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UNIVERSITY OF PENNSYLVANIA
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Smart Energy Initiative

2018 Annual Energy Briefing

Christina E. Simeone

Director of Policy and External Affairs

Kleinman Center for Energy Policy

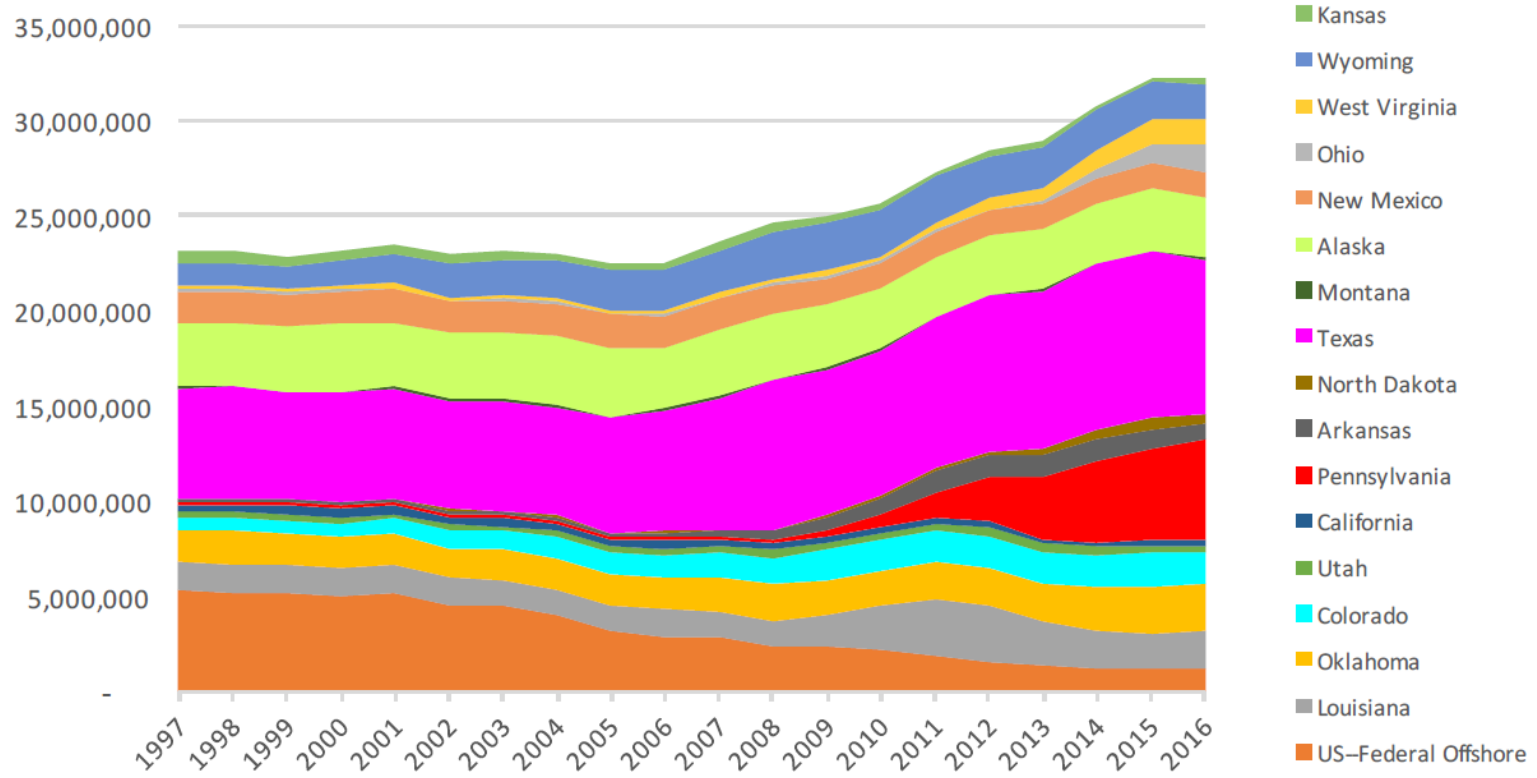
University of Pennsylvania

February 27, 2018



KLEINMAN CENTER
for **ENERGY POLICY**
PennDesign | UNIVERSITY of PENNSYLVANIA

Annual Natural Gas Gross Withdrawals and Production from Major Gas Producing States and Offshore, 1997 - 2016 (MMcf)



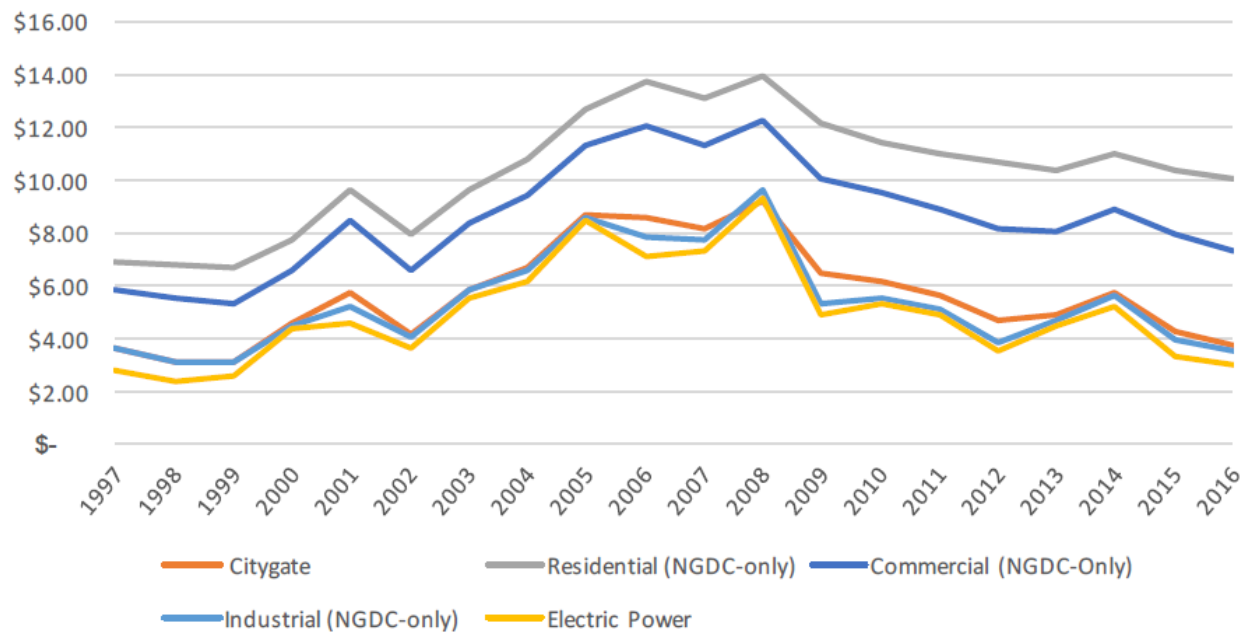
Love it or hate it,
 Pennsylvania's big energy
 story is all about
 natural gas

Pennsylvania Gas Decade,
 Simeone, Kleinman Center 2017

Growth Metrics for U.S. and Pennsylvania Annual Natural Gas Production and Withdrawals					
	1997	2007	2016	% Change	
				(1997 - 2007)	(2007 - 2016)
U.S. Total Production (MMcf)	24,212,677	24,663,656	32,647,385	1.9%	32%
PA Total Production (MMcf)	80,000	182,277	5,263,973	128%	2788%
PA as % of U.S. Production	0.33%	0.74%	16.12%		

Natural Gas Prices & Production

U.S. Annual Average Natural Gas Prices (\$/Mcf) by Sector in Nominal Terms (1997 - 2016)



U.S. and PA Average Annual Delivered Electric Power Sector Prices (\$/Mcf) and Differentials in Nominal Terms				
	US	PA	Differential	
1997	\$ 2.78	\$ 3.02	\$	0.24
2007	\$ 7.31	\$ 8.01	\$	0.70
2016	\$ 2.99	\$ 1.95	\$	(1.04)

Annual Average Pennsylvania Natural Gas Deliveries to End Use Customer Sectors, Select Years (MMcf)

