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Energy control

Wattbox: learning to manage home heating

Key words
space heating
thermostat
temperature control
energy efficiency

Too hot? Too cold? What's the heating like where you live? Coming soon is a new generation of intelligent heating controls which can learn how you live and deliver heating efficiently when and where you need it. That's the idea of Wattbox, newly developed at Leicester's De Montfort University.

Thermostats and controllers

In the UK, many households have a central heating system which uses a gas boiler to supply hot water to radiators for space heating. The boiler usually provides hot water, too.

Room temperature is controlled by a central thermostat which switches the heating on when the temperature falls below a certain level. Some homes have radiators with thermostatically-controlled valves so that the heating in individual rooms can be controlled separately. A programmable electronic controller, set by the householder, determines when the heating and hot water are on or off.

A traditional thermostat (top left) and controllers for domestic central heating systems

That sounds simple, practical and efficient. But is it? The UK Government, through its Warm Front programme, has tried to ensure that people in poorer homes are able to keep warm. To do this, they have provided better insulation and more efficient heating systems. However, a survey found that 25% of homes are persistently cold, despite the improvements. People living in cold homes are more likely to become anxious and depressed.

What is the problem? Many people find their heating controllers too complex to operate. A controller may have a combination of sliders,

More efficient heating systems:

- Use less limited resources (fossil fuels)
- Produce less greenhouse gas (carbon dioxide)
- Reduce fuel bills

switches and buttons and may require up to 30 steps to enter the desired pattern of heating times. Users complain that it is all too technical. Here's how they respond:

- Some leave the controls as originally set: "I never touch the controls."
- Others ask family members, friends or neighbours to alter the controls for them.
- Others abandon the automatic controls: "My husband switches it on when he gets up."

A survey in Norway found that many users didn't even turn down their heating when they go away on holiday. So some people are wasting energy while others are living in unnecessarily cold houses.

An engineering concept

Researchers at De Montfort University in Leicester set about tackling this problem. They wanted to devise an intelligent heating programmer which would determine the space heating requirements at any time, and which would also learn the pattern of energy use in the home, thereby reducing waste and increasing efficiency. They called their intelligent programmer 'Wattbox'.

Tenants Donna Howarth and Shaun White testing the Wattbox monitoring equipment

To begin with, the researchers identified three different levels of occupancy of a house:

- The occupants are awake and active: heating required between 19 and 23 °C.
- The occupants are asleep: heating required between 16 and 18 °C.
- The house is temporarily unoccupied: the temperature can be allowed to drop to 12 – 14 °C, avoiding dampness and allowing quick recovery when the occupants return.

But how to work out what the occupants are up to? One way is to monitor the use of electricity in the house. The graph in Figure 1 is typical; you can see that the occupants were active in the morning and evening (the tall spikes are the kettle being switched on). During the day, the occupants were out and at night they were asleep. At these times, only the fridge and freezer were using power.

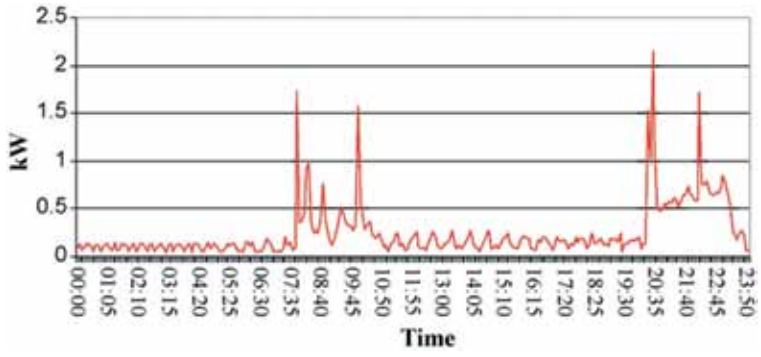


Figure 1 *How the use of electricity varied in one home over 24 h.*

Another way to tell how active the occupants are is to monitor the temperature of the hot water tank. Each time hot water is used, cold water enters at the bottom of the tank. Figure 2 shows how the temperature of the water in a tank dropped as it was used during the day; the water heater switched on at 7:00 pm to bring the temperature up to its original level. Rapid changes in the temperature at the bottom of the tank indicate when the occupants are active.

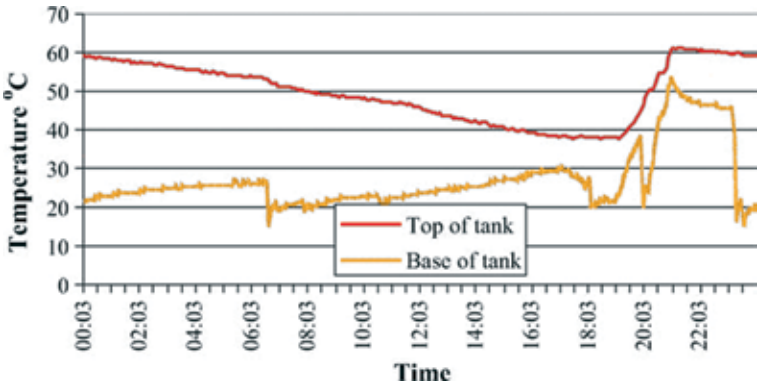


Figure 2 *How the temperature in a hot water tank varied over 24 h. When no water is being used, the temperature at the top slowly drops while the temperature at the bottom slowly rises.*

So by monitoring electricity use and water temperatures, Wattbox can work out what the residents are up to and control the space heating temperature accordingly. And once Wattbox has learned how the residents like their heating, they can forget about adjusting the controls and leave it to get on with the job.

