Exhibit No.:
Issues: Weather Normal Variable
Witness: Manisha Lakhanpal
Sponsoring Party: MO PSC Staff
Type of Exhibit: Rebuttal Testimony
Case No.: GR-2009-0355
Date Testimony Prepared: September 28, 2009

MISSOURI PUBLIC SERVICE COMMISSION

UTILITY OPERATIONS DIVISION

REBUTTAL TESTIMONY

OF

MANISHA LAKHANPAL

MISSOURI GAS ENERGY

CASE NO. GR-2009-0355

Jefferson City, Missouri

September 2009

Staff Exhibit No. 53
Case No(s). GR-2009-0355
Date 10-26-09 Rptr KF

BEFORE THE PUBLIC SERVICE COMMISSION

OF THE STATE OF MISSOURI

In the Matter of Missouri Gas Energy and Its Tariff Filing to Implement a General Rate Increase for Natural Gas Service	)))	Case No. GR-2009-0355

AFFIDAVIT OF MANISHA LAKHANPAL

STATE OF MISSOURI)
) **ss**
COUNTY OF COLE)

Manisha Lakhanpal, of lawful age, on her oath states: that she has participated in the preparation of the following Rebuttal Testimony in question and answer form, consisting of 9 pages of Rebuttal Testimony to be presented in the above case, that the answers in the following Rebuttal Testimony were given by her; that she has knowledge of the matters set forth in such answers; and that such matters are true to the best of her knowledge and belief.

Manisha Lakhanpal
Manisha Lakhanpal

Subscribed and sworn to before me this 28th day of September, 2009.

NOTARY PUBLIC NOTARY SEAL STATE OF MISSOURI

SUSAN L. SUNDERMEYER
My Commission Expires
September 21, 2010
Callaway County
Commission #06942086

Susan L. Sundermeyer
Notary Public

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REBUTTAL TESTIMONY

OF

MANISHA LAKHANPAL

MISSOURI GAS ENERGY

CASE NO. GR-2009-0355

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REBUTTAL TESTIMONY

OF

MANISHA LAKHANPAL

MISSOURI GAS ENERGY

CASE NO. GR-2009-0355

Q. Please state your name and business address.

A. My name is Manisha Lakhanpal and my business address is Missouri Public Service Commission, P. O. Box 360, Jefferson City, Missouri, 65102.

Q. Are you the same Manisha Lakhanpal who has submitted a section on weather normal variables, as part of the Cost of Service Report in the current rate case?

A. Yes, I am.

SUMMARY

Q. What is the purpose of your rebuttal testimony?

A. I will address the written direct testimony of Missouri Gas Energy (MGE or Company) witnesses Dr. Robert Livezey and Mr. Larry Loos regarding the calculation of normal heating degree days[1] (HDDs) for the MGE districts in Missouri.

Q. Please summarize your rebuttal testimony.

A. The new methodology proposed by MGE witness Dr. Livezey to forecast HDDs is perhaps progressive, but it is inconsistent with international meteorological convention, Commission rulings, and the purpose of adjusting volumes to normal HDDs in

[1]Heating Degree Days (HDDs) are used as an index to estimate the amount of energy required for heating during the winter season. (HDD=65°F – Daily Mean Temp., but if Daily Mean Temp > 65°F, then HDD=0 where Daily Mean Temp = (Daily Maximum Temp + Daily Minimum Temp)/ 2).

Missouri Public Service Commission (PSC) rate cases. The 30-year period used by Staff is consistent with all of these and Staff policy when calculating normal weather variables.

Q. Please describe your understanding of how MGE developed weather normal variable such as HDDs for weather normalizing sales in this case?

A. Dr. Livezey proposes a least square regression model called the Hinge-Fit model, to predict "normal" temperatures for calendar quarters. The Hinge-Fit model makes use of a three-month mean temperature (i.e., an average of the mean daily temperatures for three months based on 1941-2005 data) for 102 U.S. climate divisions[2] (Schedule ML 1) in a function where a trend line is fitted to the temperature data. The trend line is flat from 1940 through 1975 (i.e., assuming relatively little climate change during this time period). In his analysis Dr. Livezey assumes that a linear climate trend began in 1975, so he fits an upward sloping line for all years from then on for climate divisions. MGE witness Mr. Loos uses these assumptions to forecast monthly normal HDDs for selected Missouri weather stations for 2010, using time series data for Missouri weather stations between 1951 and 2008. The Company proposes to use this forecasted HDDs value as the Normal HDDs variable in order to weather normalize test year (January – December 2008) sales.

Q. Please explain the differences between Staff and MGE in developing weather normal variable?

A. The Company uses a forecasting model estimated using data from 1951 to 2009 to predict current and future normal HDDs. In its analysis, the Company uses predicted 2010 HDDs. Whereas Staff calculates normal HDDs using an arithmetic average of actual

[2] Climate Divisions - To simplify the national picture somewhat, the United States has been divided into 344 climate divisions, with no more than 10 per state. The divisional precipitation and temperature data are averages of typically 10-50 individual stations. Monthly divisional climate information for the 48 contiguous states is available from 1895 onward. Data from the most recent 1-3 months is provisional and based on a smaller number of stations. (definition courtesy Western Regional Climate Center)

mean daily temperatures over the 30 year NOAA[3] normal period (1971-2000) consistent with the official normals calculated by the National Climatic Data Center. Staff does not forecast weather variables but instead adjusts the test year sales to normal.

