BEFORE THE
PUBLIC SERVICE COMMISSION OF MISSOURI

Joint Application of American Transmission Company of Illinois LLC and, For Authority to Construct and Operate a New 345 kV Transmission Line from Ottumwa to Adair to Palymra, Missouri	Docket No: EA-2015-0146

REBUTTAL TESTIMONY OF WILLIAM E. POWERS, P.E. ON BEHALF OF NEIGHBORS UNITED

October 21, 2015

Bill Powers, P.E.
Powers Engineering
4452 Park Blvd., Suite 209
San Diego, CA 92116

619-295-2072 (o)
619-917-2941 (c)
bpowers@powersengineering.com

Table of Contents

BEFORE THE
PUBLIC SERVICE COMMISSION OF MISSOURI

Joint Application of American Transmission Company of Illinois LLC and, For Authority to Construct and Operate a New 345 kV Transmission Line from Ottumwa to Adair to Palymra, Missouri	Docket No: EA-2015-0146

REBUTTAL TESTIMONY OF WILLIAM E. POWERS, P.E. ON BEHALF OF NEIGHBORS UNITED

I. Introduction

Q. Mr. Powers, please state your name, position and business address.

A. William E. Powers, P.E., principal of Powers Engineering, 4452 Park Blvd., Suite 209, San Diego, California, 92116.

Q. On whose behalf are you testifying in this case?

A. I am testifying on behalf of the Neighbors United of Kirksville, Missouri.

Q. Mr. Powers, please summarize your educational background and recent work experience.

A. I am a consulting energy and environmental engineer with over 30 years of experience in the fields of power plant operations and environmental engineering. I have permitted numerous peaking gas turbine, microturbine, and engine cogeneration plants, and am involved in siting of distributed solar PV projects. I began my career converting Navy and Marine Corps shore installation power plants from oil-firing to domestic waste, including woodwaste, municipal solid waste, and coal, in response to concerns over the availability of imported oil following the Arab oil embargo. I wrote "San Diego Smart

Energy 2020" (2007) and "(San Francisco) Bay Area Smart Energy 2020" (2012). Both of these strategic energy plans prioritize energy efficiency, local solar power, and combined heat and power systems as a more cost-effective and efficient pathway to large reductions in greenhouse gas emissions from power generation compared to conventional utility procurement strategies. I have written articles on the strategic cost and reliability advantages of local solar over large-scale, remote, transmission-dependent renewable resources. I have a B.S. in mechanical engineering from Duke University, an M.P.H. in environmental sciences from the UNC – Chapel Hill, and am a registered professional engineer in California. My complete resume is provided as Exhibit PE-02.

Q. What is the purpose of your testimony?

A. The purpose of my testimony is to evaluate: 1) of the electricity demand of Ameren Missouri (MO) customers in Northeast MO, 2) the likelihood of wind projects moving forward in the Adair Wind Zone over the next decade, 3) solutions other than the proposed ATXI 345 kV transmission line to the modeled Category C North American Electric Reliability Corporation (NERC) violation on the existing 161 kV lines serving the project area, 3) the feasibility and cost of reconductoring with high capacity composite conductors the 161 kV line segment that would experience an overload if 450 to 500 MW of wind power was constructed in the Adair Wind Zone, and 4) the feasibility and cost-effectiveness of substituting local solar for wind power to allow Ameren MO to meet its 2021 Renewable Portfolio Standard (RPS) obligation without building the proposed ATXI 345 kV transmission line. My rebuttal testimony primarily responds to the testimony of David Kramer and to a lesser extent to the testimony of Todd Schatzki, Ph.D.

II. Summary and Conclusions

Q. What documents have you reviewed as part of your investigation?

A. The principal documents I have reviewed include: MTEP11 Report and MTEP14 Triennial Review, 2012 MVP Report, 2010 MISO Regional Generation Outlet Study, 2011 and 2014 Ameren MO Integrated Resource Plans (IRP), 2010 MISO Regional Generation Outlet Study, U.S. Department of Energy (DOE) evaluation of current and near-term solar costs, DOE evaluation of near-term wind power additions, and the May 29, 2015 opening testimony of ATXI witnesses Dennis D. Kramer and Todd Schatzki, Ph.D.

Q. Please summarize your findings and conclusions.

- There are few Ameren MO customers in the Northeast Missouri project area, less than 13,000, about 1 percent of the 1.2 million Ameren MO customer base.
- There is no peak load growth forecast by Ameren MO for its service territory over the 2015-2034 period.
- The NERC Category C contingency that AXTI asserts will be mitigated with the proposed $224 million project can be mitigated with planned and controlled load shedding at no cost to Ameren MO customers.
- ATXI's claim that the Category C event will occur too fast to permit controlled load shedding is unsupported by any evidence. The amount of load drop that ATXI assumed for the event is about five times higher than the peak load projected (by Powers Engineering) for the affected substation.
- Several alternatives to mitigate the contingency that would not require a new 345 kV line, such as voltage regulation, demand response, and the addition of local solar generation, were not studied by ATXI.

- The modeled overloading of the Adair-Novelty 161 kV line when 450 MW of wind power is assumed at the Adair Substation may be an error due to use of a line capacity assumption that is too low. In any case, the overload condition could be mitigated by reconductoring the Adair-Novelty 161 kV line, a length of 30 miles, with composite conductor to double the capacity of the line.
- TradeWinds Energy, Inc., a major regional wind power developer, terminated a proposed 300 MW wind project in the Adair Wind Zone in 2012, the Shuteye Creek project, after eight years of development effort, citing no interest on the part of utilities in the area in pursuing wind power projects as the principal reason for terminating the project.
- TradeWinds Energy, per MISO standard interconnection queue cost responsibility requirements, would have paid for all transmission upgrades necessary in the project area to make the wind power fully deliverable. The projected cost of the necessary transmission upgrades would be on the order of a maximum of 1 to 1. 5 percent of the estimated wind project capital cost.
- ATXI ignores the current economic competitiveness of solar power with wind power, and the better match of solar output with summer peak demand, it its economic analysis of the benefits of the proposed ATXI 345 kV line.
- There are viable and cost-effective alternatives to constructing the proposed ATXI 345 kV line that achieve the project objectives described in the ATXI CPCN application while avoiding the environmental impacts that may be caused by the project.

III. Legal Framework for the Proposed ATXI 345 kV Transmission Line

Q. What are the justifications that ATXI identifies for the proposed 345 kV transmission line?

A. The ATXI Certificate of Public Convenience and Necessity (CPCN) application provides the following justifications for the proposed project:[1]

"*There is a need for the transmission capacity to be provided by the Mark Twain Project, and the Project is in the public interest in that it will provide for the integration of wind energy in Missouri to increase the amount of electricity available from renewable resources, including wind energy that would be transported to aid Missouri public utilities in complying with Missouri's Renewable Energy Standard, section 393.1020, RSMo., et seq. The Project is also part of improvements to the regional transmission system under MISO's functional control and will improve the overall reliability of the regional transmission system and reduce transmission system congestion. The Project will provide the additional benefit of providing a remedy to several reliability issues which can result in unacceptable low voltage conditions in the Kirksville area.*"

Q. What is the basis for the assumption by ATXI that Ameren MO will contract for 400 MW to 500 MW of wind power in the Adair Wind Zone in Northeast Missouri?

A. The Ameren MO 2014 Integrated Resources Plan (IRP). The 2014 IRP states that Ameren MO will contract for 400 MW of new wind power and 45 MW of new solar power, along with hydropower and biomass resources, by 2021 to meet its 15 percent renewable portfolio standard (RPS) obligation in 2021.[2]

Q. What are the requirements of the Missouri RPS law?

A. The RPS applies only to the state's investor-owned utilities and does not place any requirements on municipal utilities or electric cooperatives. The RPS standard is 15

[1] ATXI Application for Certificate of Public Convenience and Necessity for 345,000-volt Electric Transmission Line, Application EA-2015-0146, p. 5.
[2] **Exhibit PE-03**, Ameren MO 2014 IRP webpage summary: https://www.ameren.com/missouri/environment/renewables/ameren-missouri-irp

percent by 2021 for electric utilities based on annual electricity sales. The RPS contains a solar electricity carve-out equal to 2 percent of the RPS requirement. Utilities with renewable energy obligations under the standard are required to offer a solar rebate program. Self-generated solar power is RPS-eligible. Utilities own the solar renewable energy certificates (SRECs) of any system that receives a rebate for a period of 10 years. In-state renewable energy generation receives a multiplier of 1.25 compared to out-of-state generation (i.e., in-state generation is worth 25 percent more for compliance purposes).[3]

Q. Can out-of-state RECs be used to comply with the RPS standard?

A. Yes. Compliance with the objective can be achieved through the procurement of renewable energy or renewable energy credits (RECs). Solar RECs, known as "SRECs," may be used to comply with the solar standard, or with the portion of the standard not specifically devoted to solar resources.

Q. Is the price of RECs from existing renewable generation sources consistently lower than the cost of contracts for new renewable generation, even in-state generation worth 25 percent more for RPS compliance purposes?

