Conemaugh Generating Station
1442 Power Plant Road
New Florence, PA 15944

August 27, 2021

Independent Regulatory Review Commission
333 Market Street, 14th Floor
Harrisburg, PA 17101
[via email to irrc@irrc.state.pa.us]

Re: Keystone-Conemaugh Projects, LLC Comments on EQB's Final CO_2 Budget Trading Program; EQB Regulation #7-559 (IRRC-3274).

To Whom It May Concern:

Keystone-Conemaugh Projects, LLC (KEY-CON) submits the following comments in response to the Environmental Quality's Board's (EQB) amendment to Title 25 of the Pennsylvania Code of Regulations Chapter 145 to implement a carbon cap-and-trade program in the Commonwealth, also known as the CO_2 Budget Trading Program. This rulemaking was adopted by the EQB at its July 13, 2021 meeting.

KEY-CON is the licensee for the Keystone Generating Station located in Armstrong County, PA and the Conemaugh Generating Station located in Indiana County, PA. Each station operates two pulverized bituminous coal-fired boilers (Units 1 and 2), each with a steam turbine-driven electric generator. Both Keystone and Conemaugh Generating Stations are affected units under the CO_2 Budget Trading Program. KEY-CON appreciates the opportunity to submit these comments.

Comments

KEY-CON urges the Independent Regulatory Review Commission (IRRC) to disapprove the CO_2 Budget Trading Program rule because it is inconsistent with the requirements of the Regulatory Review Act (RRA). Under the RRA, the IRRC must review a proposed regulation to determine whether the proposed regulation is consistent with the authorizing statute and whether the regulation is in the public interest. 71 Pa. Stat. § 745.5b. KEY-CON believes that the CO_2 Budget Trading Program is inconsistent with the authorizing statute and is not in the public interest. In its February 16, 2021 Comments of the Independent Regulatory Review Commission ("IRRC Comments"), the IRRC expressed similar concerns and requested that the Pennsylvania Department of Environmental Protection (PADEP) further explain aspects of its proposed rule. PADEP did not adequately address some of the IRRC's questions and concerns in its CO_2 Budget Trading Program Comment and Response Document ("C&R Document") and Regulatory Analysis Form ("RAF"). Because the rule remains inconsistent with the RRA, KEY-CON urges the IRRC to disapprove of the rule for the following reasons:

1. The CO_2 Budget Trading Program exceeds the grant of authority in the Air Pollution Control Act to collect fees and make expenditures from the Clean Air Fund.

a. The CO_2 Budget Trading Program levies an impermissible tax, not a fee.

Under the Air Pollution Control Act (APCA), PADEP may establish "fees to support the air pollution control program authorized by this act[.]" 35 Pa. Stat. § 4006.3(a). The anticipated proceeds from RGGI amount to much more than a fee. As part of its modeling scenarios, PADEP estimated that 6% of annual auction proceeds would cover the agency's programmatic costs related to the oversight of the CO_2 Budget Trading Program. Regulatory Analysis Form at 23-24. PADEP's modeling also anticipates that in the first year of participation in RGGI, the Commonwealth will generate "hundreds of millions of dollars in auction proceeds." RAF at 22.

The IRRC asked PADEP to address objections from the House and Senate Environmental Resources Committees that the auction proceeds are not a fee under the APCA, but rather an illegal tax. IRRC Comments at 1. PADEP argues that under the APCA it has authority to use fees for the elimination of air pollution and, because the rulemaking would reduce GHG emissions, the fees would be used to support the air pollution control program. C&R Document at 11-12. PADEP supports its position that auction proceeds are a fee by citing existing case law, namely *National Biscuit Company v. Philadelphia*, 98 A.2d 182 (Pa. 1953) ("*National Biscuit*"), *White v. Com. Medical Professional Liability*, 571 A.2d 9 (Pa. Cmwlth. 1990)("*White*"), and *City of Philadelphia v. Se. Pennsylvania Transp. Auth.*, 303 A.2d 247 (Pa. Commw. Ct. 1973) ("*City of Phildelphia*"). Id. at 12. Elements of these three cases support the opposite of PADEP's argument – they support the argument that the auction proceeds from the program *are* a tax.

City of Philadelphia distinguishes between taxes and fees: "The common distinction is that taxes are revenue-producing measures authorized under the taxing power of government; while license fees are regulatory measures intended to cover the cost of administering a regulatory scheme authorized under the police power of government." *City of Philadelphia at* 251. In *National Biscuit*, the Supreme Court of Pennsylvania notes that one of the four distinguishing features of a license fee is "that the legislative purpose in exacting the charge is to reimburse the licensing authority for the expense of the supervision and regulation conducted by it.[1] *National Biscuit* at 188. The *White* case says that "A tax is characterized by the production of large income and the high proportion of income relative to the cost of collection and supervision." *White* at 12 (citing *Greenacres Apartments, Inc. v. Bristol Township*, 85 Pa. Commonwealth Ct. 572, 482 A.2d 1356 (1984).

Taxes are revenue producing measures, while fees cover the cost of, or "reimbursement" to the agency for, administering a regulatory program. Only 6% of the auction proceeds are expected to be needed to cover the cost of the program, leaving 94% of the proceeds as revenue.

[1] "The distinguishing features of a license fee are (1) that it is applicable only to a type of business or occupation which is subject to supervision and regulation by the licensing authority under its police power; (2) that such supervision and regulation are in fact conducted by the licensing authority; (3) that the payment of the fee is a condition upon which the licensee is permitted to transact his business or pursue his occupation; and (4) that the legislative purpose in exacting the charge is to reimburse the licensing authority for the expense of the supervision and regulation conducted by it." *National Biscuit* at 188.

Because the RGGI auction process is designed to raise significant revenue far beyond what is necessary to administer the program, it clearly represents a tax as defined in Pennsylvania caselaw. While PADEP may establish fees sufficient to cover the costs of administering its air pollution control programs, it does not have the power to tax. The power to tax lies solely with the General Assembly in the Commonwealth of Pennsylvania. *Mastrangelo v. Buckley*, 250 A.2d 447, 452 (Pa. 1969). The IRRC should disapprove the rule because it levies an impermissible tax and thus exceeds the grant of authority under the APCA.

b. The CO_2 Budget Trading Program exceeds the grant of authority to make expenditures from the Clean Air Fund.

Section 9.2(a) of the APCA limits the use of fees for "the elimination of air pollution." 35 Pa. Stat. § 4009.2(a). PADEP's modeling anticipates investing the proceeds from allowances auctions to fund energy efficiency initiatives (such as upgrading appliances and HVACs) and renewable energy projects. RAF at 22. Such initiatives were historically (and, KEY-CON believes more appropriately) developed legislatively (*e.g.*, Act 213 of 2004 - Alternative Energy Portfolio Standards Act) and overseen by the Pennsylvania Public Utility Commission. Unlike Act 213 and subsequent legislation, PADEP has not, however, released a detailed investment plan for the auction proceeds. Without details about anticipated spending, PADEP is not allowing the IRRC to fully analyze whether PADEP's regulation will be within the grant of authority under the APCA. Because IRRC cannot fully analyze the regulation for consistency with the authorizing statute, the IRRC should disapprove the rule.

2. The CO_2 Budget Trading Program is not in the public interest because PADEP can demonstrate no actual benefit to the Commonwealth's climate due to the regulation and the benefits do not outweigh the cost of implementation.

The IRRC asked PADEP to explain why the benefits of the rulemaking outweigh the costs associated with its implementation to assist the Commission in determining whether the regulation is in the public interest. IRRC Comments at 6. The IRRC also asked PADEP to consider delaying the rulemaking for one year. IRRC Comments at 9. PADEP has not provided satisfactory answers to this request, as explained below.

a. The CO_2 Budget Trading Program is not in the public interest because it is not needed.

PADEP explains that this regulation is needed to "establish this Commonwealth's participation in a regional approach that significantly reduces CO_2 emissions and this Commonwealth's contribution to regional climate change." RAF at 3. While the program may achieve the goal of reducing CO_2 emissions to some extent in the Commonwealth, PADEP cannot demonstrate that there will not be any direct benefit to the Pennsylvania climate due to promulgating the CO_2 Budget Trading Program. If fact, PADEP admits that this regulation will not have a direct climate impact:

> As stated in this final-form rulemaking, the purpose of this rulemaking is not to solve global climate change, but to address this Commonwealth's share of CO_2 emissions from one of its highest emitting sectors. Although this final-form

> rulemaking will not solve global climate change, it will aid this Commonwealth in addressing its share of the impact, joining other states and countries that are addressing their own impacts. This Commonwealth has the fifth leading CO_2 emitting electricity generation sector in the country, and this final-form rulemaking is a significant component in achieving the Commonwealth's goals to reduce GHG emissions.

C&R Document at 42.

While this may be a laudable goal, PADEP's modeling effort demonstrated that the Commonwealth's participation in RGGI results in insignificant CO_2 emissions reductions. This outcome is primarily because Pennsylvania is part of a regional multi-state bulk electric system where electric generation and transmission are managed (by PJM) on a regional basis. Because regional bulk electric demand needs are known, generating units are dispatched and electric output monitored continuously to meet the demand. The unavailability of a generating unit (either because of operating issues or bid price) simply results in the shifting of the generation (and resulting emissions) to another available generating unit. As KEY-CON had previously commented, PADEP inappropriately focuses on CO_2 and other pollutant emission changes from the electric generating industry on an intrastate basis. This approach would be acceptable if the electric generation and transmission business in Pennsylvania was truly an intrastate business (e.g., like in Hawaii).

We acknowledge that PADEP's recent revised modeling presented summaries of changes in generation and emissions on both a state-wide and regional basis, but as noted above, PADEP inappropriately focuses on the intrastate changes for support for the subject regulation. The focus must be on a regional basis. Curiously, the revised modeling shows CO_2 emissions *increasing* throughout the entire model domain (Eastern Interconnection[2]) during the first year (2022) of Pennsylvania's participation in RGGI. For a summary of this modeling, please see Attachment A. PADEP's revised modeling also shows that the average future year CO_2 emission decreases throughout the entire model domain for the period 2021-2030 are equal to 1.9 MM tons/year, which is negligible (0.3%) in comparison with total U.S. CO_2 emissions (5,876 MM tons/year, average for 2014-2019) and less than the year-over-year variability of such national emissions (1% to 3%). See Attachment A. The 0.3% difference (which KEY-CON believes to be far less than typical model uncertainties) is about a factor of 10 less than the acceptable calibration error for a single certified CO_2 continuous emissions monitor. See 40 C.F.R. § 75 Appendix A, Section 3.1(b); PADEP, Continuous Source Monitoring Manual (Rev. No. 8) at Table III – Specifications for Oxygen and Carbon Dioxide Monitors. These statistics clearly refute PADEP's assertion that RGGI will aid in reducing "this Commonwealth's share of CO_2 emissions from one of its highest emitting sectors." C&R Document at 42.

[2] The Eastern Interconnection captures the continental U.S. and Canada from the Rocky Mountain to the Atlantic Ocean, excluding Texas and the province of Quebec.

PADEP cites to the co-beneficial reductions of SO_2 and NOx emissions as a result of Pennsylvania's participation in RGGI. As noted above, PADEP inappropriately focuses on intrastate changes in SO_2 and NOx emissions and failed to disclose how much of those reductions would be negated by increases in neighboring states that increased their electrical generation as less is generated by Pennsylvania. Impacts from SO_2 and NOx emissions are primarily on a regional basis (such as formation of ambient air PM2.5 and ground-level ozone, and local impacts from SO_2 emissions have already been addressed as part of various SO_2 NAAQS State Implementation Plans).

> **445. Comment:** The commentator states that the Department does not account for how shifts in emissions across states as a result of this proposed rulemaking will also lead to changes in co-pollutant emissions, specifically states that are upwind, and the associated health impacts of those emissions shifts.
>
> **Response:** The Department acknowledges this as outside the scope of the Department's modeling. The changes in co-pollutant emissions from states that are downwind are also not included in the scope of the modeling.

C&R Document at 206.

PADEP also claims that this rulemaking is needed to achieve the statewide goals to reduce GHG emissions economy-wide by 26 percent by 2025 and 80 percent by 2050 in comparison to 2005 levels. C&R Document at 23. These emissions targets, however, are not mandated by law. The Pennsylvania Climate Change Act of 2008 does not set specific targets for emissions reductions nor does any other Pennsylvania law. Instead, these targets were established in Governor Wolf's January 2019 Executive Order, Commonwealth Leadership in Addressing Climate Change and Promoting Energy Conservation and Sustainable Governance, and adopted as part of PADEP's Pennsylvania Climate Action Plan. PADEP needs the regulation to achieve the Governor's goals, not those set by any legislative body.

PADEP cites meeting these targets, as well as simply stating that the "Commonwealth cannot wait any longer to address CO_2 emissions from fossil-fuel fired EGUs[,]" as the reason why the regulation cannot be delayed for one year as requested by the IRRC. C&R Document at 35. This is not a satisfactory or well-reasoned response.

Because PADEP cannot point to a single project direct benefit to Pennsylvania's climate, it relies on the co-benefits of the regulation, namely the health-related benefits of the regulation, to support the need for the regulation. PADEP, however, overstates these benefits and has not demonstrated that the regulation is necessary to protect human health. PADEP's Regulatory Analysis Form explains the health impacts of air pollution from sulfur dioxide, oxides of nitrogen, and particulate matter, and the health benefits in the Commonwealth due to the expected ancillary emission reductions of these pollutants with the adoption of this regulation. RAF at 18-21. PADEP attempts to quantify the health benefits in terms of monetary value, avoided health impacts like emergency room visits, and avoided premature deaths. *Id.* The pollutants that will be reduced, however, are "criteria pollutants" regulated under Title I of the

federal Clean Air Act, which requires the U.S. EPA to set and periodically review the National Ambient Air Quality Standards (NAAQS). EPA already sets and implements the NAAQS at a level designed to protect human health with an adequate margin of safety. Nearly all areas in the Commonwealth are in attainment with the NAAQS. See 40 C.F.R. §81.339. If the regulation is needed to address non-attainment, PADEP has skipped the step in the regulatory analysis to show any nexus between the remaining areas of non-attainment in the state and the EGUs operating in the state. PADEP has not explained why further regulation of these pollutants is necessary to protect public health, and, therefore, PADEP has not demonstrated that the regulation is needed.

