MISSOURI PUBLIC SERVICE COMMISSION

MISSOURI GAS ENERGY

CASE NO. GR-2006-0422

SCHEDULE RAF-16

TO THE REBUTTAL TESTIMONY OF

RUSSELL A. FEINGOLD

Missouri Public Service Commission

Data Request

Data Request No.	0207
Company Name	MO PSC Staff-(All)
Case/Tracking No.	GR-2006-0422
Date Requested	10/17/2006
Issue	Revenue - Weather Normalization
Requested From	Curt Wells
Requested By	Michael R Noack
Brief Description	NA
Description	Referring to Page 4, lines 11-13 of Mr. Wells' direct testimony, please provide a copy of the reference source containing the statement on climate normals made by the National Oceanographic and Atmospheric Administration ("NOAA").
Due Date	11/6/2006

Response:

Reference source can be found at web site http://cdo.ncdc.noaa.gov/climate normals/clim81/MOnorm.pdf. Specific reference is at page 3, under Computational Procedures, first sentence. (copy attached)

NOTES

Product Description:
This Climatography includes 1971-2000 normals of monthly and annual maximum, minimum, and mean temperature (degrees F), monthly and annual total precipitation (inches), and heating and cooling degree days (base 65 degrees F). Normals stations include both National Weather Service Cooperative Network and Principal Observation (First-Order) locations in the 50 states, Puerto Rico, the Virgin Islands, and Pacific Islands.

Abbreviations:

No. = Station Number in State Map
COOP ID = Cooperative Network ID (1:2=State ID, 3:6=Station Index)
WBAN ID = Weather Bureau Army Navy ID, if assigned
Elements = Input Elements (X=Maximum Temperature, N=Minimum Temperature, P=Precipitation)
Call = 3-Letter Station Call Sign, if assigned
MAX = Normal Maximum Temperature (degrees Fahrenheit)
MEAN = Average of MAX and MIN (degrees Fahrenheit)
MIN = Normal Minimum Temperature (degrees Fahrenheit)
HDD = Total Heating Degree Days (base 65 degrees Fahrenheit)
CDD = Total Cooling Degree Days (base 65 degrees Fahrenheit)

Latitude = Latitude in degrees, minutes, and hemisphere (N=North, S=South)
Longitude = Longitude in degrees, minutes, and hemisphere (W=West, E=East)
Elev = Elevation in feet above mean sea level
Flag 1 = * if a published *Local Climatological Data* station
Flag 2 = + if WMO Fully Qualified (see *Note* below)

HIGHEST MEAN/YEAR = Maximum Mean Monthly Value/Year, 1971-2000
MEDIAN = Median Mean Monthly Value/Year, 1971-2000
LOWEST MEAN/YEAR = Minimum Mean Monthly Value/Year, 1971-2000
MAX OBS TIME ADJUSTMENT = Add to MAX to Get Midnight Obs. Schedule
MIN OBS TIME ADJUSTMENT = Add to MIN to Get Midnight Obs. Schedule

Note: In 1989, the World Meteorological Organization (WMO) prescribed standards of data completeness for the 1961-1990 WMO Standard Normals. For full qualification, no more than three consecutive year-month values can be missing for a given month or no more than five overall values can be missing for a given month (out of 30 values). Stations meeting these standards are indicated with a '+' sign in Flag 2. Otherwise, stations are included in the normals if they have at least 10 year-month values for each month and have been active since January 1999 or were a previous normals station.

Map Legend: Numbers correspond to 'No.' in Station Inventory; Shaded Circles indicate Temperature and Precipitation Stations, Triangles (Point Up) indicate Precipitation-Only Stations, Triangles (Point Down) indicate Temperature-Only Stations, and Hexagons indicate stations with Flag 1 = *.

Computational Procedures:

A climate normal is defined, by convention, as the arithmetic mean of a climatological element computed over three consecutive decades (WMO,1989). Ideally, the data record for such a 30-year period should be free of any inconsistencies in observational practices (*e.g.*, changes in station location, instrumentation, time of observation, *etc.*) and be serially complete (*i.e.*, no missing values). When present, inconsistencies can lead to a non-climatic bias in one period of a station's record relative to another, yielding an "inhomogeneous" data record. Adjustments and estimations can make a climate record "homogeneous" and serially complete, and allow a climate normal to be calculated simply as the average of the 30 monthly values.

The methodology employed to generate the 1971-2000 normals is not the same as in previous normals, as it addresses inhomogeneity and missing data value problems using several steps. The technique developed by Karl *et al.* (1986) is used to adjust monthly maximum and minimum temperature observations of conterminous U.S. stations to a consistent midnight-to-midnight schedule. All monthly temperature averages and precipitation totals are cross-checked against archived daily observations to ensure internal consistency. Each monthly observation is evaluated using a modified quality control procedure (Peterson *et al.*,1998), where station observation departures are computed, compared with neighboring stations, and then flagged and estimated where large differences with neighboring values exist. Missing or discarded temperature and precipitation observations are replaced using a weighting function derived from the observed relationship between a candidate's monthly observations and those of up to 20 neighboring stations whose observations are most strongly correlated with the candidate site. For temperature estimates, neighboring stations were selected from the U.S. Historical Climatology Network (USHCN; Karl *et al.* 1990). For precipitation estimates, all available stations were potential neighbors, maximizing station density for estimating the more spatially variable precipitation values.

