



2017 Pennsylvania State Infrastructure Report

(January 1, 2017 – December 31, 2017)

May 2018

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- Load Forecast

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- **Existing Capacity:** Natural gas represents approximately 29.6 percent of the total installed capacity in Pennsylvania while coal represents 30.0 percent and nuclear represents 23.2 percent. In PJM natural gas and coal are at 37 and 32 percent of total installed capacity.
- **Interconnection Requests:** Natural gas represents approximately 96.5 percent of new interconnection requests in Pennsylvania.
- **Deactivations:** No capacity in Pennsylvania retired in 2017. However approximately 913 MW of capacity gave a notification of deactivation in 2017.
- **RTEP 2017:** Pennsylvania RTEP 2017 projects total more than \$826 million in investment. Approximately 15 percent of that represents supplemental projects.
- **Load Forecast:** Pennsylvania load growth is nearly flat, between -.1 and .8 percent per year over the next 10 years. This aligns with PJM RTO load growth projections.

- **2021/22 Capacity Market:** Pennsylvania cleared 328 MW more Demand Response and Energy Efficient resources than in the prior auction.
- **6/1/15 – 12/31/17 Market Performance:** Pennsylvania's average locational marginal prices were consistently at or below PJM average LMPs. Nuclear resources represented 39.4 percent of generation used in Pennsylvania while natural gas and coal averaged 28.7 percent and 25.5 percent, respectively. Pennsylvania exports 27.5 percent of the energy produced in the state.
- **Emissions:** 2017 carbon dioxide, nitrogen oxides, and sulfur dioxide emissions are all slightly down from 2016.

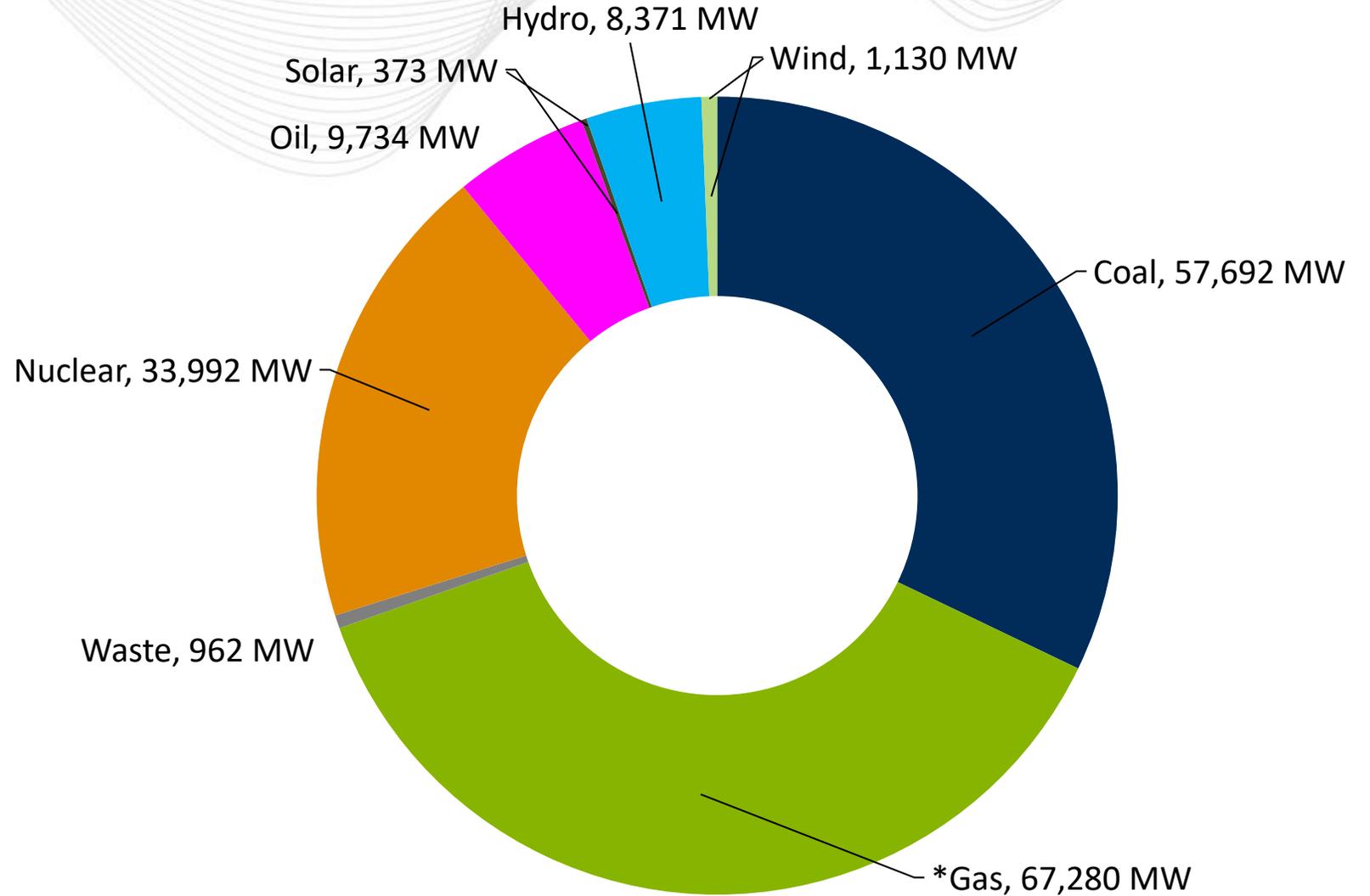
Planning

Generation Portfolio Analysis

PJM – Existing Installed Capacity

(MW submitted to PJM, December 31, 2017)

In PJM, natural gas and coal make up nearly 70 percent total installed capacity. Nuclear represents another 18.9 percent.



* Gas Contains	
Natural Gas	66,836.3 MW
Other Gas	443.8 MW

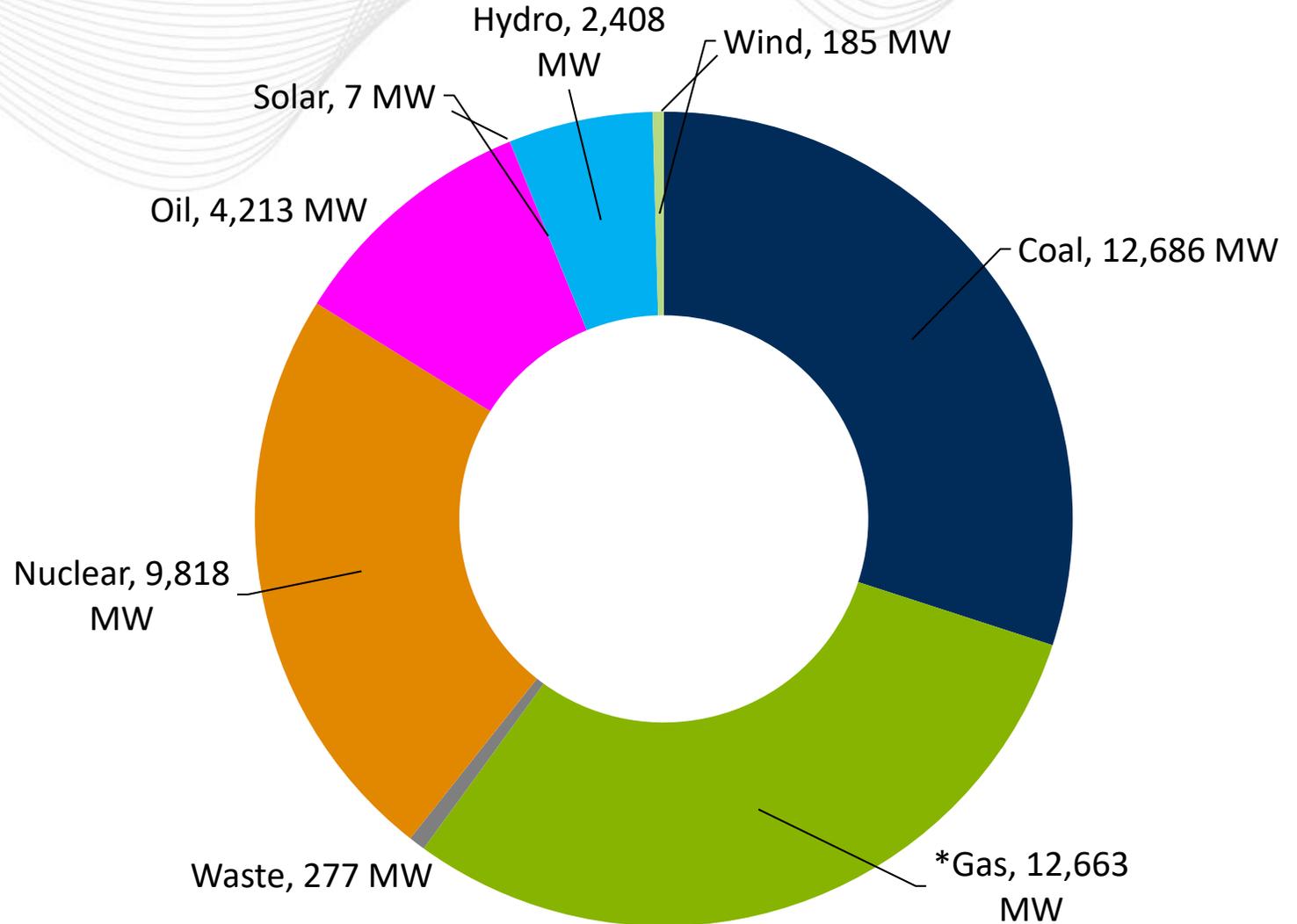
Pennsylvania – Existing Installed Capacity

(MW submitted to PJM, December 31, 2017)

Summary:

Natural gas represents approximately 29.6 percent of the total installed capacity in the Pennsylvania territory while coal represents approximately 30.0 percent.

