DEHEMS

Helping people to manage their energy consumption

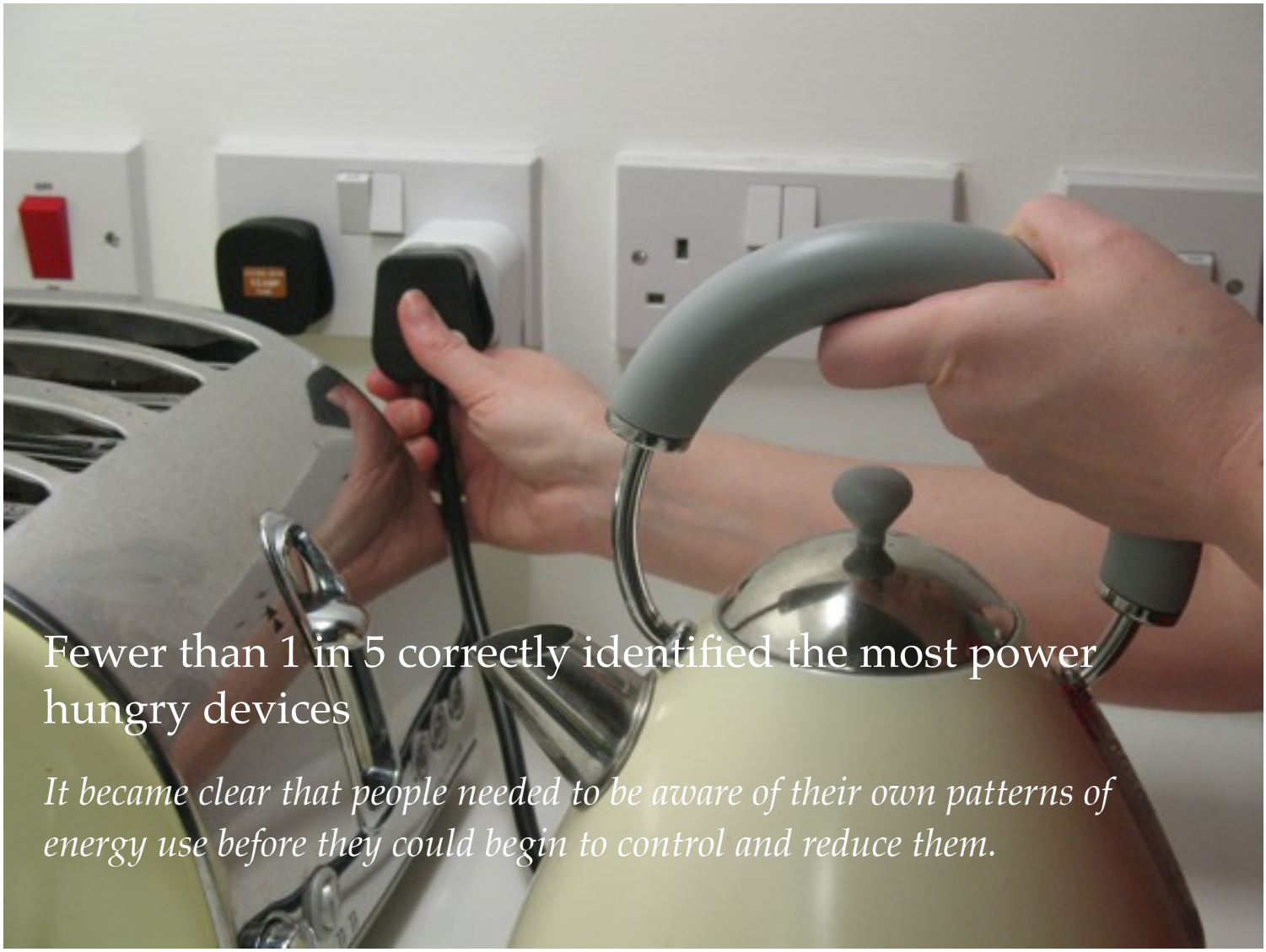
Welcome to the Digital Environment Home Energy Management System (DEHEMS) Project Report

This report explains what the DEHEMS project has been doing over the last three years. We are excited by what we have achieved and we hope you will be as you read about it.

