EXHIBIT NO. ___(JAD-1T)
DOCKET NO. UE-06___/UG-06___
2006 PSE GENERAL RATE CASE
WITNESS: DR. JEFFREY A. DUBIN

BEFORE THE
WASHINGTON UTILITIES AND TRANSPORTATION COMMISSION

WASHINGTON UTILITIES AND TRANSPORTATION COMMISSION, Complainant, v. PUGET SOUND ENERGY, INC., Respondent.	Docket No. UE-06____ Docket No. UG-06____

PREFILED DIRECT TESTIMONY (NONCONFIDENTIAL) OF DR. JEFFREY A. DUBIN ON BEHALF OF PUGET SOUND ENERGY, INC.

FEBRUARY 15, 2006

PUGET SOUND ENERGY, INC.

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DR. JEFFREY A. DUBIN

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I. INTRODUCTION

Q. Please state your name, business and address.

A. My name is Jeffrey Alan Dubin. My address is Pacific Economics Group, L.L.C. ("PEG"), 301 North Lake Avenue, Suite 330, Pasadena, California 91101.

Q. What is your position with PEG?

A. I am a Co-Founding Member of PEG.

Q. What are your duties as a member of PEG?

A. I actively consult with clients on demand issues, environmental issues, market issues, and antitrust policies, particularly as related to regulated industries. I specialize in microeconomic and micro-econometric modeling with an emphasis on limited dependent variable and demand analysis. Some of my current research topics include discrete-choice econometrics, energy economics, tax compliance, sampling and survey methods, and valuation of intangible assets.

Q. Do you hold any other positions?

A. I am a tenured Professor of Economics at the California Institute of Technology

("Caltech"). In fall of 2005 I was a Visiting Professor of Economics at Occidental College in Los Angeles and I am at present a Visiting Professor of Economics at the University of California Santa Barbara where I teach undergraduate and graduate level econometrics. I am also currently giving a lecture series on energy demand modeling and forecasting at the Donald Bren School of Environmental Science and Management.

Q. What is your educational background?

A. I received my A.B. in Economics in 1978 from the University of California, Berkeley, with highest honors and great distinction. In 1982, I received my Ph.D. in Economics from the Massachusetts Institute of Technology.

Q. Please summarize your professional experience.

A. From 1982 to 1986, I was an Assistant Professor of Economics at Caltech. In 1988, I became a tenured Associate Professor. In 2005, I assumed my current position as a tenured Professor. For the last twenty-five years, I have taught at least two courses in econometrics per year at the undergraduate or graduate level at Caltech. I regularly use econometric methods in my empirical work and frequently rely on regression techniques.

Q. Have you published any papers or articles?

A. Yes. I have published several articles on energy and environmental issues, public utility regulation, competition and antitrust. A complete listing of my publications is included in Exhibit No. ___(JAD-2).

Q. Have you ever given expert testimony in a court or administrative proceeding?

A. Yes. A list of the proceedings in which I have provided expert testimony is also included in Exhibit No. ___(JAD-2).

Q. Who retained you for this testimony?

A. I have been retained to present testimony on behalf of Puget Sound Energy, Inc. ("PSE" or "the Company").

Q. Have you previously given testimony on behalf on the Company?

A. Yes. I provided testimony on behalf of the Company in its 2004 General Rate Case on the issue of hydroelectric normalization and on the issue of forecasting natural gas prices.

Q. What have you been asked to do in this case?

A. I have been asked to review the Company's weather normalization methodology and to consider the comments and suggestions made by the Washington Utilities and Transportation Commission Staff ("Commission Staff") in the course of an ongoing collaborative regarding weather normalization methodology. I have also been asked to investigate all aspects of the weather normalization issue including data availability, appropriate methodology, economic theory, temperature measurement, and to make recommendations for changes to PSE's existing weather normalization models as necessary.

Q. What is the purpose of weather normalization in a rate case?

A. Because electricity and natural gas usage are highly dependent on the weather, weather normalization is used to estimate what electric and gas loads during a rate case test year would have been if the weather had been "normal" during that test year. A corresponding adjustment is then made to the revenues a company collected during the test year in order to better estimate the amount of revenues that the company will require during the rate year. If rates are to be set based on normalized weather, this adjustment helps keep rates from being set too high if the test year was particularly warm (resulting in test year revenues being lower than normal), and helps keep rates from being set too low if the test year was particularly cold (resulting in test year revenues being higher than normal). I describe other purposes of weather normalization calculations below.

Q. What were PSE's goals in choosing its final weather normalization models?

A. PSE attempted to construct several statistical models to answer the concerns and issues that have been raised by Commission Staff during the course of the collaborative. Additionally, PSE responded to my concerns and critiques. Our goals were to examine various statistical specifications in order to ascertain where the weather normalization method had or did not have sensitivity and to figure out what mattered and what did not matter with respect to the models or their inputs. In the end, the goal was to produce a set of models for natural gas and electric weather normalization using a consistent time period that was relevant to this proceeding, was consistent in specification, that best used the available data, and was appropriate to the temperature effects in the Company's service territory.

Q. What is your ultimate conclusion with respect to the weather normalization models that the Company has developed and applied in this case?

A. It is my opinion that the Company's weather normalization models are appropriate and sound.

Q. How is your testimony organized?

A. In Section II, I first review the suggestions and comments made by Commission Staff in the collaborative proceeding with respect to weather normalization. I also review the data that is available to conduct weather normalization studies on the PSE system and discuss the relevance of historical information to fit the relationship between load and temperature. In so doing, I explain why there is a difference between the time period one should use for fitting weather sensitivity coefficients as compared with the time period one should examine for determining normal weather. In Section II, I also return to some final issues raised by Staff which required additional empirical or theoretical analysis to answer, such as whether the sampling done by the Company was adequate or whether there was a problem with the Company's use of Seattle-Tacoma International Airport (Sea-Tac) weather information.

In Section III, I report the results of the empirical analysis I conducted in conjunction with PSE staff to explore the issues raised by Commission Staff and to explore the temperature-load relationship. In this section, I also discuss the various critiques raised by Commission Staff and how the final models answer Commission Staff's concerns while producing a set of models consistent with the goals of the Company to achieve a consistent and robust model. I then summarize the weather adjustment implied by the alternative regression specifications and explain how the final weather adjustments were made by the Company in this proceeding.

II. ISSUES RELATED TO TEMPERATURE ADJUSTMENT AND WEATHER NORMALIZATION

A. Overview Regarding Weather Normalization

Q. What is the purpose of a temperature adjustment?

A. As I stated above, electricity and natural gas usage are highly dependent on the weather. Temperature adjustment, or weather normalization, estimates electric and gas loads during a rate case test year as if the weather had been "normal" during that test year. By performing weather normalization, changes in loads over time, such as between test and rate years, can more accurately be attributed to factors other than weather, such as customer growth or changes in use per customer. Additionally, by setting rates based on normalized temperature, prices are more stable over time and more accurately reflect the costs to serve customers because they are not based merely on weather conditions that happened to prevail during a test year for a given rate case.

Q. Generally speaking, how does PSE perform its weather normalization calculation?

A. PSE first compares actual daily loads for a multi-year time period to actual daily temperatures for the same multi-year period. This permits PSE to develop coefficients that describe the relationship between temperature and load. The relationship between load and temperature on the PSE system is plainly evident for both electric and natural gas demand, as illustrated below. Multivariate regression analysis is used to isolate the incremental weather effects from other factors such as weekdays versus weekends or lower energy loads on holidays or seasonal factors not related to temperature. The estimated weather effects on load are termed "weather sensitivity coefficients."

Then, PSE uses the weather sensitivity coefficients and "normal" weather data to convert the actual test year loads to "normal" loads. PSE calculates the "normal" weather data from actual historical temperature data.

Q. Why did you state above that the relationship between load and temperature on the PSE system is plainly evident for both electric and natural gas demand?

A. In Figures 1 and 2, below, I show the Company's electric load and natural gas load versus heating and cooling degree days. Heating degree days and cooling degree days are the number of degrees difference between ambient temperature and a base level temperature. The base level temperature is supposed to approximate the outside temperature at which a person inside a house or office would need to turn on the heat or turn on a cooling system in order to remain comfortable inside. Historically, 65 degrees Fahrenheit has often been selected as that base level temperature. Heating degree days base 65 degrees are the number of degrees where the ambient temperature is colder than 65 degrees. Cooling degree days base 65 degrees are the number of degrees where the ambient temperature is warmer than 65 degrees. Larger values of heating degree days demonstrate colder temperatures for a given time period and larger values of cooling degree days demonstrate warmer temperatures for a given time period.

Figures 1 (for electric load) and Figure 2 (for gas load) demonstrate a significant correlation between temperature and electric (or natural gas) demand on the PSE system. The positive correlation between heating degree days and electric load, holding other factors constant, is a measure of the weather sensitivity coefficient and describes how load changes as temperature changes.

