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# Monthly Indices:

## A procedure for energy use display creating monthly indices for comparing the energy consumption of buildings

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## Abstract

This technical paper describes the construction of comparative monthly energy and weather indices for buildings and their usefulness in simple comparisons across sites. These graphs show monthly electric and natural gas average power levels (i.e., W/sf and Btu/hr-sf). The electricity power levels allow for the comparison of both electric demand and electricity consumption on the same graph (i.e., it is time independent). Power levels have been shown to be a useful way of displaying building energy use by MacDonald (1988) and by Haberl and Komor (1989). Other indices include Electric Load Factor (ELF), Occupancy Load Factor (OLF), and People Load Factor (PLF). ELFs are commonly used by utilities to evaluate a customers average electric load profile. OLFs and PLFs have been shown to be a useful way of determining the average monthly occupancy of a building (Landman 1996). Weather indices are also useful in determining energy use of building. Use of the energy and weather indices will help a building owner quickly decide if a building is energy efficient when compared to other buildings and if a detailed study should be performed to facilitate energy conservation measures.


## Introduction

In order to properly evaluate which buildings should be audited for energy conservation opportunities it is important for a building owner to be able to quickly and cost-effectively make comparisons of energy use trends at his/her buildings. This can be accomplished with monthly indices. Monthly data are readily available for most buildings from utility bills for both electricity and natural gas. In addition, similar analyses may be performed for oil, propane, or other fuels that have periodic deliveries. One also needs coincident weather related data which can be readily obtained from the National Weather Services in the cities where the analyses are to be completed. Specific data required will be shown in detail later in this paper.

To make comparisons of several buildings it is necessary to use similar units for comparison. For electricity a power level in W/sf is used to compare both peak demand for the month and average consumption. This may also be calculated for natural gas as Btu/(hr-sf). In order to show the affects of weather and occupancy other indices are used. ELF, OLF, and PLF, and optionally, EOLF are defined below:

$$\textbf{ELF} = \frac{kWh\ (for\ the\ billing\ period)}{kW\ (max\ in\ billing\ period) * total\ hours\ (in\ billing\ period)}$$

$$\textbf{OLF} = \frac{hours\ occupied\ (in\ billing\ period)}{total\ hours\ (in\ billing\ period)}$$

$$\textbf{PLF} = \frac{\sum_{i=1}^{hours\ in\ period} people,i\ *\ hours,\ i}{max\ \#\ people\ *\ total\ hours\ (in\ billing\ period)}$$

$$\textbf{EOLF} = \frac{ELF}{OLF}$$

ELF shows what percent of the total electricity load is used for the month, while OLF and PLF show what percent of the time a building is occupied (OLF) or occupied by a weighted people-hour index. EOLF is the ratio of ELF to OLF. EOLF values less than 1.0 are good, greater than 1.0 indicate potential for energy conservation.

The last index displays weather data. It shows the coincident weather data for the billing periods. This index is composed of the maximum (hottest) hourly dry bulb temperature read during the billing period, the minimum (coldest) hourly dry bulb temperature read during the billing period, and the Min-Max average dry bulb temperature for the billing period are displayed on a single graph. The Min-Max average dry bulb temperature is calculated in two steps. First, the average daily temperature is calculated for each day from the National Weather Service (NWS) daily minimum and maximum temperatures. Then, the average billing period temperature is determined by calculating the average of the daily average temperatures in the billing period.

For the examples shown in this report, the billing periods are the calendar months. In most buildings utility meters are rarely read on the first of the month. If the natural gas and electricity read (bill) dates do not coincide, two temperature graphs will have to be produced for each billing period, one for the electricity and one for the natural gas. All graphs are plotted using the same time period and juxtaposed as shown in Figure 1 (i.e., September 91 through December 93) for easier visual comparisons. Also, due to potential operational and weather related anomalies that may occur during one or two individual months, having access to two or more years of data improves the interpretation of the data for a particular site.