The Digital Environment Home Energy Management System is about how everyone can have a positive impact in protecting the planet by monitoring their energy consumption at home in order to reduce emissions of CO2 (Carbon Dioxide.)

This report offers an insight and overview. If you want more depth or technical information, the documents published by the project are available at www.dehems.eu.

This project is about people. We began by interviewing over 1000 people in the UK and Bulgaria about their energy consumption. Many of them then joined the project to help us design the equipment that would help meet their needs in terms of monitoring the energy they consumed. The final goal being to enable people to reduce their household energy consumption and cut the cost of running their homes. The project has become increasingly relevant to the lives of all of us. Energy prices have increased dramatically since we started work on DEHEMS in 2008 and it seems safe to assume that that this will continue in the long term.



Fewer than 1 in 5 correctly identified the most power hungry devices

It became clear that people needed to be aware of their own patterns of energy use before they could begin to control and reduce them.

What is DEHEMS?

Digital Environment Home Energy Management System (DEHEMS) aims to help people reducing CO2 emissions, important for the wellbeing of everyone of us and ultimately the planet.

All the member states of the European Union have agreed on the need to cut CO2 emissions by 20% by 2020. Taken together, households account for between 25% and 30% of these emissions.

Whilst it won't solve the problem completely, reducing CO2 emissions in individual households can make a big difference.

This is where DEHEMS comes in.

People understand the problem but in turn are often overwhelmed by it. They find it difficult to see how they, as individuals, can make a difference.

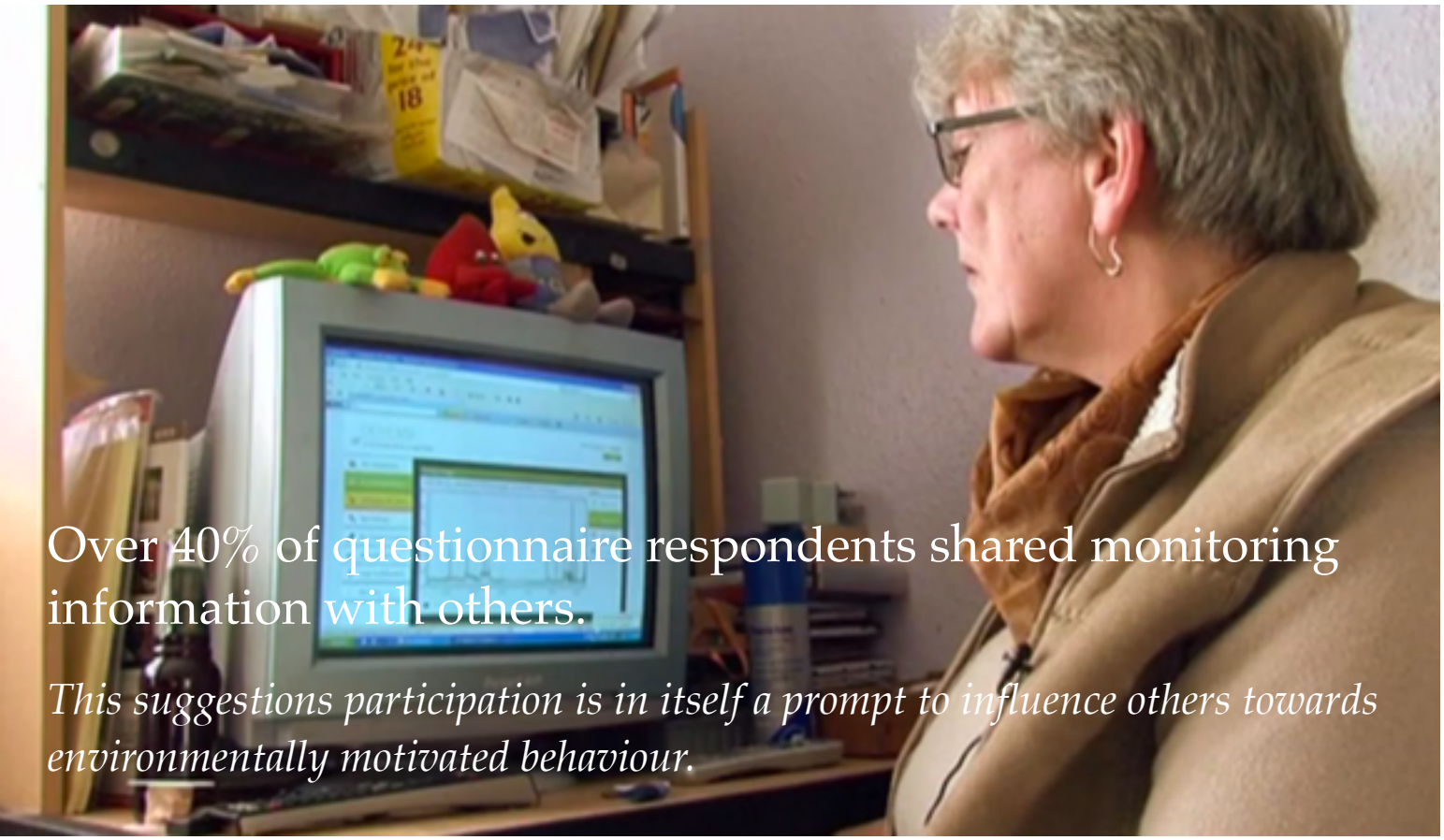
When the DEHEMS project started, a survey of more than 1000 people was conducted to find out how much people knew about the energy consumption of common household appliances like kettles, TVs, washing machines and fan heaters.

