Sunny Day as Sharping Factor of Heat Consumption Survey

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Abstract: This contribution describes one experiment focused on calculation of heat consumption for part of the town during the winter season. It is based on historical data analysis in the view of the nature of the sun activity. First step is to describe relation between heat consumption and outside temperature. This relation expresses in linear formula and then improves it by the inclusion of the information about sun activity during a day. The main idea is to separate sunny and common days and then describe heat consumption individually for them. This paper also shows simple method substituting sun intensity measurement by the comparison of temperature differences.

Key-Words: Heat, consumption, weather, temperature, sun.

1 Introduction

Now, more than any time in the past, the price of heat produced by heating plant must be considered. Even global warming is often mentioned the energy necessary for warming during the winter season doesn't fall too much. To tell the truth, there is a fall but it is more just due to better buildings isolation than reduce of request.

Most of the heat producers and distributors of heat are using weather compensation curve to control input temperature of hot water (denote qualitative part of supply), supposing growth of heat consumption with outside temperature fall (Broz, 2007). This is without questions right, verified by long time experience and practical use (Ibler et al., 2002).

This research is based on hypothesis that heat consumption is not simple function of outside temperature only but amount of consumed heat is affected by other factors. (Incropera et al., 2006). Of course, temperature has unsubstitutable role but other factors should be considered, for example to sharp the weather compensation controls.

This paper will show one experiment striving to prove significance of sunny days. It is obvious, sun warms buildings and sunny day brings savings in heat supplies. But what about reducing hot water temperature in pipes during these days. It is not so common. Usually temperature probe is placed in a shadow spot and is irresponsive to this charge. The only reaction comes late and it is due to higher temperature of surrounding air. And is this enough? Other extreme, to expose temperature probe to sun is evidently wrong way. So, let's think about finding a way to add "factor of sun" into weather compensation control but first look into the behaviour of consumption. (Ibler et al., 2003), (Reinberk, 2006). And this will be contens of the following contribution.

2 Experiment

The experiment is mostly based on the historic data analyze. Our data come from regional heat-distributor company. The part of middle size city was chosen with monitored winter season 2007/2008. Range from 1st of November 2007 to 31st of March 2008, to be specific.

The chosen part can be described as fourteen house station (HS) connected to the one heat exchanger (HE). Whole area is about one square kilometer.

There is an outside temperature probe monitoring surround of HE and also each HS has its own temperature probe. Those probes are source for weather compensation control running on each HS. The HE has also this kind of regulation but our experiment is now focused just on HS heat consumption. The comparison between significantly sunny days and common days will be presented.

2.1 Conditions

First let's have a look at the figure below. It shows average outside temperature for each day in monitored interval. This will be significant part of our later experiment.

Note: These temperatures were measured on HE, northern side with whole day shadow.

The following two figures show average outside temperature and sun intensity for investigated interval.

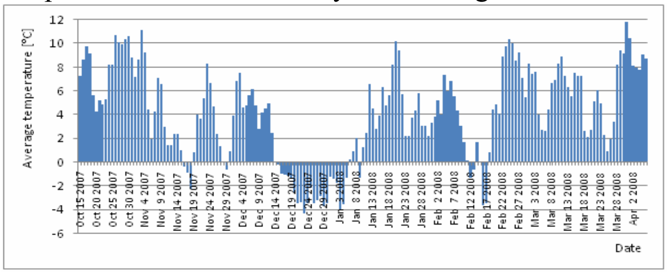

Fig. 1 Average outside temperatures

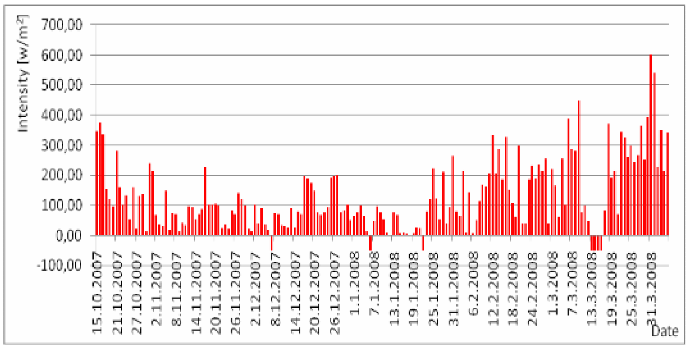

Fig. 2 Measured sun intensity (average values from 10 AM to 3 PM)

2.2 Sunshine effect

Basic analysis showed that temperatures measured on HS occasionally considerably differ.