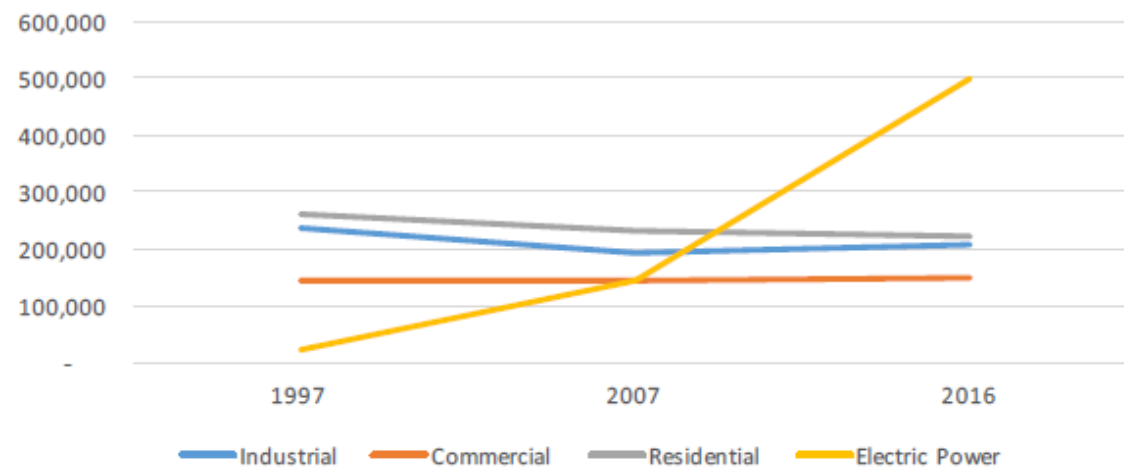


Table 12-5 Summary of PJM unit retirements by fuel (MW): 2011 through 2020

	Battery	Coal	Diesel	Heavy Oil	Hydro	Kerosene	Landfill Gas	Light Oil	Natural Gas	Nuclear	Waste Coal	Wind	Wood Waste	Total
Retirements 2011	0.0	543.0	0.0	0.0	0.0	0.0	0.0	131.0	522.5	0.0	0.0	0.0	0.0	1,196.5
Retirements 2012	0.0	5,907.9	0.0	0.0	0.0	0.0	0.0	788.0	250.0	0.0	0.0	0.0	16.0	6,961.9
Retirements 2013	0.0	2,558.9	2.9	166.0	0.0	0.0	7.0	3.0	82.0	0.0	31.0	0.0	8.0	2,858.8
Retirements 2014	0.0	2,239.0	50.0	0.0	0.0	184.0	15.3	188.0	294.0	0.0	0.0	0.0	0.0	2,970.3
Retirements 2015	0.0	7,064.8	0.0	0.0	0.0	644.2	2.0	222.3	1,319.0	0.0	0.0	10.4	0.0	9,262.7
Retirements 2016	0.0	243.0	51.0	0.0	0.5	0.0	9.9	22.0	74.0	0.0	0.0	0.0	0.0	400.4
Retirements 2017 (Jan-Sep)	0.0	2,038.0	0.0	0.0	0.0	0.0	0.8	0.0	34.0	0.0	0.0	0.0	0.0	2,072.8
Planned Retirements (Oct 2017 and later)	40.0	4,125.0	2.4	148.0	0.0	0.0	0.0	30.6	661.8	1,419.5	0.0	0.0	0.0	6,427.3
Total	40.0	24,719.6	106.3	314.0	0.5	828.2	35.0	1,384.9	3,237.3	1,419.5	31.0	10.4	24.0	32,150.7



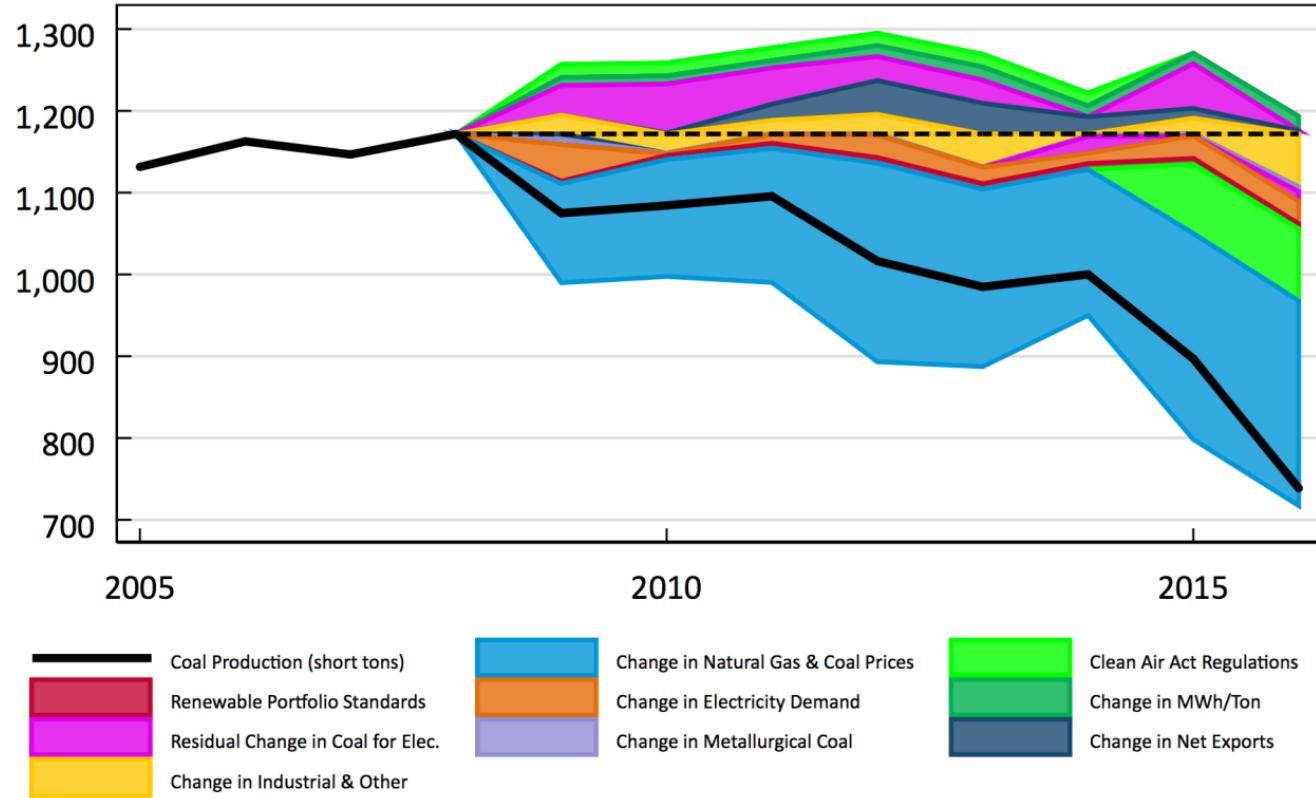
Table 12-9 Retirements (MW) by fuel type and state: 2011 through 2020

State	Battery	Coal	Diesel	Heavy Oil	Hydro	Kerosene	Landfill Gas	Light Oil	Natural Gas	Nuclear	Waste Coal	Wind	Wood Waste	Total
DC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	788.0	0.0	0.0	0.0	0.0	0.0	788.0
DE	0.0	254.0	0.0	0.0	0.0	0.0	0.0	0.0	34.0	0.0	0.0	0.0	0.0	288.0
IL	0.0	1,624.0	0.0	0.0	0.0	0.0	6.4	0.0	0.0	0.0	0.0	0.0	0.0	1,630.4
IN	0.0	982.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	982.0
KY	0.0	995.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	995.0
MD	0.0	250.0	51.0	0.0	0.0	0.0	0.8	0.0	189.0	0.0	0.0	0.0	0.0	490.8
NC	0.0	324.5	0.0	0.0	0.0	0.0	0.0	31.0	0.0	0.0	0.0	0.0	0.0	355.5
NJ	0.0	1,543.0	0.0	148.0	0.5	828.2	9.8	220.0	2,680.5	614.5	0.0	0.0	0.0	6,044.5
OH	40.0	9,248.6	52.4	0.0	0.0	0.0	0.0	228.9	0.0	0.0	0.0	0.0	0.0	9,569.9
PA	0.0	4,517.0	0.0	166.0	0.0	0.0	16.0	49.7	333.8	805.0	31.0	10.4	24.0	5,952.9
VA	0.0	2,340.5	2.9	0.0	0.0	0.0	2.0	67.3	0.0	0.0	0.0	0.0	0.0	2,412.7
WV	0.0	2,641.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2,641.0
Total	40.0	24,719.6	106.3	314.0	0.5	828.2	35.0	1,384.9	3,237.3	1,419.5	31.0	10.4	24.0	32,150.7

