Exhibit No.:	
Issue(s):	*Weather Normalization, MEEIA Adjustment*
Witness:	*Hari K. Poudel, PhD*
Sponsoring Party:	*MoPSC Staff*
Type of Exhibit:	*Surrebuttal Testimony*
Case No.:	*ER-2022-0337*
Date Testimony Prepared:	*March 13, 2023*

MISSOURI PUBLIC SERVICE COMMISSION

INDUSTRY ANALYSIS DIVISION

TARIFF/RATE DESIGN DEPARTMENT

SURREBUTTAL TESTIMONY

OF

HARI K. POUDEL, PhD

UNION ELECTRIC COMPANY, d/b/a AMEREN MISSOURI

CASE NO. ER-2022-0337

Jefferson City, Missouri
March 2023

SURREBUTTAL TESTIMONY

OF

HARI K. POUDEL, PhD

UNION ELECTRIC COMPANY,
d/b/a AMEREN MISSOURI

CASE NO. ER-2022-0337

Q. Please state your name and business address.

A. My name is Hari K. Poudel, and my business address is P.O. Box 360, Jefferson City, Missouri, 65102.

Q. By whom are you employed, and in what capacity?

A. I am employed by the Missouri Public Service Commission ("Commission") as an Economist in the Tariff/Rate Design Department in the Industry Analysis Division.

Q. Are you the same Hari K. Poudel that filed rebuttal testimony in this case?

A. Yes.

Q. What is the purpose of your testimony?

A. The purpose of my surrebuttal testimony is to respond to Ameren Missouri's witness Dr. Nicholas Bowden regarding Ameren Missouri's weather normalization and updating the Missouri Energy Efficiency Investment Act (MEEIA) annualization adjustment.

WEATHER NORMALIZATION

Q. Does Ameren Missouri's and Staff's use of the regression model specification differ in any way?

A. Yes. Ameren Missouri and Staff performed the regression analyses for weather normalization. However, there is a general difference in the selection of the

regression model specification between Ameren Missouri and Staff. Staff decided to use the autoregressive model [AR(1)][1] specification to normalize weather[2]. However, Witness Dr. Bowden of Ameren Missouri didn't use this model.

Q. Why did Staff choose the autoregressive model specification to weather normalize electricity usage?

A. Staff decided to weather-normalize electricity usage using an autoregressive model out of the various model specifications available in statistical analysis. Data from time series[3], such as weather and electricity usage, provide several possibilities to estimate relationships between them. Since the outcome of the previous time period affects the subsequent period or periods, anyone with basic statistics knowledge can refer to this relationship as having a lagged effect. To evaluate the relationship between the past, present, and future electricity usage variables, Staff included the lagged effect on the estimation.

Researchers have performed regression analysis of time series data using many different model specifications. The choice of model specifications depend on the consumer energy consumption behavior, data type, variables of interest, and so forth. Staff used the MetrixND statistical software that has an ability to perform autoregressive model. Staff's specification of

[1] An AR (1) is an autoregressive term that refers to the current value based on the immediately preceding value. The model is when a value from a time series is regressed on previous values from that same time series. For example, y_t on y_{t-1}: $y_t=\beta_0+\beta_1 y_{t-1}+\epsilon_t$. In this regression model, the response variable in the previous time period has become the predictor. The order of an autoregression is the number of immediately preceding values in the series that are used to predict the value at the present time. So, the preceding model is a first-order autoregression, written as AR(1).

[2] Wooldridge, J. M., "Introductory Econometrics: A Modern Approach," 5th Edition, page 372. "The AR(1) model is especially important in multiple regression analysis with time series data."

[3] A time series is a sequence of measurements of the same variable(s) made over time.

an AR model of order 1 included the lagged dependent variable[4]. The inclusion of a lagged dependent variable is motivated conceptually by the need to capture the common type of electricity usage patterns. A typical consumer behavior predicts that past electricity consumption will impact present and future electricity consumption.

Q. After including an AR(1) into regression analysis, does Staff's estimation of the relationship between weather and electricity usage strengthen?

