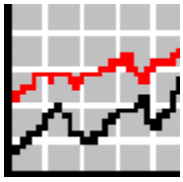
ETracker

User's Manual



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Description

ETracker makes tracking energy savings easier than ever before. ETracker was developed with support from for the US EPA Energy Star Buildings Program, and is used to help determine if buildings qualify for this label.

When measuring retrofit savings in buildings, it is useful to remove the effect of changing weather conditions on the energy consumption data. ETracker uses ambient-temperature regression models to reduce the influence of changing weather so that retrofit savings can be more accurately measured.

To measure building energy savings you need just two things: a file containing energy use data from utility bills, and a file containing average daily temperatures from the internet. To make the energy use file, simply enter the building's energy use information into a spreadsheet and save it as a text file. You can download the weather data file directly from the UD/EPA Average Daily Temperature Archive at www.engr.udayton.edu/weather/. This site has average daily temperature data from 1995 to present for over 300 cities around the world. ETracker's online help menu will guide you through the procedure.

ETracker automatically merges the energy use and temperature data, and develops a best-fit regression model of energy use and temperature from before the retrofit. To measure energy savings, energy use from after the retrofit is compared to the model's prediction of how much energy the building would have consumed if it were not retrofitted. ETracker displays numerical results, and creates easily understood graphs of pre and post-retrofit energy consumption for easy comparison. This method of measuring savings is recommended by the International Performance, Measurements and Verification Protocols (IPMVP), the Federal Energy Management Program (FEMP) Measurement and Verification Guidelines and ASHRAE Guideline 14.

Running ETracker

Running ETracker involves four simple steps: 1 loading an energy data file (*.UTL), 2 loading a weather file (*.WEA), 3 running the savings calculations, and 4 viewing energy consumption graphs (optional). These steps are explained below.

1 Loading an Energy Data File

ETracker recognizes energy data files with extensions ".UTL", such as "ZEC.UTL".

Description of *.UTL Files

ETracker uses energy consumption data that has been entered into an ASCII text file and saved with the extension ".UTL". Enter each month of utility billing information on a separate line. The required columns are:

1. meter reading month
2. meter reading day
3. meter reading year
4. electricity consumption (kWh/month)
5. peak electrical demand (kW)
6. thermal energy consumption (units/month)
7. pre/post indicator for electricity use
8. pre/post indicator for thermal energy use

Each column should be separated by at least one space, a tab or a comma. If energy use data are missing or unavailable, simply enter no-data flags "-99" in their place; ETracker will automatically exclude these data from the analysis. The "pre/post" indicators in columns 7 and 8 define the pre and post retrofit periods. Enter "1" to represent data from before the retrofit, and "2" to represent data from after the retrofit. ETracker will create regression models of pre-retrofit energy use, and use these models to calculate savings during the post-retrofit period.

A sample energy use file, "ZEC.UTL", is included with the software and shown below. ZEC.UTL includes 23 months of energy use data from a large building. Columns 7 and 8 indicate that the pre-retrofit period ended in June 1991. Thus, ETracker will create regression models of pre-retrofit energy use through June 1991, and calculate the savings during the post-retrofit period beginning in July 1991. In ZEC.UTL, the first four months of whole-building electricity use data are missing, and replaced by "–99" no-data flags. In Column 5, electric demand (kW) data were unavailable, thus cooling energy data with units MMBTU/month were inserted. (Alternately, one could insert an entire column of "-99" no-data flags.) The thermal energy use data in Column 6 represent heating energy use with units MMBtu/month

10	31	1990	-99	722	527	1	1
11	30	1990	-99	1409	1126	1	1
12	31	1990	-99	1093	1443	1	1
1	31	1991	-99	809	1301	1	1
2	28	1991	185200	1180	1392	1	1
3	31	1991	187000	1461	1351	1	1
4	30	1991	185700	1690	872	1	1
5	31	1991	172300	2021	914	1	1
6	30	1991	192500	2420	770	1	1
7	31	1991	134700	1747	701	2	2
8	31	1991	99000	1470	577	2	2
9	30	1991	115100	1013	343	2	2
10	31	1991	135400	753	299	2	2
11	30	1991	127400	572	351	2	2
12	31	1991	97700	634	334	2	2
1	31	1992	125700	436	414	2	2
2	28	1992	128000	615	383	2	2
3	31	1992	134500	717	412	2	2
4	30	1992	131500	775	423	2	2
5	31	1992	124500	905	445	2	2
6	30	1992	123500	1271	435	2	2
7	31	1992	123100	1439	437	2	2
8	31	1992	110900	1224	449	2	2

Sample energy data file: ZEC.UTL.

