BEFORE
THE PUBLIC UTILITIES COMMISSION OF OHIO

IN THE MATTER OF THE LONG-TERM FORECAST REPORT OF OHIO POWER COMPANY AND RELATED MATTERS.	)))	CASE NO.: 18-501-EL-FOR
IN THE MATTER OF THE APPLICATION SEEKING APPROVAL OF OHIO POWER COMPANY'S PROPOSAL TO ENTER INTO RENEWABLE ENERGY PURCHASE AGREEMENTS FOR INCLUSION IN THE RENEWABLE GENERATION RIDER.	))))))	CASE NO.: 18-1392-EL-RDR
IN THE MATTER OF THE APPLICATION OF OHIO POWER COMPANY TO AMEND ITS TARIFFS.	)))	CASE NO.: 18-1393-EL-ATA

DIRECT TESTIMONY OF
RICHARD E. BROWN, PH.D., P.E.

Q. Please state your name, position and business address.

A. Richard E. Brown, Ph.D., P.E. I am a Principal Engineer at Exponent, Inc. My business address is 1331 17th Street, Suite 515, Denver, Colorado 80202.

Q. What is the purpose of your testimony?

A. At the request of Benesch, Friedlander, Coplan & Aronoff, LLP, Exponent conducted a review and assessment of AEP's applications for relief in these proceedings as well as the supporting testimonies and exhibits. My expert report addresses my findings, conclusions and opinions concerning the applications. My Expert Report is attached as Exhibit 1. The purpose of this testimony is to sponsor the Expert Report and present the findings, conclusions and opinions expressed in the Report.

Q. On whose behalf are you submitting this testimony?

A. On behalf of the Ohio Coal Association and at the request of their counsel, Benesch, Friedlander, Coplan & Aronoff, LLP.

Q. Please summarize your education and work experience.

A. I am an industry-recognized expert on electric power systems, electric utility economic assessment, and benefit-to-cost assessment. I have submitted expert witness testimony to regulatory commissions in California, Florida, Maryland, Massachusetts, North Carolina, Ohio, Virginia, and Texas. I am the author of over ninety peer-reviewed technical papers and the books *Electric Power Distribution Reliability* and *Business Essentials for Utility Engineers*.

I received my BSEE, MSEE, and PhD degrees from the University of Washington in Seattle, and my MBA from the University of North Carolina at Chapel Hill.

From 1991 to 1993, I worked as an Electrical Engineer at Sverdrup Corporation (now Jacobs Engineering) performing design work for electric distribution systems. Responsibilities included engineering design of medium voltage and low voltage electrical systems for industrial facilities, institutional facilities, and public works. Typical work included design, value engineering, specification writing, construction document generation, and construction support.

From 1994 to 1996, I worked as a teaching and research assistant for the University of Washington while attending graduate school. My research was in the area of distribution system reliability assessment, risk assessment, and cost optimization. In addition to research, I served as a teaching assistant for various power systems and controls courses at the undergraduate and graduate level.

From 1993 to 2003, I worked for ABB in various roles. From 1996 to 1999, I was a Senior Engineer in the corporate research department with responsibilities of research, product development, consulting, and project management. From 1999 to 2001, I was a Principal Engineer for the Distribution Solutions group with the goal of providing customers with complete solutions based on functional requirements including design, build, own, operate, maintain, and finance. From 2001 to 2003, I was the Director of Technology for the Consulting business with the responsibility for research and development of algorithms and software tools.

From May of 2003 through June 2006, I was the Vice President of Asset Management for KEMA. As a charter member of the T&D Consulting division in the US, my role was to provide management and technical consulting services in the areas of power system reliability and asset management.

From July of 2006 through February of 2012, I was the Vice President of Consulting for Quanta Technology from July 2007 through the present. As a charter member, I was responsible for growing the business in the areas of planning, engineering, operations, reliability, and asset management.

From March of 2012 through February of 2014, I served as the Vice President of the U.S. Power Networks division of WorleyParsons. In this role I was responsible for development and execution of business strategy for my division.

From March of 2014 through the present, I have been a Principal Engineer at Exponent, Inc.

I am a Fellow of the IEEE. The grade of Fellow is conferred by the IEEE Board of Directors for an extraordinary record of industry accomplishments, and is limited to one-

tenth of one percent of the total voting membership per year. I was Vice Chair of the Power System Planning and Implementation Committee from 2006 through 2008 and Chair of the Committee's Power Delivery Reliability Working Group from 1997 to 1999. I am a registered professional engineer. My curriculum vitae is attached as Appendix B to my Expert Report. This includes a list of cases in which I have provided sworn pre-filed testimony, sworn testimony at depositions, and sworn live testimony at hearings/trials.

Q. How is your Expert Report organized?

A. My report starts with an introduction and a section on my qualifications. It then assesses the Willowbrook facility, the Hecate facility, and the RGR in terms of economics, need, ownership/operation, baseload generation, and market distortion. There is also a sections specifically responding to the summary arguments of Mr. Williams. My report ends with my conclusions, an appendix listing the materials I reviewed, and another appendix with my CV.

Q. Would you please summarize the conclusions in your Expert Report.

A. There are many assessments, findings, and conclusions throughout my report, with the major conclusions being the following:

1. AEP Ohio does not need Hecate and Willowbrook based on resource planning projections. Therefore, the RGR does not meet the "need" requirement of the Electric Security Plan statute.
2. AEP Ohio will not own or operate Hecate and Willowbrook. AEP Ohio will serve as the PJM market participant, but the facility owners are contractually responsible for all other operational functions. Therefore, the RGR does not meet the "own or operate" requirement of the Electric Security Plan statute.
3. Allowing AEP to recover costs-not-actually-incurred based on debt equivalency cost recovery is contrary to cost-of-service ratemaking. I am not aware of any

Commission allowing cost recovery for costs not actually incurred, including debt equivalency cost recovery.

4. If full cost recovery of the Hecate and Willowbrook REPAs are approved by the Commission in advance, the risk of REPA cost non-recovery is zero and debt equivalency cost is therefore zero.
5. The RGR is a subsidy that makes both Hecate and Willowbrook financially viable. Hecate and Willowbrook will only be built if the RGR subsidy is approved.
6. Subsidizing facilities like Hecate and Willowbrook distorts the PJM Market.
7. AEP's own publically disclosed financial analysis shows that Willowbrook and Hecate REPA costs are much higher than market solar rates in early years for all scenarios. Inclusion of debt equivalency cost recovery makes the cost to customers even higher: an additional 7.05 $/MWh for Hecate and an additional 6.69 $/MWh for Willowbrook.
8. There is no hedge value to the RGR since the price stability of the REPAs is exactly counteracted by the market true-up provision of the RGR.
9. The Navigant survey is highly flawed. Its results are only representative of the tiny group of respondents. None of the survey questions address customer need, and none address need based on resource planning requirements.
10. Any economic and social benefits that result from Hecate and Willowbrook will be offset by negative benefits related to higher Ohio electricity rates, reduced profitability for unsubsidized Ohio generation facilities, and reduced oil/gas exploration and extraction activity.
11. Renewable facilities like Hecate and Willowbrook do not eliminate the need for new traditional generation to serve baseload and to provide ancillary services.
12. Federal and state renewable energy tax policies are regressive and disproportionately impact poor customers.

Q. Do you adopt your Expert Report and incorporate the Report as part of your testimony in this case?

A. Yes I do. I sponsor the Expert Report, adopt it as a part of my testimony and stand prepared to respond to any questions concerning the Report.

Q. Are the findings, conclusions and opinions expressed in the Expert Report true and correct to the best of your knowledge and belief?

A. Yes.

Q. Are the opinions expressed in your Expert Report based on a reasonable degree of professional and engineering certainty and consistent with your education, training and experience?

A. Yes.

Q. Does this conclude your testimony?

A. Yes it does.

Exponent®

Engineering Sciences

Assessment of AEP Ohio Renewable Generation Rider Application

Redacted Version

Exponent®

Assessment of AEP Ohio Renewable Generation Rider Application

Redacted Version

Prepared for:

John Stock
Benesch, Friedlander, Coplan & Aronoff LLP
41 South High Street, Suite 2600
Columbus, OH 43215-6164
jstock@Beneschlaw.com

Prepared by:

Richard E. Brown, Ph.D., P.E.
Exponent Inc.
1331 17th Street, Suite 515
Denver, Colorado 80202
rbrown@exponent.com

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Limitations

At the request of Benesch, Friedlander, Coplan & Aronoff LLP, Exponent conducted an assessment of the facts related to the Ohio Public Utility Commission Case No. 18-501-EL-FOR, Case No. 18-1392-EL-RDR and Case No. 18-1393-EL-ATA.

The opinions and comments formulated during this assessment are based on observations and information available at the time of the assessment.

The findings presented herein are made to a reasonable degree of engineering and professional certainty. If new data becomes available or there are perceived omissions or misstatements in this report regarding any aspect of those conditions, we ask that they be brought to our attention as soon as possible so that we have the opportunity to fully address them.

1. Introduction

AEP Ohio[1] (also the Company) is pursuing regulatory approval to enter renewable energy purchase agreements (REPAs) for the output of a 100 MW solar facility and a 300 MW solar facility, neither of which have been built. AEP Ohio also intends in the future to enter into additional REPAs for the output of at least 500 MW of wind farm capacity. It is the intention of AEP Ohio for all of these facilities to be located in Ohio. A summary of the two proposed solar projects (Solar Projects) is:

- **Hecate Energy Highland Project (Hecate).** This is a proposed 300 MW solar photovoltaic project to be located in Highland County. It will be owned by Hecate Energy Highland LLC. The expected on-line date is 12/31/2021.

- **Willowbrook Solar I Project (Willowbrook).** This is a proposed 100 MW solar photovoltaic project to be located in Highland County. It will be owned by Willowbrook Solar I LLC. The expected on-line date is 12/31/2021.

As a condition of entering the REPAs, AEP Ohio seeks *a priori* regulatory approval for a renewable generation rider (RGR). The RGR will allow AEP Ohio to net out the difference in cost between REPA rates and PJM wholesale energy rates. For example, if the REPA rates are higher than PJM rates, AEP retail customers will pay the difference. As an additional condition of entering the REPAs, AEP Ohio seeks regulatory approval to recover an additional amount from customers based the concept of "debt equivalency cost recovery."

The position of AEP Ohio is that it will not enter the REPAs without prior regulatory approval of an RGR that has customers net out energy cost differences and also has debt equivalency cost recovery. Therefore, the two Solar Projects will not be built without this prior regulatory approval.

[1] Ohio Power Company is a regulated utility on Ohio that is owned by the parent company American Electric Power (AEP). Ohio Power Company does business as AEP Ohio.

A brief history is now provided.

On April 16th 2018, AEP Ohio filed its 2018 Long Term Forecast Report pursuant to R.C. 4935.04 and OAC Rule 4901:5-1-03 and 4901:5-3-01 (PUCO Case No. 18-0501-EL-FOR). On Sept. 19th 2018, AEP Ohio filed an Amendment to the 2018 Long Term Forecast Report. AEP Ohio submitted the Amendment to demonstrate a claimed need for at least 900 MW of renewable energy generation projects in Ohio.

Also on Sept. 19th 2018, AEP Ohio filed an application seeking approval of: (1) the inclusion of two solar energy facilities totaling 400 MW of nameplate capacity in the Company's RGR; (2) creation of a new "Green Power Tariff" permitting the purchase of renewable energy certificates (RECs); and (3) other relief.[2]

The remainder of this report assesses the RGR application from the perspective of project economics, need, ownership and operation, baseload generation, and market distortion.

There is a redacted and unredacted version of this report. In the redacted version, redacted material is blacked out. In the unredacted version, material that is blacked out in the redacted version is highlighted in yellow.

[2] PUCO Case No. 18-392-EL-RDR and Case No. 18-1393-EL-ATA

2. Author Qualifications

I am an industry-recognized expert in the areas of electric power systems, electric utility economic assessment, and benefit-to-cost assessment. I have submitted expert witness testimony to regulatory commissions in California, Florida, Maryland, Massachusetts, North Carolina, Ohio, Virginia, and Texas. I am the author of over ninety peer-reviewed technical papers and the books *Electric Power Distribution Reliability* and *Business Essentials for Utility Engineers*.

I received my BSEE, MSEE, and PhD degrees from the University of Washington in Seattle, and my MBA from the University of North Carolina at Chapel Hill.

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I am a registered professional engineer. My CV is provided in Appendix B. This includes a list of cases in which I have provided sworn pre-filed testimony, sworn testimony at trial and/or sworn testimony by deposition.

Any, and all, of the opinions expressed herein are held to a reasonable degree of engineering and professional certainty. The information on which I relied consists of the type of information that is reasonably relied upon in my field of expertise.

3. Project Economics

This section discusses the RGR application with respect to project economics. It first discusses the general issue of wholesale electricity deregulation and then discusses whether the RGR application is in the best economic interest of AEP Ohio ratepayers in the context of Ohio being a deregulated state.

Deregulation

States with wholesale electricity markets are typically referred to as being "deregulated."[3] Utilities in states that are not deregulated allow utilities to own generation and to use that generation to serve their customers. Customer-serving utilities in deregulated states are generally not allowed to own significant generation capability. A map of regulated and deregulated states (and the year of deregulation) is shown in Figure 3-1.[4]

As can be seen in Figure 3-1, Ohio has been a deregulated state since 2009. As such, AEP Ohio is generally prohibited from owning significant electricity generation capacity. Instead, AEP Ohio is required to purchase wholesale energy through its associated wholesale market and/or through purchase power agreements (PPAs). AEP Ohio is a member of the PJM wholesale electricity market (PJM Market).

Regulated utilities like AEP Ohio have exclusive franchise service territories and therefore monopoly positions for providing retail electricity to customers within their service territory. Regulated utilities are therefore is required to sell retail electricity through tariffs that are approved by state utility commissions in rate case proceedings. In Ohio, the state utility commission is the Public Utilities Commission of Ohio (Commission).

[3] An electric utility that owns generation, transmission, and distribution is referred to as being "vertically integrated." A utility that has sold its generation facilities, such as with wholesale electricity deregulation, is "vertically unbundled."

[4] energywatch-inc.com/did-deregulation-work-compete-coalition-says-it-did

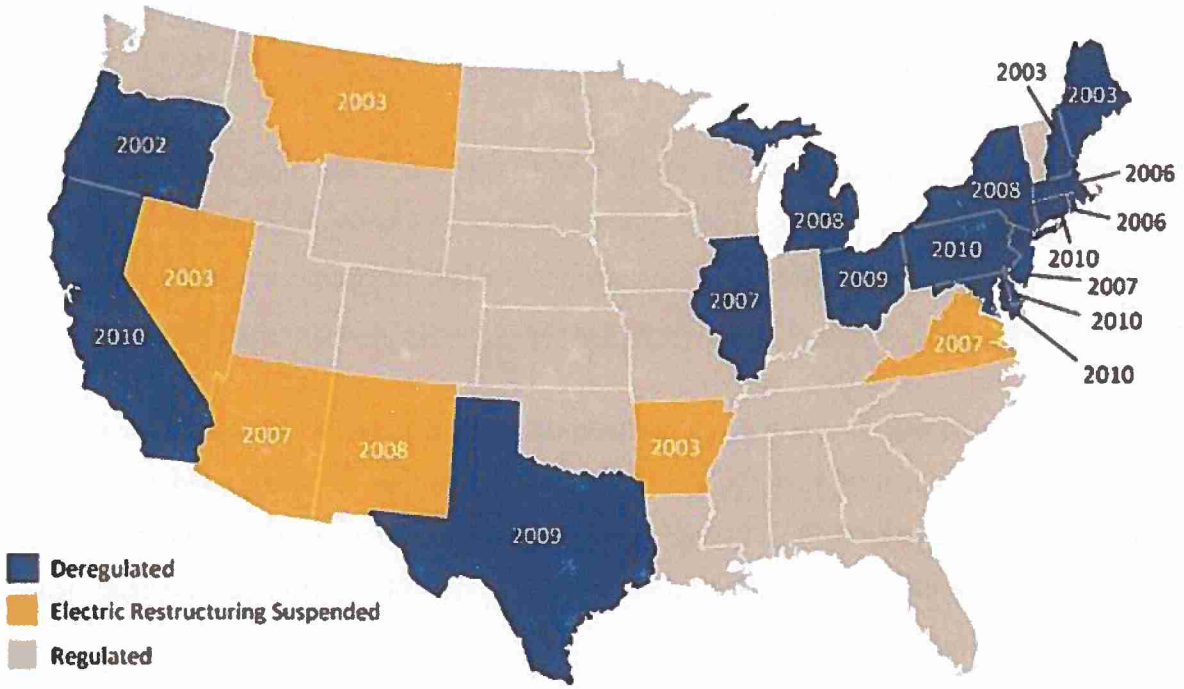

Figure 3-1. Regulated and Deregulated Energy Markets by State

The intent of deregulation is to create competition among wholesale electricity generators. In theory, competition will motivate generation facilities to achieve cost-efficiencies to remain competitive and profitable, resulting in lower rates for retail customers. As with any free market, a supplier that is cost-competitive should thrive and a supplier that is not cost-competitive should either increase its cost-competitiveness or leave the market.

As mentioned before, a deregulated utility is required to purchase wholesale energy through its associated wholesale market and/or through PPAs. A typical deregulated utility will enter into PPAs for a certain portion of its anticipated load to achieve a certain level of cost certainty, and will purchase any remaining required energy through the wholesale market. When choosing this energy procurement mix, regulated utilities are required to minimize revenue requirement, which will result in the lowest possible rates for customers.

Many states require utilities to have a certain percentage of energy come from renewable resources. Most states refer to their specific requirements as "Renewable Portfolio Standards," or

RPS. In Ohio, energy procurement requirement include renewable energy plus other technologies, referred to as an "Alternative Energy Portfolio Standard," or AEPS.

In deregulated states, utilities typically enter into PPAs with renewable energy providers to satisfy RPS or AEPS requirements. These renewable energy PPAs then become part of the utility's overall PPA portfolio that is sized in attempt to minimize revenue requirements. A renewable energy PPA is sometimes called a Renewable Energy Purchase Agreement (REPA).

In summary, it is normal for a utility in a deregulated state to have REPAs to meet renewable energy targets, additional PPAs to satisfy a base amount of anticipated load, and to purchase additional required energy through its associated wholesale electricity market. A utility is obligated to choose this energy portfolio mix to satisfy load and RPS/AEPS requirements in a manner that minimizes its revenue requirements.

The Proposed RGR Rider

Full rate case proceedings require a lot of time, effort, and money from utilities, commissions, and other interested parties. It is therefore common for utility revenue to be adjusted automatically through "riders" when utility costs increase or decrease for various reasons. For example, a utility that owns a lot of its own generation may have a "fuel adjustment rider" related to fuel costs: if the price of coal or natural gas increases, the associated added cost can be recovered from customers through a rider without requiring a new rate case. A utility that purchases a lot of power on wholesale markets may have a "purchased power rider" related to wholesale power prices: if the price of purchased electricity goes above the price assumed in the rate case, the associated added cost can be recovered from customers through a rider without requiring a new rate case.

Although riders can reduce the frequency of utility rate cases, they also transfer financial risk from the utility to its customers. For example, a purchased power rider will make utility costs less volatile, but will make customer electricity bills more volatile.

As discussed previously, AEP Ohio is requesting a renewable generation rider (RGR) related to two proposed 20-year REPAs with yet-to-be-built solar generation facilities. If entered into normally, these REPAs would provide cost certainty for AEP Ohio. The requested RGR is therefore not for the purposes of cost-certainty and rate-case avoidance.

AEP Ohio's position is that it will not enter into the REPAs unless the Commission approves a rider that would result in (1) customers paying (or being credited by) AEP Ohio for the difference between REPA rates and PJM market rates; and (2) customers paying AEP Ohio an additional amount based on the concept of "debt equivalence cost recovery," which is discussed below. In his direct testimony, Mr. Williams states the following [8:3-8]:

> Q. Is the construction of the solar facilities contingent on receiving all proper regulatory approvals?
>
> A. Yes, the Company receiving the timely regulatory approvals necessary is a condition precedent to the effectiveness of the REPAs. If regulatory approvals are not received in the periods identified in the REPAs, the Company will not move forward with the REPAs and they will be terminated.