While addressing climate change may be a laudable goal, due to the nature of greenhouse gases, only nationwide or global action will have any effect on global temperatures. The CO_2 Budget Trading Program is not the correct way to address climate change in the Commonwealth and will have no appreciable impact on the climate.

b. <u>The CO_2 Budget Trading Program is not in the public interest because the economic "benefit" is far from certain and the known economic costs outweigh the presumed "benefits."</u>

The IRRC asked PADEP to explain why the benefits of the rule outweighed the costs associated with implementation, as IRRC must consider the "economic or fiscal impacts of the regulation." 71 Pa. Stat. § 745.5b(b)(1). PADEP points to additional economic benefits of adopting the regulation based on its modeling efforts. The economic "benefit' of the regulation is far from certain. PADEP's 2020 modeling indicates that this rule would lead to an increase in Gross State Product (GSP) of $1.9 billion, a net increase of over 30,000 jobs, an addition of 9.4 gigawatts (GW) of renewable energy, and a load reduction of 29 terawatt hours of electricity from energy efficiency projects from 2022-2030, all while increasing wholesale power prices by only 2.42% in 2022. RAF at 24, 52.

Data from sources other than PADEP's modeling show very different economic impacts from program participation. For example, KEY-CON calculated the increased cost to Pennsylvania electric power consumers utilizing two modeling sources: Tabors Caramanis Rudkenich, Inc.'s ("TCR") report commissioned by Olympus Power, which provides more granular model results by PJM Zone, and PADEP's IFC modeling results presented to the Air Quality Technical Advisory Committee (AQTAC) on May 12, 2021. KEY-CON's analysis determined that PADEP underestimated the monthly impact to residential consumers by a potential $147 million (home owners who do not heat with electric) to $208 million (customers who heat with electric) in the first year of regulation alone. PADEP presented information to the AQTAC that estimated a total increase in electricity costs to retail customers in the Commonwealth of approximately $66 million in the first year of RGGI participation. Under TCR's model, the retail consumer cost will increase anywhere from approximately $214 to $303 million and, per PADEP's admission, the cost will only increase in subsequent years. KEY-CON urges the IRRC to account for this significant economic impact in its consideration of the CO_2 Budget Trading Program. For further detail about these calculations, please see Attachment B.

A copy of the above-mentioned TCR report is presented as Attachment C. In addition to the data mentioned above, this report provides information on changes in electrical generation, emissions and related on a state-specific basis for all states significantly impacted by Pennsylvania's participation in RGGI. KEY-CON had previously requested such state-specific information from the PADEP, and was disappointed in the PADEP's response to this request, which KEY-CON believe is inadequate. KEY-CON notes that PADEP expended "time and resources" to report changes in electrical generation and emissions for northern New England states (New Hampshire, Maine and Vermont) that have negligible impact on Pennsylvania's electrical generation and emissions, and inexplicably omitted impacts in other neighboring states that do not participate in RGGI, such as Ohio and West Virginia. The above-mentioned TCR report clearly documents the results from all states that are impacted by Pennsylvania's participation in RGGI, and the report clearly shows the shift in electrical generation and emissions from Pennsylvania to those states. In contrast, in responding to comments regarding its modeling, PADEP explained the following:

> **396. Comment:** The commentator states that the modeling results should have included impacts, by state, on electric generation in the PJM states that won't be participating in RGGI, as well as, the generation already coming online for 2022-23, and expected to be on-line prior to 2030 in PJM.
>
> **Response:** The Department's modeling results include results from all expected participating RGGI states, including Pennsylvania, along with the entire PJM region, RGGI participating states within the PJM region, and the other major regional grids in the eastern U.S. In order to cost-effectively obtain the modeling results, typical practice is to select participating RGGI states that will get individual emissions results, along with major regions, in contrast to getting results for every single state participating in the electricity market, as that is outside the scope of this rulemaking. Using this method, it is possible to understand the key trends and patterns of the results, without having to expend additional time and resources to receive results for every single state.

C&R Document at 1862.

It is almost certain, however, that implementing this regulation will likely result in the expedited retirement of coal-fired generation in the Commonwealth within the next year, and insufficient time to allow for an orderly and potentially Commonwealth-assisted transition of employment and economic resources for affected workers and nearby communities. The closure of the four largest coal-fired electric generating stations (including KEY-CON), will result in the loss of 8,000+ jobs, $2.87 billion in total economic impact, $539 million in employee compensation, and $34.2 million to state and local taxes base.[3] In addition, PADEP acknowledges and accepts that this regulation will have a significant impact on small businesses, and points to the use of auction proceeds as the way to assist communities and workers affected

[3] This information was included in testimony to the Pennsylvania Legislature in 2020 and attached as Exhibit A to KEY-CON's comments to the IRRC submitted in January 2021.

by this regulation. C&R Document at 120. Because PADEP cannot demonstrate why the benefits outweigh the costs of implementation, the regulation is not in the public interest and should be disapproved.

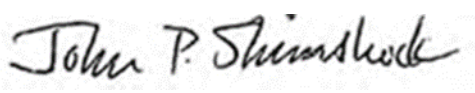
While KEY-CON acknowledges that without the implementation of the rule, most of the coal-fired generation in the Commonwealth would cease within a decade, the impact of the regulation will bring about the swift closure of these plants and allow no transition time for employees and communities to adjust to the impact. This is why KEY-CON's previous comments to PADEP and the IRRC recommended a glide path to closure by 2030 to allow for a planned and slow transition away from coal-fired generation in lieu of compliance with this rule.

3. <u>The CO_2 Budget Trading Program is not in the public interest because it is a policy decision of such a substantial nature that it requires legislative review.</u>

The IRRC asked PADEP to explain why it is appropriate to implement this carbon trading program through executive order and the rulemaking process instead of the legislative process. IRRC Comments at 2-3. PADEP contends that the regulation is not a policy decision of such a substantial nature that it requires legislative review because the General Assembly gave the agency authority to regulate air pollution, the regulation is within the grant of authority under the APCA, and the agency has promulgated rules including cap-and-trade regulations before. C&R Document 18; RAF 12-13. As explained above, the regulation is not within the grant of authority under the APCA. Additionally, other cap-and-trade programs were required under the federal Clean Air Act, for which PADEP is required to implement regulations under a separate grant of authority in the APCA. This regulation institutes voluntary participation in an interstate cap-and-trade program that will raise "hundreds of millions of dollars" in revenue, eliminate at least 8,000 jobs and significantly increase electricity rates for businesses and residential users, all without any recognized benefit to the climate in Pennsylvania. This regulation is a policy decision of a substantial nature and it requires legislative review. In fact, all other participating states except New York (which enacted an express statutory mandate to regulate CO_2 emissions) have joined RGGI through the passage of authorizing legislation. The IRRC should disapprove the rulemaking on the grounds that it requires review by the General Assembly.

KEY-CON appreciates the opportunity to submit these comments. Should you have any questions about KEY-CON's submission, please contact me at (724) 235-4596 or jshimshock@keyconops.com.

Respectfully submitted,



John P. Shimshock
Environmental Specialist
Conemaugh Generating Station

PA DEP Reference Case

Affected CO2 Emissions (Million Short Tons)

	2020	2022	2025	2028	2030	2021-2030
MA	6	7	4	5	4	50
CT	10	9	7	5	3	67
ME	1	1	-	-	0	3
NH	2	1	1	0	0	6
RI	3	3	2	2	2	25
VT	0	0	0	0	0	0
NY	24	31	23	19	15	233
DE	2	1	2	1	1	15
MD	9	13	13	12	12	124
VA	30	24	26	27	27	260
NJ	14	15	17	14	13	151
PA	76	81	65	61	58	679
Total 11-state RGGI	103	106	94	85	78	935
Total CO2 Emissions PJM	311	347	301	297	294	3,128
Total CO2 Emissions SERC	406	399	372	384	395	3,859
Total CO2 Emissions EI	1,152	1,219	1,079	1,091	1,107	11,274

PA DEP Policy Case

Affected CO2 Emissions (Million Short Tons)

	2020	2022	2025	2028	2030	2021-2030	Δ
MA	6	7	4	5	4	50	
CT	11	9	7	5	3	67	
ME	1	1	-	-	0	4	
NH	2	1	1	0	0	6	
RI	4	3	2	2	2	25	
VT	0	0	0	0	0	0	
NY	24	32	23	19	15	237	
DE	2	2	2	2	2	21	
MD	9	15	13	11	10	127	
VA	30	25	26	27	27	261	
NJ	15	17	17	15	13	159	
PA	74	61	60	55	53	582	97
Total 12-state RGGI	178	173	155	142	129	1,539	
Total CO2 Emissions PJM	310	343	299	294	291	3,100	29
Total CO2 Emissions SERC	404	400	372	383	395	3,863	-4
Total CO2 Emissions EI	1,150	1,219	1,076	1,088	1,104	11,255	19
Δ Reference - Policy EI		-1	3	3	3	19	↑

The Eastern Interconnection encompasses the area east of the Rocky Mountains and a portion of northern Texas.
The Eastern Interconnection consists of 36 balancing authorities: 31 in the United States and 5 in Canada

Average = 1.9 MM tons / year
Compare with annual US and global emissions (see below)

Pennsylvania CO2 Emissions by Capacity Type (Million Tons)

	2020	2022	2025	2028	2030	2021-2030
Combined Cycle	50	46	51	49	47	486
Coal	24	34	13	11	11	188
Combustion Turbine	1	0	1	1	1	6
Oil/Gas Steam	0	0	0	0	0	0
Total	76	81	65	61	58	681

Pennsylvania CO2 Emissions by Capacity Type (Million Tons)

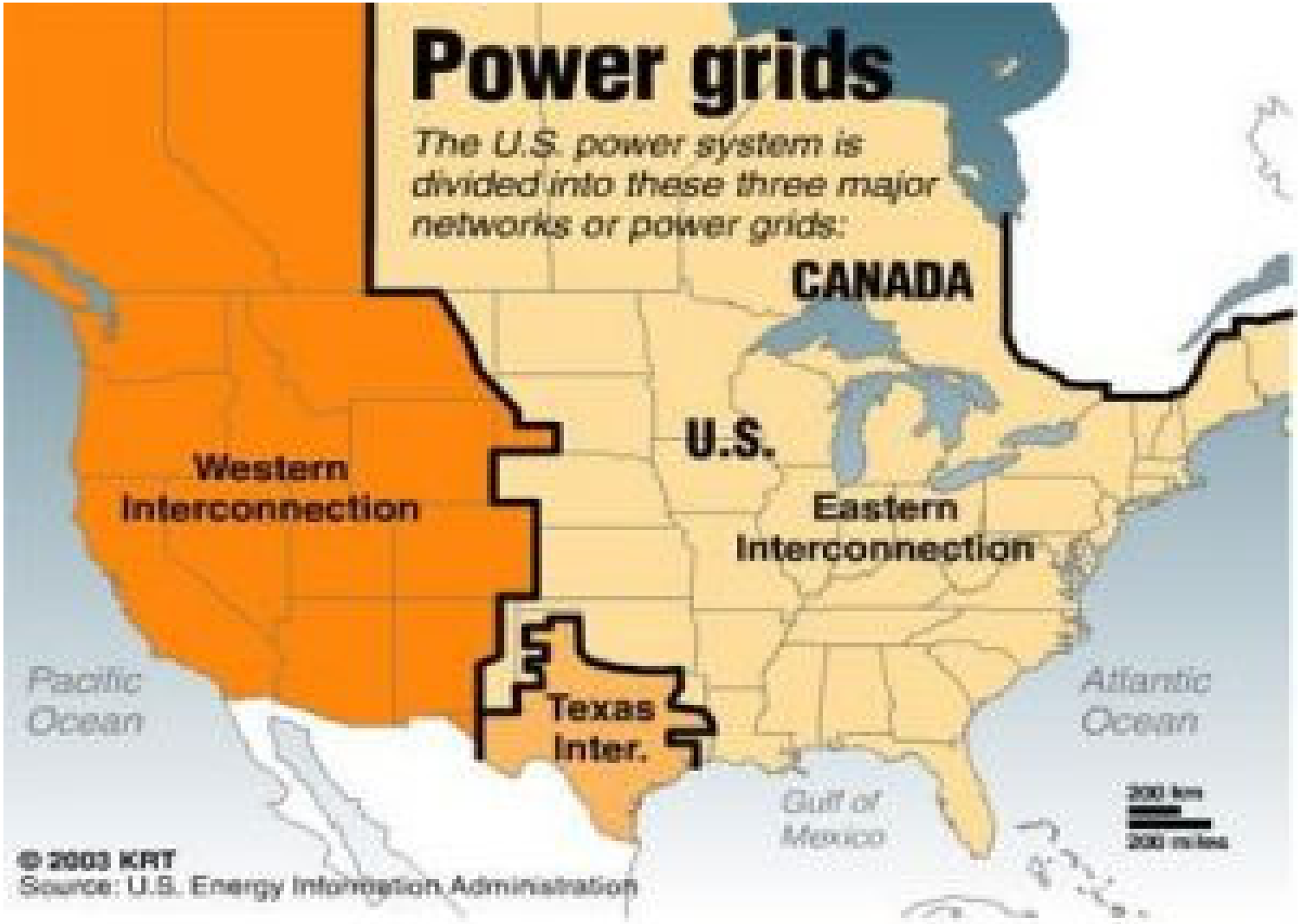
	2020	2022	2025	2028	2030	2021-2030	Δ
Combined Cycle	48	38	48	44	42	432	
Coal	22	24	11	11	11	148	
Combustion Turbine	4	0	1	0	0	5	
Oil/Gas Steam	-	-	0	0	0	0	
Total	75	61	60	56	53	584	96

Total U.S. and Global CO2 Emissions (Million Tons)

	2014	2015	2016	2017	2018	2019
Total CO2 Emissions U.S. *	6,088	5,921	5,785	5,741	5,925	5,794
% change YOY		-3%	-2%	-1%	3%	-2%
Total CO2 Emissions World **	32,389	32,366	32,375	32,837	33,513	
% change YOY		0%	0%	1%	2%	

Average
5,876
32,696

*: https://www.epa.gov/sites/default/files/2021-04/documents/us-ghg-inventory-2021-chapter-executive-summary.pdf
**: https://www.iea.org/subscribe-to-data-services/co2-emissions-statistics


Power grids
The U.S. power system is divided into these three major networks or power grids:
CANADA
U.S.
Western Interconnection
Eastern Interconnection
Texas Inter.
Pacific Ocean
Atlantic Ocean
Gulf of Mexico
© 2003 KRT
Source: U.S. Energy Information Administration

KEYSTONE-CONEMAUGH PROJECTS, LLC (KEY-CON) EVALUATION OF THE ANNUAL IMPACT OF RGGI ON PA RESIDENTIAL ELECTRIC POWER CONSUMERS

Keystone and Conemaugh calculated the increased cost to Pennsylvania electric power consumers utilizing two modeling sources:

1. Tabors Caramanis Rudkevich report commissioned by Olympus Power which provides more granular model results by PJM Zone
2. PA Department of Environmental Protection's IFC modeling results presented to the AQTAC on May 12, 2021

Key-Con's analysis determined that the PA DEP underestimated the monthly impact to residential customers by a potential $147 million to $208 million dollars within the first year of RGGI alone.

