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

SURREBUTTAL TESTIMONY OF

DR. ROBERT E. LIVEZEY

Jefferson City, Missouri

October 2009

SURREBUTTAL TESTIMONY OF

DR. ROBERT E. LIVEZEY

CASE NO. GR-2009-0355

INDEX TO TESTIMONY

SURREBUTTAL TESTIMONY OF

DR. ROBERT E. LIVEZEY

Case No. GR-2009-0355

INTRODUCTION AND SUMMARY

Q. PLEASE STATE YOUR NAME AND BUSINESS ADDRESS.

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

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

A. Yes.

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

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

Q. WHAT SPECIFIC ISSUES DO YOU ADDRESS?

A. The main issues I will address include:

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

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

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

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

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

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

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.

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

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

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

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

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

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

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

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

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

RELEVANCE OF TESTIMONY OF PROFESSORS DECKER AND HU

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

WMO AND NOAA AND NOAA/NWS POSITIONS ON USE OF CLIMATE NORMALS

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

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

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

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

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

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

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

APPLICATION AND APPLICABILITY OF THE HINGE FIT TO MGE'S MISSOURI SERVICE AREA

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

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

Q. CAN YOU CITE THESE INSTANCES?

A. Yes, I list most below:

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

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

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

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

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

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

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

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

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

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

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

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

OTHER ISSUES

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

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

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

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

CONCLUSION

Q. PLEASE SUMMARIZE YOUR SURREBUTTAL TESTIMONY.

A. Staff's recommendation that NOAA official 30-year normals be used for weather normalization in the current rate case represents the worst possible choice from the available alternatives. The choice is reasonable only if the climate is changing very slowly or not at all, so is consistent with denial of consequential climate change in Missouri. This position is counter to reality; Missouri's winter climate has changed substantially over the last recent decades and is likely to continue to change. Missouri's climate and climate record is not atypical and is an integral part of changes taking place nationwide. Ms. Lakhanpal offers no substantive arguments to negate these facts; use of official NOAA normals for weather normalization instead of the OCN or hinge fit will ensure that estimates of heating demand are too high.

Q. DOES THIS CONCLUDE YOUR SURREBUTTAL TESTIMONY?

A. Yes.