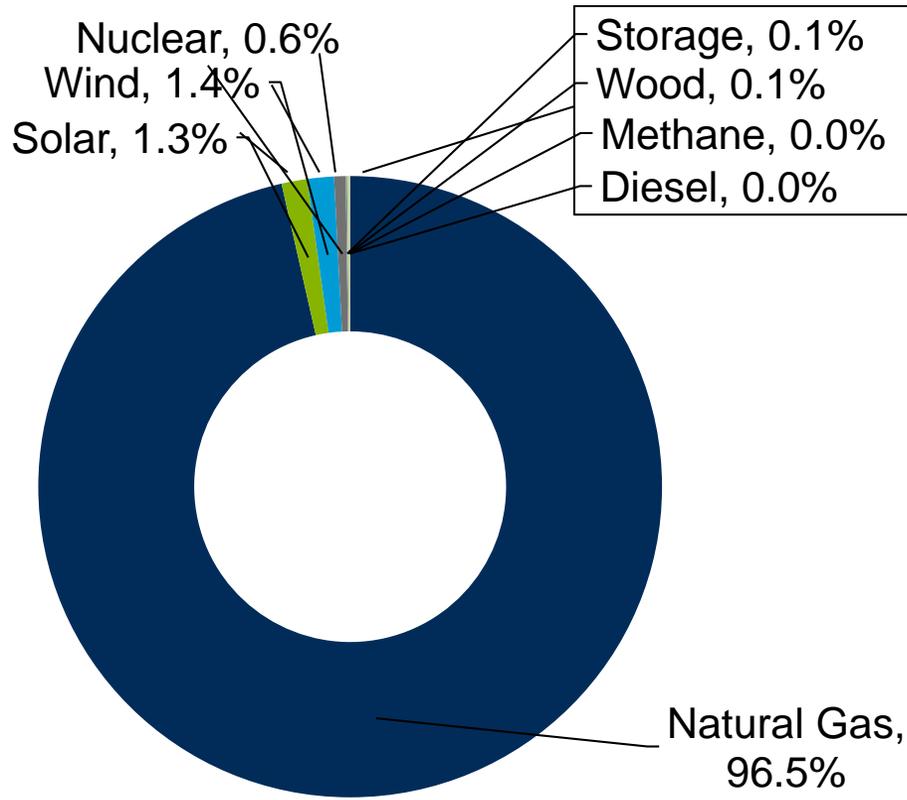
Overall in PJM, natural gas represents approximately 37 percent of installed capacity while coal represents 32 percent.



* Gas Contains	
Natural Gas	12,496.9 MW
Other Gas	166.4 MW

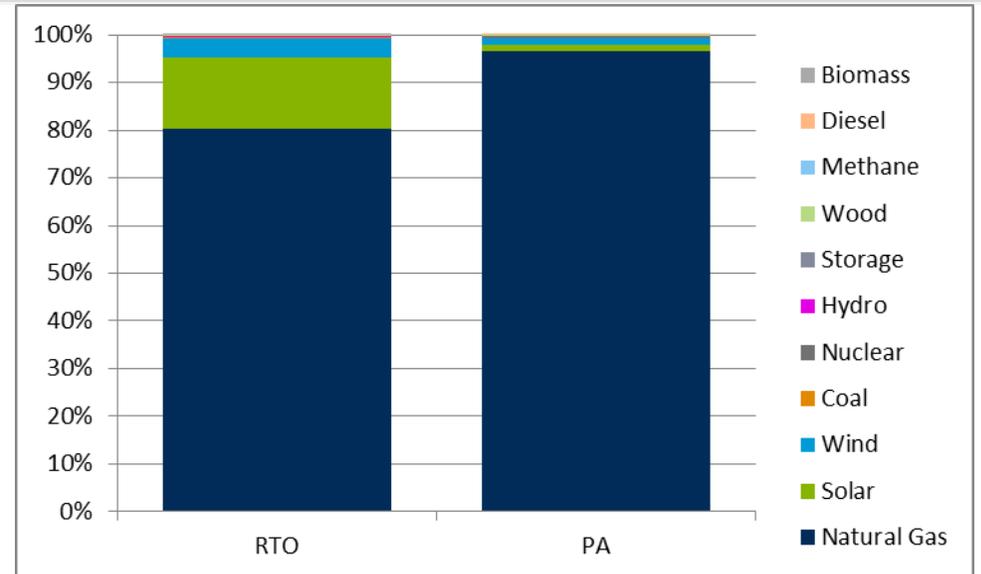
Natural gas represents approximately 97 percent of new interconnection requests in Pennsylvania.

Percent MW Capacity by Fuel Type



Fuel Source	Capacity, MW	Nameplate Capability, MW
Natural Gas	15,198.7	15,934.1
Wind	217.6	1,468.8
Solar	208.8	434.5
Nuclear	94.0	94.0
Wood	16.0	16.0
Storage	11.8	141.5
Methane	4.1	4.1
Diesel	4.1	4.0
Total	15,755.1	18,097.0

Fuel as a Percentage of Projects in Queue





Pennsylvania – Interconnection Requests

(As of December 31, 2017)

