EXHIBIT NO. ___(SJC-3)
DOCKET NO. ____________
2005 POWER COST ONLY RATE CASE
WITNESS: SARA J. CARDWELL

BEFORE THE
WASHINGTON UTILITIES AND TRANSPORTATION COMMISSION

WASHINGTON UTILITIES AND TRANSPORTATION COMMISSION, **Complainant,** **v.** **PUGET SOUND ENERGY, INC.,** **Respondent.**	**Docket No. UE-_______**

SECOND EXHIBIT TO THE PREFILED DIRECT TESTIMONY OF
SARA J. CARDWELL (NONCONFIDENTIAL)
ON BEHALF OF PUGET SOUND ENERGY, INC.

JUNE 7, 2005

Is It Hot in Here?

An improved definition of heating and cooling degree-days for power markets.

By Aaron Brasket

Anyone who owns an air conditioner and pays an electric bill knows that weather drives demand for electricity, but quantifying the relationship between weather and electricity demand isn't easy. Was last winter severely cold? Winters are always cold. If it really was cold, exactly how cold was it?

One of the underlying problems is that different regions of the country have drastically different weather, technologies for generation, and local habits for keeping cool in the summer and warm in the winter. Traditionally, people have looked at weather through heating degree-days (HDD) and cooling degree-days (CDD). A common assumption with these metrics is that 65° F is the universal thermometer setting. When the average daily temperature drops below this point, heating increases as measured by positive HDD. Alternatively, as temperatures warm above 65° F, cooling increases leading to a higher CDD score. These are reasonable assumptions and are widely used as the basis for many weather risk-management applications and standardized weather commodity trading platforms.

But assumptions can be misleading. There is a better way.

Effective Heating and Cooling Degree Days by Load Region

In reality, there is no universal thermometer setting. In Arizona, with its hot, dry climate, people still are reaching for their Ascot sweaters at temperatures that have the residents of Eastern cities planted in front of their air conditioners. Humidity is certainly a culprit, which just highlights the fact that daily temperatures alone often don't give a complete picture. Additional complexity and variables are needed in an analysis to support any decision-making process. This leaves one with two options: gain access to a multiple, variable, non-linear regression package, or regionalize one's neutral temperature.

At Global Energy Decisions, we have adjusted the standard definition of heating- and cooling degree-days to better fit the needs of power-market participants. The result is a new term: effective degree-days (EDD) by load region. Instead of the standard universal thermometer setting of 65° F as the basis for heating and cooling degree-days, we calculate the appropriate basis for each load-serving entity separately. We refer to this temperature as the neutral heating temperature and calculate it using a two-step process. First, we find which single weather station has the highest correlation with a given load region for daily maximum temperatures and load. Then, after we identify which weather station best represents the observed load variability, we estimate a temperature-demand response curve by fitting a polynomial to the observations. Table 1 provides a small cross-section of different load regions, the associated weather station with the highest correlation, and the »

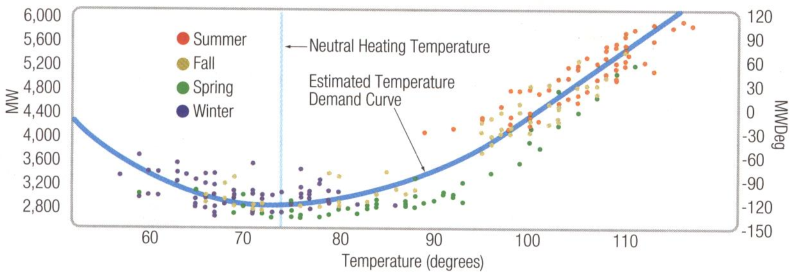
Table 1 — Load Region Neutral Heating Temperatures

Load Region	Weather Station	Neutral Heating Temperature
Arizona Public Service	Phoenix Sky Harbor Airport	73.9
ERCOT Houston Zone	George Bush/Houston Airport	63.1
Florida Power and Light	Miami International Airport	73.4
Missouri Public Service	Kansas City International Airport	61.5
New York ISO Zone J & K	La Guardia Airport	58.0
Northern States Power Co.	Minneapolis – St. Paul Intl Airport	56.2
PJM ISO APS Zone	Altoona Blair County Airport	62.2
San Diego Gas and Electric	San Diego International Airport	64.2

Source: Global Energy Decisions

Figure 1 — Daily Temperature and Demand

Arizona Public Service Co. 2003



Weather Station: Phoenix Sky Harbor Airport; Neutral Heating Temperature: 74

Source: Global Energy Decisions

neutral heating temperature we have calculated for each region.

