**DERIVATION OF END-USE LOADS**

**RESIDENTIAL SECTOR**

**Data Resources**

The residential loads were derived from data collected by the Bonneville Power Administration (Bonneville) under its End-Use Load and Conservation Assessment Program (ELCAP). ELCAP was initiated in 1984 as a basis for assessing conservation opportunities and to evaluate the impacts of new residential building standards in the Pacific Northwest region served by Bonneville. Monitoring continues at a small number of sites.

ELCAP is comprised of three studies: a Base Study, sites from Bonneville's Residential Standards Demonstration Program (RSDP), and sites from a variety of studies, grouped here under “other” (Windell 1987). The Base Study sites were recruited from residences participating in Bonneville's 1983 Pacific Northwest Residential Energy Survey. All of the sites satisfied four basic criteria:

▪Single-family detached dwelling

▪Site constructed

▪Owner occupied

▪Electric space heating equipment permanently installed

In addition, all sites used electricity to heat water.

The RSDP was designed to promote and demonstrate the building standards then being proposed for adoption throughout the Northwest region. The ELCAP sites include residences built to satisfy the Model Conservation Standards (MCS) and a control group of dwellings built to then-current building codes. All the RSDP sites have permanently installed electric space heating equipment and electric water heating equipment.

Included in the “Other” group of residences are sites from four Case Studies and residences recruited into ELCAP from a variety of sources. Each of the four Case Studies included dwellings comparable to those in the Base Study, with the exception of a single characteristic. One group of dwellings was attached, a second included manufactured homes, a third included homes occupied as rentals, and a fourth included homes heated with fuels other than electricity—most frequently, natural gas. Some of the remaining homes were occupied by members of the prime contractor's staff (Battelle, Pacific Northwest Laboratories), or by persons known by staff members. These served as original hardware test sites.

**Period of Interest**

ELCAP was not designed to support the direct estimation of regional load parameters. Thus, in attempting to develop these estimates, the data must be approached with caution. Consequently, we have treated each end use independently. That is, for each end use, we have selected a separate group of sites based on the availability of data for the end use. In cases where multiple groups of sites have been selected, relatively well-defined criteria have been used to stratify the population.

For each end use, site selection involved at least three steps. The first two steps resulted in a pool of load data from which specific end-use loads were selected. These two steps involved identifying the time period that data were available for the largest number of dwellings, and identifying the period that the weather demonstrated the greatest variability, paying particular attention to extended periods of low temperatures. The third step involved identifying sites where reasonable load data were available for the end use of interest.

In addition to the hourly load data, Bonneville has prepared a dataset containing data quality flags for each end use in each participating residence for each month beginning in 1984 and continuing through December 1992. This was the last month that complete data were available when the file version was being prepared for the study team's use (the file is updated annually). For each end use at each site, the file indicated the number of hours of data passing the verification tests, and the total number of such hours for the month. By dividing the former by the latter, we derived a data quality index ranging from 0 to 1. The higher the index, the higher the data quality (i.e., the greater the percentage of data available for the month).

As data are generally available either for the entire site or not at all, it is possible to rely on the data quality figures for the “total” end use as an indicator of data availability for a given site. Figure 1 graphically presents the number of sites where data were available at various quality thresholds over several years. These results indicate that data were available for the largest number of sites in 1987 and 1988. Data were available for fewer sites in 1986 and 1989. It is also clear that if we establish the threshold of acceptable data quality at above 50 percent, the number of sites for which data were available in any given year deteriorates rapidly.

Bonneville has also collected all the available meteorological data from 19 sites distributed throughout the region. The study team reviewed the data for April 1987 to September 1989. Figure 2 presents temperature data for each station during this period. It is clear that July 1988 to June 1989 included the greatest variability in weather. Of particular interest is the extended cold period beginning in late January 1989 and extending through the first one or two weeks of February 1989. There is evidence of this same cold period at every weather station throughout the Northwest region.

