How Generation Dispatch Affects My Industry

Perspectives from Keystone, Conemaugh (KEY-CON) and Cheswick Generating Stations

Presentation to the AQTAC – December 10, 2020

Presenters

John Shimshock – Environmental Specialist – Conemaugh Station and AQTAC
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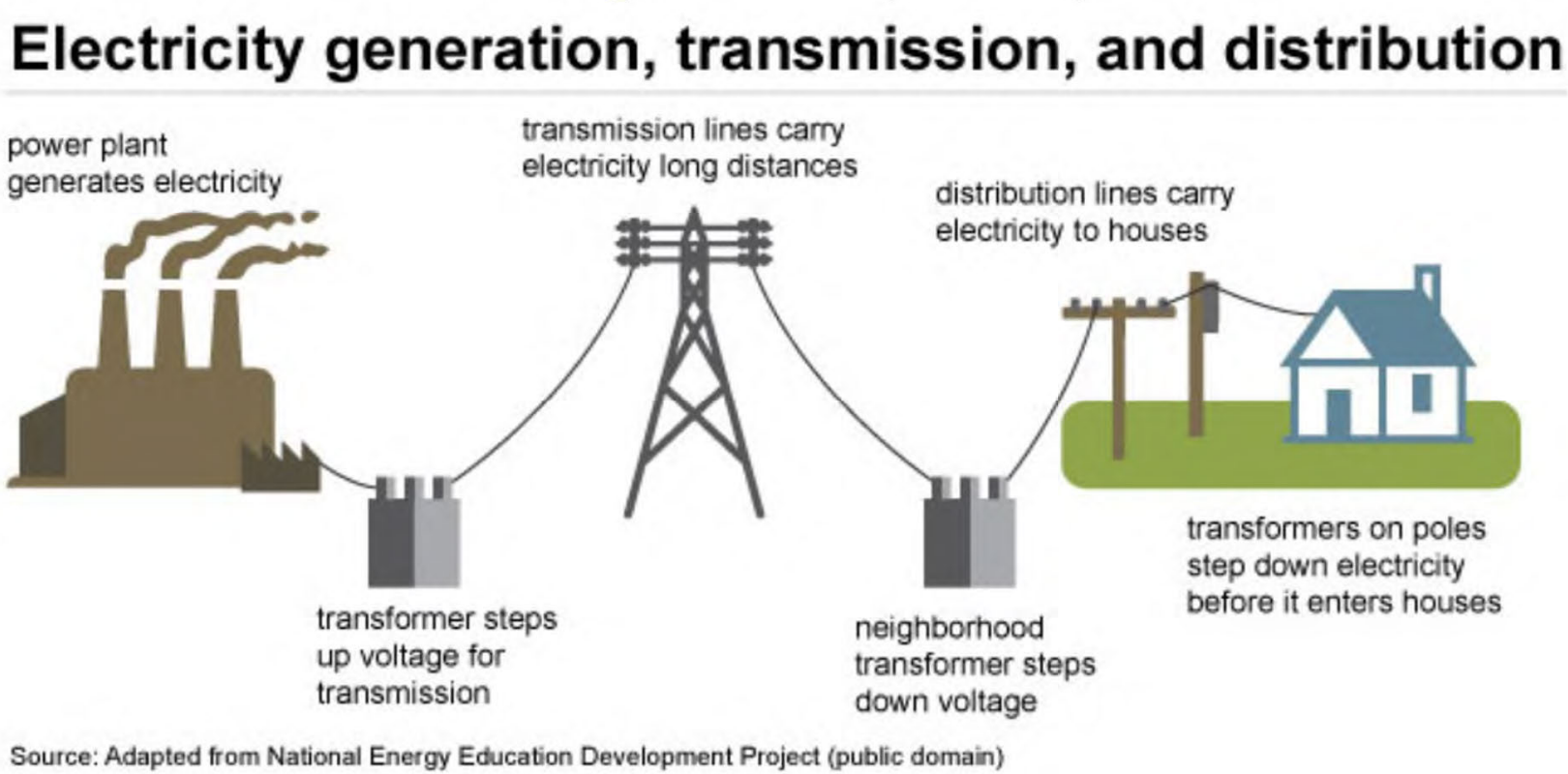
Kevin Panzino, P.E. – Plant Manager – Cheswick Station

Outline

1. Overview of the stations
2. Differences between capacity and energy markets
3. Recent generation trends
4. Summary of future challenges (environmental and non-environmental)

Bulk Electric System (BES) -



Electricity is generated at power plants and moves through a complex system ("electric grid") of electricity substations, transformers, and power lines that connect electricity producers and consumers. The stations are electricity producers ("generator").

PJM is the RTO that coordinates the movement of wholesale electricity –
PJM's Mission: provide "reliable electric service at the lowest possible cost"

Conemaugh Station – Indiana County, PA
(looking toward the west)
~160 FTEs, excludes contractors (avg. ~ 85 / weekday) and suppliers
Highly technical jobs – well trained in engineering / physics / technical service disciplines, military veterans w/ specialized experience

GROUND BROKEN: July 13, 1966

COMMERCIAL OPERATION: Unit 1 - May 21, 1970;
Unit 2 - May 27, 1971

FGD SCRUBBER OPERATION: Unit 1 - December 18, 1994; Unit 2 - November 18, 1995

FGDS MODIFICATIONS: Unit 1-Fall 2014;
Unit 2-Spring 2013

SCR OPERATION: Tie-in on both units - November 2014

PLANT INVESTMENT: $254.2 million

FGD INVESTMENT: $330 million

FGD MODIFICATION INVESTMENT: $41 million

SCR INVESTMENT: $372 million

CAPACITY: 1,700,000 kilowatts from two identical units
(850,000 kilowatts per unit)
Sufficient to light 17,000,000 lamps (100 watts each)

Keystone Station – Armstrong County, PA
(looking toward the northeast)
~160 FTEs, excludes contractors (avg. ~ 85 / weekday) and suppliers
Highly technical jobs – well trained in engineering / physics / technical service disciplines, military veterans w/ specialized experience

GROUND BROKEN: November 1964

COMMERCIAL OPERATION: Unit #1 Aug. 24, 1967/Unit #2 July 23, 1968

SCR OPERATION: 2003

FGDS SCRUBBER OPERATION: 2009

CAPACITY: The station produces 1,700,000 kilowatts from two identical units for the PJM interconnection.

Cheswick Station – Allegheny County, PA

(looking toward the north)

56 FTEs, excludes contractors and suppliers

Highly technical jobs – well trained in engineering / physics / technical service disciplines, military veterans w/ specialized experience