Q. What issues do you have with the Company's approach on weather normal variable?

A. Staff does not recommend the use of a forecasted value of HDDs, derived from the Hinge-Fit model, for weather normalization adjustment. If the Commission adopts a forecasted HDDs variable, it is setting an expectation for future weather conditions. In this case the Company uses predicted HDDs for the year 2010 to adjust usage that occurred during the test year (January-December 2008). Staff's approach has always been to adjust the test year sales to normal weather and not to an "expected" normal weather.

RATIONALE FOR THE NOAA THREE DECADE PERIOD FOR A NORMAL

Q. Is there support for using the NOAA time period (currently 1971-2000)?

A. Yes. The use of this time period is based on testimony submitted by then Missouri State Climatologist, Dr. Wayne Decker, which was adopted in Case No. GR-92-165. (Schedule ML-2). On page 6, beginning with line 22, Dr. Decker gives his recommendation for the 30-year time period for defining normal heating degree days.

> Q. What would you recommend the Commission use for the "base period" in defining degree day normals for St. Louis?
> A. I would recommend that the most recent thirty-year period with a recalculation every decade be used for the following reasons:
> (1) it would not allow events which have occurred nearly a century ago to be equally weighted with more recent events in the calculation of normals;
> (2) it would allow for an adjustment for changes in climate, both natural and anthropogenic;

[3] National Oceanic and Atmospheric Administration

(3) this procedure would bring the techniques used in Missouri in line with those used by the National Weather Service and other States;
(4) the thirty-year period is long enough to produce statistics that are stable without major variations from decade to decade;
(5) during the most recent thirty-year period (1961-1990), the observations at Lambert Field have been taken from the same site using the same type of weather instruments.

This recommendation was reaffirmed in Case No. GR-99-315 by then Missouri State Climatologist Steve Qi Hu, PhD, in his direct testimony (Schedule ML-3) beginning on page 7 line 17:

> Q. What should be a time period for developing meaningful climate normals?
> A. In describing climate "normals" the WMO (World Meteorological Organization) requires the use of 30-year temperature and precipitation data. This standard is accepted by the U.S. National Weather Service. One of the reasons for using such a time period in defining climate conditions is that climate has its natural variabilities. These variabilities are shown, in part, by oscillatory variations of temperature and precipitation at various time periods. For example, there have been many studies showing significant interannual and interdecadal temperature variations in the U.S. To minimize the impacts of these fluctuations on averaged climate conditions WMO recommends to use [*sic*] 30-year data in calculation of the normal of the surface air temperature.

Q. Has NOAA replaced the use of 30 Year Normal with any other climate normal?

A. No. NOAA still uses a three decade time period to calculate normal weather. International convention has established that three-decade periods are appropriately long and uniform time frames for the calculations of a normal. The current thirty-year period used by NOAA is January 1, 1971, through December 31, 2000.

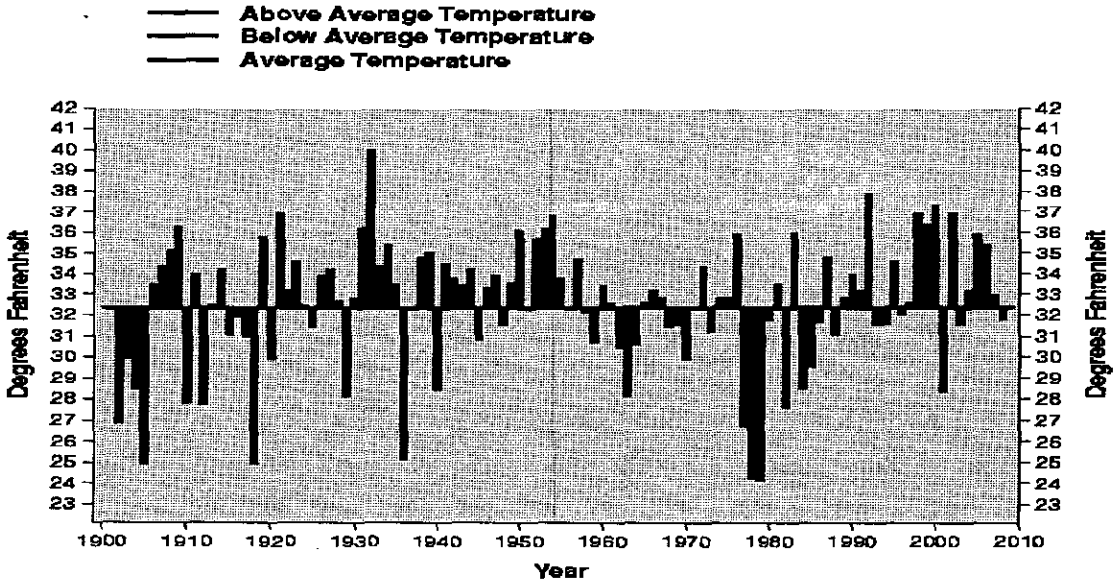
HINGE-FIT MODEL

Q. Does the use of Hinge-Fit model substantiate that climate change has occurred in Missouri?

A. Temperature change is a composite process and it is not simple to interpret temporal variations via graphs and charts. Dr. Livezey did not present any Missouri specific statistical analysis in support of the Hinge-Fit model in his direct testimony or his workpapers. Dr. Livezey uses a graph in his direct testimony, on Page 23 to plot Missouri Winter (Dec-Feb) Temperature, with 1971-2000 base period, to show how Missouri climate is changing similar to the global change in climate, but the Hinge-Fit line on the graph has been "overlaid schematically" (as explained in Dr.Livezey's Direct Testimony, page 21, line 16). There is no apparent statistical analysis done using Missouri data to show that this Hinge-Fit model is equally relevant at a regional or a local level in the State as it is perhaps at a global level. No prominent climate trend is clearly seen in the graph below once the overlaid Hinge-Fit line is removed.

