Exhibit No.:
Issue(s): Weather Normalization
Witness: Dennis Patterson
Type of Exhibit: Direct
Sponsoring Party: MoPSC Staff
Case No.: GR-99-315

MISSOURI PUBLIC SERVICE COMMISSION

UTILITY OPERATIONS DIVISION

DIRECT TESTIMONY

OF

DENNIS PATTERSON

LACLEDE GAS COMPANY

CASE NO. GR-99-315

Jefferson City, Missouri

June, 1999

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LACLEDE GAS COMPANY

CASE NO. GR-99-315

Q. Please state your name and business address.

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

Q. What is your present position with the Missouri Public Service Commission (Commission)?

A. I am a Regulatory Economist in the Electric Department of the Utility Operations Division.

Q. Please review your educational background and work experience.

A. I was trained as an officer and aviator in the U.S. Army. I studied economics, math, sciences and languages, receiving a B.A. in Latin American Studies (University of Missouri, 1983) and an M.S. in Agricultural Economics (University of Missouri, 1989). I joined the Staff of the Commission in April, 1986. I established the Staff's centralized weather data base, and have continued to maintain and improve it by employing data and methods from reliable sources. I have been employed by the Commission, the Missouri Army National Guard, the University of Missouri, the U.S. Army Reserves, and the U.S. Army.

PURPOSE

Q. What is the purpose of your testimony?

A. I will explain my tabulation of monthly and daily observed and normal temperature data for St. Louis Lambert Airport weather station. I began with published daily maximum and minimum daily temperatures, and then applied adjustments that were recommended by the Staff's consultant, Steve Qi Hu, Ph.D. Dr. Hu is Assistant Professor of Climatology at the University of Nebraska-Lincoln, and is the former State Climatologist for Missouri. I furnished weather data products, which included Dr. Hu's recommended adjustments, to Staff witnesses Daniel Beck, James Gray and Henry Warren. These data include an adjusted observation of each day's maximum and minimum temperature for all days from January 1, 1961 through December 31, 1998. This encompasses the 1961-1990 NOAA normals period through the test billing year used by the Staff, which ends on December 31, 1998.

WEATHER RESPONSE

Q. How do gas sales vary in response to weather?

A. The majority of residential and commercial class gas sales are for space heating. Space heating gas sales are analyzed with respect to the number of degrees accumulated below the threshold temperature of 65 degrees Fahrenheit (65 F) by using a quantity called heating degree-days (HDD). First, the day's mean daily temperature (MDT) is calculated as the average of the maximum and minimum temperatures. Then, if the MDT for the day is below 65 F, HDD are calculated by

subtracting the MDT from 65 F. If the day's MDT is 65 F or warmer, there are no HDD on that day.

A majority of customers also use natural gas for water heating. Laclede Gas Company (LGC) studies have shown that water heating gas sales vary with inlet water temperature, and that a desired hot water temperature of 140 F works well for the analysis of this end use. Subsequent Staff analysis has shown that Missouri River water temperatures (RWT) observed at Chain of Rocks treatment plant serve as a statistically reliable proxy for inlet water temperatures in the St. Louis area. Thus, water heating degree-days (WHDD) for a day may be specified as 140 degrees F minus daily RWT (140-RWT). RWT and WHDD are discussed in greater detail below.

MISSOURI RIVER WATER TEMPERATURES

Q. What was the Staff's source of RWT data for the Chain of Rocks treatment plant?

A. The Staff acquired the earliest available daily RWT data from the U.S. Army Corps of Engineers for the period January 1, 1986 through December 31, 1995. The Staff acquired RWT for the days from January 1, 1996 through December 31, 1998 from the City of St. Louis.

Q. Were these data sufficient to calculate actual and normal daily WHDD for the present case?

A. No. In order to calculate daily WHDD, an observation for RWT must be available for all days in the 1961-1990 NOAA normals period, as well as for all days in the LGC test year in the present case. However, the Missouri River water temperature

data obtained by the Staff do not begin until January 1, 1986. It was therefore necessary to estimate RWT for the observations that were missing between January 1, 1961 and December 31, 1985.

Q. How were the missing RWT observations estimated?

A. The relationship between daily RWT for the years 1986 through 1997 and lags of MDT was determined using regression analysis. The estimated relationship was then used to calculate daily RWT for the missing observations. Finally, daily WHDD are calculated from the estimates of daily RWT values (1961-1985) and daily observations (1986-1998) of RWT. The calculation of normal WHDD then proceeds as for normal HDD, using data from the years 1961 through 1990.