GROUND BROKEN: August 1967

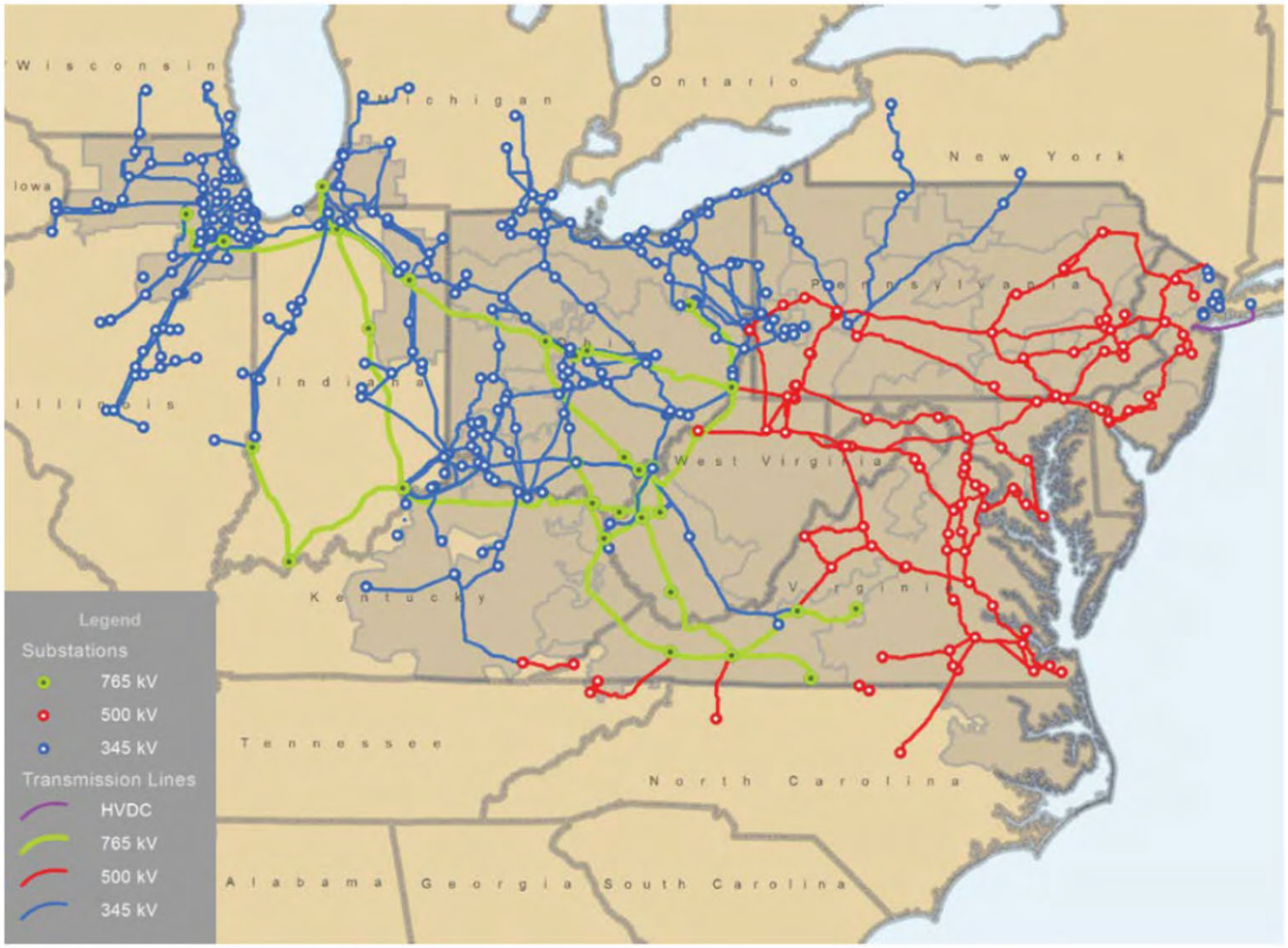
COMMERCIAL OPERATION: June 1970

SCR OPERATION: $56milion, 2003

FGD SCRUBBER OPERATION: **$**328 Million, 2009

CAPACITY: The station produces 565,000 kilowatts from a single unit for the PJM interconnection.

PJM Service Territory – All or portions of PA, NJ, DE, MD, VA, WV, NC, KY, OH, IL, IN, MI
Merchant plants in deregulated competitive market of fossil, nuclear, and renewables sources.

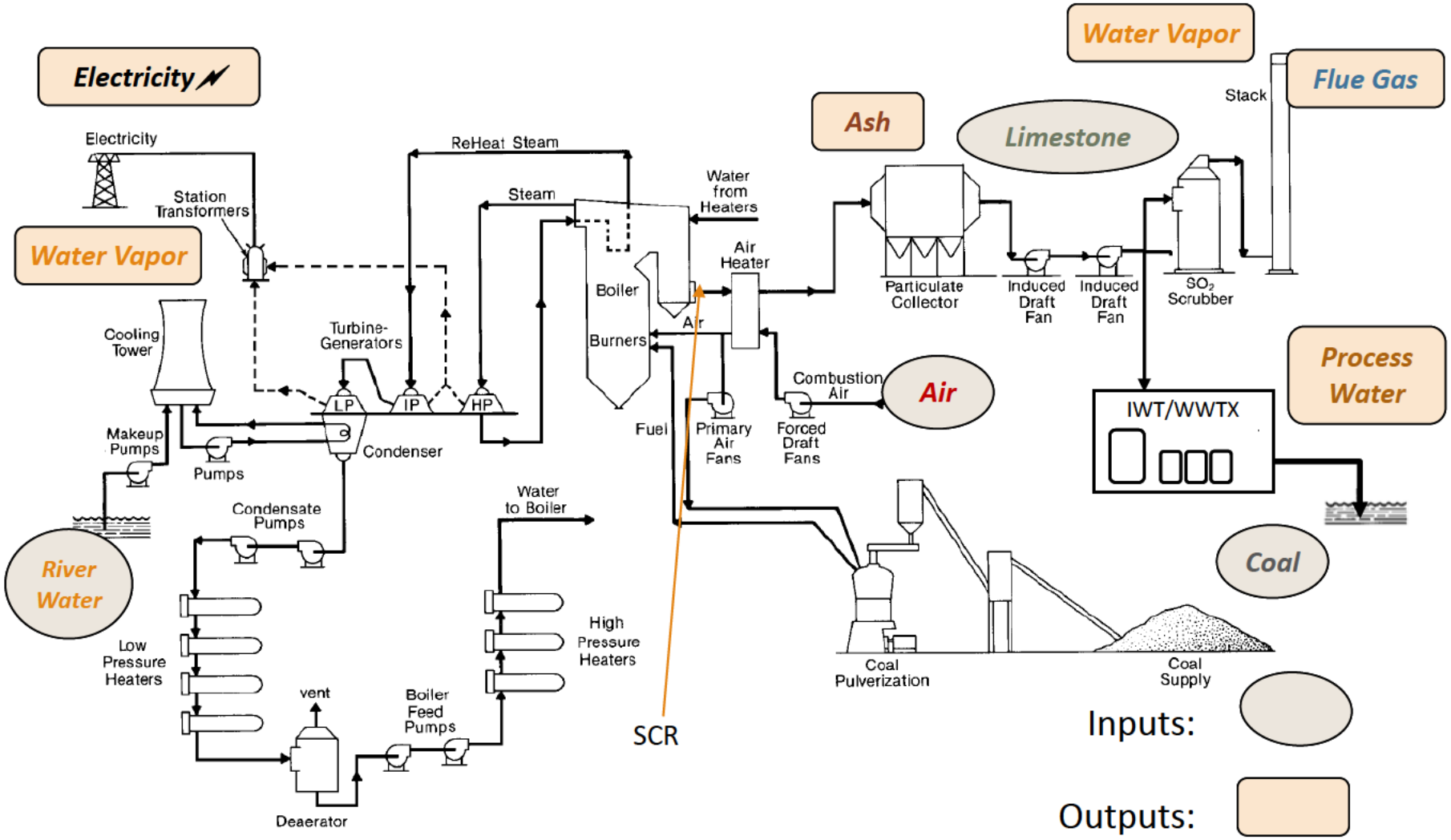


The electric grid does not have borders - power can be delivered from any part of the system barring any transmission constraints. However, individual state policies have a significant impact on generator location, which is also dependent on the legacy BES development (largely performed while stations were part of an integrated electric utility), access to fuel, water and high voltage transmission lines, land use / zoning laws and population density.

Public Notion of Working in a Coal-Fired Electric Generating Station?

Simplified Electric Generation Process Diagram

Nearly all operations are automated and computer-controlled



Pop quiz – what's the difference between a megawatt (MW) and a megawatt-hour (MWh)?

Parameter	Definition	Car Analogy
Megawatt (MW)	Rate of energy production 1 Watt = 1 Joule/sec Mega = 1,000,000 1 MW = 1,000,000 J/sec	Speedometer / capacity
Megawatt-hour (MWh)	Measure of electrical energy produced or consumed 1 MWh = amount of energy produced by a 1 MW generator operating for 1 hour 1 MWh = 1,000,000 (J/sec)-hr Gross MWh = total energy generated Net MWh = Gross MWh – station service (need electricity to run the station)	Vehicle miles driven ➢ EPA metric ➢ PJM and DOE-EIA metric

MWh (electricity supplied to the grid) is much more important than capacity -
In the energy market, generators are paid in proportion to MWh supplied to the grid.
Conversely, consumers are billed based on KWh used.

2. Difference between PJM's capacity market and energy market

- **Capacity Market** – competitive (bid) market designed to secure that adequate power supplies are and will be available for up to three years to meet peak demand

  Bids are submitted annually, and clearing prices based on $ / MW-day. Generators that cleared the capacity market auction for the June 2020 – May 2021 delivery year are paid $86.04 / MW-day (subject to availability) – more later.

  Example: 1,000 MW generator could realize capacity payment = $31 MM. Funds used for construction debt payment (new units) or routine replacement of equipment or environmental projects (existing units)

- **Energy Market** – competitive (bid) market designed to secure enough power for the following day (day-ahead market). Generators who clear the auction are paid in accordance with the real-time market prices (variable, red or black $)

  Example: 1,000 MW coal-fired generator operating at annual capacity factor = 75% could realize earnings = $33 MM (@ $5 / MWh margin)

  Example: 1,000 MW coal-fired generator operating at annual capacity factor = 15% could realize earnings = $7 MM (@ $5 / MWh margin)

What factors determine a generator's bid price ($ / MWh or $ / MW-day)?