ETracker calculates savings from the energy use data in columns 4, 5 and 6 in the UTL file. To label graph axes, ETracker assumes that then energy use data in these columns are electricity use (kWh/month), electrical demand (kW), and thermal energy (units/mo) data. However, any type of energy use data can be substituted in these fields.

Loading an Energy Data File

To load an energy data file, select the menu items:

File, Open Energy

A time series plot of electricity consumption will be displayed. Pre-retrofit data is displayed in black and post-retrofit data is displayed in blue. Clicking on a data point with the mouse, displays the value of the point. To see a time series plot of electrical demand or thermal energy use, select one of the following menu items:

View, View Elec Demand

or

View, View Thermal Use

Preparing or Editing an Energy Data File

*.UTL files may be prepared in the ETracker Editor, a word processor or a spreadsheet application. When using a word processor or spreadsheet, be sure to save the *.UTL file in as an ASCII text file. In Microsoft Excel, save the file in a text (tab delimited) or .prn (space delimited) format.

To edit an energy data file from within ETracker, call the ETracker Editor by selecting the menu items:

Edit, Editor

Change the value fields as needed using the ETracker-Editor, then save the file under a different name by selecting the menu items:

File, Save As

Exit the ETracker-Editor and load the file by selecting the main menu items:

File, Open Energy

2 Loading a Weather Data File

ETracker recognizes weather data files with extensions of .WEA, such as "COLSTATX.WEA".

Description of *.WEA Files
ETracker uses weather files that contain average daily temperatures for the time period and city corresponding to the energy file. ETracker weather files have the extension *.WEA. The columns are:

1) month
2) day
3) year
4) average daily temperature (°F).

Each column should be separated by at least one space, a tab or a comma. If temperature data are missing or unavailable, simply enter no-data flags "-99" in their place; ETracker will automatically exclude these data from the analysis.

A sample weather data file, COLSTATX.WEA, is provided with ETracker. The first few records from COLSTATX.WEA are shown below.

```
10      16      1990      76
10      17      1990      79
10      18      1990      64
10      19      1990      62
10      20      1990      70
10      21      1990      63
10      22      1990      57
10      23      1990      58
10      24      1990      63
10      25      1990      64
10      26      1990      62
10      27      1990      65
10      28      1990      68
10      29      1990      68
10      30      1990      67
10      31      1990      68
11       1      1990      68
11       2      1990      70
```

Sample WEA file: COLSTATX.WEA.

Preparing or Editing a Weather Data File

Up-to-date average daily temperature data for over 300 cities around the world can be downloaded free of charge from the UD/EPA Average Daily Temperature Archive at:

http://www.engr.udayton.edu/weather

UD/EPA Average Daily Temperature Archive files can be directly loaded into ETracker. However, you may want to "clean" the file of unnecessary control characters and excess data by removing blank lines at the beginning or end of the file, and/or remove data from before and after the testing period. You can remove unwanted lines by opening the average daily temperature file in a word processor, removing the unnecessary lines, and then saving it as a text (ASCII) file with the extension ".WEA". If using a spreadsheet, save the data as an ASCII file in a text (tab delimited) or prn (space delimited) format with the extension .WEA.

Loading a Weather Data File

To load a weather file, select the menu items:

File, Open Weather

If the WEA weather data file is loaded before the UTL energy data file, ETracker will display a time series plot of the average daily temperatures. After a UTL energy data file has been loaded, ETracker merges the average daily temperature data into the energy data periods, and average temperatures over the energy use period are displayed.

3 Calculating Savings

Once the energy and weather files have been loaded into ETracker, you are ready to run the savings calculations. To calculate savings from the data in Column 4 of the UTL file, labeled Electricity Use, select the menu items:

Calc Savings, Calc Elec Use Savings

To calculate savings from the data in Column 5 of the UTL file, labeled Electrical Demand, select the menu items:

Calc Savings, Calc Elec Demand Savings

Similarly, to calculate from the data in Column 6 of the UTL file, labeled Thermal Use, select the menu items:

Calc Savings, Calc Thermal Use Savings

Interpreting Savings Output

After each simulation, a graph of monthly electricity consumption, electricity demand, or thermal energy consumption will be displayed. Actual energy use is displayed as a solid line. Data from the pre-retrofit period are displayed in black and data from the post-retrofit period are displayed in blue. The model's projection of the energy use of the building if it had not been retrofitted is displayed as a dotted blue line. Savings are the difference between the dotted and solid lines in the post retrofit periods. Clicking on a data point identifies the values associated with that point.