Based on these results, the study team defined the period of interest as July 1, 1988 to June 30, 1989. This period included the high temperature period in summer 1988 and the cold period in January to February 1989.

[ FIGURE 1 ]

[ FIGURE 2 ]

**Site Selection—The Pool**

The study team began by selecting all sites for which data were available for at least half the hours each month during the study period. For the heating end use, the period was restricted to the peak heating months—November through March. As this represents a slightly less restrictive requirement, a few additional sites were included.

The full ELCAP pool is comprised of 354 sites. Compared to the most recent regional estimates (Bonneville,1992), the site pool contains a disproportionately large number of sites from the east side of the Cascade Mountains and a disproportionately small number of sites from the areas west of the Cascades. (Table 1).

**Table 1**

**GEOGRAPHIC LOCATION**

**FULL ELCAP POOL AND PNWRES-92**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Location** | **ELCAP** | | **PNWRES-92** | |
| West |  | 47% |  | 70% |
| Western Washington | 27% |  | 42% |  |
| Western Oregon | 20% |  | 28% |  |
| East |  | 43% |  | 28% |
| Eastern Washington | 20% |  | 12% |  |
| Eastern Oregon | 8% |  | 5% |  |
| Idaho | 15% |  | 11% |  |
| Western Montana | 10% | 10% | 3% | 3% |
| n | 354 | | 3,548,808 | |

The sites may also be grouped based on measures of the weather to which they are exposed. The single most convenient indicator is temperature and the most reliable sources are the National Weather Service (NWS) stations distributed throughout the region. Each ELCAP site has been assigned to a single most appropriate NWS station. Based on these assignments, the ELCAP sites have ben divided into four groups, or weather areas: Puget Sound, encompassing the area from Chehalis north to the Canadian border, and including the coastal region from Grays Harbor north; the Willamette Valley, including the entire area west of the Oregon Cascades as well as southwest Washington State; the Eastern Plateau, including eastern Washington, Eastern Oregon, and Idaho, except for the portion of Idaho east of Twin Falls; and the Rockies, including western Montana and eastern Idaho. These areas differ slightly from the three areas based on political boundaries, as illustrated in Table 2. Unfortunately, it is difficult to make comparisons between the distribution of ELCAP sites and regional estimates based on these weather areas.

**Table 2**

**POLITICAL GEOGRAPHY BY WEATHER GEOGRAPHY**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Political** | **Weather** | | | | **Total** |
|  | **Puget Sound** | **Willamette**  **Valley** | **Eastern**  **Plateau** | **Rockies** |  |
| West | 82 | 84 | 0 | 0 | 166 |
| East | 0 | 0 | 127 | 25 | 152 |
| W. Montana | 0 | 0 | 0 | 36 | 36 |
| Total | 82 | 84 | 127 | 61 | 354 |
| Percent | 23% | 24% | 36% | 17% | 100% |

For purposes of this study we have divided the housing stock into three groups, or vintages. The first group is comprised of homes constructed prior to 1978, a year generally accepted is making a change in building practices throughout much of the Northwest. The second group is comprised of homes constructed between 1978 and 1988. By 1988-1989, most jurisdictions in the Northwest had adopted the current building standards for energy efficiency.

We have approximated these three vintage groupings using the ELCAP residential sites, according to the following procedure: Sites in the Base and Other studies that were constructed prior to 1978 are grouped into the Pre-1978 vintage. Sites from the

Base and Other studies together with the Control sites from the RSDP study are grouped into the Post-1978 vintage. The MCS sites from the RSDP study are used to estimate the performance of homes constructed after 1988. Compared to the region as a whole, the ELCAP pool includes a disproportionately large number of homes constructed to current building energy efficiency building standards (Table 3).