And so, the normal situation is for a utility to enter a REPA to achieve cost certainty for itself and for customers. AEP Ohio will not do this for the Hecate and Willowbrook REPAs, indicating that these REPAs are not desirable to AEP Ohio on their own. However, AEP Ohio is willing to enter the REPAs if the RGR is approved. It therefore follows that the benefits of the rider to AEP Ohio outweigh the negatives of the REPAs for AEP Ohio on their own.

The AEP Ohio position indicates a preference to purchase renewable energy from the PJM Market. The proposed RGR is structured so that purchased energy costs would be the same for AEP Ohio as if it purchased renewable energy from the PJM Market. If market rates are higher than REPA rates, the RGR will have customers will pay the difference to AEP Ohio. If market rates are lower than REPA rates, the RGR will have AEP Ohio credit customers the difference.

AEP Ohio is not pursuing the Hecate and Willowbrook REPAs to achieve the best energy portfolio. Rather, AEP Ohio is pursuing the Hecate and Willowbrook REPAs to fulfill a regulatory obligation related to Ohio renewable energy development projects, even if these projects result in higher costs to ratepayers.

The proposed RGR will result in Ohio ratepayers subsidizing renewable projects in Ohio that would otherwise not be economical to build. If Hecate and Willowbrook were economical to build, they would simply compete with other renewable projects in the free market without the need for special rider treatment. In this case, Hecate and Willowbrook will not be built if the rider is not approved, proving that the RGR is a subsidy for Hecate and Willowbrook.

Since Ohio is part of a deregulated electricity market, it is questionable whether any new generation facility should be subsidized, thereby providing an advantage to subsidized facilities over non-subsidized facilities and interfering with the market.

Even if subsidization is deemed to be appropriate, it is questionable whether subsidies should come from electricity ratepayers. The subsidization of industries should not generally occur through electricity rates, as doing so is contrary to the utility obligation of minimum revenue requirements. If Ohio wishes to subsidize or encourage utility-scale solar facilities to be built in Ohio, it more appropriate to increase solar carve-outs and/or provide financial incentives through tax benefits.

Debt Equivalency Cost Recovery

When a utility enters a PPA, it enters a long-term financial obligation. In the absence of anything else, this "off-balance sheet" obligation could result in investors viewing the utility as slightly less credit-worthy since cash committed to the PPA is not available for the payment of other financial obligations.

The issue of off-balance sheet obligations is discussed in-depth in the direct testimony of Mr. Fetter, a former utility commissioner. He basically argues that a REPA, like all off balance sheet obligations, will negatively affect credit ratings. Mr. Fetter does state that he does not expect the

REPAs associated with Hecate and Willowbrook to actually result in any credit downgrades by ratings agencies.

Mr. Fetter recommends that AEP Ohio be compensated for the REPAs in an amount greater than the REPA rates. He justifies the amount of overpayment by using the concept of "debt equivalency cost recovery."

Consider a vertically-integrated utility that could secure twenty years of power by either building a new power plant or by entering a twenty-year PPA. If the utility issues new debt to build the power plant, the utility will have to pay interest on the debt, which is recoverable through rates. The concept of debt equivalency cost recovery argues that the credit of the utility would not be impacted under the PPA, *vis a vis* the build option, if it received cost recovery of the PPA plus the cost of interest if it had actually built the power plant, which it did not.

Utilities in deregulated states must purchase essentially all of the energy that they sell to customers. They are free to do this by making bids into the day-ahead market, by entering into long-term PPAs, or by a mix of the two. Average day-ahead prices are typically less expensive than PPA prices but are more volatile. Therefore, a typical deregulated utility will purchase PPAs for a certain percentage of their expected load, and purchase the required remaining energy on the day-ahead market. This approach results in the minimum revenue requirement for customers. The typical use of PPAs is intentional, not mandatory, and does not warrant the consideration of debt equivalency cost recovery. Buying energy both on the market and through PPAs is simply the way that utilities without generation facilities operate.

I am not aware of any deregulated utility that receives or has received cost recovery for a PPA above the PPA contract rate, nor am I aware of any Commission who has allowed a deregulated utility to receive cost recovery above a PPA rate based on debt equivalency cost recovery. Similarly, Mr. Fetter does <u>not identify a single utility</u> that has ever received commission-approved debt equivalency cost recovery.

A fundamental principle of utility ratemaking is that revenue requirements should be based on cost-of-service. Cost of service generally includes operational costs, depreciation costs, taxes,

interest, and return-on-equity. If a PPA results in a higher cost of capital, the proper ratemaking mechanism for recovery is through cost-of-capital proceedings in a general rate case. A 2017 California Public Utilities Commission document titled "An Introduction to Debt Equivalency" states the following:

> "The Commission's long standing position is that the impact of Debt Equivalency on utilities' financial condition should be addressed in Cost of Capital proceedings."

I agree with the California Public Utilities Commission that risk-versus return issues should be addressed in cost-of-capital proceeding.

Cost-of-service ratemaking generally involves the following revenue requirement aspects:

1. Prudently-incurred expense items, including interest on debt;
2. A rate-base with the non-depreciated component of all allowed and prudently-incurred assets; and
3. A return on the rate base based on a commission-determined return that specifically addresses the issue of return-on-equity.

This revenue-requirement determination process allows for a utility to recover its prudently-incurred costs plus a fair return for equity investors. The fair return for equity investors specifically includes the issue of utility credit worthiness, among all factors that impact equity risk. There is no place in this well-established process to allow utilities to recover costs that are not actually incurred, such as debt equivalency costs.

Mr. Fetter supports his arguments by citing a 2003 article by ratings agency Standard & Poor titled "Buy Versus Build: Debt Aspects of Purchased Power Agreements." Mr. Fetter describes this article as "seminal." This article relates to the financial risk of regulated utilities not obtaining full cost recovery for the nominal cost of a PPA. This article <u>does not</u> recommend that regulators allow utilities to recover debt equivalency associated with PPAs. Rather, the purpose of S&Ps use of debt equivalency as stated in the article is the following:

> "Standard & Poor's evaluates the benefits and costs of purchased power by adjusting a purchasing utility's reported financial statements to allow for more meaningful comparisons with utilities that build generation."

The idea of having AEP Ohio recover costs above actual PPA costs due to debt equivalency is AEP Ohio's and Mr. Fetters, not Standard & Poor's. Furthermore, if an RGR allowing for the full cost recovery of the REPAs is approved by the Commission in advance, the associated financial risk of non-recovery would be zero, corresponding to zero debt equivalency.

In summary, allowing for cost recovery above actual incurred costs, such as with PPA debt equivalency, is contrary to the principle of cost-of-service ratemaking. The impact of PPAs on cost-of-capital is most appropriately addressed in cost-of-capital proceedings. In any case, debt equivalency should be treated zero if a specific rider allows for full cost recovery, as in this situation with AEP Ohio and its proposed RGR.

Portfolio Standards in Ohio

The Commission has established an Alternative Energy Portfolio Standard (AEPS) that requires Ohio utilities to have 12.5% of electric energy come from specified alternative energy sources (including renewable energy sources) by 2026. There is a solar carve out that requires 0.5% of this amount to come from solar-electric sources.[5]

The solar carve-out of 0.5% by 2026 is small and therefore easy for AEP Ohio to meet, especially since the solar energy <u>is not</u> required to be generated in Ohio. If AEP Ohio finds that it cannot achieve the 0.5% solar carve out target at competitive prices, the carve-out requirement is waved per Section 4928.64 (C) (3) as follows (emphasis added):

[5] Details of the AEPS can be found at http://programs.dsireusa.org/system/program/detail/2934

> "An electric distribution utility or an electric services company **need not comply** with a benchmark under division (B)(2) of this section to the extent that its reasonably expected cost of that compliance **exceeds its reasonably expected cost** of otherwise producing or acquiring the requisite electricity **by three per cent or more**. The cost of compliance shall be calculated as though any exemption from taxes and assessments had not been granted under section 5727.75 of the Revised Code."

In 2017 AEP Ohio was in full compliance with both its overall AEPS goal and its solar carve-out. Its 2017 alternative energy target was 3.35%, which was met. Its 2017 solar carve out target was 0.15%, which it met. To my knowledge, AEP Ohio has never asserted that it needs Willowbrook and/or Hecate to meet its AEPS targets.

Generic Project Economics

AEP Ohio has performed a generic financial analysis of wind and solar for Case 18-501-EL-FOR. The direct testimony of Mr. Torpey summarizes the break-even REPA price point of wind and solar. This analysis calculates the 20-year fixed REPA rate for solar that has the same NPV as solar purchased at projected market rates over the same time period, given the AEP Ohio assumptions. The same analysis is done for wind power. A summary of results is shown on Page 6 of Mr. Torpey's testimony as follows:

Break-Even Analysis	Actual REPA costs lower than the REPA price noted below result in lower costs to AEP Ohio customers: • SOLAR: REPA costs below $56.82/MWh • WIND: REPA costs below $48.40/MWh

Figure 3-2. AEP Ohio Break Even REPA Rate Analysis for Solar and Wind

As can be seen from Figure 3-2, AEP Ohio has determined that a Solar REPA must be below $56.82/MWh to be more cost-effective than purchasing solar at market rates. AEP Ohio has also determined that a Wind REPA must be below $48.40/MWh to be more cost-effective than purchasing wind at market rates. This means that AEP Ohio expects that the discounted cost of solar power over the next 20 years is about 17% higher than solar. It should be noted that AEP Ohio is not required to purchase any solar in excess of the AEPS carve-out requirement.

A	B	C	D	E	F	G	H	I	J	K	L	M	N
		REPA Cost					Avoided Energy Cost		Avoided Capacity Cost				
Year	Present Value Factor	Capacity (Nameplate)	Solar Energy	Capacity Factor	Solar Energy Cost	Solar Total Cost	Solar Energy Priced at Market	Avoided Cost of Energy	Capacity Price	Solar Capacity Credit	Solar Capacity Credit Value	Total Change in Net Revenue Requirement	Net Cost of Energy
		(MW)	(GWh)	(%)	($/MWh)	($M)	($/MWh)	($M)	($/MW-Day)	(MW)	($M)	($M)	($/MWh)
2021	0.9217	400	813.9	23.2%	56.82	46.2	37.8	(30.8)	50.8	76.0	(1.4)	14.1	17.29
2022	0.8495	400	809.9	23.1%	56.82	46.0	39.2	(31.7)	30.1	76.0	(0.8)	13.4	16.59
2023	0.7829	400	805.8	23.0%	56.82	45.8	40.5	(32.7)	44.2	76.0	(1.2)	11.9	14.77
2024	0.7216	400	803.3	22.9%	56.82	45.6	41.8	(33.6)	58.7	76.0	(1.6)	10.4	13.00
2025	0.6650	400	797.8	22.8%	56.82	45.3	43.0	(34.3)	73.6	76.0	(2.0)	9.0	11.23
2026	0.6129	400	793.8	22.7%	56.82	45.1	44.0	(34.9)	88.9	76.0	(2.5)	7.7	9.73
2027	0.5649	400	789.8	22.5%	56.82	44.9	44.6	(35.2)	104.7	76.0	(2.9)	6.7	8.53
2028	0.5207	400	787.4	22.4%	56.82	44.7	55.6	(43.8)	120.9	76.0	(3.4)	(2.4)	(3.03)
2029	0.4799	400	781.9	22.3%	56.82	44.4	57.2	(44.7)	137.6	76.0	(3.8)	(4.1)	(5.22)
2030	0.4423	400	778.0	22.2%	56.82	44.2	60.7	(47.2)	154.8	76.0	(4.3)	(7.3)	(9.41)
2031	0.4076	400	774.1	22.1%	56.82	44.0	62.7	(48.6)	172.2	76.0	(4.8)	(9.4)	(12.08)
2032	0.3757	400	771.8	22.0%	56.82	43.9	64.9	(50.1)	190.1	76.0	(5.3)	(11.5)	(14.87)
2033	0.3463	400	766.4	21.9%	56.82	43.5	66.5	(51.0)	208.5	76.0	(5.8)	(13.2)	(17.27)
2034	0.3191	400	762.6	21.8%	56.82	43.3	68.1	(52.0)	227.3	76.0	(6.3)	(15.0)	(19.62)
2035	0.2941	400	758.8	21.7%	56.82	43.1	70.8	(53.7)	246.5	76.0	(6.8)	(17.5)	(23.01)
2036	0.2711	400	756.5	21.5%	56.82	43.0	72.2	(54.6)	266.3	76.0	(7.4)	(19.0)	(25.16)
2037	0.2499	400	751.2	21.4%	56.82	42.7	74.2	(55.7)	286.5	76.0	(7.9)	(21.0)	(27.95)
2038	0.2303	400	747.4	21.3%	56.82	42.5	78.0	(58.3)	307.1	76.0	(8.5)	(24.4)	(32.66)
2039	0.2122	400	743.7	21.2%	56.82	42.3	78.1	(58.1)	328.6	76.0	(9.1)	(24.9)	(33.52)
2040	0.1956	400	741.4	21.1%	56.82	42.1	80.7	(59.8)	350.6	76.0	(9.7)	(27.4)	(36.94)
Present Worth	9.4633					423.1		(389.2)			(33.9)	0.0	
Levelized			786.9	22.4%	56.82	44.7	52.3	(41.1)	129.0	76.0	(3.6)	0.0	0.00

Figure 3-3. Torpey Solar Break Even Analysis

The AEP Ohio break-even analysis summarized above is useful in a relative sense, but uses very aggressive market price increase assumptions. The full break-even analysis is documented in the report "Integrated Resource Planning Report and Forecast Report Requirements for Electric Utilities to the Public Utilities Commission of Ohio," (IRP Report) which is attached as Exhibit JFT-1 of Mr. Torpey's testimony. The solar break even analysis (Table 7 in the report) is reproduced here as Figure 3-3.

As can be seen in the "Net Cost of Energy" column from Figure 3-3, solar energy cost assumptions are projected to be higher than market rates in years 2021 through 2027, and projected to be lower than market rates from years 2028 through 2040. Any financial analysis with losses in the more-certain early years and benefits in the less-certain later years deserves scrutiny, especially when the increased uncertainty of later years is not accounted for with a

higher discount rate.[6] In this case, later years reflect much higher prices for solar energy and capacity market prices, which is counterintuitive since the cost to build solar facilities has been declining and is expected to continue to decline.

The energy and capacity market price assumptions from Figure 3-3 have been reproduced in Table 3-1, along with the percentage increase assumed in each year.

Table 3-1. Torpey Market Price Increase Assumptions

Year	Energy		Capacity	
	$/MWh	% Increase	$MW-day	% Increase
2021	37.8		50.8	
2022	39.2	3.7%	30.1	-40.7%
2023	40.5	3.3%	44.2	46.8%
2024	41.8	3.2%	58.7	32.8%
2025	43.0	2.9%	73.6	25.4%
2026	44.0	2.3%	88.9	20.8%
2027	44.6	1.4%	104.7	17.8%
2028	55.6	24.7%	120.9	15.5%
2029	57.2	2.9%	137.6	13.8%
2030	60.7	6.1%	154.8	12.5%
2031	62.7	3.3%	172.2	11.2%
2032	64.9	3.5%	190.1	10.4%
2033	66.5	2.5%	208.5	9.7%
2034	68.1	2.4%	227.3	9.0%
2035	70.8	4.0%	246.5	8.4%
2036	72.2	2.0%	266.3	8.0%
2037	74.2	2.8%	286.5	7.6%
2038	78.0	5.1%	307.1	7.2%
2039	78.1	0.1%	328.6	7.0%
2040	80.7	3.3%	350.6	6.7%
Average		**4.2%**		**12.1%**

As can be seen from Table 3-1, Torpey assumes an average market price increase for solar energy of 4.2% over 20 years and an average market price increase for capacity of 12.1% over 20 years. Average U.S. inflation for the 20 year period of 1998 to 2017 was 2.16%.[7] It is not

[6] It is generally incorrect to use the same discount rate for all years in a 20-year financial analysis. Even when considering just inflation risk, yield curves (i.e., return on treasuries with different term lengths) have significantly different values for short terms versus longer terms.

[7] www.thebalance.com/u-s-inflation-rate-history-by-year-and-forecast-3306093

clear why Mr. Torpey thinks that the market price for solar energy will increase about twice the historical inflation rate when all analyses I have seen predict continued lower costs for new solar facilities. It is also not clear why Mr. Torpey thinks that the market price for capacity will increase more than five times the historical inflation rate. In fact, the IRP Report attached to Mr. Torpey's testimony shows a forecast of solar installation costs going down in the Future (Figure 2 in the IRP report, reproduced here as Figure 3-4).

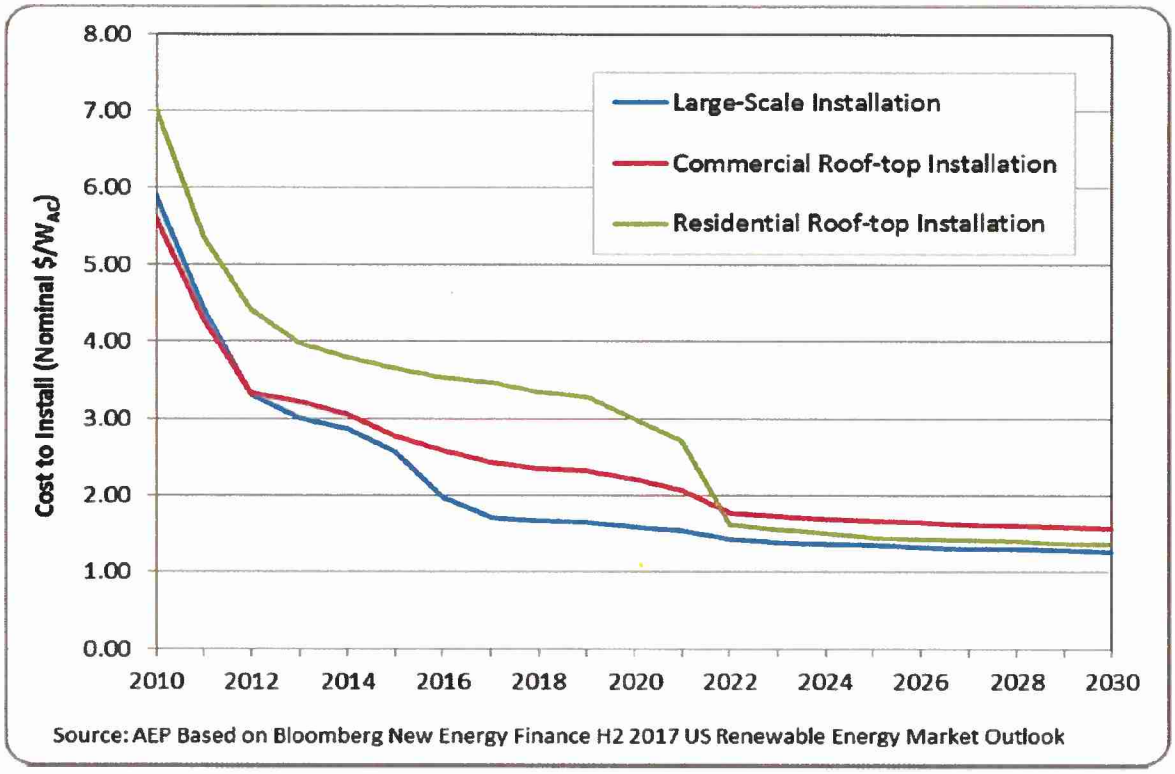

Figure 3-4. PJM Average Solar PV Installation Cost Trends

Mr. Torpey does not justify his very high price escalation assumptions for solar market prices, does not justify his ridiculously high price escalation assumptions for capacity prices, and does not properly apply higher discount rates for later years when compared to early years. Therefore, the actual break-even Solar REPA price for AEP Ohio is significantly lower than his calculated value of $56.82/MWh.

