LBL-19914
EEB-BED-85-07

Presented at the Building Energy Simulation Conference, Seattle, WA, August 21-22, 1985.

CHARACTERIZING THE EFFECTS OF WEATHER ON COMMERCIAL BUILDING ENERGY USE

Joseph H. Eto

Buildings Energy Data Group
Applied Science Division
Lawrence Berkeley Laboratory
University of California
Berkeley, CA 94720

August 1985

The work described in this paper was funded by the Assistant Secretary for Conservation and Renewable Energy, Office of Building and Community Systems, Building Systems Division of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

ABSTRACT

Energy service companies, whose returns are a function of energy savings, have developed energy-normalization methods, based on degree-day measures of weather variation. True tests to determine the adequacy of these methods, however, require careful control of other determinants of building energy use. This paper uses a building energy simulation model to evaluate one of these methods for a large office building in Madison, WI using twelve years of actual weather data.

Techniques for accounting for the effects of weather on building energy use based on degree-days are reviewed. A three parameter model, consisting of an intercept, slope, and variable base temperature degree-day terms, is evaluated with simulations. Parameter estimates energy use were found to be sensitive to the year of data selected to develop the parameter. The resulting annual estimates of energy use tended to exceed DOE-2 predictions by up to ten percent.

KEYWORDS: Commercial Buildings, Energy Conservation, Weather/Climate

INTRODUCTION

Intelligent decisions to invest in energy conservation are based on the anticipated energy savings of the investment. Engineering calculations alone, however, often fail to explain subsequent changes in actual utility bills. This failure should come as no surprise since measures designed to save energy are only one of many factors influencing total building energy use. One important and uncontrollable factor is the influence of weather. A cold year can understate savings as easily as a hot year can overstate them. To measure the energy savings attributable to conservation investments in real buildings, techniques must be developed to account for the influence of weather on building energy use.

Energy service companies, whose returns are a function of energy savings, have begun to develop energy-normalization methods. These methods commonly rely on heating and cooling degree-days to represent weather variations. True tests to determine the adequacy of these methods, however, require careful control of the other determinants of building energy use. This requirement forms the basis for our evaluation of degree-day-based, energy-normalization methods for commercial buildings with the aid of a building energy simulation model.

The outline of this paper is as follows. First, we describe the use of degree-day weather statistics in normalization techniques for building energy use. Second, we outline the analytical approach employed to study these techniques, including descriptions of the building energy simulation model, climate, and large office building used. Third, we correlate the results of the simulations to degree-days calculated to various base temperatures and discuss the implications these correlations have for the energy-normalization techniques examined.

ENERGY-NORMALIZATION TECHNIQUES

Two factors have guided the development of energy-normalization formulas contained in shared savings contracts. The first is accuracy and the second is ease of implementation. Implementation issues include weather data availability and simplicity of the normalization procedures. While we will address only the issue of accuracy in the present work, it is important to understand that ease of implementation has tended to drive current formulations of these procedures. It is primarily for this reason that the most common techniques for normalization rely on degree-day representations of weather. Both heating and cooling degree-days may be used depending on the nature of the conservation measure.

Heating degree-days were first developed by heating fuel and district heating suppliers to anticipate customer heating requirements. In the present context, it is important to understand that the suppliers were primarily interested in forecasting the *aggregate* demands of *residential* customers, not those of individual residences or commercial structures. Much of the subsequent discussion involving degree-days has continued to center on residential buildings but has shifted to examinations of the appropriateness of the concept for predicting energy use of individual structures.

Heating degree-days are defined as the sum of the positive differences between a base temperature and the mean daily outdoor dry-bulb temperature for a given time period (1). Formally,

$$Heating\ Degree\text{-}Days = \sum_{i=1}^{N} (Mean\ Daily\ T_i - Base\ T)$$

where:

$$(\text{Mean Daily T - Base T}) > 0$$

and

$$\text{Mean Daily T} = (\text{Max Daily T - Min Daily T})/2$$

Cooling degree-days are calculated in an analogous manner by summing the *negative* differences between the base and mean daily outdoor temperature.

