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June 16, 2020

**VIA E-File**

Rosemary Chiavetta
Secretary
Pennsylvania Public Utility Commission
400 North Street, Filing Room
Harrisburg, PA 17120

Re: *Direct Testimony of Karl R. Rábago on Behalf of the Environmental Stakeholders*
Docket No. P-2020-3019290

Dear Secretary Chiavetta,

Enclosed for filing in the above-referenced proceeding, please find the Direct Testimony of Karl R. Rábago on behalf of Sierra Club, Clean Air Council, and Philadelphia Solar Energy Association (collectively, the "Environmental Stakeholders"). As evidenced by the Certificate of Service, all parties to the proceeding are being served with a copy of this document. Thank you.

Should you have any questions, please contact me at dmcdougall@earthjustice.org.

Sincerely,

*/s/ Devin McDougall*
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**BEFORE THE**
**PENNSYLVANIA PUBLIC UTILITY COMMISSION**

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| **PETITION OF PECO ENERGY COMPANY FOR APPROVAL OF ITS DEFAULT SERVICE PROGRAM FOR THE PERIOD FROM JUNE 1, 2021 THROUGH MAY 31, 2025** | **)<br>)<br>)<br>)<br>)** | **DOCKET NO. P-2020-3019290** |

**DIRECT TESTIMONY**

**OF**

**KARL R. RÁBAGO**

**ON BEHALF OF THE**

**ENVIRONMENTAL STAKEHOLDERS**

**June 16, 2020**

Environmental Stakeholders Statement No. 1

## TABLE OF CONTENTS



## LIST OF FIGURES



## LIST OF EXHIBITS

**I. WITNESS IDENTIFICATION AND QUALIFICATIONS.**

**Q. Please state your name, business name and address, and role in this proceeding.**

A. My name is Karl R. Rábago. I am the principal of Rábago Energy LLC, a Colorado limited liability company, located at 2025 E. 24th Avenue, Denver, Colorado. I appear here in my capacity as an expert witness on behalf of Sierra Club, Clean Air Council, and the Philadelphia Solar Energy Association (the "Environmental Stakeholders").

**Q. Please summarize your experience and expertise in the field of electric utility regulation and the renewable energy field.**

A. I have worked for nearly 30 years in the electricity industry and related fields. I have been actively involved in a wide range of electric utility issues across the United States as an expert witness and, until recently in my capacity as Executive Director of the Pace Energy and Climate Center, as a party in New York rate cases and in Reforming the Energy Vision proceedings.

My previous employment experience includes Commissioner with the Public Utility Commission of Texas, Deputy Assistant Secretary with the U.S. Department of Energy, Vice President with Austin Energy, and Director with AES Corporation, among others.

My experience includes making hundreds of decisions on the record in cases involving avoided costs, rates, tariffs, certificates of need, rulemakings, and other proceedings. I have also held executive responsibility for managing public and private budgets ranging to hundreds of millions of dollars. A detailed resume is attached as Exhibit KRR-1.

**Q. Have you ever testified before the Pennsylvania Public Utility Commission ("Commission" or "PUC") or other regulatory agencies?**

A. No, I have not previously testified before the Commission. I was a co-presenter on an alternative ratemaking webinar in August 2017 that was part of the Pennsylvania Department of Environmental Protection's "Pennsylvania's Solar Future Plan." Additionally, in the past six years, I have submitted testimony, comments, or presentations in proceedings in Alabama, Arkansas, Arizona, California, Colorado, Connecticut, District of Columbia, Florida, Georgia, Guam, Hawaii, Indiana, Iowa, Kansas, Kentucky, Louisiana, Massachusetts, Michigan, Minnesota, Missouri, Nevada, New Hampshire, New York, North Carolina, Ohio, Pennsylvania, Puerto Rico, Rhode Island, Vermont, Virginia, Washington, and Wisconsin. I have also testified before the U.S. Congress and have been a participant in comments and briefs filed at several federal agencies and courts. A listing of my previous testimony is attached as Exhibit KRR-2.

**Q. What is the purpose of your testimony?**

A. In this testimony, I will review and offer recommendations to the Commission regarding issues arising in the Petition of PECO Energy Company ("Company") for approval of its proposed Default Service Plan V ("DSP V") covering the period June 1, 2021 through May 31, 2025. In particular, I will address:

- The evolved and evolving policy and electricity market environment during which DSP V will be in effect;
- Ways in which the Company's DSP V must change to meet the needs and opportunities presented over the next four years and beyond; and
- Opportunities to leverage time of use ("TOU") rates to advance clean distributed

generation development, electrification of medium- and heavy-duty transportation fleets, and reduce peak costs for all customers.

**Q. What information did you review in preparing this testimony?**

A. I reviewed relevant pre-filed testimony of Company witnesses and associated exhibits, relevant Pennsylvania laws and regulations, and relevant Company responses to information requests submitted by the Environmental Stakeholders and other parties.

**Q. Please summarize your recommendations to the Commission.**

A. I recommend that the Commission direct the Company: (1) to develop and implement a planning process aimed at constructing, through competitive processes, an adequate default service supply portfolio; (2) that actively engages stakeholders (meaning, at a minimum, soliciting comments from a wide range of stakeholders; holding public working sessions on plan development processes, decisions, and assumptions; inviting and considering stakeholder input on plan structure and elements; incorporating stakeholder concepts and ideas in planning activities and plans, including alternative scenarios; frequently sharing analysis on a timely, transparent, and frequent basis; and accounting for stakeholder inputs in reporting and submission of proposals to the Commission); (3) that transparently evaluates the full range of cost and benefits associated with supply options over time; (4) that includes due consideration of the factors of price stability, reduced environmental compliance risk, reduced transmission and distribution costs, and other factors as appropriate; (5) that accounts for current and emerging Commonwealth and municipal energy and climate policy by incorporating more renewable energy resources and distributed energy resources in order to secure the operational, technical, economic, and financial benefits of those resources in the default service plan; (6) that corrects a neglect of resource adequacy, resiliency, and reliability issues that functions as a discriminatory barrier to renewable energy; (7) that corrects an excessive and unreasonable focus on short-term contracts that functions as a discriminatory barrier to renewable energy; and (8) that demonstrates a strong likelihood, based on substantial evidence submitted into the record, that it is a plan that is least cost, over time, to customers, and that reflects a prudent mix of short- and long-term contracts for supply.

I further recommend that the Commission condition any approval of the proposed TOU rate upon the Company's commitment to perform a detailed and comprehensive evaluation of the results and impacts of the rate. In addition, I recommend that the Commission direct the Company to use a benefit-cost analysis framework to develop proposals for TOU rate pilots directed at opportunities associated with beneficial electrification of direct thermal loads currently served by gas and for electrification of medium- and heavy-duty transportation applications, including fleets.

## II. LEGAL, REGULATORY, AND POLICY CONSIDERATIONS RELEVANT TO THE REVIEW OF THE PECO DSP V PROPOSED PLAN.

**Q. What are the key statutory provisions governing the review of the Company's proposed DSP V?**

A. Pennsylvania law[1] requires that the Company, as a default service provider, to:

- Provide default service electric generation supply service to non-shopping customers pursuant to a commission-approved competitive procurement plan;

[1] 66 Pa.C.S.A. § 2807.

- Procure electric power supply through a prudent mix of spot, short-term, and long-term contracts;
- Configure and acquire a prudent mix of contracts that is designed to ensure adequate and reliable service, least cost to customers over time, and compliance with competitive procurement provisions of the law; and
- Propose a plan and provide sufficient and competent evidence to support the Commission's determination that the plan includes prudent steps necessary to negotiate favorable supply contracts and obtain least-cost generation supply contracts on a long-term, short-term, and spot market basis; and that neither the DSP nor its affiliated interest has withheld from the market any generation supply in a manner that violates Federal law.

**Q. How has the Commission reflected these requirements in its rules and policies?**

A. The Commission has promulgated rules relating to Default Service[2] and a "Default Service and Retail Electric Markets -- Statement of Policy"[3] that track and implement the requirements of the Pennsylvania statute.

**Q. How did the Commission articulate the goal of its default service regulations?**

A. The Commission stated that "[t]he goal of the default service regulations is to ensure that each DSP provides default service customers with adequate and reliable service at the least cost to customers over time. This goal can be accomplished by structuring default service in a way that brings competitive market discipline to historically regulated

[2] 52 Pa. Code § 54.181–.190.

[3] 52 Pa. Code § 69.1801–.1817.

markets and by encouraging the entry of new retail and wholesale suppliers. Greater diversity of suppliers will benefit ratepayers and the Commonwealth."[4]

**Q. Did the Commission impose any restrictions on the use of long-term contracts in its Policy Statement?**

A. No. Originally, the Commission had proposed that long-term contracts "only be used when necessary and required for DSP compliance with alternative energy requirements, and should be restricted to covering a relatively small portion of the default service load."[5] However, after careful consideration, the Commission determined that the proposed language would limit the use of long-term contracts only to meeting the requirements of Pennsylvania's Alternative Energy Portfolio Standards Act[6] which would have been "too restrictive."[7]

**Q. Has the Commission provided additional guidance relevant to the review of the Company's proposed DSP V?**

A. Yes. In a Secretarial Letter issued January 23, 2020,[8] the Commission raised other issues it wanted addressed in proposed default service plans. The Commission urged DSPs to consider how TOU rates specific to electric vehicles ("EVs") could be made available to consumers. The Commission stated that the topic of long-term contracts should be considered further in upcoming DSP proceedings and requested that the electricity

[4] 52 Pa. Code § 69.1802.

[5] PUC, *Final Policy Statement*, Docket No. M-2009-2140580, at 8–9 (Sept. 22, 2011) ("Policy Statement").

[6] Alternative Energy Portfolio Standards Act of 2004, 73 P.S. § 1648.1, *et seq.* ("AEPS Act").

[7] Policy Statement at 11.

[8] PA PUC, Secretarial Letter- Closing Default Service Investigation, Docket No. M-2019-3007101 (Jan. 23, 2020).

distribution companies ("EDCs") submit evidence with DSP proposals showing how the proposal complies with the prudent mix requirements of the law.

**Q. Are there other Commonwealth policies and findings that provide context for the Commission's consideration of PECO's DSP V proposal?**

A. Yes. On January 8, 2019, Governor Wolf issued Executive Order No. 2019-01, entitled "Commonwealth Leadership in Addressing Climate Change and Promoting Energy Conservation and Sustainable Governance."[9] EO 2019-01 states that "the Commonwealth is resolved to do its part to address climate change, the most critical environmental threat confronting the world."[10] EO 2019-01 further states that "the Commonwealth is committed to further reducing its net greenhouse gas emissions which, left unchecked, would create a high risk of irreversible, widespread, severe climate impacts in the Commonwealth and beyond..." [11] To implement this commitment, EO 2019-01 sets a target of a 26% reduction in net greenhouse gas emissions statewide by 2025 from 2005 levels, and an 80% reduction by 2050.[12] EO 2019-01 instructs that "[a]ll Commonwealth agencies shall work to achieve the Goals set forth in this Order" and that the Commonwealth can take steps to "increase reliance on clean energy..."[13]

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[9] Exec. Order 2019-01 (Jan. 8, 2019) ("EO 2019-01").

[10] *Id*.

[11] *Id*.

[12] *Id*.

[13] *Id*.

On October 3, 2019, Governor Wolf issued Executive Order No. 2019-07, entitled "Commonwealth Leadership in Addressing Climate Change through Electric Sector Emissions Reductions".[14] EO 2019-07 stated that "the Commonwealth must take concrete, economically sound and immediate steps to reduce GHG ["Greenhouse Gas"] emissions."[15] EO 2019-07 also directed the Pennsylvania Department of Environmental Protection ("PA DEP") to begin the process of rulemaking necessary for the Commonwealth to join the Regional Greenhouse Gas Initiative ("RGGI"), an emissions trading market operated by ten East Coast states to reduce greenhouse gas emissions from the power sector.[16] PA DEP published draft RGGI regulations in February 2020, and expects that the regulation will ultimately be finalized and take effect by fall 2021.[17]

On April 29, 2019, PA DEP published an updated Pennsylvania Climate Action Plan.[18] In it, PA DEP stated that climate change is "the most critical environmental threat facing the world" and reaffirmed the Commonwealth's target of reducing its greenhouse gas emissions by 80% from 2005 levels by 2050.[19] On November 13, 2019, the Pennsylvania Auditor General released a report entitled, "Climate Crisis: The Rising Cost

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[14] Exec. Order 2019-07 (Oct. 3, 2019) ("EO 2019-07").

[15] *Id*.

[16] *Id*.

[17] PA DEP, *Pennsylvania's Proposed CO2 Budget Trading Program* (Feb. 13, 2020), http://files.dep.state.pa.us/Air/AirQuality/AQPortalFiles/Advisory%20Committees/Air%20Quality%20Technical%20Advisory%20Committee/2020/2-13-20/AQTAC%20PA%20CO2%20Budget%20Trading%20Program_February%202020.pdf.

[18] PA DEP, *Pennsylvania Climate Action Plan* (Apr. 29, 2019) ("Climate Action Plan"), http://www.depgreenport.state.pa.us/elibrary/GetDocument?docId=1454161&DocName=2018%20PA%20CLIMATE%20ACTION%20PLAN.PDF%20%20%20%3cspan%20style%3D%22color:blue%3b%22%3e%28NEW%29%3c/span%3e.

[19] *Id*. at 12.

of Inaction."[20] The report found that in 2018, "climate-related costs to Pennsylvania totaled at least $261 million," including losses from floods and landslides, and stated that "[y]our tax dollars will increasingly be spent to clean up after such disasters if state government does not step up now and limit our contribution to the climate crisis."[21]

**Q. Has the City of Philadelphia adopted any policies and findings that provide context for the Commission's consideration of PECO's DSP V proposal?**

A. Yes. On September 26, 2019, the City of Philadelphia passed Resolution No. 190728 committing that "the City of Philadelphia shall take measures to achieve a fair and equitable transition to the use of 100% clean renewable energy for electricity in municipal operations by 2030, for electricity City-wide by 2035, and for all energy (including heat and transportation) city-wide by 2050 or sooner."[22] Resolution No. 190728 also noted that over 130 municipalities around the country have adopted goals to transition to 100% renewable energy, including over 20 Philadelphia suburban towns.[23]

Resolution No. 190728 built on, widened, and accelerated the goals set by the City in Resolution No. 170706, adopted by the City Council on September 14, 2017.[24] Resolution No. 170706 urged the City to commit to becoming carbon-neutral in city

[20] Eugene A. Depasquale, *Climate Crisis: The Rising Cost of Inaction*, Office of the Auditor General, (Nov. 13, 2019).

[21] *Id*. at 1.

[22] City of Philadelphia, *Res. No. 190728*, at 3 (Sept. 26, 2019) ("Resolution No. 190728").

[23] *Id.* at 2. Sierra Club maintains a website which hosts many of the resolutions adopted by municipalities in PECO's service territory. Sierra Club Pennsylvania, *RF100 Support: Resolutions*, https://www.sierraclub.org/pennsylvania/southeastern/rf100-support-resolutions#examples (last visited June 15, 2020).

[24] City of Philadelphia, *Res. No. 170706* (Sept. 14, 2017) ("Resolution No. 170706").

operations by 2050.[25] Resolution No. 170706 also urged the City to "to stimulate the generation of secure, family-supporting, local jobs in the fields of energy efficiency and renewable energy with equitable access to green career pathways for inner-city workers."[26]

## III. THE EVOLVED AND EVOLVING ELECTRICITY MARKET CONTEXT FOR DEFAULT SERVICE.

**Q. How have the electricity and energy sectors changed in the years since Pennsylvania's electricity choice and default service structures were first implemented?**

A. An exciting new study from the Goldman School of Public Policy dramatically reveals the new energy reality in the United States.[27] Over the past ten years, the costs of renewable energy, natural gas, storage, and financing have all plummeted. What this means is that a rapid scale-up to a 90% clean energy mix for the continental United States can be achieved as soon as 2035 and with cost savings compared to the current electricity mix.[28] Achieving a 90% clean energy mix in the U.S. would cost less than a no-new-

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[25] *Id.* at 2.

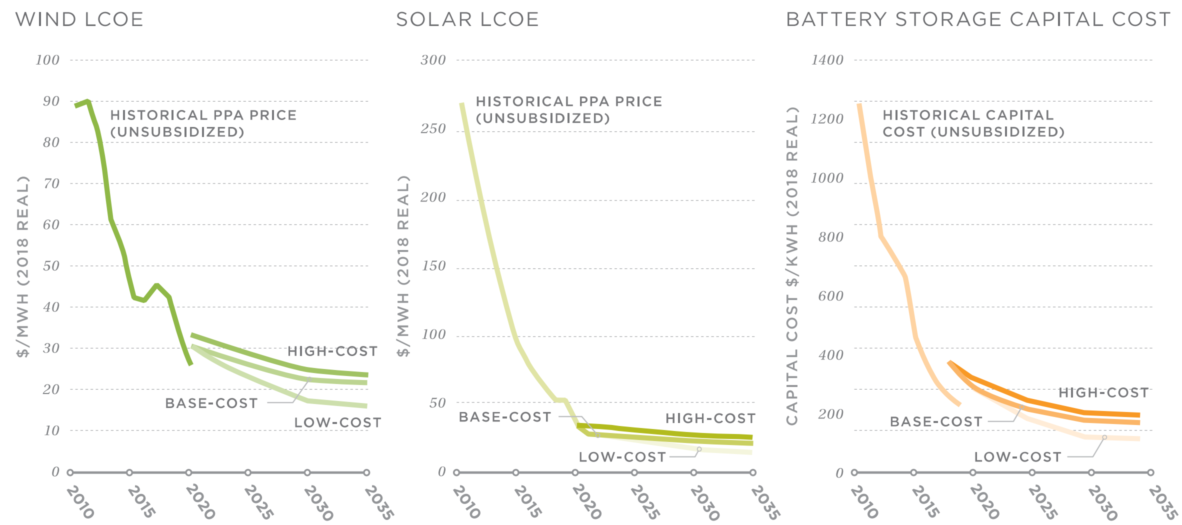
[26] *Id*. at 3.

[27] Univ. Of Calif. Berkeley: Goldman School of Public Policy, *2035 Report: Plummeting Solar, Wind, and Battery Costs Can Accelerate Our Clean Energy Future* (June 2020) ("2035 Report"), http://www.2035report.com/wp-content/uploads/2020/06/2035-Report.pdf?utm_referrer=https%3A%2F%2Fwww.2035report.com%2F.

[28] *Id*. Already a growing number of states, cities, and counties are committing to 100% renewable energy. The Sierra Club maintains a list of these commitments online. *See* Sierra Club, *Ready for 100: 100% Commitments in Cities, Counties, & States*, https://www.sierraclub.org/ready-for-100/commitments (last visited June 15, 2020). The Union of Concerned Scientists ("UCS") reports on the additional states that have made commitments to 100% clean energy (which may include nuclear energy), citing the improving economics for renewable energy as a major driver. *See* Jeff Deyette, *States March toward 100% Clean Energy – Who's Next?*, UCS (Aug. 28, 2019), https://blog.ucsusa.org/jeff-deyette/states-march-toward-100-clean-energy-whos-next.

policy mix when over $1.2 trillion in avoided health and environmental costs are considered and would lead to the creation of 8.5 million more job-years of employment.[29]

Figure 1: Historical and Projected Technology Cost Declines for Wind, Solar, Battery Storage.[30]




**Q. What other trends are now discernable?**

A. There are two major additional trends that characterize the energy landscape. First, the prices of smaller-scale energy resources—distributed energy resources ("DERs")—are likewise falling rapidly, portending rapid and dramatic growth in distributed generation as well as distributed storage, EV charging load, and other DERs. U.S. DERs and connected devices peak demand impacts are expected to double during the period of the Company's proposed DSP V, as shown in Figure 2.[31] DERs are increasingly recognized for their resource value—as non-wires solutions to infrastructure requirements—and for their contributions to environmental, employment, and other benefits. The second additional trend is characterized by the impacts of electrification of transportation and

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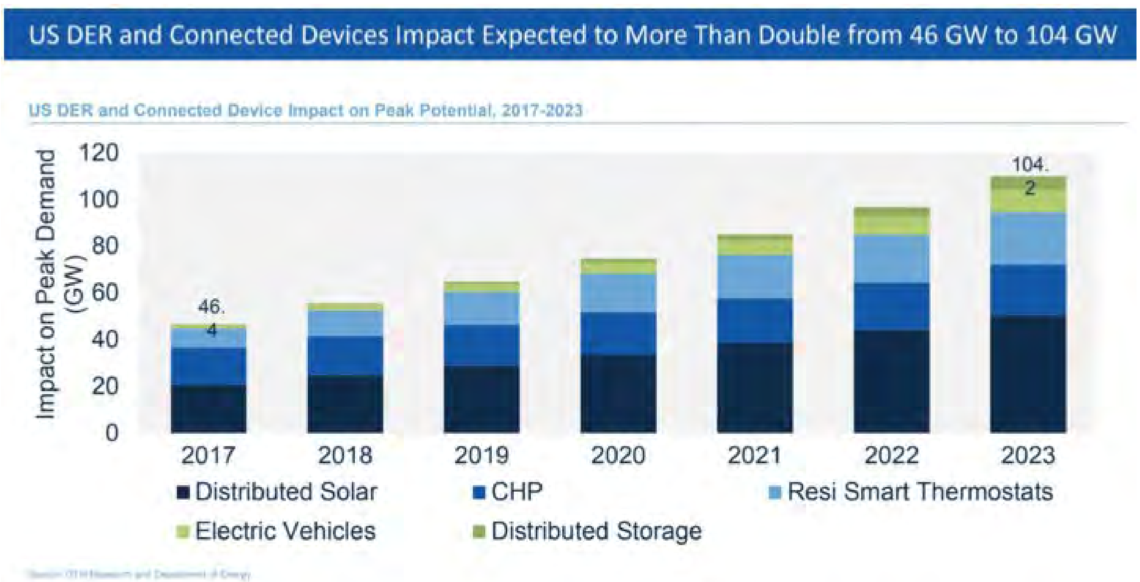
[29] 2035 Report at 5–7.

[30] 2035 Report at 14.

[31] Jeff St. John, *Distributed Energy Poised for 'Explosive Growth' on the US Grid*, GTM (June 21, 2018), https://www.greentechmedia.com/articles/read/distributed-energy-poised-for-explosive-growth-on-the-us-grid.

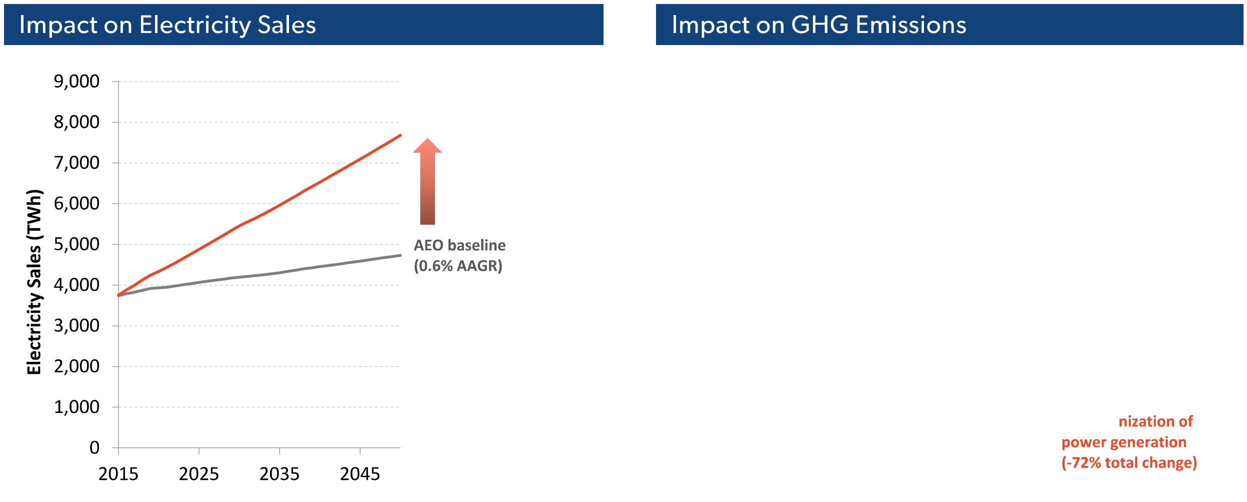
direct thermal energy uses (e.g., building heat, cooking, and process energy) combined with deep decarbonization strategies such as the 90% by 2035 scenario previously discussed. As one report from the Brattle Group revealed electricity sales could nearly double by the year 2050, with energy-related carbon emissions falling by a factor of 5 or more.[32] In short, the technological and economic opportunities are aligning with the growing climate imperative to rapidly accelerate a fundamental transformation in the electricity and energy sectors.

Figure 2: U.S. DERs and Connected Devices Peak Demand Impacts, 2017-2023.




[32] Jurgen Weiss *et al.*, *Electrification: Emerging Opportunities for Utility Growth*, The Brattle Group, at 2 (Jan. 2017), https://brattlefiles.blob.core.windows.net/files/7298_electrification_emerging_opportunities_for_utility_growth.pdf.

Figure 3: Impact of Electrification Combined with Deep Decarbonization of Power Sector.




Source: The Brattle Group analysis based on EIA AEO 2015 data

**Q. How are these market trends and actions relevant to this proceeding?**

A. This proceeding is basically about the Company procuring extremely large quantities of electric power to serve many thousands of PECO default service customers. The process and terms under which that power is procured must be viewed in light of extant market, economic, technology, and policy trends in order to ensure that the mix of supply is prudent—least-cost over time, adequate, and reliable in meeting the needs of default service customers.

**Q. Has the Company ever received a bid for supply with high renewable energy content, say over 50% renewables?**

A. No. The Company has never once received a bid submission that reflected 50% or more renewable energy content.[33] Under early iterations of the default service program, this could have been largely an artifact of costs, but given the explosive growth in renewable

[33] Company Resp. to ES-I-11 (Response of Company to Interrogatories of the Environmental Stakeholders ES Set I is attached as Exhibit KRR-3).

energy development in the U.S. over the past four years, this lack of bids likely reflects discriminatory barriers resulting from a solicitation process based exclusively on short-term fixed-price full requirements ("FPFR") supply contracts. Other than the procurement of solar alternative energy certificates ("SAECs") to partially meet the Company's AEPS Act minimum requirements, the Company in no way accounts for relative market maturity of different generation resources, or for the competitive advantages or disadvantages of different kinds of generation that exist and that are accentuated by the Company's short-term FRFR contracting approach.[34] The Company acknowledges that "the choice, definition, timing, and procurement process of the supply products can also contribute to the determination of whether the supply constitutes a prudent mix of contracts designed to ensure least cost to customers over time,"[35] but nonetheless proposed continued exclusive reliance on short-term FPFR supply contracts in its DSP V proposal.

**Q. What do you recommend that the Company do?**

A. The Company should develop a plan that takes advantage of these trends and aligns with these policies. Rather than doing only the minimum required by the AEPS Act, the Company should apply its expertise to developing a default service procurement process that secures additional long-term cost savings and reliability benefits from renewables and DERs.

[34] Company Resp. to ES-I-12.

[35] Company Resp. to ES-I-26.

**Q. Is there any good reason to ignore these trends and policy actions in crafting a default service plan?**

A. No. Pennsylvania law and Commission policy and regulations require both short- and long-term perspective in assembling a prudent mix of contracts through a default service plan. The rapidly improving economics and carbon-reduction benefits of renewable energy at all scales demands doing more than the minimum in composing that prudent mix. A process that fails to take advantage of those benefits on behalf of default service customers is therefore imprudent.

## IV. OVERVIEW OF THE COMPANY'S DSP V PROPOSAL.

**Q. Please summarize the Company's DSP V proposal.**

A. The Company's DSP V proposal is substantially the same as its DSP IV program.[36] The Company intends to conduct competitive solicitations for FPFR supply for residential and small commercial customers with twelve- and twenty-four-month terms, and with hourly terms for larger commercial and industrial customers.[37] The Company proposes to preserve contract terms used in DSP IV as well.[38]

**Q. Are there major changes in the Company's DSP V proposal from DSP IV?**

A. Yes. The Company proposes to solicit new ten-year contracts for SAEC, including some from within its service territory, to partially satisfy requirements of law.[39] The Company also proposes a new TOU rate that would be available to default service customers.

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[36] Company, *Direct Test. of John J. McCawley, P.E.*, Docket No. P-2020-3019290, at 8 (Mar. 13, 2020).

[37] *Id.* at 8–9.

[38] *Id.* at 9.

[39] *Id.* at 10.

**Q. Based on your review of the Company's proposals in this proceeding, do you think the Company has proposed a plan that will secure a prudent mix of contracts for supply to serve default customers?**

A. I would expect the Company's proposed DSP V to perform well against the standards the Company has set for itself, but I find that those standards are now no longer well-aligned with Commonwealth policy in light of changed and changing market and policy conditions. That is, the Company operates a well-oiled machine when it comes to procuring short-term supply on the cheapest, most commoditized terms available for such contracts. The systems and processes to achieve that result have been used for more than seven hundred FPFR default service supply product tranches procured by the Company alone.[40] I disagree with the Company that the efficiency with which it secures supply—entirely through short-term contracts—results in a prudent mix of contracts.

**Q. Why do you take the position that the Company's short-term supply contracting approach is inconsistent with achieving a prudent mix of contracts?**

A. The Company does not use and does not propose to use long-term contracting to secure any supply except SAECs required for AEPS Act compliance. This is exactly the approach to contracting that the Commission rejected as "too restrictive" when it adopted its Final Policy Statement in 2011.[41]

[40] Company Resp. to ES-I-34.

[41] Policy Statement at 11.

**Q. How could procurement of supply at least in part through long-term contracts support development of a prudent mix of contracts as required under Pennsylvania law?**

A. Long-term contracts can add price stability to the prices in a supply portfolio. In addition, long-term contracts are particularly well-suited for procurement of supply from renewable energy facilities, which have very small marginal operating costs and are not subject to the kind of fuel price volatility associated with fossil methane gas-fired generation. Creating demand for long-term contract supply will have the effect of inducing innovation in supply provision, which will in turn increase the scope and benefits of competition in the marketplace. Finally, a mix of supply that includes long-term contracts will provide a better reference point and benchmark for competitive supply shopping.

**Q. What is the Company's position on long-term supply contracts?**

A. The Company has been opposed to inclusion of long-term contracts in its supply portfolio since 2009, and in spite of the kinds of changes that have emerged in the generation marketplace over the past ten years, the Company has not developed any new arguments or analysis to support its continued position on long-term contracts.[42]

**Q. The backbone of the Company's plan is competitive procurement of FPFR supply through mixed and overlapping short-term contracts. Do you take issue with that approach?**

A. The Company has committed to fixed-price full requirements contracting obligations for default suppliers to provide some benefits to customers. However, it appears that the

[42] *See* Company Resp. to ES-I-30.

primary beneficiary is the Company. The risk of portfolio management is on the suppliers, as is the burden of ensuring that the supplier can meet the obligation over the length of the contract. This almost-complete transfer of supply and market risk seems to have been the major driver for reliance on short-term contracts. That is, it is doubtful that competitive suppliers could accept full deliverability risk and portfolio management risk with long-term FPFR contracts.

**Q. Does the FPFR-only approach create volatility problems or impact least cost over the long term?**

A. Yes. The Company has instituted a six-month contract overlap and mixing strategy to address price volatility issues and to prevent a sudden change in prices at the end of the plan term. This is the extent of the Company's efforts to manage its supply portfolio and is a fix that is only required because of exclusive reliance on short-term contracts for supply. Mixing and overlapping of contracts smooths changes in supply rates by blending those changes with previous and subsequent contract prices but does not eliminate the impacts customers see from price volatility.[43] In addition, the Company's focus on short-term contracting narrows the range of competitive supply proposals to those with the lowest short-run marginal cost, but does not necessarily reflect lowest cost over both the short- and long-term. A portfolio option that would not require such a fix to address volatility and that would better obtain the benefits that the Company must use contract mixing and overlapping to achieve, would be reliance on long-term contracts as part of a prudent mix of contracts, especially renewable energy supply contracts. And with long-term renewable energy supply contracts, the Company could secure a portfolio

[43] Company Resp. to ES-I-36.

that captures the rapidly improving price characteristics of large renewable resources, the local benefits of distributed renewable resources, and supply for default customers that is truly least cost over time.

**Q. What is the Company's view of the impacts on competition of its supply sourcing strategy of exclusive reliance on short-term supply contracts?**

A. The Company asserts that FPFR contracts promote competition because they provide all the benefits of competition on all aspects of FPFR contracts, a circular argument that ignores the potential benefits of other approaches to contracting, including greater reliance on longer-term renewable energy-based supply and DERs.[44] The Company recognizes that the DSP procurement practice of only sourcing FPFR supply contracts drives the competitive market to compete on the same terms, which would likely weaken competition and product innovation in the choice market.[45]

**Q. What role does price pay in the Company's proposed DSP V?**

A. Short-term fixed price for full requirements service is, beyond contract terms and tenor, the Company's only criteria relied upon in securing default service.[46]

**Q. What is your opinion of the Company's reliance on short-term price as its dominant determinant for supply procurement?**

A. The Company's short-term contract procurement approach focused on price is unreasonable in several respects. First, price and cost are not the same. The Company focus on price as the determinant of bid selection among its qualified bidders fails to

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[44] *See* Company Resp. to ES-I-37 (stating that "having bidders compete and be selected based on the lowest price for full requirements products, default service customers will be provided the benefits of competition on all aspects of the full requirements supply obligation...").

[45] *Id.* (stating that "EGSs will compete against . . . default service rates," as the "price-to-compare benchmark...").

[46] *Id. See also* Company Resp. to ES-I-2, -4, -23, -24, and 25.

account for the total cost of its procurement decisions. An assessment of least cost must account for environmental impacts, relative market position among suppliers, differences in supply types, and other factors that inform the cost to customers of the selected portfolio. It is not enough to assert that all bidders can respond to the solicitation if the terms for selection predetermines the range of successful bidders and means that only lowest short-term price commodity bidders can win a contract. Second, the Company's approach means that contracts with lowest price over the short term will be selected, but the process does not identify or select the supply mix that is lowest price or cost over the mid- or long-term. Finally, the Company's approach creates a risk of price volatility that the Company finds it necessary to address with overlapping and mixing of contracts, and completely precludes and places no value on supply proposals that would inherently offer price stability over longer terms.

**Q. What kinds of supply contracts could offer price stability over longer contract tenors?**

A. The best example of supply sources that could provide long-term price stability, as well as other benefits such as the near-total elimination of environmental costs are renewable energy-based, such as wind and solar.

**Q. What do you recommend that the Company do to reflect least cost in its supply mix for default service customers?**

A. The Company should develop and propose a portfolio approach to default service that reflects true least cost and not just least price. Even if the Company did not want to take on the full job of managing a supply portfolio with diverse supply resources, a job that I believe the law and regulations require, it should at least work with bidders to construct a solicitation that would encourage supply proposals that included longer contract tenors and a supply mix that provided true least cost benefits over time.

**Q. How does the Company purport to meet the "least cost to customers over time" requirement under Pennsylvania law and regulation?[47]**

A. The Company's position on the least cost over time standard is somewhat confused. The statute requires that the Company provide a plan that is designed to ensure the least cost to customers over time.[48] On the other hand, and notwithstanding the statutory obligation, the Company asserts that a default service plan becomes the least cost over time solely by operation of a Commission decision approving a proposed plan.[49] Finally, the Company takes the position that the standard is met by proposing to procure a portfolio of short-term contracts, with some overlap, over the four-year tenor of the proposed DSP V.[50] As a result, the Company's view of least cost over time seems to be no longer than the time period defined by the Commission regulations as short-term for contracting.[51]

**Q. Isn't the Company proposing to procure SAECs through ten-year contracts?**

A. The Company is proposing ten-year procurements of SAECs in partial satisfaction of its AEPS Act obligations.[52] This is more in keeping with the least cost over time obligation, but it is not enough to establish that the Company is complying with the law. In addition,

[47] 66 Pa.C.S.A. § 2807(e)(3.4).

[48] *Id*.

[49] Company Resp. to ES-I-1.

[50] Company Resp. to ES-I-2, -3, and -7. The Company does not consider inter-generational impacts of its default service practices, such as the climate change impacts associated with reliance on fossil-based generation. *See* Company Resp. to ES-I-5 and -6.

[51] 52 Pa. Code § 54.186.

[52] Company Resp. to ES-I-7.

the SAEC proposal does not appear to be based on any reasoning associated with procuring the mix of *supply* with the least cost over time. First, SAECs are not energy supply. As such, the long-term contract procurement is a step removed from the underlying renewable energy supply. Second, the Company cites, as the sole reason for proposing its ten-year procurement of SAECs, the fact that it used ten-year contracts in the past and pursuant to a settlement reached in a prior case.[53] As previously noted, the Company maintains its more than decade-long opposition to long-term contracts.[54] Finally, the amount of the SAECs that the Company proposes to obtain through long-term contracts is a small portion of the total number of SAECs and an even smaller fraction of the total number of AECs it has had to procure in the past and must procure over the term of the proposed DSP V.[55] This fraction and amount is insufficient to serve as a major market driving force. The Company's proposal does not meet the standard of a prudent mix of contracts and is not reasonably designed to ensure least cost over time.

**Q. In your opinion, is the Company's approach to the "least cost over time" standard in the laws reasonable and appropriate?**

A. No. First, as I previously explained, the Company reads and applies the term "least cost" as "least price" and does not account for all the cost factors associated with supply over time. Second, the Company's approach essentially reads the words "over time" out of the law, regulation, and policy. Instead, it defines "over time" as a time period no longer than the term of its DSP V proposal—four years. And due to its contracting approach,

[53] Company Resp. to ES-1-4.

[54] Company Resp. to ES-I-30.

[55] Company Resp. to ESC-III-3 and -4 (Response of Company to Interrogatories of the Electric Supplier Coalition ESC Set III is attached as Exhibit KRR-4).

the Company actually limits the definition of least cost over time to a maximum of two years—the term of the longest contracts it secures.  Finally, the Company's approach denies default service customers the benefits that could be obtained by blending a balanced and optimal share of long-term contracts into the default service mix.  Given the price stability benefits and improving economics of renewable energy resources like solar and wind generation, this means the Company's approach to the least cost over time standard means that such resources are effectively and practically excluded from the mix.

**Q. What do you recommend that the Company do to better reflect and meet the least cost over time standard in its default service plan development?**

A. The Company should develop and implement an approach that transparently evaluates the full range of cost and benefits associated with supply options over time, including price stability, reduced environmental compliance risk, reduced transmission and distribution costs, and other factors, and, in a fashion similar to that used under integrated resource planning or other planning approaches, construct and compare supply scenarios that can be evaluated not only in terms of short-term price, but also least cost over time.

**Q. How does the Company establish that its plan and the supply it would procure would be "adequate and reliable?"**

A. While the Company statements of Mr. McCawley and Mr. Fisher acknowledge the legal and regulatory obligation the Company faces to configure a prudent mix of contracts that is designed to ensure adequate and reliable service to customers, neither witness provides any testimony that demonstrates how the proposed DSP V meets that standard.

**Q. What supply characteristics could help ensure adequate and reliable service?**

A. First, and foremost, the Company should evaluate availability characteristics associated with different types of generation supply. That is, what kinds of resources are most likely to be operating as projected for the greatest percentage of time. Solar, wind, and some biomass energy facilities meet the criteria of having high availability—and therefore higher reliability—because they are mechanically simple in design and less subject to breakdown and maintenance downtime than rotating machines that rely on fossil fuel combustion. Second, the Company should evaluate which types of generation are more or less vulnerable to fuel supply disruptions, such as may occur in emergencies and extreme weather events. Again, renewable resources offer adequacy and reliability benefits in this regard. Evaluation and procurement processes designed to harness these benefits are completely missing from the Company's DSP V proposal. As previously discussed, the Company's exclusive reliance on short-term FPFR contracts for supply actually frustrates the obtaining of such benefits. It is true that the Company proposal to obtain some of its minimum requirement of SAECs will indirectly support the operation of solar resources, but this proposal is not based on a design intention of the Company's approach.[56]

**Q. In your opinion, does the Company's proposed DSP V ensure adequate and reliable supply for default service customers?**

A. No. First, the Company does not directly address this standard with evidence in this proceeding and therefore their proposal is deficient. Second, as previously explained, the Company's excessive and unreasonable reliance on short-term contracts for supply, and

[56] Company Resp. to ES-I-9.

the failure to meet the least cost and least cost over time tests means that the proposal does not and cannot meet the test for ensuring adequate and reliable supply.

**Q. What do you recommend based on these findings?**

A. Again, I recommend that the Company develop and implement an approach that transparently evaluates the full range of costs and benefits associated with supply options over time, including price stability, reduced environmental compliance risk, reduced transmission and distribution costs, and other factors, and, in a fashion similar to that used under integrated resource planning or other planning approaches, and that this planning effort include evaluation of resource adequacy and reliability in constructing the default service supply portfolio.

**Q. Does the Company propose a plan that would secure a prudent mix of contracts, including short- and long-term contracts?**

A. No.

**Q. Does the Company plan to take advantage of falling costs and lower emissions from large- and small-scale renewable energy generation?**

A. No. These trends are discussed in greater detail earlier in this testimony and are significant. But the Company demonstrates no intention to capture these cost savings and benefits in its DSP V proposal and places no value on these emerging benefits in its procurement design or bid evaluation processes.

**Q. Does the Company's proposed DSP V plan optimize the peak reduction, locational, and other benefits of distributed generation?**

A. No. Distributed generation resources are right-sized resources that can be more easily sited to optimize grid value and reduce costs. The Company's short-term FPFR program design reflects no intention to secure these benefits through the DSP V proposal.[57]

**Q. Does the Company's proposed DSP V plan assess and seek to obtain the resilience and reliability benefits of distributed generation?**

A. No. As previously discussed, the Company's proposal points to no evidence that supports a finding that its proposed plan would result in adequate and reliable supply to default service customers. In addition, the Company fails to consider that distributed generation can provide resilience benefits, especially when deployed with storage and energy management capabilities. These benefits are of increasing import in maintaining reliability in a world subject to more frequent weather events—especially those impacting bulk power generation and transmission infrastructure. A prudent mix of supply contracts should include resources not dependent on transmission infrastructure for the delivery of energy services.

**Q. Has the Company ever conducted any surveys or other research to determine customer preferences relating to default service?**

A. No.[58] As a result, the supply procured by the Company is unrelated to customer preferences and therefore is less likely to support the development of competitive markets. As customers acquire greater familiarity and understanding of a wide array of

[57] Company Resp. to ES-I-9 and -22.

[58] Company Resp. to ES-I-13e.

energy service and technology options, they begin to form more specific consumption and purchase preferences. These preferences should be tracked and evaluated by the Company in preparing its default service plan in order to support its claim that the resulting supply mix is adequate and prudent. In addition, increasing reflection of customer preferences in the default service plan will more closely align default service with the kinds of service options customer want from the competitive market, thereby supporting the development of competitive markets that give customers what they want. It is also worth noting that a great many comments delivered by citizens and customers at the public input hearing in this proceeding expressed dissatisfaction with the Company's proposed plan, further indicating the value of asking default customers about what they want in default service.[59]

**Q. Does the Company's DSP V proposal create an opportunity for default service customers to contribute to incremental reductions in greenhouse gases beyond the minimums required by law in Pennsylvania?**

A. No. The Company's DSP V approach to supply procurement constrains default service customers to supporting only the lowest required level of greenhouse gas reductions through electricity supply[60] and does not account for the carbon emissions associated with supply procurements.

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[59] *See, e.g.*, Ron Celentano, *Written Testimony to Accompany Oral Testimony at the June 9th Public Input Hearing for the PECO DSP V*, Docket No. P-2020-3019290 (June 9, 2020) (attached as Exhibit KRR-5); Linnea Bond, *Written Testimony to Accompany Oral Testimony at the June 9th Public Input Hearing for the PECO DSP V*, Docket No. P-2020-3019290 (June 9, 2020) (attached as Exhibit KRR-6); Gregory Holt, *Written Testimony to Accompany Oral Testimony at the June 9th Public Input Hearing for the PECO DSP V*, Docket No. P-2020-3019290 (June 9, 2020) (attached as Exhibit KRR-7); Julie Greenberg, *Written Testimony to Accompany Oral Testimony at the June 9th Public Input Hearing for the PECO DSP V*, Docket No. P-2020-3019290 (June 9, 2020) (attached as Exhibit KRR-8).

[60] Company Resp. to ES-I-53.

**Q. What then is your overall assessment of the Company's proposed DSP V?**

A. While the Company has developed an efficient and effective method for securing electricity supply through short-term FPFR contracts, the Company has failed to show that its proposed DSP V will meet the required standard of producing a supply mix that reflects a prudent mix of contracts designed to ensure adequate and reliable supply, least cost over time, and reliance on contracting methods that can meet prudent mix requirements.

**Q. What is your overall recommendation to the Commission regarding the Company's proposed DSP V?**

A. The Company needs to rebuild its default service program from the ground up. Given the Company's deeply embedded current approach such an effort will not be easy and may be difficult to fully achieve within the time available before the current DSP IV expires. The good news is that the Company's short-term contracting approach means that new supply procurements can be phased in as soon as they are developed and well-before the end of the term of the current DSP V proposal. Therefore, I recommend that the Commission direct the Company: (1) to develop and implement a planning process aimed at constructing, through competitive processes, an adequate default service supply portfolio; (2) that actively engages stakeholders (meaning, at a minimum, soliciting comments from a wide range of stakeholders; holding public working sessions on plan development processes, decisions, and assumptions; inviting and considering stakeholder input on plan structure and elements; incorporating stakeholder concepts and ideas in planning activities and plans, including alternative scenarios; frequently sharing analysis on a timely, transparent, and frequent basis; and accounting for stakeholder inputs in reporting and submission of proposals to the Commission); (3) that transparently evaluates the full range of cost and benefits associated with supply options over time; (4) that includes due consideration of the factors of price stability, reduced environmental compliance risk, reduced transmission and distribution costs, and other factors as appropriate; (5) that accounts for current and emerging Commonwealth and municipal energy and climate policy by incorporating more renewable energy resources and distributed energy resources in order to secure the operational, technical, economic, and financial benefits of those resources in the default service plan; (6) that corrects a neglect of resource adequacy, resiliency, and reliability issues that functions as a discriminatory barrier to renewable energy; (7) that corrects an excessive and unreasonable focus on short-term contracts that functions as a discriminatory barrier to renewable energy; and (8) that demonstrates a strong likelihood, based on substantial evidence submitted into the record, that it is a plan that is least cost, over time, to customers, and that reflects a prudent mix of short- and long-term contracts for supply.

## V. OPPORTUNITIES TO IMPROVE THE COMPANY'S PROPOSED DSP V.

**Q. What benefits are possible for the Commonwealth and the Company's default service customers from increased reliance on supply from renewable and distributed resources?**

A. Renewable and DERs outperform conventional energy supply options in terms of job creation, pollution reduction, supply diversity (which improves supply adequacy and reliability), reduced supply cost volatility, customer engagement and satisfaction, alignment with local and state policy direction, and other factors.[61]

**Q. In particular, what added benefits does distributed generation-based supply bring to the default service mix?**

A. DERs, including distributed generation, offer even greater benefits relating to resilience and reliability, jobs, local pollution reduction, local economic benefits, and customer satisfaction. That is because the resources are located closer to load, are less dependent on transmission infrastructure, are less exposed to severe weather events, are typically installed by businesses that are local and or rely upon local workers, and become a visible part of the community.[62]

**Q. What are the competitive market effects of increased reliance on renewable and distributed generation in the default service supply mix?**

A. The Company exerts significant market power and influence through its default service supply procurements. Just as current FPFR drives the competitive market toward similar commoditized products, greater reliance on clean and distributed resources could inspire competitive sector innovation and reliance on those resources. Simply stated, if the Company procured supply from renewable energy and distributed renewable energy facilities, the market for those resources would grow. And, as previously described, this growth would align with clean energy and climate friendly policy in the Commonwealth.

[61] *See, e.g.*, PA DEP, *Pennsylvania's Solar Future Plan* at 21–22 (Nov. 2018) (attached as Exhibit KRR-9); City of Philadelphia: Office of Sustainability, *Powering Our Future: A Clean Energy Vision for Philadelphia* at 23–25 (2018) (attached as Exhibit KRR-10); Ex. KRR-5; Ex. KRR-6; Ex. KRR-7; Ex. KRR-8.

[62] Ex. KRR-9 at 47; Ex. KRR-10 at 30–31; Ex. KRR-5; Ex. KRR-8.

**Q. Is it appropriate for the Company to modify its DSP V to align with Pennsylvania and Philadelphia policy?**

A. Yes. The improved alignment of default service supply composition with energy and climate policies will support the achievement of policy objectives, save money on policy implementation, and support early realization of policy benefits. Moreover, such alignment would directly engage default service customers in action to support achievement of policy objectives—better democratizing policy implementation.

## VI. THE COMPANY'S PROPOSED TOU RATE.

**Q. Do you support the Company's offering of a voluntary TOU rate?**

A. Generally, yes. While I don't support discounts for load-building *per se,* my experience has taught me that in some cases, the net benefits of increased electrification can outweigh the consequences of increased electricity generation and use, especially when that new generation is from clean, non-carbon emitting sources. Whether or not such rates are a good idea depends upon objective benefit-cost analysis.

**Q. What are some of those cost-effective cases?**

A. I have in mind TOU rates to provide or improve economic incentives for transportation electrification, especially when the vehicles electrified are highly polluting and frequently operate in dense urban environments where health impacts are greater and more regressive. I also believe that TOU rates can be designed to incentivize customers to help reduce system peak demand, though care must be taken to account for load shift impacts and unintended burdens on customers with little opportunity to shift or manage consumption levels. Well-designed TOU rates can also increase the value of customer-sited solar or other clean distributed generation. For that reason, it is important to think of TOU rates as an incentive mechanism, to avoid punitive impacts, and to conduct thorough cost-effectiveness evaluation before and during program implementation.

**Q. What are the potential benefits of well-designed TOU rates?**

A. Well-designed TOU rates can advance a number of economic, environmental, and market development objectives. For example, TOU rates such as the one proposed by the Company in this proceeding, can help manage and reduce peak demand while also providing inviting bill-saving benefits for customers transitioning from fossil to electric transportation modes. TOU rates can also help accelerate the development of energy storage markets and the deployment of storage technologies. Because some distributed generation output, like that of distributed solar generation, has good coincidence with system peak demand periods, TOU rates can create incentives for adoption of and investment in distributed generation and can encourage deployment of and investment in hybrid clean energy systems.

**Q. What are some of the features of well-designed TOU rates?**

A. Among other things, well-designed TOU rates have clear objectives; take advantage of prior company and industry experience in design, scope, and implementation; are based on rigorous benefit-cost analysis prior to implementation; provide incentive levels that are likely to induce desired changes in consumption behavior; are not regressive; and are designed for improvement and modification based on experience.

**Q. What is your assessment of the Company's proposal in this case?**

A. First, I find no good justification for the Company's failure to conduct a benefit-cost analysis of its proposed TOU rate or other TOU rate designs.[63] Second, I do think it is

[63] Company Resp. to ES-I-42 and -43.

wise that the Company conducted and relied upon experience from its "PECO Smart Time Pricing Pilot" program.[64] Third, I do agree with the Company that the program is unlikely to garner large scale participation.[65] My opinion is based on the fact that the rate is designed to be revenue neutral but does not benefit from any *ex ante* benefit-cost analysis, and because the contract supply foundation for the rate is the Company's short-term portfolio. That is, the TOU rate might well be more effective if developed without the revenue neutrality constraint and as a strategic component of a supply portfolio that made greater use of long-term supply contracts and contracts with distributed generation suppliers. As discussed later in this testimony, the small level of participation may have the salutary effect of reducing costs and potential negative consequences of the TOU rate, but may also suggest better opportunities for reducing peak demand-related system costs. Fourth, I think the Company should have developed tailored rate designs for specific purposes. For customers with personal electric vehicles, the proposed super off-peak rates might be more effective when combined with peak time rebates. In addition, the Company missed an important opportunity to encourage other kinds of transportation electrification and building electrification options that could be incentivized through well-designed TOU rates.

**Q. Please expand on your concerns about potential negative impacts from TOU rates that are not designed well with regard to potential load shifts.**

A. The greatest risks of negative impacts from TOU rates relate to temporal demand elasticity of customers. For customers with little opportunity or ability to reduce or shift

[64] Company, *Direct Test. of Joseph A. Bisti*, Docket No. P-2020-3019290, at 10 (Mar. 13, 2020).

[65] Company Resp. to ES-I-17.

on-peak consumption, mandatory TOU rates can be punitive and regressive. That issue is avoided with voluntary TOU rates. However, if only well-to-do customers can or are likely to take advantage of voluntary rates, their avoidance of on-peak higher rates through lower consumption during those hours could leave customers without demand flexibility bearing a disproportionate share of peak costs. There is also a risk of inter-class distributional impacts that could adversely impact customers without demand flexibility. These problems can also be avoided with careful rate design. Given the small likely participation rate in the Company's proposed rate, and the effort to constrain revenue impacts—so called "revenue neutrality"—to the class rate, I do not believe that the Company's proposed voluntary TOU rate bears a great risk of creating the negative impacts I described.

**Q. Is there any other concern you would like to raise regarding the Company's TOU proposal?**

A. My biggest concern is whether, in light of the likely low enrollment and other design elements, the Company's proposed TOU rate is worth the effort and expense. In my experience, there are far more direct, effective, and predictable ways to attack high peak demand and costs. Energy efficiency, energy management, and demand response are often less expensive and more reliable ways to reduce peak demand and can be targeted by location, customer demographics, and other factors as well.

**Q. What kinds of building electrification opportunities could be encouraged with TOU rates?**

A. The best examples are distributed generation, dispatchable heat pump water heaters, and behind-the-meter battery storage systems. Those appliances can effectively reduce peak consumption or shift building consumption off-peak with minimal disruption to lifestyle. Well-designed TOU rates aimed at encouraging investment in, adoption of, and optimized operation of these resources can produce benefits that exceed costs for the utility, program participants, the environment, and all customers.

**Q. What kinds of transportation electrification options, in addition to EVs for personal use, should the Company explore?**

A. There is a significant opportunity to secure direct and co-benefits from electrification of medium- and heavy-duty vehicles like buses, garbage trucks, delivery and shuttle vans, and other fleet vehicles in the Company's service territory. Such vehicles today are often diesel-powered, producing significant local air pollution and health impacts, especially in low-income neighborhoods. Effective TOU rate design for electric versions of these vehicles can be built around a thorough understanding of duties cycles, charging infrastructure, and other factors. Again, a benefit-cost analysis is an essential step in designing an effective TOU rate to support electrification. In addition, special attention must be directed at understanding demand charge impacts where those apply. There are several good resources that could help the Company design TOU rates to achieve these benefits.[66]

[66] *See, e.g.*, Elliott, Z., *Comments Regarding Philadelphia's Use of Volkswagen Env'tl Mitigation Trust Funds* (Mar. 7, 2019), http://phillyclimateworks.org/wp-content/uploads/2019/04/Comments-Regarding-Philadelphia's-Use-of-Volkswagen-EMT-Funds.pdf; U.S. Dep't of Transp. Fed. Transit Admin., *Peak Demand Charges and Electric Transit Buses* (Oct. 1, 2014), https://calstart.org/wp-content/uploads/2018/10/Peak-Demand-Charges-and-Electric-Transit-Buses.pdf; Synapse Energy Economics, *Best Practices for Commercial and Industrial EV Rates* (May 4, 2020), https://www nrdc.org/sites/default/files/media-uploads/best-practices-commercial-industrial-ev-rates_0.pdf.

**Q. Based on your review of the Company's proposed TOU rate, what do you recommend?**

A. I do not oppose the implementation of the voluntary TOU rate for default service customers. However, I do believe the Commission should condition approval upon and the Company should commit to a detailed and comprehensive evaluation of the rate results and impacts. This evaluation should include a benefit-cost analysis conducted from the utility and societal perspectives and a *post hoc* evaluation of how the rate performs against other actual and potential programs for reducing peak demand-related system costs. In addition, I recommend that the Commission direct the Company to use a benefit-cost analysis framework to develop proposals for TOU rate pilots directed at opportunities associated with beneficial electrification of direct thermal loads currently served by gas and for electrification of medium- and heavy-duty transportation applications, including fleets.

## VII. CONCLUSIONS AND RECOMMENDATIONS

**Q. Based on your review of the evidence, what conclusions do you reach?**

A. In reviewing the Commonwealth law and regulations, the Company's statements and responses to information requests, the evolving policy and market context for electricity supply and operations, my experience in the electricity industry, and other factors, I reach several conclusions. The application and DSP V proposal from the Company:

- Is excessively and unreasonably reliant on short-term contracting in a manner that discriminates against renewable energy and fails to comply with the requirement that it result in a prudent mix of contracts,
- Fails to demonstrate that it will ensure adequate and reliable supply for customers,

- Fails to demonstrate that it is least cost over time,
- Relies upon an unreasonably short period of time for ensuring that it will be least cost over time,
- Is out of step with emerging market economics and energy and climate policy, and
- Could be redesigned to procure a more diverse, environmentally-responsible, climate-friendly, and prudent mix of contracts.

I also conclude that the Company's proposed TOU rate should have been based on benefit-cost analysis and could have been complemented with rate design options aimed at providing support for beneficial electrification and transportation electrification opportunities.

**Q. Based on your conclusions, what recommendations do you offer the Commission in this matter?**

A. I recommend that the Commission direct the Company: (1) to develop and implement a planning process aimed at constructing, through competitive processes, an adequate default service supply portfolio; (2) that actively engages stakeholders (meaning, at a minimum, soliciting comments from a wide range of stakeholders; holding public working sessions on plan development processes, decisions, and assumptions; inviting and considering stakeholder input on plan structure and elements; incorporating stakeholder concepts and ideas in planning activities and plans, including alternative scenarios; frequently sharing analysis on a timely, transparent, and frequent basis; and accounting for stakeholder inputs in reporting and submission of proposals to the Commission); (3) that transparently evaluates the full range of cost and benefits associated with supply options over time; (4) that includes due consideration of the factors of price stability, reduced environmental compliance risk, reduced transmission and distribution costs, and other factors as appropriate; (5) that accounts for current and emerging Commonwealth and municipal energy and climate policy by incorporating more renewable energy resources and distributed energy resources in order to secure the operational, technical, economic, and financial benefits of those resources in the default service plan; (6) that corrects a neglect of resource adequacy, resiliency, and reliability issues that functions as a discriminatory barrier to renewable energy; (7) that corrects an excessive and unreasonable focus on short-term contracts that functions as a discriminatory barrier to renewable energy; and (8) that demonstrates a strong likelihood, based on substantial evidence submitted into the record, that it is a plan that is least cost, over time, to customers, and that reflects a prudent mix of short- and long-term contracts for supply.

I further recommend that the Commission condition any approval of the proposed TOU rate upon the Company's commitment to perform a detailed and comprehensive evaluation of the results and impacts of the rate. In addition, I recommend that the Commission direct the Company to use a benefit-cost analysis framework to develop proposals for TOU rate pilots directed at opportunities associated with beneficial electrification of direct thermal loads currently served by gas and for electrification of medium- and heavy-duty transportation applications, including fleets.

**Q. Does this conclude your testimony?**

A. Yes.

**BEFORE THE**
**PENNSYLVANIA PUBLIC UTILITY COMMISSION**

| | | |
|---|---|---|
| Petition of PECO Energy Company for | : | |
| Approval of Its Default Service Program | : | Docket No. P-2020-3019290 |
| for the Period from June 1, 2021 through | : | |
| May 31, 2025 | : | |

**VERIFICATION**

I, Karl R. Rábago, hereby verify that the facts set forth in my testimony are true and correct to the best of my knowledge, information and belief and that I expect to be able to prove the same at a hearing held in this matter. I understand that the statements herein are made subject to the penalties of 18 Pa. C.S. § 4904 (relating to unsworn falsification to authorities).

Dated: June 16, 2020

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EARTHJUSTICE

## CERTIFICATE OF SERVICE

I hereby certify that I have this day served a true copy of the foregoing document, **Direct Testimony of Karl R. Rábago on Behalf of Environmental Stakeholders**, electronically filed today at the Pennsylvania Public Utility Commission upon the parties of **Docket No. P-2020-3019290**, listed below, in accordance with the requirements of § 1.54 (relating to service by a party).

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Dated this 16th day of June, 2020.

Sincerely,

*/s/ Devin McDougall*
Staff Attorney
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1617 John F. Kennedy Blvd., Suite 1130
Philadelphia, PA 19103
Telephone: (215) 717-4520
Email: dmcdougall@earthjustice.org

**Exhibit KRR-1:**

Statement of Qualifications

# Karl R. Rábago

**Rábago Energy LLC**
**2025 E. 24th Avenue, Denver, CO 80205**
c/SMS: +1.512.968.7543 | e: karl@rabagoenergy.com

Nationally recognized leader and innovator in electricity and energy law, policy, and regulation. Experienced as a regulatory expert, utility executive, research and development manager, sustainability leader, senior government official, educator, and advocate. Successful track record of working with U.S. Congress, state legislatures, governors, regulators, city councils, business leaders, researchers, academia, and community groups. Nationally recognized speaker on energy, environment, and sustainable development matters. Managed staff as large as 250; responsible for operations of research facilities with staff in excess of 600. Developed and managed budgets in excess of $300 million. Law teaching experience at Pace University Elisabeth Haub School of Law, University of Houston Law Center, and U.S. Military Academy at West Point. Military veteran.

## Employment

### RÁBAGO ENERGY LLC

Principal: July 2012—Present. Consulting practice dedicated to providing business sustainability, expert witness, and regulatory advice and services to organizations in the clean and advanced energy sectors. Prepared and submitted testimony in more than 30 states and 100 electricity and gas regulatory proceedings. Recognized national leader in development and implementation of award-winning “Value of Solar” alternative to traditional net metering. Additional information at www.rabagoenergy.com.

- Chairman of the Board, Center for Resource Solutions (1997-present). CRS is a not-for-profit organization based at the Presidio in California. CRS developed and manages the Green-e Renewable Electricity Brand, a nationally and internationally recognized branding program for green power and green pricing products and programs. Past chair of the Green-e Governance Board.
- Director, Solar United Neighbors (2018-present).

### PACE ENERGY AND CLIMATE CENTER, PACE UNIVERSITY ELISABETH HAUB SCHOOL OF LAW

Senior Policy Advisor: September 2019—Present. Part-time advisor and staff member. Provide expert witness, project management, and business development support on electric and gas regulatory and policy issues and activities.

Executive Director: May 2014—August 2019. Leader of a team of professional and technical experts and law students in energy and climate law, policy, and regulation. Secured funding for and managed execution of research, market development support, and advisory services. Taught Energy Law. Provided learning and development opportunities for law students. Additional activities:

- Former Director, Alliance for Clean Energy – New York (2018-2019).
- Former Director, Interstate Renewable Energy Council (IREC) (2012-2018).
- Former Co-Director and Principal Investigator, Northeast Solar Energy Market Coalition (2015-2017). The NESEMC was a US Department of Energy’s SunShot Initiative Solar Market Pathways project. Funded under a cooperative agreement between the US DOE and Pace University, the NESEMC worked to harmonize solar market policy and advance supportive policy and regulatory practices in the northeast United States.

# Karl R. Rábago

### AUSTIN ENERGY – THE CITY OF AUSTIN, TEXAS

Vice President, Distributed Energy Services: April 2009—June 2012. Executive in 8th largest public power electric utility serving more than one million people in central Texas. Responsible for management and oversight of energy efficiency, demand response, and conservation programs; low-income weatherization; distributed solar and other renewable energy technologies; green buildings program; key accounts relationships; electric vehicle infrastructure; and market research and product development. Executive sponsor of Austin Energy's participation in an innovative federally-funded smart grid demonstration project led by the Pecan Street Project. Led teams that successfully secured over $39 million in federal stimulus funds for energy efficiency, smart grid, and advanced electric transportation initiatives. Additional activities included:

- Director, Renewable Energy Markets Association. REMA is a trade association dedicated to maintaining and strengthening renewable energy markets in the United States.
- Membership on Pedernales Electric Cooperative Member Advisory Board. Invited by the Board of Directors to sit on first-ever board to provide formal input and guidance on energy efficiency and renewable energy issues for the nation's largest electric cooperative.

### THE AES CORPORATION

Director, Government & Regulatory Affairs: June 2006—December 2008. Director, Global Regulatory Affairs, provided regulatory support and group management to AES's international electric utility operations on five continents. Managing Director, Standards and Practices, for Greenhouse Gas Services, LLC, a GE and AES venture committed to generating and marketing greenhouse gas credits to the U.S. voluntary market. Government and regulatory affairs manager for AES Wind Generation. Managed a portfolio of regulatory and legislative initiatives to support wind energy market development in Texas, across the United States, and in many international markets.

### JICARILLA APACHE NATION UTILITY AUTHORITY

Director: 1998—2008. Located in New Mexico, the JANUA was an independent utility developing profitable and autonomous utility services that provide natural gas, water utility services, low income housing, and energy planning for the Nation. Authored "First Steps" renewable energy and energy efficiency strategic plan with support from U.S. Department of Energy.

### HOUSTON ADVANCED RESEARCH CENTER

Group Director, Energy and Buildings Solutions: December 2003—May 2006. Leader of energy and building science staff at a mission-driven not-for-profit contract research organization based in The Woodlands, Texas. Responsible for developing, maintaining and expanding upon technology development, application, and commercialization support programmatic activities, including the Center for Fuel Cell Research and Applications; the Gulf Coast Combined Heat and Power Application Center; and the High-Performance Green Buildings Practice. Secured funding for major new initiative in carbon nanotechnology applications in the energy sector.

- President, Texas Renewable Energy Industries Association. As elected president of the statewide business association, led and managed successful efforts to secure and implement significant expansion of the state's renewable portfolio standard as well as other policy, regulatory, and market development activities.
- Director, Southwest Biofuels Initiative. Established the Initiative as an umbrella structure for a number of biofuels related projects.

# Karl R. Rábago

- Member, Committee to Study the Environmental Impacts of Windpower, National Academies of Science National Research Council. The Committee was chartered by Congress and the Council on Environmental Quality to assess the impacts of wind power on the environment.
- Advisory Board Member, Environmental & Energy Law & Policy Journal, University of Houston Law Center.

### CARGILL DOW LLC (NOW NATUREWORKS, LLC)

Sustainability Alliances Leader: April 2002—December 2003. Integrated sustainability principles into all aspects of a ground-breaking bio-based polymer manufacturing venture. Responsible for maintaining, enhancing and building relationships with stakeholders in the worldwide sustainability community, as well as managing corporate and external sustainability initiatives.

- Successfully completed Minnesota Management Institute at University of Minnesota Carlson School of Management, an alternative to an executive MBA program that surveyed fundamentals and new developments in finance, accounting, operations management, strategic planning, and human resource management.

### ROCKY MOUNTAIN INSTITUTE

Managing Director/Principal: October 1999–April 2002. Co-authored "Small Is Profitable," a comprehensive analysis of the benefits of distributed energy resources. Provided consulting and advisory services to help business and government clients achieve sustainability through application and incorporation of Natural Capitalism principles.

- President of the Board, Texas Ratepayers Organization to Save Energy. Texas R.O.S.E. is a non-profit organization advocating low-income consumer issues and energy efficiency programs.
- Co-Founder and Chair of the Advisory Board, Renewable Energy Policy Project-Center for Renewable Energy and Sustainable Technology. REPP-CREST was a national non-profit research and internet services organization.

### CH2M HILL

Vice President, Energy, Environment and Systems Group: July 1998–August 1999. Responsible for providing consulting services to a wide range of energy-related businesses and organizations, and for creating new business opportunities in the energy industry for an established engineering and consulting firm. Completed comprehensive electric utility restructuring studies for the states of Colorado and Alaska.

### PLANERGY

Vice President, New Energy Markets: January 1998–July 1998. Responsible for developing and managing new business opportunities for the energy services market. Provided consulting and advisory services to utility and energy service companies.

### ENVIRONMENTAL DEFENSE FUND

Energy Program Manager: March 1996–January 1998. Managed renewable energy, energy efficiency, and electric utility restructuring programs. Led regulatory intervention activities in Texas and California. In Texas, played a key role in crafting Deliberative Polling processes. Participated in national environmental and energy advocacy networks, including the Energy Advocates Network, the National Wind Coordinating Committee, the NCSL Advisory Committee on Energy, and the PV-COMPACT Coordinating Council. Frequently appeared before the Texas Legislature, Austin City Council, and regulatory commissions on electric restructuring issues.

# Karl R. Rábago

## UNITED STATES DEPARTMENT OF ENERGY

Deputy Assistant Secretary, Utility Technologies: January 1995–March 1996. Manager of the Department's programs in renewable energy technologies and systems, electric energy systems, energy efficiency, and integrated resource planning. Supervised technology research, development and deployment activities in photovoltaics, wind energy, geothermal energy, solar thermal energy, biomass energy, high-temperature superconductivity, transmission and distribution, hydrogen, and electric and magnetic fields. Managed, coordinated, and developed international agreements. Supervised development and deployment support activities at national laboratories. Developed, advocated, and managed a Congressional budget appropriation of approximately $300 million.

## STATE OF TEXAS

Commissioner, Public Utility Commission of Texas. May 1992–December 1994. Appointed by Governor Ann W. Richards. Regulated electric and telephone utilities in Texas. Co-chair and organizer of the Texas Sustainable Energy Development Council. Vice-Chair of the National Association of Regulatory Utility Commissioners (NARUC) Committee on Energy Conservation. Member and co-creator of the Photovoltaic Collaborative Market Project to Accelerate Commercial Technology (PV-COMPACT).

## LAW TEACHING

**Professor for a Designated Service:** Pace University Elisabeth Haub School of Law, 2014-2019. Non-tenured member of faculty. Taught Energy Law. Supervised a student intern practice.

**Associate Professor of Law:** University of Houston Law Center, 1990–1992. Full time, tenure track member of faculty. Courses taught: Criminal Law, Environmental Law, Criminal Procedure, Environmental Crimes Seminar, Wildlife Protection Law.

**Assistant Professor:** United States Military Academy, West Point, New York, 1988–1990. Member of the faculty in the Department of Law. Honorably discharged in August 1990, as Major in the Regular Army. Courses taught: Constitutional Law, Military Law, and Environmental Law Seminar.

## LITIGATION

Trial Defense Attorney and Prosecutor, U.S. Army Judge Advocate General's Corps, Fort Polk, Louisiana, January 1985–July 1987. Assigned to Trial Defense Service and Office of the Staff Judge Advocate.

## NON-LEGAL MILITARY SERVICE

Armored Cavalry Officer, 2d Squadron 9th Armored Cavalry, Fort Stewart, Georgia, May 1978–August 1981. Served as Logistics Staff Officer (S-4). Managed budget, supplies, fuel, ammunition, and other support for an Armored Cavalry Squadron. Served as Support Platoon Leader for the Squadron (logistical support), and as line Platoon Leader in an Armored Cavalry Troop. Graduate of Airborne and Ranger Schools. Special training in Air Mobilization Planning and Nuclear, Biological and Chemical Warfare.

# Karl R. Rábago

## Formal Education

**LL.M., Environmental Law, Pace University School of Law, 1990:** Curriculum designed to provide breadth and depth in study of theoretical and practical aspects of environmental law. Courses included: International and Comparative Environmental Law, Conservation Law, Land Use Law, Seminar in Electric Utility Regulation, Scientific and Technical Issues Affecting Environmental Law, Environmental Regulation of Real Estate, Hazardous Wastes Law. Individual research with Hudson Riverkeeper Fund, Garrison, New York.

**LL.M., Military Law, U.S. Army Judge Advocate General's School, 1988:** Curriculum designed to prepare Judge Advocates for senior level staff service. Courses included: Administrative Law, Defensive Federal Litigation, Government Information Practices, Advanced Federal Litigation, Federal Tort Claims Act Seminar, Legal Writing and Communications, Comparative International Law.

**J.D. with Honors, University of Texas School of Law, 1984:** Attended law school under the U.S. Army Funded Legal Education Program, a fully funded scholarship awarded to 25 or fewer officers each year. Served as Editor-in-Chief (1983–84); Articles Editor (1982–83); Member (1982) of the Review of Litigation. Moot Court, Mock Trial, Board of Advocates. Summer internship at Staff Judge Advocate's offices. Prosecuted first cases prior to entering law school.

**B.B.A., Business Management, Texas A&M University, 1977:** ROTC Scholarship (3–yr). Member: Corps of Cadets, Parson's Mounted Cavalry, Wings & Sabers Scholarship Society, Rudder's Rangers, Town Hall Society, Freshman Honor Society, Alpha Phi Omega service fraternity.

# Karl R. Rábago

## Selected Publications

“Achieving 100% Renewables: Supply-Shaping through Curtailment,” with Richard Perez, Marc Perez, and Morgan Putnam, PV Tech Power, Vol. 19 (May 2019).

“A Radical Idea to Get a High-Renewable Electric Grid: Build Way More Solar and Wind than Needed,” with Richard Perez, The Conversation, online at http://bit.ly/2YjnM15 (May 29, 2019).

“Reversing Energy System Inequity: Urgency and Opportunity During the Clean Energy Transition,” with John Howat, John Colgan, Wendy Gerlitz, and Melanie Santiago-Mosier, National Consumer Law Center, online at www.nclc.org (Feb. 26, 2019).

“Revisiting Bonbright’s Principles of Public Utility Rates in a DER World,” with Radina Valova, The Electricity Journal, Vol. 31, Issue 8, pp. 9-13 (Oct. 2018).

“Achieving very high PV penetration – The need for an effective electricity remuneration framework and a central role for grid operators,” Richard Perez (corresponding author), Energy Policy, Vol. 96, pp. 27-35 (2016).

“The Net Metering Riddle,” Electricity Policy.com, April 2016.