The Lawrence Berkeley National Laboratory has compiled data on historical wind PPA prices in the U.S. by region. A graph showing this data is provided in Figure 3-5. Recent solar REPAs have generally been priced in the range of 20-30 $/MWh. There is no PPA data for Midwest REPAs for the last several years, but historical Midwest REPA prices have general been on the high end of the central pricing cluster in a given year. Therefore, new competitive Midwest REPAs can be expected to be in the 30 $/MWh range, which corresponds to the high end of recent REPAs.

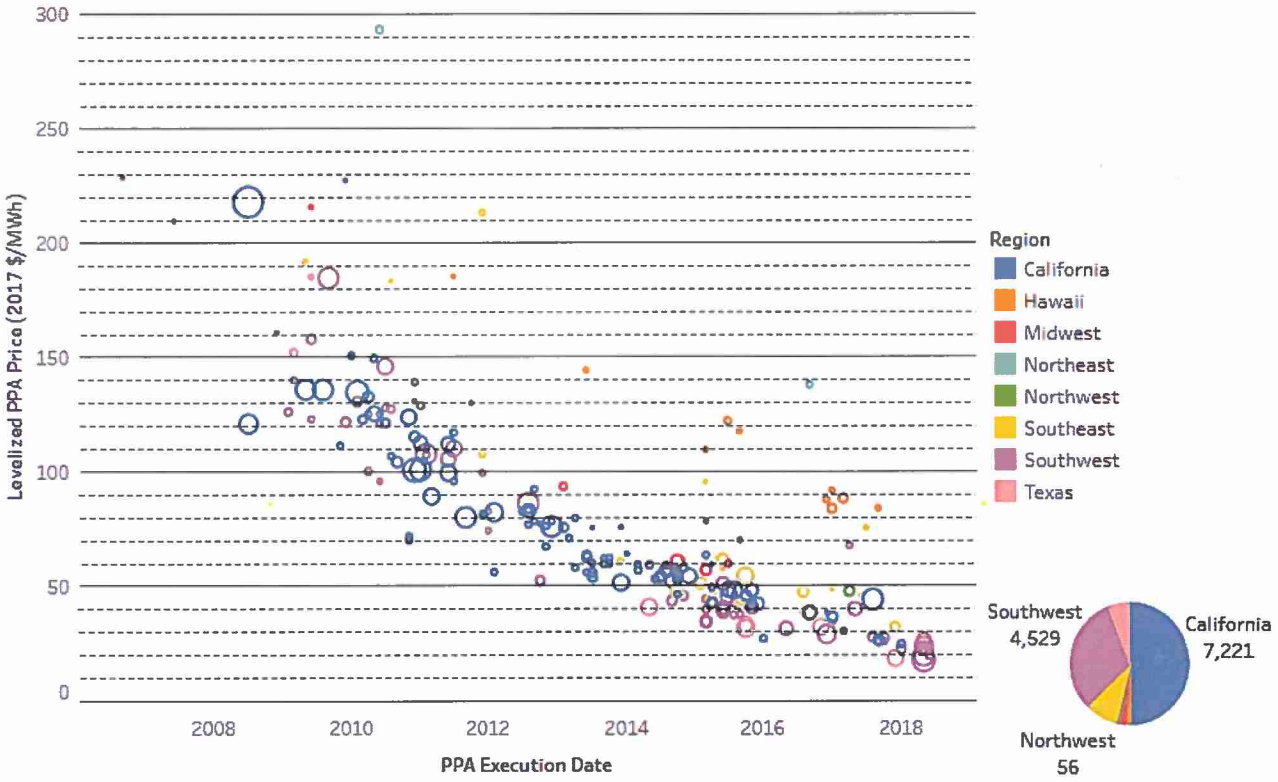

Figure 3-5. Historical Solar PPA Prices by Region[8]

[8] https://emp.lbl.gov/pv-ppa-prices

Hecate and Willowbrook Economics

Mr. Torpey's Sept. 8th 2018 direct testimony summarizes his economic assessment of Hecate and Willowbrook. The following three scenarios are examined: (1) a "base" case that assumes average natural gas prices; (2) a "low" case that assumes low natural gas prices; (3) a "high" case that assumes low natural gas prices. Each of these three scenarios assumes a cost of CO_2 emissions starting in 2028. A fourth "status quo" case is examined that is the same as the "base" case but without any cost of CO_2 emissions. These analyses compare REPA costs to projected solar market prices, with natural gas prices simply affecting the clearing price of energy.

A graphical summary of Mr. Torpey's results is reproduced in Figure 3-6, showing his calculated REPA savings when compared to projected market prices.

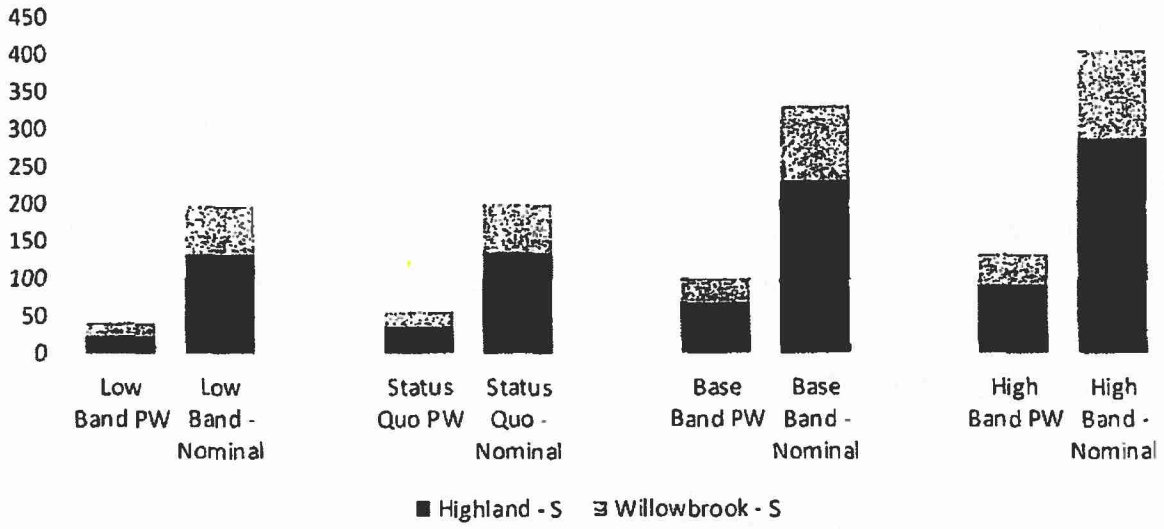

Figure 3-6. AEP Ohio Economic Assessment of the Solar Facilities: Projected Life-Cycle Savings in Present Worth and Nominal $ (Millions)

And so, Mr. Torpey is showing in Figure 3-6 that all scenarios result in lower discounted solar energy costs for both Hecate and Willowbrook. **If AEP Ohio truly believes its analysis it should enter both REPAs without any RGR since this will achieve minimum revenue requirement and therefore the lowest rates for customers.** To my knowledge AEP Ohio has not explained why it will not enter the Hecate and Willowbrook REPAs without the RGR when

its own analysis shows that both REPAs will result in present worth savings for all scenarios examined. It appears that either (1) AEP Ohio does not have much confidence in its own present worth analysis; or (2) it is not interested in lowering its energy costs.

I myself do not have much confidence in the present worth analysis. As discussed above: (1) the aggressive price escalation assumptions used in the present worth analysis are not credible; and (2) the lack of discount rate escalation is incorrect. Both of these issues, if treated appropriately in the present worth analysis, will result in lower present and potentially negative present worth values.

A much simpler method of assessing the economics of the REPAs is to simply compare the REPA rates to recently executed solar REPA rates. This comparison cannot be done directly using public data since the REPA rates have been redacted. However, the REPA rates can be estimated using only public data.

If the same capacity factors used in the IRP Report (see Figure 3-3) are assumed for the Hecate and Willowbrook economic analysis, an approximate REPA rate can be back-calculated so that the calculated $/MWh impact is equal to the stated $/MWh impact provided by Mr. Torpey. I have done this for the 2021 Status Quo cases for both Hecate and Willowbrook as follows:

Willowbrook 2021 Status Quo

- Market rate for solar energy: $37.30 / MWh
- Market rate for capacity: $46.50 / MW-day
- Nameplate plant output: 100 MW
- Capacity factor (from IRP Report): 0.232
- MWh Output in 2021: 100 MW x 0.232 x 8760 = 203,232 MWh
- Derived REPA rate: [redacted]
- REPA Rate – Market Rate: [redacted]
- Incremental Energy Cost: 203,232 x 2.60 = $528,403
- Incremental Capacity Cost: ($300,000)
- Total Incremental Cost: 528,403 – 300,000 = $228,403
- Net Cost per MWh (Calculated): $228,403 / 203,232 = **$1.12 / MWh**
- Net Cost per MWh (Publically Provided): **$1.12 / MWh**

Hecate 2021 Status Quo

- Market rate for solar energy: $37.50/ MWh
- Market rate for capacity: $46.50 / MW-day
- Nameplate plant output: 300 MW
- Capacity factor (from IRP Report): 0.232
- MWh Output in 2021: 300 MW x 0.232 x 8760 = 609,696 MWh
- Derived REPA rate: [redacted]
- REPA Rate – Market Rate: [redacted]
- Incremental Energy Cost: 609,696 x 7.22 = $4,402,005
- Incremental Capacity Cost: ($1,000,000)
- Total Incremental Cost: 4,402,005– 1,000,000 = $3,402,005
- Net Cost per MWh (Calculated): $3,402,005 / 609,696 = **$5.58 / MWh**
- Net Cost per MWh (Publically Provided): **$5.58 / MWh**

And so, my back-calculations based on only public information results in approximate REPA Rates as follows:

Approximate REPA Rates Based on Public Information

- The 100 MW Willowbrook Facility: [redacted]
- The 300 MW Hecate Facility: [redacted]

The testimony of Mr. Allen presents the requested amount of debt equivalency to be $4.30 million annually for Hecate and $1.36 million annually for Willowbrook. This can be used to calculate an additional effective $/MWh for each project. The results assuming year 2021 output levels are shown in Table 3-2.

Table 3-2. $/MWh including Debt Equivalency Cost Recovery

Project	REPA $/MWh	MWh per Year	Debt Equivalency		Effective $/MWh
			$	$/MWh	
Hecate	[redacted]	609,696	4,300,000	7.05	[redacted]
Willowbrook	[redacted]	203,232	1,360,000	6.69	[redacted]

Figure 3-7. Rates of 2018 Solar PPAs

As can be seen from Figure 3-7, all 2018 Solar PPAs in the U.S. have been below 27 $/MWh, with several below 20 $/MWh (Figure 3-7 replicates the 2018 data of Figure 3-6). If a fair market-based solar REPA of 30 $/MWh is assumed, the effective $/MWh cost to customers for Willowbrook is [redacted] more expensive than fair market rates and the effective $/MWh cost to customers for Hecate is [redacted] more expensive than fair market rates.

A summary of Mr. Torpey's net cost of energy (NCOE) for each project for each year for each scenario is shown in Figure 3-8. I have already discussed why these analyses overstate benefits to customers due to high price escalation assumptions, and why these lead to overstated present value calculation based on uncertain future years.

AEP Ohio Renewable Bids Net Cost of Energy (NCOE)

HIGHLAND SOLAR 300 MW

YEAR	HIGH NCOE ($/MWh)	BASE NCOE ($/MWh)	STATUS_QUO NCOE ($/MWh)	LOW NCOE ($/MWh)
2021	$1.11	$5.11	$5.58	$10.31
2022	$0.67	$4.42	$5.13	$10.20
2023	($1.28)	$2.60	$3.66	$9.16
2024	($3.29)	$0.81	$1.94	$7.86
2025	($4.78)	($0.96)	$0.23	$6.47
2026	($6.58)	($2.45)	($1.54)	$5.47
2027	($8.01)	($3.67)	($2.88)	$4.17
2028	($20.20)	($15.26)	($5.26)	($7.07)
2029	($22.64)	($17.44)	($7.33)	($9.09)
2030	($27.40)	($21.62)	($10.61)	($12.99)
2031	($29.88)	($24.32)	($12.91)	($15.25)
2032	($33.00)	($27.13)	($15.52)	($17.33)
2033	($36.48)	($29.52)	($18.57)	($20.44)
2034	($37.10)	($31.86)	($19.54)	($21.78)
2035	($40.80)	($35.28)	($22.54)	($25.59)
2036	($42.34)	($37.48)	($24.09)	($28.23)
2037	($44.53)	($40.25)	($25.80)	($29.57)
2038	($47.72)	($44.93)	($27.62)	($32.57)
2039	($50.42)	($45.84)	($30.03)	($34.48)
2040	($53.33)	($49.31)	($32.60)	($38.20)
Levelized	($16.75)	($12.22)	($6.26)	($4.29)

WILLOWBROOK SOLAR 100 MW

YEAR	HIGH NCOE ($/MWh)	BASE NCOE ($/MWh)	STATUS_QUO NCOE ($/MWh)	LOW NCOE ($/MWh)
2021	($3.33)	$0.67	$1.12	$5.83
2022	($3.82)	($0.09)	$0.62	$5.65
2023	($6.09)	($2.17)	($1.14)	$4.35
2024	($7.74)	($3.63)	($2.51)	$3.35
2025	($9.33)	($5.50)	($4.33)	$1.85
2026	($10.83)	($6.70)	($5.82)	$1.10
2027	($12.32)	($8.00)	($7.24)	($0.27)
2028	($24.47)	($19.54)	($9.56)	($11.52)
2029	($27.16)	($21.96)	($11.87)	($13.72)
2030	($31.60)	($25.78)	($14.85)	($17.35)
2031	($34.21)	($28.68)	($17.24)	($19.75)
2032	($37.13)	($31.24)	($19.70)	($21.62)
2033	($40.61)	($33.65)	($22.74)	($24.79)
2034	($41.61)	($36.39)	($24.03)	($26.50)
2035	($45.21)	($39.58)	($26.90)	($30.04)
2036	($46.40)	($41.48)	($28.14)	($32.49)
2037	($48.14)	($43.89)	($29.49)	($33.51)
2038	($51.43)	($48.68)	($31.40)	($36.53)
2039	($54.14)	($49.66)	($33.81)	($38.48)
2040	($57.30)	($53.33)	($36.53)	($42.34)
Levelized	($21.09)	($16.56)	($10.63)	($8.75)

Figure 3-8 Summary of Torpey Net Cost of Energy Calculations

Table 3-3. Payback Period Analysis for Status Quo Case

#	Year	Hecate Cost of Energy ($/MWh)				Willowbrook Cost of Energy ($/MWh)			
		Nominal		Nominal + $7.05		Nominal		Nominal + $6.69	
		Year	Sum	Year	Sum	Year	Sum	Year	Sum
1	2021	5.58	5.58	12.63	12.63	1.12	1.12	7.81	7.81
2	2022	5.13	10.71	12.18	24.81	0.62	1.74	7.31	15.12
3	2023	3.66	14.37	10.71	35.52	-1.14	0.60	5.55	20.67
4	2024	1.94	16.31	8.99	44.51	-2.51	-1.91	4.18	24.85
5	2025	0.23	16.54	7.28	51.79	-4.33		2.36	27.21
6	2026	-1.54	15.00	5.51	57.30	-5.82		0.87	28.08
7	2027	-2.88	12.12	4.17	61.47	-7.24		-0.55	27.53
8	2028	-5.26	6.86	1.79	63.26	-9.56		-2.87	24.66
9	2029	-7.33	-0.47	-0.28	62.98	-11.87		-5.18	19.48
10	2030	-10.61		-3.56	59.42	-14.85		-8.16	11.32
11	2031	-12.91		-5.86	53.56	-17.24		-10.55	0.77
12	2032	-15.52		-8.47	45.09	-19.70		-13.01	-12.24
13	2033	-18.57		-11.52	33.57				
14	2034	-19.54		-12.49	21.08				
15	2035	-22.54		-15.49	5.59				
16	2036	-24.09		-17.04	-11.45				

When making investment decisions where benefits are far into the future, a simple payback period analysis can serve as a reality check. I have done this for Status Quo Hecate and Willowbrook results in Table 3-3, both for REPA rates only and for the REPA Rates plus debt cost equivalency (analysis assumes equal energy output each year, which is conservative).

Table 3-3 shows that the Hecate payback period for customers is 16 years (including debt cost equivalency). Table 3-3 shows that the Willowbrook payback period for customers is 12 years (including debt cost equivalency). I know of no investor that would fund a project with a payback period of 12 or 16 years or anything close. Even with the AEP Ohio aggressive price escalation assumptions, the Hecate and Willowbrook REPAs make no financial sense from the perspective of payback period.

Project Economics Using Confidential Data

[redacted]

[redacted]

[redacted]

Project	REPA $/MWh	MWh per Year	Debt Equivalency		Effective $/MWh
			$	$/MWh	
[redacted]					

[redacted]

Hedge Value of REPAs

AEP Ohio cites the hedge value of the REPAs being a benefit of the RGR. It is true that fixed energy REPA rates offer increased price certainty when compared to market prices. The Hecate and Willowbrook REPAs therefore would have a hedge value if AEP Ohio were to enter into them without the RGR. However, this is not the case. The RGR would re-introduce price volatility to AEP Ohio and its customers through its market true-up provision. Consider the following three cases that illustrate this point.

Case 1: a utility purchases energy on the wholesale market. In this case, the utility is exposed to market price volatility but receives a lower price, on average, when compared to fixed-price REPAs.

Case 2: a utility purchases energy through a 20 year REPA with a fixed rate. In this case, nominal prices remain the same for the utility, but will generally be higher than market rates, on average. Case 2 represents a "hedge" against Case 1 because the utility is paying a premium to lower price volatility. This is not what the RGR does.

Case 3: The proposed REPA structure. In this case, the utility pays a fixed price over the REPA contract, but is then trues up the difference between the fixed REPA rate and the market rate by charging/crediting its customers. In this case, cash flow volatility for the utility is identical to Case 1, and there is therefore the hedge value of the REPAs along with the RPR is zero.

In summary, it is common and appropriate for utilities to enter into PPAs and REPAs to achieve a higher level of price certainty and therefore cash-flow predictability. However, the structure of the RGR re-introduces the full impact of market price volatility into AEP Ohio cash flow and therefore has zero hedge value. Normally, a utility will pay a bit more for increased cash flow predictability. With the RGR, AEP Ohio would pay more with no improvement whatsoever in cash flow predictability.

Socio Economic Benefits

The impact of solar plant construction on the Ohio economy is addressed in a report by Dr. Bill LaFayette of Regionomics and Dr. Stephen Buser of Ohio State University titled, "Impacts of Solar Plant Construction and Operation on the Ohio Economy" (Regionomics Report). Dr. Buser summarizes and sponsors the Regionomics Report in his direct testimony. Dr. LaFayette's direct testimony summarizes the model and data analysis employed in the Regionomics Report.

The Regionomics Report essentially addresses the following three areas:

- Economic impact of the construction phase;
- Ongoing economic impact after the construction phase; and
- Non-quantitative socio-economic benefits.

These three areas of the Regionomics Report are now addressed.

Economic impact of the construction phase

The Regionomics Report uses the RIMS II model to estimate the Ohio economic impact of Willowbrook and Hecate construction in terms of direct, indirect, and induced benefits. The methodology of this approach is widely accepted, but requires a large number of assumptions that can greatly impact results. This is why the Regionomics Report qualifies its results by saying "… an important point is that the results of even the most carefully-constructed economic impact analysis represent only the order of magnitude of the true impacts." I agree with this statement. An order of magnitude is a factor of ten. Therefore, the Regionomics Report admits that actual economic benefits could anywhere from ten times higher to ten times lower than calculated benefits. An analysis with a range this large should be given very little weight.

Ongoing economic impact after the construction phase

The ongoing economic benefits calculated in the Regionomics Report are comprehensive, but not a single negative economic impact is identified. The Regionomics Report does identify one potential economic impact as follows:

> "Care also must be taken to net out the impacts of any operations for which these new facilities are a replacement … But no shutdowns are planned as a result of these projects. Consequently, these facilities represent a net increase in available power."

Since it is uncertain whether Hecate and Willowbrook will be built, it is no surprise that no shutdowns have yet been planned. It is not clear why the Regionomics Report does not examine possible shutdowns if Hecate and Willowbrook are, in fact, constructed.