## Data required:

Several types of data are needed to create the tables and graphs that will be used for comparison. The following tables display the data required as well as the indices created from the data collected. Table 1 displays the data required to create the indices and the indices that are created from previous columns of data. Table 2 is an example of the indices for a South Texas High School. Table 1 displays both the data that need to be collected: (Columns 1-16) and the indices created from these data: (Columns 17-26). The electric power levels (Columns 17 and 18) (i.e., W/sf ) allow for the comparison of both electric demand and electricity consumption on the same graph (i.e., it is time independent). Other indices in the table are Natural Gas Power Levels (Column 7) (i.e., Btu/(hr-sf)), Electric Load Factor (ELF) (Column 20), Occupancy Load Factor (OLF) (Column 21), People Load Factor (PLF) (Column 22), and EOLF (Column 23). The last indices are the temperature related indices (Columns 24-26). Comparing Peak, Minimum, and Min-Max monthly temperature related data may help explain variation in energy usage by seasonal changes. In addition to this, gross square footage (sf) for the building to be analyzed is required. Also, the natural gas is data should be provided in standard cubic feet (scf) and will be converted into Btu/hr for the different time periods.

**Table 1:** Data required to calculate the indices, including units, and the indices created. Indices created are marked with an asterisk (*)

| Column: | Label: | Description: |
|---|---|---|
| 1 | Start Date | Start date of the utility data in the period. |
| 2 | End Date | End date of the utility data in the period. |
| 3 | Period | The time period used for the analysis. |
| 4 | Days in Period | Days in Period Calculated from (End Date - Start Date). |
| 5 | Electricity | Electricity consumed for the corresponding period in kWh |
| 6 | Demand | Electric demand for the corresponding period in kW |
| 7 | Natural Gas | Natural Gas consumed for the corresponding period in standard cubic feet (scf). |
| 8 | Total Hours | Total number of hours in the period (Column 4*24). |
| 9 | Total Hours Occupied | Total hours the building is occupied in the period (definition of occupancy is 1 or more people). |
| 10 | Total # of People | Maximum number of different people to occupy the building during a given day in the defined period. |
| 11 | Group 1 : # People | Number of people to occupy the building for X number of hours <= the total hours in the period (8). |
| 12 | Group 1 : # of Hrs Occupied | Number of hours occupied by Group 1 in the period. |
| 13 | Group 2 : # People | Number of people to occupy the building for X number of hours <= the total hours in the period (8). |
| 14 | Group 2 : # of Hrs Occupied | Number of hours occupied by Group 2 in the period. |
| 15 | Group 3 : # People | Number of people to occupy the building for X number of hours <= the total hours in the period (8). |
| 16 | Group 3 : # of Hrs Occupied | Number of hours occupied by Group 3 in the period. |
| *17 | Average W/sf | {(**Column 5** * 1000) / (**Column 8** * sf)} = (kWh consumed in the period * 1000 W/kW) / (hours in the period * building square footage). |
| *18 | Peak W/sf | (**Column 6** * 1000/sf) = (Peak kW in the period * 1000 W/kW) /sf. |
| *19 | Ave Btu/(hr-sf) | (scf * 1.03) / **Column 8** * sf) = (scf of Natural Gas consumed in the period * average BTU content per scf) / (hours in the period * building square footage). |
| *20 | ELF | {(**Column 5** / (**Column 6** * **Column 8**)} = (kWh in period) / (peak kW in period * total hours in period). |
| *21 | OLF | (**Column 9** / **Column 8**) = (# of hours building is occupied in period) / (total # hours in period). |
| *22 | PLF | {(**Column 11** * **Column 12** + **Column 13** * **Column 14** + **Column 15** * **Column 16**) / (**Column 8** * **Column 10**)} = (summation of # hours occupied for each groups * number of people per group) / (total number of people * total hours in period). |
| *23 | EOLF | ( **Column 20** / **Column 21** ) = Optional, gives the ratio of ELF/OLF. |
| 24 | Max Temp | Maximum dry bulb temperature recorded by the NWS for the period. |
| 25 | Min Temp | Minimum dry bulb temperature recorded by the NWS for the period. |
| *26 | Min-Max Ave Temp | Calculated by taking the average of the maximum and minimum dry bulb temperatures recorded for each day in the period. Then average the sum or the daily Min-Max averages over the number or days in the period. |

