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Case No.: GR-99-315

ON BEHALF OF THE

MISSOURI PUBLIC SERVICE COMMISSION

UTILITY OPERATIONS DIVISION

SURREBUTTAL TESTIMONY

OF

STEVE QI HU, PH.D.

LACLEDE GAS COMPANY

CASE NO. GR-99-315

Jefferson City, Missouri

August, 1999

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Q. Please state your name and business address.

A. My name is "Steve" Qi Hu, and my business address is 237 L.W. Chase Hall, University of Nebraska-Lincoln, Lincoln, Nebraska 68583-0728.

Q. Are you the same Steve Qi Hu that filed direct and rebuttal testimony in this case?

A. Yes, I am.

Q. What is your purpose of this surrebuttal testimony?

A. The purpose of my surrebuttal testimony is to clarify the misunderstanding expressed in the rebuttal testimony of Dr. Jay Robert Turner (Dr. Turner) on several results and issues related to my direct testimony and help the Commission to interpret my results correctly.

Q. What fundamental misunderstanding does Dr. Turner have regarding your analysis?

A. The fundamental question appears to be: Why did we make such an adjustment? While Dr. Turner's rebuttal testimony is not clear on whether or not there is a need to make the kinds of adjustments which I performed at the request of the Staff, I want it to be clear that it is my professional opinion as a climatologist that absent

corrections for the significant changes that have occurred in the measurement of temperature at the St. Louis Lambert International Airport (Lambert Field), the official NOAA data is inconsistent between the normal period (1961 through 1990) and the period used for the test year in this case.

Q. Why does Dr. Turner's rebuttal testimony lead you to believe that he does not see the need for making these changes?

A. First, Dr. Turner has not proposed to make any changes to the official NOAA data. In order for his analysis to be complete, he must either offer an alternative calculation of changes or argue that no changes are required. He did neither, which implies that either he supports no change or his analysis is incomplete. Second, Dr. Turner appears to infer that since NOAA makes similar types of adjustments in their calculation of "official" normal weather, there is no need to make further calculations.

Q. Does NOAA make adjustments to historical measurements of weather in its calculation of normal weather?

A. While it is true that NOAA does provide an adjustment to its official normal temperatures and heating degree days for the normal period (1961-1990), it does not mean that further adjustments are not recommended. This is especially true when a particular station's data is to be used in a decision making process for future time periods that are outside the time period used by NOAA for calculating normal weather, such as in this case. I hope that this clears up any question of whether or not there is a need to make the adjustments to the official NOAA data.

Q. Do you have any additional evidence showing Dr. Turner's misunderstanding of your methods?

A. Yes. On page 3, lines 8-13 of Dr. Turner's rebuttal testimony, he questioned the use of 5-year temperature data records in detecting possible bias that was induced to the weather station's temperature series by a single move of the station or sensor change at the station. Dr. Turner suggested the use of a much longer data series in order to reduce so-called compounding effects of the change at the station.

Requiring a longer data series than five years in this case goes beyond statistical sampling requirements. It is statistically sufficient to use a 5-year (60 months) record in analysis of the effect of a change occurring within one of the 60 months. In most cases, a sample of size 30 or greater is sufficiently large to derive statistically valid conclusions.

With respect to compounding effects, when multiple sources of possible biases and their locations in the data series for the target weather station are known (e.g., 1978-79, 1985, 1988 and 1996 for Lambert Field station), one then develops subsets of time periods around each of these potential bias events. The choice of time periods that make up the subsets surrounding each potential bias is driven, in part, by having as few sources of bias in each subset as possible, but also by having an adequate length. These subsets allow us to analyze the effects for the individual potential bias events by minimizing possible interference effects from other potential bias events. To use as large of a data set as Dr. Turner suggests implies several potential bias events in a single analysis.

I should also point out that there are no compounding effects in the double mass analysis that I performed for Lambert Field. The accumulated difference between the temperatures of two stations is a linear function of time. The variation of accumulated difference will show every single effect from station move or sensor changes. An

additional bias is simply added on top of the existing ones, because there are no cross interactions.

Q. Do you have any response to Dr. Turner concern on missing seasonal effects because of the double mass analysis method that you applied?

A. Since the problem is linear, as I discussed above, nothing in the double-mass analysis will change because of seasonal variation in the data. For example, if the data series experiences a warming bias of 0.5 degree F, say, after relocation of the station, that 0.5 degree F bias will be in the data regardless of seasons, even though seasonal fluctuations may exist from time to time. These seasonal fluctuations will be difficult to separate from random patterns or noise in the data. Temperature data is noisy, as Dr. Turner admitted.

Q. What is your response to Dr. Turner's criticism regarding the so called "urbanization effect?"

A. Although the "urbanization effect" of warming local temperatures over time has long been recognized, there are no accepted quantitative methods to measure this effect. One of the primary characteristics assumed for this warming effect is that it builds up slowly over time. Therefore, since the choice of data length for the double-mass analysis in my analysis is limited to 5 or 6 years, it is doubtful that an "urbanization effect" would be of significant magnitude. The final results at most would have only a small residue of this urbanization effect, if any at all.