1. Cost to generate a unit amount of heat ($ / MMBtu)
   - Fossil-fueled units, fuel ~ 80% of this cost
   - Labor and non-fuel O&M ~ 20% of this cost

2. Efficiency of converting heat into electricity
   - Expressed as "heat rate" Btu / KWh of electricity generated
   - Some generation is used for station service (gross vs. net generation)
   - EPA's New Source Review (NSR) regulations are a deterrent to stationary sources who wish to make significant efficiency improvements (some at EPA now understand this problem)

Generators with the lowest fuel and VOM costs and lowest heat rate have the lowest bid price.

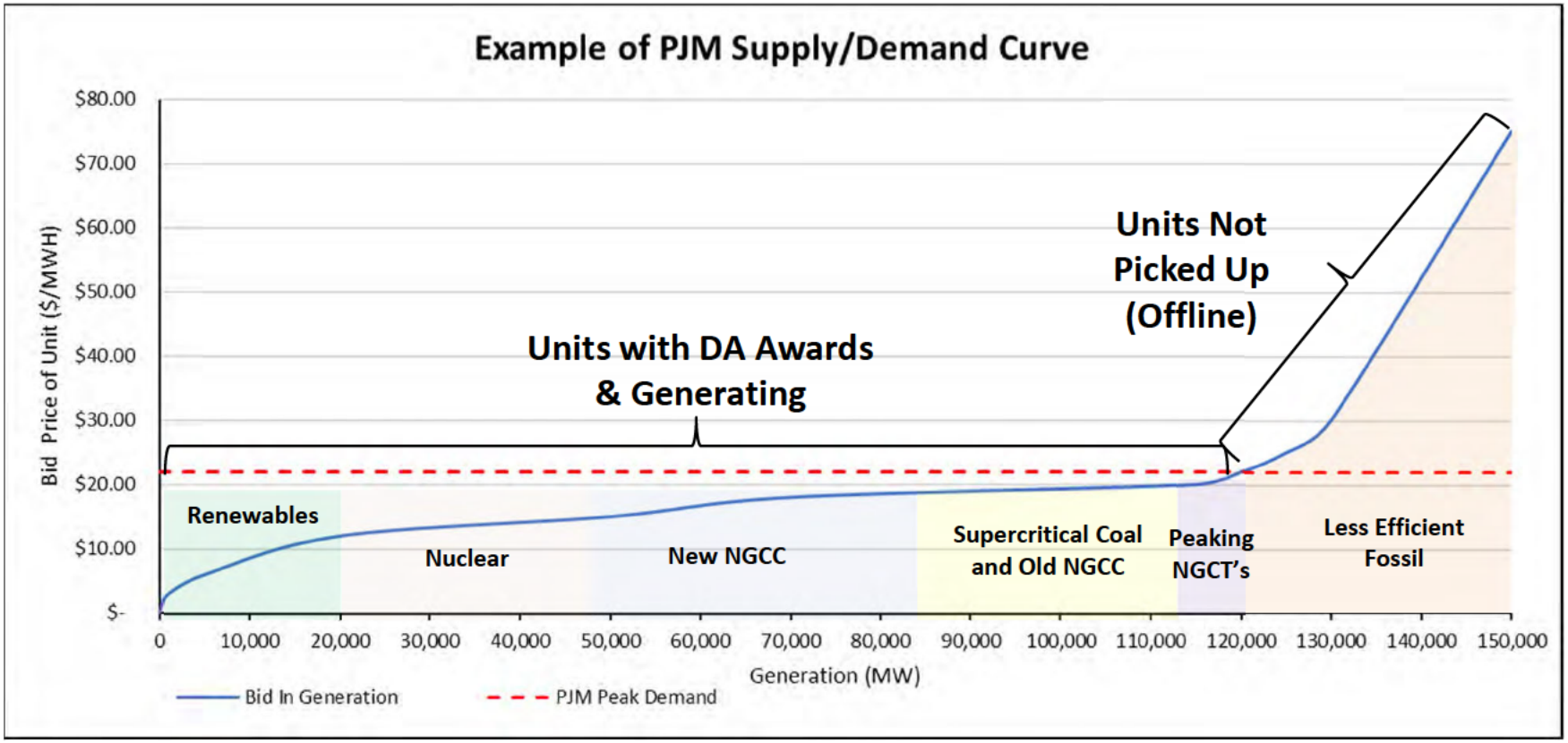
<u>IMPORTANT</u> - Federal regulations govern how bid prices are to be calculated, Discounting / sales / market manipulation are illegal (PJM Market Monitor oversight)

More about thermal efficiency –

Typical thermal efficiencies (% of fuel energy converted to useful power)

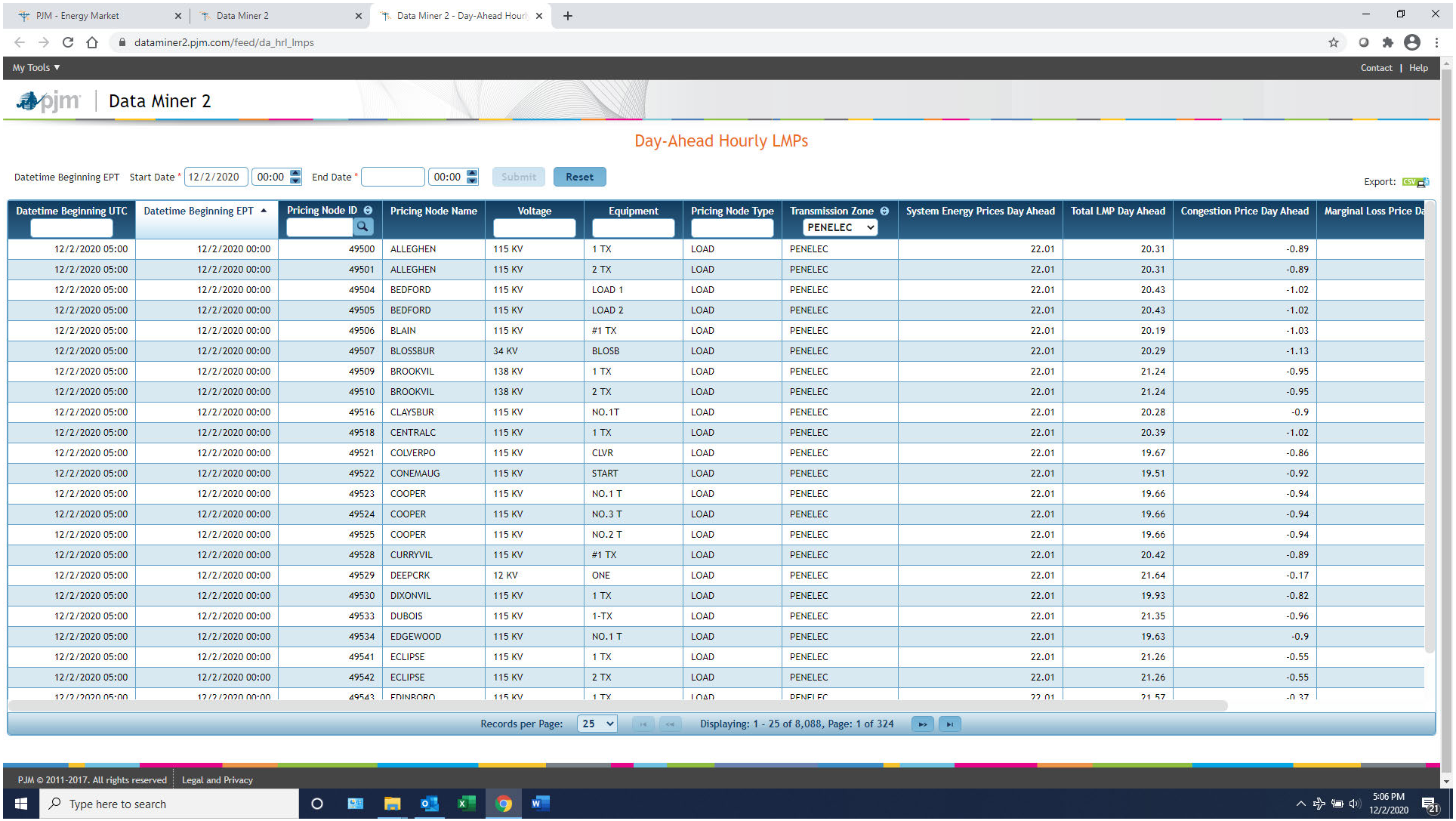
- KEY-CON and Cheswick 34.5% - 37%
- 1985 Chevy Caprice 18%
- 2010 Toyota Camry 25%
- 2020 Ford 150 Pickup, EcoBoost Engine 27%
- 2020 Ford Fusion, EcoBoost Engine 33%
- 2020 Toyota Prius, Hybrid 40% (#1 in the world)

Ford EcoBoost engine = turbocharged, direct-injection gasoline engine,
~ 30% increase in fuel efficiency as compared with non-turbocharged engines



PJM has a stack of units sorted from lowest to highest cost of production who bid into the Day Ahead Market. The lowest cost units are called upon first and PJM moves up the list until the day's electric demand is met. Many units are not awarded Day Ahead generation and remain shutdown most days.