A. Yes. The average 2014-2015 cost of RECs in the Western U.S. was $16.55 per megawatt-hour ($/MWh).[4]

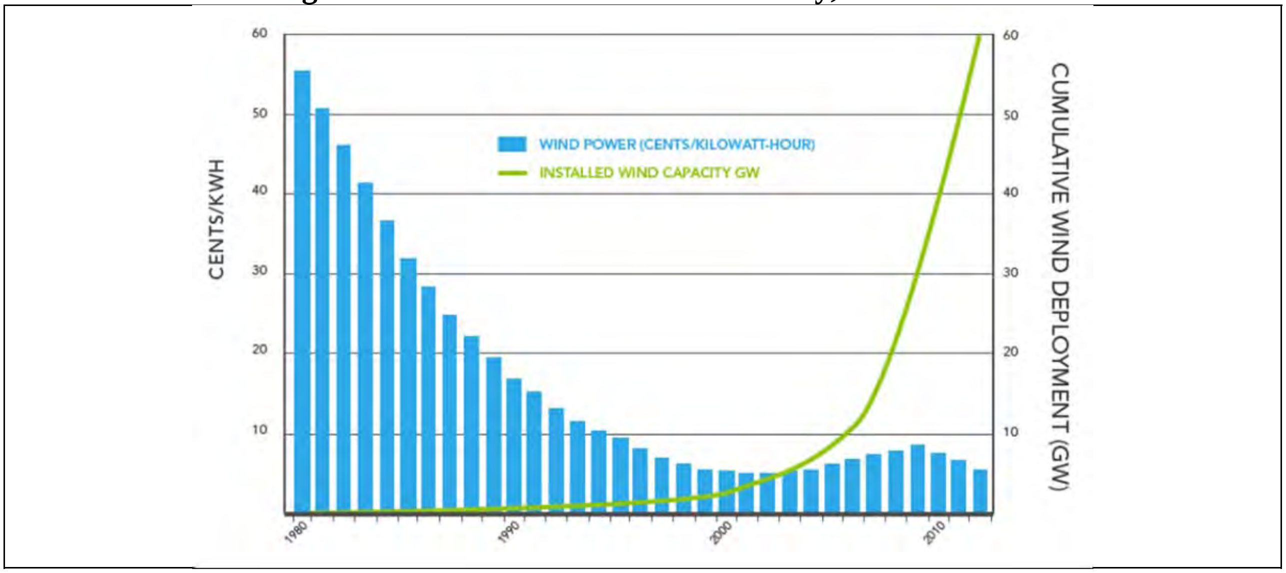
Q. What is a typical price range and the price trend for wind power, according to the Department of Energy?

A. The typical current price range of wind power is $50/MWh to $60/MWh, or $0.05 per kilowatt-hour (kWh) to $0.06/kWh, as shown in Figure 1. The price of wind power at the end of 2012 was almost unchanged from the price of wind power in 2000.

---

[3] Missouri Revised Statutes, Section 393.1030.1, August 28, 2014.
[4] **Exhibit PE-04**, 2014-2015 DOE survey of REC prices in Western U.S.

Figure 1. Cost of Wind Power Electricity, 1980 - 2012[5]



Q. Does the Missouri RPS law structurally favor lower-cost RECs from existing sources, primarily existing wind farms, at the expense of new renewable energy construction in Missouri or elsewhere?

A. Yes. There are no restrictions on the use of RECs to meet RPS targets in Missouri.

Q. Therefore, is new wind development of any kind by investor-owned utilities likely in Missouri absent some restrictions on the use of RECs to meet RPS obligations?

A. No.

IV. Ameren MO Has Very Few Customers in the Project Area and No Projected Peak Demand Growth

Q. How many customers does Ameren MO have?

A. Ameren MO has 1,190,821 customer meters.[6]

---

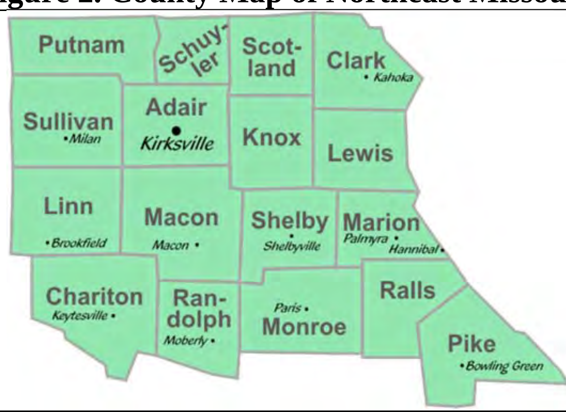
[5] **Exhibit PE-05**, U.S. DOE, *Revolution Now - The Future Arrives for Four Clean Energy Technologies*, September 17, 2013, p. 2.

[6] **Exhibit PE-06**, Ameren MO number of meters by county.

Q. How many Ameren MO meters are located in Northeast Missouri counties along the pathway of the proposed ATXI 345 kV transmission line and including counties in the Adair Wind Zone (Schuyler, Putnam, Sullivan, Adair, Shelby, Knox and Marion Counties)?

A. 12,946. The counties in the Adair Wind Zone include Schuyler, Putnam, Sullivan, and Adair. The total number of Ameren MO meters in these four counties is 11,557, of which 10,308 meters are in and around Kirksville, MO in Adair County. The proposed 345 kV transmission line would continue southeast from Adair County through Shelby and Knox counties, terminating at the Palmyra Substation in Marion County. Shelby, Knox, and Marion counties have 1,389 Ameren MO meters. A county map of Northeast Missouri is provided in Figure 2.

Figure 2. County Map of Northeast Missouri[7]



Q. The number of Ameren MO meters in Northeast Missouri counties along the pathway of the proposed ATXI 345 kV transmission line, and including the adjacent Adair Wind Zone, is about 1 percent of Ameren MO total number of meters?

A. Yes.

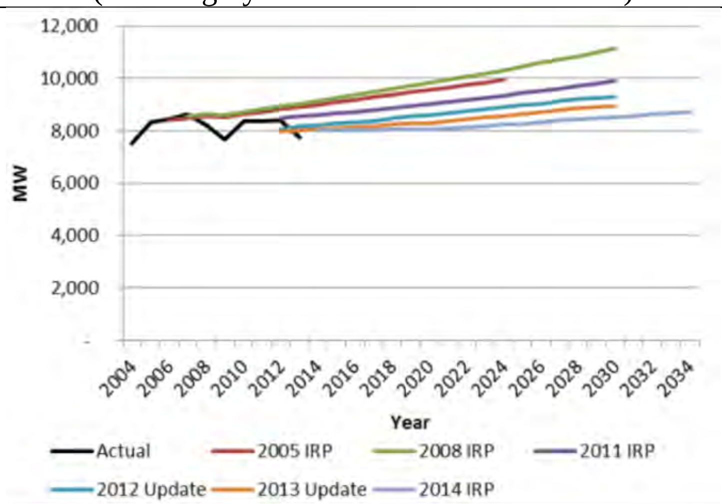
[7] Source of NE Missouri county map: http://northeastmissourirealty.com/northeast-missouri-real-estate-maps-links/

Q. Does Ameren MO forecast any peak load growth through 2034?

A. No. The Ameren MO all-time actual peak load was 8,784 MW in 2007.[8] The Ameren MO peak load forecast included in the 2014 IRP does not return to the all-time actual peak load level until after 2034. This is shown in Figure 3. The current forecast is the gray line identified as "2014 IRP". Peak load is forecast to remain relatively constant at about 8,000 MW, 10 percent below the historic peak in 2007, until 2024.

Figure 3. Ameren MO Peak Load Growth Forecast Through 2034[9]

(bottom gray line is current 2014 forecast)



Q. Therefore the Northeast Missouri fraction of 2021 projected peak load should be about 1 percent of 8,000 MW, or about 80 MW, correct?

A. Yes.

Q. How much of this 80 MW regional load would be at the Adair Substation?

A. About 64 MW. About 80 percent of the Ameren MO customer meters in the project area, 10,308 of 12,946, are located in Adair County.

[8] **Exhibit PE-07**, Ameren MO 2014 IRP, Table 3-7, p. 51.

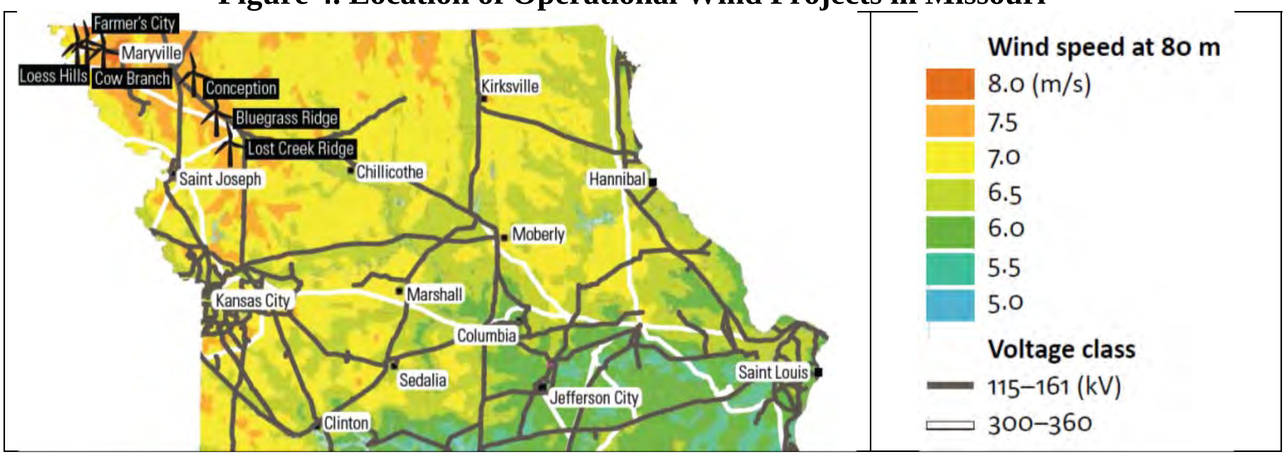
[9] Ibid, p. 6.

V. No Wind Projects Proposed in Northeast Missouri, that Have Completed the MISO Interconnection Study Process, Have Been Stalled by Lack of Transmission Capacity

Q. How much wind capacity is operational in Missouri and where is it located?

A. The six operational wind projects in Missouri, totaling 458 MW, are located in Northwest Missouri as shown in Figure 4. Approximately two-thirds of this wind power output is contracted to Missouri electric cooperatives, and one-third is supplied to MidAmerica Energy Corporation.[10] No wind power generated in Missouri is contracted to Ameren MO. Ameren MO does contract for 102 MW of wind power from the Pioneer Prairie II wind farm in McIntire, Iowa, located on the Iowa border with Minnesota.[11]

Figure 4. Location of Operational Wind Projects in Missouri[12]



Q. Has any wind developer completed the MISO interconnection study process for a project in Northeast Missouri?

A. Yes. The MISO interconnection study process was completed in 2007 for one project, TradeWind Energy's proposed 300 MW Shuteye Creek wind farm, that would connect with the Adair Substation.[13]

---

[10] **Exhibit PE-08**, Missouri Partnership, *Missouri's Advantages for Wind Energy*, September 2014, p. 11.
[11] **Exhibit PE-09**, Ameren "Utility Scale Wind-Powered Electric Generation" webpage, October 19, 2015: https://www.ameren.com/missouri/environment/clean-energy/wind
[12] **Exhibit PE-08**, p. 11.

