Energy management leaflet 7

Accounting for the weather

In order to manage the energy used in heating or air-conditioning systems, you need to take account of the weather. Degree-day figures provide a simple and convenient way to do this by reducing your local or regional weather to a single weekly or monthly number representing how cold it was (or how hot, in the case of cooling).

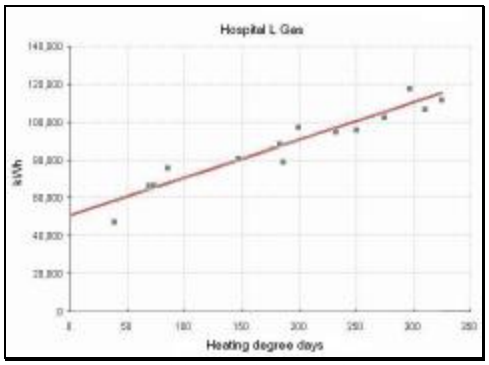

Figure 1: monthly analysis of heating demand

Figure 1 shows an example of a hospital building. Each point on this chart represents one month's data, with consumption on the vertical axis and degree-day values on the horizontal axis.

The diagonal line represents "expected" consumption. In this case, the value where the line intercepts the vertical axis shows that there is a fixed demand of about 50,000 kWh per month while the slope of the characteristic line indicates a weather-related demand of about 200 kWh per degree day.

This means that knowing what the weather was like, we can calculate the expected fuel consumption. For example, if there had been 250 degree-days in the month, the straight line shows that expected consumption would have been 100,000 kWh.

Month	Year	kWh	DegDay
4	2004	96,948	199
5	2004	80,829	147
6	2004	66,527	69
7	2004	66,293	73
8	2004	47,126	38
9	2004	75,554	85
10	2004	88,189	183
11	2004	95,440	250
12	2004	111,742	325
1	2005	118,349	298
2	2005	106,710	310
3	2005	102,343	274
4	2005	94,378	232
5	2005	78,944	186

Figure 2: source data for the chart

This now gives you the ability to

- detect abnormal consumption caused by hidden faults and human error;
- calculate and track budgets accurately;
- assess savings achieved by energy efficiency measures
- compare the performance of buildings in different climate regions

Many of these activities fall within the scope of a technique called *monitoring and targeting*[1]

[1] See www.vesma.com/mt

Monthly or weekly?

Monthly data are adequate for the smaller user but weekly assessments are better for active waste avoidance because when excess consumption occurs, it will be evident all the sooner. Weekly analysis is also more reliable because the assessment intervals are all exactly the same length — monthly results can be distorted not just by differences in the number of days, but more crucially, by the varying number of weekends.

Your energy consumption may also be affected by holiday closures, or by busy periods such as the pre-Christmas rush in retail sites. Assessing performance on a weekly cycle makes it a great deal easier to "patch out" unrepresentative periods when setting the performance characteristic. Finally, using weekly data will reduce the delay when trying to establish the performance characteristic line of a building for the first time.

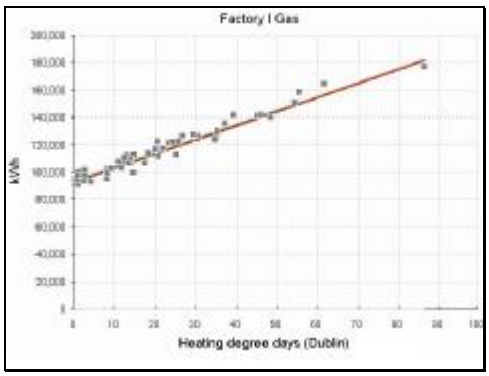

Figure 3: using weekly data

Figure 3 shows the heating demand for a factory, using weekly consumption and degree-day data.

Cooling

Figure 4 shows that degree-day data also have a role to play in monitoring chiller demand. *Cooling* degree days measure how *hot* the weather has been.

This again is an example using weekly data, but the monitored commodity is electricity rather than gas. Note that the fixed component of demand is more dominant than for heating: this is because the meter serves all the site's energy requirements, not just the chillers.