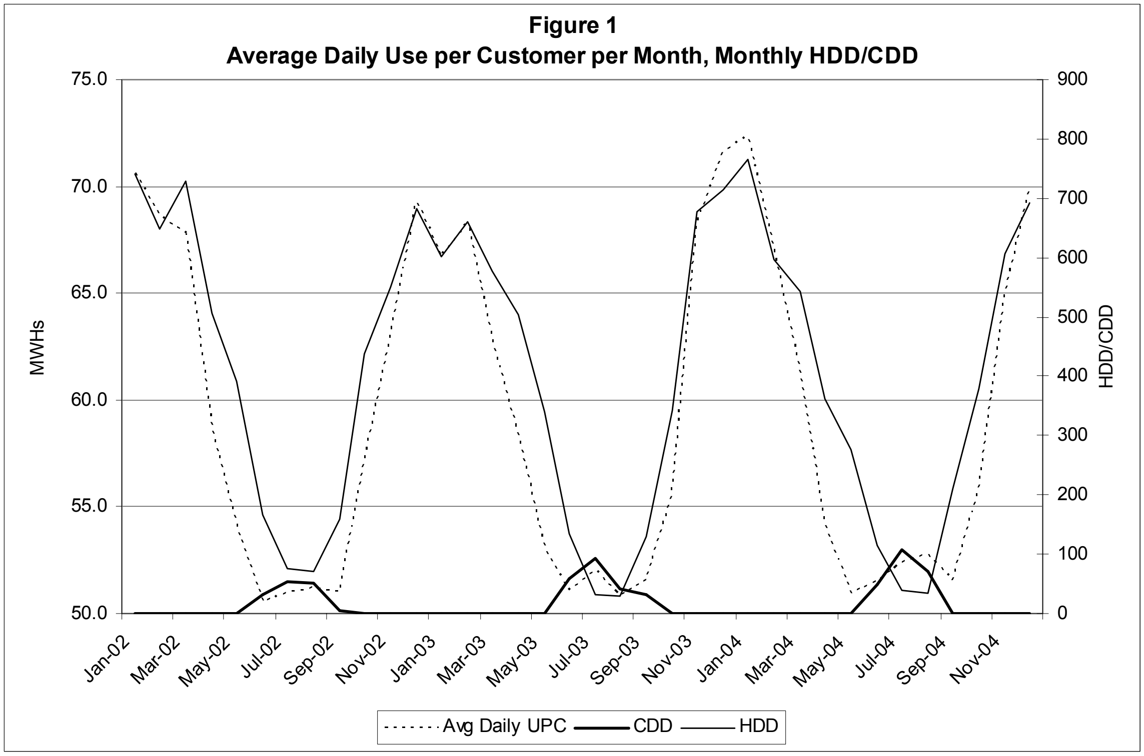


Figure 1
Average Daily Use per Customer per Month, Monthly HDD/CDD

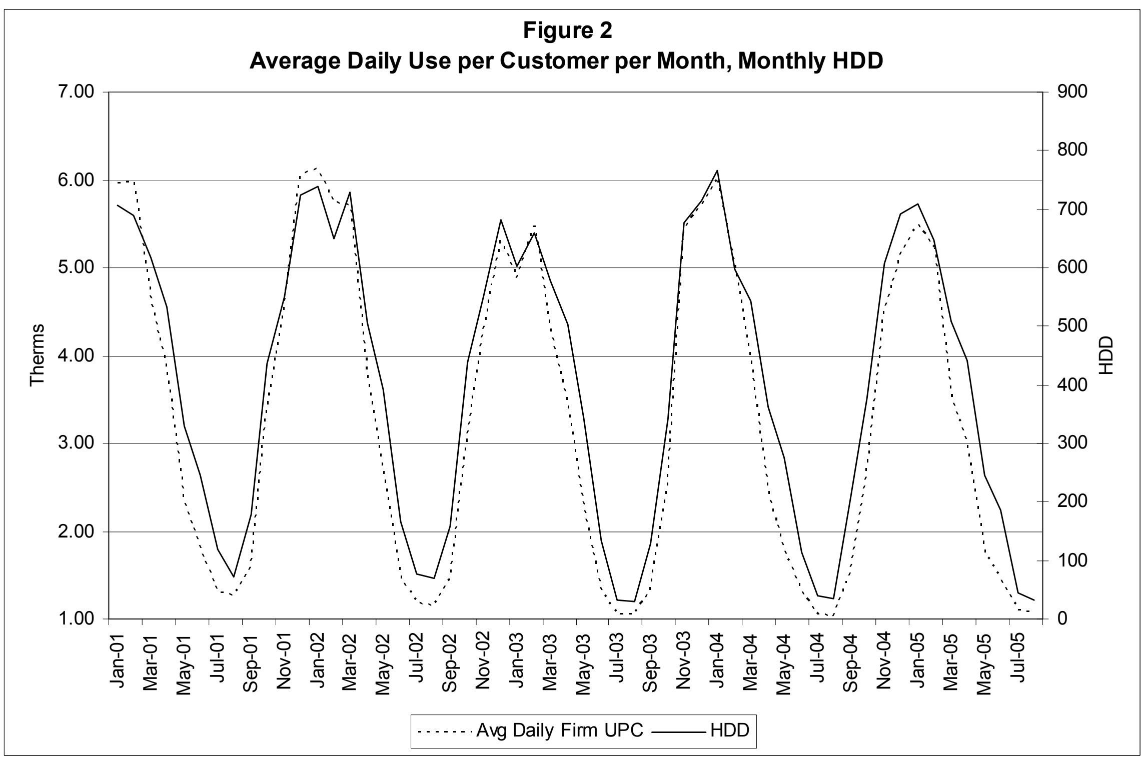


Figure 2
Average Daily Use per Customer per Month, Monthly HDD

B. Weather Normalization Disputes and the Collaborative Process

Q. How has temperature adjustment methodology been addressed in PSE's recent cases?

A. In PSE's 2003 Power Cost Only Rate Case, Docket No. UE-031725 ("2003 PCORC"), PSE and the Commission Staff concluded that the weather normalization methodology and calculations would best be refined and resolved in a collaborative discussion permitting further research and analysis, rather than in a contested adjudicative proceeding. In the meantime, PSE agreed to accept Commission Staff's weather normalization adjustment only for the purposes of the 2003 PCORC case. A stipulation outlining this agreement was accepted by the Commission in Order No. 10 in the 2003 PCORC on February 11, 2004. The collaborative was commenced but not yet concluded by the time of PSE's 2004 general rate case, Docket No. UE-040640 et al.

Q. How were temperature adjustment issues addressed in PSE's 2004 general rate case?

A. Commission Staff challenged PSE's "normal" weather dataset with respect to PSE's weather normalization for natural gas rates. Commission Staff proposed instead that gas weather normalization should be based on NOAA's "normal" weather dataset. Commission Staff did not propose any changes to PSE's electric weather normalization in the 2004 general rate case.

The Company's electric weather normalization for the 2004 general rate case also included a change from prior cases that grew out of the collaborative process. Commission Staff had recommended that PSE review customer groups beyond the residential class to ascertain whether these classes are also affected by temperature. PSE performed that analysis and, as a result, shifted a small component of the temperature adjustment to classes other than residential as part of its original rate increase request in the case. This proposal was not contested in the 2004 general rate case.

Q. How were temperature adjustment issues addressed in PSE's 2005 power cost only rate case, Docket No. UE-050870?

A. The Company's filed case utilized a revised temperature normalization methodology that incorporated some changes stemming from the collaborative but rejected using the NOAA "normal" weather dataset. The all-party agreement in that case incorporated the Company's filed weather normalization methodology, but footnote 1 to that agreement noted continuing disagreement between Commission Staff and PSE over certain aspects of weather normalization. It indicated that further attempts would be made to resolve their disputes through the collaborative process.

Q. Did you meet with Commission Staff prior to the time this case was filed to present the results of your research and investigations prior?

A. No. And as of this time, I have not had the opportunity to do so. It is my understanding that the Company will be offering to arrange a meeting between PSE, me, and Commission Staff so that Commission Staff can investigate and discuss the results presented in this testimony. In the absence of any further agreement by the Company and Commission Staff, I would recommend approval of the Company's weather normalization methodology in this case.

C. Investigation of Issues Related to PSE's Weather Normalization Methodology

Q. Would you summarize the economic and econometric issues that have been raised in previous rate cases as well as in the collaborative process?

A. Yes. In brief, Commission Staff has recommended that:

i. The weather adjustment statistical models should be based on at least ten years of data by rate schedule.

ii. When sampling methodologies are employed, sample sizes should be sufficient to do proper statistical analysis and ensure that the samples represent the population.

iii. PSE should do robust statistical analysis using, for example, auto-regressive corrections to account for correlations that occur in load in adjacent days.

iv. Factors such as price, income, seasonality, trends in housing developments, and the penetration of energy efficient appliances should be included in the models.

v. PSE's heating and cooling degree day factors should be based on NOAA data.

vi. County differences in weather in the PSE service territory should be explored.

vii. Statistical models used for weather normalization of the total system load should be consistent with the models used to allocate normalized energy to the various customer classes, between electric and gas, and between test and rate year models.

viii. Redundant variables should be eliminated.

Q. Did you review PSE's modeling methodologies and Commission Staff suggestions?

A. Yes. As described below, I reviewed the weather normalization models currently used by PSE and ascertained whether relevant data was available to conduct an econometric analysis of weather normalization for both electricity and natural gas. Based on my review and Commission Staff suggestions, I worked with PSE staff to implement a series of tests and modifications to PSE's weather normalization models.

