Exhibit No.:	
Issue(s):	*365-Day Adjustment, Weather Variables, Weather Normalization, Hourly Load Requirement Energy Efficiency Adjustment*
Witness:	*Hari K. Poudel, PhD*
Sponsoring Party:	*MoPSC Staff*
Type of Exhibit:	*Direct Testimony*
Case Nos.:	*ER-2022-0337*
Date Testimony Prepared:	*January 10, 2023*

MISSOURI PUBLIC SERVICE COMMISSION

INDUSTRY ANALYSIS DIVISION

TARIFF/ RATE DESIGN DEPARTMENT

DIRECT TESTIMONY
Revenue Requirement

OF

HARI K. POUDEL, PhD

UNION ELECTRIC COMPANY,
d/b/a AMEREN MISSOURI

Case No. ER-2022-0337

Jefferson City, Missouri
January 2023

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HARI K. POUDEL, PhD

UNION ELECTRIC COMPANY, d/b/a AMEREN MISSOURI

Case No. ER-2022-0337

DIRECT 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 a Regulatory Economist in the Tariff/Rate Design Department in the Industry Analysis Division.

Q. Please describe your educational and work background.

A. I received a Ph.D. in Public Policy and a master's degree in Public Health from the University of Missouri, Columbia, and another master's degree in Agricultural Economics from University of Hohenheim, Germany.

In January of 2020, I began working for the Missouri Department of Health and Senior Services as a research/data analyst. I was employed with the Division of Community and Public Health from January 2020 until October 2021. I started my career with the Commission as a Regulatory Economist in October 2021.

Q. Please provide your credentials.

A. Please see Attachment HKP-d1.

Q. Have you previously testified before the Commission or any other regulatory agency?

A. Yes. As an expert, I have provided written testimony in different rate cases. I have also made several recommendation to the Commission in the form of memorandums. The testimonies and memoranda I have given to the Commission are listed below:

SN	**Case Number**	**Company Name**	**Issue**
1.	ER-2022-0146	Ameren Missouri	Rider Energy Efficient Investment Charge (EEIC)
2.	GR-2022-0235	Spire Missouri, Inc.	Weather Normalization Adjustment Rider (WNAR)
3.	GT-2022-0233	Liberty Utilities	Weather Normalization Adjustment Rider (WNAR)
4.	ER-2022-0129 & ER-2022-0130	Evergy Metro, Inc. & Evergy Missouri West, Inc.	General Rate Case
5.	GO-2023-0002	Spire	Weather Normalization Adjustment Rider (WNAR)
6.	GR-2021-0320	Liberty Utilities	Tariff Compliance
7.	GT-2023-0088	Liberty Utilities	Weather Normalization Adjustment Rider (WNAR)
8.	ER-2022-0337	Ameren Missouri	General Rare Case

<u>EXECUTIVE SUMMARY</u>

Q. What is the purpose of your direct testimony?

A. The purpose of my direct testimony is to provide Staff's weather normalization recommendation. Within this testimony, I will:

1. Discuss the 365-day adjustment;
2. Discuss the source of the weather variables;
3. Provide a detailed explanation on the weather normalization;
4. Discuss the analysis of the load requirement at transmission, and;
5. Discuss about the energy efficiency adjustment.

365-DAYS ADJUSTMENT

Q. Did you perform the 365-day adjustment to usage for this case?

A. Yes. I applied the 365-day adjustment to usage for this case.

Q. What is the 365-day adjustment?

A. Calendar months and revenue months differ from one another because of the periods they cover and the differing beginning and ending times. Calendar months coincide with the calendar, beginning on the first day of the month and ending on the last day of the month. Ameren Missouri's customers' usage is measured and rate revenues are collected over a period known as a “revenue month,” which is the interval over which Ameren Missouri reads customers' meters and issues bills. A bill rendered for a given revenue month may charge for usage in parts of two calendar months. Revenue months usually take their names from the calendar month in which the customer's bill is rendered. For example, assume a customer's meter was read and usage determined on June 10 and again on July 10, and that the bill was sent to the customer on July 15. The revenue month for this bill is July, even though 20 days of the usage measured for this bill occurred from June 11 through June 30, and it contained only ten days of usage in July.[1]

