Capacity

RASTF

05.26.2022

IMM

Monitoring Analytics

Capacity market history

- PJM capacity obligation predated PJM markets
  - Part of PJM OA prior to 1999
  - Required capacity equal to load plus reserve margin
  - Gray market in capacity prior to 1999
- PA PUC requested PJM capacity market in 1999
  - Required for retail competition
  - Addressed market power of incumbent utilities that owned all the capacity
- Daily/monthly (capacity credit market) (1999 – 2007)
- Annual (reliability pricing model) (2007 - present)

Why capacity market?

- The capacity market exists to make the energy market work.
- The capacity market exists to facilitate retail competition.
- The capacity market exists to provide incentives for entry and exit.
  - Provides additional revenues to generation assets given that energy market required to be long (reliability requirement)
- The capacity market is a competitive mechanism to meet objectives.

Obligations of capacity resources

- **The current definition of capacity requires:**
  - **Physical assets (not financial; not planned, unless physical milestones met)**
  - **Deliverable energy at ICAP (formal definition; not failure to be interrupted) (CIRs: capacity interconnection rights)**
  - **Definition of ICAP (testing)**
  - **Energy from capacity resources is recallable in an emergency**
  - **Capacity resources must offer in energy market every day equal to full ICAP**
    - Under CP: Does not apply to storage, intermittent, DR
  - **Outages must be reported (GADS)**

Capacity market design (1)

- Forward looking (three years)
- Annual
- Locational
  - Transmission constraints modeled per CETO/CETL
- Sellers must offer all capacity resources
  - Capacity resources defined by deliverability test
  - Capacity resource MW based on CIRs
  - Does not apply to storage, intermittent, DR
- Load must buy to meet defined reliability goals
  - Administrative capacity market demand curve (VRR curve)

Capacity market design (2)

- Definition of product
  - Homogeneous
  - Energy delivery for 8,760 hours per year
  - ELCC for conversion to homogeneous product
- Performance incentives
- Competitive
- Market power and market power mitigation
- Role of demand side resources
- Role of imports (pseudo tie rules)
- Retirements and RMRs

Capacity market and energy market

- **Must offer in energy market**
  - **Every day**
  - **Full capacity (ICAP)**
  - **With physical parameters (PLS)**
  - **Firm fuel not required**
  - **Follow PJM dispatch and commitment instructions**
  - **Must offer obligation should apply to all capacity resources without exception, including storage, intermittent, and DR.**

The capacity market results were not competitive: 2021/2022 BRA and 2022/2023 BRA

Market Element	Evaluation	Market Design
Market Structure: Aggregate Market	Not Competitive	
Market Structure: Local Market	Not Competitive	
Participant Behavior	Not Competitive	
Market Performance	**Not Competitive**	**Mixed**

Capacity market issues

- Market seller offer cap (MSOC)
- VRR curve shape and location
- Definition of capacity
- Intermittent capacity definition: ELCC
- DR/EE
- MOPR
- Reserve margin
  - Must offer requirement