Further calculating the DEP's estimated cost increase to retail customers and considering the number of housing units in the state, the DEP did disclose the magnitude of which retail customers are going to pay each year to reduce CO2 emissions from PA power plants. The DEP's estimate is at least $66 million of costs to the state's retail customers starting the first year of RGGI. However, though the scale of that impact on PA consumers is already high, it is obvious that DEP underestimated the impact. Back-calculating the electricity rate from DEP's estimates, they assumed PA customers are paying 4.4 cents per KWh. Nowhere could Key-Con find retail electric power in that low of a price range. Key-Con's sources estimated base electric rate of 6.5 cent per KWh which is well in line with going retail rates. That comparison only substantiates the improved accuracy, and more realistic, results of the TCR modeling. Under the TCR Model, RGGI will cost residential electric retail customers in PA anywhere from $214 to $302 million on top of their existing power bills each year. Per DEP's admission, the cost will only increase in the subsequent years. Key-Con urges the IRRC to account for this large economic impact in their consideration of DEP's CO2 Budget Trading Program regulation.

Calculations of Increase Costs to PA Residential Electric Consumers in the First Year of PA RGGI

SUMMARY RESULTS

Column	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*	
	Incr. LMP per MWH	**% to DEP Ref. LMP**	**Residential Incr. A $/mnth***	**Residential Incr. B $/mnth***	**Annual Resid. Incr A**	**Annual Resid. Incr B**	**Cost PA Households A**	**Cost PA Households B**	*Row*
Residentially Weighted LMP Avg	$1.73	5.8%	$3.77	$5.31	$45.19	$63.73	*$213,676,003*	$301,337,953	*1*
PA DEP AQTAC Increase	$0.80	2.7%	$1.17	$1.65	$14.04	$19.80	*$66,386,343*	$93,621,766	*2*
							Delta $147,289,660	$207,716,187	

Equivalent Monthly Rate ($/KWh)	**Cust A**	**Cust B**	
TRC Reference	$0.065	$0.066	*Calulation = Monthly Increase / % Increase / 1000 KWh per month of use for Cust A and 1400 KWh for Cust B*
PA DEP	$0.044	$0.044	

Calculations Utilizing TCR Report, US Census Data, and Publically Available Retail Rates

Residentially Weighted LMP — *Col/Row* *A 1*

SUMPRODUCT of LMP* and No. of Housing Units	$8,162,991	$/MWH*HU	*Table 1*
÷ by Total Housing Units	4,728,372	HU (Housing Unit)	*Table 1*
=	$1.73	Residentially Weighted LMP $/MWH	

Percent Increase of LMP — *Col/Row* *B 1*

Residentially Weighted LMP	$1.73	$/MWH
÷ DEP Estimate Annual Avg LMP Pre-RGGI	$30.00	$/MWH
=	5.8%	Percent Increase of LMP %

Monthly Increase to Customer A — *Col/Row* *C 1*

SUMPRODUCT of Retail Price and No. of Housing Units	$309,427	$/KWh/HU Table 1	
÷ by Total Housing Units	4,728,372	HU (Housing Unit)	*Table 1*
x Avg Retail Customer Power Usage	1000	KWh/mo.	
x Percent Increase of LMP	5.8%		
=	$3.77	$/mo. per HU - Cust. A	

Monthly Increase to Customer B — *Col/Row* *D 1*

Percent Difference btwn DEP Ref Cust A & B ((1.65-1.17)/1.17)	41%	%
x Calculated $/mo. per HU - Cust A	$3.77	$/mo. per HU - Cust. A
+ Calculated $/mo. per HU - Cust A	$3.77	$/mo. per HU - Cust. A
=	$5.31	$/mo. Per HU - Cust. B

Annual Increase to Customers A & B — *Col/Row* *E 1 & F 1*

Monthly Increase to Customer A	$3.77	$/mo. per HU - Cust. A
x 12 months/yr	12	Months
=	$45.19	$/yr. per HU - Cust. A
Monthly Increase to Customer B	$5.31	$/mo. per HU - Cust. B
x 12 months/yr	12	Months
=	$63.73	$/yr. per HU - Cust. B

Total Annual Cost to Customers A & B — *Col/Row* *G 1 & H 1*

Annual Increase to Customers A	$45.19	$/yr. per HU - Cust. A		
x by Total Housing Units	4,728,372	HU (Housing Unit)	*Table 1*	
=	$213,676,003	$ per Year Total		$147,289,660
Annual Increase to Customers B	$63.73	$/yr. per HU - Cust. B		
x by Total Housing Units	4,728,372	HU (Housing Unit)	*Table 1*	
=	$301,337,953	$ per Year Total		$207,716,187

Calculations of Increase Costs to PA Residential Electric Consumers in the First Year of PA RGGI

Calculations Utilizing Slide 16 of PA DEP's Presentation to AQTAC on May 17, 2021

Values from Slide 16 *B 2, C 2, D 2*

Col/Row

Percent Increase of LMP *B 2*

DEP Estimated Increase in LMP Due to RGGI	$0.80	$/MWH	
÷ DEP Estimate Annual Avg LMP Pre-RGGI	$30.00	$/MWH	
=	2.7%	Percent Increase of LMP %	

Col/Row

Annual Increase to Customers A & B *E 2 & F 2*

Monthly Increase to Customer A	$1.17	$/mo. per HU - Cust. A	
x 12 months/yr	12	Months	
=	$14.04	$/yr. per HU - Cust. A	
Monthly Increase to Customer B	$1.65	$/mo. per HU - Cust. B	
x 12 months/yr	12	Months	
=	$19.80	$/yr. per HU - Cust. B	

Col/Row

Total Annual Cost to Customers A & B *G 2 & H 2*

Annual Increase to Customers A	$14.04	$/yr. per HU - Cust. A	
x by Total Housing Units	4,728,372	HU (Housing Unit)	*Table 1*
=	$66,386,343	$ per Year Total	
Annual Increase to Customers B	$19.80	$/yr. per HU - Cust. B	
x by Total Housing Units	4,728,372	HU (Housing Unit)	*Table 1*
=	$93,621,766	$ per Year Total	

Calculations Reference

PA DEP AQTAC 5/17/21 Presentation Slide 16

Key Takeaways: Electricity Price Changes

- **Wholesale power prices** ($/MWh) are slightly higher with RGGI participation- though smaller than 2020 modeled price impacts.

	2022	2025	2028	2030
Reference Case	$33.0	$34.8	$37.9	$40.3
Policy Case (RGGI)	$33.8	$36.0	$39.4	$41.0
$ Difference	+$.80 (2.42%)	+$1.20 (3.45%)	+$1.30 (3.96%)	+$.70 (1.73%)

- **Residential electricity bills** are slightly higher with RGGI participation- with bill impacts declining to just $.84- $1.19 per month by 2030.

RGGI Price Changes	2022	2025	2028	2030
Customer A: Heats w/ other fuel	+$1.17	+$1.67	+$1.92	+0.84
Customer B: Heats w/ electric	+$1.65	+$2.36	+$2.70	+$1.19

*Does not include anticipated electricity price decreases resulting from energy sector investments.

Compilation of Aggregated Costs in First Year of RGGI on Occupied Housing Units by PA County

TABLE 1

PA County	PJM Zone[1]	PA RGGI Year 1 LMP Impact[2]	Housing Units[4]	Impact $ Per Unit	Retail Rate $/kwh[3]	Impact $ Per Unit
Adams County	METED	1.82	38,703	$70,439	0.06174	$2,390
Allegheny County	DQE	1.35	553,858	$747,708	0.0707	$39,158
Armstrong County	APS	1.35	29,095	$39,278	0.06435	$1,872
Beaver County	DQE	1.35	70,745	$95,506	0.07	$5,002
Berks County	METED	1.82	154,696	$281,547	0.06174	$9,551
Blair County	PENLC	2.3	52,497	$120,743	0.05598	$2,939
Bucks County	PECO	1.77	240,491	$425,669	0.0627	$15,079
Butler County	APS	1.35	77,920	$105,192	0.06435	$5,014
Cambria County	PENLC	2.3	56,490	$129,927	0.05598	$3,162
Carbon County	PPL	1.88	27,107	$50,961	0.07317	$1,983
Centre County	APS	1.35	58,963	$79,600	0.06435	$3,794
Chester County	PECO	1.77	193,234	$342,024	0.0627	$12,116
Clearfield County	PENLC	2.3	31,990	$73,577	0.05598	$1,791
Columbia County	PPL	1.88	26,219	$49,292	0.07317	$1,918
Crawford County	PENLC	2.3	35,387	$81,390	0.05598	$1,981
Cumberland County	METED	1.82	101,823	$185,318	0.06174	$6,287
Dauphin County	PPL	1.88	113,905	$214,141	0.07317	$8,334
Delaware County	PECO	1.77	209,502	$370,819	0.0627	$13,136
Erie County	PENLC	2.3	110,128	$253,294	0.05598	$6,165
Fayette County	APS	1.35	54,955	$74,189	0.06435	$3,536
Franklin County	APS	1.35	60,260	$81,351	0.06435	$3,878
Indiana County	PENLC	2.3	30,704	$70,619	0.05598	$1,719
Lackawanna County	PPL	1.88	88,154	$165,730	0.07317	$6,450
Lancaster County	PPL	1.88	204,701	$384,838	0.07317	$14,978
Lawrence County	ATSI	1.27	37,282	$47,348	0.06674	$2,488
Lebanon County	METED	1.82	53,861	$98,027	0.06174	$3,325
Lehigh County	PPL	1.88	137,847	$259,152	0.07317	$10,086
Luzerne County	PPL	1.88	130,890	$246,073	0.07317	$9,577
Lycoming County	PPL	1.88	44,842	$84,303	0.07317	$3,281
Mercer County	ATSI	1.27	46,427	$58,962	0.06674	$3,099
Monroe County	PPL	1.88	56,274	$105,795	0.07317	$4,118
Montgomery County	PECO	1.77	321,373	$568,830	0.0627	$20,150
Northampton County	METED	1.82	114,950	$209,209	0.06174	$7,097
Northumberland County	PPL	1.88	38,592	$72,553	0.07317	$2,824
Philadelphia County	PECO	1.77	619,505	$1,096,524	0.0627	$38,843
Schuylkill County	PPL	1.88	58,242	$109,495	0.07317	$4,262
Somerset County	PENLC	2.3	29,456	$67,749	0.05598	$1,649
Washington County	APS	1.35	86,716	$117,067	0.06435	$5,580
Westmoreland County	APS	1.35	155,147	$209,448	0.06435	$9,984
York County	METED	1.82	175,441	$319,303	0.06174	$10,832
	Totals		**4,728,372**	**$8,162,991**	**$2.61**	**$309,426.89**

