BEFORE THE NEW MEXICO PUBLIC REGULATION COMMISSION

IN THE MATTER OF THE APPLICATION OF NEW MEXICO GAS COMPANY, INC. FOR APPROVAL OF REVISIONS TO ITS RATES, RULES, AND CHARGES PURSUANT TO ADVICE NOTICE NO. 87	)	**Case No. 21-00267-UT**
NEW MEXICO GAS COMPANY, INC.	)	
Applicant.	)	

DIRECT TESTIMONY AND EXHIBITS

OF

DEIRDRE M. KANN, Ph.D.

DECEMBER 13, 2021

Q. PLEASE STATE YOUR NAME AND BUSINESS ADDRESS.

A. My name is Deirdre M. Kann, and my business address is P.O. Box 35282, Albuquerque, New Mexico, 87176.

Q. BY WHOM ARE YOU CURRENTLY EMPLOYED?

A. I am currently self-employed.

Q. PLEASE DESCRIBE YOUR PROFESSIONAL BACKGROUND.

A. I received a B.S. degree in Mathematics with a minor in Geography from Towson University (formerly Towson State University); an M.S. degree in Geography (Meteorology concentrate) from Northern Illinois University; and a Ph.D. in Atmospheric Sciences from Purdue University. After obtaining my Ph.D., I worked for the National Meteorological Center (now the National Center for Environmental Prediction) for eight years in various positions, including: 1) Postdoctoral Scientist; 2) Research Meteorologist; and 3) Senior Research Scientist. I was then employed by the National Weather Service and worked for 22 years as the Science and Operations Officer for the Albuquerque National Weather Service Forecast Office before retiring from the Federal Government.

I have co-authored 9 manuscripts in professional journals, and an article for a non-technical weather publication. I have also taught classes at four universities: the

University of New Mexico, Johns Hopkins University (Continuing Education), Kishwaukee College, and Northern Illinois University. For additional details relating to my professional background, please see NMGC Exhibit DMK-1.

Q. HAVE YOU EVER TESTIFIED BEFORE?

A. Yes. I previously submitted written testimony in NMPRC Case No. 18-00038-UT and NMPRC Case No. 19-00317-UT.

Q. FOR WHAT PURPOSE WERE YOU ENGAGED BY NEW MEXICO GAS COMPANY, INC. AND WHAT IS THE PURPOSE OF YOUR TESTIMONY IN THIS PROCEEDING?

A. New Mexico Gas Company, Inc. ("NMGC" or the "Company") hired me to analyze weather and climate data. Specifically, I was asked to evaluate methods for using climate data to estimate the climate component of expected natural gas consumption which is based, in part, on weather during the heating season. For this investigation, I analyzed weather and climate data from several sites in New Mexico at or near population centers in NMGC's service area. Projected energy consumption is related to temperatures during the heating season, specifically by the degree to which temperatures are above or below a specified threshold. Therefore, computation of the expected departures from a base state is an integral component of projected consumption. My analyses were completed using Heating

Degree Day ("HDD") data and normals obtained from the National Center for Environmental Information ("NCEI"). The results of my investigation are summarized in this testimony and described in more detail in NMGC Exhibit DMK-2.

Q. PLEASE SUMMARIZE YOUR CONCLUSIONS.

A. After analyzing monthly HDD data and testing three sources of estimates for expected HDDs at 12 sites across New Mexico, I conclude that 10-year averages remain the recommended estimate or predictor for expected HDDs. Errors are reduced when using 10-year averages and, unlike official normals that are updated only once every decade, the 10-year average always samples the most recent observational record. This is important in a warming climate. Additionally, 10-year averages could be calculated for new observation sites for which official NCEI normals do not exist. The use of 10-year averages as estimates of anticipated annual HDDs has been previously approved and the results of this analysis continue to support that conclusion.

Q. PLEASE SUMMARIZE HOW YOU REACHED THESE CONCLUSIONS.

A. I first analyzed observations at nine sites in New Mexico and documented warming trends, with a corresponding decrease in HDDs, at all sites. Next, I tested NCEI normals and 10-year averages to evaluate anticipated annual HDDs. Errors, in the

form of biases and mean absolute errors, were calculated at the 9 analyzed sites. Similar statistics were calculated at three additional sites for which long data records were not available. These errors form the basis of my conclusion.