Base Period Winter (Dec-Feb) 1971 - 2000 Average = 32.32 degF

Winter (Dec-Feb) 1900 - 2009 Trend = 0.10 degF / Decade



Source: NOAA Satellite and Information Service

Q. Is there anything atypical about Missouri weather that makes it difficult to compare it to a global climate change pattern?

A. Based on the results from Dr. Livezey's study Missouri exhibits a moderate temperature trend as compared to some other states. Dr. Livezey's research paper titled "Estimation and Explanation of Climate Normals and Climatic Trends" uses seasonal data from various climate divisions across the country to study climate change using the Hinge-Fit model. The results are presented in Fig. 1a[4] and Fig. A1[5] in Schedule REL-1 attached to his testimony. Using these results, Dr. Livezey goes on to explain in his direct testimony page 21, lines 18-21, and page 22, lines 1-2:

> First the trend to warmer temperatures in recent decades is not as obvious as in the other maps shown. In addition to being a smaller area, Missouri is in the zone of transition for the United States between modest temperature trends to the southeast and very large trends to the northwest. Second, Missouri temperature records in other seasons (see Schedule REL-1, Fig A1) indicate no trends whatsoever, underlying the significance of the winter trends.

As mentioned earlier, Dr. Livezey uses seasonal Climatological data from various climate divisions across the country and we do not know how many Missouri climate divisions were used in the Hinge-Fit model. There is no conclusive evidence related specifically to Missouri weather.

Q. Has Dr. Livezey presented any methodology to apply the Hinge-Fit model developed for seasonal data across climate divisions in the United States to Missouri monthly local weather station data that is used in weather normalization adjustment?

A. No, he has not.

Q. Has the Staff analyzed data from Missouri Climate Divisions?

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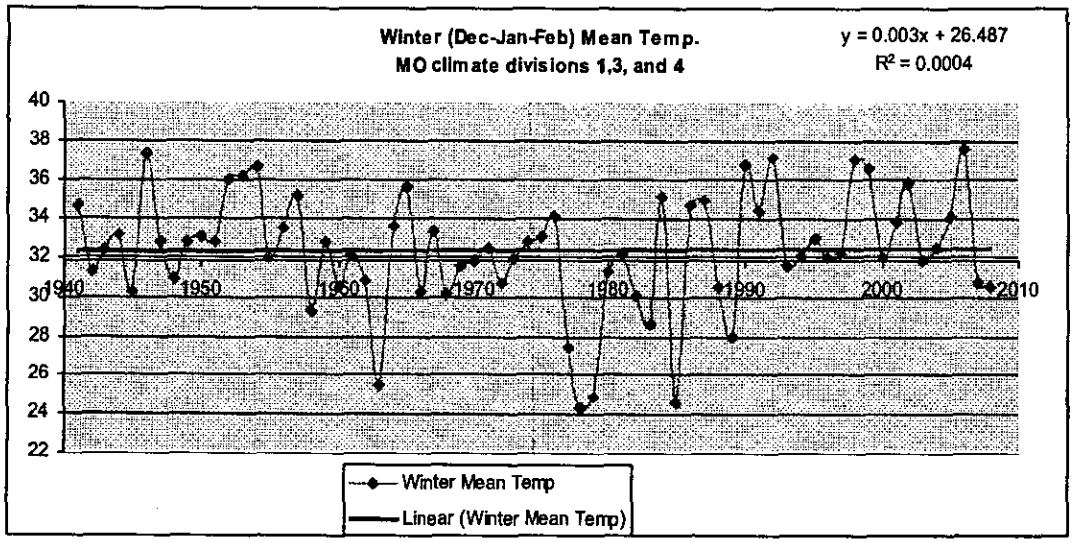
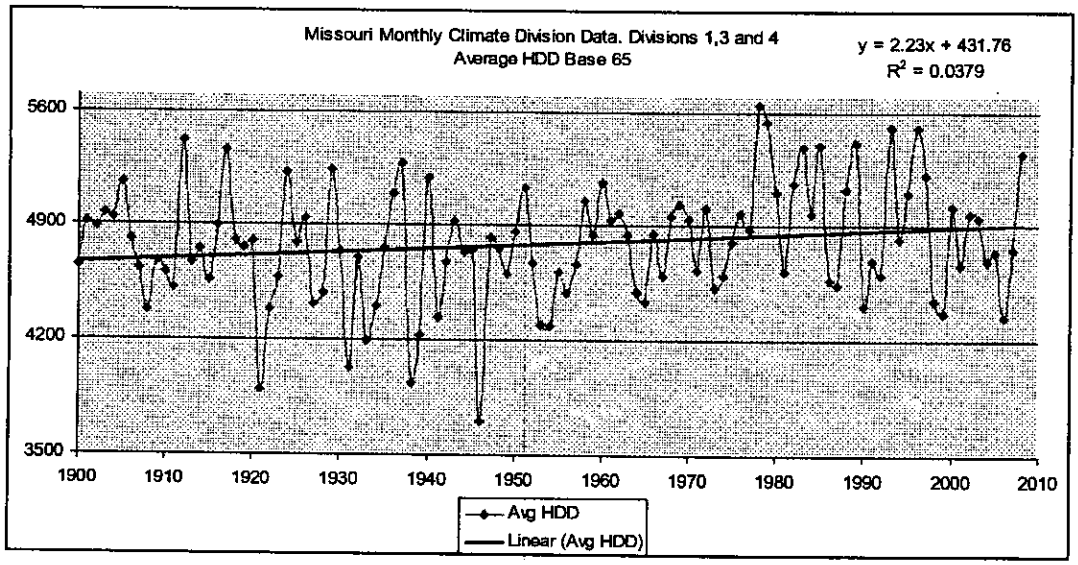
[4] Page 3 of 19
[5] Page 15 of 19