**Table 2:** Data example for a South Texas High School

| **School Name=** South Texas High School | | | | **Building Area =** | | | 210,474 sf | | **Natural Gas =** | | 1,030 btu/scf | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| Start Date | End Date | Period | Days in Period | Electricity (kWh) | Demand (kW) | Natural Gas (scf) | Total Hrs | Total Hrs Occ | Total # People | Group 1 # People | Group 1 Hrs Occ. | Group 2 # People |
| 9/1/91 | 9/30/91 | Sep-91 | 30 | 169,838 | 647 | 243,000 | 720 | 280 | 1674 | 145 | 200 | 1529 |
| 10/1/91 | 10/31/91 | Oct-91 | 31 | 158,147 | 649 | 205,500 | 744 | 322 | 1674 | 145 | 200 | 1529 |
| 11/1/91 | 11/30/91 | Nov-91 | 30 | 108,713 | 567 | 492,000 | 720 | 266 | 1674 | 145 | 200 | 1529 |
| 12/1/91 | 12/31/91 | Dec-91 | 31 | 98,261 | 537 | 475,500 | 744 | 210 | 1674 | 145 | 200 | 1529 |
| 1/1/92 | 1/31/92 | Jan-92 | 31 | 103,942 | 480 | 906,500 | 744 | 266 | 1674 | 145 | 200 | 1529 |
| 2/1/92 | 2/29/92 | Feb-92 | 29 | 110,489 | 554 | 380,500 | 696 | 280 | 1674 | 145 | 200 | 1529 |
| 3/1/92 | 3/31/92 | Mar-92 | 31 | 108,627 | 551 | 278,000 | 744 | 224 | 1674 | 145 | 200 | 1529 |
| 4/1/92 | 4/30/92 | Apr-92 | 30 | 135,041 | 608 | 202,500 | 720 | 280 | 1674 | 145 | 200 | 1529 |
| 5/1/92 | 5/31/92 | May-92 | 31 | 154,895 | 612 | 121,500 | 744 | 294 | 1674 | 145 | 200 | 1529 |
| 6/1/92 | 6/30/92 | Jun-92 | 30 | 113,735 | 501 | 77,000 | 720 | 308 | 1674 | 145 | 200 | 1529 |
| 7/1/92 | 7/31/92 | Jul-92 | 31 | 106,627 | 477 | 70,500 | 744 | 308 | 1674 | 145 | 200 | 1529 |
| 8/1/92 | 8/31/92 | Aug-92 | 31 | 147,626 | 644 | 86,500 | 744 | 266 | 1674 | 145 | 200 | 1529 |
| 9/1/92 | 9/30/92 | Sep-92 | 30 | 170,285 | 708 | 98,000 | 720 | 294 | 1674 | 145 | 200 | 1529 |
| 10/1/92 | 10/31/92 | Oct-92 | 31 | 157,064 | 619 | 134,000 | 744 | 308 | 1674 | 145 | 200 | 1529 |
| 11/1/92 | 11/30/92 | Nov-92 | 30 | 112,781 | 592 | 341,000 | 720 | 266 | 1674 | 145 | 200 | 1529 |
| 12/1/92 | 12/31/92 | Dec-92 | 31 | 89,561 | 532 | 442,000 | 744 | 196 | 1674 | 145 | 200 | 1529 |
| 1/1/93 | 1/31/93 | Jan-93 | 31 | 101,377 | 478 | 639,500 | 744 | 266 | 1674 | 145 | 200 | 1529 |
| 2/1/93 | 2/28/93 | Feb-93 | 28 | 100,015 | 519 | 445,500 | 672 | 266 | 1674 | 145 | 200 | 1529 |
| 3/1/93 | 3/31/93 | Mar-93 | 31 | 112,168 | 543 | 221,500 | 744 | 252 | 1674 | 145 | 200 | 1529 |
| 4/1/93 | 4/30/93 | Apr-93 | 30 | 124,099 | 566 | 99,500 | 720 | 280 | 1674 | 145 | 200 | 1529 |
| 5/1/93 | 5/31/93 | May-93 | 31 | 138,951 | 624 | 98,000 | 744 | 266 | 1674 | 145 | 200 | 1529 |
| 6/1/93 | 6/30/93 | Jun-93 | 30 | 92,268 | 423 | 67,500 | 720 | 308 | 1674 | 145 | 200 | 1529 |
| 7/1/93 | 7/31/93 | Jul-93 | 31 | 81,059 | 406 | 48,500 | 744 | 294 | 1674 | 145 | 200 | 1529 |
| 8/1/93 | 8/31/93 | Aug-93 | 31 | 142,507 | 674 | 79,000 | 744 | 266 | 1674 | 145 | 200 | 1529 |
| 9/1/93 | 9/30/93 | Sep-93 | 30 | 174,573 | 693 | 105,000 | 720 | 266 | 1674 | 145 | 200 | 1529 |
| 10/1/93 | 10/31/93 | Oct-93 | 31 | 159,881 | 667 | 126,500 | 744 | 294 | 1674 | 145 | 200 | 1529 |
| 11/1/93 | 11/30/93 | Nov-93 | 30 | 107,694 | 530 | 298,500 | 720 | 266 | 1674 | 145 | 200 | 1529 |
| 12/1/93 | 12/31/93 | Dec-93 | 31 | 87,551 | 576 | 235,500 | 744 | 182 | 1674 | 145 | 200 | 1529 |