A. Yes.

Q. Can you provide any empirical evidence that supports the argument made by Staff above?

A. Yes. With the use of the Durbin-Watson statistic values, Staff conducted a thorough evaluation of the regression model. The statistic is a test for autocorrelation[5]. If there is no autocorrelation, the Durbin-Watson statistic is near 2.0; if there is perfect positive correlation, it is equal to 0; and if there is perfect negative autocorrelation, it is equal to 4.0[6].

continued on next page

[4] The model is represented in the following form, which includes the lagged dependent variable:

$$\text{electricity\_usage}_t = \alpha + \beta\ \text{temperature}_t + \gamma\ \text{electricity\_usage}_{t-1} + \varepsilon_t$$

where the notation of $_{t-1}$ refers to the autoregressive model of order 1 included in the model.

The inclusion of a lagged dependent variable, *electricity_usage*$_{t-1}$ in regression analysis that occurred on the day before day *t* reflects the effect of yesterday's electricity usage on today's usage. The model is when a value from a time series is regressed on previous values from that same time series. For example, y_t on y_{t-1}: $y_t=\beta_0+\beta_1 y_{t-1}+\epsilon_t$. In this regression model, the response variable in the previous time period has become the predictor. The order of an autoregression is the number of immediately preceding values in the series that are used to predict the value at the present time. So, the preceding model is a first-order autoregression, written as AR(1).

[5] Autocorrelation measures the relationship between a variable's current value and its past values. It represents the degree of similarity between a given time series and a lagged version of itself over successive time intervals.

[6] Meier, K. J., Brudney, J. L., & Bohte, J. (2015). *Applied Statistics for Public and Nonprofit Administration*. 9th Edition. Cengage Learning. P. 354.

The following table shows Staff and Ameren Missouri's Durbin-Watson scores.

Rate Class	Durbin-Watson Statistic	
	Staff	Company
Residential	1.95	1.13
Commercial Small General Service	2.09	1.05
Commercial Large General Service	2.08	1.01
Commercial Small Primary Service	2.01	0.79
Commercial Large Primary Service	2.19	0.58
Industrial Small General Service	2.02	1.25
Industrial Large General Service	2.10	1.34
Industrial Small Primary Service	2.15	0.83
Industrial Large Primary Service	2.34	0.90
WHOLESALE	2.12	1.49

Based on the above table, it is evident that the Company's Durbin-Watson scores for all rate classes are less than 2.0, indicating a possible autocorrelation issue. In such a circumstance, the regression model fails to effectively capture the variations in electricity usage over time. The selection of the AR1 model could be one possible statistical method to correct autocorrelation.

However, scores for Staff's analysis are very close to 2.0, indicating that autocorrelation is not a concern. In such a circumstance, the regression model effectively captures the variations in electricity usage over time. In fact, this fact provides empirical support for the claim that

Staff's model, which includes a lagged dependent variable[7], has accurately forecasted the relationship between weather and electricity usage.

Q. Does the addition of a lagged effect to Staff's regression model "soak up" the influence that the weather variable's beta coefficient (β) would otherwise capture, as described by Ameren Missouri witness Dr. Bowden in his rebuttal testimony, page 7, line 8?

A. No. The addition of a lagged effect in Staff's regression model does not necessarily "soak up" the influence that the beta coefficient (β) would otherwise capture. The argument is not self-sufficient in statistical language. The effects of weather variables on electricity usage won't completely be soaked by the lagged dependent variable. However, the effect will resonate in the current electricity usage and will also affect the future electricity usage. In the model including the lagged dependent variable, the main independent variable (for example, weather in this case) retains the estimation power and statistical significance of the relationship between the variables.

Q. On page 14, lines 3 through 7, Dr. Bowden states that Staff's weather normalization procedure "does more than remove the effect of abnormal weather…" Is this correct?

A. No. Dr. Bowden reaches this erroneous result because he purposefully established misleading assumptions about Staff's model specifications in hopes of increasing electricity use. The staff's approach for weather normalization is a well-established method for estimating the relationship between weather and electricity use. Staff conducts regression

[7] Keele, L., & Kelly, N. J. (2006). Dynamic models for dynamic theories: The ins and outs of lagged dependent variables. Political analysis, 14(2), 186-205.

analysis in order to provide an accurate estimate of the impact of unexpected weather on the billing determinants. Dr. Bowden does not appear to comprehend that the weather normalization technique includes all significant factors, including the weather. Variables of significance could only reflect changes in electricity use among consumers.