This table shows that there can be a significant range in neutral temperature values. As one might expect, warmer climates such as Arizona and Florida seem to be slower to turn on the air (and quicker to turn up the heat) than their more northerly peers. But there are some surprises. Houston's neutral point is most similar to Pittsburgh or Kansas City. Each region has a complex interaction between weather, seasonality, and local conditions that goes into generating its own neutral heating temperature.

An example of the temperature-demand curve used to generate the neutral heating temperature is shown in Figure 1, with the typical "U"-shape one expects. The curve for most load regions includes a relatively flat center where the demand for electricity is almost independent of temperature. On either side, as temperatures warm above or drop below the neutral heating temperature, load levels increase sharply. For convenience, we have chosen to fit a relatively simple curve, a second degree polynomial, to this distribution. This allows us to calculate the neutral heating temperature as the bottom of the curve.

This example for Arizona Public Service Co. is a good illustration of why traditional HDD and CDD measures can be misleading. A daily maximum temperature near 65°F, which for Phoenix probably occurs in December or January, lies very much in the heating portion of the Arizona Public Service curve. It takes significantly warmer temperatures to lead to an increase in demand on the cooling side. It should be noted that you wouldn't necessarily expect the heating and cooling slopes to be the same. For most regions, the cooling slope of the curve is steeper than the heating portion, reflecting that the electrical requirements for heating aren't as demanding as the power draw for cooling. There are regions however, such as upstate New York, where peak demand periods often fall in winter.

Effective degree-day calculations can be used to improve analysis, develop better predictive tools, and most important, produce superior market decisions, improving weather and demand correlation in almost all energy applications.

Building Better Predictive Tools

Although finding a good way to accurately describe the impact of weather variability on power markets from a historical perspective is important on its own, weather becomes a little more interesting when it comes to predictive applications. Weather, compared to, say, price, is highly predictable, and short-term forecasts are quite good. Even if you extend the time horizon to the seasonal level, you can still find measurable skill for weather prediction in a probabilistic sense. Also, weather data is widely available with good geographic coverage from airports across the country at frequent sampling intervals. This combination lends itself well to using a wide variety of sophisticated analytical methods.

Choosing a local neutral heating temperature as a basis for EDD can be used to improve analysis, develop better predictive tools, and most important, produce superior market decisions. Figure 1 shows that Arizona Public

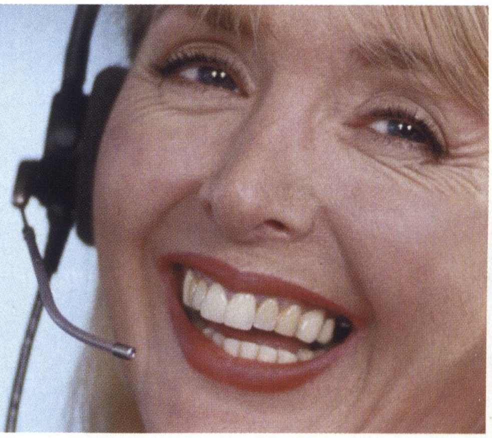
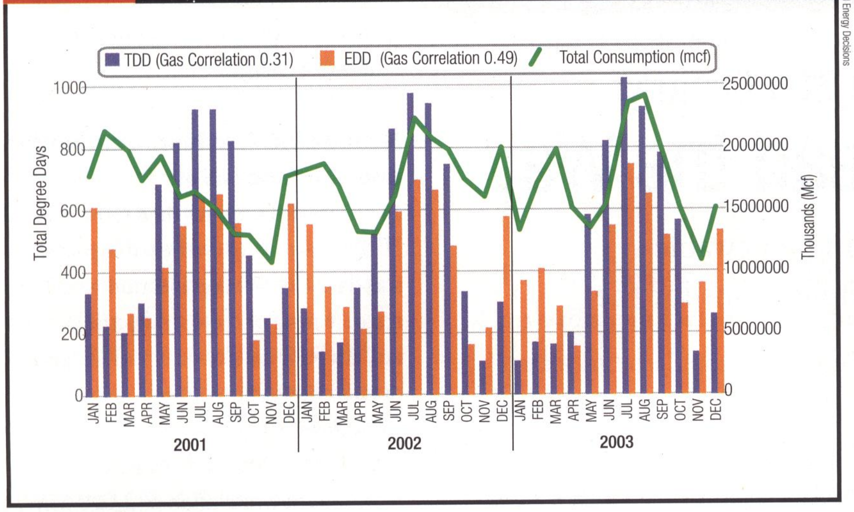
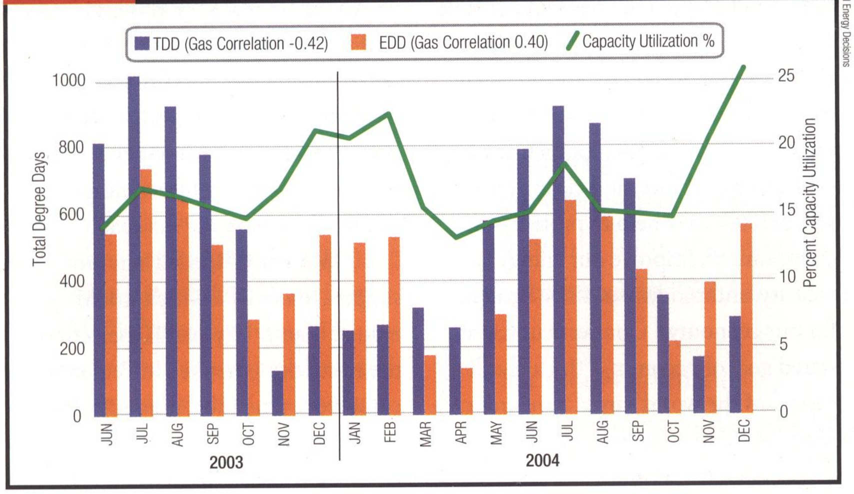


