# 1996-1997 RESIDENTIAL APPLIANCE EFFICIENCY INCENTIVES PROGRAM

# FIRST YEAR LOAD IMPACT EVALUATION

## (DSM Pilot Bidding Program)

**Study ID No. 717**

**Submitted to:**

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**Acknowledgement**

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## 1.0 Executive Summary

Energx Controls Incorporated and its measurement and evaluation subcontractor, Occidental Analytical Group (OAG), conducted a study of second year installations, costs and load impacts of Energx's Residential Energy Efficiency DSM Pilot Bidding Program. In Energx's program, property management firms and owners of multi-family dwellings are given incentives for installing water-heating measures that result in significant natural gas savings. The program goal was to install 900 controllers for temperature control of central water heaters, 45 high efficiency non-storage water heaters, and 18 steam boiler controllers over a period of two years beginning November 1, 1995.

The first-year program, consisting of half of the total goals, ended on October 31, 1996. For the first program year 1995-1996, Energx installed 340 controllers on central water heaters. The *First Year Load Impact Study for the First Program Year* was submitted in May 1997 and approved by the Southern California Gas Company (SoCalGas). The present report, the *First Year Load Impact Study for the Second Program Year*, summarizes the performance of the program for the second program year 1996-1997. The goal of the second program year was to install the remaining 560 of the original target goal of 900 water heater controllers. Energx installed 492 controllers for the second year. Conforming to the ex-post measurement protocols, all 492 participant sites and 152 non-participant control sites were surveyed.

On-site surveys were conducted. Statistical modeling of the survey data was conducted to determine the treatment impact, the savings of therms consumed, while controlling for other site characteristics that have effects on consumption. Three approaches are used in statistical modeling. One is the Engineering Model using a rate realization approach to validate engineering estimates. The engineering model will not be used to estimate program savings; rather, it is intended to validate a-priori estimates of saving rates. Another approach is the Treatment Effect Model, also called the Production Function Model, estimated with and without the comparison group. The last model is the Fixed Effects Model, also called the Change Model, estimated with the comparison group included.

Table 1.1 summarizes the results from the estimated models. Average therms saved per unit per year and estimated annual savings are reported along with the estimated rates derived from the alternative models. The calculations are based on the 24,905 apartment units in the survey that were affected by the treatment.

**Table 1.1 — Estimated Savings Based on Alternative Models**

| Estimates based on | Estimated Savings rate | Average therms saved per unit per year | Estimated annual savings |
|---|---|---|---|
| **Production function, participants only:** | | | |
| Entire sample, trimmed least-squares | 26.42% | 94.29 | 2,348,312 |
| Hydronic, trimmed LS | 26.19% | 93.48 | |
| Non-hydronic, trimmed LS | 28.81% | 102.82 | |
| Sum | | | 2,516,094 |
| **Production function, with comparison group:** | | | |
| Entire sample, trimmed least-squares | 21.75% | 77.60 | 1,932,685 |
| **Fixed-effects, Change model:** | 14.00% | 49.90 | 1,242,760 |

Note: calculations based on 24,905 units, 19.18% hydronic, 29.7 therms consumed per unit per month.

The engineering model, as estimated in this study, should not used to estimate program savings, and so Table 1.1 does not included estimates from the engineering model. The savings rates assumed for the engineering model, a constant 19 percent savings rate for hydronic-heated units and 13 percent for non-hydronic units, imply average therms saved per unit per year of 67.72 and 46.33 therms respectively. While these amounts can be used as benchmarks, our analysis indicates realized savings rates are higher. Realized savings rates for hydronic and non-hydronic units are closer to 28.8 and 26.2 percent respectively, based on the models estimated for participants only. Therefore, the rate realization model should not be used to measure actual program savings. Based on the production function model, estimated separately for hydronic and non-hydronic units, realized annual savings is closer to 2,516,094 therms over all installation sites.

The best estimate of the likely savings rate for sites chosen at random from the service area is the fixed-effects estimate from the change model. Fixed-effects estimates are less subject to sample-selection bias and the omission of unmeasured fixed effects. The savings rate from the fixed-effects model is 14.0 percent, and the estimated average therms saved, per unit per year, is 49.90. It is not appropriate to apply this savings rate to installation sites to generate program savings because the installation sites were not chosen randomly – they self-select themselves onto the treatment group.

The annual savings predicted by the production function model, estimated for participants only in the analysis, are 2,348,312 therms annually. When participants and nonparticipants are included, estimated the annual savings is 1,932,685. We do not believe that these versions of the production model generate estimated savings as accurately as that estimated separately for hydronic and non-hydronic units separately. This is because the coefficient on each variable is constrained to be the same for hydronic and non-hydronic units when the model is estimated with the pooled sample. However, since savings for the first-year program were measured using the pooled sample with nonparticipants included, we propose using that same model to measure savings for the second program year.

A conservative estimate of the program saving is obtained from the trimmed least squares estimate of the production function model with both the participant and comparison groups included in the analysis. The trimmed least squares method minimizes any bias caused by outlier observations in the data. With this method for a combined participating and comparison group analysis, the estimated average savings rate is 21.75 percent, a reduction of 77.6 therms per apartment unit per year. Total program savings is estimated to be 1,932,685 therms over the program year. The total life cycle savings from the second-year program is 43,957,005 therms. This figure represents 141 percent of savings from the second-year program goal of 31,199,040 therms to be derived from 900 controller installations.

## 2.0 Introduction

The California Public Utilities Commission (CPUC), in its Order D.92-09-080, directed California investor-owned utilities to develop and implement pilot bidding programs to learn about alternative demand-side management (DSM) delivery mechanisms. Pursuant to this decision, the Southern California Gas Company issued a Request for Proposal (RFP) inviting bids from various energy service companies for innovative DSM programs that produce persistent and sustainable natural gas savings. SoCalGas then selected Energx Controls Incorporated (previously Delta-Pro Tech Incorporated) as one of the successful bidders, and they agreed to a 2-year contract commencing on November 1, 1995 to install water-heating measures in multifamily residential buildings.

The program consists of offering cash incentives to property owners and management firms for installing water-heating measures that result in natural gas savings. The target market consists of residential, multi-family apartment and town-homes complexes that have central gas-fired water heaters with re-circulating loops. At this time, the technology is more cost effective in larger buildings with 30 units or more per heater, and so this program concentrated its efforts on that segment of the market. The program goals, as stipulated in the contract, were to install 900 central water heater controllers, 45 non-storage instant water heaters and 18 steam boiler controllers over a 2-year period starting November 1, 1995.

The Measurement and Evaluation Plan, within this contract with SoCalGas, requires Energx to submit a measure gross and net impact study for each of the first two program years. This report presents the results of the Load Impact study in support of documenting the progress of Energx Controls' Residential Energy Efficiency Program for the second program year.

## 3.0 Program Achievement

The program consists of offering cash incentives to property owners and management firms for installing water-heating measures that result in natural gas savings. The program goals, as stipulated in the contract, consist of installing 900 Central Water Heater Controllers, 45 Non-Storage Instant Water Heaters and 18 Steam Boiler Controllers over a 2-year period starting November 1, 1995.

Of the planned goal of 450 installations in the first program year, Energx installed 340 controllers. The goal of the second program year was to install the balance of 560 controllers. During the second program year, Energx installed 492 central water heater controllers. The total number of controllers installed over the two-year period is 492. This represents 92.4 percent of the goal of 900 controller installations. Table 3.1 summarizes the second-year program goals and the estimated life-cycle therm savings (ELTS). The table also is a summary of the program performance for the entire two-year period. There were no installations of non-storage water heaters and steam boiler controllers. The table also summarizes the average number of multi-family dwelling units per water heater controller. For the second year, the average number of dwelling units per installed controller is 51 units which is higher than the proposed number of 35 units originally planned in the program. With the higher number of dwelling units per controller installation, it is expected that life cycle therm savings per controller will also be higher than anticipated.

Energx has expended $543,649 in incentives for the second year. The average incentive per installation of $1,105 is close to the program design. However, the average customer contribution of $2,084 is well below the program design goal of $2,750 per installation.

Program achievment for the second year of Energx's DSM program is well within the general guidelines as set by SoCalGas. Savings are expected to be higher, and costs are expected to be lower per installation. This will result in a better than expected cost effectiveness, as verified in the first-year load impact studies for the first and second program years.

Table 3.1 Summary of Program Performance (Oct. 1995 – Dec. 1998)

| | Planned | First-year Actual | Second-year Actual | Two-year Actual |
|---|---|---|---|---|
| **Water Heater Controllers:** | | | | |
| Number of Controllers | 900 | 340 | 492 | 832 |
| Number of MF Dwellings Effected | 31,500 | 44,709 | 24,905 | 39,614 |
| Number of MF Dwellings/Controller | 35 | 43 | 51 | 48 |
| ELTS/Installation (therms) | 31,185 | 44,020 | 58,923 | 52,833 |
| Total Incentive ($) | $1,125,000 | $393,504 | $543,649 | $937,153 |
| Average Incentive/Controller ($) | $1,250 | $1,157 | $1,105 | $1,126 |
| Total Customer Contribution ($) | $2,475,000 | $778,260 | $1,025,450 | $1,803,710 |
| Average Customer Contribution ($) | $2,750 | $2,289 | $2,084 | $2,168 |
| Actual ELTS for Measure (therms) | 28,066,500 | 14,966,730 | 28,900,275 | 43,957,005 |
| **Non-Storage Water Heaters:** | | | | |
| Number of Non-storage Heaters | 45 | 0 | 0 | 0 |
| ELTS/Installation | 20,040 | | | |
| Actual ELTS for Measure | 901,800 | | | |
| **Steam Boiler Controllers:** | | | | |
| Number of Steam boiler Controllers | 18 | 0 | 0 | 0 |
| ELTS/Installation | 123,930 | | | |
| Actual ELTS for Measure | 2,230,740 | | | |
| **Program total ELTS** | 31,199,040 | 14,966,730 | 28,990,275 | 43,957,005 |

Note: ELTS is Estimated Life-cycle Therm Saving

As can be seen from Table 3.1, overall program performance far exceeded the planned program. Program incentive costs and customer contributions were lower than planned. The estimated life-cycle therms saved was 43,957,005 therms which is 141 percent of the planned goal of 31,199,000 therms.

## 4.0 Measure Description

The Energx T2000 controller is a demand type controller that sets the hot water supply temperature based on current demand of the system. The system consists of three individual temperature sensors and a control logic center. The logic control system consists of relays that are designed for use with 120Vac, 24Vac and 750Mv heater systems. The control center needs a 120Vac power supply which is then stepped down to 24Vac for the relay control.

The temperature sensors are of low voltage wiring. The 120Vac power supply to the system consists of shielded wiring and plug that is connected to a site 120Vac receptacle. System installation does not require a permit since there are no piping changes and/or changes to the water heater system. The three temperature sensors sense the hot water supply, return, and input (city) water temperatures. For most efficient operation, the controller must be installed in a hot water system that incorporates a re-circulating return water loop. Some systems may also incorporate a storage tank in the system. Most apartment buildings and condominiums incorporate these features in the water heating systems.

The system operates in the following manner. Typically, during the early hours of the morning and evening, when the hot water demand in a multi-family apartment complex or condominium is highest, the controller sets the leaving hot water temperature from the water heater at the highest appropriate temperature. As the demand decreases during other hours, the controller sets a lower hot water delivery temperature. This reduces fuel consumption in the water heater due to fewer firings of the burner and reduced heat losses in the supply and return water piping.

The system has the ability to monitor and react to the changes in the system-input temperature based upon a desired minimum temperature determined by the change in usage. The controller establishes an optimum set-point for the supply temperature based upon demand and then controls the relays to maintain this value. The optimum set-point is the minimum temperature that will fully satisfy the user needs. The result is reduced heat loss, reduced scale deposits and increased life of the water heating system.

The control logic center also has a single line LED display with a status button. There are three modes that display the supply water, control set point, and return water temperatures. A RS232 cable connection that enables one to download up to seven (7) days of data from the system. This data is displayed in a graph indicating the set point temperature, supply water temperature, and the return water temperature. This feature is useful in diagnostics and verification of system operation. The Energx T2000 brochure and the manufacturer's installation manual are reproduced in Appendix D of this report. These documents were used in the verification of installation sites.

## 5.0 Survey Procedure

As per the Measurement Protocols, Energx surveyed all participating sites and 152 non-participating sites. On-site surveys were conducted by OAG and Energx personnel. A sample of the survey instrument is included in Appendix C of this report. This is an abbreviated version of the instrument used for the first program year study. Any variable that could not be measured or that proved not to be useful was omitted from the original questionnaire. As is evident in the instrument, OAG and Energx attempted to collect all relevant and measurable data that might impact natural gas consumption at a site.

The survey procedure involved an on-site meeting, usually with the apartment manager. In some cases, a clearance from the property management firm's headquarters office was necessary to interview the apartment manager.

A typical survey lasted approximately 90 to 120 minutes with 30 minutes spent with the apartment manager. The remainder of the time was spent collecting equipment data. The apartment manager answered most of the questions about site characteristics. The only data that were difficult to obtain were specific to apartment units, data such as the number of occupants and occupancy rates. The managers could only provide rough estimates of the average number of occupants and annual occupancy rates. Inspection of occupied apartments was not permitted because managers would not permit intrusion on tenants' privacy. Data on water heating equipment and other end-use equipment were collected by visually inspecting the equipment. Again, since many of the apartment buildings were fully occupied, it was not possible to collect data on equipment inside those apartments.

Many of the characteristics that impact gas consumption, such as dimensions the of hot water piping, insulation type and amount, location of piping, actual breakdown of occupancy by dwelling unit type, and square footage of apartments, were not measurable. Apartment managers have little or no knowledge of the site piping layout and plan. Most sites do not have detailed engineering plans. The surveyors also found that after controller installation, some of the properties changed hands. New property management firms were less cooperative.

The non-participating comparison sites could not be selected on an entirely random basis. Since the participating group was self selecting due to their larger size and existence of central water heaters with re-circulating loops, the non-participants had to be selected accordingly. Furthermore, many non-participants were not eager to participate in such a study. The selection of non-participants was also hampered by the fact that they had to reveal their natural gas billing data. Because of the confidentiality issue, SoCalGas could not release billing data to Energx. Thus, Energx had to be satisfied with the first 150 qualifying non-participants that agreed to voluntarily supply the billing data. We were able to include 152 non-participant sites.

## 6.0 Statistical Modeling Methods

The analysis has two main components. In one, we work with the level of therms consumed. The relevant dependent variable is measured as monthly therms consumed per apartment unit, and a least-squares treatment-effect model of conditional demand is estimated. In the other, the level data are transformed into monthly changes and a fixed-effects model of conditional demand is estimated. Three statistical models are used to analyze the data. First, using the level data, a Production Function Model is estimated with and without the comparison group to estimate the treatment effect. The production model should be most useful in estimating the actual treatment effect on program participants. Hence, the production model is appropriate to estimate actual program savings. Second, using the level data, an Engineering Model using the rate realization approach is estimated for the treatment group to test *a priori* engineering estimates of expected savings due to treatment. Third, using the change data, a Fixed-Effects Model is estimated to measure the treatment effect while controlling for unmeasured fixed effects. The fixed-effects model estimates should be useful in estimating treatment effects that can be expected if apartment complexes were selected at random rather than self-selecting into the treatment group. Hence, the fixed-effects model is most useful in estimating savings that might be realized if the program were extended to complexes chosen at random. The sections that follow discuss the structure and assumptions used in each model. All of these models are conditional demand models.

### 6.1 Treatment Effect (Production Function) Model

The production function model estimated for the treatment sites alone is

$$\ln y_{it} = a + \mathbf{b}\mathbf{z}_i + \mathbf{c}\mathbf{x}_{it} + dT_t + e_{it} \tag{6.1.1}$$

The variable $\ln y_{it}$ represents the natural logarithm of therms (adjusted therms) consumed per apartment unit for the $i^{th}$ controller-site during month t. The vector $\mathbf{z}_i$ represents a collection of site-specific characteristics that vary by site but do not vary over time. The vector $\mathbf{x}_{it}$ represents a collection of variables, measures of weather and occupancy rates, which vary over time as well as by site. The term $e_{it}$ represents a random error. Variable $T_t$ represents the treatment (installation and operation of the controller) that is time dependent. T is equal to zero prior to installation, and T is equal to unity after a post-installation adjustment period.

One advantage of measuring the dependent variable in logarithms is that the estimated coefficient for d can be used to calculate an estimate of the percentage savings using the following formula:

$$\text{savings percent} = 100\{\exp(-d) - 1\}$$

An additional advantage is that the distribution of log therms is more symmetric and, hence, more bell-shaped. Moreover, the fit of the estimated equation is much better when the logarithm is used.

The treatment effect can also be estimated by including a control group for comparison. The model can be specified as before, but with an additional indicator for the participant group sites:

$$\ln y_{it} = a + \mathbf{b}\mathbf{z}_i + \mathbf{c}\mathbf{x}_{it} + dT_{it} + fF_i + e_{it} \tag{6.1.2}$$

This model constrains the coefficients **b** and **c** to be equal for the treatment and non-treatment sites. The coefficients d and f shift the intercept c. The treatment indicator $T_{it}$ is now both site and time dependent, but the variable $F_i$ is only site dependent. A value F = 1 (SITE = 1) indicates that an observation corresponds to an installation site. A value T = 1 (POSTIS = 1) indicates that an observation corresponds to an installation site after the treatment. The estimate of d measures the treatment effect, and the estimate of the coefficient f measures the average difference in consumption between the treatment and comparison groups before the treatment

### 6.2 Engineering Model Using the Rate Realization Approach

The rate-realization approach is of limited importance to this study because an estimate of saving can be determined directly from the production function model. However, the rate-realization approach can be used to validate engineering estimates of the reduction in therms anticipated from the treatment. One version of the rate-realization model is

$$y_{it} = a + \mathbf{b}\mathbf{z}_i + \mathbf{c}\mathbf{x}_{it} + rE_i + e_{it} \qquad (6.2.1)$$

The dependent variable is $y_{it}$, the level of therms consumed per month per apartment unit at each site. The vector $\mathbf{z}_i$ is a set of fixed effects that are site specific, and $\mathbf{x}_{it}$ is a vector of variable effects that vary by site and over time. The variable E, which is site specific, is an engineering estimate of the reduction in consumption caused by the treatment. These savings estimates are then included as explanatory variables in lieu of the treatment variable. The coefficient r, when estimated, gives an estimate of how close the estimated savings is to realized savings, on average. An estimate of r close to unity in absolute value indicates that the engineering estimate was accurate. However, we do not have an estimate of the reduction in therms E for each site each month. Nevertheless, we do have engineering estimates of predicted savings rates.

Conservative engineering estimates of savings rates are a 19% reduction for units that are totally hydronic and a 13% percent reduction for non-hydronic units. These are the same estimates used for analysis in the first year impact study for the first program year. The consumption levels for the pre-treatment period can be multiplied by 0.19 and 0.13 for hydronic and non-hydronic units respectively. This generates estimates of saving that would have occurred if the controller had been present during the pre-treatment period. The savings estimates are set to zero for post-treatment observations. For estimation, these estimates of savings must be measured in natural logarithms to be consistent with the dependent variable used in the production function model. However, the preceding version of the rate-realization model cannot be estimated when the dependent variable is measured in logarithms because the logarithm of zero is undefined. Therefore, an alternative version of the rate-realization model must be estimated.

An alternative specification of the rate-realization model in the current application is given below. An estimate S of therms per unit saved can be subtracted from actual therms in the pre-treatment period. The model becomes

$$\ln(y_{it} - S_{it}) = a + \mathbf{b}\mathbf{z}_i + \mathbf{c}\mathbf{x}_{it} + dTi + ei \qquad (6.2.2)$$

The variable $S_{it} = r_i y_{it} > 0$ for pre-treatment consumption periods, but $S_{it} = 0$ for post-treatment periods. The site-specific engineering estimate for the savings rate is $r_i$. The inclusion of the variable T is used to test the accuracy of the estimated savings. If the estimated coefficient for d is not statistically different from zero, the inference is that the engineering-based savings estimate is representative of average realized savings.

## 6.3 Fixed Effects Model

It is likely that sites in both the treatment group and the control group differ in characteristics that are not observed by the analyst, but which nonetheless affect therm consumption. The problem is one of unobserved heterogeneity, and under certain conditions, this will lead to statistical estimates of savings based on ordinary least squares estimates that are biased and inconsistent. The bias arises because the unobserved site characteristics that affect therm consumption are likely to be correlated with explanatory variables that are included in the regression. The most common manifestation of the unobserved heterogeneity problem is the so-called model of self-selection. In the present application, self-selection could arise if treatment sites adopted the treatment because, for reasons unobserved to the analyst, they anticipated greater savings.

A solution to this problem is to estimate savings using a fixed-effects model. The fixed-effects model exploits the panel aspect of the data (multiple time-series observations for the same site) to analyze how changes in the level of the dependent variables are related to changes in the level of the independent variables. If the unobservable characteristics are fixed over the period of observation, the effects of any unobserved heterogeneity are eliminated.

Consider the following example:

$$\text{AdjTherms}_{it} = a + \mathbf{b}\mathbf{z}_i + \mathbf{c}\mathbf{x}_{it} + d_i + e_{it} \qquad (6.3.1)$$

In Equation (6.3.1), "i" indexes sites and the subscript "t" indexes the time period. The variables of the right-hand side of the equation are as follows. The vector $\mathbf{z}_i$, stands for site-specific variables that are fixed over time. That is, $\mathbf{z}_i$ includes such factors as whether a swimming pool or spa is present at the site. The vector $\mathbf{x}_{it}$, on the other hand, represents explanatory variables that vary across sites and by time, such as temperature and rainfall. Unobservable fixed effects are captured by the expression $d_i$. The presence of $d_i$ in the adjusted therms equation will bias the remaining parameter estimates if it is correlated with the included explanatory variables.

The solution is to eliminate the fixed effects from the estimating equation by taking first-differences. That is, consider the adjusted therms equation for period t+1,

$$AdjTherms_{it+1} = a + b\,\mathbf{z}_i + c\,\mathbf{x}_{it+1} + d_i + e_{it+1} \qquad (6.3.2)$$

Subtracting Equation (6.3.2) from Equation (6.3.1) gives

$$(AdjTherms_{it+1} - AdjTherms_{it}) = c\,(\mathbf{x}_{it+1} - \mathbf{x}_{it}) + (e_{it+1} - e_{it}) \qquad (6.3.3)$$

According to Equation (6.3.3), the change in consumption of adjusted therms over time is related only to changes in temperature and rainfall. The variable $d_i$ as well as observed fixed characteristics, represented by the $\mathbf{z}_i$, are removed by taking first differences.

## 7.0 Construction of Work Files from Survey Data

Site surveys were conducted for the treatment group (sites where controllers were installed) and for the comparison group (sites where controllers were not installed). The survey instrument is reproduced in Appendix C. The entire population of sites where the controllers were installed was surveyed. Site surveys were conducted for 152 non-installation sites. This comparison group, the control group, was selected if they had at least 30 apartment units at the site and had a re-circulation hot-water system. Moreover, they must have been willing to give permission for surveyors to visit the site, and they must have been willing to share billing information.

An Excel spreadsheet was constructed that includes monthly consumption of therms for all sites along with site characteristics collected from the surveys. Consumption data were drawn from monthly billing records. It was not possible to obtain days in each billing period for the control group because billing records for non-installation sites are regarded as confidential. In addition, detailed consumption data on treatment sites that were sold are confidential. Therefore, just as in the *First-year Impact Report for the First Program Year*, all analyses use monthly consumption rates rather than daily averages. The use of monthly consumption rates, rather than daily consumption rates, introduces extra variation in the consumption data because the days in each billing cycle are not constant. Subsequent statistical analyses will not be able to explain this extra variation.

This spreadsheet (work) file was used to create a stacked data set with monthly consumption and site characteristics recorded in every row. The stacked (pooled) data set has multiple recordings for many sites because several controllers were installed at some sites, but consumption was reported by a single account number. A weighting-factor was created by dividing the therms per meter attached to each controller by the total therms per account. Total therms is then multiplied by the weighting factor and divided by the number of apartment units to obtain "adjusted" therms (therms per unit per controller per month).

Data validation and corrections were made to the stacked file. Outlier observations were verified as accurate, corrected, or treated as missing values. For instance, a few observations were changed to "missing" because the recorded therms for the month was less than 100, an unreasonably low level. Table 7.1 lists those specific cases.

**Table 12.3 - Observations excluded because monthly therm consumption was less than 100**

| Name | MeterID | Account | Therms | Month |
|---|---|---|---|---|
| Park Place HOA | 5383035 | 038-302-0100 | 0 | 60 |
| Park Place HOA | 5383035 | 038-302-0100 | 0 | 60 |
| Versailles on Lake | 10276717 | 134-809-1500 | 0 | 60 |
| Lakeside Apts | -9 | 009-721-4853 | 1 | 68 |
| Lakeside Apts | -9 | 009-721-4853 | 1 | 69 |
| Lakeside Apts | -9 | 009-721-4853 | 1 | 70 |
| Lakeside Apts | -9 | 009-721-4853 | 1 | 71 |
| Mdwbrk HOA | 5024327 | 089-909-7000 | 21 | 69 |
| Sycamore Springs | 10526616 | 111-822-5000 | 26 | 49 |
| Sycamore Springs | 10526616 | 111-822-5000 | 35 | 48 |
| Lakeside Apts | -9 | 173-521-4692 | 36 | 32 |
| Woodbridge Meadow | 2348163 | 101-208-5600 | 43 | 64 |
| Lakeside Apts | -9 | 173-521-4692 | 44 | 33 |
| Lakeside Apts | -9 | 074-821-4832 | 58 | 33 |
| Lakeside Apts | -9 | 074-821-4832 | 59 | 32 |
| Lakeside Apts | -9 | 079-021-4702 | 79 | 32 |
| Lakeside Apts | -9 | 173-521-4692 | 80 | 44 |
| Lakeside Apts | -9 | 173-521-4692 | 80 | 45 |
| Lakeside Apts | -9 | 079-021-4644 | 82 | 68 |
| Lakeside Apts | -9 | 173-521-4692 | 89 | 34 |
| Lakeside Apts | -9 | 074-821-4832 | 93 | 34 |
| Lakeside Apts | -9 | 173-521-4692 | 96 | 41 |
| Marquesa | -9 | 158-323-5200 | 98 | 31 |

The weather data were matched with the month and geographic location for each observation. The weather data on minimum temperature, maximum temperature, and rainfall are reported in Appendix B. Thus, the stacked data set pools the cross-section information on site characteristics with the time-series information on consumption and weather patterns. There are 30,864 rows in the stacked data set consisting of blocks of 48 months of potential consumption observations for each controller. Each row represents an observation on a month's adjusted consumption for each boiler. Site characteristics and the weather data are matched with each observation. Table 7.2, "Pooled File Variables," describes the variables included in the stacked file.

The empirical models estimated and reported below are essentially the same as those applied in the *First-year Load Impact Study for the First Program Year*. The dependent variables are the same. The potential explanatory variables are the same with two types of exceptions. First, measures of the number of solar heaters, the numbers of gas dryers, and the number of bar-BQs were divided by the number of apartment units and weighted by *Factor* in the level regressions of the second program-year impact study. A judgement was made that these alternative measures better allocated the influence on gas consumption than their previous measures. Second, a monthly trend variable called TIME was used in lieu of the occupancy rate. A judgement was made that a monthly trend was a better measure of the influence of a changing economic environment, including its influence on occupancy rates, than the crude annual measures of occupancy rates used in the first-year impact study. Descriptive statistics for the pooled sample, for the installation sites, and for the comparison sites, for all the explanatory variables used in the regression estimates are reported in Appendix A of this report. Also included is a correlation matrix for the explanatory variables.