Day-ahead energy market clearing price PJM 12/02/2020 = $22.01 / MWh



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Day-Ahead Hourly LMPs

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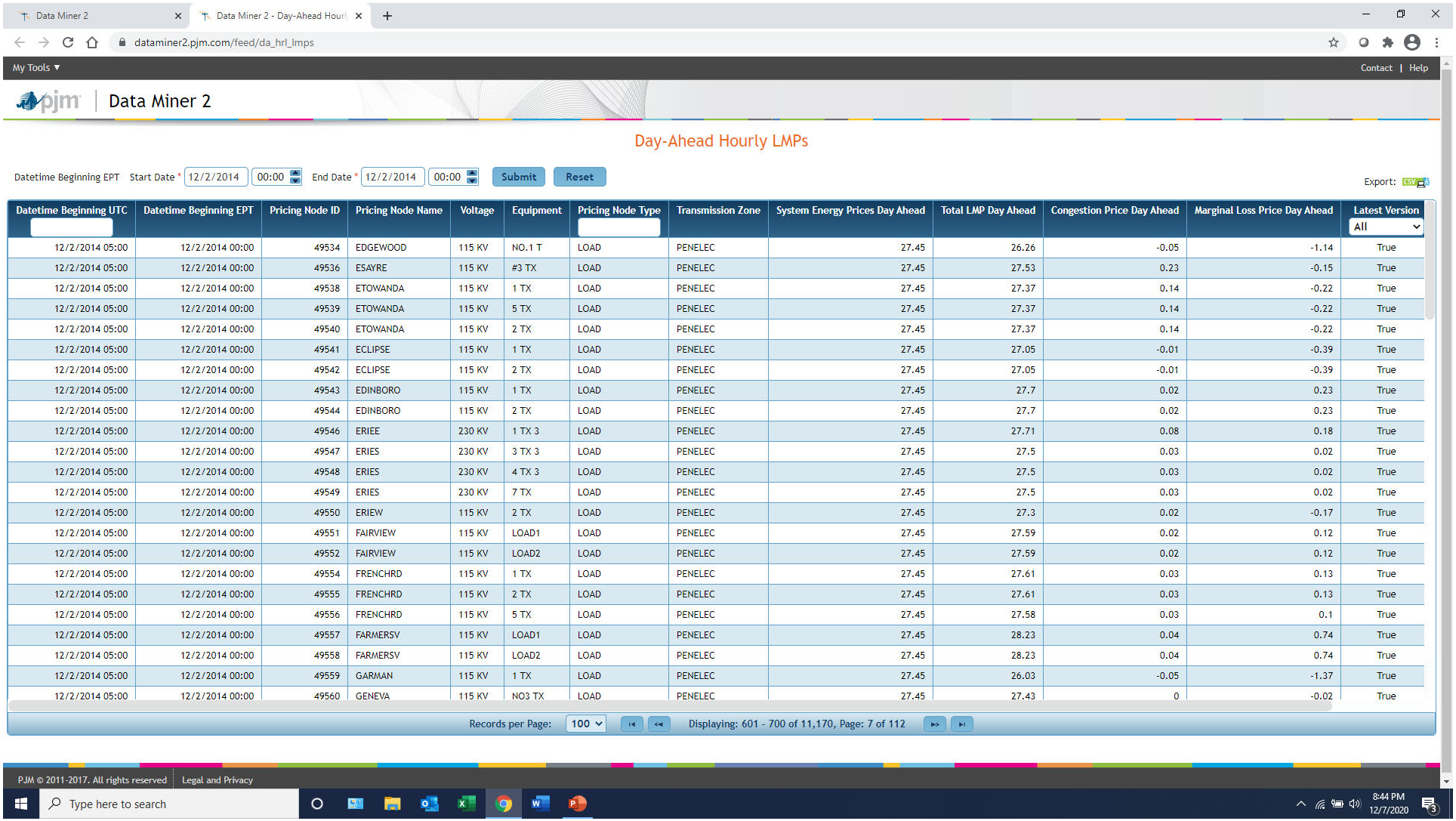
Day-ahead energy market clearing price PJM 12/02/2014 = $27.45 / MWh (25% higher than $22.01 / MWh)



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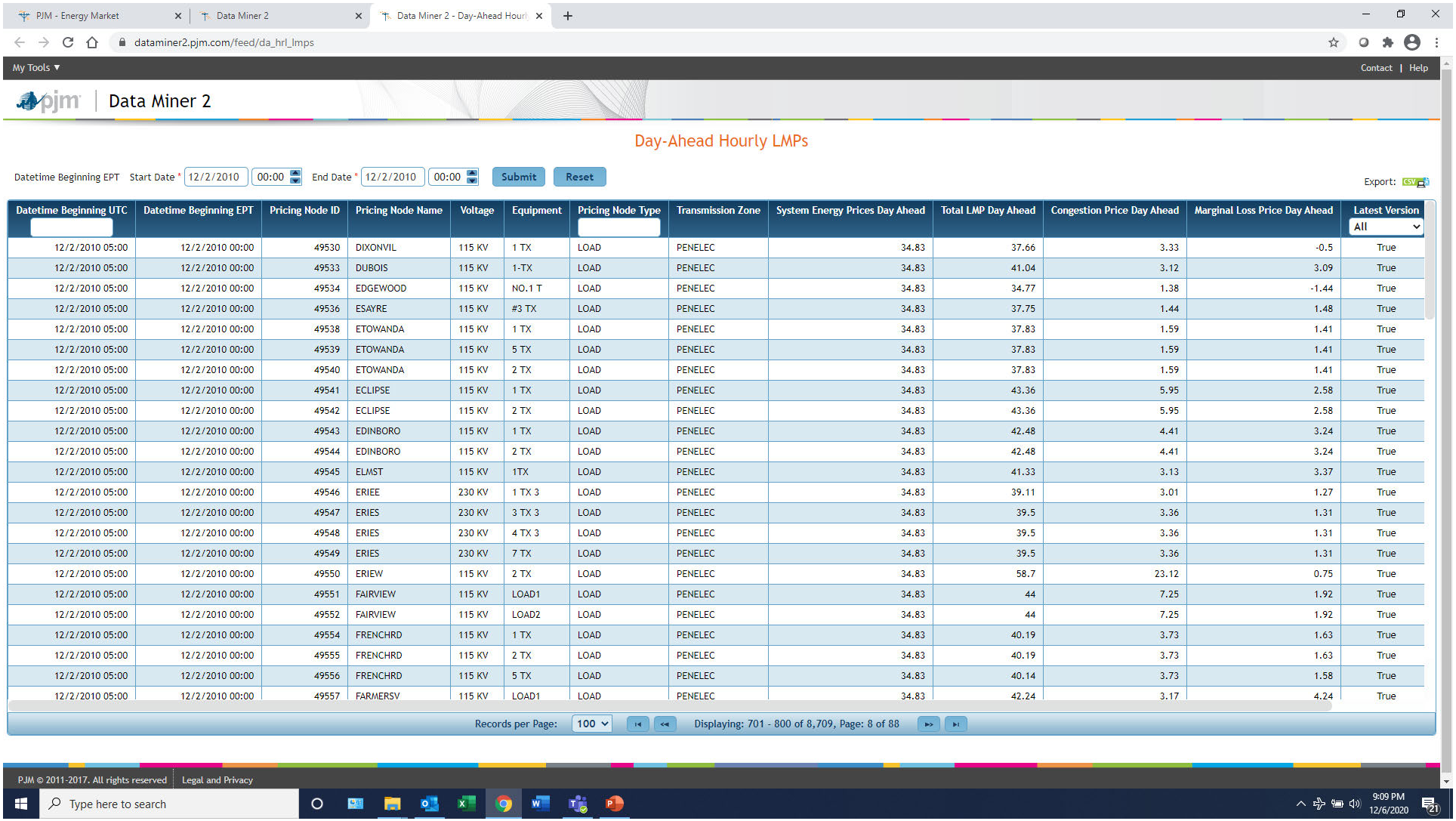
Day-ahead energy market clearing price PJM 12/02/2010 = $34.83 / MWh (58% higher than $22.01 / MWh)