| 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Group 2 Hrs Occ. | Group 3 # People | Group 3 Hrs Occ. | Ave W/sf | Peak W/sf | Btu/hr-sf | ELF | OLF | PLF | EOLF | Tdb Max | Tdb Min | Tdb MIn-Max Ave |
| 216 | | | 1.12 | 3.08 | 1.65 | 0.36 | 0.39 | 0.30 | 0.94 | 93 | 53 | 78 |
| 248 | | | 1.01 | 3.08 | 1.35 | 0.33 | 0.43 | 0.33 | 0.76 | 99 | 44 | 74 |
| 205 | | | 0.72 | 2.69 | 3.34 | 0.27 | 0.37 | 0.28 | 0.72 | 83 | 32 | 59 |
| 155 | | | 0.63 | 2.55 | 3.13 | 0.25 | 0.28 | 0.21 | 0.87 | 81 | 32 | 58 |
| 200 | | | 0.66 | 2.28 | 5.96 | 0.29 | 0.36 | 0.27 | 0.81 | 72 | 30 | 52 |
| 216 | | | 0.75 | 2.63 | 2.68 | 0.29 | 0.40 | 0.31 | 0.71 | 83 | 37 | 61 |
| 170 | | | 0.69 | 2.62 | 1.83 | 0.27 | 0.30 | 0.23 | 0.88 | 89 | 37 | 67 |
| 216 | | | 0.89 | 2.89 | 1.38 | 0.31 | 0.39 | 0.30 | 0.79 | 88 | 47 | 70 |
| 116 | | | 0.99 | 2.91 | 0.80 | 0.34 | 0.40 | 0.17 | 0.86 | 91 | 53 | 75 |
| 60 | | | 0.75 | 2.38 | 0.52 | 0.32 | 0.43 | 0.10 | 0.74 | 99 | 68 | 83 |
| 60 | | | 0.68 | 2.27 | 0.46 | 0.30 | 0.41 | 0.10 | 0.73 | 95 | 72 | 85 |
| 124 | | | 0.94 | 3.06 | 0.57 | 0.31 | 0.36 | 0.18 | 0.86 | 99 | 62 | 83 |
| 227 | | | 1.12 | 3.37 | 0.67 | 0.33 | 0.41 | 0.31 | 0.82 | 97 | 52 | 81 |
| 238 | | | 1.00 | 2.94 | 0.88 | 0.34 | 0.41 | 0.32 | 0.82 | 92 | 49 | 74 |
| 198 | | | 0.74 | 2.81 | 2.32 | 0.26 | 0.37 | 0.28 | 0.72 | 85 | 28 | 60 |
| 148 | | | 0.57 | 2.53 | 2.91 | 0.23 | 0.26 | 0.20 | 0.86 | 79 | 40 | 59 |
| 200 | | | 0.65 | 2.27 | 4.21 | 0.29 | 0.36 | 0.27 | 0.80 | 80 | 32 | 54 |
| 205 | | | 0.71 | 2.47 | 3.24 | 0.29 | 0.40 | 0.30 | 0.72 | 84 | 38 | 58 |
| 194 | | | 0.72 | 2.58 | 1.46 | 0.28 | 0.34 | 0.26 | 0.82 | 87 | 35 | 63 |
| 216 | | | 0.82 | 2.69 | 0.68 | 0.30 | 0.39 | 0.30 | 0.78 | 87 | 47 | 68 |
| 110 | | | 0.89 | 2.96 | 0.64 | 0.30 | 0.36 | 0.16 | 0.84 | 91 | 58 | 74 |
| 105 | | | 0.61 | 2.01 | 0.46 | 0.30 | 0.43 | 0.16 | 0.71 | 91 | 65 | 81 |
| 100 | | | 0.52 | 1.93 | 0.32 | 0.27 | 0.40 | 0.15 | 0.68 | 98 | 73 | 84 |
| 128 | | | 0.91 | 3.20 | 0.52 | 0.28 | 0.36 | 0.18 | 0.79 | 99 | 73 | 86 |
| 205 | | | 1.15 | 3.29 | 0.71 | 0.35 | 0.37 | 0.28 | 0.95 | 100 | 53 | 82 |
| 227 | | | 1.02 | 3.17 | 0.83 | 0.32 | 0.40 | 0.30 | 0.82 | 93 | 31 | 72 |
| 205 | | | 0.71 | 2.52 | 2.03 | 0.28 | 0.37 | 0.28 | 0.76 | 81 | 26 | 58 |
| 138 | | | 0.56 | 2.74 | 1.55 | 0.20 | 0.24 | 0.19 | 0.83 | 80 | 31 | 57 |