The length of a revenue month is dependent upon the interval between meter readings and does not necessarily have the same number of days that occur in a given calendar month of the same name; that is, a revenue month may have more than or less than the number of days for the same-named calendar month. For the example given above, the

[1] Primary months are used to distinguish in which month the usage is billed under and whether summer or winter rates apply. For example, a customer’s sixth bill of the year is deemed the customer’s June bill even if it is billed to the customer on May 29. In this example, the primary month is June and the summer rate will apply to all usage on the bill, even though the revenue month would be May.

usage is for 30 days (June 11 through July 10), even though the revenue month is July, which has 31 days. When revenue month usage is totaled over the year, the resulting revenue year will include usage from the immediately prior calendar year and assign usage to the next calendar year, meaning a revenue year may contain more than or less than 365-day usage. Therefore, since the costs and expenses are accounted for over a calendar year, Staff calculates an annualization adjustment to bring the revenue year kWh into a 365-day interval. This adjustment is stated in kWh and is referred to as the "365-day adjustment."

Q. How was the 365-day adjustment to usage made?

A. Staff calculated the 365-day adjustment by adjusting individual bill cycles that had more than or less than 365-day usage from the first date in that cycle's revenue test year to the last meter read date in that cycle's revenue test year. The overall average usage per day of that cycle was then multiplied by the number of days over or under 365 to determine the kWh adjustment.

Q. Did Staff incorporate the recently updated residential customer billing periods?

A. No. Staff received updated information on December 15, 2022. However, Staff did not have time to review and update analysis prior to filing direct.

Q. How are the 365-day adjustments used for different rate classes?

A. The 365-day adjustment for residential (RES), small general service (SGS), large general service (LGS), small primary service (SPS), and large primary service (LPS) were provided to Staff Witness Kim Cox, who used the 365-day adjustment to adjust the revenues of the weather-normalized class revenues months to the twelve months ended June 30, 2022.

WEATHER VARIABLES

Q. What source did you use for weather data?

A. Staff used weather data produced by the Midwestern Regional Climate Center ("MRCC").[2] MRCC is a cooperative program between the National Centers for Environmental Information ("NCEI") and Purdue University, Indiana. The NCEI is a part of the Department of Commerce, National Oceanic and Atmospheric Administration ("NOAA").[3] Staff used the weather station data from the Lambert - St. Louis International Airport ("STL"), Missouri, for the twelve months of July 1, 2021, through June 30, 2022, for the service territories of Ameren Missouri, for actual and normal weather variables. This weather station was selected based on the availability and reliability of the weather data as well as their approximate location to the customer base of Ameren Missouri.

Q. What are weather variables used in this rate case?

A. The weather data sets consist of actual daily maximum temperature ("T_{max}") and daily minimum temperature ("T_{min}") observations. As is customary, "mean temperature" (T_{avg}) is defined as the average of T_{max} and T_{min} for the day.

WEATHER NORMALIZATION

Q. Define a weather adjustment or weather normalization.

A. A weather adjustment, also known as weather normalization, is a process that is carried out with the goal of removing any influence that the weather may have had on a company's income during a test year. The rate will be designed on the basis of normal weather rather than any anomalous weather in the test year. In its simplest form, this means estimating

[2] Midwestern Regional Climate Center, https://mrcc.purdue.edu/.
[3] About | National Centers for Environmental Information (NCEI) (noaa.gov)

the change in energy consumption associated with a change in weather, where the change in weather is the difference between normal weather and actual weather.

Q. What is a climate normal?

A. According to the National Oceanic and Atmospheric Administration ("NOAA"), a climate "normal" is defined as the average temperature computed for a relatively long period consisting of at least three consecutive 10-year periods.[4] The normals serve as benchmarks against which the test-year weather data can be compared. The climate normals are utilized to make predictions on the conditions that are most likely to be encountered in a certain location. NOAA calculates climate normals from monthly values during the averaging periods.

Q. How was the weather data normalized in this rate case?

A. In developing climate normals, the NOAA focuses on the monthly maximum and minimum temperature time series to produce the serially-complete monthly temperature ("SCMT") data series.[2] The serially-complete monthly temperature is an intermediate product that includes adjustments for inconsistencies and biases that may occur in the 30-year time series of daily temperature, including:

- Weather station relocations;
- Changes in instruments;
- Recalibration of the weather instruments;
- Changes in the local site environment (e.g., a change in vegetation or the construction of a building in close proximity to the site).