1. Data Available for Weather Normalization Studies

Q. What data is available to PSE to conduct its weather normalization studies?

A. PSE has generally relied on daily data at the system level to estimate weather adjustment coefficients. For natural gas, daily system level information is further broken down by firm, interruptible, and transportation market segments. For electric rate schedule level weather normalization, PSE relies on data samples obtained from the Meter Data Warehouse ("MDW") of all locations with an Automatic Meter Recording ("AMR") device. These data are customer level daily data by rate schedule. In contrast, for natural gas, therms consumed by rate schedule are available only on a monthly basis.

The various data are available historically for different time periods. For instance, system level daily electric data is available for roughly the last decade. System level gas information on a daily basis is available since 1998. Rate schedule daily data for electricity is available going back to 2002 (for sampled customers), and monthly rate schedule gas information is available back to 2001.

Q. Please summarize the issues pertaining to data availability and how data availability affects the weather normalization studies.

A. At present, there is no single information source that can be used for PSE's weather normalization studies. While PSE is constrained, to a limited degree, by the availability of data, it has, in my opinion, appropriately used the available data for its weather normalization studies.

PSE uses system level daily data for both the electric and gas system weather normalization and uses the electric customer daily data to allocate the normalized loads to the weather sensitive electric rate classes. Similarly, monthly customer therm data is used to allocate the normalized loads to the weather sensitive gas customer classes. The application of these data sources is appropriate as system level normalized load is also the basis for establishing the Company's power costs.

2. Historical Data Period Used to Estimate Weather Sensitivity Effects

Q. What is the historical period of information used to calibrate the Company's weather normalization models?

A. I suggested to PSE that the Company's weather adjustment proposed in this proceeding should rely on a more recent period of historical information for system level weather normalization of electric loads even though the Company has system level daily electric data going back to 1994. The Company agreed and is using historical data for the period after 2002 for electricity. For natural gas normalization, it is using all of the monthly rate schedule gas information that is available, which goes back only to 2001. This procedure as to the electric load data deviates from the approach PSE used in the 2005 PCORC and prior general rate cases where system level information for electric normalization was employed going back to 1994.

Q. Does this procedure differ from the approach suggested by Commission Staff?

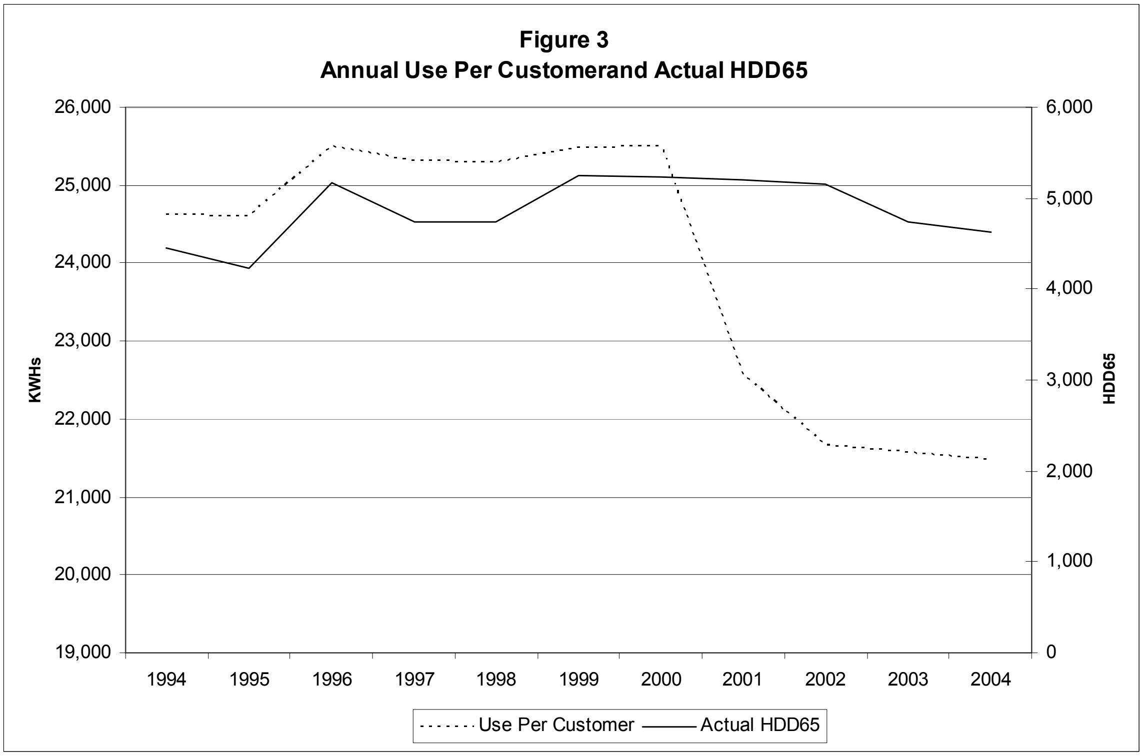
A. Yes. Staff has recommended consistency between the gas and electric models, while also recommending using at least ten years of daily information by rate schedule. This simply is not possible. While I agree with Commission Staff that it is desirable to have consistency in the models and data used for normalization across electricity and natural gas and across rate schedules, the available data does not allow this. It is simply not possible to employ 10 years of rate schedule level daily data because the data do not exist.

Q. Why did you suggest that the Company rely on more recent information?

A. It is undesirable to rely on the Company's older electric data for several reasons. The PSE electric system has undergone important structural shifts over the last decade. Some customers migrated off the system in 2001. There have also been trends in conservation, improvements in the energy efficiency of appliances, and trends in energy usage in buildings and by time of day. While, in theory, it is possible to adjust for changes that have occurred over the last decade, good measures of many of these factors are simply not available for earlier time periods. Moreover, it is important that weather normalization coefficients reflect the sensitivity of PSE system loads *as measured today* to weather, and that they do not combine the load response of the historical PSE system with the new PSE system. It is the load response of customers *today* to weather differences that we are trying to measure. The best way to do this is to favor the more recent information.

Q. Please show the evolution of the electric load per customer on the PSE system.

A. In Figure 3, I show the electric usage per customer as compared with historical heating degree days base 65 degrees. The break in 2001 is clearly evident as is the decline in usage, which is not related to changes in temperature over time.



Q. Did you conduct econometric tests for structural stability in order to verify whether or not the weather normalization relationship had changed over time?

A. Yes. Under my direction, PSE tested for structural shifts in its weather normalization using Chow-Fischer tests. Econometric tests of structural stability attempt to determine whether the regression relationship has changed over time. These tests detect changes in estimated levels of model parameters such as weather sensitivity coefficients. The Chow-Fischer F-test for structural change for the period before and after 2001 has a value of 5.9. Thus, we can reject structural stability between the pre-2001 and post-2001 periods at conventional statistical significance levels.

In other words, the relationship between electric load, temperature, and other factors is not the same on the PSE system today as it was in the past. These tests confirm that the PSE system has undergone important structural changes. Additionally, I found that the weather sensitivity coefficients were similar over time (with the exception of the December weather coefficient), but that there had been significant changes in load, seasonality, and the amount of electricity used over time.

Given the prior significance of trend and conservation factors (using additional historical data) and based on these Chow test results, it is my opinion that it is sensible and desirable to limit the data period used for weather normalization to the most recent four years of electric data (January 2002 to present). This allows a more consistent time period to be used for system level electric and natural gas models, as well as for rate schedule level allocations. Moreover, many of the issues raised by Commission Staff with respect to omitted key variables (such as changes in customer income and commodity price) are moot when more recent data for the PSE system is relied upon because it is unnecessary to introduce explanatory factors for each of the variables that have shown significant shifts over time. Nonetheless, in the empirical work, reported below, I tested for the significance of some of these factors including omitted price, income, and trend variables.

Q. Does PSE's use of system level data post 2001 (for gas) and 2002 (for electric) also extend to the period over which a "normal" weather measurement is undertaken?

A. No. The two issues are very different. "Normal" weather should be based on long-term horizons in order to measure average conditions. However, once normal weather is established and compared to the test year, the energy required to adjust the test year to the normal level of load will depend on current customer behavior, current energy efficiency levels, and current conservation levels.

3. <u>Empirical Investigations of Weather Normalization Models</u>

Q. Did you adopt the PSE weather normalization model that was offered in the 2005 PCORC?

A. No. Although my investigation began with the basic econometric model used in the 2005 PCORC, I recommended changing this model based on a series of statistical tests and refinements. The 2005 PCORC daily regression model has heating and cooling degree day measures at base 65 for each calendar month, dummy variables for day of the week, a dummy variable for holidays, dummy variables for certain outliers in 1995 and 1996, and a special treatment for Schedule 48 customers. The regression equation has a very high R-squared value (97.5%) and was estimated using daily data from 1994 through 2004.

Consequently, it explained a very significant fraction of the variation in electric load on the PSE system. Nonetheless, I undertook additional research to improve the basic PSE gas and electric models.

Q. Based on your review of PSE's methodology and existing weather normalization models, what additional tests and modifications to these models did you recommend?

A. Working with PSE personnel, I undertook a series of modifications and experiments that would simultaneously answer Commission Staff's issues and attempt to correct some possible deficiencies in PSE's methods. These changes included adding factors for price, income, customer composition, conservation changes over time, trends, seasonality, and richer weather response effects.

Q. Did these tests and modifications answer the questions and concerns posed in the collaborative?

A. Yes. As I discuss below, the alternative models answer both Commission Staff's concerns and modify the existing PSE weather normalization models to improve their treatment of weather effects. This is particularly important given that the purpose of this analysis is to provide the best possible estimate of weather normalized energy.