The base temperature has been traditionally defined as 65 F (18.3 C), but this is only a rule of thumb. The physical significance of the base temperature can be thought of as the outdoor temperature at which internal plus solar gains exactly offset heat losses. Outdoor temperatures below this threshold indicate the need for additional heat. Correspondingly, outdoor temperatures above this threshold indicate the need for heat removal (cooling). For this reason, the term "balance point" temperature is often used interchangably with base temperature. The additive nature of the degree-day statistic assumes that the need for cooling or heating varies linearly with these temperature differences.

Work described in Reference 2 indicates that, for residential structures, much lower base temperatures are appropriate due to better construction practices, which include higher insulation levels. Indeed, it is possible to solve for the appropriate balance point temperature analytically by explicitly considering the indoor temperature, internal and solar gains, and the envelope heat loss due to conduction, air leakage, and sky radiation (3). In this formulation, it is clear that the balance point temperature is uniquely determined by the physical properties, location, and operation of each structure. In practice, however, the analytical solution is extremely difficult to implement, given the enormous data requirements involved.

Researchers at Princeton University's Center for Energy and Environmental Studies have by-passed the need for a direct analytical solution for the balance point temperature (4). Their approach utilizes statistical techniques to decompose energy use into three parameters, a non-temperature sensitive component or "intercept", and a temperature sensitive component consisting of a heating "slope" and the number of degree-days to a calculated base temperature. In this approach, the base temperature is defined by the base temperature corresponding to the best fit of energy use to degree-days, as measured by R-squares. To date, work has concentrated on analyses of heating energy consumption in residential structures (5).

Recently, variants of this approach have appeared in more sophisticated shared savings contracts for commercial buildings (6). While not identical to the Princeton approach, these contracts acknowledge the uniqueness of the balance point for each building and attempt to find the appropriate base temperature based on statistical fits of energy use to degree-days to different base temperatures.

It is not obvious that a method well-proven for residential structures is appropriate for commercial ones, as well. Commercial buildings differ considerably from residential buildings, both in the types of systems used to provide space conditioning and in the hours the building systems are operated. For example, degree-days are calculated based on temperatures occurring throughout a 24 hour period, while commercial buildings are typically operated during only a fraction of these hours. Also, larger commercial buildings may have simultaneous heating and cooling requirements, due to lower surface area to volume ratios, greater internal gains, and more complex HVAC systems.

ANALYTICAL APPROACH

Field tests of the accuracy of any energy-normalization technique for commercial (or residential) buildings are difficult to carry out. The primary reason is that a true test of the accuracy of a energy-normalization technique must hold fixed all conditions but variations in weather. Building operation and occupancy must be held constant to ensure that all changes in energy use are due solely to the effects of weather. In real buildings, these conditions cannot be met. For this reason, computerized building energy simulation models are a practical alternative for studying the effects of weather on energy use.

In the present study, we used one such building energy simulation model to estimate the monthly energy requirements of a large office building using 12 years of *actual* weather for a single location. In each of these runs, only weather data were allowed to change; all other aspects of the building were held fixed. Monthly heating and cooling degree-day statistics were generated for 20 base temperatures between 4 F (- 15.6 C) and 80 F (26.7 C) in four degree F increments. Finally, correlations of energy use with these degree-day statistics were performed. These correlations took the following form:

$$Energy\ Use = A + BX$$

where:

A = Intercept (BTU/Month)
B = Heating or Cooling Slope (BTU/Month-DD)
X = Heating or Cooling Degree-Days

In the next section, we describe the results of these fits and their implications for degree-day-based, energy-normalization techniques. In the remainder of this section, we describe briefly the building energy simulation model, climate, and large office building used to study the effects of weather on commercial building energy use.

Modeling Commercial Building Energy Use

We used the DOE-2 building energy analysis program (version DOE-2.1C) to study the effects of weather on commercial building energy use. The DOE-2 program was developed by the Lawrence Berkeley and Los Alamos National Laboratories for the Department of Energy to provide architects and engineers with a state-of-the-art tool for estimating building energy performance (7).

The DOE-2 program has been validated in many studies. Perhaps the most comprehensive recent comparison of predicted versus measured results for an office building is Tishman (8). This study found excellent correspondence between sub-metered measurements and predicted values.

Madison Weather Data

Simulations were performed using 12 years of SOLMET weather data for Madison, WI. The SOLMET data set was developed by the National Climatic Center to provide building energy researchers quality controlled, historical hourly solar insolation and collateral meteorological data for 27 US weather stations (9).