A. Yes. Staff uses three climate divisions relevant to MGE's service territory. These are MO climate divisions 1, 3 and 4 (See Schedule ML-4). First, winter mean temperatures (Dec-Feb) based on 1941-2008 data, similar to the time period used by Dr. Livezey in his research paper are examined. Dr. Livezey has assumed that a global climate trend (warming) started in 1975, but in the graph below winter mean temperatures dropped in the late '70s. It would be inappropriate to apply a Hinge-Fit model to Missouri weather data with an assumption that the warming trend began in 1975.



Second, plots of HDDs, which are a primary weather variable used in weather normalization adjustment, are also examined. There is a slight increase in trend over the years as shown below, implying that data does not correspond to a global climate change pattern as proposed by Dr. Livezey.



Q. Does the Staff agree with the idea of climate change?

A. Staff does not accept or oppose the idea of climate change at this point. There is much debate in the scientific community about climate change, its impact, and proposal on what future weather trend would be like and Staff does not want to base its weather normalization adjustment factor on a predicted weather normal variable using a Hinge-Fit Model that was not even estimated using Missouri weather data.

Q. Has the Hinge-Fit model been proposed at other state regulatory commissions?

A. Yes, Staff is aware of two such cases. Black Hills/Iowa Gas Utility Company, LLC d/b/a Black Hills Energy f/k/a Aquila, Inc. d/b/a Aquila Networks filed an initial case on June 30, 2008 with the Iowa Utilities Board proposing the use of Hinge-Fit Model. Similarly Aquila, Inc filed a case on June 30, 2008 with the Public Utilities Commission of the State of Colorado proposing a Hinge-Fit model for weather normalization. In both cases the respective Commissions did not adopt the Hinge-Fit Model and stated that the use of the NOAA 30-year normal method for the weather normalization adjustment is reasonable.

CONCLUSION

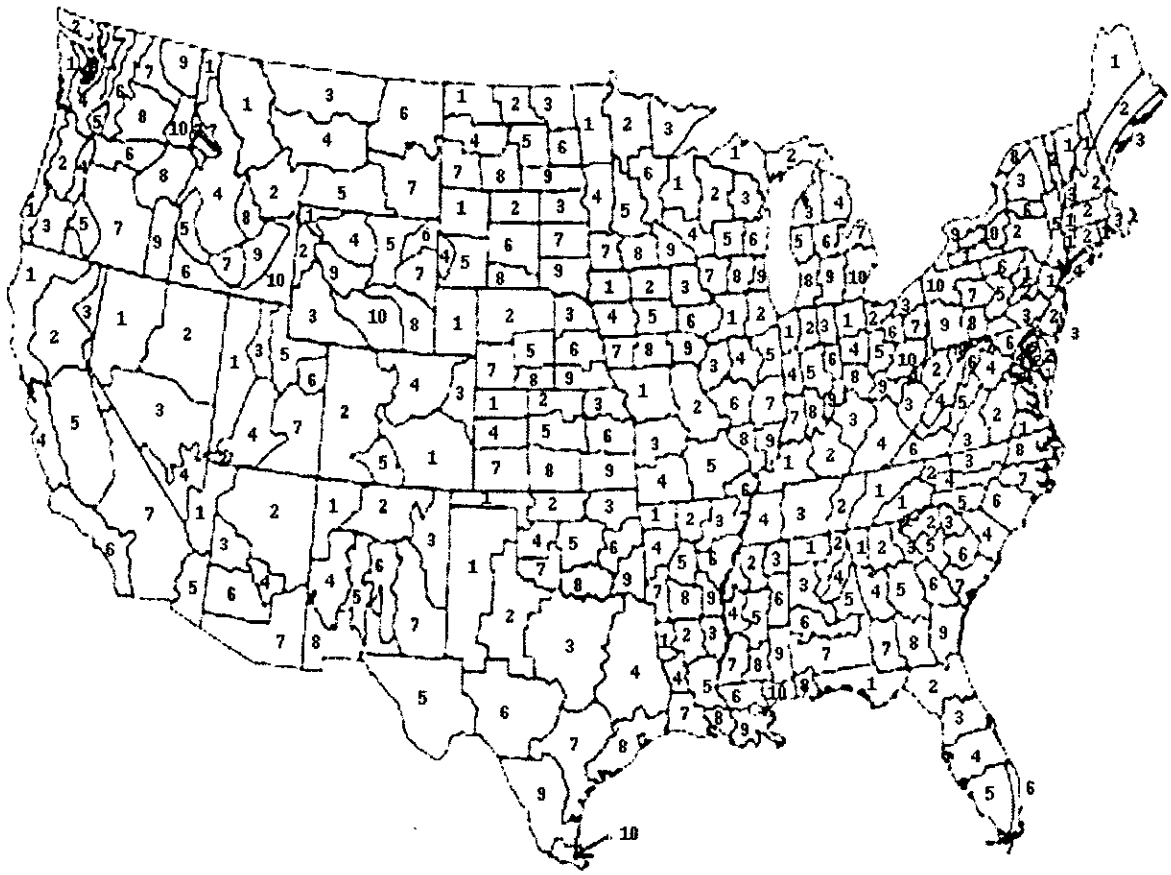
Q. What are your conclusions?