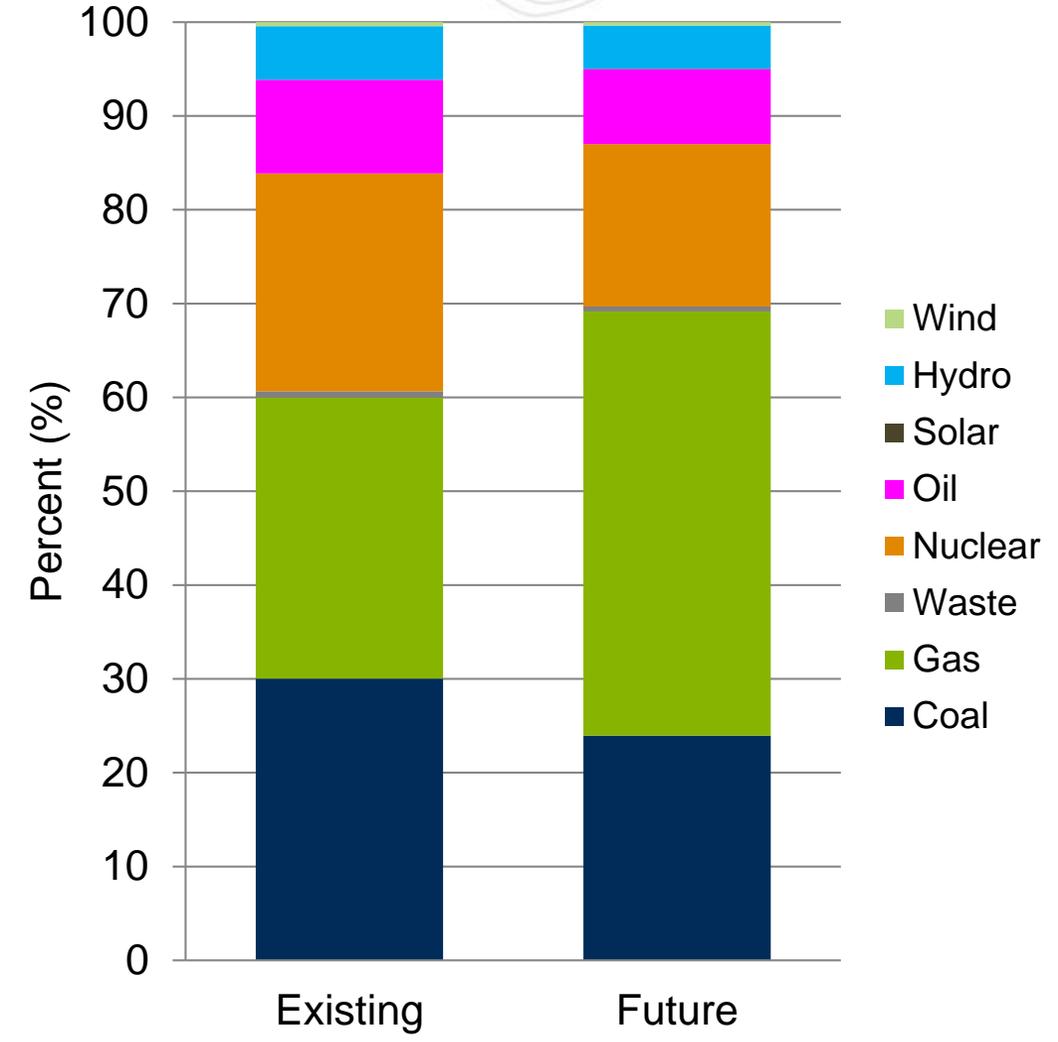
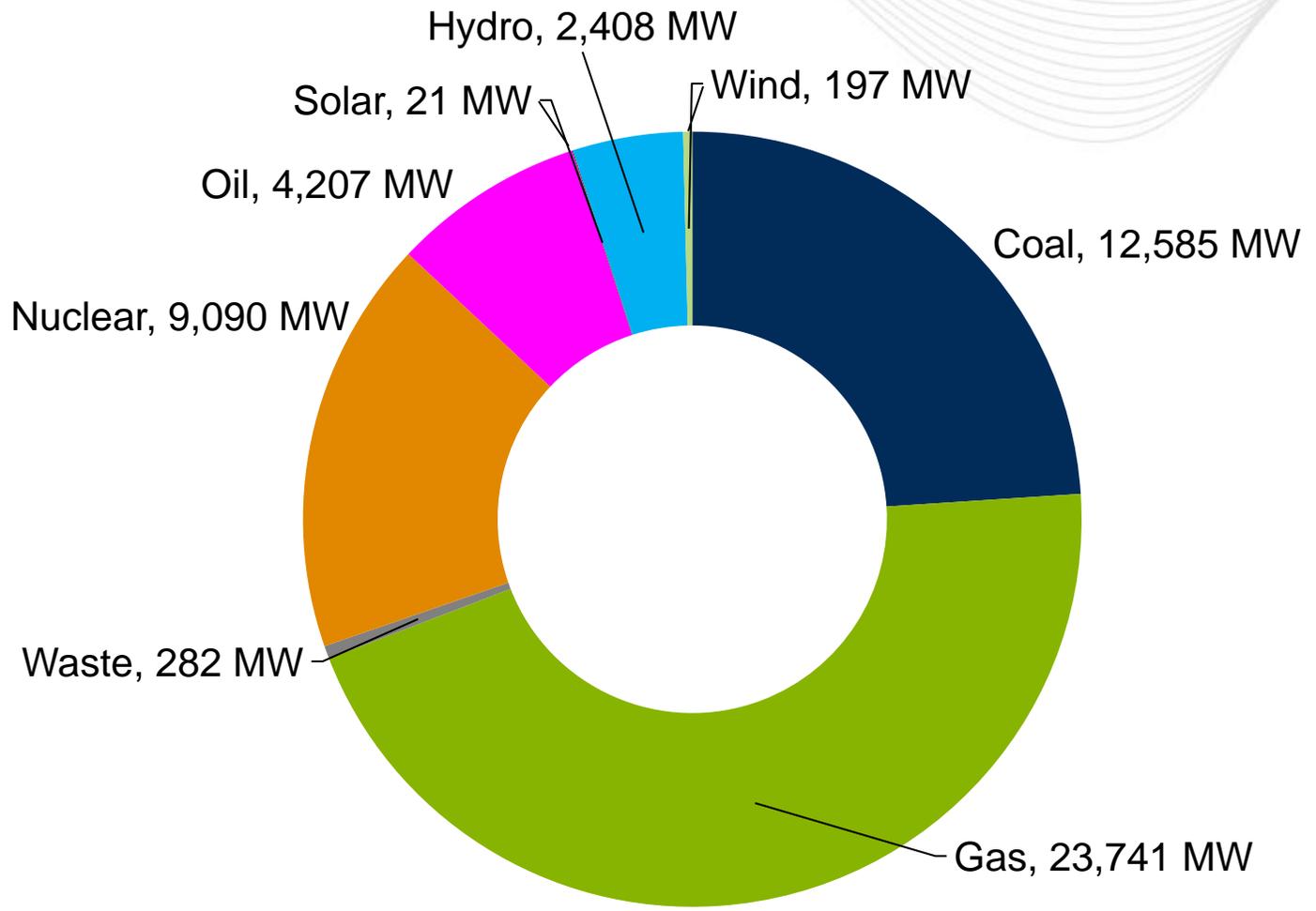
	Complete				In Queue						Grand Total	
	In Service		Withdrawn*		Active		Suspended**		Under Construction**			
	MW	# of Projects	MW	# of Projects	MW	# of Projects	MW	# of Projects	MW	# of Projects	MW	# of Projects
Non-Renewable	14,924	108	103,233	295	5,001	37	743	13	9,565	31	133,466	484
Coal	229	17	14,355	28							14,584	45
Diesel	33	3	52	12					4	1	89	16
Natural Gas	11,744	61	85,495	217	4,895	29	743	13	9,561	28	112,438	348
Nuclear	2,582	15	1,681	8	94	5					4,357	28
Oil	9	3	1,307	9							1,316	12
Other	327	3	344	6							671	9
Storage	0	6	0	15	12	3			-	2	12	26
Renewable	895	82	2,706	266	277	20	98	10	71	7	4,048	385
Biomass	31	3	37	4							68	7
Hydro	481	12	189	15							669	27
Methane	136	27	197	36	4	1					337	64
Solar	7	3	716	89	183	12	21	4	4	1	931	109
Wind	240	37	1,568	122	90	7	61	5	67	6	2,026	177
Wood							16	1			16	1
Grand Total	15,819	190	105,940	561	5,277	57	842	23	9,636	38	137,514	869

*May have executed final agreement

** Executed final agreement (ISA / WMPA)

Pennsylvania – Future Capacity Mix

Based on known queued interconnection requests and deactivation notices through December 31, 2022, adjusted to reflect the probability of commercialization as indicated by historical trends specific to an interconnection request's state/zonal location and fuel type.





Pennsylvania – Progression History Interconnection Requests

Projects under construction, suspended, in service, or withdrawn – As of December 31, 2017

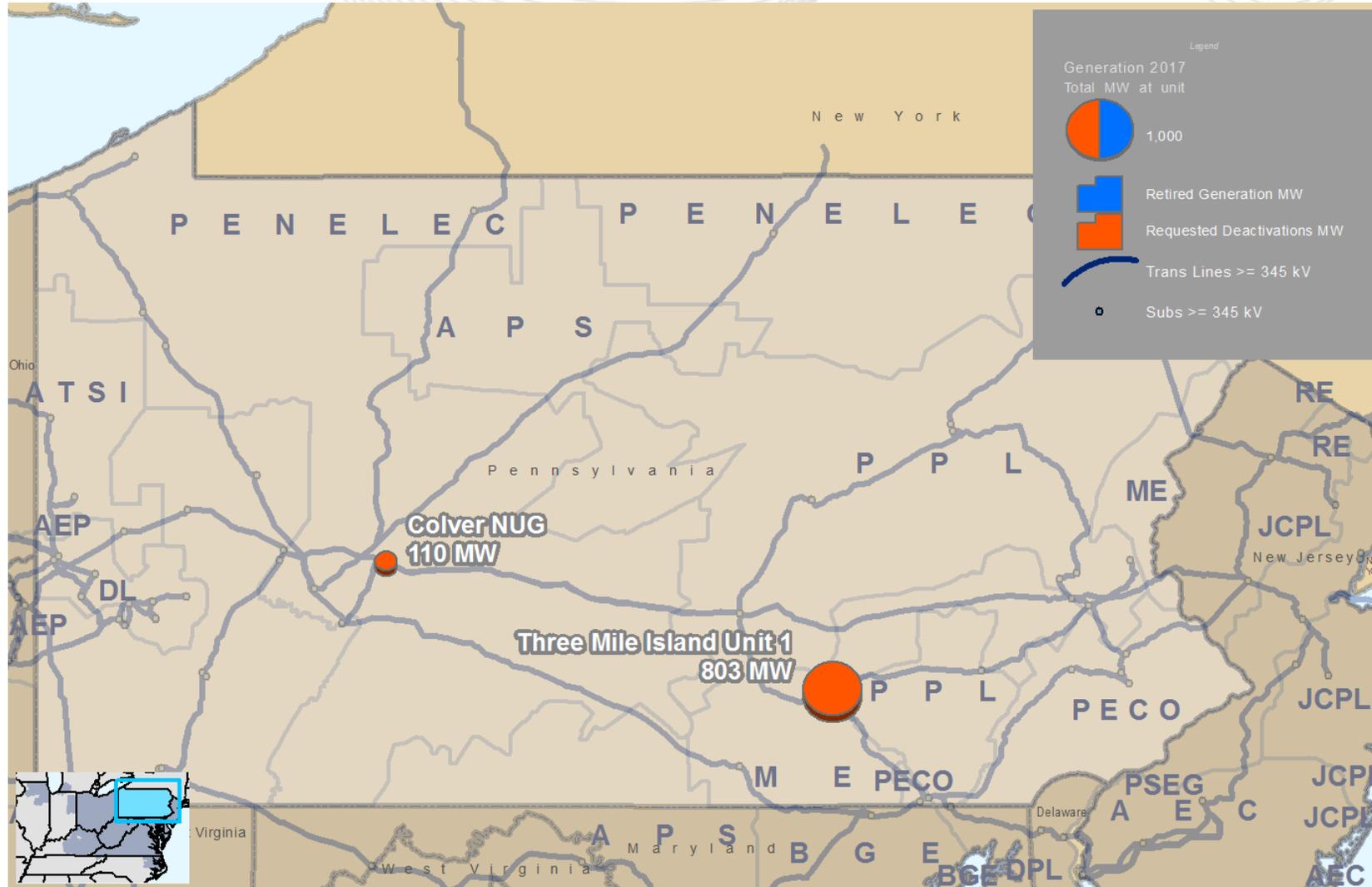


Projects that withdrew after a final agreement

	Number of Projects	Capacity, MW	Nameplate Capacity, MW
ISA	44	4,859	6,219
WMPA	36	126	212