Peak energy demand in Ohio must be met. If part of this energy demand is met by Hecate and Willowbrook, it will not be met by other generation sources. At a minimum, this will reduce the revenue and profitability of competing plants, reducing state tax revenue and potentially reducing employment. This will also send a signal to potential new power plants in Ohio that they better build in states that do not subsidize competitors. Not recognizing these negative economic impacts results in an overstatement by the Regionomics Report of ongoing net economic benefits.

The Regionomics Report also fails to quantify the negative impact of higher electricity rates for AEP Ohio customers. The REPA rates for Hecate and Willowbrook are much higher than PJM market rates for traditional generation and are much higher than PPA rates for traditional generation. In addition, AEP Ohio customers will have to pay an additional amount for debt equivalency cost recovery. When AEP Ohio customers pay more for electricity, they spend less on local businesses, hurting the local economy, reducing sales tax revenue, reducing employment, and discouraging new businesses from locating in Ohio. In addition, higher electricity rates result in higher operating cost for Ohio businesses, reducing profitability, reducing employment, and further discouraging new businesses from locating in Ohio. Not

recognizing these negative economic impacts results in an overstatement by the Regionomics Report of ongoing net economic benefits.

Although the construction of Hecate and Willowbrook will likely bring some economic benefits to Ohio during the construction phase, the ongoing impact of Hecate and Willowbrook is likely to hurt the Ohio economy – consistent with the general principle that subsidization interferes with the free market and is harmful to the overall economy.

Non-quantitative socio-economic benefits

The Regionomics Report addressed the following categories of non-quantitative socio-economic benefits:

- Public health benefits;
- Enhanced gender equality in the energy industry;
- Economic benefits;
- General benefits of improved living standards; and
- Helping address the growing Opioid crisis.

Each of these non-quantitative socio-economic benefits is now discussed.

Public health benefits. The Regionomics Report links public health benefits to high fatality rates associated with oil & gas extraction and coal mining. The Regionomics Report doesn't actually state that Hecate and Willowbrook will result in less oil & gas extraction and less coal mining, but these public health benefits would not otherwise occur. If less oil & gas extraction and less coal mining do result from Hecate and Willowbrook, which is implied, the negative economic consequences to Ohio should have been quantified, which they were not.

Enhanced gender equality in the energy industry. The Regionomics Report states that the oil and gas exploration field employs about 12.8% women whereas the renewable energy sector employs about 35% women. The Regionomics Report doesn't actually state that Hecate and Willowbrook will result in less oil & gas exploration, and does not address the more relevant

industry of oil & gas extraction at all. If less oil & gas exploration result from Hecate and Willowbrook, which is implied, the negative economic consequences to Ohio should have been quantified, which they were not. The Regionomics Report does not explain why an industry employing fewer women than men represents gender inequality. If true (which it is not), the renewable energy sector is also guilty of gender inequality.

The Regionomics Report is basically arguing that shifting jobs from oil & gas exploration to the renewable energy sector is good because more women will be employed and fewer men will be employed. The Regionomics Report makes no specific argument for gender equality at all. Even so, the Regionomics Report does not quantify any impact to the reduction in oil and gas exploration employment.

Economic Benefits. The Regionomics Report addresses non-quantifiable economic benefits by arguing that local job creation will not come at the expense of extraction jobs. It argues that oil and gas exploration employment is increasing in Ohio and so Hecate and Willowbrook should not have any impact. This is not a valid conclusion at all. Any energy produced by renewable resources reduces energy produced by fossil fuels, which is the entire purpose of renewable energy. When convenient, the Regionomics Report assumes a reduction in extraction jobs. When not convenient, the Regionomics Report assumes a reduction in extraction jobs will not occur.

General benefits of improved living standards. This section argues that an improved Ohio economy will result in a host of benefits for Ohio residents including better health, personal security, and subjective well-being. It also urges for public policies that "help close the income gaps among social groups." As discussed earlier, forcing AEP Ohio ratepayers to pay for uneconomic energy and to further pay for debt equivalency cost recovery will harm the Ohio economy, not help it. It will also disproportionally impact low-income customers, thereby increasing the purchasing power gap among social groups.

Helping address the growing opioid crisis. The Regionomics Report does not say how the construction of Hecate and Willowbrook will specifically help to mitigate the opioid crisis, which it cannot. Forcing AEP customers to pay higher rates for uneconomic energy and to pay

further amounts for debt equivalency cost recovery will not help the opioid crisis. There is no free lunch when it comes to industry subsidization, and certainly no free opioid crisis benefit.

4. Project Need

AEP Ohio is required to demonstrate a public need for the 100 MW Willowbrook project and the 300 MW Hecate project. Traditionally the term "need" in the context of new generation facilities would refer to one of the following:

- Forecasted generation capacity is not sufficient to meet forecasted electricity demand. New generation capacity is therefore needed; or

- Forecasted renewable generation capacity is not sufficient to meet required renewable generation portfolio obligations. New renewable generation capacity is therefore needed.

By its own admission, AEP Ohio does not need either of the two solar projects according to the two criteria listed above. Furthermore, it is the role of the PJM capacity market to ensure adequate generation resources for the PJM load, which it does. Because there is no need in the traditional sense, AEP Ohio uses a new interpretation of "need." AEP essentially argues that it needs these projects because new solar projects in Ohio would be a good thing.

To be more specific, (1) AEP Ohio argues that it customers <u>want</u> more renewable generation in Ohio, and therefore these two specific solar projects are needed; and (2) that renewable generation projects in Ohio are good for Ohio, and therefore these two specific solar projects are needed. Even if true, which they are not, neither of the above arguments demonstrates need.

The remainder of this section discussed why these two specific projects are not needed to serve load, are not needed for renewable portfolio requirements, and would not be wanted by most fully-informed AEP Ohio customers.

The Navigant Survey

AEP Ohio retained the consulting company Navigant to survey customers about renewable energy. Results of this survey are documented in the report "AEP Ohio Voice of the Customer: Attitudes and Expectations for Renewable Energy." This report is sponsored by Navigant consultants Nicole Fry and Trina Horner in their direct testimony.

In the introduction, the report states, "This report seeks to examine AEP Ohio customer expectations by assessing attitudes and behaviors of the utility's energy customer segments as well as legal and regulatory requirements."

Navigant worked with AEP Ohio to randomly select customers from the following three segments: residential customers on a Percent of Income Payment Plan (PIPP), residential non-PIPP customers, and small commercial/industrial customers (C&I). The survey completion rate for each of these customer segments is shown in Table 4-1.

Table 4-1. Survey Completion Rate

Metric	Residential Non-PIPP	Residential PIPP	Small C&I
Survey Invitations Sent	120,000	20,000	20,000
Survey Invitations Completed	7,498	6,670	664
Completion Rate	6.2%	33.4%	3.3%

Response rates for the survey are very low, especially for residential non-PIPP and Small C&I (only residential non-PIPP and Small C&I were asked willingness-to pay questions). These low response rates raise a large concern about non-response bias. How does Navigant know that the opinions of the small percentage of responding customers are representative of the opinions of all AEP Ohio Customers? Unfortunately, Navigant does <u>not</u> know if survey responses are representative of all customers and does not even address the issue of non-response bias in its Report.

For example, the Report states, "The survey also revealed that a majority of residential non-PIPP customers and many small C&I customers are willing to pay some additional amount on their

electricity bills for AEP Ohio investments in renewable energy." This statement is factually incorrect, as it only reveals information about responding customers, not all customers.

The survey design is described in Appendix A of the Report. Customers were sent an online survey link with the message, "The purpose of this survey is to better understand your perspective on utility-sourced renewable generation." The vast majority of customers did not complete the survey: 92.8% of residential non-PIPP customers and 96.7% of small C&I customers did not complete the survey. This raises the question, "Which type of customer actually completed the survey and are they representative of their broader customer class?" It is possible (and I think likely) that renewable energy advocates were far more motivated to complete the survey and, therefore, the survey results are primarily representative of renewable energy advocates. I do not know for sure and Navigant does not know for sure.

Non-response bias is a problematic issue for on-line surveys. However, a transparent description of the intended use of the survey would at least have provided potential respondents the proper context when choosing to spend their valuable time in responding or not. A comparison of the actual survey invitation versus a more descriptive survey invitation illustrates this point:

> **Actual Survey Invitation**
> The purpose of this survey is to better understand your perspective on utility-sourced renewable generation.
>
> **A More Descriptive Survey Invitation**
> Results of this survey will be used to justify the construction of new renewable electricity generation facilities in Ohio. AEP Ohio is seeking regulatory approval to purchase the output of at least 900 MW of new Ohio renewable generation facilities at a fixed rate over twenty years. If market rates are higher than fixed rates, ratepayers will pay the difference. If market rates are less than fixed rates, ratepayers will be credited the difference. AEP Ohio intends to keep rates confidential. For each approved facility, AEP Ohio will charge customers a "debt equivalency" cost each year.

It is likely that customers interested in the specific issue of RGR approval would be more likely to respond to the survey with the more descriptive invitation, leading to a more balanced response between pro-renewable customers and keep-rates-low customers.

Another survey design flaw relates to response choices for certain questions. A proper survey design will provide a balance of positive and negative response choices to avoid biasing the response. For example, some of the survey questions have response options of the following:

Unbiased response choices

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

There is a certain amount of random variation in multiple-choice question responses. When negative and positive choices are balanced (such as with the unbiased response choices shown above), positive choices due to random variation will tend to cancel out negative choices due to random variation. Compare this to the biased response choices shown below, which are used in some of the survey questions.

Biased Response Choices

- Not important
- Slightly important
- Moderately important
- Important
- Very important

The above response choices are biased in that there are four choices indicating importance and only one choice indicating non-importance. Therefore, any randomness in responses will bias overall survey results to indicate more importance than actually exists. Consider a hypothetical situation where all respondents provide a purely random response. Instead of the survey properly resulting in a neutral result, the biased question will result in an incorrect "moderately important" result. Response choices that avoid this problem are the following:

Unbiased Alternative Response Choices

- Very unimportant
- Unimportant
- Neutral
- Important
- Very important

In summary, results from the Navigant survey are flawed due to a non-transparent survey invitation, very low response rates, the possibility of significant non-response bias, and biased response choices for certain questions. It is not appropriate to give this survey any weight whatsoever when attempting to understand AEP Ohio ratepayer opinions regarding specific renewable generation riders.

Willingness to Pay for Green Power

Many utilities have voluntary "Green Power" programs that allow customers to voluntarily pay more on their electricity bill, with this extra amount being used to fund green power generation through a variety of mechanisms.[9] It is therefore better to use actual customer behavior to assess customer willingness-to-pay rather than relying on surveys.

The National Renewable Energy Laboratory has performed an assessment of utility green power programs in 2017. [10] Green power programs with the most number of participants are shown in Table 4-1. I have also included the total number of utility retail customers, allowing a participation rate to be calculated. I have also included the name of each program and the participation cost.

Table 4-1. Largest Green Power Programs by Participants

Rank	Utility	Participants	Total Customers	Participation Rate	Program	Cost ($/kWh)
1	Portland General Electric	173,856	875,000	19.9%	Green Source	0.0080
2	PacifiCorp	120,423	1,867,000	6.5%	Blue Sky	0.0105
3	Xcel Energy (Colorado)	113,772	1,400,000	8.1%	Renewable Connect	0.0010
4	Sacramento Municipal Utility District	71,873	1,500,000	4.8%	Greenergy	0.0050
5	Puget Sound Energy	46,211	1,100,000	4.2%	Green Power	0.0100
6	Dominion Energy (Virginia)	27,779	2,500,000	1.1%	Green Energy	0.0130
7	DTE Energy	22,425	2,200,000	1.0%	MI Green Power	0.0315
8	Austin Energy	17,557	450,000	3.9%	Green Choice	0.0075
9	National Grid	16,955	3,400,000	0.5%	New England Wind	0.0380
10	Avangrid (NYSEG and RG&E)	15,539	1,272,500	1.2%	New Wind Energy	0.0250
	Total	**626,390**	**16,564,500**	**3.8%**		

[9] AEP Ohio is proposing such a voluntary green energy program in this proceeding, which is not relevant to my analysis or conclusions in this section.

[10] www.nrel.gov/analysis/assets/pdfs/utility-green-power-ranking.pdf

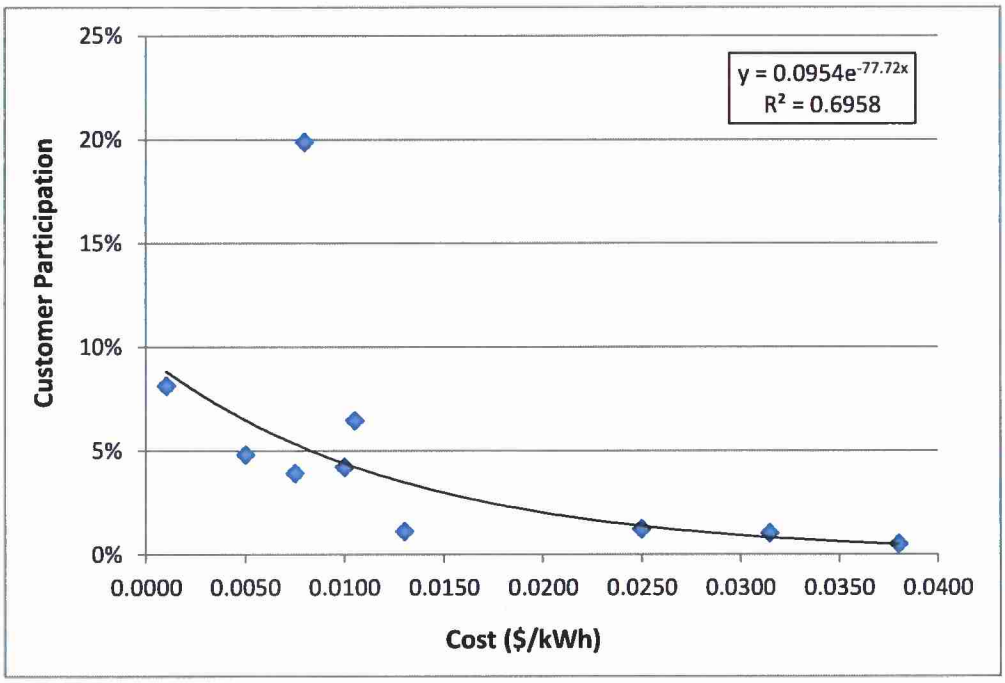

Figure 4-1. Customer Participation vs. Green Power Program Cost

A graph of customer participation versus green power program cost is shown in Figure 4-1. I have also included an exponential curve fit, which resulted in a higher r-squared value than linear, logarithmic, and power function options.

As can be seen, from Figure 4-1, customer participation rates tend to decrease as program participation cost increases. The data is well-behaved, with the sole outlier being Portland General Electric (a municipal service territory). Table 1 demonstrates that well over ninety five percent of customers that have the option to participate in the largest utility green power programs choose not to do so. Figure 4-1 shows that when green power programs costs are greater than $0.01 per kWh, over 98.8 percent of customers choose not to participate.

AEP Ohio Initial and Amended Forecast

On April 16th 2018 AEP Ohio submitted its 2018 Long-Term Forecast Report ("LTFR") to the Commission, and supplemented the 2018 LTFR on May 31st 2018 ("LTFR Supplement"). Neither of these filings identified any potential generation shortfalls, any concern with the availability of renewable resources to meet renewable portfolio targets, any concern with the availability of solar resources to meet solar carve-out requirements, or any concerns about a lack of renewable generation facilities in Ohio.

On Sept. 19th 2018 AEP Ohio filed an Amended LTFR "to demonstrate the need for at least 900 megawatts (MW) of renewable energy in Ohio." This demonstration of need is a requirement for renewable energy projects to receive cost recovery through a PPA rider. Specifically, the Electric Security Plan (ESP) statute requires that the commission "first determines in the proceeding that there is a need for the facility based on resource planning projections submitted by the electric distribution facility."

As mentioned, the filed LTFR and LTFR supplement do not demonstrate any need for new renewable generation facilities in Ohio or elsewhere. The Amended LTFR recognizes this and states the following:

Amended LTFR Admissions

- "PJM wholesale markets are adequately supplying capacity and energy to the AEP Ohio Load zone."
- "And the Company acknowledges that the PJM wholesale markets are adequately supplying capacity and energy to the AEP load zone."
- "Nor is the Company proposing through this filing that it has a traditional integrated resource planning (IRP) need for generation."

And so, there is no traditional resource planning need for renewable generation facilities generally, there is no traditional resource planning need for renewable generation facilities in Ohio specifically, and is there is no traditional resource planning need for either Hecate or Willowbrook. If Hecate and Willowbrook are not built, AEP Ohio and its customers will be just

fine. In fact, AEP Ohio only wants Hecate and Willowbrook to be built if it gets rider treatment including debt equivalency cost recovery. AEP Ohio is fine with Hecate and Willowbrook not being built otherwise, and does not mention anywhere in any of its filings how it will address the supposed "need" of Willowbrook and Hecate if they are not constructed and the "need" is therefore not addressed.

In short, AEP Ohio admits that there is no need for Hecate and Willowbrook in the "traditional integrated resource planning." The Amended LTFR therefore argues for need in ways not related to the statutory language of "based on resource planning projections."

I will now describe how all of the arguments for need in the Amended LTFR are not related to the statutory requirement that need be "based on resource planning projections." The arguments are presented as Arguments 1 through 6 in the Amended LTFR.

Amended LTFR Argument 1: Provided the projects can be developed within a reasonable price range, large-scale development of Ohio renewable energy projects support a finding of need by conveying a price advantage and rate stability for customers.

Argument 1 of the Amended LTFR does not shows a need for Hecate and Willowbrook based on resource planning projections. It is an economic argument, not a resource planning argument. In its elaboration of Argument 1, the Amended LTFR does not cite any resource planning data or analyses whatsoever.

Argument 1 has additional weaknesses beyond it not being related to resource planning projections. The first is that PJM is a free market specifically created to provide the lowest cost of energy. Interfering with the PJM market by allowing new generation sources not having to compete results in a less efficient market and a corresponding higher cost of energy. The second is that the AEP economic analysis is flawed, as discussed in Section 3. The that Hecate and Willowbrook REPA rates are far higher than other recent solar PPAs, also discussed in Section 3.

Amended LTFR Argument 2: A formal study by an independent consultant shows that AEP Ohio customers want and need long-term renewable power generated by new Ohio renewable projects.

Argument 2 of the Amended LTFR does not shows a need for Hecate and Willowbrook based on resource planning projections. It is a customer preference argument, not a resource planning argument. In its elaboration of Argument 2, the Amended LTFR does not cite any resource planning data or analyses whatsoever.

Argument 2 intentionally misrepresents the Navigant Study by stating it shows that AEP Ohio customers "need" long-term renewable power generated by new Ohio renewable projects. The study itself makes no such conclusion (or anything close), and none of the survey questions ask anything even closely related to customer need. Some of the survey questions ask whether the customers feel that it is "important" for AEP Ohio to make greater use of renewable generation generally and in Ohio. The survey questions and Report conclusions address customer preferences (i.e., "want"), not customer need.

Further, the Navigant Study has major flaws that likely result in its conclusions not being representative of all AEP Ohio customers (see Section 4).

Last, in its elaboration of Argument 2, the LTFR makes arguments that are not addressed in the Navigant Study at all. These extraneous arguments are made without providing any supporting evidence whatsoever. Examples of completely unsupported statements in Argument 2 include: (1) "Numerous major commercial and industrial customers in Ohio have announced that they are planning to energize their businesses, manufacturing plants, data centers, or other corporate locations with renewable energy." (2) "Those customers and others … have publically committed to purchase renewable energy." (3) "… it is far from evident that the competitive market will meet the renewable needs of AEP Ohio customers," and (4) … there is an unfulfilled customer need for development of renewable energy projects deliverable to AEP Ohio's service territory." Argument 2 does not cite a single commercial customer that has a specific and unfulfillable need for Ohio produced renewable energy.

Amended LTFR Argument 3: Developing renewable projects in Ohio that are deliverable to AEP Ohio's service territory can help reduce congestion costs and ultimately transmission rates.

