Docket No, UG-06____
Exhibit ____(PWM-1T)
Witness: Philip W, Mote

BEFORE THE

WASHINGTON UTILITIES & TRANSPORTATION COMMISSION

UG-06_____

GENERAL RATE APPLICATION

OF

February 14, 2006

Prepared Direct Testimony of
Philip W. Mote

The Effect of Climatic Change on Heating Degree Day Normals

Prepared Testimony of Philip Mote
(The Effect of Climatic Change on Heating Degree Day Normals)

Q. Please state your name and qualifications.

A. My name is Philip Mote. I have a B.A. in physics from Harvard and a Ph.D. from University of Washington in atmospheric sciences. I have more than 10 years experience after the Ph.D. in research and teaching on subjects related to climate, especially climate change in the Pacific Northwest. I have written more than 40 scientific articles. Since 1998, I have been a research scientist and public information specialist with the University of Washington Climate Impacts Group. I also serve as state climatologist for the state of Washington.

Q. What is the purpose of your testimony?

A. I will evaluate the use of the National Oceanic And Atmospheric Administration's (NOAA) published report of Monthly Station Normals of Temperature, Precipitation, and Heating and Cooling Degree Days 1971 – 2000 in establishing the expected sales of natural gas under "normal" weather conditions. My testimony and exhibits also supports a different set of "normal" Heating Degree Days (HDDs) that would provide an improved measurement of the expected temperatures that will occur during the period of time that the rates from this general rate case are in effect.

Q. Are the HDD normals published by NOAA a good indicator of the most likely HDDs that will occur next year or the next four or five years?

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A. No. In the presence of a strong warming trend, the 1971-2000 average substantially underestimates the actual temperature (and overestimates heating degree days) in the 2001-2010 time period. In fact, that average was even a poor estimate of the mean in the 1990s. Cascade's rates established in this rate case are likely to be in effect in 2007 through perhaps 2010 or 2011. The 1971-2000 average as published by NOAA will increasingly overestimate HDDs each year going forward.

Q. NOAA publishes this information as "normal". Is it your testimony that NOAA's use of normal should not be interpreted as the expected or most likely HDDs to occur in future years?

A. That is correct. The information published by NOAA as normal is merely the arithmetic mean or average of the 30-year history the report covers. These published normals do not take into account the existence of a warming trend in globally averaged surface air temperatures. This warming trend is no longer disputed within the scientific community and scarcely disputed beyond.

Q. What is meant by NOAA by the term normal or climate normal?

A. As the NOAA web site (http://www.ncdc.noaa.gov/oa/climate/normals/usnormals.html) explains in the Frequently Asked Questions section, the term climatic "normal" has faced a dilemma since its introduction a century and a half ago. A climate normal is defined, by convention, as the arithmetic mean of a climatological element computed over three consecutive decades. The casual user, however, tends to (erroneously) perceive the normal as what they should expect. Dr. Helmut E. Landsberg, who became Director of Climatology of the U.S. Weather Bureau in 1954 and, later, Director of the Environmental Data Service, summarized the dilemma quite well over four decades ago (Landsberg, 1955): "The layman is often misled by the word. In his every-day language the word

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normal means something ordinary or frequent. ...When (the meteorologist) talks about 'normal', it has nothing to do with a common event..... For the meteorologist the 'normal' is simply a point of departure or index which is convenient for keeping track of weather statistics..... We never expect to experience 'normal' weather." This is especially true with precipitation in dry climates, such as the desert southwestern region of the United States, where the average daily rainfall is near zero but the average rainfall on rainy days can be rather high because few days have any rain. Likewise with temperature at continental locations which frequently experience large swings from cold air masses to warm air masses.

It might be "normal" for the weather to swing radically between extremes from day to day and year to year, but the "climatic normal" is simply an arithmetic average of what has happened at such a "swinging" place. This is why it's important to use a measure of the variability of climate (such as the standard deviation and extremes) in conjunction with the climatic normal when studying the climate of a location (Guttman, 1989).

In accordance with national and international convention, the official climate normals computed for U.S. stations by NCDC consist of the arithmetic average of a meteorological element over 30 years. The "official" normals are provided solely by National Climate Data Center (NCDC), which should be noted in light of other non-official means computations from a myriad of sources.

Q. How can we be sure that the Northwest is really warming?

A. In addition to the instrumental records discussed earlier, there is ample evidence from Nature that warming is occurring. Virtually every glacier in the Northwest has been receding in most of the 20th century, a trend consistent with warming but not with the

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observed fluctuations in precipitation. Mountain snowpack has been declining in the past 50 years and peak spring snowmelt-driven streamflow has been occurring earlier. Various plants and animals have tended to reach milestones in their springtime development earlier as well. Measurements of sea surface temperature at Race Rocks Lighthouse, near Victoria BC, show warming very similar to the measured warming of air temperatures in the Puget Sound region.

Evidence for a warming trend globally includes direct temperature measurements from both land- and ship-based surface thermometers, soil temperature profiles in boreholes, changes in the timing of spring snowmelt in the western US, and recession of nearly every glacier in the world (Folland et al. 2001, and refs. therein). Assessment efforts by the Intergovernmental Panel on Climate Change and by the US National Academy of Sciences, as well as policy statements from all the major scientific societies, underscore the confidence of the finding that Earth is warming.