“The Clean Power Plan,” Power Engineering Magazine (invited editorial), Vol. 119, Issue 12 (Dec. 2, 2015)

“The ‘Sharing Utility:’ Enabling & Rewarding Utility Performance, Service & Value in a Distributed Energy Age,” co-author, 51st State Initiative, Solar Electric Power Association (Feb. 27, 2015)

“Rethinking the Grid: Encouraging Distributed Generation,” Building Energy Magazine, Vol. 33, No. 1 Northeast Sustainable Energy Association (Spring 2015)

“The Value of Solar Tariff: Net Metering 2.0,” The ICER Chronicle, Ed. 1, p. 46 [International Confederation of Energy Regulators] (December 2013)

“A Regulator’s Guidebook: Calculating the Benefits and Costs of Distributed Solar Generation,” co-author, Interstate Renewable Energy Council (October 2013)

“The ‘Value of Solar’ Rate: Designing an Improved Residential Solar Tariff,” Solar Industry, Vol. 6, No. 1 (Feb. 2013)

“Jicarilla Apache Nation Utility Authority Strategic Plan for Energy Efficiency and Renewable Energy Development,” lead author & project manager, U.S. Department of Energy First Steps Toward Developing Renewable Energy and Energy Efficiency on Tribal Lands Program (2008)

“A Review of Barriers to Biofuels Market Development in the United States,” 2 Environmental & Energy Law & Policy Journal 179 (2008)

“A Strategy for Developing Stationary Biodiesel Generation,” Cumberland Law Review, Vol. 36, p.461 (2006)

“Evaluating Fuel Cell Performance through Industry Collaboration,” co-author, Fuel Cell Magazine (2005)

“Applications of Life Cycle Assessment to NatureWorks™ Polylactide (PLA) Production,” co-author, Polymer Degradation and Stability 80, 403-19 (2003)

“An Energy Resource Investment Strategy for the City of San Francisco: Scenario Analysis of Alternative Electric Resource Options,” contributing author, Prepared for the San Francisco Public Utilities Commission, Rocky Mountain Institute (2002)

“Small Is Profitable: The Hidden Economic Benefits of Making Electrical Resources the Right Size,” co-author, Rocky Mountain Institute (2002)

# Karl R. Rábago

“Socio-Economic and Legal Issues Related to an Evaluation of the Regulatory Structure of the Retail Electric Industry in the State of Colorado,” with Thomas E. Feiler, Colorado Public Utilities Commission and Colorado Electricity Advisory Panel (April 1, 1999)

“Study of Electric Utility Restructuring in Alaska,” with Thomas E. Feiler, Legislative Joint Committee on electric Restructuring and the Alaska Public Utilities Commission (April 1, 1999)

“New Markets and New Opportunities: Competition in the Electric Industry Opens the Way for Renewables and Empowers Customers,” EEBA Excellence (Journal of the Energy Efficient Building Association) (Summer 1998)

“Building a Better Future: Why Public Support for Renewable Energy Makes Sense,” Spectrum: The Journal of State Government (Spring 1998)

“The Green-e Program: An Opportunity for Customers,” with Ryan Wiser and Jan Hamrin, Electricity Journal, Vol. 11, No. 1 (January/February 1998)

“Being Virtual: Beyond Restructuring and How We Get There,” Proceedings of the First Symposium on the Virtual Utility, Klewer Press (1997)

“Information Technology,” Public Utilities Fortnightly (March 15, 1996)

“Better Decisions with Better Information: The Promise of GIS,” with James P. Spiers, Public Utilities Fortnightly (November 1, 1993)

“The Regulatory Environment for Utility Energy Efficiency Programs,” Proceedings of the Meeting on the Efficient Use of Electric Energy, Inter-American Development Bank (May 1993)

“An Alternative Framework for Low-Income Electric Ratepayer Services,” with Danielle Jaussaud and Stephen Benenson, Proceedings of the Fourth National Conference on Integrated Resource Planning, National Association of Regulatory Utility Commissioners (September 1992)

“What Comes Out Must Go In: The Federal Non-Regulation of Cooling Water Intakes Under Section 316 of the Clean Water Act,” Harvard Environmental Law Review, Vol. 16, p. 429 (1992)

“Least Cost Electricity for Texas,” State Bar of Texas Environmental Law Journal, Vol. 22, p. 93 (1992)

“Environmental Costs of Electricity,” Pace University School of Law, Contributor–Impingement and Entrainment Impacts, Oceana Publications, Inc. (1990)

**Exhibit KRR-2:**

List of Prior Testimony

# Testimony Submitted by Karl R. Rábago, on behalf of Pace Energy and Climate Center, or through Rábago Energy LLC

## (as of 8 June 2020)

| Date | Proceeding | Case/Docket # | On Behalf Of: |
|---|---|---|---|
| Dec. 21, 2012 | VA Electric & Power Special Solar Power Tariff | Virginia SCC Case # PUE-2012-00064 | Southern Environmental Law Center |
| May 10, 2013 | Georgia Power Company 2013 IRP | Georgia PSC Docket # 36498 | Georgia Solar Energy Industries Association |
| Jun. 23, 2013 | Louisiana Public Service Commission Re-examination of Net Metering Rules | Louisiana PSC Docket # R-31417 | Gulf States Solar Energy Industries Association |
| Aug. 29, 2013 | DTE (Detroit Edison) 2013 Renewable Energy Plan Review (Michigan) | Michigan PUC Case # U-17302 | Environmental Law and Policy Center |
| Sep. 5, 2013 | CE (Consumers Energy) 2013 Renewable Energy Plan Review (Michigan) | Michigan PUC Case # U-17301 | Environmental Law and Policy Center |
| Sep. 27, 2013 | North Carolina Utilities Commission 2012 Avoided Cost Case | North Carolina Utilities Commission Docket # E-100, Sub. 136 | North Carolina Sustainable Energy Association |
| Oct. 18, 2013 | Georgia Power Company 2013 Rate Case | Georgia PSC Docket # 36989 | Georgia Solar Energy Industries Association |
| Nov. 4, 2013 | PEPCO Rate Case (District of Columbia) | District of Columbia PSC Formal Case # 1103 | Grid 2.0 Working Group & Sierra Club of Washington, D.C. |
| Apr. 24, 2014 | Dominion Virginia Electric Power 2013 IRP | Virginia SCC Case # PUE-2013-00088 | Environmental Respondents |
| May 7, 2014 | Arizona Corporation Commission Investigation on the Value and Cost of Distributed Generation | Arizona Corporation Commission Docket # E-00000J-14-0023 | Rábago Energy LLC (invited presentation and workshop participation) |
| Jul. 10, 2014 | North Carolina Utilities Commission 2014 Avoided Cost Case | North Carolina Utilities Commission Docket # E-100, Sub. 140 | Southern Alliance for Clean Energy |
| Jul. 23, 2014 | Florida Energy Efficiency and Conservation Act, Goal Setting – FPL, Duke, TECO, Gulf | Florida PSC Docket # 130199-EI, 130200-EI, 130201-EI, 130202-EI | Southern Alliance for Clean Energy |
| Sep. 19, 2014 | Ameren Missouri's Application for Authorization to Suspend Payment of Solar Rebates | Missouri PSC File No. ET-2014-0350, Tariff # YE-2014-0494 | Missouri Solar Energy Industries Association |
| Aug. 6, 2014 | Appalachian Power Company 2014 Biennial Rate Review | Virginia SCC Case # PUE-2014-00026 | Southern Environmental Law Center (Environmental Respondents) |

**Testimony Submitted by Karl R. Rábago, on behalf of Pace Energy and Climate Center, or through Rábago Energy LLC**

**(as of 8 June 2020)**

| | | | |
|---|---|---|---|
| Aug. 13, 2014 | Wisconsin Public Service Corp. 2014 Rate Application | Wisconsin PSC Docket # 6690-UR-123 | RENEW Wisconsin and Environmental Law & Policy Center |
| Aug. 28, 2014 | WE Energies 2014 Rate Application | Wisconsin PSC Docket # 05-UR-107 | RENEW Wisconsin and Environmental Law & Policy Center |
| Sep. 18, 2014 | Madison Gas & Electric Company 2014 Rate Application | Wisconsin PSC Docket # 3720-UR-120 | RENEW Wisconsin and Environmental Law & Policy Center |
| Sep. 29, 2014 | SOLAR, LLC v. Missouri Public Service Commission | Missouri District Court Case # 14AC-CC00316 | SOLAR, LLC |
| Jan. 28, 2016 (date of CPUC order) | Order Instituting Rulemaking to Develop a Successor to Existing Net Energy Metering Tariffs, etc. | California PUC Rulemaking 14-07-002 | The Utility Reform Network (TURN) |
| Mar. 20, 2015 | Orange and Rockland Utilities 2015 Rate Application | New York PSC Case # 14-E-0493 | Pace Energy and Climate Center |
| May 22, 2015 | DTE Electric Company Rate Application | Michigan PSC Case # U-17767 | Michigan Environmental Council, NRDC, Sierra Club, and ELPC |
| Jul. 20, 2015 | Hawaiian Electric Company and NextEra Application for Change of Control | Hawai'i PUC Docket # 2015-0022 | Hawai'i Department of Business, Economic Development, and Tourism |
| Sep. 2, 2015 | Wisc. PSCo Rate Application | Wisconsin PSC Case # 6690-UR-124 | ELPC |
| Sep. 15, 2015 | Dominion Virginia Electric Power 2015 IRP | Virginia SCC Case # PUE-2015-00035 | Environmental Respondents |
| Sep. 16, 2015 | NYSEG & RGE Rate Cases | New York PSC Cases 15-E-0283, -0285 | Pace Energy and Climate Center |
| Oct. 14, 2015 | Florida Power & Light Application for CCPN for Lake Okeechobee Plant | Florida PSC Case 150196-EI | Environmental Confederation of Southwest Florida |
| Oct. 27, 2015 | Appalachian Power Company 2015 IRP | Virginia SCC Case # PUE-2015-00036 | Environmental Respondents |
| Nov. 23, 2015 | Narragansett Electric Power/National Grid Rate Design Application | Rhode Island PUC Docket No. 4568 | Wind Energy Development, LLC |
| Dec. 8, 2015 | State of West Virginia, et al., v. U.S. EPA, et al. | U.S. Court of Appeals for the District of Columbia Circuit Case No. 15-1363 and Consolidated Cases | Declaration in Support of Environmental and Public Health Intervenors in Support of Movant Respondent-Intervenors' Responses in Opposition to Motions for Stay |

# Testimony Submitted by Karl R. Rábago, on behalf of Pace Energy and Climate Center, or through Rábago Energy LLC

## (as of 8 June 2020)

| | | | |
|---|---|---|---|
| Dec. 28, 2015 | Ohio Power/AEP Affiliate PPA Application | PUC of Ohio Case No. 14-1693-EL-RDR | Environmental Law and Policy Center |
| Jan. 19, 2016 | Ohio Edison Company, Cleveland Electric Illuminating Company, and Toledo Edison Company Application for Electric Security Plan (FirstEnergy Affiliate PPA) | PUC of Ohio Case No. 14-1297-EL-SSO | Environmental Law and Policy Center |
| Jan. 22, 2016 | Northern Indiana Public Service Company (NIPSCO) Rate Case | Indiana Utility Regulatory Commission Cause No. 44688 | Citizens Action Coalition and Environmental Law and Policy Center |
| Mar. 18, 2016 | Northern Indiana Public Service Company (NIPSCO) Rate Case – Settlement Testimony | Indiana Utility Regulatory Commission Cause No. 44688 | Joint Intervenors – Citizens Action Coalition and Environmental Law and Policy Center |
| Mar. 18, 2016 | Comments on Pilot Rate Proposals by MidAmerican and Alliant | Iowa Utility Board NOI-2014-0001 | Environmental Law and Policy Center |
| May 27, 2016 | Consolidated Edison of New York Rate Case | New York PSC Case No. 16-E-0060 | Pace Energy and Climate Center |
| June 21, 2016 | Federal Trade Commission: Workshop on Competition and Consumer Protection Issues in Solar Energy | Invited workshop presentation | Pace Energy and Climate Center |
| Aug. 17, 2016 | Dominion Virginia Electric Power 2016 IRP | Virginia SCC Case # PUE-2016-00049 | Environmental Respondents |
| Sep. 13, 2016 | Appalachian Power Company 2016 IRP | Virginia SCC Case # PUE-2016-00050 | Environmental Respondents |
| Oct. 27, 2016 | Consumers Energy PURPA Compliance Filing | Michigan PSC Case No. U-18090 | Environmental Law & Policy Center, "Joint Intervenors" |
| Oct. 28, 2016 | Delmarva, PEPCO (PHI) Utility Transformation Filing – Review of Filing & Utilities of the Future Whitepaper | Maryland PSC Case PC 44 | Public Interest Advocates |
| Dec. 1, 2016 | DTE Electric Company PURPA Compliance Filing | Michigan PSC Case No. U-18091 | Environmental Law & Policy Center, "Joint Intervenors" |
| Dec. 16, 2016 | Rebuttal of Unitil Testimony in Net Energy Metering Docket | New Hampshire Docket No. DE 16-576 | New Hampshire Sustainable Energy Association ("NHSEA") |
| Jan. 13, 2017 | Gulf Power Company Rate Case | Florida Docket No. 160186-EI | Earthjustice, Southern Alliance for Clean Energy, League of Women Voters-Florida |

**Testimony Submitted by Karl R. Rábago, on behalf of Pace Energy and Climate Center, or through Rábago Energy LLC**

**(as of 8 June 2020)**

| | | | |
|---|---|---|---|
| Jan. 13, 2017 | Alpena Power Company PURPA Compliance Filing | Michigan PSC Case No. U-18089 | Environmental Law & Policy Center, "Joint Intervenors" |
| Jan. 13, 2017 | Indiana Michigan Power Company PURPA Compliance Filing | Michigan PSC Case No. U-18092 | Environmental Law & Policy Center, "Joint Intervenors" |
| Jan. 13, 2017 | Northern States Power Company PURPA Compliance Filing | Michigan PSC Case No. U-18093 | Environmental Law & Policy Center, "Joint Intervenors" |
| Jan. 13, 2017 | Upper Peninsula Power Company PURPA Compliance Filing | Michigan PSC Case No. U-18094 | Environmental Law & Policy Center, "Joint Intervenors" |
| Mar. 10, 2017 | Eversource Energy Grid Modernization Plan | Massachusetts DPU Case No. 15-122/15-123 | Cape Light Compact |
| Apr. 27, 2017 | Eversource Rate Case & Grid Modernization Investments | Massachusetts DPU Case No. 17-05 | Cape Light Compact |
| May 2, 2017 | AEP Ohio Power Electric Security Plan | PUC of Ohio Case No. 16-1852-EL-SSO | Environmental Law & Policy Center |
| Jun. 2, 2017 | Vectren Energy TDSIC Plan | Indiana URC Cause No. 44910 | Citizens Action Coalition & Valley Watch |
| Jul. 28, 2017 | Vectren Energy 2016-2017 Energy Efficiency Plan | Indiana URC Cause No. 44645 | Citizens Action Coalition |
| Jul. 28, 2017 | Vectren Energy 2018-2020 Energy Efficiency Plan | Indiana URC Cause No. 44927 | Citizens Action Coalition |
| Aug. 1, 2017 | Interstate Power & Light (Alliant) 2017 Rate Application | Iowa Utilities Board Docket No. RPU-2017-0001 | Environmental Law & Policy Center, Iowa Environmental Council, Natural Resources Defense Council, and Solar Energy Industries Assoc. |
| Aug. 11, 2017 | Dominion Virginia Electric Power 2017 IRP | Virginia SCC Case # PUR-2017-00051 | Environmental Respondents |
| Aug. 18, 2017 | Appalachian Power Company 2017 IRP | Virginia SCC Case # PUR-2017-00045 | Environmental Respondents |
| Aug. 23, 2017 | Pennsylvania Solar Future Project | PA Dept. of Environmental Protection - Alternative Ratemaking Webinar | Pace Energy and Climate Center |
| Aug. 25, 2017 | Niagara Mohawk Power Co. d/b/a National Grid Rate Case | New York PSC Case # 17-E-0238, 17-G-0239 | Pace Energy and Climate Center |

**Testimony Submitted by Karl R. Rábago, on behalf of Pace Energy and Climate Center, or through Rábago Energy LLC**

**(as of 8 June 2020)**

| | | | |
|---|---|---|---|
| Sep. 15, 2017 | Niagara Mohawk Power Co. d/b/a National Grid Rate Case | New York PSC Case # 17-E-0238, 17-G-0239 | Pace Energy and Climate Center |
| Oct. 20, 2017 | Missouri PSC Working Case to Explore Emerging Issues in Utility Regulation | Missouri PSC File No. EW-2017-0245 | Renew Missouri |
| Nov. 21, 2017 | Central Hudson Gas & Electric Co. Electric and Gas Rates Cases | New York PSC Case # 17-E-0459, -0460 | Pace Energy and Climate Center |
| Jan. 16, 2018 | Great Plains Energy, Inc. Merger with Westar Energy, Inc. | Missouri PSC Case # EM-2018-0012 | Renew Missouri Advocates |
| Jan. 19, 2018 | U.S. House of Representatives, Energy and Commerce Committee | Hearing on "The PURPA Modernization Act of 2017," H.R. 4476 | Rábago Energy LLC |
| Jan. 29, 2018 | Joint Petition of Electric Distribution Companies for Approval of a Model SMART Tariff | Massachusetts D.P.U. Case No. 17-140 | Boston Community Capital Solar Energy Advantage Inc.<br>(Jointly authored with Sheryl Musgrove) |
| Feb. 21, 2018 | Joint Petition of Electric Distribution Companies for Approval of a Model SMART Tariff | Massachusetts D.P.U. Case No. 17-140 - Surrebuttal | Boston Community Capital Solar Energy Advantage Inc.<br>(Jointly authored with Sheryl Musgrove) |
| Apr. 6, 2018 | Narragansett Electric Co., d/b/a National Grid Rate Case Filing | RI PUC Docket No. 4770 | New Energy Rhode Island ("NERI") |
| Apr. 25, 2018 | Narragansett Electric Co., d/b/a National Grid Power Sector Transformation Plan | Rhode Island PUC Docket No. 4780 | New Energy Rhode Island ("NERI") |
| Apr. 26, 2018 | U.S. EPA Proposed Repeal of Carbon Pollution Emission Guidelines for Existing Stationary Stories: Electric Utility Generating Units, 82 Fed. Reg. 48,035 (Oct. 16, 2017) – "Clean Power Plan" | U.S. EPA Docket No. EPA-HQ-OAR-2016-0592 | Karl R. Rábago |
| May 25, 2018 | Orange & Rockland Utilities, Inc. Rate Case Filing | New York PSC Case Nos. 18-E-0067, 18-G-0068 | Pace Energy and Climate Center |
| Jun. 15, 2018 | Orange & Rockland Utilities, Inc. Rate Case Filing | New York PSC Case Nos. 18-E-0067, 18-G-0068 – Rebuttal Testimony | Pace Energy and Climate Center |
| Aug. 10, 2018 | Dominion Virginia Electric Power 2018 IRP | Virginia SCC Case # PUR-2018-00065 | Environmental Respondents |

**Testimony Submitted by Karl R. Rábago, on behalf of Pace Energy and Climate Center, or through Rábago Energy LLC**

**(as of 8 June 2020)**

| | | | |
|---|---|---|---|
| Sep. 20, 2018 | Consumers Energy Company Rate Case | Michigan PSC Case No. U-20134 | Environmental Law & Policy Center |
| Sep. 27, 2018 | Potomac Electric Power Co. Notice to Construct Two 230 kV Underground Circuits | District of Columbia Public Service Commission Formal Case No. 1144 | Solar United Neighbors of D.C. |
| Sep. 28, 2019 | Arkansas Public Service Commission Investigation of Policies Related to Distributed Energy Resources | Arkansas PSC Docket No. 16-028-U | Arkansas Audubon Society & Arkansas Advanced Energy Association |
| Nov. 7, 2018 | DTE Detroit Edison Rate Case | Michigan PSC Case No. U-20162 | Natural Resources Defense Council, Michigan Environmental Council, Sierra Club |
| Mar. 26, 2019 | Guam Power Authority Petition to Modify Net Metering | Guam PUC Docket GPA 19-04 | Micronesia Renewable Energy, Inc. |
| Apr. 4, 2019 | Community Power Network & League of Women Voters of Florida v. JEA | Circuit Court Duval County of Florida Case No. 2018-CA-002497 Div: CV-D | Earthjustice |
| Apr. 25, 2019 | Georgia Power 2019 IRP | Georgia PSC Docket No. 42310 | GSEA & GSEIA |
| May 10, 2019 | NV Energy NV GreenEnergy 2.0 Rider | Nevada PUC Docket Nos. 18-11015, 18-11016 | Vote Solar |
| May 24, 2019 | Consolidated Edison of New York Electric and Gas Rate Cases – Misc. Issues | New York PSC Case Nos. 19-E-0065, 19-G-0066 | Pace Energy and Climate Center |
| May 24, 2019 | Consolidated Edison of New York Electric and Gas Rate Cases – Low- and Moderate-Income Panel | New York PSC Case Nos. 19-E-0065, 19-G-0066 | Pace Energy and Climate Center |
| May 30, 2019 | Connecticut DEEP Shared Clean Energy Facility Program Proposal | Connecticut Department of Energy and Environmental Protection Docket No. 19-07-01 | Connecticut Fund for the Environment |
| Jun. 3, 2019 | New Orleans City Council Rulemaking to Establish Renewable Portfolio Standards | New Orleans City Council Docket No. UD-19-01 | National Audubon Society and Audubon Louisiana |
| Jun. 14, 2019 | Consolidated Edison of New York Electric and Gas Rate Cases – Rebuttal Testimony | New York PSC Case Nos. 19-E-0065, 19-G-0066 | Pace Energy and Climate Center |

**Testimony Submitted by Karl R. Rábago, on behalf of Pace Energy and Climate Center, or through Rábago Energy LLC**

**(as of 8 June 2020)**

| | | | |
|---|---|---|---|
| Jun. 24, 2019 | Program to Encourage Clean Energy in Westchester County Pursuant to Public Service law Section 74-a; Staff Investigation into a Moratorium on New Natural Gas Services in the Consolidated Edison Company of New York, Inc. Service Territory | New York PSC Case Nos. 19-M-0265, 19-G-0080 | Earthjustice and Pace Energy and Climate Center |
| Jul. 12, 2019 | Application of Virginia Electric and Power Company for the Determination of the Fair Rate of Return on Common Equity | Virginia SCC Case # PUR-2019-00050 | Virginia Poverty Law Center |
| Jul. 15, 2019 | New Orleans City Council Rulemaking to Establish Renewable Portfolio Standards – Reply Comments | New Orleans City Council Docket No. UD-19-01 | National Audubon Society and Audubon Louisiana |
| Aug. 1, 2019 | Interstate Power and Light Company – General Rate Case | Iowa Utilities Board Docket No. RPU-2019-0001 | Environmental Law & Policy Center and Iowa Environmental Council |
| Aug. 19, 2019 | Consolidated Edison of New York Electric and Gas Rate Cases – Surrebuttal | New York PSC Case Nos. 19-E-0065, 19-G-0066 | Pace Energy and Climate Center |
| Aug. 21, 2019 | Connecticut Department of Energy and Environmental Protection and Public Utility Regulatory Authority Joint Proceeding on the Value of Distributed Energy Resources - Comments | Connecticut DEEP/PURA Docket No. 19-06-29 | Connecticut Fund for the Environment and Save Our Sound |
| Sep. 10, 2019 | Interstate Power and Light Company – General Rate Case - Rebuttal | Iowa Utilities Board Docket No. RPU-2019-0001 | Environmental Law & Policy Center and Iowa Environmental Council |
| Sep. 18, 2019 | Connecticut Department of Energy and Environmental Protection and Public Utility Regulatory Authority Joint Proceeding on the Value of Distributed Energy Resources – Comments and Response to Draft Study Outline | Connecticut DEEP/PURA Docket No. 19-06-29 | Connecticut Fund for the Environment, Save Our Sound, E4theFuture, NE Clean Energy Council, NE Energy Efficiency Partnership, and Acadia Center |
| Sep. 20, 2019 | Connecticut Department of Energy and Environmental Protection and Public Utility Regulatory Authority Joint Proceeding on the Value of Distributed Energy Resources – Participation in Technical Workshop 1 | Connecticut DEEP/PURA Docket No. 19-06-29<br>http://www.ctn.state.ct.us/ctnplayer.asp?odID=16715 | Connecticut Fund for the Environment and Save Our Sound |

# Testimony Submitted by Karl R. Rábago, on behalf of Pace Energy and Climate Center, or through Rábago Energy LLC

## (as of 8 June 2020)

| | | | |
|---|---|---|---|
| Oct. 4, 2019 | Connecticut Department of Energy and Environmental Protection and Public Utility Regulatory Authority Joint Proceeding on the Value of Distributed Energy Resources – Participation in Technical Workshop 2 | Connecticut DEEP/PURA Docket No. 19-06-29<br>http://www.ctn.state.ct.us/ctnplayer.asp?odID=16766 | Connecticut Fund for the Environment and Save Our Sound |
| Oct. 15, 2019 | Electronic Consideration of the Implementation of the Net Metering Act (KY SB 100) | Kentucky Public Service Commission Case No. 2019-00256 | Kentuckians for the Commonwealth & Mountain Association for Community Economic Development |
| Oct. 15, 2019 | New Orleans City Council Rulemaking to Establish Renewable Portfolio Standards – Comments on City Council Utility Advisors' Report | New Orleans City Council Docket No. UD-19-01 | National Audubon Society and Audubon Louisiana, Vote Solar, 350 New Orleans, Alliance for Clean Energy, PosiGen, and Sierra Club |
| Oct. 17, 2019 | Indiana Michigan Power Co. General Rate Case | Michigan Public Service Company Case No. U-20359 | Environmental Law & Policy Center, The Ecology Center, the Solar Energy Industries Association, and Vote Solar |
| Dec. 4, 2019 | Alabama Power Company Petition for Certificate of Convenience and Necessity | Alabama Public Service Commission Docket No. 32953 | Energy Alabama and Gasp, Inc. |
| Dec. 5, 2019 | In the Matter of Net Metering and the Implementation of Act 827 of 2015 | Arkansas Public Service Commission Docket No. 16-027-R | National Audubon Society and Arkansas Advanced Energy Association. |
| Dec. 6, 2019 | Proposed Revisions to Vermont Public Utility Commission Rule 5.100 | Vermont Public Utility Commission Case No. 19-0855-RULE | Renewable Energy Vermont ("REV") |
| Jan. 15, 2020 | General Rate Case | Washington Utilities and Transportation Commission Docket Nos. UE-190529 & UG-190530 | Puget Sound Energy |

**Exhibit KRR-3:**

Response of Company to Interrogatories of the Environmental Stakeholders ES Set I

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-1

As referenced in Paragraph 6 of PECO's Petition for Approval of its Default Service Program for the Period from June 1, 2021 through May 31, 2025, filed March 11, 2020 (hereinafter "Petition"), please provide the specific definition for "least cost" relied upon by the Company.

RESPONSE:

PECO assumes that the reference to "least cost" refers to Act 129's requirement that the "prudent mix of contracts" in a default service plan be designed to ensure "least cost to customers over time," in addition to "adequate and reliable service," and in compliance with certain competitive procurement requirements. The Commission has stated that the "least cost" standard is "somewhat ambiguous and not susceptible to a precise 'one size fits all' definition," but "must give the [default service provider, or "DSP"] sufficient latitude to select contracts that constitute a 'prudent mix' which includes a sufficient variety of products that adequately take into consideration price volatility, changes in generation supply, customer usage characteristics and the need to assure safe and reliable service." Final Rulemaking Order, *Implementation of Act 129 of October 15, 2008*; Default Service and Retail Electric Markets, Docket No. L-2009-2095604 (Order entered Sept. 23, 2011), p. 38. The Commission has further explained that the "least cost" standard "requires the DSP to develop a procurement plan that will capture the benefits of the competitive wholesale market and reflect the lowest rates to customers over the term of the plan and beyond." Final Rulemaking Order, p. 39. PECO relies upon this guidance in designing DSP V, as well as the Commission's prior approvals of PECO's first four default service programs. Act 129 further provides that the costs incurred under a Commission-approved plan are deemed to be "the least cost over time" (66 Pa.C.S. § 2807(e)(3.6)).

Responsible Witness: John J. McCawley

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-2

Please explain what particular attributes PECO evaluates to determine "least cost," as referenced in Paragraph 6 of the Petition.

RESPONSE:

PECO notes that Act 129's statutory standard for a default service plan includes "review of the competitive procurement process employed, the 'prudent mix' of supply contracts negotiated and the ability of the default plan to ensure adequate and reliable service, as well as the 'least cost to customers over time' standard." Final Rulemaking Order, p. 11. The prudent mix of products selected for the proposed portfolio for each customer class was designed to satisfy the requirements of Act 129, considering price and other attributes. See the Company's responses to ES-I-23, ES-I-26, and ES-I-33(a).

Responsible Witness: John J. McCawley

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-3

Please explain what time frame is utilized to evaluate "least cost over time," as referenced in Paragraph 6 of the Petition.

RESPONSE:

In large part, PECO has utilized the four-year term of the proposed DSP V plan in designing the "prudent mix" of contracts to be competitively procured, with additional time periods for products for residential and small commercial customers that may extend beyond the term of DSP V for price stability.  PECO has also proposed ten-year solar AEC contracts in light of PECO's prior successful Solar AEC RFP, as well as decisions of the Commission that require Solar AECs to be generated by facilities located within the Commonwealth for compliance with Act 40 of 2017.

Responsible Witness:   John J. McCawley

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-4

Please explain whether PECO's "least cost" evaluation includes only costs, or if its analysis includes consideration of both costs and benefits in order to determine net costs. Please also describe the rationale for inclusion or exclusion of consideration of benefits in the Company's "least cost" evaluation.

RESPONSE:

PECO's consideration of "least cost over time" in its "prudent mix" of contracts includes both costs and benefits, including the benefits of the competitive wholesale market and price stability for certain customer groups, as required by the Commission. Given a Commission-approved program, evaluation of the cost of products by bid price alone in PECO's competitive procurements, subject to any supplier load caps, enables an objective means for selecting winning bidders. See the Company's responses to ES-I-1, ES-I-2, ES-I-23, ES-I-25, ES-I-26 and ES-I-33(a).

Responsible Witness: John J. McCawley

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-5

Please explain whether PECO's "least cost" evaluation includes assessment of costs not directly reflected in fuel costs or prices (*e.g.*, "externalities"), and the Company's rationale for inclusion or exclusion of such analysis.

RESPONSE:

PECO's procurement plan is designed to obtain a "prudent mix" of contracts at least cost in compliance with Commission-approved competitive processes. See the Company's response to ES-I-1. PECO considers all costs that are addressed by the Commission's Default Service Regulations and Policy Statement.

Responsible Witness: John J. McCawley

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-6

Please describe how PECO's evaluation of "least cost" addresses impact of current energy usage on future generations.

RESPONSE:

See PECO's response to ES-I-5.

Responsible Witness: John J. McCawley

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-7

Please explain whether and how PECO's definition of "least cost" differs from its definition of "least cost over time."

RESPONSE:

See PECO's response to ES-I-1.

Responsible Witness: John J. McCawley

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-8

Please explain where PECO's definition of "least cost over time" originated, and whether PECO's definition of "least cost over time" differs from that of the NorthBridge Group.

RESPONSE:

See PECO's response to ES-I-1. PECO does not believe its understanding and application of "least cost to customers over time" differs from that of PECO witness Scott G. Fisher of the NorthBridge Group.

Responsible Witness: John J. McCawley

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-9

Paragraph 8 of the Petition references the Commission's request that PECO address ways to incentivize customers to lower on-peak demand in this proceeding. Please explain how PECO has evaluated distributed generation as a supply resource that may help reduce on-peak demand. If PECO has not conducted such analysis, please explain why not.

RESPONSE:

Paragraph 8 of the Petition references a Commission investigation of potential opportunities to better reflect wholesale cost causation in default service rates and thereby incentivize customers to reduce peak demand. The evaluation of distributed generation as a supply resource was not part of scope of that investigation. PECO notes that its proposed procurement of solar AECs in DSP V is expected to support the development of additional distributed solar generation.

Responsible Witness: John J. McCawley

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-10

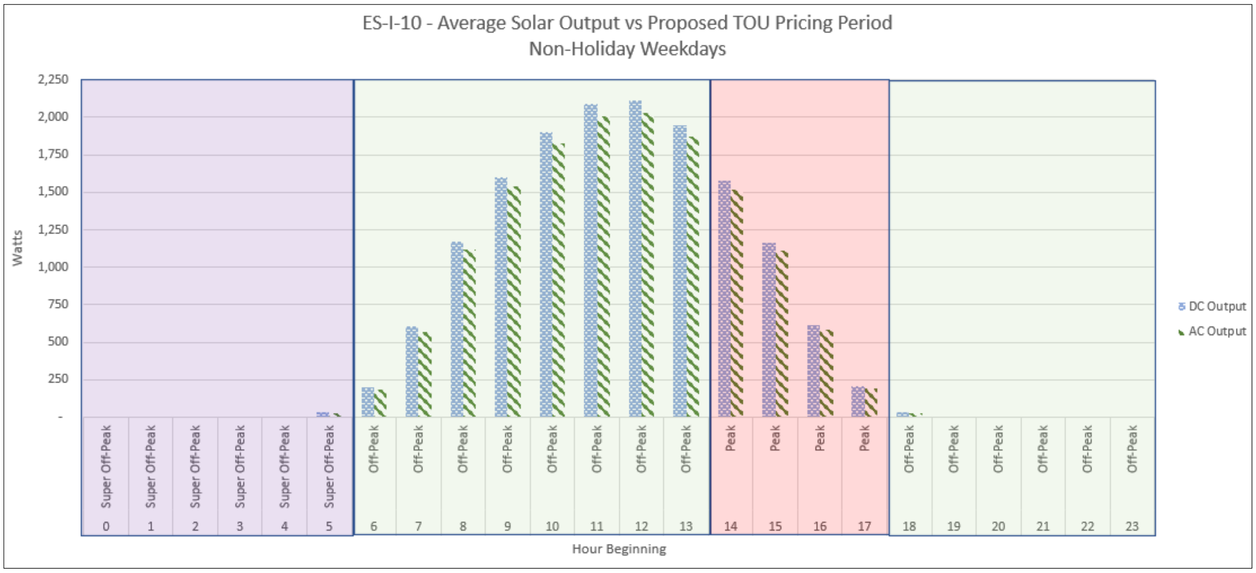
Please explain how solar generation output aligns with the Time of Use ("TOU") periods proposed for TOU rates in the Petition. Please provide any and all documents or analysis used in formulating a response.

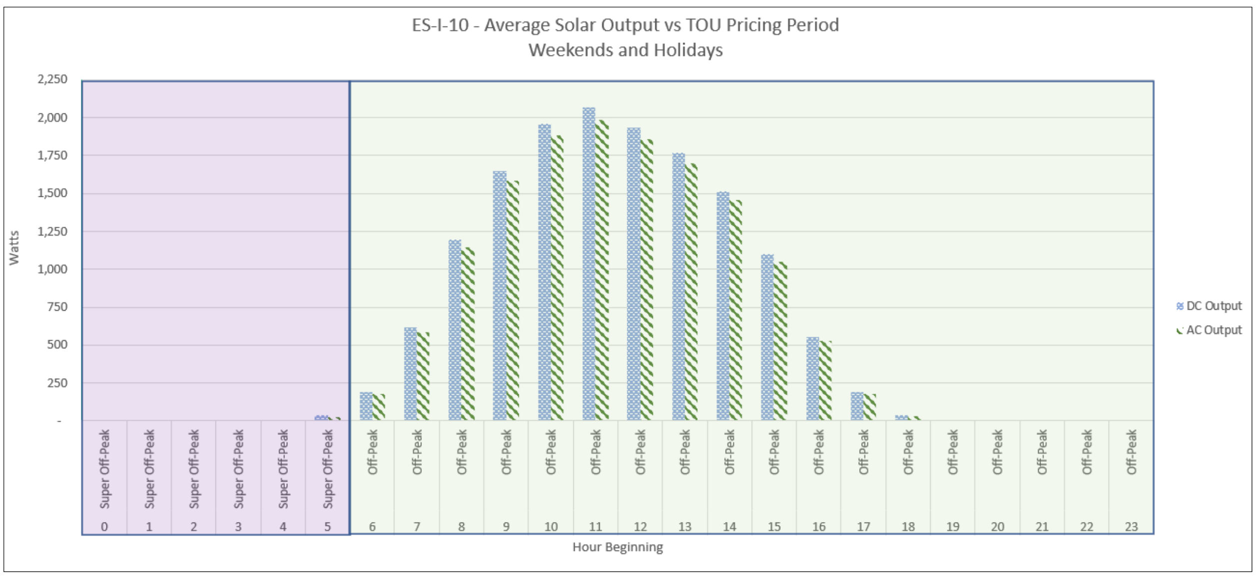
RESPONSE:

To develop this response, PECO submitted the following inputs to the National Renewable Energy Laboratory (NREL) PVWatts Calculator, available at https://pvwatts.nrel.gov/:

| | | |
|---|---|---|
| Requested Location: | 2301 Market Street, Philadelphia, PA | |
| Location: | Lat, Lon: 39.97, -75.18 | |
| Lat (deg N): | 39.97 | |
| Long (deg W): | 75.18 | |
| Elev (m): | 24.55999947 | |
| DC System Size (kW): | 4 | *(PVWatts default)* |
| Module Type: | Standard | *(PVWatts default)* |
| Array Type: | Fixed (roof mount) | |
| Array Tilt (deg): | 20 | *(PVWatts default)* |
| Array Azimuth (deg): | 180 | *(PVWatts default)* |
| System Losses: | 14.08 | *(PVWatts default)* |
| Inverter Efficiency: | 96 | *(PVWatts default)* |
| DC to AC Size Ratio: | 1.2 | *(PVWatts default)* |
| Ground Coverage Ratio: | 0.4 | *(PVWatts default)* |
| Capacity Factor (%): | 15.1 | *(PVWatts default)* |

Graphical summaries comparing the resulting solar output and PECO's proposed TOU rates are shown below. The supporting detail is available in Attachment ES-I-10(a).




Responsible Witness: Joseph A. Bisti

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-11

Please explain whether PECO has ever received any bids pursuant to Default Service Program ("DSP") solicitations from suppliers that proposed to deliver supply based on high (greater than 50%) renewable energy percentages?

a. If PECO has not received any such bids, please provide the Company's opinion as to why such supply bids have not been submitted and the basis for this opinion. Please provide any documents supporting the Company's opinion.

b. If PECO has received such bids, please describe the bids and indicate if they were awarded contracts as suppliers.

c. If PECO has received such bids, but they have not been selected, please explain why the bids were not selected.

RESPONSE:

a. No such bids have been received. PECO does not have an opinion as to why such supply bids have not been submitted, as there are no restrictions on the generation sources that full requirements suppliers may use to obtain energy to meet their contractual obligations in PECO's default supply program procurements.

b. Not applicable.

c. Not applicable.

Responsible Witness: John J. McCawley

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-12

Refer to PECO Statement No. 1, Direct Testimony of John J. McCawley, P.E. ("McCawley Testimony"), page 6. Please explain how Company-conducted competitive procurements account for the relative market maturity and competitive advantages or disadvantages of various types of wholesale power.

RESPONSE:

PECO conducted the first competitive early procurements of non-solar and solar alternative energy credits in Pennsylvania under the Alternative Energy Portfolio Standards Act (in part to support the early development of solar energy projects), and PECO is proposing to increase its direct procurement of solar alternative energy credits from solar systems in Pennsylvania and its service territory in DSP V. The Company-conducted competitive procurements for full requirements default service supply do not include any restrictions on the type of generation sources that suppliers may use to meet their contractual obligations. Notably, the Commission has declined to provide for the construction of generation facilities in its default service regulations, and explained its rationale as follows (Final Rulemaking Order, p. 46):

> [W]e decline at this time to consider revising the current default service regulations to provide for construction of needed generation in Pennsylvania. Our reluctance to move further on this proposal is based on the potential uncertainty that such a requirement would present to the current operation of PJM wholesale markets as well as the potential for contravening provisions of our Competition Act and the provisions of Act 129 which mandate establishment of a least cost standard for evaluating EDC plans.

Responsible Witness: John J. McCawley

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-13

Refer to McCawley Testimony, page 7.

a. Please describe the evaluation and selection criteria that PECO uses to select electric generation supplier ("EGS") participants in the Company's "Standard Offer" program.

b. Please explain whether PECO has ever used different criteria for such evaluations in the past. If so, please explain why the criteria have changed.

c. Please explain whether PECO is proposing any changes to such criteria in DSP V, and the Company's rationale for changing the criteria or for keeping them the same.

d. Please explain whether PECO has ever proposed any changes to such criteria, and the Company's rationale for changing the criteria or for keeping them the same.

e. Please explain whether PECO has ever surveyed customers about the Standard Offer Program and what offering features they find attractive. If so, please provide any and all information and documents relating to such surveys.

RESPONSE:

a. PECO does not select EGS participants for the Standard Offer program. Any supplier who is certified to serve PECO customers and who submits to PECO an executed Standard Offer Supplier Application and Standard Offer Supplier Agreement can participate in the program. Please see Attachment ES-I-13(a) and Attachment ES-I-13(b).

b. The criteria for EGS participation in the PECO Standard Offer program has not changed since the program's inception.

c. PECO is not proposing any changes to EGS participation criteria for the Standard Offer program.

d. See PECO's response to part (b) above.

e. PECO has not surveyed customers about the Standard Offer program and what offering features they find attractive.

Responsible Witness: Carol Reilly

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-14

Refer to McCawley Testimony, page 8.

a. Please describe the source and justification for the principles for DSP design adhered to by PECO.

b. Please describe and provide documentation of any and all research and analysis underpinning the decision to adopt and maintain a principle as a “central principle.”

c. Please explain how the “different needs of various customer types” are determined.

d. Please explain what the “different needs of various customer types” are, as determined by PECO.

e. Please describe how PECO measures and ensures understandability.

f. Please explain what aspects of “the competitive procurement of generation supply service” are reflected in default service rate design.

g. Please explain how “competitive procurement of generation supply” is reflected in default service rate design.

RESPONSE:

a) These principles summarize key provisions of Act 129 of 2008 and the Competition Act and have been presented by PECO's witnesses in PECO default service programs beginning with DSP I.

b) PECO is unaware of documentation of the decision to adopt and maintain any of the principles as a "central principle."

c) Consistent with DSP IV, PECO is proposing to maintain the three customer procurement classes -- Residential, Small Commercial and Consolidated Large Commercial and Industrial -- based on its review of customer usage patterns and Commission guidance regarding the need for price stability.

d) Residential and Small Commercial customers have different usage patterns that warrant separating those customers from other customers to avoid cross-subsidization in costs. Larger commercial customers have a propensity to shop in higher percentages and a spot energy-priced product is appropriate for this class.

e) The Price-to-Compare is proscribed by the Commission as the appropriate pricing for default service and a benchmark to be used by customers to shop for electric supply. PECO therefore ensures that its communications regarding the Price-to-Compare use consistent terminology (e.g., cents per kWH) to ensure understandability.

f) The retail rates for generation are based primarily on the actual costs of competitively procured supply.

g) See PECO's response to part (f) above.

Responsible Witness: John J. McCawley

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-15

Refer to McCawley Testimony, page 8.

a. Please explain how customer and market feedback is incorporated or reflected iterations of competitive solicitations.

b. Please explain whether PECO has ever changed the form, or other elements, of competitive solicitations based on feedback from bidders or based on bids received. Please provide details of all such instances.

RESPONSE:

a. PECO's procurement documents are developed with the Independent Evaluator (National Economic Research Associates, Inc.), which proposes changes to the procurement documents based on past procurements. Changes proposed for DSP V based on prior procurements are shown in McCawley Exhibit JJM-8.

b. See PECO's response to part (a). All changes to PECO's procurement documents are reflected in the procurement documents maintained on PECO's procurement website http://www.pecoprocurement.com/index.cfm?s=background&p=archives.
Beginning with DSP III, PECO began use of a tailored version of the Uniform Supply Master Agreement developed in conjunction with the Commission's Office of Competitive Market Oversight. PECO proposed minor modifications to the Supply Master Agreement in DSP IV, and is proposing to revise the Supply Master Agreement to require suppliers to provide a generation supply report as described by Mr. McCawley in PECO Statement No. 1, p. 22.

Responsible Witness: John J. McCawley

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-16

Refer to McCawley Testimony, page 14.

a. Please explain whether PECO imposes any conditions or obligations on the alternative energy credits (“AECs”) that full requirements suppliers must provide.

b. Please explain whether PECO has ever evaluated imposing additional conditions or obligations relating to AECs. If so, please describe these conditions or obligations and the reasons for not imposing them. If not, please explain why not.

RESPONSE:

a. All terms and conditions are specified in the Supply Master Agreement- Appendix E (DS Supplier’s Obligations for AEPS Compliance).

b. PECO has not evaluated imposing conditions or obligations related to AECs on Default Service Suppliers (as defined in the Supply Master Agreement) as PECO believes the current conditions and obligations in the SMA are sufficient for compliance.

Responsible Witness: John J. McCawley

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-17

Refer to McCawley Testimony, page 19. Please explain why PECO chose an approach for TOU rates that was designed to result only in small rates of enrollment. Please provide the cost-effectiveness analysis that supports the decision regarding overall TOU program design.

RESPONSE:

PECO is introducing TOU rate options as part of DSP V in accordance with Act 129 of 2008 ("Act 129") and Commission guidance on TOU rate design. As explained by Mr. Bisti in PECO Statement No. 2 (pp. 13-14), PECO's proposed TOU rate design balances several objectives, including simplicity and the customer value proposition for enrollment, to comply with Act 129 requirements and to implement lessons learned from the PECO Smart Time Pricing Pilot. PECO's TOU rate options are not "designed to result only in small rates of enrollment," but PECO's expectation is that the number of customers who elect PECO's TOU default service is likely to be small relative to the overall default service customer base based on PECO's customer enrollment experience with its opt-in TOU pilot program. See also PECO's response to OCA-II-8. PECO has not performed the requested quantitative cost-effectiveness analysis of overall TOU program design.

Responsible Witness: Joseph A. Bisti

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-18

Refer to McCawley Testimony, page 22. Please explain whether or not, and why or why not, PECO plans to provide default service customers with energy source information, including a detailed breakdown of renewable resources relied upon for default supply.

RESPONSE:

If PECO's proposed changes to the Supplier Master Agreement in DSP V are approved, a detailed breakdown of renewable and other generation resources consistent with the Commission's reporting regulations will be available annually, starting in the spring of 2022.

Responsible Witness: John J. McCawley

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-19

Refer to McCawley Testimony, page 29. Please provide any analysis or projections of increased costs associated with wholesale supply relating to the increased Solar AEPS requirement. Please provide any analysis of alternative methods for meeting the 75% of increased requirements referenced in Mr. McCawley's testimony, if conducted. If no such analysis has been conducted, please explain why not.

RESPONSE:

There are no projections of increased or decreased cost associated with wholesale supply relating to the increase of an additional 8,000 AECs annually to separately procured solar requirements. The contribution of 8,000 solar credits annually compared to the total cost of supply is not significant, as the 8,000 solar credits represent about 12.5% of the 0.5% AEPS requirement for solar AECs. The 75% is not an increased AEPS requirement but refers only to the portion of the AEPS requirement that will be met by wholesale suppliers.

Responsible Witness: John J. McCawley

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-20

Refer to McCawley Testimony, page 30. Please provide a detailed description of how PECO engaged with potential Solar AEC sellers and other solar market participants in developing the Solar RFP and related processes and requirements. Please explain how the proposed approach differed from the recommendations of solar market participants.

RESPONSE:

On January 30, 2020, PECO presented an overview of its Solar RFP and related process requirements to solar market participants at a solar collaborative organized by PECO's Green Connect Team, which coordinates implementation of PECO's solar-related programs. A copy of a PowerPoint used in the presentation is attached as Attachment ES-I-20. Based on recommendations of participants at the solar collaborative, PECO reordered the manner in which bids will be evaluated in the second stage of the procurement to facilitate participation by entities in PECO's service territory who may offer relatively smaller amounts of solar alternative energy credits.

Responsible Witness: John J. McCawley

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-21

Refer to McCawley Testimony, page 36. Please explain how the absence of a "determination by a court or regulatory agency of competent jurisdiction that Exelon Generation has withheld from the wholesale market any generation supply in a manner that violated federal law" proves that such withholding has not, in fact, occurred.

RESPONSE:

Mr. McCawley's job responsibilities involve the operation of PECO Energy Company. He does not have knowledge of or visibility into the operations of PECO's generation and power marketing and retail affiliates beyond that which is made public. The Commission has relied upon the absence of such determinations in approving prior default service plans.

Responsible Witness: John J. McCawley

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-22

Refer to McCawley Testimony, page 36. Please explain whether PECO has ever studied or estimated the effect that distributed generation sited and operating behind the customer meter, the distributed substation, or the PJM delivery point has on allocated 5CP costs for customers on the same or nearby circuits. If so, please provide the results of that analysis. If not, please explain why not.

RESPONSE:

PECO has not conducted such a study or estimate. The allocation of PECO zone 5CPs to customer accounts in the determination of account Peak Load Contribution or Network Service Peak Load kW is independent of whether or not a customer has distributed generation on the same circuit, or behind the customer meter, or on or near any particular substation or at any particular delivery point.

Responsible Witness: John J. McCawley

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-23

Refer to PECO Statement No. 4, Direct Testimony of Scott G. Fisher ("Fisher Testimony"), pages 6-9. Please list and describe all product design elements and features—in addition to price, term/delivery period, and class of customer served—that are to be used by PECO under DSP V and how each of these elements and features contributes to meeting statutory and regulatory requirements for default service.

RESPONSE:

Mr. Fisher evaluated PECO's DSP V with respect to certain requirements of Act 129, specifically that the plan include a prudent mix of contracts designed to ensure the least cost to customers over time, taking into account the benefits of price stability, and includes prudent steps necessary to obtain least cost generation supply contracts on a long-term, short-term and spot market basis, as required by Section 2807(e)(3.4) and Section 2807(e)(3.7) of the Act. Given these requirements, Mr. Fisher considered product design elements and features, including but not limited to the mix of products, how the supply products are acquired (e.g., competitive solicitations), the solicitation process (e.g., standardized supply contract, objective evaluation criteria, etc.), the supply product delivery periods and how the delivery periods overlap, the product type (e.g., full requirements products as compared to products that do not follow changes in load), the timing of solicitations, reliability, and the alignment of the products with established environmental requirements in Pennsylvania. These elements and attributes were considered holistically in light of the guidance provided in prior Commission orders and regulations related to Act 129 requirements and how those requirements were satisfied in previously approved DSP plans at PECO and elsewhere in Pennsylvania. See Mr. Fisher's Direct Testimony, pages 4-5, 23-27 and footnote 8. See the Company's response to ES-I-1.

Responsible Witness: Scott G. Fisher

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-24

Refer to Fisher Testimony, page 10. Please describe the key differences between bids submitted by suppliers in past DSP cycles.

RESPONSE:

While Mr. Fisher does not know how each supplier derived its bids, Mr. Fisher believes that it is reasonable to assume that key differences between bids submitted by suppliers in past DSP cycles included differences in the prices offered, the delivery periods, the contract terms, the customer classes served, the numbers of participating suppliers, the market conditions and environmental requirements at the time the bids were submitted, the types of products solicited (e.g., full requirements products, block products, etc.), pricing structures of the products solicited (e.g., fixed-price products, spot-priced products), and the retail market conditions and retail programs in place at the time of the solicitations.

Responsible Witness: Scott G. Fisher

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-25

Refer to Fisher Testimony, page 11. Please explain whether the NorthBridge Group has ever conducted or been asked to conduct, whether on behalf of PECO or anyone else, any analysis of DSP solicitation responses on the basis of any factor other than price?

RESPONSE:

Mr. Fisher cannot address all analyses requested of, or performed by, the NorthBridge Group. Each individual DSP product (and contract) is standardized to help satisfy the requirements of Act 129. Once the prudent mix of standardized DSP products has been selected and approved by the Commission, bidders compete to sell the products solely on the basis of price, subject to any supplier load caps. As such, Mr. Fisher's evaluations of individual solicitation responses are based on price and supplier participation, as shown in Mr. Fisher's Direct Testimony, pages 10-18, recognizing that the mix of solicited products has already been approved by the Commission in accordance with the requirements of Act 129. Also see the Company's response to ES-I-23.

Responsible Witness: Scott G. Fisher

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-26

Refer to Fisher Testimony, page 11. Is it the witness's view that any other factors besides price can impact whether supply provided in response to solicitations represents the least cost over time? If so, what are those factors and how do they impact determination of least cost over time? If not, please explain why not.

RESPONSE:

Yes. Other factors besides price can impact whether supply provided in response to solicitations represents the least cost over time, as the choice, definition, timing, and procurement process of the supply products can also contribute to the determination of whether the supply constitutes a prudent mix of contracts designed to ensure least cost to customers over time. See the Company's responses to ES-I-1, ES-I-23, and ES-I-25.

Responsible Witness: Scott G. Fisher

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-27

Refer to Fisher Testimony, page 14.

a. Please confirm that "various individual costs" included on the chart are the witness's estimate of a competitive price that would be paid for individual component.

b. Please provide any analysis conducted, on behalf of PECO or anyone else, to confirm whether the witness's estimates of individual component prices match those experienced by a successful bidder and default service provider.

c. If the witness does not have or has not conducted such analysis, please explain why not.

RESPONSE:

a. The magnitudes of the bars on the chart are illustrative. Non-illustrative values for the various individual costs may be valid in the context of the fixed-price full requirements obligation overall. As indicated in Mr. Fisher's Direct Testimony, pages 15-16, certain costs and risks captured in the residual compensation relate to other cost components. Furthermore, Mr. Fisher used market price information and load data available at the time of each given solicitation to quantify cost components, yet actual costs experienced by any given supplier may vary based on changes in market conditions throughout the contract period and the approach used by the supplier to satisfy its obligations under the contract. As such it would be inaccurate to broadly state that "…'various individual costs' included on the chart are the witness's estimate of a competitive price that would be paid for individual component."

b. Mr. Fisher's analysis uses market price information and load data available at the time of each given solicitation to quantify cost components, but the actual costs experienced by any given supplier may deviate based on changes in market conditions throughout the contract period and the approach used by the supplier to satisfy its obligations under the contract.

c. See the Company's response to ES-I-27(b).

Responsible Witness: Scott G. Fisher

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-28

Refer to Fisher Testimony, page 14. Please explain how suppliers price profit, margin, or premium into their bids, if the "residual compensation" calculation does not reflect profit, margin, or a premium.

RESPONSE:

Mr. Fisher did not attempt to determine in his analysis "how suppliers price profit, margin, or premium into their bids." The residual compensation may include some intended profit for the winning bidders, but the residual compensation must cover other costs and risks that were not quantified and deducted from the winning bid prices, as explained in Mr. Fisher's Direct Testimony, pages 14-16.

Responsible Witness: Scott G. Fisher

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-29

Refer to Fisher Testimony, page 19. In the witness's view, does the mixing and overlapping of supply contracts have the effect of masking actual market price fluctuations and weakening wholesale competitive price signals to customers, in addition to providing customers with price stability?

RESPONSE:

It is unclear what is meant by "having the effect of masking actual market price fluctuations and weakening wholesale competitive price signals to customers." Providing appropriate levels of price stability can provide the benefit of reducing customers' exposure to short-term market volatility. However, each of the supply product prices in PECO's DSP V is based on a competitive solicitation process and therefore provides a competitive price signal to customers. The default service rates therefore reflect competitive market prices. See Mr. Fisher's Direct Testimony, pages 23-27. Also see the Company's response to ES-I-37.

Responsible Witness: Scott G. Fisher

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-30

Refer to Fisher Testimony, page 19. Has the witness conducted any evaluation of the ability to provide price stability benefits to customers through the selection of fixed-price supply contracts of long duration, such as long-term (e.g. 10-year prices) renewable energy PPA-based supply, as a complement to or substitute for contract term mixing and overlapping?

RESPONSE:

See Attachment ES-I-30(a) for an assessment of considerations regarding the inclusion of long-term contracts in a default service portfolio. Pages 19-21 addresses considerations pertaining to the inclusion of long-term contracts in a default service portfolio, and pages 12-14 discuss additional risks that customers may bear when default service supply contracts do not match the default service load obligations in a supply portfolio. Mr. Fisher supports the use of long-term contracts in certain circumstances, but the use of long-term contracts for default service supply can result in risks for customers, especially given the uncertainty about default service load levels over longer periods of time.

Responsible Witness: Scott G. Fisher

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-31

Refer to Fisher Testimony, page 20.

a. Has the witness conducted or been asked to conduct, whether on behalf of PECO or anyone else, an analysis of any other factors or indicators relating to competitive retail electricity market growth or development due to the basic default service model besides the number of EGS entities participating in the PECO zone?

b. How has the amount of supply provided, in total and per EGS, changed?

c. How has the average price for EGS supply changed? Has EGS pricing been lower on average than competitive market pricing?

d. How has the mix of energy types—coal, nuclear, gas, renewable—changed in EGS supply over time?

e. Are there any other factors that suggest that the basic default service model used by PECO has supported the competitive retail electricity market?

RESPONSE:

a. Yes. For example, Mr. Fisher's Direct Testimony, at pages 29-30, addresses aspects of the default service model that support the competitive retail electricity market. Furthermore, on page 21, Mr. Fisher notes that 60% of PECO's total customer load is currently being served by an EGS, while as of October 1, 2010, only a few months before supply deliveries under DSP I began, only 1.7% of PECO's total customer load was being served by an EGS. Mr. Fisher concludes on page 21 that PECO's transition from long-term, capped default service rates to default service rates based on competitive market pricing for PECO's prudent mix of default service supply products has supported a competitive retail market in PECO's service area.

b. Please see the Retail Choice activity reports at the Commission dockets shown below.

| **Electric Choice Reports** | | |
|---|---|---|
| | | |
| **Year** | **Docket #** | **Comment** |
| 2010 | L-00070184 | |
| 2011 | L-00070184 | |
| 2012 | L-00070184 | |
| 2013 | L-00070184 | |
| 2014 | L-00070184 | |
| 2015 | L-00070184 | |
| 2016 | L-00070184 | |
| 2017 | L-00070184 | |
| 2018 | M-2018-2640824 | Changed in April 2018 |
| 2019 | M-2019-3006862 | |
| 2020 | M-2020-3015223 | |

c. See PECO's response to Turn-I-17.

d. Mr. Fisher does not have information regarding the mix of energy types—coal, nuclear, gas, renewable—that EGSs have relied upon for supply over time.

e. See the response to (a.) above.

Responsible Witness: Scott G. Fisher and John J. McCawley

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-32

Refer to Fisher Testimony, page 21. Please provide year by year numbers showing the amount of total customer load and customer load by class that was served by an EGS in each year since 2010. Please explain how each annual change in the amount was due to the basic default service model used by the Company, and not due to other factors in the marketplace or the economy.

RESPONSE:

Please see Attachment ES-I-32(a). Mr. Fisher does not claim on page 21 of his Direct Testimony that each annual change in the amount was due to the basic default service model used by the Company, and not due to other factors in the marketplace or the economy.

Responsible Witness: Scott G. Fisher and John J. McCawley

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-33

Refer to Fisher Testimony, page 24. Please confirm that the witness takes the position that "least cost" and "lowest price" are the same.

a. If not, please explain.

b. Please explain why the witness believes that "[i]t is reasonable to assume that bidders in the FPFR product solicitations will consider the costs and risks associated with all forms of supply available to them to satisfy their fixed-price full requirements obligation, and will reflect in their bid prices the benefits of any opportunity that they believe is the least cost supply opportunity." Please provide full documentation of any research, analysis, studies, or other information supporting this belief.

RESPONSE:

a. Mr. Fisher does not take the position that "least cost" and "lowest price" are the same. See the Company's responses to ES-I-1, ES-I-23 and ES-I-25.

b. On page 24 of his Direct Testimony, Mr. Fisher explains that bidders in the supply product solicitations will compete and be selected based on the lowest price. Consequently, bidders have the incentive to consider any supply opportunity that would allow them to offer a lower-priced bid. Furthermore, through the procurement of fixed-price full requirements supply products, the benefits of this competition apply to all aspects of the full requirements supply obligation, including the portfolio management function. The participation by multiple suppliers in PECO's open solicitations for FPFR default service supply products noted on pages 9-10 of Mr. Fisher's Direct Testimony, combined with the quantitative analysis of the results of these solicitations presented on pages 11-18 of Mr. Fisher's Direct Testimony, indicate that the resulting contract prices obtained by PECO have been reasonable, considering the costs and risks that the suppliers under these contracts assume to the benefit of customers. See pages 10-11 of Mr. Fisher's Direct Testimony.

Responsible Witness: Scott G. Fisher

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-34

Refer to Fisher Testimony, page 25. Please provide a detailed explanation of the meaning of the term "well-tested in the marketplace" as used by the witness. Please provide copies and reports of all market tests or related research or studies referenced in reaching the conclusion stated in in the testimony.

RESPONSE:

As noted in Footnote 14 of Mr. Fisher's Direct Testimony, to date the Pennsylvania Public Utility Commission has approved the bid results for over 700 fixed-price, full requirements, default service supply product tranches procured by PECO alone. Furthermore, the Pennsylvania Public Utility Commission has repeatedly approved default service plans for PECO and other Pennsylvania utilities that include fixed-price full requirements products, including the last four plans for PECO (DSP I, DSP II, DSP III, and DSP IV). Full requirements supply products are also procured in Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, Ohio, Pennsylvania, and Washington D.C.

Responsible Witness: Scott G. Fisher

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-35

Refer to Fisher Testimony, page 25. Is there any other information, research, or reports known to the witness or the Company and relied upon to support the conclusion that the products relied upon under the DSP "have been shown to be reasonably priced" besides the conclusion of the witness himself? Please provide all such information, research, or reports.

RESPONSE:

See Attachment ES-I-35(a). See also the Company's responses to OCA II-3 (with attachments) and ES-I-34.

Responsible Witness: Scott G. Fisher

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-36

Refer to Fisher Testimony, page 25. If the witness asserts that full requirements products in the default service portfolio insulate default supply customers from market price volatility, why is further mixing and overlapping of contract terms required to further insulate customers from market price volatility?

RESPONSE:

The mix of one-year and two-year fixed-price full requirements products in PECO's default service supply portfolio, the timing of their procurements, and the overlapping of their delivery periods, provide important additional price stability benefits distinct from the general use of full requirements products. PECO's portfolio of overlapping one-year and two-year products limits the percentage of supply that must be solicited or replaced at any given time or in any given short period, thereby reducing the likelihood of significant rate changes due to adverse circumstances or market conditions at any given time. See pages 19-20 of Mr. Fisher's Direct Testimony. The product mix also avoids subjecting Residential and Small Commercial customers to a "hard stop" with regard to their supply products at the end of the DSP V period, which helps to avoid the risks associated with the need to replace a large portion of default service supply in a short period at the end of the DSP V period. See page 28 of Mr. Fisher's Direct Testimony.

Responsible Witness: Scott G. Fisher

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-37

Refer to Fisher Testimony, page 26. Please explain how full requirements products promote competitive markets if they expose customers to lower price opportunities, but also insulate them from high market prices?

RESPONSE:

First, by having bidders compete and be selected based on the lowest price for full requirements products, default service customers will be provided the benefits of competition on all aspects of the full requirements supply obligation, including the portfolio management function. See pages 24-25 of Mr. Fisher's Direct Testimony, and the Company's response to ES-I-33(b). Second, EGSs will compete against market-based default service rates that are based on the lowest prices offered in competitive supply solicitations approved by the Commission. Third, the use of fixed-price full requirements supply products for the Residential and Small Commercial classes will allow those classes' default service rates to closely match the market-based supply costs, reducing the likelihood of significant over- and under-collections from retail customers and enhancing rate transparency for retail supply decisions. Furthermore, the FPFR supply products and their procurement timing under PECO's proposed DSP V will result in a relatively stable and transparent residential price-to-compare benchmark against which residential customers can compare competing retail offers. See page 29 of Mr. Fisher's Direct Testimony. See also the response to ES-I-31(a).

Responsible Witness: Scott G. Fisher

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-38

Refer to Fisher Testimony, page 27. Has the witness ever evaluated, on behalf of the Company or anyone else, the potential benefits of class-specific product mixes based on resource type or any other factors besides price and term/delivery period? Please explain in detail.

RESPONSE:

Yes, Mr. Fisher has considered for different customer classes what constitutes a prudent mix of contracts designed to ensure the least cost to customers over time, taking into account the benefits of price stability, and the inclusion of prudent steps necessary to obtain least cost generation supply contracts on a long-term, short-term and spot market basis. See pages 23-27 of Mr. Fisher's Direct Testimony, as well as the Company's responses to ES-I-1, ES-I-23, and ES-I-25.

Responsible Witness: Scott G. Fisher

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-39

Refer to Fisher Testimony, page 30. Did the witness evaluate or review any other TOU rate design options considered by the Company besides that proposed in this application? If so, please provide information about those options and the results of that review or evaluation.

RESPONSE:

The scope of Mr. Fisher's testimony does not include the details of the rate design for PECO's Time-of-Use default service offering. It is limited to whether fixed-price full requirements suppliers' bid prices will be noticeably higher due to PECO's proposal to include the supply for PECO's Time-of-Use default service customers in the fixed-price full requirements products.

Responsible Witness: Scott G. Fisher

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-40

Refer to PECO Statement No. 2, Direct Testimony of Joseph A. Bisti ("Bisti Testimony"), including Exhibit JAB-10.

a. Please provide Exhibit JAB-10 in Microsoft Excel format with cells unlocked and all formulas and data intact.

b. Please indicate whether the values in the table in Exhibit JAB-10 are real or nominal. If real, please provide discount rates used.

c. Please explain whether the "Variance" and "% Change" values in Exhibit JAB-10 have been adjusted for market prices for gas or other fuel.

d. Please provide average fuel prices per year over the same period as the data in Exhibit JAB-10.

RESPONSE:

a. Please refer to Attachment ES-I-40(a).

b. The values in Exhibit JAB-10 are nominal.

c. The "Variance" and "% Change" values in Exhibit JAB-10 are intended to directly compare the Price To Compare for the associated quarter with the Price To Compare from the immediately preceding quarter. The values in these two columns do not include any additional adjustments for market prices, gas, or other fuels.

d. Fuel prices per year over the same period as the data in Exhibit JAB-10 can be found in Section 3 of the PJM "State of the Market" reports for those years. Please see https://www.monitoringanalytics.com/reports/PJM_State_of_the_Market/2020.shtml.

Responsible Witness: Joseph A. Bisti

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-41

Refer to Bisti Testimony, page 6. Please provide, in Excel spreadsheet form with cells unlocked and values and formulas intact, the amount of over- and under-collections for each quarter and the resulting E-Factors assessed, for each DSP procurement class, for each of the ten years prior to and including 2019.

RESPONSE:

Refer to Attachment ES-I-41 (a) through Attachment ES-I-41 (ll) for the Generation Supply Adjustment ("GSA") over- and under-collection amounts and the resulting E-Factors assessed, by DSP procurement class, for each quarter from January of 2011 through December of 2019. The start date of January 1, 2011 is based on when PECO's GSA rates first became effective.

The attachments contain spreadsheets for the requested information. The specific tabs in each spreadsheet that contain the requested data begin at the left-hand side of each of the above-mentioned spreadsheets and are titled "*[Procurement Class]* File Rate Calc". The name "*[Procurement Class]*" is defined as GSA 1, GSA 2, GSA 3, GSA 3 Hourly, GSA 4 Hourly and GSA 3/4 Hourly, depending on when these classes were applicable. The current effective procurement classes are GSA 1, GSA 2 and GSA 3/4 Hourly. The E-Factor information for each procurement class is in the middle section of each of these tabs and can be traced through formulas that refer to other tabs in the spreadsheets.

Responsible Witness: Joseph A. Bisti

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-42

Refer to Bisti Testimony, page 11. Regarding the PECO Smart Time Pricing Pilot:

a. Please provide any cost-effectiveness evaluations and analysis conducted on the Pilot.

b. Please provide the results of the Pilot in terms of kW and kWh reductions or increases by customer class by usage pricing periods.

c. Please provide any summary reports and recommendations based on the experience of the Company and participants for the Pilot.

RESPONSE:

a. The PECO Smart Time Pricing Pilot was a research project designed to fulfill the requirements of Act 129, as stated in PECO's February 22, 2013 Supplement to PECO Energy Company's Initial Dynamic Pricing and Customer Acceptance Plan. Please reference page 31, Section 3.1 of Attachment ES-I-42(a). PECO's objectives included gauging the level of customer interest in this type of rate offering as provided by an Electric Generation Supplier (EGS), per the Commission's recommendation at that time under Docket No. I-2011-2237952 (Order entered December 16, 2011). Since an EGS was identified as the supplier for customers enrolled in the Pilot, PECO did not evaluate the Pilot's overall cost-effectiveness.

b. Please reference Attachment OCA-II-18(b), specifically Section 4 beginning on page 19, which summarizes the residential load impact results of the PECO Smart Time Pricing Pilot.

c. PECO commissioned two reports for the Pilot. Attachment OCA-II-18(b) referenced above is the Final Report, published in April of 2015. Please also reference Attachment OCA-II-18(a), the Pilot Enrollment Report, published in June of 2014.

Responsible Witness: Joseph A. Bisti

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-43

Refer to Bisti Testimony, page 13. Please list and describe all options, including rate design options and technology options, considered and/or evaluated by the Company to address peak demand from default service providers. Such options may include Peak Time Rebates, Critical Peak Pricing, Programmable Thermostats and other End-Use Equipment/Appliances, Bring-Your-Own-Device programs, and others.

RESPONSE:

In developing its Initial Dynamic Pricing and Customer Acceptance Plan approved by the PUC in 2012, PECO considered and evaluated several rate designs options which are summarized in the two tables presented below. These options are more fully explained in PECO witness Dr. Ahmad Faruqui's direct testimony submitted at Docket M-2009-2123944. Please reference Attachment TURN-I-12(e).

**PECO Exhibit AF-1:**
**Rate Options Initially Considered**

| Rate | Description |
|---|---|
| **Time-of-Use (TOU)** | Charges a higher price during all weekday peak hours and a discounted price during off-peak and weekend hours |
| **Super Peak TOU** | Similar to the TOU except that the peak price is offered during a much smaller number of hours of the year, leading to a stronger price signal |
| **Inclining Block Rate (IBR)** | Customer usage is divided into tiers and usage is charged at higher rates in the higher tiers; meant to encourage conservation |
| **Critical Peak Pricing (CPP)** | Customers are charged a higher price during the peak period on a limited number of event days (often 15 or less); the rate is discounted during the remaining hours |
| **Variable Peak Pricing (VPP)** | Critical Peak Pricing rate with added variability |
| **CPP-TOU Combination** | A TOU rate in which a moderate peak price applies during most peak hours of the year, but a higher peak price applies on limited event days |
| **Peak Time Rebate (PTR)** | The existing flat rate combined with a rebate for each unit of reduced demand below a pre-determined baseline estimate during peak times on event days |
| **Real Time Pricing (RTP)** | A rate with hourly variation that follows Locational Marginal Pricing (LMPs), but with capacity costs allocated equally across all hours of the year |
| **Critical Peak RTP (CP-RTP)** | A rate with hourly variation based on LMPs and with a capacity cost adder focused only during event hours, creating a strong price signal at these times |

**PECO Exhibit AF-2:**
**Results of Rate Evaluation**

| | Simplicity | Value Proposition | Retail-Wholesale Connection | Peak Reduction | Load Shifting | Description |
|---|---|---|---|---|---|---|
| TOU | H | L | M | M | H | **Provides strong incentive for permanent load shifting** |
| CPP | M | H | M | H | L | **Simple, focused rate for targeted reductions during top load hours** |
| CPP/ TOU | M | H | H | H | M | **Provides combined incentive of load shifting and demand response** |
| PTR | M | M | L | H | L | **Residential rate produces no immediate "losers"; potentially most applicable for low income residential customers** |
| RTP | L | L-H | H | L | M | **Conveys variability in hourly LMP which provides some load shifting value** |
| CP RTP | L | L-H | H | H | M | **Provides additional curtailment incentive beyond LMP during top load hours** |

L = Low, M = Moderate, H = High

The technology options that PECO considered at the time included an In Home Displays (IHD) and a Programmable Communicating Thermostat (PCT) which were tested and approved for use on the Sensus network.

Responsible Witness: Joseph A. Bisti

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

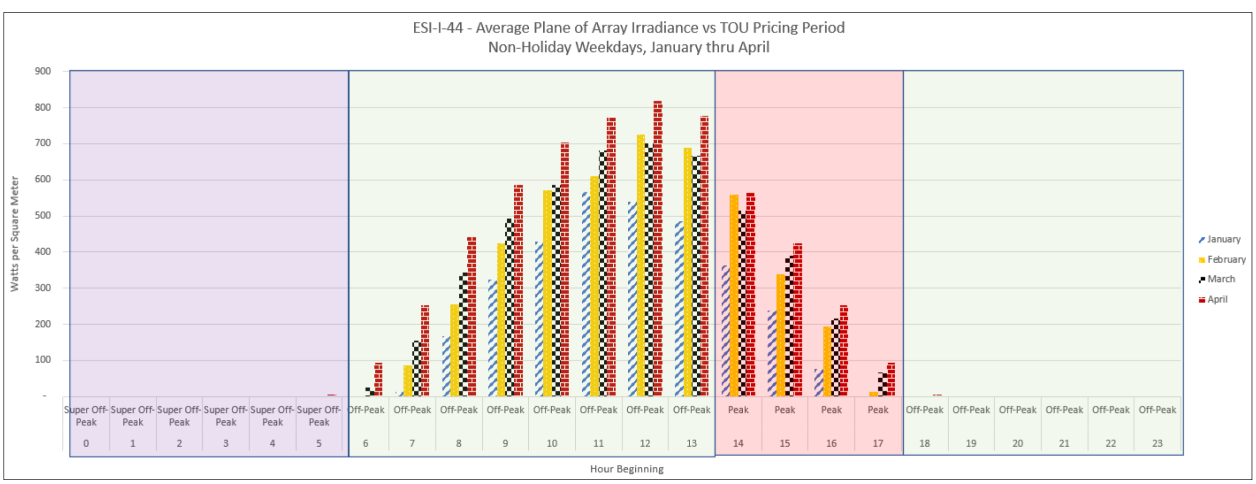
ES-I-44

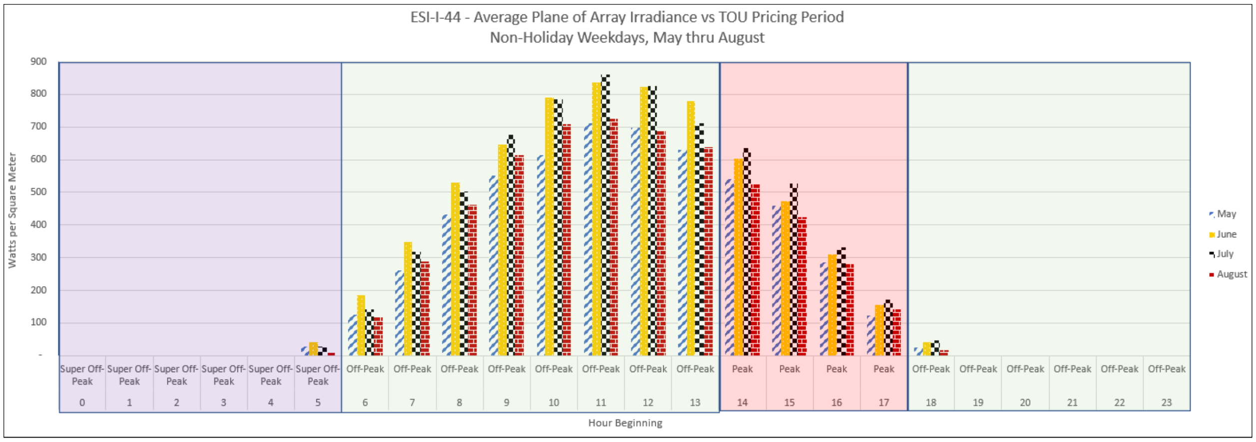
Refer to Bisti Testimony, page 14. Please explain how the propose TOU Pricing Period hours coincide with average monthly and annual solar insolation hours.

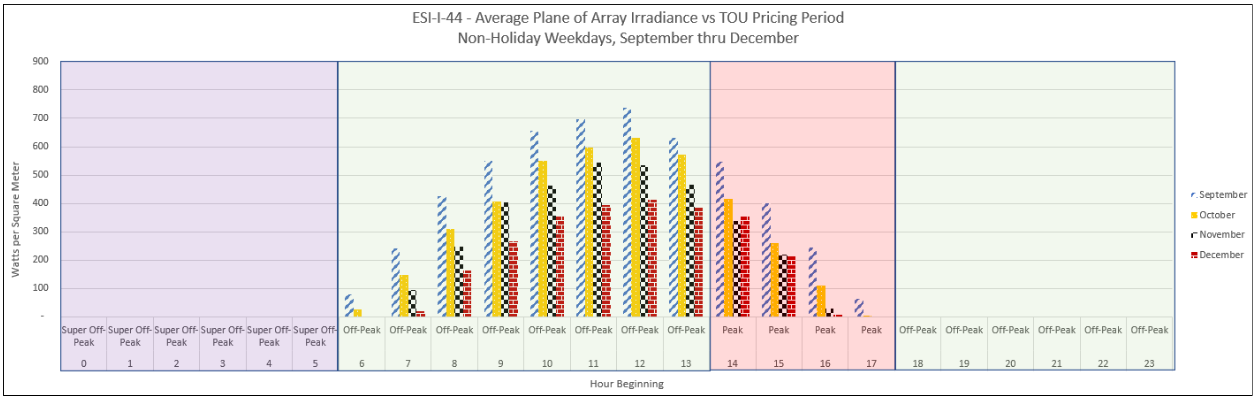
RESPONSE:

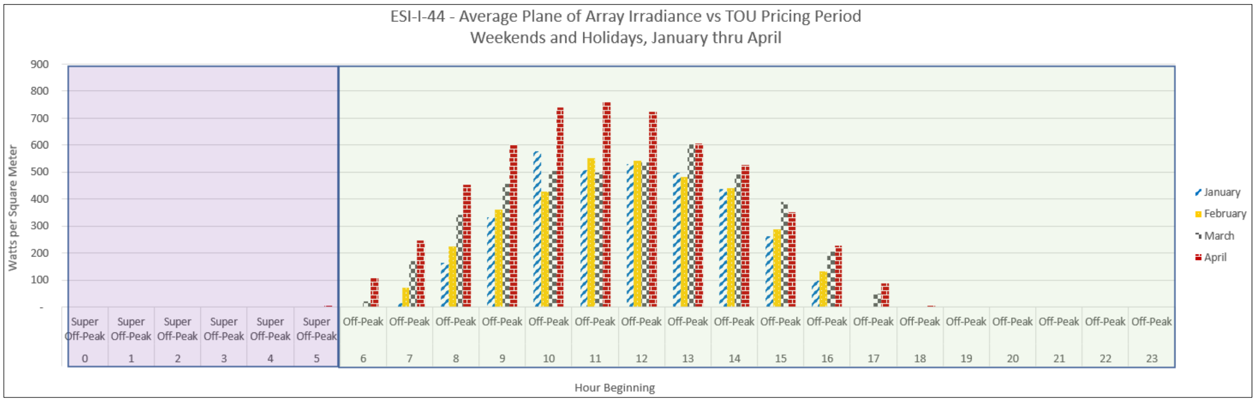
The NREL PVWatts Calculator inputs and outputs detailed in PECO's response to ES-I-10 were also used to develop this response. Please reference PECO's response to ES-I-10 for the related inputs and Attachment ES-I-10(a) for the supporting detail.

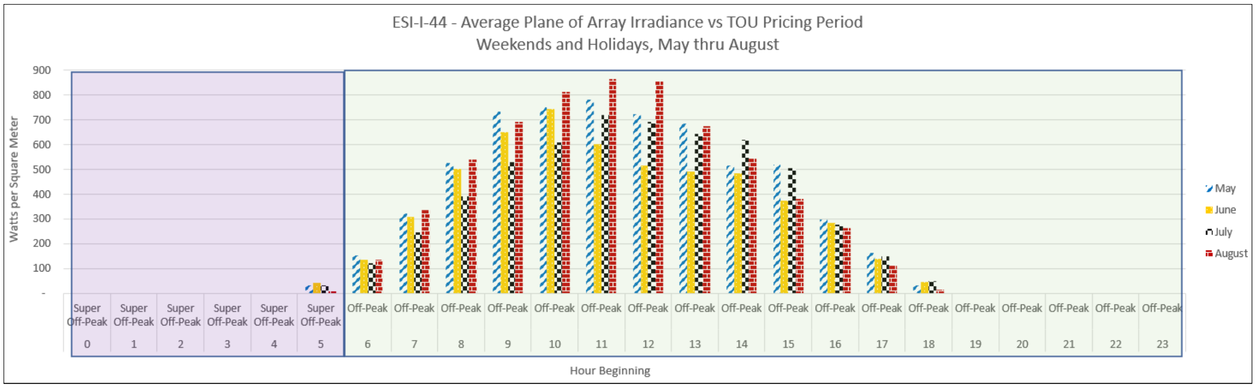
PECO compared its proposed TOU Pricing Period hours with the average Plane Of Array Irradiance values output by PVWatts. Graphical summaries of the results are shown below.

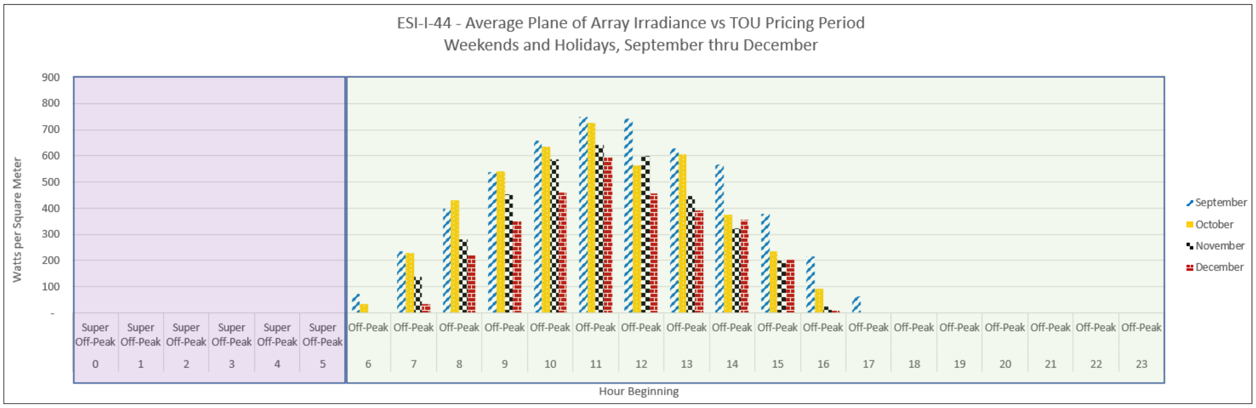



ESI-I-44 - Average Plane of Array Irradiance vs TOU Pricing Period
Non-Holiday Weekdays, May thru August
Watts per Square Meter
Hour Beginning
May
June
July
August
Super Off-Peak
Off-Peak
Peak


ESI-I-44 - Average Plane of Array Irradiance vs TOU Pricing Period
Non-Holiday Weekdays, September thru December
Watts per Square Meter
Hour Beginning
September
October
November
December
Super Off-Peak
Off-Peak
Peak


ESI-I-44 - Average Plane of Array Irradiance vs TOU Pricing Period
Weekends and Holidays, January thru April
Watts per Square Meter
Hour Beginning
January
February
March
April
Super Off-Peak
Off-Peak




Responsible Witness: Joseph A. Bisti

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-45

Refer to Bisti Testimony, page 15. Please provide data on how many default service customers in each class have smart meters installed, in numbers, by percentage, and by zip code.

RESPONSE:

The table below contains the number and percentage of default service customers in each procurement class with smart meters installed:

| **GSA 1 (Residential)** | **GSA 2 (Small Commercial)** | **GSA 3/4 (Large C&I)** |
|---|---|---|
| 1,106,532 | 96,277 | 1,203 |
| 99.5% | 98.0% | 98.9% |

Please refer to Attachment ES-I-45(a) for this data by zip code.

Responsible Witness: Joseph A. Bisti

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-46

Refer to Bisti Testimony, page 15. Please explain what programs or services the Company intends to provide to CAP customers during the term of DSP V that will help those customers in reducing demand during system peak hours.

RESPONSE:

Please note that PECO has proposed CAP customers as ineligible for selection of the optional TOU rate.

PECO provides discounts to CAP customers to reduce their current bills, grants to reduce arrearages, and in-home energy assessments and home improvements to improve the energy efficiency of their homes. CAP customers may also be eligible for PECO's program to reduce overall energy usage, known as its Low Income Usage Reduction Program. No program within CAP specifically targets reducing demand during system peak hours as opposed to overall usage reduction.

Responsible Witness: Joseph A. Bisti

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-47

Refer to Bisti Testimony, page 16. Please provide the following data, in Excel spreadsheet form with cells unlocked and values and formulas intact, relating to peak usage for each of the ten years prior to and including 2019:

a. Monthly peak and average annual peak demand, and time of peak, by customer class and DSP procurement class for default service customers.

b. Monthly peak and average annual peak demand, and time of peak, for all net energy sales.

c. Number of default service customers served, on average, by class and DSP procurement class.

d. Monthly and average annual energy delivered to customers, by customer class and DSP procurement class for default service customers.

e. Monthly and average annual energy delivered to all customers for all net energy sales.

f. Average annual transmission loss rate.

g. Average annual distribution loss rate.

h. Marginal transmission loss rate during peak demand hours (2 pm to 6 pm).

i. Marginal distribution loss rate during peak demand hours (2 pm to 6 pm).

RESPONSE:

a. See Attachment ES-I-47(a).

b. See Attachment ES-I-47(b).

c. See Attachment ES-I-47(c).

d. See Attachment ES-I-47(d).

e. See Attachment ES-I-47(e).

f. See Attachment ES-I-47(f). PECO does not breakout transmission and distribution losses.

g. See Attachment ES-I-47(f). PECO does not breakout transmission and distribution losses.

h. The marginal transmission loss rate during peak demand hours (2 pm to 6 pm) is not available.

i. The marginal distribution loss rate during peak demand hours (2 pm to 6 pm) is not available.

Responsible Witness: John J. McCawley

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-48

Refer to Bisti Testimony, page 17. Please provide copies of all analysis, customer surveys, or other data relied upon by the Company to support the Company's beliefs about year-round price-differentiation versus seasonal variation in pricing.

RESPONSE:

The Company's proposed year-round TOU price differentiation is based on the results of PECO's Smart Time Pricing Pilot and on stakeholder feedback reinforcing the need for simple, stable rates that allow customers to more easily understand their bills. See Attachment OCA-II-18(b), pages 55-56.

In addition, as part of the Commission's Investigation into Default Service and PJM Interconnection, LLC. Settlement Reforms at Docket M-2019-3007101, several stakeholders emphasized the importance of simple and stable default service rates for residential and small commercial customers. Please refer to the following attachments as examples:

- Attachment ES-I-48(a) – Comments from the Consumer Advisory Council to the Commission, pages 2-5, stressing the importance of customers understanding both their default service options and their bills.
- Attachment OCA-II-8(a) – Comments from the Pennsylvania Office of Consumer Advocate (OCA), suggesting clear and understandable TOU rates that avoid variable and complex time period definitions to the extent possible.

Responsible Witness: Joseph A. Bisti

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-49

Refer to Bisti Testimony, page 19. Please explain what changes in energy consumption, including total usage per billing period, and incremental and net revenues to the Company are expected to result from the proposed TOU rates, by procurement class for default service customers.

RESPONSE:

As discussed in PECO's response to ES-I-17, PECO expects enrollment in its proposed TOU rates to be small relative to the overall default service customer base. PECO has not quantitatively estimated potential changes in energy consumption or billed usage that may result from these rates.

As discussed in Mr. Bisti's testimony, PECO's proposed TOU rate design is revenue neutral. PECO therefore does not expect changes in incremental or net revenues to the Company as a result of the proposed TOU rates.

Responsible Witness: Joseph A. Bisti

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-50

Refer to Bisti Testimony, page 21. Please provide copies of all analysis or estimates of impacts to the Company and to customer-generators under the proposed TOU rates.