Peterson and Easterling (1994) and Easterling and Peterson (1995) outline the method for adjusting temperature inhomogeneities. This technique involves comparing the record of the candidate station with a reference series generated from neighboring data. The reference series is reconstructed using a weighted average of first difference observations (the difference from one year to the next) for neighboring stations with the highest correlation with the candidate. The underlying assumption behind this methodology is that temperatures over a region have similar tendencies in variation. If this assumption is violated, the potential discontinuity is evaluated for statistical significance. Where significant discontinuities are detected, the difference in average annual temperatures before and after the inhomogeneity is applied to adjust the mean of the earlier block with the mean of the latter block of data. Such an evaluation requires a minimum of five years between discontinuities. Consequently, if multiple changes occur within five years or if a change occurs very near the end of the normals period (*e.g.*, after 1995), the discontinuity may not be detectable using this methodology.

The monthly normals for maximum and minimum temperature and precipitation are computed simply by averaging the appropriate 30 values from the 1971-2000 record. The monthly average temperature normals are computed by averaging the corresponding monthly maximum and minimum normals. The annual temperature normals are calculated by taking the average of the 12 monthly normals. The annual precipitation and degree day normals are the sum of the 12 monthly normals. Trace precipitation totals are shown as zero. Precipitation totals include rain and the liquid equivalent of frozen and freezing precipitation (*e.g.*, snow, sleet, freezing rain, and hail). For many NWS locations, indicated with an '*' next to 'HDD' and 'CDD' in the degree day table, degree day normals are computed directly from daily values for the 1971-2000 period. For all other stations, estimated degree day totals are based on a modification of the rational conversion formula developed by Thom (1966), using daily spline-fit means and standard deviations of average temperature as inputs.

References:
Easterling, D.R, and T.C. Peterson, 1995: A new method for detecting and adjusting for undocumented discontinuities in climatological time series. *Intl. J. Clim.*, 15, 369-377.
Karl, T.R., C.N. Williams, Jr., P.J. Young, and W.M. Wendland,1986: A model to estimate the time of observation bias associated with monthly mean maximum, minimum, and mean temperatures for the United States. *J. Clim. Appl. Met.*, 25, 145-160.
Peterson, T.C., and D.R. Easterling, 1994: Creation of homogeneous composite climatological reference series. *Intl. J. Clim.*, 14, 671-679.
Peterson,T.C., R. Vose, R. Schmoyer, and V. Razuvaev, 1998: Global Historical Climatology Network (GHCN) quality control of monthly temperature data. *Intl. J. Clim.*, 18, 1169-1179.
Thom, H.C.S., 1966: Normal degree days above any base by the universal truncation coefficient. *Month. Wea. Rev.*, 94, 461-465.
World Meteorological Organization, 1989: Calculation of Monthly and Annual 30-Year Standard Normals. WCDP-No. 10, WMO-TD/No. 341, Geneva: World Meteorological Organization.

Missouri Public Service Commission

Data Request

Data Request No.	0208
Company Name	MO PSC Staff-(All)
Case/Tracking No.	GR-2006-0422
Date Requested	10/17/2006
Issue	Revenue - Weather Normalization
Requested From	Curt Wells
Requested By	Michael R Noack
Brief Description	NA
Description	At page 4, lines 20-23 of his direct testimony, Mr. Wells states that "International agreements have established that three-decade periods are appropriately long and uniform time frames for the calculation of normals." Please provide copies of all such "international agreements" that reach this conclusion.
Due Date	11/6/2006

Response:

International agreements referred to are agreements among the 185 member states and territories of the World Meteorological Organization to, among other purposes, "promote standardization of meteorological and related observations and ensure uniform publication of observations and statistics."(www.wmo.ch/web-en/wmo_purposes.html)

To further that purpose, members accepted the convention of the three consecutive decade definition of normal, the current period running from 1971-2000. (See response to DR 207)

This convention was promulgated by the World Meteorological Organization in 1989 as "Calculation of monthly and Annual 30-year Standard Normals, WCDP-No.10, WMO-TD/341", Geneva. Page two, Section III., STANDARD NORMALS AND PROVISIONAL NORMALS, states: "The Technical Regulations define normals as 'period averages computed for a uniform and relatively long period comprising at least three consecutive ten-year periods...'" (attached)

WORLD CLIMATE PROGRAMME

CALCULATION OF MONTHLY AND ANNUAL 30-YEAR STANDARD NORMALS

Prepared by a meeting of experts, Washington, D.C., USA,

March 1989

WCDP-No. 10

WMO-TD/No. 341

WORLD METEOROLOGICAL ORGANIZATION

The World Climate Programme launched by the World Meteorological Organization (WMO) includes four components:

- The World Climate Data Programme
- The World Climate Applications Programme
- The World Climate Impact Studies Programme
- The World Climate Research Programme

The World Climate Research Programme is jointly sponsored by the WMO and the International Council of Scientific Unions.

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This document is the result of an expert meeting held in Washington, D.C., USA, in March 1989. Its intent is to provide general information to Members as they prepare to calculate standard and/or provisional 30 year Normals. The expert participants in the meeting were:

K. Davidson, WMO
N. Guttman, National Climatic Data Center, USA
C. Ropelewski, Climate Analysis Center, USA
N. Canfield, Climate Analysis Center, USA
E. Spackman, Meteorological Office, UK
D. Gullett, Atmospheric Environment Service, Canada

CALCULATION OF MONTHLY AND ANNUAL 30-YEAR STANDARD NORMALS

I. PURPOSE

The purpose of this document is to establish general procedures to be used for the calculation of the WMO monthly and annual 30 year (1961-1990 and following periods) standard and provisional normals and to suggest other climatic descriptors. These procedures were produced for use by all countries, and will be produced and distributed as a computer application and written document. However, all countries may use this information but certain procedures may be difficult to implement without the use of computers.