Commonly cited causes for doubt about this warming, for example the effects of urbanization or the measurements of tropospheric temperatures from satellites, have been addressed in dozens of peer-reviewed papers and do not refute the basic conclusion that Earth is warming.

Q. Could this be a natural cycle that will eventually reverse?

A. Although there are unquestionably natural cycles in climate, the human-induced forcing of the climate is growing in strength and its importance as a factor in determining global climate now rivals that of El Niño: the biggest El Niño on record (1997-98) appears to have raised global average temperature by at most 0.2°C for one year, whereas greenhouse gases appear to be changing the mean temperature irreversibly by almost that amount each decade since 1970.

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More rigorous evidence that the recent warming is likely of human origin comes from several lines of analysis. Some groups have developed techniques for comparing the observed pattern of warming with that expected to occur with rising greenhouse gases, and they generally find that the observed warming is increasingly consistent with expected warming. Other groups simulate 20th century climate with climate models, including both natural and human forcing factors of climate; they all find that it is impossible to simulate observed recent warming without including the increases in greenhouse gases. When all forces are included, all of the modeling groups find that the models simulate observed 20th century global average temperature fairly well, including the rise in temperature since the 1970's.

The current warming trend will not reverse for many years. This warming trend will continue during the 3 to 5 years that Cascade's rates from this rate case are in effect.

Q. How does the warming trend affect Cascade's attempt to establish gas consumption under normal weather?

A. Unfortunately, the current practice that purports to set revenue-neutral targets for Cascade uses the 1971-2000 "normals" (i.e., arithmetic averages) for four locations in Washington. Such an assumption would be valid if the time series of temperature at these locations were stationary, but they are not. As shown in Exhibit __(PWM-2), most stations in the Northwest warmed during the 20th century, with a regionally averaged warming of 1.5°F, typical of global land areas. Table 1 lists some annually averaged warming trends for high-quality climate stations in the CNGC service areas. In seasonal breakdowns (see Exhibit __(PWM-2)), warming has been largest in winter, when demand for natural gas is highest, and trends in autumn have been near zero at many locations.

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CNGC service area	station	trend	starting year monthly	daily
Northwest	Blaine	1.7	1893	1948
	Clearbrook	2.4	1904	1931
	Bellingham	1.6	1891	--
	Olga	1.1	1890	1891
	Sedro Woolley	0.7	1896	1931
	average	**1.5**		
West	Grapeview	1.9	1907	1948
	Aberdeen	2.5	1891	1931
	Longview	1.2	1924	1931
	average	**1.9**		
Central	Wenatchee	2.9	1912	1931
	Cle Elum	1.8	1899	1931
	Ellensburg	1.4	1892	--
	Sunnyside	2.9	1894	1948
	Kennewick	2.6	1897	1948
	Walla Walla	1.4	1872	
	average	**2.2**		

Table 1. Trends in annually averaged temperature at USHCN stations in the CNGC service areas in Washington. Trends are linear fits to the data from 1920-1997 and are expressed as degrees Fahrenheit per century. Source: Exhibit __(PWM-2) Mote (2003). The third and fourth data columns also indicate the starting year for monthly and daily data.

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What is needed is a better way to estimate future HDDs, taking account of the fact that the statistics of climate are not stationary. In particular, some combination of past trends and future projections in monthly temperatures at each of the four locations would provide a more accurate estimate of future HDDs. This could be done in several ways, but the two primary approaches would be (1) statistical analysis of observed data and (2) numerical modeling using state-of-the-art climate models. Owing to the difficulty of accessing and applying the results of climate models, I have selected a statistical approach.

Q. Please describe your statistical analysis.

A. I have calculated the linear trends of the past observations in the HDD data and simply extrapolated forward to the year 2007 to establish the expected HDDs. Calculation of HDDs in this manner is a vast improvement over the use of 1971-2000 averages as normals. As with any linear analysis, the question arises as to what time period to use, and the extent to which the results depend on the period of analysis. The scientific consensus that human influence on climate has emerged in the past 50 years suggests that earlier data be used only to estimate natural variability, and more recent data be used for trends analysis. With the restriction that daily USHCN data are available only to 1948 at many stations, linear trends over that period of record would be sensible. However, this may lead to an excessively large upward trend in temperature (or downward trend in HDDs) because there were two very cold winters around the middle of the century, and January 1950 was the coldest month on record for the state. I selected data from 1951 through 2005 for my analysis to provide a more conservative estimate of the trends.

Exhibit __(PWM-3), pages 1 – 12 show the monthly graphs of the four weather stations Cascade uses to observe actual weather in its Washington service areas. All 50+ observed HDDs for each month is plotted on the graphs. I also calculated the linear equation associated with this data and extrapolated the HDD value for the corresponding month in

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2007. I have also shown the arithmetic average of the 1971 – 2000 period. Exhibit __(PWM-4) lists the HDD values Cascade should use as normals in determining the amount of gas that would be required of its customers under normal weather.

Q. Does this conclude your testimony?

A. Yes.

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