Q. WHAT IS A CLIMATE NORMAL?

A. By convention of the World Meteorological Organization, climate normals are three-decade averages computed for a number of climatological variables including temperature and heating degree days. Climate normals are regularly used to place observed climate or weather conditions into a historical context. In this regard, observations can be compared to the normal or base value. For a given period values tend to fluctuate around the normal such that terms "above normal" and "below normal" are regularly used to describe a specific observation, period of time, or event. Climate normals are essential for planning in many economic sectors.

Q. IS THERE AN ESTABLISHED STANDARD FOR CALCULATING CLIMATE NORMALS?

A. The standard is evolving such that in addition to a 30-year normal, the climatic scientist community is accepting shorter periods. For many years, climate normals have been computed mainly for 30-year periods. These three-decade averages are updated for locations in the U.S. every ten years by the National Oceanographic

and Atmospheric Administration's NCEI. The World Meteorological Organization supports this strategy for maintaining the 30-year normal for locations across the globe. In order to compute climate normals, an observational network of stations with well-maintained equipment and complete records is required.

The NCEI computes 30-year climate normals for numerous sites across the country, and HDDs are one of the many variables for which a normal is calculated. NCEI normals are updated every 10 years. The current NCEI 30-year normals were released in May 2021 and represent the period from 1991-2020 while the previous NCEI normals were for the period 1981-2010.

It is important to note that a 30-year normal computed by NCEI is not just a mathematical average of available data. NCEI uses sophisticated statistical techniques to account for missing data and questionable data, to compare nearby sites, and to calculate other measures - a complicated and lengthy process. In the past, when the NCEI normals were updated to include a new decade, the process could take two to three years, but for this cycle the new normals were available five months after the end of 2020.

Q. CAN CLIMATE NORMALS BE USED TO ESTIMATE FUTURE CLIMATE CONDITIONS?

A. For a "stationary" climate, or a climate that is not changing or is changing very slowly, a 30-year normal is useful to describe the climate of a specific location and can be extended to predict the future state of the climate. However, with the well-documented warming trend, a sign of a "non-stationary" climate, a 30-year normal is still valuable as a measure of the historic record, but it is less useful as a predictor of the future state of the climate. The normal can become even less representative several years following the end of the 30-year period as warming continues but the normals are not updated and do not reflect the observed warmer conditions. This was an important consideration in previous evaluations, but for this study the most recent NCEI 30-year normals represent a period that extends through 2020 and covers most of the test period.

Q. HOW HAS NCEI ADDRESSED THE IMPACTS OF CLIMATE CHANGE ON CLIMATE NORMALS?

A. NCEI has engaged the members of the energy industry to develop alternatives to the conventional, or standard, 30-year normals. Research studies over the past 10 to 15 years have evaluated alternative averaging periods from five to twenty years and have concluded that shorter averaging periods can be more appropriate for many economic sectors particularly energy supply and consumption outlooks. Several years after the release of the 1981-2010 normals were released, NCEI calculated normals for several shorter, non-standard periods. In the most recent

release of climate normals, NCEI also included 15-year supplemental normals for the first time. They cover the years 2006-2020, and were designed to represent periods closer to the present

Q. PLEASE DESCRIBE THE NORMALS AND AVERAGES YOU UTILIZED AND EVALUATED IN YOUR ANALYSIS.

A. For this analysis, I used the 30-year NCEI normals of heating degree days for the period 1991-2020 as well as the 15-year normals for the period 2006-2020. Similar to previous studies, I also calculated the average of HDDs from the previous 10 years to be used as an estimate of expected HDDs. All three values were tested as estimates of the observed HDDs in ten "target" years from 2012 through 2021, or the 10-year test period. Note that most of the test period is included in the new normals, thus the 10-year averages are independent of the target years, while the normals are not.

Q. WHAT ARE HDDS?

A. HDDs are values of temperature departures from a base value and are used as indicators of energy/fuel consumption. Simply stated, HDDs are used to assess how cold it has been. By definition, one HDD is assigned for each degree that the daily mean temperature is below 65°F. Daily mean temperature is defined as the arithmetic average of the maximum and minimum temperature for a day (and not

the average of hourly observations when available). For example, a day with a mean temperature of 40°F would be assigned 25 HDDs (65 – 40) while any day with a mean temperature of 65°F or greater would have zero HDDs.

HDDs were developed to relate temperatures to energy demands. HDDs are particularly valuable when they are summed over the course of a season. This provides information on the degree of temperature departures for the season and allows comparison to other seasons or years.