12.5% of requested capacity megawatt and 24.4% of projects reaches commercial operation

Pennsylvania – Actual Generation Deactivations and Deactivation Notifications Received in 2017





Pennsylvania – Pending Deactivation Notifications Received in 2017

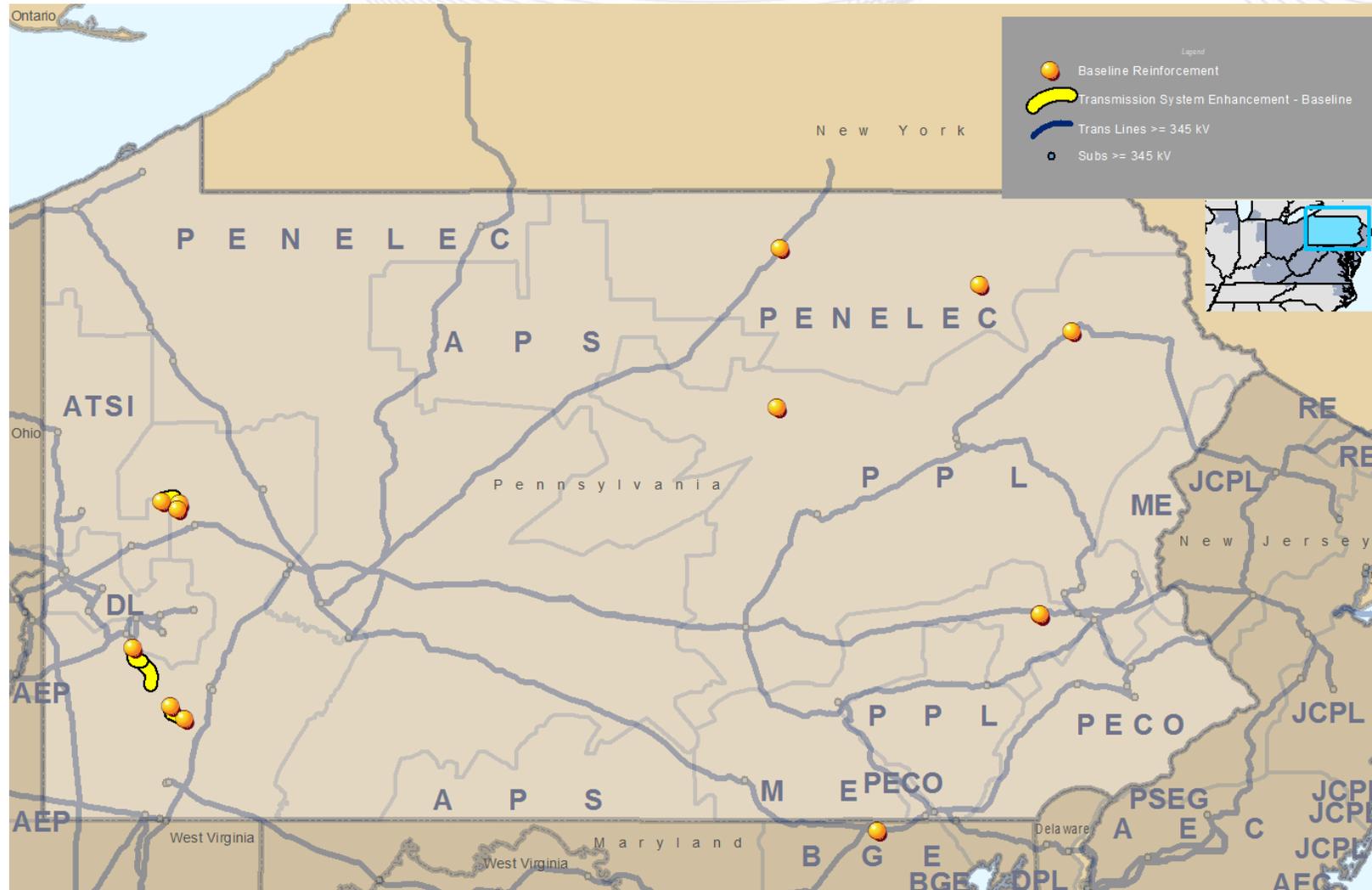
Unit	TO Zone	Fuel Type	Request Received to Deactivate	Projected Deactivation Date	Age	Capacity
Three Mile Island Unit 1	ME	Nuclear	5/30/2017	9/30/2019	43	802.8
Colver NUG	PENELEC	Coal	11/22/2017	9/1/2020	22	110.0

Summary:

- There were no actual generation deactivations in Pennsylvania in 2017.
- Two generating units in Pennsylvania announced their intention to deactivate in 2017.
- Ten generating units totaling 2,084 MW of capacity deactivated in PJM in 2017.

Planning

Transmission Infrastructure Analysis



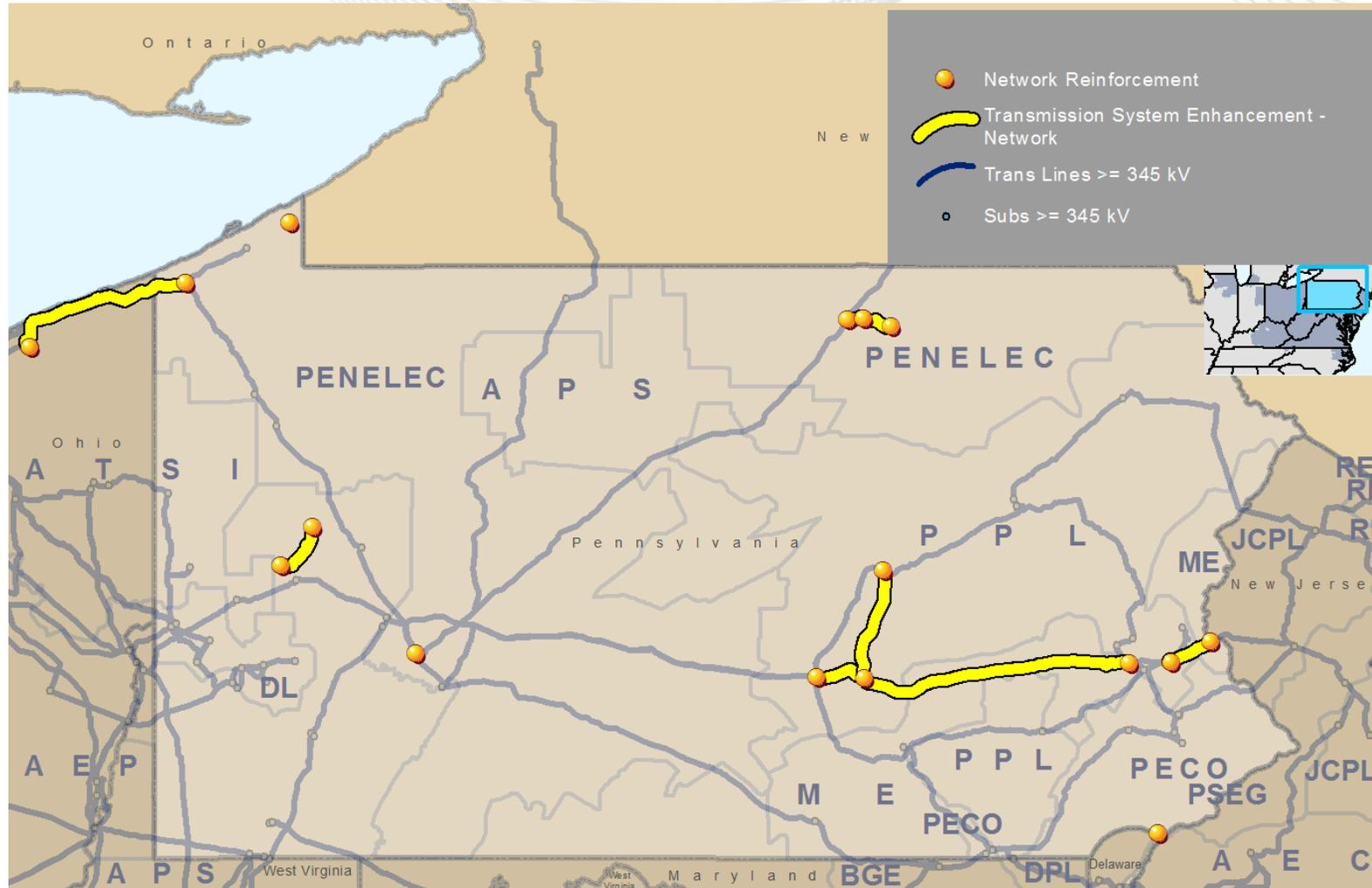
Note: Baseline upgrades are those that resolve a system reliability criteria violation.