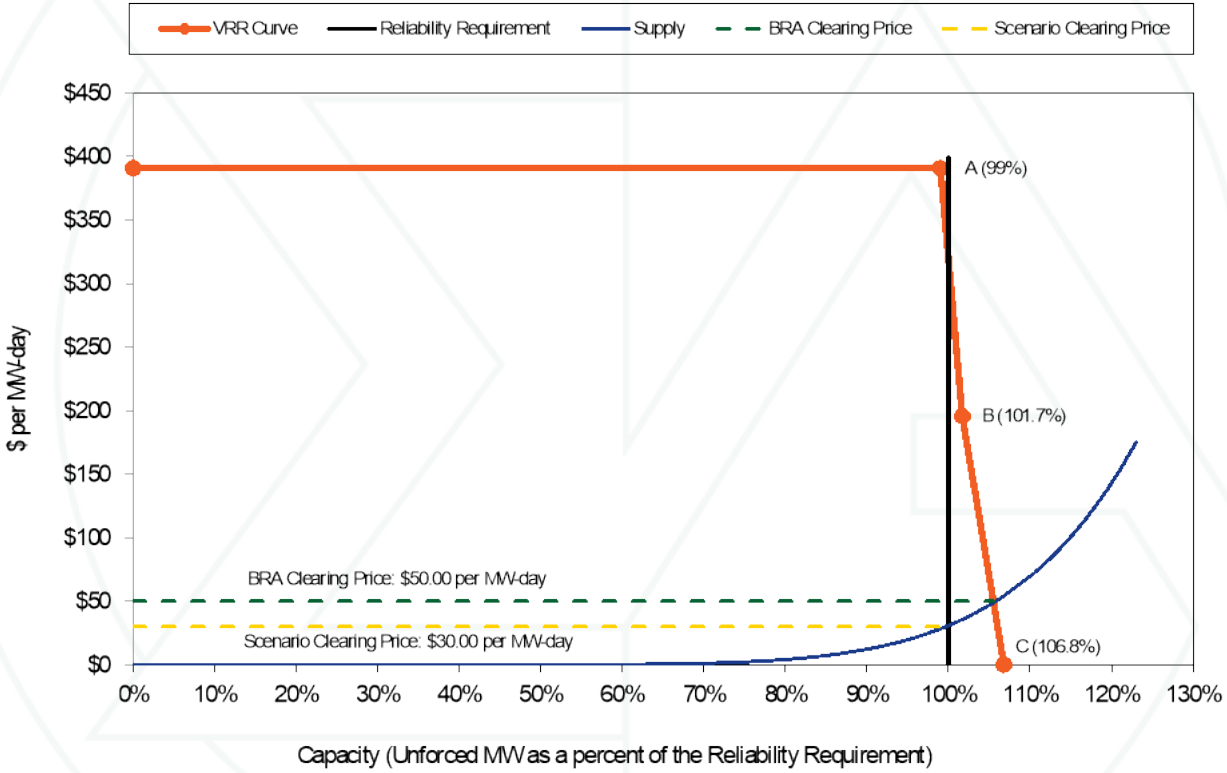
2022/2023 RPM Base Residual Auction

Scenario	Scenario Description	RPM Revenue ($ per Delivery Year)	Scenario Impact RPM Revenue ($ per Delivery Year)	Percent
0	Actual Results	$3,916,990,303	NA	NA
1	Impact of Downward Sloping VRR Curve	$2,659,527,128	$1,257,463,175	47.3%
2	Impact of Forecast Peak Load	$3,038,859,236	$878,131,066	28.9%
3	Impact of ComEd CETL	$4,045,468,797	($128,478,494)	(3.2%)
4	Impact of Dominion FRR	$4,009,821,399	($92,831,097)	(2.3%)
5	Impact of Intermittent Capacity	$4,209,145,809	($292,155,506)	(6.9%)
6	Inclusion of Demand Resources	$4,667,530,509	($750,540,206)	(16.1%)
7	Inclusion of EE Offers and EE Addback	$3,723,175,053	$193,815,249	5.2%
8	Impact of Incorrect EE Addback	$3,860,997,114	$55,993,189	1.5%
9	Inclusion of PRD	$3,971,098,221	($54,107,919)	(1.4%)
10	Inclusion of Seasonal Products	$4,088,669,913	($171,679,610)	(4.2%)
11	Inclusion of Seasonal Matching Across LDAs	$4,007,550,697	($90,560,395)	(2.3%)
12	Inclusion of Offers from External Generation	$4,227,125,093	($310,134,790)	(7.3%)
13	Impact of DR, EE, PRD, Seasonal Resources, Capacity Imports, and Intermittent Capacity Overstatement	$6,657,417,211	($2,740,426,908)	(41.2%)
14	Impact of Low MOPR Offers	$4,078,113,024	($161,122,722)	(4.0%)
15	Inclusion of Nuclear Offers	$3,480,464,207	$436,526,096	12.5%
16	Impact of Noncompetitive Offers	$3,694,010,658	$222,979,644	6.0%