II. BACKGROUND

The International Meteorological Committee in 1872 decided to compile mean values over a uniform period in order to assure comparability between data collected at various stations. The outgrowth of this was the recommendation for calculation of 30 year normals for stations. As stated in WMO Technical Regulation No. 49, Vol. 1, Section B "Each Member should establish and periodically revise normals for stations whose climatological data are distributed on the Global Telecommunications System in accordance with the provisions of Annex II (Manual on Codes, Volume 1) and forward these normals to the Secretariat". The initial period was determined to be 1901-1930. Succeeding periods were decided to be at 30-year intervals (i.e. 1931-1960, 1961-1990). However, many WMO members have been updating their 30-year normals at the completion of each decade. This was recommended in 1956 and noted in Technical Note No. 84. The WMO regulations require the calculations only each 30-year period. The WMO guidelines and regulations provide little guidance on "how to" calculate the 30-year normals; "how to" handle missing data; "how to" handle periods of data that contain obviously erroneous data; or "how much" data is required for a 30-year normal verses provisional normals. This paper is intended to provide a procedure with generalized rules and data completeness or quality indicators to be used in the calculation of the 30-year normals and to provide suggested ancillary data descriptors that will help to better describe the climate in statistical terms. These procedures are presented as practical advice only and are not considered to be the "best or only" methods of calculating normals.

III. STANDARD NORMALS AND PROVISIONAL NORMALS

Climate data are often more useful when they are compared with standard or normal values. The Technical Regulations define normals as "period averages computed for a uniform and relatively long period comprising at least three consecutive ten-year periods" and climatological standard normals as "averages of climatological data computed for consecutive periods of 30 years as follows: 1 January 1901 to 31 December 1930, 1 January 1931 to 31 December 1960, etc." In the case of stations for which the most recent climatological standard normal is not available (either because the station has not been in operation for the period of 30 years or for some other reason), provisional normals should be calculated. Provisional normals are short-period means based on observations extending over a period of at least ten years. The concept of "normals calculation" is extended in this document to include an analysis of data homogeneity and the calculation of other climate descriptors. This extension is based on WMO Tech Note 84.

IV. DATA EXAMINATION

It is assumed that routine hourly, daily and monthly quality control has been performed on the data as suggested in the WMO/TD-No. 111, WCP-85, Guidelines on the Quality Control of Surface Climatological Data. Climatological quality control (i.e. homogeneity) investigation and data inspection over a long period should also be performed. The following paragraphs recommend steps to analyze data homogeneity and identify heterogeneities (ref. WMO Guide to Climatological Practices). Suggested procedures to examine data homogeneity are:

1. Examine the data for trends, shifts (step functions), spurious data values, other data problems and evidence of data heterogeneity. Techniques include:

    a. Basic data descriptions e.g. frequency counts, means, medians, standard deviations, variances, extremes, and percentiles.

    b. Graphical analysis e.g. histograms, time series displays and areal comparisons.

    c. Nonparametric tests e.g. runs, sign, trend and serial correlation. The significance level should be .95.

2. Examine the data for heterogeneities by analyzing the results of the techniques listed above for identifying the cause of non-climatic discontinuities and variations. Potential non-climatic heterogeneities are:

    a. Station/sensor relocation e.g. horizontal and/or vertical movement of some or all of the station sensors to a new location.

    b. Instrument effects e.g. drift, calibration, maintenance and new/replacement instruments.

    c. Environmental effects e.g. vegetation changes, building effects on airflow and land use changes.

    d. Systematic observer bias and observing/coding changes.

After the data have been examined, it is necessary to decide if heterogeneity exists and if the cause is climatic or non-climatic. Reasons for the decision should be documented. Data should be classified as:

i Essentially homogeneous;
ii Essentially heterogeneous because of:
- station/sensor relocation
- instrument effects
- observing and coding practices
- local environmental effects.
iii Data not examined.

Adjustments may be made, if heterogeneities are known to be caused by documented non-climatic effects. Spurious data values may be eliminated/corrected. There are three options:

a. Adjust data to make a homogeneous record, e.g. to latest location or proper sensor calibration, if the form and magnitude of the correction is known. Sometimes adjustments can be made for station/sensor relocations, instrument effects and observing/coding practices. Adjustments for environmental effects should not be made (e.g. urban warming).

b. Split the long-term heterogeneous series into one or more separate, homogeneous parts and treat the individual parts separately.

c. Process data as if it were homogeneous, but identify the data as heterogeneous. If changes have been made to the data then at the completion of the above process the data should be re-examined. If desired, interstation comparisons may be made.

Suggested procedures include:

a. Determine statistical distributions and characteristics of the data.

b. Use statistical characteristics to determine the applicability and validity of models such as:

i Double mass analysis
ii Multiple regression
iii Spatial analysis
iv Time series analysis
v Principal component analysis.

c. Apply valid models.

d. If the comparisons indicate potential heterogeneities, the data should be further investigated.

. CALCULATION PROCEDURES FOR SURFACE ELEMENTS

. CALCULATION OF MONTHLY VALUES (DAILY TO MONTHLY)

Table 1 identifies the principal climatological elements and units of easure for which monthly values should be calculated.

