Institution: DE MONTFORT UNIVERSITY

Unit of Assessment: 16 – Architecture, Built Environment and Planning

Title of case study: The Wattbox heating controller

1. Summary of the impact (indicative maximum 100 words)

Research on comfort and the effectiveness of existing domestic heating controls motivated the invention, patenting and development of a group of technologies, collectively known as the Wattbox. One application is a "smart" domestic heating controller that automates time and temperature settings and thereby is estimated to save consumers between 5% and 25% of their energy use with concomitant savings in cost and carbon emissions, leading to economic, environmental and quality of life impacts. Following the formation and sale of a spin-out company, Wattbox Ltd (which deployed demonstration devices in about 90 homes) products are now being marketed and further developed for the mass market by AlertMe Ltd [text removed for publication].

2. Underpinning research (indicative maximum 500 words)

The Institute of Energy and Sustainable Development (IESD, DMU) has performed research into both physical and behavioural aspects of domestic energy use over many years. This is underpinned by building physics and thermodynamics, and extensive use of computer simulation of thermal behaviour of buildings combined with empirical field data and qualitative analysis. Prof Mark Rylatt (Sept 1998–present) has developed community level models of domestic energy use and renewables. The first national domestic energy survey formed part of the Carbon Reduction in Buildings (CaRB) project – a socio-technical, longitudinal study of carbon use in buildings (EPSRC GR/S94377/01). At DMU, detailed temperature data and household face-to-face surveys were collected by Prof Kevin Lomas (Jan 1984–Oct 2008), Dr Andrew Wright (Sep 2004–present), Dr Stephen Firth (2005–08) and Dr Neil Brown (Feb 2005–present). The data were very informative about how people used controls and the shortcomings of current installations. The conclusions from this research were:

- that existing time and temperature controls for domestic heating are inconvenient, widely misunderstood and misused, and offer no efficiency benefits over an on/off switch
- the adaptive model of human thermal comfort proposed by Humphreys and Nichol presents opportunities for energy saving given suitable controls
- wide adoption of micro generation technologies at the household level is possible but implies a need for more sophisticated energy management techniques to ensure their effective use

With this background, Dr Peter Boait (DMU, initially 2004–08, then 2009–present, Senior Research Fellow) investigated the automation of domestic energy control. He observed that an accurate model of domestic electricity consumption, developed by Dr Stokes (IESD) in her PhD, implied that occupancy could be deduced from the pattern of electricity use. Validation of this hypothesis and subsequent development by Boait (under Rylatt's guidance) led to a group of patent applications, covering automated recognition and modelling of household occupancy and micro generation, which were submitted between Nov 2005 and Feb 2007. They also concluded that as the human metabolic rate varies during the day and sensations of comfort depend on outside temperature and other parameters, room temperature should be varied automatically for efficiency rather than remain static at the user's setting.

To ensure micro generation could be integrated with the "smart grid" while meeting household needs, Rylatt and Boait investigated signalling concepts between a domestic energy management system and the electricity grid, leading to a further patent application on overall system management, submitted in May 2007. All the patent applications were granted by April 2009.

Under Rylatt's guidance, Boait constructed a prototype system in late 2007, implementing the in*novations* which:

- detected occupancy automatically from the use of electricity and hot water, thereby replacing the conventional time switch
- varied room temperature automatically, using an adaptive comfort model with a very simple user interface consistent with the findings of behavioural research
- optimised simultaneous operation of solar thermal and combined heat and power (CHP) micro generation, while having the capability to respond to supply and demand control signals from the electricity grid

This successfully demonstrated usability and efficiency benefits and provided a case for further research. This research was funded by the EPSRC consortium grant (in partnership with EoN) Carbon, Control and Comfort: User-centred control systems for comfort, carbon saving and energy management (CCC) (EP/G000395/1, PI Rylatt, CoI Boait, and Research Assistant Fan), under which a robust and replicable prototype was developed and installed in homes. This research also identified opportunities and methods for improved control of heat pumps

3. References to the research (indicative maximum of six references)

Peer-reviewed Journal References

1. Stokes M, Rylatt R & Lomas K (2004), A simple model of domestic lighting demand. *Energy and Buildings*, Vol 36, Iss 2, pp 103-116, DOI 10.1016/j.enbuild.2003.10.007

2. Boait P, Rylatt RM & Stokes M (2006), Optimisation of consumer benefits from micro Combined Heat and Power, Energy and Buildings, Vol 38, Iss 8, pp 981-987, DOI 10.1016/j.enbuild.2005.11.008

3. Shipworth M, Firth SK, Gentry MI, Wright AJ, Shipworth DT & Lomas KJ (2009), Central heating thermostat settings and timing: building demographics, Building Research & Information, Vol 38, Iss 1, pp 50-69, ISSN 1466-4321, DOI 10.1080/09613210903263007 – *3rd most cited papers within the 2011 Impact Factor window (i.e. papers published in 2009–2010 that were cited in 2011. Citations are those received in 2011 only) – personal message from Richard Lorch, editor BR&I*

4. Boait PJ & Rylatt RM (2010), A method for fully automatic operation of domestic heating, Energy & Buildings, Vol 42, Issue 1, pp 11–16, ISSN 0378-7788, DOI 10.1016/j.enbuild.2009.07.005

5. Boait PJ, Fan D & Stafford A (2011), Performance and control of domestic ground-source heat pumps in retrofit installations, Energy and Buildings, Vol 43, Iss 8, pp 1968-1976, DOI 10.1016/j.enbuild.2011.04.003

4. Details of the impact (indicative maximum 750 words)

Demonstration of a working prototype from the research in section 2 attracted investment from partners, particularly Oswald Consultancy Ltd, leading to the formation of a spin-out company "Wattbox Ltd" in 2009, which licensed the patents from DMU. Mr Oswald held patents in the same field (GB2408592B, US77787732B2), allowing the company to hold a valuable pooling of intellectual property (IP). The company was immediately successful in obtaining customers amongst architects and HVAC (heating, ventilation, and air conditioning) practices bidding for the TSB's *Retrofit for the Future* competition. Five practices bidding with Wattbox as part of their proposal were successful in the TSB competition (e.g. Encraft Ltd) and 32 homes were fitted with Wattbox units. Further orders followed, despite the high cost of pre-production devices (circa £2000 each) resulting in ca. 100 units being installed around the UK.

