Air Quality Technical Advisory Committee Meeting: Nuclear Power & Generation Dispatch

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About Exelon

**Generation**
- Nation’s largest producer of clean energy
- More than 31,000 MW of owned capacity
- Generates enough electricity to power 20 million homes and businesses

**Competitive Energy Sales**
- Retail and wholesale sales through Constellation business unit
- ~2 million residential, public sector and business customers
- Two-thirds of Fortune 100 companies

**Transmission and Delivery**
- Six utilities delivering electricity and natural gas to more than 10 million customers: BGE (MD), ComEd (IL), Delmarva (DE and MD), PECO (PA), Pepco (D.C. and MD), Atlantic City Electric (NJ)

Committed to powering a cleaner and brighter future for our customers and communities
Exelon Generation: Leader in Zero-Carbon Electricity Production

### Top 20 Largest Producers of Zero-Carbon Generation

<table>
<thead>
<tr>
<th>Company</th>
<th>Million MWh</th>
<th>Exelon</th>
<th>171.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>NextEra Energy</td>
<td>93.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duke</td>
<td>85.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>US Corps of Engineers</td>
<td>76.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tennessee Valley Authority</td>
<td>73.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entergy</td>
<td>61.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dominion</td>
<td>47.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Southern</td>
<td>45.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>US Bureau of Reclamation</td>
<td>43.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Berkshire Hathaway Energy</td>
<td>34.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FirstEnergy</td>
<td>33.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSEG</td>
<td>32.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PG&amp;E</td>
<td>29.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EDF</td>
<td>25.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>New York Power Authority</td>
<td>24.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AEP</td>
<td>19.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Riverstone</td>
<td>18.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Xcel</td>
<td>18.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NRG</td>
<td>17.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vistra Energy</td>
<td>17.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Benchmarking Air Emissions of the 100 Largest Electric Power Producers in the United States, M.J. Bradley & Associates (June 2019). Data used in the benchmarking report was calendar year 2017.

### CO₂ Emission Rates of the Top 20 Investor-Owned Power Producers

<table>
<thead>
<tr>
<th>Producer</th>
<th>Emission Rate (lb/MWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exelon (2)</td>
<td>107</td>
</tr>
<tr>
<td>NextEra Energy (4)</td>
<td>458</td>
</tr>
<tr>
<td>PSEG (17)</td>
<td>451</td>
</tr>
<tr>
<td>Entergy (6)</td>
<td>596</td>
</tr>
<tr>
<td>Dominion (9)</td>
<td>641</td>
</tr>
<tr>
<td>Calpine (12)</td>
<td>796</td>
</tr>
<tr>
<td>Duke (1)</td>
<td>945</td>
</tr>
<tr>
<td>Riverstone (18)</td>
<td>979</td>
</tr>
<tr>
<td>Southern (3)</td>
<td>1,034</td>
</tr>
<tr>
<td>LS Power (23)</td>
<td>1,043</td>
</tr>
<tr>
<td>Berkshire Hathaway Energy (8)</td>
<td>1,233</td>
</tr>
<tr>
<td>FirstEnergy (15)</td>
<td>1,238</td>
</tr>
<tr>
<td>ArcLight Capital (22)</td>
<td>1,300</td>
</tr>
<tr>
<td>Xcel (16)</td>
<td>1,376</td>
</tr>
<tr>
<td>NRG (11)</td>
<td>1,425</td>
</tr>
<tr>
<td>Dynegy (7)</td>
<td>1,520</td>
</tr>
<tr>
<td>Vistra Energy (13)</td>
<td>1,557</td>
</tr>
<tr>
<td>DTE Energy (21)</td>
<td>1,563</td>
</tr>
<tr>
<td>AEP (10)</td>
<td>1,619</td>
</tr>
<tr>
<td>Ameren (20)</td>
<td>1,696</td>
</tr>
</tbody>
</table>

Source: Benchmarking Air Emissions of the 100 Largest Electric Power Producers in the United States, M.J. Bradley & Associates (June 2019). Number in parentheses is the company generation ranking in 2017. i.e., Exelon was the second largest generator in 2017.
Exelon Nuclear owns and operates the largest fleet of nuclear plants in the nation. The fleet consists of 22 reactors at 13 locations in Pennsylvania, Illinois, Maryland, New Jersey and New York.
## Exelon Generation Pennsylvania Nuclear Units

### Limerick Generating Station
- **Location:** Limerick Twp., Montgomery County
- **Number of Units:** 2 operating units
- **Began Providing Power:** 1986/1990
- **Remaining Useful Life:** 28/33 yrs
- **Net MW:** 2,317 MW
- **Customers Served:** More than 2 million homes
- **Total Employees:** 890
- **Annual Payroll:** Approximately $86M
- **Annual Contractor and Outage Contractor Spend:** $52M