4. <u>Temperature-Load Relationship on the PSE System</u>

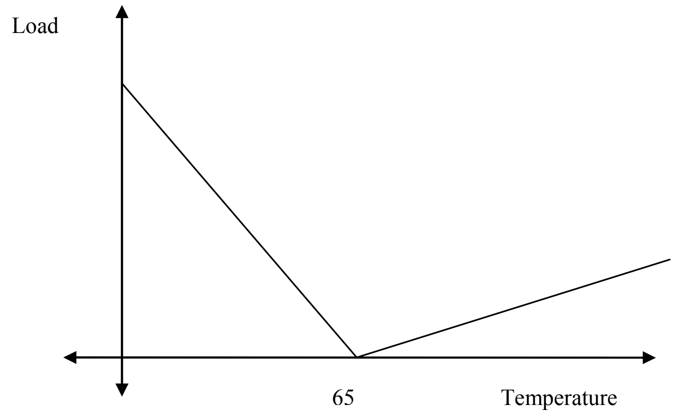
Q. What did you suggest with respect to "richer weather effects"?

A. PSE had previously employed a load regression specification in which heating degree days ("HDDs")[1] and cooling degree days ("CDDs") were defined using a constant base level temperature of 65 degrees and compared to daily electric loads. This approach is not uncommon. However, it has been recognized for some time that this specification is overly restrictive and too simplistic. For instance, Engle, Granger, Rice, and Weiss (1986)[2] discuss that electric load varies in a non-linear manner with temperature. The old method of using HDDs and CDDs based at 65 degrees in the regression assumes that the load response is essentially V shaped. This V-shaped load response is shown in Figure 4.

[1]HDDs are the number of degrees in a day in which temperature is lower than a base temperature. This measure has different implementations. If t_i, i = 1,2,…24 are hourly temperatures in a given day, then HDD may be calculated as (a) $|65 - t_{mid}|$, where $t_{mid} = (t_{low} + t_{high})/2$; or (b) $|65 - t_{ave}|$ where $t_{ave} = \frac{1}{24}\sum t_i$; or (c) $\frac{1}{24}\sum |65 - t_i|$. In principal, the various measures may differ (see e.g. H.C.S. Thom, "The Rational Relationship Between Heating Degree Days and Temperature," *Monthly Weather Review*, Vol. 82, pp. 1-6, 1954 so in the econometric analysis, reported below, I compare the alternative measures.

[2] Engle, Robert, C.W.J. Granger, John Rice, and Andrew Weiss, "Semiparametric Estimates of the Relation Between Weather and Electricity Sales," *Journal of the American Statistical Association*, Vol. 81, pp. 310-320, 1986.

Figure 4



Recall that HDDs based on 65 degrees are defined to be positive and decreasing in temperature for temperatures less than 65 degrees (i.e. HDD falls when the temperature outside rises up to 65 degrees) while CDDs based on 65 degrees are positive and increasing for temperatures over 65 degrees. Including these two measures (heating degree days base 65 degrees and cooling degree days base 65 degrees) in a load-temperature regression allows the slopes of the two segments of the V to be measured.

The slopes (or weather sensitivity coefficients) determine the degree to which load is increased (for heating) when it is colder than 65 degrees and the degree to which load is increased (for cooling) when it is warmer than 65 degrees.

The apex of the V occurs at 65 degrees while the leading and trailing segments are given by line segments with slopes estimated from the HDD and CDD (based 65) explanatory factors. In this model, the load-temperature relationship is assumed to be linear in each segment.

Q. Is there a reason to make any other assumption?

A. Engle *et. al.* and others have observed that the temperature-load relationship is non-linear. They attribute this to basic laws of thermodynamics and limitations on existing heating and cooling equipment. The non-linearity of the load response to temperature has been noted by researchers for years. For instance, the theoretical relationship between load and temperature was discussed in Dubin (1985, Chapter 2)[3]. The empirical evidence has also recently been discussed and summarized by Moral-Carcedo and Vicens-Otero (2005).[4]

Q. Do these theories have any relevance for PSE's system?

A. Non-linearity in the temperature-load relationship is present on the PSE system. I show this in Figure 5 below, which shows the average daily temperature versus electric use per customers and in Figure 6, which shows the average daily temperature versus natural gas use per customer.

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[3] Dubin, Jeffrey A. Consumer Durable Choice and the Demand for Electricity, North-Holland Elsevier Publishing Company, New York: New York, 1985.

[4] Moral-Carcedo, Julian and Jose Vicens-Otero, "Modeling the Non-Linear Response of Spanish Electricity Demand to Temperature Variations," *Energy Economics*, Vol. 27, pp. 477-494, 2005.

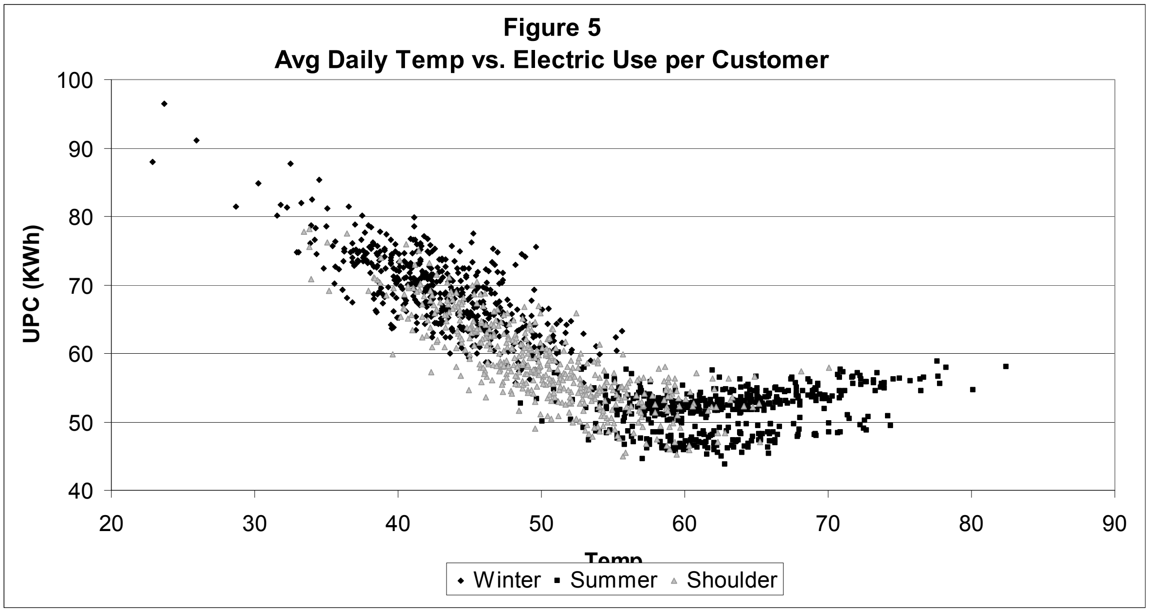


Figure 5
Avg Daily Temp vs. Electric Use per Customer

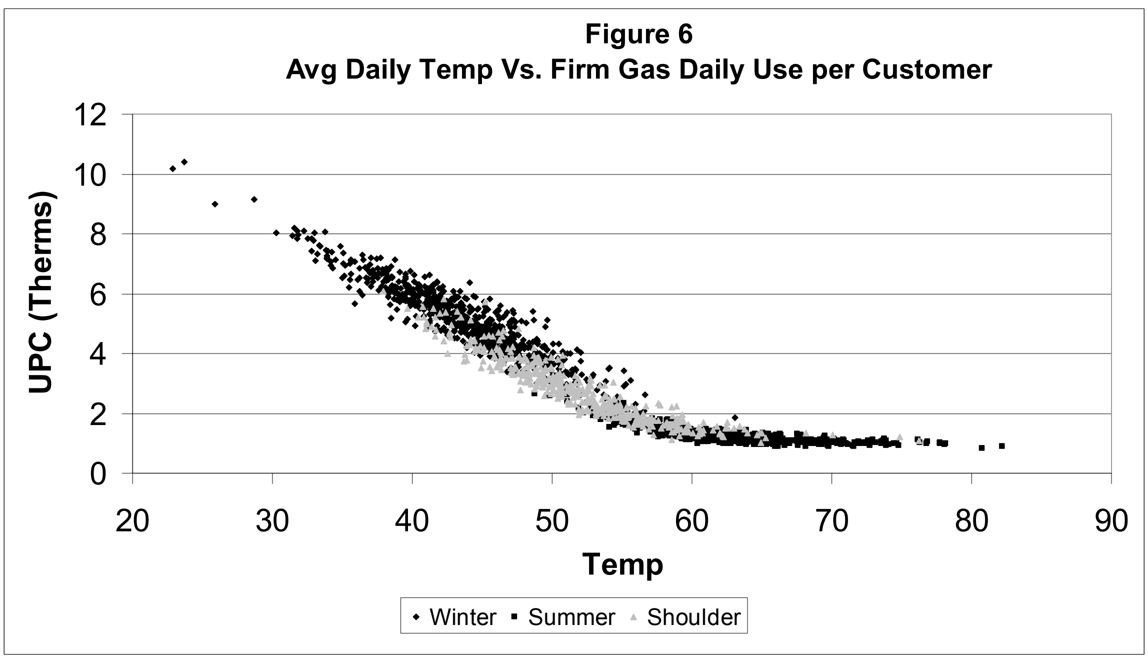
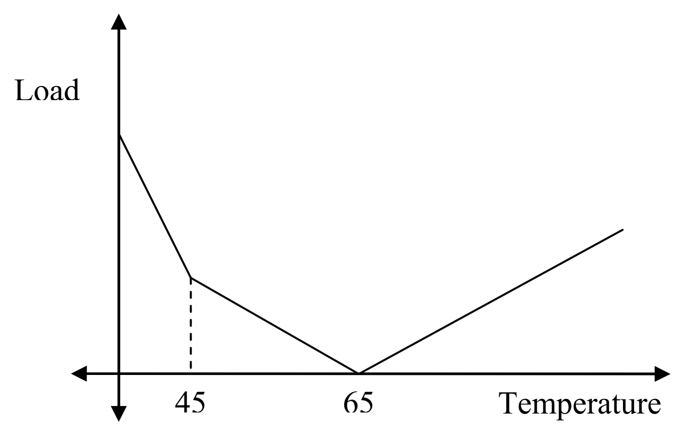