**Table 3**

**DWELLING VINTAGE**

**FULL ELCAP POOL AND PNWRES-92**

|  |  |  |  |
| --- | --- | --- | --- |
| **Vintage** | **ELCAP** | | **PNWRES-92** |
| < 1978 |  | 66% | 73% |
| Base Study | 55% |  |  |
| Other | 11% |  |  |
| 1979-1988 |  | 18% | 19% |
| Base Study | 9% |  |  |
| Other | 3% |  |  |
| RSDP-Control | 6% |  |  |
| 1989-1992 |  | 16% | 8% |
| MCS | 16% |  |  |
| n | 347 | | 3,548,808 |

**Site Selection: Refrigerator End use**

The refrigerator end use is identified at all ELCAP sites. However, in many cases the circuit feeding the refrigerator also includes some other end use, such as a clock, microwave oven, toaster, or lighting. Since the ELCAP monitoring equipment was installed during the construction of many of the RSDP (both Control and MCS), the refrigerator has been isolated in most of these sites.

We refer to the former as “mixed refrigerators” and the latter as “pure refrigerators.” In comparing the mean profiles for the two groups of sites, the mixed refrigerator profiles were found to be systematically higher and the peaks more extended than for the pure refrigerator profiles. Due to this clear difference, we have excluded mixed refrigerator sites from the refrigerator profile. The result is a group of 69 pure refrigerator sites that we used to derive the estimate of the refrigerator end-use load profile.

Having identified pure refrigerator sites that satisfy the minimum data requirements, we next analyzed the overall distribution of hourly readings. The initial distribution is extremely skewed (6.8). Slightly less than 10% of the observations are 0 (zero), while the maximum is 2,313 Watts, the median 150 Watts, and the mean 171 Watts. In fact, only about 1% of the distribution exceeds 600 Watts. We eliminated observations that exceeded this threshold and recalculated the profile. The overall mean is reduced by about 8 Watts, or about 5%, while the standard deviation is reduced by nearly 50 Watts, or nearly one-third (147 to 98 Watts).

The load profile derived by excluding the extreme values may be slightly lower than the actual population mean due to a larger portion of the site group including newer, slightly more efficient refrigerators. However, it may also be slightly higher due to the homes and the households being slightly larger. Because the homes and households are larger, it is also likely that the extreme values are legitimate values indicating the presence of second refrigerators. Thus, as an estimate of the mean load profile for the refrigerator end use, the study team recommends using the profile derived by excluding extreme values.

**Site Selection: Freezer End use**

A larger number of ELCAP sites include a separate food freezer, though it is cleanly monitored in only a relatively few (n=36). As the initial step in our analysis, we calculated the mean, standard deviation, and other measures of the hourly load distribution. The initial distribution was less skewed than the refrigerator group (1.2 versus 6.8). At least 10% of the observations were 0, but the maximum reading was 1,654 Watts and the standard deviation was 138 Watts. As with the refrigerators, only about 1% of the distribution was above approximately 600 Watts. Thus, we recalculated the profile excluding these extreme values.

Excluding the extreme values proved to have less dramatic impact on the profile than for refrigerators. The mean was reduced about 4 Watts, or about 3%, while the standard deviation was reduced about 9 Watts, or about 6%. The profiles were nearly identical, except the evening peak was reduced by a proportionally larger amount than were the other hours.

As with the refrigerator end use, the study team recommends using the profile derived by excluding the extreme values as the best estimate of the freezer end use.

**Site Selection: Food Preparation**

All of the ELCAP sites included a stove and oven, usually combined into a single appliance. In most cases, the range or separate stove-top and ovens are served by one or more separate circuits. As a result, the group of sites used for the food preparation end use is comparatively large (n=328).

The analysis began with the calculation of a suite of basic distribution statistics. The first three quartiles are accounted for by readings of 0 (zero) Watts, and 95% of the readings are less than 322 Watts. However, the maximum reading is over 11,000 Watts, so that the distribution is very highly skewed (21.5). The 99th percentile is 1,066 Watts. We excluded readings above 2,000 Watts and recalculated the profile. The overall mean was reduced by 8 Watts (60 to 52 Watts), and the standard deviation was reduced by 134 Watts, or approximately 43%. The profile retains the same basic shape, except that there is a somewhat greater reduction in the evening peak. The study team recommends using the profile that excludes extreme values as an estimate of the residential cooking mean profile.