2022/2023 RPM Base Residual Auction

Scenario	Scenario Description	Cleared UCAP (MW)	Scenario Impact Cleared UCAP (MW)	Scenario Impact Percent
0	Actual Results	144,477.3	NA	NA
1	Impact of Downward Sloping VRR Curve	132,006.7	12,470.6	9.4%
2	Impact of Forecast Peak Load	138,811.6	5,665.7	4.1%
3	Impact of ComEd CETL	144,581.9	(104.6)	(0.1%)
4	Impact of Dominion FRR	143,140.5	1,336.8	0.9%
5	Impact of Intermittent Capacity	144,184.3	293.0	0.2%
6	Inclusion of Demand Resources	138,083.6	6,393.7	4.6%
7	Inclusion of EE Offers and EE Addback	139,272.3	5,205.0	3.7%
8	Impact of Incorrect EE Addback	144,068.6	408.7	0.3%
9	Inclusion of PRD	144,727.2	(249.9)	(0.2%)
10	Inclusion of Seasonal Products	144,052.8	424.5	0.3%
11	Inclusion of Seasonal Matching Across LDAs	144,363.9	113.4	0.1%
12	Inclusion of Offers from External Generation	143,951.3	526.0	0.4%
13	Impact of DR, EE, PRD, Seasonal Resources, Capacity Imports, and Intermittent Capacity Overstatement	136,610.7	7,866.6	5.8%
14	Impact of Low MOPR Offers	144,310.2	167.1	0.1%
15	Inclusion of Nuclear Offers	144,581.9	(104.6)	(0.1%)
16	Impact of Noncompetitive Offers	144,477.3	0.0	0.0%