Tables 1 and 2 summarize annual heating and cooling degree-days for each of the base temperatures examined for this location. Variations can be noted both across years for a given base temperature and within years as the base temperature changes.

Large Office Building Prototype

The large office building prototype is based on an actual building in Indianapolis built in 1981. For this study, only the office tower complex was modeled. The complex consists of 38 floors and two basement levels. The tower is a flattened hexagon in cross-section, with approximately 18,000 square feet (1670 square meters) per floor, that flares out to a larger base at the bottom floors. The building structure is a steel frame with 4 inches (10 cm) of limestone cladding. The tower is about 25% double-paned, bronze-tinted glass, predominantly on the NW and SE faces. Modifications were made to the DOE-2 input file to ensure that the prototype was in compliance with ASHRAE Standard 90-1975 (10).

Building operation followed a typical office schedule. The schedules for occupancy, lighting, equipment, elevators, and fan operation were taken from the Standard Evaluation Technique prepared for the BEPS program: 8 AM to 6 PM on weekdays, with some evening work, about 30 % occupancy on Saturdays (no evenings), and closed on Sundays and holidays (11). The zone thermostat settings were 78 F (26 C) cooling and 72 F (22 C) heating with a night and weekend heating setback of 55 F (13 C). Lighting was provided by recessed fluorescent fixtures, which returned 30 % of the lighting heat directly to the plenum. Light loads were estimated at 1.7 W/sqft and equipment was .5 W/sqft.

The perimeter systems were variable air volume (VAV) reheat systems with a minimum stop on the VAV reheat box of 30 %. Separate interior systems were 100 % shut-off VAV, with no reheat coil. Combined motor/fan efficiency was 55 % for the supply air and 47 % for the return air. All air handling units were equipped with drybulb-actuated economizers with a control limit of 62 F (17 C). Heat and hot water were furnished by two gas-fired hot water generators. Cooling was furnished by two hermetic centrifugal chillers. Cooling tower water temperatures were allowed to float to a minimum of 65 F (18 C) entering the condensers.

RESULTS

Correlations of monthly energy use and degree-days were performed in two phases. First, one set of correlations was performed for each year of data for each fuel type. This procedure would correspond to that taken by an energy service company to determine the appropriate base temperature for use in calculating subsequent savings. Second, one set of correlations was performed for all twelve years of data, taken together. In all cases, natural gas consumption was correlated with heating degree-days, since natural gas was the primary heating fuel. Correspondingly, electricity consumption was correlated with cooling degree-days since only electricity was used for chiller operation.

Tables 3 and 4 present the "goodness" of fit statistics (R-square) for the natural gas and electricity correlations, respectively. Before discussing the results for each fuel type, it is worth noting that, for each year of correlations (the vertical columns), the R-squares rise smoothly to a high point and then smoothly retreat. Thus, it is clear that a unique balance point temperature will be found for each year of data. On the other hand, the highest R-square for a given year of data is never dramatically higher than that for neighboring base temperatures; the curve is rather flat near the summit.

Natural gas consumption is highly correlated with heating degree-days (see Table 1). R-squares consistently range above 0.95 for every year of data. The base temperature associated with the highest R-square is consistently either 52 F (11.1 C) or 56 F (13.3 C), far below the 65 F (18.3 C) rule of thumb. The results for the data set containing all twelve years of data are consistent with these observations.

Electricity consumption is poorly correlated with cooling degree-days (see Table 2). R-squares are much lower in every year data than the natural gas counterparts. The base temperature associated with the highest R-square also varies considerably from year to year, from a high of 68 F (20.0 C) to a low of 52 F (11.1 C). These results stem from the specification of electricity as the fuel source for reheat, in addition to cooling. The results for the twelve year data set correspond more closely to the results developed for the natural gas correlations. The base temperatures associated with the highest R-squares are 56 F (13.3 C) and 60 F (15.6 C) indicating a small dead-band between the need for heating and the need for cooling.

Tables 5 and 6 presents the parameter estimates associated with the correlations having the highest R-square for each of the thirteen data sets for natural gas and electricity, respectively. Averages and standard deviations are calculated for the twelve single year estimates; the estimates for the data set containing all twelve years of data are presented separately. Selecting the parameter estimates associated with highest R-square parallels the procedure used in many energy-normalization techniques.