**Site Selection: Clothes Dryers**

Clothes dryers are usually served on separate circuits at the electric service panel, so then can be frequently identified as a separate end use under ELCAP. As a result, the group is relatively large—329 sites. As with the other end uses, the study team first calculated a load profile using all data from eligible sites. As with the cooking end use, the simple distribution of the mean hourly readings was highly skewed (5.9). Three-quarters of the readings were 0 (zero) Watts, while the highest was over 20,000 Watts; 99% were less than 3,000 Watts. The study team excluded readings over 4,000 Watts (representing less than 0.1% of the full set of observations) and recalculated the load profile. The profile mean from the reduced set of observations is approximately 10 Watts lower (118 versus 128), and the standard deviation is reduced by nearly 60 Watts (483 compared to 540).

**Site Selection: Space Heat**

Space heating is at once the most important and the most difficult end-use to understand, from several perspectives. It is important because the largest amount of electricity is devoted to space heating, based on energy, and because it has the highest peak demand use, from both an instantaneous and a seasonal view. It is difficult to understand primarily because many Northwest homes have two or more different types of space heating systems installed, particularly wood in addition to some other fuel. In some cases, wood is used exclusively for space heating; however, in many cases, electricity is used some of the time and wood some of the time. For purposes of this project we have developed the load profile only for customers who appear to depend almost exclusively on electricity for space heating purposes; no attempt has been made to estimate the profile for partial users.

The space heat end-use has been segmented based on the system type and dwelling vintage. There are three primary types of systems: baseboard, forced air furnace, and heat pump. In selecting sites, the study team first reviewed the lists of installed equipment. The ELCAP characteristics data allow for three systems. Sites were categorized based on the presence of the system type. In a few cases, the characteristics data indicated the presence of two different types of electric space heating equipment. For sites that indicated having forced air and baseboard equipment, the study team compared the profiles to those for sites with pure forced air and pure baseboard systems. Sites exhibiting a profile similar to those with pure baseboard equipment have been classified as baseboard sites; those exhibiting a profile similar to pure forced air sites have been classified as forced air sites.

A similar process was carried out for sites that the characteristics data indicated the presence of heat pump systems together with baseboard or forced air systems. In these cases, the study team also reviewed the data for the summer cooling months. Sites with appreciable summer cooling loads were considered to be valid heat pump sites.

For a number of sites, the characteristics data indicated the presence of wood burning equipment. The heating loads for January 1989 were reviewed. If the heating use was minimal during the winter heating months, the site was set aside from further analysis.

For each system type a matrix of dwelling vintage by climate area was constructed. To the extent possible, the study team sought to develop a separate profile for each cell in the 12 cell matrix. Unfortunately, the sample sizes were insufficient to realize this objective. In collapsing categories in the matrix, the study team retained the vintage distinctions and pooled sites from the different climate areas. When possible, the distinction between the two western areas (Puget Sound and the Willamette Valley) versus the eastern areas was retained. In addition, for each profile, a weather weighing matrix was developed. The matrix indicates the number of sites from each weather station that are included in the profile. In this way, the space heating profile from the relevant site may be weighted by the temperature to which the site was exposed over the study period.

*Baseboard Heating*

There are a total of 128 ELCAP sites that have baseboard heating systems installed and for which valid data were available for the study period. Compared to the full ELCAP pool, a larger portion of these sites are located in the Puget Sound area and fewer in the Willamette Valley (Table 4). Compared to estimates for the region, the group includes an over-representation of dwellings constructed to satisfy current (MCS) building standards (Table 5).

The distribution of the sites simultaneously over the climate areas and the three vintages is presented in Table 6. The largest number of sites are located in the Eastern Plateau and were built before 1978. Load profiles for the pre-1978 vintage were developed for the Puget Sound area, the Willamette Valley area, and a combined profile for the Eastern Plateau and the Rockies. For each profile a simple weather weighing scheme was also developed. That is, for each profile, the weather stations within the relevant area are assigned a weight based on the number of sites that are assigned to the station.