Q. Were there any statistical problems with the regression between RWT and MDT?

A. Yes, there was one. Since the temperature of any large body of water can respond only incrementally to changes in air temperature, the current day's RWT is highly correlated with the previous day's RWT as well as with the current day's values of the other regressors. This is, identically, first-order serial correlation. The presence of positive serial correlation is very evident in the pattern of residuals from an uncorrected regression, as well as from the very low value of the Durbin-Watson statistic that is calculated from these residuals.

Q. How did you correct the linear regression for serial correlation?

A. I took the standard statistical measures to correct for the effects of serial correlation. I used the MicroTSP© statistical program to calculate a non-linear

least squares regression model with a first-order autoregressive component. The procedure is detailed in my working papers.

WATER HEATING DEGREE-DAYS

Q. How do WHDD behave?

A. The maximum observed Chain of Rocks RWT has been 91 degrees F (seen only in the exceptionally warm summers of 1987 and 1988). Since liquid fresh water is not usually observed below 32 degrees F, daily observations of WHDD have therefore ranged between (140-32)=108 degree-days in the winter and (140-91)=49 degree-days in the hottest summer weather. Annual total WHDD since 1961 have varied between 28,789 (1990) and 30,240 (1976), for a range of 1,451 WHDD. This range is 4.9% of the 1961-1990 normal of 29,679 WHDD. The varying annual total is a signal that gas sales for the water heating end use should also be weather normalized.

Q. Are WHDD levels the same every summer?

A. No. The sum of July and August WHDD has varied from 3,339 WHDD in the exceptionally hot summer of 1988 to 3,906 WHDD in the cool summer of 1967. This is a spread of 567 WHDD, or 15.4 per cent of the 1961-1990 normal level of 3,678 WHDD. This varying summer level of WHDD indicates that summer gas sales are also weather sensitive.

NORMAL WEATHER

Q. What is normal weather?

A. The National Oceanographic and Atmospheric Administration (NOAA) usually expresses normal weather as the average level of a climatological

element over thirty years. "Normals have been defined as the arithmetic mean of a climatological element computed over a long time period." (**Climatography of the United States No. 81, Monthly Station Normals of Temperature, Precipitation, and Heating and Cooling Degree-days 1961-90, MISSOURI**, NOAA, National Climatic Data Center, Asheville, North Carolina, January, 1992) (Monthly Station Normals). Examples of published normals that are available for Missouri weather stations would be the normal daily average temperature for each month, and the normal annual precipitation.

Q. What period is used by NOAA in its calculations of its thirty-year temperature normals?

A. NOAA uses the three most recent consecutive decades, which are currently the thirty years ending in 1990. International agreement among members of the World Meteorological Organization has established that three decades are the desirable period for the calculation of normals. NOAA recalculates thirty-year normals at the end of each decade, as a way of dealing with climatic and non-climatic changes.

Q. Does the Staff consistently use the NOAA thirty year normals products and procedures to tabulate weather data?

A. Yes, it does, since April, 1994. The need for such a procedure became evident when NOAA replaced the 1951-1980 normals with the 1961-1990 normals in 1992. The narrative portion of NOAA's 1961-1990 Monthly Station Normals disclosed that the normals were calculated from weather data that had been adjusted for inconsistencies. As a result, the Staff devised a data tabulation process that incorporated NOAA's adjusted temperatures.

This data tabulation process was first established in November, 1992. A period of internal and external review followed. I have used the process exclusively since April, 1994, for all weather data sets I have provided to Staff witnesses. However, this process does not address temperature data inconsistencies which have not yet been adjusted by NOAA.

Q. Do the published temperature data for St. Louis Lambert Airport contain any such inconsistencies?

A. Yes. The timing and nature of these inconsistencies, and the adjustments that he recommends for their correction, are discussed in the direct testimony of Dr. Hu.

Q. What products did Dr. Hu provide to the Staff?

A. Dr. Hu provided adjustments for the time series of daily maximum and minimum temperatures for St. Louis Lambert Airport. Dr. Hu recommended that the Staff apply the adjustments to correct them for measurement inconsistencies.

Q. Are Dr. Hu's adjustments intended to replace NOAA adjustments that were included in the 1961-1990 normals.

A. Yes, because more data are available. First, a NOAA adjustment for a 1979 station move is re-evaluated. Second, an adjustment for a 1988 station move is re-considered and now included at the end of the 1961-1990 normals period. Finally, a new adjustment is calculated to address a station move and equipment change in 1996.