Statistical information about the pre-retrofit regression model is displayed in the box above the graphs. To measure savings, it is not necessary to understand the details of the pre-retrofit model. For the interested user, more information about pre-retrofit models is presented below.

The quantity of savings, with the associated uncertainty, during the post-retrofit period is displayed below the pre-retrofit model information. Total savings have the same units as the data in the UTL file, but represent the total savings in the post retrofit savings. For example, electricity use savings from ZEC.UTL and COLSTATX.WEA are:

Total Savings = 942,807 +- 51,869.5 (5.5%) after 428 days

This indicates daily savings of about:

942,807 kWh / 428 days = 2,203 kWh/day

with an uncertainty of about:

51,869.5 kWh / 428 days = 121 kWh/day (or about 5.5% of the savings).

Output Data Files

Each time savings are calculated, model and savings information is automatically saved in output data files. Model and savings summary information are saved in output files with the same filename prefix as the UTL file, but with filename extensions "KWH", "KWD" and ".THM" for electricity use, electrical demand and thermal energy savings respectively. The output files are created in the same directory as the UTL energy data file. For example, model and savings summary results from:

- Calculating electricity use savings from ZEC.UTL are stored in ZEC.KWH
- Calculating electricity demand savings from ZEC.UTL are stored in ZEC.KWD
- Calculating thermal energy use savings from ZEC.UTL are stored in ZEC.THM

The data used to create the models, and the models' projected energy use, are saved in an output file with the same filename prefix as the UTL file, but with filename extension ".DAT". For example, the output data from modeling energy use data in ZEC.UTL are saved in ZEC.DAT. As before, the output data file is created in the same directory as the UTL energy data file. The fields in the DAT output file are:

1. meter reading month
2. meter reading day
3. meter reading year
4. electricity consumption (kWh/month)
5. peak electrical demand (kW)
6. thermal energy consumption (units/month)
7. pre/post indicator for electricity use
8. pre/post indicator for thermal energy use
9. average temperature during each energy data interval
10. model's projection of post-retrofit elec consumption in post (kWh/month)
11. model's projection of post-retrofit electrical demand (kW)
12. model's projection of post-retrofit thermal consumption (units/month)

Output data files are overwritten each time savings are calculated.

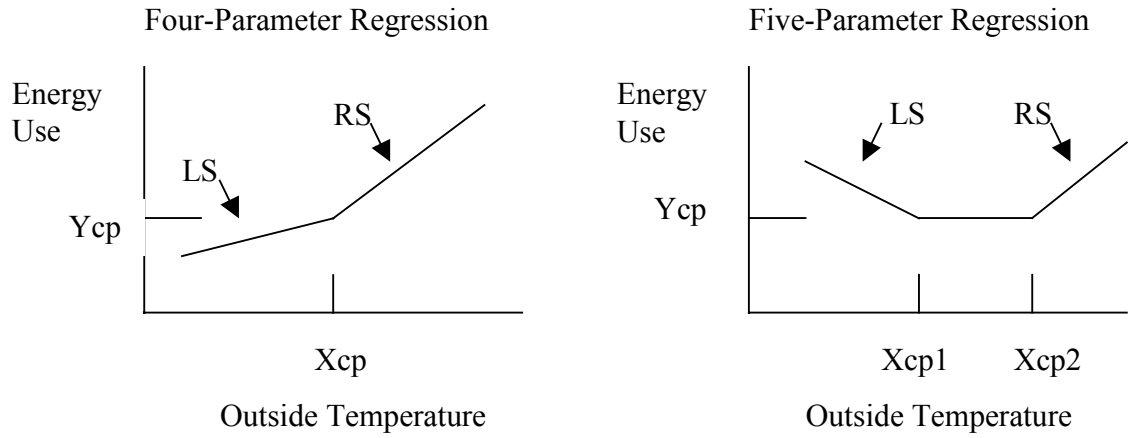
More Information About Measuring Savings and Pre-retrofit Models (Optional)

Perhaps the simplest method of measuring retrofit energy savings is to directly compare energy consumption in the pre and post-retrofit periods. However, building energy consumption is also influenced by other factors including weather, occupancy, and system settings, all of which may change between the pre and post-retrofit periods. If these changes are not accounted for, savings determined by this simple method will be erroneous.