Generation Retirements

Decomposition of Changes in the Market for Coal, 2008-2016

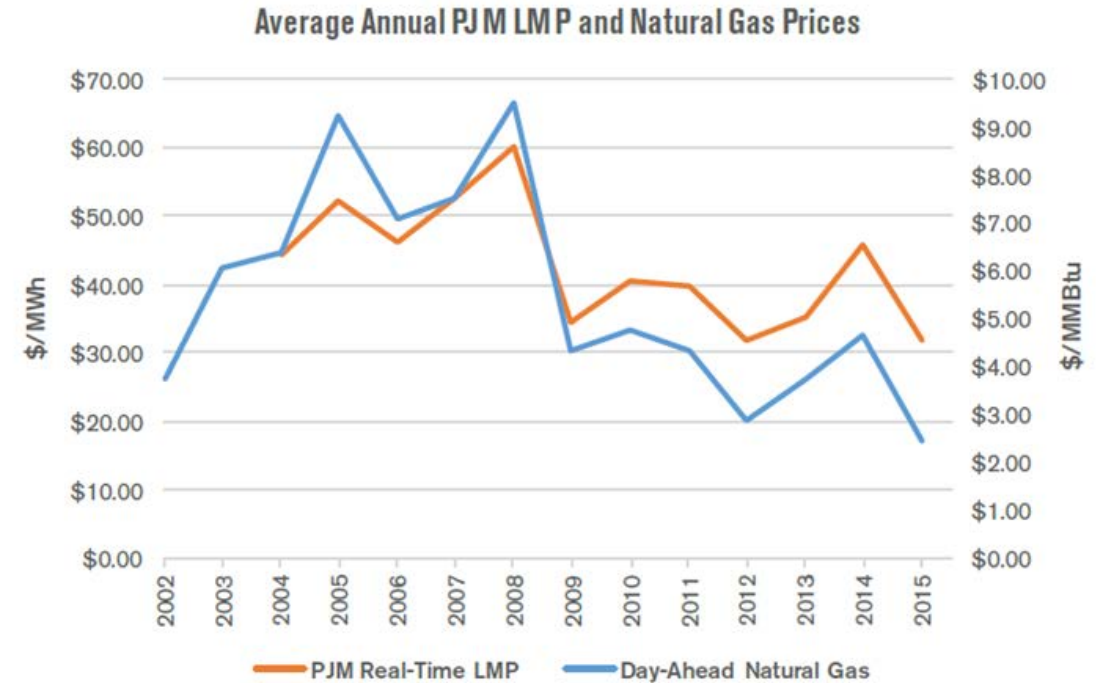
Million Short Tons



Sources: EIA Form 923, Electric Power Monthly, EIA API, FRED.

*“Prospects for a coal Renaissance”, James Stock, Harvard University, MIT CEEPR
Spring 2017 Research Workshop, April 27, 2017*

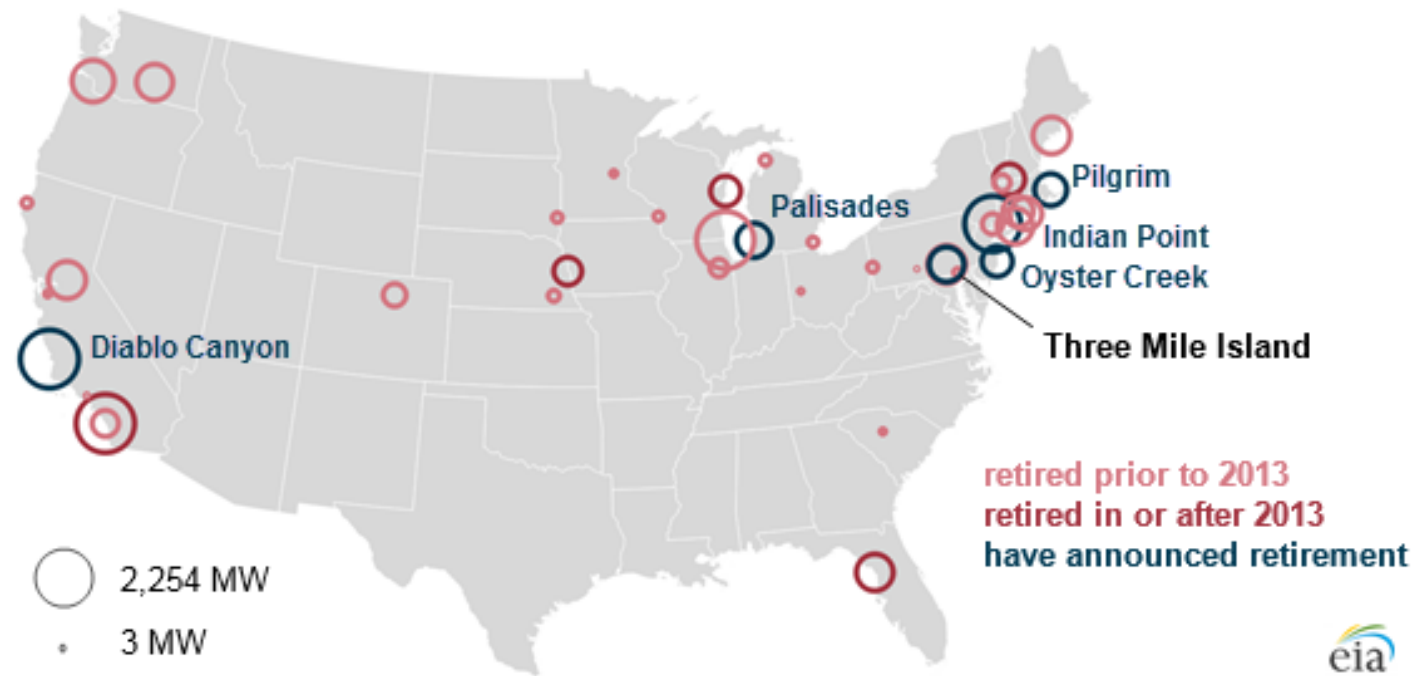
Natural Gas is Killing Coal



A Case Study of Electric Competition in Pennsylvania,
Simeone & Hanger, Oct 2016

Will Natural Gas Kill Nuclear Too?

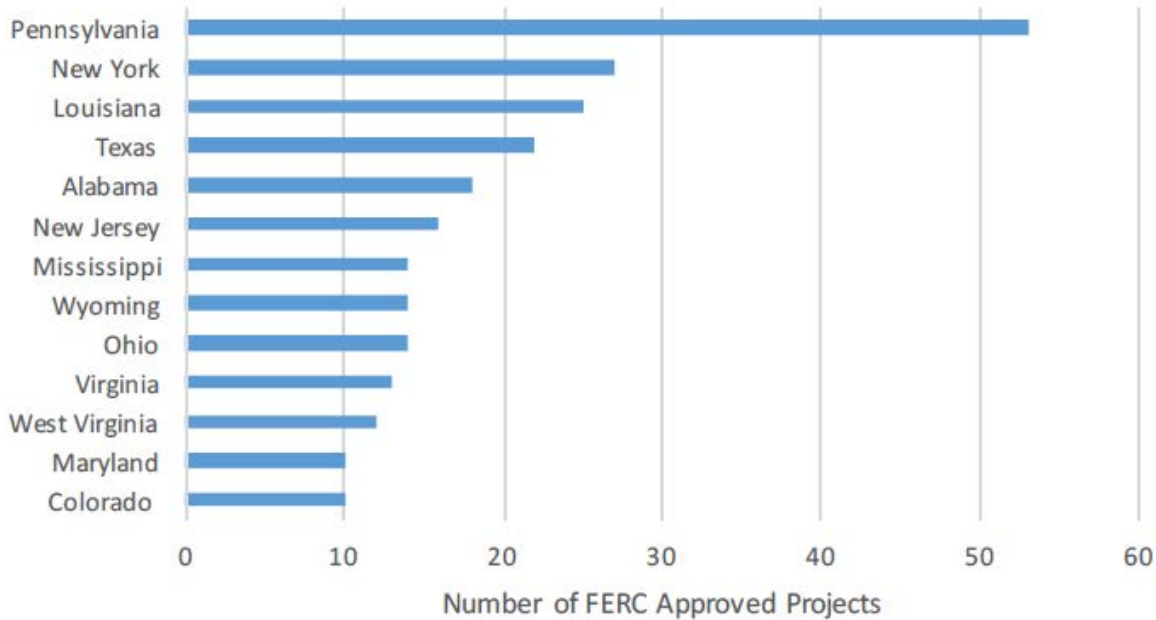
Retired nuclear power plants and nuclear power plants that have planned to retire