Table 1 - Reference 1

Map of PJM Zones in PA Overlaid with Outline of Pennsylvania Counties

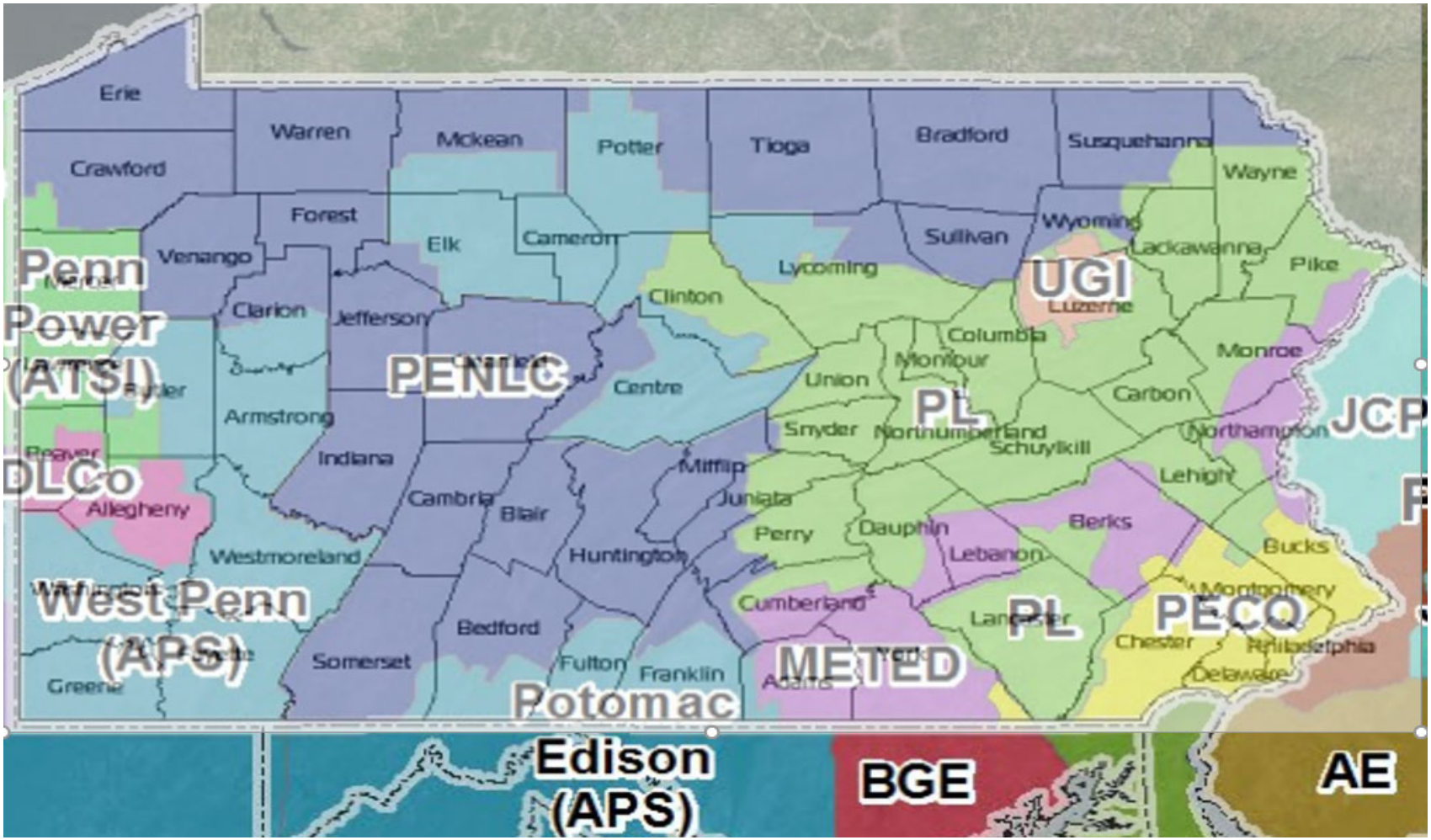


Table 1 - Reference 2

Tabors Caramanis Rudkevich Report -Table 2. LMP Impact by Zone. 2021 $/MWh

	30	31	31	30	31	30	31	31	28	31	30	31	
	22-Jun	22-Jul	22-Aug	22-Sep	22-Oct	22-Nov	22-Dec	23-Jan	23-Feb	23-Mar	23-Apr	23-May	Total
AE	1.81	1.59	4.19	1.73	0.38	0.95	1.17	2.04	1.52	1.54	1.68	1.6	1.78
AEP	0.72	0.84	3.27	0.97	0.26	0.54	0.75	1.08	1.04	0.91	0.75	0.69	1.01
APS	0.96	1.19	3.62	1.17	0.37	0.76	1.15	1.81	1.66	1.27	0.97	0.88	1.35
ATSI	1.04	1.19	3.49	1.19	0.41	0.8	1.1	1.32	1.22	1.26	0.99	0.92	1.27
BGE	-0.96	-0.47	2.29	0.01	0.04	0.47	0.2	1.91	1.78	0.56	0.11	-0.21	0.51
COMED	0.51	0.53	3.06	0.82	0.14	0.36	0.56	0.89	0.94	0.64	0.66	0.41	0.83
DAY	0.76	0.85	3.44	0.98	0.26	0.51	0.77	1.01	1.04	0.9	0.72	0.68	1.03
DEOK	0.69	0.78	3.27	0.93	0.23	0.46	0.67	0.93	0.98	0.8	0.7	0.64	0.97
DOM	0.32	0.6	3.16	0.79	0.17	0.3	-0.32	1.41	1.32	0.56	0.6	0.56	0.83
DPL	1.86	1.55	4.09	1.8	0.42	0.96	1.18	1.97	1.43	1.49	1.71	1.66	1.72
DQE	1.11	1.3	3.61	1.26	0.48	0.96	1.33	1.23	1.12	1.35	1.02	0.99	1.35
EKPC	0.63	0.77	3.36	0.87	0.21	0.41	0.58	0.98	0.97	0.72	0.68	0.6	0.92
JCPL	1.74	1.66	4.32	1.79	0.35	0.92	1.34	2.3	1.75	1.5	1.52	1.44	1.8
METED	1.6	1.59	3.67	1.88	0.5	1.02	1.43	2.57	2.57	1.58	1.62	1.32	1.82
OVEC	0.67	0.77	3.13	0.95	0.19	0.5	0.71	0.94	0.97	0.91	0.67	0.59	0.93
PECO	1.85	1.58	3.98	1.76	0.43	1	1.24	2.13	1.67	1.58	1.72	1.64	1.77
PENLC	1.68	2.03	4.07	1.64	0.52	1.04	2.67	4.63	4.27	1.66	1.4	1.28	2.3
PEPCO	-0.16	0.22	2.89	0.51	0.15	0.44	-0.02	1.82	1.81	0.61	0.45	0.27	0.79
PPL	1.63	1.66	3.65	1.84	0.48	1.02	1.51	2.86	2.81	1.59	1.61	1.37	1.88
PSEG	1.66	1.55	3.97	1.77	0.33	0.95	1.45	2.34	1.81	1.52	1.49	1.38	1.75
RECO	1.63	1.6	4.3	1.74	0.34	0.95	1.5	2.43	1.92	1.5	1.43	1.34	1.8
PJM RTO	**0.86**	**0.97**	**3.42**	**1.13**	**0.29**	**0.64**	**0.8**	**1.62**	**1.49**	**1.04**	**0.95**	**0.83**	**1.21**

Table 1 - Reference 3

Retail Rate c/kwh
6.435
6.674
7.07
6.174
6.27
5.598
7.317
Average 6.51

Ref. 3 Data derived from the standard utility rates from the following source: https://www.electricrate.com/residential-rates/pennsylvania/

Table 1 - Reference 4	

SELECTED HOUSING CHARACTERISTICS

Note: The table shown may have been modified by user selections. Some information may be missing.

DATA NOTES	
TABLE ID:	DP04
SURVEY/PROGRAM:	American Community Survey
VINTAGE:	2019
DATASET:	ACSDP1Y2019
PRODUCT:	ACS 1-Year Estimates Data Profiles
UNIVERSE:	None
FTP URL:	None
API URL:	https://api.census.gov/data/2019/acs/acs1/profile
USER SELECTIONS	
VINTAGES	2019
TOPICS	Housing Units
GEOS	All Counties within Pennsylvania
EXCLUDED COLUMNS	None
APPLIED FILTERS	None
APPLIED SORTS	None
WEB ADDRESS	https://data.census.gov/cedsci/table?q=United%20States&t=Housing%20Units&g=0400000US42.0500000&y=2019&tid=ACSDP1Y2019.DP04&hidePreview=true&moe=false&tp=true

TABLE NOTES	Although the American Community Survey (ACS) produces population, demographic and housing unit estimates, it is the Census Bureau's Population Estimates Program that produces and disseminates the official estimates of the population for the nation, states, counties, cities, and towns and estimates of housing units for states and counties.
	Supporting documentation on code lists, subject definitions, data accuracy, and statistical testing can be found on the American Community Survey website in the Technical Documentation section. Sample size and data quality measures (including coverage rates, allocation rates, and response rates) can be found on the American Community Survey website in the Methodology section.
	Source: U.S. Census Bureau, 2019 American Community Survey 1-Year Estimates
	Data are based on a sample and are subject to sampling variability. The degree of uncertainty for an estimate arising from sampling variability is represented through the use of a margin of error. The value shown here is the 90 percent margin of error. The margin of error can be interpreted roughly as providing a 90 percent probability that the interval defined by the estimate minus the margin of error and the estimate plus the margin of error (the lower and upper confidence bounds) contains the true value. In addition to sampling variability, the ACS estimates are subject to nonsampling error (for a discussion of nonsampling variability, see ACS Technical Documentation). The effect of nonsampling error is not represented in these tables.
	Households not paying cash rent are excluded from the calculation of median gross rent.
	Telephone service data are not available for certain geographic areas due to problems with data collection of this question that occurred in 2015, 2016, and 2019. Both ACS 1-year and ACS 5-year files were affected. It may take several years in the ACS 5-year files until the estimates are available for the geographic areas affected.
	The 2019 American Community Survey (ACS) data generally reflect the September 2018 Office of Management and Budget (OMB) delineations of metropolitan and micropolitan statistical areas. In certain instances the names, codes, and boundaries of the principal cities shown in ACS tables may differ from the OMB delineations due to differences in the effective dates of the geographic entities.
	Estimates of urban and rural populations, housing units, and characteristics reflect boundaries of urban areas defined based on Census 2010 data. As a result, data for urban and rural areas from the ACS do not necessarily reflect the results of ongoing urbanization.

	Explanation of Symbols: * An "**" entry in the margin of error column indicates that either no sample observations or too few sample observations were available to compute a standard error and thus the margin of error. A statistical test is not appropriate. * An "-" entry in the estimate column indicates that either no sample observations or too few sample observations were available to compute an estimate, or a ratio of medians cannot be calculated because one or both of the median estimates falls in the lowest interval or upper interval of an open-ended distribution, or the margin of error associated with a median was larger than the median itself. * An "-" following a median estimate means the median falls in the lowest interval of an open-ended distribution. * An "+" following a median estimate means the median falls in the upper interval of an open-ended distribution. * An "***" entry in the margin of error column indicates that the median falls in the lowest interval or upper interval of an open-ended distribution. A statistical test is not appropriate. * An "*****" entry in the margin of error column indicates that the estimate is controlled. A statistical test for sampling variability is not appropriate. * An "N" entry in the estimate and margin of error columns indicates that data for this geographic area cannot be displayed because the number of sample cases is too small. * An "(X)" means that the estimate is not applicable or not available.
COLUMN NOTES	None

	HOUSING OCCUPANCY			
		Total housing units		
PA County	Occupied housing units		Occupied housing units	Vacant housing units
Adams County	38,703			
Estimate		42,760	38,703	4,057
Percent		42,760	90.5%	9.5%
Allegheny County	553,858			
Estimate		604,269	553,858	50,411
Percent		604,269	91.7%	8.3%
Armstrong County	29,095			
Estimate		32,834	29,095	3,739
Percent		32,834	88.6%	11.4%
Beaver County	70,745			
Estimate		79,792	70,745	9,047
Percent		79,792	88.7%	11.3%
Berks County	154,696			
Estimate		167,863	154,696	13,167
Percent		167,863	92.2%	7.8%
Blair County	52,497			
Estimate		57,025	52,497	4,528
Percent		57,025	92.1%	7.9%
Bucks County	240,491			
Estimate		252,245	240,491	11,754

	HOUSING OCCUPANCY			
		Total housing units		
PA County	Occupied housing units		Occupied housing units	Vacant housing units
Percent		252,245	95.3%	4.7%
Butler County	77,920			
Estimate		84,871	77,920	6,951
Percent		84,871	91.8%	8.2%
Cambria County	56,490			
Estimate		66,019	56,490	9,529
Percent		66,019	85.6%	14.4%
Carbon County	27,107			
Estimate		34,885	27,107	7,778
Percent		34,885	77.7%	22.3%
Centre County	58,963			
Estimate		67,401	58,963	8,438
Percent		67,401	87.5%	12.5%
Chester County	193,234			
Estimate		203,192	193,234	9,958
Percent		203,192	95.1%	4.9%
Clearfield County	31,990			
Estimate		39,351	31,990	7,361
Percent		39,351	81.3%	18.7%
Columbia County	26,219			

	HOUSING OCCUPANCY			
		Total housing units		
PA County	Occupied housing units		Occupied housing units	Vacant housing units
Estimate		30,431	26,219	4,212
Percent		30,431	86.2%	13.8%
Crawford County	35,387			
Estimate		45,003	35,387	9,616
Percent		45,003	78.6%	21.4%
Cumberland County	101,823			
Estimate		107,924	101,823	6,101
Percent		107,924	94.3%	5.7%
Dauphin County	113,905			
Estimate		125,440	113,905	11,535
Percent		125,440	90.8%	9.2%
Delaware County	209,502			
Estimate		225,011	209,502	15,509
Percent		225,011	93.1%	6.9%
Erie County	110,128			
Estimate		121,861	110,128	11,733
Percent		121,861	90.4%	9.6%
Fayette County	54,955			
Estimate		64,068	54,955	9,113
Percent		64,068	85.8%	14.2%

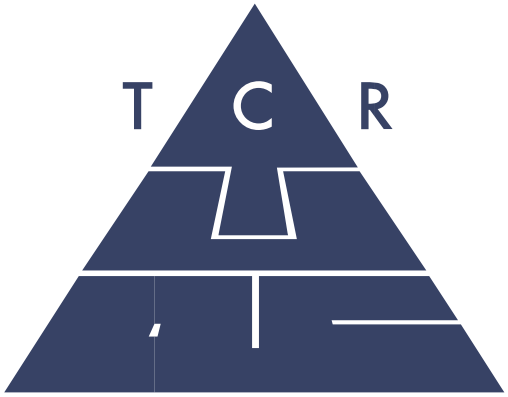
Table: ACSDP1Y2019.DP04

	HOUSING OCCUPANCY			
		Total housing units		
PA County	Occupied housing units		Occupied housing units	Vacant housing units
Franklin County	60,260			
Estimate		66,195	60,260	5,935
Percent		66,195	91.0%	9.0%
Indiana County	30,704			
Estimate		39,020	30,704	8,316
Percent		39,020	78.7%	21.3%
Lackawanna County	88,154			
Estimate		100,848	88,154	12,694
Percent		100,848	87.4%	12.6%
Lancaster County	204,701			
Estimate		213,299	204,701	8,598
Percent		213,299	96.0%	4.0%
Lawrence County	37,282			
Estimate		41,363	37,282	4,081
Percent		41,363	90.1%	9.9%
Lebanon County	53,861			
Estimate		58,258	53,861	4,397
Percent		58,258	92.5%	7.5%
Lehigh County	137,847			
Estimate		147,125	137,847	9,278