The reason could be:

- The probe is near the source of heat, such as open cellar window and so on,
- the probe can be broken,
- the probe is inappropriately installed (exposed to the direct sunshine).

The subsequent tests comparing characteristics showed, the sun was the main reason. The knowledge of this disadvantage enabled the possibility to pick the dependent and independent HS's temperature probes.

The following figures show temperature measured on each HS with 5 minutes period during the sunny day.

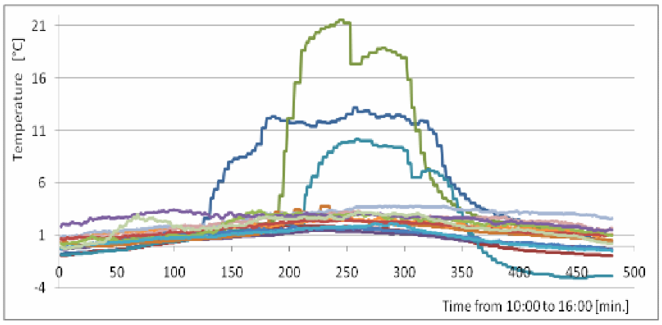

Fig. 3 Temperature course at 28.11.2007

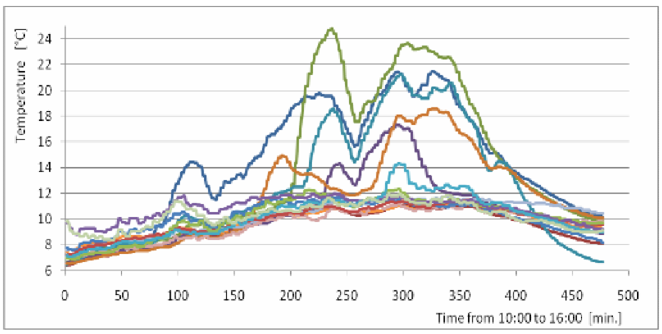

Fig. 4 Temperature course at 28.02.2008

2.3 Advantage of disadvantage

As mentioned before and also figure above shows, some temperature probes are affected by the sun. Also from the time course can be seen, that orientation of those affected probes to the sun slightly differ. Nevertheless, this disadvantage gives possibility to obtain information advising us whether day was sunny or not eventually estimation of the intensity.

3 Sunny-Day Function

- Two HSs, without affection of the sun, was chosen as referential for shadow temperature. (HS_{x1}, HS_{x2})
- Other two HS, significantly affected, was used as for comparison. (HS_{y1}, HS_{y2})

The HS_{xy} temperatures were calculated as average value from time 10 AM to 4 PM.

Then result Su can by obtain by this formula:

$$Su = \frac{(HS_{y1} + HS_{y2})}{2} - \frac{(HS_{x1} + HS_{x2})}{2} \quad (1)$$

Days when Su is significantly higher than zero can be though as sunny. "Significantly higher" value divides days into two categories:

- Significantly sunny
- Common

The value selected to perform this division is Su higher than 2.

3.1 Relation between consumption and outside temperature

Let's presume that consumption is defined by:

$$\mathbf{E = m^* \, cwh * \Delta T \quad [W.h]} \quad (2)$$

where cwh specific thermal capacity [(W.h)/(kg.K)] is equal to 1.163
T temperature [°C]
M weight [kg]

From the equation above we can assume that decline in the outside temperature, supposing constant inside temperature, cause consumption rise.