VRR curve impacts: 2022/2023 BRA



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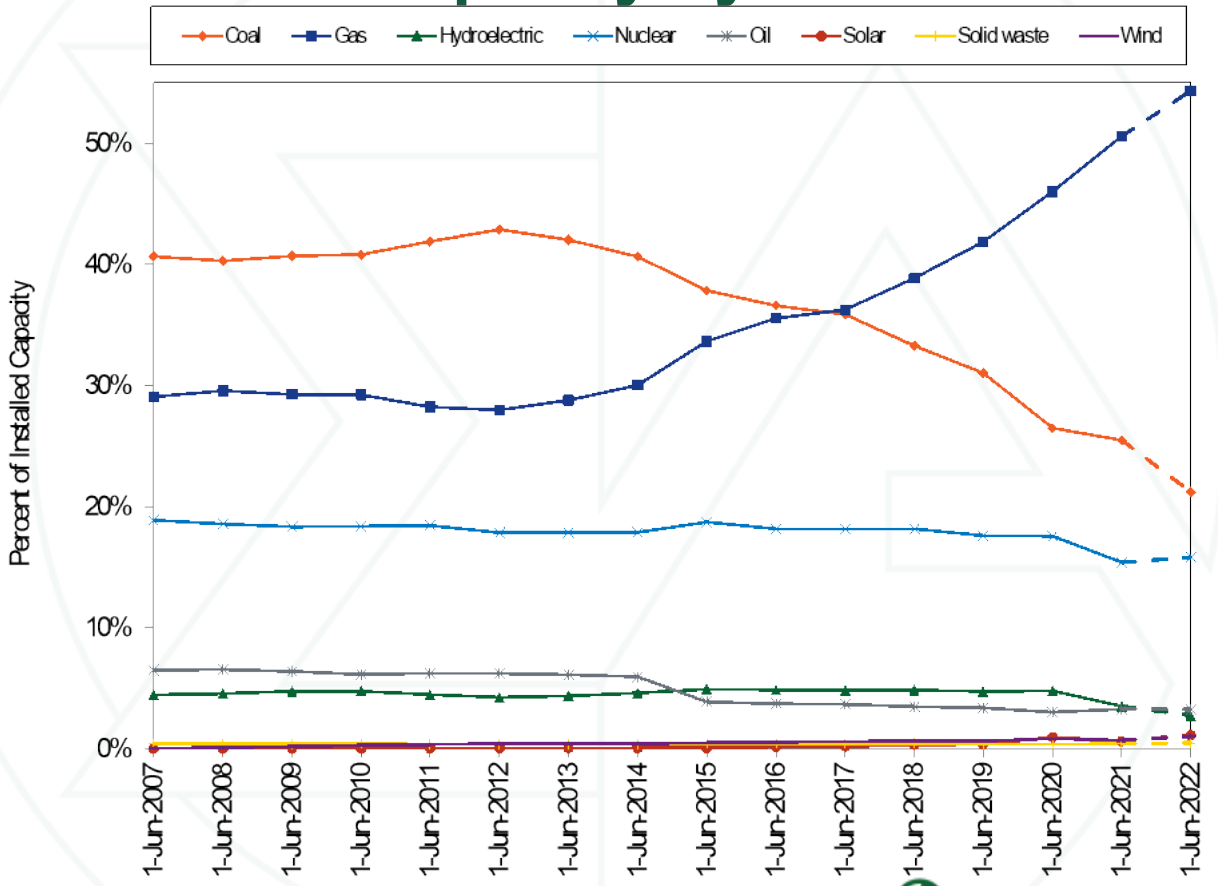
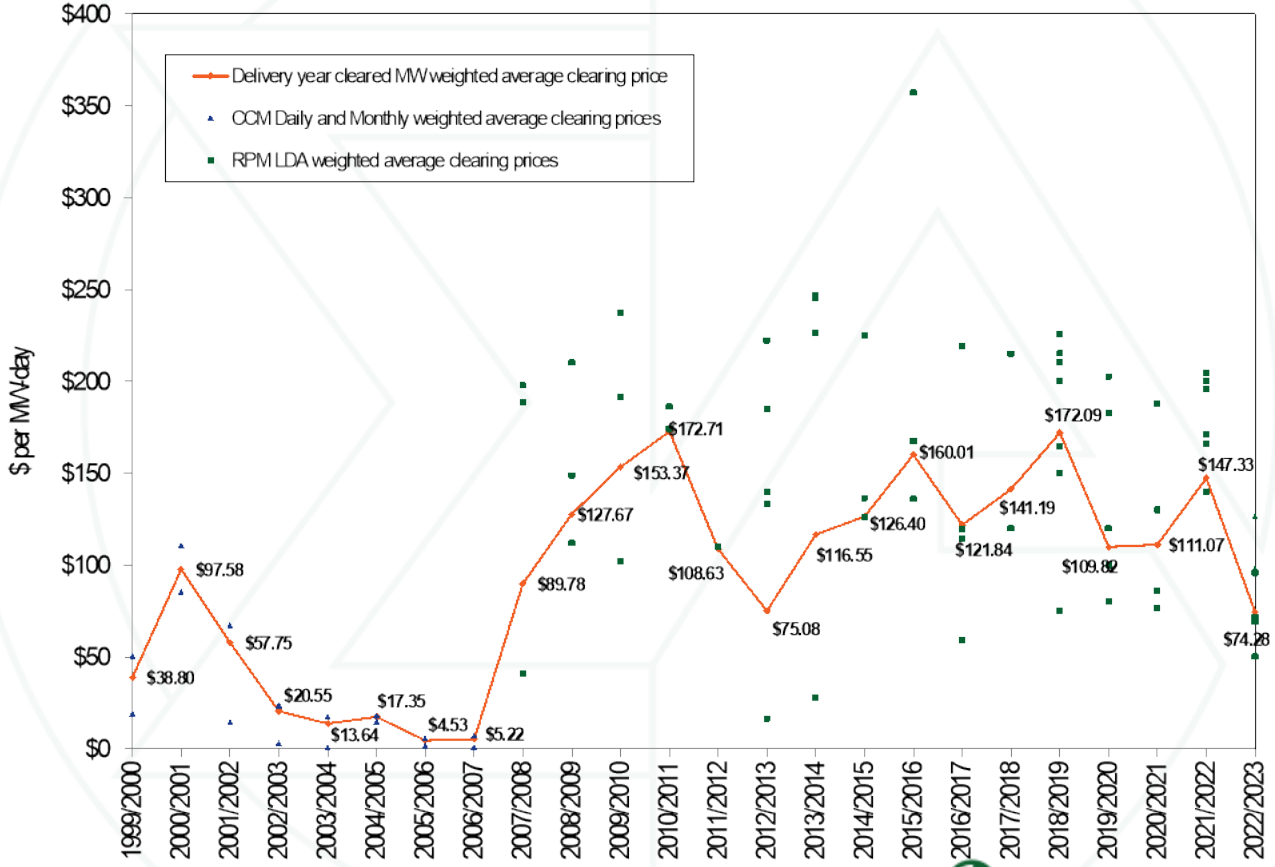
Installed capacity by fuel source