Argument 3 of the Amended LTFR does not shows a need for Hecate and Willowbrook based on resource planning projections. It is an economic argument, not a resource planning argument. In its elaboration of Argument 3, the Amended LTFR does not cite any resource planning data or analyses whatsoever.

Argument 3 relies on the results of a computer simulation of Locational Marginal Prices using the computer program PROMOD. However, the results are not based simulations of Hecate and Willowbrook, which constitute 400 MW of new solar. Rather, the results are based on "three renewable energy projects (one wind and two solar projects)" that have a combined capacity of 650 MW. Any PROMOD results demonstrating the LMP impact of Hecate and Willowbrook should be based on 400 MW of new solar located at the approximate proposed locations of Hecate and Willowbrook.

It should be noted that transmission congestion is properly managed by PJM, the regional PJM transmission planning process according to FERC Order 890 and FERC Order 1000, and the resulting PJM Regional Transmission Expansion Plan. This process would be untenable if each distribution utility in PJM justified building its own generation facilities based on congestion mitigation.

Amended LTFR Argument 4: There is a clear urgency to develop renewable projects in Ohio because significant federal tax credits are expiring soon.

Argument 4 of the Amended LTFR does not shows a need for Hecate and Willowbrook based on resource planning projections. It addresses "urgency," not need. In its elaboration of Argument 4, the Amended LTFR does not cite any resource planning data or analyses whatsoever.

In fact, the Federal Investment Tax Credit (ITC) for commercial solar systems currently has no expiration date. According to current legislation, benefits are scheduled to decline but then

remain permanently at 2022 levels. Of course, Congress can and does change tax law all the time. The original ITC was enacted in 2005 and was only for two years. It was extended in 2006 for an additional year, was extended again in 2008 for an additional 8 years, was modified in 2015 to its current form, and was maintained in 2017 legislation.

Amended LTFR Argument 5: New renewable projects in the state will help reverse the trend that Ohio is a net importer of power and avoid Ohio consumers being price-takers for out-of-state generation supply.

Argument 5 of the Amended LTFR does not shows a need for Hecate and Willowbrook based on resource planning projections. It is an Ohio Economy argument, not a resource planning argument. In its elaboration of Argument 5, the Amended LTFR does not cite any resource planning data or analyses whatsoever.

Argument 5 states that "... payment of Ohio's energy dollars to out-of-state generators provides economic development benefits to residents and businesses in those states. Investing in in-state, utility-scale renewable generation will help to reverse this trend." Argument 5 seems to be asserting that subsidizing Ohio industries that cannot compete with out-of-state competitors is good for the Ohio economy. This reasoning is contrary to economic theory. Forcing Ohio ratepayers to pay more for electricity will result in net harm to the Ohio economy. Subsidies only result in potential net economic benefits to an economy when used to counter unfair competition, which is not the case for Hecate and Willowbrook.

Amended LTFR Argument 6: New renewable projects in the state will promote fuel diversity, advance the development of renewable technology, and help reduce carbon emissions in Ohio.

Argument 6 of the Amended LTFR does not shows a need for Hecate and Willowbrook based on resource planning projections. It is mostly an emotional argument, not a resource planning argument. In its elaboration of Argument 6, the Amended LTFR does not cite any resource planning data or analyses whatsoever.

Building Hecate and Willowbrook will not "promote fuel diversity." There is a robust free market for renewable energy in PJM. Building Hecate and Willowbrook will only result in some of the utility demand being met through subsidized facilities rather than through more competitive facilities.

Building Hecate and Willowbrook will not "advance the development of renewable technology." I can think of no research, development, or innovation related to renewable technology that would occur only if Hecate and Willowbrook are built. AEP Ohio presents absolutely no evidence to support this statement, nor can it.

Building Hecate and Willowbrook will not "help reduce carbon emissions in Ohio." The only scenario where this might be true is if the construction of Hecate and Willowbrook result in either (1) a CO_2 emitting plant that would have been built in Ohio is not built; or (2) a CO_2 emitting plant that exists in Ohio would have remained in service, but decided to shut down because Hecate and Willowbrook are built. The Amended LTFR presents no evidence whatsoever that either will happen, which they will not.

In summary, ESP statute requires that the commission "first determines in the proceeding that there is a need for the facility based on resource planning projections submitted by the electric distribution facility." AEP Ohio presents six reasons why it thinks building Hecate and Willowbrook is a good idea, but none of these reasons are related to resource planning projections, and do not show need based on resource planning projections.

5. Project Ownership and Operation

The RGR requires AEP Ohio to either own or operate the renewable generation facilities. AEP Ohio will not own either Hecate or Willowbrook.

It is the position of AEP Ohio that it will operate the Solar Projects such as to comply with the requirements of Section 4928.148(B)(2)(c) of the Ohio Revised Code. However, the only significant operational role of AEP Ohio will be to serve as the role of Market Participant. All other operational activities of Hecate are the contractual responsibility of Hecate Energy LLC. All other operational activities of Willowbrook are the contractual responsibility of Willowbrook Solar I, LLC.

A more detailed discussion of operational responsibilities of the Solar Projects is now provided.

Operation of Hecate

Operational responsibilities of Hecate are enumerated in the Hecate REPA. Article 10 specifically addresses Operations and Maintenance. Section 10.1 is titled "Facility Operation" and summarizes the operational responsibility of the Hecate Energy LLC (Seller) and AEP Ohio (Purchaser) as follows:

> 10.1 Facility Operation.
>
> As described in Sections 5.3 and 5.6, the Facility will be associated with Purchaser's PJM sub-account and Purchaser will be responsible for PJM Market Participant duties, including scheduling requirements. In addition to the operation of the Facility by Purchaser through the exercise of PJM Market Participant duties, Seller shall perform other maintenance and operation functions as described in this REPA on behalf of Purchaser, as Purchaser is generally considered the operator of the Facility. Seller hereby represents that it is and will remain a Qualified Operator during the Delivery Period or that Seller will engage a Qualified Operator to operate and maintain the Facility during the Delivery Period. Seller shall staff, control, and operate the Facility consistent at all times with Good Utility Practice(s) and the Contract Administration Procedures developed pursuant to Section 10.3. Personnel capable of starting, operating, and stopping the Facility shall be available, either at the Facility or capable of remotely starting, operating and stopping the Facility. In all cases, personnel capable of starting, operating, and stopping the Facility shall be continuously reachable by phone or pager. Seller shall maintain the Communications Equipment in good operating order at all times during the Term.

Figure 5-1. Hecate Operational Responsibilities

It is clear from Section 10.1 the sole operational responsibility of AEP Ohio is to be the PJM Market Participant. It is also clear from Section 10.1 that the Hecate Energy LLC shall perform all other required maintenance and operational functions for the facility. Some of the operational responsibilities of the Hecate Owner include the following:

- "remain a Qualified Operator .. or engage a Qualified Operator … to operate and maintain the Facility"
- "staff, control, and operate the Facility consistent at all times with Good Utility Practices"
- "Personnel capable of starting, operating, and stopping the Facility shall be available"
- "shall maintain the Communications Equipment in good operating order"

Specific operational responsibilities are detailed throughout the REPA, with AEP Ohio only being responsible for serving as the PJM Market Participant and the Hecate Energy LLC being responsible for all other operational responsibilities.

Despite the fact that the Hecate Owner is responsible for the vast majority of Facility operational duties, Section 10.1 states that these operational duties shall be performed "on behalf of Purchaser, as Purchaser is generally considered the operator of the Facility." This statement is

simply defining AEP Ohio as the operator of the facility even though it contractually prevented from performing virtually all operational functions. The actual operator of a facility is the entity that is contractually obligated to perform operational functions. In this case, the operator of the facility is clearly the Hecate Energy LLC, not AEP Ohio.

The statement in Section 10.1 that AEP Ohio "is generally considered the operator of the Facility" is meaningless. Who, precisely, would consider AEP Ohio to be the operator of the Facility when it is contractually prevented from operating the facility? In my opinion, under the circumstances, that AEP Ohio would not be the owner of operator of the facility

Operation of Willowbrook

Operational responsibilities of Willowbrook are enumerated in the Willowbrook REPA. Article 10 specifically addresses Operations and Maintenance. Section 10.1 is titled "Facility Operation" and summarizes the operational responsibility of Willowbrook Solar I LLC (Seller) and AEP Ohio (Purchaser) as follows:

10.1 Facility Operation.

As described in Sections 5.3 and 5.6, the Facility will be associated with Purchaser's PJM sub-account and Purchaser will be responsible for PJM Market Participant duties, including scheduling requirements. In addition to the operation of the Facility by Purchaser through the exercise of PJM Market Participant duties, Seller shall perform other maintenance and operation functions as described in this REPA on behalf of Purchaser, as Purchaser is generally considered the operator of the Facility. Seller hereby represents that it is and will remain a Qualified Operator during the Delivery Period or that Seller will engage a Qualified Operator to operate and maintain the Facility during the Delivery Period. Seller shall staff, control, and operate the Facility consistent at all times with Good Utility Practice(s) and the Contract Administration Procedures developed pursuant to Section 10.3. Personnel capable of starting, operating, and stopping the Facility shall be available, either at the Facility or capable of remotely starting, operating and stopping the Facility. In all cases, personnel capable of starting, operating, and stopping the Facility shall be continuously reachable by phone or pager. Seller shall maintain the Communications Equipment in good operating order at all times during the Term.

Figure 5-2. Willowbrook Operational Responsibilities

It is clear from Section 10.1 the sole operational responsibility of AEP Ohio is to be the PJM Market Participant. It is also clear from Section 10.1 that the Willowbrook Solar I shall perform all other required maintenance and operational functions for the facility. Some of the operational responsibilities of Willowbrook Solar I include the following:

- "remain a Qualified Operator .. or engage a Qualified Operator to operate and maintain the Facility"
- "staff, control, and operate the Facility consistent at all times with Good Utility Practices"
- "Personnel capable of starting, operating, and stopping the Facility shall be available"
- "shall maintain the Communications Equipment in good operating order"

Specific operational responsibilities are detailed throughout the REPA, with AEP Ohio only being responsible for serving as the PJM Market Participant and Willowbrook Solar I being responsible for all other operational responsibilities.

Despite the fact that Willowbrook Solar I is responsible for the vast majority of Facility operational duties, Section 10.1 states that these operational duties shall be performed "on behalf

of Purchaser, as Purchaser is generally considered the operator of the Facility." This statement is simply defining AEP Ohio as the operator of the facility even though it contractually prevented from performing virtually all operational functions. The actual operator of a facility is the entity that is contractually obligated to perform operational functions. In this case, the operator of the facility is clearly Willowbrook Solar I, not AEP Ohio.

The statement in Section 10.1 that AEP Ohio "is generally considered the operator of the Facility" is meaningless. Who, precisely, would consider AEP Ohio to be the operator of the Facility when it is contractually prevented from operating the facility? In my opinion, under the circumstances, that AEP Ohio would not be the owner of operator of the facility.

6. Baseload Generation

A bulk electric power system can be thought of as having "baseload generation," which is available to generate electricity at full output for a large percentage of the time, and non-baseload generation, which cannot. Solar generation facilities do not contribute significantly to baseload generation, since they can only provide electricity when the sun is shining, and therefore may not be available when needed (e.g., it is not "dispatchable").

Electricity markets such as PJM must ensure that there is enough baseload generation to supply peak electricity demand. The percentage of generation plant output that can be counted on to supply peak demand is called its "capacity credit." Traditional sources of electricity such as coal-fired plants, natural-gas-fired plants, and nuclear plants have a capacity credit of 100%.

When calculating the value of capacity bids for Willowbrook and Hecate into the PJM market, Mr. Torpey uses a capacity credit of 19%.

The low capacity credit of solar facilities means that the construction of solar facilities does not significantly reduce the need for new traditional generation. For example, assume that PJM forecasts the need for 1000 MW of new baseload generation. Now assume that 1000 MW of solar facilities is approved to be built. If the solar facilities are assigned a capacity credit of 19%, they will only contribute to 190 MW of the required new baseload generation, and 810 MW of new traditional generation will still have to be built. These two scenarios are:

Options for Meeting 1000 MW of PJM Demand Increase

1. Add 1000 MW of traditional generation; or
2. Add 810 MW of traditional generation and 1000 MW of solar facilities.

In Option 2, the same amount of energy will be produced through facilities costing much more to build, resulting in higher electricity rates. The electricity produced by solar will not produce emissions, but most new traditional generation in Ohio has been combined-cycle natural gas plants.

The trend towards more electricity production based on natural gas is true for both the United States as a whole and for Ohio specifically. A chart showing U.S. historical electric generation capacity additions is shown in Figure 6-1.[11]

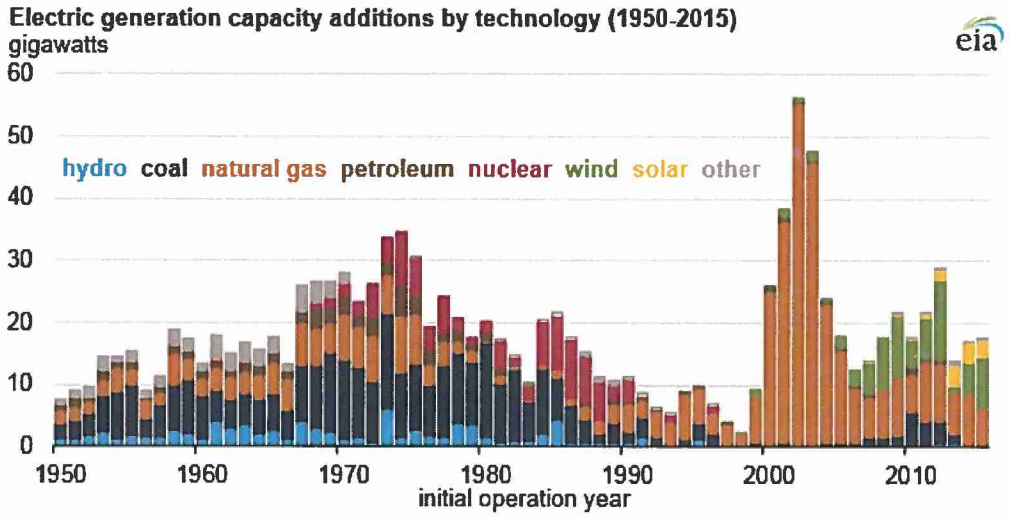

Figure 6-1. Electric generation capacity additions

As can be seen from Figure 6-1, coal plant capacity additions in the U.S. virtually stopped in the late 1990s, with many of the worst-emitting coal plants having been shut down. This, coupled with a simultaneous dominance in natural gas plant and wind farm capacity additions, has resulted in significantly lower overall annual power plant emissions in the U.S.

In Ohio, the amount of electricity produced by natural gas and renewables is increasing and the amount of electricity produced by coal is decreasing. Historical data is available from the U.S. Energy Information Agency (EIA).[12] A graph based on EIA data is shown in Figure 5-2.

[11] http://www.eia.gov/todayinenergy/detail.cfm?id=25432

[12] EIA power generation data available at eia.gov/electricity/data/browser

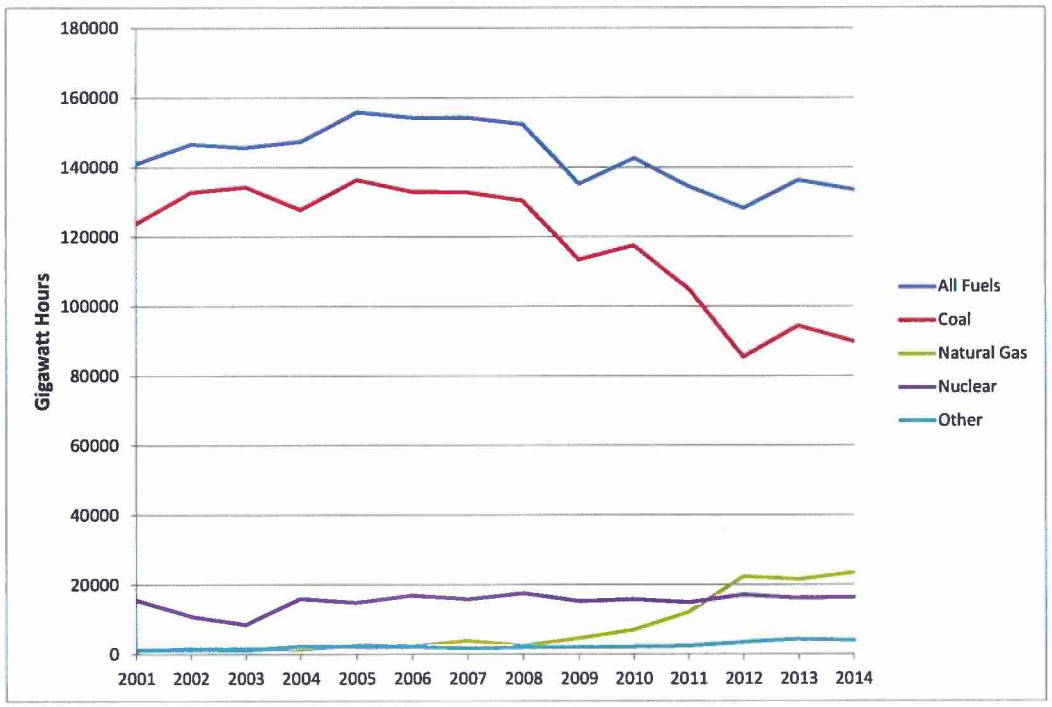

Figure 5-2. Historical Energy Production in Ohio

As can be seen, electricity generation from coal has dropped from a high of about 136,000 GWh in 2005 to a low of about 90,000 GWh in 2014, a drop of about 44%. At the same time, electricity generation from natural gas has grown from a low of about 0.7 GWh in 2001 to a high of about 23 GWh in 2014, growth of over 3000 percent. Electricity generation from "other" sources, including renewables, has experienced a significant increase.

And so, PJM will have to build traditional baseload generation regardless of the extent to which new solar facilities are built. Virtually all of this baseload generation will be through efficient combined-cycle natural gas plants, which have lower annual carbon emissions. The effect of new Ohio solar capacity will not significantly impact the need for new baseload construction, but may deter baseload construction development due to market distortions, which is discussed in Section 7.

Ancillary Services

The preceding section discussed the differences between traditional generation facilities and solar facilities with respect to base load. Traditional generation facilities are dispatchable and are therefore available when necessary to supply load. Solar generation facilities are not dispatchable and their full output cannot be counted on to supply load.

There are other engineering functions that are required for a reliable bulk power system. These "ancillary services" can be provided by traditional sources of generation such as nuclear power plants, coal-fired power plants, and natural gas-fired power plants. These ancillary services cannot be provided by solar facilities. In de-regulated wholesale markets like PJM, ancillary services are provided by the market in a manner similar to energy and capacity.

PJM currently operates three markets for ancillary services – regulation, synchronized reserve and non-synchronized reserve. PJM describes these as follows (emphasis added):[13]

> **Regulation service** corrects for short-term changes in electricity use that might affect the stability of the power system. It helps match generation and load and adjusts generation output to maintain the desired frequency.
>
> **Synchronized reserve and non-synchronized reserve services** supply electricity if the grid has an unexpected need for more power on short notice. The power output of generating units supplying synchronized reserve can be increased quickly, while units providing non-synchronized reserve can be brought online quickly, to supply the needed energy to balance supply and demand.
>
> **Load-serving entities can meet their obligations** to provide regulation or synchronized reserve to the grid by using their own generation, by purchasing the required regulation or synchronized reserve under contract with another party or by buying them in the Regulation or Synchronized Reserve markets.

[13] https://learn.pjm.com/-/media/about-pjm/newsroom/fact-sheets/pjms-markets-fact-sheet.ashx

And so, load-serving entities like AEP Ohio cannot just purchase the energy output of renewable facilities such as Hecate and Willowbrook. They must also purchase all required ancillary services which are almost entirely are provided by traditional power plants.

Large-scale penetration of solar generation in an area can adversely impact reliability and may eventually increase the amount of ancillary services that load-serving entities are required to purchase (resulting in price increases for customers). Consider Southern California, which has a very large penetration of rooftop solar and utility-scale solar. Certain grid disruptions can result in all of this solar capacity tripping off line at the same time, creating a mismatch between the remaining generation and load. Currently, ancillary services are designed to accommodate the loss of the largest single generation facility. When solar capacity exceeds this amount, the system may not be able to recover if all of the solar facilities trip off line, per current practices.