	HOUSING OCCUPANCY			
		Total housing units		
PA County	Occupied housing units		Occupied housing units	Vacant housing units
Percent		147,125	93.7%	6.3%
Luzerne County	130,890			
Estimate		150,503	130,890	19,613
Percent		150,503	87.0%	13.0%
Lycoming County	44,842			
Estimate		53,647	44,842	8,805
Percent		53,647	83.6%	16.4%
Mercer County	46,427			
Estimate		52,406	46,427	5,979
Percent		52,406	88.6%	11.4%
Monroe County	56,274			
Estimate		81,828	56,274	25,554
Percent		81,828	68.8%	31.2%
Montgomery County	321,373			
Estimate		338,480	321,373	17,107
Percent		338,480	94.9%	5.1%
Northampton County	114,950			
Estimate		123,896	114,950	8,946
Percent		123,896	92.8%	7.2%
Northumberland County	38,592			

Table: ACSDP1Y2019.DP04

	HOUSING OCCUPANCY			
		Total housing units		
PA County	Occupied housing units		Occupied housing units	Vacant housing units
Estimate		45,625	38,592	7,033
Percent		45,625	84.6%	15.4%
Philadelphia County	619,505			
Estimate		691,653	619,505	72,148
Percent		691,653	89.6%	10.4%
Schuylkill County	58,242			
Estimate		70,037	58,242	11,795
Percent		70,037	83.2%	16.8%
Somerset County	29,456			
Estimate		38,587	29,456	9,131
Percent		38,587	76.3%	23.7%
Washington County	86,716			
Estimate		96,602	86,716	9,886
Percent		96,602	89.8%	10.2%
Westmoreland County	155,147			
Estimate		170,858	155,147	15,711
Percent		170,858	90.8%	9.2%
York County	175,441			
Estimate		185,652	175,441	10,211
Percent		185,652	94.5%	5.5%



SUMMARY IMPACT OF PENNSYLVANIA JOINING RGGI ON ELECTRICITY PRICES AND GENERATION FLEET OPERATION IN PJM INTERCONNECTION

Prepared by:
Tabors Caramanis Rudkevich

June 21, 2021

Tabors Caramanis Rudkevich, Inc.

300 Washington Street, Suite 402

Newton, MA 02458

http://tcr-us.com

Executive Summary

This report summarizes the results of the of the simulation analysis prepared by Tabors Caramanis Rudkevich (TCR) of the impact of the State of Pennsylvania joining the Regional Greenhouse Gas Initiative (RGGI) on wholesale electricity prices, carbon dioxide emissions and generator performance within the footprint of power market administered by PJM Interconnection.

The report is based on power market simulations performed by TCR for two simulation scenarios – the Base Case and the Change Case (the case with RGGI in place in Pennsylvania) modeling PJM wholesale electricity market over one-year long time period from June 1, 2022 through May 31, 2023.

TCR derived several observations from the comparison of these two scenarios.

The immediate impact of the expansion of RGGI into Pennsylvania would be a shift in emissions, electricity generation, and revenues to other states, primarily to New Jersey, Ohio, Illinois, Virginia and West Virginia.

RGGI expansion into Pennsylvania will reduce carbon emission in that state by 24.4 Million short tons but will increase emissions in all other states served by PJM such that the net reduction would be 8.7 Million short tons as shown in Table ES-1.

Table ES-1. Impact on Carbon Emissions by Technology and State (million short tons)

	IC/GT	CC	ST	Coal	Total
NJ	0.1	3.1	0.0	0.0	3.2
OH	0.1	0.3	0.0	2.8	3.1
IL	0.0	1.7	0.0	0.8	2.5
VA	0.1	2.2	0.0	0.0	2.4
WV	0.1	-	-	1.8	1.8
MD	0.0	0.6	(0.0)	0.1	0.7
DE	0.0	0.4	0.0	0.0	0.5
IN	0.0	0.1	0.0	0.3	0.5
MI	-	0.4	-	-	0.4
KY	0.0	-	0.0	0.4	0.4
NC	(0.0)	0.0	0.0	-	0.0
DC	0.0	0.0	-	-	0.0
TN	-	-	0.0	0.0	0.0
PA	(0.2)	(5.0)	(2.1)	(17.1)	(24.4)
PJM	**0.2**	**3.9**	**(2.0)**	**(10.8)**	**(8.7)**

RGGI expansion into Pennsylvania will increase wholesale electricity prices in all zones of PJM resulting in overall increase in annual cost served load.by $960 million.

PJM zones serving Pennsylvania will see the highest price increase as shown in Fig. ES-1

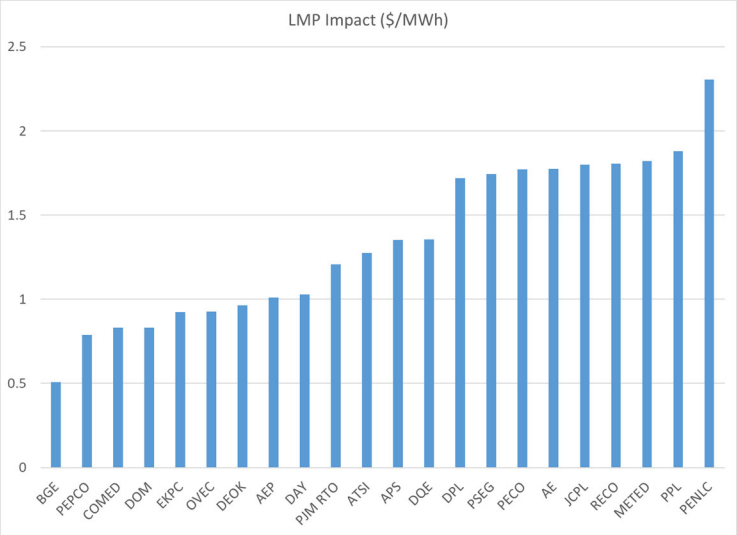


Figure ES-1

Annual electricity generation in Pennsylvania will decline by 31 TWh as shown in Table ES-1. That generation will shifted to other PJM states, primarily to New Jersey, Virginia, Illinois and Ohio.

Table ES-2. Change in Generation Technology and State (TWh)

State	IC/GT	CC	ST	Coal	SubTotal
NJ	0.13	8.17	0.00	0.02	**8.32**
VA	0.09	6.04	0.04	0.05	**6.22**
IL	0.05	4.42	0.04	0.86	**5.37**
OH	0.19	0.62	0.01	2.81	**3.63**
WV	0.09	-	-	2.00	**2.10**
MD	0.04	1.57	(0.03)	0.06	**1.64**
DE	0.07	1.09	0.04	0.01	**1.21**
MI	-	1.19	-	-	**1.19**
IN	0.01	0.32	0.02	0.38	**0.74**
KY	0.07	-	0.02	0.35	**0.43**
NC	(0.00)	0.03	0.03	-	**0.06**
DC	0.00	0.01	-	-	**0.01**
TN	-	-	0.01	0.00	**0.01**
PA	(0.43)	(12.25)	(1.82)	(16.46)	**(30.97)**
PJM	**0.31**	**11.20**	**(1.64)**	**(9.92)**	**(0.06)**

Generators in Pennsylvania will see a reduction in net operating revenues by $116 million while generators in other PJM states will see significant increase in net operating revenues as shown in Table ES-3.

Table ES-3. Impact on Generators Performance by State

State	Change In Generation (TWh)	Change in Generators' Margin (mln)
OH	3.6	$168.03
NJ	8.3	$88.97
IL	5.4	$86.80
VA	6.3	$69.89
WV	2.1	$68.65
MI	1.2	$29.74
IN	0.7	$28.01
MD	1.6	$25.15
KY	0.4	$12.70
DE	1.2	$10.82
NC	0.1	$3.59
TN	0.0	$0.42
DC	0.0	$0.14
PA	-31.0	($116.22)
Grand Total	**0**	**$476.7**

I. Introduction and Summary of Approach

This report summarizes the results of the of the simulation analysis prepared by Tabors Caramanis Rudkevich (TCR) of the impact of the State of Pennsylvania joining the Regional Greenhouse Gas Initiative (RGGI) on wholesale electricity prices, carbon dioxide emissions and generator performance within the footprint of power market administered by PJM Interconnection.

The report is based on power market simulations performed by TCR using the ENELYTIX® modeling platform and the PJM model dataset maintained by TCR.

For the purpose of this study, TCR developed two simulation scenarios – the Base Case and the Change Case. Both scenarios cover a one-year long time period from June 1, 2022 through May 31, 2023. The Base Case represents a Business-as-Usual type of the PJM market outlook assuming no RGGI expansion into Pennsylvania. The Change Case deviates from the Base Case in one and only assumption – application of the same as in the Base Case RGGI Allowance Price of carbon dioxide emissions to power plants physically located within the state of Pennsylvania.

Under both scenarios, dispatch of power generating plants in PJM was chronologically simulated with an hourly time step. TCR then compared results of these simulations specifically focusing on the differences in Locational Marginal Prices (LMPs), wholesale load payments, electricity generation by technology, state and PJM zone; generators' operating margins; and carbon dioxide emissions by technology, state and PJM zone.

The balance of the report is organized as follows:

Section II provides a brief summary of the Base Case and Change Case.
Section III presents the summary of the impact.

Appendix 1 summary of numerical results.
Appendix 2 provides a summary of data sources and modeling assumptions.
Appendix 3 provides a summary of the ENELYTIX modeling system.

II. The Base Case and Change Case

A. The Model Footprint

The footprint modeled in the TCR study includes all PJM market zones shown in Figure 1. The ENELYTIX® model include the physical representation of the electrical network of PJM and neighboring systems. The system includes engineering economic model of power generating units, electricity demand and their locations on the PJM network. The key engineering and economic parameters of these supply, demand and transmission objects are defined within the dataset TCR maintains for all project studies the company undertakes.

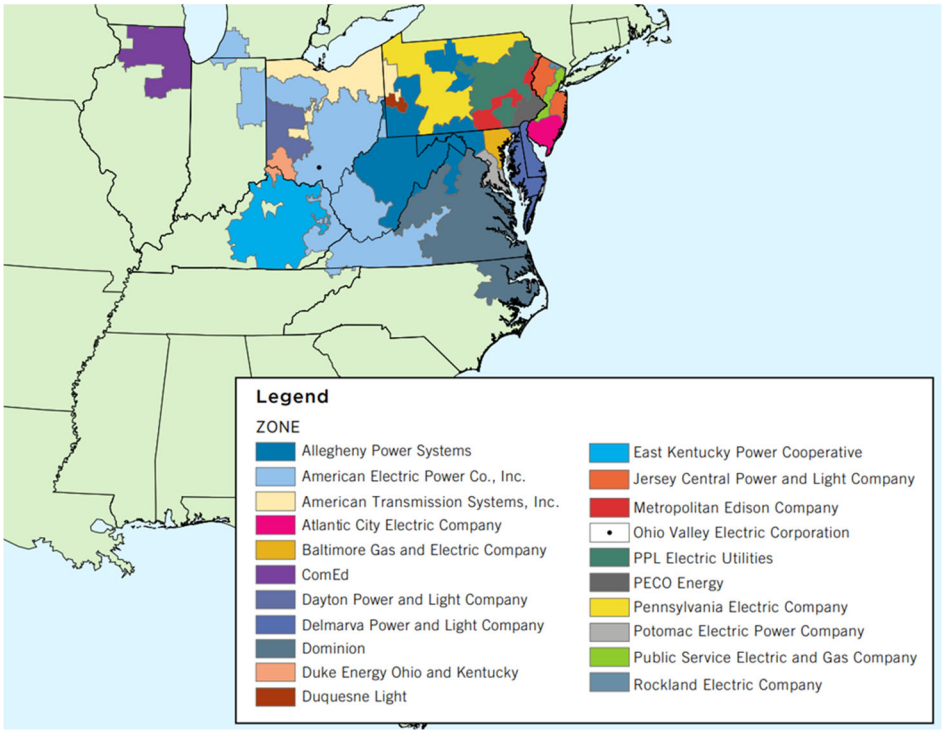


Figure 1. Map of the PJM Model Footprint

B. Key Model Inputs

The model is frequently updated to reflect the changing market conditions and inflow of information on such categories as:

- on-going changes in generation fleet (new additions, plants under constructions, generator retirement or repowering decisions);
- transmission topology changes;
- electricity demand forecasts; and
- market outlook at fuel and emission allowance prices.

Using industry information, TCR updated its outlook on the state of the PJM electrical system as of end of March of 2021 and used the most current at that time projection of electricity demand by zone obtainable from PJM.

Both the Base Case and Change Case used market outlook assumptions as of March 31, 2021. Thus, TCR used forward curves for the burner-tip natural gas a fuel oil prices as traded on that date. Similarly, the study uses the forward RGGI price as traded on ICE on March 31, 2021. The projected price slightly changes during the study period rising from $8.03/short ton in June 2022 to $8.12/short ton in May 2023. All prices are in real 2021 dollars.

As stated above, the only difference between the Base Case and the Change Case is the assumption that all carbon emitting generating units physically located within the State of Pennsylvania.[1] The key implication of that assumption is the corresponding increase in operating rates of these units.

The increase is factored in internally by PSO, the market simulation engine within ENELYTIX. That increase equals the emission rate per MWh of the unit at specific operating point and by carbon price. Thus, given the carbon prices used, in June 2022, a coal-fired power plant in Pennsylvania with the emission rate of 1 short ton per MWh would see an increase in operating rate of $8.03/MWh, a typical peaking gas-fired generator with emission rate of 0.6 short ton per MWh would see an increase of $4.82/MWh and a combined cycle gas-fired unit with emission rate of 0.4 short ton per MWh would see an increase of $3.21/MWh.

These changes in operating rates for affected power plants will change their position in the dispatch order within PJM and result in different generation, power flow, emissions and price patterns within the system.

[1] Physical location is established in accordance with the EIA Form 860 data.