Q. Isn't it true under Missouri RPS accounting rules that in-state renewable energy generation is credited with a 25 percent multiplier, such that a 300 MW in-state wind project has the RPS value of 375 MW out-of-state wind project?

A. Yes.

Q. What were the results of the MISO interconnection study?

A. The result was that the project developer would need to pay for $10.9 million in upgrades to the existing Associated Electric Cooperative Inc. (AECI) 161 kV transmission and 69 kV sub-transmission systems to make the project fully deliverable per MISO network resource interconnection requirements.[14]

Q. What percentage is $10.9 million of the total cost of a 300 MW wind project?

A. The mean wind power capital cost identified in the MTEP14 Triennial Report Update is $2.4 million per MW. Therefore, the capital cost of a 300 MW project would be: $2.4 million/MW × 300 MW = $720 million.

Q. So the $10.9 million cost to upgrade the existing transmission system to make the wind power fully deliverable would be about 1.5 percent of the overall $720 million cost, correct?

A. Yes.[15]

Q. Is it your opinion that a transmission system upgrade cost that is about 1.5 percent of the overall wind project capital cost would have little or no impact on the financial viability of the wind project?

A. Yes.

---

[13] MISO Interconnection Queue, Missouri wind projects, October 19, 2015: https://www.misoenergy.org/PLANNING/GENERATORINTERCONNECTION/Pages/InterconnectionQueue.aspx.
[14] **Exhibit PE-10**, 2007 MISO interconnection study, 300 MW Shuteye Creek wind farm p. 4.
[15] $10.9 million ÷ $720 million = 0.015 (1.5 percent).

Q. Under MISO interconnection requirements the project developer is responsible for the interconnection costs to make the project fully deliverable, correct?

A. That is correct.[16]

Q. There would be no cost to the Ameren MO ratepayers, correct?

A. That is correct.

Q. The cost of the proposed ATXI 345 kV transmission line is $224 million, correct?

A. Yes.[17]

Q. Ameren MO customers will pay 8 percent of this $224 million, or approximately $18 million, whether or not any wind power is ever built in the Adair Wind Zone, correct?

A. Yes.[18]

Q. Was the Shuteye Creek wind project built?

A. No.

Q. Why not?

A. Lack of interest on the part of any Missouri utility to contract for the wind power. The CEO of TradeWind Energy, Inc. stated at the time the project was terminated in April 2012 that, "*TradeWind has invested millions of dollars to lease and develop the Shuteye project area, including funding transmission interconnection studies, collecting wind data, conducting environmental studies, and developing engineering plans. Unfortunately it has become increasingly evident that the wind energy market in Missouri will simply*

[16] **Exhibit PE-10**, p. 4.
[17] ATXI J. Jontry opening testimony, May 29, 2015, p. 11, lines 10-11.
[18] ATXI M. Borkowski opening testimony, May 29, 2015, p. 6, lines 5-10. 0.08 × $224 million = $17.92 million.

not develop in the foreseeable future given the lack of interest in wind energy in the state."[19]

Q. Is it true that Ameren MO opted not to pursue a 300 MW wind project in the Adair Wind Zone, despite the fact that the project output would be fully deliverable via the existing 161 kV transmission system at no cost to Ameren MO customers?

A. Yes.

VI. The Existing Ameren MO and AECI 161 kV Transmission Lines Are Sufficient to Address Reliability Justifications for ATXI 345 kV Line

Q. What are the two reliability justifications offered by ATXI to construct the proposed 345 kV line?

A. The two reliability contingency conditions that ATXI states the proposed 345 kV transmission line would resolve are: 1) on-peak low voltage Category C NERC contingency at the Adair Substation if the two Ameren MO 161 kV lines go out-of-service at the same time with a 300 MV load on the substation, and 2) shoulder peak capacity violations if 450 MW of wind power is dispatched into the 161 kV transmission system at the Adair Substation.[20]

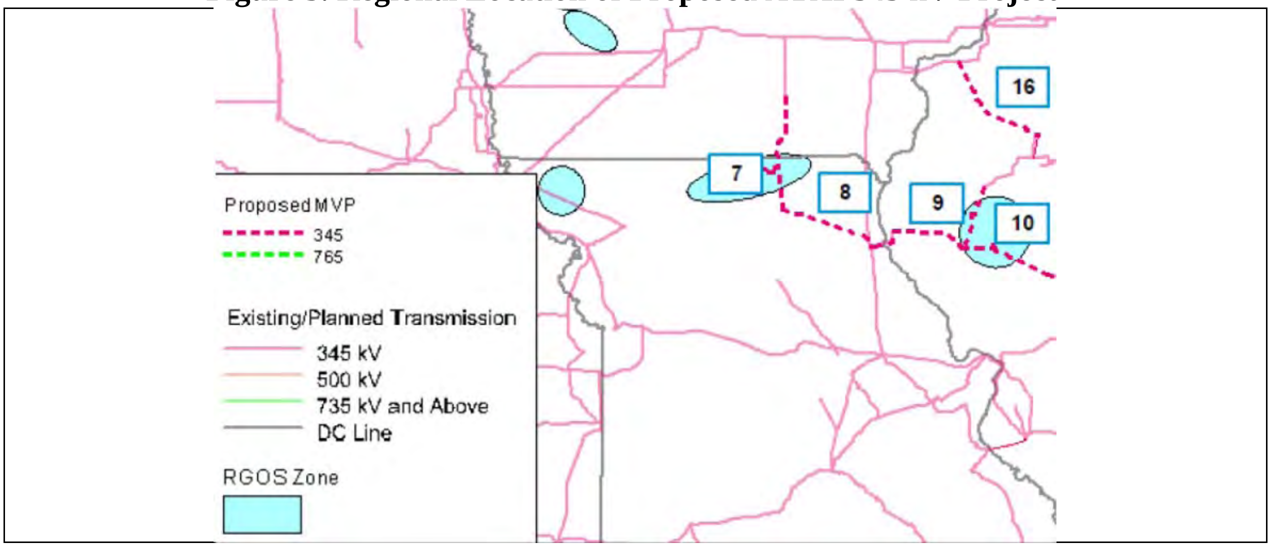
Q. Where is the proposed ATXI 345 kV project located?

A. A map showing the regional location of the proposed transmission project, as well as regional wind resources and nearby MVP transmission projects, is provided in Figure 5. The proposed ATXI 345 kV project under consideration by the Missouri PSC consists of the Missouri portion of MVP Project 7, and MVP Project 8. The Adair Wind

[19] **Exhibit PE-11**, KTVO.com, *Economic hopes blow away as wind farm falls through*, April 5, 2012.
[20] For the purposes of this testimony, "MVA" and "MV" are assumed to be equivalent.

Zone, with a projected potential of 450 to 500 MW of wind capacity, is shown in Figure 5 as a blue oval under the box containing the MVP project number "7".[21]

Figure 5. Regional Location of Proposed ATXI 345 kV Project[22]



RGOS = Regional Generation Outlet Study

Q. How many transmission lines currently serve the proposed project area in Northeast Missouri?

A. Three 161 kV lines, two owned by Ameren MO and one owned by AECI. All three transmission lines interconnect at the Adair Substation near Kirksville, MO. See Figure 6. The proposed pathway of the ATXI 345 kV line is also shown in Figure 6.

//

//

//

//

//

//

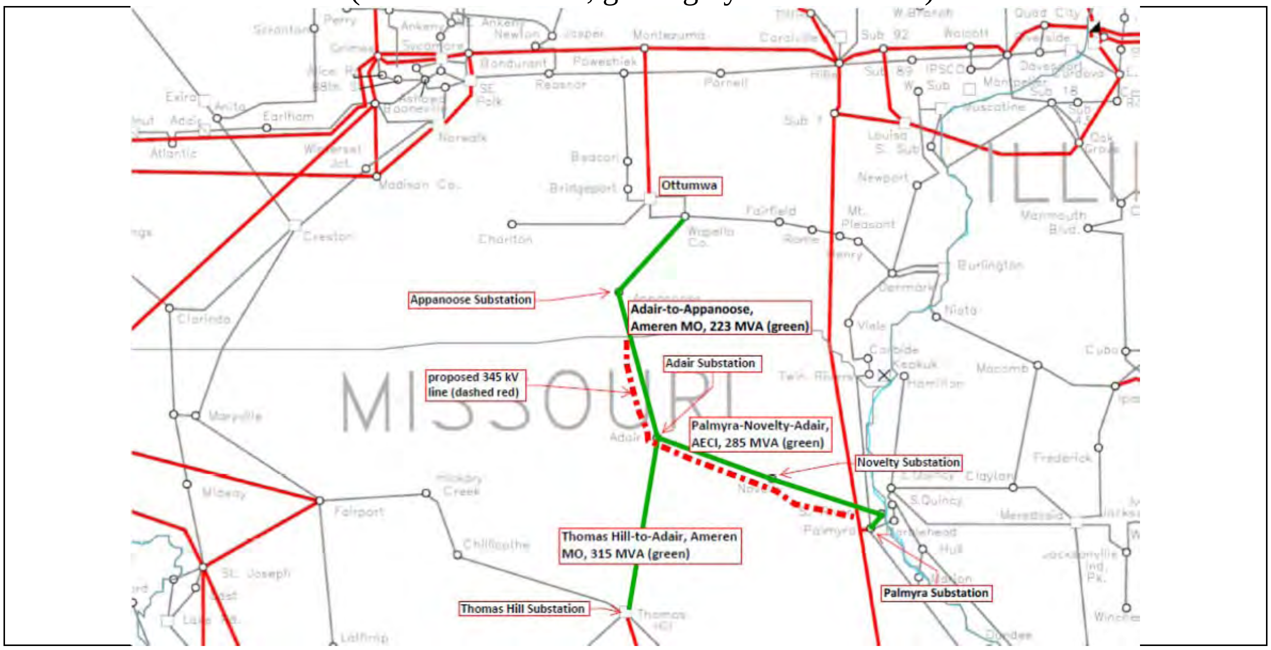
//

//

[21] MISO, *Multi Value Project Analysis Report*, Appendix B: Powerflow Modeling Approach, January 20, 2012, Table 20, p. 9. The Adair Wind Zone is also known as the "MO-C" wind zone.
[22] MTEP11 Report, Figure 4.1-11, p. 58.