RESPONSE:

PECO has not conducted a quantitative analysis of the impact of the proposed TOU rates on the Company and customer-generators. PECO's proposed eligibility requirements, monthly accounting approach, and annual cash out process for customer-generators who employ net metering were based on internal discussions regarding several factors, including:

- Compliance with the annual cashout requirements mandated by the Commission in its December 2012 Order at Docket No. F-2011-2270675. Please refer to Attachment ES-I-50(a).

- Maintaining consistency between TOU and non-TOU methodologies to leverage PECO's existing billing system functionality and simplify related customer and Company communications.

- Administrative complexity associated with offering the proposed TOU rates to customer satellite accounts employing virtual net metering.

Responsible Witness: Joseph A. Bisti

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

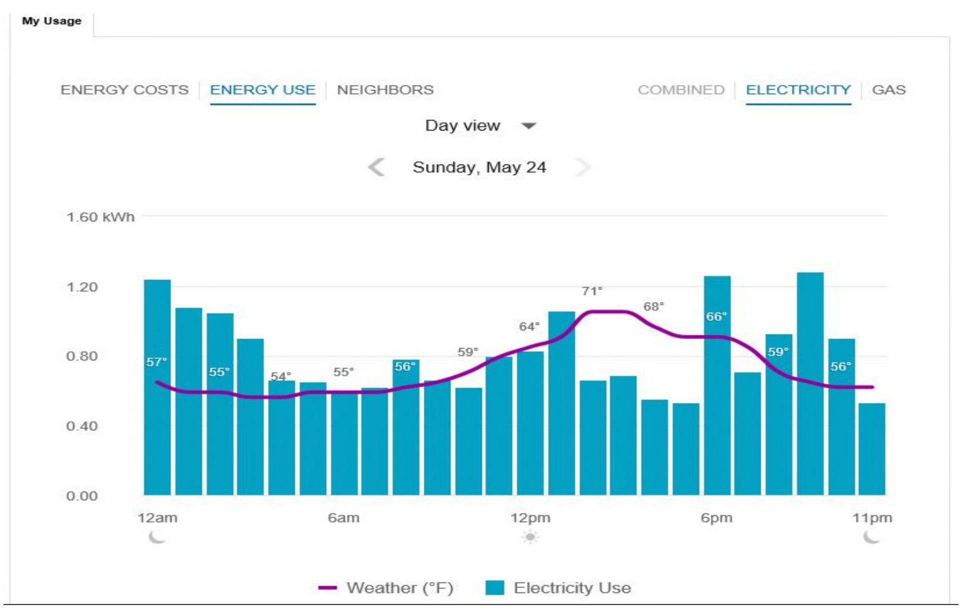
Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-51

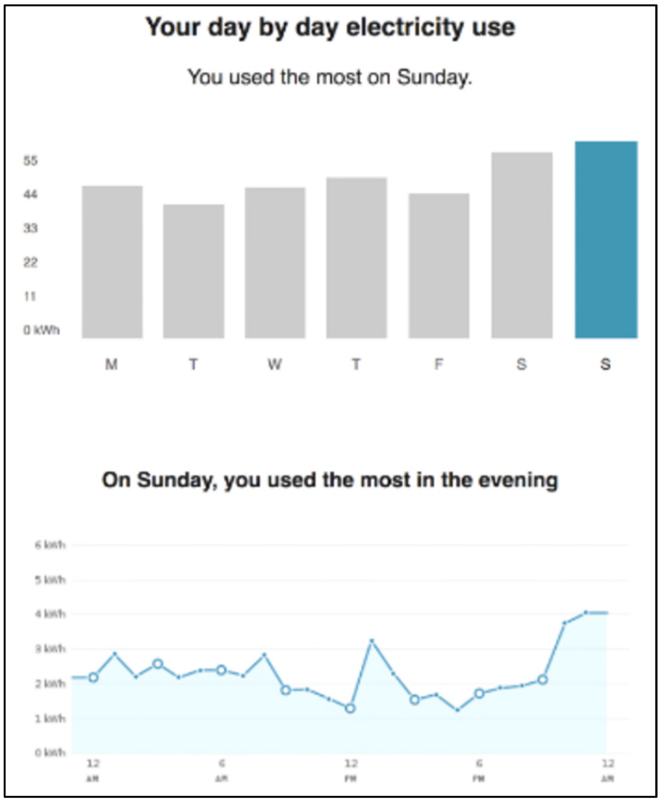
Refer to Bisti Testimony, page 21. Please provide a detailed description of all information and delivery methods that the Company has in place or proposes that will communicate how and when a customer is using energy during on- and off-peak pricing periods.

RESPONSE:

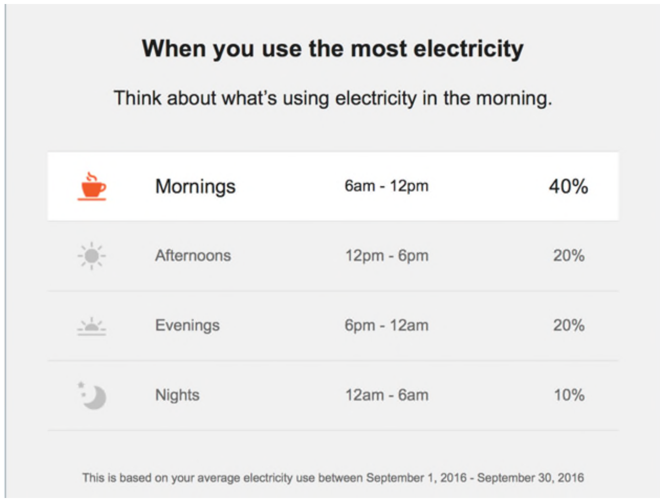
PECO currently provides several online self-service tools to help customers track and manage their energy usage. First, the "My Account" feature of PECO's website allows customers with smart meters to view the most recent 24 months of their usage history down to the interval level. The example below from PECO's website illustrates this for a residential customer.



Second, customers with smart meters can opt into weekly AMI reports and high-usage alerts. The weekly AMI reports outline the customer's energy consumption over a one-week period. They contain tips for reducing energy consumption and an energy breakdown of each day of that week, including an hour-by-hour visual of energy consumption on the peak day of the week as shown below.




By default, the high-usage alerts will trigger when customers are on track to use at least 20% more energy in the current billing month than they used in the same billing month during the prior year, though customers can elect a different bill threshold trigger if they choose. These alerts also include information on when customers use the most electricity in a given month, as shown in the example below.




Customers can also download their energy usage data from PECO's website in an Excel or CSV file that conforms to the Green Button "Download My Data" national standard for customer energy data. This download includes the customer's interval data for the selected date range.

All of the above tools will remain available to customers following PECO's implementation of the proposed TOU rates. In addition, as discussed in Mr. Bisti's testimony, PECO plans to distribute progress letters via e-mail to enrolled TOU customers on a monthly basis that will update customers on their current savings on the TOU rate and remind customers about the mechanics of the TOU rate.

Responsible Witness: Joseph A. Bisti

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-52

Refer to Bisti Testimony, page 23. Please provide any and all cost-effectiveness evaluations, analysis, or projections developed or relied upon by the Company relating to the proposed TOU rates.

RESPONSE:

PECO has not performed cost-effectiveness evaluations, analyses, or projections relating to its proposed TOU program design.

Responsible Witness: Joseph A. Bisti

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Environmental Stakeholders
ES Set I
Response Date: 06/01/2020

ES-I-53

Please provide a detailed explanation of the Company’s views on the following energy policy issues:

a. Does the Company hold a corporate position that fossil energy use for electricity generation contributes to climate change, which in turn is creating and/or will create significant problems and increased costs for electricity customers? If so, please explain how the Company reflects those views in its design of the DSP proposal. If not, please explain why not.

b. Does the Company hold a corporate position that default service customers should contribute to reductions in greenhouse gas emissions through use of renewable energy-generated electricity? If so, please explain how the Company reflects those views in its design of the DSP proposal. If not, please explain why not.

c. Does the Company hold a corporate position that increased reliance on renewable energy generation can be driven by greater reliance on renewable energy choice markets? If so, please explain how the Company reflects those views in its design of the DSP proposal. If not, please explain why not.

RESPONSE:

a. The Company’s position is that greenhouse gasses (GHG) contribute to climate change. The DSP V proposal meets state policy guidelines and regulations for the default service provider, which includes meeting state standards for renewable energy in the supply portfolio. In addition, elements of PECO’s plan support the development and sustainability of Pennsylvania and local solar resources through the proposed solar AEC procurement program.

b. PECO supports competitive markets, customer choice, and informed energy consumers. Customers who choose default service should have access to information about the generation resources that comprise the default service supply mix. Customers who would like their electricity supply to include components that exceed Pennsylvania renewable standards should have access to the competitive retail choice market to procure this type of supply. The DSP V plan supports both objectives through PECO's proposed Supply Master Agreement resource mix reporting requirement and through the Company's continuing support of electric choice market enhancements.

c. See the Company's response to part (b) above.

Responsible Witness: John J. McCawley

**Exhibit KRR-4:**

Response of Company to Interrogatories of the Electric Supplier Coalition ESC Set III

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Electric Supplier Coalition
ESC Set III
Response Date: 06/12/2020

ESC-III-1

Reference Bisti Direct Testimony, at p. 23. You indicate that PECO's communication plan regarding its TOU Rates will "include a one-time bill insert" to introduce the new TOU Rates and instruct customers on how to obtain more information.

A. If PECO received a request from an EGS to include information regarding the EGS's TOU Rates as part of a bill insert, would that request be honored? If not, why not?

B. Please provide bill inserts sent with monthly customer bills over the past 4 years, beginning June 1, 2016 through June 1, 2020.

RESPONSE:

A. PECO would not honor this request for the following reasons:

- **Lead time required may lead to outdated TOU content.** PECO rigorously schedules the development and production of its bill inserts for the entire calendar year no later than the last quarter of the prior year. Up to five inserts are sent with the bill each month in varying combinations, including gas/electric safety inserts, mandatory regulatory inserts, and others. The development and production schedule includes copy, draft, design, review, and printing for each of these. EGS TOU rate information that is not fixed for extended periods may therefore become outdated prior to reaching customers.

- **The costs of expanding insert capacity may outweigh its benefits.** The current weight limit for the bill (including inserts) is 2 ounces, and the equipment used by PECO's bill print vendor is programmed to stop inserting once that weight limit is reached. Consequently, some pre-planned inserts may not make it into the bill due to weight limits driven by postal costs. Assuming PECO's existing scheduled inserts continue as-is, expanding insert capacity to accommodate TOU content for all EGSs may require PECO to incur substantial costs associated with machinery purchases, upgrades, and maintenance deemed necessary by its bill print vendor.

- **EGSs serving customers may use available bill messaging space.** PECO provides the EGS up to four lines, each 80 characters in length, in the Message Center section of a utility-consolidated bill for messages directly related to the calculation or understanding of the EGS's portion of the bill. Please reference Page 92 of PECO's EGS Coordination Tariff at https://www.peco.com/SiteCollectionDocuments/CurrentEGSTariff.pdf. To the extent that the EGS's TOU rates are related to EGS billing of that customer, EGSs may use this space for related messages to their customers.

B. Bill inserts from March of 2019 through June of 2020 are currently available on PECO's website at https://www.peco.com/MyAccount/MyBillUsage/Pages/ViewBillInserts.aspx. Please refer to Attachments ESC-III-1(a)-(d) for the remaining bill inserts from June of 2016 through March of 2019.

Responsible Witness: Joseph A. Bisti

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Electric Supplier Coalition
ESC Set III
Response Date: 06/12/2020

ESC-III-2

Over the 4-year period beginning June 1, 2016 through June 1, 2020, please identify all charges for non-regulated service or products that PECO has included on its utility consolidated bill.

A. In responding, please indicate whether PECO has included any EGS charges for non-regulated service on the utility consolidated bill.

B. Describe PECO's policy if an EGS would request the inclusion of charges for non-regulated service or product on the utility consolidated bill.

RESPONSE:

A. PECO has not included any EGS charges for service other than basic generation service on the utility consolidated bill over the period from June 1, 2016 through June 1, 2020.

B. PECO's policy is to allow and purchase the receivables for basic generation service of an EGS on the utility consolidated bill. The supplier would be referred to PECO's Electric Generation Supplier Coordination Tariff page 94, Paragraph No. 13.

Responsible Witness: Carol Reilly

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Electric Supplier Coalition
ESC Set III
Response Date: 06/12/2020

ESC-III-3

For the applicable AEPS Reporting Years in the current DSP Plan program period, specify the amount of AECs, by Tier I Solar, Tier I Non Solar, and Tier II, that have been retired to satisfy PECO's AEPS requirements.

RESPONSE:

| Energy Year | Retired Tier I Solar AECs | Retired Tier I Non-Solar AECs | Retired Tier II AECs |
|---|---|---|---|
| 2017/2018 | 38,551 | 744,089 | 929,754 |
| 2018/2019 | 46,938 | 848,715 | 986,910 |
| 2019/2020 | We are currently in the makeup period. AECs to be retired by August 31, 2020 | | |
| 2020/2021 | Compliance year started June 1, 2020. No AECs are retired yet. | | |

Note: The Tier I Non-Solar AECs category contains some solar AECs that do not qualify for the current Tier I Solar requirement, i.e. out-of-state solar AECs.

Responsible Witness: John J. McCawley

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Electric Supplier Coalition
ESC Set III
Response Date: 06/12/2020

ESC-III-4

For the proposed Default Service Program Plan period, identify the amount of AEPS AECs identified by Tier I Solar, Tier I Non Solar and Tier II, that PECO is projecting will need to be retired to satisfy PECO's AEPS requirements.

RESPONSE:

| Energy Year | Projected Tier I Solar AECs | Projected Tier I Non-Solar AECs | Projected Tier II AECs |
|---|---|---|---|
| 2021/2022 | 60,470 | 907,056 | 1,209,408 |
| 2022/2023 | 60,286 | 904,287 | 1,205,716 |
| 2023/2024 | 60,234 | 903,509 | 1,204,679 |
| 2024/2025 | 60,553 | 908,290 | 1,211,035 |

Note: Tier I Non-Solar AECs may be solar AECs that do not qualify for the Tier I Solar requirement, i.e. out-of-state solar AECs.

Responsible Witness: John J. McCawley

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Electric Supplier Coalition
ESC Set III
Response Date: 06/12/2020

ESC-III-5

Please confirm that PECO's proposed Solar AEC Procurement is anticipated to deliver a total of 16,000 annually starting in 2021 through 2031. If this is not confirmed, please explain why not.

RESPONSE:

This is not confirmed. If the 2021 procurements are fully subscribed, total annual deliveries under agreements would total 8,000 AECs annually. If the 2022 procurements are fully subscribed, the total annual deliveries under agreement would then total 16,000 AECs annually. Because these agreements would start a year later, they would end a year later than the first set of agreements from 2021.

Responsible Witness: John J. McCawley

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Electric Supplier Coalition
ESC Set III
Response Date: 06/12/2020

ESC-III-6

Reference PECO's Response to ESC-II-3. In responding, you referred to PECO's answer to OCA-I-13. While that answer provided some of the responsive information, it does not respond to the request to explain how having only one or two interested suppliers, or a number less than five suppliers, should result in the program not being implemented. That request also sought an explanation if you do not agree that one supplier could serve the same number of CAP customers as suppliers. Please respond to those portions of ESC-II-3.

RESPONSE:

As explained in PECO Statement No. 3 (p. 14), in light of the projected expense and outreach to CAP customers under the Plan, PECO believes that the receipt of five non-binding CAP notices from EGSs is a reasonable threshold to ensure verifiable supplier interest in serving CAP customers in PECO's service territory before incurring the necessary program and information technology expenses. A requirement for five suppliers also helps ensure choice for customers, particularly if one or two CAP suppliers subsequently chose not to supply CAP customers after program implementation.

PECO does not have sufficient information to form a belief about whether one supplier could serve the same number of CAP customers as multiple suppliers, which would depend on the business model and financial strength of individual suppliers.

Responsible Witness: Carol Reilly

Pennsylvania Public Utility Commission
v.
PECO Energy Company

Petition of PECO Energy Company for Approval of
Default Service Program

Docket No. P-2020-3019290

Response of PECO Energy Company
To Interrogatories of the
Electric Supplier Coalition
ESC Set III
Response Date: 06/12/2020

ESC-III-7

Reference PECO's Response to ESC-II-8. In that response, you provide the number of customers that have been enrolled in the SOP to date. The data shows that enrollment peaked in 2015 and 2016 and that the number of enrollments has steadily declined from 2017 through 2019. Given this declining enrollment, did you give any consideration to changing the parameters of the program to make it more attractive to consumers? If yes, please identify those modifications and explain why you do not propose them.

RESPONSE:

No. PECO's current Standard Offer Program has evolved over the course of PECO's DSP II, DSP III and DSP IV proceedings and is consistent with the parameters, scripts and call handling procedures approved by the Commission in those proceedings.

Responsible Witness: Carol Reilly

**Exhibit KRR-5:**

Ron Celentano, *Written Testimony to Accompany Oral Testimony at the June 9th Public Input Hearing for the PECO DSP V*, Docket No. P-2020-3019290 (June 9, 2020)

**BEFORE THE**
**PENNSYLVANIA PUBLIC UTILITY COMMISSION**

| | | |
|---|---|---|
| Petition of PECO Energy Company for Approval of its Default Service Program for the Period from June 1, 2021 through May 31, 2025 | : : : : : : | Docket No. P-2020-3019290 |

**PUBLIC HEARING TESTIMONY of PASIEA/MSSIA**

My name is Ron Celentano, and I live and work at 7821 Flourtown Avenue, Wyndmoor, PA 19038. I am President of the Pennsylvania Solar Energy Industries Association ("PASEIA"), and also the Pennsylvania Vice President of the Mid-Atlantic Solar & Storage Industries Association ("MSSIA"). PASEIA is a Division of MSSIA. MSSIA is a not-for-profit trade association made up of businesses and professionals working in Pennsylvania, New Jersey and Delaware involved in the development, manufacturing, design, construction and installation of solar photovoltaic (PV) and energy storage systems.

PECO Energy has petitioned the Public Utility Commission ("PUC") with several requests under their proposed Default Supply Program ("DSP V"), only a couple of which are addressed here. First, we applaud PECO Energy for proposing to solicit new ten-year contracts for Solar Alternative Energy Credits ("SRECs"), and second, we appreciate the addition of pilot time-of-use ("TOU") rate options as part of their proposed default service rate design.

PECO Energy proposes to purchase a total of 16,000 SRECs per year for ten years, which is twice the amount of SRECs they purchased per year under their current ten year contracts that are about to expire. While we support the long-term contract component of their proposal, the total amount of SRECs they seek to purchase is far too light, when considering that the solar requirement under the Alternative Energy Portfolio Standard ("AEPS") is 0.5% in 2021, which is over 15 times the solar requirement 10 years ago. But, it should be far more than this, when considering the recent DOE funded DEP Pennsylvania Solar Future Plan [Exhibit 1], which assessed the goal of 10% solar in Pennsylvania by 2030.

Pennsylvania compared to our neighboring states, is very far behind in installed total solar capacity and capacity per capita [Exhibit 2], as well as far behind in solar jobs. In fact, the growth in solar jobs in PA was only 0.3%, according to the Solar Foundation Solar Job Census 2019 (http://www.solarstates.org/#states/solar-jobs/2019), compared to 7.5% for Maryland, 5.7% for Delaware, 10.4% for New York, and even Ohio with 1.7%. [Exhibit 5]

This is also reflected in E2's CLEAN JOBS AMERICA 2020 report [Exhibit 3].
In addition to long-term contracts for SRECs, PECO Energy's proposal should include long term contracts for direct procurement of solar generated electricity and the solar attributes from solar facilities in the region. This would hedge against years of fuel price volatility.

As mentioned, we welcome PECO Energy's pilot TOU rate options as part of their proposed default service rate design. At first glance, the proposed TOU schedules and suggested residential rates in PECO Energy's Petition example for net metering are generally favorable for customer-generators with solar, though this needs closer inspection. Net metering is an essential financial mechanism for solar investment to work for distributed generation customer-generators. It provides significant benefits to the distribution system with minimum cost impacts to ratepayers. In a recent Carnegie Mellon University study, "Stakeholder Costs and Benefits of Distributed Energy Resources on Distribution Networks" [Exhibit 4], it concluded that with 5% solar penetration in the PECO Energy territory, residential bills would only increase 0.8%.

Finally, PECO should also take concrete steps to consider how to mitigate distribution reliability issues through procurement choices in this DESP. In particular, distributed solar and storage can provide resiliency during outages and brown-outs, such as the one experienced by many PECO ratepayers last Thursday.

More broadly, PECO should develop pilot projects to design and deploy solar/storage and switchgear control to help redirect power, if possible, under these conditions. The Borough of Media comes to mind, as the distribution system often goes down. This would be a great region to target such a pilot.

Respectfully submitted,

Ron Celentano, President
Pennsylvania Solar Energy Industries Association
7821 Flourtown Avenue
Wyndmoor, PA 19038

Date: June 9, 2020

**Exhibit KRR-6:**

Linnea Bond, *Written Testimony to Accompany Oral Testimony at the June 9th Public Input Hearing for the PECO DSP V*, Docket No. P-2020-3019290 (June 9, 2020)

Submitted by **Linnea Bond**
Written testimony to accompany oral testimony at the June 9th public input hearing for the PECO DSP, **P-2020-3019290**.

Good day to everyone gathered, members of the PUC and Judge Vero. My name is Linnea Bond, and I am a theatre artist and teacher living in Philadelphia.

Before I begin, I want to acknowledge that even as we are meeting virtually, our discussion centers on land originally inhabited by the Lenni Lenape tribe, who were forced from this region through genocide and deception. We who occupy the land now are here through the violence of their forced removal. We are also on land that housed enslaved people, and Philadelphia was built in large part by and through the labor of enslaved people. These injustices are in the past, but their legacy is ongoing. We are responsible for these injustices and violent in our complacency if we do not act intentionally against their contemporary manifestations.

We do right when we first, understand the circumstances of a situation and second, have the will to act in light of those circumstances. Two years ago, despite my well-educated upbringing, I would not have spoken out against PECO. My Christian parents' legacy to me was a passion for social justice and Earth's natural beauty, and I received an excellent education in science up through my undergraduate degree at a top 10 liberal arts college. Yet, even as I understood human-caused climate change generally, it took learning the facts of the immediacy of climate change just over a year ago for me to begin to speak out.

According to the UN's Intergovernmental Panel on Climate Change 2018 report, the world's governments have 10 years to avoid potentially irreversible climate disruptions.

These disruptions include natural disasters – hurricanes, cyclones, tsunamis, and floods – which are increasing as a result of preventable human impact on the environment through greenhouse gases from fossil fuels.

PECO is required to provide the "least cost" energy over time; however, the effects of climate change from their ongoing use of fossil fuels necessitates ever increasing energy costs in their proposed DSP. PECO expects taxpayers to pay for increasing flooding in a wetter northeast, and the resulting increased outages and destruction; increasing expenses of local farming; increasing medical costs associated with increasing Lyme disease and lung disorders. According to conclusions of EPA scientists pursuant from the 2017 EPA report, the current trajectory of global emissions will cost the US $224 billion per year across 22 sectors of society by 2090.[1]

A pandemic and unrest due to police brutality has had and will have a massive bill, destabilizing our entire national and regional economy. PECO's DSP, which ignores the most conservative established environmental science, will similarly cost our region and taxpayers exponentially.

Today, the PUC, PECO, and the public have the facts to understand the circumstances of the situation. We do not have 4 years to wait for a DSP that responds to climate change, as we are already behind on the infrastructure we need to build to avoid climate crisis over this decade. With this DSP, we will not

[1] Martinich, J., Crimmins, A. Climate damages and adaptation potential across diverse sectors of the United States. *Nature Climate Change*. 9, 397–404 (2019). https://doi.org/10.1038/s41558-019-0444-6

only pay many times over the discounts PECO is claiming in the short term, but our children will not survive the planet that we are making inhospitable to them. You have the facts, now your will is required to reject PECO's DSP.

Thank you for your time.

**Exhibit KRR-7:**

Gregory Holt, *Written Testimony to Accompany Oral Testimony at the June 9th Public Input Hearing for the PECO DSP V*, Docket No. P-2020-3019290 (June 9, 2020)

**Submitted by: Gregory Holt, Earth Quaker Action Team Communications Specialist Written testimony to accompany oral testimony at the June 9th public input hearing for the PECO DSP, P-2020-3019290**.

Hello, thank you Judge Vero and all gathered here for hearing my testimony today. My name is Gregory Holt, and I work part time as Communications Specialist for Earth Quaker Action Team. I do this work because I feel a deep moral call for us to build a just and sustainable world.

PECO's proposed DSP relies on short one- and two- year, load-following contracts for 99% of its power. This is a major problem for clean energy. Renewables are cheapest in long term contracts, because the power they produce is nearly free once it is built. In addition, while renewables are abundant and predictable, they are not load-following. So it's like trying to buy coffee at a place that only accepts cash. PECO's procurement simply can't take advantage of renewables. PECO should begin incorporating long-term contracts with cheap renewables immediately, thereby increasing the share of clean power it provides.

This is a reasonable practice that has been taken by utilities such as PEPCO in Washington DC. Last year, the DC Public Service Commission ordered that a portion of default load would be sourced from long-term PPAs which will not be load-following contracts. The PSC ordered PEPCO to consider a target of up to 10% in the future, after the initial contract with a target quantity of 5% percent of default load is executed.[1] PECO should be employing similar methods to increase the share of renewable power on its grid.

Please allow me to speak from the heart. I am 38 years old and the basic science on climate change has been clear for my entire life. I thank God that electricity emissions have recently fallen from their very worst, but electricity is still the largest contributor to CO2 emissions in Pennsylvania.[2] If we continue on this path, the future will be hotter, wetter, hungrier, and deadlier.

Let me share with you just two small examples. In September 2018, my 7-year-old niece's private school was, luckily, NOT closed 5 times due to excessive heat, because she is fortunate enough to have air conditioning in the building. But her fortune was not shared by the students of the Philly public school district and many others, where the school year was delayed and many hours of learning were lost due to excessive heat closures.[3] Later that same month, at South Philly High where my twin brother used to work, the ceiling collapsed and the school flooded due to prolonged days of heavy rains.[4] 2018 was Pennsylvania's wettest year on record

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[1] http://www.energychoicematters.com/stories/20190412qz.html
[2] 2017 State energy-related carbon dioxide emissions by sector https://www.eia.gov/environment/emissions/state/
[3] https://www.nbcphiladelphia.com/news/local/philadelphia-public-schools-early-dismissal-heat/214709/
[4] https://www.inquirer.com/philly/education/academy-at-palumbo-south-philly-rain-flooding-ceiling-collapse-20180911.html

so far,[5] but the trend is rising.[6] As you can see, these increasing losses and damages fall most heavily on the most disadvantaged among us.

I do not lay responsibility for the entirety of climate change at PECO's feet, but I do hold PECO accountable to do its part. This will require massive changes this decade, starting now, in the period of this DSP.

According to the PA Auditor General, climate change cost Pennsylvania taxpayers at least $261 million in 2018.[7] Fortunately, the PA DEP sees increasing solar to 10% of in-state generation has net economic benefits in excess of $25 billion by 2030.[8] PECO must begin now by seeking long-term contracts with solar developers, especially developers who are hiring local workers.

In 2017, I marched in the rain with over 200 people to yet again call on PECO for solar jobs. Some of us had marched 100 miles through all five counties. Across the territory, we met communities who knew that we need clean, solar power from PECO. In fact, later that year PECO spokeswoman Alexandra Coppadge said "It's important to point out that we don't disagree with the overall vision, just with their timeline of how to get there."[9]

Three years later, this Default Service Program makes it clear that PECO has no timeline at all. By choosing to consider only short-term, load-following contracts, PECO is not guaranteeing lowest cost electricity, it is merely guaranteeing that renewable developers are effectively shut out of providing default power.

The climate crisis we face is of our own making. The draught crisis we face. The flooding crisis we face. The famine crisis we face. The hurricane crisis we face. The wildfire crisis we face. The heat wave crisis we face. The smog crisis we face. And the people who are suffering are doing so because of our brutal unwillingness to make simple and prudent changes like using long term contracts to secure an increasing share of electricity from renewables. PECO must modify its proposed DSP to create a green future.

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[5] https://www.wnep.com/article/news/local/schuylkill-county/wettest-year-on-record-in-pennsylvania/523-252672d2-9e78-4a83-b758-3920a0cbe6f6

[6] Pennsylvania Climate Change Impacts Assessment Update April 2020
http://files.dep.state.pa.us/Energy/Office%20of%20Energy%20and%20Technology/OETDPortalFiles/ClimateChange/2020ClimateChangeImpactsAssessmentUpdate.pdf

[7] https://www.paauditor.gov/press-releases/auditor-general-depasquale-state-s-unfocused-efforts-on-climate-change-crisis-risk-lives-drive-costs-to-taxpayers-economy

[8] Pennsylvania's Solar Future Plan
http://www.depgreenport.state.pa.us/elibrary/GetDocument?docId=1413595&DocName=PENNSYLVANIA%26%2339%3bS%20SOLAR%20FUTURE%20PLAN.PDF%20%20%3cspan%20style%3D%22color:blue%3b%22%3e%28NEW%29%3c/span%3e

[9] https://www.timesherald.com/news/environmental-group-holds-day-of-action-at-peco-s-phoenixville-facility/article_d5575743-5c1f-5441-b4e4-6900de494b88.html

**Exhibit KRR-8:**

Julie Greenberg, *Written Testimony to Accompany Oral Testimony at the June 9th Public Input Hearing for the PECO DSP V*, Docket No. P-2020-3019290 (June 9, 2020)

Submitted by **Rabbi Julie Greenberg**, POWER Interfaith Director of Climate Justice and Jobs

Written testimony to accompany oral testimony at the June 9th public input hearing for the PECO DSP, **P-2020-3019290**.

Your Honor and members of the Public Utility Commission:
I am Rabbi Julie Greenberg, Director of POWER's multifaith work for racial and economic justice on a livable planet. For four years we have been educating and meeting with PECO executives to try to collaborate in building a local renewable energy economy. For four years, PECO has talked the talk about energy leadership and listening to the public but PECO has not listened. PECO has not made any significant progress towards bold and substantial procurement of renewable energy.

When we do surveys asking our hundreds of congregations "How much solar energy do you think PECO purchases as part of its energy pie?" people say things like, "Maybe fifty percent?" "Ten percent?" "Five percent?" It is hard to think as small as PECO is thinking. PECO proposes to purchase only half of one percent solar energy, not even local solar energy, in its proposed Default Service Plan. This is shocking in a world in which many countries, states and cities are moving towards 100 % renewable energy, driven by the needs of communities that are devastated by the destruction of fossil fuel pollutants, especially Black, Brown and low-income communities labeled "Environmental Justice" areas by the federal Environmental Protection Agency. The places where fossil fuel toxins are most concentrated are now experiencing the worst health outcomes in the COVID pandemic. This is in a big context in which the majority of the world's scientists agree that these same fossil fuel pollutants are de-stabilizing the climate, causing extreme weather, fires, floods and adding further insecurity to the lives of PECO's already over-burdened energy users. (UN International Panel for Climate Change (IPCC) report, 2019)

Yet PECO continues to propose Business as Usual to the PUC. PECO tries to distract the public by sprinkling lovely philanthropic contributions around its service area, offering a smattering of funding to civic and arts groups and occasionally a bit to a solar training program. But we are not calling for philanthropy. We are calling for energy leadership in service of people and the planet.

In particular, energy users want PECO to think bigger about what "least cost" actually means in procuring our energy. We need PECO to consider the impact of continuing to prioritize fossil fuels without considering the health of our communities. What are the costs of fossil fuel's impact on climate stability and the well being of real people?

Furthermore, we do not want to hear PECO say, "Well individuals can opt for a green source of energy if they want to." We are talking here about the bulk of PECO's energy procurement, through its DSP, used by two thirds of its customers. There are no individual solutions to climate crisis and extreme inequality of impact. Alternative energy choices made by well-informed individuals who have the time to consider different plans and pay a little extra for green energy are not a solution. In making revisions to this DSP proposal, PECO must consider how to respond to the crisis of these times with actual energy leadership. PECO is falling behind the many other places that are moving rapidly toward the renewable energy necessary for our future and PECO is failing us.

We urge the PUC to fulfill its mandate as a public regulatory body, to regulate PECO in service of the common good, and to be free of the biased, conflict-of-interest grip of the very fossil fuel industry that is trying to profit from PECO's Default Service Plan. As people of faith in hundreds of congregations throughout PECO's service area, we are counting on the PUC to hear our voices.

Thank you and be safe.

**Exhibit KRR-9:**

Pennsylvania Department of Environmental Protection, *Pennsylvania's Solar Future Plan* (Nov. 2018)

*Pennsylvania's*

# Solar Future Plan

Strategies to increase electricity generation from in-state solar energy

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

Finding Pennsylvania's SOLAR FUTURE

# Pennsylvania's Solar Future Plan

Strategies to increase electricity generation from in-state solar energy November 2018

## CONTACT INFORMATION

For questions about this report, please contact:

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Read the complete plan: https://www.dep.pa.gov/PASolarFuture/plan

To learn more: https://www.dep.pa.gov/PASolarFuture

## COVER PHOTOS

**Top:** Sunset in Spring Grove, York County

**Middle:** Farm in Cogan Station, Lycoming County; Tom Ridge Environmental Center, Presque Isle, Erie County; farm in Germansville, Lehigh County

**Bottom:** Estes Trucking, West Middlesex, Mercer County; Community Energy's Keystone Solar Project, Radnor, Lancaster County; residence in Schuylkill County

**Acknowledgment:** This work is based upon work supported by the U.S. Department of Energy Solar Energy Technologies Office, under Award Number DE EE0007666.



Finding Pennsylvania's SOLAR FUTURE | pennsylvania DEPARTMENT OF ENVIRONMENTAL PROTECTION | VEIC | PennFuture

## A Message from Governor Tom Wolf

A diverse energy portfolio is one of Pennsylvania's strongest assets. Expanding the use of solar energy builds on this strength and positions Pennsylvania to gain advantages increasingly being pursued across the United States from this clean, reliable, and renewable source of electricity.

Solar energy development brings diverse benefits, including reduced emissions and related public health problems; new jobs statewide; increased grid security; and protection for our farming, recreation, tourism, and other business sectors in the face of climate change.

If implemented, the strategies presented in Pennsylvania's Solar Future, along with other initiatives by my administration, from supporting the use of in-state solar renewable energy credits to increased grants and loans for solar installations, will help ensure that we fully leverage these benefits for all Pennsylvanians. I thank the many stakeholders who participated in this project for sharing their expert knowledge to set Pennsylvania on a path to a clearer future in renewable energy, for the benefit of our citizens, businesses, farms, towns and cities, schools, and organizations alike.

Tom Wolf
Governor

## A Message from Secretary Patrick McDonnell

As the source of nearly 33 percent of greenhouse gas emissions in Pennsylvania, electricity generation is a key area for renewable energy innovations to reduce these pollutants and the challenges they create for public health and our environment.

Solar energy is growing in Pennsylvania, as it is across the United States. However, while the number of states that get at least 5 percent or even 10 percent of electricity from solar continues to climb, Pennsylvania gets less than 1 percent of its electricity from this clean, reliable, and renewable energy source. Significant potential remains for solar energy development to transform our electricity generation sector.

What are the best ways for Pennsylvania to realize this potential? The Department of Environmental Protection Energy Programs Office assembled a statewide partnership of experts who have collaborated for more than a year to identify 15 strategies, including grid-scale solar and smaller, distributed systems (such as rooftop installations), that can achieve a 10 percent increase in solar-powered electricity. They have also detailed the associated benefits and required investments, to create a set of strategy recommendations ready for implementation.

For Pennsylvania to achieve leadership in renewable energy generation from solar, we will require more intensive leadership, investment, and recognition of the long-range economic and environmental benefits. I am proud of the leadership DEP and our partners are providing on this important aspect of Pennsylvania's energy mix. If you want to see a viable future of cleaner energy in Pennsylvania, I invite you to turn the page. Further, I encourage you to consider how this valuable work might inform your energy decisions.

Patrick McDonnell
Secretary
Department of Environmental Protection

## FINDING PENNSYLVANIA'S SOLAR FUTURE

**Project Leadership Team:**

David Althoff, *Principal Investigator*, Pennsylvania Department of Environmental Protection
Robert Altenburg, *Project Coordinator*, Citizens for Pennsylvania's Future
Kerry Campbell, Pennsylvania Department of Environmental Protection
Allen Landis, Pennsylvania Department of Environmental Protection

**Facilitation Team:**

Dr. Jeffrey Brownson, Pennsylvania State University
Ron Celentano, Celentano Energy Services
Maureen Mulligan, Sustainable Futures Communications, LLC.
Sharon Pillar, Hot Earth Collaborative, LLC.

**Modeling Team:**

David Hill, Vermont Energy Investment Corporation
Damon Lane, Vermont Energy Investment Corporation
Kate Desrochers, Vermont Energy Investment Corporation

**External Reviewers:**

Dr. Seth Blumsack, Pennsylvania State University
Dr. Willard Delavan, Lebanon Valley College

**Committed Partners**:

| | | |
|---|---|---|
| Berks County Community Foundation | Community Energy | Community Foundation for the Alleghenies |
| Energy Association of Pennsylvania | Kleinman Center for Energy Policy | Mid-Atlantic Renewable Energy Association |
| Office of the Consumer Advocate | PA Public Utility Commission | PJM Interconnection |
| PennFuture | The Reinvestment Fund—Sustainable Development Fund | SEDA-COG |
| Tesla/Solar City | The Nature Conservancy | The Sustainable Energy Fund of South Central Pennsylvania |

**Stakeholders:** This project would not be possible without the efforts of the over 500 stakeholders that have participated over the past year. This included attending quarterly meetings and additional webinars, as well as efforts reviewing and commenting on several draft documents. Names of these stakeholders appear in Appendix A.

**Funding:** This work has been funded by the U.S. Department of Energy Solar Energy Technologies Office, under Award Number DE-EE0007666.

## CONTENTS

## FIGURES

## TABLES

# ABBREVIATIONS

| | |
|---|---|
| AEPS – Alternative Energy Portfolio Standard | MWh – Megawatt hour |
| AEC – Alternative Energy Credit | NPV – Net Present Value |
| ATB – Annual Technology Baseline | NREL – National Renewable Energy Lab |
| CAFÉ – Corporate Average Fuel Economy | O&M – Operation and Maintenance Costs |
| CAGR – Compound Annual Growth Rate | PUC – Public Utility Commission |
| CFA – Commonwealth Finance Authority | PV – Photovoltaic |
| DEP – Pennsylvania Department of Environmental Protection | PACE – Property Assessed Clean Energy |
| DER – Distributed Energy Resources | PASF – Pennsylvania Solar Future |
| EDC – Electric Distribution Company | PEDA – Pennsylvania Energy Development Authority |
| EGS – Electric Generation Supplier | PEV – Pluggable Electric Vehicles |
| EIP – Energy Investment Partnership | PJM – PJM Interconnection LLC |
| EV – Electric Vehicle | PPA – Power Purchase Agreement |
| FERC – Federal Energy Regulatory Commission | PUC – Pennsylvania Public Utility Commission |
| GATS – Generation Attributes Trading System | REC – Renewable Energy Credit |
| GHG – Greenhouse Gas | RGGI – Regional Greenhouse Gas Initiative |
| GWh – Gigawatt hour | ROI – Return on Investment |
| IPP – Independent Power Producers | RPS – Renewable Portfolio Standard |
| ITC – Investment Tax Credit | RTO – Regional Transmission Organization |
| JEDI – Jobs and Economic Development Impact | SAM – System Advisor Model |
| kWh – Kilowatt hour | SACP – Solar Alternative Compliance Payment |
| LEAP – Long range Energy Alternatives Planning | SREC – Solar Renewable Energy Credit |
| LBNL – Lawrence Berkeley National Laboratory | TMI – Three Mile Island |
| LCOE – Levelized Cost of Energy | TOU – Time of Use |
| LTCs – Long Term Contracts | TWh – Terawatt hour |
| MACRS – Modified Accelerated Cost Recovery System | VOS – Value of Solar |

# EXECUTIVE SUMMARY

Solar panels at the Tom Ridge Environmental Center, Presque Isle, Erie County

Today Pennsylvania is well situated to lead the country into the next age of energy development: clean, renewable solar photovoltaic (PV) energy. While nearby states have embraced solar development to a greater degree than Pennsylvania, the experience they gained can now be used here to encourage the development of both distributed generation and large "grid scale" solar PV. In fact, whereas in 2000, Pennsylvania had less than one Megawatt (MW) of solar installed, today, there are over 300 MW installed in Pennsylvania.[1]

Pennsylvania is moving forward in the solar marketplace, but there is significant potential for solar to continue this growth and transform the electricity generation sector. The benefits of an increased share of solar in the electricity generation sector are enormous, including:

| **Benefits of Solar Generation** | |
|---|---|
| **Public Health** | Air and water pollution from fossil fuels can lead to breathing issues, neurological damage, heart attacks, cancer, premature death, and a host of other serious problems that could be reduced with more clean energy generation. |
| **Economic Growth** | The solar industry is creating economic growth across the country, with some states taking full advantage. |
| **Job Opportunities** | The amount of solar jobs in the U.S. have increased. Since 2010 solar job growth has grown by 168 percent, from just over 93,000 to more than 250,000 jobs in all 50 states in 2017.[2] |
| **Cleaner Air** | The electricity sector accounts for 29 percent of all U.S. GHG emissions,[3] and Pennsylvania has the nation's third highest energy-sector GHG emissions,[4] providing renewable energy generation in Pennsylvania an opportunity the reduce U.S. emissions. |

*Finding Pennsylvania's Solar Future* is a project of the Pennsylvania Department of Environmental Protection (DEP) Energy Program's Office (EPO) with funding from the U.S. Department of Energy Solar Energy Technologies Office. The planning project brought together expert stakeholders from across sectors to explore whether Pennsylvania has sufficient technical and economic potential to *increase in-state solar generation to provide 10 percent of in-state electricity consumption by 2030.*

Stakeholders explored likely pathways to achieving the target and identified, through modeling, associated economic, environmental, and health impacts. The process undertaken was not meant to reach a consensus but create a robust and open process, for the identification and documentation of strategies and information. The Project team took significant input from both our committed partners and our robust stakeholder group composed of over 500 members.

[1] http://www.puc.state.pa.us/Electric/pdf/AEPS/AEPS_Ann_Rpt_2016.pdf
[2] https://www.thesolarfoundation.org/national.
[3] https://www.epa.gov/sites/production/files/2018-01/documents/2018_complete_report.pdf
[4] https://www.eia.gov/environment/emissions/state/analysis/pdf/table1.pdf

Before the Finding Pennsylvania's Solar Future process began, it was clear that Pennsylvania already possessed a unique set of assets that can position the state to lead in solar development:

| **Pennsylvania's Solar Assets** | |
|---|---|
| **Resource potential** | The Commonwealth's Energy Assessment Report states that Pennsylvania has the potential to economically increase grid scale solar 3,687 percent and distributed generation solar 255 percent from 2015 – 2050.[5] |
| **Abundant land** | Pennsylvania land is reasonably priced, available for grid scale solar development, and does not present the types of challenges faced by land constricted states. |
| **Geographic location** | East coast states have largely embraced solar development in a variety of ways, especially committing to a larger solar share than Pennsylvania. These experiences can be applied to Pennsylvania due to geographic proximity. |
| **Grid readiness** | Pennsylvania's Regional Transmission Organization (RTO), PJM Interconnection LLC, studied the impacts to grid operations if renewable energy increases. PJM concluded that renewables integration can lower energy prices and concluded that the system can maintain required reliability levels with up to 30 percent of energy from wind and solar.[6] |
| **Competitive prices** | The Lawrence Berkeley National Laboratory *Tracking the Sun 10* report (2017) shows solar prices in Pennsylvania to be near the national average. |
| **Interested project developers** | In November 2017, the Commonwealth Financing Authority offered competitive grants for solar projects; 110 applicants were received, 78 were approved totaling 44 MW. |
| **Market maturity** | Solar is now a mature international and national market, with competent and competitively driven developers, solar manufacturers, financiers, installers, utilities, and others ready to work in Pennsylvania. |

[5] Commonwealth Energy Assessment Report, 2018, Department of Environmental Protection
[6] PJM Interconnection, Renewable Integration Study, (March 2014) available at: http://www.pjm.com/committees-and-groups/subcommittees/irs/pris.aspx. (note: This may require that the transmission system be expanded to meet the changing power flow).

With those assets in mind, stakeholders provided input regarding pivotal factors influencing solar PV deployment and associated considerations, risks, and benefits. Several stakeholder workshops were held across the state, with diverse sector participation (**FIGURE 1**).

During each workshop, facilitators engaged stakeholders in breakout sessions for three main workgroups: Markets and Business Models, Policy and Ratemaking, and Operations and Systems Integration. Stakeholders provided feedback within these workgroups as well as during general listening sessions.

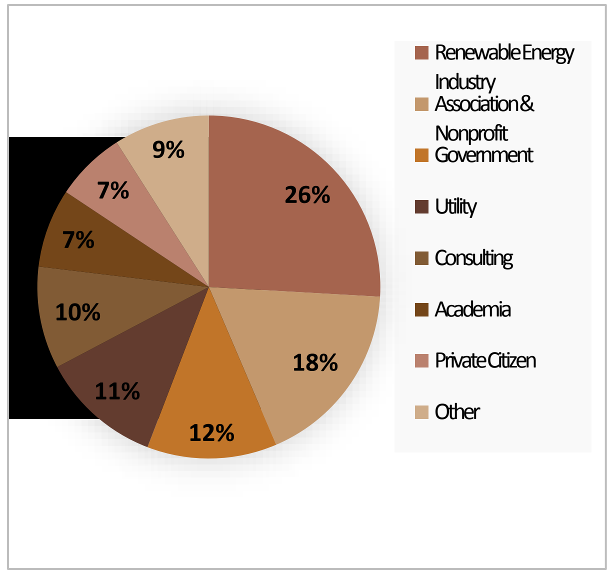


**Figure 1. Percentage of Stakeholders by Sector**

The stakeholder engagement process worked to identify the most impactful and realistic strategies that would move Pennsylvania towards the target of in-state solar generation to provide 10 percent of in-state electricity consumption by 2030. The stakeholders ultimately identified fifteen strategies that may be pursued, including cross cutting strategies that will advance solar implementation sector-wide, as well as strategies specifically aimed at promoting grid scale or distributed generation.

The price of solar is decreasing globally, and this is projected to continue. There are several local factors that impact the installed cost for new solar in the state and policies and market conditions that impact the returns on solar investments. Implementing the recommended cross-cutting strategies will shift the price point of solar and increase both grid scale and distributed generation.

## CROSS-CUTTING STRATEGIES

The following cross-cutting strategies, such as changes to the Pennsylvania Alternative Energy Portfolio Standard (AEPS) and adoption of carbon pricing, will encourage the development of both grid scale and distributed generation.

| **Cross-Cutting Strategies** | |
|---|---|
| **Alternative Energy Portfolio Standards** | 1. Implement an increase in the AEPS solar PV carve-out to between 4 and 8 percent by 2030 and ensure creditable Solar Renewable Energy Credits (SRECs) are limited to those generated in Pennsylvania wherever possible. |
| **Access to Capital** | 2. Increase access to capital by expanding availability of solar lending products to residential and commercial projects to enable solar ownership.<br><br>3. Provide loan guarantees to lower interest rates and incentivize deployment of solar generation. |
| **Carbon Pricing** | 4. Implement a carbon pricing program and invest the proceeds in renewable energy and energy efficiency measures. |
| **Siting and Land Use** | 5. Support the creation and adoption of uniform policies to streamline siting and land-use issues while encouraging conservation. |
| **Tax Incentives** | 6. Evaluate the state tax policy and consider exemptions that encourage the development of solar PV systems.<br><br>7. Assist solar project sponsors in identifying investors and/or companies that have sufficient tax equity appetite to take full advantage of the federal Investment Tax Credit (ITC) and Modified Accelerated Cost Recovery System (MACRS) depreciation if sponsors cannot do so themselves. |

## DISTRIBUTED GENERATION STRATEGIES

The modeling scenarios assume distributed solar generation will be responsible for a smaller fraction of the overall deployment than grid scale solar—likely between 10 and 35 percent. To meet these targets, the distributed generation annual growth rate would need to be sustained at current levels for the next 12 years.

Current growth rates from 2013-2017 were 22 percent for residential and 7 percent for commercial solar. The following strategies could help to continue and accelerate the growth seen in recent years and assist in meeting the overall 10 percent target.

| **Distributed Generation Strategies** | |
|---|---|
| **Virtual Net Metering** | 8. Expand customers' ability to use net metering. |
| **Community Solar** | 9. Identify and remove the barriers to the deployment of community solar systems in Pennsylvania. |
| **Alternative Ratemaking** | 10. Ensure alternative ratemaking is addressed in a manner that does not create a disincentive for solar deployment. |
| **Property Assessed Clean Energy (PACE)** | 11. Enable and encourage municipalities to offer PACE programs that include solar projects. |
| **Addressing Interconnection Issues** | 12. Accelerate use of smart inverters to manage over-voltage concerns on low voltage distribution lines and avoid unnecessarily adding costs on small solar distributed generation projects. |

## GRID SCALE STRATEGIES

Significant increases in statewide solar generation is expected to come from grid scale deployments of solar. Although not required to meet the target, the modeling anticipates that 65 to 90 percent of the solar generation be grid scale.

While cross-cutting strategies will encourage the development of both grid scale and distributed generation, the stakeholders also identified strategies that may help alleviate some of the hurdles currently impeding grid scale solar development in Pennsylvania.

| **Grid Scale Strategies** | |
|---|---|
| **Long-Term Contracts** | 13. Develop guidelines for limited use of long term contracts (LTCs) for a period of 10 or more years to ensure Pennsylvania benefits from grid scale solar energy.<br><br>14. Evaluate and consider utility ownership of solar generation especially in cases where market-driven deployment may be insufficient to achieve public goals and/or reliability concerns. This may include solar for low-income and Customer Assistance Programs in particular. |
| **Grid Modernization** | 15. Investigate opportunities for grid modernization to enable increased solar generation. |

Stakeholder input was informed by a process of modeling and data analysis investigating three primary scenarios**:** the **Solar A Scenario**, the **Solar B Scenario,** as well as a **Reference Scenario**, which presented a business as usual context as a baseline reference.

The Solar A and Solar B Scenarios provide two contrasting pathways for achieving 10 percent solar energy production, using the same total energy consumption as in the Reference Scenario (**FIGURE 1.** Percentage of Stakeholders by Sector). In both scenarios, the majority of new solar development comes from grid scale solar that is connected directly to the transmission and distribution system.

| | Reference | Solar A | Solar B |
|---|---|---|---|
| **Target for in-state solar** | 0.5% by 2020 | 10% by 2030 | 10% by 2030 |
| **Total solar capacity in 2030** | 1.2 GW | 11 GW | 11 GW |
| **Distributed capacity in 2030** | 0.6 GW | 3.9 GW (35% of total)<br>50% residential<br>50% commercial | 1.1 GW (10% of total)<br>50% residential<br>50% commercial |
| **Grid scale capacity (>3MW) in 2030** | 0.6 GW | 7.1 GW (65% of total) | 9.9 GW (90% of total) |

**Table 1. Comparison of the basic assumptions of the three primary scenarios**

**Economic cost**: The modeling found that over 15 years, the Solar A and Solar B scenarios have average net annual economic costs ranging from $513 million to $613 million. These estimates represent the lifetime costs and savings associated with the solar capacity in each scenario compared to the reference scenario.

For context, over the 15-year study period the investments required for the Solar A and Solar B Scenarios are 1.2 to 1.4 percent above current energy spending.

**Economic and environmental benefit:** In addition, the modeling shows that the Solar A and Solar B scenarios both provide net economic benefits in excess of $25 billion from 2018 to 2030, when accounting for environmental externality costs. Further, in both scenarios, greenhouse gas emissions from the electricity decrease by approximately 10 percent by 2030.

**Land use:** Another important issue identified by the stakeholders is how much land would be required to achieve that level of solar development for both distributed generation and grid scale. The modeling found that grid scale solar would use 89 square miles (56,800 acres) in Solar A Scenario and 124 square miles (79,200 acres) in Solar B Scenario. Rooftop systems are not included in the land use numbers; however, a 2008 study on rooftop solar potential in Pennsylvania found that there is space for more than 27 GW of solar PV panels on existing rooftops statewide alone, nearly three times the amount needed for the entire 10 percent target.

To put the acreage into perspective, the required land use to meet the grid scale levels for each scenario represent a small fraction (less than three-tenths of 1 percent) of Pennsylvania's total land area and less than half of the total abandoned mine lands in Pennsylvania. Therefore, it's clear there is more than sufficient available land to accommodate both scenarios of Grid Scale solar within Pennsylvania and land use strategies can be pursued.

**Jobs:** The modeling process estimated job impacts of the solar scenarios using the Jobs and Economic Development Impact (JEDI) model.[7] Combined with the itemized cost for solar installation and maintenance, the JEDI model uses economic input and output analysis to estimate the extent to which investment induces further investments throughout the Pennsylvania economy, supporting local businesses and jobs. (**TABLE 2**).

**Table 2. Estimated new gross jobs by scenario**

| | Solar A | Solar B |
|---|---|---|
| **Construction period jobs** | 100,604 | 67,716 |
| **Ongoing jobs** | 1,086 | 983 |

## NEXT STEPS

*Pennsylvania's Solar Future* demonstrates that by implementing strategies to increase solar generation, Pennsylvania will gain significant economic, environmental, and health benefits. Pennsylvania can continue its energy leadership role and implement policies that advance solar energy's role in the state. Achieving the 10 percent target by 2030 requires that policy makers adopt strategies that will move Pennsylvania into a solar future more quickly than is expected under business as usual projections. This Plan seeks to confirm and build upon the efforts to date and demonstrate the viability of solar in Pennsylvania.

The Pennsylvania's Solar Future Project Team and stakeholders will continue to discuss these strategies with a focus on implementation details and the keys to achieving market transformation, while minimizing ratepayer cost impacts.

[7] National Renewable Energy Laboratory, Jobs and Economic Development Model (JEDI), *available at:* https://www.nrel.gov/analysis/jedi/

## From a few of our committed partners:

*"Pennsylvania's Solar Future represents a great step toward encouraging balanced growth of the critically important solar energy industry in Pennsylvania. The plan is a careful distillation of stakeholder input and expertise. We at The Nature Conservancy look forward to helping execute the recommendations contained in the report for the benefit of Pennsylvania's economy and for the benefit of its lands and waters."* ***— Bill Kunze, State Director, The Nature Conservancy, Pennsylvania Chapter***

*"Consistent with Tesla's mission, this thorough stakeholder process has created a roadmap for Pennsylvania to achieve a more sustainable energy future. We commend Governor Wolf's Administration for their leadership on this important initiative. We look forward to providing solutions that will help the state realize these goals."* ***— Ryan Barnett, Policy and Business Development, Tesla***

*"Although we disagree with some aspects of the plan, the stakeholder process and plan development were thorough and took into account all points of view."* ***— John Costlow, President, Sustainable Energy Fund***

*"It's not easy to assemble a group of stakeholders with diverse interests and opinions and end up with a bold plan for dramatically expanding solar generation in our state, but PA DEP, with the help of the Vermont Energy Investment Corporation and the other consultants, did just that. The resulting report is a practical and feasible guide to Pennsylvania's solar future that deserves the support of our political leaders and the public."* ***— Roger E. Clark, Esq., Director, Clean Energy, Reinvestment Fund***

**March 8, 2018, Stakeholder Meeting, Pittsburgh, PA**

# INTRODUCTION

Solar panels in Germansville, Lehigh County

Solar energy is growing as a clean and reliable electricity generation source across the world, including the United States. The U.S. has seen an average annual growth rate of installed capacity of 59 percent over the last ten years[8], and a 43 percent increase of solar electricity generation from 2016 to 2017[9]. Since 2000, solar in Pennsylvania has grown from less than one megawatt (MW) to over 300 MW today[10].

There is significant potential for solar to continue this growth and transform the electricity generation sector. In the U.S., the price of solar power has decreased 66 percent from 2010 and dropped 12 percent in 2016 alone.[11,12] Internationally, photovoltaic (PV) solar is expected to garner nearly $4 trillion in funding over the next 25 years. [13]

The potential benefits of an increased share of solar in the electricity generation sector are enormous, including:

- **Public health**: Air and water pollution from fossil fuels can lead to breathing issues, neurological damage, heart attacks, cancer, premature death, and a host of other serious problems that could be reduced with more clean energy generation. For coal alone, one study estimated the life cycle costs and public health effects to be an estimated $74.6 billion every year.[14]
- **Economic growth:** The solar industry is creating economic growth across the country, with some states taking full advantage of the activity. For example, North Carolina is home to over 450 companies involved in the solar industry that represent at least $2 billion of direct investment in the state.[15]
- **Job opportunities:** The amount of solar jobs in the U.S. have increased. Since 2010 solar job growth has grown by 168 percent, from just over 93,000 to more than 250,000 jobs in all 50 states in 2017.[16] Looking forward, one study suggests that there could be 7.2 million jobs in the U.S. solar industry by 2030.[17]
- **Stable energy prices:** Unlike other energy sources, solar (and wind) have no fuel costs and can provide fixed energy prices over time.
- **Cleaner Air:** The electricity sector accounts for 29 percent of all U.S. greenhouse gas (GHG) emissions[18], providing renewable energy generation an opportunity the reduce U.S. emissions.

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[8] https://www.seia.org/solar-industry-research-data
[9] *See:* https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_1_17_b
[10] http://www.puc.state.pa.us/Electric/pdf/AEPS/AEPS_Ann_Rpt_2016.pdf
[11] SEIA, National Solar Database, www.seia.org/research-resources/national-solar-database. *Accessed* Dec. 30, 2016.
[12] Solar Foundation, 2015 National and State Solar Jobs Census, www.thesolarfoundation.org/solar-jobs-census/ Accessed Dec. 30, 2016.
[13] Bloomberg New Energy Finance, 2015.
[14] Epstein, P.R.,J. J. Buonocore, K. Eckerle, M. Hendryx, B. M. Stout III, R. Heinberg, R. W. Clapp, B. May, N. L. Reinhart, M. M. Ahern, S. K. Doshi, and L. Glustrom. 2011. Full cost accounting for the life cycle of coal in "Ecological Economics Reviews." Ann. N.Y. Acad. Sci. 1219: 73–98.
[15] https://www.seia.org/sites/default/files/resources/Duke_CGGC_NCSolarEnergyReport.pdf
[16] https://www.thesolarfoundation.org/national.
[17] http://www.irena.org/documentdownloads/publications/irena_measuring-the-economics_2016.pdf
[18] https://www.epa.gov/sites/production/files/2018-01/documents/2018_complete_report.pdf

> In fact, a study by the US Department of Energy's National Renewable Energy Laboratory (NREL) found that if the U.S. generates 80 percent of the country's electricity from renewable sources by 2050, the electricity sector's emissions could be reduced by approximately 81 percent.[19]

Pennsylvania is not capturing all of these benefits, despite its role as an energy generation powerhouse. Pennsylvania is one of the top three energy production states in the nation, and the top electricity exporting state.[20] However, this energy leadership does not extend to renewable energy sources, as Pennsylvania ranks 21st in the nation when accounting for distributed generation solar and 28th in the nation for grid scale solar.[21] Installed solar energy generation assets currently produce less than 0.25 percent of the state's net electricity generation.

[19] https://www.nrel.gov/docs/fy13osti/52409-ES.pdf
[20] http://www.eia.gov/state/seds/sep_sum/html/pdf/sum_btu_totcb.pdf
[21] *See: https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_6_02_b*

To maintain its energy generation leadership position and enhance economic growth in the energy sector, Pennsylvania could include in its portfolio a greater percentage of renewable energy sources, such as solar. There are several reasons Pennsylvania has the potential to take the lead in renewable energy and maintain its stance as an energy leader:

| **Pennsylvania's Solar Assets** | |
|---|---|
| **Resource Potential** | The Commonwealth's Energy Assessment Report states that Pennsylvania has the potential to economically increase grid scale solar 3,687% and distributed generation solar 255% from 2015 – 2050. |
| **Abundant Land** | Pennsylvania land is reasonably priced, available for grid scale solar development, and does not present the types of challenges faced by land constricted states. |
| **Geographic Location** | East coast states have largely embraced solar development in a variety of ways, especially committing to a larger solar share than Pennsylvania. These experiences can be applied to Pennsylvania due to geographic proximity. |
| **Grid Readiness** | Pennsylvania's Regional Transition Operator, PJM Interconnection LLC (PJM), commissioned a study to examine the impacts to grid operations, including energy prices, if renewable energy increases over the next 15 years. The final report concluded that renewables integration can lower energy prices and that the PJM system can maintain required reliability levels with up to 30 percent of energy from wind and solar if transmission systems are expanded to meet changing power flows.[22] |
| **Competitive Prices** | The Lawrence Berkeley National Laboratory (LBNL) *Tracking the Sun 10* report (2017) shows solar prices in Pennsylvania to be near the national average. |
| **Interested Project Developers** | In November 2017, the Commonwealth Financing Authority offered competitive grants for solar projects; 110 applicants were received, 78 were approved totaling 44 MW. |
| **Market Maturity** | Solar is now a mature international and national market, with competent and competitively driven developers, solar manufacturers, financiers, installers, utilities, and others ready to work in Pennsylvania. |
| **Adequate Rooftop Space** | A 2008 study on rooftop solar potential in Pennsylvania found that there is space for more than 27 $GW_{DC}$ of solar PV panels on existing rooftops alone.[23] |
| **Community Support** | In March 2018 a bipartisan group of 180 mayors from across the U.S. called for increased solar energy usage in a letter released by Environment America. The letter highlighted the commitment from cities and towns to support solar, as well as a call for more action to advance solar from the Federal government. There were 42 mayors from Pennsylvania who signed, the most from any one state. |

[22] *See:* http://www.pjm.com/-/media/committees-groups/subcommittees/irs/postings/pris-executive-summary.ashx?la=en
[23] This assumes 18% of single family homes, 65% of multifamily homes and 65% of commercial buildings have roofs with adequate solar access. ACEEE Pennsylvania Solar Assessment, VEIC, Nov 25th, 2008.

These assets highlight the important need to investigate the pathways to advance solar deployment in Pennsylvania. The *Finding Pennsylvania's Solar Future* project set a target for Pennsylvania to reach 10 percent of electricity consumption to come from in-state solar generation resources by 2030. However, there are existing barriers and challenges that need to be addressed before the potential of solar in Pennsylvania can be fully realized. This project was designed to help identify strategies to overcome those challenges, quantify costs and benefits, and document how opportunities to increase solar, if implemented, will benefit Pennsylvania.

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## The Power of Partnership and Solar Energy

*A Note from the Principal Investigator*

*Pennsylvania's Solar Future* brought together hundreds of community, industry, government, economic, academic, and policy stakeholders from across the state. Some served on the project facilitation team, some participated in stakeholder work groups, some contributed as committed partners, and some provided input through public comment and other feedback opportunities. Everyone supplied knowledge and perspectives based on their experience and, moreover, brought a willingness to consider the interests of others. For this reason, *Pennsylvania's Solar Future* is a strongly ground-truthed plan.

We set out to identify a path for solar energy development that challenges the status quo. To do so, we first had to look back: How is electricity currently generated in Pennsylvania? How much solar is currently installed? How did solar grow in Pennsylvania to this point? What roles did the state Alternative Energy Portfolio Standard, net metering, and the Pennsylvania Sunshine Program play? In addition, we asked, what current policies are helping solar along? How do other states' policies affect the growth of the solar industry and solar jobs in Pennsylvania?

Our data analysis shows that small investments and smart planning can achieve a much higher penetration of solar in PA beyond the current trajectory. The strategies offered in this plan ramp up solar from the approximately 300 megawatts installed as of 2018 to 10-12 gigawatts by 2030, to provide 10 percent of electricity generation.

More broadly, we hope *Pennsylvania's Solar Future* not only fosters further conversations about solar energy, but helps transition the discussion to developing strategies that fill policy gaps, provide signals to solar job creators, and further align economic opportunities with the benefits of emissions-free energy generation. The measure of our success lies in educating and encouraging those who can help accelerate the recognition and adoption of the benefits of solar in a manner that transforms the energy marketplace to improve quality of life for all Pennsylvanians.

**David Althoff**
**Director, DEP Energy Programs Office**
**Principal Investigator, Finding Pennsylvania's Solar Future**

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# THE FINDING PENNSYLVANIA'S SOLAR FUTURE PROJECT

Community Energy's Keystone Solar Project, Radnor, Lancaster County

The Finding Pennsylvania's Solar Future project was led by the Pennsylvania Department of Environmental Protection (DEP) Office of Pollution Prevention and Energy Assistance (OPPEA). The project was funded by a grant from the U.S. Department of Energy Solar Energy Technologies Office, who also provided guidance and feedback throughout the project. DEP's objective in the Finding Pennsylvania's Solar Future project was to create a forward-looking solar energy plan for Pennsylvania as a product of broad stakeholder engagement that was informed by, and represents, key policy, regulatory, and market issues from many relevant perspectives.

The Pennsylvania's Solar Future Project Team ("Project Team") consisted of representatives from DEP, Citizens for Pennsylvania's Future, The Vermont Energy Investment Corporation and Pennsylvania based solar subject matter experts ("facilitators") Sharon Pillar, Dr. Jeffrey Brownson, Ron Celentano, and Maureen Mulligan. The Project Team additionally was informed and supported by both committed partners and a robust stakeholder group.

## A. PROJECT TEAM

**Citizens for Pennsylvania's Future (PennFuture)** acted as the lead contractor and provided project management services and overall supervision of the project.

**Vermont Energy Investment Corporation (VEIC)** was responsible for the modeling tasks in the study. The general output for the modeling portion of the *Pennsylvania's Solar Future* was to provide documented analysis-based support and findings on the feasibility and implications of meeting the Plan's goals. Their work has drawn upon the experience and approach for modeling the potential for Vermont to become an advanced solar economy.[24]

**Project Facilitators** had experience in specific areas and guided the stakeholder discussions, served as expert resources, conducted gap analysis, developed stakeholder diversity and cohesion, and captured the discussion in report writing and presentations. Further, in post-meeting assessments, the Project Team debriefed to assess progress, incorporate ideas from the stakeholders, seek agreement on common terminology and develop a common understanding of key topical areas.

- **Sharon Pillar** is owner of the Hot Earth Collaborative LLC, a clean energy consultancy, working with clients such Environmental Entrepreneurs (E2) to raise business voices in support of clean energy policies. Sharon is the president of the Solar Unified Network of Western Pennsylvania (SUNWPA). She recently directed the 2.5 year Solarize Allegheny campaign helping residents and businesses to go solar, and during her eight years at PennFuture, she served as the project manager for solar programs.
- **Dr. Jeffrey Brownson** is an Associate Professor of Energy & Mineral Engineering at Penn State. Since 2007, the Brownson Group has advanced research in solar engineering, economics, resource assessment, power simulations, and community solar. Dr. Brownson has taught nearly 1,000 graduates building pathways to solar careers and has served as faculty lead in the Solar

[24] For reports and information on the Vermont Solar Market Pathways project see www.vermontsolarpathways.org.

Decathlon 2009. Penn State is an internationally recognized leader in solar energy research and education and serves as a Land Grant Institution.

- **Ron Celentano** is a solar energy industry consultant with Celentano Energy Services (CES), and President of Pennsylvania Solar Energy Industries Assoc. (PASEIA). Ron started working in the solar energy field over 40 years ago, with the last 20 years focused on solar PV. Ron's experience covers both technical and policy related fields, and he has helped shape Pennsylvania's laws and regulations regarding solar energy over the last 20 years, including net metering, interconnection, PA's solar share requirement, and many other related issues.
- **Maureen Mulligan** is a government relations strategist and lobbyist for PASEIA/MSEIA and PV Now (currently SEIA) where she led efforts resulting in the successful passage of key solar bills. She is the owner of Sustainable Futures Communications, LLC and previously worked on Public Utility Commission (PUC) solar and renewable energy rulemakings, nominations, and virtually every major and minor solar issue that came before the Pennsylvania General Assembly. Maureen has participated as a solar and energy efficiency advocate, speaker and spokesperson on a regular basis and received several awards for her work in this area.

**Committed partners** from organizations across the state provided consistent support throughout the project by attending meetings, reviewing documents, contributing in-kind support, and offering perspectives from their organizations on how Pennsylvania can increase solar deployment.

**Over 500 stakeholders** representing the solar industry, utilities, academia, government, the public interest sector, and consumers participated in meetings and webinars, and reviewed draft documents. The stakeholders were an essential part of developing valuable insights and consensus on complicated market, policy, and technical issues in the Pennsylvania solar sector. The complete list of stakeholders is provided in Appendix A.

## B. PROJECT GOALS

The Project Team, committed partners, and stakeholders came together to explore pathways to increase solar energy production to 10 percent of Pennsylvania's electricity consumption by 2030. Reaching that target would represent an approximate additional deployment of over 11 GW of solar generation capacity in Pennsylvania over the next 12 years. The Project Team undertook a stakeholder engagement process that included sustained interaction with hundreds of stakeholders across the state to address:

- **Adapting current regulatory requirements** such as Pennsylvania Alternative Energy Portfolio Standard, including its provisions for net metering; to support forward looking economic and environmental objectives; and the role of utilities in owning solar generation;
- How market incentives, conditions, and rules should **ensure benefits of solar for low and moderate-income** consumers, manufactured home communities, and other traditionally under-represented parties.
- Which soft-cost and market-enabling strategies could **help promote dissemination of cost-effective solar** in Pennsylvania; and

- What modifications in planning, operations, and system integration—including utility and solar industry interconnection and system operations expertise, the use of storage, load shifting, advanced metering infrastructure and other distributed energy resources—could **enable cost effective integration of solar into the overall resource portfolio.**

The Project Team and stakeholder group deployed an iterative process to develop and analyze technical and policy elements of pathways to significantly increase in-state solar deployment in Pennsylvania. The target of 10 percent solar by 2030 was set by DEP as a level that could be accepted as achievable by 2030 but would also challenge the business-as-usual model. The modeling process allowed the stakeholders to explore technical issues related to significantly more solar deployment occurring in Pennsylvania in the coming years and discuss how market forces influence the adoption of solar generation.

The Project Team and stakeholders investigated the influence of various laws, regulations, and other regulatory policies and provisions at the federal, state, and local levels that may impact reaching the 10 percent project target; however, this plan does not focus on advocacy for one solar deployment pathway, but instead presents stakeholder-based reviews of available paths to achieving the target.

The Project Team believes that implementation of the strategies provided in this plan will require continued collaborative planning involving a variety of experts, advocates, and citizens, working for a cleaner energy sector in Pennsylvania. This Plan will offer a model for states with similar energy generation profiles looking to increase the deployment of solar resources.

## C. ESTABLISHING THE 10 PERCENT TARGET

To develop approaches to increased solar deployment, it was necessary to set a planning target that was significant enough to require actions beyond the business-as-usual approach while still being achievable. The Project Team used detailed, scenario modeling to compare current solar development and legislation / regulation to alternative levels of solar development culminating in 10 percent of electricity sales (10 – 12 GW) from in-state solar generation by 2030. While this 10 percent target is significantly higher than Pennsylvania's current AEPS requirement of 0.5 percent in 2021, Pennsylvania's current target is significantly lower than several neighboring PJM states **(TABLE 1)**.

**Table 1. Peak solar share by state RPS program**

| State | Year | Peak Solar Share |
|---|---|---|
| District of Columbia | 2032 | 5% |
| New Jersey | 2021 | 5.1% |
| Delaware | 2025 | 3.5% |
| Maryland | 2020 | 2.5% |
| Illinois | 2025 | 1.5% |
| Pennsylvania | 2020 | 0.5% |
| Ohio | 2027 | 0.5% |
| North Carolina | 2022 | 0.2% |

It is important to distinguish the purposes of the Finding Pennsylvania's Solar Future project target and the current Pennsylvania AEPS solar requirement or target. The AEPS requirement is an enforceable obligation mandated by law and regulation. The Solar Future project target is for planning purposes only. The project target is intended to inform methods that will identify the benefits of a higher penetration of solar, contribute to Pennsylvania's compliance with current solar targets, and provide increased fuel diversity. This effort will result in a plan for solar deployment that will be available to policy makers, regulators, industry, investors, and consumers. This well-informed planning effort is expected to help lower the costs, time, and barriers to the market expansion of solar.

It is important to note that, during the stakeholder process, the project stakeholders did not reach a consensus whether the 10 percent solar target by 2030 was too low, too high, or in the correct range. However, the project moved forward with the understanding that, should a goal of 10 percent solar by 2030 be adopted, the identified strategies represent a pathway to accelerate solar deployment in Pennsylvania to that level. In response to stakeholder input, the Project Team conducted sensitivity analyses showing a range of solar targets from 8 to 12 percent.

## D. APPROACH

The purpose of the Finding Pennsylvania's Solar Future project was to develop approaches to reduce the costs of solar as well as achieve deeper understanding of the barriers to solar deployment and associated policy solutions. The project aims to examine how solar technologies, the electric grid, technology providers, and installers in the solar marketplace can address challenges to achieve a greater penetration of these resources while maximizing the benefits, such as economic development, emissions reductions, reducing fuel price volatility, grid stability and security, resource diversity, expanding access to electricity, grid resiliency and meeting the objectives of a rapidly changing energy economy.

This plan is less about "forecasting" Pennsylvania's solar deployment future, and more about constructing rigorously analyzed stakeholder-guided scenarios showing possible future strategies to a strong solar market in Pennsylvania. The Plan provides economic and policy strategies, including identification of jobs and business opportunities for Pennsylvanians. These efforts will lead to a deployment plan that illustrates options for exceeding Pennsylvania's current AEPS requirements and ultimately achieving a target of 10 percent of electricity sales from in-state solar systems by 2030.

The Project Team's approach was to operate the stakeholder input process as non-binding and non-authoritative, but to be clear in its attempt to inform future engagement and decisions. The integrative process practiced through workshops and webinars created a repeated series of engagement events across the commonwealth. The workshops employed a process of integrative design, whereby the stakeholders' vision and preferences are aligned over repeated engagement in service to the people and businesses of the Commonwealth of Pennsylvania, while also holding to compliance with project objectives. The development process commenced by repeatedly aligning the stakeholders' shared identity and purpose, motivation for change, and development and integration of human capacity among the diverse participants.

Throughout the effort, the stakeholder process attempted to document and synthesize agreement and disagreement into coherent future solar development scenarios for the 5- and 10-year horizons. The approach also included detailed energy supply/demand balance scenario modeling to help facilitate the stakeholder discussions, findings and the development of the report.

To ensure stakeholders had adequate opportunities to discuss scenarios, strategies, and challenges, three different groups were created with each one managed by a Project Facilitator.

**Markets and Business Models (MBM) Workgroup, chaired by Sharon Pillar:** The MBM Workgroup was charged with identifying the pivotal factors that may impact the various solar markets either positively or negatively in Pennsylvania through 2030.

Solar markets were defined as residential, commercial (including businesses, non-profits, schools, hospitals, institutions, and government) or industrial. Markets reflect the customer base (*i.e.,* who is purchasing the solar energy) and the unique characteristics of those market segments including the size of the solar systems, financing considerations and return on investment, incentives, regulations and policies, siting and permitting issues, and workforce development. Business models refer to the structures that permit the various market sectors to acquire solar and include such topics as ownership models, and other associated factors that allow for the development of those business models.

The MBM Workgroup also discussed the need to include equity into the discussion so that systems and models could be structured to increase solar within populations with financial or physical challenges such as low-income, rural, non-profit organizations, buildings without good solar access, etc. The goal identified was that all people across Pennsylvania should have equal opportunity not only in realizing the economic and health benefits of solar energy, but also for accessing opportunities for education and employment in the emerging clean energy economy.

**Operations and Systems Integration (OSI) Workgroup, chaired by Dr. Jeffrey Brownson:** The OSI workgroup endeavored to explore and integrate the technical, legal, and organizational challenges associated with the grid in Pennsylvania and the growth of solar power production on the grid.

Systems integration involves managing suites of generators, power transmission and distribution, and diverse user demands. Systems operation is bound by physical limitations and legal constraints. Pennsylvania's Electricity Generation Customer Choice and Competition Act of 1996[25] resulted in the

[25] Act of Jul. 2, 1996, P.L. 542, No. 94. (See: 66 Pa. Stat. Cons. § 2801 et. Seq.).

restructuring of electricity markets through opening generation to competitive supply with state regulation of transmission and distribution of power. From the engineering perspective, Pennsylvania is a very energy dense state, with a diverse portfolio of energy demand, energy exports and new power generation sources emerging.

Major topic areas which were discussed included factors that will enable both grid scale solar (often called utility-scale solar) as well as distributed generation solar (e.g. customer-sited, rooftop solar) growth within the commonwealth, with careers benefiting the surrounding communities as well. Additionally, Pennsylvania does not currently have significant contributions of grid scale solar power. The OSI Workgroup explored reasons as to why that is currently the case and how to increase grid scale solar power.

**Regulatory and Ratemaking (RR) Workgroup, chaired by Ron Celentano:** The RR Workgroup helped define the context under which market participants, including, but not limited to, the regulated utilities make investment and other business decisions.

Regulations establish the rules under which solar and other resources can participate and compete in the market. Regulations that impact solar and other energy generation systems are set at the local, state, regional and federal levels. For example, permitting or zoning often operates at the local municipal level where net metering is largely controlled by state-level policy. PJM’s market structure and rules operate at the regional level, while federal legislation or regulations impact environmental requirements, establish tax policy, and provide oversight of grid operators such as PJM.

Ratemaking is intended to identify the costs for providing services and fairly and adequately distribute those costs among rate classes. In practice, each customer carries the burden for costs based on an average of the customer class, rather than assigning to each individual customer the costs that are created and borne by that individual. In addition, the ratemaking process may consider issues and concerns about cross-subsidization issues among customer classes. The RR Workgroup was charged with identifying the legislative and regulatory issues that would either promote or detract from achieving a notable increase of solar penetration in Pennsylvania and then helping to shape strategies to maximize solar development.

# STAKEHOLDER PARTICIPATION AND PUBLIC ENGAGEMENT

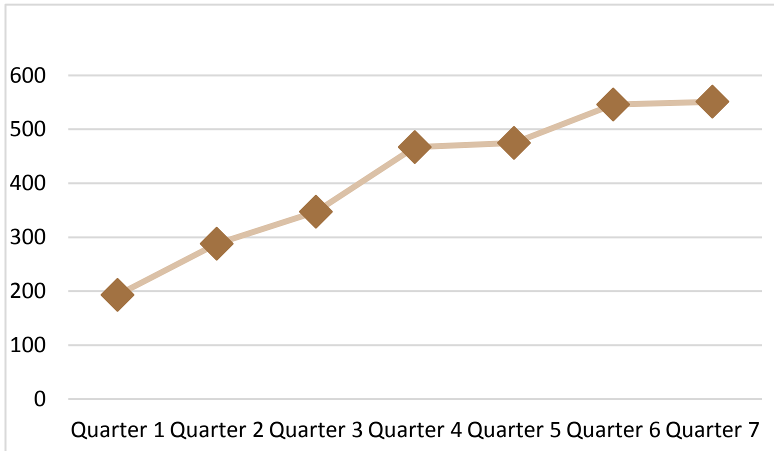
June 14, 2018, Stakeholder Meeting, Philadelphia

Stakeholder engagement was a critical part of the development process for *Pennsylvania's Solar Future*. Input from a diverse pool of stakeholders informed and validated the reference scenario, provided input regarding pivotal factors influencing solar deployment, and provided insight into all topical areas and approaches to potential implementation. The stakeholders ultimately provided valuable feedback on every aspect of the process leading up to the development of this plan.

**Stakeholder Participation**

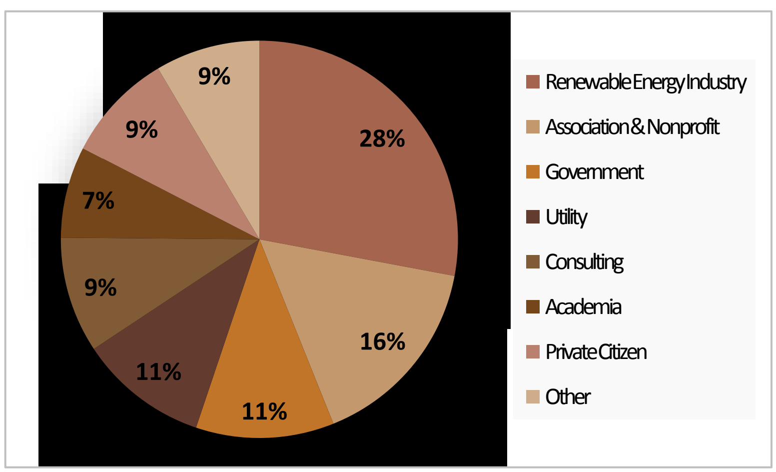
To engage with as many stakeholders as possible, the Project Team held quarterly one-day long stakeholder engagement meetings across the state rotating between Harrisburg, Pittsburgh, and Philadelphia during the first phase of the project. At least 100 stakeholders participated in each meeting either in-person or through a concurrent web-conference. At each meeting, the Project Team provided project updates and plans to the stakeholders, held discussions on various solar topics, as well as spent the afternoons providing stakeholders an opportunity for feedback, discussion, and ideas about how to increase solar deployment in Pennsylvania.