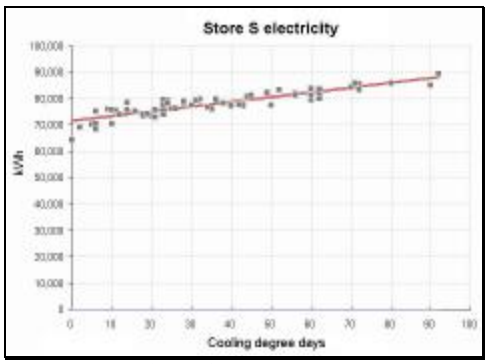

Figure 4: cooling characteristic

From the performance characteristic line we can estimate how much electricity the chillers use each year at this site. The line's slope is 181 kWh per cooling degree-day and there are typically 2,000 cooling degree days per year in the region in question. Cooling therefore accounts for:

181 x 2,000 = 362,000 kWh per year

Note: similar calculations can be carried out for heating loads as well

	Heating			Cooling		
Base	18.5°C	15.5°C	10.0°C	15.5°C	5.0°C	-20.0°C
30-Jul-04	14	3	0	17	87	262
06-Aug-04	6	1	0	29	101	276
13-Aug-04	6	1	0	29	102	277
20-Aug-04	10	2	0	17	88	264
27-Aug-04	22	6	0	6	74	248
03-Sep-04	26	11	0	7	70	245
10-Sep-04	12	3	0	19	90	264
17-Sep-04	36	16	1	1	58	234
24-Sep-04	37	17	1	1	58	232
01-Oct-04	33	15	1	3	62	237
08-Oct-04	54	32	4	0	41	216
15-Oct-04	64	43	8	0	30	206
22-Oct-04	64	44	9	0	30	205
29-Oct-04	52	32	5	0	42	217
05-Nov-04	61	40	5	0	34	209
12-Nov-04	66	46	9	0	28	203
19-Nov-04	84	64	27	0	15	185
26-Nov-04	74	52	16	0	25	196
03-Dec-04	94	73	34	0	5	176
10-Dec-04	77	56	18	0	19	192
17-Dec-04	84	64	25	0	13	185
24-Dec-04	92	71	34	0	12	177
31-Dec-04	98	78	40	0	10	171
07-Jan-05	82	60	23	0	15	188
14-Jan-05	82	61	23	0	14	188
21-Jan-05	83	62	24	0	14	186

Figure 5: weekly heating and cooling degree days to various base temperatures: UK Midlands

How degree-days are calculated

There are various methods of calculating degree-day values, but all refer to a "base temperature". For heating, this is the outside air temperature at which no artificial heat is required to keep the building comfortable. In the UK a heating base temperature of 15.5°C is traditional, the theory being that casual gains from lighting, occupants and equipment will raise the indoor temperature a few degrees higher than this.

Hospitals use heating degree-day figures calculated to a higher base (18.5°C) which may be appropriate for other installations, such as swimming pools, which require higher internal space temperatures. Most modern buildings, however, should be capable of balancing at outside air temperatures well below 15.5°C . A lower base temperature (such as 10°C) might be appropriate in such cases.

For cooling degree days the best all-purpose base temperature is 5°C. This is appropriate for a building which requires cooling all year (such as the store in Figure 4). For installations which cool only in the height of summer, a base of 15.5°C is appropriate. As can be seen in Figure 5, cooling degree days to this base temperature drop to zero at the end of the summer, implying no demand.

Published degree-day figures (such as those shown in Figure 5) are calculated from daily maximum and minimum air temperatures, using the daily difference between the mean and base temperatures. The daily temperature deficits (for heating) or excess (for cooling) are aggregated over each week or month to give a total for the period. The formulae are adjusted to allow for days when the outside air temperature falls either side of the base temperature[2].

Local recording equipment, if available, can improve on this by continuously aggregating the temperature deficit. Local figures tend to give more accurate results, provided that the temperature sensor is appropriately located.

[2] See www.vesma.com/ddd/ddcalcs.htm for the complete formulae.

About the author

Vilnis Vesma is an energy consultant and former energy manager in local government. He specializes in energy targeting and monitoring techniques, providing training, writing software, and carrying out implementation assignments in the field. He started the Degree Days Direct service in 1992 and became a director when it was incorporated as a limited company in 2003.

Where to obtain degree-day data

Degree Days Direct (www.DegreeDaysDirect.com) provides weekly and monthly heating and cooling degree-day figures for 32 regions in the UK and Ireland, and a number of other European locations.

The Meteorological Office provides a monthly heating degree-day service to a base temperature of 15.5°C for 18 UK regions. See http://www.metoffice.com/construction/pastdata4.html

Sources of degree-day data can be found on the web, but users should beware:

a) Most use the US calculation method. This is less accurate during mild weather because it does not take account of occasions when the outside air temperature exceeds base (for heating) or goes below (for cooling).
b) The base temperature is rarely stated and in many countries differs from the UK's 15.5°C (for heating)

You can calculate your own local degree days using a building management system or automatic weather station, or from daily maximum and minimum air temperatures using the appropriate formulae

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