Despite excellent correlations (high R-square), the parameter estimates for natural gas consumption as a function of heating degree-days yield inconsistent results. While the heating slope exhibits substantial constancy, the intercept term varies considerably, depending on the year examined. Order of magnitude differences exist between different estimates of this term, which is taken to be the non-weather sensitive component of consumption. This result suggests that energy-normalization techniques relying on heating degree-day correlation to natural gas consumption in commercial buildings will be influenced by the year chosen for the development of the intercept term of the equation.

This hypothesis is substantiated by the data presented on Table 7. Table 7 compares natural gas consumption estimates for four sets of heating degree-day parameters to those predicted by DOE-2. The first three sets of parameters were selected from individual years of data and span the range of heating slope estimates (Low, Mid, High); a fourth set was derived from all the twelve years of data (All Years). The three estimates based on a single year of data overestimate energy on a fairly consistent basis, by over ten percent in one year. The estimate derived from all twelve years of data, while not clearly biased in one direction, still leads to over- and under- estimates of four or more percent.

The parameter estimates for electricity are more consistent with the low R-squares associated with the correlations. For this fuel type, there are a large and relatively invariant intercept estimates, but extremely variable slope estimates (or cooling degree-day dependent terms). This variability appears to result from the specification of electricity as the fuel source for reheat as well as cooling. Once again, the year chosen has a strong influence on the parameter estimates. In this case, variability in the estimate of the intercept term has been replaced by variability in the estimate of the slope.

Despite poorer fits for electricity, the relatively larger (and less variable) intercept term means that variation in slope estimates will have a smaller impact on total consumption. Table 8 presents electricity consumption estimates for four sets of cooling degree-day parameters to those predicted by DOE-2. As with Table 7, estimates from a range of single year parameter estimates are presented along with estimates from parameters based on all twelve years of data. With the exception the High slope estimate, the cooling degree-day parameter estimates show much closer agreement with DOE-2 predictions. Again, the single year estimates tend to overestimate consumption, slightly. Finally, the estimates based on twelve years of data show the least over-all variation and lack of bias from the DOE-2 predicted values.

We conclude this discussion with a brief example to illustrate the impact of a biased estimate for a shared savings project. At an assumed price of $ 7.00 / MBTU, a ten percent over-estimate of natural gas consumption leads to a $ 8.5 k over-estimate of the savings attributable to a conservation investment on a total natural gas bill of $ 85 k. At an assumed average price (demand charges, time-of-use rates included) of $ 0.08 / kWh, a seven percent over-estimate of electricity consumption leads to a $ 50 k on a total electricity bill of $ 710 k.

CONCLUSION

We have used the DOE-2 building energy simulation model to study the effects of weather on the energy requirements of a large office building in Madison, WI. These simulations provided a carefully controlled experimental environment in which only the weather was allowed to vary. The results were used to test a degree-day-based energy-normalization technique for commercial buildings. Monthly heating and cooling degree-days were calculated to a variety of base temperatures and correlated with energy use according to a three parameter model. This model consisted of an non-weather sensitive or intercept and two weather-sensitive terms, a heating or cooling slope and the number of heating or cooling degree-days to a given base temperature. The base temperature was selected with a "goodness" of fit test that relied on R-squares from the correlation of energy use to degree-days.

For both natural gas and electricity, selecting the appropriate base temperature based on best correlation with degree-days to different base temperatures did not consistently result in the same base temperature from year to year. Excellent correlations were found between natural gas consumption and heating degree-days to base 52 F (11.1 C) and 56 F (13.3 C), R-squares were typically exceeded 0.95. Nevertheless, parameter estimates of the intercept term for natural gas produced order of magnitude differences between selected years of data. Electricity correlations with cooling degree-days were generally poorer since electricity was used for reheat in addition to cooling. Large and consistent estimates for the intercept term tended to off-set wide variations in estimates of the slope term. Far better agreement between electricity consumption estimates and DOE-2 predictions were observed.

We concluded that degree-day-based energy-normalization techniques, which rely on a three parameter, linear formulation were sensitive to the reference year chosen to develop the parameter estimates. Consumption estimates based on single-year parameter estimates tended to over-estimate consumption predicted by DOE-2. The effect of an over-estimate of energy use is to exaggerate the savings attributable to a conservation investment. The use of all twelve years of data to develop parameter estimates reduced this bias.