Figure 6. Transmission Map of Northeast Missouri and Southeast Iowa[23]

(red = 345 kV line, green/gray = 161 kV line)



Tags with text, dashed red line, and solid green lines added by B. Powers

A. The Category C NERC Violation Modeled by ATXI Can Be Mitigated Without Constructing the Proposed 345 kV Line

Q. Who owns which 161 kV line interconnecting at the Adair Substation and how long are these lines?

A. Ameren MO owns and operates the Thomas Hill-to-Adair 161 kV line. This line has a length of 44 miles.[24] The Missouri portion of the Adair-to-Appaloose 161 kV line is also owned by Ameren MO. The Missouri portion of this line has a length of 41 miles.[25] ITC Midwest owns the extension of this 161 kV line on the Iowa side of the border to the Appaloose Substation.[26] AECI owns and operates the Palmyra-to-Novelty and

[23] **Exhibit PE-12**, ATXI DR-001 response, October 16, 2015.
[24] **Exhibit PE-13**, ATXI DR response NU-A10, October 10, 2015.
[25] Ibid.
[26] Ibid, ATXI DR response NU-A1, October 10, 2015.

Novelty-to-Adair 161 kV lines. Each of these AECI lines is approximately 30 miles in length, with a total Palmyra-to-Novelty-to-Adair line length of approximately 60 miles.

Q. What are the rated capacities of these three 161 kV lines?

A. Thomas Hill-to-Adair, 315 MW; Adair-to-Appaloose, 223 MW; Palmyra-to-Novelty-to-Adair, 285 MW.[27]

Q. Are the Ameren MO and AECI 161 kV transmission systems fully compatible?

A. Yes.[28]

Q. Does AECI have the right to send 50 MW of power to the Adair Substation and over the Ameren MO 161 kV line to Appaloose and the ITC Midland 161 kV line in Iowa at any time?

A. Yes.[29]

Q. Can AECI send more than 50 MW of power over the Ameren MO 161 kV line with Ameren MO authorization?

A. Yes.[30]

Q. Are Ameren MO and AECI obligated by their interchange agreement to assist to the extent possible in an emergency condition to protect the stability of their respective systems?

A. Yes. The interchange agreement states "*in case of an emergency or other unusual operating condition, the Party supplying the Delivery Point Service, as hereinafter described, may attempt to deliver power and energy in excess of the contractual amount*

[27] **Exhibit PE-13**, ATXI DR response NU-A1, October 10, 2015. Note that "MW" and "MVA" are used interchangeably in this rebuttal testimony.
[28] **Exhibit PE-14**, Ameren MO – AECI interconnection agreement, p. 6.
[29] Ibid, p. 25.
[30] Ibid, p. 25.

if it, in its sole judgment, has additional transmission capacity available at that time."[31]

Q. What does this mean in common language?

A. This means that, for example, if Ameren MO were to lose both of its 161 kV line connections to the Adair Substation at the same time for any reason while serving a 50 MW on-peak load in the Kirksville area, AECI would immediately serve that 50 MW load if it had sufficient available capacity on its Palmyra-to-Adair 161 kV line.

Q. What percentage of AECI peak system load does 50 MW represent?

A. About 1 percent. The historic AECI summer system peak load was 4,400 MW in 2011.[32] The historic winter peak load was 4,600 MW in 2014.[33] Both summer and winter peak loads were less than 4,000 MW in 2013.[34] AECI projects the summer and winter peaks will be at about 4,600 MW in 2020.[35]

Q. Is the AECI system be able to adjust to an instantaneous load increase equal to 1 percent of system load without compromising the reliability of the AECI transmission system, assuming a 64 MW load is suddenly placed on the AECI system at the Adair Substation?

A. Yes. AECI must maintain voltage within a range, meaning some level of supply and demand imbalance is permissible, and also maintain a certain amount of spinning reserve, meaning generation sources that are online and immediately available to supply power, to assure the AECI grid can adjust to out-of-balance conditions between supply

[31] Ibid, p. 4.
[32] **Exhibit PE-15**, AECI overview PowerPoint to Missouri PSC, January 2014, p. 6.
[33] Ibid, p. 6.
[34] Ibid, p. 6.
[35] Ibid, p. 6.

and demand while staying within its post-contingency voltage deviation limits and voltage response requirements.

Q. What load does ATXI assume must be dropped at the Adair Substation in the event of loss of both Ameren MO 161 kV transmission lines interconnecting at the Adair Substation, described as a NERC Category C contingency by ATXI?

A. 300 MVA (300 MW).[36]

Q. Is the magnitude of this assumed load drop credible in light of the number of Ameren MO customers being served by the Adair Substation?

A. No. 300 MW is nearly five times higher than the actual Ameren MO peak load on the Adair Substation of 64 MW estimated by Powers Engineering.

Q. The burden of proof in a CPCN proceeding rests with the applicant, correct?

A. Yes.

Q. Has ATXI provided any evidence to explain the source of the 300 MW of load it assumes will be dropped at the Adair Substation during the Category C contingency event?

A. No.

Q. Therefore, has ATXI met its burden of proof regarding the reasonableness of the modeled Category C contingency?

A. No.

Q. What is the mission of the NERC?

A. NERC is a regulatory authority whose mission is to assure the reliability of the bulk power system in North America. NERC develops and enforces reliability standards.

---

[36] MW and MVA are used interchangeably in this testimony.

NERC is the electric reliability organization for North America, subject to oversight by the Federal Energy Regulatory Commission (FERC).[37]

Q. Are ATXI, Ameren MO, and AECI subject to NERC reliability standards?

A. Yes.

Q. Please summarize the NERC reliability standards to which the Ameren MO and AECI 161 kV systems are subject to in Northeast Missouri.

A. NERC reliability standards require the simulation of a range of potential conditions from no contingencies (Category A) to extreme events (Category D). The two intermediate categories of contingencies, Category B, events resulting in the loss of a single element and Category C, event(s) resulting in the loss of two or more elements constitute the majority of contingencies examined. An example of a Category B contingency is the fault and loss of one transformer bank. An example of a Category C contingency is the fault and simultaneous loss of two transmission lines that share a common tower. Category D contingencies are extreme events with no specific performance requirements other than an evaluation for risks and consequences.[38]

Q. Is Ameren MO required by NERC reliability standards to fully mitigate a Category C contingency involving the simultaneous loss of the two Ameren MO 161 kV lines interconnected at the Adair Substation?

A. No. Ameren MO is required to fully mitigate, meaning no loss of customer load, the loss of a single transmission element (Category B), for example loss of one of the two 161 kV lines. However, Ameren MO is allowed to utilize planned and controlled load

---

[37] NERC "About NERC" webpage, October 19, 2015: http://www.nerc.com/AboutNERC/Pages/default.aspx

[38] **Exhibit PE-16**, SCE Opening Testimony, 2012 Long-Term Procurement Proceeding Track 4, August 2013, pp. 21-22.

shedding to address a more serious, and presumptively under NERC requirements a far less likely, Category C contingency.

Q. Has ATXI provided any evidence or testimony that the simultaneous loss of its two 161 kV lines interconnected at the Adair Substation have ever been lost simultaneously under peak load conditions?

A. No. ATXI is not asserting that the project will resolve a real deficiency in the reliability of the existing 161 kV system, only that a low probability hypothetical contingency event, one that has apparently never occurred in decades of successful operation of the existing 161 kV system, would be resolved without loss of load if the proposed ATXI 345 kV line is built.

Q. But don't NERC requirements allow controlled load shedding in the Kirksville area to address this low probability Category C event, instead of building new transmission, or new generation, to mitigate the impacts of the event?

A. Yes. ATXI acknowledges this, stating: "*The NERC Reliability Standard does allow planned and controlled load shedding for a NERC Category C event*."

Q. If that is the case, given controlled load shedding – an operational tool that has apparently not been needed for this specific contingency over many decades and may never be needed – is a no-cost solution to this Category C event, why is ATXI proposing a $224 million transmission solution?

A. ATXI implies that the Category C event in question, without explicitly defining it as such, is the simultaneous loss of its two 161 kV lines interconnected to the Adair Substation. ATXI states by way of explanation that "*the loss of two 161 kV lines in northeastern Missouri results in a significant and very rapid low voltage condition* *that does not provide adequate time to implement a controlled load shedding response*."

Q. Isn't the very rapid low voltage condition also an artifact of ATXI assuming a load on the Adair Substation at the moment of the loss of the two 161 kV lines that is about five times higher, at 300 MW, than the projected actual peak load of the Ameren MO customer being supplied by the substation of about 64 MW?

A. Yes.

Q. Also, haven't multiple Western utilities successfully petitioned NERC (via the Western Electricity Coordinating Council – WECC) to reclassify the simultaneous loss of two transmission lines that are not on the same transmission pole or immediately adjacent to each other in the same right-of-way as an extreme low probability Category D contingency that does not require a mitigation plan?

A. Yes. Seven high voltage transmission line corridors with two or more transmission lines in parallel in the same corridor in the Western U.S. were reclassified between 2002 and 2012 from generic Category C contingencies to specific Category D contingencies on the basis of the low probability of the likelihood of simultaneous outages between 2002 and 2012.[39]

Q. Are the Ameren MO Thomas Hill-to-Adair and Adair-to-Appaloose 161 kV lines on the same pole or in the same right-of-way?

A. No. One line runs south from the Adair Substation, the other runs north from the Adair Substation.

Q. Therefore, wouldn't the simultaneous loss of both of these 161 kV lines at peak demand, at least in the WECC jurisdiction where a formal reclassification

[39] **Exhibit PE-17**, WECC, PURC White Paper, February 2013. Attachment 2, p. 12.

procedure has been in place for years, qualify for reclassification from Category C to Category D?

A. Yes. This would be an extreme low probability event. The two Ameren MO 161 kV lines interconnected at the Adair Substation are physically isolated from each other, do not share a common corridor, and in the opinion of Powers Engineering are less likely as a result to experience a simultaneous outage than the Western transmission lines that were re-categorized from Category C to Category D contingencies.