A. The use of 30-year NOAA normal period is appropriate to weather normalize sales and it is consistent with international meteorological convention, Commission rulings, and the purpose of adjusting volumes to normal HDDs in Missouri PSC rate cases. The use of a forecasted normal HDD for a weather normalization adjustment is not.

Q. Does this conclude your testimony?

A. Yes, it does.

Location of US Climate Divisions



Schedule ML 1-1

Exhibit No.:
Issues: Weather Normalization

Witness: Wayne L. Decker
Type of Exhibit: Direct
Sponsoring Party: MoPSC Staff
Case No.: GR-92-165

MISSOURI PUBLIC SERVICE COMMISSION

LACLEDE GAS COMPANY

Case No. GR-92-165

DIRECT TESTIMONY

OF

WAYNE L. DECKER

Jefferson City, Missouri

July, 1992

Exhibit No. 3
Date 8/13/92 Case No. GR-92-165
Reporter GM

DIRECT TESTIMONY

OF

WAYNE L. DECKER

LACLEDE GAS COMPANY

CASE NO. GR-92-165

Q. What is your name and address?

A. I am Wayne L. Decker. I live at 1007 Hulen Drive, Columbia, Missouri 65203.

Q. What is your professional position?

A. I serve the University of Missouri-Columbia as a Professor of Atmospheric Science. I have also been designated as the State Climatologist for Missouri.

Q. How long have you been employed by the University of Missouri?

A. I came to the University of Missouri an Assistant Professor in September 1949. I was designated as the State Climatologist when the National Weather Service phased-out their program of service to the States in the late 1960's.

Q. Where were you employed prior to your appointment at the University of Missouri?

A. I worked as a climatologist for the National Weather Service (called at that time the U. S. Weather Bureau) and served in World War II as a meteorologist with the U. S. Navy in the Pacific theater.

Q. What has been your formal education?

A. My undergraduate education was at Central College in Pella, Iowa with a major in Chemistry. I received post-graduate training in Meteorology at UCLA in 1943-44. I hold MS and Ph.D degrees from Iowa State University in Climatology.

Q. Do you have any other professional qualifications?

A. Yes. To save time, I have attached a copy of relevant biographical information as Schedule 1.

Q. What does the field of Climatology cover?

A. Climatology is the study of the variations in climate, both spatial and temporal, and documentation of the effects of these variations on man. Climatology involves the use of statistical procedures for determining the risks of climatic events from a probability point of view. The climatologist must asses the effects of discontinuities in the climatic records due to natural causes, changes in observational procedures, and effects of man on the environment. The climatologist interprets the historical observational series in terms of the effects of climate on human food supply and health, weather sensitive operations and economic growth and development.

Q. Does climatology provide information of value to the assessment of heating demands?

A. Yes. For many years the utility companies, consumers, and the State Commissions regulating the supply of fuel and power have used climatic records as a basis for setting rates and anticipating energy needs. The climatologist can provide valuable assistance with the interpretation of the historical climatic records.

Q. Does it make a difference where the weather observations are taken for describing the climatic characteristics of a city or region?

A. Yes, when one interprets climate data over an extended period it is very important to review the history of the weather station locations and the type of instrumentation used. Attached to this testimony as Schedule 2 is a summary prepared by the National Oceanic and Atmospheric Administration (NOAA) of the downtown and Lambert Field locations where weather observations have been taken and the instrumentation used in St. Louis.

Q. Is it a standard practice for climatologists to refer to such a NOAA summary when reviewing historical weather station locations and instrumentation?

A. Yes. In this instance, I reviewed Schedule 2 in the course of preparing this testimony.

Q. According to the data contained in Schedule 2, have the weather records at St. Louis been taken at the same location throughout the time of record keeping?

A. No, the records were first taken at a location in the center of the downtown area of St. Louis. Later, with the establishment of the airport (Lambert Field) these responsibilities were transferred to the airport location.

The downtown temperature observations were taken at roof-top, about 200 feet above the street from 1903 onward until the closing of the observing station in 1968. Prior to 1903, the roof-top station was located about 100 feet above the street.

Unless one carefully reviews the station location descriptions, it would appear that the Lambert Field Station did not experience much of a change since it was established in 1929. There are, however, two changes in the location of the instruments at Lambert Field requiring analysis.

Q. What are these changes?

A. In November 1943 the site of the temperature measurement at Lambert Field was moved from a position away from the building (in an instrument shelter at five feet above the ground) to a roof-top location on the second floor of the Administration Building. This position allowed the dark roofing and the vents from the first floor to provide a less than ideal location for documenting the climate of the area. I have reviewed the degree day values reported for Lambert Field for this period (1943 through September 1957) and these records show the period as one with low heating degree day totals. The

average degree days from the period extending from the 1943-44 season through the 1956-57 season is some 6% lower than the mean of 4838 calculated for the period currently used by the Public Service Commission. It is very likely that the warmer temperatures were, at least in part, due to heat added by the roof exposure.

On April 18, 1958, the site of measurement at Lambert Field was moved to a position between the runways and over grass. This move may have resulted in a cooler environment than when the instruments were located close to or on buildings.