**Figure 1. Number of Stakeholders By Quarter**




The Project Team also hosted four webinars in between stakeholder meetings that covered topics relevant to Pennsylvania's solar industry. The webinar topics included alternative ratemaking, low-income solar development, stakeholder meeting preparation, and the LEAP – Long Range Energy Alternatives planning modeling system. Webinars and stakeholder meetings included panels and discussions provided by experts from across the country. At the end of each discussion there was an opportunity for questions and discussions from stakeholders.

**Figure 2. Percentage of Stakeholders By Sector**




As the stakeholder process unfolded, the number of total stakeholders continued to increase (**FIGURE 1**). The stakeholder group stems from a diverse combination of backgrounds including renewable energy industry, government, utilities, nonprofits, academia, consulting, and others (**FIGURE 2**) that led to productive contributions from different perspectives. Continued and substantial engagement from stakeholders provided valuable feedback and validation on the reference scenarios and strategies that ultimately made up *Pennsylvania's Solar Future*.

**Public Engagement**

There is a tremendous amount of interest about solar energy growth in Pennsylvania. As a result, the Project Team worked to engage with media and the public to highlight project progress and keep them informed of project outcomes.

Governor Wolf's press release announcing the start of the project led to several radio and newspaper stories. Included in this was an interview with Pennsylvania DEP Secretary Patrick McDonnell on WITF, the regional National Public Radio affiliate, that provided an overview of the project and expected outcomes.

DEP followed with a series of social media posts and blogs on DEP's webpages and social media accounts, including a video and blog post about how every Pennsylvanian can put solar on their home (**FIGURE 3**). DEP Secretary McDonnell also authored a blog post titled "The Sun Is Rising on Solar Energy in PA" that described the positive momentum solar is generating in Pennsylvania, and how to continue the momentum.

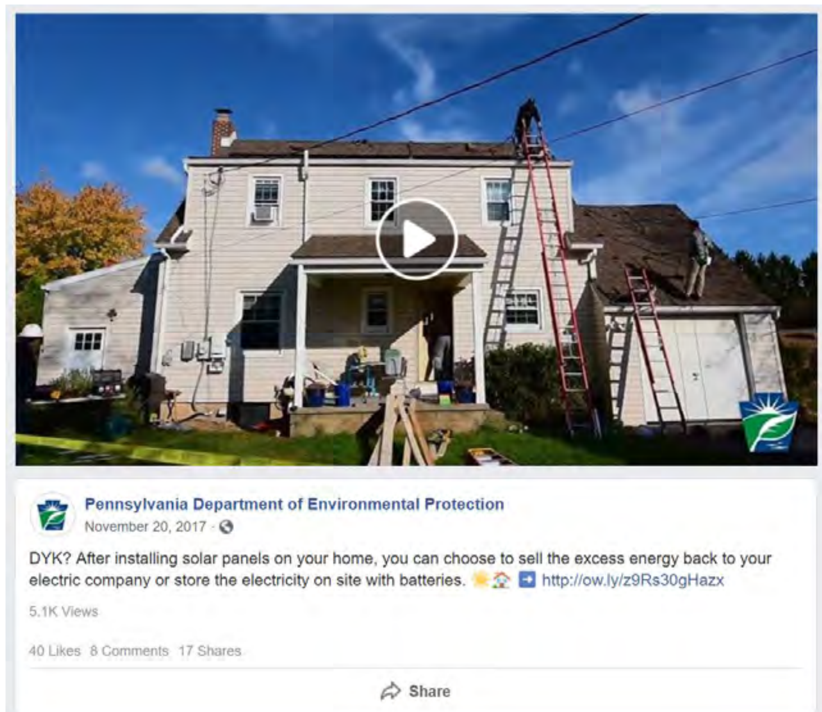



**Figure 3 Picture of DEP Facebook Post**

In addition, select committed partners participated in a podcast with Pennsylvania's Environmental Council's Josh Raulerson. Project participants Roger Clark, Director of Clean Energy at the Reinvestment Fund; Professor Vera Cole, chair of the online Energy and Sustainability Policy Program at Penn State, and Stacy Richards, founding director of the SEDA-COG Energy Resource Center, discussed what barriers exist to increasing solar energy production, how they can be removed, how Pennsylvanians can at all socioeconomic levels enjoy the benefits of solar, and other questions in the interview.

The Project Team believes that engaging the public in a variety of ways helped attract stakeholders, therefore receiving more input and ideas on how Pennsylvania can increase solar energy across the state.

***Sample Communications and Media Coverage:***
"Governor Wolf Announces Statewide Planning Project to Boost Pennsylvania's Solar Energy Development Begins in January 2017" – Governor's Press Office
"The Sun Is Rising on Solar Energy in PA – Here's How" – Op-ed, DEP Secretary Patrick McDonnell
"The Sun Is Rising on Solar Energy in Pennsylvania" – DEP blog post, Finding Pennsylvania's Solar Future Project Team
"Pennsylvania DEP Looking To Boost Solar Energy Production With New Project" – WESA FM (Pittsburgh NPR affiliate)
"Pennsylvania Launches Program Promoting Solar Energy" – State Impact
Interview with Secretary Patrick McDonnell – WITF SmartTalk (Harrisburg NPR affiliate)
"Statewide Solar Energy Development Planning Begins with First Meeting" -- Gant News
"Solar Energy Development Planning Group Meets" – Reading Eagle
"Pennsylvania Kicks Off Statewide Solar Development Planning" – Solar Industry Magazine
"DEP Unveils New Solar Energy Plan" – ABC27, Harrisburg
"DEP Releases Draft Plan of Strategies to Reduce Barriers to Solar Energy Development, Invites Public Comment" – NorthcentralPA.com
"Pennsylvania Lays Out Plan for 11GW of Solar by 2030" – PV Magazine
"Pennsylvania Draft Plan Calls for 11 GW In-State Solar" – Utility Dive
"Finding PA's Solar Future Stakeholder Group Offers Comments on Draft Plan" –PA Environment Digest

# PENNSYLVANIA'S ENERGY SYSTEM

Estes Trucking, West Middlesex, Mercer County

The stakeholder discussions that informed the development of strategies and the analysis of technical and policy elements to significantly increase in-state solar deployment in Pennsylvania, took place in the context of Pennsylvania's position in the PJM Region and as a restructured electric market. This section discusses the various existing conditions that affect, or potentially will affect, solar generation in Pennsylvania.

## A. ENERGY GENERATION PROFILE

Pennsylvania is the largest exporter of electricity in the nation with approximately 30 percent of production being consumed out of state. As shown in **FIGURE 4**, the two largest sources of the electricity on our grid are nuclear energy and natural gas (nuclear at 42 percent, followed by natural gas 30 percent and coal 24 percent)[26]. Each of these fuel sources competes for a significant share of the electricity generation marketplace. Despite retirement of thousands of MW of aging coal-fired generation, Pennsylvania is the nation's 6th largest producer of electricity from coal.[27] In addition, and in large part because of increased development of Marcellus shale, Pennsylvania has become the nation's second largest producer of natural gas. This has led to gas generation supplying a significant amount of the energy that was formerly provided by coal.

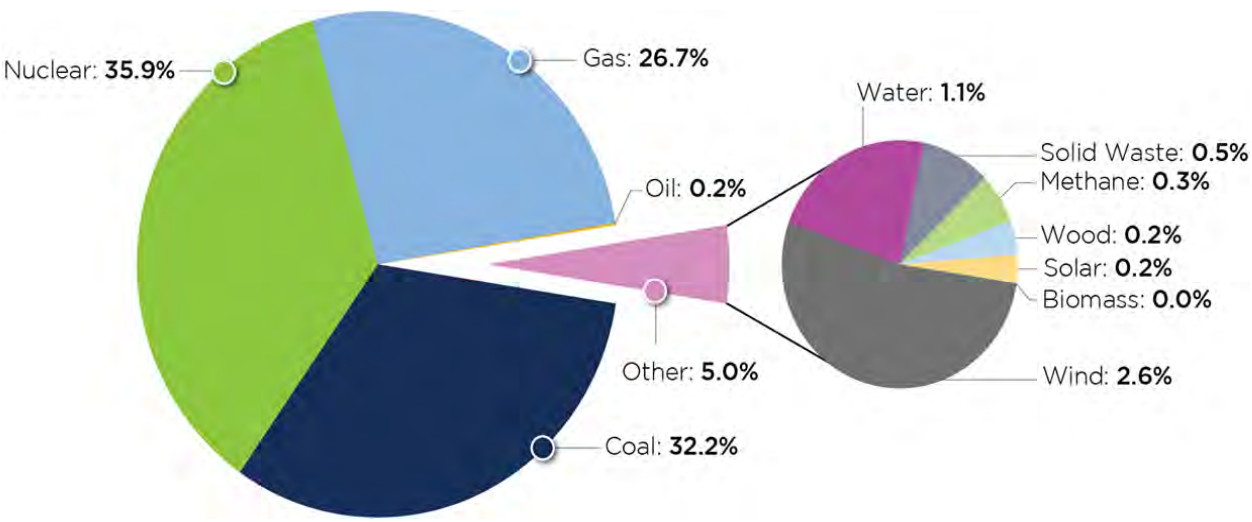



**Figure 4. PJM 2017 Fuel Mix**

Pennsylvania is also the second largest producer of electricity from nuclear power. There are currently five operating nuclear power stations in the state although the single 837 MW unit in operation at the Three Mile Island[28] Nuclear Generating Station (TMI) is anticipated to retire in 2019 after failing to clear the 2020 – 2021 PJM forward capacity auction. PJM has completed a reliability analysis related to the

[26] See: EIA, Electric Power Monthly, Table 1.3.B and 1.17.B. Available at: https://www.eia.gov/electricity/monthly/current_month/epm.pdf
[27] Id.
[28] TMI Unit 2 has been closed since the accident in 1979.

closure of TMI and expects the facility could close without negative impacts to the grid.[29] On March 28, 2018, the owners of the 1811 MW Beaver Valley Nuclear Generating station notified PJM of their request to deactivate both of its units in 2021. PJM's analysis of this retirement similarly found that necessary upgrades are expected to be completed in time for the facility to deactivate as scheduled.[30] Legislative and policy measures that could impact the decisions to deactivate these units have been proposed but no specific measures have been advanced.

Pennsylvania's status as a fuel rich state makes it a critical electricity supplier to the Mid-Atlantic region and the PJM Grid. Renewables currently provide only 4.1 percent of the electricity generation[31] ranking Pennsylvania 41st in renewable energy generation[32]. Solar photovoltaic (PV) installations are currently installed in Pennsylvania at residential, commercial, industrial and even grid scale but those assets currently produce less than 0.25 percent of the state's net electricity generation

## B. ENERGY USAGE AND SHIFTS IN GENERATION SOURCES

While Pennsylvania's energy mix is undergoing a significant change due to the impact of historic volumes of low cost natural gas entering the market, data from the US Energy Information Administration shows net utility-scale generation across all fuels has been relatively flat in Pennsylvania.[33] Negligible load growth is also reflected grid-wide with PJM's forward capacity auction[34] where no significant growth is expected for at least the next three years. The most significant changes in the fuel mix is gas replacing coal combined with a slower, but steady growth in renewable generation.

Excess natural gas supply leading to continued low gas prices is expected to have a significant influence in the electricity market, particularly in the near term. Pennsylvania experiences the "Pennsylvania gas discount", where local gas hubs have seen prices below that of the national average or key indicators such as the Henry Hub. This "discount" is typically attributed to increased supply of natural gas from Marcellus shale outstripping the capacity of pipelines to transport the gas to markets. This has had an impact on electricity generation with natural gas prices delivered to electric power plants in 2016, running $1.04/Mcf below the national average.[35]

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[29] PJM Interconnection, LLC., Future Deactivations (as of Oct. 27, 2017) (*available at:* http://www.pjm.com/-/media/planning/gen-retire/pending-deactivation-requests.ashx?la=en).
[30] PJM, Generation Deactivations, (*available at:* http://www.pjm.com/planning/services-requests/gen-deactivations.aspx)
[31] https://energy.gov/maps/renewable-energy-production-state
[32] *Id.*
[33] US Energy Information Administration, Electricity Data Browser (*available at:* https://www.eia.gov/electricity/data/browser/).
[34] Source: PJM
[35] C. Simeone, *Pennsylvania's Gas Decade*, Kleinman Center for Energy Policy (2017) (available at: http://kleinmanenergy.upenn.edu/sites/default/files/Pennsylvania%27s%20Gas%20Decade.pdf).

## Regional Transmission and Market

**Figure 5. PJM Territory**

Pennsylvania's wholesale electricity market is managed by PJM Interconnection, LLC (PJM), the regional transmission organization (RTO) that serves approximately 61 million people in 13 states and DC across the mid-Atlantic, and Midwest as shown in (**FIGURE 5**[36]). Within this region, a significant amount of energy is sold at wholesale in a day-ahead market with a much smaller percentage being sold on the spot or "balancing" market. Within PJM, energy is also sold through bilateral agreements, including long term contracts, and via self-supply agreements involving rural electric cooperatives and municipal electric companies.

## Pennsylvania's Restructured Electricity Market

For just over twenty years Pennsylvania has had a restructured electric market. Electricity customers can shop for competitive generation suppliers or opt to have their regulated utility as their default supplier.[37] To the extent that utilities need to acquire energy to service their customers, they must do so using a PUC approved "prudent mix of contracts" that results in the "least cost over time" to consumers. Most industrial customers in Pennsylvania choose competitive generation suppliers whereas business and residential customers are far more likely to rely on their utility to serve as their default supplier.[38] Consumers benefitted from lower prices resulting from competitive forces and, for the first time, gained significant access to renewable energy largely through offerings from competitive electric generation suppliers (EGSs).

PA Powerswitch[39], a retail offering comparison tool supported by the PUC, provides residential consumers with the ability to find zip code-based listings of competitive offers. These can be filtered by fixed/variable rate, renewable content, cancellation charges and length of contract. For small and large

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[36] Source: Federal Energy Regulatory Commission (FERC).

[37] In addition to regulated utilities, 35 municipalities and 13 rural electric cooperatives provide power to customers but are not under Pennsylvania PUC jurisdiction and are not subject to any of the utility legislation discussed in this document.

[38] *See generally:* C. Simeone & J. Hanger, *A Case Study of Electric Competition Results in Pennsylvania*, Kleinman Center for Energy Policy (Oct. 2016) (*available at:* http://kleinmanenergy.upenn.edu/sites/default/files/A%20Case%20Study%20of%20Electric%20Competition%20Results%20in%20Pennsylvania_0.pdf).

[39] http://www.papowerswitch.com

businesses, a list of available suppliers is provided but the customer must contact them to secure pricing. There are dozens of suppliers providing hundreds of retail electricity offers, including many based on renewable energy. In addition, the Pennsylvania Office of the Consumer Advocate provides an Electric Shopping Guide with similar information.[40] Renewable energy includes solar resources located in Pennsylvania as well as wind generation located inside and outside of the state. Businesses also use this service, generally without charge, as a means for accessing competitive suppliers. As of October 2017, shopping varies from about a third of residential customers to about 75 percent of commercial customers to over 97 percent of industrial customers. In addition to competitive generation supply, Pennsylvania consumers can also enter into power purchase agreements (PPAs) that guarantee energy at an agreed upon price for a fixed term of years.

[40] *See:* http://www.oca.state.pa.us/Industry/Electric/elecomp/ElectricGuides.htm.

# SOLAR ENERGY IN PENNSYLVANIA

Residence in Schuylkill County

As of December 31, 2017, Pennsylvania had a total of 318 MW of installed solar generation capacity from 16,770 solar systems spread across every county of the commonwealth. This approximately 0.3 GW of solar generation capacity in Pennsylvania is a small percentage of the additional 10 – 12 GW of capacity that would need to be deployed over the next 12 years to achieve the 10 percent goal of the project. Generation from these systems accounts for about 0.25 percent of the state's projected 2017 electricity consumption.

**Table 2. Cumulative Photovoltaic Systems in Pennsylvania through 2017**

| Capacity (DC) | # of Systems | Total MW | % Total MW |
|---|---|---|---|
| < 15 kW | 14,665 | 110 | 34.60% |
| > 15 kW to ≤ 1 MW | 2,070 | 133 | 41.80% |
| > 1 MW to ≤ 3 MW | 28 | 41 | 12.90% |
| > 3 MW to ≤ 5 MW | 6 | 22 | 6.90% |
| > 5 MW to ≤ 10 MW | 0 | 0 | 0.00% |
| > 10 MW | 1 | 12 | 3.80% |
| Total | **16,770** | **318** | **100%** |
| | | * as of 12/31/2017 as per PA AEPS (PUC) | |

As shown in **TABLE 2**, more than 70 percent of the generation is produced by systems with a capacity of less than 1 MW, while only one system exceeded 10 MW.[41]

The marketplace in Pennsylvania has not followed a consistent trend over the last 10 years. Installation trends reflect additional incentives offered during the 2009 – 2012 time period, the loss of the incentive programs, and then significant lower costs for solar PV systems combined with the opportunities provided by residential solar leasing from 2016 onward. **FIGURE** 6 and **FIGURE** 7 show the cumulative and yearly installed capacity in Pennsylvania since 2000 based on PJM Generation Attribute Tracking System (GATS).

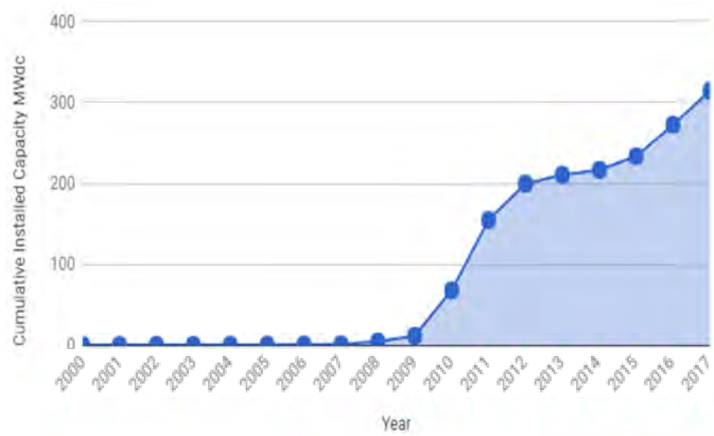
**Terminology Note**: This report uses *grid scale* to avoid possible confusion inherent in the term *utility scale*. Grid scale specifically refers to resources that participate in the PJM wholesale market or are larger than is typically interconnected to the distribution network. Their primary purpose is to produce electricity for sale and not to offset local demand. To the extent that the term utility scale is used it refers to these grid scale resources unless otherwise stated. In contrast, the term *distributed generation* is used for residential, commercial, or industrial sources of generation that are typically no larger than 3 – 5 MW and tied to the distribution network.

[41] AEPS data. We note there is a discrepancy between qualified systems report by the AEPS administrator and PJM GATS data.

Although Pennsylvania receives a very small portion of electricity from in-state solar generation, the use of solar for electric generation has the potential to be a significant resource in supplying reliable emissions-free electricity.

Pennsylvania experiences 2,600 hours of sunshine annually. Pennsylvania solar installations are no different in opportunity for success than New Jersey, Massachusetts and New York. Each of these states is within the top 10 solar states in the nation (numbers 4, 6, and 8, respectively[42]) for solar photovoltaic electricity production. The sunshine that Pennsylvania gets is also evenly distributed across the state. In fact, projects that participated in DEP's Solar Sunshine Program spanned across each region of Pennsylvania and reported similar efficacy, ranging from 1,026-1,143 kWh/kW/year (**TABLE 3**). Furthermore, solar economics are based on solar output and the baseline cost of electricity being offset. The relatively high electricity prices in urban regions may make solar economically feasible despite lower insolation than sunnier states.

**Figure 6. Cumulative Installed Solar Capacity**



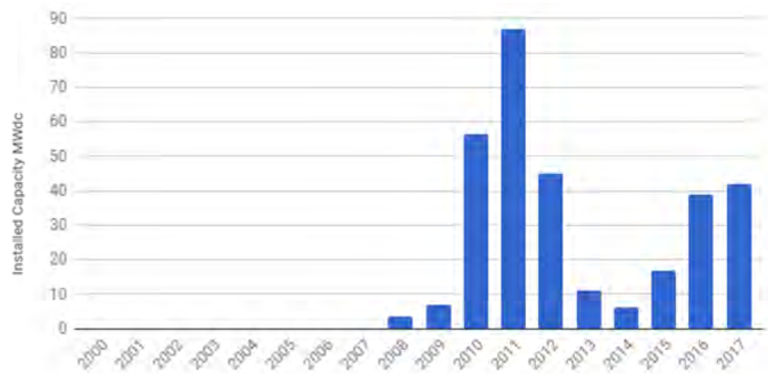




**Figure 7. Installed solar capacity by year**

| | Average Reported Efficacy (kWh/kW/yr.) | |
|---|---|---|
| **Region** | **Residential** | **Commercial** |
| **SE** | 1,108 | 1,091 |
| **SC** | 1,143 | 1,114 |
| **SW** | 1,061 | 1,026 |
| **NW** | 1,102 | 1,039 |
| **NC** | 1,088 | 1,030 |
| **NE** | 1,075 | 1,065 |

**Table 3. Reported and Predicted Efficacy by Region of Pennsylvania**

[42] See: https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_6_02_b

**REDUCING THE COSTS OF SOLAR IN PENNSYLVANIA**

The U.S. Department of Energy offers programs that include a number of initiatives aimed at reducing soft costs in the efforts to help solar PV reach cost parity with grid-supplied energy by the year 2020. One of these initiatives, the Solar Training and Education for Professionals (STEP) Program addresses roadblocks among secondary actors in the transactions that occur during a solar project.

The Building Codes Assistance Project is the lead project developer for one of the STEP programs, which is targeted toward design professionals such as architects and engineers. This training was developed throughout 2016, with enormous input from solar experts from across the country, and began offering full-day trainings early in 2017 with specially-trained trainers.

## A. SOLAR JOBS IN PENNSYLVANIA

According to U.S. Department of Energy data, the solar workforce in 2017 increased to almost 374,000 employees working in the solar industry, with more than 260,000 of those employees spending the majority of their time on solar.[43] Also, solar was found to comprise 43 percent of the electric power generation workforce, followed by fossil fuel generation employment. Fossil accounted for 22 percent of total electric power generation employment and supports 187,117 workers across coal, oil, and natural gas generation technologies.

Figure 8. Michael Skala of Exact Solar, Bucks County, PA

According to the U.S. Bureau of Labor Statistics, the occupation of solar installer is projected to be the fastest growing job in the United States from 2016 – 2026 and is expected to increase more than 100 percent through 2026.[44] By comparison, the average growth rate for all occupations is 7 percent. While the actual number of jobs in health care is projected to be greater, the solar job growth rate may achieve the highest increase by percentage of any other job.

Since 2010 solar job growth has grown by 168 percent, from just over 93,000 to more than 250,000 jobs in all 50 states in 2017.[45]

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[43] U.S. Dept. of Energy, *U.S. Employment and Energy Report,* 37 (Jan. 2017). *Available at:* https://www.energy.gov/sites/prod/files/2017/01/f34/2017%20US%20Energy%20and%20Jobs%20Report_0.pdf

[44] https://www.bls.gov/ooh/construction-and-extraction/solar-photovoltaic-installers.htm .

[45] https://www.thesolarfoundation.org/national.

According to the U.S. Department of Energy Employment & Energy Report, Pennsylvania had 4,670 people working at least some time in the solar sector in 2016.[46] The Solar Foundation Solar Jobs Census showed that Pennsylvania had 3,848 people working at least half time in the solar industry in 2017—a 26 percent increase from 2016—with 1 in every 1,523 jobs in Pennsylvania in the solar sector. However, Pennsylvania ranked 19th in the country in overall solar employment in 2017.

### SOLAR JOBS POTENTIAL IN PENNSYLVANIA

The Solar Foundation released a report that included a comparison of MW of solar generated per capita between Maryland and Pennsylvania, finding: "Maryland saw 248 MW of solar installed in 2016. At more than 6 million in population, 2016 solar installations equate to 41 Watts per person. With approximately 12.7 million in population in Pennsylvania, a target of 41 Watts per person in 2021 would bring Pennsylvania to 524 megawatts installed that year." The report shows that a significant increase in solar capacity is possible if viewed in comparison to growth already being seen in Maryland.

Source: http://www.thesolarfoundation.org/wp-content/uploads/2017/06/TSF-Census-Future-State-Solar-Jobs-2021.pdf

**TABLE 4** shows the states that surround Pennsylvania in the Northeast, the solar jobs to population ratio and the RPS goal, demonstrating that higher RPS goals can result in a greater number of jobs. Pennsylvania has the lowest goal and the lowest solar job ratio. Ohio's solar job to population ratio is likely higher due to requiring at least 50 percent of the solar accounted for to achieve the RPS goal originate from in-state projects, whereas Pennsylvania did not have an in-state project requirement until the end of 2017.

**Table 4. Correlation of Number of Solar Jobs, Population and RPS Goal by Various State**

| State | Solar Jobs in 2017 | 2017 State Population (in millions) | Solar Job to Population Ratio | RPS Goal |
|---|---|---|---|---|
| Massachusetts | 19,635 | 6.9 | 1:351 | 400 MW |
| Maryland | 13,053 | 6.1 | 1:467 | 2.5% by 2020 |
| New Jersey | 9,239 | 9.0 | 1:974 | 5.1% solar-electric by 2021 |
| Ohio | 8,350 | 11.7 | 1:1401 | 0.5 by 2027 |
| New York | 12,411 | 19.9 | 1:1603 | Not Applicable |
| Pennsylvania | 4,670 | 12.8 | 1:2741 | 0.5% by 2021 |

[46] *Supra 11.*

## 1. JOB DIFFERENCES PER SECTOR

Distributed solar installations require larger numbers of workers to install one megawatt (MW) of capacity than projects for grid scale solar.[47]

**TABLE 5** illustrates the predicted number of solar "field" jobs (*i.e.* those workers who physically install systems) in the business-as-usual scenario versus modeled options that meet the 10 percent target with a relatively high fraction of distributed generation versus a relatively low fraction.

**Table 5. Predicted solar job creation per sector by model scenario**

| | Jobs per MW | Reference Scenario | | 35% Distributed (Solar A) | | 10% Distributed (Solar B) | |
|---|---|---|---|---|---|---|---|
| Sector | | MW Predicted by 2030 | No. of Predicted Jobs | MW Predicted by 2030 | No. of Predicted Jobs | MW Predicted by 2030 | No. of Predicted Jobs |
| Residential Jobs | 4.82 | 0.3 GW | 1,446 | 1.95 GW | 9,399 | 0.55 GW | 2,651 |
| Non-Residential Jobs | 3.06 | 0.6 GW | 1,836 | 1.95 GW | 5,967 | 0.55 GW | 1,683 |
| Grid Scale Jobs | 2.42 | 0.6 GW | 1,452 | 7.1 GW | 17,182 | 9.9 GW | 23,958 |
| TOTAL Number of Predicted Jobs by 2030 | | 1.5 GW | 4,734 | 11 GW | 32,548 | 11 GW | 28,292 |

The number of jobs per megawatt in **TABLE 5** above is based on national averages from the Solar Jobs Census.[48] The Pennsylvania residential solar sector may require more workers per megawatt than the national average, possibly due to older housing stock presenting additional challenges to installation.

## 2. WAGES

According to the Solar Foundation 2017 Annual Solar Job Census, "the median reported wage for mid-level installer positions for both installation and project development companies is $21 per hour. For installation companies alone, the median mid-level installer wage is $20, and for project development

[47] *Supra* 13.
[48] *See: https://www.thesolarfoundation.org/national*

companies, the median wage is $25. The median wages for supervisory roles in the installation and project development sectors are $30 and $38, respectively. The median wage for a mid-level assembly or production worker in the manufacturing sector is $20, increasing to $30 for supervisors or foremen." In Pennsylvania, the Department of Labor & Industry, lists the prevailing wage for a solar installer at $41.05/hour with $29.99 of fringe benefits.

### 3. WORKFORCE DEVELOPMENT

Solar industry professions encompass a wide range of skill sets, education, training and occupational disciplines across the solar supply chain and offers a wide range of jobs at different entry points of experience and education or training. According to the Solar Foundation's Solar Jobs Census, only about two-thirds of solar workers have experience and only one-fifth of companies are requiring a 4-year degree.

In Pennsylvania, many of the solar companies currently train their own workers. There are a handful of training programs available to solar workers. Several colleges and universities across the state teach a variety of programs including solar design, finance and engineering, installation, and solar ecology; the Energy Coordinating Agency in Philadelphia teaches installation skills; and the International Brotherhood of Electrical Workers (IBEW) and the UL offer solar PV training and certifications.

The North American Board of Certified Energy Practitioners (NABCEP) also certifies for PV Technical Sales, Installation Professional, Design Specialist, Installer Specialist, Commissioning & Maintenance Specialist, and PA and Solar Heating System Inspector Certification Programs.[49] NABCEP certification is becoming a standard for training and certification across the nation and there is a moving demand from companies and customers to require workers with NABCEP certification to demonstrate knowledge and capability.

## B. STATUTES AND REGULATIONS AFFECTING SOLAR

The pathways to increased solar deployment in Pennsylvania will continue to be affected by existing state and federal policies as well as new policies and strategies. This section provides a brief overview of the significant existing legislation and regulations at the state and federal level.

### 1. ALTERNATIVE ENERGY PORTFOLIO STANDARDS

In Pennsylvania, renewable energy targets are mandated through the Alternative Energy Portfolio Standards (AEPS) Act.[50] This law requires regulated utilities known as electric distribution companies (EDCs) and competitive non-utility electric generation suppliers (EGSs) to supply 18 percent of electricity through alternative energy resources in 2021. As **TABLE 6** shows, this is broken down into two tiers with

[49] See: http://www.nabcep.org/certification.
[50] Alternative Energy Portfolio Standards, Act 213 of 2004.

8 percent of the supply coming from Tier I renewable energy resources (including solar photovoltaic generation, wind, conventional hydroelectric generation along with biomass generation from landfill gas) and 10 percent from Tier II "alternative" non-renewable resources like waste coal and coal bed methane. The 0.5 percent that must be generated from solar photovoltaic sources counts toward the overall Tier I goal.

**Table 6. Pennsylvania AEPS 2021 Requirements**

| Tier I | | | Tier II |
|---|---|---|---|
| **Total** | Non-Solar | Solar PV | |
| **8%** | 7.5% | 0.5% | 10% |

Compliance is measured through tracking of Alternative Energy Credits (AECs) and Solar Alternative Energy Credits (known as SAECs or SRECs)[51] through the Generation Attribute Tracking System (GATS) platform managed by PJM Environmental Information Services.[52] One AEC represents one MWh of electricity generated from a qualified alternative energy source and can be purchased separately from electricity. AECs generated anywhere within the PJM region can be used to satisfy the AEPS requirements. On October 30, 2017, Act 40 was signed into law that, among other things, seeks to restrict solar eligibility for AEPS compliance to those solar PV systems originating from within Pennsylvania.[53] As seen in **TABLE** 7, there is nearly enough capacity in Pennsylvania to satisfy the solar PV requirements from the AEPS.[54]

**Table 7. Solar demand for Pennsylvania and installed capacity**

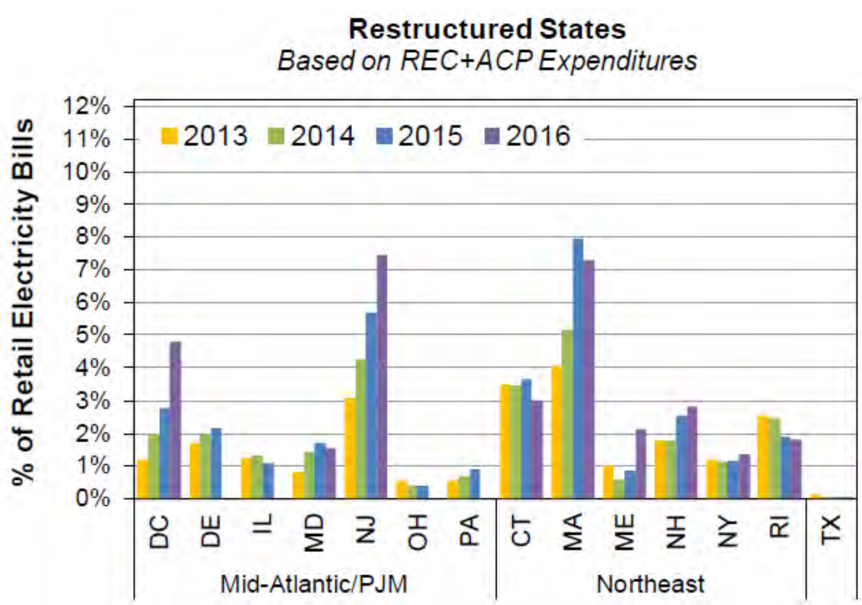
| Year | Generation Requirement (MWh) | Estimated Needed Capacity (MW) | Capacity Installed in Pennsylvania |
|---|---|---|---|
| **2015** | 204,255 | 179 | 223 |
| **2016** | 364,442 | 320 | 232 |
| **2017** | 419,460 | 368 | 294 |
| **2018** | 488,333 | 429 | |
| **2019** | 562,615 | 494 | |
| **2020** | 647,152 | 568 | |
| **2021** | 734,469 | 645 | |

51 In other states these credits are generally referred to as Solar Renewable Energy Credits (SRECs). In this discussion, the term SREC does not exclude Pennsylvania-eligible credits.
52 https://www.pjm-eis.com/
53 *See:* Act 40 of 2017 (HB 118). *Note:* At the time this plan was prepared, the implementation of Act 40 is the subject of PUC Docket No. M-2017-2631527.
54 http://www.puc.pa.gov/Electric/pdf/AEPS/AEPS_Ann_Rpt_2017.pdf

A comparison of regional AEPS/RPS solar goals described in GATS show Pennsylvania, which was a leader in solar in the mid- to late 2000s, has fallen behind. Pennsylvania's solar set-aside increases annually until 2020 – 21 when it peaks at one-half-of-one percent of all energy sold by Pennsylvania's electric utilities. In that year, most neighboring PJM states will require a compliance level that is at least several times Pennsylvania's. These range from DC, where the requirement is over three times Pennsylvania's, to New Jersey with a requirement almost seven times the percentage currently set in the AEPS. Maryland reaches the peak of its requirement in 2020 with a 2.5 percent solar goal. Further, most of neighboring states' solar requirements continue to increase after Pennsylvania's levels off in 2020 – 2021. Delaware's reaches 3.5 percent in 2025, New Jersey's advances to 4.1 percent in 2027 and DC's increases to 5 percent in 2032. All these states, having engaged in deliberative processes, arrived at solar requirements for their state that are significantly greater than Pennsylvania's.

There is a cost to ratepayers across the state for operating the AEPS program, who are essentially paying for the required purchase of the solar SRECs, as well as the Tier I and Tier II AECs. However, as shown in **FIGURE 9**, this cost represents well under 1 percent of the average electricity bill in Pennsylvania. This cost is one of the lowest of the restructured states and includes all renewable AECs (Tier I), not only solar SRECs.

Figure 9. AEPS/RPS Compliance Costs [55]




## 2. NET METERING

The AEPS Act also requires Pennsylvania utilities to offer net metering to customer generators including owners of residential systems up to 50kW and non-residential systems of 3MW (or up to 5MW if

[55] U.S. Renewables Portfolio Standards 2017 Annual Status Report; Galen Barbose; Lawrence Berkeley National Laboratory, July 2017.

additional conditions are met.)[56] Pennsylvania does not have an aggregate cap on the amount of net metered projects that can participate. Under the net metering provision in Pennsylvania, a solar customer-generator receives full retail value in the form of bill credit for all the electricity that is generated by the solar PV system throughout the year, and any annual surplus of generation is compensated at the "price to compare" value (i.e., includes only generation and transmission, not distribution).

In addition to single-meter net metering there is a virtual meter aggregation option, which allows generation and load at multiple physical meters to be aggregated if all the electric accounts for all the locations are under the same name holder, are located within a two-mile radius of the interconnected solar PV system's primary location and are within the service territory of the same utility. These limitations on virtual meter aggregation distinguish it from the less restrictive virtual net metering, which is often the billing mechanism for community solar projects. While virtual net metering is generally not permitted in the EDC territories in Pennsylvania, this restriction does not extend to municipalities and cooperatives that are not under the PUC's jurisdiction.

A 2014 study by Lawrence Berkeley National Laboratory concluded that with solar PV penetrations of 2.5 percent by 2020 in the northeast utility scenario, the average rate increase across all ratepayer classes was 0.2 percent. With Pennsylvania's AEPS solar share requirement set at 0.5 percent penetration by 2021, that would equate to about a 0.04 percent increase in rates due to net metering, assuming all of it was distributed generation in Pennsylvania. This would result in a $100 electric bill increasing by 4 cents.[57]

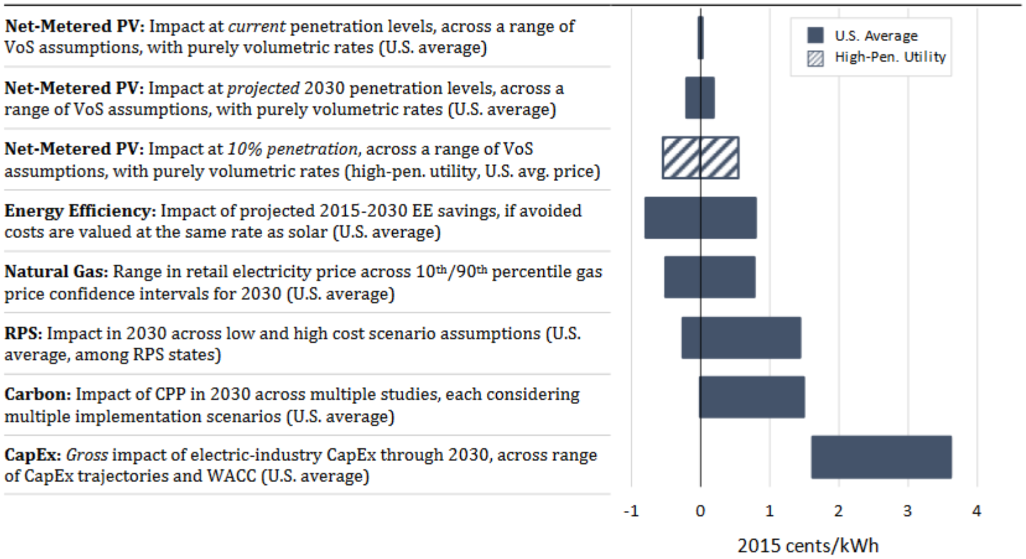
A follow up study, "Putting the Potential Rate Impacts of Distributed Solar into Context" by Lawrence Berkeley National Laboratory in January 2017, came to the same conclusions of very low costs to ratepayers from net metering billing mechanisms. This is shown in FIGURE 10, taken from this study:[58]

[56] Implemented at 52 PA Code Chapter 75, Subchapter B.

[57] Lawrence Berkeley National Laboratory, *Financial Impacts of Net-Metered PV on Utilities and Ratepayers: A Scoping Study of Two Prototypical U.S. Utilities*, September 2014.

[58] Lawrence Berkeley National Laboratory, *Putting the Potential Rate Impacts of Distributed Solar into Context*, (January 2017)

**Figure 10. Indicative ranges for potential effects on average retail prices**




*Notes: Current net-metered PV penetration equal to 0.4% of total U.S. retail electricity sales, as of year-end 2015. Projected 2030 net-metered PV penetration is 3.4%, based on Cole et al. (2016). VoS assumptions range from 50% to 150% of average cost-of-service. Please refer to the main body of the report for further details on how the ranges shown here were derived.*

## 3. FEDERAL TAX INCENTIVES

Since 2006, the federal Investment Tax Credit (ITC) has provided a credit against federal tax liability equal to 30 percent of the installed cost of solar installations. It applies to residential, commercial and utility investments. Homeowners take this credit when they pay for PV systems installed on their homes. A business or utility may take the credit if it installs, develops and/or finances a project. In 2020 the ITC drops to 26 percent and then to 22 percent in 2021. After 2021, the residential credit is eliminated but the commercial and utility credit will be set at 10 percent permanently. This is exactly when Pennsylvania's current solar requirement under the AEPS is set to reach its limit.

In addition to the investment tax credit for residential and commercial solar, businesses with sufficient tax liability can benefit from the Modified Accelerated Cost Recovery System (MACRS) depreciation schedule allowing depreciation over five years instead of the useful life of the property which may extend up to 35 years.

In addition to MACRS depreciation, in 2015 Congress extended a program of "bonus depreciation" allowing a higher percentage of qualifying capital investments to be depreciated in the first year after purchase, before reverting to the MACRS schedule thereafter. This allows a 50 percent bonus in 2017, 40 percent in 2018, and 30 percent in 2019 after which the program will phase out barring a further extension by Congress.

## 4. OTHER CURRENT POLICIES

**Act 129 Energy Efficiency:** In addition to AEPS, Pennsylvania has the “Act 129” program which requires the PUC to set cost-effective targets for both energy efficiency and peak demand reduction for qualifying utilities.[59] The EDCs then submit for approval program plans to the PUC showing how the targets will be achieved. While solar programs could be integrated into EDC plans, actual impacts are expected to be indirect with Act 129 influencing overall electricity consumption, peak demand, and the price of electricity.

**Pending Legislative and Regulatory Activity Effecting Solar**: This document is not attempting to catalog potentially relevant legislation introduced at the time of writing. But, the Project Team notes that there has been significant legislative interest related to renewable energy and energy efficiency in recent sessions. This includes the introduction of bills and/or holding of hearings related to utility ownership of generation and issues surrounding reliability and resilience. While the Project Team is not advocating for, or against, any of these bills, it also is not recommending that legislative activity on these issues be delayed pending the outcome of this project.

## C. RELIABILITY, RESILIENCE, AND GRID SECURITY

The Project Team recognizes there has been significant discussion nationally surrounding the related concepts of reliability, resilience, and grid security.

Reliability is the measure of whether electricity, sufficient to meet customer demand, is capable of being delivered. This can be presented as the percentage of customers experiencing an interruption, the percentage of time delivery is interrupted, the frequency of interruption or other metrics.[60]

Resilience "is the ability to reduce the magnitude and/or duration of [natural or man-made] disruptive events. The effectiveness of a resilient infrastructure or enterprise depends upon its ability to anticipate, absorb, adapt to, and/or rapidly recover from a potentially disruptive event."[61]

Grid security relates to both concepts as security failures, either cyber or physical, can result in disruption events.

One response to these concerns is to encourage smart-grid technologies that enable deployment of higher levels of distributed generation.[62] However, resilience has also been used as a justification for providing increased funding for selected classes of generation sources that would exclude solar energy.[63]

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[59] Act of Oct. 15, 2008, P.L. 1592, No. 129.
[60] See: IEEE, Standard 1366, IEEE Guide for Electric Power Distribution Reliability Indices, (2003).
[61] Dept. of Homeland Security, Critical Infrastructure Resilience, Final Report Recommendations. (Sept. 9, 2009).
[62] See Generally: U.S. Dept. of Energy, Solar Electric Grid Integration (SEGIS) projects.
[63] Grid Reliability and Resilience Pricing, FERC Docket No. RM18-1-000 (2017). (Terminated at 162 FERC 61,012).

# MODELING PENNSYLVANIA'S SOLAR FUTURE

Farm in Germansville, Lehigh County

The Project Team used several analytic approaches to help identify and sharpen questions related to *Pennsylvania's Solar Future*. These involved scenario modeling to examine the energy, economic, land use, and emissions impacts of solar development. The Project Team also used customer-perspective financial modeling, and complementary spreadsheet analyses to examine the viability of solar projects from the customer's perspective. The modeling and analyses help assess the need for financial incentives to spur the levels of growth needed to reach the targets.

Modeling helped inform stakeholder discussions by offering preliminary results and analysis to focus the conversation, and by providing a common frame of reference. The modeling helped answer stakeholder questions and prompted questions for further investigation and discussion. This is the purpose of the model, to help with understanding and discussion and to point to further work. Modeling the future is inherently uncertain. The model results do not predict the future, but that does not mean they are not useful.

This section of the report describes the modeling approach and software tools, the scenarios investigated, data sources, and results. More detailed information on each sub-section is provided in Appendix B.

This study does not consider solar only on its own, or even as an isolated element within the electricity system. Instead, the Project Team's investigations consider solar in the context of Pennsylvania's total energy system, across all fuel types and end uses. This approach is useful for examining issues such as emerging trends for electric vehicles and increasing the use of electricity for space conditioning. In many places, solar growth is complementary and related to emerging energy trends. The scenario modeling approach allows us to flexibly examine changes in energy patterns on both the supply and demand sides, including fuel switching and changes in end use efficiency.

The scenario modeling approach provides a flexible platform for considering these types of interactions and questions. The frame of the total energy economy also helps to keep the potential role of solar in perspective, in terms of Pennsylvania's total energy expenditures and investments.

The modeling used two different perspectives for economic analysis:

**Economic:** The Project Team used a high-level macroeconomic perspective to compare the scenarios' respective effects on the economy. This perspective helps inform economic policy and regulatory decisions. No individual or organization experiences the costs or benefits estimated in this way, but the results can be used to characterize the broader social costs and benefits of alternative-energy futures.

**Financial:** The Project Team also used customer-perspective microeconomic analyses to estimate the value of investing in solar energy, from the point of view of a home or business.

The customer-perspective financial analyses examine the need for incentives necessary for solar to be a good investment for the customer.

The Project Team used that estimated incentive to calculate the rate impact for all electric ratepayers.

These two approaches complement each other and help to answer questions related to the economic viability and impacts of meeting future solar targets. Individuals considering a solar investment will always use a financial analysis, but policy makers and regulators will need to be informed by a broader economic perspective, in assessing the costs and benefits of a growing solar market in the commonwealth.

Generally, it is helpful to consider both economic and financial results. In combination, they give a sense of how attractive solar will be for individual investors, and what levels of policy and regulatory strategies might be needed to support the market. Ultimately, the overall benefits to the State's economy, environment, energy security and equity are best considered through a combination of analyses and informed discussions.

## A. MODELING SOFTWARE AND METHODS

The Project Team used two primary software tools, one for each modeling perspective: The Long-range Energy Alternatives Planning system (LEAP; Stockholm Environment Institute) for economic analysis, and the System Advisor Model (SAM; National Renewable Energy Laboratory) for financial analyses. The Project Team also used NREL's Jobs and Economic Development Impact (JEDI) model to estimate job impacts. Using software tools that are publicly available allows interested stakeholders to review and conduct their own analyses.

### 1. ECONOMY-WIDE MODELING IN LEAP

LEAP is energy policy analysis software[64] designed to compare energy, economic, and environmental effects of alternative energy future scenarios. It is meant for total energy analysis at a relatively large scale but is flexible enough to be applied to different sectors and various levels of detail. The Stockholm Environment Institute has refined LEAP for more than 20 years. It has been used to conduct integrated energy and environmental planning in more than 190 countries.

[64] Heaps, C.G. 2016. *Long-Range Energy Alternatives Planning (LEAP) System*, version 2015.0.24. Somerville, Mass.: Stockholm Environment Institute (USA). https://www.energycommunity.org.

LEAP modeling typically begins with the development of a demand tree that represents energy demand by fuel across end uses and sectors within an economy. **FIGURE 11** offers an example of the residential portion of a demand tree structure. There are other branches with similar detail for commercial, industrial, and transportation. The Project Team used recent data to create “current accounts,” which then became the basis for projected changes in the Reference and Solar scenarios.

The Project Team entered current and projected energy use in the demand tree, across all its branches, to calculate the energy demand by fuel type and sectors. Examples of the type of information entered for each item in the tree are: the amount and type of energy used by end use devices, the level of demand for specific end uses, capital costs, and maintenance costs, and how all those change over time. The structure also reflects demographic and economic activity levels as “demand drivers”; examples are population, household size, value of industrial shipments, commercial employees, and vehicle miles traveled.

Once the demand for various types of energy is determined, LEAP calculates the necessary resources to meet that demand—for example, effects such as transmission losses and availability of generation resources. In this model, LEAP is using 24 time slices for supply and demand analysis: day and night in each month.

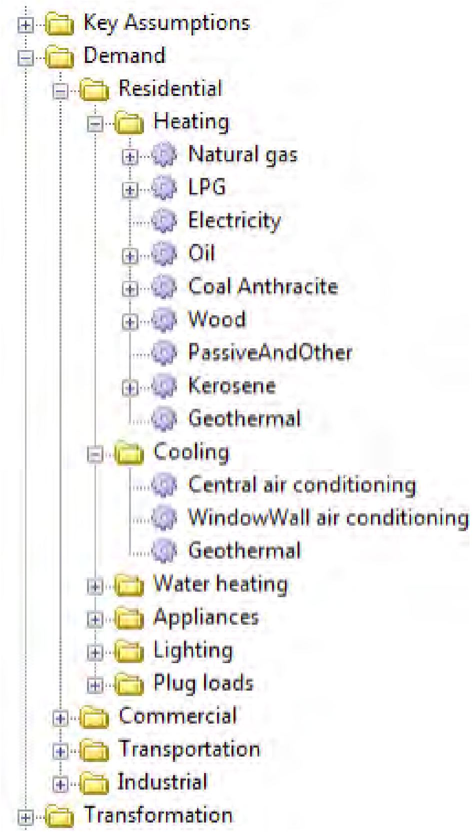
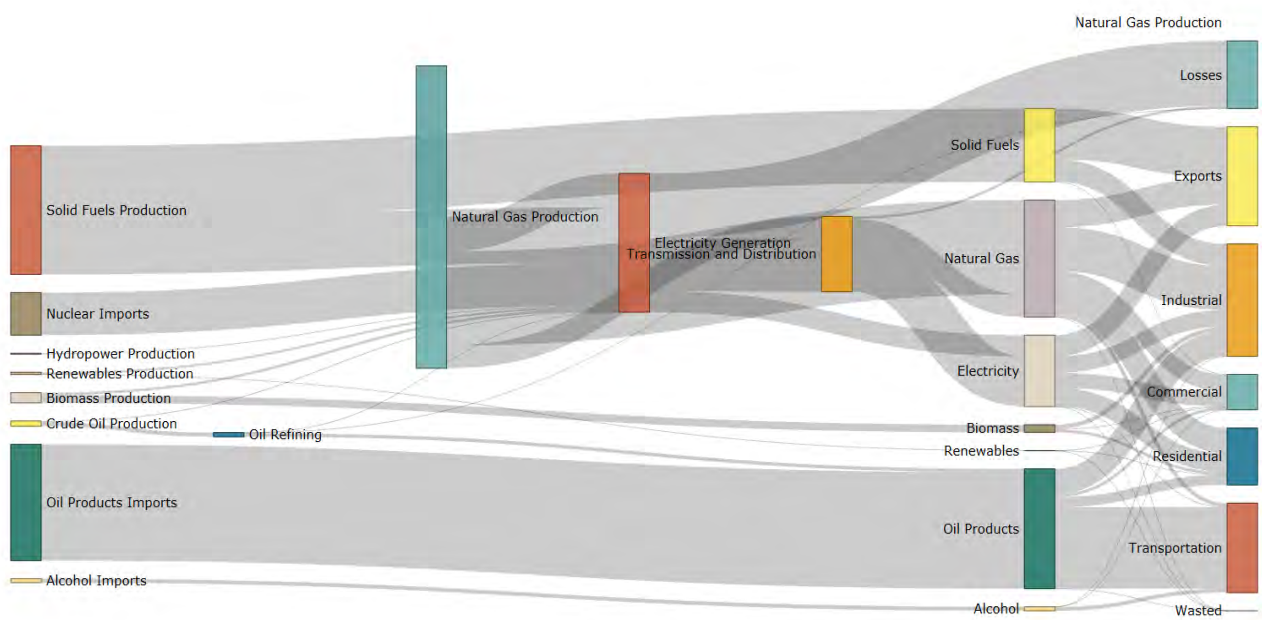



**Figure 11. Demand tree structure of LEAP expanded to show residential space**

**FIGURE 12** shows energy flow in LEAP. Fuel resources at the left move through one or more transitions to serve end uses or end up as losses, at the right. This example is from 2030 in one of the solar scenarios.

**Figure 12. A Sankey diagram of how LEAP uses energy resources to meet total energy demand**




## 2. CUSTOMER-PERSPECTIVE FINANCIAL MODELING IN SAM

For the customer-perspective financial analysis, the Project Team used SAM. NREL describes it as follow:

> *SAM is a computer model that calculates performance and financial metrics of renewable energy systems. Project developers, policymakers, equipment manufacturers, and researchers use SAM results to evaluate financial, technology, and incentive options for renewable energy projects. SAM simulates the performance of photovoltaic, concentrating solar power, solar water heating, wind, geothermal, biomass, and conventional power systems. The financial model can represent financial structures for projects that either buy and sell electricity at retail rates (residential and commercial) or sell electricity at a price determined in a power purchase agreement (utility). SAM's advanced simulation options facilitate parametric and sensitivity analyses…NREL provides both SAM and the SDK as free downloads at http://sam.nrel.gov.*[65]

SAM allowed the Project Team to simulate cash-flows for solar projects from the perspective of the owner or financer. These simulations helped estimate incentives necessary for projects to achieve reasonable returns. SAM's advanced analytic capabilities allow the Project Team to consider project financial results across location, scale, capital cost, and incentive level.

## B. OVERVIEW OF SCENARIOS

Scenarios are self-consistent story lines of how an energy system might evolve. The term *self-consistent* indicates that energy supplies are sufficient to meet energy demands, including exports and imports.

[65] NREL. 2014. *System Advisor Model, SAM 2014.1.14: General Description*. https://www.nrel.gov/docs/fy14osti/61019.pdf.

Fundamental economic and demographic drivers can be varied but are also kept consistent when comparing one scenario with another. Scenarios are based on user definition and therefore can analyze and compare a wide range of possible energy futures.

For this study, the Project Team used the LEAP system to create scenarios that reach 10 percent of total retail sales in Pennsylvania from in-state solar power generation by 2030. This goal was proposed to the Department of Energy and discussed extensively with stakeholders during the early meetings. After conducting and refining analyses for more than a year, the Project Team continues to consider the 10 percent by 2030 target to be both ambitious and achievable. The three primary scenarios analyzed in this study are Reference, Solar A, and Solar B.

The Reference scenario is "business as usual" and provides a baseline for comparison. It starts with current energy use and projections, and assumes increases in vehicle efficiency, because of Corporate Average Fuel Economy (CAFE) standards, and energy efficiency as mandated by Act 129 and continuing that pace of efficiency beyond the Act 129 period.

In the Reference scenario, electricity generation also continues current trends. That is, solar grows to meet the Alternative Energy Portfolio Standards (AEPS) carve out, and non-solar Tier I resources and Tier II resources grow at today's proportions to meet AEPS requirements.[66] The mix of fuels used for non-electric purposes does not change over time.

Solar A and Solar B articulate two different pathways for achieving the 10 percent target. The energy consumption in each solar scenario is the same as in the reference scenario. Solar A assumes an emphasis on distributed solar, with 35 percent of 2030 solar capacity distributed (half each from commercial and residential customer classes) and 65 percent is grid scale solar. In the Solar B scenario, distributed generation makes up only 10 percent of total solar capacity (again, half each from commercial and residential), and grid scale is the other 90 percent. Both scenarios require radical growth in grid scale solar.

Solar A also requires significant growth in commercial and residential solar, which would spread the direct benefits of solar among more Pennsylvanians. However, it would also require significant attention to and investment in market design and effective solar deployment.

Table 8 compares the assumptions for each scenario.

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[66] Pennsylvania Public Utility Commission, "2015 Annual Report: Alternative Energy Portfolio Standards Act of 2004," Tables 1 and 8, http://www.puc.state.pa.us/Electric/pdf/AEPS/AEPS_Ann_Rpt_2015.pdf.

**Table 8. Comparison of the basic assumptions of each primary scenario**

| | Reference | Solar A | Solar B |
|---|---|---|---|
| Target for in-state solar | 0.5% by 2020 | 10% by 2030 | 10% by 2030 |
| Total solar capacity in 2030 | 1.2 GW | 11 GW | 11 GW |
| Distributed capacity in 2030 | 0.6 GW | 3.9 GW (35% of total)<br>½ residential<br>½ commercial | 1.1 GW (10% of total)<br>½ residential<br>½ commercial |
| Grid scale capacity (>3MW) in 2030 | 0.6 GW | 7.1 GW (65% of total) | 9.9 GW (90% of total) |
| AEPS | Assumes AEPS and efficiency trends continue support beyond 2020 | | |
| Federal Investment Tax Credit (ITC) | Modeled as a reduction in capital cost. Phased out for residential in 2021 and non-residential in 2023. | | |

### 1. ADDITIONAL SCENARIOS

The Solar A and Solar B scenarios are two paths for reaching 10 percent solar electricity by 2030. The Project Team encouraged stakeholders to consider alternatives that would be worthy of investigation. Many stakeholders supported the following additional scenarios to examine how they interact with solar and how they affect the energy, emissions, and cost results:

- Electrification: More electric vehicles (EVs) and heat pumps
  - 600,000 EVs and 18 percent of residential heat/air conditioning by 2030
- 10 Percent Wind: Wind meets 10 percent of electricity needs by 2030
- High Efficiency: 2 percent electricity savings and 0.5 percent natural gas savings per year
- Solar 8 Percent and Solar 12 Percent targets
  - Created from Solar A and B, by combining the lower of distributed and Grid Scale from A and B for 8 percent, and the higher of each for 12 percent

Results for these alternative scenarios are in Appendix B.

## C. DATA SOURCES USED TO BUILD PENNSYLVANIA'S SOLAR FUTURE SCENARIOS

The Project Team collected data from publicly available state level and national sources. Information on sources and assumptions in this report and in stakeholder meeting presentations was used to summarize the modeling inputs and assumptions, and to convey a general sense of the approach and level of depth and rigor of the modeling. Appendix B contains detailed tables of LEAP and SAM model inputs and outputs. The important iterations of the LEAP model will also be retained and available for review using LEAP software, which may be downloaded and used in read-only mode for free.[67] The Project Team's approach has been a transparent one about inputs or assumptions and involves balancing the need for detail with the risk of overwhelming, confusing, or boring stakeholders.

## 1. ENERGY DEMAND AND SUPPLY PROJECTIONS

To build the models, the Project Team drew historic information and projections from state and federal sources:

- Employment data and projections from the Pennsylvania Department of Labor and Industry;
- Population and housing data from the U.S. Census American Community Survey;
- Population projections from the Center for Rural Pennsylvania;
- Residential energy characteristics from Residential Energy Consumption Survey 2009;
- Transportation data from Pennsylvania Highway Statistics 2015;
- Fuel costs and transportation projections from the U.S. Energy Information Administration's (EIA's) *Annual Energy Outlook 2017;*
- Commercial and industrial activity from the Pennsylvania Department of Labor and Industry;
- Demand by fuel from EIA's State Energy Data System 2014;
- Electricity consumption projections, by utility, from the 2017 PJM Forecast, which the Project Team extrapolated to 2030;
- Energy supply and generation data and projections from the AEPS *2015 Annual Report*, Commonwealth Economics 2013, Pennsylvania *Comprehensive Energy Analysis*, the Pennsylvania Department of Environmental Protection, the Pennsylvania Bureau of Mining Programs, and the EIA *State Energy Profile,* tables 4, 5, 8, and 10;
- Existing in-state solar capacity from the AEPS database, as of January 2018;
- Generation capacity factors and operations and maintenance costs: NREL 2017 Annual Technology Baseline; and
- Solar prices transition from Pennsylvania-specific data from Open PV toward national projections from the NREL 2017 Annual Technology Baseline.

The Project Team completed the initial draft of the energy system model in LEAP within six months of project start. Stakeholders made suggestions and corrections through meetings, written communications, and webinars, and by commenting on draft documents. The final inputs and assumptions for both LEAP and SAM models benefited significantly from this review, and from iterative process for refining the models.

## 2. COSTS

The Project Team used costs in the models to estimate the investment required to reach 10 percent solar, to estimate the resulting change in annual energy spending, and to evaluate project financials. The models looked at: capital investment in new generation that is added during the model timeframe, grid upgrades required to host additional renewables, the cost of fuels at their end uses (such as gasoline or

[67] See https://www.energycommunity.org to download.

heating oil) and in power plants, and operations and maintenance expenses for at-end uses, renewable generation, and at power plants. The sources and assumptions for cost projections are:

- Electric generation capital and operation and maintenance (O&M) current costs and projections are from NREL's Annual Technology Baseline (ATB).[68]
- Solar capital investment prices start with Open PV data for Pennsylvania and transition to projected national prices from NREL.

## 3. SOLAR COSTS AND GENERATION ASSUMPTIONS

Current solar costs are based on Pennsylvania data in Open PV, and transition to national averages in the National Renewable Energy Lab's 2017 Annual Technology Baseline (ATB). Capital costs for other energy types and O&M costs for all generators are from the ATB's "Mid-cost" case. Capital costs for other energy types and O&M costs for all generators are from the ATB's "Mid-cost" case.

**Table 9. Comparison of the basic assumptions of each primary scenario**

| | Residential | Commercial | Grid scale |
|---|---|---|---|
| Capacity factor (DC / AC, %) | 14% | 12% | 16% |
| (kWh / kW / year) | 1,205 | 1,091 | 1,433 |
| Capital cost ($ / kW) | | | |
| 2018 w/o incentive | 2,989 | 2,481 | 1,373 |
| 2018 w / ITC, tariff | 2,281 | 1,931 | 1,125 |
| 2030 (ITC gone) | 1,547 | 1,171 | 958 |
| O&M 2018 ($ / kW·year) | 20 | 15 | 12 |

The Lawrence Berkeley National Laboratory (LBNL) *Tracking the Sun 10* report (2017) shows solar prices in Pennsylvania to be near the national average, especially in years (2010-2013) when more capacity was installed. The Project Team's model inputs reflect premium system pricing currently in Pennsylvania, which is to be expected, given the slower relative pace of solar market development in Pennsylvania in the last several years. Prices are expected to move down to the national average, as installations increase to meet the 10 percent target.

Grid integration costs are based on a meta-analysis of integration cost studies.[69] Costs for individual feeders vary widely, so the extent to which solar can be guided toward more robust feeders can greatly influence the total grid upgrade cost. Given this variability, the same integration cost was assigned to all the solar scenarios, despite the 8 to 12 percent range. The scenarios with more solar cost more because the cost was entered into the model per MWh of solar output for the years when solar is growing. Once

[68] NREL (National Renewable Energy Laboratory). 2017. *2017 Annual Technology Baseline*. Golden, CO: National Renewable Energy Laboratory. http://atb.nrel.gov/.

[69] Synapse, 2015, "A Solved Problem: Existing measures provide low-cost wind and solar integration," http://www.synapse-energy.com/sites/default/files/A-Solved-Problem-15-088.pdf

the 10 percent goal is met in 2030, the Project Team assessed no further integration costs, since the levels of solar stop growing in the model.

Appendix B offers more details about the LEAP scenario modeling and other analyses, and their data inputs, providing documentation on the sources and assumptions used in assessing *Pennsylvania's Solar Future* targets.

# PENNSYLVANIA'S SOLAR FUTURE MODELING RESULTS

March 8, 2018, Stakeholder Meeting, Pittsburgh

The Project Team used quantitative analysis to investigate questions related to the requirements and feasibility of reaching the 10 percent by 2030 solar target. This section presents the main results, addressing the following questions:

- How much solar installed capacity is required to provide 10 percent of Pennsylvania's internal electric demand with in-state solar generation by 2030?
- What is the mix of project types (residential and commercial rooftop or ground-mounted systems) that could be used to meet the target?
- What rates of growth by project type are required?
- Is it likely that the individual project financial returns will make these levels of growth viable?
- From the State's perspective, what are the broader economic costs and benefits of meeting the targets?
- What are the potential job impacts of obtaining the targets?
- What are the land use, siting, environmental emissions, and grid integration impacts?
- How would alternative energy development scenarios, including higher levels of efficiency or greater electrification, affect the solar target results?

Over the course of five formal stakeholder meetings, webinars, and working group conversations, the Project Team has used draft and revised model outputs to inform discussion on these topics. This section summarizes the Project Team's modeling results, addressing these questions. Appendix B presents additional details on the modeling and results.

## A. GROWTH REQUIRED TO MEET 10 PERCENT BY 2030

In the three primary scenarios, energy demand remains roughly level during the study period. Electricity demand also maintains a stable share of total energy demand, representing roughly 17 percent of total energy needs. In 2030, total retail electric sales are estimated to be 150.4 TWh. To meet the 10 percent retail electric sales from in-state solar, Pennsylvania must install enough solar to provide 15 GWh of electricity annually by 2030. Given capacity factors between 12 percent and 16 percent for different types of systems, Pennsylvanians must install 11 GW of solar energy by 2030 to meet this goal (**TABLE** 10).

**Table 10. Total energy needs, electricity needs, and the necessary response from the Solar A and Solar B scenarios in meeting those needs**

| Total energy[70] | | Electricity | Solar A and B | | |
|---|---|---|---|---|---|
| Total energy demand (TBtu) | | Electricity demand (TWh) | Solar generation (TWh) | Share of electricity from solar | Installed capacity (GW) |
| **2015** | 2,930 | 146.9 | 0.3 | 0% | 0.2 |
| **2020** | 2,995 | 148.8 | 2.7 | 1% | 2 |
| **2025** | 2,994 | 150 | 6.8 | 5% | 5 |
| **2030** | 2,965 | 150.4 | 15.0 | 10% | 11 |

## 1. GROWTH IN SOLAR

The growth curves required to meet the 10 percent target are the same for both the Solar A and Solar B scenario. The difference between the scenarios lies in the mix of the type of solar used to meet the target. The growth curve required to meet the 10 percent solar target **FIGURE 13** illustrates the need for rapid and continued growth throughout the study period.

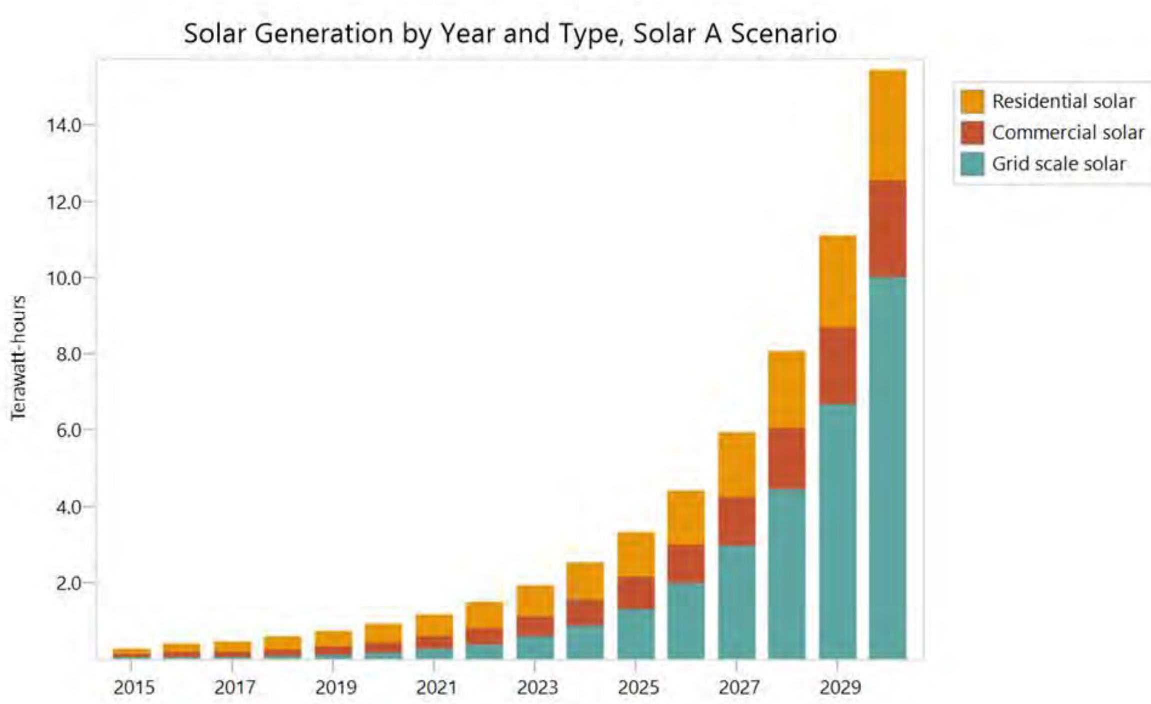


**Figure 13. Solar generation under the Solar A scenario, by year and type.**

[70] See Appendix C for more information on primary and final energy demands modeled in the scenarios.

## 2. DIFFERENCES BETWEEN SOLAR A AND SOLAR B SCENARIOS

Although both the Solar A and Solar B scenarios meet the 10 percent target, they use a different mix of solar resources. Solar A contains 35 percent of the generation from distributed (mostly rooftop) solar, whereas Solar B has a lower level 10 percent of distributed solar. In both cases, most of the new solar development is grid scale solar that is connected directly to the transmission and distribution system, rather than behind the customer meter. The following graphic represents the different levels and mix of installed solar capacity in 2030 between the three primary scenarios.

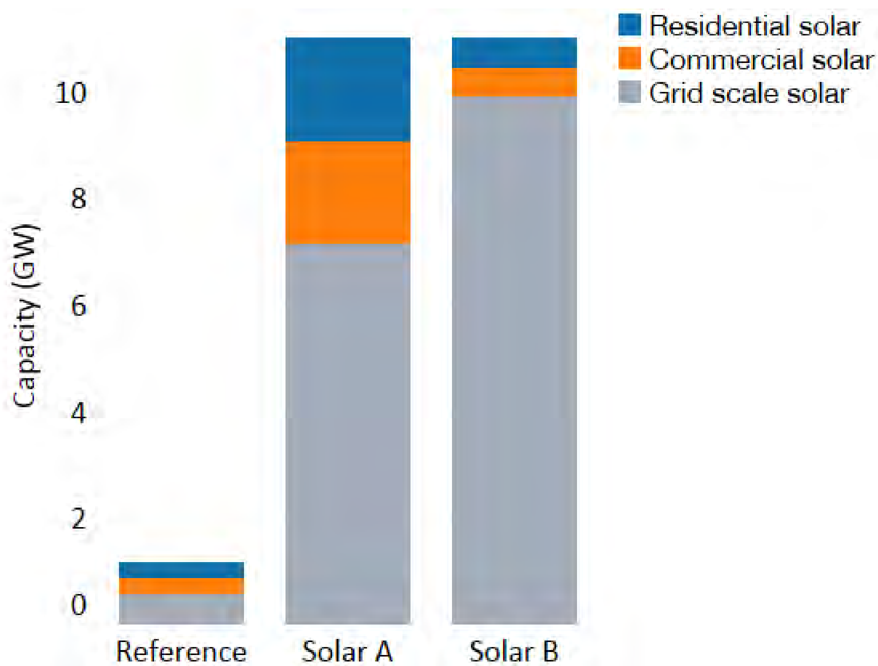


**Figure 14. 2030 Solar Capacity by Scenario**

Stakeholder discussions tended to support the anticipated larger contribution to the required growth from grid scale solar represented by both Solar A and Solar B scenarios.

While there are good reasons to expect a large contribution from grid scale systems, it is also worth noting that even residential rooftop solar has the technical potential to meet virtually all the target, and that cost reductions in time of replacement and new construction could mean this segment could see significant growth. Recent research conducted by the National Renewable Energy Laboratory[71] estimates the annual technical potential for residential rooftops (considering at time of roof-replacement and new construction) in Pennsylvania is 942 MW. This research indicates that the residential time of roof replacement and new construction markets alone, are sufficient to meet the 10 percent target. Further the researchers identify pathways whereby costs for residential rooftop systems could decline dramatically by 2030, dropping from a benchmark of 15.1 cents per kWh in 2017

[71] Kristen Ardani, Jeffrey J. Cook, Ran Fu, and Robert Margolis. 2018. *Cost-Reduction Roadmap for Residential Solar Photovoltaics (PV), 2017-2030.* Golden, CO: National Renewable Energy Laboratory. NREL/TP6A20-70748.

to a range of 5 to 8.1 cents per kWh by 2030. These findings illustrate that multiple market pathways and resources are available and may emerge as Pennsylvania's solar markets evolve.

### 3. PACE OF SOLAR GROWTH

Another question investigated by the Project Team was how reasonable it is to expect the solar industry to meet the pace of growth associated with meeting the solar target. The solar industry, globally, nationally, and in Pennsylvania has seen exponential growth. For example, **TABLE 11** presents a seven-year historic compound annual growth rate (CAGR) in Pennsylvania, and a four-year CAGR that covers more recent years with slower installation rates, and the projected rates to meet each solar scenario target.

The seven-year historic CAGR for distributed solar is higher than solar scenarios require. However, the four-year growth rate is closer to the projected rates required to meet the targets, and it would need to be sustained for the next twelve years to meet the targets.

**Table 11. Solar capacity annual growth rates, to date and required in the scenarios to meet the 10 percent target**

| | Residential | Commercial | Grid Scale |
|---|---|---|---|
| 2010-2017 CAGR | 29% | 33% | 30% |
| 2013-2017 CAGR | 22% | 7% | 3% |
| Solar A | 20% | 17% | 33% |
| Solar B | 11% | 5% | 35% |

Grid scale solar would need to maintain a growth rate higher than it has averaged in the past to reach the target. In certain years, grid scale solar has grown more quickly in Pennsylvania, and other markets around the country have seen sustained growth well above the rates required by the solar scenarios.

In both solar scenarios, grid scale grows faster than distributed solar. This is because, Pennsylvania, like other nascent solar markets, has much more distributed solar installed today than grid scale. The solar scenarios have quick growth in grid scale because that sector has driven the growth in most states with more mature solar markets. Under either solar scenario, changes will be required to accelerate grid scale growth.

## B. CUSTOMER-PERSPECTIVE FINANCIAL ANALYSIS

Another important topic investigated by the Project Team is the financial viability of various types of solar projects in Pennsylvania, given current and projected future market conditions. **TABLE 12** presents an overview of the financial modeling results for different markets, system types and years in the study horizon.

The results suggest that the financial returns to projects are expected to be favorable. Each case presented below has a positive net present value over the expected system lifetime. They also have expected simple paybacks (for the customer sited systems) of close to 10 years or less, even when there is not an SREC incentive.

The Philadelphia 2020 residential system and the Mid-State grid scale 2025 system also have estimated project financials based on some additional incentives. For the residential system this is a solar renewable energy credit (SREC) of $30 MWh for 10 years. For the grid scale system, a tariff of $110 MWh with a 1.9 percent annual escalation was examined, which represents a premium above market level wholesale prices. The feasibility of these levels of incentives are examined later in this section. The Project Team notes that the incentives that may be required are rather modest based on the favorable customer financial returns.

**Table 12. Costs and values of three types of solar installation, with goals for three regions in Pennsylvania**

| Market / Year | Type | Installed Cost | Tax Incentives | SREC or Tariff $/MWh | Simple Payback Yr. / IRR | Net Present Value |
|---|---|---|---|---|---|---|
| **Philadelphia 2020** | Residential rooftop | $2.64/Watt | ITC | $0 | 11.3 yr. | $4,398 |
| | | | | $30 | 9.8 yr. | $5,295 |
| **Mid-State 2025** | Grid scale | $1.10/Watt | MACRS<br>No ITC | $110 w 1.9% annual escalation | 9.51% | $532,814 |
| **Pittsburgh 2030** | Commercial rooftop | $1.18/Watt | MACRS<br>No ITC | $0 | 8.2 yr. | $186,420 |

Further details on the System Advisor Modeling, including parametric results which examine the impact of varying incentives and system costs are presented in Appendix B.

## C. RESOURCE SAVINGS FROM REACHING THE SOLAR TARGET

The prior analyses examined the levels of solar growth required to meet the target, and whether considering historic growth rates, and customer financial perspectives the levels of growth were reasonably attainable. Next, the Project Team analyzes the resources that are likely to be saved by increased solar generation, including fuel and operations and maintenance savings from coal and natural gas fired electric plants.

The Solar A and Solar B scenarios both reduce a similar mix of conventional generating resources to similar levels. Increasing solar generation displaces fossil fuels typically used for electric generation. In Pennsylvania, this includes coal, oil, and natural gas. **FIGURE 15** illustrates the difference in electricity generation by fuel between the reference and solar scenarios. In the Solar A and B scenarios, as compared to the Reference scenario, coal and natural gas decrease over time, replaced by solar.

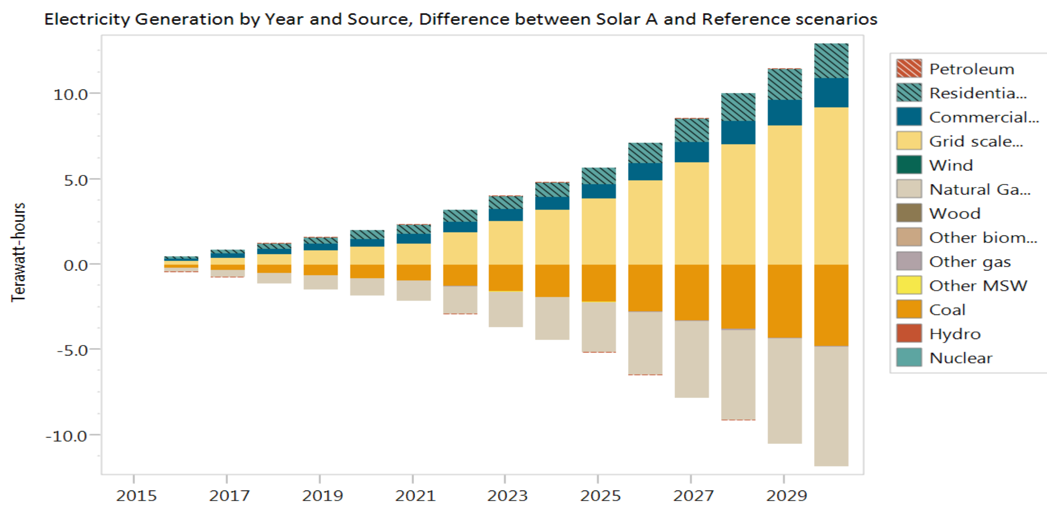


**Figure 15. Electricity generation by fuel, solar scenarios vs the Reference case**

Looking at the overall mix of generation used to meet total demand the wedge on top illustrates the growth of solar in the total mix (**FIGURE 16**). All scenarios include coal generating capacity declining at 2.1 percent per year until 2030, and nuclear capacity stepping down 819 MW in 2020. These were reasonable inputs at the time the model was built, but the electricity system is evolving rapidly. If additional analysis is performed, these numbers should be updated to include more recent changes including the potential closure of the Beaver Valley nuclear plant. In the solar scenarios, the additional solar generation displaces coal and natural gas generation equally.

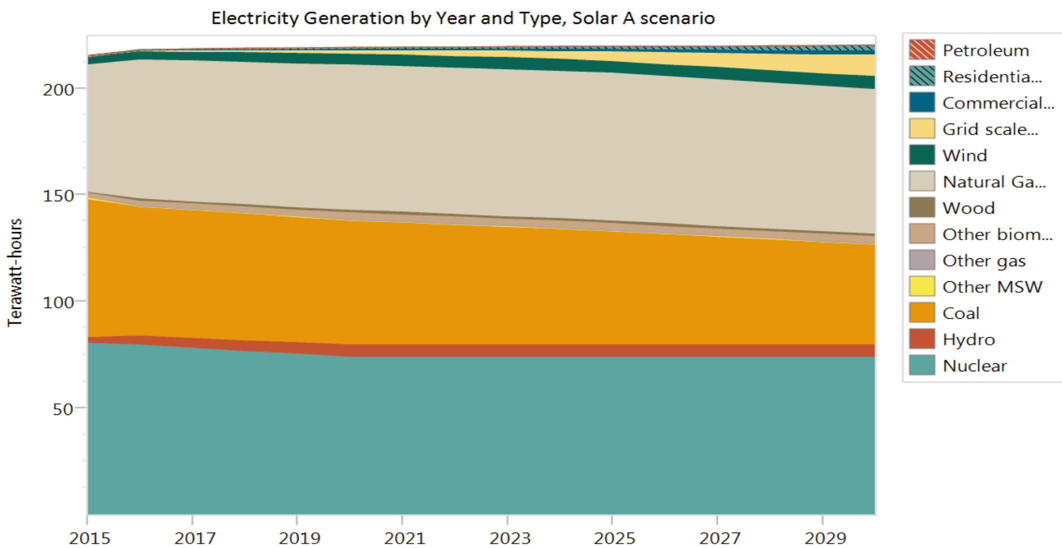


**Figure 16. Electricity Generation by Source**

The electricity generation profile represented in Figure 16 is based on Pennsylvania continuing as a significant exporter of electricity. As noted earlier, the projected in-state demand for electricity in 2030 is 150 TWh, and the growth in Pennsylvania-based solar generation associated with the Solar A and Solar B scenarios meets 10 percent of the projected in-state demand.