"How do we compare with other people?" was a question that often came up in the follow up interviews with people in Bulgaria and the UK who had completed the questionnaires on energy consumption. This question has two aspects to it.

The first is about technology. In this case we equipped people with the technology that enables them to monitor their energy consumption in real time at the household, appliance and comparative group level. The technology that DEHEMS developed is smart and discreet. The aim for users was to create something simple to use and gives them the information they want, when they want it.

The second is about people. DEHEMS brought people together so that they could meet and discuss their own experiences and swap information on how best to reduce their energy consumption.

250 households across Manchester, Birmingham and Bristol in the UK and Plovdiv and Ivanovo in Bulgaria were the real drivers of the project. Their incentive being that participation in the DEHEMS project would reduce their CO2 emissions and save them money at the same time.



Over 40% of questionnaire respondents shared monitoring information with others.

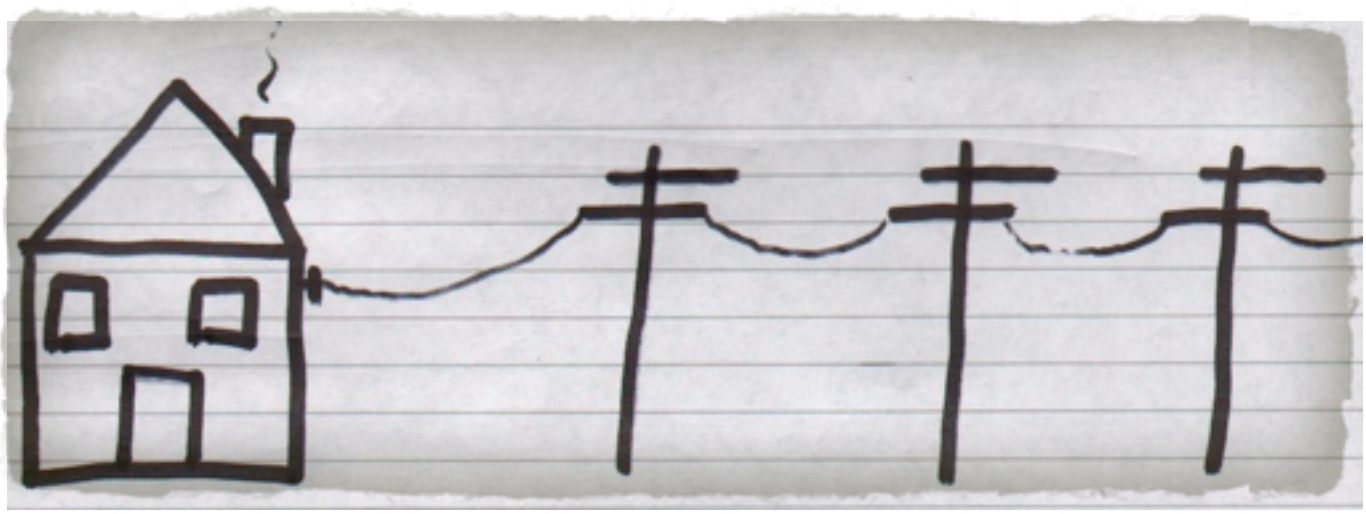
This suggestions participation is in itself a prompt to influence others towards environmentally motivated behaviour.