**Table 7.2 — Pooled File Variables**

| Variable | Definition |
|---|---|
| Site | = 1 if installation site; else = 0 |
| PostIS | = 1 if after savings date at installation site; else = 0 |
| Factor | therms per meter divided by total therms per account |
| Problem | = 1 if a serious problem existed at the site |
| HOA | = 1 if home owners association; else = 0 |
| Name | name of apartment complex |
| Region | weather regions 1 through 10 |
| Meter ID | meter identification number |
| Account | gas company account number |
| Therms | therms per month by account number |
| AdjTherms | = Factor*Therms/Units |
| Units | number of apartment units served by the boiler |
| Month | survey month; 1 = Jan-94 through 60 = Dec-97 |
| MaxTemp | maximum temperature by month by region |
| MinTemp | minimum temperature by month by region |
| Rainfall | rainfall in inches by month by region |
| DmstcHot | = 1 if site served by domestic water heater; else = 0 |
| Hydrnic | = 1 if site has hydronic space heating; else = 0 |
| Convrt | = 1 if converted from hydronic (Deerfield #1); else = 0 |
| SpcHeat | = 1 if site has space heating; else = 0 |
| BBQ | = 1 if site has outdoor gas grill; else = 0 |
| Pool | = 1 if there is a pool at the site; else = 0 |
| Spa | = 1 if there is a spa at the site; else = 0 |
| CntLdry | = 1 if the site has a central laundry facility; else = 0 |
| FirePlc | = 1 if apartments have gas fire places; else = 0 |
| GasCkg | = 1 if apartments have gas cooking; else = 0 |
| IndLdry | = 1 if apartments have individual laundry; else = 0 |
| Stories | number of stories of building |
| SqrFt | square footage of building |
| OcRate95 | occupancy rate for 1995 |
| OcRate96 | occupancy rate for 1996 |
| OcRate97 | occupancy rate for 1997 |
| OcRate98 | occupancy rate for 1998 |

**Table 7.2 — Pooled File Variables (cont.)**

| Variable | Definition |
| --- | --- |
| HtrBTU | heater BTU |
| Cpcty | capacity of heater |
| LvgTemp | leaving water temperature at boiler |
| Solar | = 1 if solar assisted heating; else = 0 |
| NumSlr | number of solar units |
| NumBBqs | number of bar-B-Q units |
| BBqBTU | BBQ BTU |
| BBqUse | days of spa use per year |
| PlHtrUsed | = 1 if pool heater is used; else = 0 |
| PlArea | area of pool in feet |
| PlDpth | depth of pool in feet |
| PlSolar | = 1 if solar assisted heating of pool; else = 0 |
| PlSetPt | temperature set point for pool heater |
| PlBTU | BTU of pool heater |
| PlUse | days of pool use per year |
| SpaArea | area of spa in feet |
| SpaDpth | depth of spa in feet |
| SpaCvr | = 1 if spa cover used; else = 0 |
| SpaSetPt | temperature set point for spa heater |
| SpaBTU | BTU of spa heater |
| SpaUse | days of spa use per year |
| WshrsN | Number of gas washers |
| DryrsN | Number of gas dryers |
| DryrBTU | BTU of gas dryer |

In subsequent empirical analyses, observations on consumption during the month of installation were omitted from the analysis. This is because it is not possible to divide consumption for the installation month into pre and post treatment amounts. Moreover, as in the study for the first program year, there was an adjustment period after installation over which the controller was "fine tuned." Observations during such adjustment periods were omitted from the analysis. However, at least 11 months of post-treatment consumption data were used in every case.

**8.0 Rate-Realization Model Estimates**

The estimated rate realization model is reported in Appendix Tables A-23 and A-24. The dependent variable is called LNNEW, the logarithm of the difference between actual consumption and estimated savings, as described by Equation (6.2.2). This model is estimated by ordinary least squares with White's correction to estimate asymptotically correct standard errors in case of heteoskedasticity. The rate-realization model is estimated for participants only. Trimmed-least squares was applied by first estimating the model for the full sample and then eliminating observations outside a 95 percent confidence interval for the residual. There are 17,690 observations for this model. The estimated coefficient for the variable d is –0.064864, and it is statistically different from zero at any conventional level of statistical significance. The standard error of the coefficient is 0.013349. A 95% confidence interval for this coefficient is [–0.09008, –0.03871]. Therefore, the hypothesis that the engineering estimates of savings is representative of actual average savings is rejected. It is important to understand that the negative sign of the estimated coefficient indicates that the engineering estimates of the savings rates were too low over the survey period. That is, program performance exceeded that originally estimated.

In order to separate estimate savings for hydronic and non-hydronic sites, the production model can be estimated separately for hydronic and non-hydronic units. Those estimates will be presented in the next section along with other estimates derived from the production function model.

## 9.0 Empirical Results of the Treatment Effect Model

The estimated equations for the production function model are reported in Appendix A. The dependent variable in this model is the logarithm of adjusted therms as described by Equations (6.1.1) and (6.1.2). White's technique was applied to generate asymptotically consistent standard errors in the presence of heteroskedasticity. Heteroskedasticity, a changing variance of the random error term, is likely because larger sites are likely to have more variation in consumption than smaller sites. White's correction does not change the coefficient estimates; rather, the procedure generates asymptotically correct standard errors. Therefore, standard statistical tests can be applied. The ordinary least squares coefficient estimates are used because they are unbiased if the remaining assumptions of the classical regression model hold.

Except for the different dependent variable, the equation specification is the same as that of the rate-realization model. In some equations, an extra explanatory variable called *Problem* is included. This variable is a dummy variable that indicates when a serious problem, like a leaking pipe or cracked slab, was present which may affect consumption adversely. When *Problem* is included as an explanatory variable, there is an increase in the adjusted-$R^2$. However, the inclusion of *Problem* had little effect on the estimated coefficient of the treatment variable, and so all calculations of estimated savings will be based on the models that did not include *Problem* as an explanatory variable.

Once again, trimmed least-squares regression was applied. Each equation was estimated by ordinary least squares. Then observations were eliminated if the residual from the estimated equation were outside a two-standard error interval. Each model was then estimated using the retained observations. This technique eliminates the possible undue influence of outliers. It should be noted, however, that the trimmed least squares estimates are not very different from the ordinary least squares estimates in this application.

The first set of estimates of the production function model is reported in Tables A-6 through A-14. The trimmed least-squares estimates without the problem variable are reported in Table A-13. This equation was estimated using all 22,202 observations, after trimming, including those for the comparison group. POSTIS (T = 1) indicates a post-treatment observation. Its coefficient can be used to measure the effect of treatment, the installation of the controller, on the consumption of therms. The estimated coefficient is – 0.197 with standard error 0.0089. A hypothesis that the controller has no effect or a positive effect on consumption is decisively rejected. The estimated average monthly savings per apartment unit is

$$\text{Savings percent} = 100\{\exp(0.196769) - 1\} = 21.75\%$$

A 95% confidence interval, calculated from the treatment coefficient, indicates that the savings rate lies within the range from 19.67% to 23.92% with 95 percent certainty.

The empirical results for the model where the comparison group is excluded from the data are reported in Tables A-15 through A-22. Again, we focus on the trimmed least-squares estimates of Table A-21. The equation was estimated using 16,957 relevant observations. The coefficient of determination is a very high 0.488. The estimated coefficient on the treatment variable is –0.234 with standard error 0.01126. A hypothesis that the treatment effect is zero of positive is decisively rejected. The estimate of percentage savings is:

$$\text{Savings percent} = 100\{\exp(0.234462) - 1\} = 26.42\%$$

A 95% confidence interval, calculated from the treatment coefficient, indicates that the savings rate lies within the range from 23.66% to 29.25% with 95 percent certainty.

Two additional specifications of the production model were estimated: one for HYDNIC = 1 and another for HYDRNIC = 0. These equations were estimated using observation on treatment sites only. These results are reported in Tables A-25 through A-31. The estimated coefficient for the POSITS variable is –0.232658 when HYDRNIC = 1 when trimmed least-squares was applied. This indicates a 26.2 percent average savings rate when hydronic heating is present. When HYDRNIC = 0, the estimated coefficient for POSTIS is –0.253190, which indicates a savings of 28.8 percent for non-hydronic units. This implies that realized savings rates were much higher than the rates used to estimate the engineering model.

The lower savings estimates obtained when the comparison group is excluded from the sample suggest that the inclusion of the comparision group results in an estimate of actual program savings that is too low. The comparison group is very different from the treatment group. The average level of consumption for the treatment group prior to treatment is 29.74 therms per apartment unit per month compared to 39.48 therms for the comparison group. This must be due to differences in site characteristics, measured and unmeasured. Many site characteristics, such as management capability, are unobservable.

## 10.0 Fixed-Effects Model Estimates

A comparison of the treatment sites with the comparison sites reveals that they are different in important measured fixed effects. This can be seen by comparing the descriptive statistics for each type of site. The differences in the measured characteristics make it very likely that the treatment and comparison groups differ in unmeasured traits also. Fortunately, there is a technique to control for differences in measured and unmeasured fixed effects across groups: the fixed-effects or change model. The change model is described by equation (6.3.3).

Changes in therm consumption are calculated as follows. For each treatment site, subtract pre-treatment therm consumption for a particular month from post-treatment consumption for the same month. If there is a reduction in consumption between the two periods, the result of this calculation will be a negative number. Analogous calculations are made for the comparison group sites. Since there is no treatment effect for the non-installation sites, the expected change over the period is zero, if other influences remain constant.

### 10.1 Empirical Results for the Fixed-Effects Model

To estimate the savings from the treatment, the parameters of Equation (6.3.3) are estimated by ordinary least squares. An intercept term is added to the estimating equation to account for possible unobservable effects that vary over time. This amounts to allowing the intercept terms in Equations (6.3.1) and (6.3.2) to vary over time.

Savings are estimated using two strategies. In the first, the parameters of Equation (6.3.3) are estimated for a pooled sample that includes sites in both the treatment and comparison groups. Savings are estimated by appending to Equation (6.3.3) a dummy variable that takes the value of 1 if the site is a treatment site. The rationale for such an approach is as follows. Savings from the treatment are realized if the difference in consumption calculated between post-treatment and pre-treatment months is smaller than it would have been without the treatment. One way to assess the effect of the treatment is to compare changes in consumption for the treatment and comparison groups. For example, suppose that, on average, consumption for treatment sites falls between pre-treatment and post-treatment monthly observations. Savings from the treatment are realized if consumption at the comparison site remains the same, rises, or falls by a smaller amount than at the treatment site. The coefficient for the treatment group dummy variable measures just such an effect.

Since it is expected that reductions in consumption will be larger or increases in consumption will be smaller at treatment sites, the expected sign for the treatment group dummy variable is negative. Moreover, the magnitude of the dummy variable coefficient will give a direct estimate of savings. For example, suppose that the coefficient estimate is –5. This suggests that, on average, the change in adjusted consumption at treatment sites is 5 therms lower than at control sites, controlling for changes in temperature and rainfall.

One limitation of the above approach to estimating savings is that it restricts the coefficients of the time and region-varying measures of temperature and rainfall to be the same across treatment and comparison groups. An alternative is to relax this restriction by estimating the parameters of Equation (6.3.3) separately for the treatment and comparison sites. Again, an intercept term is added to each equation to account for possible unobservable effects that vary over time.

Once the parameter estimates for the treatment and comparison sites are obtained, savings are estimated by applying the parameters for the treatment site to the average characteristics of comparison sites. That is, we estimate for the control sites what the average change in adjusted therm consumption would have been had they been given the treatment. As a final step, this predicted change in therm consumption is compared to the actual change in therm consumption for the control sites. The difference between these magnitudes is an estimate of savings.

The parameter estimates of Equation (6.3.3) appear Appendix Tables A-33 through A-35. Turning first to the estimates for the full sample from Table A-33, the results are as expected and give a strong indication of savings from the treatment. The coefficients for the temperature variables are both negative and statistically significant. As expected, as the change in average maximum and minimum temperature increases, the change in adjusted therm consumption falls. Similarly, when the change in average rainfall increases, the change in average therm consumption increases. The temperature and rainfall coefficients are statistically significant as can be seen by their very low probability values.

The coefficient for the variable SITE is a direct estimate of savings from the treatment. The coefficient is negative and statistically significant. The coefficient estimate of –4.015 is interpreted as follows. Controlling for changes in weather and rainfall, the change in adjusted therm consumption at treatment sites is, on average, –4.015 adjusted therms lower than at control sites. From descriptive data, we know that the average therm consumption at treatment sites is 29.74 adjusted therms per month prior to treatment. Thus, the treatment effect indicates a 13.5 percent (4.015/29.74) reduction in consumption.

The results for the separate regressions also appear in Tables A-34 and A-35. Turning first to the treatment group, the results again show that changes in temperature and rainfall are important in explaining changes in therm consumption. In the context of the change model, the estimated intercept for the separate regression model is of some importance. The intercept is included to capture any time-varying characteristics not included in the model. For the treatment group, this is obviously the effect the treatment. The estimated intercept of –3.10 indicates that if changes in temperature and rainfall are set to zero, average consumption of adjusted therms in the treatment group is reduced by –3.10 units in the post treatment period.

The parameter estimates of Table A-35 for the control group also show significant effects of temperature and rainfall. Note, however, that the intercept term, although statistically significant is positive and relatively small. Thus, for the comparison group sites, therm consumption rose slightly over time, controlling for the changes in temperature and rainfall.

As a final step, the change in average adjusted therms consumed is predicted for the comparison group using the parameter estimates for the treatment group. Again, the estimate from this procedure will give what the change in average adjusted therm consumption would have been for the comparison group had they had the treatment.

Using the average temperature and rainfall averages for the comparison group, the predicted average change in adjusted therm consumption is given as

$$\text{Predicted Change} = -3.1+(-0.043*(0.151)-0.486*(-0.299)+0.289*(-0.304))= -3.05$$

The actual average change in therm consumption for the comparison group was 1.11, an increase in consumption. Thus, the average change in adjusted therm consumption would have been 4.16 therms lower had the comparison group received the treatment. This yields a percentage reduction of 14.0 percent (4.16/29.74), which is slightly larger than the estimate obtained for the SITE dummy variable coefficient from the pooled model.

## 11.0 Quality Assurance Considerations

After submission of the first-year impact study for the first program year SoCalGas asked Energx to respond to questions listed in the "Quality Assurance Guidelines for Statistical and Engineering Models," December 1994. Please refer to that document for the exact wording of questions. The relevant section of the guideline is *Quality Assurance Guidelines for Conditional Demand Analysis (CDA) Models*. In order to assist the Gas Company in evaluating the results of the first-year impact analysis for the second program year, Energx includes the following response to those guideline questions.

### CONDITIONAL DEMAND MODEL TYPES

**Question**: Are any of the impacts adjusted for spillover?

**Answer**: Spillover is not applicable to the study. Operation of the energy saving controllers will not affect any other end use, nor are they likely to affect the behavior or managers or tenants in a way that will affect any other end use. Consumption externalities due to the program treatment are unlikely.

**Question**: What is the period covered by the analysis?

**Answer**: Forty eight months of data were collected for the period beginning January 1995 through December 1998. Not all sites are measured for every month because installation dates were not the same for every site. In addition, an adjustment period was required after installation at several sites in order to optimize the performance of the controller. In all case, however, at least 12 months of pre-treatment data and at least 11 months of post-treatment data were collected.

**Question**: Applicable tables from the M&E protocols?

**Answer**: The required tables are included in Section 12.0, Response to M&E Protocols, of this report.

**Question**: What is the frequency of data?

**Answer**: Monthly therms consumed per apartment unit.

**A. Model Types**

The following model types were used:

- Types (e) and (g): Conditional Demand Analysis (CDA) with pre/post design using cross sectional time series (CSTS) data and dummy variables to capture the impact of the treatment.
- Types (f) and (h): Conditional Demand Analysis (CDA) with pre/post design using cross sectional time series (CSTS) data and engineering estimates of impacts to test the impact of the treatment.
- Type (i): Fixed-Effects Model with pre/post design to capture the impact of the treatment when there are unobservable or improperly measured characteristics that are time invariant.

**B. Models**

1. Model types (e) and (g) are described in section 9.0 of the final report.
2. Model types (f) and (h) are described in section 8.0 of the final report.
3. Model type (i) is described in section 10.0 of the final report.

**C. Sample**

1. All participant sites are included in the analysis, the entire population. There are

152 nonparticipant sites included in the analysis. Nonparticipant sites were not randomly selected; rather, comparison group sites were eligible if they had at least 30 apartment units, had a re-circulation hot-water system, willing to share billing information, and willing to permit an on-site survey. Many potential control-group sites contacted refused to give the required permissions. In fact, it was very difficult to find 150 sites, as required by the contract, which were willing to give the required permissions. Differences in important participant and nonparticipant site characteristics are examined in the final report.

2. N/A

3. N/A

4. N/A

5. A copy of the site survey questionnaire is included in Appendix C of this report. Consumption data were taken from billing records provided by SoCalGas. These data were augmented with monthly weather data on maximum temperature, minimum temperature, and average rainfall for the region. A detailed description of the weather data is included in the final report. All data are also reported in an Excel spreadsheet provided on a computer readable disk.

6. N/A

7. N/A

8. The entire population of participant sites was used for analysis. The number of non-installation sites used as a comparison group was prescribed by the contract protocols. Therefore, no statistical procedure to determine sample size adequacy is

appropriate in this study.

9. Survey sites were exclusively multiple family dwellings that had re-circulating hot-water systems (boilers) across ten contiguous geographical regions in or near the Los Angeles basin.

**D. Data**

1. Site characteristics were collected from on-site surveys. Consumption data were extracted from billing records. Weather data were obtained from the National Weather Service.
2. See previous response.
3. A full description of the construction of the work files used for analysis is contained in section 7.0 of this report.
4. The data collection instruments are archived by the evaluation subcontractor, Occidental Analytical Group.
5. A flow chart of data collected is provided in Section 12.2 Part B below. Descriptions of the data files are provided in "read me" files along with the data on a computer readable disk. The master work-file includes all observations on consumption along with site characteristics taken from the site surveys for both treatment and non-treatment sites. The weather data is also provided as an Excel file on disk. These data were merged and stacked into a pooled cross-section time-series format for analysis. The pooled data set is also provided as an Excel file on disk along with a "read me" file. Likewise, the "change" data calculated from the master file and used to estimate the fixed-effects model are provided as an Excel file along with a "read me" file.

## E. Specification Error

1. The dependent variable was proposed originally to be average *daily* therms per apartment unit. However, the analysis was performed using *monthly* therms consumed during each billing cycle. This level of aggregation was required because SoCalGas could not release detailed billing data for legal confidentiality reasons. Therefore, no adjustment was made for differences in the number of days in each billing period. Thus, there is variation in the dependent variable that cannot be explained by any empirical model.

   Rather than engage in an expensive and time-consuming specification search, the consultant chose a specification based on logic and the availability of reliable data. When using level data in the estimation of the CDA models, initial estimates indicated that the goodness-of-fit was improved considerably by transforming the dependent variable into a natural logarithm. There are several additional advantages to using this transformed dependent variable. First, its distribution is more symmetric (bell-shaped). Second, the functional form can capture diminishing returns to inputs without losing degrees of freedom. Third, the estimated coefficient on the treatment variable generates a direct estimate of program savings as a percentage.

   Several potential explanatory variables were excluded from the analysis because there were too many missing observations. Fortunately, there were other variables to serve as proxies, and so the analysis was not compromised significantly.

2. For the first-year impact study for the first program year, a fully specified quadratic form with interaction terms was estimated because such a specification is a close

approximation to any underlying functional form. However, the quadratic form resulted in severe multicollinearity between many of the explanatory variables, and so the quadratic form was dismissed as inappropriate. The only quadratic terms retained in the final model are for the weather variables. That specification was also applied for the first-year impact study for the second program year.

3. When important explanatory variables had missing observations, the observation was omitted from the analysis. No interpolation technique was applied to generate data for missing observations. Instrumental variable techniques were not appropriate for this study because all explanatory variables are exogenous.
4. The primary characteristic of these data is that they are cross-sectional. Though monthly observations were made over a four-year interval, there is no evidence of serial correlation when the weather data were included as explanatory variables.
5. No adjustment for serial correlation, or for spatial autocorrelation, was necessary.
6. No adjustment for spatial autocorrelation was necessary for these data from relatively homogeneous sites across relatively homogeneous regions. The use of weather data should control for any spatial autocorrelation caused by changes in the weather.
7. The heteroskedasticity correction procedure used is not sensitive to autocorrelation.
8. White's technique was used to generate asymptotically correct standard errors regardless of the source of heteroskedasticity. This method only affects the estimated variance-covariance matrix. The estimated coefficients remain ordinary least-squares estimates.
9. Autocorrelation was not a problem in this study. Even when autocorrelated errors are

present, the least squares coefficient estimates remain unbiased though inefficient.

10. Weighted least-squares estimation was not applied and is not appropriate when using White's correction procedure.

**F. Collinearity**

1. Pair-wise correlation coefficients were estimated to identify variables that were collinear or nearly collinear. When present, perfect of near perfect collinearity was eliminated by omitting one of the variables.
2. Unless retained explanatory variables are orthogonal (uncorrelated), some collinearity between variables is unavoidable. Moreover, dropping properly included variables may bias the estimated coefficients of retained variables. Therefore, no further adjustments were made to the list of included variables after dropping variables because of severe collinearity. This is warranted because the most important coefficient estimate is that for the treatment indicator. Other coefficients are largely incidental in this study.

**G. Tests for Endogenous Variables**

All explanatory variables are exogenous in the empirical models used, and so tests for the presence and influence of endogenous explanatory variables are inappropriate for this study.

**H. Influential Data**

1. Unusually large or small values of variables were either verified as correct values and retained or were treated as missing observations.
2. Trimmed least-squares estimates were generated to test the sensitivity of the

estimated model to the presence of outliers. An outlier case was defined as occurring when the residual from the initial regression equation was outside a two-standard deviation interval. Those cases were eliminated and the model was re-estimated. Although estimates were not very sensitive to the trimmed-least squares procedure, the trimmed-least squares parameter estimate of the treatment effect are used as the "best" estimate of program impact.

## H. Missing Data

When data were missing, a missing-data indicator was assigned so that the observation would not be used in the analysis. Mean substitution, or any other interpolation method, was not used to substitute values for missing data. The risks associated with such techniques were judged to be unacceptable because the sample remains sufficiently large when observations are lost due to missing values on included variables.

## I. Triangulation

Estimates of program effects from the alternative models are presented separately. No attempt at meta-statistical analysis was made to generate a single estimate.

## J. Weather

1. Weather normalization was not applied in this study. Rather, weather data were used as explanatory variables.
2. N/A
3. N/A
4. Seasonal bias is not a problem in this study because a minimum of 12-months of

pre-treatment and a minimum of 11-months of post-treatment data were used.

5. N/A

## H. Engineering Priors

In the estimation of the rate-realization (engineering) model, two estimates of predicted savings were used: one for sites where hydronic space heating was present (a 19 percent reduction); a second where hydronic heating was not present (a 13 percent reduction). These conservative estimates were based on contractor experience with these two types of installations. The empirical results indicate that actual savings exceeded the engineering estimates.

## I. Precision

The specified empirical model generates a direct estimate of the treatment effect. Therefore, the standard error of the estimated coefficient provides an estimate of the precision of the treatment effect. 95%, 90% and 80% confidence intervals are presented in the final report.

## J. Comparison Group

1. A comparison group was included in the empirical models.
2. A fixed-effects model was estimated to generate an estimate of the treatment effect that is adjusted for unobservable site characteristics and self-selection that may be dependent on site characteristics, observable or unobservable. Section 10.0 contains a description of the empirical results of the fixed-effects model. The estimated treatment effect is smaller from the fixed-effects model, a results that is expected if program participants self select into the program.

## 12.0 Response to M&E Protocols

This section provides information in the format of Tables 6 and 7 of *Protocols and Procedures for Verification of Costs, Benefits, and Shareholder Earnings from Demand-Side Management Programs,* March 1998 (D.98-03-063).

## 12.1 Table 6, M&E Protocols

### 1. Average Participant and Comparison Group Energy Use

As shown in the following table, the average consumption of therms was 13.35 percent lower for the treatment group after treatment. The average consumption of therms was 53.23 percent higher for the comparison group compared to the treatment group after treatment. These estimates do not control for differences in site characteristics or for differences in weather measures.

Table 12.1 — Therms per Apartment Unit per Month,
First-Year Impact Load Analysis, Second Program Year

| | Mean | Standard Deviation | 90% Interval | 80% Interval |
|---|---|---|---|---|
| Treatment sites, pre-treatment period | 29.74 | 17.61 | [0.67; 58.71] | [7.16; 52.32] |
| Treatment sites, post-treatment period | 25.77 | 16.61 | [–1.56; 53.10] | [4.47; 47.07] |
| Comparison group | 39.48 | 21.59 | [3.97; 75.00] | [11.81; 67.16] |

Note: The confidence intervals were calculated using t=1.282 and t=1.645 assuming that the realizations come from a normal distribution. That assumption is unlikely to be true since the means are truncated below zero and the Jarque-Bera statistic indicates rejection of a hypothesis of normality.

### 2. Average Net and Gross End Use Load Impacts

Because of the unique characteristics of this study, gross load impact and net load impact are equal. Estimates of average impact are obtained from alternative empirical models. The estimated saving rates and levels of savings from those models, which control for differences in site characteristics and weather, are reported in Appendix A. The estimated mode's are reported in Appendix A. The "best" estimate of the direct impact is derived from the coefficient on the treatment effect variable in the conditional demand model estimated for participants only. The relevant statistics are reported in Table 12.2.

Table 12.2 — Saving Based on a Conditional Demand Model with Treatment Effect Estimated by Trimmed Least Squares, Participants and Non-participants, Pre- and Post-Installation Periods, First-year Load Impact Analysis, Second Program Year

| | |
|---|---|
| Coefficient (standard error): | –0.196769 (0.008902) |
| 80% interval: | [–0.2082; –0.1854] |
| 90% interval: | [–0.2114; –0.1821] |
| Saving rate: | 21.75 percent |
| 80% interval: | [20.36; 23.14] |
| 90% interval: | [19.98; 23.54] |
| Therms saved per unit per year: | 77.60 therms |
| 80% interval: | [72.67; 82.59] |
| 90% interval: | [71.29; 84.01] |
| Estimated Annual Program Savings: | 1,932,685 therms |
| 80% interval: | [1,809,904; 2,056,876] |
| 90% interval: | [1,775,392; 2,092,298] |

Note: calculations based on 24,905 units, 29.7 therms per month, and t-values of 1.282 and 1.645.

### 3. Net-to-Gross Ratios

Because of the unique characteristics of this study, the net-to-gross ratio is unity.

### 4. Designated Unit Intermediate Data

Descriptive statistics, for all variables used in the final statistical model chosen to estimate the load impact (treatment effect), are reported in Appendix A.

### 5. The Precision of the Load Impacts

Confidence intervals for the average consumption of therms for the treatment sites, pre- and post-treatment, and for the comparison sites are reported in Table 12.1. Confidence intervals for the estimated coefficient of the treatment effect variable, the calculated savings rate as a percent, therms saved per unit per year, and the estimated annual savings are reported in Table 12.2.

Confidence intervals are not calculated for the explanatory variables used to estimate the statistical model, because the Jarque-Bera statistic indicates a non-normal distribution for each variable. Many of these variables are counts or dummy variable indicators. Confidence intervals based on an assumption of normality would be misleading. Instead, the minimum and maximum values can be used to measure the range of each variable. The sample means of all variables are relatively precise (small standard deviation relative to the mean) because of the large sample size. The standard deviation of a mean is calculated as $SN^{-1/2}$ where S is the standard deviation of the variable and N is the sample size.

**6. Measure Count Data**

The number of measures installed in the participant group is equal to the number of participants. All participants installed the energy saving device. The number of measures installed by the comparison group is zero. None of the control group sites installed the device during the survey period.

**7. Market Segment Data**

All of the sites are commercial residential apartment complexes. There were no industrial installations

## 12.2 Table 7 M&E Protocols

### A. Overview Information

1. The study title is *First-Year Load Impact Study of Residential Energy Efficiency Program (DSM Pilot Bidding Program) for Second Program Year (1996-1997).* The program identification number is D-9308-116.
2. The first-year impact study for the second program year is for program years 1996-1997.

3. The impacted end use to reduce the consumption of natural gas used for water heating. The end use designation is to install 900 controllers for temperature control of central water heaters, 45 high efficiency non-storage water heaters, and 18 steam boiler controllers over two years.
4. Trimmed least-squares regression analysis was used to estimate program effects. The treatment effect specification used to estimate program savings included a comparison group, and it used site characteristics and weather data as control variables. That model and alternative models that were estimated are discussed in Sections 6.0. Empirical results are summarized in Sections 8.0, 9.0 and 10.0. Empirical results are reported in detail in Appendix A.
5. A participant is a large-scale apartment complex that installs the controller. A non-participant is a large-scale apartment complex that does not install the controller where the management is willing to permit an on-site survey and the owner is willing to share billing records.
6. There were 492 controllers installed in the second year. Conforming to the ex-post measurement protocols, all 492 participant sites and 152 non-participant sites are included in the analysis. The entire population of participants is included, and so sampling is not an issue. The protocol required at least 150 non-participants. Sampling was not used to select members of this control group. Rather, any large-scale complex that was willing to share the required information is included. Difficulties were experienced in obtaining permission from enough non-participant sites to satisfy the protocol.

## B. Data Base Management

1. Weather data on minimum temperature, maximum temperature, and rainfall by geographic region were matched with the monthly consumption data on therms consumed at each site. Site characteristics were matched with the consumption data by account name, account address, account number, and controller identification number. A data flow diagram follows:

Site characteristics (cross-section) data, matched with

Consumption (time series) data merged with

Weather data to obtain

Stacked (Pooled) data for estimation of level models

Change data for estimation of the fixed-effects model

2. Weather data were obtained from the National Weather Service. All weather data are reproduced in Appendix B. Data on site characteristics were collected from on-site surveys. The site survey instrument is reproduced in Appendix C. Consumption data were obtained from billing records provided by SoCalGas.

3. There was no sample attrition in this study.

4. Consumption data were provided by SoCalGas in the form of an Excel spreadsheet. The analysts assumed that these data were correct. Reasonable care was taken in merging these data with the weather data and site characteristics data.

5. The unit of analysis is for the dependent variable is therms consumed per month per apartment unit. Therms consumed per boiler controller were divided by the number of apartment units served by the controller. Observations were omitted from the analysis if

the recorded total for each account was less than 100. The excluded cases are summarized in Table 7.1 above. These were probably just recording errors, and they represent less than 1 percent of the total number of observations.