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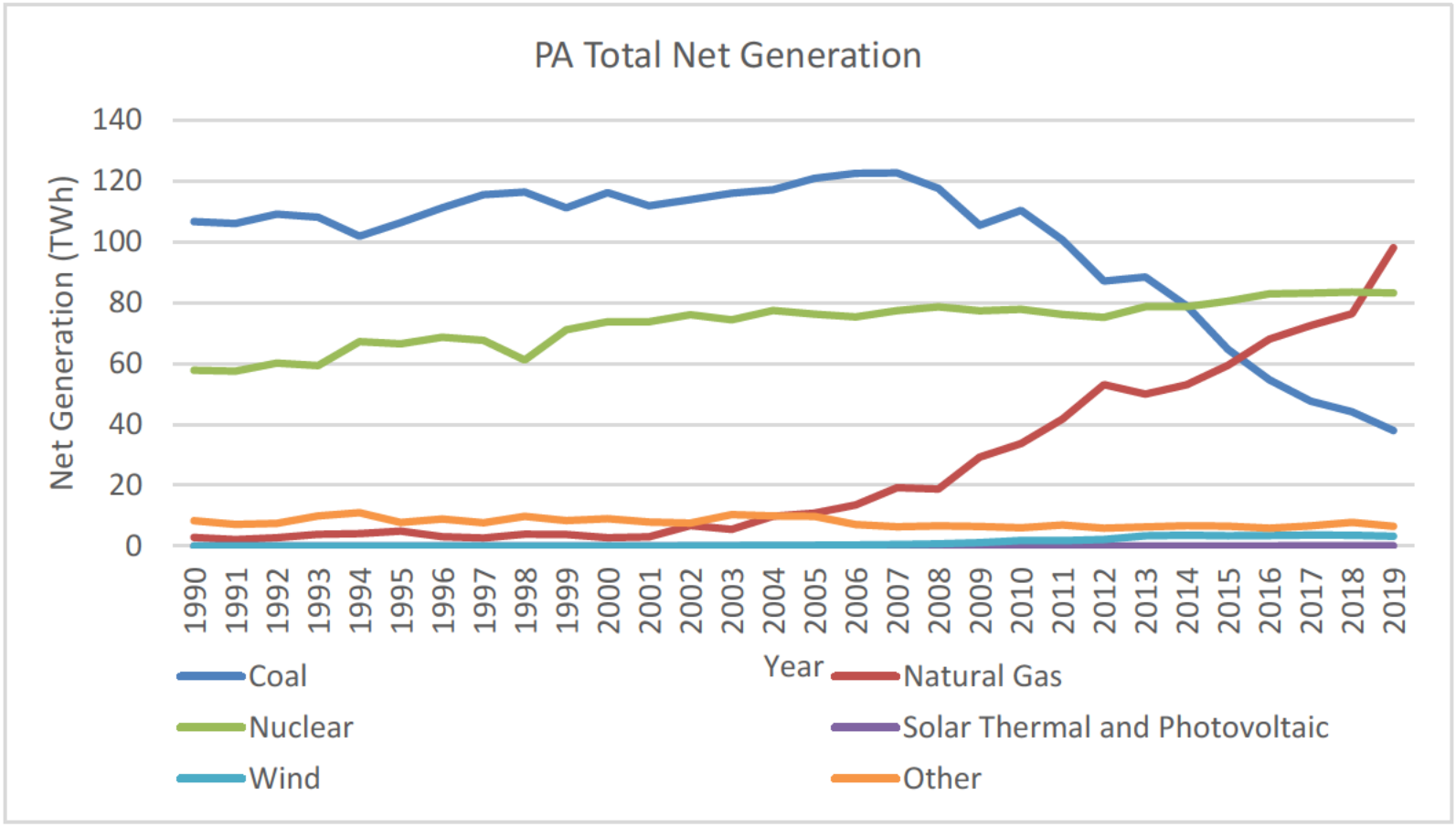
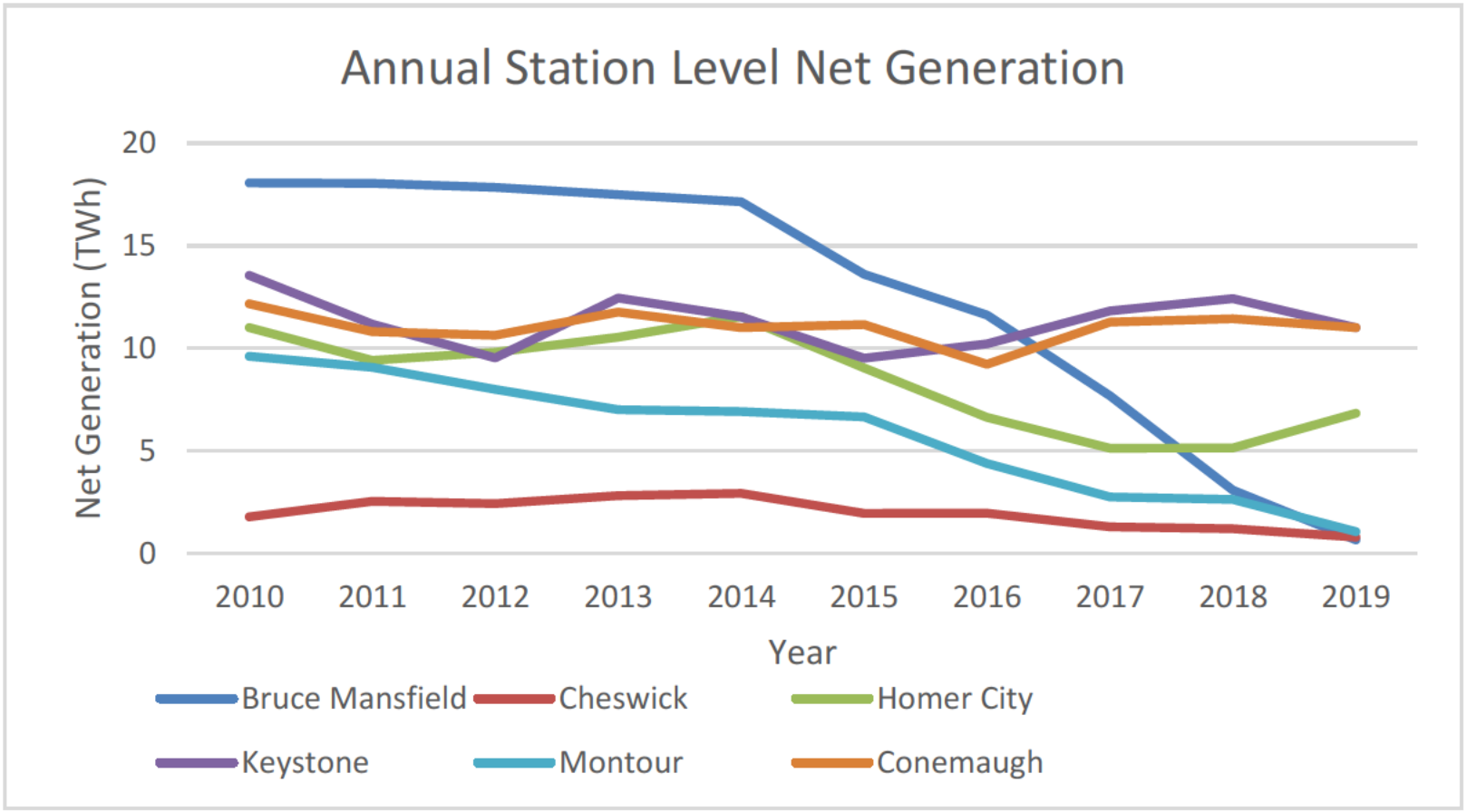
3. Recent Generation Trends - Important to distinguish between actual generation (TWh, i.e., performance) vs. installed capacity (MW, potential)