Q. Is it reasonable and prudent for the MO PSC to approve a CPCN for a $224 million transmission line, of which $18 million will be paid by Ameren MO ratepayers, to address a contingency that, in the unlikely event that it actually occurs, could inconvenience 10,308 customers, about 1 percent of Ameren MO's customer base, for minutes or hours?

A. No.

B. The Shoulder Peak Overload Condition Modeled by MISO with 450 MW of Wind Power at Adair Substation Can Be Mitigated Without Constructing the Proposed 345 kV Line

Q. What did MISO assume in its modeling when it asserted wind power interconnected at the Adair Substation would overload the existing 161 kV lines in Northeast Missouri?

A. MISO assumed that wind generation connected at the Adair Substation, with 450 MW dispatched in off-peak conditions, would overload the 161 kV line from Adair to Novelty in the base case, and during other contingencies overloads the 161 kV lines to the north and south, as well as some nearby transformers.

Q. Why does MISO assume that the overload occurs when the lines have, but for the assumed inflow of wind power, moderate or light off-peak loads?

A. Because wind power output is predominantly an evening and night-time resource that is a poor match for afternoon on-peak electricity demand periods. The capacity factor of Missouri wind power that MISO estimates for summer on-peak periods is only 6 percent.[40]

Q. Is 450 MW or 500 MW of wind power development likely in the Adair Wind Zone?

A. No. As previously explained a major regional wind energy developer, TradeWind Energy, spent eight years attempting to construct a 300 MW wind project in the Adair Wind Zone. Neither Ameren MO nor any other utility showed interest in contracting for the 300 MW of wind power proposed by TradeWind Energy. The fact that Ameren MO can meets its RPS requirements with inexpensive RECs makes it unlikely that Ameren MO will contract for a more costly power purchase agreement for new wind power in the Adair Wind Zone.

Q. Assuming for sake of argument that 500 MW wind project would be developed in the Adair Wind Zone, isn't the wind energy developer responsible under MISO interconnection requirements for paying for all transmission system upgrade costs necessary to make the wind power from the proposed project fully deliverable?

A. Yes.[41]

Q. So Ameren MO customers would not pay any charge for the wind developer to interconnect to the existing Ameren MO transmission system?

A. That is correct.

[40] **Exhibit PE-18**, MISO, *Regional Generator Outlet Study*, November 19, 2010, Appendix 1, Figure A1.3-3, p.13.
[41] **Exhibit PE-10**, p. 5.

Q. Didn't MISO state that 450 MW of connected wind power would overload the 161 kV line from Adair to Novelty in the base case?

A. Yes. MISO assumes that the Adair-to-Novelty line has a rating of 167 MW and experiences a load that is 154.6 percent of maximum loading.[42] Therefore the loading on the line imposed by 450 MW of wind power at the Adair Substation, if the line was capable of transporting it, would be 167 MW × 1.546 = 258 MW.

Q. But didn't ATXI confirm in a data response that the rated capacity of the Adair-Novelty-Palmyra 161 kV line is 285 MVA, or approximately 285 MW, which is greater than the projected 258 MW load?

A. Yes. No information has been provided by ATXI to explain why ATXI identifies the carrying capacity of the Adair-Novelty-Palmyra line as 285 MVA and MISO assumes the Adair-Novelty segment is capable of carrying only 167 MW.

Q. If MISO had assumed that the Adair-Novelty line could carry at or near 285 MW, would MISO have identified an overload condition on the line with 450 MW of wind power being dispatched at the Adair Substation?

A. No.

Q. What is one transmission upgrade that TradeWind Energy, or any other wind developer, could have proposed to make 450 MW of wind power flowing into the Adair Substation fully deliverable over the Adair-to-Novelty 161 kV line?

A. Standard "aluminum conductor steel reinforced" (ACSR) conductors are used on the two Ameren MO 161 kV lines interconnecting with the Adair Substation.[43] Powers Engineering assumes the AECI Adair-Novelty-Palmyra 161 kV transmission line is also ACSR of comparable conductor size to the Ameren MO Thomas Hill-to-Adair 161

[42] **Exhibit PE-19**, MISO, Candidate MVP Reliability Analysis, Appendix CMVP TSTF, July 28, 2011.
[43] **Exhibit PE-13**, ATXI DR response NU-A3, October 10, 2015.

kV line, due to the similar capacities of these lines as reported by ATXI.[44] The original ACSR conductor can be replaced with "aluminum conductor composite core" (ACCC) or "aluminum conductor composite reinforced" (ACCR) conductor to approximately double the capacity of a transmission line.[45] Reconductoring the AECI Adair-to-Novelty 161 kV line segment with ACCC or ACCR conductor would increase the capacity of the line from 285 MW to approximately 570 MW.[46]

Q. Has reconductoring of ACSR 161 kV lines to ACCC conductor taken place in the region?

A. Yes. See examples of where ACSR conductor has been replaced with ACCC conductor on 161 kV lines in the region in Table 1.

Table 1. Examples of 161 kV Lines that Have Been Reconductored with ACCC Conductor[47]

Client	Project	Location	Voltage, kV	Conductor	Year
AEP	Chamber Springs Substation	Rogers, AR	161	Drake	2006
AEP	Chamber Springs - Tonitown	Rogers, AR	161	Drake	2006
KAMO	Springfield - Brookline	Springfield, MO	161	Cardinal	2007
Flour Alliance - Tapoco APGI	Santeetlah Bus Upgrade	Robbinville, NC	161	Bittern	2009
Entergy	Ano - Russellville North Rebuild	Russellville, AR	161	Cardinal	2009
Entergy	Dardanelle Dam - Russellville South 161kV	Russellville, AR	161	Munich	2011
Entergy	Ano - Russellville North Rebuild	Russellville, AR	161	Cardinal	2012

[44] Ibid. Thomas Hill-to-Adair line segment conductor is 954 kcmil ACSR 45/7 Rail.
[45] **Exhibit PE-20**, CTC Global, ACCC conductor capacity and cost.
[46] **Exhibit PE-13**, ATXI DR response NU-A1, October 10, 2015.
[47] **Exhibit PE-20.**

Q. What is the distance from the Adair Substation to the Novelty Substation?

A. About 30 miles.

Q. What would be the equipment cost of 30 miles of three-phase 161 kV ACCC conductor?

A. About $4 million.[48]

Q. If it is assumed that the installed cost of the reconductoring project is double the $5 million ACCC conductor equipment cost, such that the total cost of the Adair-to-Novelty ACCC reconductoring project would be on the order of $10 million, what percentage is this $10 million of the total cost of the 500 MW wind project it would support?

A. The mean wind power capital cost identified in the MTEP14 Triennial Report Update is $2.4 million per MW. Therefore, the capital cost of a 500 MW project would be: $2.4 million/MW × 500 MW = $1.2 billion.

Q. So the approximate $10 million cost to upgrade the existing 161 kV line that would otherwise experience an overload would be about 1 percent of the overall $1.2 billion cost of the 500 MW wind project?

A. Yes.

Q. Is it your opinion that a transmission system upgrade cost that is about 1 percent of the overall wind project capital cost would have little or no impact on the financial viability of the wind project?

A. Yes.

Q. Who would pay this transmission upgrade cost?

A. The wind project developer.

---

[48] **Exhibit PE-20**. $1.5 million for 12 miles of 3-phase 161 kV line (38 miles ÷ 3 conductors per mile = ~12 miles). Therefore, cost of 30 miles of 3-phase 161 kV ACCC conductor = 30 miles/12 miles × $1.5 million = $3.75 million.

VII. Ameren MO has Multiple Options at its Disposal to Address a Category C Contingency at the Adair Substation Without Building the ATXI 345 kV Line

Q. Did the interconnection study for 300 MW of wind power at the Adair Substation determine there was no need for reactive power (voltage regulation) at the Adair Substation to accommodate 300 MW of wind power?

A. That is correct.[49]

Q. So the entirety of the need for voltage regulation at the Adair Substation would be in response to the Category C event modeled by MISO that results in a low voltage condition at the substation when 300 MW of load is abruptly dropped?

A. Yes.

Q. What are options are available other than a new 345 kV transmission line to address a Category C contingency along the Thomas Hill-Adair-Appaloose 161 kV transmission pathway?

A. Options, in addition to planned and controlled load shedding as permitted by NERC, include the addition of voltage regulation hardware at the Adair Substation, demand response to rapidly shed load as needed at times of peak demand on the Adair Substation, the addition of local generation – conventional or solar, and energy efficiency measures to reduce demand overall.

Q. What are the benefits of adding voltage regulation hardware at the Adair Substation?

A. Voltage regulation equipment installed at the Adair Substation would allow Ameren MO to "buy time" in an emergency contingency situation like the Category C contingency modeling by MISO, so the utility could initiate planned and controlled reduction of

[49] **Exhibit PE-21,** 2006 Interconnection Feasibility Study, 300 MW Shuteye Creek, p. 3.

load (load shedding), such as air conditioning load, in response to the contingency situation. The voltage regulation equipment could also provide time for AECI to adjust its system, through the Palmyra-Novelty-Adair 161 kV line, to meet the demand at the Adair Substation without shedding load.

Q. What are some examples of voltage regulation equipment that can address low voltage conditions?

A. A series capacitor or a static VAR compensator can address the abrupt low voltage Category C contingency described by ATXI.[50]

Q. How much voltage regulation, also known as reactive power, should be available to address the low voltage event?

A. Assuming a load on the substation of approximately 64 MW at the time of the Category C contingency, the maximum summer peak demand load on the Adair Substation estimated by Powers Engineering, and a 1:1 ratio of real power in MVA to reactive power in MVAR (MVA Reactive), assume 64 MVAR of reactive power is located at the Adair Substation to address the contingency.

Q. What are the costs of adding voltage regulation hardware at the Adair Substation?

A. The capital cost of a 64 MVAR series capacitor would be in the range of $2 million. The cost of a 64 MVAR static VAR compensator would be about $5.5 million.