## Sample Calculations

*Note: These are sample calculations which use the first row of the data.

**Column 4** = ***30*** days

**Column 5** = ***169,838*** kWh

**Column 6** = ***647*** kW

**Column 7** = ***243,000*** scf of natural gas

**Column 8** = ***720*** hours in period (24 hours *** Column 4** value in period)

**Column 9** = ***280*** hours occupied (number of hours <= **Column 8** value that the building is occupied)

**Column 10** = ***1674*** people (maximum number of people to occupy the building at any one time during the period

**Column 11** = ***1645*** people (number of people who occupy the building for a "set" number or hours that is different from other people. This number <= the number of people in **Column 10**

**Column 12** = ***200*** hours (number of hours the building is occupied by people from group 1 (**Column 11**). The value <= total hours in period (**Column 8**))

**Column 13** = ***1529*** people (number of people who occupy the building for a "set" number or hours that is different from other people. This number <= the number of people in **Column 10**

**Column 14** = ***216*** hours (number of hours the building is occupied by people from group 2 (**Column 13**). The value <= total hours in period (**Column 8**))

**Column 15** = ***0*** (number of people who occupy the building for a "set" number or hours that is different from other people. This group was not needed for this month. This number <= the number of people in **Column 7**

**Column 16** = ***0*** (number of hours the building is occupied by people from group 3 (**Column 15**). The value <= total hours in period (**Column 8**))

**<u>Column 17</u>** = ***1.21*** W/sf = (**<u>Column 5</u>** * 1000)/(**<u>Column 9</u>** * 210,474 {gross building square footage})

**<u>Column 18</u>** = ***3.08*** W/sf = (**<u>Column 6</u>** * 1000) )/(210,474 {gross building square footage)

**<u>Column 19</u>** = ***1.65*** Btu/(hr-sf) = (**<u>Column 10</u>** * average BTU content per scf) / (**<u>Column 12</u>** * 210,474 {gross building square footage})[1]

**<u>Column 20</u>** = ***0.36*** = (**<u>Column 5</u>**) / (**<u>Column 6</u>** * **<u>Column 8</u>**)

**<u>Column 21</u>** = ***0.39*** = (**<u>Column 9</u>**) / (**<u>Column 8</u>**)

**<u>Column 22</u>** = ***0.30*** = (**<u>Column 11</u>** * **<u>Column 12</u>** + **<u>Column 13</u>** * **<u>Column 14</u>** + **<u>Column 15</u>** * **<u>Column 16</u>**) / (**<u>Column 10</u>** * **<u>Column 8</u>**)

**<u>Column 23</u>** = ***0.94*** = (**<u>Column 20</u>**) / (**<u>Column 21</u>**)

**<u>Column 24</u>** = ***93*** F = maximum hourly dry bulb temperature recorded by the National Weather Service during the period defined for **<u>Column 4</u>**.

**<u>Column 25</u>** = ***53*** F = minimum hourly dry bulb temperature recorded by the National Weather Service during the period defined for **<u>Column 4</u>**.

**<u>Column 26</u>** = ***78*** F = average of daily temperature
Monthly Min-Max temperature represents the average value calculated from daily temperatures recorded by the National Weather Service (NWS) for each day and averaged for each month. For example, there are three days in a period. The peak temperatures for each day are 90 F, 94 F, and 100 F. The minimums are 70 F, 70F and 76 F. The average Min-Max for that three day period would be (80+82+88)/3 = 83.33 F.

*Note: values in Columns 5-7 reflect values for the period in Column 3. Column 3 is determined from the begin and end dates preceding it.

[1] For scf of natural gas use a conversion of between 1,000 and 1,100 Btu/scf if the actual value is unknown. For this calculation 1,030 was used.