ACKNOWLEDGEMENT

The work described in this paper was funded by the Assistant Secretary for Conservation and Renewable Energy, Office of Building and Community Systems, Building Systems Division of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

REFERENCES

1. American Society of Heating, Refrigeration, and Air-conditioning, Engineers, *ASHRAE Handbook, Systems*, 1980.
2. Nall, D., and Arens, E., "The Influence of Degree Day Base Temperature on Residential Building Energy Prediction", *ASHRAE Transactions*, V. 85, P. 1, 1979.
3. Kusuda, T., Sud, I., and Alereza, T., "Comparison of DOE-2-Generated Residential Design Energy Budgets with Those Calculated by Degree-Day and Bin Methods", *ASHRAE Transactions*, V. 87, P. 1, 1981.
4. Fels, M., *The Princeton Scorekeeping Method: An Introduction*, PU/CEES 163, 1984.
5. Mayer, L., and Benjamini, Y., "Modeling Residential Demand for Natural Gas as a Function of the Coldness of the Month", *Energy and Buildings*, V. 1, N. 2, 1977.

6. Personal communication with P. Breed, Lane and Edson, counsel for the National Association of Energy Service Companies, 1985.

7. Curtis, R., Birdsall, B., Buhl, W., Erdem, E., Eto, J., Hirsch, J., Olson, K., and Winkelmann, F., *The DOE-2 Building Energy Use Analysis Program*, Lawrence Berkeley Laboratory, LBL-18046, April, 1984.

8. Tishman Research Corporation, *DOE-2: Comparison with Measured Data*, U.S. Department of Energy, DOE/CS/20271-5, March, 1984.

9. National Climatic Center, *SOLMET, Volume 1 - User's Manual, TD - 9724, Hourly Solar Radiation - Surface Meteorological Observations*, August, 1978.

10. The American Society of Heating, Refrigeration, and Air-Conditioning Engineers, Inc., *ASHRAE Standard 90-75: Energy Conservation for Buildings*, 1975.

11. US Department of Energy, *Standard Building Operating Conditions*, DOE/CS-0118, November, 1979.

Table 1. Annual Heating Degree-Days to Selected Base Temperatures for Madison, WI

Base Temp (F)	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964
8	15.0	27.0	53.0	22.5	60.5	92.0	139.5	33.0	77.0	196.5	392.5	13.5
16	87.0	91.0	222.5	93.0	210.0	332.5	364.5	235.0	274.5	475.0	778.5	120.5
24	326.0	323.0	630.0	397.0	499.0	728.5	793.0	738.0	596.5	925.0	1303.0	479.0
32	821.0	844.0	1406.0	1092.5	1067.0	1356.5	1552.5	1541.0	1146.5	1595.0	2052.5	1117.5
40	1728.0	1823.5	2438.0	2134.0	2061.5	2311.0	2630.0	2614.5	2163.5	2682.5	3025.0	2100.5
48	3021.5	3111.0	3683.0	3454.0	3410.5	3582.0	4000.5	3946.5	3577.5	4062.5	4232.0	3369.5
56	4591.0	4717.5	5189.0	5031.0	5071.5	5163.5	5655.5	5536.0	5299.0	5682.0	5759.5	4955.0
64	6470.5	6665.0	7060.5	6968.5	7049.0	7102.0	7555.5	7507.5	7311.5	7615.5	7693.5	6919.5
72	8722.0	8999.0	9342.0	9323.5	9460.0	9572.0	9784.5	9987.5	9732.0	10032.5	10070.5	9284.5
80	11446.0	11731.5	11935.5	12091.0	12245.5	12395.0	12484.0	12805.0	12544.0	12880.5	12818.0	11987.5