HDDs are lowest in the summer months and peak in winter months. Thus, when examined over a year-long period, a heating year is defined as the period from 1 July through 30 June the following calendar year such that a single winter season is included in the annual value of HDDs. In New Mexico, the range of annual values of HDDs is large and related to location, with HDDs across the northern higher terrain more than double the HDD values associated with south central and eastern locales.

Q. WHY IS IT NECESSARY TO ANALYZE HISTORICAL RECORDS OF HDDS?

A. Historic or past values of HDDs are used as predictors of future energy consumption, so the statistics associated with data records including variability and

averages are used to define a historical perspective. Annual variability in temperatures as well as HDDs is a component of natural climate variability. Examination of a historical record quantifies the degree to which temperatures/HDD vary over an extended period. Because NMGC serves a large area of New Mexico, it is important to analyze HDDs at a number of locations within the service area. The analyses are then tested to determine the appropriate method of calculating HDD estimates.

Q. DO OBSERVED TEMPERATURE TRENDS SIGNIFICANTLY AFFECT CLIMATOLOGICAL ESTIMATES OF FUTURE HDDS?

A. Absolutely. Global climate change in the form of positive temperature trends, or a consistent pattern of change in temperatures, make long-term climatological normals less accurate as predictors. They can also be unrepresentative of the current climate. U.S. temperatures (and global temperatures as well) show consistent warming over the past three to four decades for most of the planet. Therefore, for most areas in the U.S. and all regions of New Mexico a 30-year normal temperature used as an estimate of a future temperature is likely to be too cool, resulting in a cool bias. Warming temperatures correspond to a decrease in HDDs, and a 30-year normal HDD used to estimate a future HDD would likely be too high resulting in an overestimate of future energy consumption.

Q. WOULD YOU PLEASE DESCRIBE IN MORE DETAIL THE APPROACH YOU USED IN YOUR ANALYSIS?

A. To complete the analysis, I obtained monthly values of HDDs since 1971 (or the earliest date possible) from 9 sites in New Mexico in or near Albuquerque, Gallup, Farmington, Los Alamos, Roswell, Artesia, Tucumcari, Truth or Consequences, and Las Cruces. These are the same sites used in my previous study. For each site, monthly HDD values were summed for the 12-month period from July 1 through June 30 to determine HDD accumulations for heating years. For all but two stations, these accumulations were calculated for heating years 1971-1972 through 2020-2021. The heating year values for each site were analyzed using a linear regression, resulting in a line that illustrates the trend for each data series. Similar to temperature, annual values of HDDs are fairly variable from year to year. These year-to-year changes were smoothed by computing 10-year running averages for each year to depict variability over longer time periods.

I then evaluated how well the NCEI 30-year and 15-year normals, and previous 10-year averages can be used as predictors of HDDs by computing the differences between the observed HDDs and the three "estimates." The sign and magnitude of the differences is referred to as the bias, or the difference between the expected number of HDDs and actual number of HDDs. The calculations were completed

for a 10-year test period for heating years ending in June of 2012 through June of 2021.

Because biases of opposite sign, but similar size, result in a small average value, absolute errors that consider the magnitude of the differences, but not the sign, were also calculated. Biases and absolute errors for the test period for each data series (individual stations) were averaged to summarize results for each station. Finally, using the same estimates for stations with a shorter, continuous data record, biases only (and not trend analyses) were completed for three additional sites.

Q. HOW DID YOU CHOOSE THE SITES YOU USED IN YOUR ANALYSIS?

A. Weather and climate information is available for a number of sites across New Mexico and for previous studies, I initially considered over 140 stations. For a station to be suitable, the siting needed to be in or close to the NMGC service area. More importantly, it was imperative to choose sites that had not moved significantly in location, had no significant equipment changes, and had very complete data records with a minimal amount of missing data. Many sites located at FAA airports have multi-year periods of missing data, including Farmington, Santa Fe, Clayton and Deming. Other sites in New Mexico which previously had long and complete data records are now inactive or closed, including Taos, Clovis and Alamogordo. Additionally, some stations had intermittent periods of missing data, with too many

missing monthly averages to be considered appropriate for this study. Though it is important to select sites near population centers within the Company's service area, the inclusion of rural stations near population centers minimizes the chance of a change in temperatures due to urbanization. After checking stations for location and complete or nearly complete data records, out of the approximately 140 considered, only nine had complete enough records to be suitable for the complete analyses I completed in 2019. These nine stations were maintained for this study and three additional sites with shorter, continuous records were included for bias-only evaluations. The monthly HDD values for the 12 sites were obtained from NCEI.

