

Exhibit No: _____
Issues: Weather Normals
Weather Normalization
Witness: Robert E. Livezey
Exhibit Type: Surrebuttal
Sponsoring Party: Missouri Gas Energy
Case No: GR-2009-0355
Date: October 2, 2009

MISSOURI PUBLIC SERVICE COMMISSION

MISSOURI GAS ENERGY

CASE NO. GR-2009-0355

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SURREBUTTAL TESTIMONY OF

**Missouri Public
Service Commission**

DR. ROBERT E. LIVEZEY

Jefferson City, Missouri

October 2009

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SURREBUTTAL TESTIMONY OF

DR. ROBERT E. LIVEZEY

CASE NO. GR-2009-0355

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DR. ROBERT E. LIVEZEY

Case No. GR-2009-0355

INTRODUCTION AND SUMMARY

1
2 Q. PLEASE STATE YOUR NAME AND BUSINESS ADDRESS.

3 A. Dr. Robert Livezey, 5112 Lawton Drive, Bethesda, MD 20816.

4 Q. ARE YOU THE SAME DR. ROBERT E. LIVEZEY WHO SUBMITTED DIRECT
5 TESTIMONY ON WEATHER NORMALS IN THE PRESENT CASE?

6 A. Yes.

7 Q. WHAT IS THE PURPOSE OF YOUR PREPARED SUREBUTTAL
8 TESTIMONY?

9 A. I will respond to the rebuttal testimony of Staff Witness Manisha Lakhanpal.

10 Q. WHAT SPECIFIC ISSUES DO YOU ADDRESS?

11 A. The main issues I will address include:

12 (1) Staff Witness Lakhanpal's assertion that the hinge-fit and National
13 Oceanographic and Atmospheric Administration (NOAA) 30-year average methods of
14 estimating heating degree day (HDD) climate normals do not share the same objective,

1 *i.e.* the former is a forecast method while the latter is a means to estimate the most likely
2 heating load.

3 (2) The implications of Staff's continued use of official 30-year NOAA normals for
4 gas rate-making purposes: Failure to accept the fact that Missouri's climate has changed
5 and is likely to continue to change, and inevitable overestimation of most likely heating
6 demands.

7 (3) Ms. Lakhanpal's use of testimonies by Professors Decker and Hu and World
8 Meteorological Organization (WMO) recommendations that were uninformed by one to
9 over two decades of scientific progress and, in the case of the testimonies, did not employ
10 analyses directed at the relative merits of different methods for estimating climate
11 normals.

12 (4) Ms. Lakhanpal's assertion that the WMO "requires" the use of 30-year climate
13 normals updated every decade, and that NOAA and NOAA's National Weather Service
14 (NWS) uses (or recommends the use of) official NOAA normals to represent most likely
15 conditions, the purpose of normals.

16 (5) Ms. Lakhanpal's assertions that the hinge-fit method for estimating climate
17 normals is not applicable and has not been applied to monthly-mean temperature and
18 HDD data at either climate divisions or stations encompassing or representing
19 respectively Missouri Gas Energy's (MGE) service area.

20

THE DEFINITION AND INTENT OF CLIMATE NORMALS

Q. HOW IS A CLIMATE NORMAL DEFINED AND FOR WHAT IS IT INTENDED?

A. The climate normal of a weather variable, like monthly mean temperature at a station or HDDs, is the expected value of the variable under all current reasonable possibilities (in statistical jargon the "population mean"). "Expected" does not imply a forecast of future conditions, but rather connotes the most likely condition. Climate normals are intended for use in this context for estimating average heating demands.

Q. HOW ARE CLIMATE NORMALS DETERMINED?

A. Climate normals cannot be known exactly, so they have to be estimated from the data record, with guidance from theory but with attendant errors. The methods noted by Ms. Lakhanpal, the official NOAA 30-year normal and the hinge-fit method, along with the Optimum Climate Normal (OCN) methodology discussed in my Direct Testimony, comprise different approaches to solving the same problem, estimating climate normals.

Q. CAN THE HINGE FIT BE CHARACTERIZED AS A FORECAST AND THE OFFICIAL NOAA NORMAL NOT IF THEY ARE APPLIED TO A TEST YEAR, AS MS. LAKHANPAL ASSERTS (PP. 2-3)?