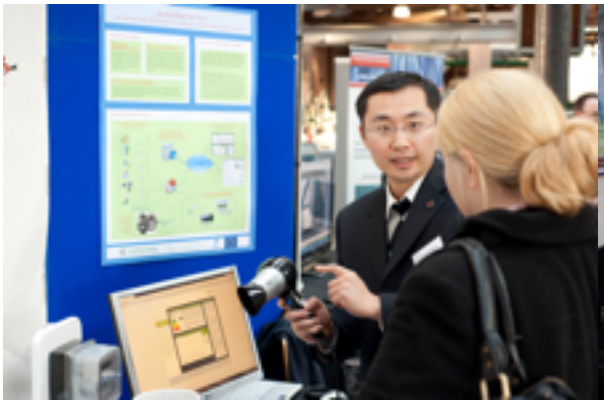
What went before?

Energy prices have increased dramatically over the last few years. Consequently people have become more interested in monitoring their energy consumption as a prelude to reducing it. Households have always been able to measure their total energy consumption by looking at the meter readings upon which their gas and electricity bills are based. In many cases the meters are located in basements and are relatively inaccessible.

There are a number of plug in meters on the market. Some are plugged into the mains and show the consumption of individual appliances whilst others attach to the meter and given an instant display showing total electricity consumption, often via a wireless device which sometimes doubles as a handset and can be positioned anywhere around the house. The more sophisticated systems will give some indication of historical consumption for comparative purposes. In other words a comparison is possible with the amount used at the same time in previous weeks or days by the same household.

One problem common to both is that they are characterised by a life cycle of intense initial enthusiasm at the start followed by a gradual decline in usage. The reason being that most of the products currently available do not meet all the needs of users.





What's different about DEHEMS?

From the start, DEHEMS has been driven by the citizen.

DEHEMS started with trying to define the needs of users first. That's why the project was carried out in cycles. This enabled the project team to see how users reacted to the various technical solutions on offer. The users in turn made suggestions as to how they could be improved and these were integrated into the next generation of the technology.

One example makes the point. Information is presented to users via the DEHEMS Dashboard. The dashboard is a screen which can be seen on a stand alone monitor as well as on a variety of hand held devices, smart phones and PCs.

Research carried out during the project showed that people wanted information to be presented in a clear, readily intelligible way. They also were keen to know how their energy consumption patterns compared with those in similar households in terms of size and age structure. The idea of being presented with tips on saving energy which were related to their own consumption pattern also caught their imagination.

How did we do it?

To deliver the information people want in a way that appeals to them has to be underpinned by intelligent technology. The DEHEMS equipment is made up of a small box that is attached to the electricity meter. In addition energy monitors sit between the appliances and individual plugs. These are all connected wirelessly. This enables comparisons to be made between households of the same type. The project also created a gas monitoring system using mobile technology.

From the users point of view, the key component is the DEHEMS Dashboard which can be customised to give specific information directly relevant to each individual household. For example DEHEMS can improve and personalise feedback on energy consumption of individual households; it can profile the average daily energy usage according to the number of bedrooms, the number of occupants, and property type.

One example of feedback is to inform a 2-occupant, single bedroom flat consuming 17kWh of daily energy that their household is consuming the energy equivalent to a 3-occupant, 3- bedroom household. Profiling could also be used for positioning the household so that its members can see if they are high, medium or low users of energy when compared to others in the same category.

Plug level monitoring

Knowing how much energy you are using in total is very useful. Plug level monitoring takes the process one stage further by measuring the consumption of individual appliances. DEHEMS researchers fitted up some of the participating households in both the UK and Bulgaria with an off the shelf product from Dutch company Plugwise. This enabled users to see exactly how much individual appliances used in real time.