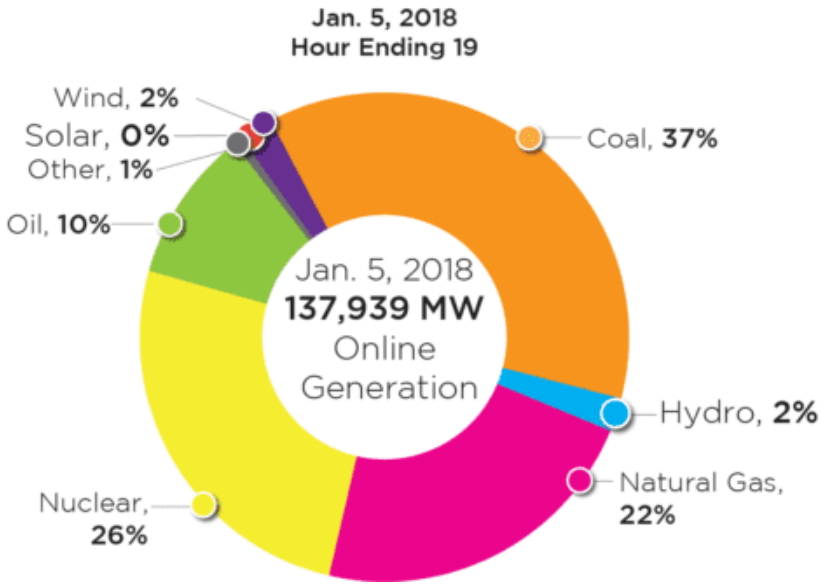


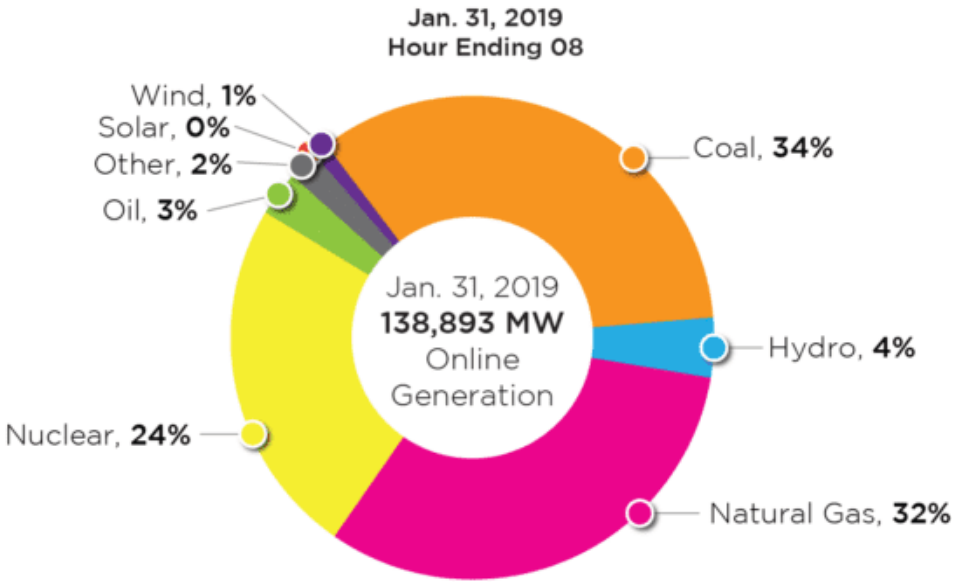
U.S. DOE Official, circa 2000: "Using natural gas to generate electricity is akin to using good Scotch to wash the dishes" (natural gas price then ~ $15 / MCF, now ~ $2 / MCF)



PA pulverized coal-fired electric generating stations (excludes waste coal units)

Despite the recent trends, depending on residential and commercial heating needs (natural gas suppliers are required to service these customers first, followed by industrial customers), coal-fired generation in PJM can exceed natural gas-fired and nuclear generation.

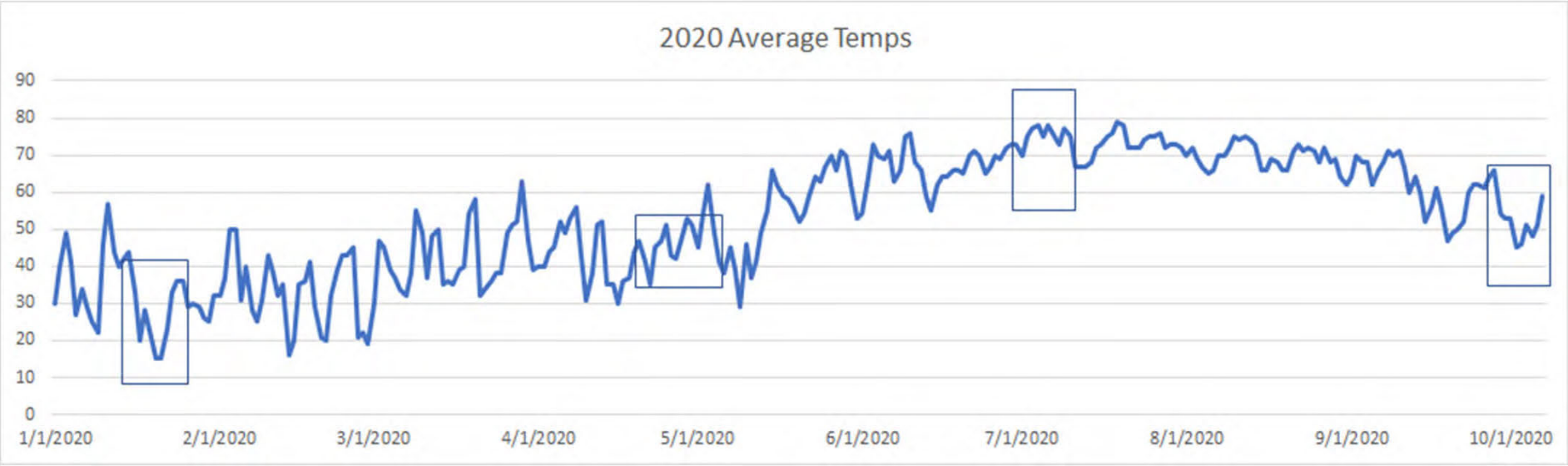




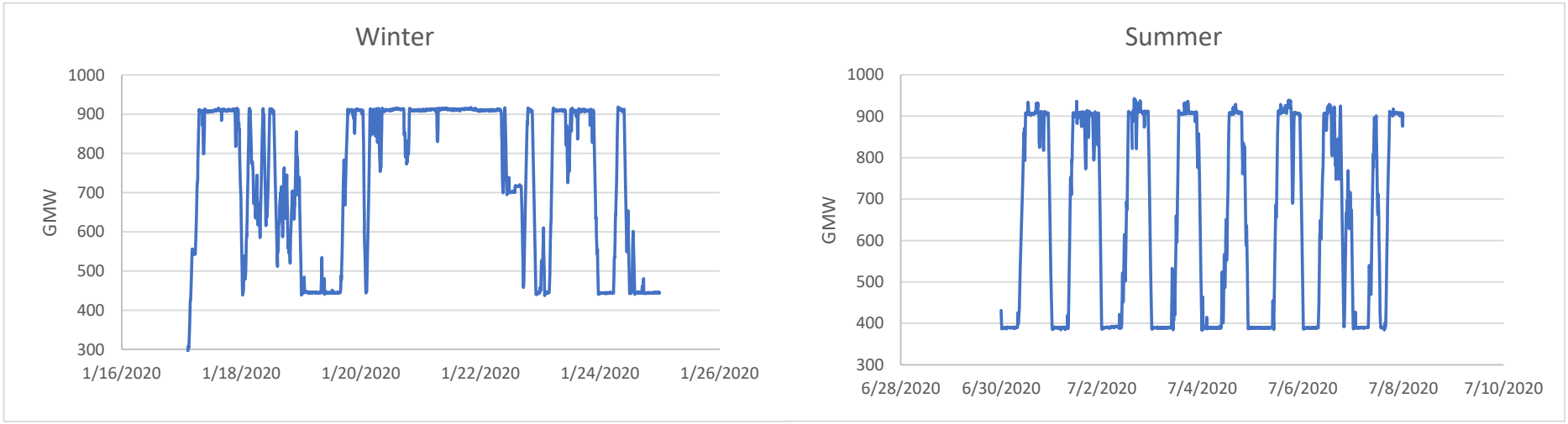
A Deeper Drive into Recent Generation Trends –