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[4] Retrieved on November 30, 2022, Guidelines for the Calculation of Climate Normals.WMO No1203_en.pdf (noaa.gov)

Changes in observation procedures or in an instrument's environment may also occur during the 30-year period. NOAA accounted for documented and undocumented anomalies in calculating its SCMT.[5] The meteorological and statistical procedures used in NOAA's homogenization for removing documented and undocumented anomalies from the T_{max} and T_{min} monthly temperature series are explained in a peer-reviewed publication.[6]

To the best of our knowledge, NOAA is the only entity that provides reasonably reliable weather data for the St. Louis City region over a 30-year historical period and test year period. For the purposes of normalizing the test year energy usage and revenues, Staff used the adjusted T_{max} and T_{min} daily temperature series for the 30-year period of January 1, 1992, through December 31, 2021, at STL.

Staff used a ranking method to calculate normal weather estimates of daily normal temperature values, ranging from the temperature that is "normally" the hottest to the temperature that is "normally" the coldest, thus estimating "normal extremes." Normal weather is used to build the base forecast for future energy use. Staff ranked Mean Daily Temperatures (MDTs) for each month of the 30-year history from hottest to coldest and then calculated the normal daily temperature values by averaging the ranked MDTs for each rank, irrespective of the calendar date. The ranking process results in the "normal extreme" being the average of the most extreme temperatures in each month of the 30-year normals period. The second-most extreme temperature is based on the average of the second most extreme day of each month, and so forth.

[5] Arguez, A., I. Durre, S. Applequist, R. S. Vose, M. F. Squires, X. Yin, R. R. Heim, Jr., and T. W. Owen, 2012: NOAA's 1981-2010 U.S. Climate Normals: An Overview. Bulletin of the American Meteorological Society, 93, 1687-1697.

[6] Menne, M.J., and C.N. Williams, Jr., (2009) Homogenization of temperature series via pairwise comparisons. J. Climate, 22, 1700-1717.

Q. Was Staff's calculation of daily normal temperatures the same as NOAA's calculation of daily normal temperatures?

A. No, the Staff's calculation of daily normal temperatures is not the same as NOAA's calculation of smoothed daily normal temperatures. NOAA's published climatic normals are not directly usable by Staff since the daily normal is based on a calendar date average rather than the ranked daily average that Staff uses. NOAA's normal values are derived by statistically "fitting" smooth curves through the monthly temperatures. As a result, the NOAA daily normal values reflect smooth transitions between seasons and do not directly relate to the 30-year time series of MDT as used by Staff.[7] Staff calculated its normal daily temperatures based on the rankings of the actual temperatures of the test year, and the test year temperatures do not follow smooth patterns from day to day. Therefore, the ranked daily average method has the ability to generate the mean daily temperatures of each rank, irrespective of the calendar date. More details of Staff's ranked average method for normal weather are explained in a peer-reviewed publication.[8] The article highlights the importance of the ranked method in which both hot and cold extreme temperature variations are incorporated in the normals calculations whereas these extreme values are dampened in the standard climate normal estimation. The standard climate estimation methodology can inadvertently introduce biases in the weather normalization adjustment.

Q. Did Company and Staff's use the same 30-year period of normal weather for this rate case?

[7] Won, S. J., Wang, X. H., & Warren, H. E. (2016). Climate normals and weather normalization for utility regulation. *Energy Economics, 54*, 405-416.
[8] *Id.*

A. Yes. Both Company and Staff used the same 30-year average temperature to define normal daily weather conditions. The 30-year time frame was from January 1, 1992, through December 31, 2021.