History of capacity prices



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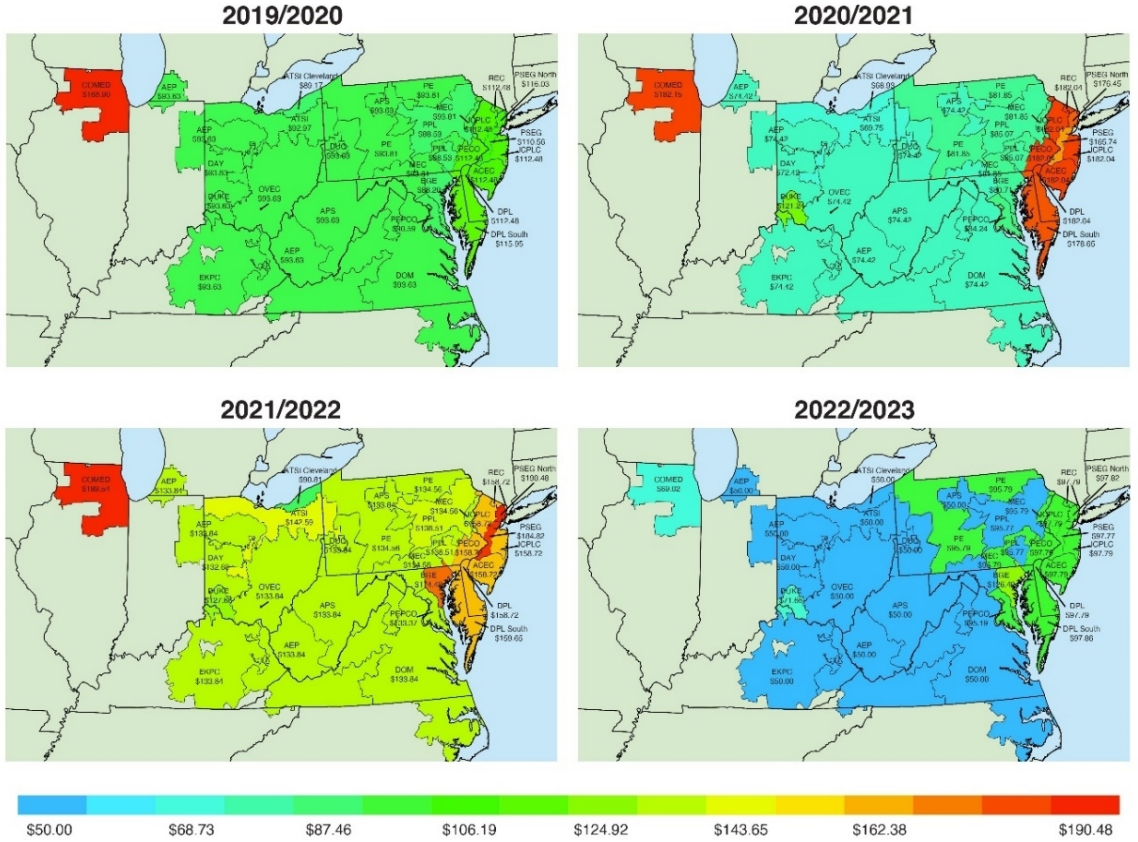
Map of capacity prices