Some above mentioned HS records immediate consumption (5 min. period). We took one of these records and looked for relation between outside temperature and consumption.

Consumption and temperature were traced as a value of day sum. See Fig. 5.

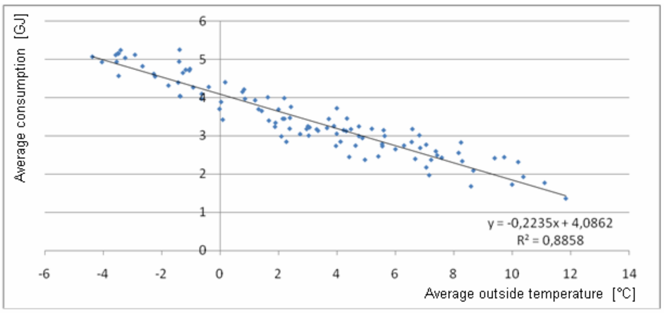

Fig. 5 Relation between outside temperature and consumption

Acquired linear function:

$$Ed = -0{,}2235 * Tdv + 4{,}0862 \quad (3)$$

where Ed determined value of consumption [GJ]
Tdv average outside temperature [°C]

Considering relation as linear we can perform simple comparison between measured and calculated consumptions. See Fig. 6.

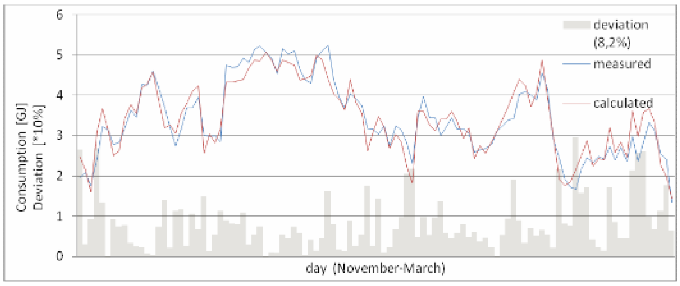

Fig. 6 Measured and calculated consumption (one relation)

3.1 Relation between consumption and outside temperature reflecting sunny days

Our database, used in preview experiment, was divided into two groups:

- Significantly sunny days
- Common days

Than relation between outside temperature and consumption was traced again.

Acquired linear functions for:

Significantly sunny

$$E_d = -0{,}2035 * T_{dv} + 3{,}9317 \quad (4)$$
$$R^2 = 0{,}8633$$

Common

$$E_d = -0{,}2326 * T_{dv} + 4{,}1806 \quad (5)$$

$$R^2 = 0{,}8997$$

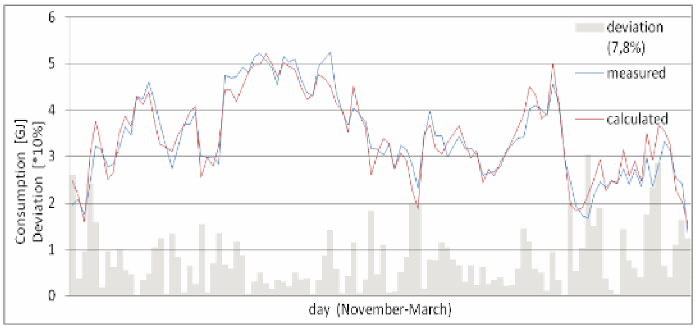

Fig. 7 Measured and calculated consumption (two relations)

4 Conclusion

This short experiment tried to show things to be considered. It pointed to significance of one factor from the large groups affecting consumption. It is important to do not forget, that each step specifying problem with possible subsequence to precise regulation can fetch in significant savings. Presented improvement were about 0.5% in identification process. If we well look for more factors affecting consumption we can surely get better percent. Better problem description opens possibilities of better regulation and so on. And we dare say the economy savings at the end of it.

Often few factors are considered, usually outside temperature as the base for weather compensation controls, day and night, and sometimes the day of the week (weekends or working day). Evidently, therefore mention several times above, effort to be more accurate is obviously suitable.

5 Acknowledgment

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