If the urbanization effect were to warm the St. Louis temperatures by a very small fraction of a degree over the 5- or 6-year period used in the double-mass analysis, this would at most results in a slight over-correction of the St. Louis temperature for the two

warming biases. However, any slight over-correction for the warming biases would be offset by an over-correction in the other direction for the cooling bias in 1996. Of course, these overcorrections were assumed here to illustrate the point rather than being the case in the analysis.

Q. What is your response to Dr. Turner's criticism regarding your selection of reference stations?

A. Selecting reference stations for the comparison analysis in this kind of case is an extremely complex task. A description of how the reference stations were chosen for this analysis will also explain why they are the best ones to use.

The ideal reference stations for this analysis would be close to the Lambert Field weather station. They would have the same environmental surroundings as that in the Lambert Field weather station, the same equipment and the observations would be taken at the same time during a day. These ideal stations will measure the same atmospheric environment. Changes of sensor or location at the Lambert Field station would be detected by the differences between these ideal reference stations' temperature records compared to those from the Lambert Field weather station. Unfortunately, such ideal stations do not exist.

The problems faced in selecting reference stations include incomplete station history, difference in observation times between the potential reference weather stations and the target weather station (Lambert Field), incomplete information of the change of the observation time, and different environmental conditions. In my earlier analysis (Case No. GR-98-374), I selected the St. Charles 7 SSW station and the St. Louis WSFO station and used their daily data in a double mass analysis with the St. Louis Lambert station. I

later found that because of some of the incomplete information on the change of daily observation time these reference stations did not provide accurate information needed to evaluate the Lambert Field station data, even though they were located the closest to the Lambert Field station among all the stations that have adequately long records.

Q. What did you do in choosing reference stations for this analysis?

A. In this analysis, I was trying to avoid the problem of observation time change and looked at the stations in NOAA's Historical Climatological Network (HCN). These stations' data, particularly their sequential data series have been subjected to NOAA's quality check. In addition, their time-of-observation difference from the midnight-to-midnight schedule (which is used at the first order stations such as the Lambert Field weather station) has been corrected using a documented procedure by NOAA. These data should be considered as established data sets and use of them should minimize the possibility of human error with respect to the choice of the basic data sets for the analysis and therefore the outcome of the analysis.

Q. Why did you select the Elsberry and Union weather stations rather than others included in the HCN data set?

A. This decision was based on a pre-analysis comparison study of all the HCN stations in the vicinity of the St. Louis area. In this comparison, Mr. Dennis Patterson and I plotted double mass analysis result for each of the stations with the Lambert Field station data. We then examined these results and I identified that the Union and the Elsberry stations had the best available data for the time periods in which the target station reported changes of station location or sensor or both. In this selection process, I also tried to select the stations that may be used in all or at least as many as possible of

the periods of interest. This should also reduce possible criticisms from using different sets of stations for each of the different periods. These were the practical criteria used for selecting Elsberry and Union as reference stations to be used in the analysis. These stations best satisfy these criteria from all available HCN weather stations within the St. Louis area.

Q. Why didn't you visit the reference stations after initially selecting them for your analysis, but before doing the analysis?

A. Visiting the station site is necessary for gathering intuitive information about the station. Discussions with observers help to confirm published information on the station's history. However, the published information is the basic source of information.

In meteorological analysis, data is used from thousands of weather stations, and we must examine station data from published sources, because those stations cannot be visited individually. In short, visiting the reference stations is constructive, but only becomes critical to the analysis when information gained is contrary to published data.

Q. Were your results and working papers as difficult to understand as Dr. Turner complained about?

A. No, I don't believe so. The figures presented in my working paper should have been easy to understand. The top panel showed the summery of the double mass analysis result for the entire period centered at a year in which a change occurred at the Lambert Field weather station: 1976-81 (for changes occurring in 1978-79); 1983-87 (for a change occurring in 1985); 1986-90 (for a change occurring in 1988); and 1994-98 (for a change occurring in 1996). The middle and bottom panels in a figure showed the magnified segments of the two legs before the after the change occurred. The fit function and its

analytic form were provided in these two panels to quantify their difference. From the analytic forms one can easily calculate the change of slopes resulting from the change at the station. I want to make it clear that my calculation was based on the data through each of the entire 5-year periods and the magnified segments are simply to show for visual benefit the details of the curves. They were not calculated separately using sections of the data series as Dr. Turner assumed or understood. The legends of the figures are correct. The working papers that I provided to the Company contain complete data sets and programs used in making these calculations and figures. If Dr. Turner can read those short and clear programs he should have no difficulties in understanding the straightforward results.

Q. Does this conclude your surrebuttal testimony?

A. Yes, it does.