7. Market Distortion

Since 2005, solar generation in the U.S. has been subsidized by a Federal investment tax credit (ITC), in which the Federal Government gives a tax credit for a certain percentage of construction costs, effectively having U.S. tax payers pay for part of the solar facility. The ITC has been a strong incentive for new solar facilities by developers, but has created significant distortion in wholesale electricity markets, including PJM. There are also accelerated depreciation tax benefits for solar facilities (Modified Accelerated Cost-Recovery System, MACRS).

The ITC was originally established by the Energy Policy Act of 2005. The current tax credit is 30% but is scheduled to ramp down starting in 2020 and then stabilizing in 2022 at 10%. Details are as follows:

ITC for Commercial Solar Facilities

- 2019: receive ITC of 30%.
- 2020: receive ITC of 26%.
- 2021: receive ITC of 22%.
- 2022: receive ITC of 10%.
- ITC remains at 10% permanently.

And so, solar facilities have been the beneficiaries of significant Federal subsidies for about 14 years. There have also been significant subsidies at the state level such as tax credits and renewable portfolio standards (RPS). For example, Ohio has an RPS that requires utilities to increase their production/procurement of energy from alternative energy sources to 12.5% by 2026, or pay significant penalties.

Federal subsidies and state RPSs have successfully resulted in more solar facilities. There are positive aspects to this but also negative aspects. Consider the PJM energy market. Since solar facilities have zero fuel cost they, once built, produce as much energy as they can all the time. When selling into the market, they can bid a zero price and are first in line to receive the market

clearing price for their output. If selling through a PPA, the energy supplied by the solar facility is not available for other generation facilities to bid on through the market. In both situations, the solar facilities displace generation facilities that are potentially more cost-effective without considering subsidies. This will make the displaced facilities less profitable and more likely to de-commission. This is also a deterrent for potential new facilities (that are potentially more cost-effective without considering subsidies) to be constructed.

Another negative impact of solar ITCs is their regressive nature and resulting negative impact on poor customers since ITCs (and state RPSs) result in higher electricity costs. Since poor households spend a higher percentage of income on electricity, ITCs and RPSs have a higher negative economic impact on poor customers when compared to rich customers. A recent paper by Dan Quinley of the UC Davis California Environmental Law & Policy Center summarizes this issue as follows:[14]

> "The existing federal and state renewable energy tax policies provide a stark reminder of the negative impact tax programs can have. The programs interact with other policies to create a system that redistributes tax benefits to wealthier tax brackets and creates a regressive tax on electric consumption."

And so, there are potential benefits to solar subsidies but a host of negative impacts as well. A recent paper by the Institute of Political Economy at Utah State University summarizes these negative impacts as follows:[15]

- Federal policies intended to boost solar energy production distort the market, unfairly transfer wealth, add to taxpayers' burden, and transfer risk from solar power producers to taxpayers.

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[14] D. Quinley, "More Power to the Wealthy: Renewable Energy Tax Programs, Markey Distortions, and the Ramifications on the Cost of Electricity," UC Davis California Environmental Law & Policy Center, May 23, 2017. https://law.ucdavis.edu/centers/environmental/files/More%20Power%20to%20the%20Wealthy%20Quinley.pdf

[15] M. E. Hansen, et. al., "The Unseen Costs of Solar-Generated Electricity," Institute of Political Economy at Utah State University. www.usu.edu/ipe/wp-content/uploads/2016/04/UnseeSolarFull.pdf

- State policies like mandates, tax incentives, feed-in tariffs, and net metering arbitrarily pick winners and losers and increase the burden on state taxpayers.
- Federal and state policies result in opportunity costs—taxpayers lose the benefits their tax dollars could have paid for had those funds been left in the hands of individuals with better local knowledge of how to spend their money.
- Government policies incentivize solar energy, distorting the energy market. Solar energy's inability to meet demand consistently leads to reduced grid reliability.
- Because solar energy is unreliable, conventional generators must be kept on reserve to meet demand when solar energy is unable to do so. This drives up the cost of electricity for consumers, as two plants are kept running to do the job of one.
- Solar energy is not as environmentally friendly as many claim because baseload cycling offsets the carbon reduction benefits of solar and wind by 20 percent, on average.

I agree that these are negative aspects of solar energy subsidization.

When examining potential market distortion for specific projects such Hecate and Willowbrook, it is helpful to examine the size of the projects when compared to the overall market. In this situation, Hecate and Willowbrook are being considered specifically because they are solar projects located in Ohio. According to the Commission website the following commercial solar facilities are currently in Ohio (facilities 3.0 MW or greater):[16]

- DG AMP Solar Bowling Green, 28.7 MW
- Wyandot Solar Energy Generation Facility, 12 MW
- BNB Napoleon Solar, 9.8 MW
- Celina Solar Project, 5 MW
- HMV Minster PV I , 4.3 MW
- AMP Napoleon Solar LLC, 4.2 MW
- Clyde Solar Array, 3.65 MW
- Ohio Northern University, 3.1 MW
- Hardin Solar Energy Facility 150 MW (Pending)

[16] www.puco.ohio.gov/be-informed/consumer-topics/how-does-ohio-generate-electricity/

- Willowbrook Solar Farm, 150 MW (Pending)
- Hillcrest Solar Energy Facility, 125 MW (Pending)
- Vinton Solar Energy Facility, 125 MW (Pending)

Based on the above list, there is about 70 MW of utility-scale solar currently operating in Ohio, and an additional 550 MW pending. Clearly the current trend is for developers to pursue large (over 100 MW) solar facilities in Ohio. I am not aware of any special rider treatment or debt equivalency cost recovery associated with any of the above pending projects. If so, this is clear evidence that special rider treatment and debt equivalency cost recovery is not needed for new utility-scale solar facilities to be built in Ohio. The free market (albeit with government incentives) is working just fine. Giving Hecate and Willowbrook special treatment is not needed, is subsidizing non-economic projects, and is unfair to the facilities that are competing without special treatment. The issue of fair competition is especially important in this situation since Hecate and Willowbrook would add almost 50% to Ohio utility-scale solar capacity if pending projects are considered, and almost 6000% if the pending projects are not considered.

8. Testimony of John Williams

The direct testimony of AEP Ohio employee John Williams states that its purpose is the following:

1. Provide an overview of the AEP Ohio filing and witnesses;
2. Provide an overview of the Solar Projects;
3. Provide an overview of economic benefits;
4. Discuss how the Solar Projects will advance state policy; and
5. Support the Company's proposed Green Power Tariff.

This section is in response to Mr. Williams.

The first issue that Mr. Williams makes clear is that the proposed RGR for Hecate and Willowbrook is a result of AEP Ohio's commitment to propose at least 900 MW of renewable energy projects. Mr. Williams states, "If regulatory approvals are not received in the periods identified in the REPAs, the Company will not move forward with the REPAs and they will be terminated." Nowhere does Mr. Williams or any other AEP Ohio witness claim that AEP Ohio will not be able to meet any regulatory obligation or resource planning need. AEP Ohio does not need Hecate and Willowbrook to be built, will not build them without prior RGR approval, and will be just fine if they are not built.

Mr. Williams cites the economic benefits of 115 jobs, guaranteed for five years guaranteed by Hecate. Mr. Williams fails to account for the negative economic impact of the admittedly higher rates of Hecate as compared to Willowbrook, even though Hecate is a much larger facility. The effect is for AEP Ohio ratepayers to overpay for energy for 20 years to subsidize 113 jobs for five years. AEP Ohio ratepayers will have less disposable income to spend in the Ohio economy, with corresponding direct, indirect, and induced negative economic impacts.

Mr. Williams states that the RGR will "advance the state policies expressed in R.C. 4928.02." Mr. Williams then cites six examples (p. 9). In fact, the RGR does not advance any of the examples cites by Mr. Williams as demonstrated below:

(A) R.C. 4928.02, "Ensure the availability to consumers of adequate, safe, efficient, nondiscrimatory, and reasonably priced retail electric service." At AEPs own admission, the PJM market is adequately supplying all wholesale generation needs, which includes adequate, safe, efficient, nondiscrimatory, and reasonably priced wholesale electric energy. Hecate and Willowbrook are not reasonable priced, as their rates are much higher than alternatives, and AEP Ohio further intends to charge customers for debt equivalency cost recovery.

(B) R.C. 4928.02, "Ensure the availability of unbundled and comparable retail electric service that provides consumers with the supplier, price, terms, conditions, and quality options they elect to meet their respective needs." AEP Ohio can procure renewable energy for less cost than Hecate and Willowbrook without the need for the RGR and debt equivalency cost recovery. Customers do not need to pay higher costs for renewable energy, do not need to assume transferred financial risk from AEP Ohio, and do not need to pay AEP Ohio for costs not actually incurred for debt equivalency cost recovery.

(C) R.C. 4928.02, "Ensure diversity of electricity supplies and suppliers, by giving consumers effective choices over the selection of those supplies and suppliers and by encouraging the development of distributed and small generation facilities." The PJM market already ensures a diversity of electricity supplies and suppliers. AEP Ohio is trying to force its retail customers to pay for the overpriced energy supplied by Hecate and Willowbrook, which is the opposite of choice. Furthermore, Hecate and Willowbrook are not distributed generation facilities and are not small generation facilities.

(D) R.C. 4928.02, "Encourage innovation and market access for cost-effective supply- and demand-side retail electric service including, but not limited to, demand-side management, time-differentiated pricing, waste energy recovery systems, smart grid programs, and implementation of advanced metering infrastructure." This section specifically refers to "demand-side management, time-differentiated pricing, waste energy recovery systems, smart grid programs, and implementation of advanced metering infrastructure," none of which apply to Hecate and Willowbrook. To the extent that Mr. Williams is invoking the "not limited to" modifier with respect to "cost-effective" supply side electric service, Hecate and Willowbrook are the opposite. They are not cost effective as their rates are exceedingly high and customers will be further charged for debt equivalency cost recovery.

(J) R.C. 4928.02, "Provide coherent, transparent means of giving appropriate incentives to technologies that can adapt successfully to potential environmental mandates." All of the technologies that will be used by Hecate and Willowbrook are mature commodities. AEP Ohio does not mention a single technology that will be incentivized through the construction of Hecate and Willowbrook.

(N) R.C. 4928.02, "Facilitate the state's effectiveness in the global economy." The Hecate and Willowbrook RGR will increase the price of electricity for retail commercial and retail industrial customers and <u>make Ohio less effective in the global economy</u> by raising the cost of Ohio businesses to produce goods and services.

Mr. Williams justifies the proposed Green Tariff because it "provides a simple method for all customers to have easy access to Ohio renewable electricity resources proposed in this filing." I have no objection for AEP Ohio to ask its customers to voluntarily pay for renewable energy certificates (REC). However, AEP Ohio could do this for any renewable facility and should not limit customer options to Ohio facilities. Also, AEP Ohio customers are already free to purchase RECs from any renewable generation facility they choose. The RGR with its overpriced energy and debt equivalency cost recovery is simply not needed for AEP Ohio to offer RECs to customers.

9. Conclusions

The following is a summary of my major conclusions. The body of this report is the controlling document and includes many other opinions, conclusions, and analyses.

1. AEP Ohio does not need Hecate and Willowbrook based on resource planning projections. Therefore, the RGR does not meet the "need" requirement of the Electric Security Plan statute.
2. AEP Ohio will not own or operate Hecate and Willowbrook. AEP Ohio will serve as the PJM market participant, but the facility owners are contractually responsible for all other operational functions. Therefore, the RGR does not meet the "own or operate" requirement of the Electric Security Plan statute.
3. Allowing AEP to recover costs-not-actually-incurred based on debt equivalency cost recovery is contrary to cost-of-service ratemaking. I am not aware of any Commission allowing cost recovery for costs not actually incurred, including debt equivalency cost recovery.
4. If full cost recovery of the Hecate and Willowbrook REPAs are approved by the Commission in advance, the risk of REPA cost non-recovery is zero and debt equivalency cost is therefore zero.
5. The RGR is a subsidy that makes both Hecate and Willowbrook financially viable. Hecate and Willowbrook will only be built if the RGR subsidy is approved.
6. Subsidizing facilities like Hecate and Willowbrook distorts the PJM Market.
7. AEPs own publically-disclosed financial analysis shows that Willowbrook and Hecate REPA costs are higher than market solar rates in early years for all scenarios. Inclusion of debt equivalency cost recovery makes the cost to customers even higher: an additional 7.05 $/MWh for Hecate and an additional 6.69 $/MWh for Willowbrook.
8. There is no hedge value to the RGR since the price stability of the REPAs is exactly counteracted by the market true-up provision of the RGR.
9. The Navigant survey is highly flawed. Its results are only representative of the tiny group of respondents. None of the survey questions address customer need, and none address need based on resource planning requirements.

10. Any economic and social benefits that result from Hecate and Willowbrook will be offset by negative benefits related to higher Ohio electricity rates, reduced profitability for unsubsidized Ohio generation facilities, and reduced oil/gas exploration and extraction activity.
11. Renewable facilities like Hecate and Willowbrook do not eliminate the need for new traditional generation to serve baseload and to provide ancillary services.
12. Federal and state renewable energy tax policies are regressive and disproportionately impact poor customers.

Dated: Dec. 27, 2018

Richard E. Brown

RICHARD E. BROWN
Practice Director and Principal Engineer
Exponent, Inc.

Appendix A – Reviewed Materials

1. The Public Utilities Commission of Ohio, Case No. 18-501-EL-FOR, Case No. 14-1693-EL-RDR and Case No. 14-1694-EL-AAM, Entry, Oct. 22, 2018
2. The Public Utilities Commission of Ohio, Case No. 18-501-EL-FOR, Case No. 14-1693-EL-RDR and Case No. 14-1694-EL-AAM, Motion to Intervene Filed by the Ohio Coal Association and [Proposed] Memorandum in Opposition to AEP Ohio's Request for Expedited Hearing and in Support of Staff's Motion for Hearing
3. The Public Utilities Commission of Ohio, Case No. 14-1693-EL-RDR and Case No. 14-1694-EL-AAM, Second Entry on Rehearing
4. The Public Utilities Commission of Ohio, Case No. 14-1693-EL-RDR and Case No. 14-1694-EL-AAM, Fifth Entry on Rehearing
5. The Public Utilities Commission of Ohio, Case No. 14-1693-EL-RDR and Case No. 14-1694-EL-AAM, Opinion and Order
6. 2018 Long-Term Forecast Report of AEP Ohio and Related Matters, Case No. 18-501-EL-FOR
7. "AEP Looking to add 400 MW of Solar Generation in Ohio," www.12abc.com/content/news/aep-looking-to-add-400-mw-of-solar-generation-in-ohio-494558841.html
8. The Public Utilities Commission of Ohio, Case No. 18-501-EL-FOR, Amendment to the 2018 Long-Term Forecast Report of Ohio Power Company
9. The Public Utilities Commission of Ohio, Case No. 18-501-EL-FOR, Amendment to the 2018 Long-Term Forecast Report of Ohio Power Company
10. The Public Utilities Commission of Ohio, Case No. 18-501-EL-FOR, Case No. 14-1693-EL-RDR and Case No. 14-1694-EL-AAM, Memorandum Contra the Motion of Ohio Power Company to Consolidate Proceedings which would Result in an Unfair Process for Consumers by the Office of the Ohio Consumer's Counsel
11. "In re Review of the Alternative Energy Rider Contained in the Tariffs of Ohio Edison Company, Cleveland Electric Illuminating Company, and Toledo Edison Company; Ohio Edison Company et al., Appellants and Cross-Appellees; et. al., No. 2013-2026, Supreme Court of Ohio, Jan. 16, 2018.
12. The Public Utilities Commission of Ohio, Case No. 18-501-EL-FOR, Case No. 18-1392-EL-RDR and Case No. 18-1393-EL-ATA,Entry Oct. 22, 2018.
13. Ohio Statutes, Title 49 – Public Utilities, Section 4928.64 – Electric distribution utility to provide electricity from alternative energy resources
14. Ohio Statutes, Title 49 – Public Utilities, Section 4928.143 – Application for approval of electric security plan – testing
15. Direct Testimony of John Torpey, Sept. 19, 2018 (redacted)
16. Direct Testimony of Kamran Ali, Sept. 19, 2018
17. Direct Testimony of Karl Betzacker, Sept. 19, 2018
18. Direct Testimony of Nicole Fry, Sept. 19, 2018
19. Direct Testimony of Trina Horner, Sept. 19, 2018
20. Direct Testimony of William Allen, Sept. 19, 2018
21. Direct Testimony of Bill LaFayette, Sept. 27, 2018
22. Direct Testimony of Daniel Bradley, Sept. 27, 2018

23. Direct Testimony of Jon Williams, Sept. 27, 2018
24. Direct Testimony of Joseph Karrasch, Sept. 27, 2018
25. Direct Testimony of Stephen Buser, Sept. 27, 2018
26. Direct Testimony of Steven Fetter, Sept. 27, 2018
27. Standard & Poor's, "Buy Versus Build: Debt Aspects of Purchased Power Agreements," May 8, 2003.
28. California Public Utilities Commission Policy and Planning Division, "An Introduction to Debt Equivalency," August 4, 2017.
29. Navigant, "AEP Ohio Voice of the Customer: Attitudes and Expectations for Renewable Energy," Sept. 12, 2018 (prepared for AEP Ohio).
30. The University of Texas at Austin Energy Institute, "New U.S. Power Costs: By County, with Environmental Externalities," July, 2016.
31. Renewable Energy Purchase Agreement for Solar energy Resources between Hecate Energy Highland LLC and Ohio Power Company, Sept. 25, 2018 (redacted).
32. Renewable Energy Purchase Agreement for Solar energy Resources between Willowbrook Solar I, LLC and Ohio Power Company, Sept. 27, 2018 (redacted).
33. AEP Ohio 2017 Solar Energy RFP, Appendix A1, Highland Solar Project Summary (redacted).
34. AEP Ohio 2017 Solar Energy RFP, Appendix A, Solar Project Summary (Willowbrook Solar I, redacted).
35. PUCO Case No. 18-501-EL-FOR, 18=1392-EL-RDR and 18-1393-EL-ATA, Ohio Power Company's Response to the Office of the Ohio Consumer's Counsel Discovery Request, Third Set.
36. PUCO Case No. 18-501-EL-FOR, 18=1392-EL-RDR and 18-1393-EL-ATA, Ohio Power Company's Response to the Office of the Ohio Consumer's Counsel Discovery Request, Fourth Set.
37. PUCO Case No. 18-501-EL-FOR, 18=1392-EL-RDR and 18-1393-EL-ATA, Ohio Power Company's Response to the Office of the Ohio Consumer's Counsel Discovery Request, Fifth Set.
38. PUCO Case No. 18-501-EL-FOR, 18=1392-EL-RDR and 18-1393-EL-ATA, Ohio Power Company's Response to the Office of the Ohio Consumer's Counsel Discovery Request, Sixth Set.
39. PUCO Case No. 18-501-EL-FOR, 18=1392-EL-RDR and 18-1393-EL-ATA, Ohio Power Company's Response to the Office of the Ohio Consumer's Counsel Discovery Request, Seventh Set.
40. PUCO Case No. 18-501-EL-FOR, 18=1392-EL-RDR and 18-1393-EL-ATA, Ohio Power Company's Response to the Office of the Ohio Consumer's Counsel Discovery Request, Eighth Set
41. PUCO Case No. 18-501-EL-FOR, 18=1392-EL-RDR and 18-1393-EL-ATA, Ohio Power Company's Response to the Office of the Ohio Consumer's Counsel Discovery Request, Ninth Set
42. PUCO Case No. 18-501-EL-FOR, 18=1392-EL-RDR and 18-1393-EL-ATA, Ohio Power Company's Response to the Office of the Ohio Consumer's Counsel Discovery Request, Supplemental Ninth Set