Figure 6
Avg Daily Temp Vs. Firm Gas Daily Use per Customer

While the econometric literature has developed both non-linear parametric and semi-parametric solutions to the non-linear load-temperature phenomenon, the deviations from non-linearity are usually small enough to be adequately captured by adding to the regression model additional heating and cooling degree day measures based on base temperatures other than base 65. In essence, this allows the leading and trailing edges of the V shape to reflect break points in the load response to temperature. Figure 7 shows how these adjustments affect the V-shape I discussed above. In this Figure, a breakpoint is introduced at 45 degrees so that the leading edge up to the 65 degree apex point is segmented into two sections. The two linear segments account for the non-linearity in the temperature-load relationship. Similar adjustments can be made on the cooling side if required empirically, although such adjustments do not appear to be necessary for PSE's system.

Figure 7



Q. Would you please summarize the implications for PSE's weather normalization model?

A. Recall the discussion above that the first step of weather normalization is to develop coefficients that express the relationship between temperature and the load that customers are placing on an electric or natural gas system. The analysis discussed above hypothesizes that the relationship between temperature and load on PSE's system is different for temperatures below 45 degrees than it is for temperatures between 45 degrees and 65 degrees. In my opinion, it is important to develop weather normalization coefficients that recognize these differences. The Company has done so for its weather normalization models used in this proceeding. As discussed below, our empirical analysis determined that nonlinearities in the load-temperature relationships on the PSE system are suitably modeled using heating degree days base 45 degrees, in addition to heating degree days base 65 degrees, for heating loads. Similarly, the PSE system is suitably modeled using cooling degree days base 60 degrees in addition to cooling degrees base 65 degrees for cooling loads.

5. <u>Alternative Weather Normalization Models</u>

a. <u>Overview</u>

Q. Please describe the work that PSE has undertaken to specify a weather normalization regression model.

A. After reviewing its 2005 PCORC system level regression model and Commission Staff's concerns, PSE implemented a series of modifications to its 2005 PCORC system level regression model. These modifications were made to test various hypotheses articulated by Commission Staff and to investigate the temperature-load relationship on the PSE system. Specifically, the modifications included: (i) individual days of the week were combined into a weekday versus weekend treatment; (ii) monthly dummy variables were added to the specifications to allow for seasonality in load (previously PSE's model allowed the weather affects to vary by month, but did not allow the regression intercepts to vary); (iii) price, income, and trend variables were added to the model; (iv) equations were developed for individual months; (v) explanatory variables were added for estimated conservation savings; (vi) explanatory variables were added for residential and commercial customer mix; (vii) a HDD measures based on the average of actual hourly heating degrees or based on the average of minimum and maximum daily temperatures were added (PSE measures HDD using daily 24-hour average temperature); and (viii) additional HDD and CDD measures were added to the models to account for temperature non-linearities. These models are summarized in Table 1 below. The electric regressions themselves are presented in Exhibit No. ___(JAD-3).

TABLE 1

Equation Descriptions (all eqtns w/ AR(1))	HDD/CDD	Monthly Intercept	Day Types	Holiday	Non-Weather Variables	Sched48 Dummy	Outlier Dummies	HDD/CDD Diff Between PSE & NOAA
	Variables in the Equation							
2005PCORC: 10 yrs data	PSE HDD65/CDD65	No	Sun-Sat	Yes	No	Yes	Yes	No
ElecEQ1: 3 yrs data	PSE HDD65/CDD65	No	Sun-Sat	Yes	No	No	No	No
ElecEQ2	PSE HDD65/CDD65	Yes	WkDay/WkEnd	Yes	No	No	No	No
ElecEQ3	PSE HDD65/CDD65	Yes	WkDay/WkEnd	Yes	Trend, Income, Avg Rate	No	No	No
ElecEQ4	PSE HDD65/CDD65	Yes	WkDay/WkEnd	Yes	Trend, Income, Avg Rate	No	No	No
ElecEQ5-Monthly	PSE HDD65/CDD65	Yes	No	No	No	No	No	Yes
ElecEQ6	NOAA HDD65/CDD65	Yes	WkDay/WkEnd	Yes	Trend, Income, Avg Rate	No	No	No
ElecEQ7	PSE HDD65/CDD65	Yes	WkDay/WkEnd	Yes	Res/Comml Cust Share	No	No	No
ElecEQ8	PSE HDD65/CDD65	Yes	WkDay/WkEnd	Yes	Conserv Savings per Customer	No	No	No
ElecEQ9	Alternative HDD65/CDD65	Yes	WkDay/WkEnd	Yes	No	No	No	No
ElecEQ10	PSE HDD65/CDD65/HDD45/CDD	Yes	WkDay/WkEnd	Yes	No	No	No	No

Q. What did you learn from these alternative specifications?

A. These models help explain and answer many of Staff's concerns, which I list here.

- First, the R-squared measures in these regressions continue to be quite high, with over 97% of the variation in load accounted for by the regression model.
- Second, monthly dummy variables to control for seasonality are statistically significant and should be included in the weather normalization models.
- Third, there is no loss in explanatory power caused by simplifying the days of the week into a weekday versus weekend treatment.
- Fourth, trend, income, and price effects are statistically insignificant in the weather normalization models when estimated over the 2002 through 2005 period.
- Fifth, there are minor deviations in the estimated weather sensitivity coefficients when using NOAA or PSE's measures of heating and cooling degree days so that using measures of heating degree or cooling degree days constructed by the Company from hourly data at Sea-Tac is not an important influence on the weather sensitivity coefficients compared to using NOAA estimated heating and cooling degree days.
- Sixth, variables added to account for customer mix changes or conservation changes are not statistically significant factors in the 2002 through 2005 estimation period.
- Seventh, alternative definitions of heating and cooling degree days produce similar weather sensitivity coefficients.
- Eighth, weather effects measured at base 45 for heating and base 60 for cooling are important to capture the non-linearity in temperature response on the PSE system.

Q. How do these results answer the questions posed in the collaborative?

A. Commission Staff had many concerns. Implicitly, Commission Staff was concerned that if important variables are omitted from the weather normalization regressions, the weather sensitivity coefficients could be measured with bias.[5] Many of Commission Staff's concerns implicitly arose because the Company used a long estimation period during which many factors on the PSE system changed. During the collaborative process, PSE attempted to collect information to capture some of these factors such as average rates, income levels, and other variables that are important to consider over longer estimation periods. Indeed, economic theory dictates that consumers respond to both price and income levels in determining demand. Higher real energy prices should curtail demand to some degree, while larger real incomes should increase demand. More efficient housing stock and conservation should help curtail demand as less energy is required to make up a given indoor versus outdoor temperature differential. These are effects we would expect to see over longer term horizons where there is significant variation in these underlying factors.

b. The Effect of Price and Income Factors

Q. Did PSE's previous investigations find that price and income were important determinants of load?

A. No. The pattern of results for price and income effects using a longer time period

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[5] The technical condition under which this could occur requires correlation between the omitted and included variables that may or may not be plausible in this case. For instance, excluding income from the regression model may not lead to bias in weather sensitivity measurement if income is not correlated with ambient temperature – which is presumably correct. In any case, the issues are generally mooted using the shorter estimation period.

were generally anomalous. Regression models including these factors (and estimated over a ten year period) found that price and income had perverse effects on demand. As price increased, demand grew, and as income increased, demand fell. However, I don't find these results too surprising in this context. First, in cases where the R-squared is very high, linear regression models may exhibit non-intuitive behavior when an additional factor is included in the model. This occurs because the regression attempts to use the additional factor to further raise the fit in a manner that may not be consistent with the bulk of the data or with economic theory.

Second, price and income variables appear with non-intuitive signs in some of these models due to, in part, the large multi-collinearity and the attempt to include monthly price and income measures in a daily regression model. Using a shorter time period for estimation is both relevant to the inquiry at hand, and results in a specification in which price, income, and trend factors are statistically insignificant. This is what we should expect when modeling the weather normalization load relationship using a shorter time interval in which price, income, and other variables are nearly constant.

To consistently measure price and income effects requires a longer time horizon and an appropriate aggregation level. Such an econometric model, along these lines, might use ten years of monthly data, for instance, but would not be appropriate for weather normalization in this proceeding.

c. **Weather Stations**

Q. Turning to other issues raised by Staff in the collaborative, what did you conclude with respect to which weather stations should be used?