Q. Do the Staff's daily temperatures contain Dr. Hu's recommended adjustments?

A. Yes. I have included Dr. Hu's adjustments in the calculation of the test year weather products (HDD and WHDD) which I furnished to the witnesses. I also used Dr. Hu's adjustments in my the calculation of new temperature and degree-day normals for the 1961-1990 NOAA normals period.

Q. Has the Commission made any findings on the use of NOAA's thirty-year normals period?

A. Yes. The use of the NOAA 30-year normals period complies with a provision of the Commission's Report and Order in the Missouri Gas Energy rate case, Case No. GR-96-285 (Report and Order). At page 18, the Commission's Report and Order states: "The Commission finds that NOAA's 30-year normals is the more appropriate benchmark . . . In addition, the data upon which Staff's recommendation is based has gone through the processes established by NOAA to ensure the best data possible."

CALCULATION OF NORMAL TEMPERATURES AND DEGREE-DAYS

Q. How are temperature and degree-day normals calculated?

A. NOAA temperature normals are usually calculated as simple averages by month over 30 years. After receiving recommended adjustments from Dr. Hu, I applied them to published temperature data for St. Louis Lambert Airport. I then calculated monthly degree-day normals in this case by first calculating observed degree-days for each day in each of the twelve calendar months in the years 1961 through 1990. I followed this step by adding up monthly totals, and then calculating an average total over thirty years for each of the twelve calendar months. As a crosscheck, I used these

12 monthly averages as the benchmark to verify the accuracy of the 365 daily normal degree-day values that I furnished to the Staff witnesses.

DEGREE-DAY QUANTITIES AND DATA PRODUCTS

Q. What degree-day quantities did you calculate for the Staff witnesses?

A. I calculated heating degree-days (HDD) so that the Staff witnesses might explain actual and normalized gas usage for space heating by LGC customers. I also calculated water heating degree-days (WHDD) so that the witnesses might explain actual and normal gas usage for water heating. These two quantities were used together to calculate weather normalized gas usage for the test year, as well as weather normalized gas usage for the peak day of the test year.

Q. What is the final product which you provided to the witnesses for use in calculating weather normalized test year gas usage for LGC?

A. This final product is daily normal degree-days. Daily normal HDD and WHDD are calculated from daily values for the thirty year period ending December 31, 1990.

The historical daily degree-days are calculated from daily temperatures that have been adjusted according to the recommendations of Dr. Hu. The daily normal degree-days are tabulated as whole degree-day values for the 365 days in a normal year. I have provided daily normal HDD and WHDD for St. Louis Lambert Airport to the witnesses and to LGC in my working papers. A comparison of test year calendar month actual degree-days and normal degree-days is presented as Schedule 1-1.

Q. What is the final product which you provided to the witnesses for use in calculating weather normalized test year peak day gas usage for LGC?

A. This final product is a tabulation of the twelve monthly normal peak (coldest) day degree-days and the maximum of these, the annual normal peak day degree-days. These values are drawn from the series of ranked normal degree-day values from the calendar years 1961 through 1990. This series includes the normal HDD for the coldest day, the second coldest day, the third coldest, and so on down through days with no expected HDD. Peak day (coldest RWT) normal WHDD and the series of ranked normal WHDD were also calculated . I have also provided the ranked daily normal HDD and WHDD for St. Louis Lambert Airport to the Staff's witnesses and to LGC in my working papers. Tables of the annual and monthly actual and normal peak values of these quantities are presented at Schedule 1-2.

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 Laclede Gas Company's Tariff to Revise Natural Gas Rate Schedules.	) Case No. GR-99-315)

AFFIDAVIT OF DENNIS PATTERSON

STATE OF MISSOURI)
) ss
COUNTY OF COLE)

Dennis Patterson, of lawful age, on his oath states: that he has participated in the preparation of the foregoing written testimony in question and answer form, consisting of 10 pages of testimony to be presented in the above case, that the answers in the attached written testimony were given by him; that he has knowledge of the matters set forth in such answers; and that such matters are true to the best of his knowledge and belief.

Dennis Patterson

Subscribed and sworn to before me this 28th day of June, 1999.