For the 1978-1988 vintage sites, two profiles were developed. One profile combines the two western climate areas and one profile combines the two eastern climate areas. Once again, a simple weather weighing scheme was developed the weights the weather stations by the number of sites to which the station is assigned. Similarly, two profiles were developed for the post-1988 sites, one using the sites from west of the Cascades and one using the sites from east of the Cascades. A weather weighing scheme was developed for each of the profiles.

**Table 4**

**GEOGRAPHIC LOCATION**

**BASEBOARD HEATING SITES AND FULL ELCAP POOL**

|  |  |  |
| --- | --- | --- |
| **Area** | **Baseboard Sites** | **Full ELCAP Pool** |
| Puget Sound | 34% | 23% |
| Willamette Valley | 16% | 24% |
| Eastern Plateau | 31% | 36% |
| Rockies | 19% | 17% |
| n | 128 | 354 |

**Table 5**

**DWELLING VINTAGE**

**ELCAP SITES AND PNWRES-92**

|  |  |  |  |
| --- | --- | --- | --- |
| **Vintage** | **ELCAP** | | **PNWRES-92** |
| < 1978 |  | 59% | 73% |
| Base Study | 56% |  |  |
| Other | 2% |  |  |
| 1979-1988 |  | 16% | 19% |
| Base Study | 3% |  |  |
| Other | 4% |  |  |
| RSDP-Control | 9% |  |  |
| 1989-1992 |  | 25% | 8% |
| MCS | 25% |  |  |
| n | 128 | | 3,548,808 |

**Table 6**

**BASEBOARD HEATING SITES BY LOCATION AND VINTAGE**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Vintage** | **Puget**  **Sound** | **Willamette**  **Valley** | **Eastern**  **Plateau** | **Rockies** | **n** |
| < 1978 | 22 | 16 | 29 | 8 | 75 |
| 78 - 88 | 9 | 1 | 2 | 9 | 21 |
| 89+ | 13 | 3 | 9 | 7 | 32 |
| n | 44 | 20 | 40 | 24 | 128 |

*Forced Air Heating*

The ELCAP pool included 52 sites with forced air heating systems. Although the distribution of the sites over the climate areas approximates that for the entire ELCAP pool, because the group is so small, there are only eight sites located in the Rockies (Table 7). Although recently constructed homes are over-represented in the ELCAP group, the single largest group are those constructed prior to 1978 (Table 8). When we combine vintage and location, by far the single largest group are those constructed before 1978 located on the Eastern Plateau (Table 9).

**Table 7**

**GEOGRAPHIC LOCATION**

**FORCED AIR HEATING SITES AND THE FULL ELCAP POOL**

|  |  |  |
| --- | --- | --- |
| **Area** | **Baseboard Sites** | **Full ELCAP Pool** |
| Puget Sound | 21% | 23% |
| Willamette Valley | 20% | 24% |
| Eastern Plateau | 44% | 36% |
| Rockies | 15% | 17% |
| n | 52 | 354 |

**Table 8**

**DWELLING VINTAGE**

**FORCED AIR HEATING SITES AND PNWRES-92**

|  |  |  |  |
| --- | --- | --- | --- |
| **Vintage** | **ELCAP** | | **PNWRES-92** |
| < 1978 |  | 65% | 73% |
| Base Study | 56% |  |  |
| Other | 10% |  |  |
| 1979-1988 |  | 23% | 19% |
| Base Study | 15% |  |  |
| Other | 2% |  |  |
| RSDP-Control | 6% |  |  |
| 1989-1992 |  | 12% | 8% |
| MCS | 12% |  |  |
| n | 52 | | 3,548,808 |

**Table 9**

**FORCED AIR HEATING SITES BY LOCATION AND VINTAGE**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Vintage** | **Puget**  **Sound** | **Willamette Valley** | **Eastern**  **Plateau** | **Rockies** | **n** |
| < 1978 | 6 | 5 | 17 | 6 | 34 |
| 78 - 88 | 3 | 4 | 3 | 2 | 12 |
| 89+ | 2 | 1 | 3 | 0 | 6 |
| n | 11 | 10 | 23 | 8 | 52 |

Due to the small number of sites for which data are available, three profiles were developed, one for each of the three vintage groupings. As with the other heat load profiles, associated with each profile is a weather weighing scheme.