A. My review of PSE's data revealed limited data currently available that would allow weather normalization analysis to be conducted on a regional basis. Preliminary research conducted by PSE (using billed sales data by county) suggests that, with minor exceptions, weather normalization coefficients do not vary significantly by county. Further, using a single weather station to weather adjust loads is appropriate because of the high correlation of weather patterns in the region. Regional temperatures are generally correlated with Sea-Tac temperatures with correlation coefficients over 0.97. Even though temperatures may be slightly colder or warmer in one region of PSE's service area versus another region, the trend in weather and usage in the regions is similar.

In addition, using the data from the weather station at Sea-Tac is appropriate because it is a "first-order" station with the most complete and accurate data. In contrast, other regional weather stations have missing data or experience technical issues from time to time that make their data less reliable for use in comparing temperatures on a daily basis over time.

d. Sampling Issues

Q. What did you conclude with respect to whether the samples used to develop electric rate schedule weather adjustments accurately represent PSE's customer population?

A. I reviewed the sampling methodology employed by PSE. The Company sampled at least 2,500 customers from each rate class, or 100 percent of customers in a rate class when there were fewer than 2,500 customers. Based on statistical comparisons, PSE found that the samples used to develop rate schedule weather adjustments are representative of their populations for the majority of rate schedules. Thus, I conclude that the samples employed for rate schedule normalization are adequate for this purpose.

e. Miscellaneous Modeling Issues

Q. Have you addressed other issues raised by Commission Staff?

A. Yes. Following Commission Staff's recommendations, I agree that PSE should continue to employ auto-regressive corrections in all its models in order to achieve robust and efficient parameter estimates. I also verified that there were no redundant variables in the regression models.

6. PSE's Weather Normals Versus NOAA's Weather Normals

Q. How are weather normals defined by NOAA?

A. NOAA defines a weather normal as the mean of a climatological factor (temperature, degree days, precipitation, etc.) computed over three decades. This differs slightly from the World Meteorological Organization definition, which is based on "period averages for a uniform and relatively long period comprising at least three consecutive periods."[6] According to NOAA, the record upon which the normal is based should be consistent, but if no significant exposure changes have occurred (no changes in location, instruments, observation practices, etc.), then a simple average is used to calculate the normal.[7]

Q. Why are weather normals based on 30 years?

A. According to Guttman (1989), long-term averages were assumed to converge to a stable or normal level. The doctrine gradually developed that climate is essentially constant during intervals that are long compared to human experience. International agreements eventually lead to the notion that 30 years would be appropriate for determining normal weather. Additionally, every 30 years, the international meteorological community meets to summarize the normal climate

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[6] See e.g. Nathaniel Guttman, "Statistical Descriptors of Climate," Bulletin of the American Meteorological Society," Vol. 70, pp. 602-607, 1989.

[7] http://lwf.ncdc.noaa.gov/oa/climate/normals/usnormalshist.html.

for all nations.[8]

Q. Does PSE rely on NOAA for *daily* weather normals, such as the heating degree days for a particular day in 2003, as inputs to the weather normalization regression models?

A. No. The Company relies on Sea-Tac temperatures reported on an *hourly* basis. These are exactly the same measurements that NOAA uses in calculating actual heating and cooling degrees days. However, NOAA's approach for daily normal values is much less direct.

First, NOAA's method does not calculate daily normals from daily data. Instead, NOAA's method first focuses on monthly normal heating degree days. Specifically, sequential monthly degree days are derived using procedures developed by Thom (1954, 1966)[9]. This technique utilizes the historical monthly average temperature and its corresponding standard deviation to compute monthly degree days.[10] Then, NOAA daily normals are derived by statistically fitting smooth curves through monthly values; daily data are ***not*** used to compute daily normals.[11] Apparently, NOAA has modified this procedure for the recent 1971-2000 normal period, and now uses a method nearly identical to that used by PSE: "For first-order stations, where daily data sets are largely devoid of missing

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[8] http://lwf.ncdc.noaa.gov/oa/climate/normals/usnormalshist.html#wmo.

[9] Thom, H.C.S. "The Rational Relationship Between Heating Degree Days and Temperature", Monthly Weather Review, Vol. 82, pp. 1-6, 1954.:Thom, H.C.S. "Normal Degree Days Above Any Base By the Universal Truncation Coefficient", Monthly Weather Review, Vol. 94, pp. 461-465, 1966.

[10] http://lwf.ncdc.noaa.gov/oa/climate/normals/usnormalsprods.html#CLIM85.

values, monthly degree day totals were derived directly from daily values."[12] Thus, for actual heating and cooling degree days on a daily basis (used in the weather normalization models), there should be little difference between PSE's measures and NOAA's in terms of the estimated effects of HDDs on loads. This is generally the result we found when employing alternative definitions of heating and cooling degree days in the regression models.

Q. Do PSE's time-period and NOAA's time period for calculating weather normals differ?

A. Yes. PSE's 30-year period is consistent with the definitions adopted by the World Meteorological Organization ("WMO") as they pertain to 30-year contiguous time-periods. The 30-year period PSE relies on is the most recent 30 year period available. NOAA calculates weather normals on a decennial basis; that is, it updates its information every ten years at the end of each decade. NOAA does not update its information more frequently. However, PSE's definition of normal weather is perfectly consistent with NOAA and the WMO in all other respects.

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[11] http://lwf.ncdc.noaa.gov/oa/climate/normals/usnormalsprods.html#CLIM85.
[12] http://www.ncdc.noaa.gov/oa/climate/normals/usnormals.html#Overview

Q. Should NOAA's 30-year normal dataset be used to develop PSE's electric and natural gas rates?

A. No. First, PSE's 30-year average values appropriately retain the daily granularity of the underlying weather data. Recall that PSE's 30-year average relies on over thirty years of 24 hourly temperatures per day. Calculating a weather normal should parallel and be consistent with the explanatory variable constructed and employed in the regression model when determining weather sensitivity coefficients.

Second, NOAA does not calculate daily normal temperature at bases other than 65 degrees. As described above, my analysis and the econometric literature both suggest that temperatures at bases other than 65 degrees are important in weather normalization. PSE's weather normalization model presented in this case uses actual temperatures at Sea-Tac to calculate historical normals at various bases (specifically heating degree days base 45 degrees and cooling degree days base 60 degrees in addition to the base 65 degree measures) to weather adjust the test year to normal conditions.

Third, the NOAA normal dataset is only updated every ten years. Utilizing this data would result in a weather adjustment that is not well correlated to energy usage behavior the further the test year moves away from the period used by NOAA to define normal weather (for example, the effect of cyclical climate changes). It could also result in significant changes in rates when a new ten-year increment is added to the NOAA data. In contrast, PSE's method uses readily available updated weather data. In addition, by updating the dataset to the most recent 30-year period each time it files a rate case, PSE's method will result in more gradual rate changes related to weather normalization if the climate is changing over time.

Fourth, I have reviewed PSE's database for calculating weather normals. It is simple to use or modify and is completely transparent.

Finally, I determined that the regression sensitivity coefficients were not significantly affected by using NOAA weather measures in the regression model.

Q. Would you please summarize the results of your investigation of the Company's calculation of "normal" weather?

A. The Company's procedure for determining normal weather as presented in this case is not complicated, is easily verified, and is easily modified. Importantly, the Company's construction of weather normals allows daily normal weather to be calculated using alternative base temperatures and is, therefore, better matched to explanatory weather factors used in the electric and natural gas weather models than if the Company used the NOAA normal weather dataset.

III. DEVELOPMENT OF REVISED PSE WEATHER NORMALIZATION MODELS

Q. What was the next step in your work?

A. After I investigated the various issues described above, a question still remained: which of the many variations of weather normalization models we had tested should be ultimately selected for use in a rate case?

A. <u>The Final Electric Model</u>

Q. How did you and PSE go about selecting the final electric weather normalization model?

A. In the end, it was not terribly difficult to select the final model that should be used for the electric weather normalization adjustments because the alternative electric weather normalization models implied a similar degree of weather normalization. Table 2 summarizes the weather normalization resulting from the alternative regression models summarized in Table 1, above. While these alternative regression models considered a range of alternative theories, measures of temperature, and various economic effects, they produced a similar degree of normalization.