Q. WHY IS IT NECESSARY TO EXAMINE HDD DATA FROM MULTIPLE SITES?

A. New Mexico covers a large area of just over 120,000 square miles which is characterized by diverse terrain with significant elevation ranges. The considerable areal expanse combined with terrain results in a wide range of climate conditions across the state. Large-scale dynamics produce a majority of the weather patterns which impact the state, while local factors including terrain features, elevation, and surface type also contribute to the resulting climate regimes across the state. Any one site would not be representative of all areas in the New Mexico Gas Service

Area, and changes observed at one location cannot be assumed to have occurred at another.

Urbanization has been shown to impact climate statistics at some locations, most often in the form of temperature increases due to heat absorption by buildings, asphalt parking lots and roads, industry emissions, and decreased vegetation. However, most of observation sites in New Mexico are not in locations influenced by urbanization, including most of the sites used for this report. The Albuquerque station would be most likely to be impacted by urbanization, but the observation site is not located in the most urbanized area. Still, a small contribution from urban impacts is possible although positive temperature trends are evident in both urban and rural sites.

It is also interesting to note that rural stations separated by relatively short distances can have fairly significant differences in the magnitude of observed trends. For all these reasons, multiple sites across the state must be analyzed.

Q. ARE THE SITES YOU USED IN THIS STUDY REPRESENTATIVE OF THE CLIMATE IN NMGC'S SERVICE TERRITORY?

A. Yes. When selecting sites for this study, considerable effort was focused on finding stations that would represent the broad expanse and diversity of NMGC's service

area. Station locations represent the middle and south central valleys, the eastern plains, the northern mountains, the southwest desert and the northwest plateau. Station sites also include both urban and rural settings, similar to NMGC's service territory.

Q. ARE THERE ANY SPECIFIC SITES YOU WOULD HAVE LIKED TO INCLUDE IN THIS STUDY, BUT COULD NOT BECAUSE THERE WAS TOO MUCH MISSING DATA?

A. Yes. As a result of missing data, I was unable to include several sites within the NMGC service including Alamogordo, Hobbs, Farmington, Taos, and Clovis. However, eliminating the evaluation of the most recent 30-year average made it possible to include stations with shorter uninterrupted records including Santa Fe, Clayton and Deming since only 20 years of data and NCEI normals were necessary to compute the various biases.

Q. PLEASE DESCRIBE RECENT TEMPERATURE TRENDS IN NEW MEXICO.

A. Numerous scientific agencies and universities have documented a positive trend in global temperatures, although magnitudes vary from location to location with a very limited area showing little change. New Mexico has seen greater warming than many other states and a majority of the warmest years have occurred in the last

decade. The average annual temperature has increased about 0.6˚F per decade or approximately 3˚F, over the last 50 years.

Q. IS IT PROBABLE THAT THE WARMING TREND IN NEW MEXICO, AS DEPICTED IN THE DECREASING ANNUAL ACCUMULATIONS OF HDDS OVER THE PAST SEVERAL DECADES, MIGHT NOT CONTINUE INTO THE FUTURE?

A. Such a scenario is not likely. The warming trend in New Mexico is well-documented as it is for much of the globe. Warming has been observed in all seasons in New Mexico. In general, trends are largest in the summer with the smallest rates of increase in the winter, with the spring and fall seasons having trends closer but less than those in the summer. The new NCEI 30-year normals, when compared to the previous 1981-2010 normals show that the warming trend continued for most of the country and was greatest in the desert southwest. Additionally, advanced climate models developed and supported by numerous governmental, private, and educational entities consistently show warming (and a decrease in HDDs) to continue at least through the mid-21st Century, and likely longer. I agree with the majority of climate experts whose research has shown temperature increases are likely to continue.

Climate models depict warming on relatively large spatial scales, but due to relatively coarse resolutions the resulting predictions are not always applicable to a regional scale. While climate models continue to improve, at this point the most appropriate basis for determining expected HDD values for energy regulatory purposes is to use statistics derived from the recent local observations within the service area.