Among the Post-1988 (MCS) sites was a single site with an unusually high and constant load during the months of July and August 1988. The remainder of the data appeared reasonable. Since there appeared to be no explanation of the constant high summer load, the study team set the data for that period to missing. The remainder of the data have been used in the derivation of the load profile for the Post-1988 vintage dwellings.

*Heat Pump Heating Sites*

The pool of ELCAP sites includes 26 that use electric heat pumps for space conditioning. The sites are equally divided between the western and eastern portions of the region. (Table 10). Notice also that the bulk of the Eastern Plateau sites are located in Idaho. In contrast to the regional population, three-quarters of which reside in homes built before 1978, the Heat Pump sites are distributed almost equally over the three vintages (Table 11). The distribution by vintage and location are presented in Table 12. Clearly, none of the cells contains very many sites, and only two areas contain at least 10 sites -- the Willamette Valley and the Eastern Plateau.

Although the number of sites is restricted, three vintage-based profiles were derived. For each profile, a weather weighing scheme was also developed.

**Table 10**

**GEOGRAPHIC LOCATION**

**HEAT PUMP SITES AND FULL ELCAP POOL**

|  |  |  |
| --- | --- | --- |
| **Area** | **Baseboard Sites** | **Full ELCAP Pool** |
| Puget Sound | 12% | 23% |
| Willamette Valley | 38% | 24% |
| Eastern Plateau | 42% | 36% |
| Rockies | 8% | 17% |
| n | 26 | 354 |

**Table 11**

**DWELLING VINTAGE**

**HEAT PUMP HEATING SITES AND PNWRES-92**

|  |  |  |  |
| --- | --- | --- | --- |
| **Vintage** | **ELCAP** | | **PNWRES-92** |
| < 1978 |  | 38% | 73% |
| Base Study | 32% |  |  |
| Other | 5% |  |  |
| 1979-1988 |  | 38% | 19% |
| Base Study | 14% |  |  |
| Other | 5% |  |  |
| RSDP-Control | 18% |  |  |
| 1989-1992 |  | 23% | 8% |
| MCS | 27% |  |  |
| n | 26 | | 3,548,808 |

**Table 12**

**HEAT PUMP HEATING SITES BY LOCATION AND VINTAGE**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Vintage** | **Puget**  **Sound** | **Willamette Valley** | **Eastern**  **Plateau** | **Rockies** | **n** |
| < 1978 | 1 | 6 | 1 | 2 | 10 |
| 78 - 88 | 2 | 2 | 6 | 0 | 10 |
| 89+ | 0 | 2 | 4 | 0 | 6 |
| n | 3 | 10 | 11 | 2 | 26 |

**Space Heat Distribution Statistics**

The distribution statistics for the space heating sites are seperated by vintage and area as in our analysis were also calculated similar to the refrigerator, freezer, cooking, and drying load shapes. These statistics include mean,standard deviation,99 th percentile, and the maximum. summarized in Table 12A.