TABLE 2

Model Equations (all eqtns w/ AR(1))	Estimation Period	MWH Adjustment
2005PCORC	1/1/94-12/31/04	129,654
ElecEQ1	1/1/02-12/31/04	125,989
ElecEQ2	1/1/02-12/31/04	131,970
ElecEQ3	1/1/02-12/31/04	131,338
ElecEQ4	1/1/02-12/31/04	131,738
ElecEQ5	1/1/02-12/31/04	135,158
ElecEQ6	1/1/02-12/31/04	128,121
ElecEQ7	1/1/02-12/31/04	130,926
ElecEQ8	1/1/02-12/31/04	131,543
ElecEQ9	1/1/02-12/31/04	139,681
ElecEQ10	1/1/02-12/31/04	145,418

Q. What do you conclude from this analysis?

A. I conclude, generally, that limiting the time-period to the post 2002 period obviated the need for special variables to control for trend, price, income, conservation, and other previously omitted factors. In other words, these affects tended to be relatively unimportant or insignificant determinants of load in the post 2002 period, whereas they clearly were showing significant trends (albeit not always in sensible directions) using the earlier data available from 1994 through 2001. Similarly, it was no longer necessary to treat the Schedule 48 customers differently from other customers as they had already migrated off system by 2002 (recall that Schedule 48 customers switched to transportation schedules prior to 2002). Finally, the seasonality factors were statistically significant, as were the separate weather effects: HDDs base 45 degrees and CDDs base 60 were statistically significant as were the heating and cooling degrees at base 65 in the load-temperature regression model. Therefore, seasonality and non-linearity were important effects missing from the electric weather normalization model used for the 2005 PCORC

Q. What was the range of weather normalization implied by the alternative regression models you considered?

A. For a comparison, I calculated the weather normalization at the system level in megawatt-hours. As the test year was warmer than normal, the weather normalization results in positive adjustments to the observed test year loads. The range of implied adjustments was between 130,000 MWHs and 145,000 MWHs with the low end of the range based on the Company's specification used in the 2005 PCORC and the high end of the range based on my preferred specification, which includes multiple weather explanatory variables and seasonal indicators. I show this in Table 3 below. The selected model is highlighted.

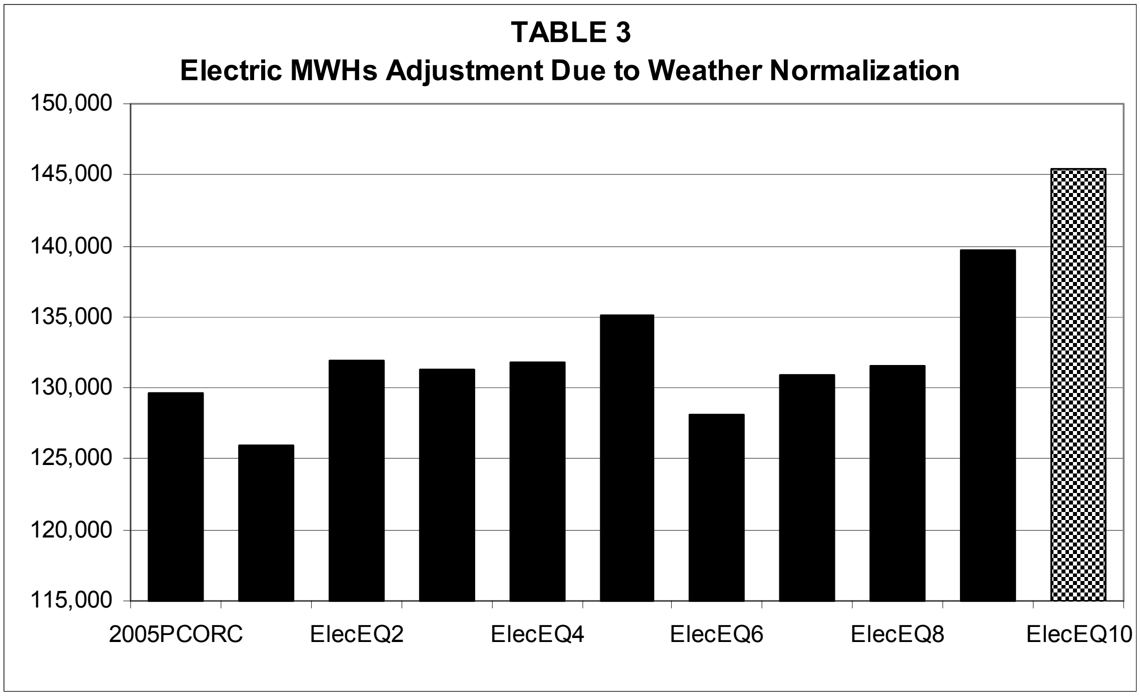


TABLE 3
Electric MWHs Adjustment Due to Weather Normalization

Q. Does the Company's allocation of the temperature adjustment among electric rate classes, in this case, follow the same allocation with respect to residential and non-residential classes as presented in the 2004 general rate case?

A. Yes.

B. <u>The Final Gas Model</u>

Q. Did PSE's natural gas weather normalization models also change as a result of your research with the Company?

A. Yes. I had PSE estimate alternative system level natural gas regression models to include seasonal effects, customer composition variables, trends, and weather effects measured using multiple degree day measures. I show these below in Table 4.

TABLE 4

Equation Description (all eqtns w/ AR(1))	Variables in the Equation: HDD	Monthly Intercept	Day Types	Holiday	Non-Weather Variables	Outlier Dummies
GasEQ1	PSE HDD65	No	WkDay/WkEnd	Yes	Trend	Winter
GasEQ2	PSE HDD65	Yes	WkDay/WkEnd	Yes	Trend	No
GasEQ3	PSE HDD65	Yes	WkDay/WkEnd	Yes	Trend, Income, Avg Rate,	No
GasEQ4	PSE HDD65	Yes	WkDay/WkEnd	Yes	Trend, Res/Comml Cust	No
GasEQ5	PSE HDD65	Yes	WkDay/WkEnd	Yes	Trend	No
GasEQ6	NOAA HDD65	Yes	WkDay/WkEnd	Yes	Trend	No
GasEQ7	Alternative HDD65	Yes	WkDay/WkEnd	Yes	Trend	No
GasEQ8-Monthly	PSE HDD65	Yes	WkDay/WkEnd	No	No	No
GasEQ9	PSE HDD65/HDD45	No	WkDay/WkEnd	Yes	Trend	No
GasEQ10	PSE HDD65/HDD45	Yes	WkDay/WkEnd	Yes	Trend	No
GasEQ11	PSE HDD65/HDD45	Yes	WkDay/WkEnd	Yes	Trend, Income, Avg Rate,	No
GasEQ12	PSE HDD65/HDD45	Yes	WkDay/WkEnd	Yes	Trend, Res/Comml Cust	No

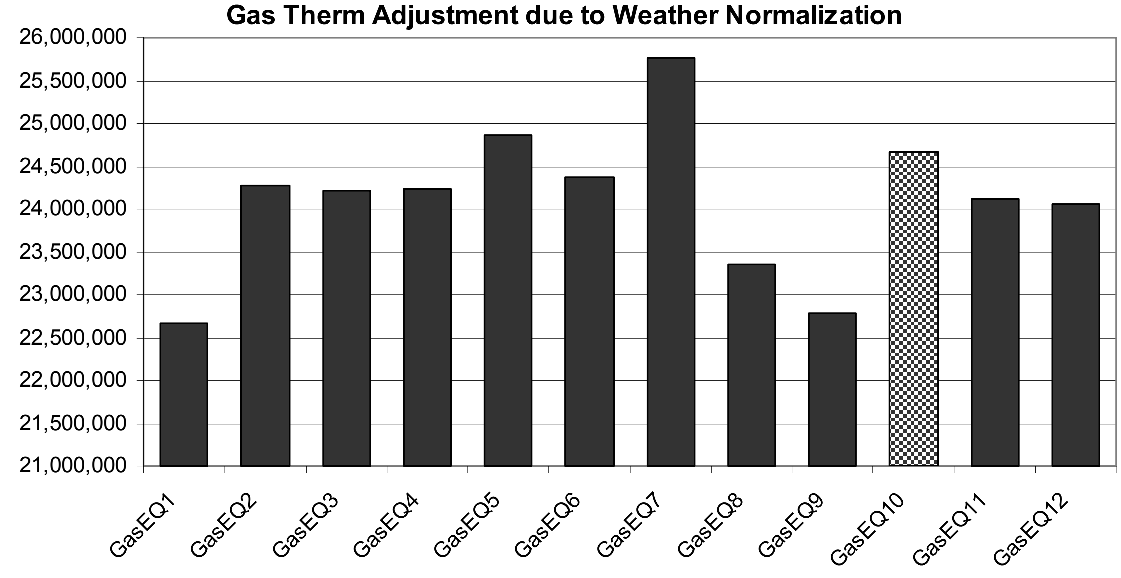
Note: GasEQ9 to GasEQ12 apply only to firm classes, not to the interruptible and transportation clas

Generally, I attempted econometric specifications that paralleled the models used in the electricity analysis. The resulting natural gas weather normalization models varied little in terms of implied weather adjustment. The majority of the weather effects were localized to the firm demand models, with interruptible and transportation showing little weather sensitivity. The range of total adjustment for weather normalization across firm, interruptible, and transportation ranged from about 22,500,000 therms to about 25,500,000 therms. I show this below in Tables 5 and 6. The detailed regressions are reported in Exhibit No. ___(JAD-4).

Model Equations (all eqtns w/ AR(1))	Firm	Interruptible	Transport	Total
GasEQ1	20,664,304	1,021,902	975,904	22,662,110
GasEQ2	22,179,645	1,082,222	1,007,541	24,269,407
GasEQ3	22,191,579	1,083,317	944,042	24,218,937
GasEQ4	22,215,109	1,092,916	921,422	24,229,447
GasEQ5	22,700,190	1,128,203	1,025,297	24,853,690
GasEQ6	22,288,036	1,107,141	967,948	24,363,126
GasEQ7	23,672,786	1,123,216	965,618	25,761,620
GasEQ8	21,512,278	961,388	888,562	23,362,227
GasEQ9	20,696,474	1,082,222	1,007,541	22,786,237
GasEQ10	22,579,456	1,082,222	1,007,541	24,669,218
GasEQ11	22,026,675	1,082,222	1,007,541	24,116,438
GasEQ12	21,962,495	1,082,222	1,007,541	24,052,258

TABLE 5

TABLE 6
Gas Therm Adjustment due to Weather Normalization



The preferred specification had an implied normalization of slightly more than 24,500,000 therms. In this case, the low end of the range corresponded to the model from the 2004 general rate case, while the high end of the range came from experimenting with the method by which HDDs and CDDs were calculated.