### Peach Bottom Atomic Power Station
- **Location:** Delta Borough, York County
- **Number of Units:** 2 operating units
- **Began Providing Power:** 1974/1974
- **Remaining Useful Life:** License extension - 2054
- **Net MW:** 2,599 MW
- **Customers Served:** More than 2.25M homes
- **Total Employees:** 870
- **Annual Payroll:** Approximately $81M
- **Annual Contractor & Outage Contractor Spend:** $50M

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Exelon Nuclear Headquarters – Kennett Square, Chester County, Pennsylvania - 650 employees
How a Boiling Water Reactor Works
Pennsylvania Energy Overview

• Most Pennsylvania electricity generation is from nuclear, gas and coal

• In 2019 Nuclear provided 36% of Pennsylvania’s electricity
  ▪ Over twice as much as coal
  ▪ 25 times as much as wind and solar combined
  ▪ 13 times as much as all renewables when hydroelectric is included

Pennsylvania Generation Mix, 2019

Zero-Carbon Energy Mix, 2019

Has dropped to 90% with the loss of TMI in 2019

Pennsylvania Nuclear Plants Drive State Economic Activity

Nuclear plants in Pennsylvania drive the economy and provide good jobs

- Inject $3.1 billion annually into the Pennsylvania economy
- $2 billion in state gross domestic product (GDP) – Net impacts that would be permanently lost without the nuclear plants
- Directly employ 4,700 workers
- Create more than 11,200 additional jobs in other industries in Pennsylvania
- About 16,000 in-state jobs
- Are responsible for $69 million dollars of in-state tax revenues annually
- Support hundreds of vital community organizations
Nuclear Energy Has Unparalleled Reliability

Pennsylvania’s Nuclear Plants Are the Most Reliable and Resilient Energy Source

- Nuclear plants consistently provide the highest capacity factor of any energy source, regardless of time of day, all year round, and during months with extreme weather.
- This kind of reliability is unequaled by any other “always-on” base-load output source.
- During the January 2014 polar vortex — like the Polar Vortex of 2018 — nuclear plants supplied 9,700 MW, or 24%, of the generator output and were not impacted by lack of fuel and temperature extremes.
- Nuclear units, with an availability average of 95%, are a reliable and robust part of the energy supply.

**JANUARY 7, 2014**

- **Total Forced Outages**: 40,200 MW
- **Coal**: 13,700 MW (34%)
- **Natural Gas Interruption**: 9,300 MW (23%)
- **Gas Plant Outages**: 9,700 MW (24%)
- **Nuclear**: 1,400 MW (4%)
- **Other**: 6,100 MW (15%)

**DURING THE POLAR VORTEX, THE NUCLEAR FLEET OPERATED AT 95% CAPACITY**

**Source**: PJM Cold Weather Summary (1/9/18)
Nuclear Generation - Pennsylvania’s Carbon-Free Leader

8 operating reactors in Pennsylvania, 2\textsuperscript{nd} highest number of all U.S. states

In Pennsylvania, nuclear energy generates 1/3 of in-state electricity and 90% of carbon-free electricity.
Nuclear Dispatch
Bulk Electric Power System

Electricity generation, transmission, and distribution

- Power plant generates electricity
- Transmission lines carry electricity long distances
- Distribution lines carry electricity to houses
- Transformer steps up voltage for transmission
- Neighborhood transformer steps down voltage
- Transformers on poles step down electricity before it enters houses

Source: Adapted from National Energy Education Development Project (public domain)
PJMWinter - Overview

PJM Interconnection is a regional transmission organization (RTO) that coordinates the movement of wholesale electricity in all or parts of Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia and the District of Columbia.

- A neutral, independent party.
- PJM operates a competitive wholesale electricity market and manages the high-voltage electricity grid to ensure reliability for more than 65 million people.
- PJM’s long-term regional planning process provides a broad, interstate perspective that identifies the most effective and cost-efficient improvements to the grid to ensure reliability and economic benefits on a system-wide basis.
- An independent Board oversees PJM’s activities.
# PJM - Differences Between Energy and Capacity Markets

## PJM Energy Market Function:
- Secures electricity to meet consumer demand in real time and near-term
  - Includes: Real-Time and Day-Ahead markets
  - Portion of wholesale electricity cost: 63 percent (2018)

## PJM Capacity Market Function:
- Ensures the future availability of power supplies three years in advance
  - Portion of wholesale electricity cost: 20 percent (2018)

## PJM Ancillary Services Markets Function:
- Helps balance the system as it moves electricity from generating resources to consumers
  - Includes: Regulation, Reserve Markets
  - Portion of wholesale electricity price: Less than 1 percent (2018)
Energy Price Formation In Competitive Markets

How generators are compensated in energy markets
(A simplified illustration)

Single market clearing price set by intersection of supply and demand curves paid to all generators

Energy margin earned by generators. Provides incentive for generators to become more efficient and lower costs, which increase total surplus for both producers and consumers.