Q. Which piece of voltage regulation equipment could address the abrupt low voltage condition in near real-time?

A. The static VAR compensator. The series capacitor would require a switching action.

[50] **Exhibit PE-22**, B&V, *Capital Costs for Transmission and Substations*, October 2012, p. 3-3 & p. 3-4.

Q. How does the cost of adding a 64 MVAR static VAR compensator to the Adair Substation to address the Category C contingency compare to the cost to Ameren MO ratepayers of constructing the proposed ATXI 345 kV transmission line?

A. At a cost of $5.5 million, the static VAR compensator would be less than one-third the $18 million cost to Ameren MO ratepayers to pay for Ameren MO's share of the proposed ATXI 345 kV transmission line.

Q. What are the benefits adding demand response measures in the Kirksville area to reduce peak load on the Adair Substation.

A. About 75 percent of Ameren MO residential summer peak load is air conditioning load. About 85 percent of Ameren MO summer peak load is residential and commercial load, with residential about 50 percent of total peak load and commercial about 35 percent of peak load. See Figures 7 and 8. It is reasonable to assume that combined residential and commercial cooling load is at least 50 percent of the Ameren MO summer peak load based on this data. Automatic central air conditioner cycling devices are used by many utilities around the country to reduce peak summer loads, including in states that border Northeast Missouri. See Table 2. Assuming most or all of the 10,308 Ameren MO customers served by the Adair Substation were equipped with automatic air conditioner cycling devices that could be accessed in emergency conditions to drop air conditioning load, the load on the Adair Substation could be reduced in emergency contingency conditions by about half almost instantly.

//

//

//

Figure 7. Cooling Is Major Contributor to Ameren MO Residential Summer Peak Load[51]

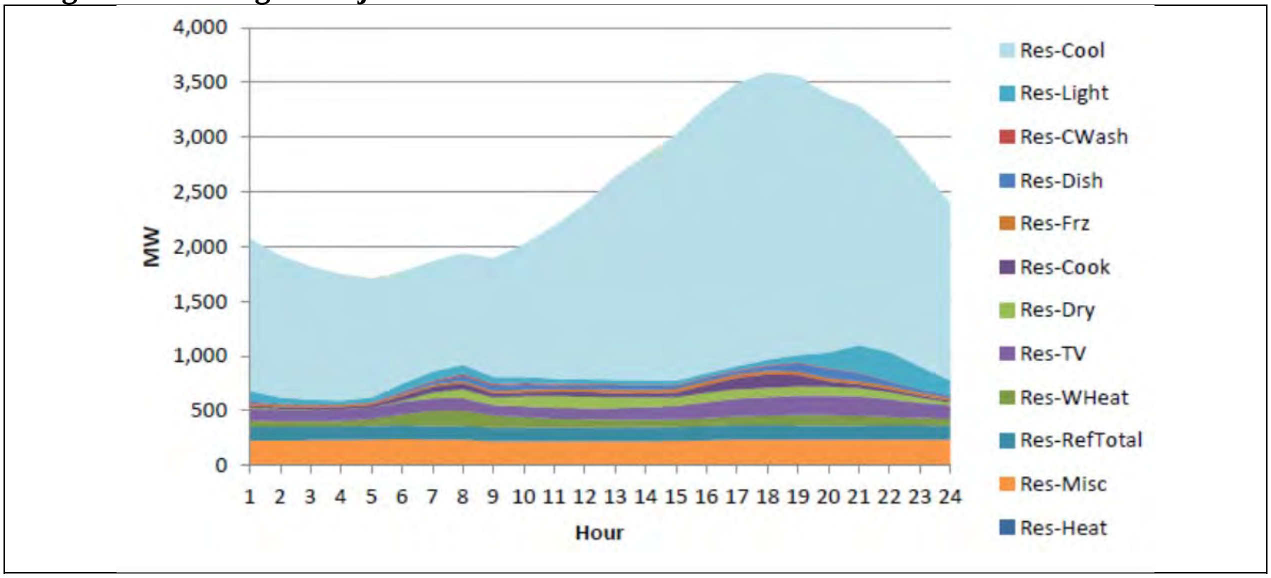


Figure 8. Residential and Commercial Load Is ~85% of Ameren MO Summer Peak Load[52]

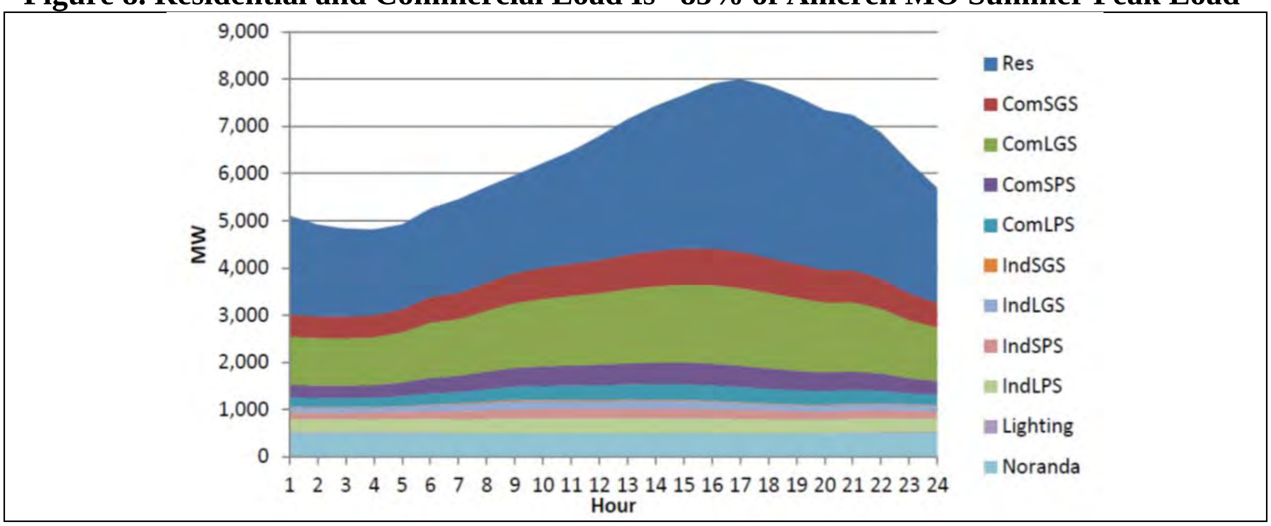


Table 2. Utility Central Air Conditioner Cycling Programs[53]

Utility	Program description	Financial terms
Iowa – MidAmerican Energy	MidAmerican Energy installs a small cycling device on the siding or your home near the central air conditioning unit. From June 1 to Sept. 30, the device will, on peak usage days, govern the degree to which your air conditioning operates. Air conditioners are cycled between approximately 2 and 7 p.m., but not on weekends or holidays.	$40 at end of first year, $30 at end of following years.

51 **Exhibit PE-07**, Figure 3.24, p. 50.
52 Ibid, Figure 3.25, p. 51.
53 ClearlyEnergy website, state-by-state demand response program summaries: https://www.clearlyenergy.com/residential-demand-response-programs.

Ohio – First Energy Ohio Edison	Easy Cool Rewards Program — you can help ease peak demand for electricity on the hottest summer days.	professionally-installed Honeywell programmable thermostat (a $250 value)

Q. Wasn't Ameren MO going to implement a demand response program in 2016?

A. Yes. In its 2011 IRP, Ameren MO proposed to initiate a demand response program in 2016 that would reduce peak load on Ameren MO's system by 100 MW by 2021.[54]

Q. Is Ameren MO in the process of launching the demand response program?

A. No. In the 2014 IRP, Ameren MO stated that the demand response program would not meet its cost-benefit requirements in the 2016-2018 time period and has delayed implementation of its demand response program.[55]

Q. What is the cost of the automatic central air conditioner cycling controllers?

A. About $250 per controller.[56]

Q. Assuming all 10,308 Ameren MO customers served by the Adair Substation were equipped with automatic central air conditioners at $250 each (per Table 2) to reduce Adair Substation load by about 50 percent during peak summer conditions, what would be the cost of this demand response program?

A. The cost would be $250 per controller × 10,308 controllers = $2,577,000, or about $2.6 million.

Q. So the cost to reduce the peak load on the Adair Substation by half would be on the order of one-seventh the Ameren MO $18 million share of the proposed ATXI 345 kV line?

A. Yes.[57]

[54] **Exhibit PE-23**, Ameren MO 2011 IRP, Chapter 7 DSM, p. 6, p. 54 (Figure 7.14).
[55] **Exhibit PE-24**, p. 1.
[56] See Table 2 of rebuttal testimony.
[57] $2.6 million ÷ $18 million = 0.144 (~1/7).

Q. What are the benefits of adding local renewable generation in the Kirksville area to reduce peak load on the Adair Substation?

A. The primary benefit, from an emergency contingency standpoint, is lowering power imports over the transmission lines connected to the Adair Substation during times of peak load.

Q. What type of generation would be inherently online at the summer peak, requiring no action by Ameren MO to provide power to address a contingency condition?

A. Solar power connected directly at the Adair Substation or located on rooftops and parking lots in the Kirksville area on distribution circuits connected to the Adair Substation.

Q. Would this solar power have the added benefit of contributing to Ameren MO achieving its 15 percent RPS target?

A. Yes.

Q. Could the 30 MW of uncommitted solar generation that Ameren MO is planning to add to meet its 45 MW solar target by 2021 be located at or near the Adair Substation?

A. Yes.

Q. Would the location of 30 MW of solar at the Adair Substation imposed any additional costs on Ameren MO customers?

A. No. This 30 MW of solar capacity is already a component of Ameren MO’s RPS compliance strategy.

Q. Can a focused effort to locate customer-owned solar on homes, businesses, and farms in the Kirksville area contribute to reducing load on the Adair Substation at summer peak conditions?

A. Yes. There would be no additional cost to Ameren MO ratepayers, as customer-owned generation is a net-metering program open to all Ameren MO customers.

Q. What are the benefits of focused deployment of energy efficiency measures by Ameren MO on residences and business served by the Adair Substation?

A. The primary grid reliability benefit is reduced load on the Adair Substation and of contingency events that could lead to loss of load. Another benefit is lowered greenhouse gas emissions associated with electricity use by Ameren MO customers in the Kirkville area.