Encraft Ltd. are an independent consultancy who specialise in low carbon buildings. They used the TSB's Retrofit for the Future competition to project manage and deliver "80% carbon reduction

projects on three social houses in Warwickshire and Birmingham, demonstrating that 80% savings are possible on hard-to-treat housing stock using existing technologies and local contractors" – full details of this cited quotation (and fuller details about the company and the Retrofit for the Future Projects) are listed in section 5.

In Aug 2011, Wattbox Ltd, and its IP, was acquired by AlertMe Ltd [text removed for publication].

AlertMe's customers include major utilities such as Centrica plc (parent company of British Gas).

[text removed for publication]

The most significant impacts from this research may thus be summarised as:
Environmental:

- Energy savings of between 5% and 25% per household when fitted with Wattbox – see section 5 for further details

Quality of Life:

- A greater sense of control of their energy use by vulnerable households – DMU holds unpublished but scientifically valid data which can support these claims

Economic:

- Job and wealth creation by Wattbox Ltd and AlertMe Ltd
- Increased competitiveness of these UK businesses in international markets

These impacts derive directly from mass market implementation of the technology developed in prototype form under the research activities described in section 2.

5. Sources to corroborate the impact (indicative maximum of 10 references)

Confirmation of DMU's role in creating the Wattbox:

- See http://www.epsrc.ac.uk/newsevents/news/2010/Pages/lowerenergybills.aspx

Confirmation of the creation of the spinout company Wattbox Ltd:

- DMU legal services can provide a redacted copy of the relevant paperwork

Confirmation of the role of Wattbox in the TSB Retrofit for the Future Competition and the vital role this TSB competition played in turning the spin-out into a viable company:

- See https://www.innovateuk.org/web/corporate1/feature-display-page/-/asset_publisher/b61wJfKPbeu8/content/cutting-emissions-growing-business and links therein (accessed 23/09/13)

A selected example of how a customer (Encraft Ltd.) used the Wattbox as part of the TSB Retrofit for the Future competition:

- see http://www.encraft.co.uk/ for details of the company, http://www.encraft.co.uk/about-us/our-history/ for a fuller explanation of their Retrofit for the Future projects (from which the quote in section 4 was extracted), and specifically http://www.encraft.co.uk/case-studies/retrofit-for-the-future-project/ for reference to the Wattbox as used in the Retrofit for the Future project (all accessed 23/09/13)

Confirmation that AlertMe bought Wattbox Ltd:

- See https://www.alertme.com/press/alertme-buys-wattbox-to-create-the-ultimate-in-intelligent-home-heating-hot-water-the-killer-app-for-energy-efficiency/ (accessed 30/07/13)
- See http://www.cabume.co.uk/software/alertme-acquires-wattbox-and-reaches-out-to-new-partners-as-smart-home-market-heats-up.html – this link also provides estimates from 2011 of the size of the market share AlertMe could reasonably expect to realise with its suite of products ("globally the smart meter market will be worth $5.3bn this year and $15.3bn within five") (accessed 23/09/13)

Confirmation about the claims about the nature of AlertMe Ltd as a company:

- AlertMe's vision can be accessed at https://www.alertme.com/what-we-do/our-vision/ where they state that "AlertMe puts the home in the cloud to enable consumers to monitor, control and intelligently automate their home, wherever they are. (…) Working with large consumer-facing businesses in Europe and the USA, we provide value-added solutions for their customers and make the connected home an affordable reality for everyone." (accessed 23/09/13)
- In terms of what their smart metering can offer, they state (on https://www.alertme.com/how-we-do-it/products-and-services/smart-monitoring/): "SmartMonitoring incorporates applications such as security sensors (motion and door & windows), safety detectors (smoke, carbon monoxide, gas and flood) cameras, keypads, locks, thermostats, keyfobs and connected home appliances.(…) SmartEnergy can be integrated seamlessly" (accessed 23/09/13)

Confirmation that British Gas are a partner of AlertMe:

- See the 'partners' drop down menu on https://www.alertme.com/ (accessed 23/09/13)

Confirmation that British Gas are a partner of AlertMe:

- See the 'partners' drop down menu on https://www.alertme.com/ (accessed 23/09/13)

Confirmation that Centrica are marketing the smart metering technology:

- See the British Gas website for their vision about 'smarter living' http://www.britishgas.co.uk/smarter-living/smart-homes.html?WT.mc_id=PPC40003436&WT.srch=1 (accessed 23/09/13)
- British Gas have also promoted the smart metering technologies in national advertising campaigns, for example see http://www.youtube.com/watch?v=a7-WppK2w6w or http://www.youtube.com/watch?v=hd4oaSigBuc (both accessed 23/09/13)

Evidence for the claimed environmental impacts:

- Journal reference [4] provides published evidence to support this claim, as does the Encraft Retrofit for the Future project cited in section 4. [text removed for publication]

Evidence for the claimed quality of life impacts:

- Data can be made available upon request [text removed for publication].

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