Reserve margin: 2022/2023 BRA Report

	01-Jun-18	01-Jun-19	01-Jun-20	01-Jun-21	01-Jun-22	
Forecast peak load ICAP (MW)	152,407.9	151,643.5	148,355.3	149,482.9	150,229.0	A
FRR peak load ICAP (MW)	12,732.9	12,284.2	11,488.3	11,717.7	28,535.5	B
PRD ICAP (MW)	0.0	0.0	558.0	510.0	230.0	C
Installed reserve margin (IRM)	16.1%	16.0%	15.5%	14.7%	14.5%	D
Pool wide average EFORd	6.07%	6.08%	5.78%	5.22%	5.08%	E
Forecast pool requirement (FPR)	1.0905	1.0895	1.0882	1.0871	1.0868	F=(1+D)*(1-E)
RPM committed less deficiency UCAP (MW) (generation and DR)	161,242.6	162,276.1	159,560.4	156,633.6	139,666.7	G
RPM committed less deficiency ICAP (MW) (generation and DR)	171,662.5	172,781.2	169,348.8	165,260.2	147,141.5	H=G/(1-E)
RPM peak load ICAP (MW)	139,675.0	139,359.3	136,309.0	137,255.2	121,463.5	J=A-B-C
Reserve margin ICAP (MW)	31,987.5	33,421.9	33,039.8	28,005.0	25,678.0	K=H-J
Reserve margin (%)	22.9%	24.0%	24.2%	20.4%	21.1%	L=K/J
Reserve margin in excess of IRM ICAP (MW)	9,499.8	11,124.4	11,911.9	7,828.5	8,065.8	M=K-D*J
Reserve margin in excess of IRM (%)	6.8%	8.0%	8.7%	5.7%	6.6%	N=M/J
RPM peak load UCAP (MW)	131,196.7	130,886.3	128,430.3	130,090.5	115,293.2	P=J*(1-E)
RPM reliability requirement UCAP (MW)	152,315.6	151,832.0	148,331.5	149,210.1	132,006.5	Q=J*F
Reserve margin UCAP (MW)	30,045.9	31,389.8	31,130.1	26,543.1	24,373.5	R=G-P
Reserve cleared in excess of IRM UCAP (MW)	8,927.0	10,444.1	11,228.9	7,423.5	7,660.2	S=G-Q
Projected replacement capacity UCAP (MW)	0.0	0.0	0.0	0.0	0.0	T
Projected reserve margin	22.9%	24.0%	24.2%	20.4%	21.1%	U=(H-T/(1-E))/J-1

Reserve margin (2022/2023 BRA Report)

- Total reserves: 24,373.5 MW
- Excess reserves: 7,660.2
- Cleared DR: 8,710.3 MW
  - > Excess reserves
- Cleared capacity with no must offer requirement: 8,113.0 MW
  - > Excess reserves
- Sum of DR and no must offer: 16,823.3 MW
  - > Required reserves
  - 69.0 percent of total reserves

Effective capacity in queues (12.31.2021)

Unit Type	MW in Queue	Completion Rate Adjusted MW in Queue	Completion Rate and Derate Adjusted MW in Queue
Battery	38,301.5	1,460.5	1,460.5
CC	18,707.9	11,128.3	11,128.3
CT - Natural Gas	5,828.3	4,025.0	4,025.0
CT - Oil	17.0	13.2	13.2
CT - Other	396.6	33.3	33.3
Fuel Cell	8.0	2.5	2.5
Hydro - Pumped Storage	730.0	707.2	707.2
Hydro - Run of River	124.9	56.8	56.8
Nuclear	189.5	73.8	73.8
RICE - Natural Gas	14.4	3.7	3.7
RICE - Oil	0.0	0.0	0.0
RICE - Other	0.0	0.0	0.0
Solar	118,957.0	16,424.1	7,670.1
Solar + Storage	31,628.6	618.6	288.9
Solar + Wind	209.0	0.0	0.0
Steam - Coal	76.0	25.9	25.9
Steam - Natural Gas	11.0	10.0	10.0
Steam - Oil	0.0	0.0	0.0
Steam - Other	20.0	5.4	5.4
Wind	39,588.7	6,485.9	1,050.7
Wind + Storage	106.3	0.0	0.0
Total	254,914.6	41,074.4	26,555.3