## Example comparison of two schools

This section has a brief description of each school that will be compared. Then the results of the indices calculated with the table above will be shown graphically and compared. The data for the South Texas High School are taken directly from Table 2 in the previous section. Each school has 4 graphs. Graph 1 (top graph) is the electric power level. The second graph is the natural gas power level. Graph 3 is the ELF, OLF, PLF, EOLF, and graph 4 is the weather index.

## Fort Worth Middle School

The Fort Worth Middle School is 92,884 square feet in gross conditioned area. There are three buildings, the main building which is two stories, a 6,128 square foot activities buildings which is heated but not cooled, and a portable building that is both heated and cooled. The main building has a brick exterior with a cinderblock interior wall. The main building is heated by a 2.5 million Btu/hr centralized sectional steam boiler and cooled with two 110 ton chillers and air handing units. The activities building has gas fired unit heaters, while the portable building has a packaged electric unit for heating and cooling.

The school is operated from August through May with approximately 774 students and 85 faculty and staff. The maximum school occupancy is from about 7:30 a.m. until 3:00 p.m. There is some usage on the weekends and afternoons for sporting events in the Fall, and to a lesser extend in the Spring. There is also a ten day summer school session starting the end of July that operates during the morning.

## South Texas High School

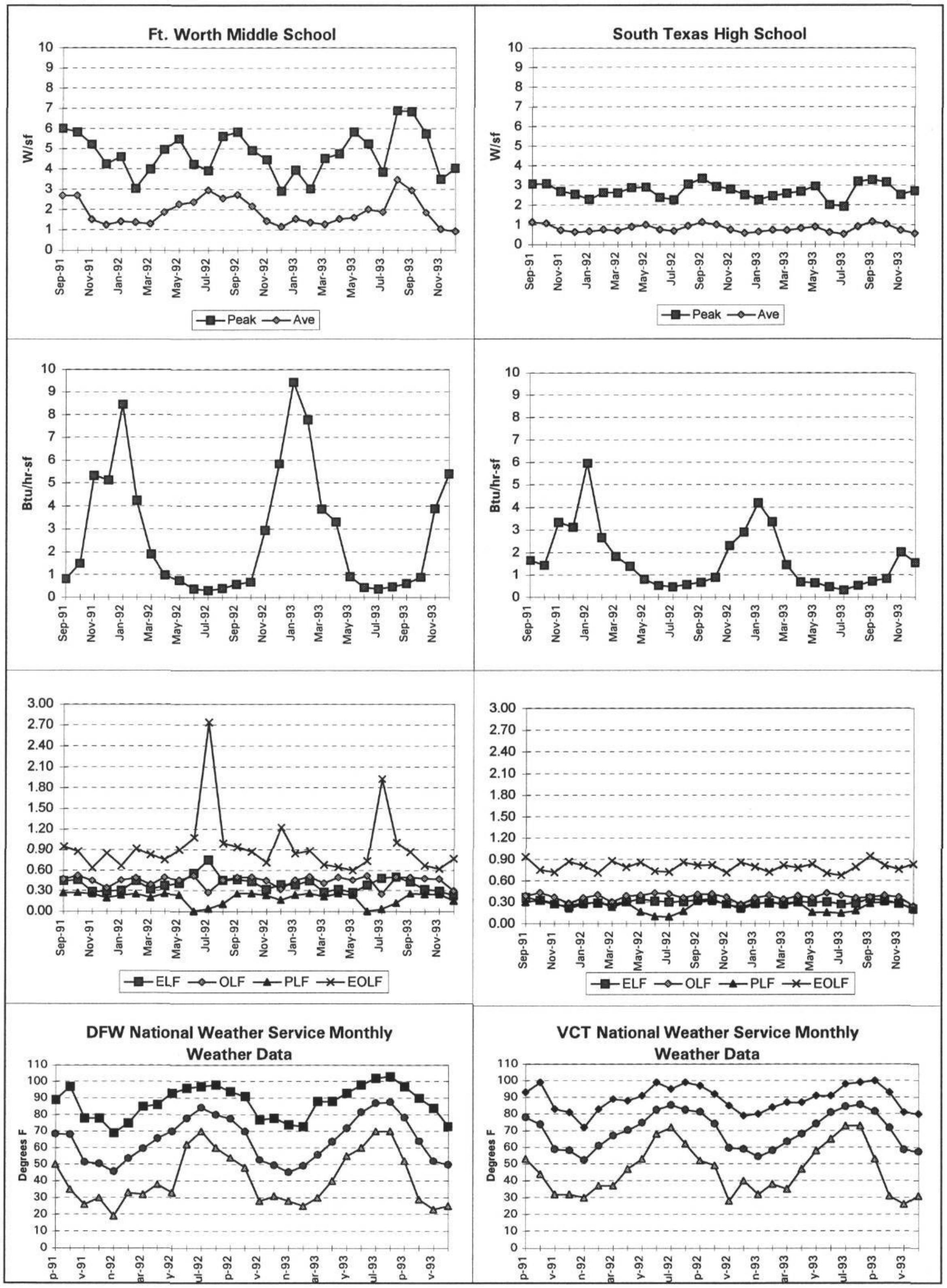
The South Texas High School is located in Victoria, TX. It consists of nine separate buildings with a total floor area of 210,474 square feet. Classrooms are heated and cooled by individual hydronic fan coil units. The first floor is heated/cooled by a hydronic air handler, and there are single air handlers on floors two through four to supply outside air to each floor. The two story Unit B contains the auditorium, choir room, band room, and drafting classrooms. It is heated/cooled by air handlers and the band hall has direct expansion cooling as well, which operate whenever the hydronic air handler does not provide cooling, in order to prevent humidity problems. Unit C is a single story building which contains the cafeteria and kitchen. It is heated/cooled by hydronic fan-coil units (six in the cafeteria, two in the kitchen). Unit D and E are in one contiguous building, a two story structure containing the library, gymnasium, locker rooms, and the main mechanical room. HVAC is provided by hydronic air handler in the library, and heating/ventilation units in the remaining athletic facilities. Unit F is a two story containing the science classrooms. It is heated and cooled by hydronic fan-coil units. Unit G is a single story shops building containing several pieces of electrical equipment from band saws to drills. It is heated and cooled by direct expansion units with gas furnaces for heating. Chilled water and hot water for units A-G are provided by a 460 ton electric chiller and a 5.05 million Btu/hr gas fired steam boiler. Auxiliary equipment includes a 50 horsepower chilled water pump, 40 horsepower condenser water pump, 30 horsepower cooling tower fan, and a 20 horsepower hot water pump. Large quartz lamps are used to light the tennis courts. These are shut off at 11:00 PM.