Q. Did Staff use a regression analysis to estimate the weather normalized energy usage?

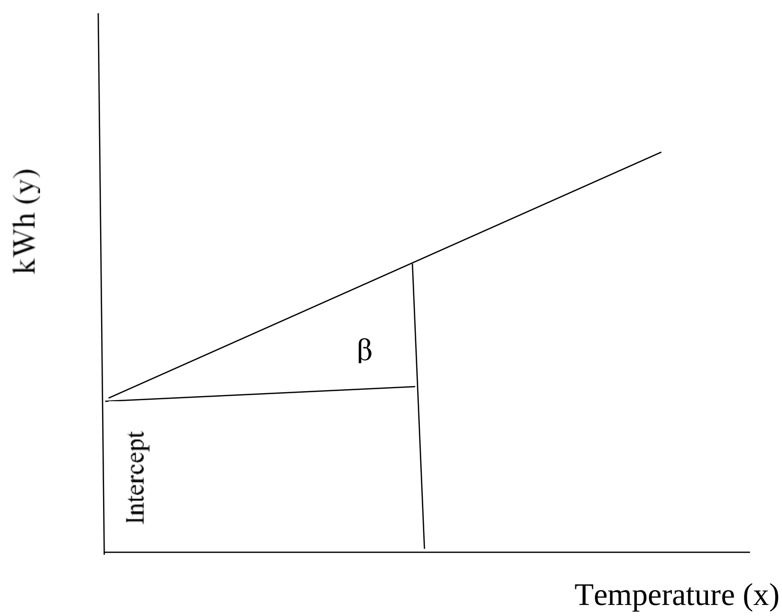
A. Yes.

Q. Please explain Staff's regression analysis.

A. The regression analysis describes the relationships between independent and dependent variables. It is capable of capturing the effect of changing weather conditions on energy consumption. By entering the values for the independent variables (for example, weather data) into the regression equation, the analysis is performed to predict the dependent variable (for example, energy consumption). The regression analysis explains how changes in weather conditions affect energy consumption.

<u>Consider the following linear model on the next page:</u>

continued on next page



$$y = a + \beta x + \varepsilon$$

where

y = energy consumption, and

x = temperature.

The intercept measures the non-weather sensitive component of the energy consumption, i.e.,

a = the energy consumption at "zero" temperature,

The slope (β) is a simple measure of the change in energy consumption associated with a unit change in temperature; i.e.,

$$\beta = \frac{\text{change in energy consumption}}{\text{change in temperature}}$$

the slope times the temperature variable measures the weather sensitive component of the energy consumption; i.e.,

βx= the energy consumption associated with "x units" of temperature,

and the error component measures that portion of the energy consumption that is not explained by the linear model; i.e.,

ε = the "random" (unexplained) energy consumption.

The assumption is that all important explanatory variables are included in the model specification. The unexplained usage is "random."

Q. How are the weather adjustment values for the different rate classes applied?

A. Staff Witness Kim Cox used the weather adjustment values in her analysis of the rate revenues.

HOURLY LOAD REQUIREMENT

Q. What is the hourly load requirement?

A. The hourly load requirement is the amount of electricity required to meet the energy demands of both the company's customers and its own needs. The hourly loads used in the analysis of the update period of July 2021 through June 2022 was obtained from Ameren Missouri's data provided in accordance with 20 CSR 4240-3.190 (1) (C).

Q. Why did Staff perform hourly load analysis?

A. Due to the high saturation of air conditioning and the presence of significant electric space heating in Ameren Missouri's electric service territory, the magnitude and shape of Ameren Missouri's load requirement are directly related to daily temperatures. The actual daily temperatures for the update period differed from normal conditions. Therefore, to reflect normal weather, daily peak and average load requirements are performed in this rate case.

Q. How was the hourly load analysis made?

A. To reflect normal weather, daily peak and average load requirements are adjusted independently, but using the same method. The independent adjustments are necessary because average loads and peak loads respond differently to weather. The daily average load is calculated as the daily energy divided by twenty-four hours, and the daily peak is the maximum hourly load for the day. Separate regression models estimate both a base component, which is allowed to fluctuate across time, and a weather sensitive component, which measures the response to daily fluctuations in weather for daily average loads and peak loads. The regression parameters, along with the difference between normal and actual cooling and heating measures, are used to calculate weather adjustments to both the average and peak loads for each day. The adjustments for each day are added, respectively, to the actual average and peak loads for each day. The actual and normal daily temperatures are used in this analysis.

