide reserves.**

Synchronized Reserve Pricing Differences for RTO Zone

		Day-Ahead				Real-Time			
Year	Month	Dispatch-Run MCP	Pricing-Run MCP	Difference	Percent Difference	Dispatch-Run MCP	Pricing-Run MCP	Difference	Percent Difference
2023	Jan	$0.34	$0.35	$0.02	4.8%	$0.78	$0.96	$0.18	22.9%
2023	Feb	$0.33	$0.36	$0.03	9.4%	$0.10	$0.20	$0.10	107.3%
2023	Mar	$0.33	$0.35	$0.01	4.4%	$0.15	$0.26	$0.11	68.9%
2023	Apr	$1.60	$1.64	$0.04	2.5%	$0.64	$1.22	$0.58	90.8%
2023	May	$4.83	$4.82	($0.02)	(0.3%)	$4.51	$6.16	$1.65	36.6%
2023	Jun	$1.94	$1.96	$0.02	1.0%	$0.55	$0.99	$0.44	80.6%
2023	Jul	$4.71	$4.79	$0.08	1.7%	$1.00	$1.64	$0.64	64.4%
2023	Aug	$1.26	$1.32	$0.06	4.4%	$0.35	$0.54	$0.20	56.6%
2023	Sep	$1.26	$1.32	$0.05	4.3%	$0.50	$0.68	$0.18	36.1%
2023	Oct	$9.60	$9.65	$0.05	0.5%	$3.02	$4.70	$1.69	55.9%
2023	Nov	$5.59	$5.69	$0.09	1.7%	$1.21	$1.85	$0.64	52.8%
2023	Dec	$1.31	$1.34	$0.03	2.6%	$1.16	$1.65	$0.49	41.8%
2023	All	$3.07	$3.11	$0.04	1.4%	$1.24	$1.84	$0.61	49.1%
2024	Jan	$1.69	$1.72	$0.03	1.9%	$1.98	$2.53	$0.55	28.0%
2024	Feb	$1.49	$1.50	$0.00	0.3%	$1.29	$1.82	$0.53	40.9%
2024	Mar	$2.72	$2.74	$0.02	0.8%	$2.69	$3.88	$1.19	44.3%
2024	Apr	$4.14	$4.15	$0.01	0.2%	$0.99	$1.54	$0.55	55.1%
2024	May	$4.29	$4.28	($0.01)	(0.2%)	$3.28	$4.99	$1.72	52.4%
2024	Jun	$2.02	$2.13	$0.11	5.5%	$2.29	$2.56	$0.27	11.8%
2024	Jul	$2.63	$2.80	$0.17	6.3%	$3.00	$3.69	$0.69	23.0%
2024	Aug	$2.33	$2.44	$0.11	4.7%	$2.81	$3.44	$0.62	22.2%
2024	Sep	$2.72	$2.82	$0.11	3.9%	$2.77	$3.73	$0.96	34.8%
2024	All	$2.69	$2.75	$0.06	2.2%	$2.39	$3.20	$0.81	33.7%