A. No, they are simply just different estimates of the test year climate. In fact, the data period used to estimate the official NOAA normal will almost always be further in the past from the test year than the hinge-fit normal.

1

2 **THE IMPLICATIONS OF USE OF NOAA 30-YEAR NORMALS FOR GAS**
3 **RATE SETTING**

4 **Q. IS THE CONTINUED USE OF OFFICIAL NOAA 30-YEAR CLIMATE**
5 **NORMALS FOR GAS RATE-MAKING PURPOSES RECOMMENDED BY MS**
6 **LAKHANPAL CONSISTENT WITH A CHANGING MISSOURI CLIMATE?**

7 A. No, because the use of 30-year averages (updated every 10 years) as the recommended
8 estimation method for climate normals is dependent on the assumption of either
9 extremely slow or no climate change.

10 **Q. IS THE CONTINUED USE OF OFFICIAL NOAA 30-YEAR NORMALS**
11 **CONSISTENT WITH MS. LAKHANPAL'S ASSERTION THAT "STAFF DOES**
12 **NOT ACCEPT OR OPPOSE THE IDEA OF CLIMATE CHANGE AT THIS**
13 **POINT" (P. 8)?**

14 A. No. With little doubt, other methods (the OCN and hinge fit) are preferred if Missouri's
15 cold season climate has changed in a meaningful way over the last several decades and is
16 likely to continue to change, therefore Staff's preferences are consistent with opposition
17 to the idea of climate change in Missouri.

18 **Q. HAS MISSOURI'S COLD SEASON CLIMATE CHANGED IN A MEANINGFUL**
19 **WAY IN RECENT DECADES AND IS IT LIKELY TO CONTINUE TO**
20 **CHANGE?**

1 A. Yes. Unquestionably, the cold season climate of Missouri, and that for most of the
2 United States, North America, and the World, has become considerably warmer. The
3 dominant weight of scientific evidence and overwhelming expert consensus is that
4 warming will continue. The official position of virtually all major governments in the
5 world recognizes this ongoing warming.

6 Q. WHAT WILL BE THE PRACTICAL CONSEQUENCES OF STAFF'S
7 PREFERENCE?

8 A. With certainty, Staff's estimates of most likely heating demand using official NOAA
9 normals will be too large, with expected error more than twice that of the best alternative,
10 the hinge-fit. This means that much more often than not, demand will be less than the
11 estimate rather than greater. The hinge-fit virtually eliminates this cold bias.

12
13 **RELEVANCE OF TESTIMONY OF PROFESSORS DECKER AND HU**

14 Q. WERE THE RECOMMENDATIONS OF WMO IN 1984, PROF. WAYNE
15 DECKER IN 1992, AND PROF. STEVE QI HU IN 1999 (CITED BY MS
16 LAKHANPAL ON PP. 3-5) INFORMED OF ALL SCIENTIFIC FINDINGS
17 PERTINENT TO THE SAME QUESTION TODAY, I.E. THE BEST METHOD
18 FOR CLIMATE NORMALS?

19 A. No. Little was known about modern climate change in 1984, it had not yet been noted
20 confidently over the United States in 1992, and its role in U. S. Winters not yet published
21 in the refereed literature in 1999. The only modern comprehensive empirical treatment of
22 OCN, a critical consideration for the question, did not appear in the refereed literature

1 until 1996. There is no indication in Prof. Hu's testimony of familiarity with U. S.
2 Winter warming or of the OCN paper. My refereed theoretical comparison of existing
3 methods and introduction of the hinge-fit was published in 2007. Thus, there is no basis I
4 am aware of (and none offered by Ms. Lakhanpal) for presuming that any of the three
5 parties would make the same recommendation in the current rate case.

6 **Q. DID EITHER PROF. DECKER OR PROF. HU CONSIDER SHORTER-PERIOD**
7 **AVERAGES (LIKE THE OCN) AS POSSIBLE ALTERNATIVES TO NOAA**
8 **NORMALS IN THEIR TESTIMONY?**

9 **A.** No reference was made by either climatologist in respective testimony to such work
10 conducted by himself or by others, whether for Missouri locations or not. Thus, there is
11 no way to characterize their bases for making their recommendations, other than the
12 verbal arguments that they offered in the testimonies.