## D. ECONOMY-WIDE EFFECTS OF THE SCENARIOS

The economic results consider the large-scale impacts to the statewide economy. Compared to the Reference scenario, the solar scenarios have higher investments in solar generation and in the transmission and distribution grids to increase hosting capacity and integrate more intermittent renewable resources. Savings from the solar scenarios come from the reduced fuel use and variable O&M costs in fossil fuel power plants. If adding solar avoids the need for new capacity, there would also be capacity savings equal to the avoided capacity cost of the unnecessary plants. However, for this to happen, either PJM capacity market rules or solar performance will need to change. In addition, to the extent that solar can provide ancillary services such as voltage support, it will accrue additional revenues and, possibly, slightly reduce capacity prices. Small scale solar will create some capacity market savings through net demand reduction but that effect, along with other market services, is uncertain and likely small at this scale, so it was not included.

In this section, the results are relative to the costs under the Reference scenario, or business as usual. So positive numbers represent additional costs, while negative numbers represent savings.

**TABLE 13** summarizes the economic results over the analysis period. The present value of the additional investments over the period are $10.2 to $11.7 billion. These are offset by roughly $2.4 billion in fossil fuel savings. The net present value of the investments for Solar A and B are respectively $9.3 billion and $7.8 billion more than the reference case, representing higher investments than the reference.

**Table 13. Economy-wide net present value (NPV) of the investments of Solar A and Solar B scenarios, relative to the Reference Scenario, excluding externalities, billion 2017 USD, 1.75 percent real discount rate[72]**

| | Spending or (Savings) | |
|---|---|---|
| | **Solar A** | **Solar B** |
| Grid upgrades | 0.1 | 0.1 |
| Electricity generation | 11.6 | 10.1 |
| Fuel costs | -2.5 | -2.5 |
| Externalities | not included | |
| **NPV (economy wide)** | **9.2** | **7.7** |
| Cost of avoided GHG ($/Ton CO2e) | 29 | 25 |

Over 15 years the Solar A and Solar B scenarios have average net annual economic costs ranging from $513 million to $613 million. These estimates represent the lifetime costs and savings associated with the solar capacity in each scenario compared to the Reference scenario. One way to put this level of net economic costs into context is to consider that Pennsylvania's annual energy expenditures are roughly $45 billion. Therefore, over the 15-year study period the investments required for the solar scenarios are 1.2 percent to 1.4 percent above current energy spending.

The Project Team suggests the finding that being able to reach Pennsylvania's solar energy target with net economic costs that are less than 1.5 percent of total annual energy expenditures, indicates the solar transition is economically viable. To illustrate this point, **FIGURE 17** presents historic increases and volatility in Pennsylvania's total cost of energy expenditures.[73] In this figure, non-electric fuels are represented by the bottom orange segment, and electric expenditures by the second grey colored segment. On top of these two, the Project Team has inserted the small yellow colored segment, visually representing what a net economic cost of $613 million per year would look like in comparison to total energy expenditures.

[72] Real discount rate chosen to be below the 10-year Treasury bill. Discussion of this choice is in Appendix A. Adapted from: Regulatory Assistance Project & Synapse, *Energy Efficiency Cost-Effectiveness Screening*, http://www.synapse-energy.com/sites/default/files/SynapseReport.2012-11.RAP_.EE-Cost-Effectiveness-Screening.12-014.pdf

[73] Energy Information Administration, State Energy Data Sets.

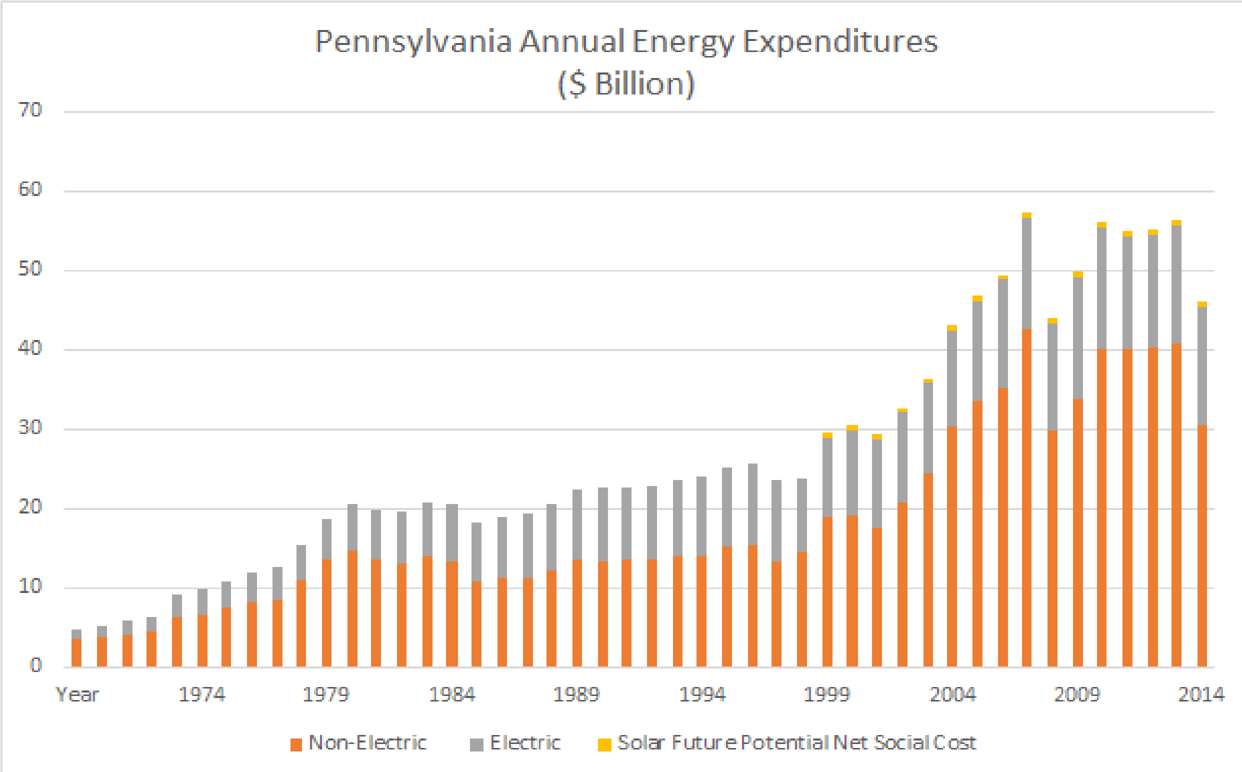


**Figure 17. Pennsylvania's annual energy expenditures, 1971 – 2015**

## E. ECONOMY-WIDE EFFECTS INCLUDING ENVIRONMENTAL COST ESTIMATES

The results in **TABLE 13** ignore any cost or impact of air pollution, local, regional, or global. As discussed in the Modeling Inputs section of Appendix B, these effects can be included in economic modeling based on the damage the pollutants cost to society, or the cost of compliance that markets have shown emissions can be reduced for. **TABLE 14** shows the net present investments when including the effect of externalities priced both ways.

**Table 14. Economy-wide 2015-2030 cumulative net present value (NPV) of the investments of Solar A and Solar B scenarios, relative to the Reference Scenario, including externalities, billion 2017 USD, 1.75 percent real discount rate[74]**

| | Spending or (Savings) | | | |
|---|---|---|---|---|
| | With damage-based externality costs | | With compliance externality costs | |
| | **Solar A** | **Solar B** | **Solar A** | **Solar B** |
| Grid Upgrades | 0.1 | 0.1 | 0.1 | 0.1 |
| Electricity Generation | 11.6 | 10.1 | 11.6 | 10.1 |
| Fuel Costs | -2.5 | -2.5 | -2.5 | -2.5 |
| Externalities | -34.4 | -33.8 | -0.9 | -0.9 |
| **NPV (economy wide)** | **-25.2** | **-26.2** | **8.3** | **6.8** |

These results show that when accounting for damages to health and the environment, the Solar A and Solar B scenarios both have net economic benefits in excess of $25 billion over the study period, or more than $1.6 billion of net economic benefit annually. Estimates of environmental externality costs based on compliance costs results in $900 million of additional economic benefits over the study horizon, equivalent to $60 million per year.

The large differences in the economic benefit cost results between the analyses with no externality costs, compliance-based costs, and damage-based costs suggests that current market and regulatory conditions for internalizing the costs of environmental impacts may be falling short of reflecting the long-term societal costs and benefits from reduced emissions.

## F. ESTIMATING INCENTIVES

The customer financial analysis comparison presented above suggests that some incentives, such as SRECs for the net metered rooftop market, or a long-term tariff for grid scale projects may be required to sufficiently increase market activity. The stakeholder meetings discussed the importance of estimating the possible need for incentives and considered how these might impact utility rates, if as is

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[74] Real discount rate chosen to be below the 10-year Treasury bill. Discussion of this choice is in Appendix B. Adapted from: Regulatory Assistance Project & Synapse, *Energy Efficiency Cost-Effectiveness Screening*, http://www.synapse-energy.com/sites/default/files/SynapseReport.2012-11.RAP_.EE-Cost-Effectiveness-Screening.12-014.pdf

common practice any such incentives would be recovered from ratepayers. As the market grows and costs continue to decline it is reasonable to expect the need for incentives will be reduced.

## 1. SREC SUPPORT FOR RESIDENTIAL ROOFTOP INSTALLATIONS

The Project Team investigated the potential impacts of two possible incentive mechanisms. The first looked at estimating what level of SREC value would provide a residential rooftop customer in Philadelphia with an expected 10-year simple payback in 2025. **TABLE 15** illustrates the values used in this analysis and the resulting SREC value of $58/MWh. The required SREC value is higher than the $30 SREC value estimated in the financial analysis section above, due to the expiration of the federal investment tax credit in this 2025 analysis.

**Table 15. Potential rate impact of SREC incentive, assuming no Federal Investment Tax Credit and 3.75 percent discount**[75]

| | Value |
|---|---|
| Residential installation cost of PA ($/W) | $2.50 |
| PV system size (kW) | 7.5 |
| Total installation cost | $18,750 |
| Assumed solar generation factor (kWh/kW/year) | 1200 |
| Projected annual solar generation (kWh) | 9,000 |
| Assumed full retail electric rate ($/kWh) | 0.15 |
| Annual electric bill savings | $1,350 |
| Assumed SREC life = target payback (years) | 10 |
| Annual SREC payment for payback target | $525 |
| SREC price to achieve target payback ($/SREC) | $58 |
| Customer's NPV after 20 years | $7,000 |

To estimate the potential magnitude of the rate impact from this level of SREC prices, the Project Team analyzed the total cost for SRECs required if customer-sited systems eligible for SREC incentives of $58/MWh account for 35 percent of the proposed 4 percent AEPS goal. This is consistent with the Solar A scenario profile (TABLE **16)**.

[75] Real discount rate chosen to be below the 10-year Treasury bill. Discussion of this choice is in Appendix B. Adapted from: Regulatory Assistance Project & Synapse, *Energy Efficiency Cost-Effectiveness Screening*, http://www.synapse-energy.com/sites/default/files/SynapseReport.2012-11.RAP_.EE-Cost-Effectiveness-Screening.12-014.pdf

**Table 16. Total cost for SRECs under the Solar A scenario profile for the distributed generation portion by 2025**

| | Value | Comment |
|---|---|---|
| 2025 PA electric sales (MWh) | 150,000,000 | MWh |
| 2025 solar share requirement | 4% | |
| SREC eligible portion of solar market | 35% | |
| SREC requirement | 2,100,000 | |
| Calculated SREC price | $58 | See previous table |
| Total incentive cost for SRECs | $121,800,000 | |
| Cost per unit for SRECs ($/kWh) | $0.00081 | |
| | | |
| Typical PA residential customer electricity use | | |
| Use per year | 10,000 | kWh/year |
| Use per month | 833 | kWh/month |
| | | |
| Residential bill impact for SREC | | |
| Cost per year in 2025 | $8.17 | |
| Cost per month in 2025 | $0.68 | |

## 2. TARIFF SUPPORT FOR GRID SCALE INSTALLATIONS

Regarding the remainder 65 percent of grid scale solar installation under Scenario A, the Project Team reviewed modeling prepared by the Mid Atlantic Solar Energy Industry Association (MSEIA). Based on calculating the potential impacts from a grid scale tariff starting at $0.1168/kWh, with 2.425 GW of capacity installed by 2025 under such a tariff, the estimated impact of the grid scale solar penetration part on an average residential bill for the extra costs of the tariff above estimated wholesale market values is $1.08 per month or rounded to .0013 cents per kWh.

The analyses of both types of incentive – SREC payments for 35 percent solar distributed generation and tariffs for 65 percent grid scale solar, and the potential rate impacts suggest electric bill impacts will be modest, at less than $2 per household per month (i.e., $0.68 + $1.08 = $1.76/month).

The incentives and possible rate impacts do not appear in economic analyses because the full price of the solar capacity investments is shown without distinguishing how much is invested by the project owner compared to rate-based or otherwise shared.

## G. ESTIMATING IMPACTS

### 1. JOBS

Job impacts of the solar scenarios were estimated using NREL's Jobs and Economic Development Impact (JEDI) model.[76] **TABLE 17** shows some of the assumptions. Combined with the itemized cost for solar installation and maintenance, the JEDI model uses economic input output analysis to provide an estimate of how much of the investment in solar recirculates within the Pennsylvania, supporting local businesses and jobs.

**Table 17. Assumptions for the Jobs Model**

| Installation Costs | Purchased | Manufactured |
|---|---|---|
| **Materials & Equipment** | Locally (%) | Locally (Y or N) |
| **Mounting (rails, clamps, fittings, etc.)** | 60% | N |
| **Modules** | 30% | N |
| **Electrical (wire, connectors, breakers, etc.)** | 95% | N |
| **Inverter** | 30% | N |
| **Labor** | | |
| **Installation** | 50% | |
| **Other Costs** | | |
| **Permitting** | 100% | |
| **Other Costs** | 100% | |
| **Business Overhead** | 100% | |
| **Sales Tax (Materials & Equipment Purchases)** | 100% | |
| | | |
| **PV System Annual Operating and Maintenance Costs** | | |
| **Labor** | Local (%) | |
| **Technicians** | 50% | |
| **Materials and Services** | Locally (%) | Locally (Y or N) |
| **Materials & Equipment** | 50% | N |
| **Services** | 100% | |

Solar panels are a very competitive world-wide commodity. They are assumed to be imported, and even purchased from out of state distributors 70 percent of the time. Other equipment, like wires and other electrical parts are assumed to be purchased locally most often, but still manufactured outside of the state.

Half of the installation and maintenance is also assumed to be from out of state. This is a conservative assumption and reflects Pennsylvania's nascent market, and the proximity to a much more developed

[76] National Renewable Energy Lab, "Jobs and Economic Development Impact (JEDI)," https://www.nrel.gov/analysis/jedi/.

solar market in New Jersey. As Pennsylvania's solar market grows, higher local percentages are expected, which increase the local benefits.

The JEDI results in **TABLE 18** show the projected job impacts for both a 50% and 90% in-state labor assumption. A potential benefit of more distributed projects is seen here, as those smaller projects cost more per kW largely because they require more labor. That additional expense, paid for by the project owner, results in more solar jobs than Solar B.

**Table 18. Estimated gross new jobs, by scenario**

| | 50% In-State Labor | | 90% In-State Labor | |
|---|---|---|---|---|
| Scenario | **Solar A** | **Solar B** | **Solar A** | **Solar B** |
| Construction period Jobs | 100,604 | 67,716 | 116,382 | 81,141 |
| Ongoing Jobs | 1,086 | 983 | 1,775 | 1,619 |

The JEDI model describes the difference between construction and ongoing jobs as follows:

> *JEDI model results are displayed in two different time periods: construction and operations. Construction-period results are inherently short term. Construction jobs are defined as full-time equivalents (FTE), or 2,080-hour units of labor (one construction period job equates to one full-time job for 1 year). A part-time or temporary job may be considered one job by other models, but would constitute only a fraction of a job according to the JEDI models. Equipment manufacturing jobs, such as tower manufacturing, are included in construction-period jobs as it is ultimately new construction that drives equipment manufacturing. Operations-period results are long term, for the life of the project, and are reported as annual full-time-equivalent jobs and annual economic activity, which continue to occur throughout the operating life of the facility.*

While the construction jobs refer to actually building a project, those jobs are likely to continue year after year. Unlike a single centralized power plant, this solar capacity will be built in many different projects, so the construction jobs are ongoing in that way as well.

The JEDI model estimates gross job impacts, that is, it does not account for any reductions in other jobs in the energy industry that are offset by solar. That effect is probably minor in these Pennsylvania scenarios because the solar penetration is not too high, and the nature of the regional market means existing plants may just export more power rather than ramp down when solar is producing.

Looking forward, coding Pennsylvania solar jobs in accordance with Department of Labor and Industry standards will help track solar jobs and skill sets, allowing training facilities better access to the solar jobs market in the future.

## 2. LAND USE

The Project Team also investigated the land use impacts from reaching the solar targets. Some observers cite the space requirements of solar as a reason for it not to play a major energy supply role. Although sunshine is one of the least dense forms of energy, and siting space might be a limiting factor in cities attempting to become energy self-sufficient, Pennsylvania has more than enough space for solar. Assuming that any grid scale solar would use 8 acres per MW, grid scale solar would use 89 square miles (56,800 acres) in Solar A and 124 square miles (79,200 acres) in Solar B[77]. In addition, 10 percent of residential, and 50 percent of commercial systems are assumed to be on the ground, contributing to land use. Rooftop systems are not included in the land use numbers. **FIGURE 18** shows how solar land use would increase over time with the increasing solar capacity.

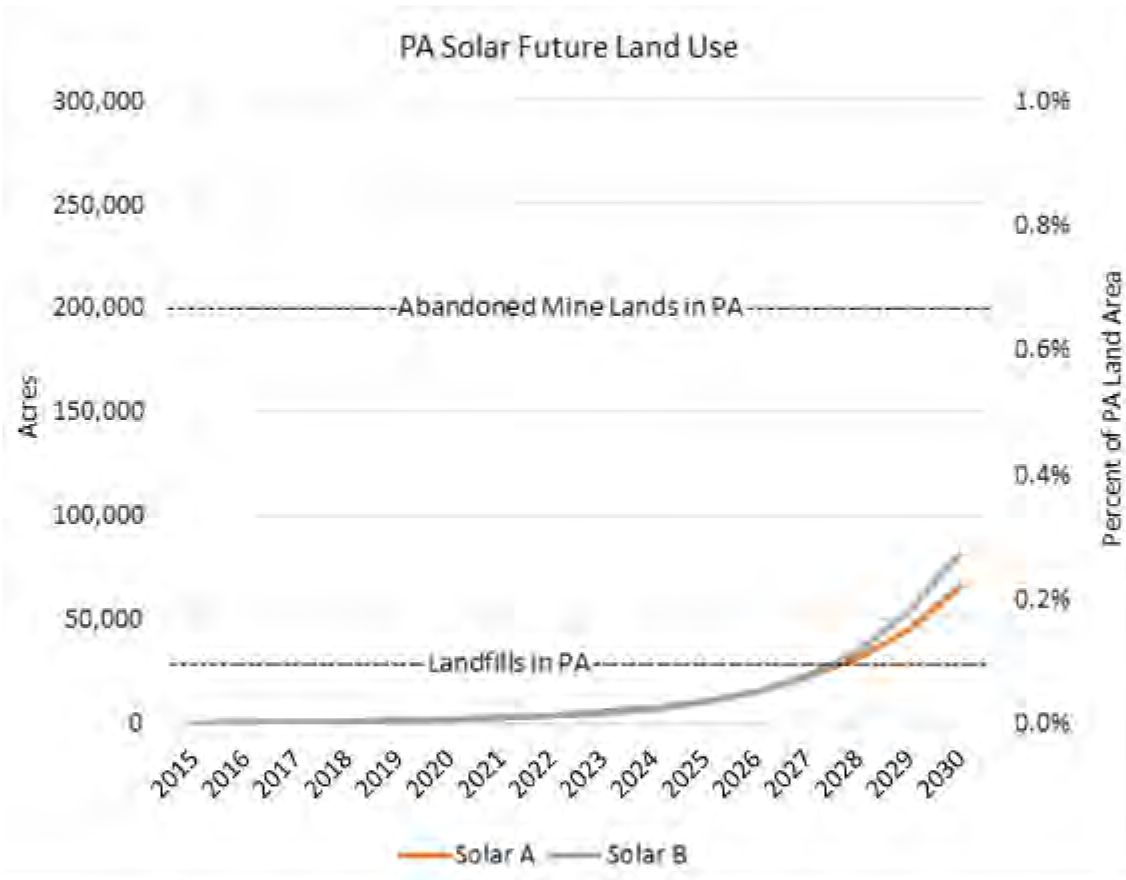



**Figure 18. Solar land use by year and scenario**

Results indicate that solar land use in the 10 percent scenarios represent a negligible fraction (<3/10ths of 1 percent) of Pennsylvania's total land area of 46,055 square miles. The availability of land for siting solar does not mean that thoughtful land use planning, solar system siting and permitting are not important, but the analysis clearly indicates that the availability of sufficient land to meet the 10 percent target is not a binding constraint. While solar is often considered a commercial or industrial land use,

[77] Sean Ong et al., "Land-Use Requirements for Solar Power Plants in the United States" (National Renewable Energy Laboratory, June 2013), http://www.nrel.gov/docs/fy13osti/56290.pdf.

solar installations do not require the same level of supporting infrastructure that other commercial uses might require.

There are opportunities to site solar development in ways that are complementary to the working land scape and rural economy, such as using solar on buffer zones, disturbed lands, and in conjunction with grazing or pollinator friendly perennials. [78]

## 3. EMISSIONS

The Project Team identified and applied two methods of assigning environmental costs, one based on compliance markets, and the other based on estimates of damage costs for emissions. The results, when using the damage-based cost method, show that if environmental externalities are counted, there are significant net economic benefits of more than $25 billion of reaching the solar targets over the 15-year study horizon.

However, it is important to note that meeting the 10 percent solar target does not translate directly to a 10 percent reduction in emissions. This is because electricity represents only about 20 percent of Pennsylvania's total energy use, and emissions. For these reasons, meeting the 10 percent solar target reduces the state's total greenhouse gas emissions by between 2 and 3 percent, as shown in **FIGURE 19**. The graph compares 2030 greenhouse gas emission using 100-year global warming potential by scenario and fuel group. As previously mentioned, electricity remains 17 percent of total energy throughout the study period. Changing 10 percent of electricity to solar amounts to 2 percent of the overall energy system.

[78] The Project Team notes that several state land use laws are currently in effect e.g. The Pennsylvania Farmland and Forest Land Assessment Act of 1974, commonly known as 'Clean and Green' or Act 319.

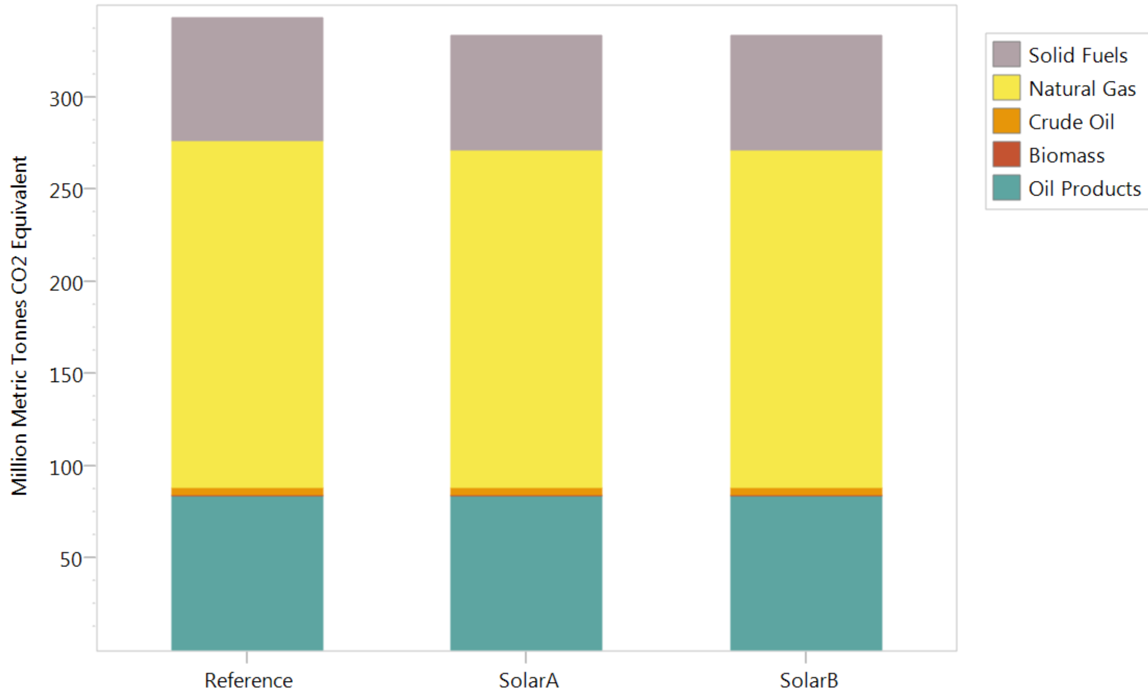



**Figure 19. Greenhouse gas emissions in 2030 by scenario and fuel group**

## H. ALTERNATIVE SCENARIOS

The Project Team developed additional scenarios which built upon the Solar A and Solar B scenarios to examine additional future energy development options. These scenarios incorporate stakeholder feedback and illustrate tradeoffs between potential future paths. Stakeholders requested scenarios with increased efficiency, electrification, and wind. The Project Team took the following modifications and combined them in a variety of scenarios listed below.

**Extra Efficiency:** Energy electric efficiency grows at 2 percent annually and gas efficiency grows at 0.5 percent annually, instead of 0.8 percent and 0.1 percent as described in the original scenarios. Leading states achieve 3 percent savings from energy efficiency programs annually.[79] Six states currently have annual energy efficiency targets of 2 percent or greater[80], and this is not considered out of reach for Pennsylvania.

**Electrification:** A combination of changes in heat pumps and electric vehicles. Air and ground source heat pumps provide 18 percent of household heat by 2030 and 40 percent by 2050. This change displaces heat currently provided by oil, propane, kerosene, and electric resistance. Additionally, this

[79] http://aceee.org/sites/default/files/publications/researchreports/u1710.pdf
[80] https://aceee.org/sites/default/files/state-eers-0117.pdf

scenario includes significant increases in electric vehicles from 3,600 in 2017 to 600,000 in 2030. For context, there were over 8,000,000 passenger vehicles in Pennsylvania in 2016.[81]

**FIGURE 20** shows the changes in demand for each of the scenario modifications in 2030. The electrification modification is split between the heat pump and electric vehicle modifications.

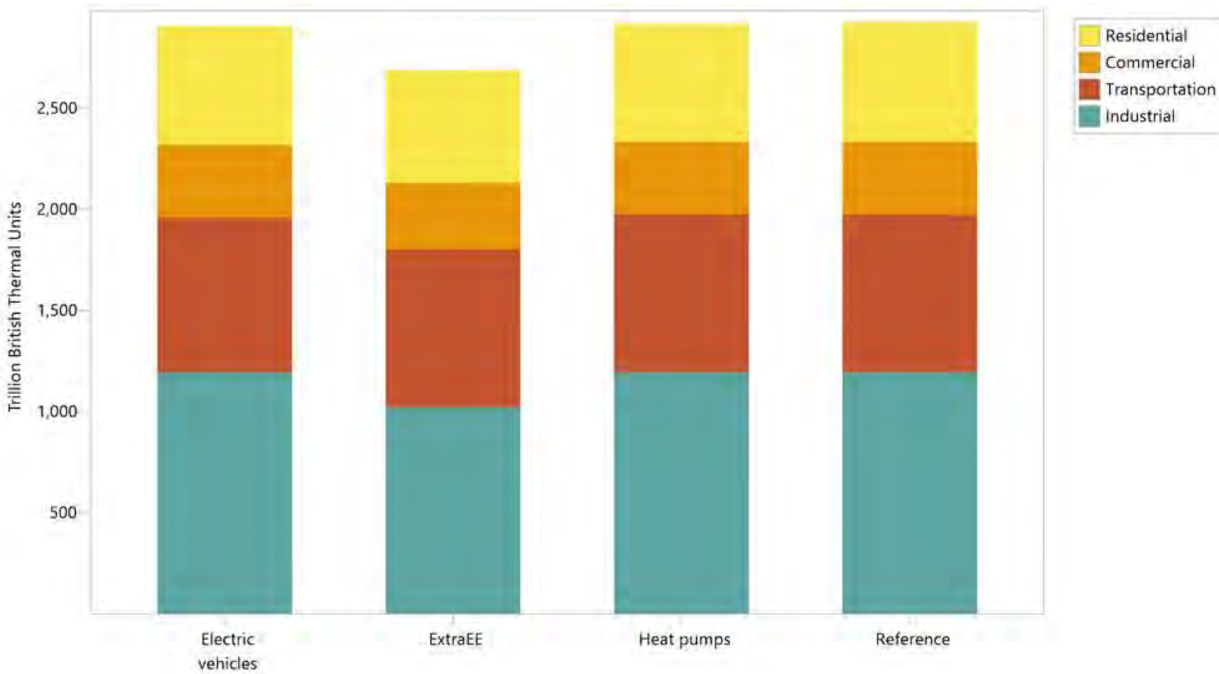



**Figure 20. Changes in final energy demand by scenario**

**Wind:** The "Wind" scenario grows wind to provide 10 percent of in-state electricity, like the solar goal. This requires 5.2 GW in 2030, as compared to 1.8 GW in 2030 in all other scenarios. Two checks show this is a reasonable number. One is that 5.2 GW can be reached with a 10 percent compound annual growth rate, which is achievable. The second was a comparison to NREL's Eastern Wind Dataset.[82] That study focuses on integrating high levels of wind generation and includes 7 GW of viable sites in Pennsylvania.

## 1. ALTERNATIVE SCENARIOS: SUMMARY RESULTS

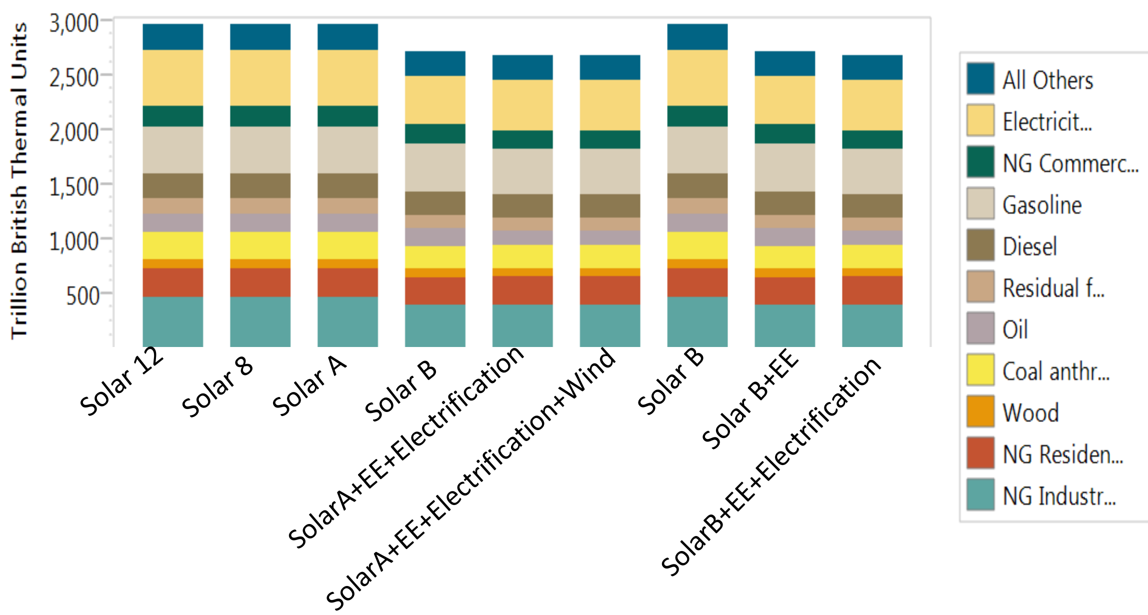
In total the Project Team developed and analyzed nine scenarios. Detailed results from the alternative scenarios are presented in Appendix B. This section provides a snapshot overview across all nine scenarios focusing on the final energy demand, and the change in total energy spending.

[81] Pennsylvania DOT, "Report of Registrations," http://www.dot.state.pa.us/public/dvspubsforms/BMV/Registration%20Reports/ReportofRegistration2016.pdf.
[82] NREL, "Eastern Wind Dataset," https://www.nrel.gov/grid/eastern-wind-data.html.

**FIGURE 21** illustrates the final energy demands in 2030 for each scenario by fuel type. The scenarios that include more efficiency and electrification result in demand up to 10 percent lower than energy demand in the reference and Solar A and Solar B scenarios. The results also show that electrification provides some reduced demand, as electric motors are more efficient than their internal combustion counterparts. However, this impact is relatively modest compared to reductions from efficiency initiatives, primarily because during the study period the saturation of electrification remains relatively small, even though it increases significantly during the study period.

Relative changes in total annual energy spending, as compared to the reference case based on the economic social cost benefit results for all nine scenarios are presented in **FIGURE 22** below.

**Figure 21. Final energy demand, 2030, by scenario and fuel**



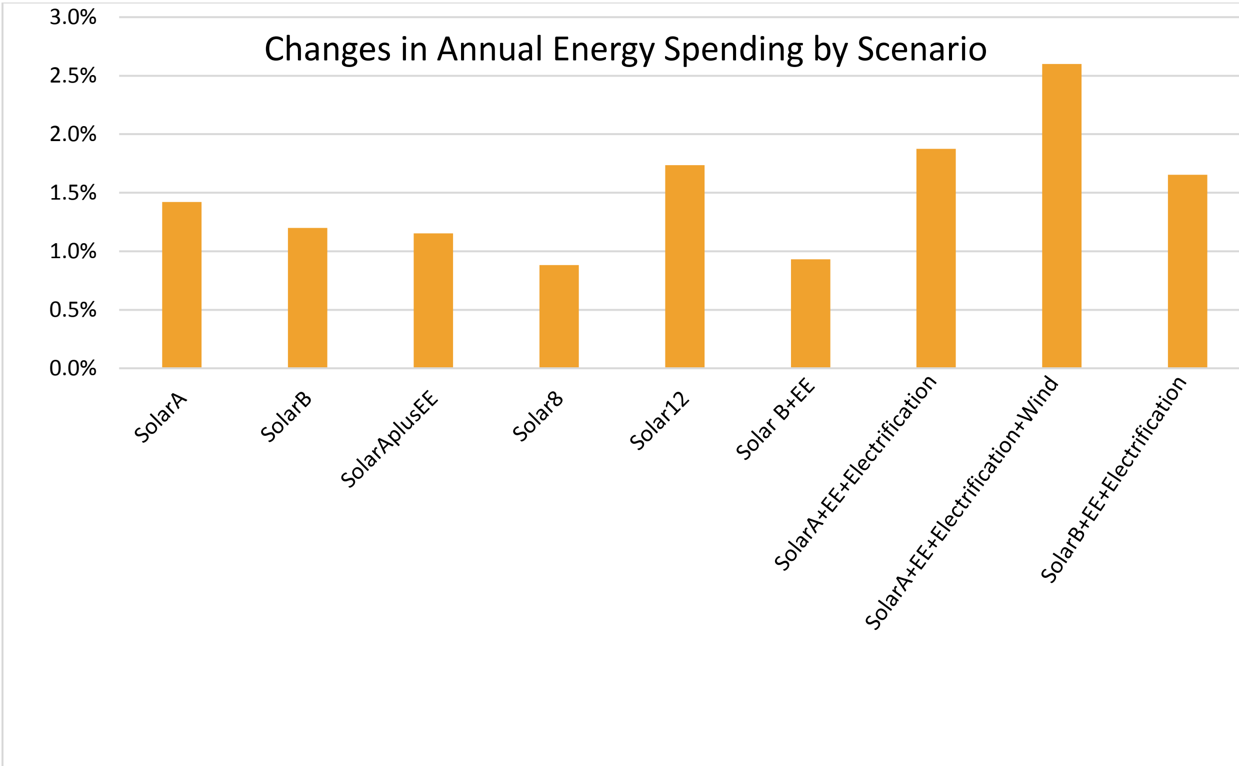



**Figure 22. Average annual change in total energy costs, by scenario, compared to Reference**

These results illustrate that increased efficiency can help to lower the overall economic costs of reaching the solar target. Integration of higher levels of wind, and strategic electrification are expected to increase costs somewhat (roughly an additional 1 percent annually) in comparison to the Solar Scenarios. Note that in return these scenarios would result in the highest share of total renewable generation in the commonwealth and transition to an energy economy with ongoing lower emissions. If emissions externalities are valued based on damage-based estimates, then all the scenarios have large positive net economic benefits and returns.

# PENNSYLVANIA'S SOLAR FUTURE STRATEGIES


**February 20, 2018, Committed Partners Meeting, Harrisburg**

The measures detailed in this plan include topics the stakeholder groups identified as affecting growth of solar deployment or shaping market conditions in Pennsylvania over the next decade, and beyond, while considering information provided throughout the project during stakeholder meetings, webinars and modeling data.

*Pennsylvania's Solar Future* is expected to inform Pennsylvanians of several potential methods for meeting state energy generation goals, resulting in the development of solar deployment strategies that policy-makers may consider. If implemented, these strategies should result in Pennsylvania sited solar electricity generation growing into a higher portion of Pennsylvania's future energy mix. The implementation of a combination of strategies resulting in scenarios, or pathways, will help to begin a transformation of the solar marketplace in Pennsylvania with positive environmental and economic impacts and increasing grid resiliency.

## A. OVERVIEW

The Finding Pennsylvania's Solar Future stakeholder engagement process identified the most impactful and realistic strategies that would move Pennsylvania towards a target of 10 percent solar by 2030. The overarching effort is to identify strategies which will bring the project costs of solar to a price point that will encourage swift adoption of the technology by the market. While there are crosscutting issues reflecting all solar deployment, the approaches and considerations that can help to achieve this goal frequently vary for grid scale and distributed solar generation.

Price is largely affected by tax and trade policy, renewable energy standards, carbon pricing, labor costs and rate structure. Readily available access to capital or long-term financing can produce an environment for which projects are economically feasible at higher price points than when they are absent. In addition, the strategies reflect the desire to incorporate social equity issues the stakeholders identified, including making solar more accessible to low-to-moderate income individuals and to non-profit, municipalities, universities, schools, and hospitals sectors that have no tax equity, protecting natural resources, and addressing climate change. Strategies for tackling other considerations such as mitigating infrastructure barriers are also included.

As demonstrated through the initial modeling, reaching a goal of 10 percent solar by 2030 will likely depend on significantly increasing the amount of grid scale solar deployment in Pennsylvania to a ratio of distributed generation to grid scale generation of 35 percent to 65 percent, respectively, as found in the Solar A scenario, or a higher ratio of 10 percent to 90 percent grid scale as found in the Solar B scenario. The scenarios are dominated by a significant build out of grid scale solar in a manner not yet experienced in Pennsylvania, however efforts should also be made to overcome barriers for distributed generation and community solar, so that Pennsylvanians may maximize the opportunities to develop all solar resources in a manner that increases net benefits. The strategies contained herein recognize that once the barriers are removed for all sectors of solar development, the actual achievable solar penetration could far exceed the goal of 10 percent by 2030.

The pathway to successfully reaching the 10 percent goal will likely require a suite of approaches. This report attempts to identify the most impactful strategies to maximize Pennsylvania's solar future. A summary of the strategies is provided below in terms of three categories:

1) Cross-cutting
2) Grid Scale Solar Generation
3) Distributed Solar Generation

The cross-cutting strategies are those that would drastically impact both grid scale and distributed generation, such as changes to the AEPS and adopting carbon pricing. The remaining strategies are focused on increasing either grid scale or distributed generation, reflective of the different proportions of grid scale and distributed solar generation evaluated in the modeling scenarios.

## B. CROSS-CUTTING STRATEGIES

### 1. INCREASE THE AEPS TARGETS AND EXPLORE ALTERNATIVES

The Alternative Energy Portfolio Standard (AEPS) Act of 2004, described in **SECTION 1**, will reach its peak alternative energy and solar targets by 2021, after which the scheduled percentages of electricity sales will be maintained as constants, indefinitely. Since Pennsylvania's requirement of 0.5 percent of generation from PV is significantly less than some other nearby states and therefore the state may be under-performing in solar development, revising the AEPS so that the solar share requirement will continue to increase up to and through 2030 is a workable mechanism for achieving a large penetration of solar development in the state.

**PROPOSED STRATEGY 1:** Implement an increase in the AEPS PV carve-out to between 4 and 8 percent by 2030 and ensure creditable SRECs are limited to those generated in Pennsylvania wherever possible.

AEPS works by creating a market for non-energy attributes of generation. The key attribute of solar PV generation is measured in SRECs, a quasi-market base tool used by those entities who are required to purchase solar to meet the mandate. SRECs are also purchased by entities like schools, universities, businesses and others who voluntarily purchase SRECs to support solar development for a variety of reasons including but not limited to climate change mitigation. To impact in-state solar deployment, the price of an SREC must be high enough to motivate parties to install solar in Pennsylvania, and not be affected by out-of-state credits being eligible to meet the AEPS solar requirement.

## The need to limit out-of-state SRECs

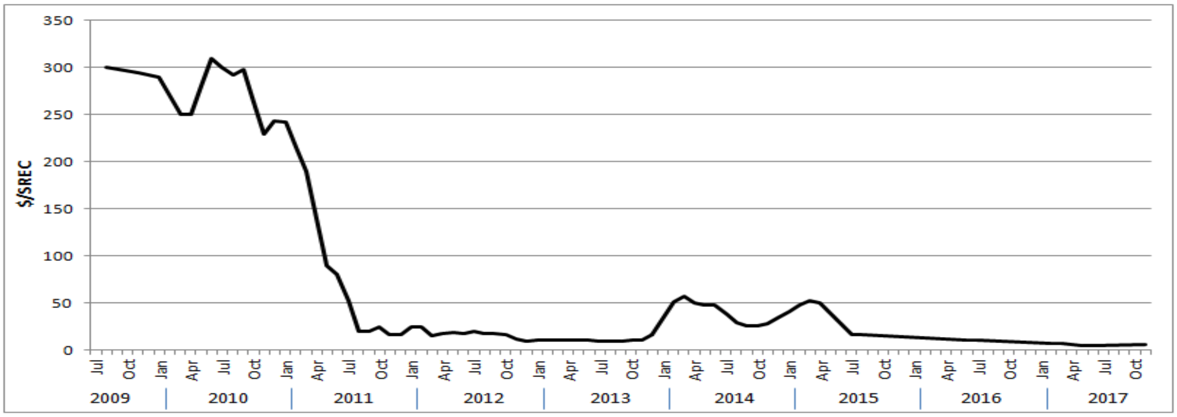



Figure 23. Average Price of Pennsylvania SRECs

As **FIGURE 23** illustrates, the trend has been towards lower average SREC prices.[83] The initial drop reflects the rapid buildout of solar in Pennsylvania resulting from the PA Sunshine Program from 2010 through 2013 where SREC prices fell from about $300 to about $15. After the PA Sunshine rebate program expired, SREC prices began to rebound through 2015; however, very large solar farms were being developed in other states and selling credits into the AEPS, depressing the SREC price again. In a number of these cases, these states have little or no market for the SRECs themselves so there is no opportunity for Pennsylvania generators to sell there. During this time, many neighboring states had closed their borders to out-of-state SRECs or limited their acceptance. In Pennsylvania, with an open market border, credits flooded into the AEPS marketplace. (see **FIGURE 24**[84]). With a vast oversupply of credits, the value of SRECs was strongly depressed.

[83] Data based on PASEIA Reports and data from SREC aggregators. This is not to be confused with weighted average SREC Prices that are influenced by long-term contracts.
[84] http://www.puc.pa.gov/Electric/pdf/AEPS/AEPS_Ann_Rpt_2017.pdf

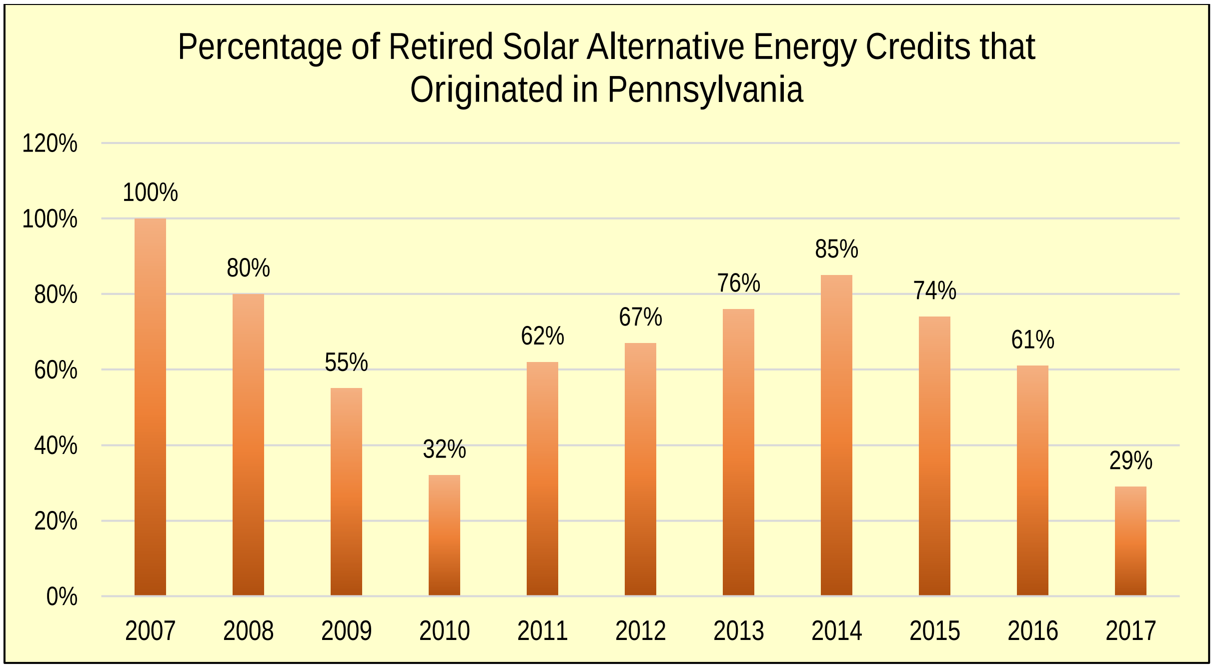



**Figure 24. Percentage of retired solar AECs that originated in Pennsylvania**

In October 2017, Governor Wolf signed into law Act 40 of 2017 to "close the SREC border" in Pennsylvania, making out-of-state solar generation only eligible as renewable energy Tier 1 alternative energy credits (AECs) under the AEPS and not under the separate Solar Share. An exception was made for existing contracts with SREC retiring entities, but not contract renewals. The PUC Final Order implementing this Act is pending.

### Arriving at the selected strategy

The selected strategy proposes an AEPS solar carve-out at a lower percentage than the Solar Future Plan's overall 10 percent target. This recognizes that while AEPS has been identified as an important policy solution, the plan does not assume AEPS will be entirely responsible for achieving the goal.

This distinction is necessary, in part, because of underlying differences between AEPS and this plan's target. AEPS requires procedural steps of registering and tracking the use of credits. Should a generator choose not to register credits, or should a purchaser voluntarily retire credits rather than use them for AEPS compliance, a situation could arise where 10 percent of Pennsylvania's consumption is produced by in-state solar PV, but sufficient credits are not available on the market.

There is also a concern if an AEPS solar target is too high relative to neighboring states, higher SREC prices could make paying a Solar Alternative Compliance Payment (SACP) preferable to procuring SRECS. The SACP provision protects ratepayers against price shocks and acts as a price cap set annually to 200 percent of the weighted average market value of SRECs sold through the GATS tracking system.[85]

[85] AEPS Act § 3(f).

The money collected for SACP is then diverted from solar installations to the state's Sustainable Energy Funds to use for renewable energy projects, which may not necessarily increase solar deployment.

### Considering the impact to ratepayers

As with any strategy, and particularly strategies directly impacting customer rates, equity issues regarding "who pays" and "who benefits" are primary concerns. Analysis was conducted assuming an increase in the solar share to 4 percent by 2025 for Scenario A, where 35 percent is solar distributed generation and 65 percent is grid scale solar. It assumed an SREC price of $58/SREC with a 10-year payback and net metering benefits for the solar DG market and a tariff-based incentive starting at $0.1168/kWh for the grid scale solar projects. Together, these incentives resulted in an average bill increase of less than $2/month, or about 1.5 percent, for a typical residential customer (assuming 10,000 kWh/yr. usage). This analysis removes the Federal tax credit which will expire after 2021.

## 2. PROVIDE ACCESS TO CAPITAL

Stakeholders identified access to capital as one of the largest barriers to solar development. Particularly for residential and commercial projects, the lack of available lending products for both residential and commercial customers with adequate terms and low interest rates were identified as barriers to deployment of solar.

**PROPOSED STRATEGY 2:** Increase access to capital by expanding availability of solar lending products to both residential and commercial projects to enable solar ownership.

Stakeholders identified a preference for ownership models over third-party ownership for residential and commercial projects because they maximize the benefits to the property owner. Third-party power purchase agreements or leasing structures for these sectors which were once prolific in other markets across the country when solar costs were higher were viewed by stakeholders as a less appealing option as the cost of solar has decreased. Alternatively, loans can provide the upfront capital needed to make projects viable and avoid the high upfront costs that third-party financing/ownership model imposes. Therefore, the strategy discussed here is focused on ownership models for residential and commercial clients.

Many potential solar system buyers are not able to access enough upfront capital for outright purchase. Lending products allow these customers to purchase solar with little or no money down and repay the cost of the system through their electricity savings earned over the first quarter to one-third of the system's life. The Nature Conservancy commissioned a report compiled by the Coalition for Green Capital in 2017 that modeled financing scenarios with varying interest rates and terms for residential and commercial projects in their report. They assumed an SREC price of $10 per MWh and installation costs of $3.00 per watt for residential systems and $2.50 per watt for commercial systems. Their modeling "consistently showed numerous scenarios in which it is cheaper for end users to get their electricity from net-metered distributed solar systems than it was to pay for grid electricity"[86] even with a loan. The lower the interest rate and the longer the term of the loan, the lower the levelized cost of energy and the more competitive solar is with other retail electricity sources.

**CASE STUDY—ESTES EXPRESS AND PENNSYLVANIA ENERGY DEVELOPMENT AUTHORITY:**

Motivated to reduce energy costs, improve efficiency, and reduce environmental impacts associated with their trucking terminal in West Middlesex, Mercer County, PA, Estes Express Lines embarked on a project to design and install a grid-tied solar photovoltaic (PV) project on their approximate 55,000-square-foot roof. The array consists of 2,150 roof-mounted solar modules of 320W each, and is expected to produce over 787,000 kilowatt hours of electricity annually, while significantly reducing carbon footprint.

The total project cost – everything from design and permitting to installation – was $2.05 per watt, or about $1.4 million. The Pennsylvania Energy Development Authority provided a grant to offset $400,000 of their investment, and combined with federal tax incentives and modest Solar Renewable Energy Credits value Estes anticipates a simple payback of about 8.5 years.

Avoiding $66,418 in electric costs also avoids 553 metric tons of carbon emissions. This savings to the environment is equivalent to removing 117 cars from Pennsylvania roads each year. It also reduces the impacts on the electric grid during peak demand, which reduces emissions from less-efficient generation sources.

[86] TNC Market Report *at 79.*

**PROPOSED STRATEGY 3:** Provide loan guarantees to lower interest rates and provide an incentive to deploy solar generation.

The commonwealth has several opportunities to directly influence the availability of long-term financing for grid scale solar energy. The Commonweath Financing Authority has a loan and grant program that can assist solar component manufacturers or developers of solar projects.[87] That program recently anounced the approval of 78 new projects for 2018. Similarly, a U.S. DOE loan guarantee program, which ran through September 30, 2011, demonstrated that every dollar provided in loan guarantees resulted in $14.25 invested in solar project deployment.[88] Pennsylvania could build on the success of these programs to develop similar programs targeted at grid scale projects.

While enhanced access to capital can take many forms, four possibilities discussed by project stakeholders are presented below:

## A) PENNSYLVANIA GREEN ENERGY INVESTMENT PARTNERSHIP

Stakeholders suggested that the state of Pennsylvania establish an Energy Investment Partnership (EIP), commonly known as a Green Bank, to assist in financing the deployment of solar. The Nature Conservancy, recommending the formation of such entities, notes that they "can be capitalized with public funds, philanthropic grants or program-related investments (PRIs), various bond structures, or other forms of private investment which are then used to offer loans, leases, credit enhancements and other financing services for clean energy projects. [And, can] offer a variety of market development services, such as demand aggregation, contractor training, and online clean energy information hubs."[89]

Other stakeholders were concerned that a "Green Bank" is a difficult goal because the likelihood of obtaining the needed resources to start the EIP (*i.e.*, the General Assembly allocating state funds, municipal bond funds or foundation funding, etc.) for its creation seem unrealistic given the large amount of capital that would be needed.

The funding issue could be addressed if the state were to join a carbon regulating program such as RGGI. Other states such as Connecticut and New York fund their EIPs partially with RGGI proceeds.

Assuming funding is available, it was noted that any lending program should include provisions for a marketing plan and other activities that can increase success of the program.

[87] *See:* https://dced.pa.gov/programs/solar-energy-program-sep/
[88] Mendelson and Kreycik, 2012.
[89] The Nature Conservancy, *Pennsylvania Energy Investment Partnership Report*, 15 (July 6, 2017) *available at:* https://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/pennsylvania/energy-investment-partnership-report-2.pdf

### B) UTILITY SOLAR LOAN PROGRAM

Allowing regulated utilities (EDCs) to issue solar loans to their customers could potentially allow them to recoup a portion of the revenue lost when customers charged on a volumetric basis increase energy efficiency or install solar generation. At the same time, this could provide low cost solar lending to customers.

In addition, the EDCs have access to capital that may add security to lending, possibly allowing lower interest rates to customers, or attracting private lenders. EDCs also have the advantage over state or county government entities, or even the private lending institutions, as they can market to their entire pool of customers and, if offered with on-bill repayment (discussed below), provide a streamlined process for loan payment that often has higher compliance than private lenders can realize.

**CASE STUDY—NEW JERSEY PSE&G:**

New Jersey PSE&G's Solar Loan Program allows qualified electric customers to finance a major portion of their solar system and allows repayment in cash or by using Solar Renewable Energy Certificates (SRECs) with a minimum floor price for each credit guaranteed by PSE&G. This program offers customers low out-of-pocket costs to install a solar system and short repayment terms needed to re-coup their investment. While the interest rates are high (more than 11 percent), the program offers guaranteed SREC prices that are created through long-term procurement contracts with SREC providers. As of 2018, over 1,100 business and residential customers finance more than 85 MWdc of solar capacity and the program is about to start their 23rd solicitation phase of the program.

(See https://www.pseg.com/home/save/solar/index.jsp)

Low-income residents may not be able to access lending products at competitive rates because the lenders must account for added risk in their offerings. One possibility that would expand access to capital for these customers is to couple a utility loan program with an interest rate buy-down for residents qualifying as low-income. It is generally difficult for low-income customers to qualify for loans. One example of this is the Mass Solar Loan program where the buy-down reduces the annual interest rate 1.5 percent below the typical rate charged by the private lenders.[90] If EDCs would offer solar loans, the PUC could possibly provide permission for rate recovery for the interest rate buy-down.

Such a program would likely need to be voluntary on the part of EDCs and may require legislative action.

### C) ON-BILL FINANCING

On-bill financing could provide a streamlined process for customers to repay their loans—whether they originate from the utility or from private lenders—on their electric, gas, telephone or cable utility bills. Repayment using the electric utility bill would normally be the most advantageous because the utility can monitor electricity usage and solar production that could be used to manage an average monthly

90 http://www.masssolarloan.com/

repayment that aligns with generation and usage. Utilities could partner with private lenders and reduce risk by buying down or securing the loans.

Utilities have been reluctant to offer on-bill financing because it produces extra administrative and equipment/software costs. However, it could allow utilities to earn additional revenue from lending services thus balancing their costs. This would further encourage the customer deployment of solar generation.

Because on-bill financing can mitigate some of the risk associated with loans, it broadens customer eligibility and can be particularly beneficial to low-income customers that may not be eligible for a conventional loan or may find a loan too expensive.

Programs can also be designed to further mitigate risk. For example, requiring “bill neutrality”—where the monthly loan payment is equal or less than the prior electric bill—removes the risk of a price-shock to customers and longer-terms or lower-interest rates can further enhance affordability. On-bill payments would be beneficial to institutional, commercial, and residential customers for similar reasons.

The PUC opened a docket, Docket # M-2012-2289411 and issued a staff report on October 31, 2013 on on-bill finance and repayment. The conclusion of that report was that the electric distribution companies (utilities) would have to obtain permission from the Public Utility Commission to pilot a program. The program would be voluntary and at that time no utility came forward even though both the Sustainable Energy Fund (SEF) and the Pennsylvania Housing Finance Agency (PHFA) submitted to the Working Group two models for discussion. The PHFA model was designed for master-metered affordable housing units and the SEF model was designed for small commercial and industrial customers. Both models envisioned an administrator role, with a net bill impact called bill neutrality, and were expected to align with Act 129 efficiency measures. The PUC-sponsored report and conclusion did not address renewable energy or include solar system purchases. Both entities were willing to put up capital for the pilot, but no further action was taken since no utility volunteered to pilot the program. Incentives for utility participation need to be identified.

### D) PROVIDE A LOAN LOSS RESERVE FOR LOW-INTEREST, LONG-TERM SOLAR LOANS

Banks or other lenders have the expectation that a certain percentage of outstanding loans will become uncollectable. These expected losses are typically shown on their cash flow statement or other records where they negatively affect earnings. As such, lenders adjust their underwriting criteria to minimize perceived loan loss risk. This results in fewer high risk borrowers being eligible for loans. For those who qualify, loans tend to be set for shorter terms and at higher interest rates—all factors that discourage deployment of solar.[91]

State or local governments can address this issue and incentivize these projects by providing a loan loss reserve for such lenders. A U.S. DOE SunShot project spearheaded by Citizens for Pennsylvania's Future commissioned a financing white paper for solar financing in 2013 with Clean Energy Finance Center concluded that a loan loss reserve fund of $350,000 would support loans for up to 1,000 households. (.35/watt) at a 10:1 leverage or $175,000 (.18/watt) at a 20:1 leverage per year).

**CASE STUDY—CITY OF MILWAUKEE:**

The City of Milwaukee's Shines program includes solar financing through a partnership with Summit Credit Union. Utilizing federal ARRA funding, the government provided $100,000 or a 5 percent loan loss reserve pool to leverage at 20:1 a $2,000,000 loan program through Summit at an interest rate range of Prime plus 2.25 percent depending on the term up to 15 years. The loan loss reserve allows the private lending market to manage the loan program that has farther reach than a revolving loan program managed by the city because more loans could be issued, and it avoided the need for a government entity to staff and administer the program and is also less expensive than an interest rate buy-down.

(See http://city.milwaukee.gov/MilwaukeeShines/Get-Solar/Solar-Financing.htm#.Wr6vY-gbPIU)

## 3. ADOPT CARBON PRICING

Carbon pricing is one way to address external environmental costs associated with fossil fuel use and to promote other policy goals. Where carbon prices are adopted, zero-carbon generation such as solar and other clean renewable generation are more cost-effective. Pricing can incentivize installation and investment by private capital. Such programs also generate revenue that can be re-invested in clean generation or directed to other purposes.

**PROPOSED STRATEGY 4:** Implement a carbon pricing program and invest the proceeds in renewable energy and energy efficiency measures.

Several models exist for carbon pricing. Broadly they can be categorized as: 1) carbon taxes where governments or other entities set prices per ton of carbon based on some criteria, and 2) emissions

[91] *See:* https://www.energy.gov/eere/slsc/rationale-and-goals-loan-loss-reserve-funds

trading systems such as cap-and-trade systems where the allowable amount of carbon emissions is fixed, and the market determines the price. (Hybrid models also exist where, for example, the market determines the price up to a pre-set limit.)

In the Northeast, the Regional Greenhouse Gas Initiative[92] (RGGI) program has introduced a carbon pricing system for electric generation, for which nine Northeast and Mid-Atlantic states—Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont, New York, Delaware, and Maryland—participate. Virginia and New Jersey may be joining soon. Pennsylvania has been an "observer" in the initiative. The Northeast and Mid-Atlantic states participating in the third RGGI control period (Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont) have implemented the first mandatory market-based regulatory program in the U.S. to reduce greenhouse gas emissions.

The 2017 RGGI cap is 84.3 million short tons. The RGGI cap declines 2.5 percent each year until 2020. The RGGI states also include interim adjustments to the RGGI cap to account for banked CO2 allowances. The 2017 RGGI adjusted cap is 62.5 million short tons. RGGI is composed of individual CO2 budget trading programs in each state, based on each state's independent legal authority. A CO2 allowance represents a limited authorization to emit one short ton of CO2, as issued by a respective state. A regulated power plant must hold CO2 allowances equal to its emissions for each three-year control period. RGGI's third control period began on January 1, 2015 and extends through December 31, 2017. In August 2017, the RGGI states announced a commitment for an additional 30 percent cap reduction by the year 2030, relative to 2020 levels.[93]

The RGGI states have reduced power sector CO2 pollution over 45 percent since 2005, while the region's per-capita GDP has continued to grow. RGGI-funded programs also save consumers money and help support businesses. RGGI investments in 2015 are estimated to return $2.31 billion in lifetime energy bill savings to more than 161,000 households and 6,000 businesses which participated in programs funded by RGGI investments, and to 1.5 million households and over 37,000 businesses which received direct bill assistance.[94]

Clean and renewable energy makes up 16 percent of 2015 RGGI investments and 14 percent of cumulative investments. RGGI investments in these technologies in 2015 are expected to return $785.8 million in lifetime energy bill savings to 19,600 participating households and 122 businesses in the region.

RGGI is a well-established and active carbon trading mechanism for which all the Northeast and most of Pennsylvania's neighboring states are participating, which is an example of a successful market-based program that has significantly reduced and continues to reduce emissions through a carbon pricing

[92] See generally: http://www.rggi.org
[93] http://rggi.org/docs/ProgramReview/2017/08-23-17/Announcement_Proposed_Program_Changes.pdf
[94] http://rggi.org/docs/ProceedsReport/RGGI_Proceeds_Report_2015.pdf

mechanism. Pennsylvania could join RGGI as an active member, or it could work with other states to develop a similar system or develop an independent carbon pricing program.

Applying a carbon price to all electric generating units sends a technology-neutral price signal to all generators to reduce emissions without creating preferences for one technology over another. The carbon price also provides cost certainty to all market participants and drives desired behaviors in terms of encouraging emissions-free capacity retention and growth and more efficient operations in the fossil sector.

By itself, carbon price does not provide certainty of emissions reductions and does not ensure that specific levels of desired technology such as solar are achieved. Programs such as renewable portfolio standards better isolate specific desired outcomes (i.e. more solar) but they do not necessarily achieve the underlying policy goal (emissions reduction) at the lowest possible cost because they are not driving economy-wide efficiencies. The Project Team therefore identified a strategy not unlike New York, Massachusetts and others, who use a combination of carbon pricing and renewable portfolio standards to increase solar deployment.

Implementing carbon pricing will likely benefit Pennsylvania's nuclear generation fleet by valuing carbon free generation sources. This may slow retirement of existing facilities, but it is not expected to result in new construction. Although all five nuclear facilities in Pennsylvania are all licensed through 2030, the single unit at Three Mile Island is scheduled to retire Sept. 30, 2019, and the two units at Beaver Valley are scheduled to retire in 2021.

## 4. ADDRESSING SITING AND LAND USE

This report documents that the availability of sufficient land to meet the 10 percent target is not a constraint, but issues around siting and land use remain.

Most parcels in Pennsylvania are divided into 100-acre tracts and so are appropriate for solar systems roughly between 5 and 15 MWs. As a result, larger grid scale projects may require more complicated multi-owner land owner lease agreements which increases costs and lower return on investment. Similarly, variations in policies between municipalities can create challenges for solar development.

### SOLAR IN PARKS: PENNSYLVANIA DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

The Department of Conservation and Natural Resources is developing solar on state parks across the state. By the end of 2018, DCNR is expected to have over 18 solar installations. These solar arrays could save more than $65,000 a year on electric, reduce 350 tons of CO2 emissions a year (average car emits 6 tons per year) and energy consumption by 600,000kWh per year (average home uses 10,812 kWh per year). Projects like these help state agencies cut both costs and emissions from state operations.

Land use issues go beyond the available tracks. Conservation programs such as Clean and Green and Conservation Reserve Enhancement Program (CREP) and other private conservation programs each have their own rules as to whether solar is restricted in their programs. Developers and owners must research any easements or other restrictions along with any township, homeowner association, or other local government rules for siting solar.

**PROPOSED STRATEGY 5:** Support the creation and adoption of uniform policies to streamline siting and land-use issues while encouraging conservation.

Consideration should also be given to preserving agricultural land, forest land, and valuable habitat. Less valuable lands such as landfills, abandoned mine lands, and other brownfields are often better choices to be redeveloped with solar projects. The Project Team notes, however, that brownfield land may provide important open space or developing habitat in certain areas. The Project Team recommends developers coordinate with state resource agencies and local authorities to ensure negative impacts are minimized.

**CASE STUDY—PSE&G DEVELOPMENT OF BROWNFIELDS:** In New Jersey, the first solar on brownfield projects went into service in 2010 and three others were completed by 2016. Between the projects, there was 52.58 MW of solar capacity on 190 acres of landfill and brownfield space with 175,000 solar panels than can power 8,500 homes. PSE&G reported that landfill and brownfield solar projects are about 40 percent less expensive than typical residential net metered solar projects because of the economies of scale. All projects included streetscaping around the site's perimeters and removed an "eyesore".

There were challenges to developing some of the sites due to the need to do more grading to do construction and in other cases developers had to use special concrete blocks to secure the racking system due to environmental regulations so that the former hazards at the site were not disturbed.

All the approved projects were considered successful and the New Jersey BPU approved an extension of the program to build out 33 additional MW on landfill and brownfields sites over the next three years.

Source: PSE&G Solar Initiative Focused on Landfills and Brownfields by Todd Hranicka, Solar Industry magazine February 2017

## 5. TAX INCENTIVES

Tax policy, at least in certain cases, is considered implicitly in other strategies such as access to capital and ownership models. The federal ITC for both commercial and residential solar has been an important market driver as well as the MACRS depreciation for commercial solar. While important, and specifically supported by many of the stakeholders, these were not included as strategies in this plan because they operate at the federal level.

There are, however, state tax policies that directly impact solar. For example, while purchase of fossil fuels or electricity for residential, or in many cases commercial, use is exempt from Pennsylvania's 6 percent sales and use tax, the purchase of solar generating equipment is subject to the tax thus raising the cost of a typical residential PV system by approximately $1,000.[95] Similarly, installation of a solar PV system could increase the assessed property value of the home and result in additional taxes. The amount of the tax depends on the assessment and the tax rate established at the county, municipal, or school board level but often results in an effective annual tax rate of between 1 and 2 percent of the property's assessed value.

Pennsylvania also can use its state tax policy to encourage grid scale solar deployment. One possibility is the creation of corporate tax incentives to site solar generation on brownfields as opposed to farmland or forest land. Another is using Partial Property Tax Exemptions, as property tax is one of the more expensive long-term line items for grid scale solar facilities. Reduction in property tax burdens significantly improve project economics, and numerous states offer some type of property tax reduction for large solar energy facilities. Finally, using state investment or Production Tax Credits could also help utility or grid-scale financing. Several states have offered investment tax credits of a limited duration to reduce the upfront cost of renewable energy projects. It will be important to consider the impacts on local governments' revenues.

**PROPOSED STRATEGY 6:** Evaluate the state tax policy and consider exemptions that encourage the development of solar PV systems.

While tax incentives can be effective, it's not uncommon for solar developers to lack the tax appetite to take full advantage of these programs. In those cases, tax equity structures may be used where, for example, the project sponsor may bring in a tax equity investor as a partner. A percentage of the taxable income and loss is then allocated to the tax equity investor until a certain yield is reached, after which point the sponsor has an option to buy out the tax equity investor's shares at fair market value. The commonwealth could aid in matching development projects with appropriate investors.

**PROPOSED STRATEGY 7:** Assist solar project sponsors in identifying investors and/or companies that have sufficient tax equity appetite to take full advantage of the federal ITC and Modified Accelerated Cost Recovery System (MACRS) depreciation if sponsors cannot do so themselves.

## C. GRID SCALE SOLAR

As the modeling scenarios discussed above indicate, any significant increase in statewide solar generation is expected to come, in large part, from grid scale units. Even with aggressive deployment of

[95] Legislation has been introduced to exempt solar equipment from sales and use tax. *See* SB 495 (Rafferty).

distributed generation, as much as 65 percent of the solar generation is envisioned to be grid scale to meet the 10 percent goal.

The cost to build grid scale solar has plummeted in the past several years. New unsubsidized grid scale solar assets are signing long-term contracts for energy in the range of $43 to $53/MWh. In comparison, new natural gas combined cycle plants currently require long-term contracts in the range of $42 to $78/MWh.[96] The falling cost of grid scale solar means that it can be a cost competitive generation source even in very low natural gas costs environments such as Pennsylvania.

Still, to acquire capital to build a facility requires financers who are sufficiently confident prices will remain high enough to recoup the substantial upfront investment. In the regulated market setting in which many of the plants serving Pennsylvania emerged, guaranteeing utilities cost recovery from ratepayers over a period of 20 years or more provided this confidence. In the current deregulated landscape however, facilities must compete for short-term energy contracts to serve load. This entails added risk and is reflected in the cost of capital.

Earlier work from the National Renewable Energy Laboratories (NREL) has shown that the critical and effective policies for encouraging grid scale solar include: maintenance of the federal Investment Tax Credit (ITC), availability of low-cost financing, and state renewable portfolio standards.[97] Aside from the changes to the AEPS recommended above, the state has the potential to impact policies supporting availability of financing.

This section contains three strategies to further deploy grid scale solar.

## 1. LONG-TERM CONTRACTS

Renewable energy projects financed in Pennsylvania typically involve either 1) an entity owning renewable generation and then contracting with an electric distribution company (EDC) for RPS compliance purposes, or 2) a wholesale transaction with a long-term power-purchase agreement (PPA) between a generator and a large customer in PJM along with the sale of Renewable Energy Credits.

Despite ongoing interest in developing projects in Pennsylvania, Independent Power Producers (IPPs) report that difficultly in securing long-term contracts with utilities is a significant obstacle in building large solar systems in the commonwealth. EDCs are reluctant to enter into long term contracts due to the concern that ratepayers will pay more over time than short-term purchases because load growth is relatively flat and energy prices have been stable or declining in recent years. Because long-term contracts are often more readily available in other states, IPPs are more likely to obtain investor financing for these projects outside Pennsylvania where the Return on Investment (ROI) is guaranteed for a longer term.

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[96] https://www.lazard.com/perspective/levelized-cost-of-energy-2017/

[97] M. Mendelson & C. Kreycik, Federal and State Structures to Support Financing Utility-Scale Solar Projects and the Business Models Designed to Utilize them, National Renewable Energy Laboratories, (April 2012).

**PROPOSED STRATEGY 8:** Develop guidelines for limited use of long term contracts (LTCs) for a period of ten or more years to ensure Pennsylvania benefits from grid scale solar energy.

Long-term contracts with large corporate purchasers or directly with utilities allow an IPP to finance projects because those structures decrease the financial risk. The capital is often secured from investors who are seeking to monetize tax equity and/or make a return on their investment over a specific length of time. These long-term contracts provide the assurance to investors that they will be able to recoup their investment and profit from it.

Across the country, many large corporations are currently procuring their own renewable energy generation through PPAs with IPPs. This is a growing market for utility-scale solar energy. In addition, the Rocky Mountain Institute recently reported[98] about the corporate renewable energy market and identified that the small to mid-size business procurement market is also growing with the help of aggregators who pool PPAs with smaller businesses to help pay for the project. These corporate off-takers have not yet emerged in Pennsylvania, but they offer development potential for utility-scale projects.

Under electricity restructuring, Pennsylvania utilities' core functions are to provide distribution and transmission services, providing default service to customers who have not chosen an electric generation supplier, administer low-income and energy efficiency programs, and meet AEPS requirements. Utilities do not currently own generating assets.

Additionally, pilot programs could be explored that competitively bid up to 20-year contracts for only grid scale projects. The tariff based incentive mechanism for grid scale solar is essentially a competitive procurement or bidding process among solar developers which bundles the price for electricity and the solar attribute, over a 10 to 20-year term. Unlike an annual schedule for a solar carve out as a growing percentage of total electric usage across the state (i.e., SRECs), the tariff based incentive mechanism would consist of a quarterly or annual schedule of installed solar capacity in megawatts (MW).

The energy and solar products would be bundled as a single contract and would be procured outside of the AEPS. Massachusetts has recently approved this process and New Jersey is looking at it as an alternative to the SREC model. The SREC model has not yet lead to grid scale development in PA.  Other mechanisms such as the competitive procurement process in Maine may be more compatible to Pennsylvania's construct. High solar penetration northeast states like Massachusetts and New Jersey are looking to experiment with competitive bidding models as a potential cost savings to ratepayers in part because no SRECs will be earned.

[98] RMI, *A Buyers Roadmap: Pushing Corporate Renewables to New Heights,* (Nov. 2, 2017) (*available at:* https://www.rmi.org/news/buyers-roadmap-pushing-corporate-renewables-new-heights/).

If FERC approves PJM's proposal on price formation, solar and renewable energy resources could be disadvantaged in the wholesale market if Renewable Energy Credits (RECs) are deemed subsidies.

This may lead to a pilot procurement process which then would prove less expensive to meeting a larger solar requirement and could ultimately replace the SREC model over time, particularly for grid scale projects. Under this approach, the SREC model should remain in place until after the pilot cost analysis is completed.

**PROPOSED STRATEGY 9:** Evaluate and consider utility ownership of solar generation especially in cases where market-driven deployment may be insufficient to achieve public goals and/or reliability concerns.

At present, the ability of Pennsylvania utilities to own solar generation is not expressly provided for in legislation and has not been directly addressed by the PUC or the courts. Some parties interpret the current rules and regulations to prohibit utility ownership of generation entirely. Other parties interpret the rules to say utility ownership is permissible, but utilities would be restricted to receiving market price and may not include generation in the rate base or receive a guaranteed rate of return. The uncertainty around the legal status of such ownership is, itself, a barrier to utility investment in such resources.

Appropriate enabling legislation[99], such as PA House Bill 1799 introduced in 2017, could allow utility ownership of solar generation provided such investment is consistent with a utility's obligation to act in a reasonable and prudent manner to provide service to customers at the least cost. Utility ownership could address access to capital issues by financing installation through the utility rate base. This may be implemented as a voluntary choice on the part of customers, particularly those that otherwise lack solar access that opt for utility-owned generation as an alternative to purchase or lease of generation assets. Or, this could be implemented where the utility owns a generation asset to reduce congestion, meet portfolio standards, acquire generation for default-service customers, or achieve other social goals.

In addition to legal issues, specific program design choices could have impacts on other market participants and on energy consumers. While a program could result in a net increase access to solar generation, care must be taken to consider consumer impacts.

Some stakeholders envision a more limited role for utilities where they would provide solar to low-income residential customers, affordable multi-family housing projects or to their default service customers. Others, particularly utilities themselves, prefer more flexibility.

[99] A bill introduced in the Legislature, HB 1799 (Bullock), would specifically allow for utility ownership, but largely leaves the design issues to the discretion of the PUC.

## 2. GRID MODERNIZATION

Grid modernization encompasses updating the hardware, software and overall functionality of the grid. It enables two-way data transfer and communication, permitting grid operators to dynamically assess the operating status of the grid so that it can function more efficiently and reliably, resulting in lower energy bills and more energy choices for customers, along with fewer and shorter power outages.[100] There is no standardized definition of grid modernization but Grid Wise Alliance in partnership with Clean Edge Navigant conducts a rating of states on a quarterly basis to assess leaders in this area. Pennsylvania ranked 13th in the December 2017 report.[101] States that employ a comprehensive approach to grid modernization ranked highest. These states are taking actions on energy storage, resiliency and reliability, cyber and physical security and change to regulations including rate design. These actions often result in development or deployment of incentives and mandates for energy storage technologies, EV infrastructure and RPS goals.

Microgrids, energy storage, smart inverter functionality, frequency regulation, demand response, rate reforms, and many other sophisticated technologies and operations, as well as legislative and regulatory actions all play a vital role in modernizing the grid.

**PROPOSED STRATEGY 10:** Investigate opportunities for grid modernization to enable increased solar generation.

More than thirty states plus the District of Columbia now have actions around grid modernization.[102] Of these actions, energy storage is of interest because it can help balance solar on the grid, allow it to qualify as a full capacity resource, and can be dispatched more flexibly than solar alone. When the NC Clean Energy Technology Center produced a catalog of actions taken in 2017 they found a significant number of actions related to energy storage, along with advanced metering, infrastructure rules, grid modernization investigations, and utility business model reforms.[103]

Storage development is assisted by the recent IRS ruling qualifying certain energy storage projects for ITC treatment. The rise of “smart cities” and initiatives focused on low carbon strategies is also driving the market for energy storage, combined with advances and declining costs for lithium ion batteries, and investments by well-established large businesses according to Navigant Research. In addition, opening wholesale energy markets to storage projects is seen as a key policy development coming out of FERC in February 2018. However, further clarification on the qualifications will be undertaken at their upcoming Technical Conference. These recent actions can provide further support for solar as a flexible

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[100] https://www.energy.gov/articles/explainer-how-grid-modernization-could-improve-your-life).
[101] Grid Modernization Index, November 2017 in partnership with Clean Edge -Navigant
[102] North Carolina Clean Energy Technology Center
[103] NCCTC "The 50 States of Grid Modernization Q1 2017 Quarterly Report

resource that can provide greater reliability and security to the grid. As a result, energy storage is expected to grow from 6 GW in 2017 to over 40 GW in 2022.[104]

## D. DISTRIBUTED SOLAR GENERATION

The Project Team's modeling scenarios assume distributed solar generation will be responsible for a smaller fraction of the overall deployment than grid scale solar—likely between 10 and 35 percent. While it does not benefit from economies of scale to the same degree as grid scale solar, public demand will support higher costs. The report prepared for the Nature Conservancy by the Coalition for Green Capital finds that "distributed solar is considered 'economically viable' when the levelized cost of energy (LCOE) is below the average retail price of electricity paid by customers. In Pennsylvania, that is about 14 cents per kWh for residential customers and 9 cents per kWh commercial customers."[105]

This section includes five proposal strategies for distributed solar generation.

### 1. VIRTUAL NET METERING

Pennsylvania's net metering policy is described in **SECTION I.B.2**. A key difference between this and other state programs is that the PUC's interpretation of the statutory requirements recognizes "virtual meter aggregation" as opposed to "virtual net metering." As a result, the regulations include several restrictions:[106] For customers of PUC-regulated EDCs, generation and load at multiple physical meters may only be aggregated if all the electric accounts for all the locations are under the same name, are located within a two-mile radius of the interconnected solar PV system's primary location and are within the service territory of the same utility. The PUC further requires that each meter in the aggregation have load independent of the PV generation system, even though the enabling legislation contains no such restriction.

**PROPOSED STRATEGY 11:** Give customer-generators the opportunity to use virtual net metering.

Virtual net metering, on the other hand, is less restrictive and allows for better access to solar and more flexible and cost-effective solar deployment. Virtual net metering permits one or more customers to receive solar generation credit against their electric bills from a solar PV facility that is not tied directly to the customers' meters. This also allows customers, who lack access to a suitable location to install solar, the opportunity to have access to solar.

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[104] N Carolina Technology Center Grid Modernization

[105] The Nature Conservancy, Pennsylvania Clean Energy Market Report, (Feb. 2017), available at: https://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/pennsylvania/pa-clean-energy-market-report-1.pdf ("TNC Market Report').

[106] 52 Pa. Code § 75.11 *et seq*.

States have different approaches to virtual net metering. Massachusetts, for example, makes no distinction in its regulations between conventional and virtual net metering.[107] California, on the other hand has programs that specifically target affordable multi-family housing.[108]

Some stakeholders, such as the utilities and ratepayer advocates, assert electricity customers with net metered distributed generation, such as solar customer-generators, shift costs for the system's infrastructure and maintenance to electric customers without solar PV, or other forms of distributed energy resources (DER). These groups may have advocated for a policy structure where "net-metered customers should be compensated at the wholesale price for the electricity they produce, like other electricity providers."[109] Solar advocates, on the other hand, argue that "most studies have shown that the benefits of distributed solar generation equal or exceed costs to the utility or other customers where penetration is low." [110] And, that cost-shifting is often a mechanism used by regulations to incentivize specific policy goals.

Any implementation of this strategy should be sensitive to the issue of cost-shifting and carefully quantify the values and avoided utility costs resulting from deploying solar to ensure rates continue to be fair and reasonable.