Q. GIVEN YOUR RESPONSE ABOVE, HOW CAN YOU EXPLAIN THE RECORD COLD CONDITIONS OBSERVED DURING FEBRUARY 2021?

A. It is true that an arctic intrusion resulted in a record cold spell across eastern New Mexico from February 11-15, 2021. A similar record cold spell occurred in February of 2011. These extreme events occur when the jet stream has an exaggerated wave pattern that acts to transport frigid arctic air southward. Recent research has shown that this type of event may occur with more frequency in a warming world because of associated changes in the jet stream patterns. However, three to four days of record cold temperatures result in relatively small changes to the cold-season averages. While still a topic under investigation, even an increase in arctic outbreaks would not offset the observed warming trend and year-to-year variability will still be present in historical records despite the positive temperature trends.

Q. DO OTHER CLIMATE SCIENTISTS AGREE WITH YOUR ASSESSMENT OF THE USE OF 30-YEAR "CLIMATE NORMALS" TO CHARACTERIZE CURRENT CLIMATE?

A. Yes. Many research studies and the NCEI have concluded that 30-year normals updated every 10 years are no longer useful for decision-making processes for which they were intended because they can be unrepresentative of the current climate and particularly the future climate. They also noted a need for the development of new normals using more complex statistical techniques and/or shorter averaging periods. When NCEI updated the 1971-2000 normals for the period 1981-2010, the decade of 2001-2010 was warmer than the decade dropped from the 30-year period (1971-1980) for many locations in New Mexico (see summary table in Exhibit 2). The resulting normal was generally a warmer normal, a clear sign of a warming trend and a non-stationary climate. Similarly, the new normals for 1991-2020 were warmer still reflecting this well-defined warming trend.

NCEI developed a set of “supplemental” monthly temperature normals for the 1981-2010 period with averages over 5-, 10-, 15- and 20-years, and well as alternative normals obtain using more advanced statistical methods. NCEI advises users to consider using an alternative normal due to the observed climate change. NCEI has taken a proactive role of engaging the energy industry to evaluate the

current use of climate normals and the energy industry's need for alternative climate normals. In the most recent release of NCEI normals, 15-year normals were included for all sites.

Because shorter averaging periods can yield more accurate estimated of future conditions, they are now employed in some operational settings. The National Oceanic and Atmospheric Administration's Climate Prediction Center now uses shorter, annually-updated averaging periods for their forecasts of seasonally average temperatures.

Q. PAST STUDIES INCLUDED THE MOST RECENT 30-YEAR AVERAGES AS AN ESTIMATE. WHY WERE THEY EXCLUDED IN THIS STUDY?

A. In my two previous studies, and those completed by others, the test period included several heating years that followed the end of the normal period. That resulted in some warm years, in fact often the warmest observed years, not being included in the estimate of future HDDs. The use of the most recent 30-years average tested the concept of an annually updated 30-year normal and generally incorporated the warmest years at an observation site. In this study observed data ended in 2021 and normals represented the period through 2020, so there was only a portion of one heating year excluded from the predictor years. Updated 30-year averages were

not necessary to evaluation and the new NCEI 15-year normals were instead used as a third estimator.

Q. COULD 10-YEAR WEATHER BECOME A MORE ACCURATE PREDICTOR OF HDDS IN THE FUTURE?

A. Yes. As the warming trend in New Mexico continues, which is highly likely, 30-year normals will become continue to be less accurate predictors of future HDD estimates for the reasons previously described in this testimony. The use of 30-year normals will nonetheless be an important component of climate-based studies, including the evaluation of climate trends. But in periods where a trend is present, shorter periods such as 10 years can provide more accurate estimates while still sampling considerable variability. While NCEI developed and released 15-year normals for the currently cycle, which were shown to be more skillful estimators at this time, their use will likely become less skillful in the upcoming years as warming continues but NCEI normal are not updated. When using previous 10-year averages, there are no excluded years.

Q. WHAT DO YOU CONCLUDE REGARDING THE APPROPRIATE LENGTH OF THE CLIMATOLOGICAL BASE PERIOD FOR ESTIMATING HDDs OVER THE NEXT SEVERAL YEARS?

A. In my opinion, the most recent 10-year averages have been consistently shown to be superior estimates of past weather compared to the NCEI normals. While the 15-year NCEI normals were more accurate estimators than the traditional 30-year normals, the most recent 10-year averages tend to be more representative of current climate while still capturing sufficient annual variability. In addition to being slightly more accurate, the use of a 10-year period allows for the use of more stations with shorter data records and no NCEI normals, which could be useful in populated areas not included in this analysis.

Q. DOES THIS CONCLUDE YOUR TESTIMONY?

A. Yes, it does.