43. PUCO Case No. 18-501-EL-FOR, 18=1392-EL-RDR and 18-1393-EL-ATA, Ohio Power Company's Response to the Office of the Ohio Consumer's Counsel Discovery Request, Tenth Set
44. PUCO Case No. 18-501-EL-FOR, 18=1392-EL-RDR and 18-1393-EL-ATA, Ohio Power Company's Response to the Office of the Ohio Consumer's Counsel Discovery Request, Eleventh Set
45. PUCO Case No. 18-501-EL-FOR, 18=1392-EL-RDR and 18-1393-EL-ATA, Ohio Power Company's Response to the Office of the Ohio Consumer's Counsel Discovery Request, Twelfth Set
46. PUCO Case No. 18-501-EL-FOR, 18=1392-EL-RDR and 18-1393-EL-ATA, Attorney Examiner Denial of Request for Certification of the Interlocutory Appeal Filed Oct. 29, 2018.
47. PUCO Case No. 18-501-EL-FOR, 18=1392-EL-RDR and 18-1393-EL-ATA, Ohio Power Company's Response to Interstate Gas Supply's Discovery Request, First Set
48. PUCO Case No. 18-501-EL-FOR, 18=1392-EL-RDR and 18-1393-EL-ATA, Ohio Power Company's Response to Interstate Gas Supply's Discovery Request, Second Set
49. PUCO Case No. 18-501-EL-FOR, 18=1392-EL-RDR and 18-1393-EL-ATA, Ohio Power Company's Response to Interstate Gas Supply's Discovery Request, Third Set
50. PUCO Case No. 18-501-EL-FOR, 18=1392-EL-RDR and 18-1393-EL-ATA, Ohio Power Company's Response to Interstate Gas Supply's Discovery Request, Fourth Set
51. Supreme Court of Ohio, Slip Opinion No. 2018-Ohio-4697
52. Supreme Court of Ohio, Slip Opinion No. 2018-Ohio-4698
53. PUCO Case No. 18-501-EL-FOR, 18=1392-EL-RDR and 18-1393-EL-ATA, Ohio Power Company's Response to Kroger Discovery Request, First Set
54. PUCO Case No. 18-501-EL-FOR, 18=1392-EL-RDR and 18-1393-EL-ATA, Ohio Power Company's Response to Industrial Users-Ohio Discovery Request, First Set
55. PUCO Case No. 18-501-EL-FOR, 18=1392-EL-RDR and 18-1393-EL-ATA, Ohio Power Company's Response to Industrial Users-Ohio Discovery Request, Second Set
56. PUCO Case No. 18-501-EL-FOR, 18=1392-EL-RDR and 18-1393-EL-ATA, Ohio Power Company's Response to Industrial Users-Ohio Discovery Request, Third Set
57. PUCO Case No. 18-501-EL-FOR, 18=1392-EL-RDR and 18-1393-EL-ATA, Ohio Power Company's Response to Industrial Users-Ohio Discovery Request, Fourth Set
58. PUCO Case No. 18-501-EL-FOR, 18=1392-EL-RDR and 18-1393-EL-ATA, Ohio Power Company's Response to Industrial Users-Ohio Discovery Request, Fifth Set
59. PUCO Case No. 18-501-EL-FOR, 18=1392-EL-RDR and 18-1393-EL-ATA, Interstate Gas Supply, Inc.'s Response to Interrogatories and Requests for Production of Documents Propounded by the Office of the Ohio Consumer's Counsel, First Set
60. PUCO Case No. 18-501-EL-FOR, 18=1392-EL-RDR and 18-1393-EL-ATA, Interstate Gas Supply, Inc.'s Response to Interrogatories and Requests for Production of Documents Propounded by the Office of the Ohio Consumer's Counsel, Second Set
61. PUCO Case No. 18-501-EL-FOR, 18=1392-EL-RDR and 18-1393-EL-ATA, Ohio Power Company's Response to Ohio Coal Association's Discovery Request, First Set
62. PUCO Case No. 18-501-EL-FOR, 18=1392-EL-RDR and 18-1393-EL-ATA, Ohio Power Company's Response to Ohio Coal Association's Discovery Request, Second Set

Material With Confidential Information

63. AEP Ohio 2017 Solar Energy RFP, Appendix A1, Highland Solar Project Summary. AEP Ohio 2017 Solar Energy RFP, Appendix A, Solar Project Summary (Willowbrook Solar I).
64. Professional Services Agreement between Navigant Consulting and Ohio Power Company, May 16, 2018.
65. Professional Services Agreement between Navigant Consulting and Ohio Power Company, Sept. 12, 2018 (1 of 2)
66. Professional Services Agreement between Navigant Consulting and Ohio Power Company, Sept. 12, 2018 (2 of 2)
67. AEP Ohio 2017 Solar Energy Resources RFP Procedures Manual, Dec. 8, 2017.
68. Renewable Energy Purchase Agreement for Solar energy Resources between Hecate Energy Highland LLC and Ohio Power Company, Sept. 25, 2018.
69. Renewable Energy Purchase Agreement for Solar energy Resources between Willowbrook Solar I, LLC and Ohio Power Company, Sept. 27, 2018.
70. Direct Testimony of John Torpey, Sept. 19, 2018
71. PUCO Case No. 18-501-EL-FOR, et. al., Staff-DR-01-001. Staff DR 1-a Confidential Attachment

Appendix B – CV of Richard E. Brown

Professional Experience

Title	Institution	Dates
Principal Engineer	Exponent	3/2014 - present
Vice President, USAC Power Networks	WorleyParsons	3/2012 - 2/2014
Vice President, Operations	Quanta Technology	7/2006 - 2/2012
Vice President, Asset Management	KEMA	5/2003 - 6/2006
Director of Technology	ABB Consulting	5/2001 - 4/2003
Principal Engineer	ABB Power Distribution Solutions	2/1999 - 4/2001
Senior Engineer	ABB Corporate Research	7/1996 - 1/1999
Research/Teaching Assistant	University of Washington	1/1994 - 6/1996
Electrical Engineer II-III	Jacobs Engineering	4/1991 - 12/1993

(Details on Page 3)

Dr. Brown was an adjunct faculty member of North Carolina State University from 2008 - 2013.

Education

Degree	Institution	Location	Year Received
M.B.A.	University of North Carolina (Kenan-Flagler)	Chapel Hill, NC	2003
Ph.D.	University of Washington	Seattle, WA	1996
M.S.E.E.	University of Washington	Seattle, WA	1993
B.S.E.E.	University of Washington	Seattle, WA	1991

Honors and Awards

- IEEE Technical Committee Working Group Recognition Awards: Electric Delivery System Reliability Tutorial Working Group (2007); Aging Power System Infrastructure (2007); T&D Asset Management (2006); Transmission Planning (2008)
- IEEE PES Walter Fee Outstanding Young Engineer Award (2003)
- ABB Award of Excellence: President's Award (1999)
- ABB Award of Excellence: Product Development (1998)
- Member, Eta Kappa Nu (Electrical Engineering Honor Society)
- Member, Beta Gamma Sigma (Business Honor Society)

Professional Registration and Professional Societies

- IEEE Fellow
- Registered Professional Engineer in the State of North Carolina (Certificate No. 23088)

IEEE Power Engineering Society Activities

- Elected IEEE Fellow in 2007 for "contributions to distribution system reliability and risk assessment." The grade of Fellow is conferred by the IEEE Board of Directors for an extraordinary record of industry accomplishments, and is limited to one-tenth of one percent of the total voting membership per year.
- Awards
  - Technical Committee Working Group Recognition Award (2008). *Awarded by the Power System Operations Committee for work on power system transmission planning.*
  - Technical Committee Working Group Recognition Award (2007). *Awarded by the Power System Analysis, Computing & Economics Committee for contributing to the development of an electric delivery system reliability tutorial.*
  - Technical Committee Working Group Recognition Award (2007). *Awarded by the Power System Operations Committee for work on Aging Power System Infrastructure.*
  - Technical Committee Working Group Recognition Award (2006). *For work which resulted in a special issue of the IEEE Power and Energy magazine, May 2005.*
  - Walter Fee Outstanding Young Engineer Award (2003). *For outstanding contributions in predictive reliability modelling of distribution systems.*

- Chair, Technical Awards Committee (2007 – 2010)
- Member, Power System Planning and Implementation Committee (1997-present)
  - Committee Vice Chair (2006-2008)
  - Chair, Distribution Working Group (2003-2006)
  - Chair, Power Delivery Reliability Working Group (1997-1999)
- Member, Distribution Subcommittee, Working Group on System Design (1997-2012)
- Technical Paper Reviewer
  - *IEEE Transactions on Power Systems* (1996-2012)
  - *IEEE Transactions on Power Delivery* (1996-2012)
  - *IEEE General Meeting* (2001-2012)
  - *IEEE T&D Conference and Exposition* (2001-2012)
  - *IEEE Power Systems Conference and Exposition* (2004-2012)
  - Power Systems Computation Conference 2008
- President, University of Washington Student Chapter (1994-1995)
- Vice President, University of Washington Student Chapter (1993-1994)

Books, Book Chapters, and Theses

1. **R. E. Brown,** *Business Essentials for Utility Engineers*, CRC Press, 2010.
2. **R. E. Brown,** *Electric Power Distribution Reliability, Second Edition*, CRC Press, 2009.
3. **R. E. Brown,** *Electric Power Distribution Reliability*, Marcel Dekker, 2002.
4. **D. J. Morrow and R. E. Brown,** "Future Vision: The Challenge of Effective Transmission Planning," Chapter 6, *Power System Analysis and Design*, 5th Edition, J. D Glover *et al.* (Editor), pp. 295-304.
5. **R. E. Brown,** H. L. Willis, "Substation Asset Management," Chapter 19, *Electric Power Substations Engineering*, J. D. McDonald (Editor), Taylor & Francis (CRC Press), 2007, pp. 19-1 through 19-31.
6. **R. E. Brown,** "Power System Reliability" Section 13.5, *Electric Power Engineering Handbook*, L. L. Grigsby (Editor), CRC Press LLC, 2001, pp. 13-51 through 13-65.
7. **R. E. Brown,** "Predictive Distribution Reliability and Risk Assessment," Chapter 3, *IEEE Tutorial on Probabilistic T&D System Reliability Planning*, A. A. Chowdhury (Editor), IEEE 07TP182, 2007, pp. 29-36.
8. **R. E. Brown,** "Distribution System Reliability: Analytical and Empirical Techniques", Chapter 3, *IEEE Tutorial on Electric Delivery System Reliability Evaluation*, J. Mitra (Editor), IEEE 05TP175, 2005, pp. 39-51.
9. **R. E. Brown**, *Reliability Assessment and Design Optimization for Electric Power Distribution Systems,* Ph.D. Dissertation, University of Washington, Seattle, WA, 1996.
10. **R. E. Brown**, *An Intelligent Overload Relay for Extruded Dielectric Transmission Cable,* Masters Thesis, University of Washington, Seattle, WA, 1993.

Refereed Journal Papers

1. **R. E. Brown,** C. S. Wilson, and H. van Nispen, "Becoming the Utility of the Future," *IEEE Power and Energy*, Vol. 14, No. 5, Sept./Oct. 2016, pp. 57-65.
2. **R. E. Brown**, "The Perils of Reliability Benchmarking," *IEEE Power and Energy*, Vol. 10, Issue 2, March/Apr. 2012, pp. 125-130.
3. **R. E. Brown** and D. J. Morrow, "Future Vision," *IEEE Power and Energy*, Vol. 5, Issue 5, Sept./Oct. 2007, pp. 36-45.
4. **R. E. Brown** and H. L. Willis, "The Economics of Aging Infrastructure," *IEEE Power and Energy*, Vol. 4, No. 3, May/June 2006, pp. 36-43.
5. **R. E. Brown**, M. V. Engel, and J. H. Spare, "Making Sense of Worst Performing Feeders", *IEEE Transactions on Power Systems*, Vol. 20, No. 2, May 2005, pp. 1173-1178.
6. **R. E. Brown** and B. G. Humphrey, "Asset Management for Transmission and Distribution," *IEEE Power and Energy*, Vol. 3, No. 3, May/June 2005, pp. 39-45.
7. **R. E. Brown**, G. Frimpong, and H. L. Willis, "Failure Rate Modeling Using Equipment Inspection Data", *IEEE Transactions on Power Systems*, Vol. 19, No. 2, May 2004, pp. 782-787.
8. S. S. Venkata, A. Pahwa, **R. E. Brown**, and R. D. Christie, "What Future Distribution Engineers Need to Learn," *IEEE Transactions on Power Systems*, Vol. 19, No. 1, Feb. 2004, pp. 17-23.
9. F. Li and **R. E. Brown,** "A Cost-Effective Approach of Prioritizing Distribution Maintenance Based on System Reliability," *IEEE Transactions on Power Delivery,* Vol. 19, No. 1 , Jan. 2004, pp. 439-441.

10. T. M. Taylor, **R. E. Brown,** M. L. Chan, R. H. Fletcher, S. Larson, T. McDermott, and A. Pahwa, "Planning for Effective Distribution," *IEEE Power and Energy*, Vol. 1, No. 5, September/October 2003, pp. 54-62.
11. F. Li, **R. E. Brown**, and L. A. A. Freeman, "A Linear Contribution Factor Model of Distribution Reliability Indices and its Applications in Monte Carlo Simulation and Sensitivity Analysis," *IEEE Transactions on Power Systems*, Vol. 18, No. 3, Aug. 2003, pp. 1213-1215.
12. F. Li, L. A. A. Freeman and **R. E. Brown**, "Web-Enabling Applications for Outsourced Computing," *IEEE Power and Energy*, Vol. 1, No. 1, January/February 2003, pp. 53-57.
13. **R. E. Brown** and A. P. Hanson, "Impact of Two Stage Service Restoration on Distribution Reliability," *IEEE Transactions on Power Systems*, Vol. 16, No. 4, Nov. 2001, pp. 624-629.
14. **R. E. Brown**, A. P. Hanson, H. L. Willis, F. A. Luedtke, M. F. Born, "Assessing the Reliability of Distribution Systems," *IEEE Computer Applications in Power*, Vol. 14, No. 1, Jan. 2001, pp. 44-49.
15. **R. E. Brown** and J. J. Burke, "Managing the Risk of Performance Based Rates," *IEEE Transactions on Power Systems*, Vol. 15, No. 2, May 2000, pp. 893-898.
16. **R. E. Brown** and M. M. Marshall, "Budget Constrained Planning to Optimize Power System Reliability," *IEEE Transactions on Power Systems*, Vol. 15, No. 2, May 2000, pp. 887-892.
17. **R. E. Brown**, "The Impact of Heuristic Initialization on Distribution System Reliability Optimization," *International Journal of Engineering Intelligent Systems for Electrical Engineering and Communications*, Vol. 8, No. 1, March 2000, pp. 45-52.
18. **R. E. Brown** and J. R. Ochoa, "Impact of Sub-Cycle Transfer Switches on Distribution System Reliability," *IEEE Transactions on Power Systems*, Vol. 15, No. 1, Feb. 2000, pp. 442-447.
19. **R. E. Brown**, T. M. Taylor, "Modeling the Impact of Substations on Distribution Reliability," *IEEE Transactions on Power Systems*, Vol. 14, No. 1, Feb. 1999, pp. 349-354.
20. **R. E. Brown** and J. R. Ochoa, "Distribution System Reliability: Default Data and Model Validation," *IEEE Transactions on Power Systems*, Vol. 13, No. 2, May 1998, pp. 704-709.
21. **R. E. Brown**, S. Gupta, R. D. Christie, S. S. Venkata, and R. D. Fletcher, "Distribution System Reliability: Momentary Interruptions and Storms," *IEEE Transactions on Power Delivery*, Vol. 12, No. 4, October 1997, pp. 1569-1575.
22. **R. E. Brown**, S. Gupta, R. D. Christie, S. S. Venkata, and R. D. Fletcher, "Automated Primary Distribution System Design: Reliability and Cost Optimization," *IEEE Transactions on Power Delivery*, Vol. 12, No. 2, April 1997, pp. 1017-1022.
23. **R. E. Brown**, S. Gupta, R. D. Christie, S. S. Venkata, and R. D. Fletcher, "Distribution System Reliability Analysis Using Hierarchical Markov Modeling," *IEEE Transactions on Power Delivery*, Vol. 11, No. 4, Oct. 1996, pp. 1929-1934.
24. V. N. Chuvychin, N. S. Gurov, S. S. Venkata, and **R. E. Brown**, "An Adaptive Approach to Load Shedding and Spinning Reserve Control During Underfrequency Conditions," *IEEE Transactions on Power Systems*, Vol. 11, No. 4, Nov. 1996, pp. 1805-1810.

Refereed Conference Papers

1. A. Shahsiah, **R. E. Brown** and M. Ly, "Reliability and Life Expectancy of Modern SCADA Equipment in Underground Installations: SCADA Equipment in PG&E Secondary Underground Distribution Networks," *Resilience Week (RWS)*, Wilmington, DE, Sept. 2017.
2. **R. E. Brown** and Q. Tran, "Best Poles for Power Distribution," *DistribuTECH Conference and Exhibition*, San Diego, CA, Feb. 2017.
3. **R.E. Brown,** B. Hwang, R. Touzel, "Demand Response as a Dispatchable Resource," POWER-GEN International, Orlando, FL, Nov. 2013.
4. J. Romero Agüero and **R. E. Brown,** "Distribution System Reliability Improvement Using Predictive Models," *IEEE PES 2009 General Meeting*, Calgary, Alberta, July 2009.
5. J. Romero Agüero, **R. E. Brown**, J. H. Spare, E. Phillips, L. Xu, and J. Wang, "A Reliability Improvement Roadmap Based on a Predictive Model and Extrapolation Technique", *IEEE PES 2009 Power Systems Conference and Exposition*, Seattle, WA, March 2009.
6. J. Romero Agüero, **R. E. Brown,** J. H. Spare, E. Phillips, L. Xu, and J. Wang, "A Reliability Improvement Roadmap Based on a Predictive Model and Extrapolation Technique," *DistribuTECH Conference and Exhibition*, San Diego, CA, Feb. 2008.
7. **R. E. Brown**, "Asset Management Standards and Guidelines", *EPRI Fourth Power Delivery Asset Management Conference*, Chicago, IL, Oct. 2008.