**TABLE 12A**

**SPACE HEATING DISTRIBUTION STATISTICS**

**(WATTS)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Type /vintage** | **Location** | **Mean** | **Standard Deviation** | **99 th**  **percentile** | **Maximum** |
| BB - 1 | East | 966 | 1,570 | 6,549 | 13,949 |
| BB - 1 | Willamette  Valley | 674 | 1,031 | 6,590 | 15,524 |
| BB - 1 | Puget Sound | 1,010 | 1,543 | 4,123 | 8,312 |
| BB - 2 | East | 818 | 1,097 | 4,362 | 8,995 |
| BB - 2 | West | 791 | 1,153 | 4,799 | 8,646 |
| BB - 3 | East | 635 | 1,078 | 4,628 | 14,146 |
| BB - 3 | West | 502 | 901 | 3,878 | 10,991 |
| FA - 1 | East | 1,238 | 2,379 | 10,708 | 25,219 |
| FA - 1 | West | 1,243 | 2,649 | 12,403 | 24,698 |
| FA - 2 | All | 1,494 | 3,351 | 15,666 | 41,406 |
| FA - 3 | All | 821 | 1,750 | 8,950 | 19,811 |
| HP - 1 | All | 1,053 | 2,171 | 10,455 | 28,483 |
| HP - 2 | All | 1,289 | 1,794 | 8,031 | 25,906 |
| HP - 3 | All | 738 | 1,206 | 5,056 | 21,289 |

**Site Selection: Water Heat**

Like the food processing and clothes drying end-uses, the water heating end-use is separately monitored in nearly all the ELCAP sites. However, although there is some seasonal variation to the food preparation and clothes drying end-uses, neither is temperature dependent. Water heating, on the other hand, is temperature dependent. As a result, the approach to the water heat end-use is similar to that used for space heat. Separate profiles have been developed for each of the four climate areas. Since water heaters may be replaced, no attempt has been made to develop separate profiles based on dwelling vintage.

End-use load data were available for 296 ELCAP sites, or about 85% of the full ELCAP pool. The sites are distributed much like the full pool (Table 13). For each climate area, there were a sufficient number of sites to support a relatively robust estimate of the load profile. The smallest number of sites is in the Rockies -- 52.

Based on our review of the distribution statistics, we identified one site with a number of hourly readings greater than 30 kilowatts. The site had a single standard sized water heater (52 gallons) and there appeared to be no reasonable explanation for the observed valuers. Apart from these readings, all of the water heater hourly values were less than 9 kilowatts. We declared all values greater than 9 kilowatts as missing before generating the four climate area profiles.

Also based on water heater distribution statistics, the study team found that about 25% of the readings were 0. Maximum water heater usage ranged from 7.5 to 9 kilowatts. Also, 99% of the water heaters used less than 4 kilowatts.

**Table 13**

**GEOGRAPHIC LOCATION**

**WATER HEAT SITES AND FULL ELCAP POOL**

|  |  |  |
| --- | --- | --- |
| **Area** | **Water Heat Sites** | **Full ELCAP Pool** |
| Puget Sound | 24% | 23% |
| Willamette Valley | 24% | 24% |
| Eastern Plateau | 35% | 36% |
| Rockies | 18% | 17% |
| n | 296 | 354 |

Since water heat is temperature sensitive, a weather weighing scheme has been prepared for each of the profiles. Thus, for each weather area, the relevant weather stations have been assigned a weight corresponding to the number of sites that have been assigned to the station.

**Site Selection: Total Lighting**

The lighting enduse monitors total household lighting, combining outdoor and indoor lighting. End-use load data was available for 299 ELCAP sites, or about 85% of the full ELCAP pool. Overall there were many sites to support a robust estimate of the load profile.

Based on our review of the initial distribution statistics, we identified some sites that used around 25,000 watts in a given hour; 99% of the lighting loads were below 2,600 watts. The study team prepared another load shape removing outliers over 3,000 watts. The shape did not vary significantly, except that the entire load shape was proportionally shifted down. The average hourly usage with outliers in the sample was 547 watts. However,due to outliers the skewness of the distribution was 15.72, and the standard deviation was 769. When the outliers above 3000 watts were removed the mean was reduced to 513 watts, skewness was reduced to 1.72, and the standard deviation to 469.

The study team suggests the use of the load shape with the outliers removed.

**Site Selection: Central Air Conditioning**

Of the 20 sites that have air conditioning separately metered, 10 had a central air conditioner. Of these sites nine were located in the Eastern Plateau, and one in the Willamette Valley. The study team did not further seperate the central air conditioners into East and West locations because of small sample concerns.