ABLE 1. PRINCIPAL CLIMATOLOGICAL SURFACE ELEMENTS

	UNIT	PRECISION
1. Precipitation Total	mm	.1
2. Days with Precipitation Greater than or Equal to 1 mm	count	1
3. Temperature Tx, Tn, Tm	deg C	.1
4. Pressure	kPa	.01
5. Sunshine	hours	.1
6. Vapour pressure	kPa	.01

ОТЕ: Precision recommendations are based on consistency of calculations, ven though it is meteorologically unreasonable to imply the indicated recision for annual totals.

1e method of calculation is described below. When arithmetic means are to be alculated for each month of each year from daily data the following rule hereafter referred to as the "3/5 rule") applies. If more than 3 consecutive aily values are missing or more than 5 daily values in total in a given month re missing, the monthly mean should not be computed and the year-month mean hould be considered as missing. The number of days for which monthly means re calculated is N, where N can vary from 23 to 31. The symbol S in the quations indicates a summation of all N values.

a. Precipitation Total--Totals shall be calculated for each month of each year from daily data. Monthly totals should be based on a full month's data. However, accumulated amounts during the month are acceptable in lieu of individual daily totals provided that each accumulation is for 3 or less days. If accumulated data are used, the monthly total should be identified with an "accumulation" indicator. If any daily totals are missing and the corresponding accumulated totals are also missing, the monthly total should not be computed and the year-month total should be considered as missing.

b. Days With Precipitation Greater Than or Equal to 1mm--Totals should be calculated for each month of each year from daily data. Monthly totals should be based on a full month's data, that is, no missing daily counts are permitted.

c. Temperature--Calculate average monthly maximum ($\overline{Tx}$), minimum ($\overline{Tn}$), and mean ($\overline{Tm}$) temperature from the daily values Tx, Tn, Tm as follows:

$$\bar{T}_x = \frac{ST_x}{N} \quad ; \quad \bar{T}_N = \frac{ST_N}{N}$$

$$T_M = \frac{S([T_x + T_N]/2)}{N}$$

Note that because of rounding errors, $\bar{T}m$ should not be calculated by averaging the monthly means of maximum (Tx) and minimum (Tn) temperatures, but rather by summary and averaging the daily values (Tx,Tn). The "3/5 rule" for missing data applies.

d. Pressure--Calculate average monthly sea level pressure ($\bar{P}sl$) and station level pressure ($\bar{P}st$) from the average daily pressures observed at 00,06,12,18Z.

$$\overline{Psl} = \frac{S((Psl,00 + Psl,06 + Psl,12 + Psl,18)/4)}{N}$$

$$\overline{Pst} = \frac{S((Pst,00 + Pst,06 + Pst,12 + Pst,18)/4)}{N}$$

e. Sunshine--Totals should be calculated for each month of each year from daily data. Monthly totals should be based on a full month's data, that is, no missing daily totals are permitted.

f. Vapour Pressure--Average daily vapour pressure (VP) should be computed by averaging 24 hourly observations per day. If 24 hourly values are not available for each day, the daily average may be alternatively calculated from 8 (00,03,06,09,12,15,18,21Z) observations per day. The number of observations per day should be identified with a 'frequency' indicator. The monthly mean vapour pressure (VP) should be calculated as follows and the "3/5 rule" for missing data applies.

$$\overline{VP} = \frac{SVP}{N}$$

Other climatological elements for which monthly values may be calculated are listed in Table 2.

TABLE 2. OTHER SUGGESTED CLIMATOLOGICAL ELEMENTS (LISTED IN PRIORITY ORDER) AND METHOD OF CALCULATION

ELEMENT	METHOD	UNIT	PRECISION
Relative Humidity (max, min)	i	%	1
Dewpoint (mean)	vii	deg C	.1

ELEMENT	METHOD	UNIT	PRECISION
Wind direction(prevailing)	ii	deg	10
Wind speed (mean)	vii	m/s	.1
Vector wind direction (mean)	vii	deg	1
Vector wind magnitude (mean)	vii	m/s	.1
Wind steadiness (mean)	vii	---	---
Snowfall (total)	iv	cm	.1
Soil temperature (mean per observation time at depth)	iii	deg C	.1
Days with specified phenomenon (e.g. thunder, hail, fog, gale, blowing sand)	ii	count	1
Cloud amount (total)	vii	okta	.1
Pan evaporation	vii	mm	.1
Solar radiation	vi	MJ/m^2	.01

METHOD NOTES

(i) Determine daily maximum and minimum relative humidity RH_x and RH_N from 24 hourly observations per day. If 24 hourly values are not available each day, then 8 (00,03,06,12,15,18,21Z) observations each day should be used. The number of observations each day should be identified with a frequency indicator. The average monthly values $\overline{RH}_x$ and $\overline{RH}_N$ are calculated as follows and the "3/5 rule" for missing data applies.

$$\overline{RH}_X = \frac{SRH_X}{N}$$

$$\overline{RH}_N = \frac{SRH_N}{N}$$

(ii) Prevailing wind direction should be calculated by identifying the most frequent direction that occurred within a month. Frequency counts should be based on 24 hourly observations per day. If 24 hourly observations are not available for each day, then 8 (00,03,06,09,12,15,18,21Z) observations each day should be used. The number of observations per day will be identified with a "frequency" indicator. The number of direction categories (36 is preferred) should be identified by a "direction" indicator.