III. Summary of the Impact

A. Impact on LMPs and Load Payments

With Pennsylvania joining RGGI, during the study period, annual load-weighted Locational Marginal Prices will increase in all PJM zones, as shown in Figure 2. The least affected areas of the system will be BGE, followed by PEPCO and COMED. The most affected by the price increase will be eastern PJM zones with the three highest impacted being METED, PPL and PENLC.

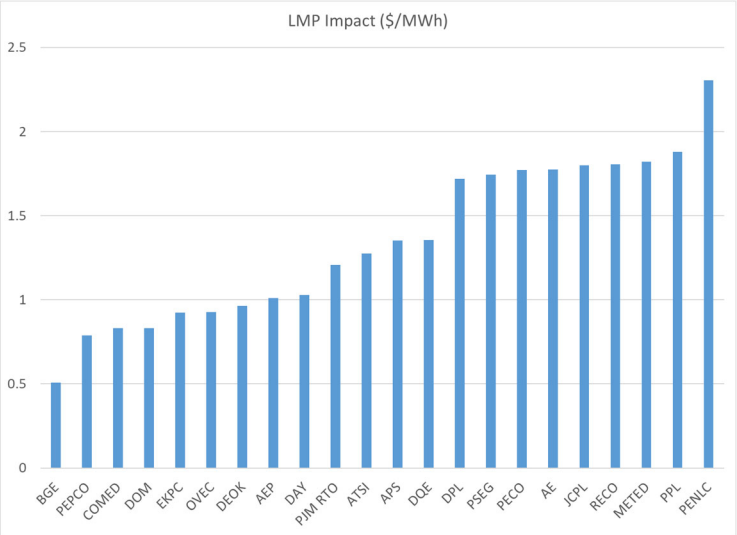


Figure 2. Increase in Load LMPs by Zone (2021 $/MWh)

The price impact is not evenly spread in time as shown in Figure 3 with highest impact occurring in summer peak and winter peak seasons.

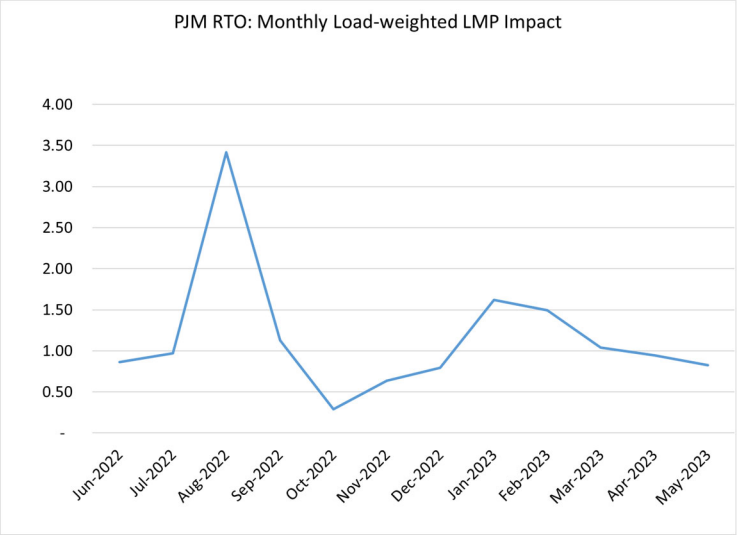


Figure 3. PJM-Wide Monthly Load-weighted LMP Impact (2021 $/MWh)

This price increase would result in the total increase in LMP-based load payments of approximately $960 million (in 2021 real dollars) over the study period as shown in Table 1 in Appendix 1.

B. Impact on Generation and Generator Margins

Pennsylvania's participation in RGGI directly affects the merit order and dispatch patterns of mostly four generating technologies – Steam Turbine Coal (Coal) units, Steam Turbine gas and oil (ST), Combined Cycle gas (CC) and Internal Combustion or Gas Turbine or (IC/GT) gas or oil units. The net effect by technology within each PJM Zone is shown graphically in Figure 4. Coal generation will decrease predominantly in PENLC zone and to a lesser extend in PPL and DQE. In other zones, coal generation will increase, especially in AEP, APS, ATSI and COMED. However, overall system-wide, coal generation

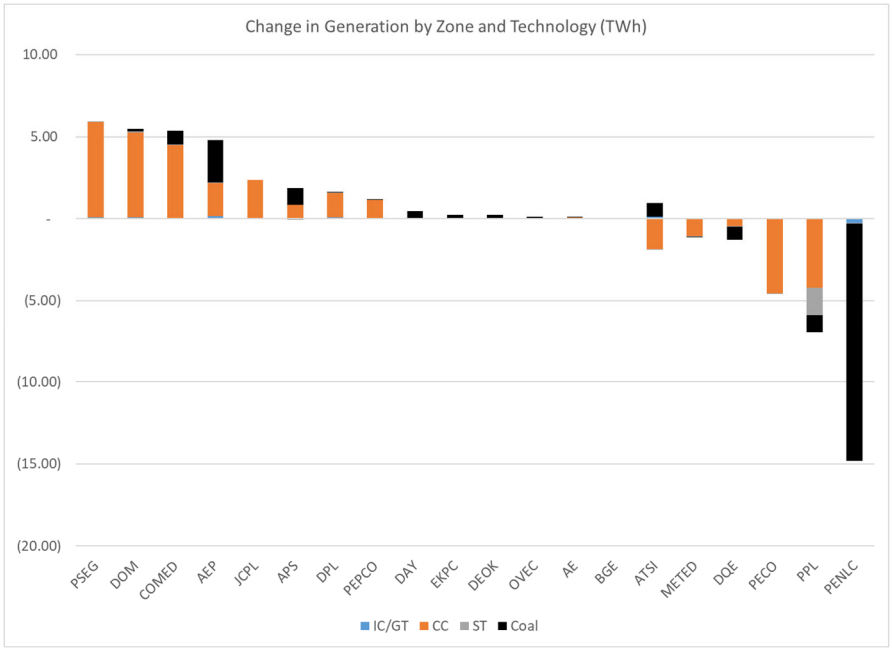


Figure 4. Change in Generation by Technology and Zone (TWh)

will decrease by nearly 10 TWh. Non-coal ST generation will decrease by 1.6 TWh, with PP making the major contribution to that decline. The loss of all ST generation will be replaced by predominantly CC (11.2 TWh) and IC/GT (0.3 TWh) unevenly spread by zone: some zones such as PSEG, DOM, COMED, JCPL and AEP will see increase in CC generation. In PPL, PECO, ATSI and METED CC generation will decline.

Change in generation by state is shown in Figure 5 which demonstrates that the entire decline in generation will occur in Pennsylvania (31 TWh). The replacement energy will be coming from other states with New Jersey, Virginal, Illinois, Ohio and W. Virginia providing the bulk of the replacement energy (26 TWh jointly). Increase in coal generation will be seen mostly in Ohio and W. Virginia.

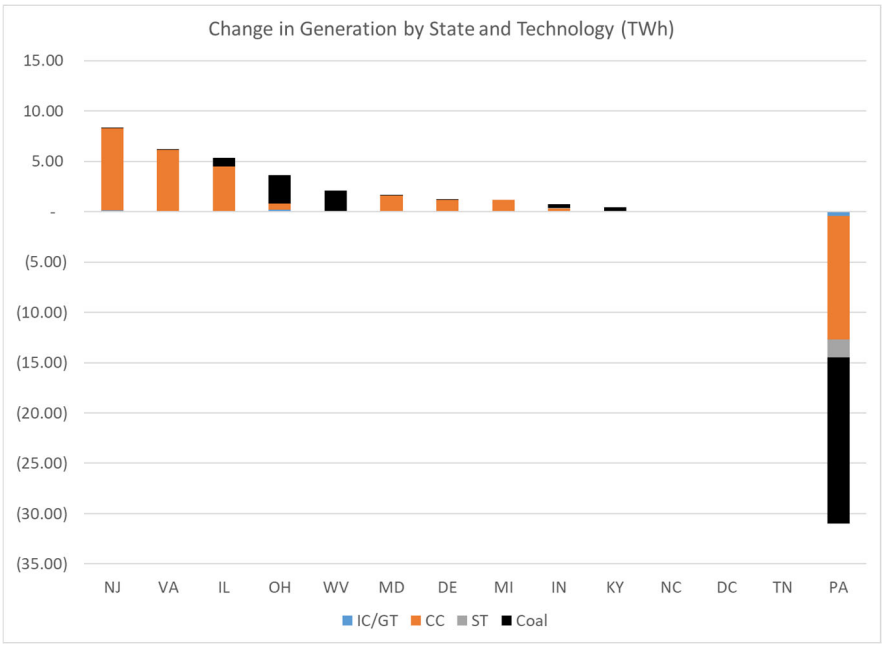


Figure 5. Change in Generation by Technology and State (TWh)

Corresponding to changes in generation and pricing, will be changes in generators' net margins defined as the difference between energy revenues and short-run operating costs. The latter include fuel and non-fuel variable O&M costs and costs of emission allowances, including those based on RGGI prices where applicable. Overall system-wide generators will see approximately $476 million

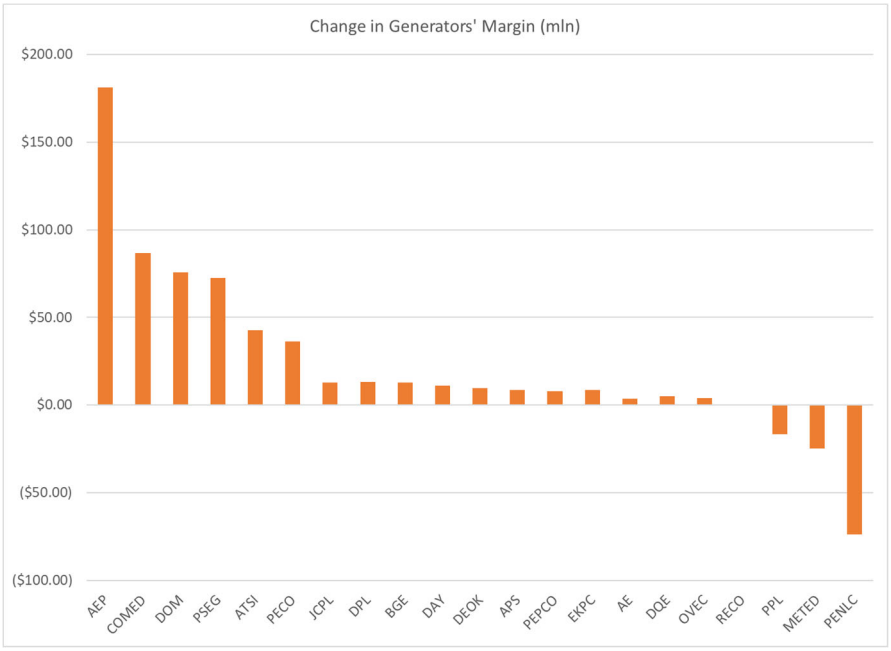


Figure 6. Change in Generators' Margins by Zone (million 2021 dollars)

(in 2021 dollars) in additional earnings in the energy market. The primary beneficiaries will be generators in AEP, COMED, DOM, PSEG, ATSI and PECO zones. The most negatively affected will be generators in PENLC, METED and PPL.

The impact on generators' margin by state is shown in Figure 7 which demonstrates that most of an increase in generators' earnings will occur in Ohio, New Jersey, Illinois, Virginia and W. Virginia. Generators in Pennsylvania will see a decline in operating margins in the magnitude of $116 million in 2021 dollars.

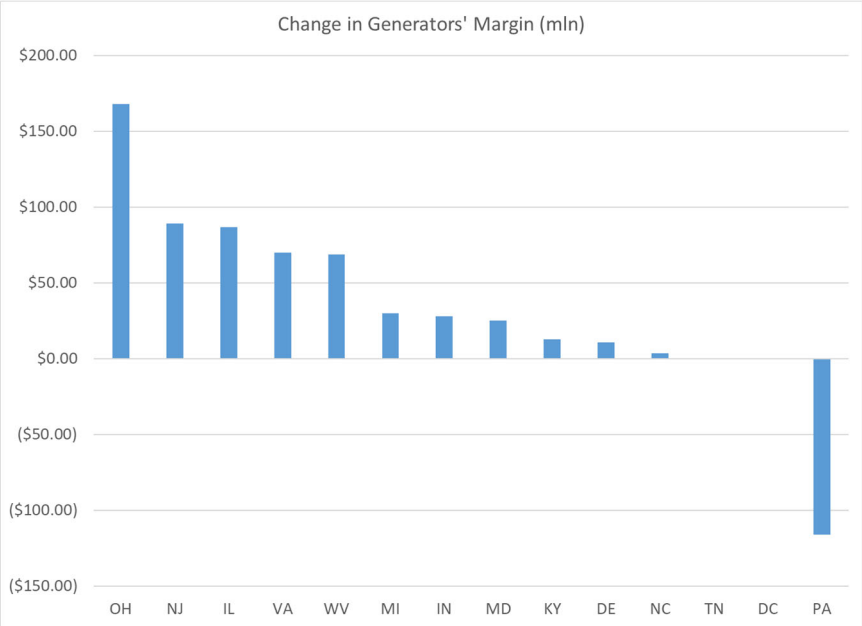


Figure 7. Change in Generators' Margins by State (million 2021 dollars)

C. Impact on Carbon Emissions

Overall system-wide PJM will see a decline in carbon emissions by 8.7 million short tons. The net balance, as shown in Figure 8. Emissions from all ST technologies will decline by 12.8 million short

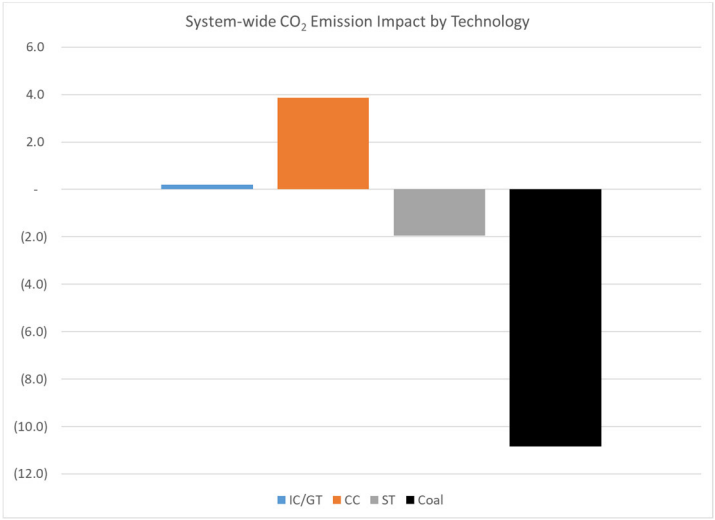


Figure 8. System-wide CO_2 Emission Impact by Technology (million short tons)

tones. That decline is partially offset by a 4.1 million short tons increase in emissions from CC and IC/GT.