Table 2. Cooling Degree-Days to Selected Base Temperatures for Madison, WI

Base Temp (F)	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964
8	14881.0	14587.0	14458.0	14219.5	14098.0	13978.0	13947.5	13512.5	13814.0	13597.5	13857.0	14234.5
16	12033.0	11731.0	11707.5	11370.0	11327.5	11298.5	11252.5	10794.5	11091.5	10956.0	11323.0	11511.5
24	9352.0	9043.0	9195.0	8754.0	8696.5	8774.5	8761.0	8377.5	8493.5	8486.0	8928.0	8950.5
32	6927.0	6644.0	7051.0	6529.5	6344.5	6482.5	4758.0	6260.5	6123.5	6236.0	6757.0	6668.5
40	4914.0	4703.5	5163.0	4651.0	4419.0	4517.0	4758.0	4414.0	4220.5	4403.5	4809.5	4731.5
48	3287.5	3071.0	3488.0	3051.0	2848.0	2868.0	3208.5	2826.0	2714.5	2863.5	3096.5	3080.5
56	1937.0	1757.5	2074.0	1708.0	1589.0	1529.5	1943.5	1495.5	151.0	1563.0	1704.0	1746.0
64	896.5	785.0	1025.5	725.5	646.5	548.0	923.5	547.0	608.5	576.5	718.0	790.5
72	228.0	199.0	387.0	160.5	137.5	98.0	232.5	107.0	109.0	73.5	175.0	235.5
80	32.0	11.5	60.5	8.0	3.0	1.0	12.0	4.5	1.0	1.5	2.5	18.5

Table 3. Monthly Heating Degree-Day Correlations (R-square) with Natural Gas Consumption

Base Temp (F)	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	All Years
24	.840	.643	.843	.788	.627	.784	.703	.777	.727	.859	.894	.843	.693
28	.856	.727	.873	.839	.697	.828	.778	.808	.761	.871	.914	.893	.765
32	.878	.798	.903	.880	.777	.865	.841	.839	.815	.888	.934	.923	.828
36	.905	.871	.931	.909	.856	.909	.892	.868	.881	.926	.953	.942	.884
40	.936	.928	.950	.935	.915	.942	.932	.901	.938	.958	.967	.959	.927
44	.965	.959	.964	.950	.951	.965	.959	.927	.971	.980	.979	.970	.955
48	.982	.977	.976	.958	.973	.977	.977	.948	.985	.989	.988	.975	.972
52	.986	.986	.984	.959	.984	.984	.984	.961	.989	.990	.992	.976	.979
56	.984	.987	.988	.958	.985	.983	.985	.967	.984	.986	.990	.972	.980
60	.976	.982	.989	.955	.980	.978	.978	.966	.973	.978	.984	.966	.975
64	.964	.970	.985	.948	.969	.970	.967	.961	.959	.968	.976	.956	.966
68	.949	.956	.976	.931	.954	.960	.955	.954	.946	.959	.965	.945	.950
72	.936	.943	.965	.931	.940	.951	.945	.948	.937	.953	.956	.936	.944
76	.929	.935	.953	.925	.933	.945	.939	.945	.933	.951	.948	.929	.938
80	.926	.932	.944	.923	.931	.943	.936	.944	.933	.950	.946	.924	.934

Highest R-square underlined

Table 4. Monthly Cooling Degree-Day Correlations (R-square) with Electricity Consumption

Base Temp (F)	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	All Years
24	.613	.464	.534	.503	.421	.384	.564	.405	.457	.340	.351	.506	.456
28	.631	.487	.554	.518	.450	.414	.586	.439	.483	.366	.383	.525	.482
32	.655	.521	.580	.543	.479	.455	.613	.479	.516	.398	.421	.549	.514
36	.683	.559	.610	.574	.508	.499	.644	.521	.552	.432	.461	.577	.549
40	.716	.605	.647	.610	.539	.544	.676	.560	.588	.469	.504	.612	.586
44	.749	.654	.684	.648	.574	.580	.708	.604	.623	.508	.546	.646	.624
48	.774	.695	.716	.682	.605	.614	.737	.644	.652	.552	.583	.683	.658
52	.799	.729	.743	.712	.631	.645	.762	.683	.669	.591	.606	.715	.685
56	.806	.760	.754	.735	.655	.669	.775	.715	.673	.621	.614	.742	.701
60	.794	.778	.748	.753	.669	.674	.777	.729	.665	.656	.607	.758	.700
64	.784	.771	.719	.775	.673	.641	.770	.685	.650	.693	.591	.758	.676
68	.770	.737	.678	.786	.658	.573	.745	.515	.653	.695	.567	.739	.614
72	.739	.680	.646	.725	.647	.394	.649	.202	.631	.649	.509	.713	.485
76	.632	.679	.638	.569	.591	.281	.441	.056	.630	.584	.429	.707	.337
80	.685	.571	.640	.715	.350	.229	.271	.027	.202	.431	.381	.567	.210