(iii) See methodology described in Section V.1.c for maximum temperature.

(iv) See methodology described in Section V.1.a. for precipitation total.

(v) See methodology described in Section V.1.b for days with precipitation greater than or equal to 1mm.

(vi) See methodology described in Section V.1.e for sunshine.

(vii) See methodology described in Section V.1.f for vapour pressure.

2. NORMALS CALCULATIONS (Year-Month to Monthly Normal to Annual Normal)

Monthly 30-year standard normals are calculated from year-month values. If for a given month (e.g. January) 3 consecutive year-month values (e.g. January 1970, 1971, 1972) are missing or more than 5 values in total for the given month are missing, the 30-year standard normal should not be calculated.

Monthly Normals Z for an element X are calculated by

$$Z = \frac{S\bar{X}}{M}$$

where M is the number of months for which year-month values are available (M can vary between 25 and 30).

Annual normals for an element are calculated by averaging the 12 monthly normals. For precipitation totals, sunshine, solar radiation, days with specified phenomenon, standard annual normals should be calculated by adding all 12 monthly normals. Normals should exist for all 12 months to calculate an annual normal, that is, no missing monthly normals are permitted if an annual normal is to be calculated.

3. PROVISIONAL NORMALS (Heterogeneous Data and/or Short-Period)

If a data series has not been examined for homogeneity or other data problems, or if a data series has at least 10 year-month values but fewer than that required for the calculation of 30-year standard normals, then provisional normals Z' for an element $\bar{X}'$ may be calculated by:

$$Z' = \frac{S\bar{X}'}{M'}$$

where M' is the number of months for which year-month values are available (M' can vary between 10 and as much as 30 for heterogeneous data). The years for which monthly values are available are identified by a "year" indicator.

Provisional annual normals are computed by averaging 12 provisional monthly normals. For precipitation totals, sunshine, solar radiation, days with specified phenomenon, provisional annual normals should be calculated by adding all 12 provisional monthly normals. Provisional monthly normals should exist for all 12 months to calculate a provisional annual normal, that is, no missing provisional monthly normals are permitted if a provisional annual normal is to be calculated.

All provisional monthly or annual normals should be identified by a "provisional" indicator.

VI. NORMALS FOR UPPER AIR ELEMENTS

Monthly averages should be calculated for the elements listed in Table 3 at the following levels:

1. Surface
2. 85 kPa
3. 70 kPa
4. 50 kPa
5. 30 kPa
6. 20 kPa
7. 15 kPa
8. 10 kPa
9. 05 kPa
10. 03 kPa

TABLE 3. PRINCIPAL CLIMATOLOGICAL UPPER AIR ELEMENTS

	UNIT	PRECISION
1. Height	gpm	1
2. Temperature	deg C	.1
3. Dewpoint depression/RH	deg C%	.1/1
4. Wind direction	deg	1
5. Wind speed	m/s	1
6. Wind steadiness	---	---

Averages should be calculated for each element at each level for the separate hours of 00,06,12,18Z by:

$$\bar{Y} = \frac{SX}{N}$$

where $\bar{Y}$ is the monthly average for element X at a given level for a given time, and N is the number of daily values for which the average is calculated.(N can vary between 1 and 31)

Decadal means should be calculated by:

$$Z_1 = \frac{S\bar{Y}_1}{M_1} \quad Z_2 = \frac{S\bar{Y}_2}{M_2} \quad Z_3 = \frac{S\bar{Y}_3}{M_3}$$

where Z_1, Z_2, Z_3 are the decadal monthly means for the periods 1961-70, 71-80, 81-90; Y_1, Y_2, Y_3 are the year-month averages at a given level, observation time and month for the periods 1961-70, 71-80, 81-90; and M_1, M_2, M_3 are the number of year-month values in the decades 1961-70, 71-80, 81-90 for which means are calculated (M_1, M_2, M_3 can vary between 1 and 10). The decadal means Z_1, Z_2, Z_3 and counts M_1, M_2, M_3 should be considered an integral part of the upper air normals.

The monthly normal Z should be calculated by:

$$Z = \frac{S\overline{Y}}{M}$$ (note $\overline{Y}$ is the monthly average, i.e. year-month value)

where

$$M=M_1+M_2+M_3$$

Note that the monthly normals Z should be calculated from the year-month value Y and not from the decadal means.

The annual normal is calculated by averaging the 12 monthly normals. Normals should exist for all 12 months to calculate an annual normal. All upper-air normals will be considered provisional unless data homogeneity can be demonstrated.

VII. OTHER CLIMATE DESCRIPTORS

Descriptors other than normals should be provided to allow more complete assessment of the variable nature of climate.

Because of CLIMAT reporting requirements (ref. WMO 306) it is necessary to calculate precipitation quintiles as described in WMO Guide to Climatological Practices, Chapter 8, 1983, pp. 8.5-8.7. Quintiles are required for monthly precipitation totals. A "method" indicator should accompany the calculated quintiles.

Other descriptors that should be considered for individual decades and the whole 1961-90 period are:

1. Standard deviation of daily and monthly maximum, minimum and mean temperatures, and sea level and station level pressure and upper air parameters.