Q. Have the weather records always been derived from the same type of weather instruments in St. Louis?

A. For most of the period since the late 1890's the temperature records have come from liquid in glass thermometers (mercury or alcohol in glass). These thermometers were shaded from the sun and protected from the earth's radiation by a louvered box mounted about five feet above the ground or roof top.

However, when the instruments were moved to the runway location at Lambert Field in April 1958, the system of measuring temperatures employed by the National Weather Service in St. Louis was changed. This change consisted of discontinuing the use of liquid thermometers mounted in the white instrument shelter in favor of electrical thermometers exposed in a reflective cylinder over the grass areas between the runways. The observations from these instruments are recorded on indicators in the National Weather Service Office. This new system was installed at all airport observing stations of the National Weather Service at about this same time. Since the instruments were located away from the buildings and the paved tarmac, the temperatures are typically cooler than those previously reported from exposures near the buildings. This system has continued in use for the past three decades. It can be noted that the heating degree days in recent years (since 1960) are markedly higher, suggesting that

the new location provides a sampling of temperatures for a slightly cooler climate for the Lambert Field area. Even when one includes the degree day totals for the warmer most recent decade (1981-82 through 1990-91) the thirty-two year average (1958-59 through 1990-91) is very close to the value suggested by the Commission as the long-time average.

Q. For describing the climatic characteristics does the climatologist usually use the entire period of record available for a particular station?

A. Climatologists tend to use a subset of the entire period of record for describing the characteristics of the climate of a city or region. The length of record for this subset should be long enough to represent the climate of the region in a manner that reduces the changes of a short sequence of cool or warm years influencing the climatic statistics. Clearly the period should be long enough to be "representative" of the climate of the region, but not be so long that it measures a condition that has already past and no longer valid for the climatological time series. This problem of defining a base period for the "normal" climate has plagued climatologists for many years. The World Meteorological Organization (a UN agency which coordinates national programs in meteorology and climatology) and the National Weather Service in the U. S. have adopted the policy of using the most recent thirty-year period as the average for comparison purposes. Under their policy, the average is "rolled over" at the beginning of each decade. The newly established "normals" are then used for the next ten years.

Q. Is using the "thirty year normals" better than using the entire record available for St. Louis?

A. The climate of any region is dynamic in the sense that there is a constant change. Some of these changes appear to be

random while others are systematic. The "rolled over average" is used for the normals to minimize the systemic errors.

One source of the systemic error is the change in the type of instruments used to measure temperature and the exposure of these instruments. It appears obvious that if a different procedure was previously used for measuring temperature than is used today that the older records should not be included in the base period which defines the climatic normals.

Another systemic error in temperature is the changes associated with the growth of the city of St. Louis. The "urban heat island" is a well documented phenomenon which notes that the urban temperatures are warmer than the nearby rural temperatures, particularly at night. This temperature difference is related to size of the city (area and population). The center of warming and the extent of warming depends on the configuration of the city. In the case of St. Louis, there has been some documentation of the urban effect from detailed studies in the 1960's. It appears that the center of development in St. Louis has been away from the Mississippi River, and the urbanization of the area around Lambert Field is apparent. The opportunity for an urban climate change in the Lambert Field weather records, although not documented, is certainly present.

Q. What would you recommend the Commission use for the "base period" in defining degree day normals for St. Louis?

A. I would recommend that the most recent thirty-year period with a recalculation every decade be used for the following reasons:

(1) it would not allow events which have occurred nearly a century ago to be equally weighted with more recent events in the calculation of the normals;

(2) it would allow for an adjustment for changes in climate, both natural or anthropogenic;

(3) this procedure would bring the techniques used in Missouri in line with those used by the National Weather Service and other States;

(4) the thirty-year period is long enough to produce statistics that are stable without major variations from decade to decade;

(5) during the most recent thirty-year period (1961-1990), the observations at Lambert Field have been taken from the same site using the same type of weather instruments.

Q. Does that conclude your testimony?

A. Yes.

DIRECT TESTIMONY

OF

STEVE QI HU

LACLEDE GAS COMPANY

CASE NO. GR-99-315

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. What is your present position?

A. I am a climatologist and an Assistant Professor of Atmospheric Science at the School of Natural Resource Sciences of the University of Nebraska-Lincoln.

Q. How long have you held your position and briefly describe your responsibilities?

A. I was appointed to my present position in February 1999. My responsibilities at this position include research, extension service and teaching. In research, I am developing and improving our understanding of the regional climate variations and climate impacts on regional agriculture and the regional economy. In extension service, I am responsible for disseminating the most recent research results in climate and climate variations to the general public of Nebraska and neighboring states including Missouri. In teaching, I am currently teaching the Agricultural Climatology course.

Q. Do you have any previous work record in the State of Missouri?

A. Yes. I was a Research Assistant Professor of Atmospheric Science at the University of Missouri-Columbia, and served as the Missouri State Climatologist and Director of the Missouri Climate Center for the time period July 1995 through January 1999.

Q. Could you briefly describe your responsibilities at that position?

A. I was developing research programs aimed at understanding the regional climate variations and climate impacts on regional agriculture. In service as the State Climatologist, I was responsible for archiving, maintaining, and disseminating weather and climate data to the general public of Missouri. I was also responsible for providing expert interpretations of weather and climate data to data users.

Q. What is your educational background?

A. I obtained my M.S. and Ph.D. degrees in Atmospheric Sciences from Colorado State University in 1986 and 1992, respectively. I had my post-doctoral training at the State University of New York-Albany from 1992 through 1994. Prior to my M.S. degree, I obtained my B.S. degree in Meteorology from Lanzhou University in China in 1982.