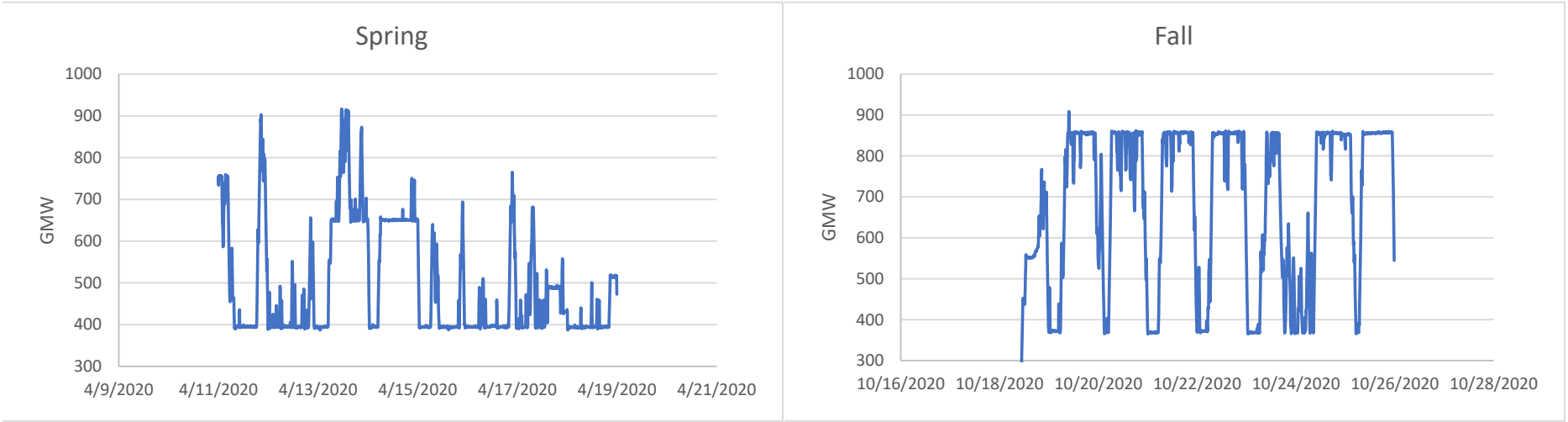
Recent Hourly Dispatch Trend for Conemaugh Unit 1 –
4 seasonal periods in CY 2020 –

1. Winter – cold snap
2. Spring – typical season
3. Summer – heat wave
4. Fall – typical season



Highly variable dispatch trend – all dictated by PJM

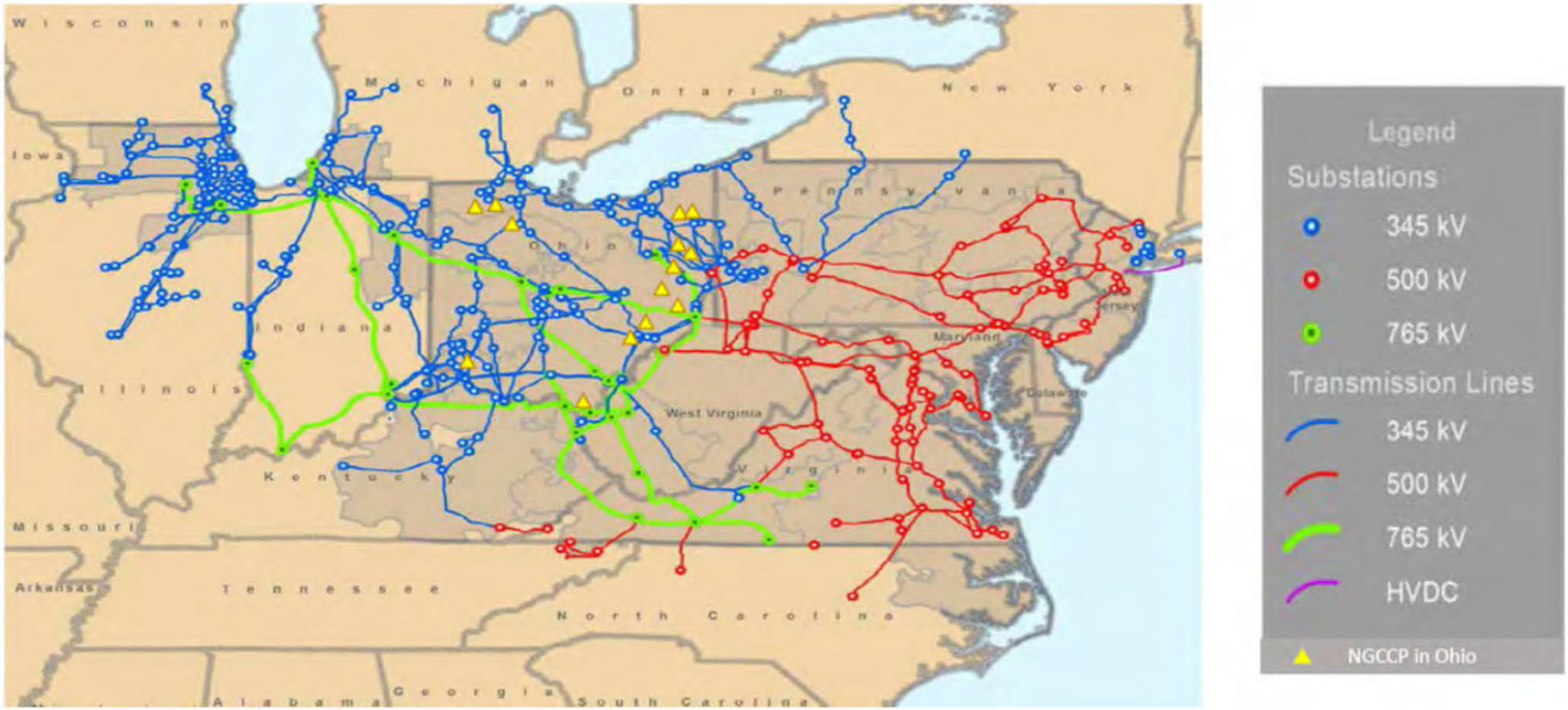




4. Future Challenges (environmental and non-environmental)

(a) Generation clearing prices (record lows) and new entries into the market

Please note number of newly permitted and constructed natural gas electric generating stations located in Ohio (▲) and their proximity to PJM's high voltage transmission lines.



(b) PJM capacity market status

Delivery Year	Clearing Price	Comment
June 2000 – May 2021	$86.04 / MW-day	In-effect now
June 2021 – May 2022	$140 / MW-day	
June 2022 – May 2023	TBD	Auction delayed, was to occur in Spring 2019, now scheduled for May 2021
June 2023 – May 2024	TBD	Auction delayed, was to occur in Spring 2020, now scheduled for December 2021
June 2024 – May 2025	TBD	Auction initially scheduled for Spring 2021, now scheduled for June 2022

Why the auction delays? It's because of the FERC's MOPR order that at nearly all state-subsidized power resources (primarily nuclear and renewable resources), inside and outside PJM's footprint, must achieve a PJM-determined price floor to participate in PJM's forward-looking capacity auctions.

(c) Forthcoming non-air environmental regulations – especially applicable for wastewater discharges from flue gas desulphurization (FGD) systems

2020 Steam Electric Reconsidera

epa.gov/eg/2020-steam-electric-reconsideration-rule

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Effluent Guidelines

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  - Preliminary Plan 14 (2019)
  - Current Plan (2018)
- Implementation & Compliance
- Industrial Wastewater Treatment Technology Database

2020 Steam Electric Reconsideration Rule

Steam Electric Power Generating Effluent Guidelines

EPA, on August 31, 2020, finalized a rule revising the regulations for the Steam Electric Power Generating category (40 CFR Part 423). The rule revises requirements for two specific waste streams produced by steam electric power plants: flue gas desulfurization (FGD) wastewater and bottom ash (BA) transport water.

On this page:

- Background
- Webinar
- Affected Facilities
- Regulatory Requirements
- Final Rule
- Background Documents
- Related Rulemaking
- Additional Information

Background

The Rule includes many compliance options, including an option for units that cease coal combustion by December 31, 2028 (minimal requirements).