## C. Sampling

1. Sampling was not used in this study. The entire population of participants was used. All non-participants that were willing to share billing records and allow on-site surveys were included.
2. Response rates were 100 percent. The site survey instrument is reproduced in Appendix C.
3. The important variables used in the analysis are described in Table 7.2 above. Descriptive statistics of these variables for the participant and non-participant groups are reported in Appendix A.

## D. Data Screening and Analysis

1. Whenever an observation had missing data, that observation was excluded from the analysis. No interpolation method was used to substitute for missing values. Trimmed least squares regression was used to control for the influence of outliers. Any observation that had a first-step residual outside a two-standard deviation interval was trimmed from the data and the model was re-estimated. This trimming had only a trivial effect on the parameter estimates.
2. A monthly trend variable was included, as a proxy, to control for changes in the economic

environment over the period of analysis. Trend was used in lieu of occupancy rates that were used in the first-program year study. A judgement was made that trend was a better proxy for effects of a steadily improving economic environment over the span of time covered by this study than the imperfectly measured occupancy rate.

3. Beyond the elimination of observations when monthly therms were unreasonably low and the application of trimmed least-squares, no screening of data was applied.
4. All regression statistics are reported in Appendix A.
5. Models that were estimated are discussed in Sections 6.0. Empirical results are summarized in Sections 8.0, 9.0 and 10.0. Estimation of a change model (first-differences) eliminated fixed effects and mitigated the impact of self-selection, at least in part. Empirical results are reported in detail in Appendix A.
6. Please see D.1 above.
7. After including the weather variables, there was no evidence of autocorrelation, as explained in Section 11.0.
8. All models using level data were estimated using White's technique to generate asymptotically correct standard errors in the presence of heteroscedasticity. This technique uses least-squares coefficient estimates since they are unbiased and consistent under the assumptions of the standard linear regression model.
9. Multicollinearity was a serious problem during the specification search conducted for the first-year impact study. However, there was no collinearity problem encountered during the estimation of the specified models for the second-year impact study. A correlation matrix is included Appendix A.

10. Please see A.4 and B.5 above.

11. Please see A.4 and B.5 above.

12. Estimated standard errors were obtained using White's correction method. A least-squares coefficient estimate of the treatment effect is used to measure program impact. Net impact and gross impact are equal in this study.

13. Not applicable.

14. Not applicable.

## E. Data Interpretation and Application

1. Method 1a was used to estimate program savings. Estimated savings from alternative models are summarized in Table 1.1 of the Executive Summary of the *Final Report*. The method of calculation is explained in the Executive Summary.

2. Not applicable. Because of the unique nature of this study, the net-to-gross ratio is equal to one.

## 13.0 Conclusion

Results of the analysis indicate the highest program savings rate is predicted by the production function model. The trimmed least squares approach estimates annual program savings of 2,348,312 therms when only participants are included and savings of 1,932,685 therms per year with the entire sample of participants and control group. However, a better estimate of savings if the same number of sites had been chosen at random from the population is 1,242,760 therms per year generated from the fixed-effects model.

We propose that the production function model, estimated by trimmed least squares results, with non-participants included, and estimated with hydronic and non-hydronic units pooled together, be used for determining program savings. That model uses the pre-treatment consumption as a direct control to measure program impact along. That model also uses non-participants as a control group. Estimation by trimmed least squares method eliminates any bias caused by outlier observations in the data. With this method and with participating and the comparison groups included, the predicted energy savings is 77.60 therms per unit per. This figure represents 141 percent of savings from the second-year program goal of 31,199,000 therms to be derived from 900 controller installations. The exceptional performance of the controllers is partially due to the fact that the expected number of MF dwelling units per controller was higher than expected. An average of 48 units were served by each controller compared to the planned 35 units. The exceptional performance may also be partially attributed to the so-called "El Nino." The second year performance measures were collected during a period with unusually high precipitation. Thus, there were more savings to be realized because overall consumption was higher.

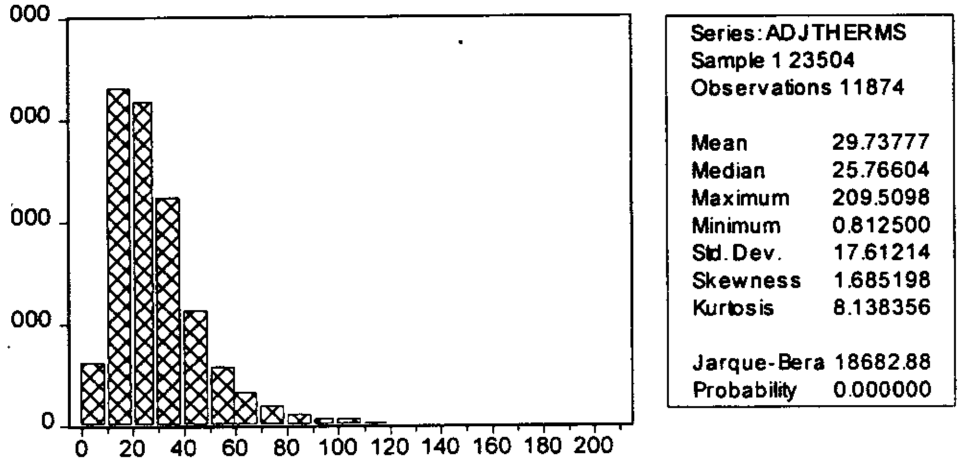
Energx Controls Incorporated, with the assistance Occidental Analytical Group, attempted to conform to all contract requirements and protocols in the execution of this first-year impact study for the second program year.

# Appendix A

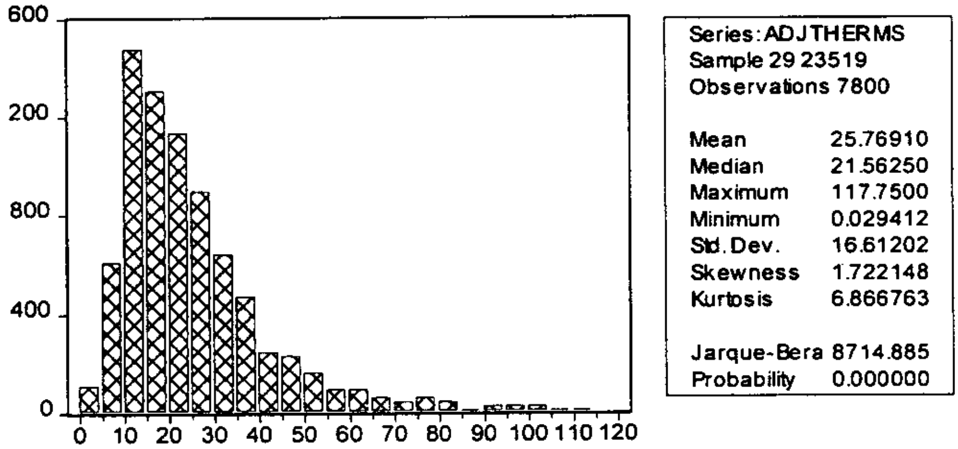
## Descriptive Statistics and Model Estimates

Table A1 – Therms per Apartment unit per Month

Pre-installation Period, Installation Sites:




Post-installation Period, Installaton Sites:




Control Sites:

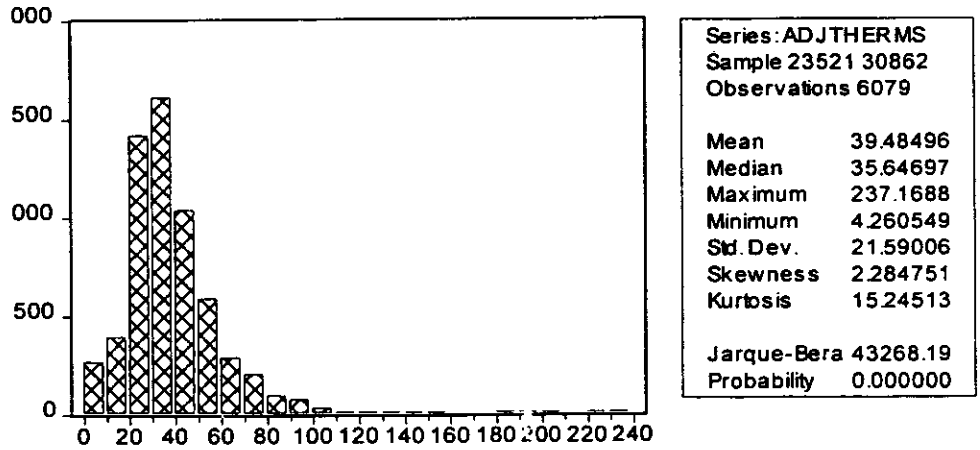


Table A2 – Descriptive Statistics Pooled Sample

| | LNTHERMS | SITE | POSTIS | HOA | PROBLEM | STORIES |
|---|---|---|---|---|---|---|
| Mean | 3.257711 | 0.754468 | 0.286860 | 0.108116 | 0.073911 | 2.211669 |
| Median | 3.293777 | 1.000000 | 0.000000 | 0.000000 | 0.000000 | 2.000000 |
| Maximum | 5.468772 | 1.000000 | 1.000000 | 1.000000 | 1.000000 | 5.000000 |
| Minimum | -3.526361 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 1.000000 |
| Std. Dev. | 0.621556 | 0.430412 | 0.452305 | 0.310534 | 0.261632 | 0.538324 |
| Skewness | -0.603434 | -1.182463 | 0.942482 | 2.523991 | 3.257227 | 2.007922 |
| Kurtosis | 6.029362 | 2.398219 | 1.888273 | 7.370532 | 11.60953 | 7.401735 |
| Jarque-Bera | 10388.55 | 5817.803 | 4678.682 | 43556.39 | 113876.3 | 34684.25 |
| Probability | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Observations | 23447 | 23447 | 23447 | 23447 | 23447 | 23447 |

| | SOLARU | DRYRSU | NBBQU | HYDRNIC | SPCHEAT | POOL |
|---|---|---|---|---|---|---|
| Mean | 0.001631 | 0.027034 | 0.004439 | 0.219005 | 0.225658 | 0.150041 |
| Median | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Maximum | 0.341463 | 1.000000 | 0.250000 | 1.000000 | 1.000000 | 1.000000 |
| Minimum | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Std. Dev. | 0.022048 | 0.085281 | 0.018694 | 0.413581 | 0.418024 | 0.357119 |
| Skewness | 13.59667 | 8.408868 | 7.268973 | 1.358872 | 1.312595 | 1.959947 |
| Kurtosis | 188.0567 | 91.52310 | 73.34082 | 2.846532 | 2.722906 | 4.841393 |
| Jarque-Bera | 34179350 | 7932096. | 5040307. | 7238.949 | 6807.842 | 18324.12 |
| Probability | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Observations | 23447 | 23447 | 23447 | 23447 | 23447 | 23447 |

| | SPA | POOLSPA | GASCKG | MAXTEMP | MINTEMP | RAINFALL |
|---|---|---|---|---|---|---|
| Mean | 0.125261 | 0.110206 | 0.219516 | 74.80936 | 55.03145 | 1.641101 |
| Median | 0.000000 | 0.000000 | 0.000000 | 73.70000 | 54.60000 | 0.380000 |
| Maximum | 1.000000 | 1.000000 | 1.000000 | 101.4000 | 71.00000 | 17.40000 |
| Minimum | 0.000000 | 0.000000 | 0.000000 | 0.120000 | 29.50000 | 0.000000 |
| Std. Dev. | 0.331022 | 0.313153 | 0.413928 | 8.562473 | 7.497198 | 2.834728 |
| Skewness | 2.264181 | 2.489532 | 1.355259 | 0.389192 | -0.304998 | 2.719302 |
| Kurtosis | 6.126515 | 7.197772 | 2.836726 | 3.684359 | 2.663313 | 10.83952 |
| Jarque-Bera | 29583.43 | 41435.13 | 7203.663 | 1049.478 | 474.2689 | 88938.89 |
| Probability | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Observations | 23447 | 23447 | 23447 | 23447 | 23447 | 23447 |

Table A-2 Cont.

| | RAINSQR | TIME |
|---|---|---|
| Mean | 10.72855 | 23.88468 |
| Median | 0.144400 | 23.00000 |
| Maximum | 302.7600 | 47.00000 |
| Minimum | 0.000000 | 1.000000 |
| Std. Dev. | 33.59330 | 13.41830 |
| Skewness | 4.433168 | 0.012668 |
| Kurtosis | 23.09178 | 1.778790 |
| Jarque-Bera | 471178.6 | 1457.619 |
| Probability | 0.000000 | 0.000000 |
| Observations | 23447 | 23447 |

Table A-3 Descriptive Statistics, Installation sites

| | LNTHERMS | SITE | POSTIS | HOA | PROBLEM | STORIES |
|---|---|---|---|---|---|---|
| Mean | 3.165425 | 1.000000 | 0.380215 | 0.100057 | 0.097965 | 2.299152 |
| Median | 3.183021 | 1.000000 | 0.000000 | 0.000000 | 0.000000 | 2.000000 |
| Maximum | 5.344771 | 1.000000 | 1.000000 | 1.000000 | 1.000000 | 5.000000 |
| Minimum | -3.526361 | 1.000000 | 0.000000 | 0.000000 | 0.000000 | 2.000000 |
| Std. Dev. | 0.611261 | 0.000000 | 0.485453 | 0.300084 | 0.297276 | 0.579137 |
| Skewness | -0.606333 | NA | 0.493512 | 2.665620 | 2.704873 | 1.866172 |
| Kurtosis | 6.932474 | NA | 1.243554 | 8.105531 | 8.316337 | 5.697179 |
| Jarque-Bera | 12482.44 | NA | 2992.056 | 40162.62 | 42403.51 | 15629.97 |
| Probability | 0.000000 | NA | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Observations | 17690 | 17690 | 17690 | 17690 | 17690 | 17690 |

| | SOLARU | DRYRSU | NBBQU | HYDRNIC | SPCHEAT | POOL |
|---|---|---|---|---|---|---|
| Mean | 0.000791 | 0.031179 | 0.004612 | 0.193160 | 0.232335 | 0.157038 |
| Median | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Maximum | 0.341463 | 1.000000 | 0.250000 | 1.000000 | 1.000000 | 1.000000 |
| Minimum | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Std. Dev. | 0.016420 | 0.096383 | 0.020053 | 0.394789 | 0.422333 | 0.363847 |
| Skewness | 20.69941 | 7.584129 | 7.385750 | 1.554496 | 1.267591 | 1.885254 |
| Kurtosis | 429.4657 | 73.02871 | 71.93698 | 3.416459 | 2.606787 | 4.554183 |
| Jarque-Bera | 1.35E+08 | 3784257. | 3663676. | 7252.365 | 4851.309 | 12259.33 |
| Probability | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Observations | 17690 | 17690 | 17690 | 17690 | 17690 | 17690 |

| | SPA | POOLSPA | GASCKG | MAXTEMP | MINTEMP | RAINFALL |
|---|---|---|---|---|---|---|
| Mean | 0.137027 | 0.118485 | 0.230526 | 75.46267 | 54.98733 | 1.644939 |
| Median | 0.000000 | 0.000000 | 0.000000 | 74.30000 | 54.70000 | 0.380000 |
| Maximum | 1.000000 | 1.000000 | 1.000000 | 101.4000 | 71.00000 | 17.40000 |
| Minimum | 0.000000 | 0.000000 | 0.000000 | 0.120000 | 29.50000 | 0.000000 |
| Std. Dev. | 0.343885 | 0.323191 | 0.421181 | 8.633682 | 7.630342 | 2.852016 |
| Skewness | 2.111075 | 2.360995 | 1.279648 | 0.301769 | -0.311447 | 2.738073 |
| Kurtosis | 5.456639 | 6.574296 | 2.637499 | 3.995450 | 2.640664 | 10.97943 |
| Jarque-Bera | 17588.01 | 25851.56 | 4924.752 | 998.8807 | 381.1590 | 69034.78 |
| Probability | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Observations | 17690 | 17690 | 17690 | 17690 | 17690 | 17690 |

Table A-3 Cont.

| | RAINSQR | TIME |
|---|---|---|
| Mean | 10.83936 | 23.40588 |
| Median | 0.144400 | 22.00000 |
| Maximum | 302.7600 | 47.00000 |
| Minimum | 0.000000 | 1.000000 |
| Std. Dev. | 34.14941 | 13.51220 |
| Skewness | 4.477115 | 0.085054 |
| Kurtosis | 23.55537 | 1.764367 |
| Jarque-Bera | 370532.9 | 1146.700 |
| Probability | 0.000000 | 0.000000 |
| Observations | 17690 | 17690 |

Table A-4 Descriptive Statistics, Comparison Group

| | LNTHERMS | SITE | POSTIS | HOA | PROBLEM | STORIES |
|---|---|---|---|---|---|---|
| Mean | 3.541288 | 0.000000 | 0.000000 | 0.132882 | 0.000000 | 1.942852 |
| Median | 3.584600 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 2.000000 |
| Maximum | 5.468772 | 0.000000 | 0.000000 | 1.000000 | 0.000000 | 2.000000 |
| Minimum | 1.449398 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 1.000000 |
| Std. Dev. | 0.564620 | 0.000000 | 0.000000 | 0.339476 | 0.000000 | 0.232145 |
| Skewness | -0.768676 | NA | NA | 2.163038 | NA | -3.815638 |
| Kurtosis | 4.644679 | NA | NA | 5.678735 | NA | 15.55909 |
| Jarque-Bera | 1215.787 | NA | NA | 6210.499 | NA | 51805.12 |
| Probability | 0.000000 | NA | NA | 0.000000 | NA | 0.000000 |
| Observations | 5757 | 5757 | 5757 | 5757 | 5757 | 5757 |

| | SOLARU | DRYRSU | NBBQU | HYDRNIC | SPCHEAT | POOL |
|---|---|---|---|---|---|---|
| Mean | 0.004211 | 0.014301 | 0.003904 | 0.298419 | 0.205142 | 0.128539 |
| Median | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Maximum | 0.275510 | 0.144316 | 0.079083 | 1.000000 | 1.000000 | 1.000000 |
| Minimum | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Std. Dev. | 0.033804 | 0.029351 | 0.013689 | 0.457604 | 0.403840 | 0.334718 |
| Skewness | 7.901644 | 2.223201 | 3.927947 | 0.881103 | 1.460400 | 2.219736 |
| Kurtosis | 63.43598 | 7.120923 | 18.04487 | 1.776342 | 3.132768 | 5.927228 |
| Jarque-Bera | 936052.5 | 8816.006 | 69099.19 | 1104.074 | 2050.619 | 6783.084 |
| Probability | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Observations | 5757 | 5757 | 5757 | 5757 | 5757 | 5757 |

| | SPA | POOLSPA | GASCKG | MAXTEMP | MINTEMP | RAINFALL |
|---|---|---|---|---|---|---|
| Mean | 0.089109 | 0.084766 | 0.185687 | 72.80191 | 55.16705 | 1.629307 |
| Median | 0.000000 | 0.000000 | 0.000000 | 71.10000 | 54.60000 | 0.330000 |
| Maximum | 1.000000 | 1.000000 | 1.000000 | 95.30000 | 70.10000 | 13.99000 |
| Minimum | 0.000000 | 0.000000 | 0.000000 | 59.80000 | 34.50000 | 0.000000 |
| Std. Dev. | 0.284926 | 0.278558 | 0.388888 | 8.013944 | 7.071323 | 2.781146 |
| Skewness | 2.884449 | 2.981568 | 1.616612 | 0.667305 | -0.268648 | 2.654501 |
| Kurtosis | 9.320048 | 9.889748 | 3.613436 | 2.785683 | 2.693775 | 10.33743 |
| Jarque-Bera | 17564.42 | 19916.25 | 2597.858 | 438.2790 | 91.74293 | 19675.36 |
| Probability | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Observations | 5757 | 5757 | 5757 | 5757 | 5757 | 5757 |

Table A-4 Cont.

| | RAINSQR | TIME |
|---|---|---|
| Mean | 10.38807 | 25.35591 |
| Median | 0.108900 | 27.00000 |
| Maximum | 195.7201 | 47.00000 |
| Minimum | 0.000000 | 1.000000 |
| Std. Dev. | 31.82420 | 13.01699 |
| Skewness | 4.234847 | -0.210811 |
| Kurtosis | 20.75349 | 1.920689 |
| Jarque-Bera | 92812.96 | 322.0748 |
| Probability | 0.000000 | 0.000000 |
| Observations | 5757 | 5757 |

Table A-5 Correlation Matrix, Pooled Sample

| | LNTHERMS | SITE | POSTIS | HOA | PROBLEM | STORIES |
|---|---|---|---|---|---|---|
| LNTHERMS | 1.000000 | -0.260276 | -0.201562 | -0.146010 | 0.092585 | -0.170590 |
| SITE | -0.260276 | 1.000000 | 0.361811 | -0.045497 | 0.161162 | 0.284876 |
| POSTIS | -0.201562 | 0.361811 | 1.000000 | 0.035167 | 0.028067 | 0.144044 |
| HOA | -0.146010 | -0.045497 | 0.035167 | 1.000000 | -0.098360 | 0.088896 |
| PROBLEM | 0.092585 | 0.161162 | 0.028067 | -0.098360 | 1.000000 | -0.097154 |
| STORIES | -0.170590 | 0.284876 | 0.144044 | 0.088896 | -0.097154 | 1.000000 |
| SOLARU | -0.027293 | -0.066762 | -0.029396 | -0.025758 | -0.020900 | 0.071527 |
| DRYRSU | -0.087577 | 0.085183 | 0.039658 | -0.099120 | -0.022304 | -0.031090 |
| NBBQU | 0.011503 | 0.016297 | -0.020555 | -0.071646 | 0.036542 | -0.041388 |
| HYDRNIC | 0.098784 | -0.109543 | 0.002502 | 0.281226 | 0.073498 | -0.022015 |
| SPCHEAT | 0.274236 | 0.027999 | 0.036143 | -0.067698 | -0.037073 | 0.058009 |
| POOL | -0.020932 | 0.034348 | 0.002859 | -0.027058 | 0.112743 | 0.182223 |
| SPA | -0.059401 | 0.062305 | 0.021505 | -0.021799 | 0.080727 | 0.209030 |
| POOLSPA | -0.054709 | 0.046344 | 0.015886 | -0.006304 | 0.098916 | 0.201405 |
| GASCKG | 0.190967 | 0.046624 | 0.015385 | -0.184647 | 0.091204 | -0.162594 |
| MAXTEMP | -0.355979 | 0.133749 | 0.048752 | -0.062734 | 0.043680 | 0.047381 |
| MINTEMP | -0.303455 | -0.010318 | 0.045093 | 0.061008 | -0.062721 | 0.139037 |
| RAINFALL | 0.226841 | 0.002373 | 0.055567 | 0.008507 | -0.001298 | 0.009767 |
| RAINSQR | 0.142711 | 0.005782 | 0.061594 | 0.011206 | -0.002237 | 0.012720 |
| TIME | -0.065281 | -0.062550 | 0.646199 | 0.011417 | -0.002772 | 0.008871 |

| | SOLARU | DRYRSU | NBBQU | HYDRNIC | SPCHEAT | POOL |
|---|---|---|---|---|---|---|
| LNTHERMS | -0.027293 | -0.087577 | 0.011503 | 0.098784 | 0.274236 | -0.020932 |
| SITE | -0.066762 | 0.085183 | 0.016297 | -0.109543 | 0.027999 | 0.034348 |
| POSTIS | -0.029396 | 0.039658 | -0.020555 | 0.002502 | 0.036143 | 0.002859 |
| HOA | -0.025758 | -0.099120 | -0.071646 | 0.281226 | -0.067698 | -0.027058 |
| PROBLEM | -0.020900 | -0.022304 | 0.036542 | 0.073498 | -0.037073 | 0.112743 |
| STORIES | 0.071527 | -0.031090 | -0.041388 | -0.022015 | 0.058009 | 0.182223 |
| SOLARU | 1.000000 | 0.013477 | -0.001565 | 0.074224 | -0.039937 | 0.044752 |
| DRYRSU | 0.013477 | 1.000000 | 0.236667 | -0.055105 | -0.022196 | 0.206284 |
| NBBQU | -0.001565 | 0.236667 | 1.000000 | -0.071610 | 0.092173 | 0.303153 |
| HYDRNIC | 0.074224 | -0.055105 | -0.071610 | 1.000000 | -0.177810 | -0.027855 |
| SPCHEAT | -0.039937 | -0.022196 | 0.092173 | -0.177810 | 1.000000 | 0.085750 |
| POOL | 0.044752 | 0.206284 | 0.303153 | -0.027855 | 0.085750 | 1.000000 |
| SPA | 0.053818 | 0.199820 | 0.303150 | -0.019383 | 0.039836 | 0.773305 |
| POOLSPA | 0.060446 | 0.164189 | 0.198886 | 0.004970 | 0.034178 | 0.837631 |
| GASCKG | -0.039235 | -0.024315 | 0.035934 | -0.219050 | 0.633375 | 0.031952 |
| MAXTEMP | -0.027973 | 0.030605 | 0.019651 | -0.055192 | 0.078814 | -0.003165 |
| MINTEMP | 0.022511 | -0.057885 | -0.081202 | -0.050815 | 0.085678 | 0.025240 |
| RAINFALL | 0.002932 | -0.001819 | 0.002477 | -0.010866 | -0.003281 | 0.007159 |
| RAINSQR | 0.002472 | -0.001309 | 0.000156 | -0.008777 | -0.008027 | 0.005431 |
| TIME | 0.032442 | -0.000584 | -0.003258 | 0.006111 | 0.023786 | 0.002240 |

Table A-5 Cont.

| | SPA | POOLSPA | GASCKG | MAXTEMP | MINTEMP | RAINFALL |
|---|---|---|---|---|---|---|
| LNTHERMS | -0.059401 | -0.054709 | 0.190967 | -0.355979 | -0.303455 | 0.226841 |
| SITE | 0.062305 | 0.046344 | 0.046624 | 0.133749 | -0.010318 | 0.002373 |
| POSTIS | 0.021505 | 0.015886 | 0.015385 | 0.048752 | 0.045093 | 0.055567 |
| HOA | -0.021799 | -0.006304 | -0.184647 | -0.062734 | 0.061008 | 0.008507 |
| PROBLEM | 0.080727 | 0.098916 | 0.091204 | 0.043680 | -0.062721 | -0.001298 |
| STORIES | 0.209030 | 0.201405 | -0.162594 | 0.047381 | 0.139037 | 0.009767 |
| SOLARU | 0.053818 | 0.060446 | -0.039235 | -0.027973 | 0.022511 | 0.002932 |
| DRYRSU | 0.199820 | 0.164189 | -0.024315 | 0.030605 | -0.057885 | -0.001819 |
| NBBQU | 0.303150 | 0.198886 | 0.035934 | 0.019651 | -0.081202 | 0.002477 |
| HYDRNIC | -0.019383 | 0.004970 | -0.219050 | -0.055192 | -0.050815 | -0.010866 |
| SPCHEAT | 0.039836 | 0.034178 | 0.633375 | 0.078814 | 0.085678 | -0.003281 |
| POOL | 0.773305 | 0.837631 | 0.031952 | -0.003165 | 0.025240 | 0.007159 |
| SPA | 1.000000 | 0.930012 | 0.024367 | 0.024501 | 2.96E-05 | 0.004123 |
| POOLSPA | 0.930012 | 1.000000 | 0.013086 | 0.015309 | 0.015775 | 0.004135 |
| GASCKG | 0.024367 | 0.013086 | 1.000000 | 0.103063 | 0.058398 | -0.003553 |
| MAXTEMP | 0.024501 | 0.015309 | 0.103063 | 1.000000 | 0.638236 | -0.513030 |
| MINTEMP | 2.96E-05 | 0.015775 | 0.058398 | 0.638236 | 1.000000 | -0.446145 |
| RAINFALL | 0.004123 | 0.004135 | -0.003553 | -0.513030 | -0.446145 | 1.000000 |
| RAINSQR | 0.000782 | 0.001466 | -0.012294 | -0.364882 | -0.284152 | 0.927421 |
| TIME | 0.003003 | -0.000122 | 0.041702 | 0.091780 | 0.088788 | -0.033696 |

| | RAINSQR | TIME |
|---|---|---|
| LNTHERMS | 0.142711 | -0.065281 |
| SITE | 0.005782 | -0.062550 |
| POSTIS | 0.061594 | 0.646199 |
| HOA | 0.011206 | 0.011417 |
| PROBLEM | -0.002237 | -0.002772 |
| STORIES | 0.012720 | 0.008871 |
| SOLARU | 0.002472 | 0.032442 |
| DRYRSU | -0.001309 | -0.000584 |
| NBBQU | 0.000156 | -0.003258 |
| HYDRNIC | -0.008777 | 0.006111 |
| SPCHEAT | -0.008027 | 0.023786 |
| POOL | 0.005431 | 0.002240 |
| SPA | 0.000782 | 0.003003 |
| POOLSPA | 0.001466 | -0.000122 |
| GASCKG | -0.012294 | 0.041702 |
| MAXTEMP | -0.364882 | 0.091780 |
| MINTEMP | -0.284152 | 0.088788 |
| RAINFALL | 0.927421 | -0.033696 |
| RAINSQR | 1.000000 | -0.029984 |
| TIME | -0.029984 | 1.000000 |

Table A-6 Regression, Pooled Sample, with Problem Variable

Dependent Variable: LNTHERMS
Method: Least Squares
Date: 03/02/99 Time: 22:19
Sample(adjusted): 1 30862
Included observations: 23372
Excluded observations: 7490 after adjusting endpoints
White Heteroskedasticity-Consistent Standard Errors & Covariance

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 5.046413 | 0.040057 | 125.9823 | 0.0000 |
| SITE | -0.266106 | 0.009392 | -28.33413 | 0.0000 |
| POSTIS | -0.197559 | 0.010865 | -18.18238 | 0.0000 |
| HOA | -0.305865 | 0.010978 | -27.86117 | 0.0000 |
| PROBLEM | 0.225640 | 0.010026 | 22.50587 | 0.0000 |
| STORIES | -0.118340 | 0.006092 | -19.42545 | 0.0000 |
| SOLARU | -1.514297 | 0.058058 | -26.08249 | 0.0000 |
| DRYRSU | -0.432898 | 0.043736 | -9.897980 | 0.0000 |
| NBBQU | -0.488344 | 0.158712 | -3.076921 | 0.0021 |
| HYDRNIC | 0.145955 | 0.007391 | 19.74878 | 0.0000 |
| HTRBTU | 3.61E-07 | 8.15E-09 | 44.33060 | 0.0000 |
| SPCHEAT | 0.371023 | 0.010809 | 34.32658 | 0.0000 |
| POOL | 0.036908 | 0.013162 | 2.804113 | 0.0050 |
| SPA | 0.032217 | 0.028272 | 1.139538 | 0.2545 |
| POOLSPA | -0.167010 | 0.032289 | -5.172320 | 0.0000 |
| GASCKG | 0.085822 | 0.011973 | 7.167718 | 0.0000 |
| MAXTEMP | -0.018073 | 0.000494 | -36.55598 | 0.0000 |
| MINTEMP | -0.007319 | 0.000547 | -13.39047 | 0.0000 |
| RAINFALL | 0.049714 | 0.003609 | 13.77336 | 0.0000 |
| RAINSQR | -0.003040 | 0.000277 | -10.96885 | 0.0000 |
| TIME | 0.001998 | 0.000349 | 5.716427 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.422532 | Mean dependent var | 3.256687 |
| Adjusted R-squared | 0.422037 | S.D. dependent var | 0.622170 |
| S.E. of regression | 0.472998 | Akaike info criterion | 1.341446 |
| Sum squared resid | 5224.250 | Schwarz criterion | 1.348688 |
| Log likelihood | -15655.14 | F-statistic | 854.2922 |
| Durbin-Watson stat | 0.169063 | Prob(F-statistic) | 0.000000 |

Table A-7 Residual for Table A-6.