Pennsylvania - RTEP Baseline Projects

(Greater than \$5 million)

Project ID	Project	Project Driver	Required In Service Date	Project Cost (\$M)	TO Zone(s)	2017 TEAC Review
b2814	Install a 3rd 230/69 kV 224 MVA Transformer at Lyons substation and install new terminal equipment for existing Lyons - East Penn(865) 69 kV Line	TO Criteria Violation	6/1/2019	\$ 5.5	ME	12/1/2016
b2813	Expand existing Lycoming 69kV yard to double bus double breaker arrangement	TO Criteria Violation	6/1/2018	\$ 22.0	PPL	12/1/2016
b2824	Reconfigure/Expand the Lackawanna 500 kV substation by adding a third bay with three breakers	Baseline Load Growth Deliverability & Reliability	1/31/2019	\$ 11.3	PPL	12/15/2016
b2689	Upgrade terminal equipment on Woodsville – Peters 138kV circuit owned by FE (Structure 27A).	Congestion Relief - Economic	6/1/2018	\$ 11.3	APS	5/31/2017
b2944	Install two 345 kV 80 MVAR shunt reactors at Mainesburg station	Baseline Load Growth Deliverability & Reliability	6/1/2017	\$ 11.5	PENELEC	9/14/2017
b2752	Replace the Conaston 230kV '2322 B5' breaker with a 63kA breaker	Short Circuit	6/1/2020	\$ 145.0	BGE	10/12/2017
	Replace the Conaston 230kV '2322 B6' breaker with a 63kA breaker					
	Replace the North Meshoppen #3 230/115kV transformer eliminating the old reactor and installing two breakers to complete a 230kV ring bus at North Meshoppen	Baseline Load Growth Deliverability & Reliability		\$ 6.8	PENELEC	10/31/2017
b2965	Reconductor the Charleroi –Allenport 138KV Line with 954 ACSR Conductor, Replace Breaker Risers at Charleroi and Allenport	Baseline Load Growth Deliverability & Reliability	6/1/2022	\$ 7.1	APS	11/2/2017
b2967	Convert the existing 6 wire Butler - Shanor Manor - Krendale 138 kV Line into two separate 138 kV lines. New lines will be Butler - Keisters and Butler - Shanor Manor - Krendale 138 kV	Baseline Load Growth Deliverability & Reliability	6/1/2022	\$ 7.0	APS	11/2/2017



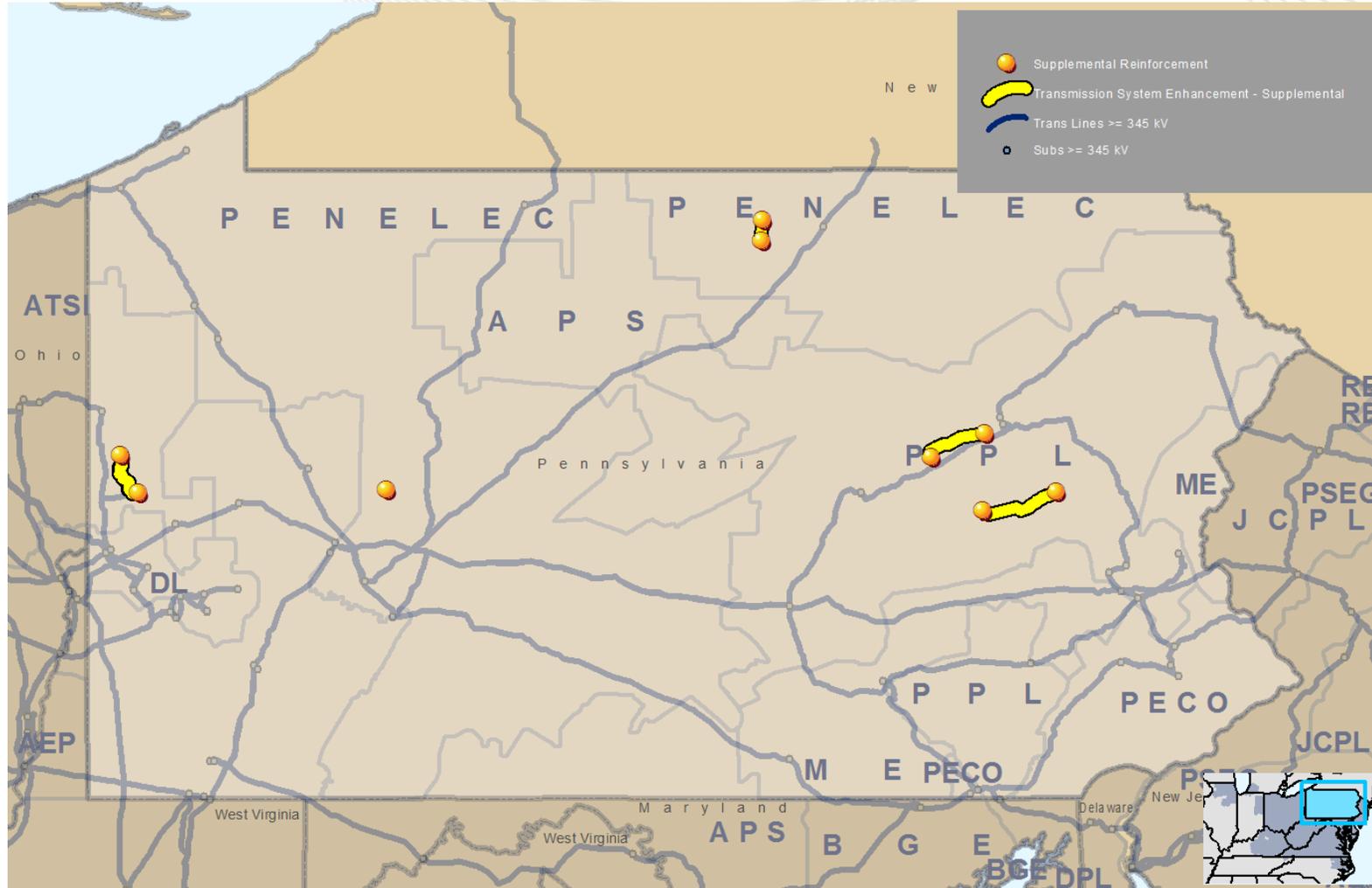
Note: Network upgrades are new or upgraded facilities required primarily to eliminate reliability criteria violations caused by proposed generation, merchant transmission or long term firm transmission service requests.



Pennsylvania – RTEP Network Projects

(Greater than \$5 million)

Project ID	Description	Project Driver	Queue	Required In Service Date	Project Cost (\$M)	TO Zone(s)	2017 TEAC Review
n4317	Build a new Leroy Center - Erie West 345 kV line	Merchant Transmission	Y3-092	12/31/2017	\$ 203.0	ATSI	10/12/2017
n4320	Reconductor the Karns City 138 kV line terminal at the Butler 138 kV including Wave Trap, lin and bus side disconnects.	Merchant Transmission	Y3-092	12/31/2017	\$ 25.9	APS	10/12/2017
	Reconductor Butler - Karns City 138 kV line -15.6 mile to achieve a 228 MVA summer emergency rating.						
	On the Butler line terminal atht the Karns City 138 kV, replace line side disconnect risers and connectors, and revise relay settings as necessary.						
n5069	Replace South Homer City Souuth Transformer		Not Specified	9/1/2019	\$ 14.8	PENELEC	10/12/2017
n5170	Tap Juniata - Alburtis 500 kV line to create a new DAUP 500kV station, and built 500kV line from Sunberry 500kV station to the new DAUP 500kV station	Generation	AA2-182	9/30/2019	\$ 200.0	PPL	10/12/2017
n5174	New 230kV series reactor and required associated substation equipment at Erie East substation	Generation	Y2-089	1/31/2019	\$ 10.0	PENELEC	10/12/2017
n5402	Reconductor the Everts Drive – South Troy 115 kV Line with high temperature conductor.		Not Specified	6/1/2020	\$ 5.9	PENELEC	10/12/2017
n5403	Reconductor ~8.8 miles of the Everts Drive – Mainesburg 115 kV Line with 795 ACSS conductor.		Not Specified	6/1/2020	\$ 17.5	PENELEC	10/12/2017



Note: Supplemental projects are transmission expansions or enhancements that are used as inputs to RTEP models, but are not required for reliability, economic efficiency or operational performance criteria, as determined by PJM.