Nonsynchronized Reserve Pricing Differences for RTO Zone

		Day-Ahead				Real-Time			
Year	Month	Dispatch-Run MCP	Pricing-Run MCP	Difference	Percent Difference	Dispatch-Run MCP	Pricing-Run MCP	Difference	Percent Difference
2023	Jan	$0.06	$0.07	$0.00	7.4%	$0.23	$0.28	$0.05	22.4%
2023	Feb	$0.05	$0.05	$0.00	0.1%	$0.06	$0.10	$0.05	81.1%
2023	Mar	$0.08	$0.08	$0.00	3.6%	$0.03	$0.06	$0.03	94.3%
2023	Apr	$0.31	$0.32	$0.01	2.1%	$0.24	$0.40	$0.16	69.4%
2023	May	$0.94	$0.94	($0.00)	(0.0%)	$1.59	$2.10	$0.51	31.8%
2023	Jun	$0.88	$0.90	$0.01	1.6%	$0.23	$0.41	$0.17	73.3%
2023	Jul	$2.28	$2.34	$0.06	2.6%	$0.47	$0.78	$0.31	65.0%
2023	Aug	$0.52	$0.55	$0.04	6.8%	$0.11	$0.18	$0.07	64.2%
2023	Sep	$0.68	$0.72	$0.04	5.9%	$0.21	$0.32	$0.11	49.8%
2023	Oct	$5.11	$5.16	$0.05	0.9%	$1.08	$1.71	$0.63	57.8%
2023	Nov	$2.66	$2.70	$0.04	1.5%	$0.32	$0.52	$0.20	63.0%
2023	Dec	$0.39	$0.40	$0.01	3.0%	$0.31	$0.45	$0.13	42.6%
2023	All	$1.00	$1.02	$0.02	2.0%	$0.40	$0.61	$0.20	49.8%
2024	Jan	$0.48	$0.49	$0.01	1.4%	$1.13	$1.38	$0.26	22.6%
2024	Feb	$0.48	$0.48	$0.00	0.3%	$0.58	$0.81	$0.23	40.4%
2024	Mar	$1.57	$1.58	$0.01	0.7%	$1.71	$2.43	$0.72	42.1%
2024	Apr	$2.77	$2.79	$0.02	0.6%	$0.47	$0.73	$0.26	54.1%
2024	May	$2.09	$2.09	($0.00)	(0.2%)	$2.00	$3.12	$1.13	56.5%
2024	Jun	$1.11	$1.19	$0.08	7.1%	$1.11	$1.26	$0.15	13.6%
2024	Jul	$1.56	$1.68	$0.11	7.4%	$1.32	$1.65	$0.32	24.6%
2024	Aug	$1.19	$1.25	$0.06	5.0%	$1.66	$1.99	$0.32	19.4%
2024	Sep	$1.39	$1.44	$0.06	4.1%	$1.31	$1.77	$0.46	35.5%
2024	All	$1.32	$1.36	$0.04	2.9%	$1.25	$1.65	$0.40	32.3%

Regulation Pricing Differences

		Weighted Average Price ($/Perf. Adj. Actual MW)				
		Capability Clearing Price		Regulation Market Clearing Price		
Year	Month	Dispatch	Fast Start	Dispatch	Fast Start	Percent Fast Start Increase
2023	Jan	$16.61	$17.25	$17.58	$18.22	3.7%
	Feb	$15.12	$15.48	$16.29	$16.65	2.2%
	Mar	$17.11	$17.80	$17.89	$18.57	3.8%
	Apr	$21.51	$23.20	$22.60	$24.29	7.5%
	May	$22.75	$24.58	$24.31	$26.14	7.5%
	Jun	$19.77	$20.88	$21.27	$22.38	5.2%
	Jul	$21.45	$23.43	$22.56	$24.54	8.8%
	Aug	$20.10	$21.32	$21.17	$22.39	5.8%
	Sep	$22.34	$23.92	$23.49	$25.08	6.7%
	Oct	$28.11	$32.37	$29.25	$33.51	14.6%
	Nov	$18.48	$20.83	$18.95	$21.30	12.4%
	Dec	$16.78	$18.12	$17.81	$19.15	7.5%
Total		$20.01	$21.60	$21.10	$22.69	7.5%
2024	Jan	$35.33	$36.70	$36.91	$38.28	3.7%
	Feb	$17.72	$19.44	$18.70	$20.42	9.2%
	Mar	$20.05	$22.88	$21.21	$24.04	13.3%
	Apr	$20.36	$24.52	$20.75	$24.90	20.0%
	May	$32.60	$37.59	$33.66	$38.64	14.8%
	Jun	$27.57	$28.96	$28.29	$29.68	4.9%
	Jul	$37.03	$39.87	$38.51	$41.35	7.4%
	Aug	$29.85	$31.48	$30.56	$32.18	5.3%
	Sep	$25.66	$28.31	$27.36	$30.01	9.7%
Total		$27.62	$30.21	$28.71	$31.30	9.0%

Fast Start and Constraints

- **Fast start pricing changes the shadow price of constraints.**
- **When a fast start unit is marginal, the amount of constraint relief provided by the fast start unit in the dispatch run differs from the pricing run.**
- **Other resources are dispatched differently to provide more or less constraint relief due to the marginal fast start unit.**
- **The marginal fast start unit in the pricing run has a different, usually higher, marginal cost than the marginal unit in the dispatch run.**
- **It can even be the case that different constraints bind in the dispatch run than in the pricing run.**
- **As a result, constraint shadow prices are higher, particularly in the real time market.**

Congestion Cost Differences (Jan-Sep 2024)