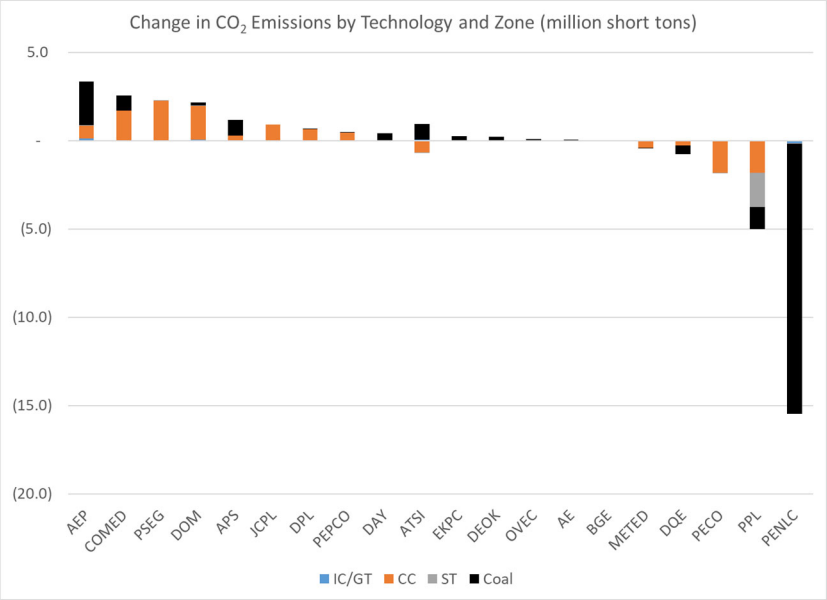


Figure 9. Change in CO_2 Emissions by Technology and Zone (million short tons)

Figure 9 shows carbon emission impact by technology and PJM Zone with bulk of the emission reduction is attributed to the loss of coal generation in PENLC. An impact by technology and state is shown in Figure 10. As shown in that figure, a decline of 24.4 million short tons of CO2 emissions in Pennsylvania will be partially offset by a 15.6 million short tons of emissions increase in other states, predominantly in New Jersey, Ohio, Illinois, Virginia and W. Virginia accounting for 13.1 million short tons of that offset.

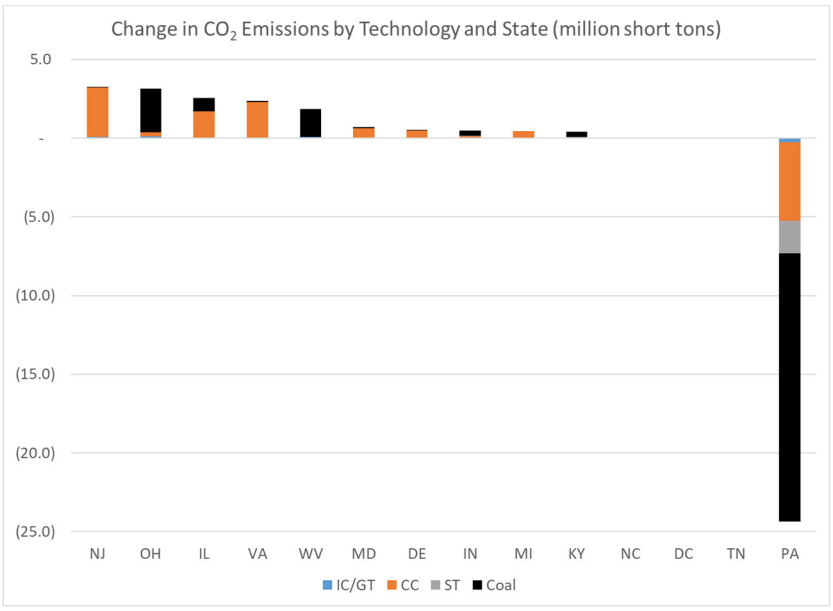


Figure 10. Change in CO2 Emissions by Technology and State (million short tons)

APPENDIX 1

Numerical Tables

Table 1. Load Costs Impact. Million 2021 dollars

	Jun-22	Jul-22	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Total
AE	1.75	2.02	4.88	1.55	0.28	0.70	0.98	1.77	1.16	1.21	1.17	1.26	18.72
AEP	7.76	9.86	37.93	9.69	2.54	5.50	8.64	13.38	11.30	10.00	7.07	6.80	130.46
APS	3.94	5.36	16.16	4.49	1.39	3.07	5.30	8.78	7.14	5.55	3.60	3.34	68.12
ATSI	5.91	7.44	21.56	6.31	2.13	4.27	6.71	8.40	6.85	7.20	4.99	4.82	86.58
BGE	(2.71)	(1.54)	7.22	0.02	0.09	1.16	0.58	5.92	4.80	1.50	0.24	(0.52)	16.76
COMED	4.32	5.12	28.69	6.41	1.02	2.67	4.49	7.46	7.00	4.95	4.50	2.96	79.60
DAY	1.15	1.40	5.70	1.36	0.35	0.69	1.16	1.62	1.49	1.30	0.90	0.91	18.02
DEOK	1.68	2.11	8.75	2.08	0.46	0.96	1.58	2.30	2.14	1.79	1.38	1.37	26.60
DOM	2.88	6.04	30.86	6.40	1.27	2.33	(2.86)	14.07	11.24	4.68	4.29	4.34	85.54
DPL	2.97	2.97	7.42	2.72	0.56	1.38	2.15	3.90	2.43	2.35	2.23	2.30	33.38
DQE	1.37	1.79	4.79	1.43	0.51	1.02	1.58	1.52	1.23	1.55	1.04	1.09	18.91
EKPC	0.58	0.78	3.33	0.71	0.17	0.38	0.64	1.20	0.99	0.69	0.51	0.48	10.46
JCPL	3.73	4.36	10.60	3.50	0.59	1.58	2.64	4.67	3.14	2.80	2.49	2.58	42.69
METED	2.16	2.46	5.56	2.37	0.60	1.27	2.05	3.86	3.44	2.17	1.89	1.61	29.45
OVEC	0.02	0.03	0.11	0.03	0.01	0.02	0.03	0.04	0.04	0.04	0.02	0.02	0.39
PECO	6.46	6.57	15.89	5.76	1.24	3.00	4.24	7.69	5.29	5.11	4.83	4.93	71.01
PENLC	2.38	3.15	6.18	2.21	0.71	1.48	4.20	7.66	6.34	2.55	1.85	1.73	40.45
PEPCO	(0.39)	0.64	8.03	1.18	0.32	0.96	(0.06)	5.01	4.38	1.46	0.91	0.58	23.04
PPL	5.39	6.26	13.32	5.76	1.45	3.35	5.66	11.54	10.01	5.65	4.82	4.17	77.39
PSEG	6.90	7.59	18.52	6.84	1.12	3.20	5.46	9.06	6.23	5.54	4.82	4.90	80.18
RECO	0.23	0.27	0.68	0.22	0.04	0.10	0.18	0.29	0.20	0.17	0.14	0.16	2.69
PJM RTO	**58.48**	**74.68**	**256.17**	**71.08**	**16.84**	**39.08**	**55.34**	**120.14**	**96.83**	**68.25**	**53.71**	**49.83**	**960.43**

Table 2. LMP Impact by Zone. 2021 $/MWh

	Jun-22	Jul-22	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Total
AE	1.81	1.59	4.19	1.73	0.38	0.95	1.17	2.04	1.52	1.54	1.68	1.60	1.78
AEP	0.72	0.84	3.27	0.97	0.26	0.54	0.75	1.08	1.04	0.91	0.75	0.69	1.01
APS	0.96	1.19	3.62	1.17	0.37	0.76	1.15	1.81	1.66	1.27	0.97	0.88	1.35
ATSI	1.04	1.19	3.49	1.19	0.41	0.80	1.10	1.32	1.22	1.26	0.99	0.92	1.27
BGE	(0.96)	(0.47)	2.29	0.01	0.04	0.47	0.20	1.91	1.78	0.56	0.11	(0.21)	0.51
COMED	0.51	0.53	3.06	0.82	0.14	0.36	0.56	0.89	0.94	0.64	0.66	0.41	0.83
DAY	0.76	0.85	3.44	0.98	0.26	0.51	0.77	1.01	1.04	0.90	0.72	0.68	1.03
DEOK	0.69	0.78	3.27	0.93	0.23	0.46	0.67	0.93	0.98	0.80	0.70	0.64	0.97
DOM	0.32	0.60	3.16	0.79	0.17	0.30	(0.32)	1.41	1.32	0.56	0.60	0.56	0.83
DPL	1.86	1.55	4.09	1.80	0.42	0.96	1.18	1.97	1.43	1.49	1.71	1.66	1.72
DQE	1.11	1.30	3.61	1.26	0.48	0.96	1.33	1.23	1.12	1.35	1.02	0.99	1.35
EKPC	0.63	0.77	3.36	0.87	0.21	0.41	0.58	0.98	0.97	0.72	0.68	0.60	0.92
JCPL	1.74	1.66	4.32	1.79	0.35	0.92	1.34	2.30	1.75	1.50	1.52	1.44	1.80
METED	1.60	1.59	3.67	1.88	0.50	1.02	1.43	2.57	2.57	1.58	1.62	1.32	1.82
OVEC	0.67	0.77	3.13	0.95	0.19	0.50	0.71	0.94	0.97	0.91	0.67	0.59	0.93
PECO	1.85	1.58	3.98	1.76	0.43	1.00	1.24	2.13	1.67	1.58	1.72	1.64	1.77
PENLC	1.68	2.03	4.07	1.64	0.52	1.04	2.67	4.63	4.27	1.66	1.40	1.28	2.30
PEPCO	(0.16)	0.22	2.89	0.51	0.15	0.44	(0.02)	1.82	1.81	0.61	0.45	0.27	0.79
PPL	1.63	1.66	3.65	1.84	0.48	1.02	1.51	2.86	2.81	1.59	1.61	1.37	1.88
PSEG	1.66	1.55	3.97	1.77	0.33	0.95	1.45	2.34	1.81	1.52	1.49	1.38	1.75
RECO	1.63	1.60	4.30	1.74	0.34	0.95	1.50	2.43	1.92	1.50	1.43	1.34	1.80
PJM RTO	**0.86**	**0.97**	**3.42**	**1.13**	**0.29**	**0.64**	**0.80**	**1.62**	**1.49**	**1.04**	**0.95**	**0.83**	**1.21**

Table 3. Change in Generation by Technology and Zone (TWh)

Zone	IC/GT	CC	ST	Coal	SubTotal
PSEG	0.07	5.82	0.00	-	**5.89**
DOM	0.07	5.18	0.07	0.18	**5.50**
COMED	0.05	4.42	0.04	0.86	**5.37**
AEP	0.16	2.01	0.05	2.56	**4.78**
JCPL	0.04	2.31	-	-	**2.35**
APS	(0.03)	0.82	(0.01)	1.04	**1.83**
DPL	0.07	1.51	0.04	0.01	**1.63**
PEPCO	0.00	1.15	(0.00)	0.04	**1.19**
DAY	0.04	-	-	0.42	**0.46**
EKPC	0.02	-	0.00	0.23	**0.25**
DEOK	0.00	0.01	0.00	0.21	**0.22**
OVEC	-	-	-	0.13	**0.13**
AE	0.02	0.04	-	0.02	**0.08**
BGE	0.01	-	(0.03)	0.01	**(0.01)**
ATSI	0.10	(1.86)	(0.00)	0.85	**(0.91)**
METED	(0.01)	(1.06)	(0.03)	(0.05)	**(1.15)**
DQE	(0.02)	(0.45)	(0.00)	(0.81)	**(1.28)**
PECO	(0.02)	(4.52)	(0.03)	-	**(4.57)**
PPL	(0.02)	(4.18)	(1.70)	(1.10)	**(7.00)**
PENLC	(0.25)	(0.01)	(0.05)	(14.50)	**(14.82)**
PJM	**0.31**	**11.20**	**(1.64)**	**(9.92)**	**(0.06)**

Table 4. Change in Generation Technology and State (TWh)

State	IC/GT	CC	ST	Coal	SubTotal
NJ	0.13	8.17	0.00	0.02	**8.32**
VA	0.09	6.04	0.04	0.05	**6.22**
IL	0.05	4.42	0.04	0.86	**5.37**
OH	0.19	0.62	0.01	2.81	**3.63**
WV	0.09	-	-	2.00	**2.10**
MD	0.04	1.57	(0.03)	0.06	**1.64**
DE	0.07	1.09	0.04	0.01	**1.21**
MI	-	1.19	-	-	**1.19**
IN	0.01	0.32	0.02	0.38	**0.74**
KY	0.07	-	0.02	0.35	**0.43**
NC	(0.00)	0.03	0.03	-	**0.06**
DC	0.00	0.01	-	-	**0.01**
TN	-	-	0.01	0.00	**0.01**
PA	(0.43)	(12.25)	(1.82)	(16.46)	**(30.97)**
PJM	**0.31**	**11.20**	**(1.64)**	**(9.92)**	**(0.06)**