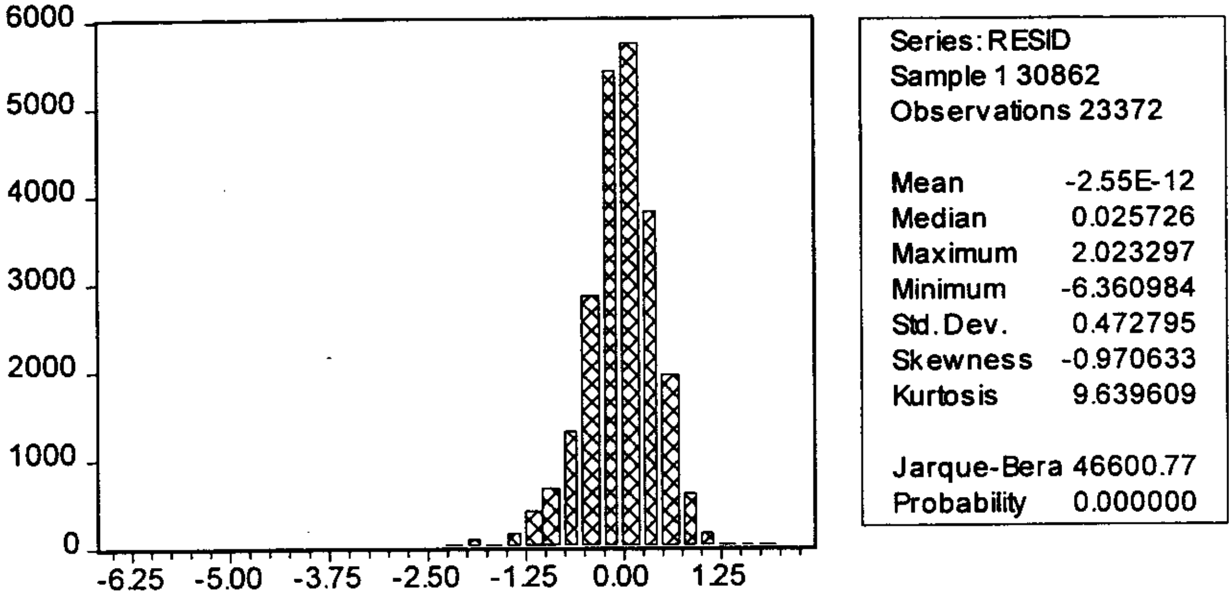


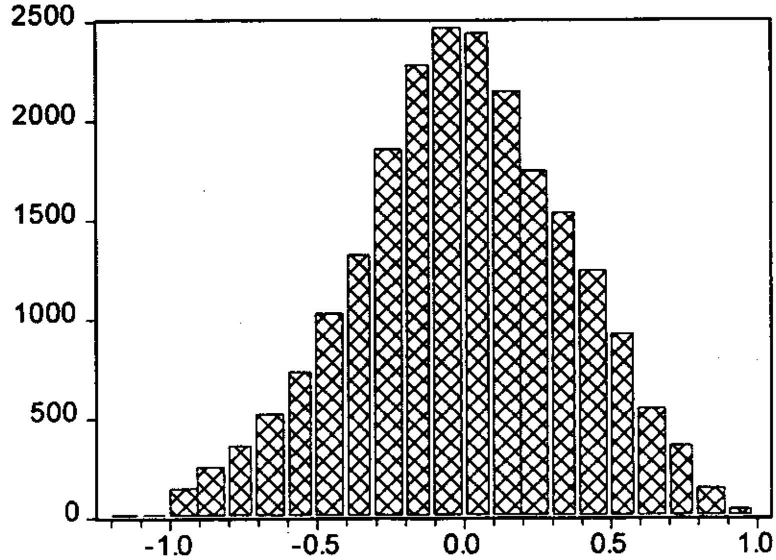
Table A-8 Trimmed Regression, Pooled Sample, with Problem Variable

Dependent Variable: LNTHERMS
Method: Least Squares
Date: 03/02/99 Time: 22:27
Sample(adjusted): 1 30862 IF TRIM=0
Included observations: 22143
Excluded observations: 7490 after adjusting endpoints
White Heteroskedasticity-Consistent Standard Errors & Covariance

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 4.953483 | 0.032585 | 152.0157 | 0.0000 |
| SITE | -0.322600 | 0.007023 | -45.93540 | 0.0000 |
| POSTIS | -0.188843 | 0.008764 | -21.54833 | 0.0000 |
| HOA | -0.192679 | 0.007428 | -25.94002 | 0.0000 |
| PROBLEM | 0.224247 | 0.008973 | 24.99091 | 0.0000 |
| STORIES | -0.122892 | 0.005430 | -22.63116 | 0.0000 |
| SOLARU | -1.576814 | 0.056984 | -27.67134 | 0.0000 |
| DRYRSU | -0.379414 | 0.031069 | -12.21194 | 0.0000 |
| NBBQU | -0.545047 | 0.135399 | -4.025483 | 0.0001 |
| HYDRNIC | 0.058961 | 0.006043 | 9.756827 | 0.0000 |
| HTRBTU | 4.19E-07 | 6.46E-09 | 64.90865 | 0.0000 |
| SPCHEAT | 0.304336 | 0.008659 | 35.14650 | 0.0000 |
| POOL | 0.009906 | 0.012648 | 0.783217 | 0.4335 |
| SPA | -0.061989 | 0.021775 | -2.846791 | 0.0044 |
| POOLSPA | -0.071062 | 0.026194 | -2.712862 | 0.0067 |
| GASCKG | 0.154048 | 0.009234 | 16.68247 | 0.0000 |
| MAXTEMP | -0.016366 | 0.000387 | -42.32063 | 0.0000 |
| MINTEMP | -0.006970 | 0.000460 | -15.14084 | 0.0000 |
| RAINFALL | 0.059203 | 0.002950 | 20.06614 | 0.0000 |
| RAINSQR | -0.003559 | 0.000229 | -15.52505 | 0.0000 |
| TIME | 0.001402 | 0.000262 | 5.358941 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.550326 | Mean dependent var | 3.294468 |
| Adjusted R-squared | 0.549919 | S.D. dependent var | 0.548929 |
| S.E. of regression | 0.368266 | Akaike info criterion | 0.840926 |
| Sum squared resid | 3000.183 | Schwarz criterion | 0.848518 |
| Log likelihood | -9289.307 | F-statistic | 1353.681 |
| Durbin-Watson stat | 0.233160 | Prob(F-statistic) | 0.000000 |

Table A-9 Residual for Table A-8




Series: RESID
Sample 1 30862
Observations 22143

| | |
|---|---|
| Mean | 3.29E-13 |
| Median | 0.001353 |
| Maximum | 0.974944 |
| Minimum | -1.139009 |
| Std. Dev. | 0.368100 |
| Skewness | -0.131938 |
| Kurtosis | 2.773057 |
| Jarque-Bera | 111.7606 |
| Probability | 0.000000 |

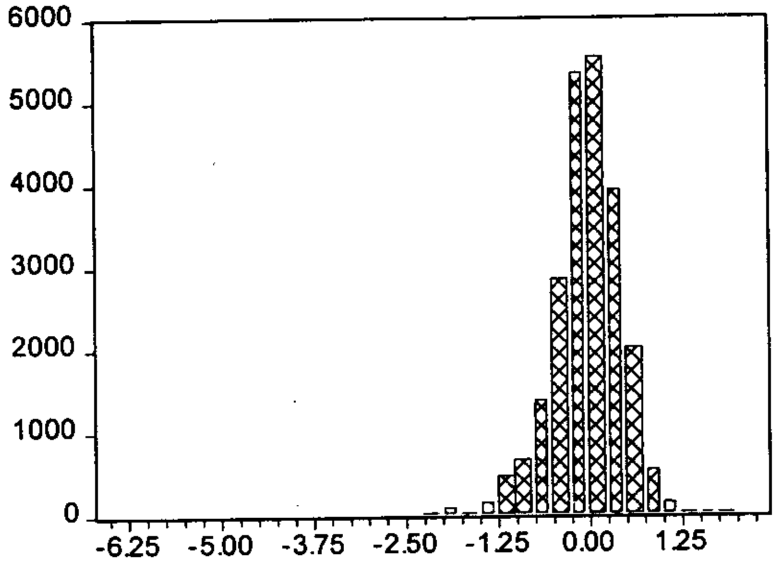
Table A-10 Regression, Pooled Sample

Dependent Variable: LNTHERMS
Method: Least Squares
Date: 03/02/99 Time: 22:43
Sample(adjusted): 1 30862
Included observations: 23372
Excluded observations: 7490 after adjusting endpoints
White Heteroskedasticity-Consistent Standard Errors & Covariance

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 5.062518 | 0.039944 | 126.7415 | 0.0000 |
| SITE | -0.236903 | 0.009157 | -25.87157 | 0.0000 |
| POSTIS | -0.203512 | 0.010915 | -18.64509 | 0.0000 |
| HOA | -0.321800 | 0.010822 | -29.73650 | 0.0000 |
| STORIES | -0.133902 | 0.006066 | -22.07526 | 0.0000 |
| SOLARU | -1.555539 | 0.058081 | -26.78223 | 0.0000 |
| DRYRSU | -0.489598 | 0.044799 | -10.92880 | 0.0000 |
| NBBQU | -0.456550 | 0.162008 | -2.818063 | 0.0048 |
| HYDRNIC | 0.161738 | 0.007375 | 21.93073 | 0.0000 |
| HTRBTU | 3.70E-07 | 8.23E-09 | 44.92991 | 0.0000 |
| SPCHEAT | 0.351345 | 0.010980 | 31.99837 | 0.0000 |
| POOL | 0.061419 | 0.013770 | 4.460505 | 0.0000 |
| SPA | 0.017162 | 0.028583 | 0.600436 | 0.5482 |
| POOLSPA | -0.151828 | 0.032931 | -4.610558 | 0.0000 |
| GASCKG | 0.107088 | 0.012110 | 8.843069 | 0.0000 |
| MAXTEMP | -0.017572 | 0.000480 | -36.58269 | 0.0000 |
| MINTEMP | -0.008003 | 0.000550 | -14.56193 | 0.0000 |
| RAINFALL | 0.049271 | 0.003646 | 13.51395 | 0.0000 |
| RAINSQR | -0.002995 | 0.000282 | -10.63255 | 0.0000 |
| TIME | 0.002170 | 0.000351 | 6.186642 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.414524 | Mean dependent var | 3.256687 |
| Adjusted R-squared | 0.414047 | S.D. dependent var | 0.622170 |
| S.E. of regression | 0.476256 | Akaike info criterion | 1.355133 |
| Sum squared resid | 5296.696 | Schwarz criterion | 1.362029 |
| Log likelihood | -15816.08 | F-statistic | 870.1829 |
| Durbin-Watson stat | 0.165756 | Prob(F-statistic) | 0.000000 |

Table A-12 Residual for table A-11




| | |
|---|---|
| Series: RESID | |
| Sample 1 30862 | |
| Observations 23372 | |
| Mean | -3.59E-13 |
| Median | 0.026463 |
| Maximum | 2.045057 |
| Minimum | -6.371624 |
| Std. Dev. | 0.476062 |
| Skewness | -0.984501 |
| Kurtosis | 9.501448 |
| Jarque-Bera | 44938.31 |
| Probability | 0.000000 |

Table A-13 Trimmed LS for Pooled Sample

Dependent Variable: LNTHERMS
Method: Least Squares
Date: 03/02/99 Time: 22:55
Sample(adjusted): 1 30862 IF TRIM=0
Included observations: 22202
Excluded observations: 7490 after adjusting endpoints
White Heteroskedasticity-Consistent Standard Errors & Covariance

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 4.968804 | 0.033298 | 149.2222 | 0.0000 |
| SITE | -0.283417 | 0.007027 | -40.33172 | 0.0000 |
| POSTIS | -0.196769 | 0.008902 | -22.10503 | 0.0000 |
| HOA | -0.220036 | 0.007690 | -28.61515 | 0.0000 |
| STORIES | -0.139498 | 0.005430 | -25.68984 | 0.0000 |
| SOLARU | -1.611268 | 0.056958 | -28.28852 | 0.0000 |
| DRYRSU | -0.435806 | 0.031998 | -13.61957 | 0.0000 |
| NBBQU | -0.528283 | 0.138877 | -3.803955 | 0.0001 |
| HYDRNIC | 0.078928 | 0.006175 | 12.78229 | 0.0000 |
| HTRBTU | 4.26E-07 | 6.59E-09 | 64.60344 | 0.0000 |
| SPCHEAT | 0.280386 | 0.008888 | 31.54628 | 0.0000 |
| POOL | 0.034057 | 0.013170 | 2.585962 | 0.0097 |
| SPA | -0.080651 | 0.022376 | -3.604340 | 0.0003 |
| POOLSPA | -0.053440 | 0.027130 | -1.969741 | 0.0489 |
| GASCKG | 0.186376 | 0.009423 | 19.77980 | 0.0000 |
| MAXTEMP | -0.015823 | 0.000400 | -39.53561 | 0.0000 |
| MINTEMP | -0.007767 | 0.000469 | -16.54585 | 0.0000 |
| RAINFALL | 0.058654 | 0.003035 | 19.32843 | 0.0000 |
| RAINSQR | -0.003508 | 0.000237 | -14.78349 | 0.0000 |
| TIME | 0.001651 | 0.000267 | 6.173032 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.536752 | Mean dependent var | 3.295723 |
| Adjusted R-squared | 0.536355 | S.D. dependent var | 0.550293 |
| S.E. of regression | 0.374703 | Akaike info criterion | 0.875532 |
| Sum squared resid | 3114.397 | Schwarz criterion | 0.882746 |
| Log likelihood | -9699.280 | F-statistic | 1352.718 |
| Durbin-Watson stat | 0.225018 | Prob(F-statistic) | 0.000000 |

Table A-14 Residual for Table A-13

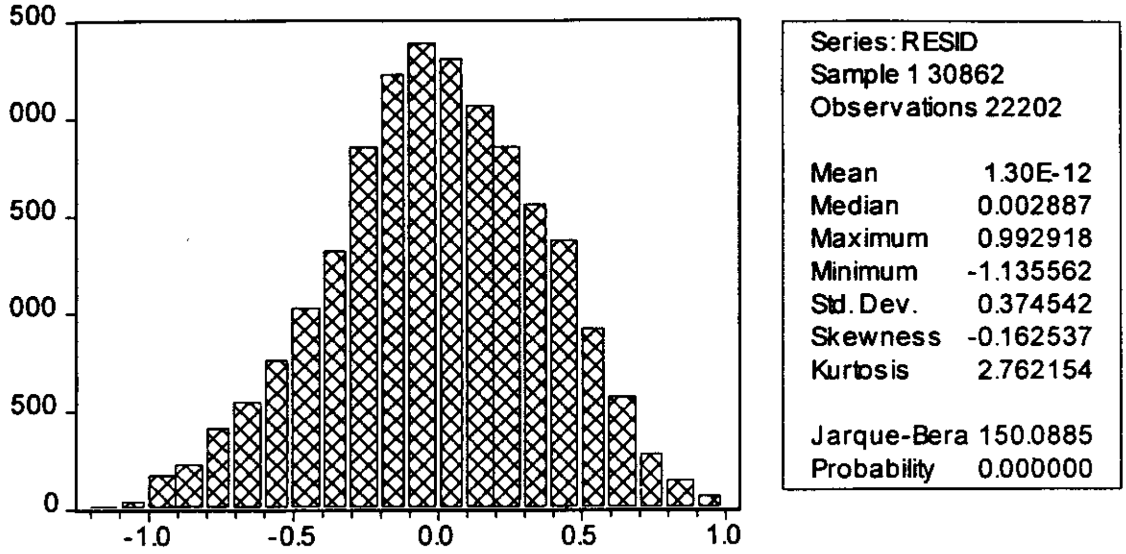


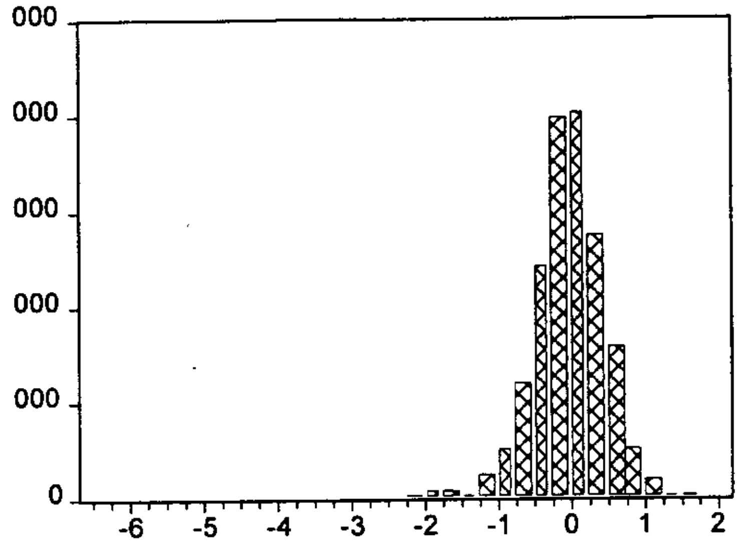
Table A-15 Regression for Installation Sites with Problem Variable

Dependent Variable: LNTHERMS
Method: Least Squares
Date: 03/02/99 Time: 23:01
Sample(adjusted): 1 23519 IF SITE=1
Included observations: 17690 after adjusting endpoints
White Heteroskedasticity-Consistent Standard Errors & Covariance

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 4.500869 | 0.045062 | 99.88151 | 0.0000 |
| POSTIS | -0.224651 | 0.013263 | -16.93804 | 0.0000 |
| HOA | -0.183774 | 0.010452 | -17.58195 | 0.0000 |
| PROBLEM | 0.226934 | 0.010174 | 22.30604 | 0.0000 |
| STORIES | -0.113177 | 0.006362 | -17.79002 | 0.0000 |
| SOLARU | -1.243984 | 0.105608 | -11.77931 | 0.0000 |
| DRYRSU | -0.489396 | 0.045294 | -10.80480 | 0.0000 |
| NBBQU | -1.040824 | 0.173759 | -5.990027 | 0.0000 |
| HYDRNIC | 0.149045 | 0.007788 | 19.13699 | 0.0000 |
| HTRBTU | 4.07E-07 | 8.60E-09 | 47.26421 | 0.0000 |
| SPCHEAT | 0.379255 | 0.012477 | 30.39749 | 0.0000 |
| POOL | 0.090918 | 0.016498 | 5.510877 | 0.0000 |
| SPA | 0.056907 | 0.029196 | 1.949133 | 0.0513 |
| POOLSPA | -0.252611 | 0.035477 | -7.120464 | 0.0000 |
| GASCKG | 0.054755 | 0.013909 | 3.936684 | 0.0001 |
| MAXTEMP | -0.011674 | 0.000559 | -20.86954 | 0.0000 |
| MINTEMP | -0.012522 | 0.000661 | -18.94680 | 0.0000 |
| RAINFALL | 0.059489 | 0.004082 | 14.57202 | 0.0000 |
| RAINSQR | -0.003482 | 0.000310 | -11.23408 | 0.0000 |
| TIME | 0.003117 | 0.000487 | 6.400871 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.397772 | Mean dependent var | 3.165425 |
| Adjusted R-squared | 0.397124 | S.D. dependent var | 0.611261 |
| S.E. of regression | 0.474614 | Akaike info criterion | 1.348501 |
| Sum squared resid | 3980.320 | Schwarz criterion | 1.357298 |
| Log likelihood | -11907.49 | F-statistic | 614.2649 |
| Durbin-Watson stat | 0.180995 | Prob(F-statistic) | 0.000000 |

Table A-16 Residual for table A-15




| | |
|---|---|
| Series: RESID | |
| Sample 1 23519 | |
| Observations 17690 | |
| Mean | 1.59E-12 |
| Median | 0.015568 |
| Maximum | 1.760598 |
| Minimum | -6.316740 |
| Std. Dev. | 0.474359 |
| Skewness | -1.022935 |
| Kurtosis | 10.78246 |
| Jarque-Bera | 47727.87 |
| Probability | 0.000000 |

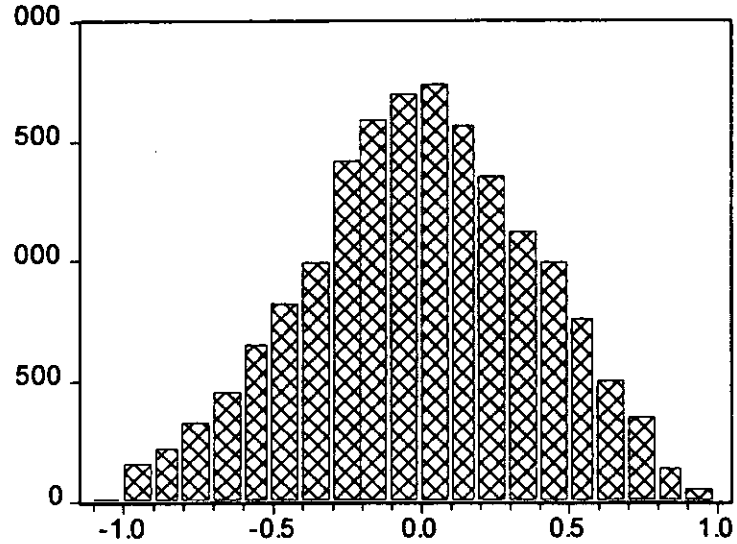
Table A-17 Trimmed LS for Installation Sites with Problem Variable

Dependent Variable: LNTHERMS
Method: Least Squares
Date: 03/02/99 Time: 23:10
Sample(adjusted): 1 23519 IF SITE=1 AND TRIM=0
Included observations: 16944 after adjusting endpoints
White Heteroskedasticity-Consistent Standard Errors & Covariance

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 4.440837 | 0.039907 | 111.2798 | 0.0000 |
| POSTIS | -0.234462 | 0.011265 | -20.81354 | 0.0000 |
| HOA | -0.171814 | 0.009406 | -18.26728 | 0.0000 |
| PROBLEM | 0.217033 | 0.009410 | 23.06357 | 0.0000 |
| STORIES | -0.109439 | 0.005681 | -19.26431 | 0.0000 |
| SOLARU | -1.318999 | 0.104499 | -12.62211 | 0.0000 |
| DRYRSU | -0.387139 | 0.030577 | -12.66109 | 0.0000 |
| NBBQU | -0.989855 | 0.148559 | -6.663024 | 0.0000 |
| HYDRNIC | 0.128124 | 0.007199 | 17.79676 | 0.0000 |
| HTRBTU | 4.21E-07 | 7.00E-09 | 60.18447 | 0.0000 |
| SPCHEAT | 0.353193 | 0.010175 | 34.71328 | 0.0000 |
| POOL | 0.069647 | 0.015708 | 4.433867 | 0.0000 |
| SPA | -0.029575 | 0.022796 | -1.297374 | 0.1945 |
| POOLSPA | -0.166575 | 0.029154 | -5.713543 | 0.0000 |
| GASCKG | 0.111486 | 0.010955 | 10.17694 | 0.0000 |
| MAXTEMP | -0.012506 | 0.000525 | -23.82553 | 0.0000 |
| MINTEMP | -0.010359 | 0.000584 | -17.73449 | 0.0000 |
| RAINFALL | 0.063581 | 0.003549 | 17.91518 | 0.0000 |
| RAINSQR | -0.003702 | 0.000272 | -13.62694 | 0.0000 |
| TIME | 0.003278 | 0.000398 | 8.230736 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.498395 | Mean dependent var | 3.190507 |
| Adjusted R-squared | 0.497832 | S.D. dependent var | 0.547358 |
| S.E. of regression | 0.387879 | Akaike info criterion | 0.944930 |
| Sum squared resid | 2546.211 | Schwarz criterion | 0.954064 |
| Log likelihood | -7985.450 | F-statistic | 885.0370 |
| Durbin-Watson stat | 0.227034 | Prob(F-statistic) | 0.000000 |

Table A-18 Residual for Table A-17




Series: RESID
Sample 1 23519
Observations 16944

| | |
|---|---|
| Mean | 9.59E-13 |
| Median | 0.004314 |
| Maximum | 0.965608 |
| Minimum | -1.028732 |
| Std. Dev. | 0.387661 |
| Skewness | -0.106906 |
| Kurtosis | 2.602943 |
| Jarque-Bera | 143.5793 |
| Probability | 0.000000 |

Table A-19 Regression for Installation Sites

Dependent Variable: LNTHERMS
Method: Least Squares
Date: 03/02/99 Time: 23:13
Sample(adjusted): 1 23519 IF SITE=1
Included observations: 17690 after adjusting endpoints
White Heteroskedasticity-Consistent Standard Errors & Covariance

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 4.521886 | 0.044914 | 100.6797 | 0.0000 |
| POSTIS | -0.235317 | 0.013323 | -17.66187 | 0.0000 |
| HOA | -0.208105 | 0.010437 | -19.93836 | 0.0000 |
| STORIES | -0.128284 | 0.006357 | -20.18021 | 0.0000 |
| SOLARU | -1.290247 | 0.105625 | -12.21536 | 0.0000 |
| DRYRSU | -0.549674 | 0.046466 | -11.82953 | 0.0000 |
| NBBQU | -1.007313 | 0.178102 | -5.655818 | 0.0000 |
| HYDRNIC | 0.177924 | 0.007741 | 22.98369 | 0.0000 |
| HTRBTU | 4.18E-07 | 8.69E-09 | 48.12446 | 0.0000 |
| SPCHEAT | 0.358181 | 0.012744 | 28.10626 | 0.0000 |
| POOL | 0.124422 | 0.017272 | 7.203500 | 0.0000 |
| SPA | 0.041873 | 0.029574 | 1.415872 | 0.1568 |
| POOLSPA | -0.239355 | 0.036331 | -6.588221 | 0.0000 |
| GASCKG | 0.081844 | 0.014111 | 5.800013 | 0.0000 |
| MAXTEMP | -0.010554 | 0.000541 | -19.52462 | 0.0000 |
| MINTEMP | -0.013819 | 0.000662 | -20.88876 | 0.0000 |
| RAINFALL | 0.059641 | 0.004137 | 14.41664 | 0.0000 |
| RAINSQR | -0.003448 | 0.000317 | -10.89123 | 0.0000 |
| TIME | 0.003508 | 0.000490 | 7.159363 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.387045 | Mean dependent var | 3.165425 |
| Adjusted R-squared | 0.386421 | S.D. dependent var | 0.611261 |
| S.E. of regression | 0.478809 | Akaike info criterion | 1.366042 |
| Sum squared resid | 4051.214 | Schwarz criterion | 1.374399 |
| Log likelihood | -12063.64 | F-statistic | 619.9009 |
| Durbin-Watson stat | 0.176678 | Prob(F-statistic) | 0.000000 |