There are also three athletic buildings just north of the main buildings that house the girls' gym, the field house, and the "athletic dome", in which weight training takes place. All three buildings are heated/cooled by direct expansion units with gas furnaces for heating.

Air distribution is primarily through single duct multi-zone systems providing cooling temperatures in the range of 75 F and heating within the range of 70-72 F. Heating and air handling systems are turned off in the evening from a central location through an EMCS.

The school is operated from the middle of August through the middle of May with approximately 1,529 students and 145 faculty and staff. The maximum school occupancy is from about 8:00 a.m. until 4:00 p.m. However, the building is occupied for much longer periods including weekends and summers.

**Figure 1 :** Comparison of Ft Worth Middle School and South Texas High School monthly data.



**Results of the Comparison**

The top graphs are electric power levels, from left to right, for the Fort Worth Middle School (FWMS) and South Texas High School (STHS). The FWMS is consistently higher than STHS for all 28 months for both demand and consumption power levels. The values for FWMS in the summer time are about 3.0 W/sf on average compared with about 1.0 W/sf for STHS. The higher consumption in the summer time tells an auditor that he/she should evaluate if air conditioning systems need to be operated during the summer , even though the building was only partially occupied. Values during other parts of the year are consistently higher, indicating a potential problem with excessive electricity use. As the result of a site visit it was confirmed that controls were not operating properly. The HVAC systems were running constantly during the summer, not just when needed. Also, the STHS has much lower electricity consumption values than the FWMS, indicating that this may be a low energy consuming building.

The peak values for the FWMS are also much higher than the STHS, about 5.0 W/sf for FWMS and 3.0 W/sf for STHS. There are distinct spikes in the peaks during the month of August for both schools in 1992 and 1993. Peak electricity use drops during June and July for both years as well. This is an indication of vacations, shutting off equipment for the summer time, and the start of school, turning up the chiller to full capacity.