Table 5. Impact on Generators Performance by Zone

AreaName	Change In Generation (TWh)	Change in Generators' Margin (mln)
AEP	4.79	$181.34
COMED	5.37	$86.80
DOM	5.58	$75.69
PSEG	5.89	$72.60
ATSI	-0.91	$42.74
PECO	-4.58	$36.12
JCPL	2.34	$12.95
DPL	1.63	$13.02
BGE	-0.01	$12.76
DAY	0.46	$11.20
DEOK	0.22	$9.72
APS	1.83	$8.41
PEPCO	1.19	$7.94
EKPC	0.25	$8.68
AE	0.08	$3.42
DQE	-1.28	$4.91
OVEC	0.13	$3.92
RECO	0.00	$0.00
PPL	-7.00	($16.51)
METED	-1.15	($24.97)
PENLC	-14.84	($74.04)
Grand Total	**0**	**$476.7**

Table 6. Impact on Generators Performance by State

State	Change In Generation (TWh)	Change in Generators' Margin (mln)
OH	3.6	$168.03
NJ	8.3	$88.97
IL	5.4	$86.80
VA	6.3	$69.89
WV	2.1	$68.65
MI	1.2	$29.74
IN	0.7	$28.01
MD	1.6	$25.15
KY	0.4	$12.70
DE	1.2	$10.82
NC	0.1	$3.59
TN	0.0	$0.42
DC	0.0	$0.14
PA	-31.0	($116.22)
Grand Total	**0**	**$476.7**

Table 7. Impact on Carbon Emissions by Technology and Zone (million short tons)

	IC/GT	CC	ST	Coal	Total
AEP	0.1	0.7	0.0	2.5	3.4
COMED	0.0	1.7	0.0	0.8	2.5
PSEG	0.0	2.2	0.0	-	2.3
DOM	0.0	1.9	0.0	0.2	2.2
APS	(0.0)	0.3	(0.0)	0.9	1.2
JCPL	0.0	0.9	-	-	0.9
DPL	0.0	0.6	0.0	0.0	0.7
PEPCO	0.0	0.4	(0.0)	0.0	0.5
DAY	0.0	-	-	0.4	0.4
ATSI	0.1	(0.7)	(0.0)	0.9	0.3
EKPC	0.0	-	0.0	0.2	0.3
DEOK	0.0	0.0	0.0	0.2	0.2
OVEC	-	-	-	0.1	0.1
AE	0.0	0.0	-	0.0	0.1
BGE	0.0	-	(0.0)	0.0	(0.0)
METED	(0.0)	(0.4)	(0.0)	(0.0)	(0.4)
DQE	(0.0)	(0.3)	(0.0)	(0.5)	(0.8)
PECO	0.0	(1.8)	(0.0)	-	(1.8)
PPL	(0.0)	(1.8)	(2.0)	(1.2)	(5.0)
PENLC	(0.1)	(0.0)	(0.0)	(15.3)	(15.5)
PJM	**0.2**	**3.9**	**(2.0)**	**(10.8)**	**(8.7)**

Table 8. Impact on Carbon Emissions by Technology and State (million short tons)

	IC/GT	CC	ST	Coal	Total
NJ	0.1	3.1	0.0	0.0	3.2
OH	0.1	0.3	0.0	2.8	3.1
IL	0.0	1.7	0.0	0.8	2.5
VA	0.1	2.2	0.0	0.0	2.4
WV	0.1	-	-	1.8	1.8
MD	0.0	0.6	(0.0)	0.1	0.7
DE	0.0	0.4	0.0	0.0	0.5
IN	0.0	0.1	0.0	0.3	0.5
MI	-	0.4	-	-	0.4
KY	0.0	-	0.0	0.4	0.4
NC	(0.0)	0.0	0.0	-	0.0
DC	0.0	0.0	-	-	0.0
TN	-	-	0.0	0.0	0.0
PA	(0.2)	(5.0)	(2.1)	(17.1)	(24.4)
PJM	**0.2**	**3.9**	**(2.0)**	**(10.8)**	**(8.7)**

APPENDIX 3

ENELYTIX

Introduction

ENELYTIX®[2] is a Software as a Service (SaaS) energy market simulation environment implemented on Amazon EC2 commercial cloud.

A central element of ENELYTIX is the Power System Optimizer ("PSO"), an advanced simulator of power markets[3]. PSO provides ENELYTIX the capability to accurately model the decision processes used in a wide range of power planning and market structures including long-term system expansion, capacity markets, Day-ahead energy markets and Real-time energy markets. ENELYTIX has this capability because it can configure PSO to determine the optimum solution to each market structure.

As a system expansion optimization model, PSO integrates resource adequacy requirements with the specific design of the capacity market and with the environmental compliance policies, such as state-level and regional Renewable Portfolio Standards (RPS) and emission constraints.

As a production cost model, PSO is built on a Mixed Integer Programming (MIP) based unit commitment and economic dispatch structure that simulates the operation of the electric power system. PSO determines the security-constrained commitment and dispatch of each modeled generating unit, the loading of each element of the transmission system, and the locational marginal price (LMP) for each generator and load area. PSO supports both hourly and sub hourly timescales. In this project, the PSO is set up to model unit commitment (DA market) and an economic dispatch (RT market). In the commitment process, generating units in a region are turned on or kept on in order for the system to have enough generating capacity available to meet the expected peak load and required operating reserves in the region for the next day. PSO then uses the set of committed units to dispatch the system on an hourly real-time basis, whereby committed units throughout the modeled footprint are operated between their minimum and maximum operating points to minimize total production costs. The unit commitment in PSO is formulated as a mixed integer linear programming optimization problem which is solved to the true optima using the commercial CPLEX solver.

The ENELYTIX/PSO modeling environment provides a realistic, objective and highly defendable analyses of the physical and financial performance of power systems, in particular power systems integrating variable renewable resources. The critical advantage of PSO over traditional production costing modeling tools is its ability to model the concurrent dynamics of:

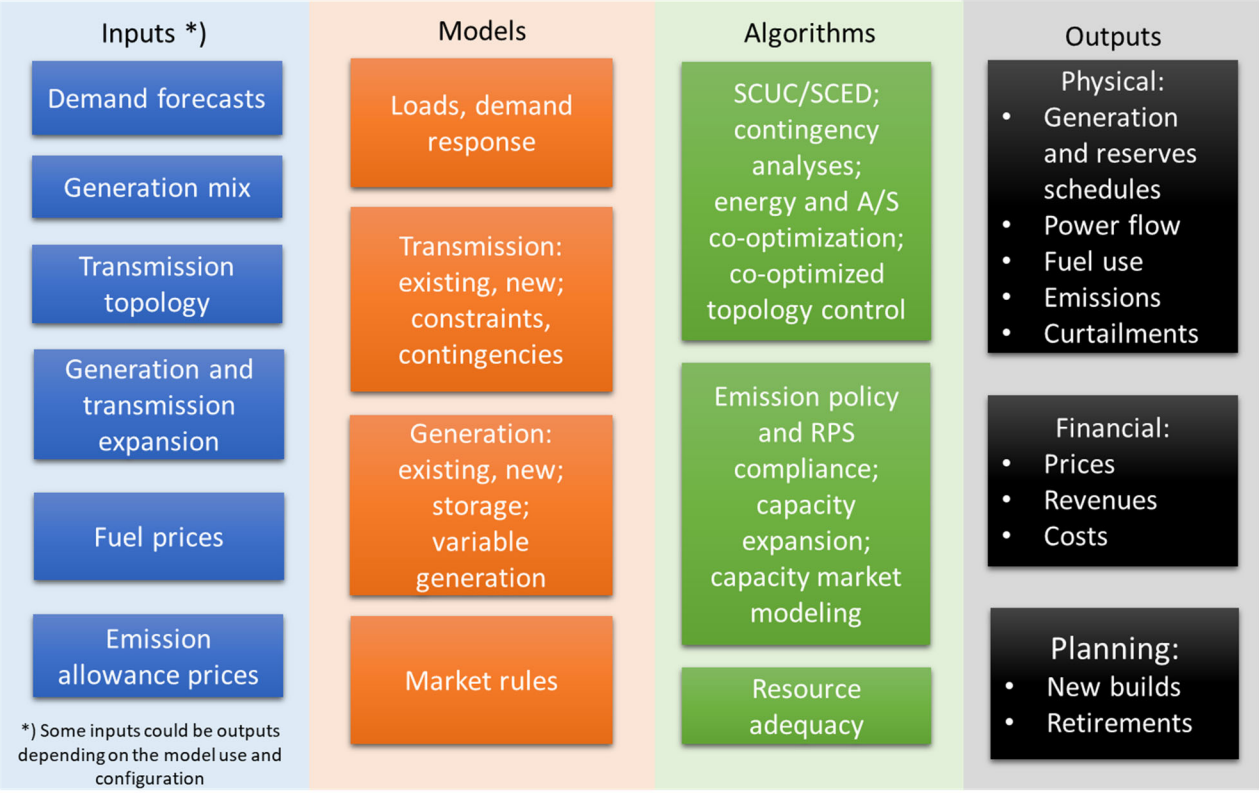
1. uncertainty of future conditions of the power system;

[2] ENELYTIX® is a registered trademark of Newton Energy Group, LLC.

[3] PSO is a product of Polaris System Optimization, Inc.

2. the scope, physical capabilities and economics of options available to the system operator to respond to these uncertain conditions;
3. the timing and optionality or irreversibility of operator's decisions to exercise these options.

By capturing these concurrent dynamics, ENELYTIX/PSO avoids the generally recognized inability of traditional simulation tools to reflect the effect of operational decisions on the physics of the power system, price formation and financial performance of physical and financial assets.



Analytical structure of PSO

ENELYTIX Modeling Architecture

ENELYTIX provides the advanced modeling features of PSO and the scalability of cloud computing. With the ENELYTIX cloud-based architecture, TCR can generate, simulate and post process a large number of Cases in a matter of hours.

ENELYTIX architecture supports parallel processing of simulation projects. A Project consists of Tasks. Each Task is a collection of Cases, and each Case is partitioned into Segments which could be processed in parallel. In ENELYTIX, implementation of a Task *is a single-click* experience. Once the Task is launched, it invokes a process in which all user requested Cases are generated at once out of the Market Model Database (MMD) pre-populated with model data.

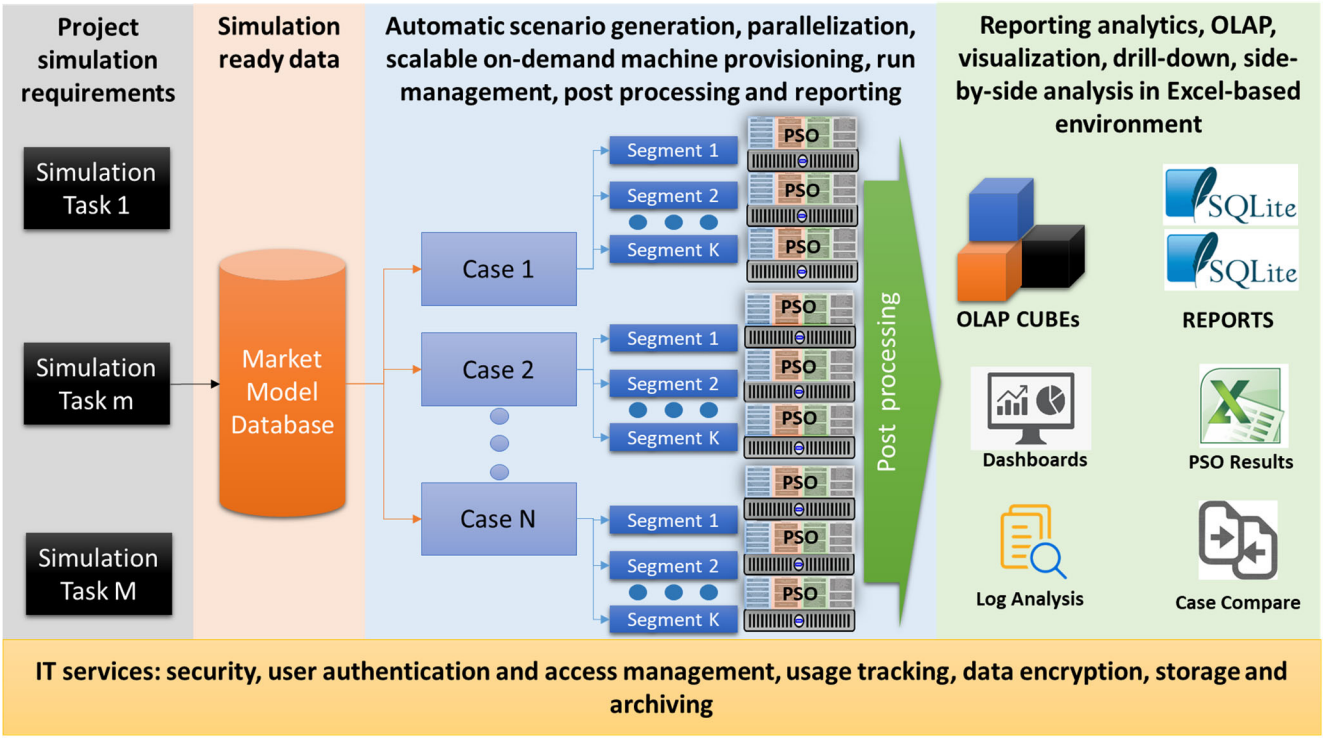
Cases are formed by specifying alternative versions of inputs (e.g. alternative supply options or portfolios of such options, load forecast, new entry and retirement assumptions or fuel price sensitivities, types and requirements for ancillary services and myriads of other alternatives the user may need to explore and compare against each other within the same task).

ENELYTIX automatically partitions each Case into Segments for parallel execution. Segments are queued and sent to servers dynamically procured on the cloud to be processed with PSO.

ENELYTIX collects output results, merges Segment related outputs corresponding to the same Case and makes both inputs and outputs available for data analytics and business intelligence tools.

ENELYTIX complies with high standards of data security properly protecting confidential and Critical Energy Infrastructure Information (CEII).

For additional information about ENELYTIX, visit www.enelytix.com.



Schematic of ENELYTIX architecture