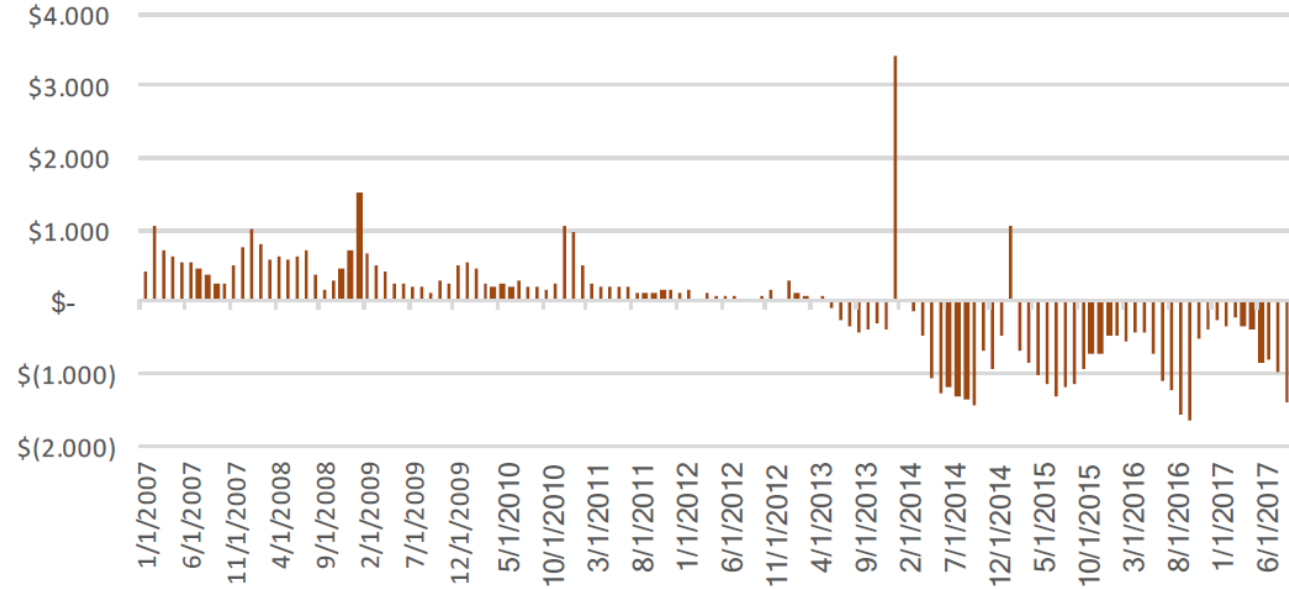
- In Pa - Three Mile Island to close in 2019
- Many more plants threaten to close (e.g. First Energy, PSEG, Dominion)
- Zero Emissions Credits policy established in NY & IL, legal challenges underway
- State policy discussions – NJ, PA, OH, CT, etc.

But, what will happen to PA gas prices as pipelines are built?

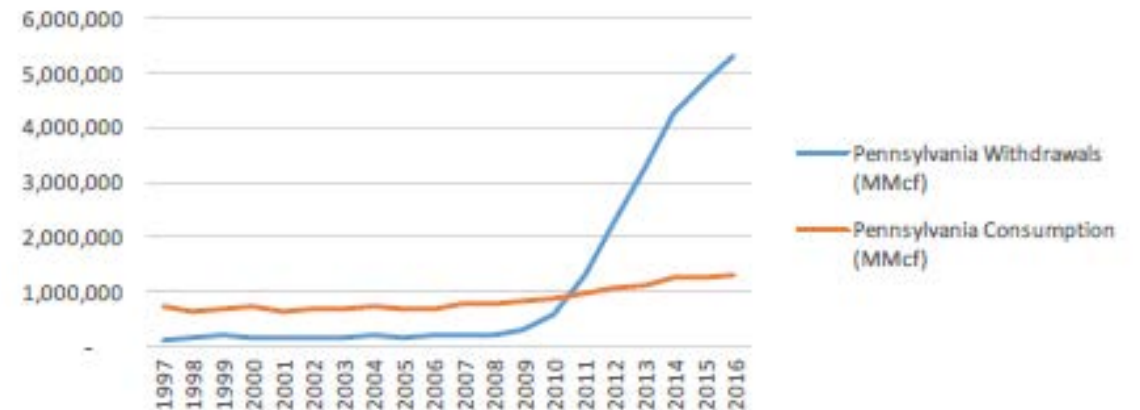
States with 10 or More FERC Approved Major Natural Gas Pipeline Projects (2007 - 2016)



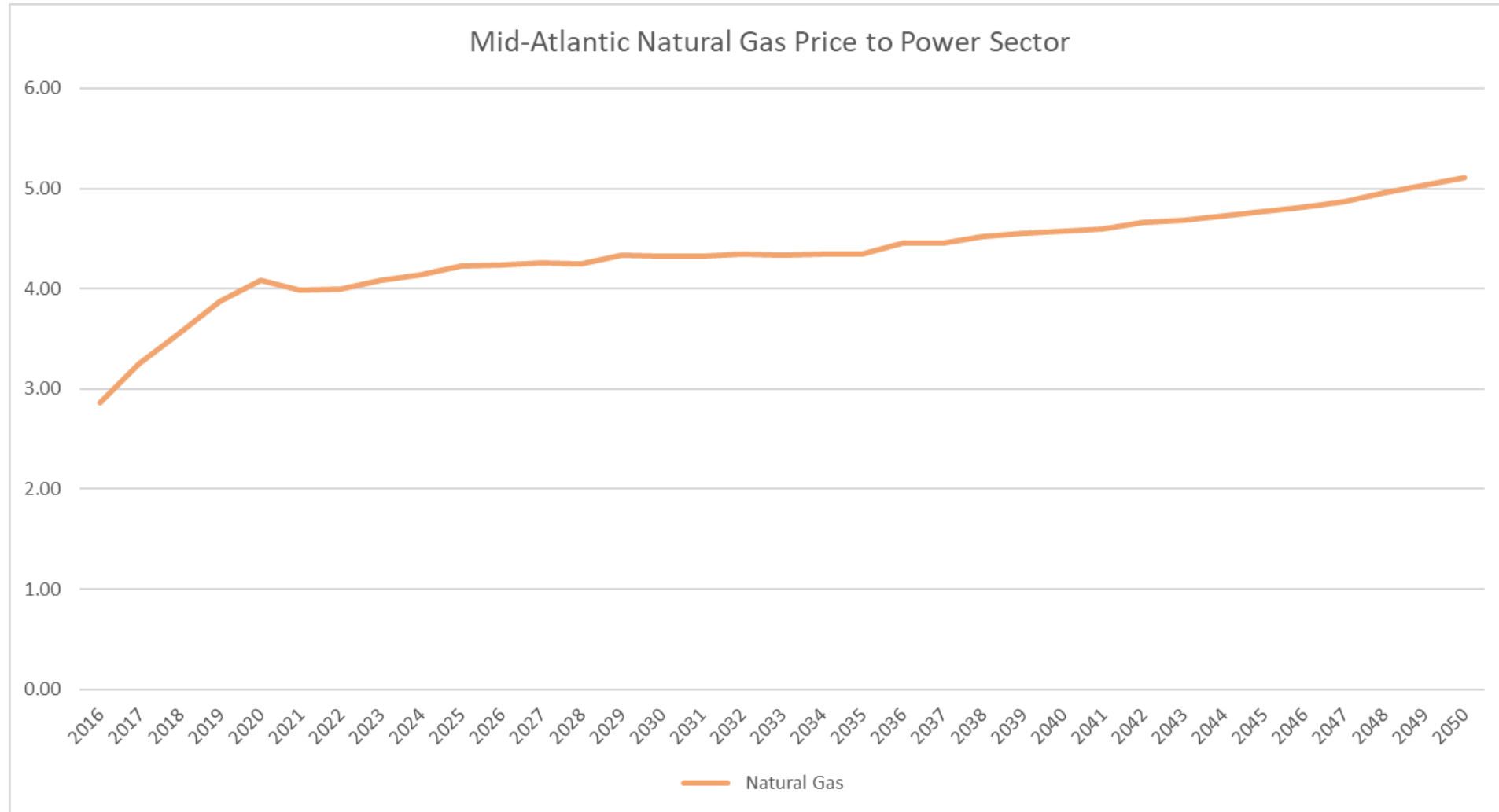
Average Pennsylvania Area Hubs Spot Price Discount to Henry Hub (\$/Mcf)