## 2. COMMUNITY SOLAR

Community solar establishes a shared solar energy resource that participants can jointly own, or subscribe to, and receive benefits in much the same way as if they had installed individual solar systems on their properties. This gives access to solar generation to parties who may otherwise be unable to install a solar system, or lack access to sufficient capital or credit to invest on their own. Programs can also be structured to accomplish specific policy goals such as controlling costs for fixed-income customers or providing low and moderate-income families access to clean generation. As of 2017, over 100 MW of shared solar projects exist across 26 different states.[111]

**PROPOSED STRATEGY 12:** Identify and remove the barriers to the deployment of community solar systems in Pennsylvania.

Community solar tends to be more cost-effective due to economies of scale. Although there is no inherent limit in system size,[112] most community solar projects are in the range of 1 – 3 MW. Developers find these larger purchases often allow for lower costs of equipment and the centralized location of the project allows for more efficient installation. Locations for community solar systems can also be chosen

[107] Massachusetts, *Net Metering Guide, available at:* http://www.mass.gov/guides/net-metering-guide.
[108] See: http://www.cpuc.ca.gov/General.aspx?id=5408
[109] Edison Electric Institute, *Solar Energy and Net Metering*, January 2016
[110] SEIA & Collaborative of Solar Organizations, *Principles for the Evolution of Net Energy Metering and Rate Design*, May 2017
[111] https://www.communitysolarhub.com/
[112] US EPA, Community Solar: An Opportunity to Enhance Sustainable Development (Dec. 2016).

for optimal generation, lower land-use costs, ease of maintenance, improved security, and other factors.[113] Projects can, therefore, be both cheaper and more productive than equivalent rooftop generation.

The preference of a consumer for solar goods and services can manifest itself in many ways, and individual stakeholders may have different reasons for engaging in a community solar project. Individuals can opt-in for personal reasons, but community solar also affords the possibility of collective action: when a group of individuals act with a common objective that reaches a mutually beneficial goal. In either case, the goal of a project can be lower electricity prices, to generate power locally, to reduce carbon emissions, to potentially increase property values and desirability of neighborhoods etc.

### Community Solar for Economically Disadvantaged Communities

Community solar can facilitate the diffusion of solar by expanding access to those with insufficient access to capital or credit for traditional purchase or leasing models. But, while community solar can foster development in low-income and urban areas, simply permitting the community solar model may not be sufficient. Available investment capital tends to focus on area with the highest return and lowest risk along with low customer acquisition costs. This would normally result in projects targeted at a fewer number of business or high-income residential subscribers before low-income communities.

Some states have addressed this by adding specific carve-outs in their enabling legislation requiring a mix of projects. Including a percentage of low-to-moderate income customers in every community solar project have added a layer of complexity has proven burdensome for the developer to complete projects in other states. Some programs state that carve-out targets do not need to be required on a per project basis.

Another option is to operate in conjunction with on-bill repayment or energy assistance programs to reduce risk. Community Solar programs can permit low-income customers to apply current energy assistance programs (e.g., LIHEAP, weatherization, customer assistance programs) to the purchase of a solar energy subscriptions from a community solar program, if the solar energy subscriptions price is same or below the price of the customer's current electricity rate. Since the utilities may already manage these payments for their low-income customers, application of those assistance funds to a community solar program may also be managed through the customer's electric bill.

[113] See generally: http://www.communitysolar.psu.edu/

### CASE STUDY—PENNSYLVANIA SOLARIZE PROGRAMS

#### PHILADELPHIA

Solarize Philly is an aggregate buying program intended to lower the price of solar and increase market development. The more customers who sign up as part of Solarize Philly, the more discounts for all participants. Solarize Philly goes beyond the traditional solarize model by adding revenue streams to expand job training programs and to offer an affordable option for low- and moderate-income households, all while providing the best price for all consumers.

The Philadelphia Energy Authority, who manages the program, ensures that the selected installers are reputable, contracts are standardized with key consumer protections, and the equipment is high quality with appropriate warranties. Since its launch in April 2017, over 3,000 households have signed up to receive a free solar assessment through Solarize Philly.

#### ALLEGHENY COUNTY

Solarize Allegheny ran from February 2015 to June 2017. The initiative helped homeowners and businesses to navigate the solar procurement process by linking them to qualified solar installers and making the process of going solar simple and easy. Solarize Allegheny aimed to double the amount of solar installed across the Allegheny County during the program using on-the-ground community-based marketing and outreach and by partnering with community leaders and organizations.

In 2014, Allegheny County had only 200 solar installations before the program began with just 18 systems installed in the previous year of 2014. During Solarize Allegheny, almost 1,000 people across the county signed up for a solar quote. The program directly resulted in more than 55 people going solar during the program period and the overall county installations increased to 924 during the time. In addition, all installers in the area saw an increase in the number of sales and a large, national solar company opened a branch office in Pittsburgh. Solarize Allegheny was funded by the Heinz Endowments and the Allegheny County Health Department.

### Community solar and micro-grids

Micro-grids are local sections of an energy grid that have the capability to disconnect from the rest of the grid and operate in “island mode” autonomously for some period. These can be used to ensure reliability, control costs, or achieve other business or policy goals. To the extent that such grids use solar PV for generation, a project could be structured as a community solar project with the micro-grid functionality adding value. The employment of a micro-grid in this case, might also justify utility ownership or other involvement in the project.

## 3. ALTERNATIVE RATEMAKING

In Pennsylvania, residential electricity rates are volumetric where much of the costs incurred by EDCs for providing electric distribution services are fixed. This results in concerns that sufficient deployment of distributed generation could result in insufficient revenue for the EDC to maintain reliability or inequitable distribution of costs. This creates a situation where EDCs have financial incentives to limit solar deployment. Increasing fixed charges to customers avoids these issues. However, this step is widely opposed because it reduces the consumer's ability to realize electric bill savings from solar distributed generation, or energy efficiency and conservation measures.

**PROPOSED STRATEGY 13:** Ensure alternative ratemaking is addressed in a manner that does not create a disincentive for solar deployment.

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Recently, Governor Wolf signed Act 58 of 2018[114] on alternative ratemaking methodologies, thereby allowing the Public Utility Commission to approve the use of alternate ratemaking mechanisms by utilities, such as decoupling, performance-based rates, formula rates and multiyear rates.

Some stakeholders advocate for the general regulatory principle that rates should reflect cost causation. This could result in the use of demand charges for residential customers and use of higher fixed charges to fully recover fixed costs. Other stakeholders maintain that cost causation alone may undervalue externalities such as public health and environmental benefits associated with solar power and that cost shifts inherent in revised rate making may be justified in pursuit of other policy goals.

While the Project Team does not propose any specific rate design be included as a strategy, we note that to the extent a policy-level choice has been made to incentivize solar deployment, rate designs could either support or detract from that goal.

Increases in fixed or unavoidable costs lowers the return on investment in solar systems. For that reason, higher fixed charges or separate demand charges for residential customers could act as a significant disincentive for solar deployment. Demand charges are also of concern because they don't necessarily correspond to the utility system peak demand.

Other suggested approaches, including time-of-use (TOU) rates, net billing (buy all, sell all), and value of solar tariffs have all been explored in different markets and could, depending on implementation, ensure adequate operating revenue for utilities while either incentivizing solar generation or limiting disincentives.

Consideration of Value of Solar is of importance in Pennsylvania both as a possible feature of alternative ratemaking and because the existing law specifies that "Excess generation from net-metered customer-

[114] https://www.prnewswire.com/news-releases/legislation-allowing-new-utility-rate-structures-becomes-law-300674475.html

generators shall receive *full retail value* for all energy produced on an annual basis."[115] In spite of this, current net metering regulations result in customer-generators receiving the *full retail rate* when excess generation is carried over month-to-month and only the costs of generation or transmission for annual net generation. There have been several studies conducted across the country over the last fifteen years to assess solar value and the results vary depending on what factors are considered[116]. On average the value of solar may be higher than the residential retail rate.[117]

Aside from the specifics of the rate design, it has also been noted that overly complex designs can negatively impact adoption. For that reason, some stakeholders have indicated a preference for simple and clear designs whenever possible.

## 4. PROPERTY ASSESSED CLEAN ENERGY (PACE)

PACE is a mechanism for financing energy efficiency upgrades or renewable energy projects for property owners that allows the owner to finance the project with a private lender and the pay back the loan through the property tax bill. Because PACE loans are land-secured, the loan repayment obligation stays with the property in the event of a sale. This can result in lower finance charges or access to financing for a wider range of individuals or business. This can also reduce the risk that a consumer who invests in energy efficiency or renewable energy and then sells a building will pay a disproportionate share of the cost.

**PROPOSED STRATEGY 14:** Encourage municipalities to offer PACE programs.

PACE programs may be limited to commercial entities (C-PACE) or to residential customers (R-PACE). Recently, Governor Wolf signed Act 30 of 2018 which permits, but does not require, Pennsylvania jurisdictions such as municipalities and/or counties to individually create local Property Assessed Clean Energy districts for the commercial, agricultural, and industrial sector (C-PACE).

Having state legislation authorizing PACE is just the first step. Local jurisdictions also need to adopt ordinances permitting PACE obligations and then lenders need to be willing to use the vehicle. One issue that needs to be explored is whether and to what extent PACE results in more lending made available, lower interest rates, longer term loans and changes to underwriting standards.

A 2014 study of R-PACE in California showed PACE financing increased solar installations by 108 percent over the mean watts per owner-occupied household.[118]

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115 AEPS Act, Section 5. amended July 17, 2007, P.L.114, No. 35. (emphasis added)
116 A Review of Solar PV Benefit & Cost Studies, 2nd Edition, Rocky Mountain Institute, 2013; https://rmi.org/wp-content/uploads/2017/05/RMI_Document_Repository_Public-Reprts_eLab-DER-Benefit-Cost-Deck_2nd_Edition131015.pdf
117 Value of Solar and Grid Benefits Studies - Alternative Approaches and Results (2014-2016 Era); EUCI NEM Workshop; RAP, 2016; https://www.raponline.org/wp-content/uploads/2016/08/rap-lazar-euci-value-of-solar-studies-2016-july-21-2016.pdf
118 A. Justin Kirkpatrick, Lori S. Bennear, *Promoting Clean Energy Investment: An Empirical Analysis of Property Assessed Clean Energy,* Journal of Environmental Economics and Management (Sept. 2014).

There is concern that PACE programs, particularly residential PACE, could encourage predatory lending or other forms of fraud and abuse. Many states have responded by limiting programs to commercial PACE, although best practices guidelines have been developed to address many of the consumer protection issues for residential customers.[119]

## *5.* ADDRESSING INTERCONNECTION ISSUES

There have been some interconnection application issues with solar distributed generation project in most of the EDC regions for various reasons but interconnecting to low voltage distribution service is particularly problematic. Solar PV systems under normal operation, slightly increase the AC voltage at the point of interconnection. In areas served by 4kv distribution lines—in contrast to 13 kV, 34 kV, and higher distribution voltages—the system is particularly limited to how much voltage rise they can tolerate between the substation and the end of the line. Homes or businesses close to substations may have issues with interconnection as higher voltage levels there are required to maintain adequate voltage throughout the circuit. In other cases, homes or businesses further from the substation could have over-voltage issues, like those near the substation voltage due to capacitors, regulators and other devices used to maintain proper voltage levels.

However, "smart inverters" could be a very promising alternate solution at little or no additional cost. Most of the inverters installed today are already smart inverters, which can be programmed to adequately minimize the output voltage or temporarily shut down the inverter if a high voltage threshold is reached. Consequently, there may be some minor loss of solar generation that would offset the electric bill for net metered systems, but this would probably be insignificant in most cases.

**PROPOSED STRATEGY 15:** Accelerate use of smart inverters to managed over-voltage concerns on low voltage distribution lines and avoid unnecessarily adding costs on small solar distributed generation projects.

Note that programming and/or hardware adjustments needed for the inverter to function in this manner is conducted at the site and does not give the EDC any remote control of the system. However, it is also possible that the smart inverters can be programmed for remote control applications by the utilities, with the customer-generator's consent (and maybe along with an incentive), or with large grid scale solar facilities. Smart inverters used this way could address some of the concerns and challenges associated with high variable renewable energy integration into the electric grid via sophisticated monitoring and communication of the grid status, the ability to receive offsite operation instructions, and the capability to make autonomous decisions to maintain grid stability and reliability. However, to enable the use of smart inverters in this way in the market, decision-makers must ensure that regulations allow them to be used.

[119] US Dept. of Energy, *Best Practices Guidelines for Residential PACE Financing Programs.* (Nov. 16, 2017). *Available at: https://energy.gov/sites/prod/files/2016/11/f34/best-practice-guidelines-RPACE.pdf*

# NEXT STEPS

Spring Grove, York County

The target of 10 percent of Pennsylvania's consumption satisfied by in-state generation of solar PV by 2030 is aggressive given the current status of solar deployment, but the Project Team finds that the required generation is within the state's technical and economic potential. The cost of such deployment represents a modest (less than 1.5 percent) increase in our state's annual energy spending, the combination of fuel savings and accounting for externalities such as avoided public health and environmental damages results in a net benefit of over $1.6 billion annually.

A significant increase in solar deployment will also bring jobs to Pennsylvania. Currently, Pennsylvania lags behind many surrounding states in terms of solar jobs per capita but achieving the 10 percent goal could reverse that trend. The Project team found that more than 60,000 construction jobs would be created, with many other opportunities in the workforce.

Perhaps the first step to a solar future for Pennsylvania is education. This report confirms that solar can provide a more significant share of the electric generation resources in Pennsylvania through implementation of the 15 strategies suggested by stakeholders. This is not an exhaustive list and these strategies can be combined to create different pathways that lead to the 10 percent goal, if policy makers commit to that path.

During the development of this report there were ongoing legislative and regulatory actions at the state and federal level creating a constantly changing policy landscape. Any set of strategies chosen for implementation must consider these changes. However, a common theme in these changes is a recognition that solar power will increasingly be part of Pennsylvania's future.

This report does not represent the end of the Finding Pennsylvania's Solar Future project. Over the next few months, the Project Team and stakeholders will develop the Strategy Support and Market Transformation Plan. This document will describe how the strategies identified in this plan can be implemented, and highlight what additional information is needed to continue to grow solar in Pennsylvania.

# APPENDICES

## A. STAKEHOLDERS

This project would not be possible without an active group of stakeholders. As such, the Project Team would like to recognize and thank the following individuals for their contributions. (*Please Note: Participation as a stakeholder does not imply endorsement of this report.)*

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# B. MODELING

## 1. INTRODUCTION

The team has used several analytic tools to help inform *Pennsylvania's Solar Future*, working group meetings and discussions. This appendix presents details on the following models, and how they were used to inform the study and stakeholder discussions:

- Long Range Energy Alternatives Planning System (LEAP) model
- The System Advisor Model (SAM) and the
- Jobs and Economic Development Impact (JEDI) model

The Project Team reviewed the structure and functional objectives for each of the three models, identified data inputs and sources used by the Project Team, reviewed results, and discussed any sensitivity analyses. This appendix presents additional information in the following tables and figures:

## 2. LEAP MODELING STRUCTURE

LEAP is energy policy analysis software[120] designed to compare energy, economic, and environmental effects of alternative energy future scenarios. It is meant for total energy analysis at a relatively large scale but is flexible enough to be applied to different sectors and various levels of detail. The Stockholm Environment Institute has refined LEAP for more than 20 years. It has been used to conduct integrated energy and environmental planning in more than 190 countries.

The LEAP analyses focused on modeling a future with 10% electricity in state demand being met from in state solar by 2030, with a focus on long term planning and the implications for Pennsylvania's total energy economy, including both supply and demand side resources. The level of detail achieved in the model differed between sectors and was based on best available data at the granularity needed to address the identified focus areas.

LEAP modeling typically begins with the development of a demand tree that represents energy demand by fuel across end uses and sectors within an economy. **Figure 1** offers an example of the residential portion of a demand tree structure. There are other branches with varying levels of detail for commercial, industrial, and transportation. The Project Team used recent data to create "current accounts," which then became the basis for projected changes in the Reference and Solar scenarios.

The Project Team entered current and projected energy use in the demand tree, across all of its branches, to calculate the energy demand by fuel type and sectors. Examples of the type of information entered for each item in the tree are: the amount and type of energy used by end-use devices, level of demand for specific end uses, capital costs, maintenance costs, and how all of these change over time. The structure also reflects demographic and economic activity levels as "demand drivers"; examples are population, household size, value of industrial shipments, commercial employees, and vehicle miles traveled.

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[120] Heaps, C.G. 2016. Long-Range Energy Alternatives Planning (LEAP) System, version 2015.0.24. Somerville, Mass.: Stockholm Environment Institute (USA). https://www.energycommunity.org.

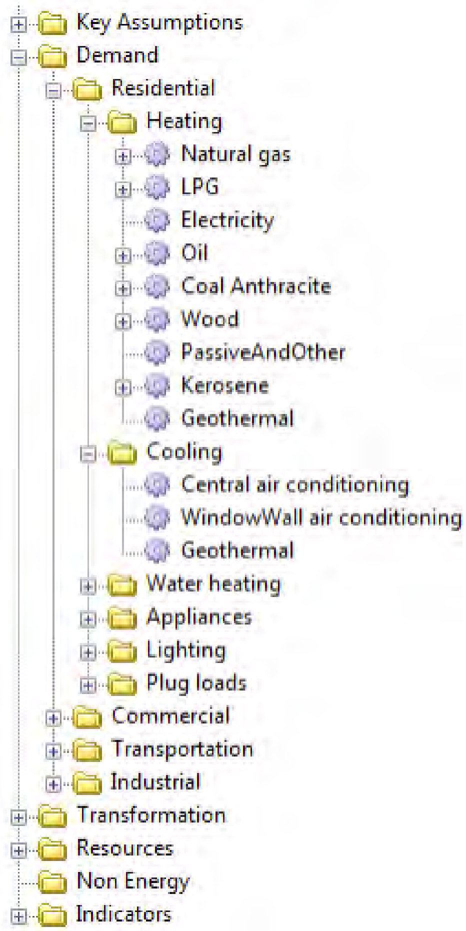



**Figure 1. Demand tree structure of LEAP expanded to show residential space**

Once the demand for various types of energy is determined, LEAP calculates the necessary energy infrastructure (such as electric generation plants, or natural gas pipelines) and the natural resources (such as fossil fuel or renewable resources) required to meet that demand. The transformation and resources are used to match demand by time period, as an economy grows, or, for example, as energy demand varies throughout the year.

Analysts start by defining current accounts which is a snapshot of current energy demand and supply. The tool is structured so that you then develop business-as-usual and comparison scenarios to help investigate possible energy futures. For example, **Figure 2** illustrates the Current Accounts for Residential Water Heating. All households have water heating with Natural gas and electricity each representing roughly forty percent of the total market share by fuel type. The input data used to create the current accounts, future years and alternative scenarios are drawn from the Energy Information Administration Residential Energy Consumption Survey, and other state specific sources.

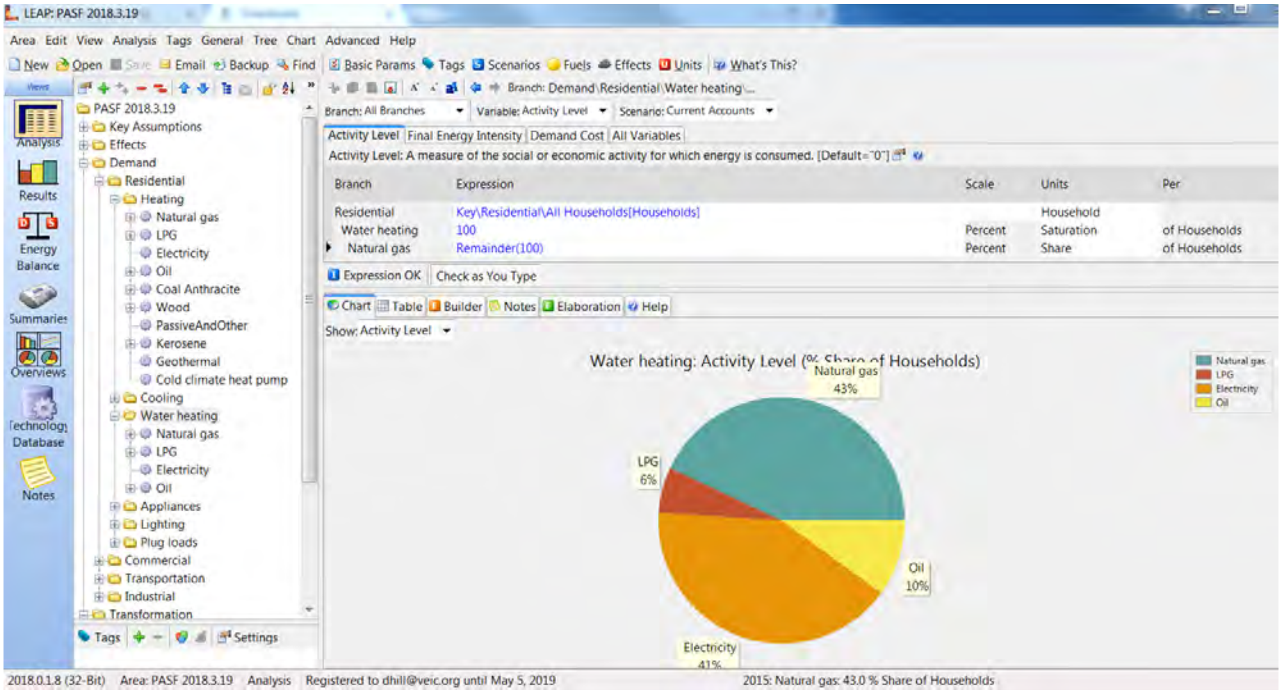



**Figure 2: LEAP Current Accounts Input Screen for Residential Water Heating.**

LEAP sums the demands by fuel type and by end use for each sector. This allows the analyst to compare the energy use under different scenarios and with different input and data.

For example, **Figure 3** below illustrates a comparison of the total final demand by type for residential space heating, comparing the solar A scenario with a scenario that includes higher levels of energy efficiency and more strategic electrification of space heating. The first chart illustrates the total energy use in the Solar plus EE plus electrification scenario and illustrates the total amount saved because of efficiency and electrification. **Figure 4**, further examines this difference of roughly 40 Trillion BTUs, identifying the savings by fuel type as well as indicating the increased use in geothermal and cold climate air source heat pumps.

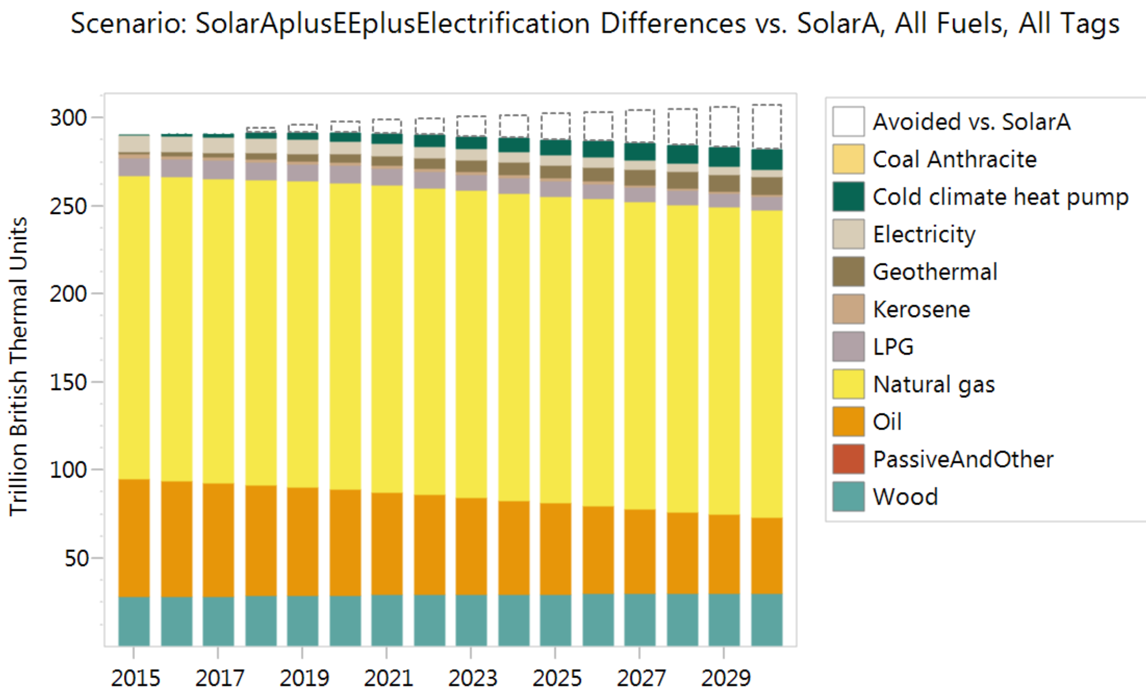



**Figure 3: Residential Space Heating, Comparison of Total Energy Demand for Residential Space Heating between Solar Scenarios with and without Additional Efficiency and Electrification of Space Conditioning**

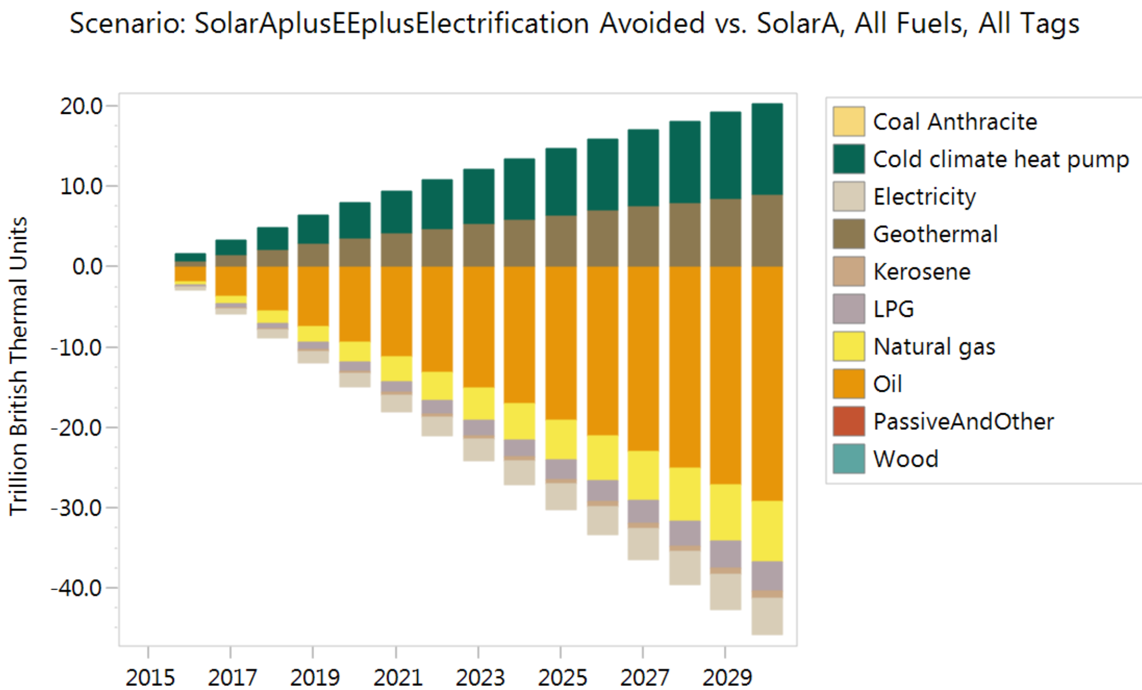



**Figure 4: Residential Space Heating, increase in cold climate heat pumps and geothermal and decline in oil, natural gas, and kerosene. SolarAplusEEplusElectrification compared to Reference.**

Once the demand for various types of energy is determined, LEAP calculates the necessary resources and to meet that demand. The transformation module in LEAP accounts for losses from the energy production facility to the end user, including transmission and distribution losses for natural gas and electricity.

Electric generation is defined by plant type, with each plant type having input fuels, conversion efficiencies, maximum availability, operating and capital costs. Dispatch order is also specified. For *Pennsylvania's Solar Future*, the Project Team used merit order dispatch, specifying that when solar and other intermittent resources were available they were dispatched first to meet loads. Scenarios can then vary inputs for the generation plants defined in the transformation module.

As an example, Figure 5 illustrates a comparison between the reference and four of the solar scenarios in terms of the annual energy generation by system type in 2025.

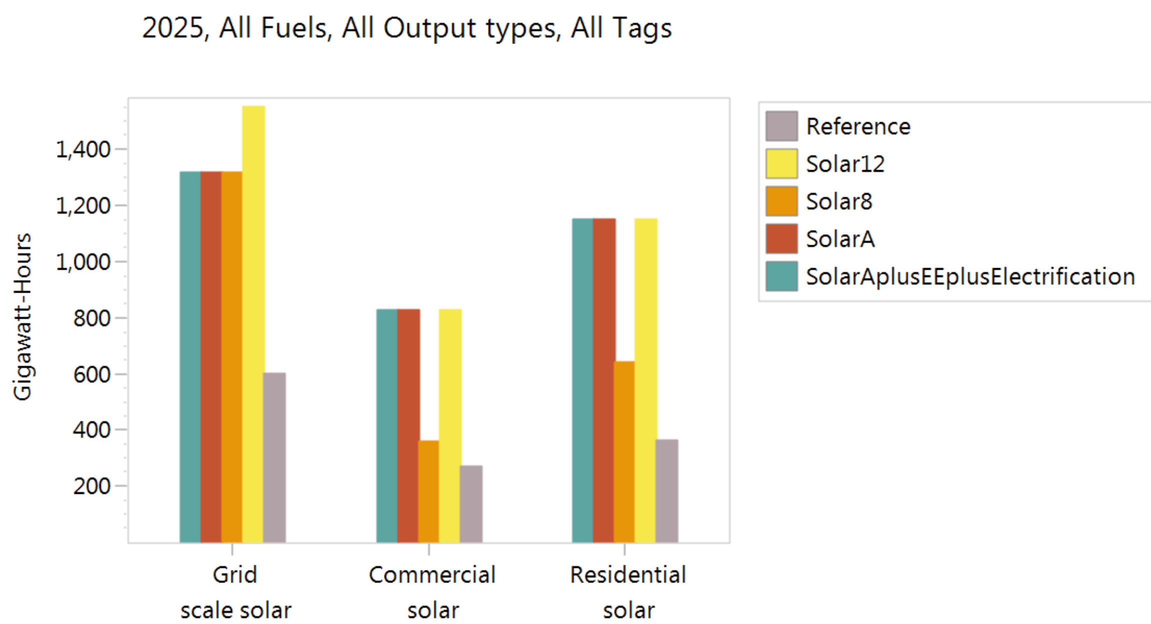


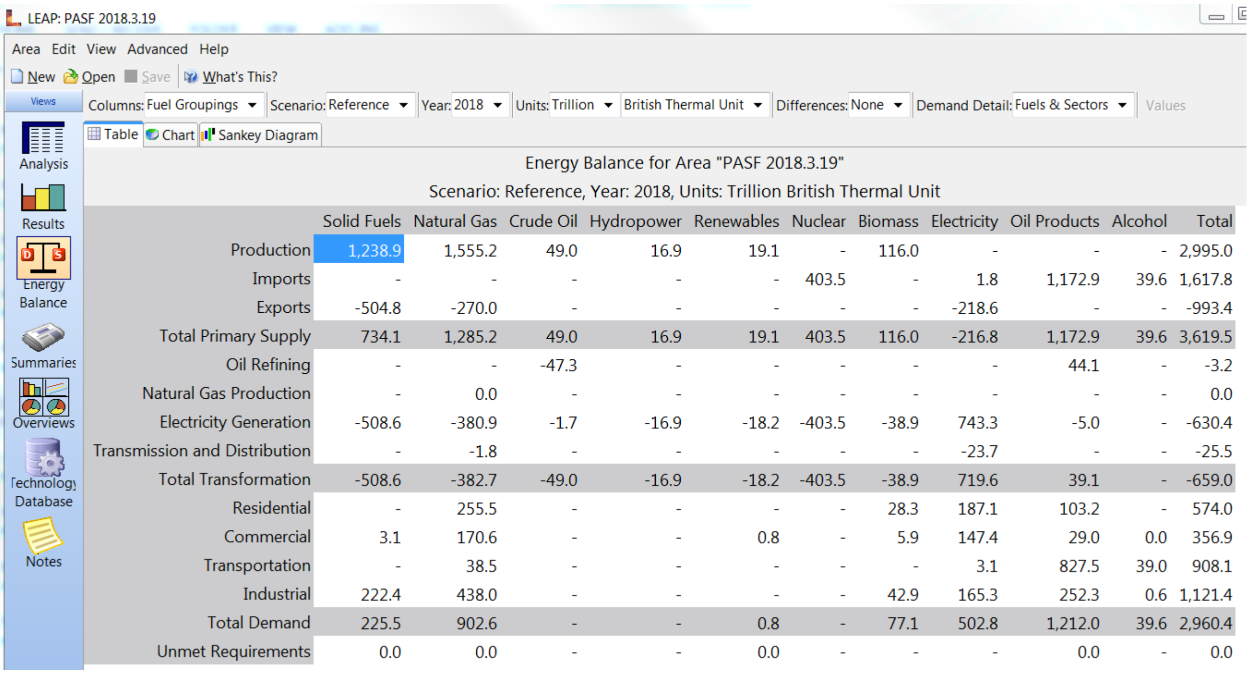

**Figure 5: Annual Solar Generation 2025 in Reference and Four Solar Scenarios**

After the demand and transformation modules have been specified and developed the LEAP system examines available energy resources (primary resources include anthracite coal, natural gas, and solar; and secondary resources include products such as gasoline, diesel and heating fuel oil) that are available indigenously both in terms of stocks (for non-renewable) and annual yields (for renewable resources. Import and export availability and or targets can also be specified.

Based on Pennsylvania's history as an electricity exporter, the Project Team modeled electricity generation that meets in state demand of roughly 150 TWh per year, as well as exports of roughly 80 TWh. The Finding PA Solar Future target is based on 10 percent of the instate annual consumption of roughly 150 TWh.

For each year and each scenario LEAP calculates an energy balance which identifies any short falls in supply and resources needed to meet the energy demands. The energy balance and flows in each year are then used to calculate the costs and environmental impacts associated with each scenario.

**Figure 6** illustrates a LEAP energy balance table, using 2018 in the reference scenario as an example. All the energy units are presented in Trillion British Thermal Units (TBtu). LEAP permits easy conversion of energy units so that results can be presented in electric equivalent, such as TWh and other physical or energy units.




Energy Balance for Area "PASF 2018.3.19"

Scenario: Reference, Year: 2018, Units: Trillion British Thermal Unit

| | Solid Fuels | Natural Gas | Crude Oil | Hydropower | Renewables | Nuclear | Biomass | Electricity | Oil Products | Alcohol | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Production | 1,238.9 | 1,555.2 | 49.0 | 16.9 | 19.1 | - | 116.0 | - | - | - | 2,995.0 |
| Imports | - | - | - | - | - | 403.5 | - | 1.8 | 1,172.9 | 39.6 | 1,617.8 |
| Exports | -504.8 | -270.0 | - | - | - | - | - | -218.6 | - | - | -993.4 |
| Total Primary Supply | 734.1 | 1,285.2 | 49.0 | 16.9 | 19.1 | 403.5 | 116.0 | -216.8 | 1,172.9 | 39.6 | 3,619.5 |
| Oil Refining | - | - | -47.3 | - | - | - | - | - | 44.1 | - | -3.2 |
| Natural Gas Production | - | 0.0 | - | - | - | - | - | - | - | - | 0.0 |
| Electricity Generation | -508.6 | -380.9 | -1.7 | -16.9 | -18.2 | -403.5 | -38.9 | 743.3 | -5.0 | - | -630.4 |
| Transmission and Distribution | - | -1.8 | - | - | - | - | - | -23.7 | - | - | -25.5 |
| Total Transformation | -508.6 | -382.7 | -49.0 | -16.9 | -18.2 | -403.5 | -38.9 | 719.6 | 39.1 | - | -659.0 |
| Residential | - | 255.5 | - | - | - | - | 28.3 | 187.1 | 103.2 | - | 574.0 |
| Commercial | 3.1 | 170.6 | - | - | 0.8 | - | 5.9 | 147.4 | 29.0 | 0.0 | 356.9 |
| Transportation | - | 38.5 | - | - | - | - | - | 3.1 | 827.5 | 39.0 | 908.1 |
| Industrial | 222.4 | 438.0 | - | - | - | - | 42.9 | 165.3 | 252.3 | 0.6 | 1,121.4 |
| Total Demand | 225.5 | 902.6 | - | - | 0.8 | - | 77.1 | 502.8 | 1,212.0 | 39.6 | 2,960.4 |
| Unmet Requirements | 0.0 | 0.0 | - | - | 0.0 | - | - | - | 0.0 | - | 0.0 |

**Figure 6: LEAP Energy Balance, Finding Pennsylvania's Solar Future Reference Scenario 2018.**

## 3. LEAP MODELING INPUTS AND DATA SOURCES

The Project Team collected data from publicly available state level and national sources. Information on sources and assumptions in this report and in stakeholder meeting presentations was used to summarize the modeling inputs and assumptions, and to convey a general sense of the approach and level of depth and rigor of the modeling.

### A) DEMOGRAPHIC AND ECONOMIC ACTIVITY DEMAND DRIVERS

Each sector of the demand tree has a unit that measures activity in the sector.  That unit is the "demand driver." LEAP multiplies it by the energy intensity of activities to calculate sector energy demand.

Pennsylvania's population is assumed to grow from 12.8 million in 2015 to 13.2 million in 2020, and 14.1 million in 2030. The number of people per household is assumed to remain constant at 2.29. These assumptions combine to give the number of households, the model's demand driver for residential energy consumption.

The Project Team based the projected change in the energy demand from the industrial sector on the value of products shipped. The Census Bureau provided data from 2014 and 2015, and the Project Team used the national growth rate from the 2017 Annual Energy Outlook to project forward.

Energy consumption in the commercial sector was based on employment in the services-providing sectors. Data from 2014 and projections for 2024 from the Department of Labor were used, with growth beyond 2024 assumed to continue, though at a slower pace.

Transportation energy use was based on the EIA State Energy Data System and the Department of Transportation's Pennsylvania Highway Statistics 2015. There is no demand driver in the transportation sector, total energy by fuel was entered directly in the subsectors: road/rail/air/other.

**Table 1: Sources used for Demographic and Economic Demand Drivers**

| Input and Value | Source | Notes |
|---|---|---|
| Population:<br>2015: 12.8 Million<br>2030: 14.1 Million | Census Bureau, Center for Rural Pennsylvania | Population serves as a demand driver for residential energy use and transportation. |
| People Per Household<br>All years: 2.29 | Census Bureau, American Community Survey | Residential energy consumption is primarily calculated on a per-home basis. |
| Commercial Services Employment<br>2015: 4.9 Million<br>2030: 5.4 Million | Pennsylvania Department of Labor and Industry | Employment serves as the demand driver for commercial energy use. |
| Industrial Products Value Shipped<br>2015: ~$200 billion<br>2030: ~ $300 billion | Census Bureau, Manufacturers' Shipments, Inventories, & Orders | Industrial energy consumption is primarily driven by this metric. |
| Electric End Use Efficiency<br>2% Annual increase in efficiency | Alternative Energy Portfolio Standard (AEPS) targets extended through modeling period, US Energy Information Administration (EIA) Annual Energy Outlook 2017, and professional judgement | All scenarios show some moderate efficiency at the level of the AEPS targets extended through the modeling period. EE scenarios include higher rates of efficiency. |
| Natural Gas End Use Efficiency<br>.05% Annual increase in efficiency | AEPS targets extended through modeling period, EIA Annual Energy Outlook 2017, and professional judgement | All scenarios show some moderate efficiency at the level of the AEPS targets extended through the modeling period. EE scenarios include higher rates of efficiency. |
| Industrial End Use Efficiency<br>1.1% Annual increase in structural efficiency<br>1% Annual increase in industrial energy efficiency | EIA Annual Energy Outlook 2017, and professional judgement | Includes structural efficiency due to shifts to production of less energy intensive products and improvements in process and end use equipment. |

## B) FINANCIAL INPUTS

LEAP also uses other basic parameters, including real and nominal discount rates to calculate economic returns.

Long term economic models rely on assumptions about discount rate and inflation to account for the time value of money and future uncertainty.

Real discount rate: 1.75%[121]

- The scenarios consider large scale changes from investments by many different individuals and organizations, and potential public policy.
- While utility investment may be significant, in grid upgrades and potentially owning solar, utilities are not expected to contribute a large share of the scenario investments.
- Therefore utility weighted average cost of capital (WACC) may not be the most appropriate estimate of the discount rate.
- As a whole, the scenarios are a societal investment for societal benefits, similar to the Societal Cost Test (SCT), which uses a low discount rate reflecting a higher valuing of future savings.
- The SCT does not have a specific source for a rate, but it is lower than that for the similar Total Resource Cost (TRC) Test, which can use the 10-year Treasury bill rate, which has averaged near 2.25% for the past five years.

Inflation rate: 2.0%

- This is the target rate for the Federal Reserve. PA's Independent Fiscal Office assumes this rate is achieved in their Economic and Budget Outlook.

## C) DEMAND BRANCH INPUTS

Values and inputs used in the LEAP model for the residential branch of the demand tree are documented in **Table 2**:

**Table 2: Residential Energy Demand**

| Input and Value | Source | Notes |
|---|---|---|
| End use saturation | EIA Residential Energy Consumption Survey 2009, Table 8 | Cooling is expected in 90% of residential households, 100% for other end uses. |
| Residential heating end use shares | American Community Survey | In all non-heat pump scenarios, ~50% of residential heating comes from natural gas, ~20% from electric heat, ~15% from oil, and less than 5% each from propane, kerosene, wood, geothermal, and coal. |
| Residential heating energy intensity | EIA Residential Energy Consumption Survey 2009. Table CE 4.7 | Cold climate heat pumps and natural gas boilers are expected to increase in efficiency over time. Other residential heating devices remain constant in energy consumption per house. |

[121] Regulatory Assistance Project & Synapse, *Energy Efficiency Cost-Effectiveness Screening*, http://www.synapse-energy.com/sites/default/files/SynapseReport.2012-11.RAP_.EE-Cost-Effectiveness-Screening.12-014.pdf

| Input and Value | Source | Notes |
|---|---|---|
| Residential cooling end use shares | EIA Residential Energy Consumption Survey 2009, Table HC 8 | |
| Residential cooling energy intensity | EIA Residential Energy Consumption Survey 2009, Table HC 8 | Cooling is expected to increase slightly in efficiency over time. |
| Residential water heating end use shares | EIA Residential Energy Consumption Survey 2009, Table HC8.8 | Share of water heating provided by natural gas, propane, electricity, and oil are steady over the modeling period. |
| Residential water heating energy intensity | EIA Residential Energy Consumption Survey 2009, Table CE 4.7 | Electric and natural gas water heaters are expected to slightly improve in efficiency over the modeling period |
| Residential appliance end use shares | EIA Residential Energy Consumption Survey 2009, Table CE 4.7 | |
| Residential appliance energy intensity | EIA Residential Energy Consumption Survey 2009 | |
| Residential lighting and plug loads end use shares | EIA Residential Energy Consumption Survey 2009 | Full saturation for both categories for duration of the model. |
| Residential lighting and plug loads energy intensity | EIA Residential Energy Consumption Survey 2009 | Average lighting and plug load efficiency is expected to increase throughout the model period as the transition to LED lighting and more efficient devices continues. |

The commercial, industrial, and transportation sector demand trees were modeled based upon total fuel use and economic drivers. The Project Team did not conduct an end use level of analysis at the same level of detail as was conducted for the residential sector (space conditioning → heating → device → intensity). The diversity of end uses and devices in the commercial and particularly the industrial sector mean that such a detailed analysis would be time consuming and was not deemed to add sufficient value for the objectives of this study. The LEAP model allows users to vary the level of detail by each of the model segments and still conduct an integrated analysis of the total energy economy which is very helpful and adaptable based on the research objectives. Table 3 summarizes the commercial and industrial branch inputs and sources.

**Table 3: Commercial, Industrial, and Transportation Energy Demands**

| Input and Value | Source | Notes |
|---|---|---|
| Commercial total use by fuel | EIA State Energy Data System | Employment in services is demand driver for future years. Also impacted by efficiency factors. |
| Industrial total use by Fuel | EIA State Energy Data System | |
| Transportation total use by mode, and fuel | EIA State Energy Data System, PA Highway Statistics, EIA's Annual Energy Outlook for 2017, Electric Vehicle Industry Expertise | |

## D) PV COSTS AND PERFORMANCE

Current solar costs are based on Pennsylvania data in the National Renewable Energy Laboratory's OpenPV data set[122], and cost projections are sourced from the national averages projections in the National Renewable Energy Lab's 2017 Annual Technology Baseline (ATB). The Open PV data contains cost information from more than 1 million solar installations representing more than 16 GW of installed capacity.

Current Pennsylvania solar costs are above national averages in Open PV as a result of Pennsylvania having a less developed market and policies that have yet to build the market for solar as seen in other parts of the nation. The discrepancy is largest for commercial solar projects, followed by residential and utility scale, respectively.

**Figure 7** illustrates the costs for systems by class in Pennsylvania in the darker colors and national average in the same color with a lighter shade. As the market in Pennsylvania grows to meet the Finding PA Solar Future target, the gaps in installed costs are projected to diminish and disappear by 2030.

[122] https://openpv.nrel.gov/

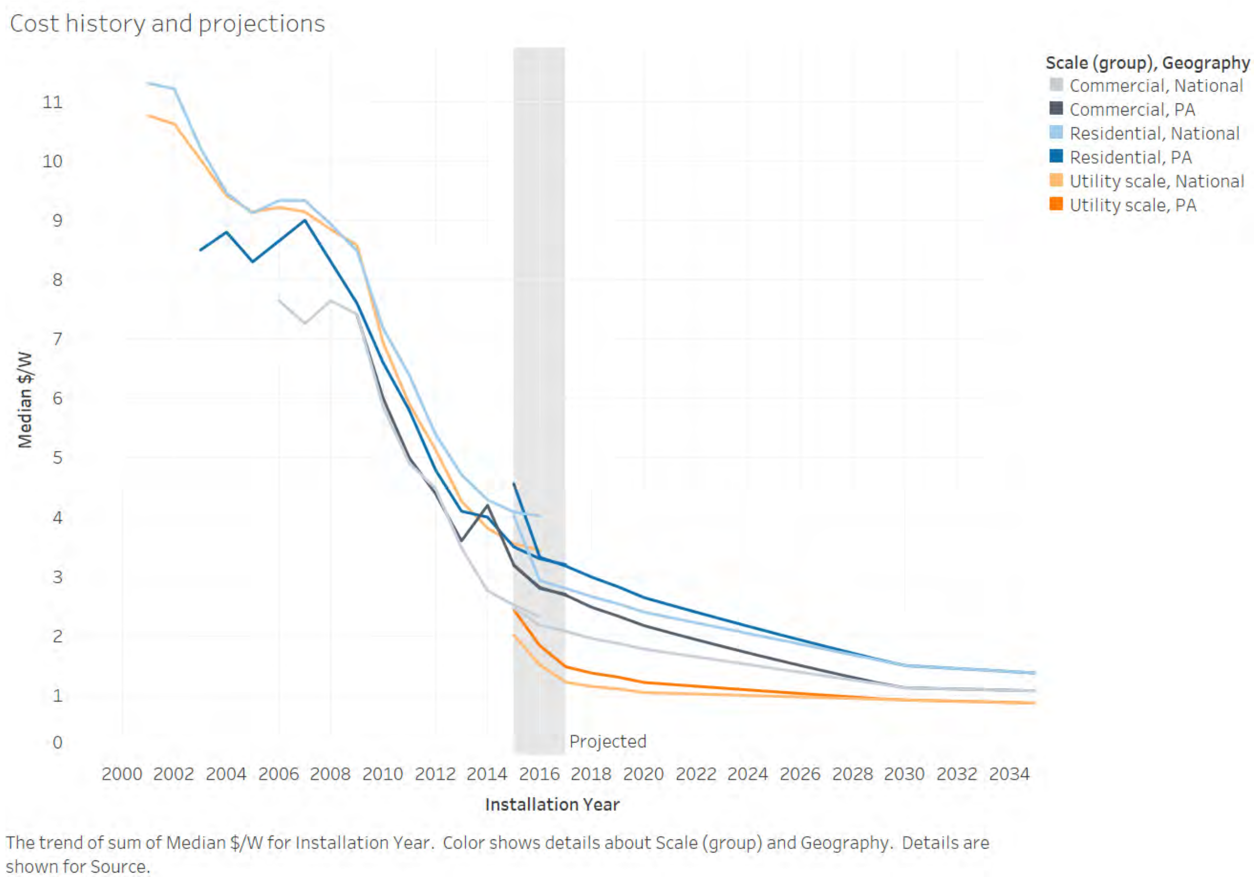



**Figure 7: Historic and Projected PV costs (Open PV and NREL Technology Database)**

The starting and projected 2030 costs and performance for three system types are based on the Open PV data and the cost projections in the Technology Database are summarized in Table 4.

**Table 4. PV Cost and Performance Inputs**

| | Residential | Commercial | Grid scale |
|---|---|---|---|
| Capacity factor (DC / AC, %) | 14% | 12% | 16% |
| (kWh / kW / year) | 1,205 | 1,091 | 1,433 |
| | | | |
| Capital cost ($ / kW) | | | |
| 2018 w/o incentive | 2,989 | 2,481 | 1,373 |
| 2018 w / ITC, tariff | 2,281 | 1,931 | 1,125 |
| 2030 (ITC gone) | 1,547 | 1,171 | 958 |
| O&M 2018 ($ / kW·year) | 20 | 15 | 12 |

## E) GRID INTEGRATION COSTS

Reaching the 10% solar target can have additional costs related to the integration of solar as an intermittent and distributed resource on the grid. During the September 2017 meeting in Villanova, stakeholders heard a presentation from PJM on integration potential for the bulk power system. The presentation referenced earlier research commissioned by PJM to look at the impact to grid operations from integration of higher levels of renewables into the PJM interconnection system.[123] Key findings included that integration of up to 30% energy from wind and solar would not cause significant reliability issues. At a more granular level, estimates showed that up to 11 GW of solar in Pennsylvania could be handled without causing significant issues. This value is similar to what the Project Team has calculated to be the required new solar capacity in Pennsyvania to meet the 10% by 2030 target.

On the distribution side of the utility system, the Project Team included estimated upgrade costs based on a meta-study of integration cost studies.[124] **Figure 8** and **Table 5** are drawn directly from the Synapse report, and illustrate that the value of $5/MWh for solar integration costs on the distribution system are relatively conservative. This is particularly true if steps or strategies are developed to locate solar on distribution feeders where there is available hosting capacity, or where costs for increased hosting capacity are relatively low.

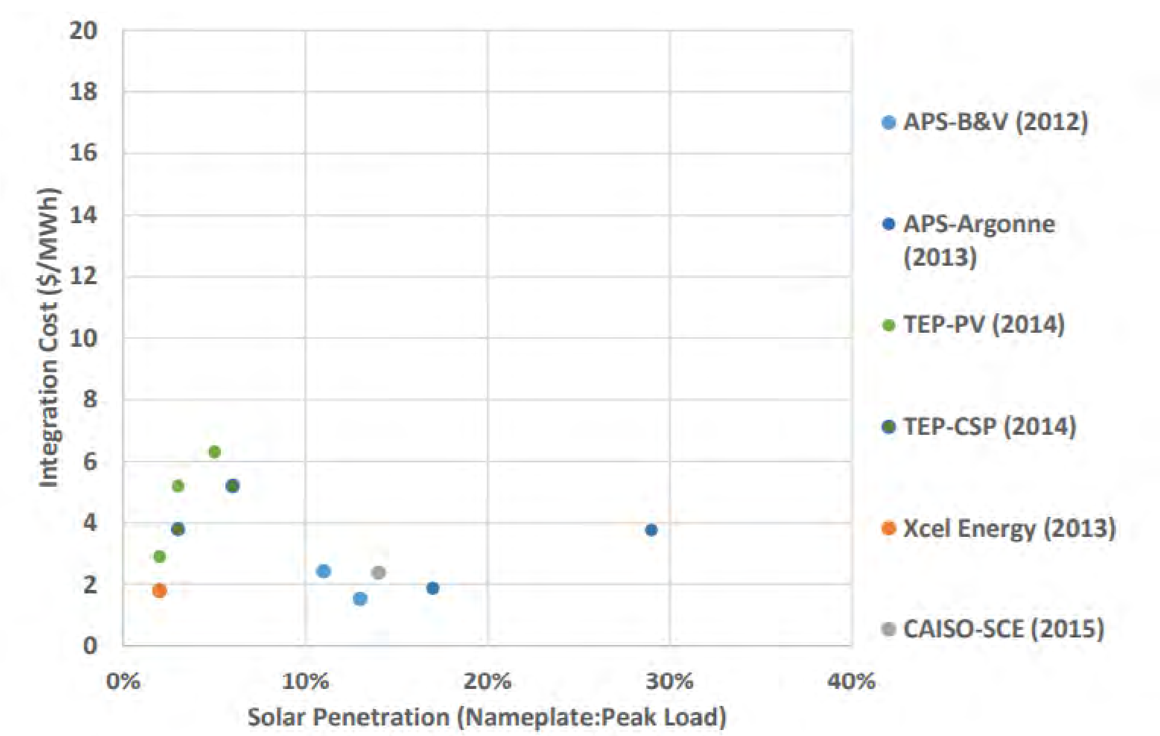



**Figure 8: Solar integration costs by level of penetration (From Synapse report).**

[123] http://www.pjm.com/committees-and-groups/subcommittees/irs/pris.aspx
[124] Synapse, 2015, "A Solved Problem: Existing measures provide low-cost wind and solar integration," http://www.synapse-energy.com/sites/default/files/A-Solved-Problem-15-088.pdf

**Table 5: Source Studies cited by Synapse Report**

| Study | Study Period | System Peak (MW) | Type of Solar | Penetration on Peak Demand Basis (%) | Integration Cost ($/MWh) |
|---|---|---|---|---|---|
| **B&V - APS 2012[a]** | 2020 | 8,200 | PV | 13% | $1.53 |
| | 2030 | 10,900 | PV | 11% | $2.43 |
| **Argonne – APS 2013[b*]** | 2027 | 10,090 | PV | 17% | $1.88 |
| | 2027 | 10,090 | PV | 29% | $3.77 |
| **TEP IRP 2014[c]** | 2014-2028 | 3,198 | PV | 2% | $2.90 |
| | 2014-2028 | 3,198 | PV | 3% | $5.20 |
| | 2014-2028 | 3,198 | PV | 5% | $6.30 |
| | 2014-2028 | 3,198 | CSP | 3% | $3.80 |
| | 2014-2028 | 3,198 | CSP | 6% | $5.20 |
| **Xcel Energy 2013[d]** | 2012-2034 | 8,000 | DG PV | 2% | $1.80 |
| **CAISO-SCE 2015[e†]** | 2024 | 51,000 | PV | 14% | $2.38 |

See report for citations for each of the studies in Table 5.

## F) COSTS FOR FUELS DISPLACED BY SOLAR

Computing the economic results of the solar and alternative scenarios requires the Project Team to have forecasts of the future fuel prices for the fuels that are displaced as solar generation grows. The Project Team used the Energy Information Administration's Annual Energy Outlook as its source for future fuel costs.

Figure 9 illustrates the EIA's Annual Energy Outlook forecasts relatively level fuel prices throughout the analysis period.

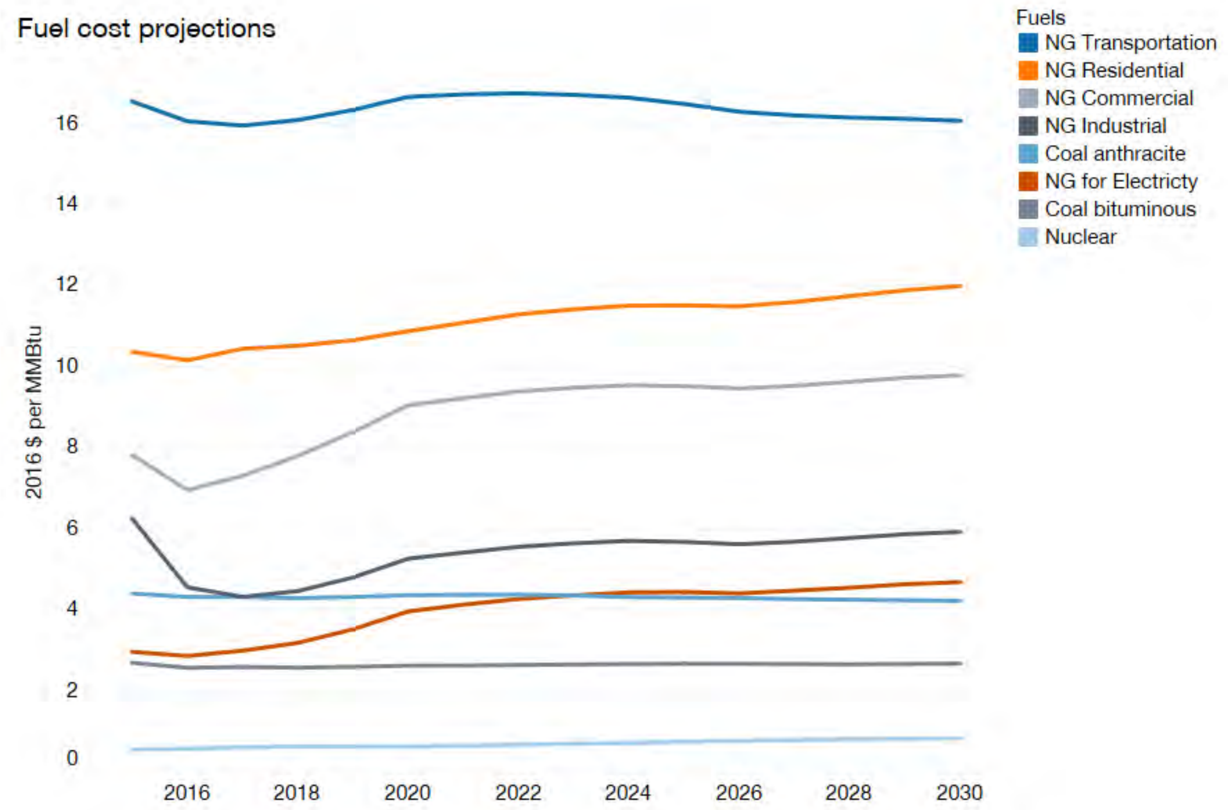



**Figure 9: Data from EIA's Annual Energy Outlook (AEO) 2017, Reference scenario, Mid-Atlantic.**

The savings in the economic modeling come from reduced purchase of these fuels, as well as a reduction in variable O&M costs, by plant type. The later data are drawn from the National Renewable Laboratory's Annual Technology Baseline.[125]

## G) EXTERNALITY COSTS

Externalities include the environmental impacts of emissions from fossil fuels. The economic value of environmental externalities can be estimated using two approaches: according to their impact on society, or according to their compliance cost.

**Table 6** gives the damage or impact based costs, and recent compliance based costs used to calculate the scenario costs including externalities.

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125 https://atb.nrel.gov/

Damage costs are from a study that used "a high-resolution model to simulate and compare the monetized public health and climate benefits of four different illustrative EE/RE installation types in six different locations within the Mid-Atlantic and Lower Great Lakes of the United States." [126]

Compliance costs are based on 2017 auction results from the relevant markets:

- The carbon dioxide price is from the Regional Greenhouse Gas Initiative (RGGI).[127]
- The nitrogen oxides price is a rough estimate based on recent seasonal and annual prices in the monthly spot market.[128]
- The sulfur dioxides price is the weighted average of the 2017 spot auction and the advanced auction, for allowances first usable in 2017 and 2024 respectively.[129]

**Table 6. Externality costs based on: estimated impact to society and estimated cost to mitigate.**

| Pollutant | Damage Cost | Compliance Cost | Cost Units |
|---|---|---|---|
| Carbon Dioxide | 47 | 4 | USD/metric ton |
| Nitrogen Oxides | 10 | 0.20 | USD/kilogram |
| Sulfur Dioxides | 20 | 0.035 | USD/kilogram |

## 4. LEAP MODELING RESULTS

### A) PRIMARY AND FINAL ENERGY DEMAND

When considering the total energy system, it is important to understand the difference between primary and final energy demands. Primary energy demand is the total amount of resources consumed. It includes energy that provides end use services as well as energy used to source and move that energy: energy lost at power plants, and energy lost from power lines in transmission and distribution. Primary and final energy vary based on many factors including the type of fuel used, the type of power plant, and proximity to end users. Final energy consumption refers only to energy directly consumed by end users. In this report, final energy is used unless otherwise noted.

| | Primary Energy Demand (TBtu) | Final Energy Demand (TBtu) |
|---|---|---|
| 2015 | 3,420 | 2,930 |
| 2020 | 3,450 | 2,974 |
| 2025 | 3,443 | 2,973 |
| 2030 | 3,384 | 2,922 |

**Table 7. Primary and final energy demand (Solar A scenario).**

[126] Buonocore et al., "Health and climate benefits of different energy-efficiency and renewable energy choices," (Nature 2015, doi:10.1038/nclimate2771), Fig 4.
[127] RGGI, "Allowance Prices and Volumes," https://rggi.org/auctions/auction-results/prices-volumes.
[128] Monitoring Analytics LLC, "Quarterly State of the Market Report for PJM: January through March 2017," http://www.monitoringanalytics.com/reports/PJM_State_of_the_Market/2017/2017q1-som-pjm-sec8.pdf.
[129] EPA, 2017 SO2 Allowance Auction, https://www.epa.gov/airmarkets/2017-so2-allowance-auction-0.

## B) FINAL DEMAND BY SECTOR

As noted above, energy demand does not vary across the three primary scenarios. It does vary slightly over time. **Figure 10** shows final energy consumption by year and sector. Population growth and increasing industrial production is offset by an increase in transportation efficiency, making energy demand nearly flat from 2015 to 2030.

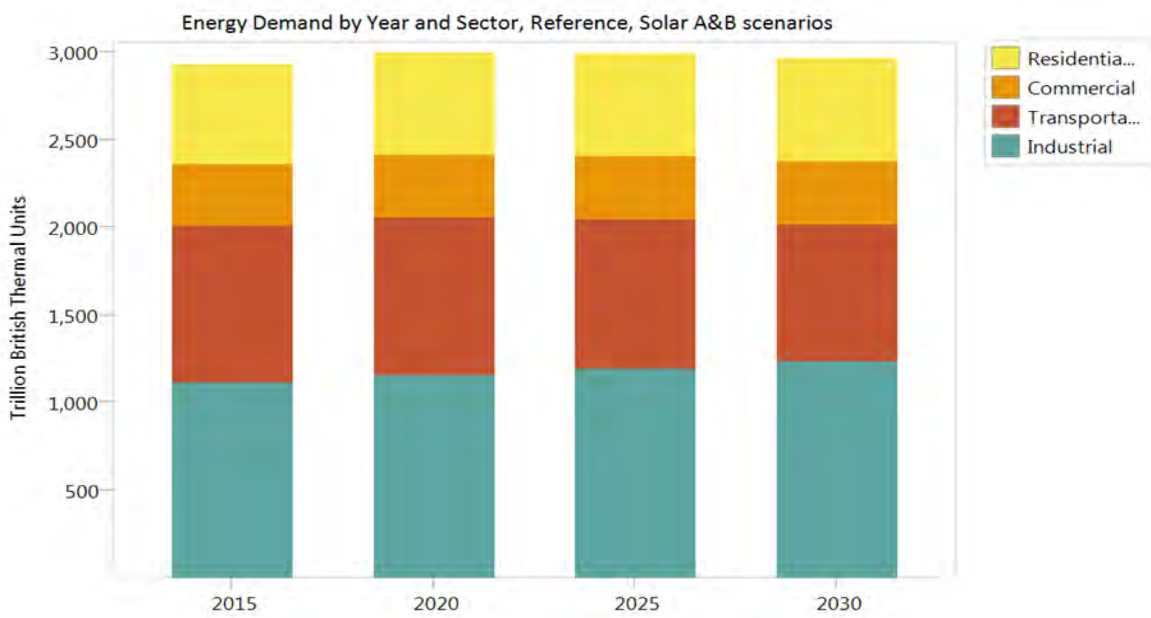



**Figure 10. Energy Demand by Year and Sector**

## C) ADDITIONAL SCENARIOS COMPARISONS

The Project Team developed additional scenarios which built upon the Solar A and Solar B scenarios to incorporate stakeholder feedback and illustrate tradeoffs between potential future paths. Stakeholders requested scenarios with increased efficiency, electrification, and wind. The Project Team took the following modifications and combined them in a variety of scenarios listed below.

**Extra Efficiency, "EE":** Energy electric efficiency grows at 2% annually and gas efficiency grows at 0.5% annually, instead of 0.8% and 0.1% as described in the original scenarios. Leading states achieve 3% savings from energy efficiency programs annually[130]. Six states currently have annual energy efficiency targets of 2% or greater[131], and this is not considered out of reach for Pennsylvania.

**"Electrification":** A combination of changes in heat pumps and electric vehicles. Air and ground source heat pumps provide 18% of household heat by 2030. This change displaces heat currently provided by oil, propane, kerosene, and electric resistance. Additionally, this scenario includes significant increases in

[130] http://aceee.org/sites/default/files/publications/researchreports/u1710.pdf
[131] https://aceee.org/sites/default/files/state-eers-0117.pdf

electric vehicles from 3,600 in 2017 to 600,000 in 2030. For context, there were over 8,000,000 passenger vehicles in PA in 2016.[132]

**"Wind":** The "Wind" scenario grows wind to provide 10% of in-state electricity, like the solar goal. This requires 5.2 GW in 2030, as compared to 1.8 GW in 2030 in all other scenarios. Two checks show this is a reasonable number. One is that 5.2 GW can be reached with a 10% compound annual growth rate, which is achievable. The second was a comparison to NREL's Eastern Wind Dataset.[133] That study focuses on integrating high levels of wind generation and includes 7 GW of viable sites in Pennsylvania.

**Figure 11** illustrates changes in final energy demand for the additional scenarios in comparison to the reference.

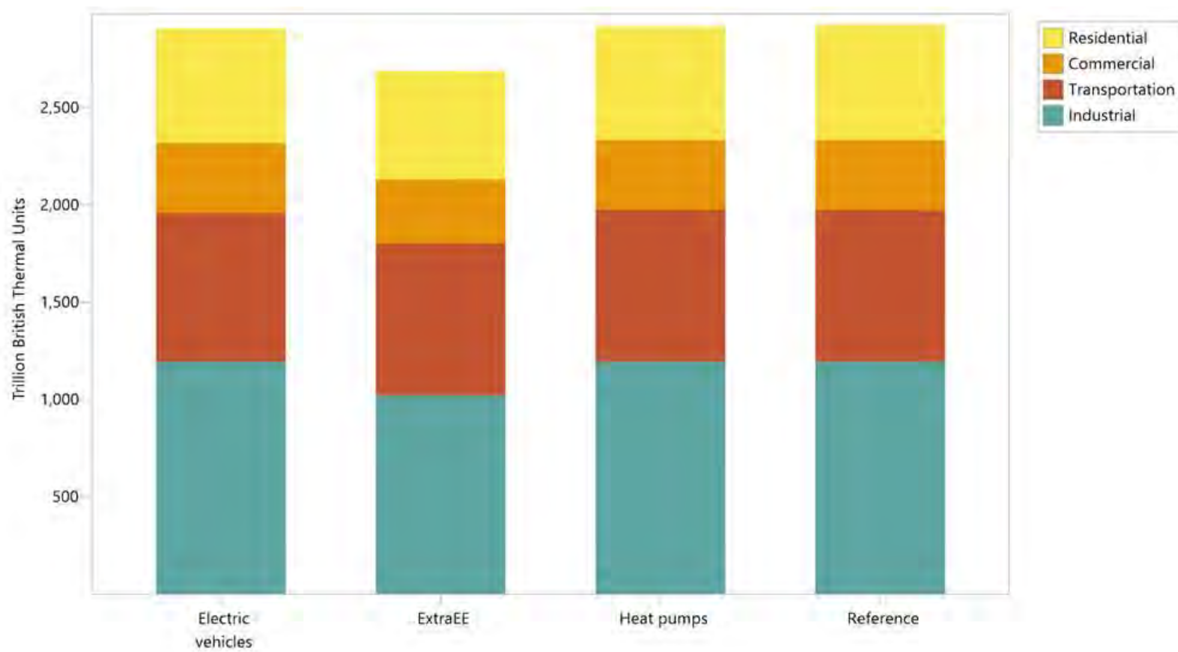



**Figure 11: Energy demand by scenario.**

132 PA DOT, "Report of Registrations," http://www.dot.state.pa.us/public/dvspubsforms/BMV/Registration%20Reports/ReportofRegistration2016.pdf.
133 NREL, "Eastern Wind Dataset," https://www.nrel.gov/grid/eastern-wind-data.html.

**Table 8** compares the additional scenarios developed by the Project Team across several key indicators.

**Table 8: Alternative Scenarios in the PA Solar Future Study**

| | Scenario | 2030 Total Primary Energy Consumption (TBTUs) | 2030 Final Electrical Energy Consumption (TBTUs) | Solar as % of retail power | Wind as % of retail power | Total Renewables as % of power |
|---|---|---|---|---|---|---|
| **Reference** | No Modification | 3,440 | 514 | 1% | 4% | 12% |
| | EE | 3,110 | 441 | 1% | 5% | 14% |
| | Wind | 3,415 | 514 | 1% | 11% | 19% |
| | Heat Pumps | 4,451 | 535 | 1% | 4% | 11% |
| | Electric Vehicles | 3,428 | 519 | 1% | 4% | 12% |
| SolarA | No Modification | 3,410 | 514 | 10% | 4% | 20% |
| | EE | 3,083 | 441 | 11% | 5% | 23% |
| | EE, Electrification | 3,076 | 465 | 11% | 4% | 22% |
| | EE, Electrification, Wind | 3,052 | 465 | 11% | 12% | 30% |
| | Solar 8% | 3,417 | 514 | 8% | 4% | 18% |
| | Solar 12% | 3,410 | 514 | 12% | 4% | 23% |
| SolarB | No Modification | 3,408 | 514 | 10% | 4% | 21% |
| | EE | 3,082 | 441 | 12% | 5% | 24% |
| | EE, Electrification | 3,074 | 465 | 11% | 4% | 23% |

## D) ECONOMIC RESULTS FOR ADDITIONAL SCENARIOS

The economic results for the additional scenarios are summarized in Tables 9,10, and 11. Table 9 compares Solar A and its modifications to the Reference case. Note that Solar A plus EE has lower net costs and reduces total emissions significantly more than Solar A without additional efficiency.

## Table 9: Solar A and variations economic results compared to reference

| Cumulative Costs && Benefits: 2015-2030. Relative to Scenario: Reference. Discounted at 1.8% to year 2017. Units: Billion 2017 U.S. Dollar | SolarA | SolarA plusEE | Solar A Plus EE Plus Elec | Solar A Plus EE Plus Elec Plus Wind |
|---|---|---|---|---|
| Demand | - | 0.9 | 5.5 | 5.5 |
| Residential | - | 0.5 | 3.7 | 3.7 |
| Commercial | - | 0.2 | 0.2 | 0.2 |
| Transportation | - | - | 1.4 | 1.4 |
| Industrial | - | 0.1 | 0.1 | 0.1 |
| Transformation | 10.1 | 10.0 | 10.1 | 15.4 |
| Transmission and Distribution | 0.1 | 0.1 | 0.1 | 0.2 |
| Electricity Generation | 10.0 | 9.9 | 10.0 | 15.2 |
| Natural Gas Production | - | - | - | - |
| Oil Refining | - | - | - | - |
| Resources | -0.3 | -2.8 | -2.6 | -3.0 |
| Production | -0.3 | -2.7 | -2.3 | -2.7 |
| Imports | -0.0 | -0.1 | -0.3 | -0.3 |
| Exports | - | - | - | - |
| Unmet Requirements | - | - | - | - |
| Environmental Externalities | - | - | - | - |
| Non Energy Sector Costs | - | - | - | - |
| Net Present Value | 9.8 | 8.0 | 13.0 | 17.9 |
| GHG Savings (Mill Tonnes CO2e) | 317.8 | 2,270.5 | 2,265.9 | 2,574.0 |
| Cost of Avoiding GHGs (U.S. Dollar/ | 30.9 | 3.5 | 5.7 | 7.0 |

**Table 10** compares the economic results for Solar B and its modifications. The same pattern as illustrated for Solar A emerges, with the extra EE reducing net costs and increasing emissions reductions significantly.

## Table 10: Solar B and variations economic results compared to reference

| Cumulative Costs && Benefits: 2015-2030. Relative to Scenario: Reference. Discounted at 1.8% to year 2017. Units: Billion 2017 U.S. Dollar | SolarB | Solar B Plus EE | Solar B Plus EE Plus Elec |
|---|---|---|---|
| Demand | - | 0.9 | 5.5 |
| Residential | - | 0.5 | 3.7 |
| Commercial | - | 0.2 | 0.2 |
| Transportation | - | - | 1.4 |
| Industrial | - | 0.1 | 0.1 |
| Transformation | 8.6 | 8.5 | 8.5 |
| Transmission and Distribution | 0.1 | 0.1 | 0.1 |
| Electricity Generation | 8.5 | 8.4 | 8.4 |
| Natural Gas Production | - | - | - |
| Oil Refining | - | - | - |
| Resources | -0.3 | -2.8 | -2.6 |
| Production | -0.3 | -2.7 | -2.2 |
| Imports | -0.0 | -0.1 | -0.3 |
| Exports | - | - | - |
| Unmet Requirements | - | - | - |
| Environmental Externalities | - | - | - |
| Non Energy Sector Costs | - | - | - |
| Net Present Value | 8.3 | 6.5 | 11.4 |
| GHG Savings (Mill Tonnes CO2e) | 314.3 | 2,266.8 | 2,262.3 |
| Cost of Avoiding GHGs (U.S. Dollar/Tonne CO2e) | 26.4 | 2.9 | 5.0 |

Finally, **Table 11** compares the Solar 8 and Solar 12 to the Reference scenario. They have relatively lower and higher net costs than the Solar A and B scenarios which attain the ten percent target.

**Table 11: Solar 8 and Solar 12 economic results compared to reference**

| Cumulative Costs && Benefits: 2015-2030. Relative to Scenario: Reference. Discounted at 1.8% to year 2017. Units: Billion 2017 U.S. Dollar | Solar8 | Solar12 |
|---|---|---|
| Demand | - | - |
| Residential | - | - |
| Commercial | - | - |
| Transportation | - | - |
| Industrial | - | - |
| Transformation | 6.3 | 12.4 |
| Transmission and Distribution | 0.1 | 0.1 |
| Electricity Generation | 6.2 | 12.3 |
| Natural Gas Production | - | - |
| Oil Refining | - | - |
| Resources | -0.2 | -0.4 |
| Production | -0.2 | -0.4 |
| Imports | -0.0 | -0.0 |
| Exports | - | - |
| Unmet Requirements | - | - |
| Environmental Externalities | - | - |
| Non Energy Sector Costs | - | - |
| Net Present Value | 6.1 | 12.0 |
| GHG Savings (Mill Tonnes CO2e) | 225.5 | 407.5 |
| Cost of Avoiding GHGs (U.S. Dollar/Tonne CO2e) | 27.0 | 29.5 |

## 5. FINANCIAL MODELING RESULTS

The System Advisor Model (SAM) is a software tool developed by the National Renewable Energy Laboratory to model the performance of energy systems on an hour-by-hour basis and to develop energy performance into a cash flow analysis.

For solar projects serving residential and commercial customers, as well as grid scale projects selling power through power purchase agreements, SAM accounts for solar system design, hourly weather (including cloud cover), and hourly solar insolation. By combining energy and financial performance, SAM allows users to compare systems based on a range of revenues, costs, tax credits, incentives, and financing options.

The Project Team prepared project scenarios serving residential and commercial customers in a number of different locations. For example, the residential system modeled for Philadelphia estimates energy production for 7.5 kW open-rack system installed on a south-facing roof with a 20 degree pitch. SAM accounts for system inefficiencies and panel degradation over time, as well as escalating costs and the value of avoided electricity purchases. In addition to the Philadelphia residential system, the Project Team modeled a 200 kW commercial rooftop system in Pittsburgh and a 20 MW grid scale.

SAM is capable of conducting a parameter analysis that calculates a project's financial value given a range of possible inputs. While precise future costs are unpredictable, the Project Team analyzed solar project profitability at a range of module costs and incentive levels. SAM uses the term Production Based Incentive, or PBI, for incentives that are based on actual electricity generation. By contrast, other incentives may be based on the generating capacity of the system, such as tax credits or accelerated depreciation. The value of SRECs are treated as production-based incentives because they are linked to each MWh that is generated.

An analysis found that customer financial return, as measured by payback period and levelized cost of energy (LCOE), are favorable in nearly all scenarios. In Philadelphia's residential scenario, for example, even when accounting for higher module costs or lower SREC prices, payback periods generally ranged between 8 and 13 years. The grid scale scenario is evaluated using LCOE rather than payback period because LCOE is more easily compared to other energy resources. Nominal LCOE generally ranged between 5 and 9 cents per kilowatt-hour, which is generally comparable with the cost of other new resources.

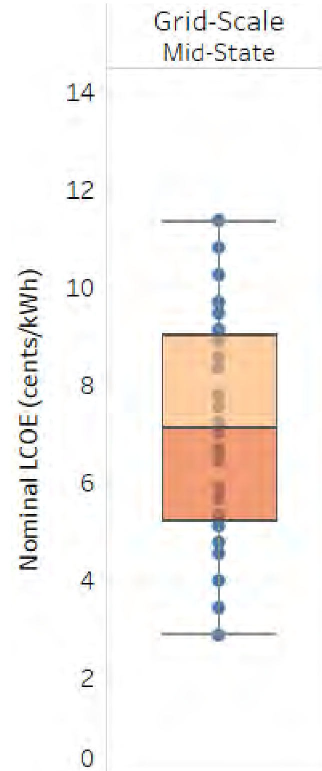
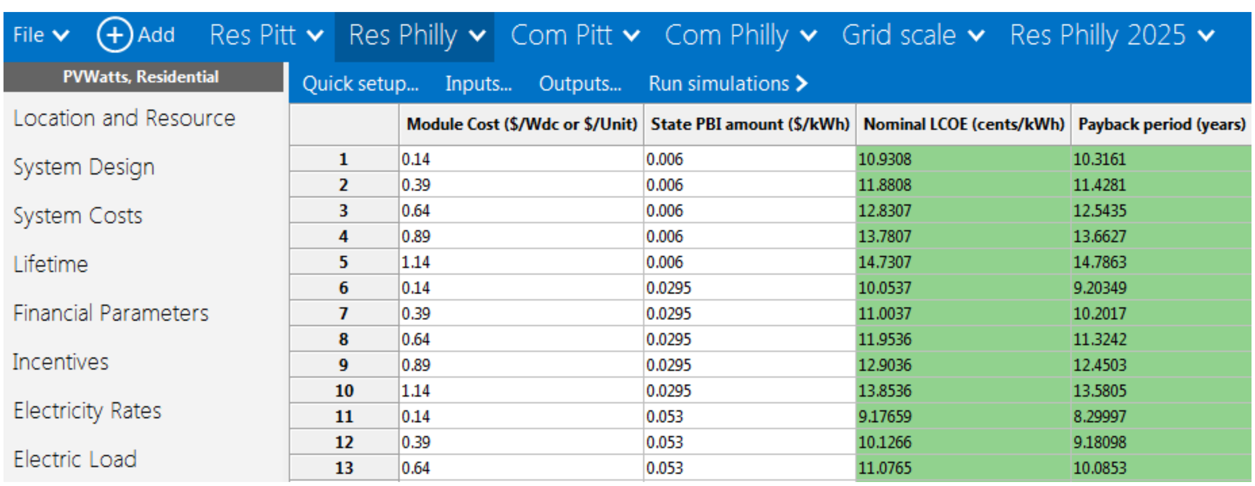



**Figure 12: Nominal levelized cost of energy (LCOE) for grid scale solar system mid - state 2025 with varying PV module and SREC prices.** This box plot chart identifies the middle 50% of outcomes in orange. Each point represents one outcome as measured by LCOE; lower costs are more desirable.




| | Module Cost ($/Wdc or $/Unit) | State PBI amount ($/kWh) | Nominal LCOE (cents/kWh) | Payback period (years) |
|---|---|---|---|---|
| 1 | 0.14 | 0.006 | 10.9308 | 10.3161 |
| 2 | 0.39 | 0.006 | 11.8808 | 11.4281 |
| 3 | 0.64 | 0.006 | 12.8307 | 12.5435 |
| 4 | 0.89 | 0.006 | 13.7807 | 13.6627 |
| 5 | 1.14 | 0.006 | 14.7307 | 14.7863 |
| 6 | 0.14 | 0.0295 | 10.0537 | 9.20349 |
| 7 | 0.39 | 0.0295 | 11.0037 | 10.2017 |
| 8 | 0.64 | 0.0295 | 11.9536 | 11.3242 |
| 9 | 0.89 | 0.0295 | 12.9036 | 12.4503 |
| 10 | 1.14 | 0.0295 | 13.8536 | 13.5805 |
| 11 | 0.14 | 0.053 | 9.17659 | 8.29997 |
| 12 | 0.39 | 0.053 | 10.1266 | 9.18098 |
| 13 | 0.64 | 0.053 | 11.0765 | 10.0853 |

**Figure 13: Screenshot of parametric analysis in SAM tool**

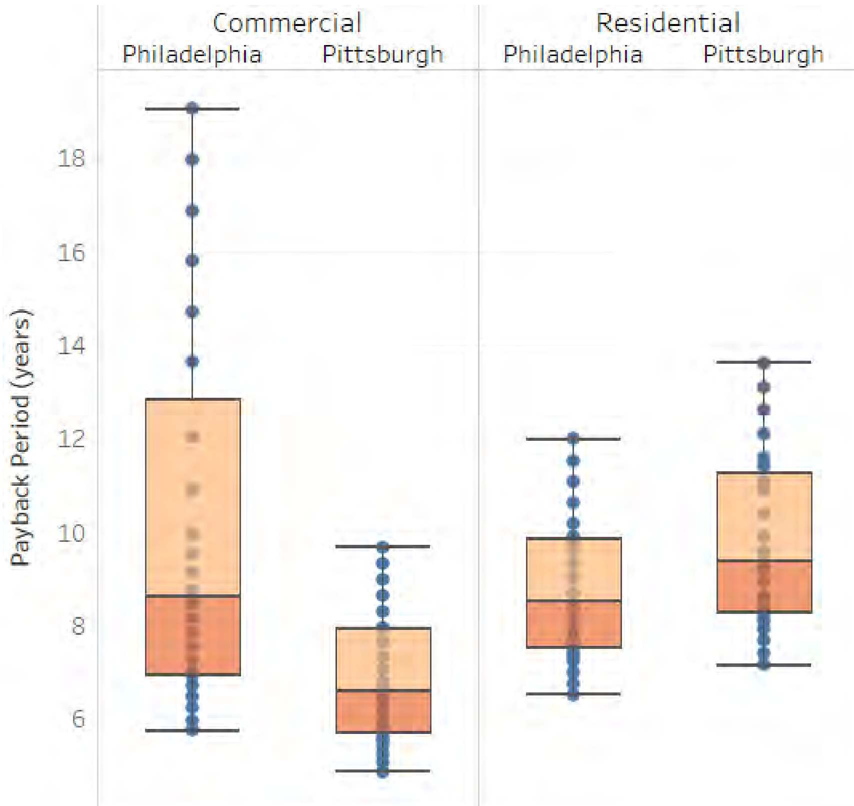



**Figure 14: Simple payback in years for residential and commercial solar systems with varying PV module and SREC prices.** This box plot chart identifies the middle 50% of outcomes in orange. Each point represents one outcome as measured by payback period; shorter payback periods are more desirable. The residential examples are based on 2020 projected costs; and the commercial examples are for 2030.