Table A-20 Residual for Table A-19

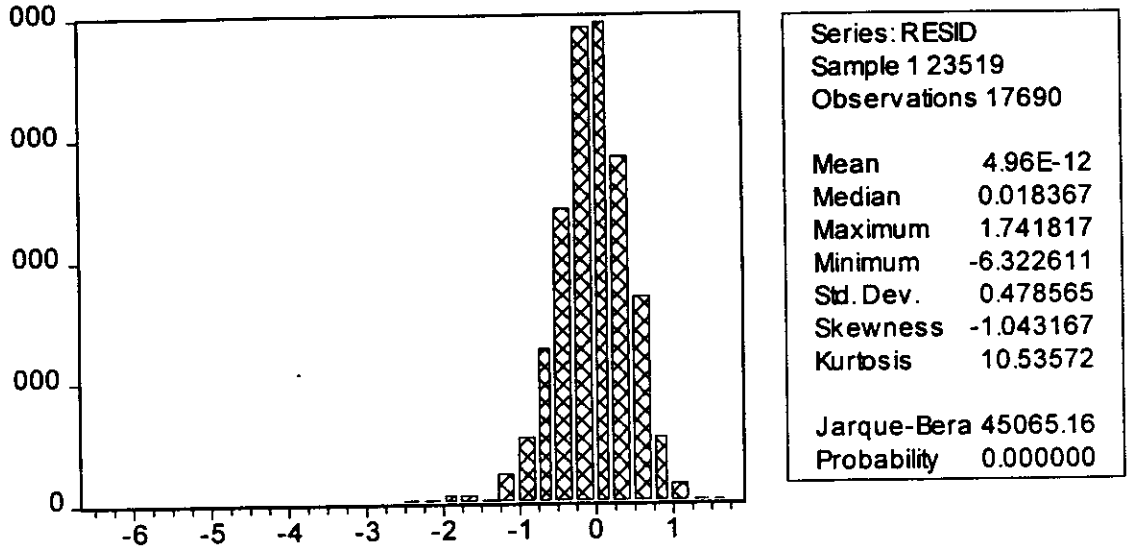


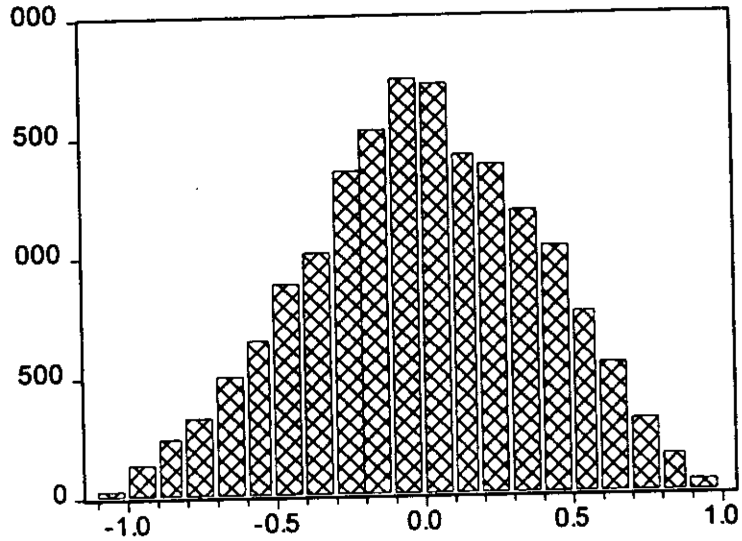
Table A-21 Trimmed LS for Installation Sites

Dependent Variable: LNTHERMS
Method: Least Squares
Date: 03/02/99 Time: 23:22
Sample(adjusted): 1 23519 IF SITE=1 AND TRIM = 0
Included observations: 16957 after adjusting endpoints
White Heteroskedasticity-Consistent Standard Errors & Covariance

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 4.467330 | 0.039645 | 112.6821 | 0.0000 |
| POSTIS | -0.240125 | 0.011370 | -21.11911 | 0.0000 |
| HOA | -0.195399 | 0.009352 | -20.89353 | 0.0000 |
| STORIES | -0.127119 | 0.005658 | -22.46551 | 0.0000 |
| SOLARU | -1.355222 | 0.104633 | -12.95214 | 0.0000 |
| DRYRSU | -0.441573 | 0.031574 | -13.98536 | 0.0000 |
| NBBQU | -0.970463 | 0.151610 | -6.401043 | 0.0000 |
| HYDRNIC | 0.151935 | 0.007174 | 21.17955 | 0.0000 |
| HTRBTU | 4.37E-07 | 7.10E-09 | 61.56767 | 0.0000 |
| SPCHEAT | 0.325562 | 0.010498 | 31.01191 | 0.0000 |
| POOL | 0.104178 | 0.016257 | 6.408166 | 0.0000 |
| SPA | -0.046517 | 0.023497 | -1.979720 | 0.0478 |
| POOLSPA | -0.154054 | 0.030310 | -5.082642 | 0.0000 |
| GASCKG | 0.153921 | 0.011260 | 13.67004 | 0.0000 |
| MAXTEMP | -0.011378 | 0.000503 | -22.63676 | 0.0000 |
| MINTEMP | -0.011642 | 0.000583 | -19.97060 | 0.0000 |
| RAINFALL | 0.063498 | 0.003619 | 17.54752 | 0.0000 |
| RAINSQR | -0.003636 | 0.000279 | -13.02363 | 0.0000 |
| TIME | 0.003427 | 0.000403 | 8.503197 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.487937 | Mean dependent var | 3.192433 |
| Adjusted R-squared | 0.487393 | S.D. dependent var | 0.548143 |
| S.E. of regression | 0.392452 | Akaike info criterion | 0.968314 |
| Sum squared resid | 2608.764 | Schwarz criterion | 0.976984 |
| Log likelihood | -8190.847 | F-statistic | 896.6657 |
| Durbin-Watson stat | 0.218811 | Prob(F-statistic) | 0.000000 |

Table A-22 Residual for Table A-21




Series: RESID
Sample 1 23519
Observations 16957

| | |
|---|---|
| Mean | -1.95E-12 |
| Median | 0.004440 |
| Maximum | 0.994860 |
| Minimum | -1.055739 |
| Std. Dev. | 0.392243 |
| Skewness | -0.123076 |
| Kurtosis | 2.552378 |
| Jarque-Bera | 184.3769 |
| Probability | 0.000000 |

Table A-23 Rate-Realization Model, Installation Sites

Dependent Variable: LNNEW
Method: Least Squares
Date: 03/03/99 Time: 09:14
Sample(adjusted): 1 23519 IF SITE=1
Included observations: 17690 after adjusting endpoints
White Heteroskedasticity-Consistent Standard Errors & Covariance

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 4.437604 | 0.045006 | 98.60103 | 0.0000 |
| POSTIS | -0.064864 | 0.013349 | -4.858928 | 0.0000 |
| HOA | -0.148793 | 0.010361 | -14.36057 | 0.0000 |
| STORIES | -0.135365 | 0.006460 | -20.95420 | 0.0000 |
| SOLARU | -1.328969 | 0.105135 | -12.64064 | 0.0000 |
| DRYRSU | -0.566189 | 0.047993 | -11.79727 | 0.0000 |
| NBBQU | -1.076327 | 0.178718 | -6.022497 | 0.0000 |
| HTRBTU | 4.45E-07 | 8.56E-09 | 51.93335 | 0.0000 |
| SPCHEAT | 0.342813 | 0.012532 | 27.35481 | 0.0000 |
| POOL | 0.113502 | 0.017436 | 6.509591 | 0.0000 |
| SPA | 0.026712 | 0.029706 | 0.899215 | 0.3686 |
| POOLSPA | -0.218782 | 0.036575 | -5.981747 | 0.0000 |
| GASCKG | 0.073547 | 0.014064 | 5.229334 | 0.0000 |
| MAXTEMP | -0.010900 | 0.000539 | -20.20618 | 0.0000 |
| MINTEMP | -0.013887 | 0.000661 | -21.01845 | 0.0000 |
| RAINFALL | 0.057022 | 0.004151 | 13.73536 | 0.0000 |
| RAINSQR | -0.003332 | 0.000318 | -10.48068 | 0.0000 |
| TIME | 0.003010 | 0.000492 | 6.117944 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.366125 | Mean dependent var | 3.071304 |
| Adjusted R-squared | 0.365515 | S.D. dependent var | 0.604123 |
| S.E. of regression | 0.481211 | Akaike info criterion | 1.375996 |
| Sum squared resid | 4092.204 | Schwarz criterion | 1.383913 |
| Log likelihood | -12152.69 | F-statistic | 600.4292 |
| Durbin-Watson stat | 0.173863 | Prob(F-statistic) | 0.000000 |

Table A-24 Residual for Table A-23

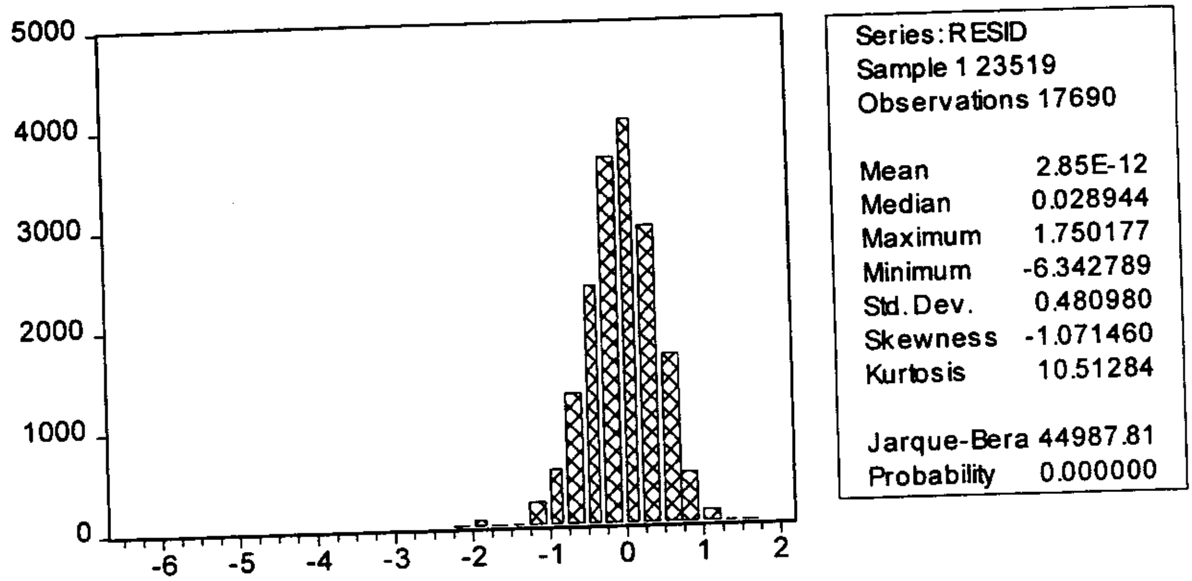


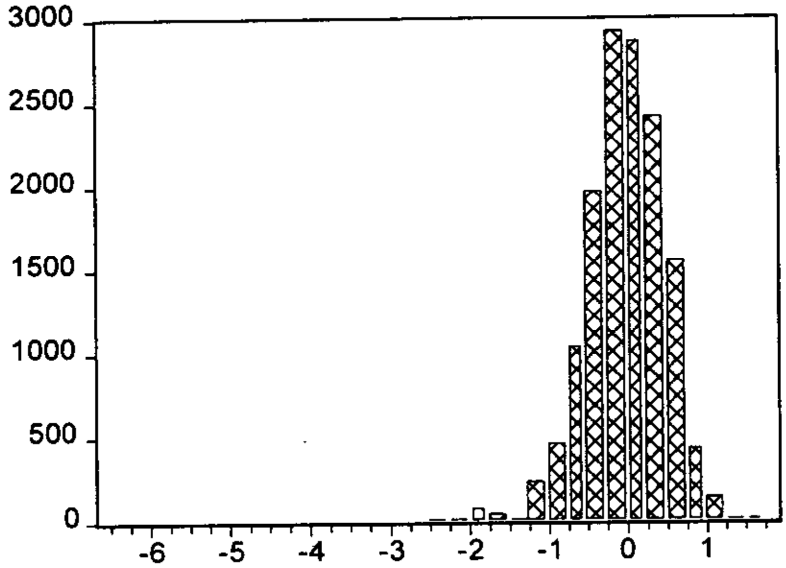
Table A-25 Regression, Installation Sites, Non-Hydronic

Dependent Variable: LNTHERMS
Method: Least Squares
Date: 03/03/99 Time: 09:38
Sample(adjusted): 1 23519 IF SITE=1 AND HYDRNIC=0
Included observations: 14273 after adjusting endpoints
White Heteroskedasticity-Consistent Standard Errors & Covariance

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 4.656409 | 0.054922 | 84.78149 | 0.0000 |
| POSTIS | -0.244987 | 0.015609 | -15.69515 | 0.0000 |
| HOA | -0.091846 | 0.013225 | -6.944855 | 0.0000 |
| STORIES | -0.149693 | 0.007508 | -19.93795 | 0.0000 |
| SOLARU | -1.163527 | 0.107208 | -10.85295 | 0.0000 |
| DRYRSU | -0.682661 | 0.062887 | -10.85544 | 0.0000 |
| NBBQU | -0.815074 | 0.184780 | -4.411047 | 0.0000 |
| HTRBTU | 4.36E-07 | 1.11E-08 | 39.15159 | 0.0000 |
| SPCHEAT | 0.309726 | 0.016511 | 18.75882 | 0.0000 |
| POOL | 0.120697 | 0.018456 | 6.539614 | 0.0000 |
| SPA | 0.058006 | 0.029702 | 1.952940 | 0.0508 |
| POOLSPA | -0.256717 | 0.037205 | -6.899987 | 0.0000 |
| GASCKG | 0.128720 | 0.016911 | 7.611731 | 0.0000 |
| MAXTEMP | -0.013570 | 0.000694 | -19.54828 | 0.0000 |
| MINTEMP | -0.011604 | 0.000769 | -15.08244 | 0.0000 |
| RAINFALL | 0.053645 | 0.004879 | 10.99461 | 0.0000 |
| RAINSQR | -0.003160 | 0.000363 | -8.698126 | 0.0000 |
| TIME | 0.004167 | 0.000569 | 7.325983 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.370491 | Mean dependent var | 3.137945 |
| Adjusted R-squared | 0.369740 | S.D. dependent var | 0.634817 |
| S.E. of regression | 0.503975 | Akaike info criterion | 1.468679 |
| Sum squared resid | 3620.634 | Schwarz criterion | 1.478221 |
| Log likelihood | -10463.23 | F-statistic | 493.5071 |
| Durbin-Watson stat | 0.159591 | Prob(F-statistic) | 0.000000 |

Table A-26 Residual for Table A-25




Series: RESID
Sample 1 23519
Observations 14273

| | |
|---|---|
| Mean | 6.14E-13 |
| Median | 0.022040 |
| Maximum | 1.736478 |
| Minimum | -6.316370 |
| Std. Dev. | 0.503674 |
| Skewness | -1.084746 |
| Kurtosis | 10.23716 |
| Jarque-Bera | 33947.87 |
| Probability | 0.000000 |

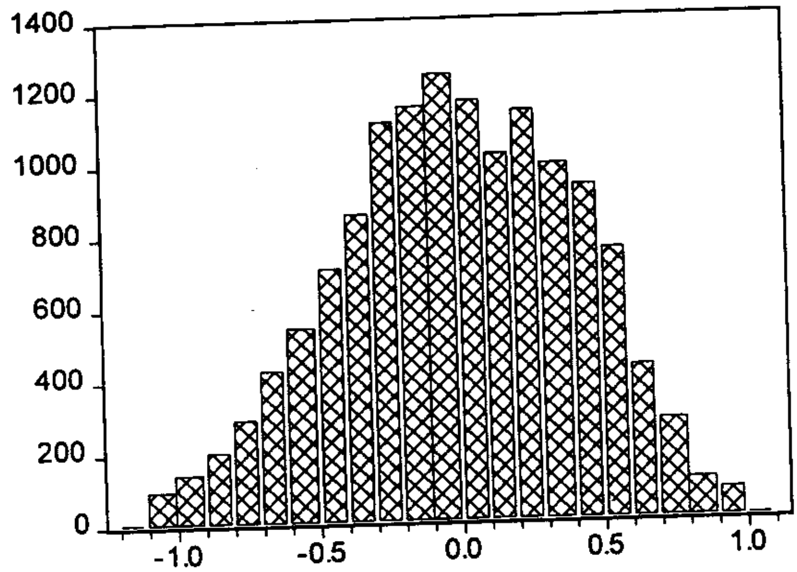
Table A-27 Trimmed LS, Installation Sites, Non-Hydronic

Dependent Variable: LNTHERMS
Method: Least Squares
Date: 03/03/99 Time: 10:19
Sample(adjusted): 1 23519 IF SITE=1 AND HYDRNIC=0 AND TRIM=0
Included observations: 13714 after adjusting endpoints
White Heteroskedasticity-Consistent Standard Errors & Covariance

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 4.596384 | 0.049591 | 92.68640 | 0.0000 |
| POSTIS | -0.253190 | 0.013264 | -19.08842 | 0.0000 |
| HOA | -0.113934 | 0.012777 | -8.917129 | 0.0000 |
| STORIES | -0.148658 | 0.006933 | -21.44255 | 0.0000 |
| SOLARU | -1.213599 | 0.106630 | -11.38140 | 0.0000 |
| DRYRSU | -0.574654 | 0.044050 | -13.04555 | 0.0000 |
| NBBQU | -0.796152 | 0.156863 | -5.075464 | 0.0000 |
| HTRBTU | 4.70E-07 | 9.11E-09 | 51.60012 | 0.0000 |
| SPCHEAT | 0.241343 | 0.013340 | 18.09168 | 0.0000 |
| POOL | 0.080850 | 0.017527 | 4.612887 | 0.0000 |
| SPA | -0.032569 | 0.023900 | -1.362679 | 0.1730 |
| POOLSPA | -0.165708 | 0.031710 | -5.225755 | 0.0000 |
| GASCKG | 0.226515 | 0.013364 | 16.94958 | 0.0000 |
| MAXTEMP | -0.014517 | 0.000660 | -21.99880 | 0.0000 |
| MINTEMP | -0.009294 | 0.000685 | -13.56645 | 0.0000 |
| RAINFALL | 0.057282 | 0.004314 | 13.27723 | 0.0000 |
| RAINSQR | -0.003389 | 0.000325 | -10.44310 | 0.0000 |
| TIME | 0.004239 | 0.000466 | 9.087128 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.468723 | Mean dependent var | 3.169003 |
| Adjusted R-squared | 0.468064 | S.D. dependent var | 0.569899 |
| S.E. of regression | 0.415650 | Akaike info criterion | 1.083366 |
| Sum squared resid | 2366.191 | Schwarz criterion | 1.093245 |
| Log likelihood | -7410.644 | F-statistic | 710.7880 |
| Durbin-Watson stat | 0.206443 | Prob(F-statistic) | 0.000000 |

Table A-28 Residual for Table A-27




Series: RESID
Sample 1 23519
Observations 13714

| | |
|---|---|
| Mean | -2.37E-13 |
| Median | 0.005542 |
| Maximum | 1.019433 |
| Minimum | -1.133056 |
| Std. Dev. | 0.415393 |
| Skewness | -0.170527 |
| Kurtosis | 2.508181 |
| | |
| Jarque-Bera | 204.6838 |
| Probability | 0.000000 |

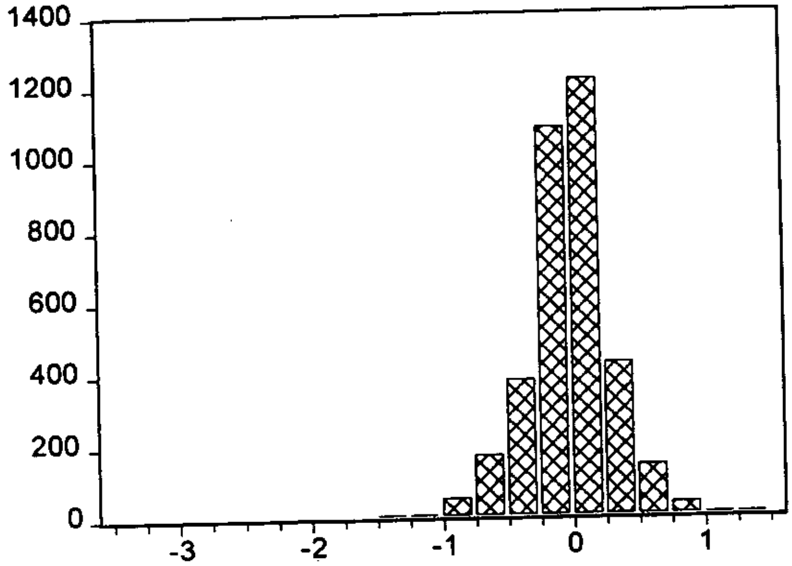
Table A-29 Regression, Installation Sites, Non-Hydronic

Dependent Variable: LNTHERMS
Method: Least Squares
Date: 03/03/99 Time: 10:24
Sample(adjusted): 97 22175 IF SITE=1 AND HYDRNIC=1
Included observations: 3551 after adjusting endpoints
White Heteroskedasticity-Consistent Standard Errors & Covariance

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 4.843518 | 0.089730 | 53.97910 | 0.0000 |
| POSTIS | -0.228051 | 0.020942 | -10.88979 | 0.0000 |
| HOA | -0.446428 | 0.019303 | -23.12787 | 0.0000 |
| STORIES | -0.264892 | 0.013260 | -19.97645 | 0.0000 |
| DRYRSU | -0.069938 | 0.040445 | -1.729228 | 0.0839 |
| NBBQU | 0.767934 | 0.861038 | 0.891870 | 0.3725 |
| HTRBTU | 5.06E-07 | 2.51E-08 | 20.11194 | 0.0000 |
| SPCHEAT | 0.958891 | 0.042551 | 22.53494 | 0.0000 |
| POOL | 0.043144 | 0.043472 | 0.992471 | 0.3210 |
| SPA | -0.088861 | 0.042437 | -2.093931 | 0.0363 |
| GASCKG | -0.210993 | 0.014676 | -14.37653 | 0.0000 |
| MAXTEMP | -0.009967 | 0.001046 | -9.527646 | 0.0000 |
| MINTEMP | -0.012242 | 0.001245 | -9.835652 | 0.0000 |
| RAINFALL | 0.072226 | 0.006690 | 10.79689 | 0.0000 |
| RAINSQR | -0.004283 | 0.000551 | -7.778743 | 0.0000 |
| TIME | 0.001707 | 0.000755 | 2.259686 | 0.0239 |

| | | | |
|---|---|---|---|
| R-squared | 0.553295 | Mean dependent var | 3.294101 |
| Adjusted R-squared | 0.551399 | S.D. dependent var | 0.482799 |
| S.E. of regression | 0.323368 | Akaike info criterion | 0.584443 |
| Sum squared resid | 369.6433 | Schwarz criterion | 0.612266 |
| Log likelihood | -1021.678 | F-statistic | 291.8996 |
| Durbin-Watson stat | 0.400911 | Prob(F-statistic) | 0.000000 |

Table A-30 Residual for Table A-29




Series: RESID
Sample 97 22175
Observations 3551

| | |
|---|---|
| Mean | 5.79E-13 |
| Median | 0.008022 |
| Maximum | 1.324215 |
| Minimum | -3.378920 |
| Std. Dev. | 0.322684 |
| Skewness | -0.460920 |
| Kurtosis | 7.237515 |
| Jarque-Bera | 2782.552 |
| Probability | 0.000000 |

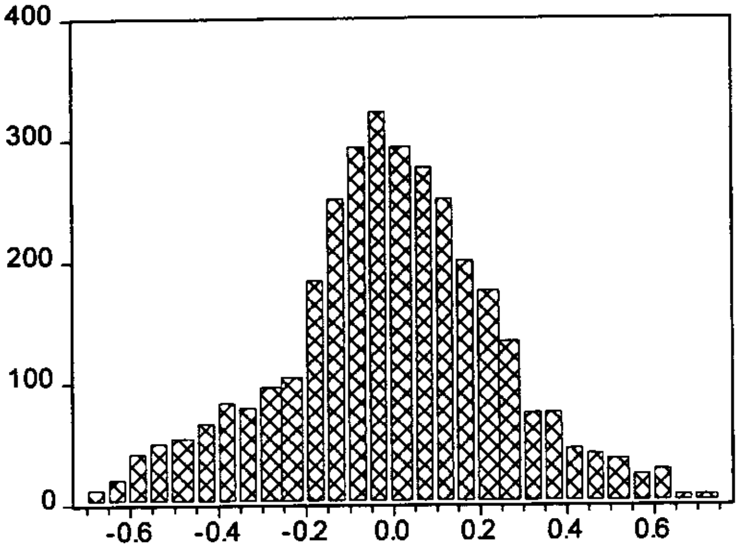
Table A-31 Trimmed LS, Installation Sites, Hydronic

Dependent Variable: LNTHERMS
Method: Least Squares
Date: 03/03/99 Time: 10:32
Sample(adjusted): 101 22175 IF SITE=1 AND HYDRNIC=1 AND TRIM=0
Included observations: 3330 after adjusting endpoints
White Heteroskedasticity-Consistent Standard Errors & Covariance

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 4.677056 | 0.071156 | 65.72955 | 0.0000 |
| POSTIS | -0.232658 | 0.017583 | -13.23175 | 0.0000 |
| HOA | -0.373419 | 0.013647 | -27.36306 | 0.0000 |
| STORIES | -0.273171 | 0.010983 | -24.87166 | 0.0000 |
| DRYRSU | -0.075730 | 0.038061 | -1.989728 | 0.0467 |
| NBBQU | 1.650494 | 0.795547 | 2.074665 | 0.0381 |
| HTRBTU | 6.14E-07 | 1.95E-08 | 31.51948 | 0.0000 |
| SPCHEAT | 0.908510 | 0.034433 | 26.38506 | 0.0000 |
| POOL | 0.121682 | 0.039906 | 3.049183 | 0.0023 |
| SPA | -0.159041 | 0.039797 | -3.996271 | 0.0001 |
| GASCKG | -0.234005 | 0.013645 | -17.14899 | 0.0000 |
| MAXTEMP | -0.009410 | 0.000813 | -11.57651 | 0.0000 |
| MINTEMP | -0.011903 | 0.001010 | -11.78693 | 0.0000 |
| RAINFALL | 0.073116 | 0.005391 | 13.56192 | 0.0000 |
| RAINSQR | -0.004426 | 0.000433 | -10.22667 | 0.0000 |
| TIME | 0.001984 | 0.000622 | 3.187698 | 0.0014 |

| | | | |
|---|---|---|---|
| R-squared | 0.672964 | Mean dependent var | 3.306890 |
| Adjusted R-squared | 0.671483 | S.D. dependent var | 0.439163 |
| S.E. of regression | 0.251712 | Akaike info criterion | 0.083732 |
| Sum squared resid | 209.9717 | Schwarz criterion | 0.113092 |
| Log likelihood | -123.4131 | F-statistic | 454.6287 |
| Durbin-Watson stat | 0.411848 | Prob(F-statistic) | 0.000000 |

Table A-32 Residual for Table A-31




| | |
|---|---|
| Series: RESID | |
| Sample 101 22175 | |
| Observations 3330 | |
| Mean | 1.82E-13 |
| Median | 0.001274 |
| Maximum | 0.725451 |
| Minimum | -0.684653 |
| Std. Dev. | 0.251144 |
| Skewness | -0.055616 |
| Kurtosis | 3.181723 |
| Jarque-Bera | 6.298667 |
| Probability | 0.042881 |

Table A-33 Regression Results for the Change Model, Full Sample

The SAS System 14:31 Wednesday, March 3, 1999 2215

Dependent Variable: THERMCH THERMCH

Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 4 | 60018 | 15005 | 418.96 | <.0001 |
| Error | 7502 | 268677 | 35.81404 | | |
| Corrected Total | 7506 | 328695 | | | |

| | | | |
|---|---|---|---|
| Root MSE | 5.98448 | R-Square | 0.1826 |
| Dependent Mean | -0.76090 | Adj R-Sq | 0.1822 |
| Coeff Var | -786.49599 | | |

Parameter Estimates

| Variable | Label | DF | Parameter Estimate | Standard Error | t Value | Pr > \|t\| |
|---|---|---|---|---|---|---|
| Intercept | Intercept | 1 | 0.88210 | 0.09616 | 9.17 | <.0001 |
| MAXCH | MAXCH | 1 | -0.08908 | 0.01702 | -5.23 | <.0001 |
| MINCH | MINCH | 1 | -0.49440 | 0.02723 | -18.15 | <.0001 |
| RAINCH | RAINCH | 1 | 0.30952 | 0.02228 | 13.90 | <.0001 |
| SITE | SITE | 1 | -4.01505 | 0.13900 | -28.89 | <.0001 |