Q. Will you briefly describe your experience as a Climatologist?

A. My research in regional climate variations has produced many refereed publications and numerous conference presentations. I have used various methods in analyzing climatic data and understanding regional climate variations.

Q. What is the purpose of your testimony?

A. I will explain the necessity for adjusting the station temperatures and a procedure I used in correcting the Saint Louis Lambert International Airport station temperature time series for the time period 1961-1998.

Q. What kind of weather station is at the Saint Louis Lambert International Airport?

A. The Saint Louis Lambert International Airport station is a first-order weather station of the U.S. National Weather Service and is operated by properly trained professionals.

Q. Why do you need to adjust the observed temperature?

A. Adjustments of observed air temperature from an individual weather station are needed to remove potential errors and biases in the temperature data.

Q. What possible errors could exist in the observed temperature values?

A. The errors in observed temperature data may be categorized into two groups. 1) The error resulting from observer's human error. This kind of error enters the data when, for example, observers read incorrectly the scales of a thermometer or take the observation at a time different from the specified observation time. 2) The error resulting from malfunctioning thermometers falls into the second category.

Q. How do you find these errors and how do you correct them?

A. These errors are identified at the National Climatic Data Center at Asheville, North Carolina, after the data are reported to the center. The data are checked using a developed quality control method. Erroneous data is flagged and then an estimated value is assigned to replace the erroneous data. The estimated value can be derived using different methods.

Q. What are potential biases in the observed temperature data?

A. There are two sources producing biases in the observed temperature data. 1) The sensor bias. This is a bias due to systematic overestimate or underestimate of the temperature by a thermometer. This kind of bias may be introduced to the data due to drifting of aging sensors. 2) The bias resulting from physical environment change of the weather station. These include station location changes and the surrounding environment change as consequences of economic development, e.g., the new buildings and parking areas, and natural change such as maturing trees. These changes alter the environment of the station and, hence, the averaged thermal condition the station measures.

Q. What kind of biases have you found in the Saint Louis Lambert International Airport weather station data, and what may have caused them?

A. I found that the station location change and consequent exposure changes have caused systematic biases in the station temperature data. My investigation of the station history of the Saint Louis Lambert International Airport station has disclosed that the station location changed four times during the 38-year period of 1961-1998. These occurred in November 1979, January 1985, February 1988, and June 1996. My analysis revealed that two of the four location changes, i.e., the ones in 1979 and 1988, caused systematic warming biases to the station temperature data and the change in 1996 resulted in a reversal of this warming bias.

Q. Why was a warming bias introduced to the data by the location changes in November 1979 and February 1988?

A. The warming bias was introduced to the data because each of those two location changes brought the station to a less open area. For example, in November 1979

the thermometer was moved from a relatively open field to a new location very close to a building with an improved parking area. The building and parking lot pavement absorb solar radiation and emit long-wave radiation to warm the environment during the day. The building also emits more heat during night. The thermal effect of the building and the parking lot added a warming bias to the temperature data of the station. In June 1996, the station was moved back to the airfield, where the thermal effects of the building and the parking lot would no longer impact the temperature readings.

Q. What procedures have you used to correct the bias in the temperature data?

A. The procedures include the following: 1) identify the dates of the station location change by reviewing the station history files and interviewing the observers during visits to the station; 2) identify reference weather stations for which normals are published and which did not experience location changes during the time when the Saint Louis Lambert International Airport station was moved; 3) compare the temperature series of the Saint Louis Lambert International Airport station and the reference stations over the period covering the time of the station location change, and identify any bias introduced to the Saint Louis Lambert International Airport station temperature record from the station's location change; and 4) calculate the correction value and apply it to the daily temperature series of the Saint Louis Lambert International Airport station to remove the bias.

Q. What was the application of these procedures to correct for the location changes at the St. Louis Lambert International Airport?

A. For the November 1979 and February 1988 changes, the reference stations chosen were at Elsberry, MO and Unionville, MO. Five years of monthly maximum and

monthly minimum temperatures were used to calculate the changes that had occurred at the St. Louis Lambert International Airport. For the June 1996 change, five years of consistent daily temperature series were available from the Elsberry, MO and Jerseyville, IL weather stations. These data were used to calculate the changes that occurred at the St. Louis Lambert International Airport weather station when the station was moved back to the airfield and the ASOS was commissioned. Further details of the procedures and data used are provided in my work papers.

Q. What are the differences between the uncorrected and corrected temperature data?

A. The warming bias resulting from the November 1979 location change is 0.700°F. There was no bias added to the station temperature from the location change in January 1985. My analysis revealed that the uncorrected temperature was warmer by 0.783°F as a result of the station being moved to a location close to a building and a parking area in February 1988. The station location change in June 1996 was from a site close to a building and a parking area to an open area (see Figure 2 on Schedule 1-8). This location change was accompanied with the observation system change from the conventional unit to the ASOS (Automated Surface Observation System). This change in location resulted in a reversal of the warming bias of -1.875°F. The net effect for the three changes is that the post June 1996 temperatures will read 0.392°F cooler than temperatures read prior to November 1979. This is within the ASOS cooling bias of 0.5°F found by climatologist Thomas McKee ["Climate Data Continuity Project Ends:" Silver Spring, MD 20910, ASOS Program Office Wx23, 8455 Coleville Rd., Suite 705].