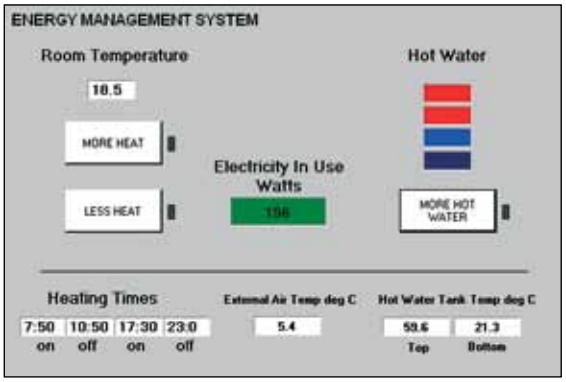
A prototype system

The researchers built a prototype system and installed it in a home. Initially, it had to be programmed with one of three 'standard' lifestyle options. These are shown in Table 1. But then it set about modifying this standard pattern according to the occupants' behaviour.

Option	Lifestyle	Chosen by
1	We are out of the home weekdays, otherwise at home	Office workers, families with children at school
2	We are at home most of the time	Retired people, home workers, invalids. families with young children
3	We do not have a regular pattern of being at home	Shift workers, students

Table 1 *Three lifestyle options which users of Wattbox can select*

The controller allowed the users to increase the level of heating ("More Heat" button), or reduce it ("Less Heat"). In this way, the controller could learn the occupants' preferred pattern of heating and adjust the level of heating it automatically provided.



The user interface of the prototype control system

Assessing the prototype

How well did the prototype system work? This was assessed in April 2008. For two weeks, the test home used a heating system with a traditional controller. Then, for another two weeks, the system was controlled by the Wattbox.

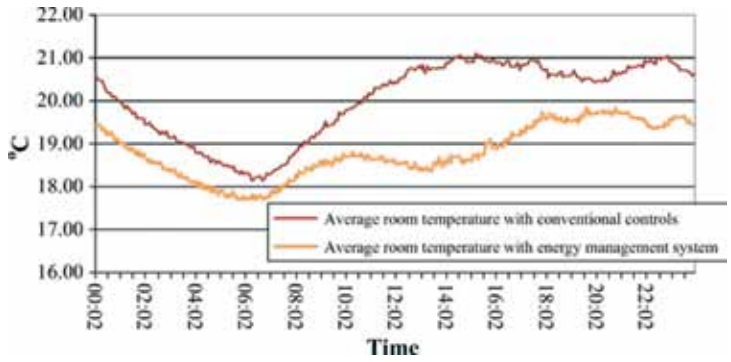
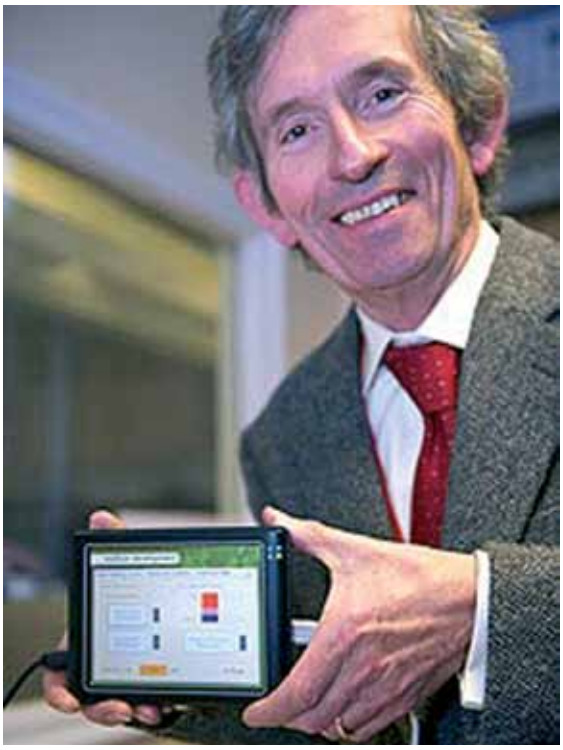


Figure 3 *Testing the Wattbox - average room temperature before and after introducing the prototype*

The graph (Figure 3) shows how the use of the Wattbox kept the room temperature under better control, so that less energy was used on space heating. To make the comparison of the two systems a fair test, several factors had to be taken into account, including the outdoor temperature, energy gain from sunshine, and heat coming from electrical appliances.

How much energy did Wattbox save? Results showed that it cut daily consumption by about one-seventh, a total of almost 20 kWh of gas per day. That means 4 kg less of carbon dioxide poured into the atmosphere, and a saving of about 80 p per day.



The Wattbox was developed at the Institute of Energy and Sustainable Development at De Montfort University, Leicester, by a team including Dr Peter Boait, shown here. His colleague Jim Oswald has recently obtained a US patent for its design, opening up a large future market for the product.

Watt next?

The Wattbox team now have several patents for their device. They are working on a programme of further trials, with many more households taking part.

When the Wattbox is in more general use, it is likely to have wireless signalling from the electricity meter, providing it with data on electricity use. It will be fitted in a kitchen, above a worktop, where the user will get immediate feedback on their electricity use. This is the same principle as the 'smart meters' which are now becoming more common. Householders who have a visual display showing their electricity consumption are more likely to switch off unnecessary appliances.

Another advantage of Wattbox is that it will help householders make better use of low-carbon technologies such as solar hot water (which works intermittently because of the variable level of sunlight), heat pumps and micro-CHP (Combined Heat and Power).

David Sang is physics editor of Catalyst. Thanks to Dr Peter Boait of De Montfort University for his help with this article.