	Congestion Costs (Millions)								
	Dispatch Run			Pricing Run			Difference		
Control Zone	Day-Ahead	Balancing	Total	Day-Ahead	Balancing	Total	Day-Ahead	Balancing	Total
ACEC	$16.6	($2.6)	$14.0	$16.6	($2.8)	$13.8	($0.0)	($0.2)	($0.2)
AEP	$267.0	($33.2)	$233.9	$255.9	($35.4)	$220.5	($11.1)	($2.3)	($13.4)
APS	$113.7	($14.9)	$98.9	$112.7	($15.9)	$96.8	($1.1)	($1.0)	($2.1)
ATSI	$135.3	($17.1)	$118.3	$133.9	($18.2)	$115.7	($1.4)	($1.2)	($2.6)
BGE	$63.1	($8.4)	$54.7	$62.9	($9.0)	$53.9	($0.2)	($0.6)	($0.8)
COMED	$275.0	($20.8)	$254.2	$222.0	($22.1)	$199.9	($53.0)	($1.3)	($54.3)
DAY	$30.7	($4.5)	$26.2	$30.6	($4.8)	$25.9	($0.0)	($0.3)	($0.3)
DOM	$229.3	($33.6)	$195.7	$228.6	($36.0)	$192.6	($0.7)	($2.4)	($3.1)
DPL	$52.0	($5.6)	$46.4	$52.0	($6.3)	$45.7	$0.0	($0.7)	($0.6)
DUKE	$46.4	($6.9)	$39.5	$46.4	($7.3)	$39.1	$0.0	($0.5)	($0.4)
DUQ	$21.4	($3.5)	$17.9	$21.1	($3.7)	$17.4	($0.3)	($0.2)	($0.5)
EKPC	$25.5	($3.7)	$21.8	$25.5	($4.0)	$21.5	($0.0)	($0.3)	($0.3)
EXT	$41.0	($6.4)	$34.5	$33.1	($6.8)	$26.3	($7.9)	($0.4)	($8.3)
JCPLC	$45.4	($7.3)	$38.1	$45.2	($7.8)	$37.4	($0.1)	($0.5)	($0.6)
MEC	$29.0	($4.7)	$24.3	$28.9	($5.0)	$24.0	($0.1)	($0.3)	($0.3)
OVEC	$2.3	($0.2)	$2.1	$2.3	($0.3)	$2.1	($0.0)	($0.0)	($0.0)
PE	$33.8	($4.3)	$29.5	$33.5	($4.6)	$28.9	($0.3)	($0.3)	($0.6)
PECO	$62.9	($10.2)	$52.7	$62.8	($10.9)	$51.9	($0.1)	($0.7)	($0.8)
PEPCO	$52.5	($7.8)	$44.7	$52.3	($8.3)	$44.0	($0.1)	($0.5)	($0.7)
PPL	$76.4	($10.3)	$66.1	$76.2	($11.0)	$65.2	($0.1)	($0.7)	($0.9)
PSEG	$72.7	($11.2)	$61.5	$72.5	($12.0)	$60.5	($0.2)	($0.8)	($1.0)
REC	$3.3	($0.4)	$2.9	$3.3	($0.4)	$2.9	($0.0)	($0.0)	($0.0)
Total	$1,695.2	($217.6)	$1,477.6	$1,618.5	($232.7)	$1,385.8	($76.7)	($15.1)	($91.8)

FTR Target Allocation Differences

Planning Period		Pricing Run	Dispatch Run	Difference	Percent Difference
2021/2022*	Not Self Scheduled	$1,499,077,738	$1,497,963,895	$1,113,844	0.1%
	Self Scheduled	$429,271,338	$430,800,598	($1,529,260)	(0.4%)
	Total	$1,928,349,076	$1,928,764,493	($415,416)	(0.0%)
2022/2023	Not Self Scheduled	$1,641,324,421	$1,586,284,502	$55,039,919	3.4%
	Self Scheduled	$622,535,802	$668,468,552	($45,932,751)	(7.4%)
	Total	$2,263,860,223	$2,254,753,054	$9,107,169	0.4%
2023/2024	Not Self Scheduled	$1,396,273,015	$1,435,733,398	($39,460,383)	(2.8%)
	Self Scheduled	$371,433,164	$371,620,633	($187,469)	(0.1%)
	Total	$1,767,706,179	$1,807,354,031	($39,647,853)	(2.2%)
2024/2025**	Not Self Scheduled	$737,700,646	$744,837,863	($7,137,216)	(1.0%)
	Self Scheduled	$194,072,242	$194,471,153	($398,912)	(0.2%)
	Total	$931,772,888	$939,309,016	($7,536,128)	(0.8%)

* starting in September 2021

** first four months of the 2024/2025 planning period

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