Changing weather conditions, in particular, can have a dramatic effect on building energy use and savings determined from measured data. ETracker uses ambient-temperature regression models to remove the effect of changing weather conditions so that retrofit

savings may be more accurately measured. If other influential variables, such as occupancy, change significantly between the pre and post-retrofit periods, then regression models and software that can accommodate additional variables are required. However, in many cases, changing weather is the biggest factor that influences the measurement of savings. Use ETracker for these cases. For more information about measuring savings and more sophisticated savings measurement software see references at the end of this section.

To model pre-retrofit energy as a function of outdoor air temperature, ETracker generates both a four-parameter and a five-parameter regression models and chooses the best fit. The basic forms of four and five-parameter models are shown below. Using one of these models, ETracker predicts the energy consumption if no retrofit taken place. This predicted energy consumption is compared to the measured energy use during the post-retrofit period to calculate savings.



ETracker displays the following information about the pre-retrofit model.

Model type: 4P or 5P
N: number of data points used in regression model.
R2: squared correlation coefficient
CV-RMSE: ratio of RMSE to mean of independent variable
Model Coefficients: Xcp1, Xcp2 (for 5P only), Ycp, LS and RS
Equation to calculate energy use from regression parameters

Selected References

- "Methods for Analysis of Measured Energy Data In Commercial Buildings", Special Issue of the *Journal of Solar Energy Engineering*, D. Claridge, Editor, Vol 120, August 1998.

- "Ambient-Temperature Regression Analysis for Estimating Retrofit Savings in Commercial Buildings", K. Kissock, T. Reddy, and D. Claridge, American *Journal of Solar Energy Engineering*, D. Claridge, Editor, Vol 120, August 1998.

- "ASHARE Inverse Modeling Toolkit", ASHRAE, 2003.

- "Inverse Modeling Toolkit (1050RP): Numerical Algorithms", K. Kissock, J. Haberl and D. Claridge, *ASHRAE Transactions*, Vol. 109, Part 2., 2003

- "Inverse Modeling Toolkit (1050RP): Application and Testing", J. Haberl, A. Sreshthaputra, D. Claridge and K. Kissock, *ASHRAE Transactions*, Vol. 109, Part 2., 2003

- "Measuring Energy Savings: The Scorekeeping Approach", Special Issue of *Energy and Buildings*, Vol 9. Num 1&2, February, 1986.

- "Energy Retrofits in Performance Contracts: Linking Modeling and Tracking, R. Sonderegger", *Cool Sense National Forum on Integrated Chiller Retrofits*, Sept. 1997.

Other Software For Measuring Savings

- Enertel Analysis, K. Kissock, University of Dayton, Dayton, OH, kkissock@udayton.edu

- Metrix, R. Sonderegger, http://www.tridium.com/

- Advanced PRISM, M. Fels, Princeton University

- Faser 2000, OmniComp

4 Viewing Energy Consumption Graphs (Optional)

ETracker enhances data analysis by providing time series and XY plots of energy use and temperatures.

Time Series Plots

To view a time series plot of temperature, electricity use, electrical demand or thermal energy use, select one of the following menu items:

View, View Temperatures
View, View Elec Use
View, View Elec Demand
View, View Thermal Use

Pre-retrofit data is displayed in black and post-retrofit data is displayed in blue. Clicking on a data point with the mouse, displays the value of the point.

XY Plots

To view a XY plot of electricity use, electrical demand or thermal energy use versus temperature, select on of the following menu items:

View, View Elec Use vs. Temperature
View, View Elec Demand vs. Temperature
View, View Thermal Use vs. Temperature

Pre-retrofit data is displayed in black and post-retrofit data is displayed in blue. Clicking on a data point with the mouse, displays the value of the point. If a pre-retrofit model has been generated, the model will be displayed as a heavy back line. Savings are the difference between the pre-retrofit model line and the blue post-retrofit data points.

Acknowledgments

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