## 6. JOBS AND ECONOMIC DEVELOPMENT IMPACT MODEL

The Jobs and Economic Development Impacts (JEDI) uses an Excel-based model to estimate the impact of energy infrastructure development at the state level. The models account for three elements related to a project, such as a new power plant: (1) on-site labor and project development impacts; (2) local revenue (including tax revenue) and supply chain impacts; and, (3) induced impacts on jobs and the economy. The tool was developed by the National Renewable Energy Laboratory.

The Solar A and Solar B scenarios described in the report were modeled using JEDI. The models used costs taken from NREL's SAM tool (version 2017.9.5) and scaled such that totals matched the Pennsylvania scenarios described in NREL's Annual Technology Baseline. Balance of system costs (excluding modules and inverters) were split between mounting costs at 75% and electrical costs at 25%.

Table 10 and 11 in the report are based on assumptions that 50% of the installation labor force is based outside Pennsylvania. Table 12 below illustrates inputs if 90% of installation labor is Pennsylvania-based, as might be expected as solar installations grow and the solar workforce matures. Table 13 compares the job impacts of the 50% and 90% in state labor models.

**Table 12: JEDI 90% In-State Labor Inputs**

| Installation Costs | Purchased | Manufactured |
|---|---|---|
| Materials & Equipment | Locally (%) | Locally (Y or N) |
| Mounting (rails, clamps, fittings, etc.) | 60% | N |
| Modules | 30% | N |
| Electrical (wire, connectors, breakers, etc.) | 95% | N |
| Inverter | 30% | N |
| Labor | | |
| Installation | 90% | |
| Other Costs | | |
| Permitting | 100% | |
| Other Costs | 100% | |
| Business Overhead | 100% | |
| Sales Tax (Materials & Equipment Purchases) | 100% | |
| PV System Annual Operating and Maintenance Costs | | |
| | Local | |
| Labor | Share (%) | |
| Technicians | 90% | |
| | Purchased | Manufactured |
| Materials and Services | Locally (%) | Locally (Y or N) |
| Materials & Equipment | 50% | N |
| Services | 100% | |

**Table 13: Estimated gross new jobs, by scenario and local labor rate**

| | 50% In-State Labor | | 90% In-State Labor | |
|---|---|---|---|---|
| Scenario | **Solar A** | **Solar B** | **Solar A** | **Solar B** |
| Construction period Jobs | 100,604 | 67,716 | 116,382 | 81,141 |
| Ongoing Jobs | 1,086 | 983 | 1,775 | 1,619 |

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

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0120-RE-DEP4991 11/2018
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**Exhibit KRR-10:**

City of Philadelphia: Office of Sustainability, *Powering Our Future: A Clean Energy Vision for Philadelphia* (2018)

THE CITY OF PHILADELPHIA
OFFICE OF
SUSTAINABILITY

# POWERING OUR FUTURE:
# A CLEAN ENERGY VISION FOR PHILADELPHIA

# Letter from the Mayor

Dear Friends,

In *Greenworks: A Vision for a Sustainable Philadelphia*, my administration set forth a vision for our city where all Philadelphians efficiently use clean energy that they can afford. Using less energy and getting it from cleaner sources is critical to facing the challenges of climate change, which is already bringing wetter and hotter weather to Philadelphia. But moving towards clean energy has other benefits, such as creating local jobs, lowering utility bills, and improving air quality for all Philadelphians.

This work has become all the more critical in the wake of the Trump Administration's decision to withdraw from the Paris Climate Agreement and proposal to rescind the Clean Power Plan. Without leadership from the federal government, cities, residents, and businesses are continuing the important work of reducing the carbon pollution warming our planet. That's why I've pledged to meet a 100 percent clean energy goal as part of Philadelphia's long-term commitment to reduce citywide carbon emissions 80 percent by 2050.

*Powering Our Future: A Clean Energy Vision for Philadelphia* is a roadmap for our city that highlights opportunities for all Philadelphians to contribute to and benefit from a clean, affordable, and efficient energy future by reducing carbon emissions from our buildings and industry. While the Vision does not set a prescribed path to meet this future, we must take action across each of the focus areas in this report to meet our energy and climate goals.

To lead by example, my administration has already issued a Municipal Energy Master Plan that outlines how the City will better manage our own assets (including buildings and street lighting) while reducing energy use and greenhouse gas emissions. In the next year, we will build on these and other strategic planning efforts by issuing a climate action plan encompassing energy and the built environment, waste, and transportation.

Turning this vision to reality will require action from every one of us. I look forward to working together to move Philadelphia toward a clean, affordable, and healthy energy future.

Sincerely,

James F. Kenney

Mayor Jim Kenney

# Table of Contents



ON THE COVER: CHILDREN LEARNING ABOUT ENERGY EFFICIENCY AT THE SCIENCE CARNIVAL. PHOTO: LEANNE HARVEY | GRAPHIC DESIGN:

# Glossary

The Office of Sustainability uses the following definitions for these terms throughout Powering Our Future:

***Built Environment****:* Homes, businesses, factories, streetlights, and other physical infrastructure using energy.

***Carbon Footprint***: The amount of carbon pollution attributed to a given source (e.g. energy production).

***Carbon Pollution***: Carbon dioxide and equivalent pollutants (including methane, nitrous oxide, and many chlorofluorocarbons, nitrous oxide) that warm the planet. (See also: Greenhouse Gas)

***Co-Benefits***: Secondary advantages to pursuing a program or policy.

***Electricity grid***: The network of infrastructure that takes electricity from the generating source to a home or business.

***Emissions***: Pollutants generated by the production of energy.

***Energy Benchmarking***: The process of reporting and disclosing energy usage to compare a property to similar buildings locally or nationally.

***Energy Burden***: The share of a household income dedicated to paying energy bills. Residents are considered energy-burdened if a high percentage of their income is used to pay for electricity and heating.

***Energy Efficiency***: The process of saving money and minimizing energy waste by investing in buildings. This can include upgrading lighting and appliances, sealing leaky doors, windows, and attics, and monitoring energy usage.

***Energy Waste***: Energy generated and dissipated without providing value to a user.

***Fossil Fuel***: A fuel source, derived from the remains of once-living organizations, extracted from the earth and contributing to climate change (e.g. coal, natural gas, oil).

***Geothermal***: A system using the naturally moderate temperatures below ground to cool buildings in the summer and keep them warm in the winter.

***Global Climate Change***: Earth's climate shifting from historic patterns. Current global climate change is leading to higher temperatures and sea levels, and overwhelming scientific consensus attributes this change to human activity.

***Greenhouse Gas***: Carbon dioxide and equivalent pollutants (including methane, nitrous oxide, and many chlorofluorocarbons, nitrous oxide) that warm the planet. (See also: Carbon Pollution)

***Municipal Energy Usage***: Energy used by the City of Philadelphia in the operation of City-owned assets, including recreation centers, libraries, and fire stations.

***Power Purchase Agreement***: A contract for a large electricity customer to purchase from a single generating project, often for the purpose of adding clean electricity generation to the grid.

***Renewable Energy***: Energy generated through a fuel source that cannot be depleted (e.g. wind, solar, or hydro power).

***Resilience***: A system able to continue to operate under stress (e.g. extreme weather or a changing climate).

***Solar Energy***: Energy generated by harnessing direct sunlight, often through solar panels fixed to rooftops, parking garages, or in large arrays at ground level.

***Thermal Energy***: Energy used for heating or cooling.

***Utility Scale***: Electricity generation, often a distributed source like solar or wind, concentrated in one place such that it can act as a single, large power plant.

# A Clean Energy Vision for Philadelphia

## WHY AN ENERGY VISION?

Energy is at the center of our lives. We need energy for heating in the winter months and cooling in our increasingly hot summers. We need energy to transport our food and keep it fresh when it arrives, to power our subways, and keep our water clean. Energy is critical to our way of life.


City Hall at night. (Photo: LeAnne Harvey)

But while all Philadelphians use energy, not all Philadelphians can easily afford its costs. For many residents, energy is the second-greatest household expense after mortgage or rent payments. Using energy more efficiently in our homes and transitioning away from burning fossil fuels to create energy will save money and reduce carbon pollution, which causes climate change. Because our most vulnerable residents are disproportionately harmed by changes in our climate, the transition to a just energy system that is clean and affordable for all is critical to achieving an equitable Philadelphia.

## WHAT'S IN THIS REPORT?

Powering Our Future covers three major parts of Philadelphia's energy system: our city's 600,000 buildings, local industry, and the regional electricity system that powers them. Taken together, these sectors account for nearly 80 percent of carbon emissions in Philadelphia, and transforming them will be critical to achieving a clean and just energy future.

The second-largest source of carbon emissions in Philadelphia is transportation. The Office of Transportation and Infrastructure Systems is preparing to publish their strategic transportation plan, Connect, which will prioritize transit and improve walking and biking infrastructure to help cut carbon pollution.

Powering Our Future covers carbon emissions local to Philadelphia. But from intercontinental travel to purchase of manufactured goods, many of our actions contribute to climate change beyond the borders of Philadelphia. OOS is partnering with the Urban Sustainability Directors' Network (USDN) to learn more about emerging practices in measuring these impacts, and is committed to sharing those findings and potential actions in the future.

### PHILADELPHIA'S CARBON FOOTPRINT (2014)

**Buildings & Industry**
79%
of citywide emissions

**Transportation**
17%
of citywide emissions

**Waste**
3%
of citywide emissions

## DEVELOPING THE CLEAN ENERGY VISION

OOS committed to energy planning as part of *Greenworks: A Vision for a Sustainable Philadelphia*, published in November 2016. OOS contracted with a consultant, ICF, to develop a citywide energy model to help assess the current trajectory of energy usage and carbon emissions in Philadelphia. We then used this data to understand opportunities to move toward a cleaner and healthier energy future.

To gain public input on Philadelphia's energy future, OOS held several public stakeholder meetings in spring and summer 2017. OOS met with advocacy groups and issue experts to come away with these key takeaways:

- **Stakeholder process:** Philadelphians are eager to be a part of determining how we work together to move toward our long-term energy goals.
- **Industry:** Participants in the meetings expressed concern over the climate and health impacts of legacy industrial infrastructure in Philadelphia, including the Philadelphia Energy Solutions refinery, and a desire to see the City address that infrastructure.
- **Co-benefits:** Participants also encouraged the City to continue to take a holistic view of energy and climate action, considering not just energy reductions and carbon savings but potential for job creation, air quality improvements, and transition toward a more equitable Philadelphia.

Based on this outreach, OOS shifted its focus from a shorter-term energy plan to a long-term vision for a Philadelphia that achieves Mayor Kenney's goal of reducing carbon emissions 80 percent from 2006 levels by 2050 while emphasizing equity and health for all Philadelphians. Powering Our Future: A Clean Energy Vision for Philadelphia is the result of this effort, but it's just the start of a citywide conversation about achieving our goals.

Powering Our Future was first published in November 2017 as a public draft. The Office of Sustainability held a public open house on the draft and provided a comment period for stakeholders to offer feedback, which is incorporated into this final report.



## CLEAN ENERGY VISION VALUES

**CLEAN:** Philadelphians use clean, carbon-free energy to reduce our contributions to climate change and local air pollution.

**EFFICIENT:** Philadelphians cut energy waste which saves money and reduces pollution.

**RESILIENT:** Philadelphians continue to have access to energy even as climate change increases temperatures, precipitation, and extreme weather.

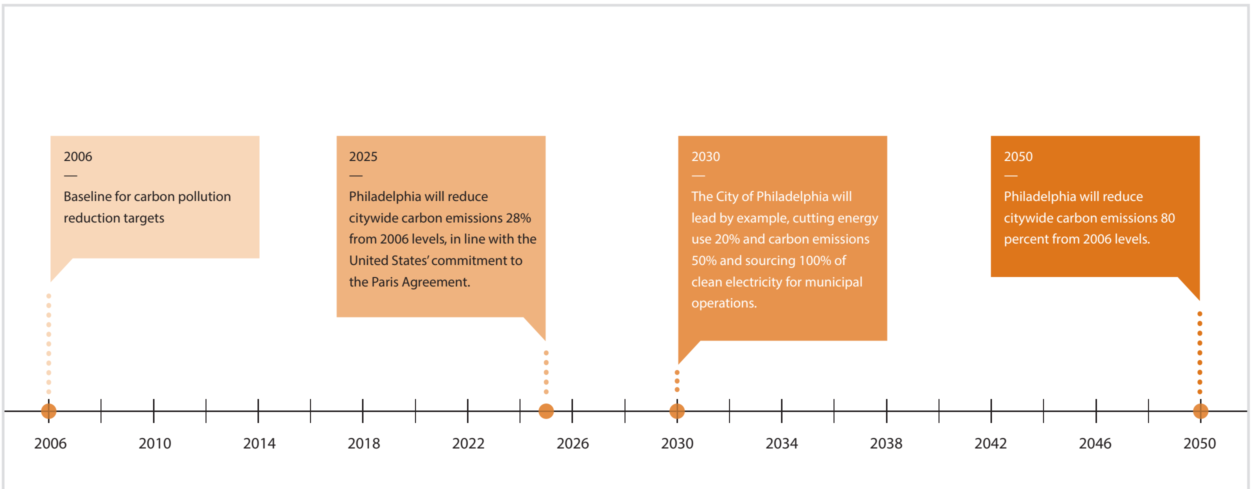
**AFFORDABLE:** Changes to our energy system help reduce utility bills, particularly for vulnerable Philadelphians.

**EQUITABLE:** Our energy vision acknowledges historical and existing inequities in how the energy system impacts Philadelphians and works to eliminate those inequities.

## PHILADELPHIA'S ENERGY AND CLIMATE GOALS

In the past two years, Mayor Kenney and the City of Philadelphia have set a series of ambitious targets to reduce carbon emissions and move our city toward a clean energy future:

### PHILADELPHIA'S ENERGY AND CLIMATE TIMELINE




Setting clear and measurable climate and energy goals is critical to successfully achieving our clean energy vision. However, meeting these goals alone will not achieve the Greenworks vision of equity: a Philadelphia in which all residents efficiently use clean energy that they can afford. To meet that challenge, we will:

- Prioritize investments that reduce energy burdens (the percentage of income spent on utility bills) of vulnerable residents and improve indoor and outdoor air quality.
- Build a resilient energy system that provides heating, cooling, and other energy services to Philadelphians even as our climate changes.
- Ensure that Philadelphia's communities of color, which have not historically had access to sustainability opportunities and are most likely to be harmed by climate change, benefit from new programs and investments.
- Transition to a clean energy economy that benefits all Philadelphians, creating employment opportunities for workers displaced through that transition and for those currently not able to access sustainable job opportunities.

### ECONOMIC OPPORTUNITIES FROM OUR CLEAN ENERGY VISION

Meeting the goal of a clean energy future for Philadelphia will create economic opportunities for residents now and in the years to come. You can find more about the potential for job creation and skills training from a clean energy transition on pages 25, 31, 37, 50, and 54 .

Mayor Kenney signing on to Sierra Club's Ready for 100% Clean Energy Campaign (Photo: Samantha Madera)

### Philadelphia Is Ready for 100

At the urging of Philadelphia residents in the wake of the Trump Administration's decision to withdrawal from the Paris Agreement, Mayor Kenney and the City of Philadelphia became the 100th city to sign the Sierra Club's **Ready for 100** pledge on June 21, 2017.

The pledge commits cities to work toward a goal of 100 percent clean energy citywide. Powering Our Future is our first step to meet this commitment.

## HOW WE'LL GET THERE

Meeting Philadelphia's energy and carbon reduction goals will require work across all levels of government and throughout our community. OOS has grouped this work into five categories:

- **Clean Electricity Supply (PAGE 23):** Philadelphia's electricity is generated by power plants not only in Pennsylvania but from a regional grid stretching from New Jersey and Delaware to West Virginia and Ohio. To achieve our goal of reducing carbon emissions 80 percent by 2050, the power plants in our regional grid must generate carbon-free electricity by 2050.
- **Citywide Solar (PAGE 30):** As part of the transition toward a cleaner grid, Philadelphians can do our part by installing solar generation on rooftops and other surfaces throughout the city. Like energy efficiency, this strategy can save residents money while spurring economic growth and moving us toward a clean energy future.
- **Energy-Efficient Homes and Businesses (PAGE 37):** The Environmental Protection Agency estimates that 30 percent of energy in an average commercial building is wasted. Eliminating this waste in our homes and businesses will save money, improve indoor air quality and tenant comfort, and reduce our reliance on fossil fuel-generated energy.
- **Low-Carbon Thermal Energy (PAGE 49):** Most buildings in Philadelphia are currently heated by oil, on-site gas furnaces, or the Veolia steam loop (which uses natural gas to generate heat and electricity). Emerging technologies like microgrids, high-efficiency heat pumps, fuel cells, geothermal and solar heating systems, and renewable biogas can reduce our reliance on fossil fuel energy for heating and domestic hot water.
- **Low-Carbon Economy (PAGE 54):** Factories, shipping, and refineries are a major source of carbon pollution within our city. Achieving our clean energy vision will create new clean economic opportunities for residents and businesses. OOS is committed to working with all stakeholders to understand how we can move together to achieve a just, healthy, and low-carbon economy that works for all our residents.

# Beyond 80 by 50: Toward a Climate-Neutral Philadelphia

Mayor Kenney committed to a goal of cutting Philadelphia's carbon pollution 80 percent by 2050 when he took office in January 2016. At the time, this matched ambitious climate commitments being made by other large cities in the United States, representing an emerging global standard fo  climate action.

Since this time, climate science and actions by the Trump Administration have underscored the critical need to cut carbon emissions as quickly as possible. In response to the Administration's decision to withdrawal from the Paris Climate Agreement, Mayor Kenney committed to moving Philadelphia toward a clean energy future and meeting the globally determined U.S. carbon reduction goal of 28% by 2025.

But to avoid the worst causes of climate change, scientists are increasingly concluding that global emissions must fall at an even faster trajectory and potentially exceed an 80 percent reduction by 2050. With aggressive action by individuals, institutions, and local government, Philadelphia can position itself to meet this trajectory through the strategies outlined in Powering Our Future.

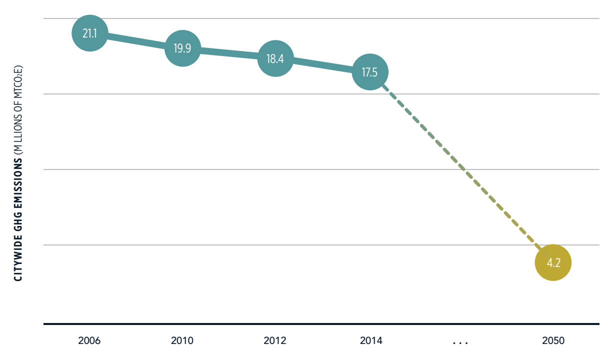
## WHAT WOULD IT TAKE TO ACHIEVE A CARBON-NEUTRAL PHILADELPHIA?

Meeting the 80% by 2050 goal set out by Mayor Kenney will itself require transformative effort by Philadelphia residents, businesses, and institutions, as well as by forces outside the City of Philadelphia's direct control. As shown in the pages that follow, cutting carbon pollution 80% will require Philadelphians to get all their electricity from clean energy sources, necessitating the retirement of all coal and natural gas power generation on the regional electricity grid by 2050.

Remaining carbon pollution produced on-site in Philadelphia's buildings and industrial facilities must also be eliminated. Initial opportunities for this transformation are laid out in the Low-Carbon Thermal Energy and Low-Carbon Economy sections of this report, and OOS is committed to continuing to track the fast-moving technological changes in this space.

Philadelphia will also need to tackle the other sources of carbon pollution in our city: waste and transportation. The Zero Waste and Litter Plan sets a goal of eliminating all waste going from Philadelphia to landfills by 2035, and sets out ambitious strategies to achieve this goal. The Office of Transportation and Infrastructure Systems is currently evaluating transportation strategies across five key goal areas, including sustainability, and the City is currently working toward establishing a Clean Fleet strategy to lead by example for its own vehicle purchasing.

### PHILADELPHIA'S CARBON TRAJECTORY




Philadelphia has made significant progress in cutting carbon pollution, and we know that the pace of progress must accelerate to meet the Mayor's 80 by 50 commitment. Further decarbonization will require significant effort by the City and its residents and businesses, as well as action at the state and federal levels.

## HOW CAN PHILADELPHIA MOVE QUICKLY TOWARD A ZERO-CARBON FUTURE?

Even if Philadelphia's building, transportation, and waste sectors ceased emitting carbon tomorrow, our residents and businesses would still be at risk of facing the worst consequences of climate change. The City will continue to both prioritize actions that to cut citywide carbon pollution as quickly as possible and provide a voice for climate action at the state, federal, and global level. More information on immediate steps the City will take to meet the goals of a zero-carbon future will be published as part of the Clean Energy Vision Action Plan in Fall 2018.

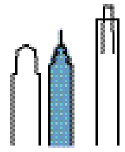
Achieving a zero-carbon future begins with a zero-carbon electricity grid. To help meet this ambitious goal, the City is currently pursuing its first-ever renewable power purchase agreement, which aims to secure zero-carbon electricity generation for City assets on the regional electricity grid. If successful in completing this agreement, the City can pursue additional opportunities itself or in cooperation with other large institutional purchasers.

Residents and businesses also have a role to play in working toward a zero-carbon future. As described in the pages that follow, many decisions that influence Philadelphia's carbon emissions will be made at the state and federal level, and will have repercussions far beyond our city. Contacting your elected officials across all levels of government both on specific policy interventions as well as general support for climate action will be critical to allowing Philadelphia to meet our climate goals.

The Office of Sustainability will continue to monitor the most current climate science and adjust climate goals and priorities in the years ahead. These adjustments are ongoing: as part of the C40 Cities network, Philadelphia and its peers around the globe are committing to leading by example to cut carbon pollution quickly as part of the Deadline 2020 Initiative. As part of this initiative, OOS will publish a follow-up to Powering Our Future in 2019 focused on climate action across every sector of the city's carbon emissions profile.

# Philadelphia Energy Snapshot

## PHILADELPHIA'S CARBON FOOTPRINT (2014)



Buildings & Industry

The majority of Philadelphia's emissions come from its 600,00 buildings, industrial users, and the electricity that powers them.

**79%**
of citywide emissions

Transportation

Transportation emissions are relatively low in Philadelphia thanks to residents riding SEPTA and other low-carbon options.

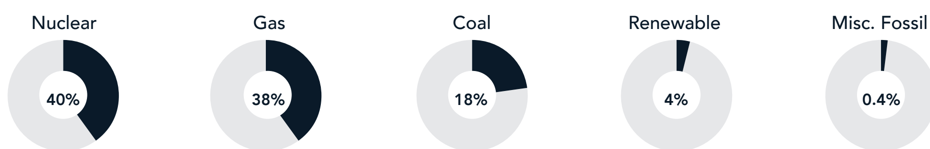
**17%**
of citywide emissions

Waste

Sending trash to landfills or incinerating waste for energy contribute to carbon pollution. Meeting our zero waste goal will eliminate this pollution and beautify our streets and communities.

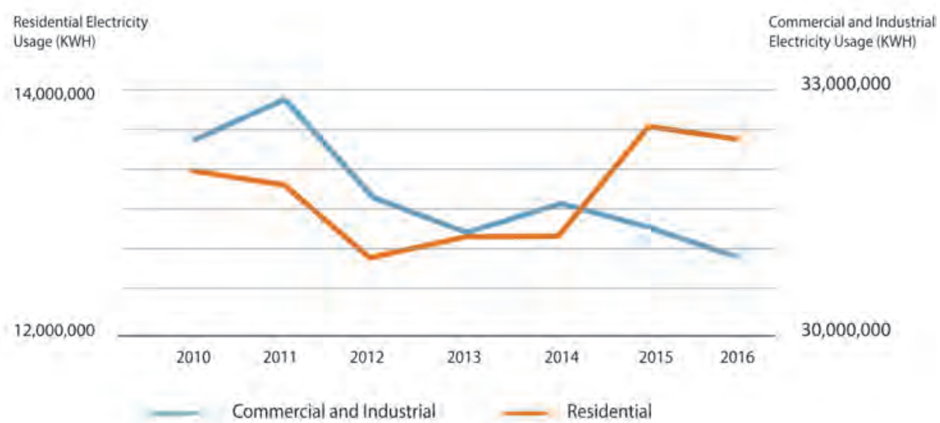
**3%**
of citywide emissions

## PHILADELPHIA'S REGIONAL ELECTRICITY GRID MIX (2016)




The biggest sources of electricity in our regional grid are nuclear power, which does not produce carbon pollution, and coal and natural gas plants, which contribute to climate change.

## PHILADELPHIA'S ELECTRICITY USAGE OVER TIME

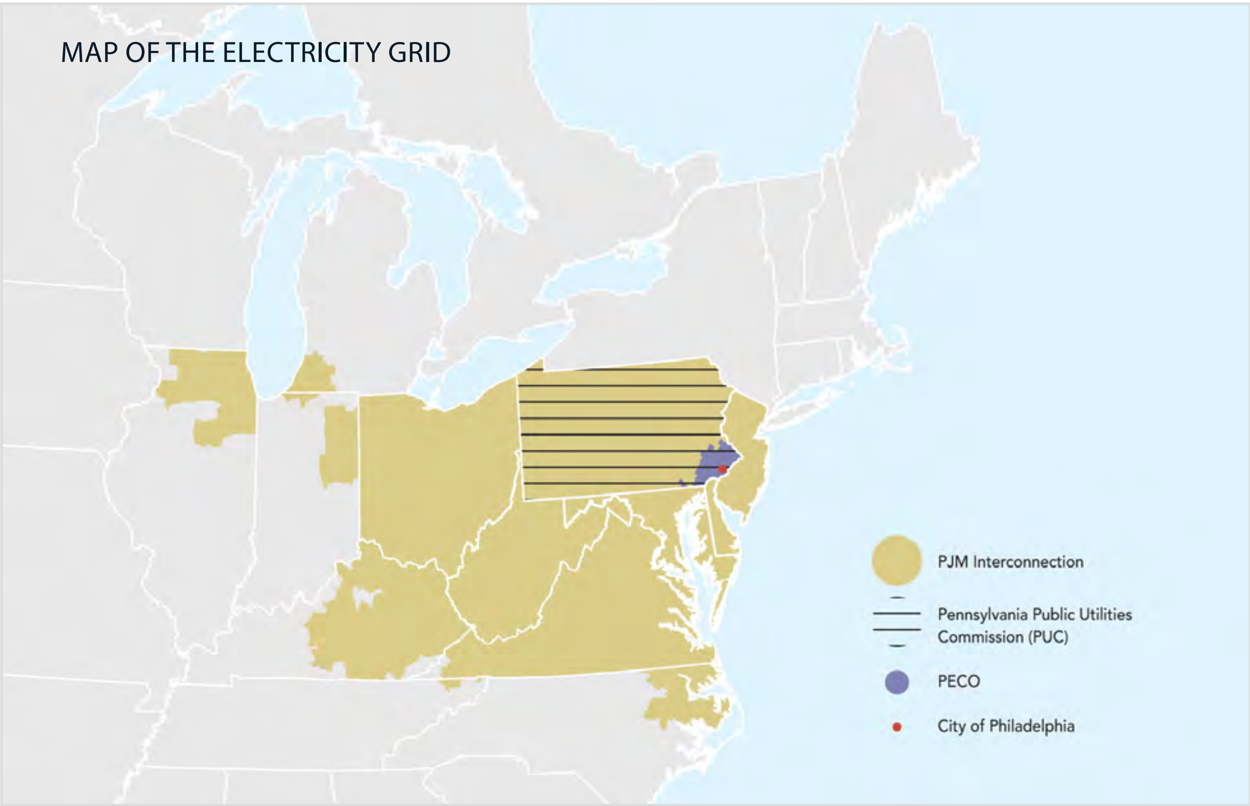



**46%**
OF PHILADELPHIANS HAVE ALREADY MADE THEIR HOME MORE ENERGY EFFICIENT

**33%**
OF PHILADELPHIANS HAVE TROUBLE PAYING THEIR ENERGY BILLS

Electricity usage from commercial customers peaked in 2010, but despite efforts by Philadelphia residents, home electricity usage is still near its highest levels, leaving many Philadelphians struggling to pay bills.

# How Philadelphia Homes and Businesses Get Energy

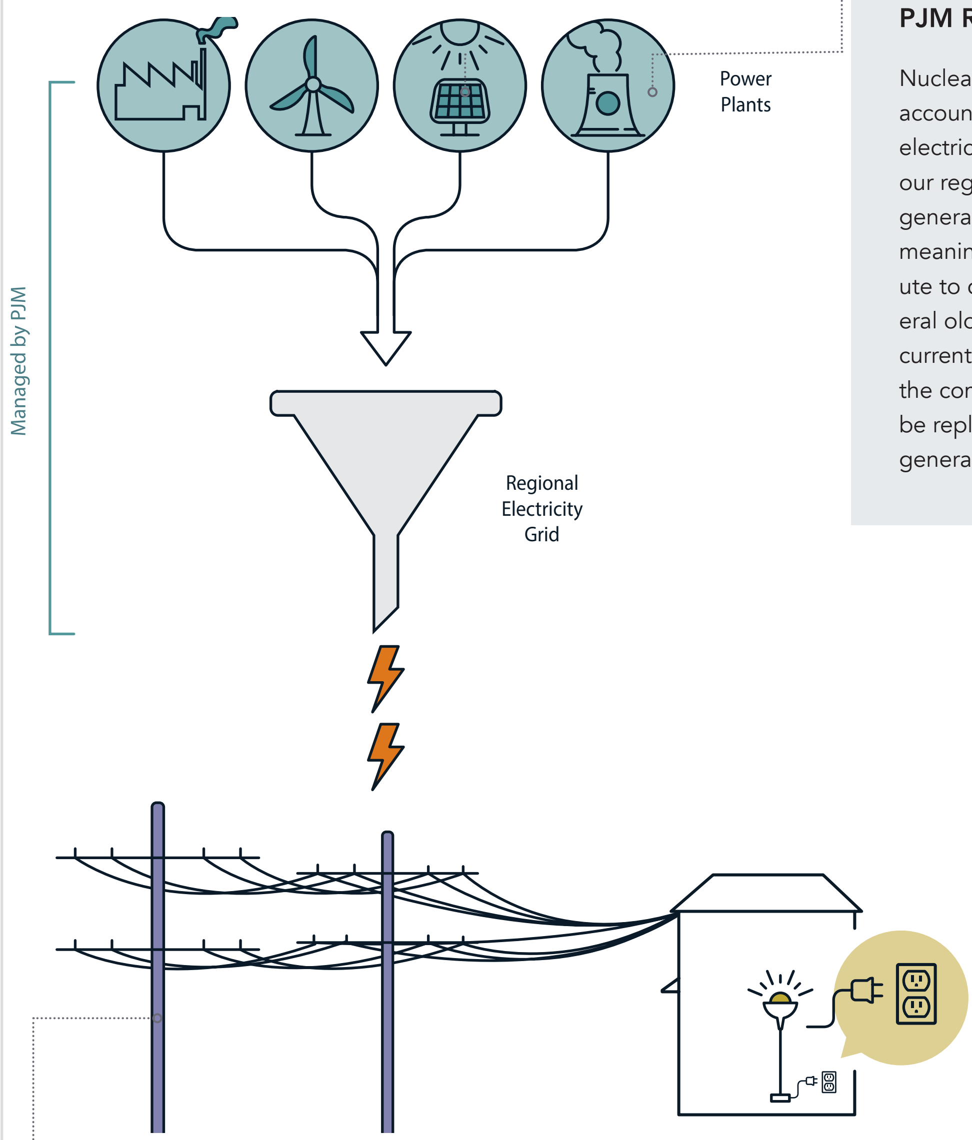





The electricity we use in Philadelphia is generated across the regional electricity grid, and several entities are collectively responsible for providing our electricity:

- **PJM Interconnection:** PJM operates the wholesale electricity marketplace, ensures reliability of the electricity grid, and conducts long-term planning for the future of electricity generation and transmission across 13 states and the District of Columbia.
- **Pennsylvania Public Utilities Commission (PUC):** Electricity is regulated at the state level by the PA PUC. The PUC sets rates (which influence how much your electricity costs) and manages programs to improve energy efficiency and promote renewable electricity.
- **PECO:** PECO is the distribution company in Philadelphia. While all customers can choose electricity suppliers through the PUC's PAPowerSwitch website, PECO is the only distributor for Philadelphia homes and businesses.
- **City of Philadelphia:** The City has a strong working relationship with PECO and regularly files comments on relevant proceedings with the PUC. The Office of Sustainability is working with other cities in the region to evaluate opportunities to be more involved with PJM decision-making to support clean energy generation on our electricity grid.

HOW PHILADELPHIA HOMES AND BUSINESSES GET ELECTRICITY




### Nuclear Energy in the PJM Region

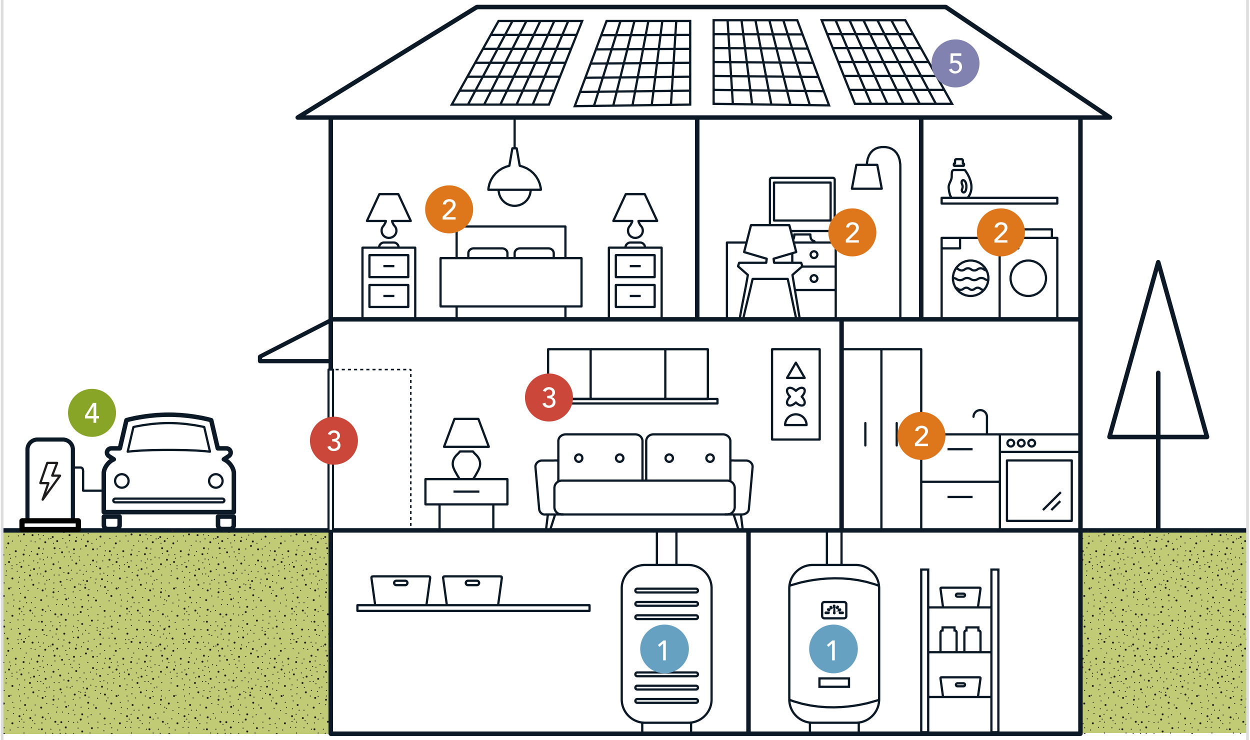
Nuclear energy currently accounts for 40% of the electricity generated in our region. This electricity generation is carbon-free, meaning it does not contribute to climate change. Several older nuclear plants are currently slated for closure in the coming years, and could be replaced by fossil fuel generation.

### How Renewable Energy Will Change Our Grid

While Philadelphia has space on rooftops, parking areas, and vacant land to generate electricity via solar photovoltaic systems and other renewables, most of the city's electricity will continue to be imported from the regional grid. To meet our clean electricity goals, new regional generation must come from utility-scale projects, which can generate thousands as much electricity as the solar PV systems on our homes and businesses.

Additional infrastructure will be required to support this grid transformation. Large batteries and other storage mechanisms will be needed to support the intermittent nature of solar and wind energy, and new electricity transmission lines will help Philadelphia both connect with new renewable generation resources and further manage variability.

## HOW ENERGY IS USED IN YOUR HOME




1

Furnaces, air-conditioning units, heat pumps, and hot water heaters can be powered by electricity from the grid, natural gas, or fuel oil burned on-site. Geothermal and solar heating systems are also options for some Philadelphia homes.

2

Electricity to power home appliances, lighting, and electronic devices is generated on the regional grid and delivered to your home.

3

Ensuring your doors and windows are properly insulated will help keep your home cool in the summer and warm in the winter, reducing the energy you'll need to purchase to stay comfortable.

4

Electric vehicle owners use energy from the regional electricity grid to charge their vehicles.

5

Philadelphians can add solar energy generation to their homes, reducing and in some cases almost eliminating the need to purchase electricity from the regional grid. (In nearly all cases, residents will still need to be connected to the grid even if electricity is generated on-site.)

# CHOOSE THE ELECTRICITY THAT'S RIGHT FOR YOU

from PAPowerSwitch.com

Electricity suppliers can sell over the phone or door-to-door, but we encourage residents to use PA Power Switch to find the supplier that's right for you.

START HERE

Are you currently enrolled in the Customer Assistance Program (CAP) with PECO?

YES

Residents currently enrolled in the CAP should continue to use PECO as their electricity supplier.

NO

Visit
www.PAPowerSwitch.com

Enter your zip code, choose "Regular Residential Service," then click "See Full Results."


Enter your average monthly electricity usage (see sample PECO bill to right) to see rates for all suppliers in your zip code and consider the 4 factors below:

### 1. AVERAGE PRICE

You'll see an Estimated Per Month cost for each supplier. This is only a portion of your bill, so your actual monthly bill will be higher.

### 2. PRICE STABILITY

Choose a Fixed Price if you want your rate to stay the same. Variable rates may be lower at some times, but can end up costing you more.

### 3. CLEAN ELECTRICITY

You can choose a percentage (up to 100%) of your electricity from renewable energy. Also consider:

GENERATION TYPE

"Renewable" is broadly defined by the PUC. Choose wind or solar generation to ensure you are purchasing zero-emission electricity.

LOCATION

Under Special Programs, you can also choose PA Wind or Renewable PA to ensure your electricity is generated within the region, promoting local clean electricity.

### 4. HIDDEN FEES

INTRODUCTORY PRICES

Some suppliers may charge you a low initial price, then increase the price after a period of time. This will be listed in the offer.

ENROLLMENT FEES

Some suppliers charge an initial upfront fee to sign up. Depending on how much electricity you use, this might be a good option to lock in a lower monthly rate.

Click "Sign Up for This Offer" and follow directions to complete your switch. You'll receive a notification from both PECO and your new supplier.

If you choose an alternative supplier, you'll continue to pay PECO for electricity each month.

# Climate Change and Energy

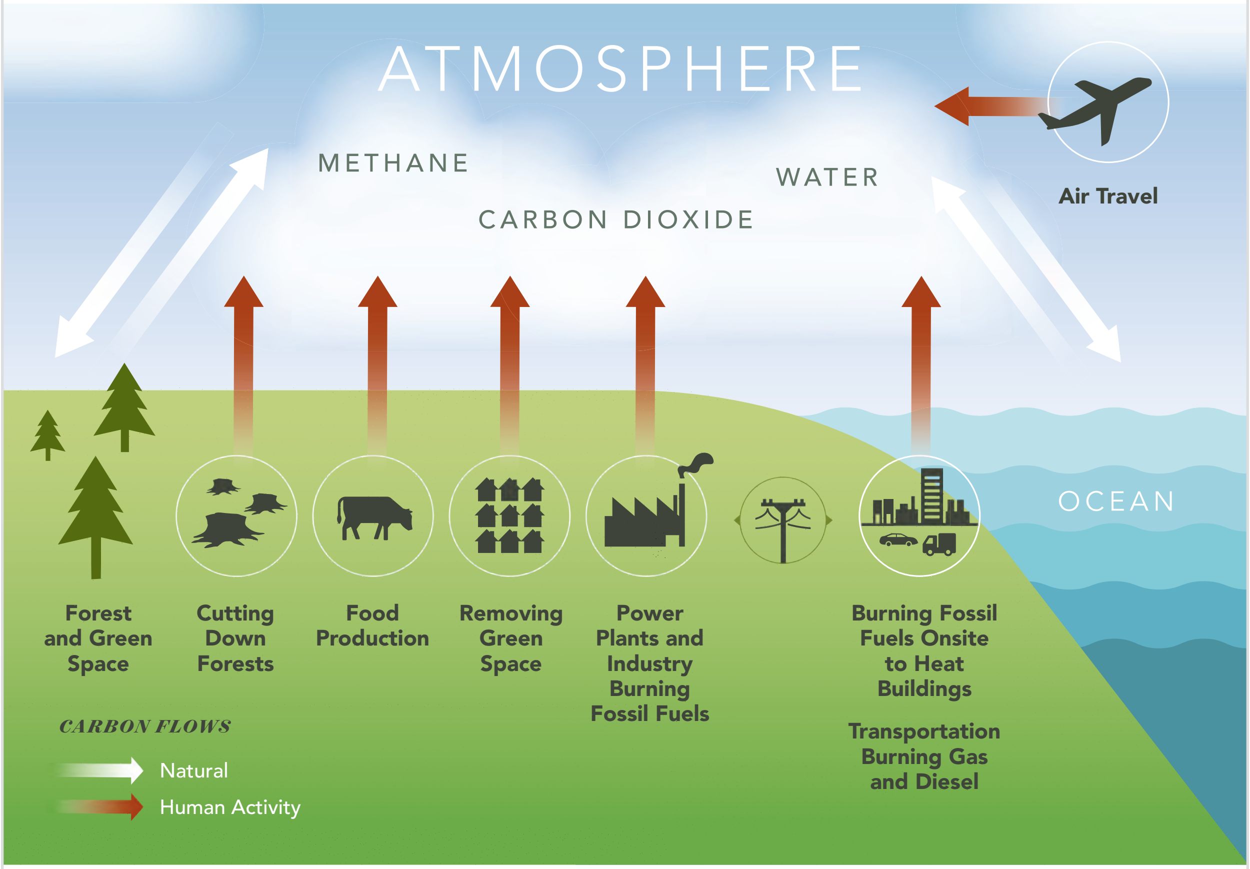
## WHY IS OUR CLIMATE CHANGING?

In the past, the natural carbon cycle kept our planet at a steady temperature.

Since the Industrial Revolution humans have changed the carbon cycle by burning fossil fuels (including coal, oil, natural gas, and gasoline) at a rapid rate, releasing more carbon dioxide ($CO_2$) into the atmosphere than natural systems can handle.

Excess carbon dioxide (along with other "greenhouse" gases like methane and chlorofluorocarbons) in our atmosphere acts like a blanket, trapping heat on Earth which leads to higher temperatures, melting ice, and rising seas.

THE CAUSES OF CLIMATE CHANGE




Human activity in Philadelphia and worldwide has altered the natural carbon cycle, warming the planet.

## WHAT WILL CLIMATE CHANGE MEAN FOR PHILADELPHIA?

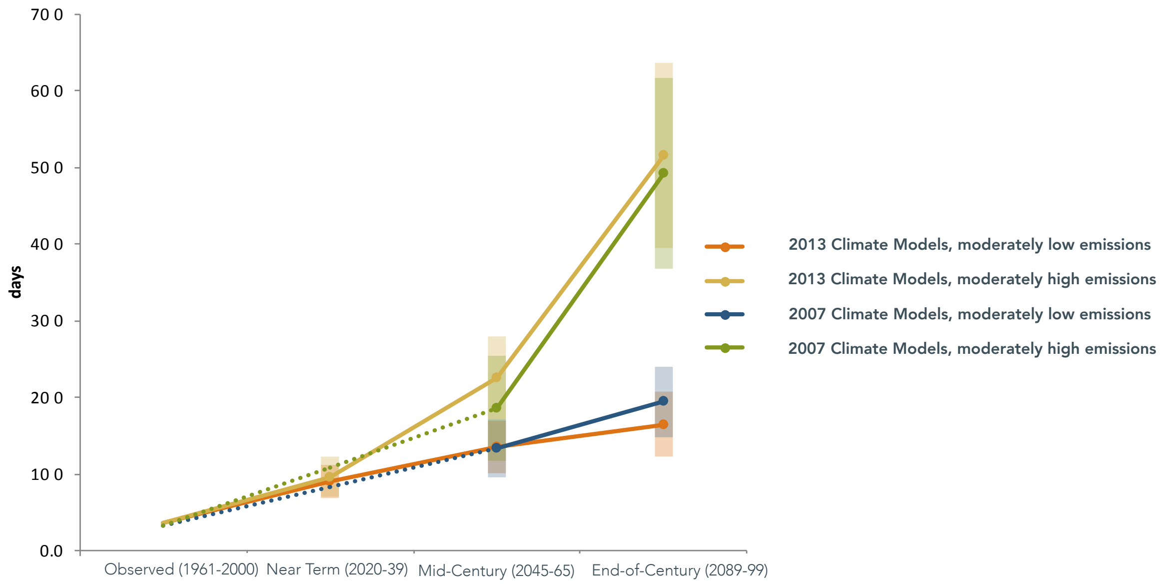
Climate change is a global challenge, but our warming planet will bring distinct changes to different parts of the Earth. In Philadelphia, climate change will have two major impacts: hotter temperatures and more precipitation.

Philadelphians are already accustomed to our sticky, humid summers, but climate change will make the worst of these days more frequent. In an average summer during the 1900s, we experienced four days above 95 degrees. By 2100, we could face as many as 52 days above 95 degrees, with many of those days coming in multi-day heat waves.

A changing climate will also make precipitation more common and heavier in Philadelphia in all four seasons. This means that although temperatures will be warmer on average, Philadelphia will still see heavy snowfalls in the winters to come.

Global climate change will have other local effects. Melting ice caps will bring higher riverfronts, which will worsen flooding along the Schuylkill and Delaware Rivers. Climate change will also make extreme storms more common, meaning more events like Hurricanes Irene and Sandy in all seasons.

### AVERAGE NUMBER OF DAYS PER YEAR ABOVE 95°




Philadelphia has historically experienced only a few days a year warmer than 95 degrees. By end-of-century, that number could rise to nearly 20 even with global efforts to cut carbon pollution. If greenhouse gas emissions continue to rise, the number of days above 95 degrees could increase to more than 50.

## HOW WILL CLIMATE CHANGE IMPACT THE HEALTH OF PHILADELPHIANS?

The increase in extreme heat from climate change will worsen health risks Philadelphians face during humid summer months. Dehydration, heat exhaustion, and heat strokes for vulnerable populations like the elderly, the very young, low-income people, and those without access to air-conditioning may all become more common as the climate changes. Increased hot weather will also encourage the formation of ground-level ozone, which worsens air quality and poses risks to individuals with respiratory conditions such as asthma.

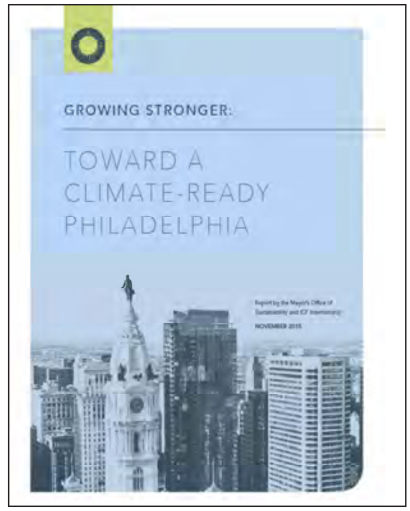
Other climate impacts may also worsen the health of Philadelphians. Increased flooding could damage businesses and homes, leading to mold, and stagnant water from flooding or extreme precipitation can attract pests like mosquitoes that carry diseases.

## HOW IS THE CITY PREPARING FOR THE IMPACTS OF CLIMATE CHANGE?

The Office of Sustainability (OOS) worked with scientists to use global models to assess how the climate will change in the Philadelphia region. This analysis is summarized in the Useful Climate Information for Philadelphia report.

The scientists' models considered scenarios where we slow the burning of fossil fuels and others where we continue to emit carbon at a similar rate to the past. If we take climate action now, we can reduce future harm from climate change in Philadelphia. That's why climate action is a core value of *Greenworks: A Vision for a Sustainable Philadelphia* and this report.

But we know that even if we reduce carbon pollution, Philadelphia's climate will still change. In fact, we're experiencing the impacts of climate change in our city already. To ensure the City continues to provide essential services to residents as the climate changes, a Climate Adaptation Working Group made up of many City departments released *Growing Stronger: Toward a Climate-Ready Philadelphia*, which details actions city government can take to adapt to the changing climate.




Growing Stronger, Philadelphia's first climate adaptation report, is available at www.phila.gov/green.


To help residents prepare for climate change, the City is working with Hunting Park community groups through the **Beat the Heat pilot** to reduce the impacts of extreme heat and educate neighbors about how climate change will increase heat in the years to come.

## HOW DOES CLIMATE FIT INTO THE CLEAN ENERGY VISION?

Philadelphia's local carbon emissions contribute to the global challenge of climate change. The energy used by our buildings and industry account for 80 percent of those local emissions, and each of the efforts described on the following pages will help reduce local carbon emissions.

The strategies described on the following pages can also help address the impacts of climate change Philadelphia residents are already experiencing. Building a more resilient energy system will ensure our critical buildings (like hospitals, shelters, and public safety facilities) can continue to operate in emergencies. Moving toward a clean and efficient energy system also helps residents save money and preserve housing affordability, which improves individual resilience to extreme weather.

## What Do Philadelphians Think about Energy?

To create Powering Our Future, the Office of Sustainability (OOS) held meetings to hear from residents and advocates on their goals for a clean energy future and worked with partners conducting surveys of their own to help understand the priorities and goals of Philadelphians.

### Clean Energy Vision Engagement Meetings

During the development of the first draft of this report, OOS heard from hundreds of residents through a series of listening and engagement sessions and an online survey. Though this represents just a fraction of the voices in our city, these engaged residents helped guide the process toward creating Powering Our Future and challenged OOS to deepen community engagement around energy issues in the years to come.

### Powering Our Future Public Comment Period

Following the draft publication of Powering Our Future in November 2017, OOS received comments from more than a dozen advocacy groups and individuals as well as numerous responses to a public survey about the report. Many of the comments received are integrated into this final draft. Several larger themes emerged from these comments, including:

- *Beyond 80 by 50*: Climate science increasingly suggests we must work globally to cut carbon emissions as fast and as far as possible. Thoughts on moving beyond the 80 by 50 target are included on page 9.
- *Concrete next steps*: Achieving our clean energy vision will take effort by individuals, institutions, and all levels of government. To understand how the City will lead on implementing the vision, OOS will publish a Clean Energy Vision Action Plan in September 2018.
- *Economic opportunity*: We know that transitioning to a clean energy future will mean new job opportunities for local residents. This is now reflected for each of the five focus areas of the report.
- *Summary and simplification*: Powering Our Future reflects our complex energy system and the effort it will take to transform it. To provide an introduction to this work, a summary of the clean energy vision will be available on the OOS website at www.phila.gov/green.

### Resident Surveys

OOS participated in the 2016-17 Philadelphia Resident Survey, asking participants whether they had worked to make their homes energy efficient and if they struggled to pay utility bills. Nearly half of weighted survey participants have made their homes more energy efficient, but nearly a third have difficulty with energy costs, underscoring the need to ensure affordability in our energy system.

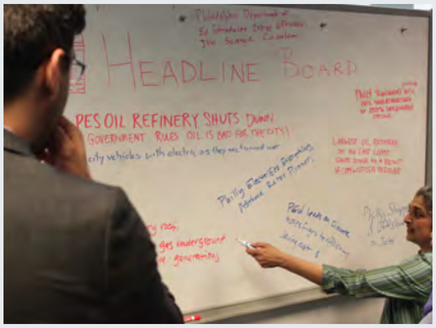
A local environmental justice organization, Philly Thrive, surveyed more than 300 residents in South Philadelphia to hear their priorities for a clean energy transition. Nearly 34% of surveyed residents living in and around the South Philadelphia refinery are asthmatic, underscoring the need to prioritize public health to achieve our clean energy vision. You can find the full results of this survey at www.phillythrive.org.

**46%**
OF PHILADELPHIANS HAVE ALREADY MADE THEIR HOME MORE ENERGY EFFICIENT

**33%**
OF PHILADELPHIANS HAVE TROUBLE PAYING THEIR ENERGY BILLS

### What's Next

To achieve Philadelphia's clean energy vision, individuals and organizations of all kinds will need to work together to accomplish our shared goals. Through Powering Our Future's proposed implementation working groups, OOS hopes to bring together residents, advocates, and large institutions to develop strategies for implementing the clean energy vision that reflect the priorities and needs of Philadelphians. OOS and the City are committed to continuing to engage with Philadelphians on how to build a clean energy future for all, and will share future engagement opportunities through community partners, on our website at www.phila.gov/green, and through our monthly newsletter.



# Clean Energy Vision Goals at a Glance

Through a series of stakeholder engagement sessions and climate modeling, the City of Philadelphia has identified new goals for meeting its climate action commitments. Our clean energy vision must go beyond climate action and also deliver equity, health, and economic benefits to all Philadelphians.

**Cut citywide carbon pollution 25 percent by 2025 from 2006 levels**

**Reduce carbon pollution from the City-owned buildings and streetlights 50 percent by 2030**

**Cut citywide carbon pollution 80 percent by 2050 from 2006 levels**

**Achieve a 100 percent carbon-free electricity grid by 2050**

=

EQUITY: Building a clean energy future for Philadelphia means investing in systems that work for residents and businesses in every zip code of the city.

+

HEALTH: Cutting air pollution from coal and oil-fired power plants in our region will improve local air quality and lessen the health impacts of climate change.

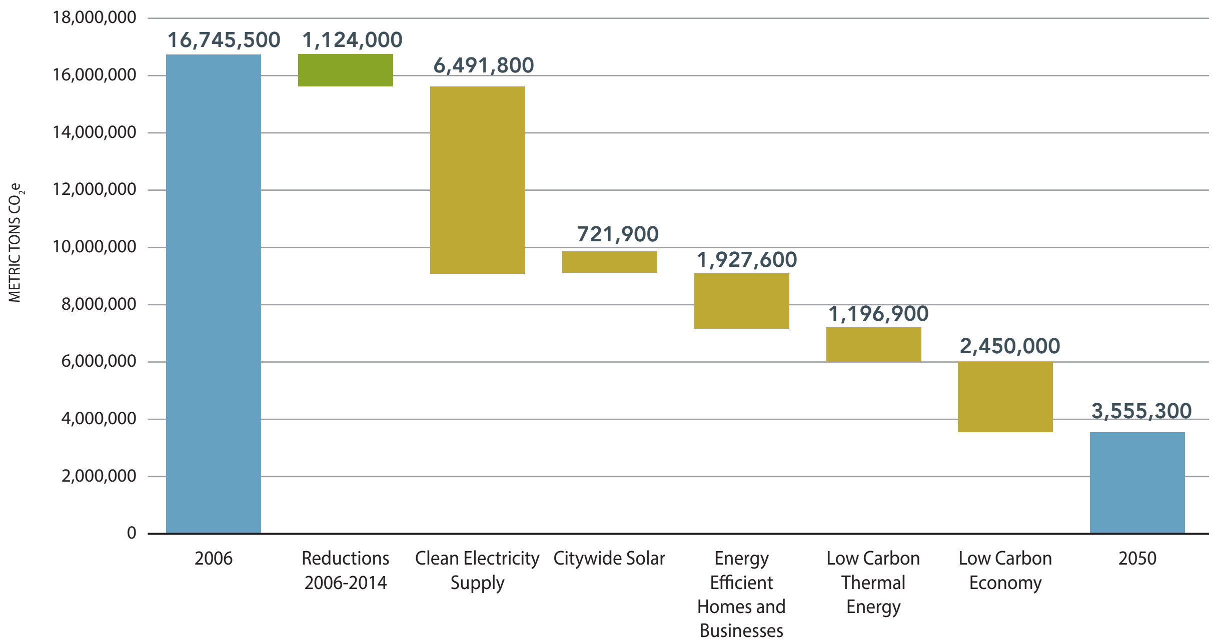
$

ECONOMY: Our clean energy future must work to eliminate the energy burden for the 33% of Philadelphians struggling to pay bills while creating family-supporting clean energy job opportunities.

# How Will We Achieve Our Clean Energy Vision?

Meeting Philadelphia's energy and carbon reduction goals will require work across all levels of government and throughout our community. The Office of Sustainability has grouped this work into five categories: clean electricity supply, citywide solar, energy-efficient homes and businesses, low-carbon thermal energy, and low-carbon economy.

POTENTIAL TO REDUCE CARBON POLLUTION IN PHILADELPHIA'S BUILT ENVIRONMENT




The carbon reduction potential of each of these strategies is interrelated: we will need to make greater efficiency investments if carbon emissions from electricity grid generation do not decline as quickly as modeled. Grid intensity similarly impacts the effectiveness of a transition to low-carbon thermal energy. Though shown as a separate set of strategies above, citywide solar is part of the transition to a clean electricity supply.

**Achieving our clean energy vision will take significant effort by the City, residents and businesses, and others in Philadelphia and at the state and federal levels.** The following pages describe each of the five categories in more detail and outline how Philadelphians can work together to achieve our clean energy vision.

# Clean Electricity Supply

## WHERE WE'RE GOING

39 percent of Philadelphia's built environment carbon emissions come from electricity generated by fossil fuel-burning power plants throughout the region. **By 2050 the electricity generators supplying our grid must be fossil fuel-free to meet Philadelphia's goal of reducing citywide emissions 80 percent from 2006 levels.**

Cleaning our electricity supply is critical to reduce current carbon emissions, but it is also necessary for further climate action. Moving toward electricity for some thermal energy uses (see Low-Carbon Thermal Energy section) and electrifying both personal vehicles and large fleets like the City's and SEPTA's will add demand to the electricity grid, and new clean generation will be needed to meet this demand without increasing carbon pollution.

Moving toward a clean supply will create other benefits. Construction and installation of new clean grid infrastructure can create new jobs for Philadelphians, particularly in the solar industry (see Citywide Solar section). And while most electricity generation happens outside of Philadelphia, eliminating the air pollution from fossil fuel-fired power plants, particularly those burning coal, elsewhere in Pennsylvania could lead to health benefits for Philadelphians.

The transition to a clean electricity supply must also consider Philadelphia residents who are already struggling to pay utility bills. This transition can reduce those bills in the long term (particularly when paired with energy efficiency and local solar generation opportunities), but must also work to avoid price spikes as older coal and gas plants are retired.

Because the electricity grid is regional, the City of Philadelphia and our residents and businesses cannot clean the grid on our own. To meet our goals we'll need to advocate for a clean grid in Harrisburg and Washington, encourage our elected representatives to strengthen Pennsylvania's Alternative Energy Portfolio Standard, and preserve the proposed Clean Power Plan to ensure a shift to a clean grid that benefits all Philadelphians.

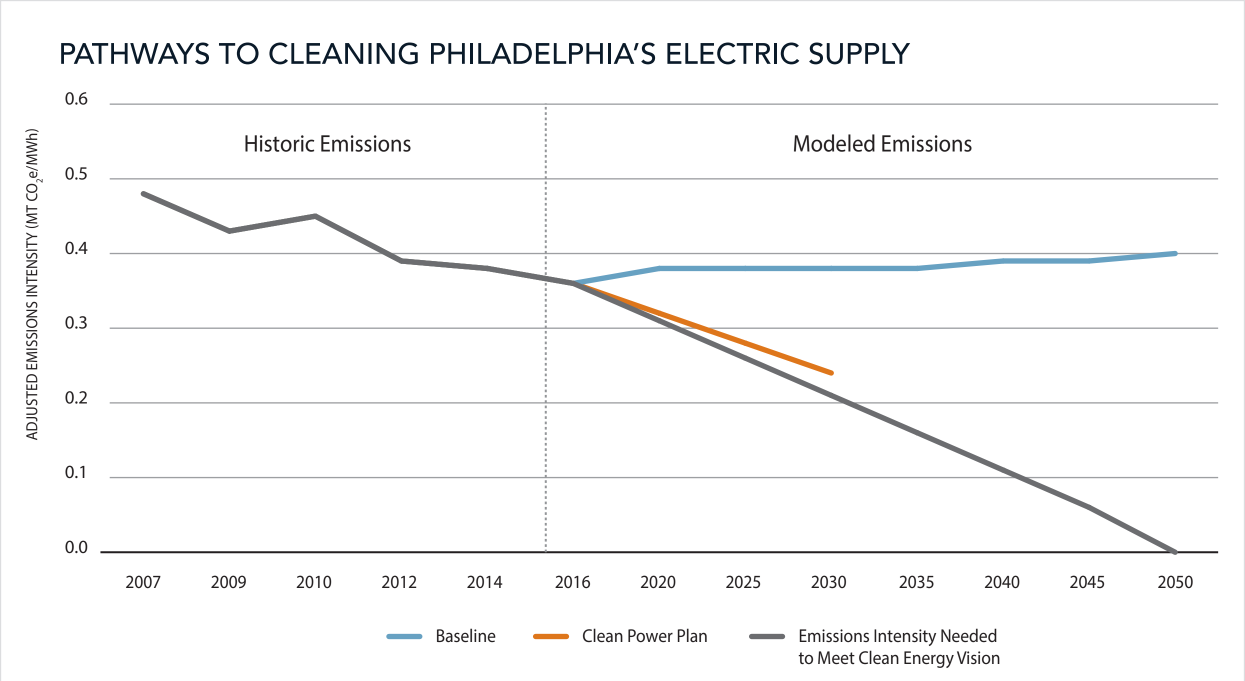
### Co-Benefits

**EQUITY**
A smart transition to a clean grid will maintain or even lower energy costs for low-income residents.

**HEALTH**
A clean grid will improve regional air quality, reducing incidences of asthma and other respiratory illnesses.

**ENVIRONMENTAL**
Eliminating the burning of fossil fuels in the regional grid will reduce the need to extract those fuels, improving the health of rivers and other natural systems.

**ECONOMIC**
The clean grid transition will be a massive economic opportunity, particularly because key renewable electricity resources like solar and wind can be generated at smaller-scale, distributed locations.




To meet the clean electricity supply goals necessary to achieve our clean energy vision, Philadelphians should continue to advocate for the implementation of the Clean Power Plan or another strategy to reduce carbon pollution from our regional electricity grid.

## HOW WE'LL GET THERE

OOS evaluated current electricity grid trends alongside projections of the future grid developed by the Energy Information Agency. These trends were then modeled both with and without the implementation of the Clean Power Plan.

Because the electricity grid is regional, eliminating fossil fuel generation will require a combination of market forces and actions across all levels of government, including at the federal level.

The Clean Grid Playbook on the following pages evaluates both short- and long-term opportunities to use existing mechanisms to move the grid away from fossil fuel generation and toward a clean energy future.

## WHAT YOU CAN DO

- **Choose clean energy for your home or business:** Through the Public Utility Commission's PAPowerSwitch.com website, you can select your electricity supplier, including companies offering 100 percent clean energy generated within the Commonwealth of Pennsylvania. Make the switch at home, and encourage your employer to also commit to purchasing clean, local energy.
- **Advocate at the local, state, and federal level:** Achieving a carbon-free grid will require action across all levels of government. Let your elected officials know a clean electricity grid is a priority, and see the Playbook on the following pages for specific advocacy opportunities.
- **Consider local renewable generation:** Investing in solar energy in your home or business reduces carbon emissions on the grid and helps move Philadelphia toward a clean energy future.

### Current Progress Toward A Clean Grid

Moving our regional electricity grid away from fossil fuel generation will be incredibly challenging, but there are positive signs this transition is already underway.

Since 2007, the carbon intensity of the grid has declined more than 26 percent. While this is largely due to electricity generation switching from coal to natural gas—which is also a fossil fuel—this transition demonstrates the grid is capable of rapid and dramatic change in response to market signals.

There is also opportunity for renewable energy generation in our grid region. Western Pennsylvania's hills and proximity to major metros make wind economically viable there. And while solar generation has been slow to ramp up in Pennsylvania due to state policies and historic market conditions, the results of the City's recent Request for Proposals from the Energy Office, the success of the Solarize Philly program, and recent action in Harrisburg to require mandated solar energy to be generated within state all indicate the solar market is strengthening.



### ECONOMIC OPPORTUNITY FROM CLEAN ELECTRICITY SUPPLY

Providing a carbon pollution-free supply of electricity to Philadelphia homes, businesses, and institutions will require a transformation of our regional electricity grid, including new clean generation, storage mechanisms, and transmission and distribution lines. A recent report by E2 estimates there are currently 4,000 clean grid jobs in Pennsylvania, mostly focused on storage technology; this number will need to scale up significantly as variable renewable energy like solar and wind becomes more prevalent in our grid.

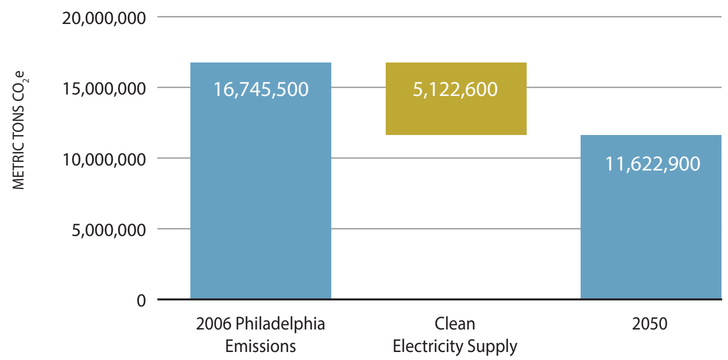
Much of this work will happen across the PJM region (see page 12), but there will still be opportunities for Philadelphians. The City of Philadelphia is currently considering proposals for a power-purchase agreement (see page 27) and investigating opportunities for ensuring local workers are part of the process, even if those proposals involve construction outside city limits.

# Clean Electricity Supply Playbook

The Clean Electricity Supply Playbook evaluates both short- and long-term opportunities to use existing mechanisms to move the grid away from fossil fuel generation and toward a clean energy future. These strategies are split into local, state, and federal opportunities. Implementing these strategies will require buy-in from multiple stakeholders, who are identified in the Key Players boxes.

Even without further action at the local or federal levels, eliminating carbon pollution from our electricity supply would dramatically reduce our local impacts on global climate change. Cleaning electricity supply is also critical for effectively achieving other strategies to fight climate change, including running Philadelphia's cars and buses on electricity.

CLEAN ELECTRICITY SUPPLY
CARBON EMISSION REDUCTION POTENTIAL



KEY PLAYERS

*City of Philadelphia Renewable Purchasing*

**Philadelphia City Council:** Must approve Power Purchase Agreement.

**Energy Office and Philadelphia Energy Authority (PEA): Energy Office** will manage project for the City, and **PEA** will hold long-term contract.

**Renewable energy developers:** Develop, finance, install, and maintain renewable energy project.

KEY PLAYERS

*Institutional Renewable Power Aggregation*

**Large Institutions:** Pool energy purchasing to develop a renewable energy project within the regional electricity grid.

**City of Philadelphia:** Convene institutional partners and lead effort to collectively develop renewable energy project.

KEY PLAYERS

*PA Power Switch and Community Choice Aggregation*

**Pennsylvania Public Utilities Commission (PUC):** Implements PA Power Switch program.

**City of Philadelphia and community partners:** Educate residents and businesses about opportunities to purchase clean energy.

## LOCAL RENEWABLE ENERGY PURCHASING

Nearly all the electricity used by Philadelphians is generated outside the city, giving residents, businesses, and institutions a considerable opportunity to influence the grid through electricity purchasing decisions.

### City of Philadelphia Renewable Purchasing

Since 2012 the City of Philadelphia has purchased local renewable energy credits to help meet Greenworks sustainability goals and drive the local renewable energy market. Improving market conditions in Pennsylvania and interest from the City and stakeholders has led the Office of Sustainability's Energy Office to evaluate more direct opportunities to spur renewable energy development, including a renewable energy power purchase agreement (PPA).

Under the PPA model, a renewable energy developer would develop, finance, install, operate, and maintain a renewable energy project. Power produced at the project would be fed into the electricity grid and purchased by the City. The third party would own the solar array or renewable energy generation asset, but the City would own the renewable energy credits and the zero-emission electricity produced.

The City issued a Request for Proposals for a renewable energy PPA in October 2017, which will help the City decide what percentage of its electricity purchase can be affordably purchased through a PPA in the short term. If the PPA model successfully meets the City's environmental and economic goals, the City will consider additional PPAs to directly purchase more clean electricity.

### Institutional Renewable Power Aggregation

Philadelphia's municipal electricity buying power is significant, but could be bolstered by collectively developing a renewable power purchasing strategy with other large institutions within Philadelphia.

Independently or in cooperation with the City, large institutions (including businesses, universities and colleges, quasi-governmental agencies, and large non-profits) could collectively seek proposals for a large renewable energy development to off-set their electricity usage. The project would provide cost stability for the institutions while also helping to clean the regional electricity supply.

### PA Power Switch and Community Choice Aggregation

Currently, any Philadelphia resident or business paying an electricity bill through PECO can choose an electricity supplier with 100 percent renewable electricity through the Pennsylvania Public Utility Commission's PAPowerSwitch.com website.

As of July 2017, 34 percent of residential customers in the PECO territory, which includes Philadelphia, have switched their electricity supplier. Though the PUC does not publish data on what percentage of those have switched to 100 percent renewable suppliers, these numbers are promising.[1] The City of Philadel-

[1] http://www papowerswitch com/sites/default/files/PAPowerSwitch-Stats.pdf

phia will increase education efforts to inform residents and businesses of the opportunity to contribute toward a clean electricity grid. (Residents currently enrolled in the Customer Assistance Program should not consider enrolling in PA Power Switch at this time.) See page 15 for a guide to purchasing electricity.

To further leverage the collective buying power of city residents, many jurisdictions around the United States are implementing Community Choice Aggregation programs, where municipalities act as a collective energy purchaser, buying clean energy on behalf of its residents. In the most effective iterations of these programs, new electricity accounts are defaulted into the CCA, and residents must opt out to purchase electricity elsewhere on the market.

The Commonwealth of Pennsylvania's Public Utilities Commission currently prohibits opt-out CCAs. Changing this rule would enable the City of Philadelphia to explore creating a CCA and help residents move toward clean and affordable grid electricity.

## BEYOND PHILLY: STATE AND FEDERAL ADVOCACY

Renewable energy purchasing is a key strategy toward a cleaner grid, but even if every dollar spent on electricity in Philadelphia went to clean energy generation, our regional electricity supply would still not be carbon-free. To meet that goal, we must work beyond city limits and advocate for policies at the state and federal levels that influence our transition to a clean electricity generation.

### Strengthening Alternative Energy Portfolio Standard

Pennsylvania's Alternative Energy Portfolio Standard (AEPS), Act 213 of 2004, requires 18 percent of the electricity supplied by Pennsylvania's electric distribution companies and electric generation suppliers to come from alternative energy resources by 2021. The AEPS further requires these entities to generate the equivalent of 0.5% of that electricity from solar energy systems, or offset 0.5% of the their generation with solar renewable energy credits (SRECs).

**KEY PLAYERS**

*Strengthening Alternative Energy Portfolio Standard*

**PA Legislature:** Responsible for legislation to strengthen AEPS.

In November 2017 Governor Wolf signed an update to the Administrative Code, modifying the AEPS to require SREC purchases to come from solar generation within the Commonwealth of Pennsylvania. This change should increase the value of solar statewide, helping spur further solar development in the regional electricity grid.

The Commonwealth of Pennsylvania could further strengthen the AEPS to help move toward a cleaner grid in three ways:

- Extend the AEPS beyond the current 2021 program end date.
- Increase the total requirement for alternative energy purchasing within the AEPS above 18%.
- Increase the percentage of the AEPS that must be achieved through solar generation or SREC purchases above 0.5%. As a potential target, the Pennsylvania's recently released draft report, Finding Pennsylvania's Solar Future, discusses opportunities to meet 10 percent of Pennsylvania's demand with solar power by 2030.

### Joining the Regional Greenhouse Gas Initiative

The Regional Greenhouse Gas Initiative (RGGI) is a program of nine Northeastern states to reduce carbon emissions from fossil fuel-fired power plants through a regional market for greenhouse gas permits. RGGI auctions allowances for carbon emissions which are then traded on the market. Proceeds from the auctions are used to fund energy efficiency and clean energy programming across the nine states.

**KEY PLAYERS**

*Joining the Regional Greenhouse Gas Initiative*

**PA Governor's Office and Legislature:** Can bring Pennsylvania into multi-state RGGI pact.

The Commonwealth of Pennsylvania has been an observer since RGGI's launch in

2006, but has thus far declined to join RGGI as a participating state. Joining RGGI could be a significant financial benefit to Pennsylvanians: the state's 2014 CO2 emissions of over 100 million tons could generate $300 million or more in new funds based on recent RGGI auction prices. This is more than the $217 million currently spent on energy efficiency through the Act 129 mandate alone. (See page 45 for more details on Act 129.)

Governor Wolf has indicated support for Pennsylvania joining RGGI, but action from the Pennsylvania Legislature would be required to achieve this goal.

## Protecting the Clean Power Plan

The Environmental Protection Agency proposed the Clean Power Plan (CPP) in 2015 to limit carbon pollution from power plants in the United States. CPP instructs each state to create a strategy to improve the efficiency of existing fossil fuel-fired power plants so that by 2030 carbon pollution from the power sector will be between 24 and 33 percent below 2005 levels.

In addition to reducing our carbon footprint, the CPP would provide other benefits to Philadelphians as well as residents and businesses across the United States. Fossil fuel-fired power plants, particularly coal-burning plants, are among the greatest contributors to poor air quality in the United States. The CPP would curb particulate matter pollution which can lead to asthma and other health hazards. The CPP would also spur job growth through the retrofitting of existing power plants and in the renewable energy and energy efficiency sectors.

KEY PLAYERS

*Protecting the Clean Power Plan*

**U.S. Environmental Protection Agency:** Responsible for reducing carbon pollution nationwide.

In Fall 2017 the Trump Administration's Environmental Protection Agency (EPA) announced the proposed rollback of the CPP. This rollback will be subject to a public comment period. The EPA indicated that a future announcement on another mechanism to reduce carbon emissions, as currently required by law, is forthcoming.

The City of Philadelphia has joined litigation to protect the CPP and will continue to make the case of the value of the proposed regulations. Philadelphia City Council and the Kenney Administration hosted an opportunity for residents to read comments on CPP repeal into public record. The City aggregated these comments and submitted them, along with the City's objections to the proposal, to the EPA. OOS will continue to seek opportunities to support residents and businesses in making the case for the Clean Power Plan.

## Maintaining Existing Nuclear Generation

Nuclear power plants provide nearly 40% of our region's electricity, and are currently the largest producer of zero-carbon electricity in the country. In recent years, low electricity costs spurred by cheap natural gas have made existing nuclear generation less competitive in deregulated electricity markets. As a result, nuclear plants in several states including Pennsylvania are slated to shut down in the coming years.

Electricity provided by nuclear energy does not contribute to climate change, and premature closure of existing nuclear power plants would have significant carbon impacts if displaced carbon-emitting fossil fuel generation. States like Illinois, New York and New Jersey have created legislation to preserve existing nuclear generation through state subsidies while simultaneously incentivizing investment in new, renewable electricity generation, and Pennsylvania could consider similar legislation.

# LOCAL RENEWABLE ENERGY GENERATION

Philadelphia's dense population and high land values have made most large-scale local renewable energy generation proposals economically challenging. Given these factors, the most feasible renewable electricity generation for Philadelphia is currently solar power, which is covered on the following pages.

# Citywide Solar

## WHERE WE'RE GOING

By 2050 80 percent of the Philadelphia rooftop space currently suitable for solar generation (39 percent of total rooftops) will be producing clean electricity for residents and businesses.

Philadelphia will also take advantage of solar generation opportunities in other parts of the city, including on vacant parcels and on parking lots (a strategy already successful at Lincoln Financial Field). These solar installations could be privately-owned large-scale projects or neighborhood-serving community solar.

Meeting this vision citywide would represent a significant increase from the current pace of solar installation in Philadelphia (see chart on Page 31). While generating all of Philadelphia's electricity needs within city boundaries isn't possible with current technology, citywide solar will make a significant contribution to our clean grid vision while providing location job opportunities and providing utility bill stability for Philadelphia residents.

As described in the Municipal Energy Master Plan, the City will continue to lead by example. The City has already installed solar on the Water Department's Southeast Water Pollution Control Plant, and is studying opportunities for further solar generation on municipal rooftops and other City-owned spaces.

### Co-Benefits

EQUITY
As solar generation becomes more affordable, it will become easier to add to Philadelphia homes in every neighborhood to lower energy bills and provide clean power.

HEALTH
Citywide solar will help displace fossil fuel generation from our regional electricity grid, reducing air pollution making its way into Philadelphia.

ENVIRONMENTAL
Providing renewable electricity to Philadelphians is one of the most effective mechanisms for combating climate change.

ECONOMIC
Installing solar generation citywide will generate new local job opportunities.

CITYWIDE SOLAR

### Success Story: Solarize Philly

In 2017 the Philadelphia Energy Authority (PEA) launched Solarize Philly, a group buying program designed to help Philadelphians go solar at home. As with other Solarize models, the more customers who sign contracts, the deeper the discounts for all participants. The program built in revenue streams to expand job training programs and to offer an affordable option for low- and moderate-income households.

More than 2,100 Philadelphia households expressed interest in Solarize Philly during the first phase of the program.

Solar Philly reopened for applications in Spring 2018. This phase includes special financing for 45 low- and moderate-income households. Any homeowner in Philadelphia can sign up for a free solar assessment at www.solarizephilly.org.

PEA is partnering with the School District of Philadelphia to pilot a solar training program for high school students. Solar States, a Philadelphia-based solar installer, taught the "Find Your Power" course. The first cohort in summer 2017 equipped 18 Philadelphia students to pursue careers as solar installers, and an additional 14 students attended the class in spring 2018, which included a new curriculum on energy efficiency and job readiness. PEA will be training a new cohort of 20 students in the summer of 2018 through the Philadelphia Youth Network's WorkReady program.