Proportion of units recovering avoidable costs

Technology	Units with full recovery from energy and ancillary net revenue											Units with full recovery from all markets										
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
CC - Combined Cycle	55%	46%	50%	72%	59%	63%	57%	66%	64%	67%	50%	85%	79%	79%	95%	88%	93%	89%	98%	90%	93%	83%
CT - Aero Derivative	15%	6%	6%	53%	15%	8%	10%	30%	46%	42%	2%	100%	96%	76%	98%	100%	99%	100%	99%	96%	96%	89%
CT - Industrial Frame	26%	23%	17%	38%	13%	8%	3%	21%	30%	21%	2%	99%	98%	83%	100%	100%	100%	100%	96%	92%	86%	84%
Coal Fired	31%	17%	27%	78%	16%	15%	12%	11%	2%	2%	22%	82%	36%	54%	83%	64%	40%	36%	63%	31%	5%	66%
Diesel	48%	42%	37%	69%	56%	33%	32%	39%	11%	37%	25%	100%	100%	77%	100%	100%	100%	100%	97%	91%	89%	83%
Hydro	74%	61%	95%	97%	81%	79%	95%	94%	90%	72%	95%	81%	77%	97%	98%	100%	100%	97%	98%	100%	74%	95%
Nuclear	-	-	50%	94%	17%	6%	17%	53%	0%	0%	88%	-	-	61%	100%	56%	17%	50%	88%	81%	0%	100%
Oil or Gas Steam	8%	6%	11%	15%	3%	0%	0%	10%	73%	6%	10%	92%	78%	86%	85%	91%	88%	81%	76%	66%	34%	67%
Pumped Storage	100%	100%	95%	100%	100%	100%	100%	100%	100%	100%	29%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Solar	-	95%	97%	99%	97%	95%	95%	98%	96%	95%	100%	-	95%	97%	99%	97%	95%	95%	98%	96%	95%	100%
Wind	88%	85%	96%	93%	92%	89%	93%	91%	88%	79%	94%	88%	85%	96%	93%	92%	89%	93%	91%	89%	79%	95%

New entrant CC net revenue and total cost

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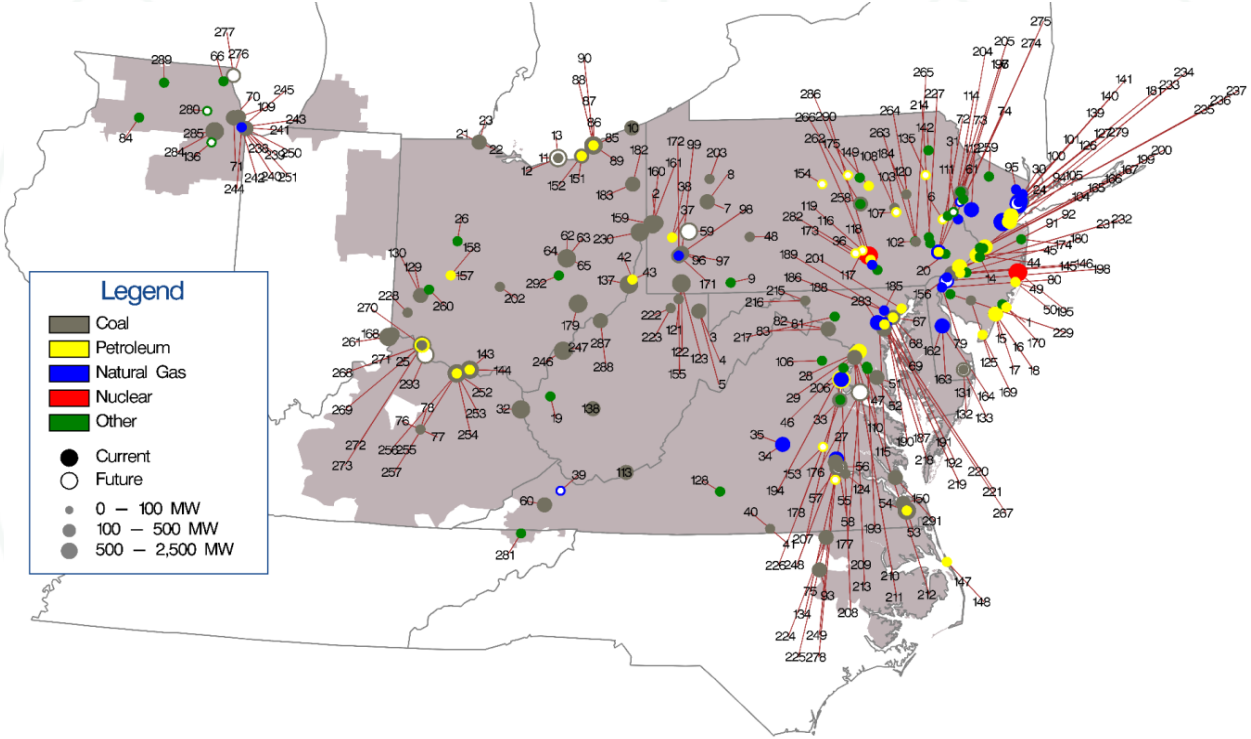
Map of unit retirements: 2011 - 2024



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