Q. How could these differences be affecting the calculated heating degree days and cooling degree days using the uncorrected Saint Louis Lambert International Airport temperature data?

A. Because the heating degree days are defined as the summation of the differences of the actual temperature below a reference temperature, e.g., 65°F, in each hour during each day and over a one year period, a warming bias in observed temperature will lower the difference between the reference and the observed temperatures and, hence, reduce the total number of heating degree days in a year. The opposite effect will occur for cooling degree days. In this case, the warming bias in the Saint Louis Lambert International Airport station temperature data can cause a decrease in the number of heating degree days and an increase in cooling degree days recorded at the station.

Q. Did you provide these corrections for the Saint Louis Lambert International Airport station to Mr. Dennis Patterson for use in calculating normal heating degree days?

A. Yes, Mr. Patterson used these corrections in his calculation of normal heating degree days for the Saint Louis Lambert International Airport station.

Q. What should be a time period for developing meaningful climate normals?

A. In describing climate "normals" the WMO (World Meteorological Organization) requires the use of 30-year temperature and precipitation data. This standard is accepted by the U.S. National Weather Service. One of the reasons for using such a time period in defining climate conditions is that climate has its natural variabilities. These variabilities are shown, in part, by oscillatory variations of temperature and precipitation at various time periods. For example, there have been

many studies showing significant interannual and interdecadal temperature variations in the U.S. To minimize the impacts of these fluctuations on averaged climate conditions WMO recommends to use 30-year data in calculation of the normal of the surface air temperature.

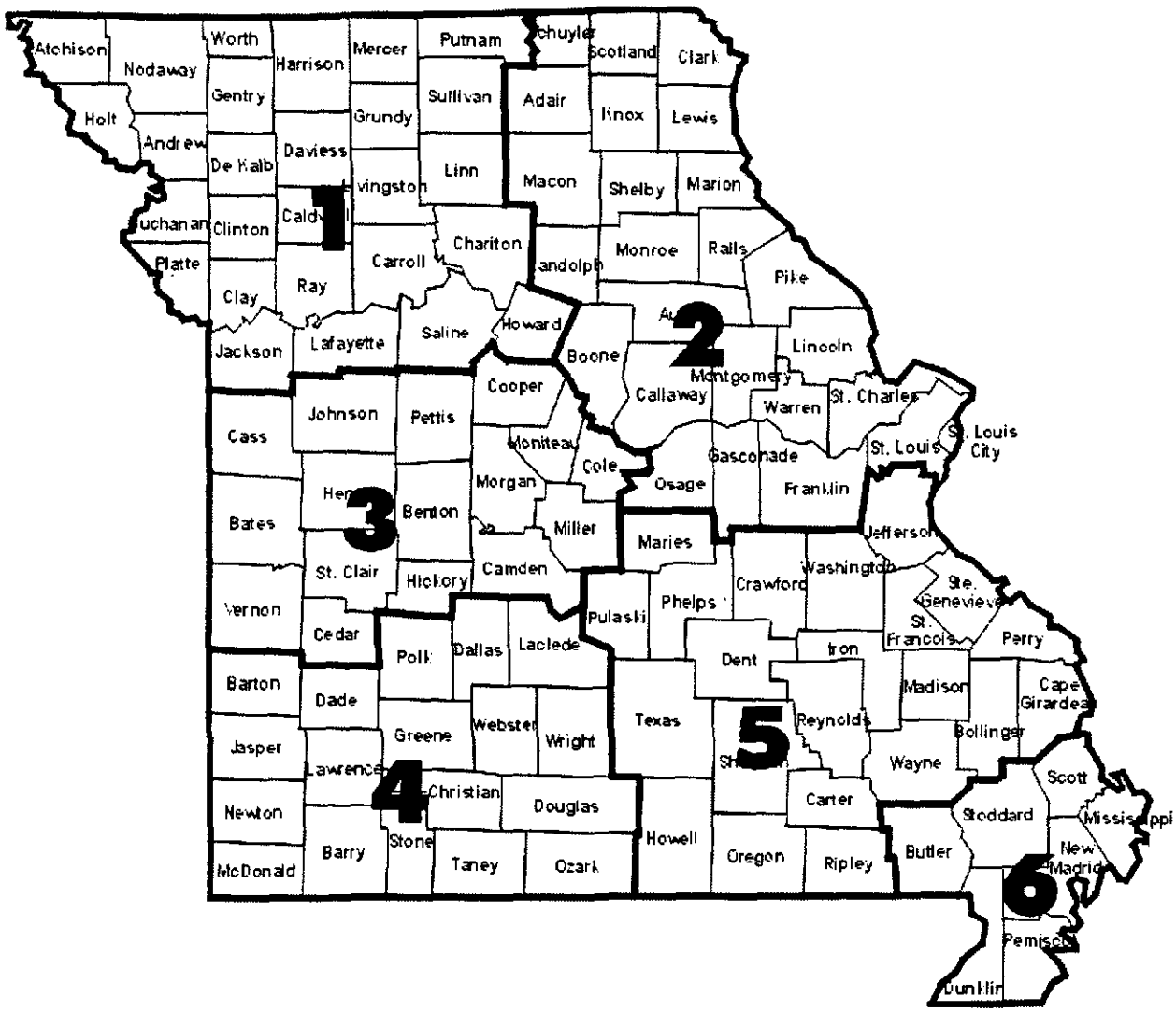
Q. Does this conclude your direct testimony?

A. Yes it does.

Rebuttal Testimony of
Manisha Lakhanpal

Missouri Climate Divisions

Missouri



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