Q. Which model did you conclude should be used?

A. I recommended that PSE adopt a model with an implied adjustment near the highest end of the range -- "GasEQ10" -- because it is the best model for accounting for the same issues encountered in the electric normalization model (*i.e.,* non-linear load and weather relationship, seasonality, and varying weather effects by month). Again, this model is highlighted in Table 6.

Q. Does the Company's allocation of the temperature adjustment among natural gas rate classes, in this case, follow the same allocation with respect to residential and non-residential classes as presented in the 2004 general rate case?

A. No. There were several modifications to the prior procedure.

- For gas rate schedule allocation, the Company made changes to the weather normalization process to make the analysis more consistent with the weather normalization of electric loads.
- The Company used longer historical monthly data (2001 through mid 2005), consistent with the electric rate schedule historical period, to develop the econometric equations it used to estimate weather normalized volumes at the rate schedule level. Previously, the Company had only used test year data.
- The Company defined normal weather using the Company's 30-year average of HDD, consistent with the normal weather data set used for the electric weather normalization. In the past the Company used a 20-year average with the coldest and warmest years removed, which was effectively an 18 year average.

- The econometric equations used to estimate the effect of weather on gas consumption at the rate schedule level account for different weather adjustment by month, monthly effects not related to temperature, and auto-regressive corrections. In prior rate cases, the equations did not consider these effects.

- PSE also examined monthly usage patterns of all of the Company's gas rate classes to identify which classes are weather sensitive. As a result of this analysis, the Company expanded weather normalization to some rate classes that had not been weather adjusted in previous rate cases. The added rate schedules were 85 commercial (interruptible), 87 commercial (non-exclusive interruptible), 57 commercial (transportation), and one contract customer.

- The Company also weatherized total gas send-out. The Company allocated this system level adjustment to rate classes based on the rate class level analysis. This approach is now more consistent with the electric normalization procedure.

C. The Final Weather Normalization Calculations

Q. Please describe how the Company normalized the test year delivered load in this case.

A. As described above, PSE used weather sensitivity coefficients based on actual daily load data and actual Sea-Tac temperature. PSE's "normal" weather dataset was developed by calculating daily HDDs and CDDs using several base temperatures (as reported at Sea-Tac) over the 30-year period from 1975 through 2004. The actual HDDs and CDDs were calculated using the average of the 24 hourly temperatures compared against the base temperature. (Weather adjustments using the average of all hourly HDDs or CDDs by hour produced similar results). The amount of weather adjustment was calculated by taking the weather sensitivity coefficients and multiplying it by the difference between the actual and normal HDDs and CDDs. This process was done for each base HDD or CDD that appeared in the model.

Q. How did the Company use temperature normalized GPI electric load to calculate the load adjustment that should be made to various customer classes (rate schedules) related to weather effects?

A. PSE made these adjustments for electric in a three-step process. The first step was to develop linear regression equations to characterize the relationship between temperature and load for each rate schedule. The coefficients of those equations were permitted to vary by month and by class. The data source for this step was a large sample of daily energy readings from PSE's AMR database. The second step was to simulate daily customer loads using the historical heating and cooling degree days and determine the average monthly load for each customer class. The third step was to weight the sample to the population and normalize the class loads to the net-of-losses weather-normalized GPI load. The amount of weather adjustment at the GPI level was allocated to each of the applicable schedules by taking the percentage share of each schedule's weather adjustment amount to total weather adjustment for all schedules as calculated by the rate schedule normalization equations, and then multiplying the system load temperature adjustment by these percentage shares.

Q. What were the results of this process?

A. The test year Generated, Purchased and Interchange ("GPI") electric load of 21,613,588 MWhs was normalized using equation "ElecEQ10", presented above, to reflect normal temperature. Applying this process to the test year resulted in a total adjustment of 145,418 MWhs, or 135,823 MWh delivered load when adjusted for losses. As the test year was warmer than normal, this adjustment adds MWhs to the actual load.

For natural gas, actual energy in the test year was 1,013,781,683 therms. This amount was weather normalized using equation "GasEQ10" presented above. The weather adjustment was estimated to be 24,669,218 therms, net of losses. This amount is again added to the test year system load as the test year was warmer than normal. The adjustments (net of losses) are 0.67% and 2.43% of system load for electricity and natural gas, respectively.

With regard to rate schedule normalization, the allocation of normalized electric load applies roughly 82% of the normalization to residential service (Schedule 7 customers). For the natural gas weather normalization, residential customers are allocated approximately 60% of the total weather adjustment and firm demand (residential, general service-commercial, and subtotal commercial heavy) receives about 90% of the total adjustment.

IV. CONCLUSIONS

Q. Please review the suggestions made in the collaborative or prior rate cases and your conclusions with respect to these issues?

A. First, a preference has been expressed for consistency in the weather normalization models, with modeling done at the rate schedule level using at least ten years of data. I conclude that this is neither possible nor desirable. The PSE system has undergone important structural shifts over time and it is the weather response of the system today that is required to calculate a weather normalization adjustment, not the weather response for the PSE system of ten years ago. It is possible to have consistency in the econometric models and rely on recent data (2002 to present) while avoiding issues of omitted factors that arise when attempting to use ten years of historical data.

Second, a question has arisen as to whether PSE's samples are representative of the population. Sampling is only applied in the context of weather normalization to estimate rate schedule allocation models. These data are sampled because they are customer specific. However, the sample's sizes are more than adequate and the resulting samples represent the PSE population.

Third, the suggestion has been made that PSE should employ robust statistical methods. I agree with this point and PSE's models continue to employ appropriate auto-regressive corrections.

Fourth, an issue of missing data factors was raised. I have found that this issue is relevant over a longer term estimation period, but is moot in a shorter term period. It is correct to assert that factors such as price, income, trend, and conservation may have important influences in the weather normalization regression models if they are not accounted for. However, these factors were not statistically significant in the 2002-2005 estimation period. Further, they did not produce economically reasonable results when considered over long-term estimation periods. However, one important aspect of this discussion raised by Commission Staff is the issue of seasonality. PSE's models now incorporate monthly dummy variables to track the seasonality that apparently occurs on the system beyond the obvious seasonality in weather itself.

Fifth, a question has been raised as to whether heating and cooling degree measures should be based on NOAA data. Using NOAA or PSE heating degree day data produced very similar weather sensitivity coefficients. Using NOAA data would, however, result in a stale estimate of "normal" temperature. Additionally, the heating degree day measures calculated by PSE are based on NOAA temperature information from a NOAA first-order temperature station at Sea-Tac airport. PSE calculates weather normals based on the most current 30-year period of temperature data. For these reasons, I believe that PSE's procedure is appropriate.

Sixth, there is a question as to whether county differences in weather exist on the PSE system and should be accounted for. Our empirical investigation found that there was a very high degree of correlation of the various counties to Sea-Tac temperatures. Additionally, there was little ability to incorporate this information because system level load data was not available at the county level.

Finally, a preference has been stated for a consistent modeling approach between rate schedule and system normalization. However, other than AMR data, it is not possible to perfectly achieve this consistency as rate schedule data is generally customer specific rather than system wide or exists at a different level of periodicity (monthly data is available by natural gas rate schedule and daily therm data does not currently exist). I agree that consistency in the models is desirable to the extent the data permit it, and I have selected specifications for electric and natural gas models to achieve this consistency.

In sum, I have examined and considered the issues raised and suggestions made in the collaborative. These suggestions have resulted in a revised set of temperature adjustment normalization models for PSE that answer these various issues.

Q. Please summarize the other modifications PSE made to its weather normalization models.

A. The primary improvement in the weather normalization models was to account for non-linearity in the load-temperature relationship that is present on the PSE system. PSE's previous models assumed a linear relationship between load and temperature. However, the economic literature has recognized that this relationship is generally non-linear. My work with PSE verified the non-linearity and has introduced additional heating and cooling degree day measures to reflect this non-linearity on the PSE system. This change is important as it allows the econometric models for electricity and natural gas to more accurately reflect the relationship of load to temperature.

Additionally, PSE's models now rely on more recent data for calibrating its electric weather normalization model which is consistent with the time frame used for natural gas and consistent with the time frame used for rate schedule allocation. Using more recent data is desirable given the important structural shifts which have occurred on the PSE system. This obviates the need to collect and possibly include various controlling factors that have affected load over the last ten-years (Schedule 48 customers for instance).

Q. Please summarize your conclusions.

A. I have reviewed PSE's data sources and weather normalization methodologies. I have also fully considered the suggestions made by Commission Staff during the collaborative process. I produced a set of normalization specifications that were robust across specifications, while using the available data in a manner that was consistent across electricity and natural gas and consistent in the time period employed. The resulting specifications answer Commission Staff's concerns, my concerns, and are robust to adding or deleting factors. These models do not produce the most favorable financial outcome for PSE, but I believe they are appropriate for the weather normalization adjustments required in this case.

Q. Does this conclude your testimony?

A. Yes, it does.

[BA060420028]