8. **R. E. Brown**, "Impact of Smart Grid on Distribution System Design", *IEEE PES 2008 General Meeting*, Pittsburg, PA, July 2008.
9. L. Xu and **R. E. Brown**, "A Hurricane Simulation Method for Florida Utility Damage and Risk Assessment", *IEEE PES 2008 General Meeting*, Pittsburg, PA, July 2008.
10. **R. E. Brown**, "Hurricane Hardening Efforts in Florida", *IEEE PES 2008 General Meeting*, Pittsburg, PA, July 2008.
11. L. Xu and **R. E. Brown**, "Simulation of Hurricane Damage to Utilities in Florida," *DistribuTECH Conference and Exhibition*, Tampa Bay, FL, Jan. 2008.
12. **R. E. Brown**, "Reliability Benefits of Distributed Generation on Heavily Loaded Feeders", *IEEE PES 2007 General Meeting*, Tampa, FL, June 2007.
13. **R. E. Brown,** "Pole Hardening Following Hurricane Wilma," 2007 Southeastern Utility Pole Conference, Tunica, MS, Feb. 2007.
14. B. Ramanathan, D. Hennessy and **R. E. Brown**, "Decision-making and Policy Implications of Performance-based Regulation," *IEEE Power Systems Conference and Exhibition*, Atlanta, GA, Oct. 2006.
15. **R. E. Brown,** "The Regulatory Usefulness of Reliability Reporting," 2006 IEEE Rural Electric Power Conference, Albuquerque, NM, April 2006.
16. M. Butts, J. H. Spare and **R. E. Brown**, "Practical and Verifiable Reliability Improvement at the Baltimore Gas and Electric Company," *DistribuTECH Conference and Exhibition*, Tampa Bay, FL, Feb. 2006.
17. **R. E. Brown,** "Project Selection with Multiple Performance Objectives," *2005 IEEE/PES Transmission and Distribution Conference and Exposition*, New Orleans, LA, Sept. 2005.
18. **R. E. Brown** and J. H. Spare, "The Effects of System Design on Reliability and Risk," *2005 IEEE/PES Transmission and Distribution Conference and Exposition*, New Orleans, LA, Sept. 2005.
19. **R. E. Brown** and J. H. Spare "A Survey of U.S. Reliability Reporting Processes," *2005 IEEE/PES Transmission and Distribution Conference and Exposition*, New Orleans, LA, Sept. 2005.
20. Y. Zhou and **R. E. Brown**, "A Practical Method for Cable Failure Rate Modeling," *2005 IEEE/PES Transmission and Distribution Conference and Exposition*, New Orleans, LA, Sept. 2005.
21. **R. E. Brown** and J. H. Spare, "Asset Management and Financial Risk," *DistribuTECH Conference and Exhibition*, San Diego, CA, Jan. 2005.
22. **R. E. Brown** and J. H. Spare, "Asset Management, Risk, and Distribution System Planning," *IEEE Power Systems Conference and Exhibition*, New York, NY, Oct. 2004.
23. **R. E. Brown**, "Identifying Worst Performing Feeders," *Probabilistic Methods Applied to Power Systems, PMAPS 2004,* Ames, IA, September 2004.
24. H. L. Willis, M. V. Engel and **R. E. Brown**, "Equipment Demographics – Failure Analysis of Aging T&D Infrastructures," *2004 Canada Power Conference,* Toronto, Canada, September 2004.
25. **R. E. Brown**, "Failure Rate Modeling Using Equipment Inspection Data", *IEEE PES 2004 General Meeting*, Denver, CO, June 2004.
26. **R. E. Brown**, "Coming to Grips with Distribution Asset Management," *2003 Real World Conference: It's All About Cost and Reliability*, Transmission and Distribution World, Ft. Lauderdale, FL, Oct. 2003.
27. **R. E. Brown**, "Reliability Standards and Customer Satisfaction," *2003 IEEE/PES Transmission and Distribution Conference and Exposition*, Dallas, TX, Sept. 2003.
28. A. Pahwa, S. Gupta, Y. Zhou, **R. E. Brown**, and S. Das, "Data Selection To Train A Fuzzy Model For Overhead Distribution Feeders Failure Rates," *International Conference on Intelligent Systems Applications to Power Systems*, Lemnos, Greece, Sept. 2003.
29. **R. E. Brown**, "Network Reconfiguration for Improving Reliability in Distribution Systems," *IEEE PES 2003 General Meeting*, Toronto, Canada, July 2003.
30. **R. E. Brown**, , J. Pan, Y. Liao, and X. Feng, "An Application of Genetic Algorithms to Integrated System Expansion Optimization," *IEEE PES 2003 General Meeting*, Toronto, Canada, July 2003.
31. **R. E. Brown** and L. A. A. Freeman, "A Cost/Benefit Comparison of Reliability Improvement Strategies," *DistribuTECH Conference and Exhibition*, Las Vegas, NV, Feb. 2003.
32. S. Gupta, A. Pahwa, **R. E. Brown** and S. Das, "A Fuzzy Model for Overhead Distribution Feeders Failure Rates," *NAPS 2002: 34th Annual North American Power Symposium*, Tempe, AZ, Oct. 2002.
33. **R. E. Brown**, "Web-Based Distribution System Planning," *IEEE PES Summer Power Meeting*, Chicago, IL, July 2002.
34. **R. E. Brown**, "System Reliability and Power Quality: Performance-Based Rates and Guarantees," *IEEE PES Summer Power Meeting*, Chicago, IL, July 2002.

35. **R. E. Brown**, "Modeling the Reliability Impact of Distributed Generation," *IEEE PES Summer Power Meeting*, Chicago, IL, July 2002.
36. S. Gupta, A. Pahwa, **R. E. Brown**, "Data Needs for Reliability Assessment of Distribution Systems," *IEEE PES Summer Power Meeting*, Chicago, IL, July 2002.
37. **R. E. Brown**, "Meeting Reliability Targets for Least Cost," *DistribuTECH Conference and Exhibition*, Miami, FL, Feb. 2002.
38. S. Gupta, A. Pahwa and **R. E. Brown**, "Predicting the Failure Rates of Overhead Distribution Lines Using an Adaptive-Fuzzy Technique," *NAPS 2001: 33rd Annual North American Power Symposium*, College Station, TX, Oct. 2001.
39. P. R. Jones and **R. E. Brown**, "Advanced Modeling Techniques to Identify and Minimize the Risk of Aging Assets on Network Performance," *Utilities Asset Management 2001*, London, UK, July 2001.
40. **R. E. Brown**, "Distribution Reliability Modeling at Commonwealth Edison," *2001 IEEE/PES Transmission and Distribution Conference and Exposition*, Atlanta, GA, Oct. 2001.
41. **R. E. Brown**, "Distribution Reliability Assessment and Reconfiguration Optimization," *2001 IEEE/PES Transmission and Distribution Conference and Exposition*, Atlanta, GA, Oct. 2001.
42. **R. E. Brown**, J. Pan, X. Feng and K. Koutlev, "Siting Distributed Generation to Defer T&D Expansion," *2001 IEEE/PES Transmission and Distribution Conference and Exposition*, Atlanta, GA, Oct. 2001.
43. D. Ross, L. Freeman and **R. E. Brown**, "Overcoming Data Problems in Predictive Distribution Reliability Modeling," *2001 IEEE/PES Transmission and Distribution Conference and Exposition*, Atlanta, GA, Oct. 2001.
44. **R. E. Brown** and L. A. A. Freeman, "Analyzing the Reliability Impact of Distributed Generation," *IEEE PES Summer Power Meeting*, Vancouver, BC, Canada, July 2001.
45. **R. E. Brown**, P. R. Jones and S. Trotter, "Planning for Reliability," *Trans-Power Europe*, Vol. 1, No. 1. March 2001, pp. 10-12.
46. **R. E. Brown** and M. Marshall, "Microeconomic Examination of Distribution Reliability Targets," *IEEE PES Winter Power Meeting*, Columbus, OH, Jan. 2001, Vol. 1, pp. 58-65.
47. P. R. Jones and **R. E. Brown**, "Investment Planning of Networks Using Advanced Modeling Techniques," *Utilities Asset Management 2001*, London, UK, Jan. 2001.
48. **R. E. Brown**, "Probabilistic Reliability and Risk Assessment of Electric Power Distribution Systems," *DistribuTECH Conference and Exhibition*, San Diego, CA, Feb. 2001.
49. C. LaPlace, D. Hart, **R. E. Brown**, W. Mangum, M. Tellarini, J. E. Saleeby, "Intelligent Feeder Monitoring to Minimize Outages," Power Quality 2000 Conference, Boston, MA, Oct. 2000.
50. **R. E. Brown**, H. Nguyen, J. J. Burke, "A Systematic and Cost Effecting Method to Improve Distribution Reliability," *IEEE PES Summer Meeting*, Edmonton, AB, July 1999. Vol. 2, pp. 1037-1042.
51. **R. E. Brown**, T. M. Taylor, "Modeling the Impact of Substations on Distribution Reliability," *IEEE PES Winter Meeting*, New York, NY, Feb 1999, pp. 349-354.
52. **R. E. Brown**, A.P. Hanson, M.M Marshall, H.L. Willis, B. Newton, "Reliability and Capacity: A Spatial Load Forecasting Method for a Performance Based Regulatory Environment," *1999 Power Industry Computer Applications Conference*, Dayton, OH, February 1999, pp. 139-144.
53. **R. E. Brown**, A. P. Hanson, D. Hagan, "Long Range Spatial Load Forecasting Using Non-Uniform Areas," *1998 IEEE/PES Transmission and Distribution Conference*, New Orleans, LA, April 1999, Vol. 1, pp. 369-373.
54. **R. E. Brown**, W. S. Zimmermann, P. P. Bambao Jr., and L. P. Simpao, "Basic Planning for a New Fast Growing Area in Manila with a Total Electrical Load of 650 MVA," *12th Annual Conference of the Electric Power Supply Industry*, Pattaya, Tailand, November 1998.
55. X. Y. Chao, **R. E. Brown**, D. Slump, and C. Strong, "Reliability Benefits of Distributed Resources," *Power Delivery International '97 Conference*, Dallas, TX, December 1997.
56. **R. E. Brown**, "Competitive Distribution Systems: A Reliability Perspective," *American Power Conference*, Vol. 59-II, Chicago, IL, April 1997, pp. 1115-1120.
57. **R. E. Brown**, S. S. Venkata, and R. D. Christie, "Hybrid Reliability Optimization Methods for Electric Power Distribution Systems," *International Conference on Intelligent Systems Applications to Power Systems*, Seoul, Korea, IEEE, July 1997.
58. **R. E. Brown**, S. Gupta, R. D. Christie, S. S. Venkata, and R. D. Fletcher, "Automated Primary Distribution System Design: Reliability and Cost Optimization," *1996 IEEE/PES Transmission and Distribution Conference*, Los Angeles, CA, Sept., 1996, pp. 1-6.
59. **R. E. Brown**, S. S. Gupta, R. D. Christie, and S. S. Venkata, "A Genetic Algorithm for Reliable Distribution System Design," *International Conference on Intelligent Systems Applications to Power Systems*, Orlando, FL, January 1996, pp. 29-33.

Technical Articles

1. **R. E. Brown**, "Counterintuitive Strategies," *Transmission and Distribution World*, March 2013.
2. **R. E. Brown**, "Storm Hardening Distribution Systems," *Transmission and Distribution World*, June 2010, pp. 50-56.
3. **R. E. Brown**, "A Beautiful Grid?" *Transmission and Distribution World*, Feb. 2010.
4. **R. E. Brown**, "Business Realities," *Transmission and Distribution World*, Jan. 2009.
5. H. L. Willis and **R. E. Brown**, "What Happens with a Lack of Long Range T&D Infrastructure Planning?" Natural Gas & Electricity, Vol. 24, Issue 6, Jan. 2008, pp. 22-27.
6. **R. E. Brown**, "Increased Performance Expectations for Major Storms," *Electric Perspectives*, EEI, June 2007.
7. M. V. Engel, **R. E. Brown**, E. Phillips, and N. Bingel, "Extreme Winds Test Wood Pole Strength," *Transmission and Distribution World*, May 2007, pp. 34-38.
8. **R. E. Brown**, "Asset Management: Balancing Performance, Cost, and Risk," *EnergyPulse Special Issue on Asset Management*, www.energycentral.com, Feb. 2005.
9. P. Musser, **R. E. Brown**, T. Eyford, and C. Warren, "Too Many Routes of Reliability," *Transmission and Distribution World*, June 2004, pp. 17-22.
10. **R. E. Brown** and L. A. A. Freeman, "A Cost/Benefit Comparison of Reliability Improvement Strategies," *Electric Power and Light*, May 2003.
11. **R. E. Brown**, H. Kazemzadeh, B. R. Williams and C. B. Mansfield, "Engineering Tools Move into Cyberspace," *Transmission and Distribution World*, March 2003, pp. 27-36.
12. P. Perani and **R. E. Brown**, "Maintaining Reliable Power For Semiconductor Manufacture," *What's New in Electronics*, March 2002.
13. P. Perani and **R. E. Brown**, "Rock Steady: The Importance of Reliable Power Distribution in Microprocessor Manufacturing Plants," ABB Review, No. 3, 2002, pp. 29-33.
14. H. L. Willis and **R. E. Brown**, "Is DG Ready for the Last Mile?" *Power Quality (cover story)*, March 2002. pp. 16-21.
15. **R. E. Brown** and M. W. Marshall, "The Cost of Reliability," *Transmission and Distribution World (cover story)*, Dec. 2001, pp. 13-20.
16. **R. E. Brown** and B. Howe, "Optimal Deployment of Reliability Investments," E-Source, Power Quality Series: PQ-6, March 2000.

Expert Witness Testimony for Regulatory Proceedings

1. Prepared expert report and gave **deposition testimony** and **testified at hearings** for the Matter of the Application of Icebreaker Windpower, Inc., for a Certificate to Construct a Wind-Powered Electric Generation Facility in Cuyahoga County, before the Ohio Power Siting Board, Case No. 16-1871-EL-BGN. *I represented three local resident interveners by addressing deficiencies in the Application and discussed the overall economics of the project.*
2. Prepared pre-filed direct testimony and **testified at hearings** for the submission of Duke Energy reliability targets in a regulatory proceeding in Ohio, before the Public Utilities Commission of Ohio, in the Matter of the Application of Duke Energy Ohio, Inc., to Establish Minimum Reliability Performance Standards Pursuant to Chapter 4901:1-10, Ohio Administrative Code, Case No. 16-1602-EL-ESS. *I represented Duke in justifying targets for distribution system reliability indices.*
3. Prepared written testimony and **testified at hearings** supporting the rider treatment of overhead-to-underground conversion of distribution facilities for Dominion Virginia Electric Power, North Carolina Public Utilities Commission Case No. PUE-2015-00114. *I represented Dominion in this case by developing a benefit-to-cost assessment for the second phase of the Dominion $2 billion proposed program and realized benefits from the completed first phase.*
4. Prepared written and **testified at hearings** supporting the rider treatment of overhead-to-underground conversion of distribution facilities for Dominion Virginia Electric Power, North Carolina Public Utilities Commission Case No. PUE-2015-00114. *I represented Dominion in this case by developing a benefit-to-cost assessment for the first phase of the*
5. Prepared written and **testified at hearings** for North Carolina Docket No. E-100, Sub 140, "Bi-Annual Avoided Cost Hearings." Prepared on behalf of the North Carolina Public Staff. *This testimony provided an assessment*

of the potential benefits and costs of utility-scale solar facilities in North Carolina, and the appropriateness of these costs and benefits to be included in avoided cost calculations.

6. Prepared written testimony and **testified at hearings**, "Investigation of the reliability of Pepco's electric distribution system and the quality of the service it provides to customers," Prepared on behalf of Pepco and submitted to the Maryland Public Service Commission under Case No. 9240. *This testimony performed a review of the reports generated to assess the reliability of Pepco's reliability and customer service during both normal and major event conditions.*
7. Prepared written testimony and **testified at hearings**, "Investigation by the Massachusetts Department Of Public Utilities on its Own Motion into the Preparation and Response of the Massachusetts Electric Distribution Companies to the December 12, 2008 Winter Storm," Prepared on behalf of the Massachusetts Attorney General Filed and submitted to the Massachusetts Department Of Public Utilities under Docket DPU 09-01-A. *This testimony presents an analysis of the technical aspects of Fitchburg Gas & Electric (FG&E) as they relate to the damage and restoration associated with the 2008 Ice Storm.*
8. "Technical Report: Post Hurricane Wilma Engineering Analysis." Prepared an expert report, gave **deposition testimony** and **testified at hearings** at the Florida Public Service Commission 2005 hurricane cost recovery hearings, Docket 060038-EI. Prepared on behalf of Florida Power & Light. *This report examines the infrastructure damage that occurred on the FPL system following Hurricane Wilma, and determines whether this damage was consistent with prudent management decisions and therefore eligible for recovery of the associated recovery costs.*

Expert Witness Testimony for Civil Proceedings

1. Provided consulting to counsel and gave **deposition testimony** for the case of Thomas Joseph Estarella et. al. vs. West Coast Ambulance Corporation et. al., filed in the Superior Court of California, Los Angeles County – Central District, Case No. BC527749. *I represented Southern California Edison with regards to the location of a utility pole involved in a vehicular accident.*
2. Prepared an expert report, gave **deposition testimony**, and **testified at trial** for the case of David Harrison v. Jersey Central Power & Light Company and FirstEnergy Corp. and Robert J. Peterson, filed in the Superior Court of New Jersey, Law Division, Mercer County, New Jersey, Docket No. L-1863-14. *I represented FirstEnergy in a case involving a civilian injury related to a downed wire occurring in the aftermath of Hurricane Sandy.*
3. Prepared a claim construction declaration, rebuttal declaration, and gave **deposition testimony** regarding U.S. Patent Nos. 7945502, 9569805, and 9256905 in the case of Grid Innovations LLC v. ERCOT, Civil Action No. 1:17-cv-234-SS, In The United States District Court for the Western District of Texas, Austin Division. *I represented Grid Innovations in this matter, who owned the patents at issue in an infringement case.*
4. Prepared an expert report, gave **deposition testimony**, and **testified at trial** for the case of James Tiencken vs. Rosikiewicz, et al, Superior Court of New Jersey, Law Division – Morris County, Docket No.: MRS-L-2555-14. *I represented FirstEnergy in a case involving a civilian injury related to a damaged utility pole occurring in the aftermath of Hurricane Sandy.*
5. Prepared an expert report, rebuttal report, and **deposition testimony** for the case of *ExxonMobil Corporation, a New Jersey corporation, Plaintiff, vs. Northwestern Corporation dba Northwestern Energy, a Delaware corporation,* Defendant, Case No. 1:16-cv-00005-SPW-CSO, United States District Court for The District of Montana Billings Division. *I represented ExxonMobil and prepared a report assessing two complete power interruptions to their Billings Refinery and whether NWE met its standard of care as defined in the tariff agreement.*
6. Prepared an expert report and gave **deposition testimony** for the case *Varentec v. Gridco,* Case 1:16-cv-00217-RGA in the United States District Court for the District of Delaware. *I represented Gridco in their defense of a patent infringement case by writing an expert report that was submitted to the U.S. Patent and Trademark office in Inter Partes Review No. IPR2017- 01135. The patents related to the local control of switched sources of reactive power.*
7. Prepared an expert report and gave **deposition testimony** and **trial testimony** for the case of *Gregg A. Spindler et. at (dba SGS Statistical Services) v. Virginia Electric Power Company (dba Dominion Virginia Power) and North American Transmission Forum*, United States District Court, Northern District of New York, Civil Action No. 5:15-cv-779. *I represented Dominion in a case where SGS accused them of unfair intellectual property appropriation related to transmission reliability benchmarking.*

8. "Infringement of CVR Patent," Prepared an expert report on infringement, two reports on invalidity, **two depositions** and **trial testimony**. U.S District Court for the Eastern District of Pennsylvania, Case No. 2:15-cv-00224-MAK. *Represented Dominion and reviewed material related to alleged patent infringement and validity by Alstom Grid of Dominion patents related to conservation voltage reduction (CVR).*
9. "Incident and Utility Response Assessment," Prepared a report and gave **deposition testimony** for JCP&L for the New Jersey civil case Lexington Insurance (as subrogee of School Excess Liability Fund, including its Member, Sussex County Community College) vs. Jersey Central Power & Light. *This report addressed the actions of JCP&L during restoration efforts after a snowstorm, where a community college experienced high voltages, a fire, and electronic equipment damage. This case settled for a nominal amount.*
10. "Utility Pole Placement Assessment." Prepared for FirstEnergy Corporation for the Pennsylvania civil case Wein vs. Supportive Concepts for Families Inc. et. al. Also gave a **deposition testimony** related to this report. *This report provides an assessment of Metropolitan Edison Company ("Met-Ed") with respect to utility pole NJ617 (Pole 617), in response to a vehicular collision. This report assesses whether the pole was located in an unsafe position, whether JCP&L had notice that the pole was located in an unsafe position, and whether the pole could be safely and efficiently relocated.*
11. "Utility Pole Placement Assessment." Prepared for FirstEnergy Corporation for the New Jersey civil case Seals, et al. v. JCP&L, et al. Also gave a **deposition testimony** and **trial testimony** related to this report. *This report provides an assessment of Jersey City Power & Light ("JCP&L") with respect to utility pole 50977-39347, in response to a vehicular collision. This report assesses whether the pole was located in an unsafe position, whether JCP&L had notice that the pole was located in an unsafe position, and whether the pole could be safely and efficiently relocated.*

Developed Courses

Dr. Brown has designed the curriculum, developed the material, and taught the following courses:

1. Distribution System Reliability, 40 hour course.
2. Utility Asset Management, 32 hour course.
3. Business Essentials for Utility Engineers, 40 hour course.
4. Power System Reliability and Risk Modeling, 24 hour course.
5. Utility Infrastructure Hardening, 16 hour course.
6. Capital Project Justification, 8 hour course.
7. Introduction to Electric Utilities, 16 hour course.

Summary: Testimony Direct Testimony of Richard E. Brown, PH.D., P.E. electronically filed by John F Stock on behalf of Ohio Coal Association