The average central air conditioner load over the year is equal to 151 watts, and 90% of the loads were below 50 watts.The maximum load was 6,500 watts and 99% of the loads were below 3,500 watts.

**Site Selection: Room Air Conditioning**

The remaining 10 sites used a room air conditioner. Of these sites 8 were located in the Eastern Plateau, and the rest in the Willamette Valley. Again, due to small sample size concerns the 10 sites were not subdivided into East and West.

The distribution statistics indicated that the average load over the year is equal to 63 watts, and 95% of the loads were below 20 watts.The maximum load was 4,500 watts and 99% of the loads used less than 2,400 watts. As expected, these averages indicate that room air conditioners use less energy than central air conditioners.

**Site Selection: "TOTAL" Enduse**

The is the sum of all enduses in a given site. This is available for virtually for all sites with good data availability, since at least one enduse was monitored at any given site. The sample size for the total enduse is 330, or 93% of the full ELCAP pool. Of these 330, Table 14 indicates the distribution of the sites by weather region. Since the total enduse is likely to be weather dependent, a weather matrix was provided for all the weather sites within the four weather regions. The distribution statistics show some differences between the four regions, especially in the Puget Sound region (Table 15).

**Table 14**

**GEOGRAPHIC LOCATION**

**"TOTAL" ENDUSE SITES AND FULL ELCAP POOL**

|  |  |  |
| --- | --- | --- |
| **Location** | **"Total" Enduse**  **Sites** | **Full ELCAP Pool** |
| Puget Sound | 23% | 23% |
| Willamette Valley | 24% | 24% |
| Eastern Plateau | 35% | 36% |
| Rockies | 18% | 17% |
| n | 330 | 354 |

**Table 15**

**TOTAL' ENDUSE DISTRIBUTION STATISTICS**

**(WATTS)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Location** | **Mean** | **Standard**  **Deviation** | **99 th Percentile** | **Maximum** |
| Puget Sound | 2,191 | 2,318 | 10,387 | 32,607 |
| Willamette  Valley | 2,224 | 2,833 | 10,816 | 46,046 |
| Eastern Plateau | 2,551 | 2,668 | 12,314 | 45,511 |
| Rockies | 2,547 | 2,566 | 11,420 | 45,291 |

**DERIVATION OF INDUSTRIAL SECTOR LOAD SHAPES**

**by Standard Industrial Codes (SIC's)**

The industrial loads were created primarily from Pacific Power/Utah Power 1993 industrial data, except for the alumnium load shape, and the Boeing load shape. The aluminum load shape was obtained from BPA in a HELM file format, while the Boeing load shape was obtained from data provided by Puget Power. There were two SIC's for which weather variation seemed likely to affect the load shape. These included SIC 20 ( Food Products) and SIC 24 ( Lumber and Wood Products).

In general all the Pacific Power files contain 8,760 observation hourly files - one observation per hour. However, the aluminum and Boeing load shapes were in 7daytypes per month format. All of the load shapes present the total of that sector as opposed to end-use summaries. Table 1 below lists the number of Pacific Power / Utah Power accounts which created the industrial load shapes for most of the SIC codes.

**TABLE 1**

**Pacific Power Industrial Accounts and**

**their associated sample sizes**

|  |  |  |  |
| --- | --- | --- | --- |
| **SIC code / Industry** | **Utah Power** | **Pacific Power** | **Total Accounts** |
| 20- Food Products | 11 | 27 | 38 |
| 24- Lumber /Wood Products | 4 | 110 | 114 |
| 26- Paper Products | 1 | 8 | 9 |
| 28- Chemical Products | 14 | 6 | 20 |
| 29- Petroleum Refineries | 5 | 5 | 10 |
| 33- Non DSI Metals | 12 | 9 | 21 |

It is assumed that the DSM load shapes for the industrial sector are the same as the baseline load shapes.