The next set of graphs represent the natural gas usage. Peaks are in the winter time coinciding with the coldest time of the year; however, there is a drop in December at both schools, a result of the holiday vacation, and an indication that scheduling is an important variable in the school's energy consumption. Natural gas consumption in the winter time ranges from about 5.0 to 9.5 Btu/(hr-sf) for the FWMS versus about 3.0 to 6.0 Btu/(hr-sf) for the STHS while the temperature differences in the two areas during this time are similar. This indicates that the FWMS is a high consumer of natural gas for heating purposes. The natural gas use drops off considerably with the increase of outdoor temperature, but does not go to zero. Natural gas use drops to about 0.5 Btu/(hr-sf) in the summer time indicating the use of a domestic hot water (DHW) tank or cooking. From a site visit to the FWMS it was determined that the school has separate DHW tanks and electric cooking. The STHS has both separate DHW tanks and/or gas cooking.

The third set of graphs are the ELF, OLF, and PLF, which were previously defined. If the ELF is equal to 1.0 this indicates that the systems are on all the time, if equal to 0.5 the systems are on 50 percent of the time. For example, FWMS had a high ELF, approximately, 0.75, in July 1992 indicating that cooling systems were running most of the time. The OLF measures the percent of the time the building is occupied. If the ELF and OLF are close for each period, that means that the equipment use closely matches the times that the building was occupied. The PLF is a further refinement of the OLF. If the PLF is much lower than the OLF, that means that the building had a low occupancy during that period and if the ELF isn't low as well that indicates that although there were few people around the building during the period systems were left on in unused areas as well as used areas, an indication of zoning or control problems. In the summer time the PLF is much lower than the OLF and ELF indicating that the cooling systems are being over used. This is especially noticeable in FWMS.

The fourth graph represents the billing period's peak , Min-Max average, and minimum dry bulb temperature. The temperature profiles help explain peaks in the electricity and gas power levels. DFW weather has more temperature extremes than VCT and one would expect the peak electricity in the summer time and the peak gas levels in the winter time to follow. The coldest months recorded were in January, which matches the peak gas power levels for the two schools.

## Summary

The comparative graphs described in this brochure are useful indicators of a building's energy use relative to other buildings with similar functions. These graphs can be used to plot potential areas of excess energy use. A software template for Microsoft Excel or Lotus 1,2,3. has also been developed and described for producing the graphical indices.

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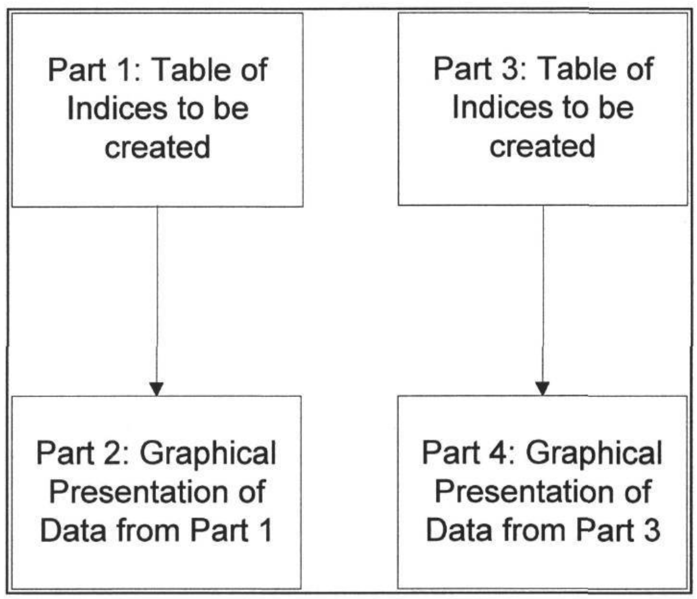
# APPENDIX

## Steps for completing the Template

When viewing the spreadsheet template there are 4 specific parts to the spread sheet displayed from upper left to lower right on the spreadsheet. The steps to completing the 4 parts are listed below.

**Figure 2**




## STEPS:

**Step 1**: Fill in Columns 1-3, 5-10, 11-16 in *Part 1* as needed.

**Step 2**: Columns 4, 17-23 in *Part 1* are calculated from the data input in **Step 1**.

**Step 3**: Fill in Columns 24 and 25 in *Part 1.*

**Step 4**: Column 26 is calculated from the data input in **Step 3**. This is also located in *Part 1*.

**Step 5**: Graphs in *Part 2* are created from all data input and calculated from **Steps 1-3** and located in *Part 1*.

* *Part 3* is an example of data created in **Steps 1-4** and *Part 4* is the graphical representation of the data from *Part 3*

The Template file is called **mo-tmplt.xls**