FIGURE 2 COMPARISON OF ARIZONA MONTHLY GAS CONSUMPTION AND TOTAL AND EFFECTIVE DEGREE-DAYS



Source: Global Energy Decisions

FIGURE 3 COMPARISON OF TOTAL AND EFFECTIVE DEGREE-DAYS VERSUS MONTHLY PIPELINE CAPACITY UTILIZATION



Source: Global Energy Decisions

Service is a good example of a regional utility where using 65° F as the basis for measuring heating and cooling is clearly out of step with demand. Just to the west for San Diego Gas & Electric, a neutral temperature of 65° F is about right. In the following examples, we explore how using load region EDD can improve energy market analysis.

Weather, Electricity, and Natural Gas Demand in Arizona

Using numbers from *EIA Natural Gas Monthly*, we can look at total monthly consumption of natural gas by state and compare this with both the standard definition of degree days and our EDD values for the 3-year period from 2001-2003. To illustrate the point, we have combined HDD and CDD into a single-time series of total degree-days (TDD), and the results are shown in Figure 2. The total consumption of natural gas in Arizona shows peaks of similar magnitude for both the heating and cooling seasons. The TDD plot shows an exaggerated cooling season and almost no winter increase in demand. The EDD totals more accurately reflect the aggregate consumption of natural gas by capturing the upturn in winter demand and more accurately representing the relative strengths of the heating and cooling seasons. To quantify this improvement, you can look at the change in the correlation coefficients. The weather-to-consumption correlation coefficient improves from 0.31 to 0.49 using the EDD series over the standard TDD results. As a result, a predictive model that estimates gas consumption from current weather using our EDD totals would allow one to better track the available supplies and usage.

A critical factor for some applications in understanding the regional market is timing the transition from heating to cooling season. Using operational capacity data from the El Paso Gas Pipeline for flow points in Arizona, Figure 3 shows the monthly capacity utilization percent against the same definitions of TDD and EDD. In this instance, a comparison shows a switch from a negative to a positive correlation (-0.425 to 0.401). The negative correlation for the standard degree day definition implies incorrectly that pipeline utilization decreases with extreme temperatures. By correctly matching the peaks and valleys of the capacity utilization time-series with EDD, we can see at a more localized level the impact of weather on gas demand and a more accurate representation of seasonal transitions.

We have determined that the use of EDD or a similar technique will improve weather and demand correlation in almost all energy applications. By defining the neutral heating temperature to be a fundamental property of the local temperature/demand relationship, we normalize the data in a way that improves linear analysis techniques when compared with traditional degree-day measures.

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