Highest R-square underlined

Table 5. Comparison of Natural Gas Parameter Estimates

Year	Base Temp (F)	R-square	Intercept (MBTU/Month)	Slope (MBTU/HDD-Month)
1953	52	.986	89.5	2.8
1954	56	.987	58.3	2.4
1955	60	.989	15.8	2.2
1956	52	.959	132.0	2.6
1957	56	.985	43.2	2.5
1958	52	.984	119.7	2.6
1959	56	.985	12.8	2.2
1960	56	.967	85.3	2.2
1961	52	.989	77.7	2.7
1962	52	.990	77.7	2.7
1963	52	.992	97.2	2.5
1964	52	.976	73.4	2.7
Average	54		73.6	2.5
(Std. Dev.)	(3)		(35.0)	(0.2)
All Years	56	.980	43.2	2.4

Table 6. Comparison of Electricity Parameter Estimates

Year	Base Temp (F)	R-square	Intercept (MBTU/Month)	Slope (MBTU/CDD-Month)
1953	56	.806	2321.4	1.2
1954	60	.778	2293.3	1.6
1955	56	.754	2373.1	1.0
1956	68	.786	2336.3	4.0
1957	64	.673	2348.4	2.1
1958	60	.674	2368.9	1.4
1959	60	.777	2343.9	1.4
1960	60	.729	2339.9	1.8
1961	52	.669	2277.3	1.0
1962	68	.695	2338.3	6.8
1963	56	.614	2383.4	1.1
1964	64	.758	2357.3	2.2
Average	60		2340.1	2.1
(Std. Dev.)	(5)		(29.8)	(1.6)
All Years	56	.701	2331.2	1.1

Table 7. Comparison of Natural Gas Predictions (MBTU)

		Low		Mid		High		All Years	
Intercept:		15.8		43.2		89.5		43.2	
Slope:		2.2		2.5		2.8		2.4	
Year	DOE-2		% Chg		% Chg		% Chg		% Chg
1953	11700	12100	2.9	11900	1.5	11700	0.0	11300	-3.5
1954	12000	12400	3.7	12200	2.2	12000	0.4	11600	-2.8
1955	13300	13300	0.0	13400	0.5	13500	1.2	12700	-4.4
1956	12300	13100	6.1	13000	5.6	13000	5.2	12400	0.4
1957	13100	13200	0.9	13100	-0.0	13000	-1.0	12500	-4.9
1958	12700	13300	5.0	13300	5.1	13300	5.1	12700	-0.0
1959	13300	14400	8.4	14600	9.4	14600	9.9	13800	4.0
1960	13200	14200	7.0	14300	7.7	14400	8.5	13600	2.5
1961	12600	13700	8.9	13700	8.5	13500	7.3	13000	3.2
1962	13800	14500	4.7	14600	5.7	14800	6.6	13900	0.5
1963	13700	14600	7.1	14800	8.4	15100	10.3	14100	3.1
1964	12000	12900	7.7	12800	6.8	12700	5.9	12200	1.6

Year from which estimates were derived are underlined

Table 8. Comparison of Electricity Predictions (MBTU)

		Low		Mid		High		All Years	
Intercept:		2373.1		2357.3		2338.3		2331.2	
Slope:		1.0		2.2		6.8		1.1	
Year	DOE-2		% Chg		% Chg		% Chg		% Chg
1953	30100	30300	0.7	30200	0.4	31400	4.4	30100	0.1
1954	29400	30200	2.5	30000	1.9	31100	5.6	29900	1.7
1955	30500	30500	0.0	30500	0.1	32600	7.0	30300	-0.5
1956	29600	30100	1.8	29900	0.9	30700	3.7	29900	1.0
1957	29500	30000	1.5	29700	0.5	30400	2.9	29800	0.7
1958	29800	29900	0.4	29500	-1.1	29900	0.1	29700	-0.4
1959	30100	30300	0.8	30300	0.6	31600	4.9	30200	0.1
1960	29800	29900	0.3	29500	-1.2	29900	0.2	29700	-0.6
1961	29500	29900	1.5	29600	0.4	30100	2.1	29700	0.6
1962	29900	30000	0.3	29500	-1.2	29900	-0.0	29700	-0.6
1963	30500	30100	-1.1	29800	-2.0	30800	1.0	29900	-0.9
1964	30000	30200	0.5	30000	-0.0	31200	4.2	29900	-0.2

Year from which parameters were derived are underlined