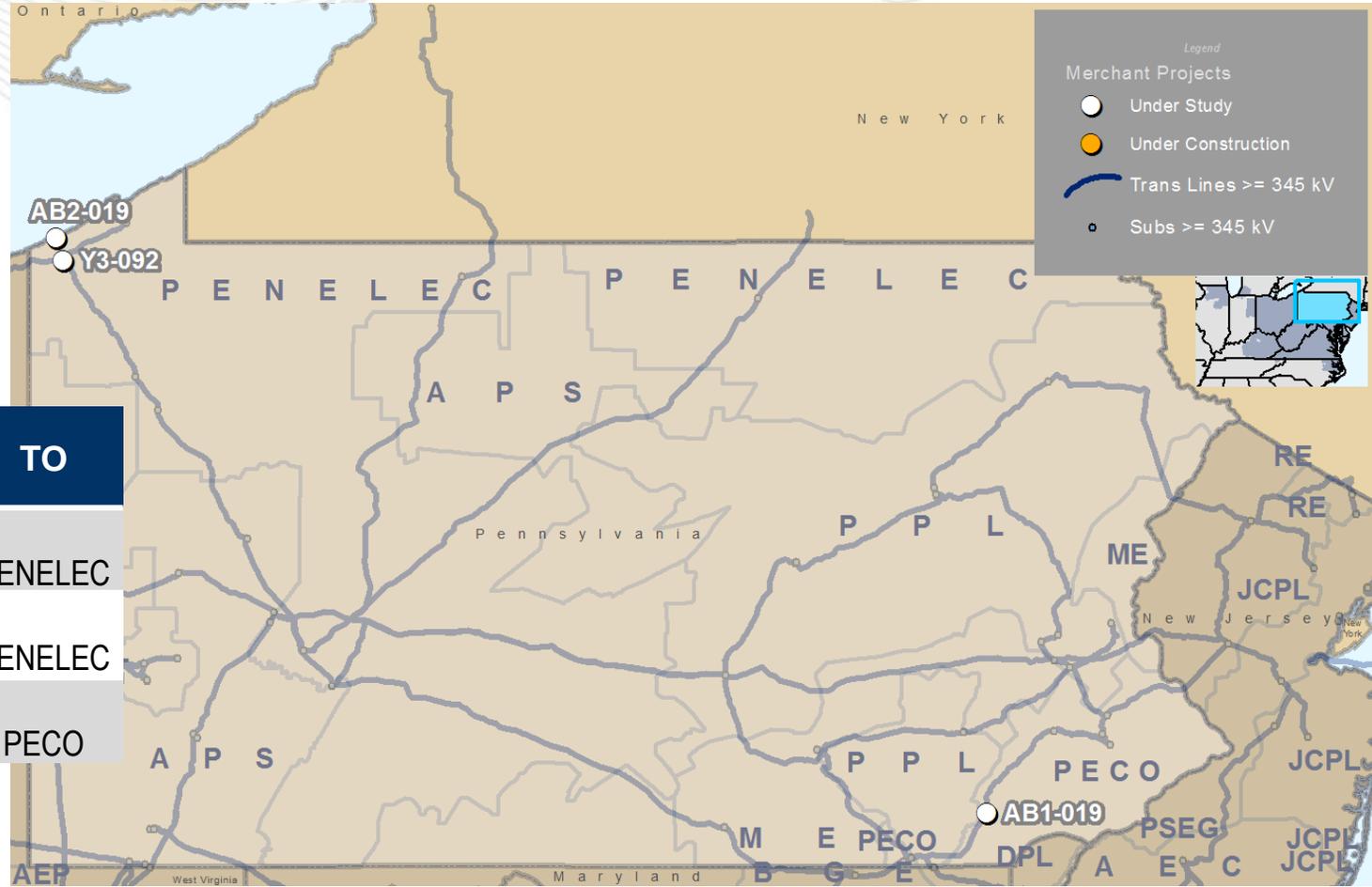
Pennsylvania – TO Supplemental Projects

(Greater than \$5 million)

Project ID	Description	Required Date	Project Cost (\$M)	TO Zone(s)	TEAC Date
s1212	Build a new single circuit 69kV Line, approximately 6 miles, from Sumner radial tap to Campbellsport substation (477 ACSR).	7/27/2017	\$ 19.0	ATSI	1/5/2017
	Rebuild approximately 1.5 miles of 69kV Line from Ravenna to Sumner tap as double circuit (477 ACSR).	8/10/2017			
	Rebuild approximately 2.5 miles of 69kV as double circuit (477 ACSR) to loop the Ravenna – West Ravenna 69kV Line into Campbellsport.	11/10/2017			
	Expand Campbellsport to a six breaker ring bus.				
s1223	Remove mixed conductor types & sizes, replace all with 336 ACSR	12/31/2017	\$ 15.7	ATSI	1/5/2017
	Includes inspect and treat grillage foundations, replace select poles, insulators and conductor.				
	Rehab Cedar Street-Frisco East & West 69kV Circuits (approximately 13 pole miles) for improved reliability and to extend life.				
s1242	Rebuild Hauto - Frackville #3 69kV line to double circuit	12/31/2018	\$ 57.8	PPL	1/5/2017
s1243	Trade City 115 kV Substation: Construct a 115 kV ring bus	12/31/2017	\$ 7.0	PENELEC	1/5/2017
s1269	String Second circuit on existing Columbia -Berick 69kV towers for approximately 12 miles (Scott distribution substation to Berwick 69kV substation).	7/1/2021	\$ 12.0	PPL	1/5/2017
s1350	Construct ~5 miles of 115 kV line using existing right-of-way (where possible). Install new 115 kV bus tie breaker at Niles Valley. Relocate Potter 115 kV line at Niles Valley. Install two SCADA controlled switches. Install switch structure for future net	6/1/2020	\$ 12.8	PENELEC	6/9/2017



Pennsylvania - Merchant Transmission Project Requests

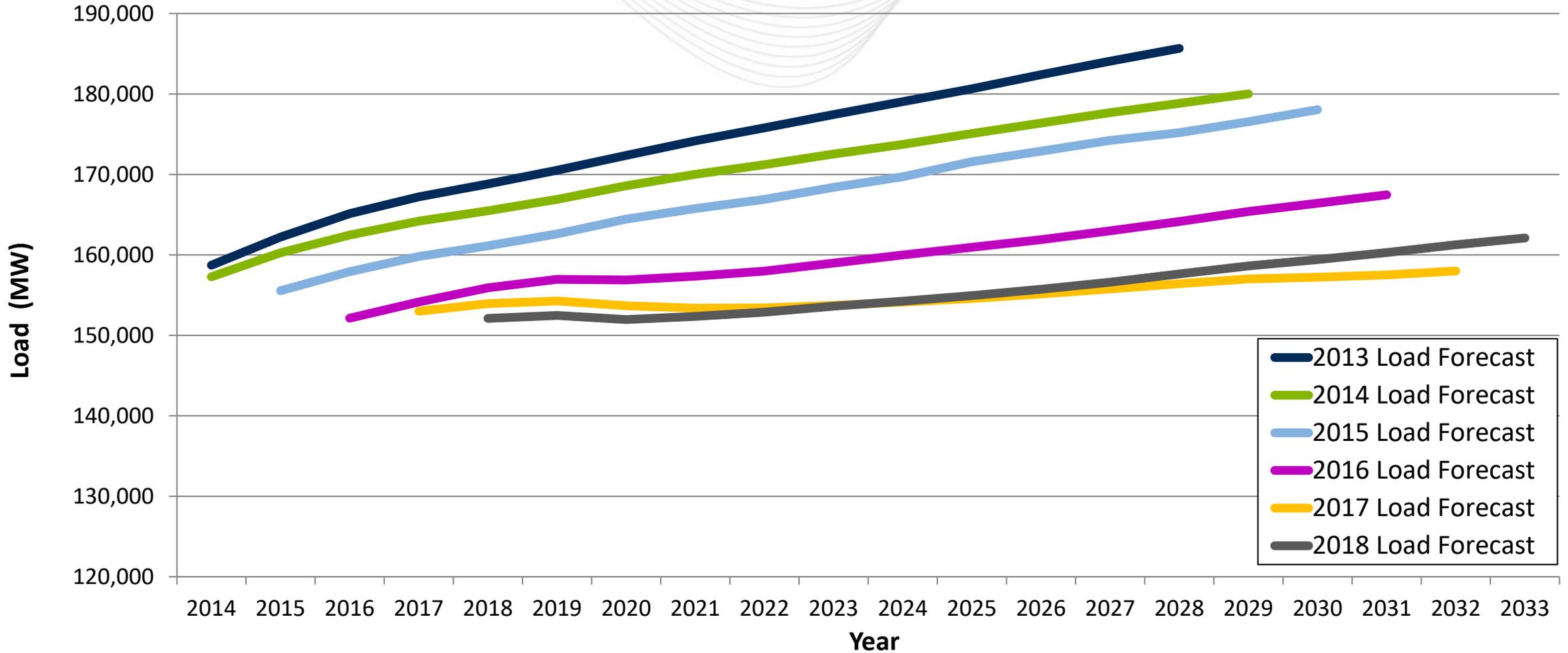


Queue	Project Name	MFO	Status	In Service Date	TO
Y3-092	Erie West 345kV	1,000	Active	12/31/2021	PENELEC
AB2-019	Erie West 345kV	28	Active	12/31/2021	PENELEC
AB1-019	Newlinville 230 kV	100	Active	6/1/2018	PECO