13 **Q. ARE PROF. DECKER'S FIVE REASONS FOR RECOMMENDING NOAA**
14 **NORMALS PERTINENT CRITERIA FOR COMPARISONS TO THE HINGE-**
15 **FIT AND OCN?**

16 **A.** Four of the five are still pertinent, but two of these have to be considered simultaneously.
17 Specifically:

18 (1) The method does not rely on data from too long ago, say more than half a century.
19 This is true for all techniques.

20 (2) The method should allow for climate change from decade to decade. For a
21 warming climate, this means the method should have a small cold bias. This bias is much
22 larger for a NOAA normal than for the other methods, in fact the hinge has virtually no

1 bias at all. This criterion needs to be weighed against Decker's reason (4), as I discussed
2 extensively in my testimony.

3 (3) The method should be in line with practices at NOAA and NOAA/NWS. As I
4 anticipated in my testimony, NOAA's National Climatic Data Center (NCDC) has begun
5 the experimental production of OCN and hinge-fit normals as alternatives to official
6 NOAA normals. NOAA/NWS now only uses official NOAA normals as references for
7 placing forecasts and observations in historical context, not for representing the current
8 climate.

9 (4) Statistics should be stable decade to decade. As I discussed in my Direct
10 Testimony and demonstrated in my 2007 paper, this stability must be weighed against
11 bias error (2). The best averaging period, the OCN, has the best tradeoff between the two
12 errors and is much shorter than 30 years. The hinge-fit tradeoff is often even better than
13 the shorter averages.

14 (5) Data records should be consistent over time, in site location and environment,
15 instrument type, and observing practices. This is a more important requirement for
16 methods that use long records, like the official NOAA normal and the hinge-fit normal.
17 Ironically, Prof. Decker testified that Lambert Field had a consistent record through 1990,
18 but Prof. Hu contradicts this by pointing out a number of inconsistencies in the Lambert
19 record.

20 **Q. WHAT THEN ARE THE PREFERRED METHODS FOR CLIMATE NORMALS**
21 **USING PROF. DECKER'S REASONS AS CRITERIA?**

22 **A.** With Prof. Decker's criteria, either the OCN or hinge fit is clearly preferred to official
23 NOAA normals.

1 Q. DOES EITHER PROF. DECKER OR PROF. HU ADDRESS THE USE OF
2 HOMOGENIZED (I.E. CORRECTED) DATA FOR ESTIMATING CLIMATE
3 NORMALS?

4 A. Prof. Decker does not explicitly address homogenized data, but does emphasize the
5 importance of using consistent data records, which are not common for Missouri
6 locations. Prof. Hu explicitly emphasizes the need for homogenized records, thereby
7 providing support for their use by MGE witness Larry Loos for estimating hinge-fit
8 normals.

9

10 **WMO AND NOAA AND NOAA/NWS POSITIONS ON USE OF CLIMATE**
11 **NORMALS**

12 Q. DOES WMO "REQUIRE" USE OF 30-YEAR NORMALS UPDATED EVERY
13 DECADE AS MS. LAKHANPAL QUOTES FROM PROF. HU'S TESTIMONY?

14 A. No. As I noted above WMO made this "recommendation" 25 years ago and has not
15 updated its advice.

16 Q. DO YOU AGREE THAT NOAA HAS NOT "REPLACED THE USE OF 30 YEAR
17 NORMAL WITH ANY OTHER CLIMATE NORMAL" AS MS. LAKHANPAL
18 ASSERTS ON P. 4?

19 A. No. As I noted above, NOAA/NCDC, the organization tasked to produce normals has
20 recognized the frequent inadequacy of traditional normals and begun the experimental
21 release of OCN and hinge-fit normals as alternatives to official NOAA normals. Further,
22 as noted in my Direct Testimony, NOAA/NWS now only uses official NOAA normals as
23 references for placing forecasts and observations in historical context, instead using OCN
24 (and on occasion the hinge fit) to represent the current climate. Neither organization has

1 published recommendations for the use of official 30-year normals for representation of
2 current climate in all circumstances.

3 **Q. DO YOU AGREE THAT "INTERNATIONAL CONVENTION HAS**
4 **ESTABLISHED THAT THREE-DECADE PERIODS ARE APPROPRIATELY**
5 **LONG AND UNIFORM TIME FRAMES FOR THE CALCULATIONS OF A**
6 **NORMAL," AS MS. LAKHANPAL ASSERTS ON PP. 4-5?**

7 **A.** No. This international convention is based on more than 25-year old science and depends
8 on the assumption of an unchanging climate for its validity.