Q. Does Staff agree with Dr. Bowden's claim that Staff weather normalization procedure "is not the goal of weather normalization, nor should it be" on page 15, lines 1 through 2?

A. No. Dr. Bowden incorrectly concludes that Staff's model does not adhere to goal of weather normalization. This criticism of Staff's model is unsupported by statistical evidence. Staff followed three steps in weather normalization procedure: model identification, determine the type and order of the model, and parameter estimator. The data used in the model is rich and accurate and is conducive to ensuring the ARMA model prediction. Based on the nature of the electricity consumption behaviors, Staff's determined the use of the ARMA prediction model is appropriate. An important premise of building an ARMA model is that an AR(1) could capture the prior day influences on the decisions to use energy in the current day. If researchers try to manipulate model specifications for their own sake, then it would estimate biased results. For example, Dr. Bowden discussed about a calculation on page 14, lines 14 through 17. His calculation is about the effect of Staff's model in kWh usage for the residential class. Staff's choice to normalize for weather follows the standard statistical procedure by including an AR(1) which could capture the effect of yesterday's usage on today's or future energy usage. The prior day's usage could be influenced by consumer preferences and any number of other real factor that are affecting customers' usage behavior.

Q. Please provide a summary of Staff's position on the topic of weather normalization.

A. Both Ameren Missouri and Staff used the same software to perform their weather normalization but used different regression model specifications. Staff used an autoregressive model to account for prior day's influence in electricity consumption in the current day. This concept is consistent with our use of a two-day weighted mean daily temperature. The two-day weighted mean daily temperature improves the prediction of consumer behavior. Staff's method is a simple and straightforward method that coherently relies on the relationship between weather and electricity consumption. On the other hand, Ameren Missouri's model ignores the influence of prior day's usage on electricity consumption. Ignoring the influence of consumer behavior on electricity consumption reduces the reliability of the usage estimates relative to the estimates developed by Staff, which in turn reduces the reliability of the normalized revenues, billing determinants, and energy requirements predicted by the Ameren Missouri model.

MEEIA ADJUSTMENT

Q. Did Staff rectify data entry issues caused by incorrect raw Missouri Energy Efficiency Infrastructure Act (MEEIA) test year savings data?

A. Yes. Staff calculated the MEEIA annualization adjustment by entering the accurate MEEIA test year savings data.

Q. Has Staff included evaluated savings data into account when calculating the MEEIA adjustment?

A. Yes. Staff replaced deemed savings with evaluated savings values from July through December 2021 (Program Year 2021) while calculating the MEEIA Annualization Adjustment. The Company only offers this evaluated data in true-up. Staff's updated adjustments for true-up include eighteen months starting from the July 2021 through December 2022 of savings data on different energy efficiency measures.

CONCLUSION

Q. Does this conclude your surrebuttal testimony?

A. Yes. It does.

BEFORE THE PUBLIC SERVICE COMMISSION

OF THE STATE OF MISSOURI

In the Matter of Union Electric Company d/b/a Ameren Missouri's Tariffs to Adjust Its Revenues for Electric Service	)))	Case No. ER-2022-0337

AFFIDAVIT OF HARI K. POUDEL, PhD

STATE OF MISSOURI	)	
	)	ss.
COUNTY OF COLE	)	

COMES NOW HARI K. POUDEL, PhD and on his oath declares that he is of sound mind and lawful age; that he contributed to the foregoing *Surrebuttal Testimony of Hari K. Poudel, PhD*; and that the same is true and correct according to his best knowledge and belief.

Further the Affiant sayeth not.

HARI K. POUDEL, PhD

JURAT

Subscribed and sworn before me, a duly constituted and authorized Notary Public, in and for the County of Cole, State of Missouri, at my office in Jefferson City, on this 8th day of March 2023.

D. SUZIE MANKIN
Notary Public - Notary Seal
State of Missouri
Commissioned for Cole County
My Commission Expires: April 04, 2025
Commission Number: 12412070

Notary Public