2. Percentiles at the 10, 25, 50, 75, 90 levels for all elements calculated for both daily and monthly data.

3. Frequency of non-occurrence of precipitation, sunshine and cloud amount.

4. Distribution of extremes.

VIII. SUPPLEMENTAL INFORMATION

To ensure proper use and understanding of the Normals (provisional or standard), the following information should accompany the normals:

1. Country code
2. Country name
3. Station name

4. WMO region
5. Latitude (deg, min, N or S)
6. Longitude (deg, min, E or W)
7. Elevation
8. WMO Block/Index Number
9. Quality and processing indicators

   a. Accumulation (number of accumulation periods)
   b. Frequency (either 24 or 8 observations per day)
   c. Years (individual years with data)
   d. Direction (either 36, 16 or 8 point compass)
   e. Method for computing quintiles

      i. From data
      ii. From gamma distribution model
      iii. From other model

   f. Provisional normal

      i. Yes or no (no indicates standard normal)

   g. Reasons for provisional normal

      i. Insufficient period of record
      ii. Heterogeneity

         1. Station/sensor relocation
         2. Instrument effects
         3. Observing/coding practices
         4. Local environmental effects
         5. Unknown

      iii. Both VIII.9.g.i and VIII.9.g.ii

   h. Data completeness

      i. Standard normal with no monthly values missing
      ii. Standard normal with some monthly values missing
      iii. Number of data values used to compute a provisional normal.

This document is the result of an expert meeting held in Washington, D.C., USA, in March 1989. Its intent is to provide general information to Members as they prepare to calculate its standard and/or provisional 30 year Normals. The expert participants in the meeting were:

K. Davidson, WMO
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E. Spackman, Meteorological Office, UK
D. Gullett, Atmospheric Environment Service, Canada

<u>REPORTS PUBLISHED IN THE WORLD CLIMATE DATA PROGRAMME SERIES</u>

WCDP-1 WMO REGION III/IV TRAINING SEMINAR ON CLIMATE DATA MANAGEMENT AND USER SERVICES, BARBADOS, 22-26 SEPTEMBER 1986 and PANAMA, 29 SEPTEMBER - 3 OCTOBER 1986 (Available in English and Spanish).

WCDP-2 REPORT OF THE INTERNATIONAL PLANNING MEETING ON CLIMATE SYSTEM MONITORING, WASHINGTON, D.C. USA, 14-18 DECEMBER 1987.

WCDP-3 GUIDELINES ON THE QUALITY CONTROL OF DATA FROM THE WORLD RADIOMETRIC NETWORK (Prepared by the World Radiation Data Centre, Voeikov Main Geophysical Observatory, Leningrad, 1987).

WCDP-4 INPUT FORMAT GUIDELINES FOR WORLD RADIOMETRIC NETWORK DATA (Prepared by the World Radiation Data Centre, Voeikov Main Geophysical Observatory, Leningrad, 1987).

WCDP-5 INFOCLIMA CATALOGUE OF CLIMATE SYSTEM DATA SETS, 1989 edition.

WCDP-6 CLICOM PROJECT (Climate Data Management System), April 1989 (updated issue of WCP-119)

WCDP-7 STATISTICS ON REGIONAL NETWORKS OF CLIMATOLOGICAL STATIONS (Based on the INFOCLIMA World Inventory). VOLUME II: WMO REGION I - AFRICA.

WCDP-8 INFOCLIMA CATALOGUE OF CLIMATE SYSTEM DATA SETS - HYDROLOGICAL DATA EXTRACT. (April 1989)

WCDP-9 REPORT OF MEETING OF CLICOM EXPERTS, PARIS, 11-15 SEPTEMBER 1989.

WCDP-10 CALCULATION OF MONTHLY AND ANNUAL 30-YEAR STANDARD NORMALS (Prepared by a meeting of experts, Washington, D.C., USA, March 1989).

Missouri Public Service Commission

Data Request

Data Request No.	0209
Company Name	MO PSC Staff-(All)
Case/Tracking No.	GR-2006-0422
Date Requested	10/17/2006
Issue	Revenue - Weather Normalization
Requested From	Curt Wells
Requested By	Michael R Noack
Brief Description	NA
Description	At pages 4-5 of Mr. Wells' direct testimony, he states that Staff's choice of the 30-year period derived by NOAA for normalizing MGE's annual loads for weather is based on "previous Staff analysis, Commission decisions, and these standards for normal weather variables established by NOAA and the WMO." Please provide all documents and any other explanatory information to support the basis for Mr. Wells' statement as it relates to: a. Previous Staff analysis b. Commission decisions c. Standards for normal weather variables established by NOAA and WMO.
Due Date	11/6/2006

Response:

a. Previous Staff analysis;

1. Testimony on behalf of Staff by then Missouri State Climatologist Dr. Wayne Decker in Case No. GR-92-165 (attached)

2. Testimony on behalf of Staff by then Missouri State Climatologist Dr. Steve Qi Hu in Case No. GR-99-315 (attached)

b. Commission Decisions:

Commission Report and Order relied upon is Commission Report and Order (January 22,1997) in MGE Case No. GR-96-285.

(Relevant sections attached: Cover page, List of Appearances, Table of Contents, Weather Normalization Adjustment section. Pages 1-4, 16-18.)

c. Standards for normal weather variables established by NOAA and WMO:

This convention was promulgated by the World Meteorological Organization in 1989 as "Calculation of monthly and Annual 30-year Standard Normals, WCDP-No.10, WMO-TD/341", Geneva. (See response to DR 208)

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.