Table A-34 Regression Results for the Change Model, Installation Sites Only

The SAS System 14:47 Friday, March 5, 1999 1

Dependent Variable: THERMCH THERMCH

Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 3 | 12646 | 4215.42583 | 99.07 | <.0001 |
| Error | 3554 | 151219 | 42.54884 | | |
| Corrected Total | 3557 | 163865 | | | |

| | | | |
|---|---|---|---|
| Root MSE | 6.52295 | R-Square | 0.0772 |
| Dependent Mean | -2.83796 | Adj R-Sq | 0.0764 |
| Coeff Var | -229.84664 | | |

Parameter Estimates

| Variable | Label | DF | Parameter Estimate | Standard Error | t Value | Pr > \|t\| |
|---|---|---|---|---|---|---|
| Intercept | Intercept | 1 | -3.09711 | 0.11176 | -27.71 | <.0001 |
| MAXCH | MAXCH | 1 | -0.04264 | 0.02404 | -1.77 | 0.0762 |
| MINCH | MINCH | 1 | -0.48576 | 0.04213 | -11.53 | <.0001 |
| RAINCH | RAINCH | 1 | 0.28904 | 0.03457 | 8.36 | <.0001 |

Table A-35 Regression Results for the Change Model, Comparison Sites Only

The SAS System 14:47 Friday, March 5, 1999 2

Dependent Variable: THERMCH THERMCH

Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 3 | 18977 | 6325.64641 | 213.88 | <.0001 |
| Error | 3945 | 116674 | 29.57508 | | |
| Corrected Total | 3948 | 135651 | | | |

| | | | |
|---|---|---|---|
| Root MSE | 5.43830 | R-Square | 0.1399 |
| Dependent Mean | 1.11049 | Adj R-Sq | 0.1392 |
| Coeff Var | 489.71902 | | |

Parameter Estimates

| Variable | Label | DF | Parameter Estimate | Standard Error | t Value | Pr > \|t\| |
|---|---|---|---|---|---|---|
| Intercept | Intercept | 1 | 0.89171 | 0.08830 | 10.10 | <.0001 |
| MAXCH | MAXCH | 1 | -0.16576 | 0.02444 | -6.78 | <.0001 |
| MINCH | MINCH | 1 | -0.49053 | 0.03500 | -14.01 | <.0001 |
| RAINCH | RAINCH | 1 | 0.31978 | 0.02853 | 11.21 | <.0001 |

# Appendix B

## Weather Data

Weather Data

| Region | | Jan-93 | Feb-93 | Mar-93 | Apr-93 | May-93 | Jun-93 | Jul-93 | Aug-93 | Sep-93 | Oct-93 | Nov-93 | Dec-93 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Av Max Temp | 65.3 | -5 | 73.4 | 77.2 | 79 | 81.9 | 81.3 | 84.7 | 85.5 | 81.7 | 73.9 | 70.7 |
| 1 | Av Min Temp | 47.7 | -5 | 52.4 | 53.9 | 58.5 | 60.9 | 64.3 | 63.9 | 61.2 | 58.7 | 52 | 48 |
| 1 | Rainfall | 9.17 | 4.33 | 2.23 | 0 | 0 | 1.23 | 0 | 0 | 0 | 0.05 | 0.99 | 0.86 |
| 2 | Av Max Temp | 64.4 | 65.9 | 72.2 | 76.4 | 78.3 | -5 | 80.5 | 80.7 | 79.3 | 77.6 | 72.6 | 68.5 |
| 2 | Av Min Temp | 48.8 | 48.1 | 52.1 | 52.6 | 56.8 | -5 | 64.6 | 63.6 | 60.8 | 57.2 | 51.5 | 45.8 |
| 2 | Rainfall | 13.82 | 8.77 | 2.59 | 0 | 0 | -5 | 72.6 | 0 | 0 | 0 | 0.84 | 1.16 |
| 3 | Av Max Temp | -5 | 64.8 | 70.5 | 73.9 | -5 | 78.9 | 78.4 | 79.4 | 78.2 | -5 | 72.1 | 69.8 |
| 3 | Av Min Temp | -5 | 43.7 | 47.9 | 50.2 | -5 | 57.1 | 62.5 | 58.3 | 58 | -5 | 49.1 | 43.4 |
| 3 | Rainfall | -5 | 5.65 | 1.9 | 0 | 0 | 0.88 | 0.01 | 0 | 0 | 0.16 | 1.13 | 0.81 |
| 4 | Av Max Temp | 64.9 | 65.8 | 73.3 | 76.5 | 77 | 81.1 | 80 | 83.2 | 84.1 | 80.3 | 74.9 | 71.5 |
| 4 | Av Min Temp | 49.6 | 50.8 | 55.6 | 57.5 | 60.7 | 63.6 | 65.9 | 65.6 | 64.4 | 62.1 | 54.2 | 50.1 |
| 4 | Rainfall | 11.77 | 6.61 | 2.74 | 0 | 0.02 | 0.76 | 0 | 0 | 0 | 0.16 | 0.66 | 0.78 |
| 5 | Av Max Temp | 60.9 | 61.1 | 63.8 | 65.7 | 66.4 | 68.8 | 69.5 | 69.7 | 69.2 | 70.4 | 67.4 | 66 |
| 5 | Av Min Temp | 49.2 | 51.3 | 54.3 | 55.4 | 58.9 | 61.9 | 64.7 | 64.1 | 62 | 59.7 | 52.8 | 48.7 |
| 5 | Rainfall | 9.49 | 5.01 | 1.31 | 0 | 0 | 0.82 | 0 | 0 | 0 | 0.12 | 0.77 | 0.8 |
| 6 | Av Max Temp | 62.3 | 63.8 | 68 | 69.4 | 70.3 | 73 | 73.5 | 73.5 | 73.5 | 74.6 | 70.9 | 67.1 |
| 6 | Av Min Temp | 46.5 | 47.5 | 51 | 51.8 | 55.6 | 58.9 | 62.6 | 61.5 | 58.8 | 56.1 | 50.8 | 46.8 |
| 6 | Rainfall | 7.6 | 8.63 | 3.14 | 0 | 0.11 | 0.59 | 0 | 0 | 0 | 0.39 | 0.71 | 1.97 |
| 7 | Av Max Temp | 64.3 | 66.2 | 74.8 | 79.3 | 80.6 | 84 | 84.5 | 88.4 | 92.8 | 83.1 | 76.1 | 72.1 |
| 7 | Av Min Temp | 43 | 43.1 | 48.1 | 49 | 54.1 | 56.6 | 59.9 | 57.6 | 58.4 | 54.5 | 46.5 | 39.6 |
| 7 | Rainfall | 13.39 | 10.56 | 1.82 | 0 | 0 | 0.96 | 0 | 0 | 0 | 0.56 | 0.89 | 0.5 |
| 8 | Av Max Temp | 60.5 | 61.5 | 73.4 | 79.3 | 82.9 | 89.3 | 87.6 | 93 | 92 | 81.3 | 71.5 | 66.3 |
| 8 | Av Min Temp | 42.8 | 45.2 | 48.8 | 52.3 | 57.1 | 60.1 | 61.9 | 63.7 | 60.4 | 55.2 | 46 | 40.1 |
| 8 | Rainfall | 13.87 | 9.04 | 1.68 | 0 | 0 | 0.14 | 0 | 0 | 0 | 0.11 | 0.73 | 0.72 |
| 9 | Av Max Temp | 65.7 | 66.4 | 73.5 | 76.3 | 73 | 79.5 | 79.3 | 81.5 | 81.8 | 79.7 | 74.8 | 71 |
| 9 | Av Min Temp | 48 | 49.7 | 53.5 | 54.9 | 52.3 | 61.8 | 65 | 64.7 | 62.2 | 60 | 52.3 | 47.8 |
| 9 | Rainfall | 11.78 | 4.12 | 1.66 | 0 | 0 | 1.31 | 0 | 0 | 0 | 0.11 | 0.44 | 0.88 |
| 10 | Av Max Temp | 66.4 | 71 | 84.4 | 92.5 | 96.7 | 104 | 103.7 | 106.2 | 103.4 | 93.5 | 77.6 | 73.2 |
| 10 | Av Min Temp | 42 | 44.5 | 52.6 | 58.5 | 66.1 | 75.3 | 74.2 | 76.5 | 70.1 | 62 | 45.2 | 38.8 |
| 10 | Rainfall | 4.18 | 2.01 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.22 | 0 |
| 11 | Av Max Temp | | | | | | | | | | | | |
| 11 | Av Min Temp | | | | | | | | | | | | |
| 11 | Rainfall | | | | | | | | | | | | |
| 12 | Av Max Temp | | | | | | | | | | | | |
| 12 | Av Min Temp | | | | | | | | | | | | |
| 12 | Rainfall | | | | | | | | | | | | |

| Region | | Jan-94 | Feb-94 | Mar-94 | Apr-94 | May-94 | Jun-94 | Jul-94 | Aug-94 | Sep-94 | Oct-94 | Nov-94 | Dec-94 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Av Max Temp | 72.8 | 66.9 | 73.1 | 71.7 | 71.8 | 82.9 | 81.2 | 89.3 | 86.3 | 79.4 | 69.5 | 68.8 |
| 1 | Av Min Temp | 46.8 | 47.6 | 51.5 | 54 | 55.5 | 61.1 | 63.5 | 66.5 | 62.3 | 56.5 | 46.4 | 46.2 |
| 1 | Rainfall | 0.51 | 2.61 | 1.92 | 1.14 | 0.23 | 0 | 0 | 0 | 0 | 0.1 | 0.93 | 0.71 |
| 2 | Av Max Temp | 68.4 | 66.8 | -5 | 72.2 | 73.4 | 81.5 | 80.7 | 87.3 | 81.7 | 76.7 | 66.8 | 66.5 |
| 2 | Av Min Temp | 46 | 46.3 | -5 | 53.6 | 55 | 58.6 | 61.7 | 62.1 | 59.2 | 54.7 | 47.5 | 46.5 |
| 2 | Rainfall | 0.31 | 7.02 | -5 | 0.42 | 0.1 | 0 | 0 | 0 | 0 | 0 | 1.09 | 1.06 |
| 3 | Av Max Temp | -5 | 67.5 | 70.8 | 71.7 | 70.5 | 78.1 | -5 | 83.7 | 81.5 | -5 | 68.1 | 66.7 |
| 3 | Av Min Temp | -5 | 45.1 | 50.1 | 51.9 | 52.6 | 56.5 | -5 | 62.6 | 61.7 | -5 | 47.1 | 43.8 |
| 3 | Rainfall | 0.88 | 3.42 | 2.42 | 0.65 | 0.35 | 0 | -5 | 0 | 0 | 0.35 | 0.45 | 1.33 |
| 4 | Av Max Temp | 74.4 | 68.3 | 73.7 | 72.3 | 72.1 | 83.9 | 82.1 | 90.3 | 86.3 | 79.6 | 69.7 | 68.9 |
| 4 | Av Min Temp | 50 | 50.3 | 55.7 | 56.2 | 58.1 | 64.8 | 65 | 70.7 | 66.7 | 61.2 | 50 | 50.8 |
| 4 | Rainfall | 0.33 | 3.21 | 1.86 | 0.83 | 0.28 | 0 | 0 | 0 | 0 | 0.19 | 0.61 | 1.35 |
| 5 | Av Max Temp | 64.8 | 61.2 | -5 | 61.9 | 62.3 | 67.9 | 68.6 | 73.4 | 72.7 | 69.4 | 63 | 62.1 |
| 5 | Av Min Temp | 49 | 49.1 | -5 | 54.5 | 56.3 | 61.1 | 63.4 | 66.5 | 63.3 | 58 | 47.9 | 48.7 |
| 5 | Rainfall | 0.63 | 3.89 | -5 | 0.48 | 0.1 | 0 | 0 | 0 | 0 | 0.32 | 0.56 | 0.63 |
| 6 | Av Max Temp | 68 | 63.5 | 68.1 | 66.5 | 65.8 | 72.1 | 70.3 | 77.2 | 73.7 | 72.1 | 65.7 | 64.5 |
| 6 | Av Min Temp | 46.2 | 46.8 | 51.5 | 51.4 | 53.5 | 57.7 | 59.2 | 62.1 | 58.1 | 54.6 | 44.7 | 44.6 |
| 6 | Rainfall | 0.4 | 5.19 | 2.41 | 0.49 | 0.45 | 0 | 0 | 0 | 0.22 | 0.3 | 1.5 | 1.12 |
| 7 | Av Max Temp | 75.9 | 70.3 | 74.9 | 77 | 74.8 | -5 | -5 | -5 | 88.1 | 78.8 | 67.8 | 68.5 |
| 7 | Av Min Temp | 39.1 | 42.1 | 47.9 | 49 | 52.6 | -5 | -5 | -5 | 57.2 | 50.9 | 38.7 | 39.9 |
| 7 | Rainfall | -5 | -5 | 3.25 | -5 | 0.14 | -5 | -5 | -5 | 0 | 0.44 | 0.81 | 0.96 |
| 8 | Av Max Temp | 70.4 | 63.7 | 72.1 | 75.2 | 76.8 | 94.3 | 94.1 | 98.3 | 91.4 | 78.6 | 65.4 | 65.1 |
| 8 | Av Min Temp | 43.1 | 41.6 | 48.1 | 51.1 | 53.5 | 59.9 | 63.2 | 65.2 | 60.4 | 52.3 | 39.8 | 41.1 |
| 8 | Rainfall | 0.99 | 3.68 | 3.24 | 1.47 | 0.65 | 0 | 0.03 | 0 | 0 | 0.56 | 0.9 | 1.75 |
| 9 | Av Max Temp | 72.5 | 67 | 73.2 | 71.4 | 71.3 | 80.7 | 79.7 | 87 | 84.2 | 78 | 69.1 | 67.8 |
| 9 | Av Min Temp | 47.7 | 48.3 | 52.7 | 54.2 | 56.5 | 61.2 | 63.6 | 66.6 | 63.4 | 56.7 | 46.4 | 47 |
| 9 | Rainfall | 1.7 | 6.44 | 2.08 | 0.81 | 0.16 | 0 | 0 | 0 | 0 | 0.16 | 0.91 | 0.87 |
| 10 | Av Max Temp | 77.2 | 73.1 | 83.5 | 87.6 | 93.2 | 106.5 | 106.9 | 108.1 | 102.5 | 90.1 | 71.9 | 68.4 |
| 10 | Av Min Temp | 40.7 | 42.8 | 56.5 | 61.7 | 64.4 | 77.7 | 80.6 | 81.1 | 76.6 | 63.4 | 43.8 | 43.7 |
| 10 | Rainfall | 0 | 0.53 | 0.63 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.09 | 0.32 |
| 11 | Av Max Temp | | | | | | | | | | | | |
| 11 | Av Min Temp | | | | | | | | | | | | |
| 11 | Rainfall | | | | | | | | | | | | |
| 12 | Av Max Temp | | | | | | | | | | | | |
| 12 | Av Min Temp | | | | | | | | | | | | |
| 12 | Rainfall | | | | | | | | | | | | |

| Region | | Jan-95 | Feb-95 | Mar-95 | Apr-95 | May-95 | Jun-95 | Jul-95 | Aug-95 | Sep-95 | Oct-95 | Nov-95 | Dec-95 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Av Max Temp | 63.6 | 74.3 | 70.4 | 73.2 | 70.2 | 76.7 | 84.6 | 88.6 | 86.4 | 81.4 | 76.1 | 69.5 |
| 1 | Av Min Temp | 48.5 | 52.2 | 51.1 | 51.7 | 54.9 | 57.9 | 62.3 | 63.2 | 63.2 | 57.5 | 52.8 | 48.2 |
| 1 | Rainfall | 10.49 | 1.39 | 5.94 | 2.05 | 0.24 | 1.21 | 0.03 | 0 | 0 | 0 | 0 | 1.02 |
| 2 | Av Max Temp | 63.7 | 71.3 | 71.2 | 74.5 | 71.4 | 76.4 | 81 | 81.7 | 82.5 | 76.8 | 70.2 | 67 |
| 2 | Av Min Temp | 47.8 | 47.6 | 48 | #N/A | 54.3 | 55.9 | 58.6 | 58.8 | 59 | 52.9 | 49.9 | 45.5 |
| 2 | Rainfall | 12.64 | 2.08 | 6.37 | 1.8 | 0.91 | 0.47 | 0.02 | 0 | 0 | 0.03 | 0.03 | 2.19 |
| 3 | Av Max Temp | 64.8 | 70.5 | 69.5 | 72 | #N/A | 73 | 79 | 79.5 | 80.4 | 74.6 | 69.7 | 66.4 |
| 3 | Av Min Temp | 46 | 47.8 | 48.6 | 50.6 | #N/A | 56.2 | 55.6 | 59.5 | 61.1 | 55.8 | 50.7 | 46.4 |
| 3 | Rainfall | 8.2 | 2.2 | 4.57 | 1.3 | 0 | 0.6 | 0 | 0 | 0 | 0 | 0.09 | 1.05 |
| 4 | Av Max Temp | 62.6 | 74.1 | 71 | 73.9 | 71 | 77.4 | 86.2 | 88.4 | 87.2 | 80.9 | 77.3 | 69.9 |
| 4 | Av Min Temp | 50.9 | 56.5 | 54.2 | 55.7 | 57 | 60.5 | 65.3 | 66.5 | 66.8 | 62 | 56.8 | 51.9 |
| 4 | Rainfall | 12.71 | 1.3 | 6.98 | 0.58 | 0.18 | 0.6 | 0.02 | 0 | 0 | 0 | 0.09 | 1.34 |
| 5 | Av Max Temp | 59.8 | 64.8 | 63.5 | 64.4 | 61.5 | 64.8 | 68.5 | 69.7 | 70.8 | 68.6 | 65.3 | 63.7 |
| 5 | Av Min Temp | 50.5 | 53.1 | 53 | 52.9 | 55.7 | 58.2 | 61.7 | 62.4 | 62.7 | 60 | 55.1 | 50.3 |
| 5 | Rainfall | 11.07 | 1.4 | 4.79 | 1.13 | 0.06 | 0.82 | 0.06 | 0 | 0 | 0 | 0.05 | 1.68 |
| 6 | Av Max Temp | 60.5 | 69.5 | 65.9 | 68.2 | 64.6 | 68.5 | 72.4 | 72 | 73.2 | 72.5 | 68.7 | 66 |
| 6 | Av Min Temp | 47.7 | 52.3 | 50.9 | 50.1 | 52.8 | 55.9 | 59 | 58 | 57.8 | 56.5 | 51.4 | 47.8 |
| 6 | Rainfall | 15.24 | 0.9 | 7.65 | 0.6 | 0.9 | 0.39 | #N/A | 0 | 0 | 0.11 | 0 | 1.72 |
| 7 | Av Max Temp | 63.9 | 76.4 | 68.8 | 76.1 | 75.9 | 81 | 91.4 | 95 | 91 | 82.6 | 78.2 | 68.2 |
| 7 | Av Min Temp | 44.6 | 47.9 | 46.8 | 46.8 | 51.5 | 49.2 | 53.1 | 58.6 | 55.8 | 47.8 | 43 | 36.1 |
| 7 | Rainfall | 13.79 | 1.88 | 7.06 | 1.48 | 0 | 0.53 | 0.08 | 0 | 0.01 | 0 | 0.27 | 0.38 |
| 8 | Av Max Temp | 60.6 | 72.2 | 69 | 73.9 | 73.2 | 86 | 96.4 | 98.8 | 94.7 | 86.6 | 79.4 | 69.2 |
| 8 | Av Min Temp | 44.3 | 48.9 | 47.8 | 48.3 | 51.3 | 55.9 | 63.4 | 65.8 | 62.8 | 53.7 | 48.8 | 42.4 |
| 8 | Rainfall | 11.35 | 1.54 | 5.98 | 0.76 | 0.2 | 0.86 | 0.05 | 0 | 0.2 | 0 | 0 | 0.7 |
| 9 | Av Max Temp | 64.4 | 73.9 | 70.8 | 73.2 | 69.6 | 75.6 | 82.4 | 85.8 | 84 | 78.7 | 74.8 | 68.9 |
| 9 | Av Min Temp | 49.2 | 53 | 52 | 52 | 55.4 | 58.6 | 62.1 | 63.2 | 63.7 | 59.5 | 54 | 49.1 |
| 9 | Rainfall | 13.48 | 1.36 | 6.96 | 1.04 | 0.52 | 0.53 | 0 | 0 | 0 | 0 | 0 | 1.47 |
| 10 | Av Max Temp | 67.1 | 80.1 | 78.8 | 84.5 | 86.5 | 100.4 | 107.2 | 108.7 | 103.9 | 93.9 | 84.9 | 73.4 |
| 10 | Av Min Temp | 46.3 | 53.8 | 55.2 | 60.5 | 64.5 | 71.9 | 79.8 | 84.1 | 77.5 | 63.2 | 56.2 | 46.5 |
| 10 | Rainfall | 3.66 | 0.28 | 0.4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.04 |
| 11 | Av Max Temp | 53.5 | 66.3 | 62.4 | 68.9 | 73 | 85.1 | 95.9 | 97.4 | 92.4 | 82.2 | 74.2 | 60 |
| 11 | Av Min Temp | 38.7 | 39.1 | 40.9 | 43.4 | 50.1 | 57.3 | 63.3 | 64.4 | 59.7 | 44.5 | 39.2 | 34.2 |
| 11 | Rainfall | 5.06 | 0.17 | 1.72 | 0.15 | 0.02 | 0.2 | 0 | 0 | 0 | 0 | 0 | 0.52 |
| 12 | Av Max Temp | 63.7 | 73.4 | 70.3 | 75.1 | 74.5 | 85.9 | 96.6 | 99.8 | 95.3 | 85.5 | 81.5 | 71.1 |
| 12 | Av Min Temp | 46.1 | 49.4 | 47.3 | 48.7 | 53.5 | 57 | 62.5 | 64.7 | 62.6 | 54.7 | 48 | 43.5 |
| 12 | Rainfall | 6.55 | 1.24 | 4.31 | 1.03 | 0.3 | 0.8 | 0 | 0 | 0 | 0 | 0 | 0.3 |

| Region | | Jan-96 | Feb-96 | Mar-96 | Apr-96 | May-96 | Jun-96 | Jul-96 | Aug-96 | Sep-96 | Oct-96 | Nov-96 | Dec-96 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Av Max Temp | 70.4 | 68.5 | 71.6 | 78.4 | 77.7 | 81 | 86.5 | 88 | 83 | 77.2 | 74.6 | 70.9 |
| 1 | Av Min Temp | 48.1 | 47 | 50.1 | 54.3 | 58.2 | 61.6 | 64.2 | 65 | 63.2 | 55.9 | 52 | 50.3 |
| 1 | Rainfall | 1.96 | 4.47 | 2.37 | 0.64 | 0 | 0 | 0 | 0 | 0 | 1.14 | 3.18 | 3.63 |
| 2 | Av Max Temp | 67.3 | 67.8 | 70.3 | 76 | 74 | 75.4 | 76 | 78.8 | 75.7 | 71.4 | 70.9 | 66.5 |
| 2 | Av Min Temp | 44.7 | 49.9 | 48.1 | 52.9 | 57.7 | 60.3 | 61.6 | 63.5 | 63.1 | 57.1 | 52.7 | 49.1 |
| 2 | Rainfall | 2.62 | 4.56 | 1.97 | 0.53 | 0 | 0 | 0 | 0 | 0 | 1.59 | 2.71 | 5.26 |
| 3 | Av Max Temp | 67 | 67 | 67.4 | 75.7 | 77.1 | 77.7 | 78.7 | 80.3 | 79 | 73.9 | 72.4 | 66.9 |
| 3 | Av Min Temp | 45.7 | 47.8 | 47.2 | 50.6 | 50.2 | 59.8 | 61 | 62.1 | 61.9 | 50.3 | 49.6 | 45.5 |
| 3 | Rainfall | 2.44 | 5.01 | 1.42 | 0.22 | 0 | 0 | 0.25 | 0 | 0 | 1.6 | 3.2 | 5.06 |
| 4 | Av Max Temp | 70 | 68.4 | 71.7 | 79.3 | 77.1 | 81.3 | 85.1 | 87.5 | 82.2 | 75.8 | 73.6 | 67.9 |
| 4 | Av Min Temp | 51.7 | 54.2 | 54.2 | 58.2 | 60.8 | 62.4 | 65.1 | 66.9 | 64.8 | 58.1 | 54.9 | 51.4 |
| 4 | Rainfall | 3.16 | 4.94 | 2.16 | 0.71 | 0.04 | 0 | 0 | 0 | 0 | 1.06 | 1.59 | 4.09 |
| 5 | Av Max Temp | 62.4 | 61.8 | 61.9 | 67.4 | 67.7 | 68.4 | 69.4 | 71.9 | 70.9 | 67.1 | 67.9 | 64 |
| 5 | Av Min Temp | 50.3 | 51.9 | 51.5 | 55 | 59.2 | 61.7 | 62.4 | 64.3 | 64.2 | 57.3 | 53.3 | 51.2 |
| 5 | Rainfall | 1.59 | 3.55 | 1.03 | 0.33 | 0 | 0 | 0.02 | 0 | 0 | 1.13 | 2.73 | 2.12 |
| 6 | Av Max Temp | 65.8 | 65.1 | 66.5 | 70.6 | 70.5 | 70.5 | 71.6 | 73.5 | 73.5 | 69.9 | 68.9 | 64.8 |
| 6 | Av Min Temp | 45.1 | 49.7 | 49.2 | 52.4 | 54.9 | 56.7 | 58.5 | 59.5 | 59.2 | 53.2 | 51.6 | 49.1 |
| 6 | Rainfall | 2.37 | 5.38 | 1.13 | 0.73 | 0 | 0 | 0.58 | 0 | 0 | 0.77 | 2.46 | 5.71 |
| 7 | Av Max Temp | 67.7 | 66.8 | 69.2 | 78.3 | 79.4 | 87 | 92.9 | 94.4 | #N/A | 79.7 | 73 | 66.3 |
| 7 | Av Min Temp | 36.9 | 41.8 | 40.2 | 42.4 | 48.4 | 51.4 | 58.1 | 59.4 | #N/A | 45.3 | 42.7 | 39.2 |
| 7 | Rainfall | 1.24 | 3.2 | 2.63 | 0.68 | 0.42 | 0 | 0 | 0 | 0 | 1.16 | 2.34 | 2 |
| 8 | Av Max Temp | 68 | 68.7 | 73 | 82.7 | 83.4 | 90.8 | 97.5 | 98.4 | 89.3 | 81.9 | 72.3 | 66.2 |
| 8 | Av Min Temp | 44.4 | 47.5 | 45.3 | 51 | 55 | 58.5 | 65.2 | 66 | 61.6 | 53.7 | 47.8 | 44.2 |
| 8 | Rainfall | 2.11 | 6.48 | 2.04 | 0.59 | 0 | 0 | 0 | 0 | 0 | 1.08 | 3.06 | 3.34 |
| 9 | Av Max Temp | 69.3 | 68.9 | 71.7 | 77.8 | 77.3 | 79.8 | 83.6 | 85.9 | 81.8 | 75 | 73.6 | 68.7 |
| 9 | Av Min Temp | 47.2 | 51.1 | 50.9 | 54.6 | 58.9 | 61.5 | 63.4 | 65.2 | 64.2 | 57.2 | 51.9 | 48.6 |
| 9 | Rainfall | 2.13 | 4.1 | 2.85 | 0.63 | 0 | 0 | 0 | 0 | 0 | 0.98 | 3.19 | 5.43 |
| 10 | Av Max Temp | 73.9 | 77 | 82.5 | 91.4 | 97.7 | 104.6 | 108.1 | 107.9 | 98.8 | 90.7 | 79.3 | 71.1 |
| 10 | Av Min Temp | 45.8 | 52.3 | 56.8 | 62.7 | 72 | 75.7 | 84.1 | 81.8 | 73.2 | 63.3 | 53.1 | 44.3 |
| 10 | Rainfall | 0 | 0.4 | 0.16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.53 | 0.1 |
| 11 | Av Max Temp | 62 | 62.2 | 67.3 | 75.9 | 82 | 91.8 | 99.4 | 99.2 | 88.4 | 76.7 | 65.8 | #N/A |
| 11 | Av Min Temp | 35 | 40.1 | 39 | 47.1 | 57.5 | 62.7 | 71 | 66.2 | 57.5 | 46.2 | 40.4 | #N/A |
| 11 | Rainfall | 0.72 | 1.61 | 8 | 0.03 | 0 | 0 | 0.02 | 0 | 0 | 0.66 | 0.45 | #N/A |
| 12 | Av Max Temp | 71.1 | 69.5 | 0.12 | 83.4 | 84 | 90.8 | 97.5 | 99.2 | 90.4 | 82.9 | 74.9 | 69.7 |
| 12 | Av Min Temp | 43.8 | 48 | 45.8 | 50.7 | 56.1 | 59.6 | 64.7 | 65.5 | 61.1 | 52.9 | 48.3 | 44 |
| 12 | Rainfall | 1.08 | 3.47 | 1.14 | 0.14 | 0 | 0 | 0 | 0 | 0 | 0.55 | 1.51 | 1.26 |