9
10 **APPLICATION AND APPLICABILITY OF THE HINGE FIT TO MGE'S**
11 **MISSOURI SERVICE AREA**

12 **Q. HAS MS. LAKHANPAL MISREPRESENTED AND/OR INCORRECTLY**
13 **CHARACTERIZED BOTH THE APPLICABILITY AND ACTUAL**
14 **APPLICATION OF THE HINGE FIT IN YOUR DIRECT TESTIMONY?**

15 **A.** Yes, Ms. Lakhanpal's Rebuttal Testimony is replete with such errors and
16 misrepresentations.

17 **Q. CAN YOU CITE THESE INSTANCES?**

18 **A.** Yes, I list most below:

19 (1) p. 2: Ms. Lakhanpal incorrectly states that I propose "a least square regression
20 model called the Hinge-Fit model, to predict 'normal' temperatures for calendar
21 quarters," then proceeds to describe (also incorrectly, described next) the way I
22 exemplified the use of the hinge fit in my 2007 paper, Schedule REL-1. The hinge fit is
23 quite versatile, equally applicable and appropriate for monthly, seasonal, or annual data
24 for stations or climate divisions. Additionally, the hinge fit can be applied to data records

1 that do not extend all the way back to 1941, as long as there is a reasonable amount of
2 pre-1976 to anchor the trend period properly. I proposed its application on monthly mean
3 homogenized station data representing MGE's Missouri service area and MGE witness
4 Larry Loos applied the hinge fit in the proposed manner. Examples of its application to
5 station data in MGE's Missouri service area for both cold season temperatures and annual
6 HDDs from 1950 are shown in my Direct Testimony on pp. 26 and 33 respectively.

7 (2) p. 2: Ms. Lakhanpal incorrectly states that the examples shown in Schedule REL-
8 1 were for 102 U. S. climate divisions. The paper states clearly that the calculations were
9 performed on 102 U.S. **mega** climate divisions that utilize and encompass all 344 climate
10 divisions, including all those in Missouri.

11 (3) p. 5: Ms. Lakhanpal states incorrectly that I "did not present any Missouri
12 specific statistical analysis in support of the Hinge-Fit model in [my] direct testimony or
13 [my] workpapers." The map on p. 14 of my Direct Testimony and the graphs on pp. 26
14 and 33 are all obviously successful applications of the hinge fit to Missouri mega climate
15 division and station data respectively for MGE's service area. She further states "There
16 is no apparent statistical analysis done using Missouri data to show that this Hinge-Fit
17 model is equally relevant at a regional or a local level in the State as it is perhaps at a
18 global level." The cited map and graphs in my Direct Testimony are direct evidence that
19 this statement is not true. Further, witness Loos has done extensive statistical analysis
20 demonstrating the relevance of the hinge fit down to the local level in Missouri.

21 (4) p. 5: Ms. Lakhanpal states that "No prominent climate trend is clearly seen in the
22 graph [on p. 23] once the overlaid Hinge-Fit line is removed." In actuality, the post-1976

1 warming is readily apparent in the figure with or without the overlaid hinge. Missouri
2 Winters are definitely warming because of global climate change.

3 (5) p. 6: Ms. Lakhanpal suggests that maps in my 2007 paper (Schedule REL-1), one
4 of which is included on p. 14 of my Direct Testimony, use "seasonal data
5 from various climate divisions across the country and we do not know how many
6 Missouri climate divisions were used." In fact, as explicitly stated in the paper, the maps
7 use data from all climate divisions across the country, including all those in Missouri.

8 (6) p. 7: Ms. Lakhanpal erroneously states that I have not "presented any
9 methodology to apply the Hinge-Fit model developed for seasonal data across climate
10 divisions in the United States to Missouri monthly local weather station data that is used
11 in weather normalization adjustment?" The hinge fit method is just as applicable to
12 weekly, monthly, and annual averages, as it is to seasonal averages, and MGE witness
13 Larry Loos has applied the methodology to monthly mean station data for MGE's
14 Missouri service area.