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(d) RGGI – the 800 lb gorilla in the room

RGGI price adders @ $7.41 / allowance (12/02/2020 RGGI auction clearing price)
1 allowance = 1 short ton CO2
Data compliments of Vince Brisini – Olympus Power

Facility Name	Facility ID (ORISPL)	Unit ID	Year	Gross Load (MW-h)	CO2 (short tons)	Heat Input (MMBtu)	Fuel Type (Primary)	RGGI Price Adder @$7.41/allowance ($/MWh net)
Cheswick	8226	1	2019	914,138	1,019,075	10,010,739	Coal	8.98
Homer City	3122	1	2019	2,487,061	2,526,819	24,627,892	Coal	8.18
Homer City	3122	2	2019	1,914,388	1,984,088	19,338,079	Coal	8.35
Homer City	3122	3	2019	3,142,921	3,151,884	30,720,108	Coal	8.08
Montour, LLC	3149	1	2019	445,268	440,498	4,293,340	Coal	7.97
Conemaugh	3118	1	2019	5,807,858	5,694,468	55,580,417	Coal	7.90
Conemaugh	3118	2	2019	6,004,754	5,764,802	56,233,721	Coal	7.73
Keystone	3136	1	2019	6,498,402	6,345,067	61,842,784	Coal	7.86
Keystone	3136	2	2019	5,377,298	5,181,173	50,498,750	Coal	7.76
Montour, LLC	3149	2	2019	762,061	710,178	6,921,809	Coal	7.51

In a market with day-ahead clearing prices ~ $22 / MWh, a $7.50 - $9 / MWh price adder > typical margins ($5 / MWh)
for coal-fired generators will price those units out of the market on nearly all days in the year. Consequently, those units will undoubtedly file for deactivation with PJM and, upon PJM approval (few months review process), retire.

RGGI price adders @ $7.41 / allowance (12/02/2020 RGGI auction clearing price)
1 allowance = 1 short ton CO2
Data compliments of Vince Brisini – Olympus Power

Facility Name	Facility ID (ORISPL)	Unit ID	Year	Gross Load (MW-h)	CO2 (short tons)	Heat Input (MMBtu)	Fuel Type (Primary)	
Helix Ironwood LLC	55337	1	2019	1,692,362	1,089,754	18,337,205	Pipeline Natural Gas	5.08
Helix Ironwood LLC	55337	2	2019	1,603,606	1,041,455	17,524,534	Pipeline Natural Gas	5.12
Hunterstown Combined Cycle	55976	CT101	2019	1,300,554	821,681	13,826,379	Pipeline Natural Gas	4.98
Hunterstown Combined Cycle	55976	CT201	2019	1,282,533	812,169	13,666,268	Pipeline Natural Gas	4.99
Hunterstown Combined Cycle	55976	CT301	2019	1,294,372	828,499	13,941,064	Pipeline Natural Gas	5.05
Liberty Electric Power Plant	55231	1	2019	1,275,371	850,984	14,319,538	Pipeline Natural Gas	5.26
Liberty Electric Power Plant	55231	2	2019	1,281,133	853,069	14,354,593	Pipeline Natural Gas	5.25
Springdale Generating Station (55196)	55196	1	2019	62,692	37,347	628,459	Pipeline Natural Gas	4.70
Springdale Generating Station (55196)	55196	2	2019	62,537	36,867	620,350	Pipeline Natural Gas	4.65
Springdale Generating Station (55710)	55710	4	2019	1,497,317	879,523	14,799,652	Pipeline Natural Gas	4.63
Springdale Generating Station (55710)	55710	3	2019	1,457,686	846,067	14,236,725	Pipeline Natural Gas	4.58
York Energy Center	55524	5	2019	1,321,854	735,866	12,377,774	Pipeline Natural Gas	4.39
York Energy Center	55524	6	2019	1,271,480	709,112	11,905,283	Pipeline Natural Gas	4.40
Bethlehem Power Plant	55690	1	2019	841,153	397,568	6,689,866	Pipeline Natural Gas	3.73
Bethlehem Power Plant	55690	2	2019	806,924	381,445	6,418,284	Pipeline Natural Gas	3.73
Bethlehem Power Plant	55690	3	2019	841,768	411,706	6,927,558	Pipeline Natural Gas	3.86
Bethlehem Power Plant	55690	5	2019	689,300	323,207	5,428,504	Pipeline Natural Gas	3.70
Bethlehem Power Plant	55690	6	2019	791,981	390,236	6,554,941	Pipeline Natural Gas	3.88
Bethlehem Power Plant	55690	7	2019	753,864	376,218	6,319,411	Pipeline Natural Gas	3.93
Lower Mount Bethel Energy, LLC	55667	CT01	2019	1,270,993	533,469	8,976,659	Pipeline Natural Gas	3.31
Lower Mount Bethel Energy, LLC	55667	CT02	2019	1,209,803	506,026	8,514,821	Pipeline Natural Gas	3.30

In a market with day-ahead clearing prices ~ $22 / MWh, a $3.30 - $5 / MWh price adder will likely result in infrequent dispatch of these units (peak electricity demand periods only).

RGGI price adders @ $7.41 / allowance (1 allowance = 1 short ton CO2)
Data compliments of Vince Brisini – Olympus Power
These units may or may not be dispatched, depends on other generators located elsewhere in PJM

Facility Name	Facility ID (ORISPL)	Unit ID	Year	Gross Load (MW-h)	CO2 (short tons)	Heat Input (MMBtu)	Fuel Type (Primary)	
Birdsboro Power	61035	1	2019	2,023,515	788,392	13,266,211	Pipeline Natural Gas	3.07
CPV Fairview, LLC	60589	CT-1	2019	188,671	74,138	1,247,528	Natural Gas	3.10
CPV Fairview, LLC	60589	CT-2	2019	168,543	66,310	1,115,804	Natural Gas	3.10
Dynegy Fayette II, LLC	55516	CTG1	2019	2,594,992	1,073,663	18,066,514	Pipeline Natural Gas	3.26
Dynegy Fayette II, LLC	55516	CTG2	2019	2,578,149	1,045,408	17,591,003	Pipeline Natural Gas	3.20
Fairless Energy Center	55298	1A	2019	1,974,989	758,049	12,755,644	Pipeline Natural Gas	3.03
Fairless Energy Center	55298	1B	2019	1,627,336	649,654	10,931,687	Pipeline Natural Gas	3.15
Fairless Energy Center	55298	2A	2019	1,805,527	715,680	12,042,749	Pipeline Natural Gas	3.12
Fairless Energy Center	55298	2B	2019	1,848,126	754,742	12,700,031	Pipeline Natural Gas	3.22
Lackawanna Energy Center	60357	1	2019	3,643,998	1,402,230	23,595,243	Pipeline Natural Gas	3.03
Lackawanna Energy Center	60357	2	2019	3,539,454	1,360,764	22,897,481	Pipeline Natural Gas	3.03
Lackawanna Energy Center	60357	3	2019	3,199,758	1,229,040	20,680,959	Pipeline Natural Gas	3.03
Marcus Hook Energy, LP	55801	1	2019	1,471,098	608,442	10,238,243	Pipeline Natural Gas	3.26
Marcus Hook Energy, LP	55801	2	2019	1,553,065	641,536	10,795,139	Pipeline Natural Gas	3.26
Marcus Hook Energy, LP	55801	3	2019	1,551,456	629,972	10,600,472	Pipeline Natural Gas	3.20
Moxie Freedom Generation Plant	59906	201	2019	3,661,674	1,426,988	24,011,755	Pipeline Natural Gas	3.07
Moxie Freedom Generation Plant	59906	202	2019	3,388,537	1,322,544	22,254,352	Pipeline Natural Gas	3.08
Ontelaunee Energy Center	55193	CT1	2019	2,062,194	854,670	14,381,259	Pipeline Natural Gas	3.27
Ontelaunee Energy Center	55193	CT2	2019	1,904,201	788,063	13,260,643	Pipeline Natural Gas	3.26
Panda Hummel Station	60368	CT1	2019	2,122,264	880,176	14,810,695	Pipeline Natural Gas	3.27
Panda Hummel Station	60368	CT2	2019	1,961,631	814,101	13,698,779	Pipeline Natural Gas	3.27
Panda Hummel Station	60368	CT3	2019	1,642,062	669,198	11,260,543	Pipeline Natural Gas	3.21
Panda Liberty Power Project	58420	CT1	2019	2,658,228	1,064,596	17,913,852	Pipeline Natural Gas	3.16
Panda Liberty Power Project	58420	CT2	2019	2,405,111	965,642	16,248,732	Pipeline Natural Gas	3.16
Panda Patriot Generation Plant	58426	CT1	2019	2,053,884	809,399	13,619,767	Pipeline Natural Gas	3.11
Panda Patriot Generation Plant	58426	CT2	2019	1,965,537	772,174	12,993,262	Pipeline Natural Gas	3.10
Tenaska Westmoreland Generating Station	60464	101	2019	2,489,694	1,023,716	17,226,042	Pipeline Natural Gas	3.24
Tenaska Westmoreland Generating Station	60464	102	2019	2,798,990	1,148,533	19,326,270	Pipeline Natural Gas	3.23

We made it to the end of the presentation.
I hope you found this info interesting and useful.
We'd be pleased to answer questions.