Q. What is the budget and energy saving targets of the Ameren MO energy efficiency program?

A. Ameren MO plans to spend $148 million from 2016-2018 to achieve 426 GWh of energy savings and 114 MW of peak demand savings.[58]

Q. Is the 2016-2018 Ameren MO energy efficiency program sufficient to allow focused energy efficiency investments in the Kirksville area to reduce summer peak demand loading on the Adair Substation?

A. Yes. These funds will be collected by Ameren MO from its ratepayers and directed at energy efficiency projects in its service territory. The number of Ameren MO customers in the project area is about 1 percent of Ameren MO customers. Assuming proportionate distribution of Ameren MO energy efficiency spending, about 1 percent of the targeted 114 MW of peak load savings, or 1.1 MW, would occur in the Kirksville area. Increasing the targeted peak demand savings in the Kirksville area substantially, to 5 to 10 MW, would significantly reduce the potential for grid reliability issues at the Adair Substation. It would also be a significant factor in reinforcing local grid reliability and

[58] **Exhibit PE-24**, p. 1.

avoiding Ameren MO’s $18 million share of the cost of the proposed ATXI 345 kV transmission line.

VIII. The Economic Benefit of Wind Power Over Solar Power Presumed by MISO and ATXI Is Obsolete, Invalidating the MVP Cost-Benefit Analysis

Q. Does MISO presume that the overwhelming majority of renewable energy developed in MISO territory will be wind power?

A. Yes. MISO has assumed as an article of faith that the overwhelming majority of RPS targets in MISO and PJM will be met with remote wind power. MISO determined in its 2010 “*Regional Generation Outlet Study*” that wind power will provide approximately 90 percent on average of the renewable power used to meet RPS targets for states in MISO and PJM.[59]

Q. Does MISO consider any other possibility in the MTEP11 or MTEP14 reports?

A. No. The most recent report, the MTEP14 Triennial Review Report, does not consider that other forms of renewable energy, specifically solar energy, could displace wind power as a more cost-efficient alternative to wind power to meet RPS requirements.

Q. What are the prospects for the development of wind projects in the Adair Wind Zone that would tie in directly to the ATXI 345 kV transmission line?

A. Poor. Missouri utilities have shown no interest in developing wind projects in the Adair Wind Zone.

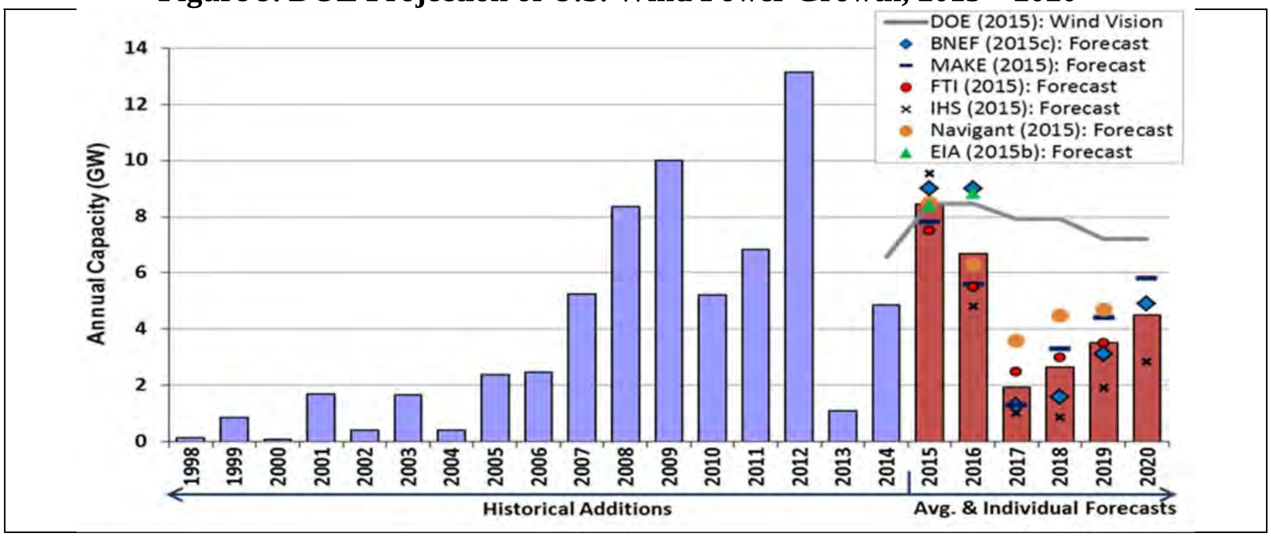
Q. What are the growth prospects for the U.S. wind industry beyond 2016?

A. Not good. The August 2015 DOE projection for wind power growth is shown in Figure 9. DOE projects a major decline in wind power growth in the U.S. after 2016. One of the

[59] **Exhibit PE-18**, p. Table 2.2-1, p. 17.

factors that DOE cites as leading to uncertainty and lower growth in wind power post-2016 is growing competition from solar energy in certain regions of the country.[60]

Figure 9. DOE Projection of U.S. Wind Power Growth, 2015 – 2020[61]



Q. What is the current MISO assumption about the capital cost of wind power?

A. The MISO MTEP14 Triennial Review Report identifies a mean capital cost of wind power of $2,400/kW.[62]

Q. What was the average annual capacity factor of operating wind projects in Missouri in 2013 and 2014?

A. About 28 percent.[63]

Q. Is the capital cost of wind power expected to increase or decrease over time?

A. Increase. The U.S. Energy Information Administration, in its *Assumptions to the Annual Energy Outlook 2015* (September 2015), states "Capital costs for wind technologies are assumed to increase."[64]

---

[60] **Exhibit PE-25**, DOE, *2014 Wind Technologies Market Report*, August 2015, p. 72.
[61] Ibid, Figure 53, p. 72.
[62] MTEP14 Triennial Review, p. 40. "*$2 to $2.8 million/MW*" is equivalent to a mean of $2.4 million/MW ($2,400/kW).
[63] **Exhibit PE-26**, EIA Form 923, 2013 and 2014, Page 1 Generator and Fuel Data, electricity production in MWh per year for five Missouri wind farms: 150 MW Lost Creek, 146 MW Farmers City, 50.4 MW Conception, 50.4 MW Cow Branch, and 56.7 MW Bluegrass Ridge.

Q. What is the typical current wind power cost-of-production?

A. In the range of \$50/MWh to \$60/MWh.[65]

Q. Isn't a large part of the value proposition of MTEP based on the value of reducing wind power curtailments by expanding west-east 345 kV transmission capacity?

A. Yes. The MTEP14 Triennial Review states: "The MTEP14 MVP Review reconfirms the MVP Portfolio's ability to deliver wind generation, in a cost-effective manner, in support of MISO States' renewable energy mandates."[66]

Q. Does ATXI compare the economic benefits of solar power to wind power in its application?

A. No. The Ameren MO 2014 IRP assumes that Ameren MO will develop 400 MW of wind power and 45 MW of solar power by 2021 to meet the 15 percent RPS requirement. This is the same ratio of wind power to other renewables, 90/10, assumed by MISO in 2010 as the renewable energy justification for the MVP projects.[67]

Q. What is the current cost of solar power?

A. DOE identifies the 2016 best-in-class to mid-range capital cost for utility-scale solar 5 MW and larger of \$1,300/kW_{dc} to \$1,625/kW_{dc}.[68] The adjusted solar capital cost, based on alternating current (ac) output and assuming a dc-to-ac conversion efficiency of 90 percent, [69] would be \$1,444/kW_{ac} to 1,806/kW_{ac}. This is a mean capital cost of about \$1,600/kW_{ac}, two-thirds the capital cost of wind power that is assumed by MISO.

---

[64] **Exhibit PE-27**, U.S. Energy Information Administration, *Assumptions to the Annual Energy Outlook 2015*, September 2015, p. 192.
[65] **Exhibit PE-04**, p. 2.
[66] MISO, MTEP14 Triennial Review, p. 3.
[67] **Exhibit PE-18**, p. Table 2.3-2, p. 19.
[68] **Exhibit PE-28**, NREL, *Photovoltaic System Pricing Trends Historical, Recent, and Near-Term Projections 2014 Edition*, September 22, 2014, p. 22.
[69] **Exhibit PE-29**, DNV KEMA Energy & Sustainability, *Austin Energy Review of Strategic Plan for Local Solar in Austin*, prepared for Austin Energy, November 22, 2013, p. 8, p. 10, and p. 16. For utility-scale solar, the dc-to-ac conversion is assumed to be 90 percent. For rooftop systems, the dc-to-ac conversion is assumed to be 85 percent.

Table 3. DOE Projected Capital Costs for Rooftop and Utility-Scale (≥ 5 MW) Solar PV Projects[70]

Type of solar PV	2014 modeled capital cost ($/kW$_{dc}$)	2016 forecast best-case & mid-point capital cost ($/kW$_{dc}$)	2016 forecast in $/kW$_{ac}$ with DC-to-AC conversion
Residential rooftop	3,290	1,500 – 2,250	1,765 – 2,647
Commercial rooftop	2,540	1,500 – 2,250	1,765 – 2,647
Utility-scale, ≥ 5 MW	2,030	1,300 – 1,625	1,444 – 1,806

Q. What is the capacity factor of solar power in Northeast Missouri?

A. 18 to 22 percent, depending on whether the solar power is fixed (18 percent) or single-axis tracking (22 percent) for a representative site in Columbia, Missouri.[71]

Q. Is the cost of production of wind power and solar power in Northeast Missouri essentially the same in late 2015?

A. Yes. Wind power has about a 50 percent higher capital cost at about $2,400/kW than solar at $1,600/kW. This higher capital cost is offset by a 27 to 56 percent higher wind capacity factor, 28 percent for wind power versus a mean solar capacity factor of 18 to 22 percent.

Q. So the gross cost-of-production from Missouri wind and solar projects is about the same in late 2015?

A. Yes.

Q. Does solar power have other grid-related attributes that enhance its value relative to wind power?

A. Yes. Unlike wind power, solar output is well matched to diurnal and summer peak load profile of Ameren MO. This attribute contributes to the higher "grid value" of solar

---

[70] **Exhibit PE-28**, p. 4, p. 22.
[71] **Exhibit PE-30**, NREL PV Watts, 100 kW (dc), 1-axis tracking and fixed array, Columbia, MO site location: http://pvwatts.nrel.gov/.

power, in the form of firm solar capacity available at summer peak demand when power prices are highest, compared to wind power. Solar arrays can also be economically connected at the distribution level of the transmission and distribution system, which reduces load and congestion on the transmission system.