## HOW WE'LL GET THERE

Meeting a citywide solar goal will require a commitment by the City, businesses, large institutions, and Philadelphia residents. In the past year, new commitments by SEPTA to invest in solar generation on their property and the success of the Philadelphia Energy Authority's Solarize Philly program demonstrate the potential for this leadership. However, more work must be done to ensure solar power is available to all Philadelphians, including low-income residents.

While solar is a smart investment for many Philadelphians today, new technology and business opportunities may create even more affordable solar generation in the years to come. The City will continue to monitor changes in technology and update citywide solar modeling as Philadelphia's capacity to generate clean electricity increases.

### ECONOMIC OPPORTUNITY FROM CITYWIDE SOLAR

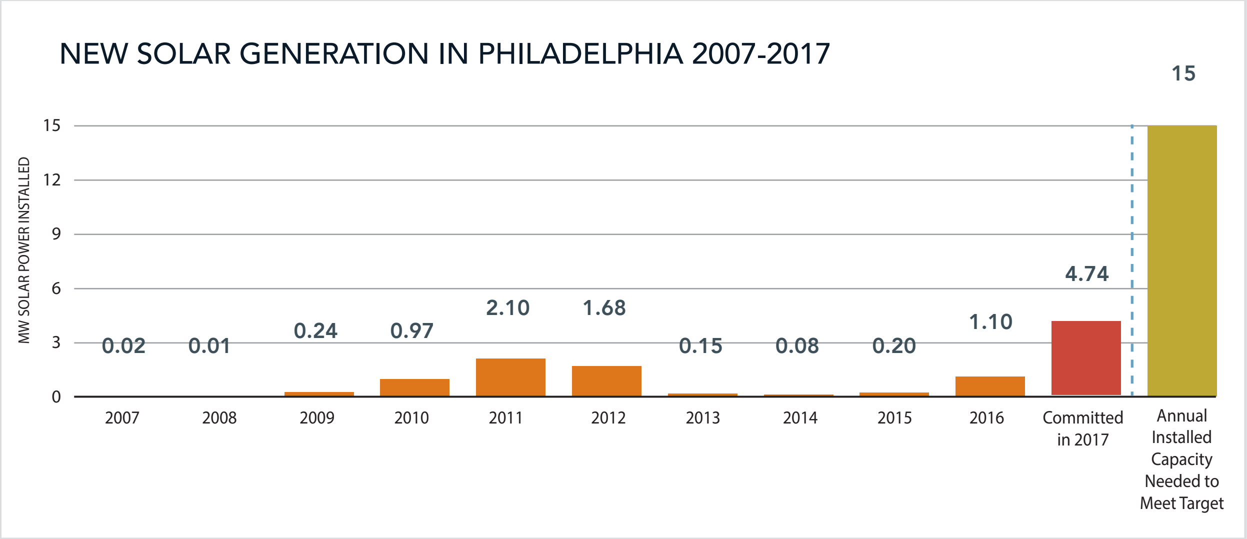
There are currently around 5,000 solar jobs in Pennsylvania, and this number will only grow in the years to come. A recent study by the Bureau of Labor Statistics reported solar installer as the single-fastest growing job opportunity in the U.S., and to meet our clean energy goals, Philadelphians will need to fill many of those jobs.

To prepare our workforce for this 21st century employment opportunity, the School District of Philadelphia, the Philadelphia Energy Authority, and Philadelphia Youth Network have been partnering on solar installation training for local high school students, helping to build a pipeline of young Philadelphians ready to bring electricity generation directly to our city's homes and businesses.

## WHAT YOU CAN DO

- **Evaluate the solar potential of your home or business:** Solarize Philly has already helped hundreds of Philadelphia residents evaluate whether solar generation was right for their households. Residents and businesses can also work with solar installers directly; Green Building United maintains a contractor database to help find an installer right for you at www.greenbuildingunited.org.
- **Invest in energy efficiency:** By cutting energy waste in your home or business, you can not only save money and cut carbon pollution, the energy you save can also make installing solar panels more cost-effective.
- **Advocate for favorable solar policies at the local, state, and federal levels:** Many local advocacy groups work at the local, state, and federal levels to support policies that help make solar panels accessible to all Philadelphians. You can find a list of these groups through the City's Environmental Action Guide: http://bit.ly/philaactionguide






Thanks to large-scale initiatives by SEPTA (3.1 MW), the Philadelphia Navy Yard (.44 MW), and the collective investment of Solarize Philly (.89 MW), 2017 solar commitments if completed would be the biggest year ever for new generation. However, even this impressive effort must be scaled up to meet current solar potential.

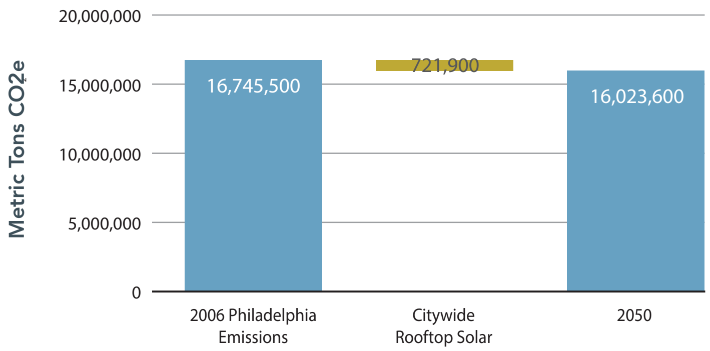
# Citywide Solar Playbook

As with strategies to clean our regional electricity supply, three types of efforts can promote solar in Philadelphia: local actions by City government and our partners, statewide advocacy to help grow the solar installation market and decrease the cost of solar installation in Pennsylvania, and federal advocacy around renewable energy policy.

Achieving our citywide solar vision will require buy-in from multiple stakeholders, who are identified in the Key Players boxes on the following pages.

**To meet the carbon reduction potential from solar, we need to install solar generation on 80% of currently suitable rooftops in Philadelphia.** This would create considerable economic opportunities but only limited carbon pollution reductions with current technology. The City will continue to monitor new technologies and opportunities and update citywide solar modeling as Philadelphia's capacity to generate clean electricity increases.

CITYWIDE ROOFTOP SOLAR
CARBON EMISSION REDUCTION POTENTIAL



## LOCAL ACTION

### Addressing Soft Cost Barriers

Since 2011 the Office of Sustainability (OOS) and the Department of Licenses and Inspections (L+I) have worked together to reduce the "soft costs" associated with developing solar projects in Philadelphia. Soft costs includes the time and effort that goes into installing solar panels, including permitting, zoning, interconnection, financing, customer acquisition, and installation.

In 2012 OOS worked with City Council to pass legislation that significantly reduced the cost of solar permitting by excluding the costs of panels and inverters from calculations.

In 2016 OOS and L+I updated the expedited solar permit standard, giving small solar projects for one- and two-family dwellings that are 10 kW or less in size the following benefits:

- Proceed with only an electrical permit (no building permit required)
- Expedited permit processing time (within five days) for qualifying permit applications

In 2017 Philadelphia became a SolSmart Gold designated community in recognition of efforts to make it faster, easier, and cheaper to install solar energy. Through discussions with solar installers and the statewide Finding PA's Solar Future initiative, the City continues to work with the local solar community to identify new opportunities to further drive down soft costs and make solar available to all residents.

KEY PLAYERS

*Addressing Soft Cost Barriers*

**OOS and L+I:** Works with solar developers to identify and reduce barriers to developing solar projects in Philadelphia.

**Philadelphia City Council:** Approves some changes to permitting rules in Philadelphia.

### Citywide Solar Installation Campaigns

Collective purchasing or "solarize" campaigns encourage solar adoption by bringing neighborhoods together to purchase solar panels in bulk, reducing the costs for everyone involved. Several solarize campaigns have been conducted in Philadelphia neighborhoods with successful results, including the Philadelphia Energy Authority (PEA)'s Solarize Philly campaign. Continuing and expanding these programs in the years ahead will ensure that solar power becomes more available for all Philadelphians.

KEY PLAYERS

*Citywide Solar Installation Campaigns*

**PEA:** Current implementer of the Solarize Philly campaign.

**Community and non-profit partners:** Leading solarize campaigns in other parts of the city and region.

### Solar in New Construction and Renovations

Through the City's density bonus for LEED construction, developers already have some incentive to consider clean electricity generation when adding to Philadelphia's skyline. Numerous other opportunities to incentivize or require new construction or major retrofits to responsibly manage their carbon footprints are addressed in the Energy Efficiency Playbook, and many of these strategies are also applicable to solar generation.

KEY PLAYERS

*Solar in New Construction and Retrofits*

**Philadelphia City Council:** Pass legislation to offer incentives.

**Real estate developers:** Implement energy-saving measures in new construction and renovation to exceed existing energy code.

**City agencies:** Support developers in meeting building performance goals and verifying compliance.

### Leverage Home Repair and Weatherization Programs

Many Philadelphians may be interested in adding solar generation to their homes, but are unable to do so given the current condition of their roof or other basic systems. Through the Basic System Repair Program (BSRP) and other programs,

KEY PLAYERS

*Leverage Home Repair and Weatherization Programs*

**City of Philadelphia and non-profit partners:** Manages BSRP and other programs to improve condition of Philadelphia homes.

**Philadelphia City Council:** Passed real estate transfer tax increase to fund new investment through BSRP.

KEY PLAYERS

*Lead by Example*

**Energy Office:** Manages research and development of opportunities to invest in clean energy on city-owned property in Philadelphia.

**Philadelphia Energy Authority:** Partners on energy projects that require long-term contracts.

the City is working with residents to bring Philadelphia's aging housing stock up into good repair, which may enable more residents to take advantage of solar opportunities in the years ahead.

As the market for solar generation continues to improve, installing solar panels as part of these home repair programs may become possible. On-site solar generation would provide low-cost electricity to residents while also improving the comfort and safety of their homes.

### Lead by Example

The City of Philadelphia has already sought to lead by example by both purchasing clean energy and installing solar energy on-site. The City's Energy Office began purchasing renewable energy credits in 2012 and transitioning this purchase to local (Pennsylvania) credits in 2015. The Philadelphia Water Department installed a large solar array on its Southeast Water Pollution Control Plant, which currently generates 330,000 KWH of electricity annually.

To further this leadership, in November 2016 the City's Energy Office in partnership with the Philadelphia Energy Authority (PEA) released a Request for Information regarding project structures that would make renewable energy development feasible for the City. Examples of the types of projects the PEA and the City were seeking to understand further included: solar power on City facilities, off-site renewable power purchase agreements, and other alternative technology applications. Responses provided information on all three types of projects. The City is now seeking requests for proposal for an off-site PPA, as described on page 27.

The Energy Office is also working with the Office of Innovation and Technology to develop a solar potential map to assess Philadelphia rooftops. This map will help the City understand their buildings' solar potential, and it will give an estimate of potential solar electricity production across all city rooftops. The map will be published as an online tool to help homeowners and businesses understand potential solar production for their properties as well.

## STATE ACTION

Throughout the nation, state level policy drives local solar markets. Pennsylvania's solar industry has lagged in recent years due to inconsistent market signals from Harrisburg and an end to incentive programs. Solar currently produces less than one percent of Pennsylvania's net electricity generation. There are several opportunities for the state to lead on promoting solar generation in Pennsylvania.

### Strengthening Alternative Energy Portfolio Standard

Pennsylvania's Alternative Energy Portfolio Standard (AEPS), Act 213 of 2004, requires 18% of the electricity supplied by Pennsylvania's electric distribution companies and electric generation suppliers to come from alternative energy resources by 2021. The AEPS further requires these entities to generate the equivalent of 0.5% of that electricity from solar energy systems, or offset 0.5% of the their generation with solar renewable energy credits (SRECs).

KEY PLAYERS

*State Action to Improve Local Market*

**PA Legislature:** Responsible for legislation to strengthen AEPS and to re-authorize the PA Sunshine Program.

**City of Philadelphia and statewide partners:** Working together to identify new opportunities to promote solar through statewide initiative.

In November 2017 Governor Wolf signed an update to the Administrative Code, modifying the AEPS to require SREC purchases to come from solar generation within the Commonwealth of Pennsylvania. This change should increase the value of solar statewide, helping spur further solar development in the regional electricity grid.

The Commonwealth of Pennsylvania could further strengthen the AEPS to help move toward a cleaner grid in three ways:

- Extend the AEPS beyond the current 2021 program end date.
- Increase the total requirement for alternative energy purchasing within the AEPS above 18%.
- Increase the percentage of the AEPS that must be achieved through solar generation or SREC purchases above 0.5%. As a potential target, the Pennsylvania Department of Environmental Protection's recently released draft report, Finding Pennsylvania's Solar Future, discusses opportunities to meet 10 percent of Pennsylvania's demand with solar power by 2030.

## Re-establish PA Sunshine Program

The Commonwealth of Pennsylvania can also offer direct incentives for solar development, as was the case under a previously robust rebate program. Launched in 2009 under Governor Rendell, the PA Sunshine Rebate program provided $100 million in rebates for solar panels on homes and small businesses, but was not been funded since the Corbett Administration. The Wolf Administration has expressed interest in restarting this program, but funds have yet to be appropriated by the Pennsylvania Legislature.

## Statewide Policy and Planning

In 2016 the state launched Finding Pennsylvania's Solar Future to identify solar development and investment strategies to increase solar electricity generation within Pennsylvania. The program's initial objective is to increase the amount of in-state electricity sales that come from in-state solar energy generation to ten percent by 2030. The City is participating in this initiative in conjunction with community members, non-profit partners, and solar policy experts from across Pennsylvania.

## Enable Community Solar Projects in Philadelphia

While installing solar on the roofs of homes and businesses is a great option for many Philadelphians, residents in rental properties or those with inconvenient roof shading or orientation, structural roof issues, or insufficient space may not be candidates for rooftop solar. Shared renewable projects, also called community solar projects, provide a solution to those barriers. Community solar allows multiple participants to benefit directly from the energy produced by one solar array. Community solar participants typically benefit by owning or leasing a portion of a system, or by purchasing a portion of the renewable electricity generation.

Pennsylvania does not currently allow shared or community solar configurations. The closest allowed configuration is dictated by the state's virtual net metering (or meter aggregation) rules. Under the state's current rules, a customer that installs a renewable energy generation system can apply portions of the system's output to other electricity accounts owned by the same customer. The meters attached to the other accounts must be within two miles of the boundaries of the customer's host property and be in the same utility territory.

The major barrier to community solar currently in Pennsylvania is that multiple customers cannot share one electric meter. Alternative community solar models that do not require a shared meter include:

- **Utility-sponsored model:** A utility owns or operates a project that is open to voluntary ratepayer participation. Depending on how the utility sets up a program, it may require legislative and/or Public Utility Commission (PUC) approval.
- **Special Purpose Entity (SPE) model:** Individual investors join in a business enterprise to develop a community solar project.
- **Non-Profit model:** Donors contribute to a community installation owned by a charitable non-profit corporation. Under current law, donors with tax liabilities can deduct donations to the non-profit.

KEY PLAYERS

*Enable Community Solar Projects in Philadelphia*

**PA Legislature:** Responsible for legislation to enable community solar in Pennsylvania.

**PA Public Utilities Commission:** Regulates rules around community solar statewide.

## FEDERAL ACTION

The combination of low electricity prices and limited state incentives can make economically justifying solar projects over the short-term challenging. But projects can still make economic sense if customers are comfortable with a longer-term investment. The federal government currently offers a 30 percent Solar Investment Tax Credit (ITC) which can help bring down costs.

Currently the ITC is scheduled to ramp down after 2019 and expire altogether by 2022. Ensuring that these incentives are renewed or replaced with a similar state program (like the PA Sunshine Program described above) would help scale solar installation in Philadelphia beyond the lifetime of the current ITC, providing cost-certainty for developers looking beyond 2019 for installation.

KEY PLAYERS

*Federal Solar Incentives*

**U.S. Congress:** Responsible for passing legislation to extend or update the solar ITC.

# Energy-Efficient Homes and Businesses

## WHERE WE'RE GOING

Energy efficiency is the foundation of any strategy to meet Philadelphia's climate goals and move our city toward a more equitable energy future. The Environmental Protection Agency estimates as much as 30 percent of the energy in our buildings is "energy waste" and could be eliminated without reducing occupant comfort. **By 2050 Philadelphia will have eliminated this waste through the actions of local and state government, individuals, and institutions**.

Eliminating energy waste will save money for building owners and tenants and reduce reliance on fossil fuels for both electricity and on-site heating. **By reducing the demand for energy in our buildings, energy efficiency makes meeting Philadelphia's electricity needs with clean electricity generation like solar cheaper and easier.**

Every Philadelphian can save energy in our homes and businesses, and the City and other local institutions have a role to play in helping them to do so.

To achieve our energy vision, we'll need to invest in the efficiency of both our largest buildings, where the greatest carbon savings can be achieved, and in Philadelphia's rowhomes. More efficient homes will save money for Philadelphians, including those facing high energy bills, improve indoor comfort, and create local job opportunities for our residents.

### Co-Benefits

EQUITY
Increasing efficiency of rowhomes and apartments is part of a larger strategy to improve housing conditions for all Philadelphia residents.

HEALTH
Efficiency can increase tenant comfort and protect Philadelphians from extreme summer and winter weather.

ENVIRONMENTAL
Reducing energy usage in our homes and buildings is a necessary first step toward reducing Philadelphia's carbon footprint.

ECONOMIC
Energy efficiency improvements lead to energy cost savings for building occupants and create good, local job opportunities.



## HOW WE'LL GET THERE

The Office of Sustainability worked with energy experts to model the energy, climate, and health impacts of various energy efficiency policies at the state, local, and individual level. The Energy Efficiency Playbook on the following pages details the results of this modeling, outlines opportunities to improve the efficiency of our homes and businesses, and identifies key players that must be involved to achieve those efficiencies. The City of Philadelphia is committed to measuring progress toward the vision while continuing to update this modeling as new efficiency opportunities emerge.

### ECONOMIC OPPORTUNITY FROM ENERGY EFFICIENCY

Cutting energy waste across Philadelphia's 600,000 buildings will take years of effort from a well-trained local workforce, but the good news is that the infrastructure to create that workforce is already in place. Pennsylvania is home to 65,000 energy efficiency jobs, many of them local to Philadelphia thanks to the efforts of local workforce development organizations and trainers like the Energy Coordinating Agency's Knight Training Center.

To meet the workforce needs of an energy-efficient Philadelphia, we'll need to both bring new workers into the building science field and train existing workers (including electricians, HVAC technicians, general contractors, and code inspectors) to identify and implement strategies to cut energy waste and help us move toward a clean energy future.

## WHAT YOU CAN DO

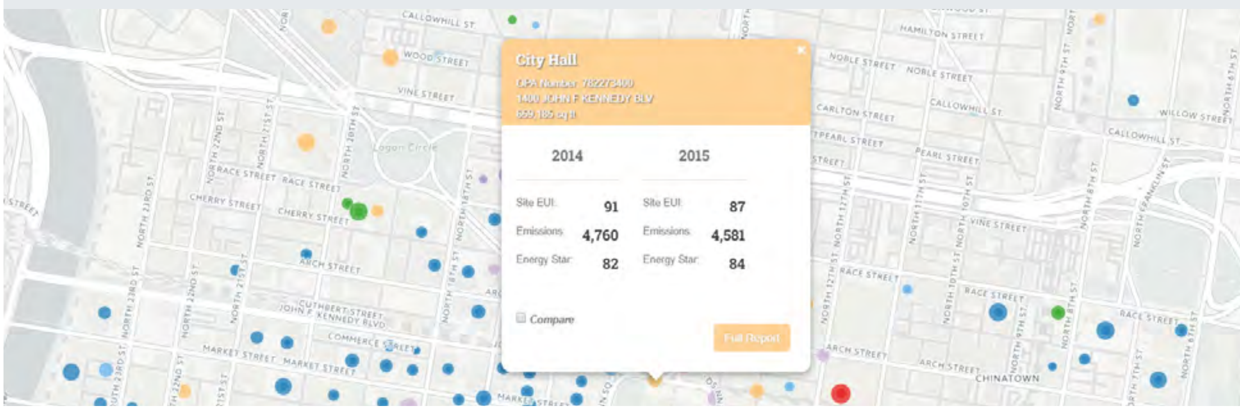
- **Take action at home:** Reducing energy waste as an individual is one of the easiest ways for Philadelphians to act on climate. See Page 39 for ideas on reducing home energy use, and check out Greenworks on the Ground at www.phila.gov/green for more opportunities.
- **Advocate for energy efficiency at work and in other spaces:** Do you know how efficient your school, business, or house of worship is? Most large buildings in Philadelphia disclose energy usage (see below), giving you the power to push for energy efficiency in your existing building or ensure energy is a consideration when choosing a new space to rent.
- **Local, state, and federal advocacy opportunities:** Achieving our energy vision will require action across all levels of government. Let your elected officials know energy efficiency is a priority, and see the Playbook on the following pages for specific advocacy opportunities.

### Success Story: Energy Benchmarking

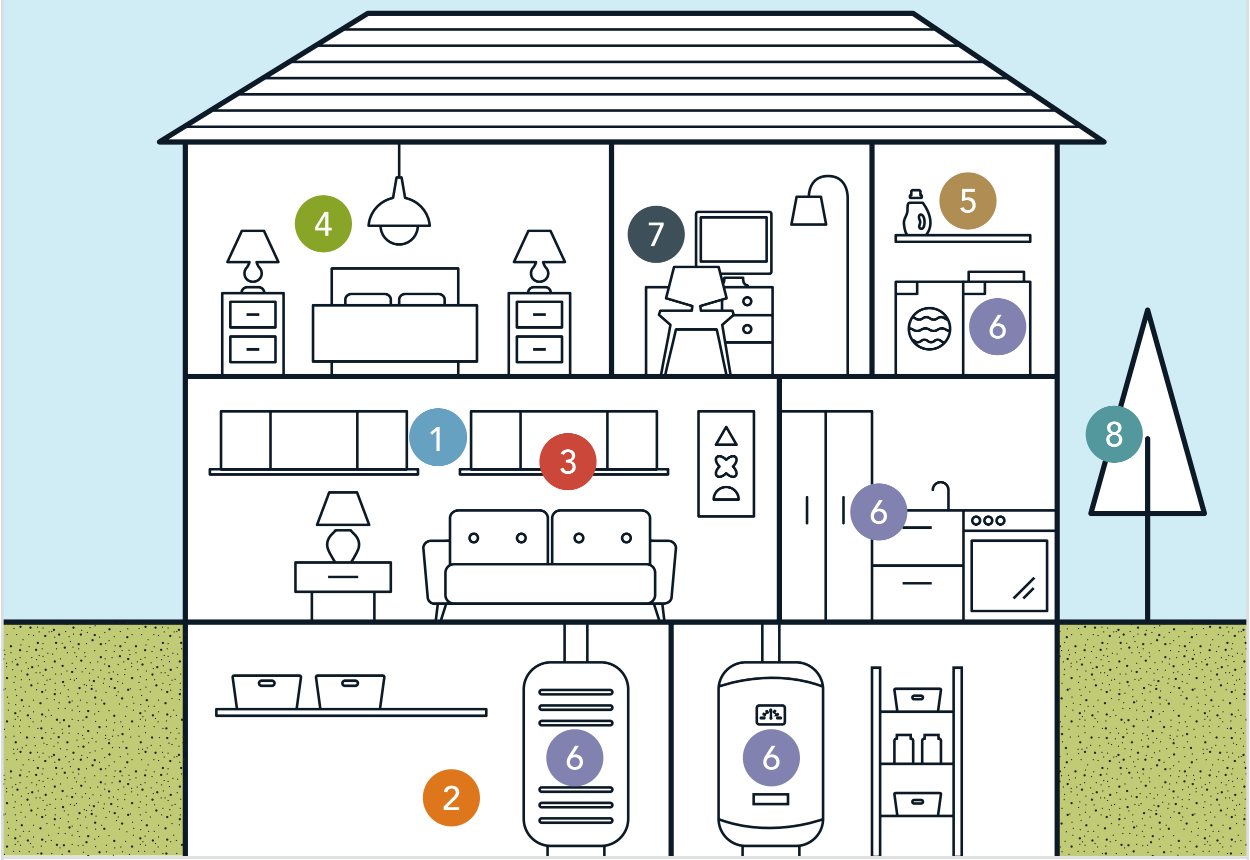
The city's energy benchmarking program helps large building owners and managers in Philadelphia better understand their energy and water use.

In 2017 more than 2,800 buildings reported their energy and water use, representing more than 30 percent of the total citywide square footage. The median Energy Star score (a 1 to 100 scale where 100 is the best energy performer) for these buildings was 63, 13 points above the national average.

OOS shares this data back with building owners via the publicly available building energy data visualization tool (http://visualization.phillybuildingbenchmarking.com) and through custom report cards that highlight their performance relative to peers and provide tips on how to improve. To learn more, visit www.phila.gov/benchmarking.



### Reducing Home Energy Use




1. Buy a **programmable thermostat** to reduce energy usage when you're away from home.
2. **Clean air filters** and **recharge coolant** to improve the efficiency of air conditioning.
3. Keep your **windows sealed** in the winter.
4. Use high-efficiency **ENERGY STAR**-labeled lightbulbs.
5. Wash your clothes in **cold water** and consider air-drying clothes on racks.
6. Check for **ENERGY STAR** label when replacing appliances and fixtures.
7. User **power management** features to improve efficiency of electronic devices and unplug any devices not in use.
8. Consider **planting trees** to provide shade in the summertime.

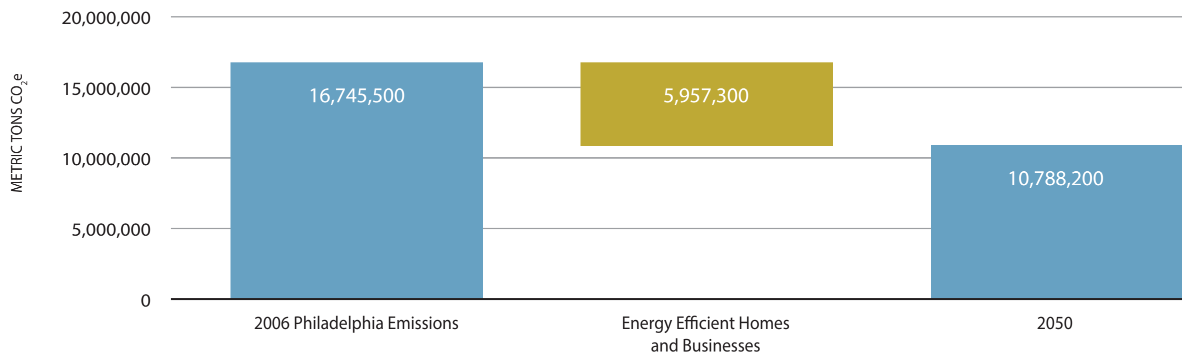
ENERGY EFFICIENCY

# Energy Efficiency Playbook

The Office of Sustainability modeled numerous strategies for improving the energy efficiency of buildings citywide. Residents and issue experts recommended many of these strategies as part of the CEV outreach process. Collectively implementing the energy efficiency playbook would result in significant carbon reductions citywide.

The following pages describe modeled energy efficiency strategies in detail. For information on modeling assumptions, see the appendix. Achieving these reductions will require buy-in from multiple stakeholders, who are identified in the Key Players boxes.

## ENERGY EFFICIENCY CARBON EMISSION REDUCTION POTENTIAL




This chart indicates the potential carbon emissions reductions from implementing all the modeled strategies for cutting energy waste, assuming a business-as-usual electricity grid. If Philadelphia achieves our clean electricity supply goals, reductions from energy efficiency will be lower.

KEY PLAYERS

*Modernize Building Energy Codes*

**PA Legislature and Governor's Office:** State action required to modernize Pennsylvania's building code (or permit Philadelphia to adopt a more stringent code).

**Real Estate Developers, Homebuilders, and Contractors:** Must support update and implementation of new building codes.

BY THE NUMBERS

*Commercial Energy Codes*

CARBON SAVINGS

186,830 $MtCO_2e$

ANNUAL COST SAVINGS

$51,304,207

BY THE NUMBERS

*Residential Energy Codes*

CARBON SAVINGS

103,290 $MtCO_2e$

ANNUAL COST SAVINGS

$27,140,667

## MODERNIZE BUILDING ENERGY CODES

Building energy codes are among the most effective policies to reduce building energy use over time. Even though new buildings typically account for a very small percentage of the building stock, over time they can have very strong impacts on energy use.

Current Pennsylvania law pre-empts the City of Philadelphia from unilaterally adopting codes other than those approved by the state. The potential impact of these strategies highlights the value of advocating for a change to those policies at the state level.

### Updating Commercial Energy Codes

Building code standards are set by the International Code Council (ICC) every three years. The Pennsylvania Legislature passed HB409 in 2017, bringing the statewide building code up to the ICC 2015 standard and enabling Philadelphia a one-time opportunity to update to 2018 code standards for commercial construction. 2018 codes were adopted by Philadelphia City Council and signed by Mayor Kenney in June 2018, making Philadelphia one of the first cities in the United States to adopt the 2018 codes.

These codes govern the safety and efficiency of new construction and major renovations. Construction and renovation are the most cost-effective opportunity to do major retrofits to cut energy waste, and the 2018 commercial codes will make new buildings in Philadelphia as much as 30 percent more efficient than under the previous 2009 codes.

To meet the energy code savings numbers modeled as part of the CEV, Philadelphia must implement the 2018 codes and remain current every three years thereafter, as well as work with code officials to ensure future IECC standards continue to prioritize energy savings. OOS and Licenses + Inspections staff voted for efficiency measures as part of the 2018 IECC code update process, and expect to continue to advocate for these measures in future code cycles.

### Updating Residential Energy Codes

Modernizing residential codes will also be critical to achieve Philadelphia's climate and energy goals. New home construction and major renovations of existing rowhomes are required to meet the IRC (International Residential Code), and increasing the baseline level of energy efficiency required in these projects can help reduce utility costs while moving us toward Philadelphia's clean energy vision.

## BUILDING CODE COMPLIANCE

While updating the energy code that Philadelphia builders must follow is currently a state issue, ensuring developers follow through with requirements must happen at the local level. To meet our climate and energy goals we must both modernize the energy code and ensure a high rate of code compliance for new development and renovations of existing buildings.

### Residential Energy Code Enforcement for Renovations and Additions

Given current resource constraints, energy codes are most actively enforced in new construction projects. However, any project that requires a City permit could be subject to energy code enforcement, including some residential renovations, additions, and alterations. Because existing-building improvements can account for a large share of total built environment investment in each year, this strategy could significantly extend the energy savings impacts of energy codes.

Analysis by the Harvard Joint Center for Housing Studies indicates there are tens of thousands of projects in the city that may be covered by this strategy, which would require significantly more resources for the Department of Licenses + Inspections (L+I) to implement successfully.

### Third-Party Energy Code Compliance

This strategy could allow consultants with energy rating expertise to assess code compliance for certain permitted projects (e.g. blower door testing of new residential construction). The 2018 version of the International Energy Conservation Code (IECC) contain an Energy Rating Index (ERI) compliance path, which enables accredited home energy rating providers to conduct code compliance analyses.

Permitting third-party compliance would engage experts who may be technically better equipped and have better capacity to conduct reviews and inspections than L+I, which is constrained by staff capacity.

### Required Energy Modeling and Disclosure for New Construction

This strategy would connect building code compliance with the City's existing energy benchmarking program. Building projects meeting the benchmarking requirement would be required to use a simulation tool to project an energy use index and/or ENERGY STAR score for the building design. After a full year of operation, the buildings' actual benchmarked energy score would be compared to its projected score.

While energy modeling and disclosure itself will not directly lead to energy, carbon, and cost savings, data from that modeling can help assess the impact of other strategies within the CEV and provide information to potential tenants of new construction about the environmental impact of leasing opportunities.

**KEY PLAYERS**

*Building Code Compliance*

**Philadelphia Licenses + Inspections:** Agency responsible for code enforcement.

**Philadelphia City Council:** Approves L+I's code enforcement budget each fiscal year and passes laws for code compliance requirements.

**BY THE NUMBERS**

*Residential Energy Code Enforcement for Renovations and Additions*

CARBON SAVINGS
9,290 $MtCO^2e$

ANNUAL COST SAVINGS
$2,440,113

**BY THE NUMBERS**

*Third-Party Energy Code Compliance*

CARBON SAVINGS
27,540 $MtCO_2e$

ANNUAL COST SAVINGS
$7,237,511

KEY PLAYERS

*PACE Financing*

**Pennsylvania Legislature:** Must pass enabling legislation to permit PACE financing.

**Philadelphia City Council:** Would subsequently pass legislation to create PACE financing program.

BY THE NUMBERS

*Commercial PACE*

CARBON SAVINGS
6,440 $MtCO_2e$

ANNUAL COST SAVINGS
$1,882,000

## PACE FINANCING

The property-assessed clean energy (PACE) model is a mechanism for financing energy efficiency and renewable energy improvements on private property. PACE programs allow local governments to fund the up-front cost of energy improvements on commercial and residential properties, which are paid back over time by the property owners. This allows property owners to engage in energy efficiency and renewable energy projects without taking on the full upfront costs. The property owner pays these funds back over time through property assessments, which are secured by the property itself and paid as an addition to the owners' property tax bills.

The Pennsylvania Legislature passed a bill to enable PACE for commercial properties (excluding any residential property) in Pennsylvania. The City of Philadelphia and Philadelphia Energy Authority are currently evaluating opportunities to implement a commercial PACE program locally. Loan servicing is legally complex and integration with the Revenue Department and other relevant stakeholders will require resources and coordination to ensure the program is successful.

KEY PLAYERS

*2030 District*

**GBU:** Non-profit leading the creation of Philadelphia's 2030 District.

**Building owners and operators:** Volunteering to set energy reduction targets by joining District.

**City agencies:** Can encourage building owners to join District and provide support for energy savings initiatives.

BY THE NUMBERS

*2030 District*

CARBON SAVINGS
525,560 $MtCO_2e$

ANNUAL COST SAVINGS
$162,856,453

## 2030 DISTRICT

2030 Districts are geographically-defined, private-sector led partnerships that commit to reducing energy use 50 percent by 2030 from a 2003 baseline. 2030 goals also address water consumption and transportation carbon emissions. Stakeholders including property owners, managers, and local government work together to leverage financing and shared resources to reach voluntary reduction goals.

Green Building United (GBU) launched the Philadelphia 2030 District in October 2017 with representation from major segments of Philadelphia's building stock in Center City and University City. By joining the District, building owners will have the opportunity to share best practices, access trainings and resources, and work together toward the District's ambitious shared climate goals.

The City of Philadelphia was among the first large real estate owners to join the 2030 District initiative. The City will further support the program by encouraging businesses and institutions to join the District and work with GBU and District participants to help meet goals and address barriers to achieving them.

KEY PLAYERS

*Incentives for High-Performing Buildings*

**Philadelphia City Council:** Pass legislation to offer incentives.

**Real estate developers:** Implement energy-saving measures in new construction and renovation to exceed existing energy code.

**City agencies:** Support developers in meeting building performance goals and verifying compliance.

BY THE NUMBERS

*Permit Streamlining*

CARBON SAVINGS
155,660 $MtCO_2e$

ANNUAL COST SAVINGS
$48,798,567

BY THE NUMBERS

*Density Bonus*

CARBON SAVINGS
559,440 $MtCO_2e$

ANNUAL COST SAVINGS
$158,667,619

BY THE NUMBERS

*Property Tax Incentives*

CARBON SAVINGS
28,250 $MtCO_2e$

ANNUAL COST SAVINGS
$8,753,754

## INCENTIVES FOR HIGH-PERFORMING BUILDINGS

In addition to strengthening the required energy code for new construction, the City of Philadelphia can also incentivize real estate developers to go beyond code through a variety of mechanisms, including some that are already in place but could be further strengthened.

### Permit Streamlining

Permit streamlining shortens the time to construction for projects that meet certain conditions. The City of Philadelphia has worked with solar developers to streamline permitting for renewable energy permitting, reducing the soft costs associated with permitting processes that may discourage installation and drive up the cost per kilowatt energy generated. This approach could be extended to new construction or major retrofits that commit to exceeding the required energy code (e.g. by committing to meeting LEED or Passive House requirements or seeking an ENERGY STAR label upon completion).

Several jurisdictions, including the Commonwealth of Massachusetts and cities of Chicago and Seattle have some form of expedited permitting for development that meets sustainability and green building goals. Streamlining opportunities may be combined with other permitting incentives, such as reduced permitting fees, access to technical assistance, and "as-of-right" development. Streamlining can combine several related permits or set time frames for each step to be completed.

### Expand Density Bonus Incentive

Density bonuses offer developers an allowance to exceed existing zoning for taller buildings, more units or more floor space if the development provides a public benefit. The City of Philadelphia currently offers a density bonus for meeting LEED requirements and installing green roofs. To take further advantage of this opportunity, bonuses could also be awarded to projects that demonstrate they will exceed the required building energy code or provide other climate or energy benefits.

This strategy would require properties receiving density bonuses to achieve an ENERGY STAR score of 75 or higher or 70 percent reduction below national median for the property type within two years of occupancy (matching ENERGY STAR certification score requirement and 2030 District requirement for new construction and major renovations).

### Property Tax Incentives for High-Performing New Buildings

The City of Philadelphia provides a ten-year tax abatement to all new construction and major renovation. Philadelphia City Council has considered various proposals to amend the abatement to meet the City's long-term goals, which should include considerations of Philadelphia's long-term energy and climate goals.

Multiple jurisdictions provide property tax abatements for efficient buildings. For example, Montgomery County, Maryland, provides tax exemptions of varying rates depending on the type of building and level of LEED certification. For this analysis, OOS evaluated the impact of incentivizing above-code construction for new construction and major renovation.

Providing a property tax incentive for high-performing buildings could be part of a larger strategy to reconsider the tax abatement. Council members and advocates have also proposed using the tax abatement as a tool to promote affordable housing and spur development outside of Center City, both of which could incorporate additional clean energy incentives.

### Municipal Impact Fees

To ensure compliance with the planning mechanisms described above, the City of Philadelphia could consider implementing an impact fee on all large new residential, new commercial, or certain renovation projects that do not meet specified requirements or fail to follow through with commitments during the development process. If projects do not meet these targets, the fees are withheld and are used to support public benefit initiatives such as energy efficiency programs.

In spring 2016 Miami Beach, Florida, became one of the first jurisdictions in the United States to implement an impact fee: new development that fails to meet green development standards will be required to pay a five percent fee on the cost of the project, with funding directed to programs to mitigate the impact of climate change on the coastal community.

ENERGY EFFICIENCY

## UTILITY-FUNDED EFFICIENCY OPPORTUNITIES

In 2008, the Commonwealth of Pennsylvania passed Act 129, requiring investor-owned utilities to invest a percentage of their revenue in energy efficiency programming. PECO has since invested hundreds of millions of dollars in its service territory to improve the efficiency of homes and businesses, primarily through the Smart Ideas program. PGW voluntarily launched a similar program, Energysense, which provides a robust portfolio of market rate and low income usage reduction programs for residential, commercial and industrial customers.

Both Smart Ideas and Energysense provide rebates, incentives, and reduced costs for auditing services. The City and non-profit partners like the Energy Coordinating Agency work with the utilities to promote these efforts, which could be bolstered to supplement PECO and PGW's marketing and ensure that Philadelphians are maximizing the opportunity to save money and energy.

The City, key partners, and individuals and businesses should also continue lobbying for the next phase of Act 129 funding. The Pennsylvania Public Utilities Commission (PUC) will design future programs, set cost-effectiveness measurements, and authorize spending.

Both the City and residents can extend their roles advocating for Act 129 and future programs that benefit Philadelphia homes and businesses. Requests could include increased spending and programming designed to reach populations not currently benefitting from energy efficiency. Stakeholders interested in advocating for these changes can testify at public hearings, submit written comments, and participate in PUC working groups.

KEY PLAYERS

*Utility-Funded Efficiency Opportunities*

**PECO and PGW:** Manage efficiency programming in Philadelphia.

**PUC:** Regulatory body authorizing Act 129 investment across Pennsylvania.

**City and residents: Can** advocate for Act 129 programming benefitting Philadelphians.

BY THE NUMBERS

*Act 129 Opportunities*

**CARBON SAVINGS**
573,910 $MtCO_2e$

**ANNUAL COST SAVINGS**
$186,209,120

## EXISTING BUILDING REQUIREMENTS

While the City of Philadelphia cannot currently increase the stringency of the building codes for new and existing buildings, the City does have authority to set other requirements for existing buildings, as was done with the creation of Philadelphia's energy benchmarking requirement. Additional existing building requirements could help building owners identify and implement energy savings opportunities in their homes and businesses.

### Expand Energy Benchmarking Program

Energy benchmarking and disclosure policies require owners of large buildings to report their energy usage annually, providing a basis for comparing performance among buildings and driving energy improvements over time. As one of the first cities to mandate energy benchmarking, Philadelphia completed its fifth year of data collection in 2017.

Philadelphia's benchmarking requirement was last amended in 2015, adding residential buildings 50,000 square feet and larger. This threshold is consistent with other jurisdictions, though some cities have required smaller buildings to report their energy usage.

Reducing the benchmarking threshold to 25,000 square feet would increase the number of properties required to report from 2,900 to more than 4,000. Many of these buildings would be smaller apartment buildings, which could provide valuable information both to the City and to potential tenants.

Requiring additional buildings to report would increase the administrative costs of the program to the Office of Sustainability and local utilities providing data. OOS has found that buildings from 50-100,000 square feet are often under-resourced and thus less able to easily comply with the benchmarking requirement. The expectation is that buildings smaller than 50,000 square feet would be similarly challenged by the request without significant support from the City or a partner.

KEY PLAYERS

*Existing Building Requirements*

**Philadelphia City Council:** Must pass legislation for additional building requirements.

**OOS:** Implements existing benchmarking program.

**Local utilities:** Provides energy data building owners.

**Building owners and real estate community:** Must support new requirements.

BY THE NUMBERS

*Expand Energy Benchmarking Program*

CARBON SAVINGS

25,110 $MtCO_2e$

ANNUAL COST SAVINGS

$7,441,115

### Building Tune-up Program

Several jurisdictions across the country have introduced requirements that go beyond energy benchmarking to require the implementation of specific measures to improve energy performance. In Seattle, building owners will soon be required to perform building tune-ups (also called retro-commissioning), where a building professional will identify energy- and cost-saving measures that can be implemented immediately.

By optimizing building's controls, systems, and maintenance, tune-ups can save building owners between 5 and 20 percent annually on energy costs, with a typical payback over a period of 6 months to 2.5 years. Tune-ups also provide detailed systems information for owners and operators, increased comfort for building occupants, and opportunities for skilled energy efficiency services jobs.

Unlike the energy benchmarking program, building owners would incur an estimated average cost of $0.20 per square foot for building tune-ups. This may be burdensome to some building owners, particularly if the building is already high performing and has few tune-up opportunities. Like the expansion of the benchmarking program, a tune-up requirement would also require staff time from OOS or another implementing agency to help owners and operators understand the requirement and manage program compliance.

BY THE NUMBERS

*Building Tune-Up Program*

CARBON SAVINGS

183,380 $MtCO_2e$

ANNUAL COST SAVINGS

$54,640,606

## Residential Energy Disclosure at Time of Sale

When you buy a home in Philadelphia, you receive a disclosure from the seller that covers the physical condition of the house. By adding a disclosure for energy performance (either through a rating system or through a direct sharing of recent utility bills), buyers would be better informed about the potential energy costs of their new homes, and sellers could improve the efficiency of a property before listing.

Several jurisdictions, including Chicago, Portland, Austin, Denver, and Berkeley, have adopted residential energy disclosure policies for existing homes. Portland, the latest city to approve residential energy disclosure, will require single-family home owners to obtain a home energy score through a professional and disclose the score at time of listing for sale. Factors to consider for a residential disclosure policy include:

- **Timing of disclosure:** at time of listing, contract period, or at closing.
- **Method of disclosure:** utility data, home energy rating system (HERS), or Home Energy Score.
- **Where disclosure is posted:** Multiple Listing Service listing or inspection.
- **Costs to the buyer, seller, and agent.**
- **Resource availability:** City staff for implementation, home energy professionals, access to utility data.

BY THE NUMBERS

*Residential TOS Requirements*

CARBON SAVINGS

1,125,830 $MtCO_2e$

ANNUAL COST SAVINGS

$311,223,662

BY THE NUMBERS

*Commercial TOS Requirements*

CARBON SAVINGS

1,533,550 $MtCO_2e$

ANNUAL COST SAVINGS

$432,233,682

## Landlord Disclosure Requirement

Most Philadelphia renters currently have no reliable data on the potential cost and quality of energy in houses and apartments during the leasing process. Renters are often also the most financially insecure households, underscoring the need to provide information on energy costs prior to a lease agreement. A disclosure requirement for landlords would provide much-needed information to the marketplace, similar to Philadelphia's current energy benchmarking program for large commercial and multifamily properties.

A recent report by Rocky Mountain Institute, Better Rentals, Better City, highlighted the opportunity to require landlords to share energy usage with prospective tenants as well as to consider energy upgrade requirements for properties not meeting a certain level of efficiency. These upgrades must be balanced against the risk of displacement and gentrification for current and prospective residents, and the Office of Sustainability is currently working with the C40 Cities Exchange to understand more about the opportunities and challenges of this policy opportunity.

## Energy Conservation Requirements at Time of Sale

Meeting the energy conservation code is currently required to receive a certificate of occupancy after construction or major renovation. Given the high percentage of buildings constructed prior to the advent of today's modern energy codes, requiring buildings to meet the energy conservation code or require other conservation measures at the time of sale (TOS) could have a significant impact.

Large commercial buildings frequently change ownership, which means TOS requirements could quickly result in energy savings. Frequent turnover may also make TOS requirements inefficient because they could result in substantial and expensive retrofits as frequently as every three years (the international code update cycle).

Residential properties change hands less frequently, but given the structural challenges in many of our city's rowhomes, time-of-sale energy code requirements may need to be part of a larger strategy to improve Philadelphians' homes.

To reduce the cost of compliance for sellers, Philadelphia could model this requirement after similar ordinances in San Francisco and Berkeley, California which require a list of measures subject to technical and financial feasibility.

KEY PLAYERS

*Lead by Example*

**Energy Office:** Implements energy efficiency investments for city-owned buildings.

**Philadelphia Energy Authority:** Provides technical expertise and holds long contracts for guaranteed energy savings projects.

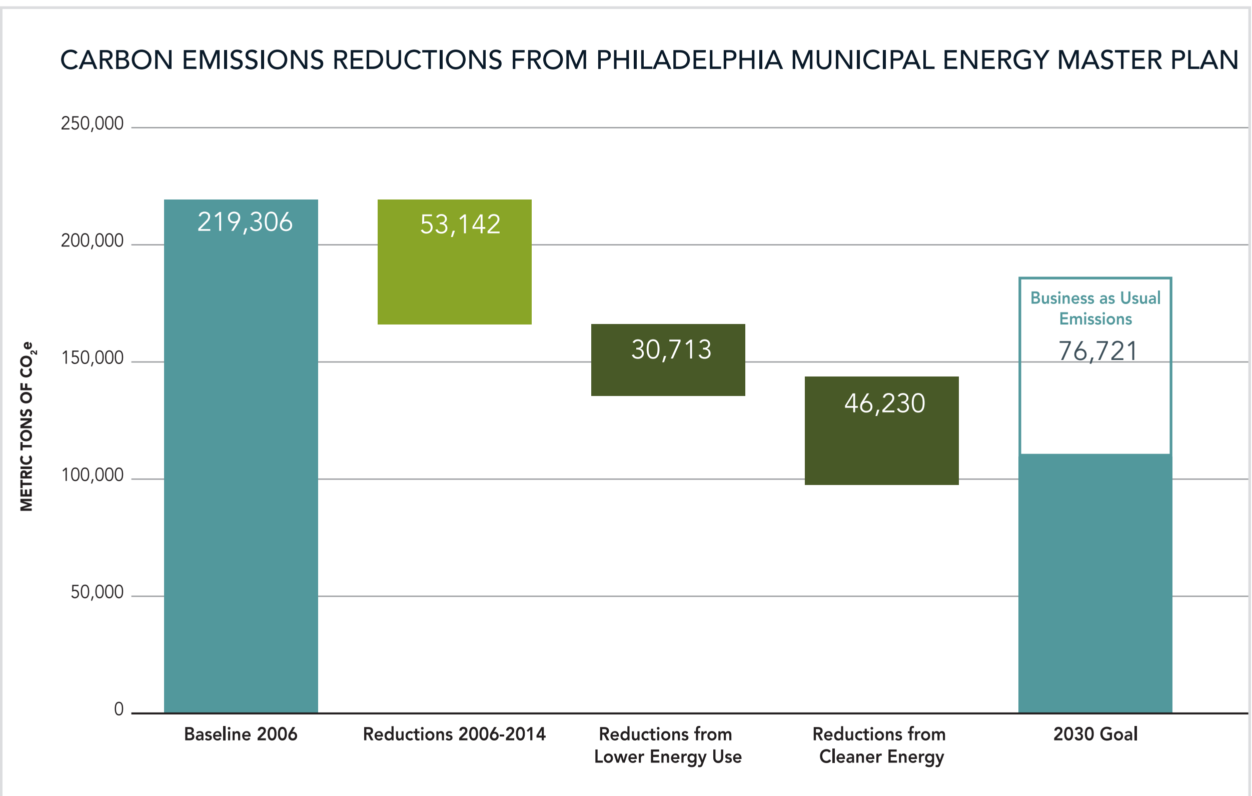
**Philadelphia City Council:** Allocates capital and operating funding for energy efficiency and approves long-term contracts.

## LEAD BY EXAMPLE

Since 2013 the City of Philadelphia's energy consumption has decreased, and the City's carbon footprint has been declining since 2006. The City will deepen this progress and demonstrate leadership in climate action by continuing to reduce energy consumption and carbon emissions from its own buildings through strategies including:

- **Municipal Energy Master Plan:** The Office of Sustainability's Energy Office recently published the city's first energy master plan, which addresses centralized programs and actions that the City can take to reduce carbon emissions and improve efficiency in more than 600 City-owned facilities.
- **Philadelphia Museum of Art energy retrofit:** The City, Philadelphia Energy Authority, and Philadelphia Museum of Art have begun construction on $11.3 million in energy efficiency upgrades to the museum's Main, Perelman and Rodin Museum buildings, among the City's largest energy users. The project will reduce energy usage by more than 20%.
- **Rebuild initiative:** Rebuilding Community Infrastructure (Rebuild) is a $500 million program to upgrade parks, recreation centers, and libraries throughout Philadelphia. The Energy Office is developing energy efficiency guidelines to help reduce municipal energy usage as the City improves these assets for Philadelphia residents.
- **Energy Efficiency and Sustainability Fund:** The Energy Efficiency and Sustainability Fund, which provides operating departments funding through the Energy Office to invest in projects to improve the energy efficiency and sustainability of City-owned facilities.

ENERGY EFFICIENCY




The Municipal Energy Master Plan sets long-term energy and carbon reduction targets for City-owned buildings and streetlighting.

# Low-Carbon Thermal Energy

## WHERE WE'RE GOING

Today most of Philadelphia's homes and businesses are heated by burning natural gas (directly on-site or via the Veolia steam system) or fuel oil. **By 2050 Philadelphia will dramatically reduce the carbon intensity of heating our buildings, through greater building efficiency and transitioning to new strategies and technologies to stay warmer in the winter and comfortable in the summer, even as our climate changes.**

This transition is already beginning. Buildings in Philadelphia today are heated by a variety of alternative energy technologies, including biomass, renewable natural gas, geothermal energy, and solar thermal (see definitions below). Each of these technologies have the potential to reduce carbon emissions in buildings while maintaining tenant comfort.

To meet our clean energy vision, electricity from a low-carbon grid must also play a larger role in heating our buildings. As we move toward a clean electricity supply, electrification of thermal energy becomes a viable low-carbon option. Newer electric heat pumps can function in cold climates like ours, and as these technologies continue to evolve, they will become a crucial tool for reducing carbon pollution. Expanding the use of district energy systems can provide both local electricity generation and cleaner thermal energy. This expansion would lower emissions while ensuring reliable operations of critical facilities like hospitals and shelters.

One important consideration in the evolution of these technologies is their cost-competitiveness. Many Philadelphia residents face economic challenges to heat their homes with existing technologies. Recent efforts by the federal government to cut funding for the critical Low-Income Heating Assistance Program (LiHEAP) could further harm low-income residents. PGW's Low Income Usage Reduction Program and Customer Assistance Program currently help reduce energy burden for low income households. The City is committed to monitoring the economic landscape of new thermal energy technologies and will advocate for opportunities to both cut carbon pollution and reduce the energy burden for our most vulnerable residents.

### Co-Benefits

EQUITY
Many Philadelphians currently struggle to heat their homes. Emerging low-carbon thermal opportunities must ease the energy burden on those residents.

HEALTH
Replacing heating oil with low-carbon thermal solutions improves regional air quality and reduces incidences of asthma and other respiratory illnesses.

ENVIRONMENTAL
Reducing the burning of fossil fuels used to heat our buildings will cut carbon pollution and improve the health of local natural resources.

ECONOMIC
The transition to new thermal systems in Philadelphia buildings will create local clean energy jobs for Philadelphians.

**Low-Carbon Thermal Energy Definitions**

*Biomass*: Energy derived from organic or plant-derived materials usually through combustion or transformation into various fuels. The carbon emissions from biomass exist primarily in the natural carbon cycle.

*Renewable Natural Gas*: This term encompasses multiple technologies, including:

> *Biogas*: Gas derived from the breakdown of biological sources (like agricultural waste or wastewater).
>
> *Landfill gas*: Gas derived from the decomposition of municipal solid waste in landfills.

*Geothermal energy*: In this document, geothermal energy refers to geo-exchange heat pump systems which use the constant temperature of the ground and a heat pump to heat and cool spaces.

*Solar thermal*: In this document, solar thermal refers to hot water derived from solar heating collectors.

## HOW WE'LL GET THERE

Most buildings in Philadelphia are currently heated by oil, on-site gas furnaces, or the Veolia steam loop. Emerging technologies like district energy systems, high-efficiency heat pumps, geothermal, solar heating systems, and renewable natural gas can reduce our reliance on fossil fuel energy for heating and domestic hot water, but are currently cost-prohibitive for the typical Philadelphia household.

The Playbook on the following pages outlines opportunities for the City and large institutions to lead by example. Piloting these technologies would significantly reduce the carbon intensity of thermal energy in buildings they own and operate, while also studying further steps that can be taken to move toward Philadelphia's clean energy vision.

## WHAT YOU CAN DO

- **Explore all options for lowering carbon intensity of thermal energy** when replacing HVAC systems in your home or business. Depending on geography and cost considerations, some low-carbon thermal technologies are feasible for Philadelphia homes and businesses.
- **Invest in energy efficiency.** Cutting energy waste in your home or business will reduce the energy needed to heat your space, reducing your carbon footprint.
- **Advocate for research and incentives at the local, state, and federal levels.** Many of the emerging technologies in this field are the result of work done by federal research agencies at the Department of Energy, which are currently threatened by budget cuts. Both the state and federal government provide incentives for some low-carbon thermal technologies, including geothermal and solar heating systems.

THERMAL ENERGY

### Success Story: Geothermal at Bartram's Garden

In 2014 Bartram's Garden underwent a multimillion dollar restoration project, creating the new Ann Bartram Carr Garden and improving existing infrastructure. This renovation provided a unique opportunity to install a geothermal heating and cooling system.

Geothermal heat pumps are a low-carbon, energy-efficient, and reliable option. Because they do not burn fossil fuels, they generate far fewer greenhouse gas emissions than conventional furnaces. They are also efficient, using less electricity from the grid. Bartram's Garden expects a 53% decrease of electricity use going forward. Geothermal is also quieter than traditional heat pumps, ensuring a tranquil environment for visitors.

Bartram's Garden. (Source: Bartram's Garden)

### ECONOMIC OPPORTUNITY FROM LOW-CARBON THERMAL ENERGY

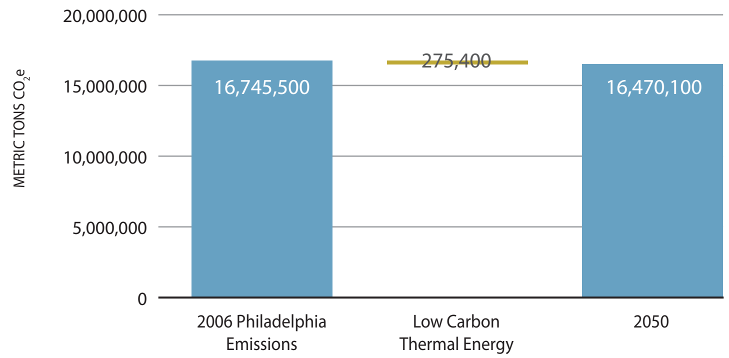
Regardless of which mix of technologies help Philadelphians cut the carbon intensity of heating in our homes and businesses, we know that changes to these systems will require training and staffing a workforce to work across Philadelphia's buildings. Many of the potential low-carbon thermal technologies are currently effort-intensive, representing significant job-creation potential for our residents. The City will continue to track emerging trends in low-carbon thermal energy and work with workforce development partners to ensure residents are prepared to take on these new roles in the years ahead.

# Low-Carbon Thermal Energy Playbook

Achieving a low-carbon thermal energy future will require new technologies and practices in our homes and businesses as well as policies and incentives to support those changes. Many of the playbook actions in this section require further research or technology development, and OOS and the City are committed to leading these efforts to help Philadelphia meet our low-carbon thermal energy goal. Implementing these strategies requires buy-in from multiple stakeholders, who are identified in the Key Players boxes.

There are limited opportunities to reduce carbon from the current thermal energy system that aren't accounted for by the clean energy supply and energy-efficient homes and businesses sectors. Achieving those goals will allow Philadelphia to dramatically lower emissions in this sector.

LOW CARBON THERMAL ENERGY CARBON EMISSION REDUCTION POTENTIAL




THERMAL ENERGY

## SCALE EXISTING AND EMERGING TECHNOLOGIES

### Track Low-Carbon Thermal Technology Development

Many technologies that can be used to provide low-carbon thermal energy still need to mature (either technically or economically) before they can be adapted widely in Philadelphia. These technologies and solutions need to be tracked and studied to understand their potential and evaluate opportunities to pilot and scale across the city.

Electrification of heating and cooling using heat pump technologies such as mini-split systems, variable refrigerant flow, and hot water heat pumps are commercially available solutions for some homes and businesses today. As this technology continues to evolve, it must address the carbon intensity of refrigerants, a potent greenhouse gas that can have hundreds of times the heat-trapping potential of carbon. To be widely used in Philadelphia, heat pumps for use in cold weather heating must also show they can consistently meet the needs of our winters.

KEY PLAYERS

*Scale Existing and Emerging Technologies*

**City of Philadelphia and Issue Experts:** Tracking energy trends locally and globally.

**Large institutions:** The City, businesses, and universities can all lead by example by investing in low-carbon thermal technologies for new and existing buildings.

National studies have shown that biogas and renewable natural gas could supply between four and ten percent of current natural gas usage. The City of Philadelphia uses biogas from its wastewater treatment plants to heat buildings and generate electricity. The City will continue to explore both biogas and renewable natural gas to understand what steps are needed to make these technologies cost-competitive and available to Philadelphia consumers.

In 2017 the City of Philadelphia joined the Renewable Thermal Collaborative (RTC) to explore solutions that use renewable heating and cooling technologies (such as biogas, solar thermal, and geothermal projects) in their facilities. RTC members are working together to identify opportunities and barriers to integrating renewable thermal technologies into operations. Through this partnership, the City of Philadelphia hopes to continue to track technologies and work with partners to drive market transformation.

### Evaluate District Energy System Opportunities

District energy systems use centralized heating, cooling, and sometimes electricity generation to provide energy. When managed correctly, district energy systems use their large scale to maximize efficiency. For example, a large hot water plant serving several businesses is likely to operate more efficiently than if each business was served by their own individual boiler, because it can use larger, more efficient equipment and scale up and down to meet demand. Newer systems are designed to maximize heat recovery, provide resilience benefits, and reduce energy waste.

Philadelphia currently has several district energy systems providing thermal energy to businesses and institutions. Veolia Energy operates a natural-gas-fired district steam system which provides steam to institutions like the University of Pennsylvania and Drexel University and large buildings like the Comcast Center and the Philadelphia Museum of Art. Additionally, Penn and Jefferson University operate district chilled water systems on their campuses.

Many cities are currently exploring new district energy opportunities for new construction and large-scale neighborhood development, including incorporating microgrids (which can leverage solar photovoltaic and battery storage options to provide clean backup power to institutions). The City and other large institutions can explore potential investments in these systems, particularly in large new developments.

### Promote Geothermal Heating and Cooling

Geothermal exchange systems are a proven, extremely high-efficiency technology. A geothermal heat pump uses the steady temperature underground to harness energy through heat exchange. To be deployed further in a cost-competitive manner, these systems must overcome a few existing barriers:

- Geothermal exchange systems require significant access to open space and land. In a dense urban environment like Philadelphia, this limits the scale at which this technology is feasible, particularly for existing buildings.
- Geothermal exchange systems can be expensive due to the cost of drilling horizontal or vertical well systems.

Even with these current barriers, geothermal systems can be a cost-effective choice in parts of Philadelphia where land is more readily available and accessible. The City has invested in geothermal in several facilities (see page 50) and can advocate to state and federal leaders so that these clean thermal energy sources continue to be incentivized.

### Explore Solar Heating and Hot Water Systems

Solar hot water panels are a clean-energy technology for replacing certain types of heating systems. In many current systems, solar panels are used to heat water which is either used to provide domestic hot water to buildings or other heating systems (when combined with heat pumps). The City of Philadelphia can work to remove soft cost barriers by easing permitting of these systems while advocating for state and federal policies incentivizing solar investment.

In addition to solar hot water panels, as solar photovoltaic panels and battery storage technologies continue to evolve, they may open up new opportunities to provide additional clean thermal energy to Philadelphians. OOS will continue to evaluate new technologies and inform residents and partners about those opportunities.

## LOW-CARBON THERMAL STUDY

### Philadelphia Gas Works (PGW) Business Operations Evaluation

PGW is the largest municipally-owned gas utility in the country, putting it in a unique position to help with the transition to a low-carbon future in line with the City's goals. PGW currently invests in energy efficiency through its Energysense program, helping reduce the carbon intensity of Philadelphia's thermal energy usage while reducing residents' and businesses' utility bills.

As Philadelphia transitions to a clean energy future, PGW and the City can work together to ensure the utility's business model is aligned with the City's clean energy goals while continuing to provide cost-effective thermal energy to residents. A full evaluation of PGW's current environmental impact and business opportunities in the low-carbon economy will help position the utility to thrive in a clean energy future. Among the key considerations in that evaluation should be:

- Opportunities to accelerate or alter gas line replacement plans, which will reduce natural gas losses which emit methane, a potent greenhouse gas.
- Evaluation of standards needed to inject renewable natural gas into PGW's existing infrastructure and the costs of using renewable natural gas to supply homes and businesses currently served by PGW.
- PGW's sourcing considerations when buying natural gas to evaluate if less carbon-intensive natural gas sources can be prioritized.
- PGW's business diversification opportunities both including and beyond natural gas distribution and sales.

**KEY PLAYERS**

*Low-Carbon Thermal Study*

**City of Philadelphia and Issue Experts:** Tracking energy trends locally and globally.

**Philadelphia Gas Works:** Publicly-owned utility responsible for heating nearly all of Philadelphia's buildings.

### Tracking Carbon Intensity of Thermal Electrification Strategy

Electrification of thermal energy requires a clean and decarbonized grid electricity. If grid emissions aren't improving at the pace needed, switching to electricity has minimal decarbonization benefits. OOS has been tracking the carbon intensity of the grid since 2008, and will continue to monitor and report on the efficacy of fuel-switching to electric heating to reduce carbon pollution.

# Low-Carbon Economy

## WHERE WE'RE GOING

The first four sections of Powering Our Future lay out an ambitious energy future for Philadelphia: energy-efficient investment across Philadelphia's 600,000 buildings, thousands of new solar energy generation systems on our roofs and parking structures, and a commitment to transitioning the infrastructure that heats our buildings away from fossil fuels. **Achieving this vision will require a dramatic transition to a low-carbon economy where economic growth no longer leads to increased carbon pollution, but reduces it.**

In addition to generating new clean jobs, Philadelphia must grapple with existing industrial assets within our city. Philadelphia's industry produces "process emissions" (emissions derived from the generation of goods or industrial processes) that contribute to citywide carbon pollution. By 2050 these emissions will be cut at least 80 percent to ensure Philadelphia is on track to meet Mayor Kenney's 80 by 50 pledge.

To do so Philadelphia must reduce carbon emissions while including all Philadelphians in a long-term vision for Philadelphia's economy.

### Co-Benefits

**EQUITY**
New low-carbon opportunities should be targeted toward residents historically disadvantaged by carbon-intensive industry.

**HEALTH**
A low-carbon economy will improve air quality, reducing the causes of asthma and other respiratory illnesses among Philadelphians.

**ENVIRONMENTAL**
Industry is among the biggest sources of carbon pollution in Philadelphia, and also impacts the quality of our air and waterways.

**ECONOMIC**
As Philadelphia shifts toward a low-carbon economy, we must connect displaced workers with job training and placement

## HOW WE'LL GET THERE

Reducing carbon pollution from industrial sources 80 percent by 2050 will require a rethinking of major parts of Philadelphia's economy. Some institutions are already planning for a low-carbon future. For instance, the Philadelphia Regional Port Authority is currently working to electrify large parts of its operations. To achieve our low-carbon economy goal, these efforts will need to be expanded and intensified in the coming years.

The City, residents, and other stakeholders will also need to work together to determine the future of the South Philadelphia oil refinery currently operated by Philadelphia Energy Solutions. The refinery is the single-largest source of particulate emissions in the city and alone accounts for nearly 16 percent of Philadelphia's carbon footprint, not including the fossil fuel products exported off-site. OOS is committed to advancing the citywide conversation on the role of PES and other heavy industry as we move toward a clean-energy future.

### ECONOMIC OPPORTUNITY FROM LOW-CARBON ECONOMY

Meeting Philadelphia's clean energy vision will have a transformative impact on our local workforce. Per E2 there are already 9,000 clean energy jobs in Philadelphia, and a recent analysis by Stanford University for The Solutions Project found that meeting clean energy goals could create nearly 27,000 construction jobs and almost 10,000 operations jobs in clean energy by 2050.

Stanford further found that these are not short-term opportunities: those 37,000 jobs will keep Philadelphians employed over the course of a 40-year career. To help position our residents to take advantage of the opportunities to come, the Philadelphia Energy Campaign has set a target of creating 10,000 jobs in energy, and is working with workforce partners to train and connect residents to opportunities already available today.

ECONOMY

### Point-Source Pollution in Philadelphia

Both climate change and air quality are challenges that exist beyond city boundaries—climate impacts are global, and air pollution from our neighbors can drift into our city. But industry within Philadelphia also contributes local pollution, and the EPA and local Air Management Services track major sources of both carbon and air quality pollutants in the city.

Philadelphia's air quality is impacted by transportation, agriculture, industrial facilities, and natural sources. In 2016 Philadelphia ranked the 12th most polluted city in the U.S. by year-round particle pollution (PM2.5). PM2.5 and other particulate pollutants have negative effects on human health and the environment. For nearly all particulate pollutants, the single-largest source of local air pollution is the Philadelphia Energy Solutions (PES) refinery, which accounts for more than 50 percent of local emissions for each of those pollutants.

While not a particulate pollutant, carbon dioxide (the primary contributor to global climate change) is also emitted at the local level. Again, the PES refinery is the single-largest source of carbon emissions citywide. Other major point-sources for carbon emissions include the Port of Philadelphia and the Philadelphia International Airport. Addressing particulate and carbon emissions from these sources is necessary to achieving Philadelphia's health and sustainability goals.

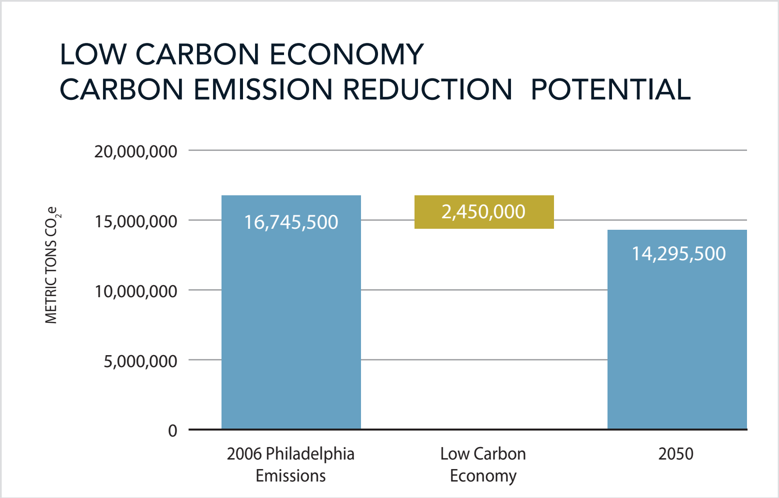
## WHAT YOU CAN DO

- **Invest in energy efficiency or renewable energy in your home and business.** Take advantage of the opportunities described throughout this report to improve the efficiency of local buildings or invest in renewable energy. This creates sustainable job opportunities locally and helps to grow Philadelphia's economy by providing a model for climate-positive economic growth. PECO Smart Ideas and PGW's EnergySense programs offer incentives for building efficiency for residential, commercial, and industrial customers.
- **Join your local community group and raise environmental concerns.** Philadelphia has an existing network of Registered Community Organizations (RCOs) that advocate for neighborhood priorities. RCOs can help connect residents to efficiency or clean energy resources and raise neighborhood environmental concerns to the City or other regulatory bodies.
- **Advocate at the local, state, and federal levels.** Moving Philadelphia toward a low-carbon economy will require action across all levels of government. Consider joining a local environmental action group and let your elected officials know carbon reduction and job creation are priorities for you.

# Low-Carbon Economy Playbook

Nearly all the actions described elsewhere in this report will contribute to moving Philadelphia toward a low-carbon economy by spurring new job opportunities in energy efficiency, home weatherization, clean energy generation installation and maintenance, and community education and organizing. Below are specific opportunities to help hasten the transition to a low-carbon economy while producing economic opportunity for Philadelphians. Achieving this transition requires buy-in from multiple stakeholders, who are identified in the Key Players boxes.

Reducing carbon emissions from existing industrial sources 80 percent by 2050 will have a significant impact on Philadelphia's carbon footprint on its own. This graph does not include emissions reductions from each of the other four areas of work in this report, which together will help move Philadelphia toward a low-carbon economy that works for all our residents.




ECONOMY

KEY PLAYERS

*Expand Philadelphia's Energy Community of Practice*

**Office of Sustainability:** Will identify opportunities to convene new voices in Philadelphia's energy conversation.

**Residents, businesses, and technical experts:** Will act as educators and sources of knowledge for their neighbors and decision-makers.

## EXPAND PHILADELPHIA'S ENERGY COMMUNITY OF PRACTICE

As we developed the Clean Energy Vision, the Office of Sustainability (OOS) heard from hundreds of Philadelphians passionate about our city's energy future. However, those residents are just a fraction of the population of our city, and to achieve the goals in this document we need to engage Philadelphians in every zip code.

### Deepen Energy Collaboration Citywide

To help facilitate conversations on how to achieve our vision of a clean and affordable energy future, the City will collaborate with different segments of the city:

- **Community:** Philadelphia residents passionate about energy and climate can serve as educators within the community about the importance of individual and community action, while sharing neighborhood perspectives on priorities, opportunities, and hurdles with city leadership.
- **Institutions:** Leadership from major businesses, non-profits, academic partners, and utilities can commit to help Philadelphia meet its long-term energy and climate goals. Through energy purchasing, employee and resident engagement, and policy advocacy across all levels of government, these institutions can help hasten our transition toward a clean energy future.
- **Technical Experts:** Experts can advise OOS and other City partners on existing and emerging best practices in energy and climate policy, review potential programs and policies for technical hurdles, and provide guidance on the long-term trajectory of Philadelphia's climate action planning.

KEY PLAYERS

*Support Philadelphia's Transition to a Clean Economy Future*

**City agencies:** The Commerce Department, Office of Sustainability, and Philadelphia International Airport are among the many City departments who will help Philadelphia transition to a clean economy future.

**Philadelphia Energy Authority:** Public authority responsible for leading the Philadelphia Energy Campaign.

**Residents and businesses:** Philadelphians must continue to demand climate action and work to create clean economy jobs in our city.

### Educate Philadelphians about Industrial Emissions

One early opportunity for CEV implementation is to convene conversations around the current impacts of large industrial facilities like the PES refinery on the health of our residents and the city's carbon footprint. Convening these conversations could allow parties to work together to identify opportunities to meaningfully improve the lives of impacted Philadelphians.

## SUPPORT PHILADELPHIA'S TRANSITION TO A CLEAN ECONOMY FUTURE

### Prioritize Supporting Clean Economy in New and Existing Businesses

Since 2010 the City of Philadelphia has provided a sustainable business tax credit to 25 businesses each year who meet the B-Corp certification criteria (see www.bcorporation.net) or otherwise demonstrate a commitment to local sustainability in Philadelphia. In 2016 City Council increased both the value of the credit and the number of businesses eligible to receive it.

Moving forward, the City will launch a companion program for new sustainable businesses in 2018, and continue to evaluate opportunities to strengthen the tax credit to create new opportunities for businesses and residents in the clean economy.

## Reduce Carbon Emissions from the Port of Philadelphia

Since 2015 the Commonwealth of Pennsylvania has committed $300 million to modernizing shipping operations at the Port of Philadelphia, including adding new electrified cranes and retrofitting existing cranes that were previously powered by diesel fuel. These changes will help make the Port of Philadelphia a more attractive destination for commerce in the years ahead, while reducing Philadelphia's carbon footprint.

The Port and City of Philadelphia are exploring additional opportunities to invest in updating facilities to reduce carbon emissions. Future opportunities include retrofitting the last remaining backup diesel crane, electrification of other port systems, and retrofitting support vehicles across Port operations.

## Implement Philadelphia Energy Campaign

The Philadelphia Energy Authority, through the leadership and support of City Council President Darrell Clarke, launched the Philadelphia Energy Campaign in February 2016. The Campaign aims to create jobs, strengthen communities and cut energy bills while reducing Philadelphia's carbon footprint. The Campaign will leverage $1 billion in public and private financing to invest in clean energy and energy efficiency projects in four key sectors: City buildings, Schools, low and moderate income residential housing and small businesses. To learn more about the development and successes of the Campaign, visit www.philaenergy.org.

PEA estimates that work currently being piloted will, when brought to scale, create more than 10,000 jobs for Philadelphia residents. Fully implementing the Energy Campaign will help move toward achieving our clean energy vision and provide opportunities for Philadelphians in the clean economy.




By leveraging $1 billion in public and private financing, the Philadelphia Energy Authority's Energy Campaign aims to create jobs, strengthen communities, and cut energy bills all while reducing our city's carbon footprint.

# What's Next?

The Office of Sustainability (OOS) will publish a Clean Energy Vision Action Plan in Fall 2018, and will continue to update that document to reflect progress toward Philadelphia's clean energy vision and opportunities for new work by the City as well as individuals, communities, and institutions. Keep up to date on OOS's climate action planning by joining our newsletter at www.phila.gov/green.

# Further Reading

Powering Our Future builds on existing planning documents, programs, and toolkits developed by OOS and partners in city government and the community. To learn more about climate action in Philadelphia, see the resources below.

*Plans and Reports*

- Greenworks: A Vision for a Sustainable Philadelphia (2016): The sustainability framework for Philadelphia built around eight visions for a more equitable and efficient city.
- Municipal Energy Master Plan (2017): Provides a roadmap of how Philadelphia's city government will lead by example on mitigating the causes of climate change by reducing energy use and costs, making operations more efficient, and advancing environmental stewardship.
- Growing Stronger: Toward a Climate-Ready Philadelphia (2015): Provides local projections of the impacts of climate change on Philadelphia and details how the City will lead by example in responding to those impacts.
- Zero Waste and Litter Plan (2017): Describes a set of actions to help Philadelphia reach Zero Waste by 2035.
- EV Task Force Report (2018): Outlines a strategy to encourage electric vehicles (EVs) as part of the City's wider multi-modal strategy that encourages transit, walking, and bicycling.

*Programs and Initiatives*

- Philadelphia Energy Benchmarking and Disclosure Program: Helps building owners reduce their energy use and save money by providing information on how their energy performance compares to peers.
- Solarize Philly: A group buying program to help bring down costs of solar energy for Philadelphia residents.
- Municipal Energy Management: The City's Energy Office manages the utility bills, assists in implementing energy efficiency projects, purchases energy, and benchmarks buildings in order to save the City money, reduce greenhouse gas emissions, and track energy performance.
- Philadelphia Energy Campaign: A bold, neighborhood-driven plan to invest $1 billion in energy efficiency and clean energy over the next ten years, leveraging both public and private dollars.
- Green City, Clean Waters: Philadelphia's plan to reduce stormwater pollution currently entering our Combined Sewer System through the use of green infrastructure.

*Action Guides*

- Greenworks on the Ground: Guides to help residents, communities, and institutions work toward each of the Greenworks visions.
- Philadelphia Environmental Action Guide: Toolkits on federal policies during the Trump Administration, including facts, ways to help, and other resources.

# Appendix: Energy Modeling Assumptions

The Clean Energy Vision (CEV) is based on research and modeling completed by the Office of Sustainability (OOS) with the support of consultants with ICF. Listed below are some of the key assumptions that were made to create the analysis shown throughout this report. For more information, please contact OOS at sustainability@phila.gov.

## GENERAL MODEL ASSUMPTIONS

The CEV uses population projections from DVRPC and assumes current construction rates continue to estimate increase in electricity and natural gas demand through 2050. Current emissions from Philadelphia's built environment are derived from citywide PECO and PGW data along with supplementary information on individual buildings from the city's energy benchmarking program. The modeling in this report assumes a zero-carbon grid is technically feasible, but does not make any assumptions about the technologies or costs required to achieve it.

## CLEAN ELECTRICITY SUPPLY

The CEV considers two electricity supply scenarios and assumes carbon intensity ($CO_2$e/MWh) pathways for each scenario. The business-as-usual scenario assumes the carbon intensity of the grid follows the Energy Information Agency's generation fuel mix projections.

The clean electricity supply grid scenario assumes the regional electricity grid follows a linear reduction trend to zero carbon emissions in 2050. This scenario does not make assumptions about which technologies or generation sources will be used in the zero-emissions grid.

## CITYWIDE SOLAR

The CEV projections for solar generation within the city are based on existing solar panel technology. A study by Penn State University found that nearly half of Philadelphia rooftops are suitable for solar generation, and the CEV assumed that 80% of these rooftops were producing electricity from solar by 2050. The resulting electricity generation is treated as a portion of the clean electricity supply.

## ENERGY-EFFICIENT HOMES AND BUSINESSES

Data from PECO, PGW, and the energy benchmarking program were used as a baseline for modeling programs in the Energy-Efficiency Playbook.

Key assumptions for specific programs include:

- Commercial and Residential Energy Codes: Philadelphia adopts new building code with each triennial International Code Council update through 2030 and 75% of new construction and major renovations completed through 2050 comply with code.
- Residential Energy Code Enforcement for Renovations and Additions: Building codes continue to become more energy efficient through 2030, and all renovations completed through 2050 meet code.
- Third-Party Energy Code Compliance: Compliance rates increase from an estimated 75% to 95% for residential properties.
- 2030 District: 70% of existing buildings in Center City and University City meet the 2030 District targets.
- Permit Streamlining: Streamlining leads to 75% of expected new construction meeting LEED or ENERGY STAR standards.
- Density Bonus: 30 new properties take advantage of bonus annually.
- Property Tax Incentives for High-Performing New Buildings: 50% of new office space in Center City and University City take advantage of incentives.

- Utility-Funded Efficiency Opportunities: Act 129 savings targets extend to 2050 with an annual savings rate of 1.1%.
- Expanded Energy Benchmarking Program: Benchmarking threshold is reduced to 25,000 square feet. 90% of buildings comply, and they reduce energy use 2% annually.
- Building Tune-Up Program: Program applies to buildings 25,000 square feet and larger, and 75% of eligible buildings comply, achieving 10% one-time savings.
- City Government Leading by Example: For more on this analysis, see the recently released Municipal Energy Master Plan, available at www.phila.gov/green.

## LOW-CARBON THERMAL ENERGY

The Low-Carbon Thermal Energy section assumes that natural gas and fuel oil use for heating, hot water, and cooking will be partially displaced by new no- and low-carbon technologies. The model assumes that 70% of residences and 30% of commercial buildings will use these new technologies by 2050. The model does not make any assumptions about which technologies will be used.

## LOW-CARBON ECONOMY

The city's greenhouse gas inventory includes emissions from Philadelphia's local industry. The inventory includes large point source emissions from the EPA's Greenhouse Gas Reporting Program tool and Philadelphia's share of additional industrial emissions from the Pennsylvania Department of Environmental Protection greenhouse gas inventory. The Low-Carbon Economy section assumes that the carbon dioxide-equivalent output of industry is 80 percent lower by 2050.

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