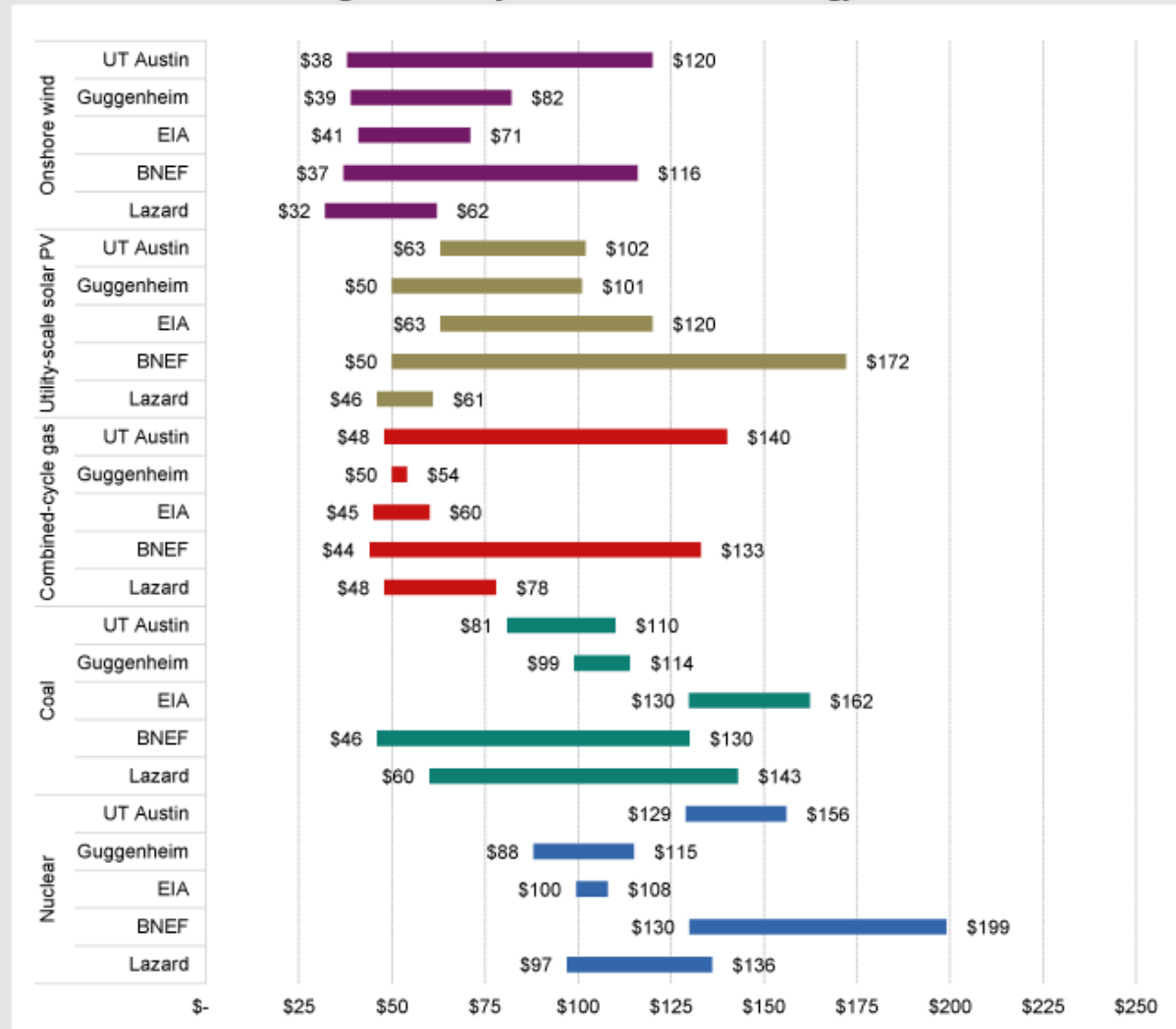
Pennsylvania Natural Gas Consumption and Withdrawals (MMcf)



EIA Annual Energy Outlook 2018 Projections



S&P Global Market Intelligence survey of levelized cost of energy (LCOE) studies (\$/MWh)



Data compiled Jan. 5, 2017.

Lazard: Data pulled from Unsubsidized Levelized Cost of Energy Comparison slide published on Dec. 15, 2016. Utility-scale solar PV figure is a blended range of crystalline and thin film technologies.

Guggenheim Securities LLC: Data pulled from Dec. 5, 2016, report. Analysis conducted on an unsubsidized basis for wind and solar, and does not account for cost considerations around fuel diversity or access to midstream and transmission infrastructure. Coal price data does not include CCS. Nuclear does not include maintenance capex or decommissioning costs.

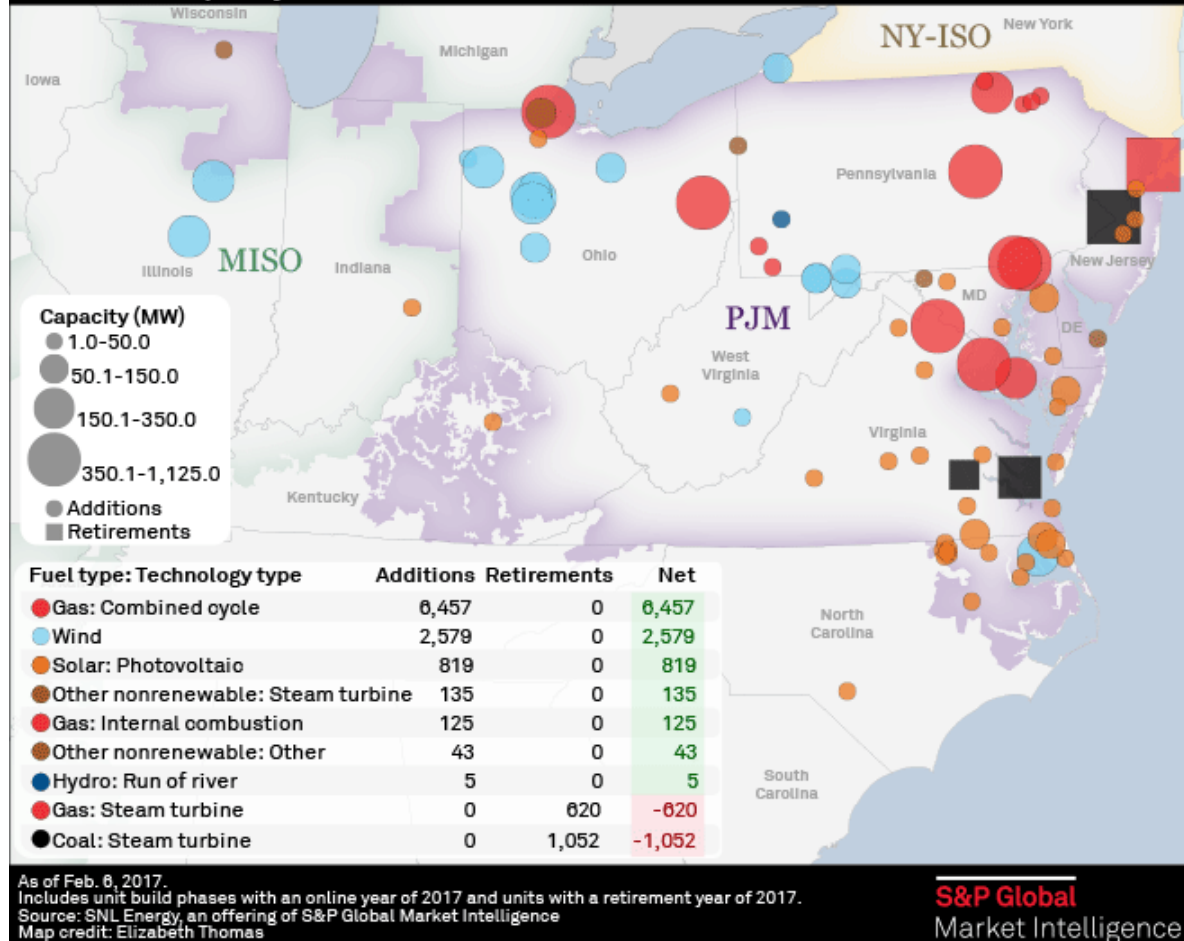
UT Austin Energy Institute: Data pulled and adjusted from Full Cost of Electricity study published on Dec. 8, 2016. Analysis does not include emissions costs, renewable energy tax credits or CCS cost on coal, and is based on range of minimum cost technology at a county by county basis.