# Weather Data

| Region | | Jan-97 | Feb-97 | Mar-97 | Apr-97 | May-97 | Jun-97 | Jul-97 | Aug-97 | Sep-97 | Oct-97 | Nov-97 | Dec-97 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Av Max Temp | 66.4 | 70.7 | 77.4 | 73.7 | 81.3 | 77.4 | 81.6 | 87.2 | 89.7 | 81.4 | 75.5 | 69.4 |
| 1 | Av Min Temp | 48.2 | 47.6 | 51.7 | 51.9 | 60.9 | 62.8 | 58.8 | 65.1 | 66 | 59.4 | 54.2 | 47.6 |
| 1 | Rainfall | 4.84 | 0.24 | 0 | 0 | 0 | 0.05 | 0 | 0 | 0.47 | 0 | 2.48 | 3.42 |
| 2 | Av Max Temp | 64.9 | 69.2 | 70.8 | 71.6 | 75.8 | 75.3 | 76.5 | 81.3 | 83.2 | 76.7 | 73.2 | 68.2 |
| 2 | Av Min Temp | 50.5 | 48.7 | 51 | 54.9 | 61.1 | 63 | 62.8 | 65.5 | 65.4 | 57.8 | 53.4 | 46.6 |
| 2 | Rainfall | 7.07 | 0.09 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.17 | 3.15 | 3.71 |
| 3 | Av Max Temp | 65.9 | 67.3 | 77.2 | 72.6 | 78.1 | 77.4 | 78.4 | 84.5 | 85.2 | 78.3 | #N/A | 68.4 |
| 3 | Av Min Temp | 47 | 43.5 | 44.1 | 50.4 | 59.6 | 59.4 | 59.9 | 56.2 | 57.8 | 56.2 | #N/A | 45.6 |
| 3 | Rainfall | 5.57 | 0.27 | 0 | 0 | 0 | 0 | 0 | 0 | 0.55 | 0 | 2.97 | 7.6 |
| 4 | Av Max Temp | 65.9 | 70.4 | 75.4 | 75 | 81.5 | 77.8 | 81.5 | 87 | 89.4 | 80.7 | 74 | 68.5 |
| 4 | Av Min Temp | 51.4 | 51.5 | 54.7 | 56.4 | 63.8 | 64.2 | 64.8 | 68.2 | 70.1 | 61.5 | 56.4 | 49.2 |
| 4 | Rainfall | 5.58 | 0.08 | 0 | 0 | 0 | 0 | 0 | 0 | 0.45 | 0 | 2.06 | 2.52 |
| 5 | Av Max Temp | 62.8 | 63.3 | 64.6 | 64.4 | 69.2 | 68.7 | 70.1 | 72.9 | 75.8 | 72.9 | 68.8 | 66.5 |
| 5 | Av Min Temp | 51.1 | 49.5 | 54 | 54.8 | 61.6 | 63.2 | 63.5 | 65.1 | 67.1 | 60.2 | 55.8 | 49.2 |
| 5 | Rainfall | 4.56 | 0.06 | 0 | 0 | 0 | 0 | 0.01 | 0 | 0.68 | 0.01 | 2.12 | 6.84 |
| 6 | Av Max Temp | 63.6 | 66.9 | 68.3 | 69 | 72.6 | 71.9 | 72.8 | 76.7 | 79.5 | 77.1 | 72 | 65.9 |
| 6 | Av Min Temp | 48.5 | 45.8 | 49.7 | 50.8 | 57.8 | 59.3 | 60.3 | 62.1 | 63.6 | 56.7 | 52 | 46.2 |
| 6 | Rainfall | 4.4 | 0.03 | 0 | 0 | 0 | 0 | 0 | 0 | 0.06 | 0 | 3.28 | 6.25 |
| 7 | Av Max Temp | 63.2 | 66.1 | 75.9 | 74.1 | 85.1 | 80.8 | 87.4 | 91.9 | 91.4 | 79.8 | #N/A | 64.5 |
| 7 | Av Min Temp | 41.3 | 34.5 | 39.3 | 41.2 | 51.5 | 53 | 54.6 | 51.5 | 59.7 | 49.5 | #N/A | 35.2 |
| 7 | Rainfall | 4.97 | 1.25 | 0 | 0.11 | 0 | 0 | 0 | 0 | 1.2 | 0.29 | #N/A | 2.48 |
| 8 | Av Max Temp | 62.3 | 69.2 | 80 | 78.2 | 59.5 | 86.8 | 93.3 | 97.2 | 94.5 | 82.3 | 73 | #N/A |
| 8 | Av Min Temp | 46.1 | 44 | 47.1 | 50.2 | 59.8 | 61 | 62.4 | 66.4 | 65.8 | 55.1 | 48.6 | #N/A |
| 8 | Rainfall | 8.88 | 0.84 | 0 | 0 | 0 | 0.18 | 0 | 0 | 1.26 | 0.54 | 2.38 | #N/A |
| 9 | Av Max Temp | 67.5 | 71 | 75.9 | 74.2 | 80.9 | 77.4 | 81.1 | 86.4 | 89.3 | 81.5 | 74.7 | 69.8 |
| 9 | Av Min Temp | 49.6 | 47.4 | 51.8 | 53.4 | 61.8 | 63.2 | 63.2 | 66.2 | 66.5 | 59.7 | 54 | 46 |
| 9 | Rainfall | 5.2 | 0.11 | 0 | 0 | 0.01 | 0 | 0 | 0 | 1.2 | 0.01 | 1.7 | 5.35 |
| 10 | Av Max Temp | 70.6 | 75.5 | 87.1 | #N/A | #N/A | 100.7 | 105.2 | #N/A | #N/A | #N/A | #N/A | #N/A |
| 10 | Av Min Temp | 48.3 | 48.5 | 56.2 | #N/A | #N/A | 73.5 | 77.1 | #N/A | #N/A | #N/A | #N/A | #N/A |
| 10 | Rainfall | 0.68 | 0 | 0 | #N/A | #N/A | 0 | 0 | #N/A | #N/A | #N/A | #N/A | #N/A |
| 11 | Av Max Temp | #N/A | 60.6 | 73.7 | 72.6 | 89 | 86 | #N/A | 96 | #N/A | 76.3 | #N/A | 54 |
| 11 | Av Min Temp | #N/A | 32.7 | 39.1 | 48.9 | 61.5 | 61 | #N/A | 64.2 | #N/A | 44.9 | #N/A | 29.5 |
| 11 | Rainfall | #N/A | 0 | 0 | 0 | 0 | 0 | #N/A | 0 | #N/A | 0 | #N/A | 2.25 |
| 12 | Av Max Temp | 65.3 | 70.6 | 80 | 79.1 | 89.1 | 85.6 | 91.9 | 96.9 | 96.4 | 83.5 | 76.6 | 67.4 |
| 12 | Av Min Temp | 46.3 | 43.1 | 47.3 | 50 | 60 | 61.2 | 62.3 | 65.2 | 65 | 55.3 | 49.1 | 41.5 |
| 12 | Rainfall | 3.57 | 0.37 | 0 | 0.12 | 0 | 0.05 | 0 | 0 | 0.66 | 0 | 1.14 | 3.12 |

| Region | | Jan-98 | Feb-98 | Mar-98 | Apr-98 | May-98 | Jun-98 | Jul-98 | Aug-98 | Sep-98 | Oct-98 | Nov-98 | Dec-98 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Av Max Temp | 68 | 64.3 | 71.3 | 71.2 | 71.1 | 75.6 | 84.8 | 90.5 | 81.3 | 79.6 | 72 | #N/A |
| 1 | Av Min Temp | 47.1 | 46.5 | 49.5 | 49.2 | 54.1 | 58.2 | 63.6 | 65.5 | 64 | 56.2 | 51.6 | #N/A |
| 1 | Rainfall | 2.65 | 11.54 | 2.82 | 1.07 | 2.68 | 0.05 | 0 | 0 | 0.1 | 0 | 1.17 | #N/A |
| 2 | Av Max Temp | 65.5 | 64 | 68.6 | 67.5 | 69.5 | 72.3 | 76.9 | 79.8 | 76.4 | 74.4 | 68.3 | #N/A |
| 2 | Av Min Temp | 49.6 | 48.7 | 50.5 | 49.6 | 54.7 | 58.1 | 63.2 | 64.9 | 63.9 | 55.7 | 49.3 | #N/A |
| 2 | Rainfall | 4.09 | 12.45 | 3.86 | 1.37 | 3.27 | 0.11 | 0 | 0 | 0 | 0 | 0.5 | #N/A |
| 3 | Av Max Temp | 67.1 | 66 | 70.2 | 68.6 | 71.1 | 75.2 | 79.3 | 82.6 | 79.4 | 76.8 | 70.3 | #N/A |
| 3 | Av Min Temp | 45.5 | 42.5 | 47.9 | 46.7 | 51.9 | 55.7 | 54.3 | 57.5 | 60.6 | 57.1 | 46.6 | #N/A |
| 3 | Rainfall | 2.83 | 14.12 | 3.64 | 2.02 | 1.17 | 0.26 | 0 | 0 | 0.5 | 0.04 | 1.57 | #N/A |
| 4 | Av Max Temp | 66.5 | 64.3 | 70.2 | 71.1 | 71.2 | 76.1 | 85.7 | 90.5 | 81 | 78.5 | 71.9 | #N/A |
| 4 | Av Min Temp | 51 | 49.8 | 53.6 | 53.3 | 57.2 | 61.4 | 66.7 | 69.2 | 66.2 | 59.5 | 52.9 | #N/A |
| 4 | Rainfall | 4.12 | 13.68 | 4.06 | 0.97 | 3.1 | 0.05 | 0 | 0 | 0.01 | 0 | 1.32 | #N/A |
| 5 | Av Max Temp | 62.8 | 61.5 | 63.6 | #N/A | 74.6 | 74.8 | 77.8 | 81.4 | #N/A | #N/A | 73.8 | #N/A |
| 5 | Av Min Temp | 50.8 | 49.9 | 51.9 | #N/A | 56.9 | 60.2 | 64.1 | 67.1 | #N/A | #N/A | 52.7 | #N/A |
| 5 | Rainfall | 1.85 | 12.22 | 1.87 | #N/A | 0.97 | 0.05 | 0 | 0 | 0.24 | #N/A | 0.89 | #N/A |
| 6 | Av Max Temp | 64.3 | 62.5 | 66 | 64.7 | 67.5 | 69.1 | 90.1 | 76.4 | 74.1 | 72.7 | 67 | #N/A |
| 6 | Av Min Temp | 46.2 | 45.8 | 49.1 | 48 | 52.3 | 56.7 | 57.9 | 62.8 | 60.6 | 52.2 | 46.8 | #N/A |
| 6 | Rainfall | 3.27 | 17.4 | 3.14 | 1.26 | 2.11 | #N/A | 0 | 0 | 0.16 | 0 | 0.87 | #N/A |
| 7 | Av Max Temp | 63.9 | 59.8 | 65.6 | 68.5 | 69 | 77.2 | #N/A | 95.3 | 83.3 | #N/A | #N/A | #N/A |
| 7 | Av Min Temp | 39.4 | 40.2 | 41.9 | 41.4 | 46.9 | 50.2 | #N/A | 60 | 55.4 | #N/A | #N/A | #N/A |
| 7 | Rainfall | 3.46 | 11.66 | 4.36 | 3.39 | 2.44 | 0.12 | #N/A | 0.69 | 0 | #N/A | #N/A | #N/A |
| 8 | Av Max Temp | 64.4 | 61.9 | #N/A | 72.3 | #N/A | #N/A | 97.5 | #N/A | #N/A | #N/A | 72.6 | #N/A |
| 8 | Av Min Temp | 44 | 44 | #N/A | 47.4 | #N/A | #N/A | 65.4 | #N/A | #N/A | #N/A | 43.4 | #N/A |
| 8 | Rainfall | 1.83 | 15.03 | #N/A | 1.67 | #N/A | #N/A | 0 | #N/A | #N/A | #N/A | 0 | #N/A |
| 9 | Av Max Temp | 68.2 | 65.7 | 71.5 | 71.1 | 71.7 | 75.5 | 83.3 | 88.6 | 80.8 | 78.5 | 72.6 | #N/A |
| 9 | Av Min Temp | 49.4 | 48 | 50.9 | 51.3 | 55.7 | 59.8 | 64.2 | 66.5 | 65 | 57.2 | 50.2 | #N/A |
| 9 | Rainfall | 2.19 | 13.99 | 2.95 | 0.94 | 2.48 | 0.07 | 0 | 0 | 0.05 | 0.06 | 1.51 | #N/A |
| 10 | Av Max Temp | #N/A | #N/A | #N/A | #N/A | #N/A | #N/A | 108.2 | 108.4 | 100.8 | #N/A | 79.8 | #N/A |
| 10 | Av Min Temp | #N/A | #N/A | #N/A | #N/A | #N/A | #N/A | 81.2 | 82.6 | 74 | #N/A | 52 | #N/A |
| 10 | Rainfall | #N/A | #N/A | #N/A | #N/A | #N/A | #N/A | 0 | 0 | 0 | #N/A | 0 | #N/A |
| 11 | Av Max Temp | 67.5 | 54 | 63.9 | 65.5 | 68.3 | 80.9 | 96.3 | 99.1 | 83 | 74.8 | 64.6 | #N/A |
| 11 | Av Min Temp | 42.1 | 38.2 | 40.4 | 40.4 | 48.3 | 56.1 | 64.9 | 65.9 | 57.5 | 43.1 | 35.6 | #N/A |
| 11 | Rainfall | 2.66 | 6.23 | 2.85 | 0.34 | 0.94 | 0 | 0 | 0.16 | 0.73 | 0 | 0.38 | #N/A |
| 12 | Av Max Temp | 58 | 64.2 | 70 | 75.3 | 74.1 | 82.5 | 95.7 | 101.4 | 87.7 | 80.8 | 73.8 | #N/A |
| 12 | Av Min Temp | 36.3 | 43.9 | 46.9 | 46.7 | 52.4 | 57.1 | 64.5 | 67.3 | 62.5 | 52.3 | 45.3 | #N/A |
| 12 | Rainfall | 0.95 | 10.08 | 1.94 | 0.82 | 1.53 | 0.12 | 0.1 | 0.2 | 0 | 0 | 0.55 | #N/A |

## Weather Data

| Region | City |
|---|---|
| 1 | Anaheim, Brea, Buena Park,Downey, Fullerton,Orange, Yorba Linda, La Habra, Cypress |
| 2 | Culver City |
| 3 | Laguna Beach |
| 4 | Los Angeles, Newberry Park,Stanton |
| 5 | Newport Beach, Huntington Beach,Costa Mesa, San Juan Capistrano, Dana Point |
| 6 | Oxnard |
| 7 | Pomona, Covina,Diamond Bar,Ontario,Rancho Cucamonga, Rowland Heights,San Dimas,Upland, West Covina |
| 8 | San Bernardino |
| 9 | Santa Ana, Santa Ana,Garden Grove,Irvine, La Mirada,Laguna Nigel, Lake Forest, El Toro |
| 10 | Indio |
| 11 | Riverside, Corona, Redlands |
| 12 | Lancaster |

Notes:

-5 = Not applicable

# Appendix C

## Site Survey Questionnaire

**Site Survey Questionnaire**

| Completed by: | Date: |
|---|---|

**1.0** Is this an installation site or control site? (Check one) Installation ______ Control ______

**2.0** How many controllers are present at this site? __________

**If there are more than one controller for this site, complete a separate form for each.**

**3.0** Address:

| | |
|---|---|
| Property Name | |
| Street | |
| City | ZIP |
| County | |
| Contact person | |
| Phone number ( ) ______—__________ | |

**4.0** Meter/account information (if applicable):

| | |
|---|---|
| Controller ID number | |
| Meter ID number | |
| SCG Account number | |

**5.0 End uses on this gas meter:**

| | | |
|---|---|---|
| 5.1 Domestic hot water | Yes ______ | No ______ |
| 5.2 Hydronic heating | Yes ______ | No ______ |
| 5.3 Space heating | Yes ______ | No ______ |
| 5.4 Bar-be-Que | Yes ______ | No ______ |
| 5.5 Swimming Pool | Yes ______ | No ______ |
| 5.6 Spa | Yes ______ | No ______ |
| 5.7 Central laundry | Yes ______ | No ______ |
| 5.8 Gas-fired fire places | Yes ______ | No ______ |
| 5.9 Gas cooking | Yes ______ | No ______ |
| 5.10 Individual laundry | Yes ______ | No ______ |

**8.0 Out-door Bar-BQ information**

**Verify if Bar-BQ is on this meter. If yes, complete the following questions. If no, skip next question.**

8.1 How many Bar-BQs are present? ________________

8.2 What are the days of use per year? ____________________

**9.0 Pool heater information**

**Verify if pool heating is on this meter. If yes, complete the following questions. If no, skip to next question.**

9.1 Is this heater used? (Check one) Yes ____ No ____

**If the answer to this last question was no, skip to next question.**

9.2 Has there been any change in usage since last year? Yes ____ No ____

Please explain any change in usage: ________________________________________

________________________________________________________________.

9.3 What is the surface area (in sq. ft.) of this pool? ___________________

9.4 What is the average depth (in feet) of this pool? ____________________

9.5 Is a pool cover used? (Check one) Yes ______ No ______

9.6 Is solar assisted heating used? (Check one) Yes ______ No ______

9.7 If yes, is the system working? (Check one) Yes ______ No ______

**For each pool heater, complete the following:**

| | Heater #1 | Heater #2 | Heater #3 |
|---|---|---|---|
| Rate of use (days/year) | | | |

**6.0** Characteristics of site:

6.1 How many stories high is the building? ____________________

6.2 Total square footage of building? ____________________

6.2.1 Has the square footage changed since 1998? _____ Yes _____No

6.2.2 If YES what was the square footage of the building in 1998? _________

6.3 Occupancy rate (percent) for building 1998? ________________

6.4 Bedroom types:

| | Single BR unit | Two BR unit | Three BR unit |
|---|---|---|---|
| Number of units: | | | |
| Square footage/unit: | | | |

**Note: If the square footage of the building changed since 1997, indicate the number of units in 1997 in parenthesis.**

**7.0** Water heating system information.

7.1 Manufacturer ____________________________________

7.2 Model number ____________________________________

7.3 Input BTU ______________

7.4 Output BTU ______________

7.5 Capacity (gallons) ______________

7.6 Recovery rate (gals. per hour) ___________

7.7 Leaving water temperature ____________

7.8 Is the supply line insulated? (check one) Yes ______ No ______

7.9 Is the supply line above ground? (check one) Yes ______ No ______

7.10 Is the return line insulated? (check one) Yes ______ No ______

7.11 Is the return line above ground? (check one) Yes ______ No ______

7.12 Presence of solar assisted heating? (check one) Yes ______ No ______

7.12.1 Number of solar collectors ___________

7.12.2 Surface size (sq. ft / unit) ___________

7.12.3 Are these collectors working? (check one) Yes ______ No ______

**8.0 Out-door Bar-BQ information**

**Verify if Bar-BQ is on this meter. If yes, complete the following questions. If no, skip next question.**

8.1 How many Bar-BQs are present? ________________

8.2 What are the days of use per year? ____________________

**9.0 Pool heater information**

**Verify if pool heating is on this meter. If yes, complete the following questions. If no, skip to next question.**

9.1 Is this heater used? (Check one) Yes ____ No ____

**If the answer to this last question was no, skip to next question.**

9.2 Has there been any change in usage since last year? Yes ____ No ____

Please explain any change in usage: ________________________________________

____________________________________________________________________.

9.3 What is the surface area (in sq. ft.) of this pool? ___________________

9.4 What is the average depth (in feet) of this pool? ____________________

9.5 Is a pool cover used? (Check one) Yes ______ No ______

9.6 Is solar assisted heating used? (Check one) Yes ______ No ______

9.7 If yes, is the system working? (Check one) Yes ______ No ______

**For each pool heater, complete the following:**

| | Heater #1 | Heater #2 | Heater #3 |
|---|---|---|---|
| Rate of use (days/year) | | | |

**10.0 Spa heating information**

**Verify if spa heating is on this meter. If yes, complete the following questions. If no, skip to next question.**

10.1 What is the surface area (in sq. ft.) of this spa? ____________________

10.2 What is the average depth (in feet) of this spa? ____________________

10.3 Is a spa cover used? (check one) Yes ______ No ______

**For each spa heater, complete the following:**

| | Heater #1 | Heater #2 | Heater #3 |
|---|---|---|---|
| Rate of use (days/year) | | | |

**11.0 Central laundry information**

**Verify if central laundry is on this meter. If yes, complete the following questions. If no, skip to next question.**

11.1 How many washers are there? ____________________

11.2 How many gas dryers are there? ____________________

**12.0** Use this space to record any relevant comments. Please review the entire questionnaire for accuracy before leaving the site.

# Appendix D

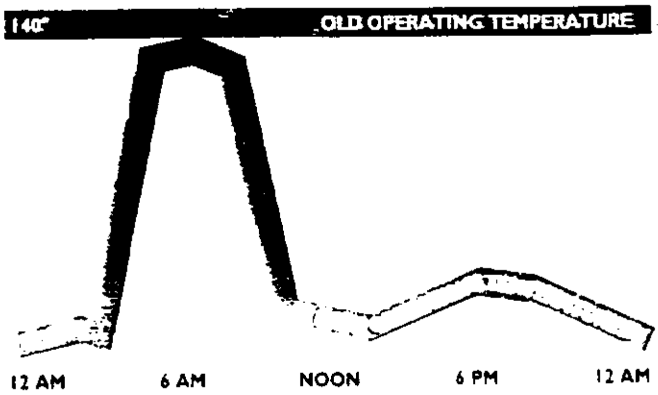
## Energx Brochure and Installation Manual

# Discover the Gold in Your Water Heater

Energx T2000
Water Heater Controller

- Save 25% plus on your water heating bill
- Increase property value
- Decrease liability from scalding
- Increase life of water heating system
- Minimize hot water complaints

Controller
Energx T2000™




## How can I save 25% on my water heating bill?

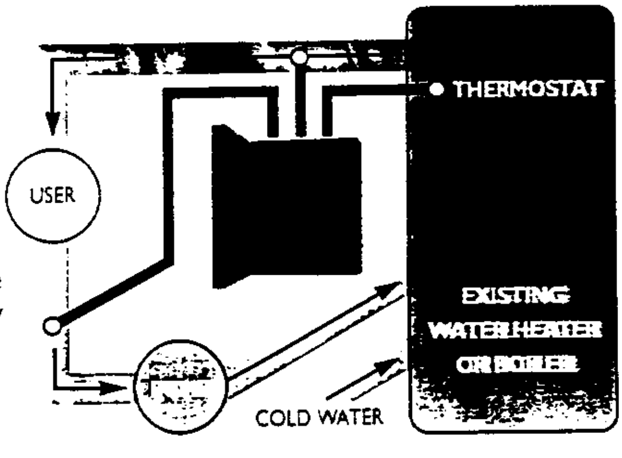
By regulating the temperatures of the water heating system according to time and usage, recirculation losses are reduced and heater efficiency is increased. Savings typically average 25% or greater.

## What is the payback?

Savings depend on many factors, such as number of units per system, cost of fuel, and efficiency of equipment. The annual Return On Investment (ROI) typically ranges from 50% to 150%. That represents a payback of 6 months to 2 years.

## How does property value increase?

Since net operating expenses are reduced, property values are increased. For every $1,000 dollars saved, property value is increased by $10,000, based upon capitalization values.




## How does the Energx controller work?

The computer senses hot water usage through a series of temperature sensors that indicate current demand. The computer saves energy by raising temperatures during times of high usage and lowering them during times of low demand.

## How can it minimize hot water complaints?

Using the computer's telecommunication capability, temperature adjustments and other diagnoses can be made without an on-site service call.

## What problems can the computer diagnose?

Through the use of Windows-based graphical reports, problems such as ignition failure, recirculating pump problems, main boiler pump, gas valve failure or hot water leaks can be identified. Other problems can frequently be detected by viewing the reports.

## What about financing?

A variety of financing options are available for qualified properties, including terms, lease/purchase and shared savings.

**Increase your bottom line today. Test a unit without obligation to purchase.**

# Energx Controls, Inc.

P.O. Box 519, Cypress, CA 90630
energx@juno.com
Licensed under Patent No. 5,626,287

# Energx T2000

## Instruction Manual

## *Model T2000 Overview*

The Energx Model T2000 introduces the utilization of current and recent water use to establish heater Demand and determine the Setpoint for control of water heating systems. The unit controls water temperature by monitoring water usage information obtained from two temperature sensors. Temperature sensor #1 measures the temperature of hot water leaving the heater to Supply the recirculation loop. Sensor #2 measures temperature of the system Input city-water, which is used to determine demand. A third sensor measures the temperature of water Returning from the recirculation loop. The Model T2000 controls the water heating system via an internal relay, turning it on or off to maintain an ideal temperature.

The Energx Model T2000 is a "Demand" type of hot water heater controller using up to three temperature sensors and four relays which are designed for use with 120Vac, 24Vac and 750Mv heater systems.

Demand type control can be described as the ability of the controller to monitor and react to changes in the system Input temperature based upon a desired Minimum temperature determined by the immediatly preceeding history. The T2000 will establish an optimum Control-Setpoint for the Supply Temperature based on this Demand and then control the relays to maintain this value. Thus, the Model T2000 controls water Supply at the minimum temperature which will fully satisfy user needs. This operation will dramatically lower costly heat loss, scale deposits and increase the life of any water heating system.

## *Temperature Sensors*

**Temperature Sensor Locations:**

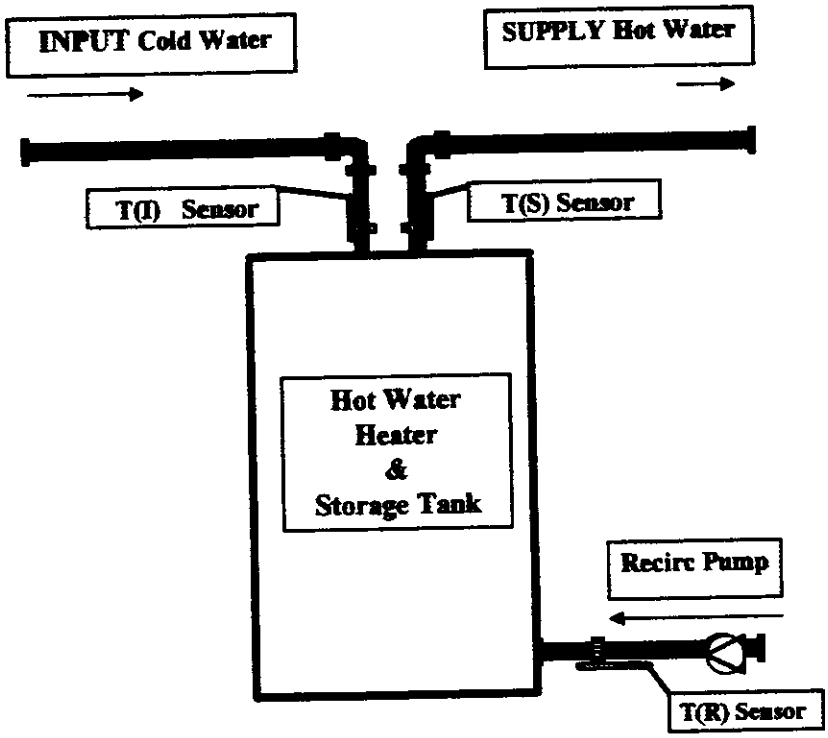



Figure _____ Tank type Hot Water Heater

# Temperature Sensors (Cont.)

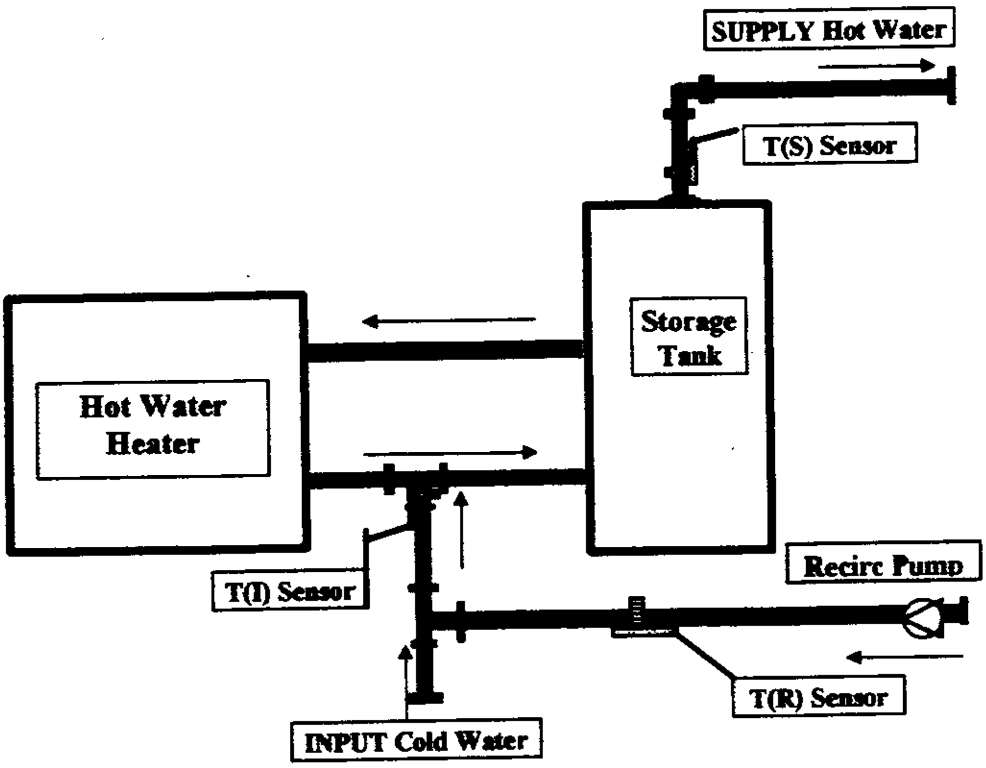



Figure _____ Hot Water Heater with Storage Tank

**Temperature Sensor Description**:

Info

**Temperature Sensor Mounting Instructions**:

Sensor #1 --- Supply sensor is T(S)

Sensor #2 — Input sensor is T(I)

Sensor #3 --- Return sensor is T(R)

More Info

# Installation Procedure

Installation Codes

Electrical General

Wiring Shielded Cable and Ground Wire

Controller Location

Power Transformer: A grounded wall-mount power supply capable of delivering 0.5 Amps at 10Vac to 24Vac is required. The lower the voltage, the cooler the controller electronics operation will be. A reccommended UL Approved power supply is the Ault AC Transformer Part Number 318-2012-000 which is 12Vac at 20VA and has screw terminals..