BEFORE THE PUBLIC SERVICE COMMISSION

OF THE STATE OF MISSOURI

In the Matter of Missouri Gas Energy's Tariff Sheets Designed to Increase Rates for Gas Service in the Company's Service Area.	))))	**Case No. GR-96-285**

REPORT AND ORDER

Issue Date: January 22, 1997

Effective Date: February 1, 1997

WX NORM P.16

BEFORE THE PUBLIC SERVICE COMMISSION

OF THE STATE OF MISSOURI

In the Matter of Missouri Gas Energy's Tariff Sheets Designed to Increase Rates for Gas Service in the Company's Service Area.	))))	Case No. GR-96-285

APPEARANCES

Gary W. Duffy, James C. Swearengen, Paul A. Boudreau, and Dean L. Cooper, Brydon, Swearengen & England, P.C., 312 East Capitol Avenue, Post Office Box 456, Jefferson City, Missouri 65102, for Missouri Gas Energy, a division of Southern Union Company.

Richard S. Brownlee, III, Hendren & Andrae, 235 East High Street, Post Office Box 1069, Jefferson City, Missouri 65102, for Williams Natural Gas Company.

Jeremiah D. Finnegan, Finnegan, Conrad & Peterson, 1209 Penntower Office Center, 3100 Broadway, Kansas City, Missouri 64111, for County of Jackson, Missouri, Central Missouri State University, and University of Missouri-Kansas City.

James M. Fischer, Attorney at Law, 101 West McCarty Street, Suite 215, Jefferson City, Missouri 65101,

and

Susan B. Cunningham, Attorney, Kansas City Power & Light Company, 1201 Walnut Street, Kansas City, Missouri 64106, for Kansas City Power & Light Company.

Richard W. French, French & Stewart Law Offices, 1001 East Cherry Street, Suite 302, Columbia, Missouri 65201,

and

James P. Zakoura, Smithyman & Zakoura, Chartered, 7300 West 110th Street, Overland Park, Kansas 66210, for Mid-Kansas Partnership, and Riverside Pipeline Company, L.P.

Mark W. Comley, Newman, Comley & Ruth, P.C., 205 East Capitol Avenue, Post Office Box 537, Jefferson City, Missouri 65102-0537, for City of Kansas City, Missouri.

Victor S. Scott, Andereck, Evans, Milne, Peace & Baumhoer, L.L.C., 301 East McCarty Street, Post Office Box 1483, Jefferson City, Missouri 65102-1438,

and

Richard W. Stavely, Attorney at Law, 257 North Broadway, Suite 200, Wichita, Kansas 657202-2318, for Mountain Iron & Supply Company.

Bruce A. Dotson, Bruce A. Dotson Law Firm, 1124 Southwest Main Street, Suite 203, Blue Springs, Missouri 64015-3612, for Gas Service Retirees' Association of Missouri.

Stuart W. Conrad, Finnegan, Conrad & Peterson, 1209 Penntower Office Center, 3100 Broadway, Kansas City, Missouri 64111, for Midwest Gas Users Association.

Douglas E. Micheel, Senior Public Counsel, Office of the Public Counsel, Post Office Box 7800, Jefferson City, Missouri 65102-7800, for the Office of the Public Counsel and the public.

Jeffrey A. Keevil, Deputy General Counsel, **Penny G. Baker**, Deputy General Counsel, **Thomas R. Schwarz, Jr.**, Senior Counsel, and **Roger W. Steiner**, Assistant General Counsel, Missouri Public Service Commission, Post Office Box 360, Jefferson City, Missouri 65102, for the staff of the Missouri Public Service Commission.

ADMINISTRATIVE LAW JUDGE: **Thomas H. Luckenbill, Deputy Chief.**

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(Table of Contents, cont'd)

On December 2, 1996, Riverside/Mid-Kansas filed a motion to strike a portion of late-filed Exhibit 172. Riverside/Mid-Kansas requests that the portion beginning with page 3, line 7, through the bottom of page 4, be stricken, because it goes beyond the information requested by Commissioner Crumpton.

On December 10, 1996, MGE filed a response to the motion to strike. MGE argues that all of late-filed Exhibit 172 is responsive to Commissioner Crumpton's request.

The Commission finds that all of Exhibit 172 is responsive to Commissioner Crumpton's request. The Commission will deny the motion to strike.

The Commission has received no objections to the receipt of the late-filed exhibits other than the objection of Riverside/Mid-Kansas discussed above.

Late-filed Exhibits 113, 114, 115, 116, 117, 120, 163, 163HC, 164, 171, 172, 173, 174, 179 and 179HC shall be received into the record.

Findings of Fact

The Missouri Public Service Commission, having considered all of the competent and substantial evidence upon the whole record, makes the following findings of fact.

I. Revenue Adjustments

A. Weather Normalization Adjustment

This issue concerns the appropriate period of time to use for the purpose of establishing "normal" temperatures in the context of setting rates for MGE. MGE advocates the use of ten years of data ending March 31, 1996. Staff advocates the use of 30 years of data (1961 through 1990). Public Counsel agrees with the Staff on this issue.

MGE witness Cummings maintains that the ten-year average of Heating Degree Days (HDD) compiled by the National Oceanographic and Atmospheric Administration (NOAA) better reflects the temperatures experienced in recent years and is not influenced by several consecutive cold winters which occurred many years ago and have not repeated themselves. (Ex. 9, p. 8). Dr. Cummings performed an analysis where he calculated the median temperatures over the last ten and fifteen years and he concluded that the ten-year measure is more representative of recent years' temperatures than the use of the 1961-1990 measure. (Ex. 9, p. 9). The reason for this result is that there were some winters with extremely cold temperatures a number of years ago that are reflected in the 30-year measure, and these extremes have not repeated themselves in the last decade. (Ex. 9. p. 10).