Q. Does the $0/MWh production cost that the MTEP14 Triennial Review Report attributes to wind power (p. 5) apply equally to solar power?

A. Yes.

Q. Does the fuel savings benefit the MTEP14 Triennial Review Report attributes to wind power (p. 5), as a result of its lower production cost relative to natural gas-fired generation, apply equally to solar power?

A. Yes.

Q. What is the price decline trend for solar power?

A. The price decline trend is steep. An example is provided in Figure 10 of the solar price decline trend of a California public utility over the last three years. These are mid-sized utility-scale projects. The most recent project in Figure 10, sPower 2015, is 50 MW.[72] The City of Lancaster (California) signed a 20-year fixed power purchase agreement for a single 10 MW solar array on the outskirts of the city at a fixed price of $54.99/MWh.[73]

//

//

//

//

[72] **Exhibit PE-31**, City of Riverside PPA, 50 MW Antelope Valley Solar, $53.75/MWh.
[73] **Exhibit PE-32**, Lancaster Clean Energy PPA, 10 MW, $54.99/MWh.

Figure 10. Riverside Public Utilities Solar Project Price Decline Trend, 2012 - 2015[74]

Q. Could a 10 MW solar array be interconnected to the transmission and distribution system at the 12 kV distribution level, and thereby reduce load on the transmission system?

A. Yes. A 10 MW solar would occupy in the range of 50 acres, a size range that could be located at or near a substation like the Adair Substation. The output of the array, at 10 MW, would be sufficiently limited that the project's output could be interconnected at the substation distribution voltage to serve local load. This form of interconnection would have the same effect on the transmission system as point-of-use rooftop solar. It would reduce the need for power imported over the transmission system to serve the load in the Kirksville area.

Q. How do the prices of these recent solar PPA contracts compare to the 2014 on-peak MISO wholesale energy price?

A. The lowest reported contract prices for solar arrays in the 10 to 50 MW range are competitive with the average 2014 MISO on-peak wholesale electricity price. Austin

[74] **Exhibit PE-33**, City of Riverside PowerPoint, June 19, 2015, solar PPA contract price trend, p. 20.

Energy (Texas) signed solar PPAs in 2014 for less than $50/MWh.[75] The average on-peak wholesale electricity price in MISO in 2014 was $48/MWh.[76]

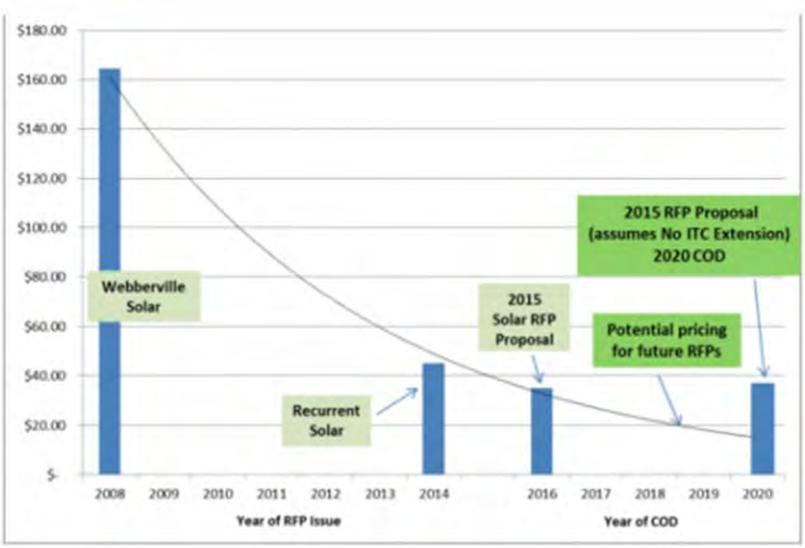
Q. Are solar contract prices continuing to drop at a rapid pace?

A. Yes.

Q. What contract prices did Austin Energy receive for its recent April 2015 RFP for 600 MW of solar capacity?

A. About 15 percent of the bids received were priced at less than $40/MWh.[77] The solar bid price trend over the last years documented by Austin Energy is shown in Figure 11. The $40/MWh bid prices for 2016 projects are one-quarter the $160/MWh PPA price for Austin's first solar project (Webberville Solar) in 2008. 2008 is also the year MISO began planning the MVP transmission build-out assuming remote wind power would be the predominant form of renewable energy relied on to meet RPS targets in MISO and PJM.[78]

Figure 11. Solar Price Decline Trend in Solar Bids Received by Austin Energy, 2008-2016[79]



---

[75] **Exhibit PE-34**, GreenTech Media, Cheapest solar ever? Austin Energy buys at 5 cents per kWh, March 10, 2014.
[76] **Exhibit PE-35**, 2014, FERC, PowerPoint, MISO on-peak wholesale electricity prices, p. 11.
[77] **Exhibit PE-36**, GreenTech Media, Austin Energy solar RFP, June 30, 2015.
[78] MTEP11 Report, p. 44.
[79] **Exhibit PE-36**, GreenTech Media, Austin Energy RFP bids, June 30, 2015.

Q. Does Austin Energy predict that solar PPA prices will continue to drop?

A. Yes. Austin Energy predicts that solar PPA prices will drop below $20/MWh in 2020 if the solar investment tax credit is extended, and that PPA prices will remain under $40/MWh in 2020 if it is not. See Figure 11 above.

Q. Is distributed solar already in operation in Ameren MO service territory?

A. Yes. Ameren MO began operation of its 5.7 MW O'Fallon Renewable Energy Center in December 2014.[80] This solar project is located on the adjacent to Ameren MO Belleau substation and is shown in Figure 12. Ameren MO is also in the process of constructing a 15 MW solar array along I-70 in Montgomery County on 70 acres.[81]

Figure 12. Ameren MO 5.7 MW O'Fallon Renewable Energy Center, Operational in December 2014[82]

Q. Could the remaining 30 MW of Ameren MO's planned 45 MW solar portfolio in 2021 be located at or near the Adair Substation to minimize load on the substation during modeled summer peak contingency events?

A. Yes.

[80] Ameren MO O'Fallon Renewable Energy Center webpage: https://www.ameren.com/missouri/solar/ofallon-rec.
[81] **Exhibit PE-37**, St. Louis Post-Dispatch, July 1, 2015.
[82] Ameren MO O'Fallon Renewable Energy Center webpage: https://www.ameren.com/missouri/solar/ofallon-rec.

Q. Does Missouri also have a net-metered rooftop solar program?

A. Yes. The 2008 Proposition C Missouri Solar Rebate established incentive funding for net metered solar rooftop installations. Total program funding is $91.9 million, with installation in the 2014 to 2016 timeframe.[83] The incentive funding is fully subscribed. The initial funding level was $2 per watt. The final funding level was $1 per watt. Ultimately somewhere between 46 and 92 MW of net-metered rooftop solar will be installed in part due to this incentive program. At the lower incentive rate of $1 per watt, 1 MW of rooftop solar capacity is installed per each $1million of incentive funding.

Q. What will the average annual customer-installed solar installation rate be over the 2014-2016 time period?

A. About 20 MW per year, assuming the average incentive payment for program participants is $1.50 per watt.[84]

Q. Assuming Ameren MO continues to average about 20 MW per year of customer installed solar over the 2017-2021 timeframe, how much additional solar will be installed?

A. About 100 MW.

Q. Has Ameren MO accounted for an additional 100 MW of customer generated solar power in its RPS calculations?

A. No.

Q. Could an additional 100 MW of solar by 2021 displace a comparable amount of wind power in Ameren MO's RPS portfolio?

A. Yes.

---

[83] Ameren MO webpage: https://www.ameren.com/missouri/solar/customerownedgeneration

[84] $91.9 million ÷ $1.5 million per MW = 61 MW (or about 20 MW per year over three years).

IX. There Are Viable and Cost-Effective Alternatives that Would Eliminate the Environmental Impacts of the Proposed ATXI 345 kV Line

Q. ATXI must assess potential impacts and develop mitigation strategies to address numerous environmental concerns along the pathway of the proposed 345 kV transmission line, including: the endangered Indiana bat and proposed endangered northern long-eared bat, raptor nesting areas, fragmentation of woodland habitat, degradation of spawning streams, and degradation of conservation easements.[85] **How would the use of the alternatives described in your rebuttal testimony compare to the proposed 345 kV transmission line regarding such impacts?**

A. Reconductoring the Adair-to-Novelty 161 kV line with composite conductor, adding voltage regulation at the Adair Substation, installing automatic demand response on central air conditioner systems used by Ameren MO customers served by the Adair Substation, and selectively focusing energy efficiency measures on Ameren MO customers served by the Adair Substation would have no environmental impacts. Solar on rooftops and parking lots in the Kirksville area would have no significant air, water, or land impacts. The environmental advantages of rooftop solar relative to remote utility-scale renewable energy, and associated transmission lines, were recognized by the California Public Utilities Commission at the time of its approval of a 500 MW urban warehouse rooftop PV project:[86]

> Added Commissioner John A. Bohn, author of the decision, "This decision is a major step forward in diversifying the mix of renewable resources in California and spurring the development of a new market

---

[85] **Exhibit PE-38**, documents describing environmental issues associated with transmission line pathway.
[86] **Exhibit PE-39**, CPUC Press Release – Docket A.08-03-015, *CPUC Approves Edison Solar Roof Program*, June 18, 2009.

> niche for large scale rooftop solar applications. Unlike other generation resources, these projects can get built quickly and without the need for expensive new transmission lines. And since they are built on existing structures, these projects are extremely benign from an environmental standpoint, with neither land use, water, or air emission impacts. By authorizing both utility-owned and private development of these projects we hope to get the best from both types of ownership structures, promoting competition as well as fostering the rapid development of this nascent market."

X. Conclusion

Q. Does this conclude your rebuttal testimony?

A. Yes.