Unit A

Unit B

Unit C

Unit D

Demand Curve customer electric load

Supply Curve
All supply resources stacked in order of increasing variable (marginal) cost

PJM does not allow operationally-constrained baseload units like nuclear to set price even when they are operating and serving load
Energy Price Formation In Competitive Markets

How generators are compensated in energy markets
(A simplified illustration)

Single market clearing price set by intersection of supply and demand curves paid to all generators

Demand Curve customer electric load

Supply Curve
All supply resources stacked in order of increasing variable (marginal) cost

Higher variable cost units always set the price, but without nuclear the last unit to clear is even higher variable cost resulting in higher energy prices
Merchant nuclear plants in all regions of the country face a shortfall of market revenues relative to costs.

Average 2019 Nuclear Costs ($/MWh)

<table>
<thead>
<tr>
<th>Multi-Unit Nuclear</th>
<th>Single-Unit Nuclear</th>
</tr>
</thead>
<tbody>
<tr>
<td>$35</td>
<td>$46</td>
</tr>
</tbody>
</table>

2021 Energy Year Forward All-In Nuclear Market Prices ($/MWh)

![Bar chart showing market prices for different regions.]

- Upstate NY: $23
- MISO: $24
- West PJM: $27 (Capacity: $27, Energy: $27)
- Central PJM: $29 (Capacity: $3, Energy: $26)
- Texas: $30
- East PJM: $32 (Capacity: $3, Energy: $29)
- New England: $40 (Capacity: $4, Energy: $36)

(1) Source: Nuclear Energy Institute, “Nuclear by the Numbers.” April 2020 – costs in $2019
(2) Contingency (or risk) is calculated as 10% of total costs plus $4/MWh
(3) Based on 4/23/20 ICE forward energy prices from 6/2021 through 5/2022 for relevant hub less 2017-2019 average basis differential to nuclear plants. Capacity price component weighted by % cleared nuclear MW in region where appropriate.
Nuclear Challenge
Nuclear Plant Challenges – A Perfect Storm

CHALLENGES

- Historically low power prices
  - Abundant natural gas
  - Subsidies for some zero emission resources
  - Low load growth
- Market doesn’t value the 24/7 reliability, on-site fuel resilience & environmental attributes
- No national or regional cost of carbon

Recent nuclear retirement announcements are further proof that the industry has reached an inflection point in the debate over market reforms to recognize the value of the nation’s largest and most resilient source of emissions-free energy.
## Prematurely Retired Nuclear Plants & Announced Retirements

<table>
<thead>
<tr>
<th>PLANT/SITE</th>
<th>STATE</th>
<th>SUMMER CAPACITY (MWe)</th>
<th>CLOSURE YEAR</th>
<th>FINAL YEAR ELECTRICITY (billion kilowatt-hours/year)</th>
<th>FINAL YEAR CARBON (million metric tons/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indian Point 3</td>
<td>NY</td>
<td>1,038</td>
<td>2021</td>
<td>8.3</td>
<td>3.9</td>
</tr>
<tr>
<td>Byron 1 &amp; 2</td>
<td>IL</td>
<td>2,300</td>
<td>2021</td>
<td>20.1</td>
<td>12.8</td>
</tr>
<tr>
<td>Dresden 2 &amp; 3</td>
<td>IL</td>
<td>1,797</td>
<td>2021</td>
<td>15.1</td>
<td>9.6</td>
</tr>
<tr>
<td>Palisades</td>
<td>MI</td>
<td>772</td>
<td>2022</td>
<td>6.9</td>
<td>5.4</td>
</tr>
<tr>
<td>Diablo Canyon 1 &amp; 2</td>
<td>CA</td>
<td>2,240</td>
<td>2024</td>
<td>16.2</td>
<td>6.7</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>8,147</strong></td>
<td></td>
<td><strong>66.6</strong></td>
<td><strong>38.5</strong></td>
</tr>
</tbody>
</table>

| TOTAL          |       | **8,343**             |              | **69.0**                                            | **42.7**                                      |

Source: Emissions avoided are calculated using regional and national fossil fuel emissions rates from the U.S. Environmental Protection Agency and latest plant generation and average household electricity usage data from the U.S. Energy Information Administration.

Updated: August 2020
Pennsylvania’s Nuclear Fleet – What’s at Stake

**ECONOMIC IMPACT**
- Contribute $2.01B to state GDP
- $69 million annually in net state tax revenues
- PA consumers electricity costs increase ~$788M without PA nuclear fleet

**JOBS**
- 16,000 direct and indirect jobs within Pennsylvania
- Provided 7 million labor hours to building and construction trades (2014-2016)

**ENVIRONMENTAL**
- Avoid over 37 million tons of CO2 annually
- Equivalent to adding 8M cars to the Pennsylvania roads
- Announced retirements in PJM reverses 25 years of progress with renewables

**RELIABILITY/SECURITY**
- Most reliable electricity production in PA (93% Capacity Factor)
- Represents 42% of Pennsylvania’s generation production portfolio

*Market policies do not compensate nuclear units for unique attributes (clean energy, fuel security, fuel diversity)*
QUESTIONS?