Staff maintains that the Commission should use the 30-year measure of normal temperatures published by NOAA, which are based on properly adjusted monthly Heating Degree Day data from the FAA weather stations at Kansas City International Airport and the Joplin Airport. Staff argues that the 30-year average is the more proper measure of "normal weather" rather than the ten-year moving average proposed by the Company. NOAA's 30-year normal averages are compiled independently of the regulatory process and are set for a period of ten years at a time after each decade of data can be analyzed. The calculations of "normals" are done only once every ten years because they require a substantial effort and commitment of NOAA's resources. The published normals used by Staff remain the same for those ten years until another decade's worth of data is collected and analyzed by NOAA.

Staff believes that the 30-year period utilized by NOAA is necessary to constitute a normal period. This period is long enough to compensate for shorter-term cycles that may be present in the data, while not being so long that historical conditions which are no longer relevant might influence the calculations of normals. Staff maintains that the use of a ten-year moving average as proposed by MGE results in great fluctuations of "normals" which has no place in setting rates on a forward-looking basis.

The Commission finds that NOAA's 30-year normals is the more appropriate benchmark. The ten-year moving average would needlessly cause frequent rate changes based on the introduction of new data every year. If one takes MGE's argument to its logical extreme, the Commission would use the most recent year's experience in MGE's service territory and re-set rates each year. This could lead to serious financial problems for MGE if its rates were set after a record-setting cold year. 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. This safeguard is not present in MGE's approach.

B. Economic Development Discounts

OPC maintains that the Commission must impute the full level of revenues based on the Large Volume contract rate. OPC bases this position on the tariff language contained on MGE's Sheet 74, which states:

> Prior to any determination of the Company's revenue requirement for rate making purposes before the Commission, test year revenues shall first be adjusted to the level corresponding to that which would be produced under the standard Large Volume contract rate schedule with respect to the customers qualified for service hereunder.

OPC maintains that this language precludes Staff and MGE from making their recommended adjustment that has the effect of having ratepayers fund approximately 25 percent of the amount of economic development discounts.

This issue is the extent to which MGE's shareholders should bear the cost associated with discounted rates which MGE offers under MGE's economic

Missouri Public Service Commission

Data Request

Data Request No.	0210
Company Name	MO PSC Staff-(All)
Case/Tracking No.	GR-2006-0422
Date Requested	10/17/2006
Issue	Revenue - Weather Normalization
Requested From	Curt Wells
Requested By	Michael R Noack
Brief Description	NA
Description	Define the term "weather normal" as understood by Mr. Wells within the context of his direct testimony.
Due Date	11/6/2006

Response:

Mr. Wells understands "Weather normal" in this context to be, as defined by NOAA and the WMO, the arithmetic average of a weather variable-- in this case daily average temperature (the arithmetic average of the day's maximum and minimum) over the 30-year period from Jan 1, 1971 through December 31, 2000.

Missouri Public Service Commission

Data Request

Data Request No.	0211
Company Name	MO PSC Staff-(All)
Case/Tracking No.	GR-2006-0422
Date Requested	10/17/2006
Issue	Revenue - Weather Normalization
Requested From	Curt Wells
Requested By	Michael R Noack
Brief Description	NA
Description	Would Mr. Wells agree that the choice of a weather normal for MGE should best reflect the weather expected to occur when its approved rates in this case go into effect? If not, please fully explain the factors he believes should be considered in choosing a weather normal for a gas utility such as MGE.
Due Date	11/6/2006

Response:

No, Mr. Wells does not agree because Missouri is a test year state. In Missouri, utility sales data from a test year are adjusted for departures from the normal condition in order to calculate a revenue requirement and a set of rates for a year where the normal condition would have been experienced. The weather normal chosen should be sufficiently long to provide the necessary stability without major variations, yet not excessively long to inappropriately weight long past values collected with now obsolete instruments using different procedures. NOAA and the WMO have determined that the three-decade normal period with updates each ten years meets these requirements.

Missouri Public Service Commission

Data Request

Data Request No.	0212
Company Name	MO PSC Staff-(All)
Case/Tracking No.	GR-2006-0422
Date Requested	10/17/2006
Issue	Revenue - Weather Normalization
Requested From	Curt Wells
Requested By	Michael R Noack
Brief Description	NA
Description	Has Mr. Wells in this proceeding conducted any specific analysis to determine the most appropriate weather predictor to normalize MGE's annual customer loads for weather? If not, please fully explain why such an analysis has not been conducted.
Due Date	11/6/2006

Response:

The analysis performed was to determine the appropriate weather stations to which to apply the 30-year normal. As stated in the response to DR 211, Missouri is a test year state. Sales data from a test year are adjusted for departures from the normal condition to calculate a revenue requirement and set of rates for a year in which the normal condition would have been experienced. The test year is compared to a "normal" year. No attempt is made to "predict" future weather.

Previous analyses, listed in response to DR 209, have shown that the NOAA/WMO 30-year normals period is the most appropriate time frame for determination of a normal. Customer loads are based on Heating Degree Days, defined as the number of degrees daily average temperature is below a 65 degree base. These loads are compared to the normal daily heating degree days defined using the NOAA 30-year period.