Planning

Load Forecast

PJM RTO Summer Peak Demand Forecast





Pennsylvania – 2018 Load Forecast Report

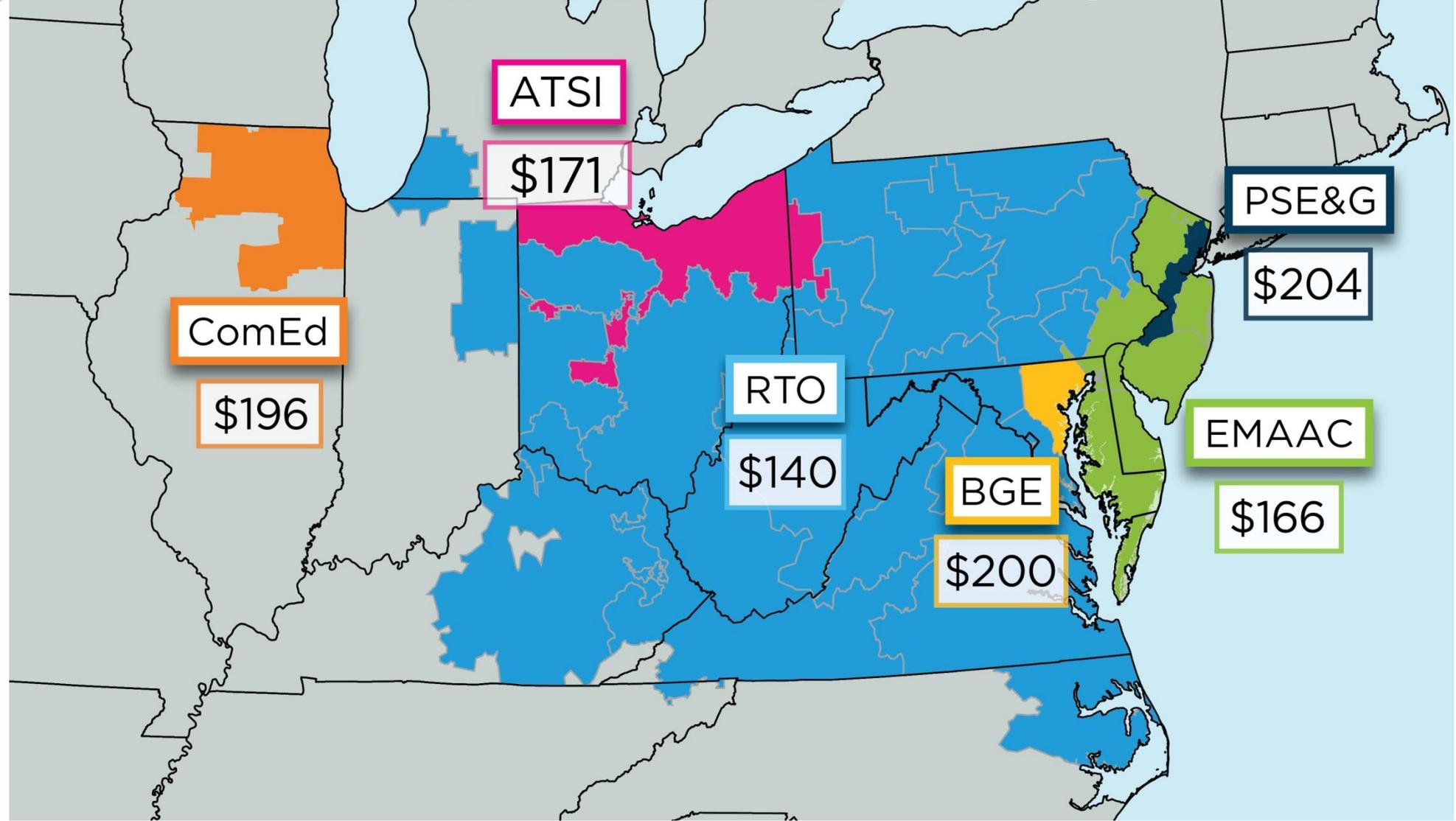
Transmission Owner	Summer Peak (MW)			Winter Peak (MW)		
	2018	2028	Growth Rate (%)	2017/18	2027/28	Growth Rate (%)
Allegheny Power *	3,949	4,228	0.7%	3,737	4,055	0.8%
American Transmission Systems, Inc. *	932	958	0.3%	877	898	0.2%
Duquesne Light Company	2,872	2,924	0.2%	2,153	2,175	0.1%
Metropolitan Edison Company	2,974	3,115	0.5%	2,607	2,697	0.3%
PECO Energy Company	8,642	8,979	0.4%	6,752	6,881	0.2%
Pennsylvania Electric Company	2,895	2,922	0.1%	2,866	2,875	0.0%
PPL Electric Utilities Corporation	7,140	7,350	0.3%	7,211	7,343	0.2%
UGI	190	188	-0.1%	194	188	-0.3%
PJM RTO	152,108	157,635	0.4%	131,463	136,702	0.4%

* PJM notes that Allegheny Power and ATSI serve load other than in Pennsylvania. The Summer Peak and Winter Peak MW values in this table each reflect the estimated amount of forecasted load to be served by each of those transmission owners solely in Pennsylvania. Estimated amounts were calculated based on the average share of each transmission owner's real-time summer and winter peak load located in Pennsylvania over the past five years.

Markets

Capacity Market Results

2021/22 Base Residual Auction Clearing Prices (\$/MW-Day)





Pennsylvania - Cleared Resources in 2021/22 Auction

(May 23, 2018)

	Cleared MW (Unforced Capacity)	Change from 2020/21 Auction
Generation	41,535	(853)
Demand Response	2,531	280
Energy Efficiency	281	48
Total	44,348	(525)

RTO Clearing Prices
\$140

EMAAC Clearing Prices
\$166

ATSI Clearing Prices
\$171

NOTE: Demand Response and Energy Efficiency are reported to PJM by Transmission Zone. The numbers above reflect the state's pro-rata share of cross-state zones for illustrative purposes.



PJM - 2021/2022 Cleared MW (UCAP) by Resource Type

	Annual	Summer	Winter	Total
Generation	149,616 MW	54 MW	716 MW	150,385 MW
DR	10,674 MW	452 MW	- MW	11,126 MW
EE	2,623 MW	209 MW	- MW	2,832 MW
Total	162,912 MW	716 MW	716 MW	164,343 MW



Pennsylvania – Offered and Cleared Resources in 2021/22 Auction

(May 23, 2018)

		Unforced Capacity
Generation	Offered MW	47,067
	Cleared MW	41,535
Demand Response	Offered MW	2,637
	Cleared MW	2,531
Energy Efficiency	Offered MW	306
	Cleared MW	281
Total Offered MW		50,010
Total Cleared MW		44,348

NOTE: Demand Response and Energy Efficiency are reported to PJM by Transmission Zone. The numbers above reflect the state's pro-rata share of cross-state zones for illustrative purposes.