Bloomberg New Energy Finance: Data received from Bloomberg New Energy Finance from second half 2016 Americas LCOE Outlook presentation from October 2016. Americas region includes North America and South America. Utility-scale solar PV prices based on use of tracking technology.

U.S. Energy Information Administration: Data pulled from Aug 6, 2016, report where wind, solar and conventional combined-cycle gas price data provided on an unsubsidized basis from regional variation for new generation resources for 2018 (Table A2). Advanced coal and nuclear price data pulled from 2022 set (Table 2), given assumed delay in project development timeline for those technologies.

Source: SNL Energy, an offering of S&P Global Market Intelligence

PJM's 2017 capacity additions and retirements



As of Feb. 6, 2017.

Includes unit build phases with an online year of 2017 and units with a retirement year of 2017.

Source: SNL Energy, an offering of S&P Global Market Intelligence

Map credit: Elizabeth Thomas

S&P Global
Market Intelligence

<<<Unsubsidized LCOE

Table 12-4 Queue capacity by LDA, control zone and fuel (MW): September 30, 2017²²

September 30, 2017, and December 31, 2020.

LDA	Zone	Biomass	CC	CT	Diesel	Fuel Cell	Hydro	Nuclear	Solar	Steam	Storage	Wind	Total Queue Capacity	Planned Retirements	
EMAAC	AECO	0.0	1,674.6	462.0	0.0	1.9	0.0	0.0	75.3	0.0	20.0	25.0	2,258.8	303.0	
	DPL	4.0	802.0	0.0	13.6	0.0	0.0	0.0	1,431.2	0.0	25.0	649.6	2,925.4	0.0	
	JCPL	0.0	1,767.1	0.0	0.0	0.4	0.0	0.0	201.8	0.0	85.0	0.0	2,054.3	614.5	
	PECO	0.0	1,221.0	0.0	4.5	0.0	0.0	94.0	18.0	0.0	0.0	0.0	1,337.5	50.8	
	PSEG	0.0	2,566.5	677.0	5.0	3.6	0.0	0.0	79.1	24.0	0.0	0.0	3,355.2	611.0	
	RECO	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	EMAAC Total	4.0	8,031.2	1,139.0	23.1	5.9	0.0	94.0	1,805.4	24.0	130.0	674.6	11,931.2	1,579.3	
SWMAAC	BGE	0.0	0.0	0.0	0.0	1.3	0.0	0.4	30.3	22.0	0.0	0.1	0.0	135.0	
	Pepco	0.0	0.0	1,857.6	0.0	0.0	0.0	0.0	0.0	62.5	0.0	0.0	0.0	0.0	
	SWMAAC Total	0.0	0.0	1,857.6	0.0	1.3	0.0	0.4	30.3	84.5	0.0	0.1	1,974.2	135.0	
WMAAC	Met-Ed	0.0	485.0	34.1	0.0	0.0	0.0	0.0	158.0	30.0	0.0	0.0	707.1	805.0	
	PENELEC	0.0	1,170.0	521.1	121.1	0.0	17.0	0.0	63.5	590.0	0.0	458.8	2,941.5	0.0	
	PPL	16.0	5,818.0	19.9	19.9	0.0	0.0	0.0	30.0	0.0	30.0	441.1	6,374.9	0.0	
	WMAAC Total	16.0	7,473.0	575.1	141.0	0.0	17.0	0.0	251.5	620.0	30.0	899.8	10,023.4	805.0	
Non-MAAC	AEP	0.0	10,156.0	394.0	15.2	0.0	46.5	28.0	4,274.8	149.0	90.0	7,387.0	22,540.5	0.0	
	APS	0.0	5,805.1	30.0	99.6	0.0	15.0	0.0	669.6	10.0	37.8	1,010.7	7,677.8	0.0	
	ATSI	0.0	5,191.0	0.0	0.9	0.0	0.0	0.0	426.0	0.0	0.0	815.7	6,433.5	776.0	
	ComEd	0.0	8,270.2	1,127.0	18.8	0.0	22.7	0.0	495.0	64.0	85.5	3,445.5	13,528.7	0.0	
	DAY	0.0	1,150.0	0.0	0.0	0.0	0.0	0.0	762.9	12.0	39.9	300.0	2,264.8	2,404.0	
	DEOK	0.0	513.0	0.0	0.0	0.0	0.0	0.0	290.0	20.0	19.8	0.0	842.8	0.0	
	DLCO	0.0	205.0	0.0	0.0	0.0	0.0	0.0	11.7	0.0	20.0	0.0	236.7	0.0	
	Dominion	62.5	6,879.7	155.0	8.0	0.0	5.6	0.0	9,709.1	14.0	34.0	1,047.5	17,915.5	728.0	
	EKPC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	
	RMU	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.0	0.0	0.0	0.0	40.0	0.0	
	Non-MAAC Total	62.5	38,170.0	1,706.0	142.4	0.0	89.8	28.0	16,779.1	269.0	327.0	14,006.4	71,580.2	3,908.0	
	Total in PJM	Total	82.5	53,674.2	5,277.7	306.5	7.2	106.8	122.4	18,866.3	997.5	487.0	15,580.9	95,508.9	6,427.3

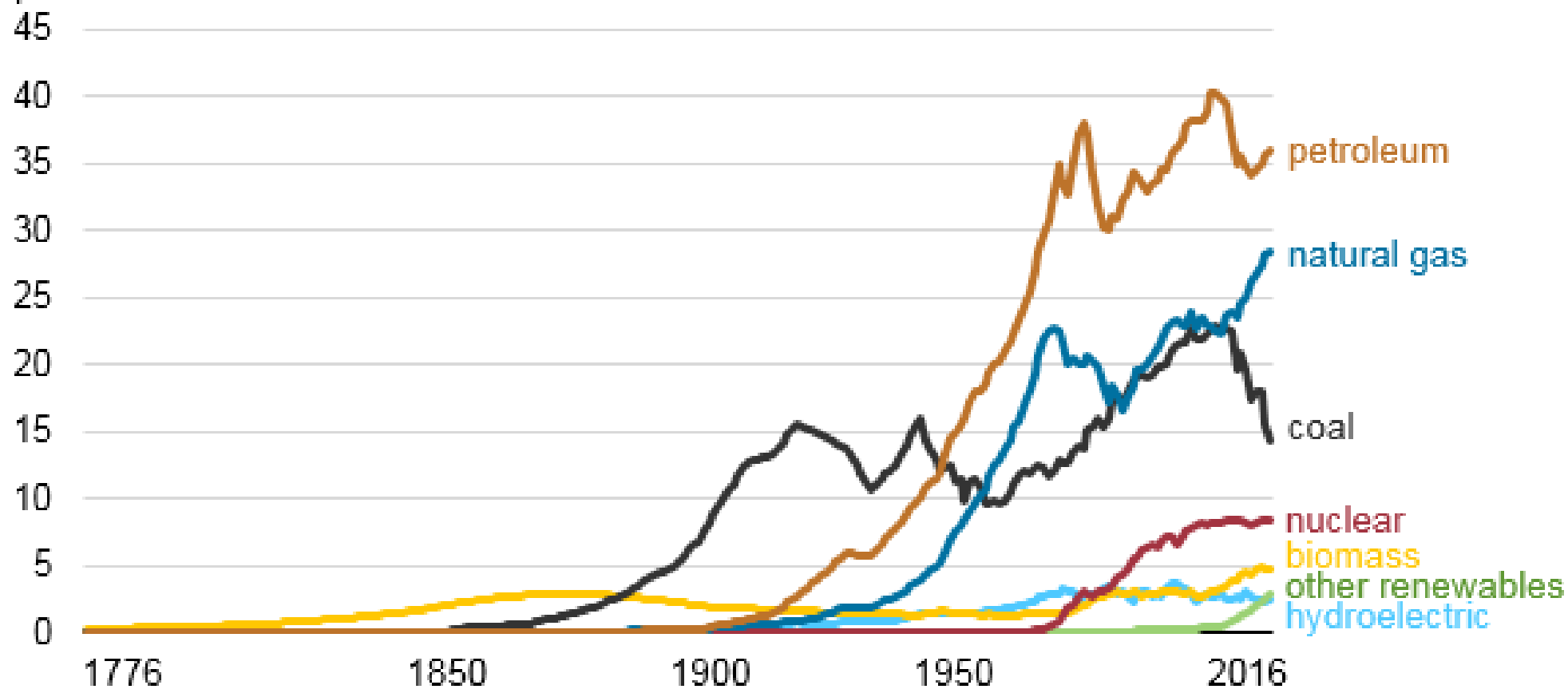


Renewable Generation Still Small



Energy consumption in the United States (1776-2016)