Joyce C. Neuner
Notary Public, State of Missouri
County of Osage
My Commission Exp. 06/18/2001

Notary Public

My commission expires _____

Laclede Gas Company
GR-99-315
Actual and Normal Degree Days
Calendar Year Ending December 31, 1998

ST LOUIS LAMBERT AIRPORT HEATING DEGREE DAYS BY MONTH					
YEAR	MONTH	ACTUAL	NORMAL	DEPARTURE FROM NORMAL	
YYYY	MM	HDD	HDD	HDD	PERCENT
1998	1	887.5	661.0	226.5	34.3%
1998	2	628.0	316.4	311.6	98.5%
1998	3	695.0	105.1	590.0	561.6%
1998	4	299.0	8.0	291.1	3661.0%
1998	5	20.0	0.7	19.3	2798.6%
1998	6	25.0	2.0	23.0	1143.8%
1998	7	0.0	53.1	-53.1	-100.0%
1998	8	0.0	276.8	-276.8	-100.0%
1998	9	2.0	607.0	-605.0	-99.7%
1998	10	179.5	1004.8	-825.3	-82.1%
1998	11	462.0	1145.4	-683.4	-59.7%
1998	12	870.0	914.5	-44.5	-4.9%
TEST CALENDAR YEAR		4068.0	5094.6	-1026.6	-20.2%

ST LOUIS MISSOURI RIVER WATER HEATING DEGREE DAYS BY MONTH					
YEAR	MONTH	ACTUAL	NORMAL	DEPARTURE FROM NORMAL	
YYYY	MM	WHDD	WHDD	WHDD	PERCENT
1998	1	3137.0	2990.4	146.6	4.9%
1998	2	2742.0	2567.9	174.1	6.8%
1998	3	2986.0	2325.2	660.8	28.4%
1998	4	2514.0	1967.5	546.6	27.8%
1998	5	2177.0	1831.1	345.9	18.9%
1998	6	1970.0	1824.6	145.5	8.0%
1998	7	1723.0	1919.1	-196.1	-10.2%
1998	8	1779.0	2318.7	-539.7	-23.3%
1998	9	1824.0	2588.5	-764.5	-29.5%
1998	10	2256.0	3062.9	-806.9	-26.3%
1998	11	2597.0	3259.2	-662.2	-20.3%
1998	12	2929.0	2920.6	8.4	0.3%
TEST CALENDAR YEAR		28634.0	29575.7	-941.7	-3.2%

Laclede Gas Company
GR-99-315
Maximum Actual and Ranked Normal Degree Days
Calendar Year Ending December 31, 1998

ST LOUIS LAMBERT AIRPORT MAX DAILY HEATING DEGREE DAYS BY MONTH					
YEAR	MONTH	MAX ACTUAL	RANK NORM	DEPARTURE FROM NORMAL	
YYYY	MM	HDD	HDD	HDD	PERCENT
1998	1	45.5	64.0	-18.5	-28.9%
1998	2	31.0	57.8	-26.8	-46.3%
1998	3	48.0	40.4	7.6	18.9%
1998	4	23.5	27.3	-3.8	-13.8%
1998	5	8.0	13.6	-5.6	0.0%
1998	6	9.0	2.8	6.2	226.1%
1998	7	0.0	0.0	0.0	
1998	8	0.0	0.2	-0.2	-100.0%
1998	9	1.5	10.3	-8.8	-85.4%
1998	10	18.0	23.3	-5.3	-22.7%
1998	11	29.0	38.7	-9.7	-25.1%
1998	12	52.5	56.3	-3.8	-6.8%
TEST CALENDAR YEAR		52.5	64.0	-11.5	-18.0%

ST LOUIS MO. RIVER MAX DAILY WATER HEATING DEGREE DAYS BY MONTH					
YEAR	MONTH	MAX ACTUAL	RANK NORM	DEPARTURE FROM NORMAL	
YYYY	MM	WHDD	WHDD	WHDD	PERCENT
1998	1	105	108	-3	-3.1%
1998	2	101	108	-7	-6.7%
1998	3	102	103	-1	-0.7%
1998	4	87	92	-5	-5.4%
1998	5	83	81	2	2.9%
1998	6	71	71	0	0.6%
1998	7	63	63	0	0.3%
1998	8	63	62	1	1.4%
1998	9	65	69	-4	-5.5%
1998	10	78	81	-3	-4.0%
1998	11	90	93	-3	-3.2%
1998	12	105	105	0	0.0%
TEST CALENDAR YEAR		105	108	-3	-3.1%