Markets

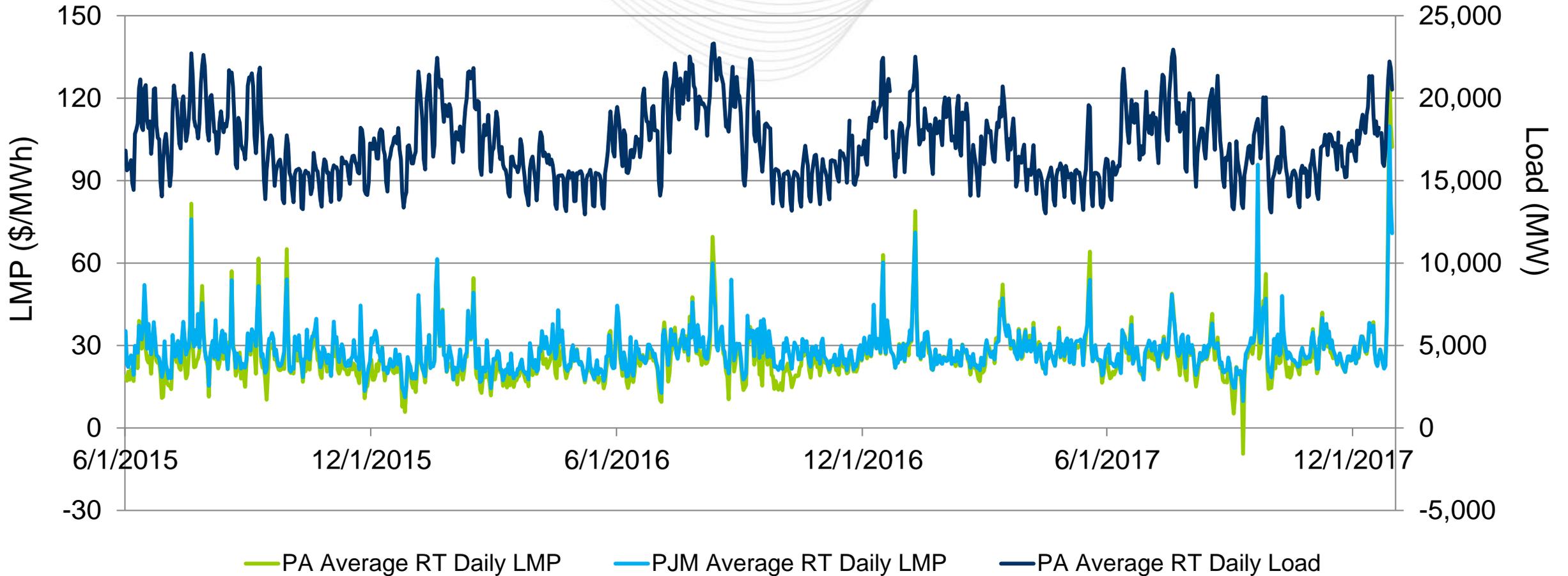
Market Analysis



Pennsylvania - Average Daily Load and LMP

(June 1, 2015 - December 31, 2017)

Pennsylvania's average daily LMPs generally align with the PJM average daily LMP



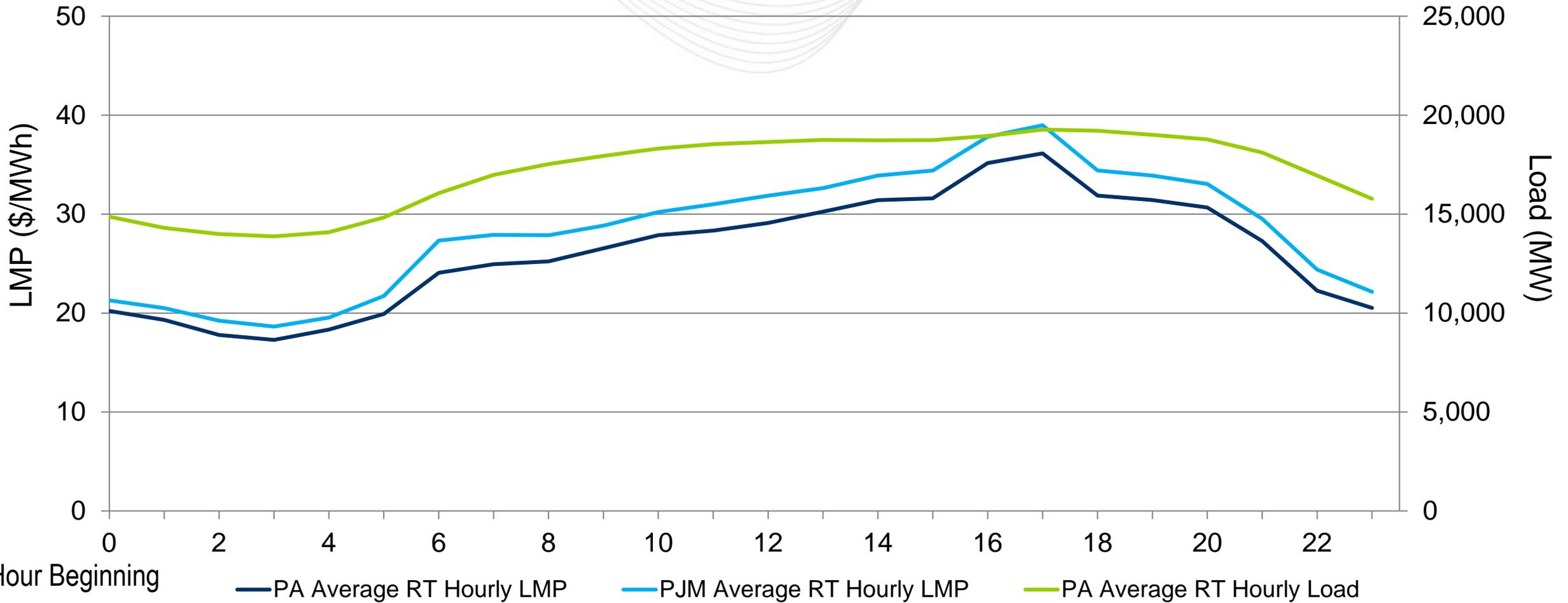
Note: The price spike on 9/21/2017 reflects the PJM shortage pricing event. The price spike starting 12/28/2017 reflects the beginning of the Cold Snap.



Pennsylvania – Hourly Average LMP and Load

(June 1, 2015 – December 31, 2017)

Pennsylvania's average hourly LMPs are lower than the PJM average.

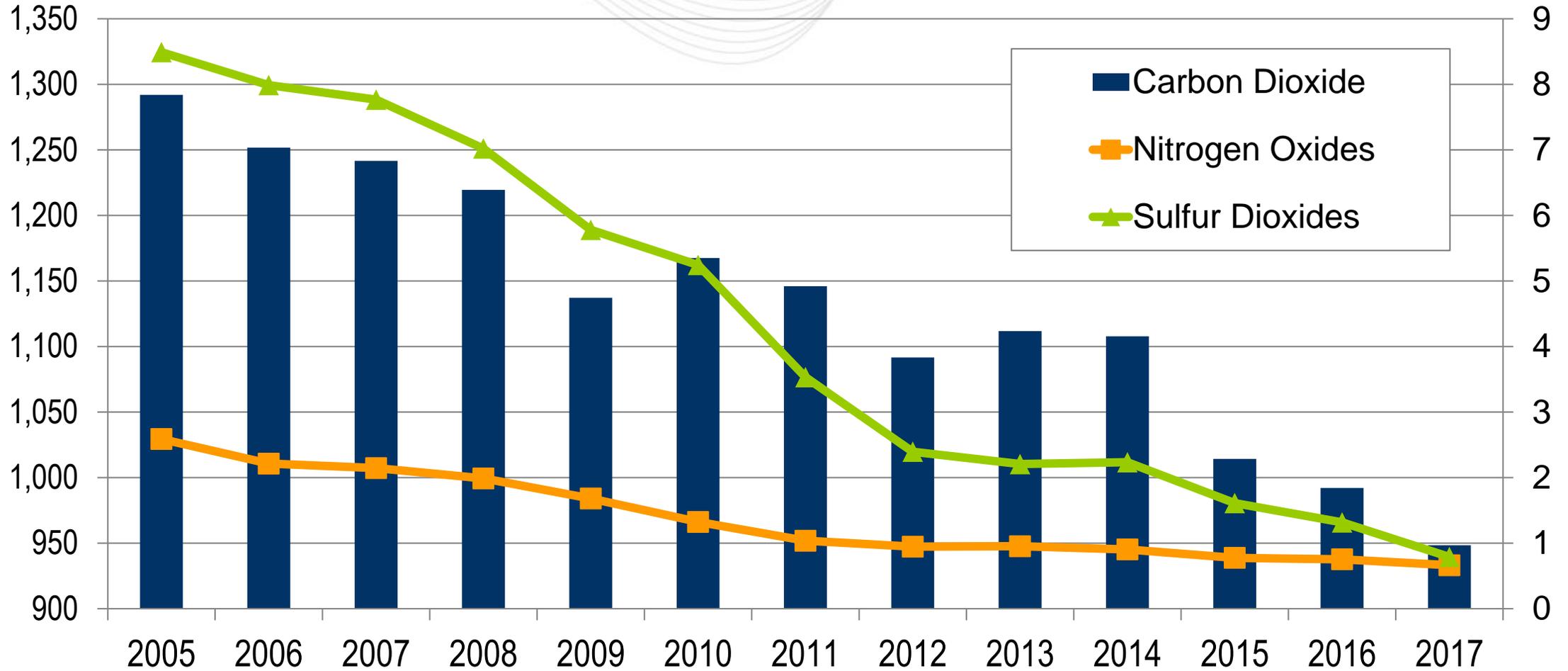


Operations Emissions Data

CO₂
(lbs/MWh)

PJM Average Emissions (lbs/MWh)

SO₂ and NO_x
(lbs/MWh)



CO₂
(lbs/MWh)

Pennsylvania Average Emissions (lbs/MWh)

SO₂ and NO_x
(lbs/MWh)