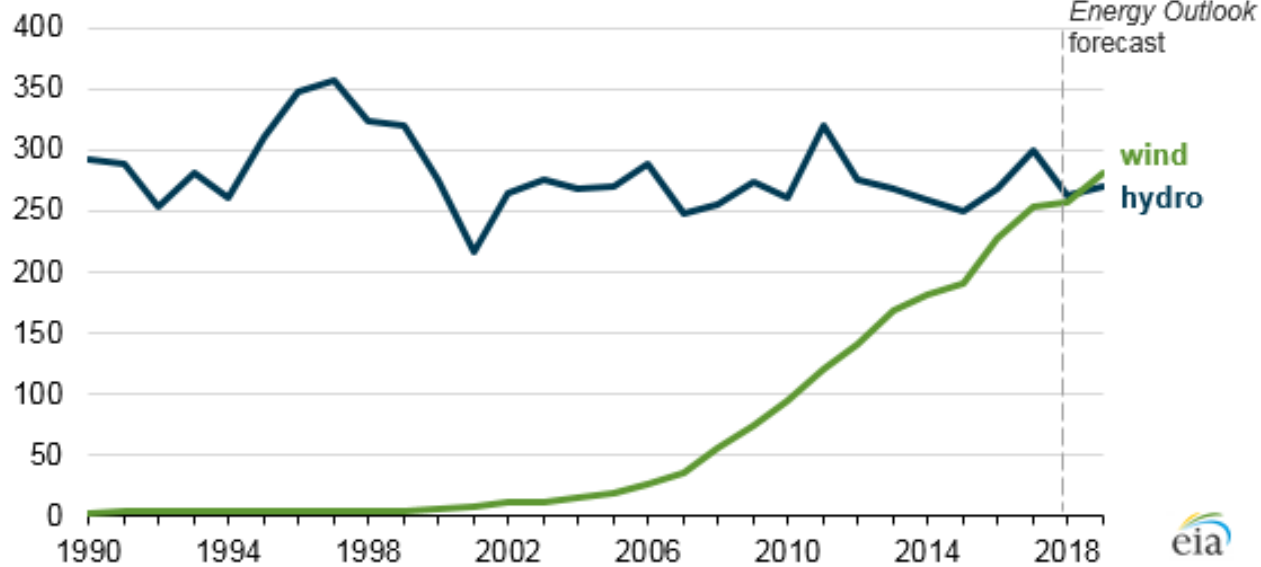
quadrillion British thermal units



<https://www.eia.gov/todayinenergy/>

U.S. electricity generation from selected sources (1990-2019)

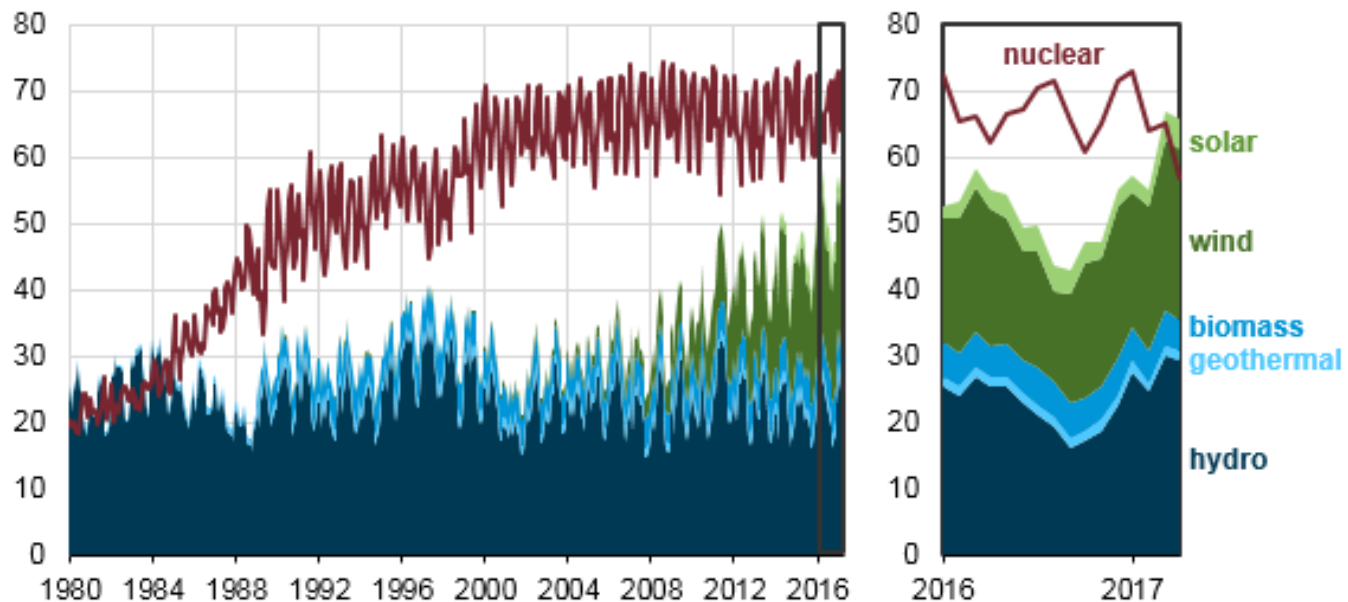
thousand megawatthours



Wind predicted to overtake hydro generation in 2019

Monthly electricity generation from selected fuels (Jan 1980 - Apr 2017)

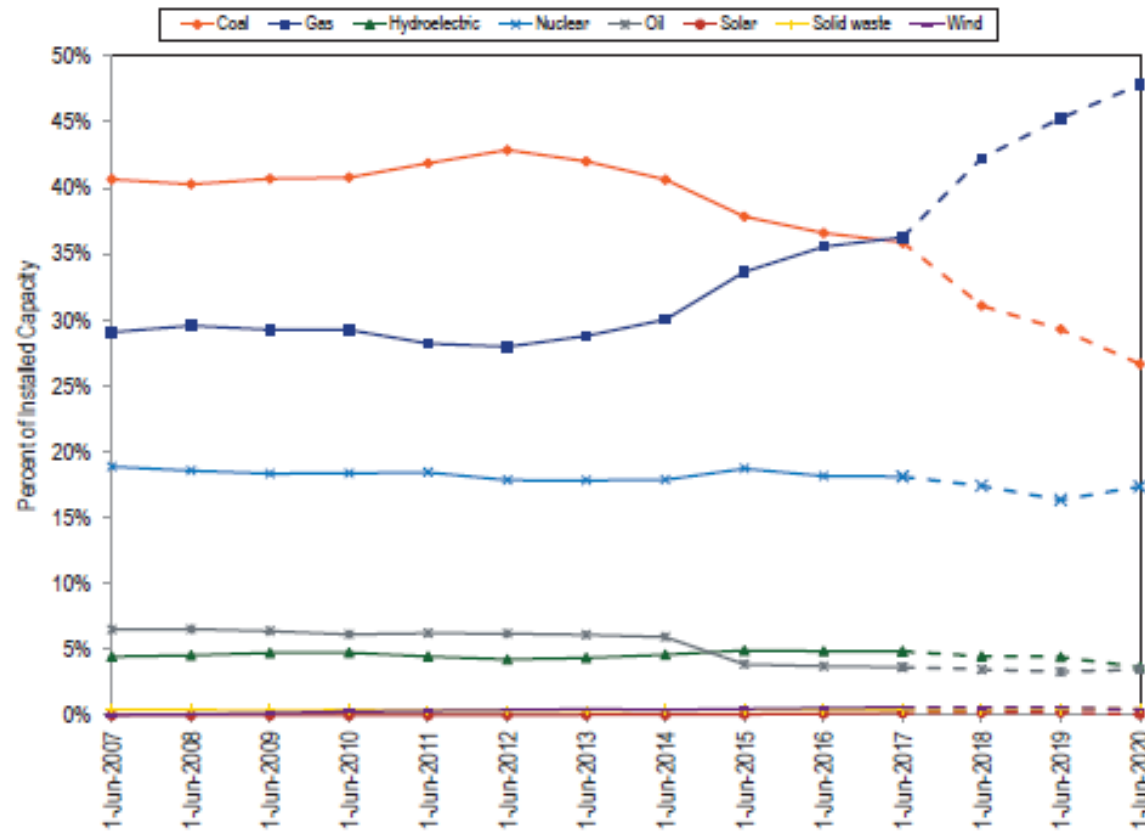
billion kilowatthours



Monthly renewable generation surpasses nuclear generation in April 2017.