Wiring Details.

Normally Closed Relays: Jumper selectable to be a Dry-Contact closure or to supply AC Power from the Power Transformer.

R-I-B connections.

H.O.A availability and operation

Connection for Normally Open relay operation.

Wiring Details

Wiring To The Thermostat:

Wiring Details

# *T2000 Controller*

## Display and Push-buttons:

The Energx T2000 Led Display can show sensor temperatures with the first (Green) digit being the sensor ID Number. Two push-buttons are used to provide operator control. The Led's are turned on to a steady display when either push-button is touched. The Red push-button selects temperature for display as shown in the simplified operator instructions.

After the Energx T2000 has gone for about 4 minutes without any operator control by use of a push-button, the display will "blank out". This provides cooler operation and lower power consumption. While the display is "blanked out", it is normal for display to flash on for 2 seconds of temperature display at about a 15 second interval. This flashing sequentially scans temperatures 1, 2, 3 and 4 in a one minute cycle. Display flashing on at a 5 second interval indicates **a bad sensor** alert, see Chapter 9.

**Decimal Point Indicators:**

Digit #1 (Green) -- On indicates Relay #1 Heater is On.
Digit #2 ( Red ) -- On indicates Relay #2 Heater is On.
Digit #3 ( Red ) -- On indicates the system is in "Off-Line" status.
Digit #4 ( Red ) -- Ticks at one second interval with system clock.

## Hot Water Heater System Testing and Check-out:

During testing and check-out of a hot water heating system, it may be desired to return it to normal operation. Use the Red push-button to place the system in "Off-Line" status by pressing it for a longer time, as shown in the following "Emergency" instructions. The White push-button will return the system "On-Line".

# Simplified Operator Instructions:

**RED | SELECTS DISPLAYED TEMPERATURE**
**V**

**1 SUPPLY TEMPERATURE**
**2 CONTROL SET-- POINT**
**3 RETURN TEMPERATURE**
**4 INPUT TEMPERATURE**

# EMERGENCY:

**OFF-LINE: PRESS RED FOR 6 SECONDS — UNTIL DISPLAY SAYS " OFF "**
**ON-LINE: PRESS WHITE — UNTIL DISPLAY SAYS " on "**



## Method of Control:

Hot water heater on-off control is accomplished by a control set-point temperature, with hysteresis level determined by the deadband. Control set-point is determined by the minimum temperature plus a use factor. This use factor is a function of:

User demand level,
Heater output and
Conduction heat loss.

The **Control Variables** in the "Site Information Edit / T2000 Installation" screen are used to calibrate these three values for a hot water heater system.

**Ratio:**

With no demand, the input sensor reading will increase as the piping is warmed by recirculating hot water and approach a steady state level. This level is called the "Reference" temperature. When demand occurs, the input temperature drops as cool city water flows into the system. A lower input temperature indicates more demand because of more hot water usage and more heat required to warm the cooler input water. Thus demand can be measured as a function of the input temperature drop below the reference temperature and a system calibration factor. This calibration factor is known as "Ratio".

- Increasing "Ratio" will decrease the off-time between burns.

**Gain:**

The increase of water temperature as a result of the heater being on is calibrated by "Gain".

- Increasing "Gain" will cause shorter Burns.

**Loss:**

The net value of all insulation conduction and convection heat losses is set by the "Loss" variable and usually has only a slight impact on system control operation.

- Increasing "Loss" will cause a greater automatic increase of control set-point with time.

**Deadband:**

Heater on-off hysteresis is controlled by "Deadband".

- Increasing "Deadband" will give longer burns and greater temperature variations.

**Maximum T:**

- Set "Maximum T" to the desired maximum supply delivery temperature level.

**Minimum T:**

- Set "Minimum T" to desired minimum supply temperature level, consider return also.

**Reference:**

The "Reference" temperature is set by laptop computer editing. A proprietary technique provides for automatic reference temperature adjustment. Thus the "Reference" temperature is immune to annual climatic changes daily diurnal temperature variations and rapid temperature drops resulting from passage of cold weather fronts. No automatic adjustments are made during periods of high demand.

## Temperature Readings:

Additional information on the display and temperatures is shown later in this Chapter.

Display flashing on at a 5 second interval indicates **a bad sensor** alert, see Chapter 9. It is normal for display to flash on for a 2 second display of temperature at about a 15 second interval. This flashing will sequentially scan temperatures 1, 2, 3 and 4 in a one minute cycle.

A bad supply temperature sensor reading is automatically replaced in control functions by the return sensor reading plus the historical difference between supply and return temperatures. This maintains system control even when the supply sensor malfunctions.

Lower minimum temperature settings will provide more energy savings. Automatically adjusting the "Minimum T" value to a lower setting at midnight can be set up with the -Adjust Days and -Adjust Degrees functions. Automatic adjustment can be set for 1 to 8 half-degrees per day for 1-31 days

- -Adjust Days is the number of days to use in smoothly decreasing the Minimum T value, thus allowing residents to unknowingly adapt (acclimate).
- -Adjust Degrees controls how many degrees the Minimum T is decreased during the total number of -Adjust Days set above.

## State-of-Art Features:

Virtual Relays – assignment of either relay to one of four control functions.

Sensor Connection Flexibility – connector interchangeability and automatic replacement.

Fast Data Retrieval – 10 seconds at 9600 Baud.

Easy Data Handling – historical data filing, retrieval and system editing in "Windows".

Control While Communicating – allows local and remote data logging at 1 second intervals.

History is posted to EEPROM at 20 Minute intervals:

Automatic daily resets at 12:22 AM keeps time and all variables correctly set.

## System Connection Alternatives:

Two heaters may be set up with two Energx T2000 controllers, the second controller operating only on the "Minimum T" setting. This would be lower than the "Minimum T" of the first and thus perform the high demand augmentation.

Heaters may be connected with "Relay In a Box" and provide an "HOA" system control override.

## MORE INFORMATION ON DISPLAY AND TEMPERATURES:

ENTER TOTAL DISPLAY MODE BY HOLDING WHITE BUTTON DOWN UNTIL ['1' ^F] FLICKERS ONTO DISPLAY. WHEN DISPLAY BLANKS OUT IT WILL AUTOMATICALLY RETURN TO SIMPLIFIED OPERATOR MODE.

## TOTAL DISPLAY MODE OPERATOR INSTRUCTIONS:

['1' ^F] '1'=FLASHING — **DISPLAY TEMPERATURES**

```
['1' ^F] '1'=FLASHING
     RED | GOES TO '2'
         V  WHITE --> TEMPERATURE DISPLAY
                    RED | SELECTS DISPLAY TEMPERATURE
                        V  [ 1123 ] SUPPLY TEMP        = 123
                           [ 2124 ] CONTROL SETPOINT   = 124
                           [ 3115 ] RETURN TEMP        = 115
                           [ 4102 ] INPUT TEMP         = 102
          EDITABLE         [ 5135 ] MAXIMUM TEMP       = 135
          EDITABLE         [ 6118 ] MINIMUM TEMP       = 118
                           [ 7110 ] REFERENCE TEMP     = 110
                           [ 8133 ] MAX SUPPLY TEMP    = 133
                           [ 9118 ] MIN SUPPLY TEMP    = 118
                           [ A124 ] MAX INPUT TEMP     = 124
                           [ B 87 ] MIN INPUT TEMP     =  87
                    WHITE -->  EDIT OR --EDIT
                    RED EDITS TEMPERATURE (TEMP FLASHES FOR --EDIT)
                    HOLD WHITE DOWN >1SEC --> GOES BACK TO [ '1' ^F ]
```

['2'REL] '2'=FLASHING — **DISPLAY RELAY STATUS**

```
['2'REL ] '2'=FLASHING
     RED | GOES TO '3'
         V  WHITE --> RELAY DISPLAY
                    RED | INCREASES RELAY #
                        V  [ 1Con ]RELAY #1 CONTROLLED
                           [ 2 on  ]RELAY #2 MANUAL ON
                           [ 1OFF ]RELAY #1 MANUAL OFF
                           [ 2non ]RELAY #2 NONACTIVE
                    WHITE --> EDIT SELECTED RELAY (Con DIGITS FLASH)
                    RED EDITS RELAY STATUS
                    HOLD WHITE DOWN >1SEC --> GOES BACK TO [ '2'REL ]
```

['3' ##] '3'=FLASHING — **% ON-TIME DURING LAST 8 DAYS**

```
['3' ## ] '3'=FLASHING
     RED | OR WHITE GOES TO '4'
         V
```

['4' on] '4'=FLASHING — **BLANKING STATUS**

```
['4' on ] '4'=FLASHING
     RED | GOES TO '1'
         V  WHITE -->     [ '4'OFF ] BLANKING OFF
                     OR   [ '4' on ] BLANKING on
```

## SELECTED DISPLAY TEMPERATURE:

1 **SUPPLY TEMPERATURE** — AS SUPPLIED TO THE RECIRCULATION LOOP. A MEASURED VALUE.

2 **CONTROL SETPOINT** — THE COMPUTER CALCULATED VALUE WHICH IS COMPARED TO SUPPLY TEMPERATURE FOR THE BURNER-ON T2000 STATUS DECISION.

3 **RETURN TEMPERATURE** — RECIRCULATION LOOP RETURN TEMPERATURE. A MEASURED VALUE.

4 **INPUT TEMPERATURE** — THE INPUT WATER TEMPERATURE FROM CITY. A MEASURED VALUE.

5 **MAXIMUM TEMPERATURE** —[EDIT] THE MAXIMUM ALLOWED TEMPERATURE VALUE OF SUPPLY WATER FROM BOILER; THE T2000 WILL ALWAYS TURN OFF BOILER ABOVE THIS TEMP. A "SYSTEM CONTROL" OPERATOR VALUE.

6 **MINIMUM TEMPERATURE** — [EDIT] THE DESIRED SUPPLY TEMPERATURE; OPERATOR DEFINED.
THIS VALUE CAN BE AUTOMATICALLY ADJUSTED BY T2000: -1/2 TO -4 DEGREES EACH MID-NIGHT FOR 1 TO 31 DAYS.

7 **REFERENCE TEMPERATURE** — [EDIT] REFERENCE VALUE OF INPUT TEMP WHICH IS USED TO ESTIMATE THE CURRENT "DEMAND" ON BOILER SYSTEM. A "SYSTEM CONTROL" VALUE.
THIS REFERENCE IS AUTOMATICALLY ADJUSTED BY T2000: 1 DEGREE CLOSER TO MAX INPUT TEMP FOR EACH 20 MINUTE TIME PERIOD.

8 **MAX SUPPLY TEMPERATURE**- THE MAXIMUM VALUE REACHED BY SUPPLY TEMPERATURE DURING A 20-MINUTE PERIOD. A COMPUTER POSTED VALUE.

9 **MIN SUPPLY TEMPERATURE**- THE MINIMUM VALUE REACHED BY THE SUPPLY TEMPERATURE DURING A 20-MINUTE PERIOD. A COMPUTER POSTED VALUE.

A **MAX INPUT TEMPERATURE** - THE MAXIMUM VALUE REACHED BY THE INPUT TEMPERATURE DURING A 20-MINUTE PERIOD. A COMPUTER POSTED VALUE.

B **MIN INPUT TEMPERATURE** - THE MINIMUM VALUE REACHED BY THE INPUT TEMPERATURE DURING A 20-MINUTE PERIOD. A COMPUTER POSTED VALUE.

## T2000 Controller Software

The Lap-top program to control the Energx T2000 is run from Windows starting with the

"ENERGX T2000 – EXCEL Export" screen
From this screen you can sellect the other three screens:
"Communicating",
"Site Variable Display", &
"Site Information Edit / T2000 Installation".

### The ENERGX T2000 – EXCEL Export screen and menus:

Menu selection – "Save" will save the Retrieved T2000 information or altered Site data-base to disk. Listen for Beep to verify data recording.

Menu selection – "Data" will enable the The "Communicating" Screen to retrieve data. If no Site data-base has been loaded, this command will auto-load correct site.

Menu selection – "Exit" exits to Windows.

Menu selection – "Load" will allow selection and loading the data-base for any Site. Normal data-base file extensions are ".DHW". Select ".DHM" to find only locations which have modem communications.

Menu selection – "View" will Graph the next Day-of-Week.
The +/- at the bottom left of graph modifies the Temperature scale Zero value.
The +/- at the top left of graph modifies the Temperature Span value.
"View" following Saturday will go to "Site Variable Display".

Menu selection – "Later Data" will load the T2000 values for the next data collection.
Menu selection – "Prior Data" will load the T2000 values for previous data collection.
Either selection sets Day-of-Week to go to "Site Variable Display" next.

Menu selection – "Print" will send the graph or the Week you are viewing to printer. If Excel option is selected, print will post loaded site retreived data to disk.

Menu selection – "Options" will allow the setting of several options.
Top Check-Mark determines printout mode:
"Print All 7 Days"
"Print Viewed Day"
"Excel Data"
"Cover Sheet Only"
Lower Check-Marks select the data to be Graphed:
"Control Set-Piont" Temperature.
"Supply" Temperature.
"Return" Temperature.

## The ENERGX T2000 – EXCEL Export screen and menus: (Cont.)

Menu selection -- "Options" will allow the setting of several options. (Cont.):

Lower Check-Marks select the data to be Graphed: (Cont.):

"Input" Temperature.

"Burn Time" % of time hot water heater is on.

"Status Byte" checked enables display of codes as in Status Legend below for each 20 minute time history.

"Colorize Graph" checked will enable colored data curves, on both computer screen and Graph printouts.

"Cover Sheet" checked adds a cover sheet to 7 Day printouts.

"Graph Days On Line Only" checked will limit screen graphs to the actual days on line at installation time (no blank days).

"Printer Set-Up" enables a printer control menu.

Menu selection – "Phone In" will enable a menu:

"Call" to dial up the selected site with modem.

"Hang-up"

"Comm Port x" sets comm port in Windows program.

"Edit" goes to the "Site Information Edit / T2000 Installation" screen.

## Data Retrieval and Display:

When "Data" is selected, The "Communicating" Screen will show progress. Data retrieval should take 10 seconds at 9600 Baud. Slow progress is caused by the communications timing out (and Beeping) while waiting on information from the T2000 and the communications cable should be checked. A single Beep indicates thet the Serial# in the T2000 differs from the Serial# in the Lap-top database. Notice the Commo Exit which is activated by about any key or the Mouse action.

After "Data" retrieval is completed, the "Site Variable Display" screen automatically shows the retrieved "Read Data" information.

Menu selection -- "Disk Data" will Display Disk values for the Site database.

Menu selection – "Read Data" will again show the retrieved "T2000" information.

Also on keyboard:

"D" will display the Disk Data.

"R" will display the Retrieved T2000 information.

Menu selections – "Exit" or "View" go to "ENERGX T2000 – EXCEL Export" screen. After Data retrieval, be certain to save good data. "View"—"Save"(Beep). No Beep @ Save = No-Save.

Menu selection -- "Later Data" will load the T2000 values for the next data collection.

Menu selection – "Prior Data" will load the T2000 values for previous data collection.

(Notice that the Site Information time and data change for each Data Set.)

STATUS LEGEND: A = Alarm, R = Reset, C = Communications, T = Time Was Edited, K = Relay Edit, X = Max Temp Edit, N = Min Temp Edit, P = Pushbutton Touched.

## Graphs and Printouts:

Determine Graph variables in "Options" menu by selecting desired checked items. Each time "Options" is selected will set Day-of-Week to one day earlier for repeat of last graph. This allows the selection of a new curve for display on the current graph.

The preferred Temperature scale factors can be set for any Site by adjusting :

The +/- at the bottom left of graph modifies the Temperature scale Zero value.

The +/- at the top left of graph modifies the Temperature scale Span value.

These Temperature scale values will be saved with the Site data-base when the program is "Exited". Then, the Site specific Temperature scale values will automatically be set when this Site's data-base is Loaded again.

The "Print Viewed Day" option will print out only the day currently viewed along with the readings which were current at data retrieval time. The "Print all 7 Days" option will print four pages of two days at a time along with current readings for data retrieval time on the final page.

Select "Cover Sheet" to print out the Site Discription and Heater Details. These items will be printed down to the point where "Many Lines of What" is found in data base.

The Serial Number format is: Serial # YYMMDDS1 with the first 6 digits being date of manufacture, while "S" is type and "1" is unit number for that day.

The best way to utilize the "Graph Scale" selection of the Options menu is to ignore it.

# *Laptop Programming*

## Existing System Display/Edit:

Load selected data-base file and go to "Site Information Edit / T2000 Installation" screen:
"Load" selected Site data-base file.
"Phone In" to get sub-menu:
"Edit".

Menu selection -- "Disk Data" will Display Disk values for entire display.

Menu selection -- "Read Data" will Read all values from the T2000 for entire display.

Menu selection -- "Update T2000" will post T2000 ram values to nonvolatile EEPROM.

Menu selection -- "Save" will set save data to disk flag and do an "Exit".
Altered Site data-base can then be recorded to disk by the "Save" menu selection in the "ENERGX T2000 -- EXCEL Export" screen.

Menu selection -- "Initialize T2000" will enable a pull-down menu:
"Reset T2000 Communications" resets Communication buffer.
"W-Dog Check" tests the Watch-Dog timer on T2000.
"Set Time" in T2000 to equal lap-top time +/- 60 seconds.
"T2000 Reset" writes all displayed values to T2000 ram and EEPROM.
"Data Base Init to Last 2 Files" will retain only the last 2 data collections.
"Really Do It!!!" does "T2000 Reset" , "Set Time" & Installation Setup.
"Really Do It!!! And Zero Memory" takes a little over 1 minute.

When entering this "Site Information Edit / T2000 Installation" screen, the cursor will be located as an (X) in the first value change/display block. The cursor may be moved with the TAB; Up, Down, Left & Right Arrow keys or by Left Clicking the Mouse.

The selected display block value may be increased by using the "+" or "]" key
or it may be decreased by using the "-" or "[" key.

"D" will Display Disk values for entire display.
"R" will Read all values from the T2000 for entire display.
"W" will Write the value to T2000 for selected item.
A "BEEP" will indicate Commo Problem

**NOTE:** If you want any new values edited by "W" to be posted to EEPROM Memory, do the "Update T2000", otherwise the values will be replaced by EEPROM Values at Mid-Night.

# *Controller Start-Up Procedure*

## System setup:

The Site File Name and Directory Path can be used with an organized sub-directory structure to provide easy Site location for each customer installation.

First set up a Sub-Sub-Sub-Directory Structure in Windows or DOS which will best represents the customer data-base. It is suggested to keep all sites of any given customer located together in a common sub-directory for ease in modem and report printing operations. The geographic location does not mater because the on-site data retrieval is done with the "Data" menu-selection, which will automatically identify and load the proper site data-base by information from the Energx T2000 unit. Under remote data retrieval with modem control, the auto-dialing and telephone company will find the proper location. This sub-directory structure can be modified at any time. It will function the easiest when the master Desk-Top computer and field data gathering Lap-Top computer have exactly the same sub-directory data structures. This way, the entire data-base may be transferred between them by one (1) command with a "Lap-Link Windows" connection.

## Establish data-base for new site installation:

After the sub-directory structure is set, start the Energx T2000 program and create the data-base for a new customer site:

"Load" a similar file.
Select "Load" one more time.
Set the desired Sub's Structure where the new site will be.
"Cancel".

This operation will preload the new data-base and set the proper sub-directory structure for its storage.

Next go to the "Site Information Edit / T2000 Installation" screen:
"Phone In" to get sub-menu:
"Edit"

Select the File Name block (the one with drive\path).
Edit this block to be the desired drive\path\filename.
"Save" — will Exit to "ENERGX T2000 – EXCEL Export" screen.

A Save-File menu will appear: Do "OK".
This will cause the creation of a new file data-base.
"Load" the new file.

Return to the "Site Information Edit / T2000 Installation" screen:
"Phone In" to get sub-menu:
"Edit"

The Site Description and Water Heating System blocks can be edited to say whatever you want. Note that if you do the first part of the Site Description block properly, the Site Information in the View screen will be helpful at data retrieval time. Mouse Editing can be used to advantage on these data blocks.

"Control-End" goes to bottom of data.
"Control-Home" goes to top of data.
"Click-Drag" will select data:
- "Control-C" copies to clip-board.
- "Control-V" pastes from clip-board.
- "Delete" will actually delete.

Lower in the Site Description block, you will see GrafTitle="Caesar——————etc.———|". This is where you can set the Title to be displayed on that site's Graphs. The exact wording of: [ GrafTitle="X|" ] must be precise, with X being the Title displayed. Site Description Data print-outs will include all the Site information and Water Heating System blocks down to the "Many Lines of WhatEver" marker.

Now edit Control Variables, Temperatures, and Status to the desired values for the new site:

The cursor can be positioned at the first value change/display block with a mouse click. The cursor may be moved with the TAB; Up, Down, Left & Right Arrow keys or by clicking the mouse.

The selected display block value may be increased by using the "+" or "]" key or it may be decreased by using the "-" or "[" key.

The range of possible values for Control Variables and Temperatures will be shown as you increase or decrease them. Note that they wrap-around at range over-run.

The -Adjust Days is the number of days to use in smoothly decreasing the Minimum T value, thus allowing residents to unknowingly adapt (acclimate).

The -Adjust Degrees is set next to control how many degrees the Minimum T is decreased during the -Adjust Days.

The data-base editing up to this point can be done prior to actual connection to an Energx T2000 unit. Perform the following operations while the communication link is set-up with a powered-up unit.

Select -- "Initialize T2000" menu.
Select -- "Really Do It!!! And Zero Memory" takes about 1 minute and 5 Seconds. Observe that the display started with Temperature #5 and should have flickered through all of the initialized values, ending with Temperature #6
Select --"Read Data" to Read all values from the T2000 for display. Verify data validity.
Select -- "Save" will set a save data to disk flag and do an automatic "Exit" to the "ENERGX T2000 -- EXCEL Export" screen.
Select -- "Save" will now record the New Site data-base to disk.

**The Energx T2000 is now ready for control and data collection.**

# Modem Installation:

## Hardware:

Install.

## Data-base Software modifications:

Load data-base file and go to "Site Information Edit / T2000 Installation" screen:
"Load" selected Site data-base file.
"Phone In" to get sub-menu:
"Edit".

Edit the "Modem Phone Installation" block to the site phone number.
Select -- "Save" will set save data to disk flag and do an "Exit".
Edited Site data-base was recorded to disk at sound of beep.

Menu selection --"Load" selects renamed Site data-base file.

Notice that the data-base file extension has been modified from ".DHW" to ".DHM" indicating that this site now has modem communications. This new ".DHM" causes a new filename and requires the T2000 to be updated:

Go to "Site Information Edit / T2000 Installation" screen:
Menu selection --"Phone In" to get sub-menu:
"Edit".

Menu selection -- "Read Data" to Read all values from the T2000 for entire display.
Verify validity.
Set the "Modem Ring #".
Select -- "Initialize T2000" menu.
Select -- "T2000 Reset" to post this new information to Energx T2000.
Observe that the display should have flickered through all of the initialized values, ending with Temperature #6.
Select --"Read Data" to Read all values from the T2000 for display. Verify data validity.
Select -- "Save" will set a save data to disk flag and do an automatic "Exit" to the "ENERGX T2000 -- EXCEL Export" screen.
Select -- "Save" will now record the New Site data-base to disk.

Data-base Software modifications are now complete and this new information has been posted to Energx T2000. Note that by selecting ".DHM" data-base file extensions you can find only locations which have modem communications.

By using File-Manager to copy a data-base to a new name which only differs in the last character of the extension (".DHx"), any number of archived data-bases may exist for one Energx T2000 Site.

# Modem Communication:

Menu selection – "Load" will allow selection and loading the data-base for any Site.
Select ".DHM" data-base file extensions to find only locations which have modem communications.

Menu selection – "Phone In" will enable a menu:
"Call" to dial up the selected site with modem.

Control the Energx T2000 as if on site until interrogation is completed.

"Off-Line" status for the T2000 can be seen on computer display screens as a "Status = OFF" title for the status data block. Status can be monitored in both the "Site Variable Display" screen and the "Site Information Edit / T2000 Installation" screen with the "Read Data" Menu selection.

The T2000 unit in an "OFF" state can be reset to "on" state through the modem remote control by editing the Status of either relay.

Menu selection – "Phone In" will enable a menu:
"Hang up" to terminate call.

# Changing Sub-Directory Location:

Modifying the sub-directory location/filename of a site's data-base requires the changing of disk data-base and the posting of this information to the Energx T2000. Failure to properly make these changes will prevent the automatic loading of correct data-base with the "Data" command.

In Windows File Manager, make the desired sub-directory tree structure.
Move the selected "*.dhw" file to the desired sub-directory.
Load selected file and go to "Site Information Edit / T2000 Installation" screen:
"Load" selected Site data-base file.
"Phone In" to get sub-menu:
"Edit".

Menu selection – "Read Data" to Read all values from the T2000 for entire display.
Verify data validity.
Select – "Initialize T2000" menu.
Select – "T2000 Reset" to post this new information to Energx T2000.
Observe that the display should have flickered through all of the initialized values, ending with Temperature #6.
Select – "Save" — will Exit to "ENERGX T2000 – EXCEL Export" screen.

# Troubleshooting

- **No LED Display:**

A dark display when power is connected and push-button is pressed indicates faulty T2000 unit.

- **Beeping and Delay at communications are the symptoms of communications failure:**

Communication failure can be caused by a bad hardware connection (cable) or by an incorrect baud rate setting. The Opn Mode Control block in the "Site Information Edit / T2000 Installation" screen displays and controls the Energx T2000 Operating Mode. Setting this value to "0" will maintain the T2000 at 9600 Baud. When bit "3" is set (as shown by a value of 2^3 or "8") the T2000 unit will set communications to 2400 Baud at start of Blanking. Communications are Re-Set to 9600 Baud by pressing a Push-button.

- **Flashing Display:**

It is normal for display to flash on for a 2 second display of temperature at about a 15 second interval. This flashing will sequentially scan temperatures 1, 2, 3 and 4 in a one minute cycle.

Display flashing on at a 5 second interval indicates **a bad sensor** alert. The temperature displays a reading of 35 degrees for a disconnected sensor or a reading of 183 degrees for a shorted sensor. Displays of multiple sensor problems are in a Supply (1), Input (4) or Return (3) priority order.

- **Continuous Automatic Resets:**

1 Second Intervals – Hardware Watch-Dog Resets.

4 Second Intervals – Non-volatile variable storage error. Will occur with new U4 chip.
The Energx T2000 should have a "T2000 Reset" initialization.

4 Minute Intervals – System software problem.

- **Displaying "OFF" Status:**

Operator actuation of "OFF" – Hold down White Push-button until "on" status is displayed.

Automatic Resets and "OFF" status at 4 Second Intervals -- Non-volatile variable storage error.
The Energx T2000 should have a "T2000 Reset" initialization.

"Off-Line" status of the Energx T2000 can be seen on computer display screens and on the unit display. See "Modem Communications" of Chapter 8 for remote operations.

- **Heater Burn Cycle Rates and "ON" times:**

The **Control Variables** in the "Site Information Edit / T2000 Installation" screen affect burn cycle timings:

Increasing Deadband gives a longer Burn.

Increasing Gain will cause shorter Burns.

Decreasing Ratio will increase the off time between Burns.

- **Testing Program:**

An Energx T2000 test program is available which runs under MD-DOS and automatically guides testing through the following events:

Power supply checks for 5 & 12 Volts.

Watch-Dog hardware check.

Non-volatile memory check.

Display check.

Sensor analog/digital conversion check with standard resistor plug.

Serial communication check.

Push-button operation.

Relay ON / OFF checks for both relays.