15 (7) p. 7: Ms. Lakhanpal claims, "It would be inappropriate to apply a Hinge-Fit
16 model to Missouri weather data with an assumption that the warming trend began in
17 1975." Actually, it would be inappropriate to apply it with any other assumption. The
18 reason is that many scientists, including myself, have unquestionably linked the pattern of
19 North American and U. S. climate change to global climate change. The modern global
20 change signal trend, independent of the inevitable climate noise from region to region,
21 began in the mid-1970s. Thus any other choice for a hinge fit, whose objective is to
22 capture trends tied to climate change (not a result of the year-to-year noise), has no

1 justification. For example, Staff's trend fit to the whole record has no corroborative
2 support whatsoever.

3 If the hinge point had been arbitrarily specified in the late 1970s instead of the mid-
4 1970s, this would have amounted to fitting to noise. In this case, the noise is a transient,
5 regional and anomalous three-year cold spell largely independent of global climate
6 change. The result of moving the hinge point would be an even faster warming rate than
7 the standard hinge-fit implies. Local and short-term weather variability making up
8 climate noise often obscures or distorts the climate change signal in a particular record,
9 but a weather normal has to be free of this noise to be useful for its intended purpose.

10 (8) p. 9: Ms. Lakhanpal states "Staff does not want to base its weather
11 normalization adjustment factor on a predicted weather normal variable using a Hinge-Fit
12 Model that was not even estimated using Missouri weather data." I have already pointed
13 out that application of official NOAA normals to the current year for weather
14 normalization adjustment constitutes a very long forecast (9 years in this instance) while
15 the hinge fit is not a forecast at all. Likewise, I have mentioned several times above that
16 the hinge fit is appropriate for and has been successfully applied to Missouri
17 homogenized data records.

18

1 **OTHER ISSUES**

2 **Q. AT THE TOP OF P. 7, DOES MS. LAKHANPAL QUOTE YOUR DIRECT**
3 **TESTIMONY (P. 21) APPROPRIATELY TO SUPPORT HER CASE THAT**
4 **MISSOURI WEATHER IS ATYPICAL, MAKING IT DIFFICULT TO**
5 **COMPARE IT TO A GLOBAL CLIMATE CHANGE PATTERN?**

6 A. No. The quote is inappropriate because Ms. Lakhanpal applies it to the maps on p. 14 of
7 my Direct Testimony and in my 2007 paper (Schedule REL-1). In fact the quote applies
8 to the bar graph of Missouri Winter temperatures on p. 23 of my Direct Testimony,
9 comparing it to the other two bar graphs on p. 22 of U. S. and Missouri annual
10 temperatures.

11 **Q. IS THERE ANYTHING ATYPICAL ABOUT MISSOURI WEATHER THAT**
12 **MAKES IT DIFFICULT TO COMPARE IT TO A GLOBAL CLIMATE**
13 **CHANGE PATTERN?**

14 A. No. The map on p. 14 of my Direct Testimony shows that Missouri is an integral part of
15 a larger winter pattern that has been unambiguously linked to global climate change. Bar
16 graphs (constructed from good data records) of annual and winter temperatures for a
17 large number of other states will be qualitatively similar to those for Missouri on pp. 22
18 and 23 of my Direct Testimony.

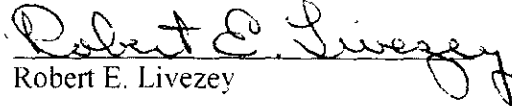
**BEFORE THE PUBLIC SERVICE COMMISSION
OF THE STATE OF MISSOURI**

In the Matter of Missouri Gas Energy's)
Tariff Sheets Designed to Increase Rates) Case No. GR-2009-0355
for Gas Service in the Company's Missouri)
Service Area)

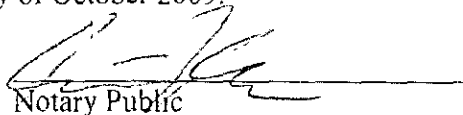
AFFIDAVIT OF ROBERT E. LIVEZEY

STATE OF MARYLAND)
) ss
COUNTY OF MONTGOMERY)

Robert E. Livezey, of lawful age, on his oath states: that he has participated in the preparation of the foregoing Surrebuttal Testimony in question and answer form, to be presented in the above case; that the answers in the foregoing Surrebuttal Testimony were given by him; that he has knowledge of the matters set forth in such answers; and that such matters are true and correct to the best of his knowledge and belief.


Robert E. Livezey

Subscribed and sworn before me this 2nd day of October 2009.


Notary Public

My commission expires: 11/1/10