PJM and PA Installed Capacity

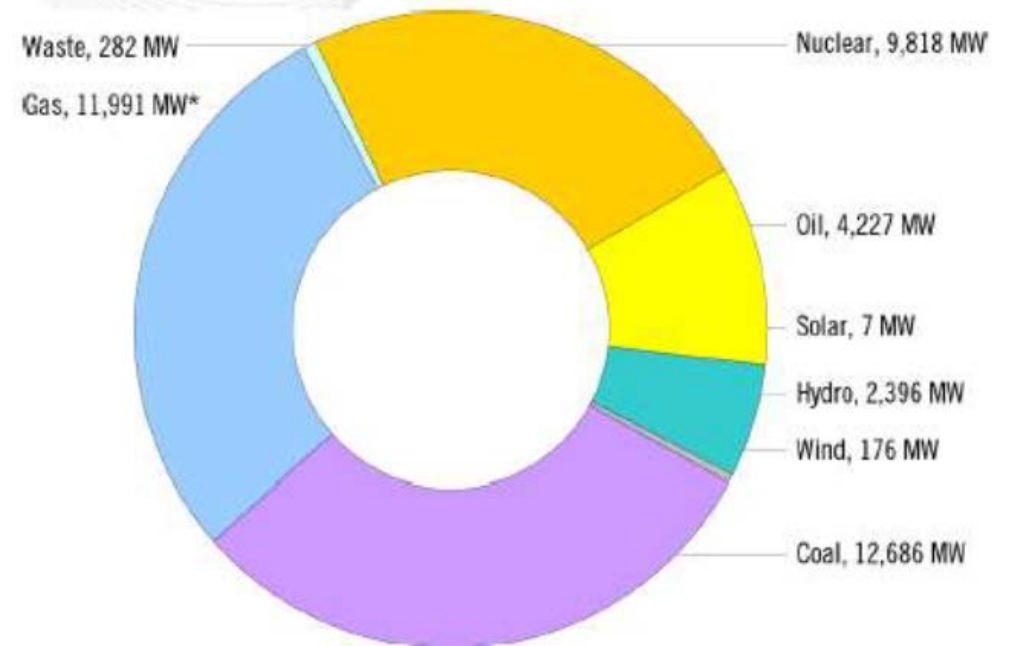
Figure 5-1 Percent of PJM installed capacity (By fuel source): June 1, 2007 through June 1, 2020



PJM SOTM Report 2017 3Q, Monitoring Analytics

Pennsylvania – Existing Installed Capacity

(Capacity Rights, December 31, 2016)



PA PUC, Electric Power Outlook, 2017

Federal Policy

- **Tax Reform**

- Lowering corporate tax rate likely to reduce tax equity appetite that drives renewable project finance (e.g. PPA's with corporations) through federal ITC/PTC.
- Base erosion anti-abuse tax (BEAT) – reduce the value of tax credits for multinational companies.

- **Solar Tariff**- 30% tariff on important panels and cells for 4-years (de-escalating 5% per year), with 2.5 GW cells exempt each year.

- **DOE Resilience NOPR** – rejected by FERC

- Regulatory rollback efforts targeting energy sector and energy intensive industries.

- Reduced funding for EE/RE, climate science, research, and programs.

- Aggressive trade stance – is this at odds with energy export strategy?

Highlights on PJM Policy

- **Price Formation**

- PJM predicts a 2%-5% increase in annual net power costs (\$440M - \$1.4 Billion)
- What units are eligible to set market price (marginal price)?

- **Capacity Market Changes**

- MOPR-Ex – Mitigate impact of certain subsidies
- Two Tiered Repricing – Allow subsidies, but approximate competitive prices

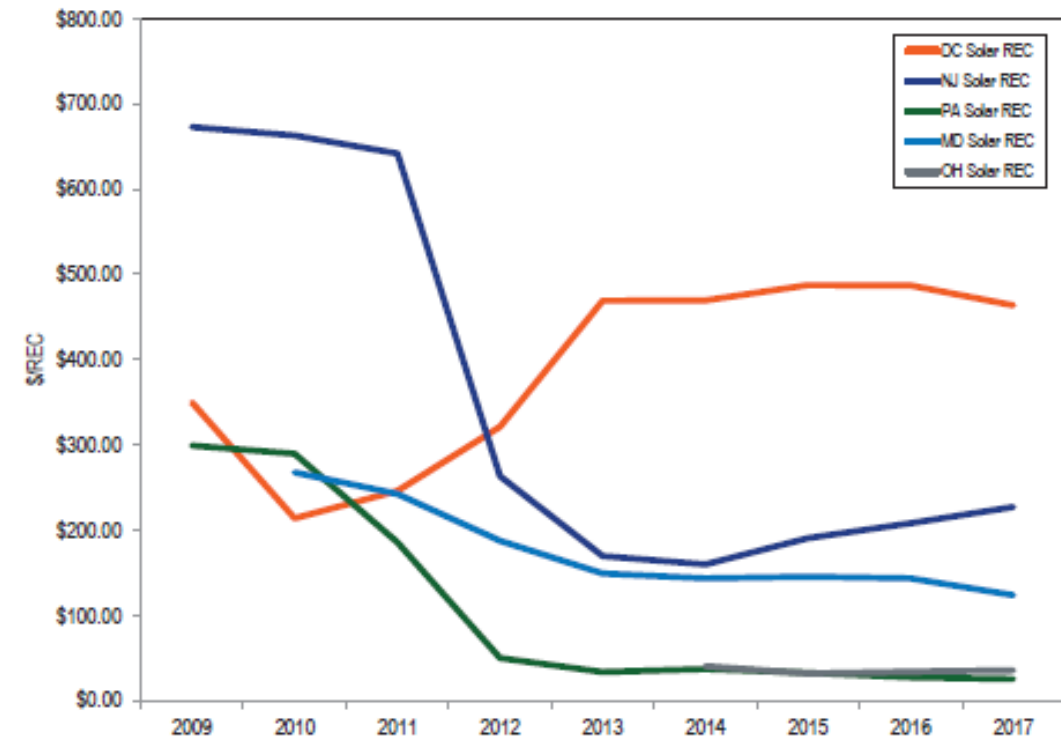
- **FERC's RTO/ISO Resilience Docket (AS18-7-000)**

- Asks key questions to RTO/ISO on various aspects of resilience, 60 day comment period
- 30-day reply comment period for stakeholders

Pennsylvania Policy

- Act 40 of 2017
 - Intent - Only solar within PA's borders can qualify for compliance.
 - December Implementation Order from PA PUC. Issue related to grandfathering existing contracts.
- PA DEP's solar roadmap
- Pending Legislation – EV's, Microgrids, etc.
- Nuclear caucus
 - supportive of PJM price formation

Figure 8-5 Average SREC price by jurisdiction: January 1, 2009 through September 30, 2017



Take Home Points

- PA shale gas reduced gas and power prices.
- PJM's power prices are so low that many existing resources are economically stressed. Only lowest cost resources entering the market.
- Policy changes at all levels of government trying to navigate real and political challenges.
- PA natural gas prices projected to stay low, but cumulative impacts of new pipelines, exports are not yet known.
- Renewable energy costs continue to decrease, but policy environment is neutral to negative.