The starting point for allocating both the weather-normalized daily peak and the weather--normalized average loads to the hours is the actual hourly loads. A unitized load curve is calculated for each day as a function of the actual peak and average loads for that day. The corresponding weather-normalized daily peak and average loads, along with the unitized load curves, are used to calculate weather-normalized hourly loads. This process includes many checks and balances, which are included in the spreadsheets that are used. In addition, the analyst is required to examine the data at several points in the process. For more information, the process is described in greater detail in the document "Weather Normalization of Electric Loads, Part A: Hourly Net System Loads".[9]

Once Staff's normalized, annualized test year usage for Ameren Missouri's retail customer classes is completed, weather-normalized wholesale usage is added. Then, the non-LTS class annual usage was increased by the average annual loss factor supplied by Staff Witness Alan J. Bax. The LTS class' annualized usage was added to the non-LTS annual usage to produce an annual sum of the hourly load requirement that equals the adjusted test year usage and is consistent with Staff's normalized revenues.

[9] "Weather Normalization of Electric Loads, Part A: Hourly Net System Loads" (November 28, 1990), written by Dr. Michael Proctor, Manager of the Economic Analysis Department.

A factor was applied to each hour of the weather-normalized loads to produce an annual sum of the hourly load requirement that equals the adjusted test year usage, plus losses, and is consistent with normalized revenues.

Q. How are the weather normalized hourly system loads applied?

A. The weather normalized hourly system loads were used by Staff Witness Shawn Lange in his analysis of test year fuel and purchased-power expenses.

ENERGY EFFICIENCY ADJUSTMENT

Q. What does MEEIA stand for?

A. MEEIA stands for the Missouri Energy Efficiency Investment Act.

Q. Why was the energy efficiency adjustment made?

A. The goal of the energy efficiency adjustment is to account for the annualized impact of energy efficiency measures installed during the test year. This adjustment makes up for the drop in billing units and related income that the Company experienced as a direct result of the implementation of end-use savings measures.

Q. How was the energy efficiency adjustment made?

A. Staff calculated the energy efficiency adjustment based on the number of end-use measures installed during the test year. The first input required for the analysis is the kWh savings by end-use category by rate class. The total deemed savings are calculated from these end-use measures installed in each category of saving and the low-income deemed savings of the test year. For the energy efficiency adjustment, a half-month convention was used to estimate the energy savings in each month of the installation. A half-month convention assumes that all energy-efficient capacity was installed halfway between the beginning and end of the month, which is mathematically equal to assuming that investments were made consistently throughout the month. Company estimated savings with the same half-month convention methodology. The second input data is the installed savings, also called actual savings, for each calendar month. The actuals are the values that would have been realized for each calendar month of the test year.

The difference between the actual monthly energy efficiency savings realized and the annualized energy efficiency savings for each end-use measure category and rate class is the calendar month energy efficiency annualization adjustment. For each end-use measure, the applicable monthly load shape is multiplied. The load pattern reflects the seasonality of the savings. To represent the effect of the energy efficiency adjustment on the company's revenue, the energy efficiency adjustment is provided to Staff Witness Kim Cox.

CONCLUSION

Q. Does this conclude your direct 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 *Direct 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 4th day of January 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

Hari K. Poudel

PRESENT POSITION:

Currently, I work for the Missouri Public Service Commission ("Commission") as a Regulatory Economist in the Tariff/Rate Department of the Industry Analysis Division. The Department of Tariff and Rate Design takes part in and offers advice on matters filed with the Commission, such as rate, complaint, application, territorial agreements, sale, and merger. The department also handles rate design, weather variables, and weather normalization tasks and offers technical assistance. I am responsible for using quantitative economic techniques and statistical analysis to address energy-related challenges that have an effect on utility ratemaking. I am also responsible for recommendations for the Commission based on a rigorous economic analyses of the problems relating to energy.

EDUCATIONAL CREDENTIALS AND WORK EXPERIENCE:

I received a Doctor of Philosophy in Public Policy from the University of Missouri, Columbia, Missouri in May 2020. I graduated with a Master's in Public Health from the University of Missouri, Columbia in May 2019. In 2008, I received a Master's in Agricultural Economics degree from Hohenheim University in Germany.

I've been employed with the Missouri Public Service Commission since October 25, 2021, in the Tariff/Rate Department of the Industry Analysis Division as a Regulatory Economist. Prior to joining the Commission, I was a Research/Data Analyst for the Missouri Department of Health and Senior Services. I analyzed public health data that directly affects Missourians in my capacity as an analyst.

SUMMARY OF CASE INVOLVEMENT:

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1.	ER-2022-0146	Ameren Missouri	Rider Energy Efficient Investment Charge (EEIC)
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