Gas as well

As DEHEMS progressed gas consumption was also monitored in households that were connected to a gas supply. This presented a real challenge. Techniques had to be developed that were economical - the retro fitting of gas flow meters is very expensive - and it was important not to interfere with existing gas installations. The solution was to develop an optical sensor that could read the meter and transmit the data via mobile phone (GSM) text messaging.

Empowering Communities

The DEHEMS research shows that people want to monitor and save energy for a variety of reasons. For many the key motivation is to reduce household expenditure in order to save money. For others it is to reduce their carbon footprint by reducing their CO2 emissions. In the course of the project it became clear that for many people the two worked in combination as awareness of environmental issues increased.

Cutting energy consumption, for example by buying more efficient appliances or investing in insulation systems to make the home more energy efficient, costs money in the short term and acts as a very real constraint. The “ratio of return” is important to consumers.

But this is not the whole story. Energy saving can also be made at zero cost.

Our research revealed that over 90% of households do not know their own home’s energy performance rating. There is also a clear lack of knowledge about the energy consumption of home appliances. For example, over 50% assume that the kettle, hot water shower and washing machine are the highest energy consuming appliances if switched on for 20 minutes. In reality, a cooker hob, oven and grill have the highest peak energy requirement. Less than 20% realised this.

Our research also shows that one of the best ways of saving energy in the homes is by switching off appliances when they are not in use. Similarly, limiting the standby use of appliances such as set top boxes, televisions, computer monitors, DVD players and microwaves all saves energy.

Why Communities?

From the start of the project, all the DEHEMS users were organised in “Living Labs”. A Living Lab is a group of people who are actively involved in the creation and evaluation of technologies which they will ultimately use. They then go on to assess the impact of these technologies on their own lives. The project took this approach because the evidence suggests that behaviour change is often best carried out in a group or community context. The presence of other people with the same interest and motivation helps to reinforce the change in behaviour and eventually turn it into a habit. It becomes the new norm. DEHEMS used focus groups, i.e a group of people discussing a set of common issues with the assistance of a facilitator to help guide our research and interact with users. These formed part of the regular, recorded activity of the Living Labs and underpinned the collaborative process.

The DEHEMS Dashboard has already been mentioned as an example of this collaborative process. Its design and the way in which information was presented was shaped by the users who were organised in Living Labs.

Many users who liked the DEHEMS dashboard used it as a game for investigating their real time energy usage by switching on and off various appliances and viewing the impact. Those who liked the web interface tended to be more computer confident and enjoyed the ability to remotely access their home to monitor home activities and to compare their consumption patterns with others.

Participants in the Living Labs agreed that they shared hints and tips about reducing energy consumption with other members of the Living Labs as well as friends and colleagues. In some cases, people even became quite competitive about who could save the most!

In the course of the project we became aware of the fact that a number of the participants in the Living Labs were users of social media and designed a Facebook App to enhance their DEHEMS experience.

DEHEMS and Carbon Trading

Carbon emissions trading is normally thought of as something which happens within and between nation states. It specifically targets carbon dioxide emissions (calculated in tonnes of carbon dioxide equivalent or tCO2e). The principal objective is to reduce emissions and their impact on climate change.

Recent research has also looked at personal carbon trading models. The underlying principle of such schemes often takes the form of allocating carbon credits to individuals. These are spent when they buy fuel and electricity. Those that remain can then be traded.

DEHEMS looked at how a model could be adapted to provide incentives to reduce energy consumption and reinforce behaviour which helped reduce greenhouse gas emissions.

The clue as to how this might be done came from analysing the behaviour of users in the Living Labs. Two things very quickly became obvious. Firstly the majority of users in all the Living Labs were enthusiastic about reducing their energy consumption and secondly the DEHEMS dashboard made this relatively easy to monitor. They could take control.

Living Labs participants were encouraged to organise themselves into teams. From January 2011 all their energy use was measured and used to form a baseline against which their energy consumption in the following weeks could be measured at both the individual household level and the team level.

At the end of a four week period incentives were awarded to the households in each Living Labs team and the team which had managed to reduce their energy consumption the most. Most successful individual household and the most successful Living Labs team came from Ivanovo in Bulgaria.

DEHEMS implemented a model on a pilot basis to illustrate the principles of how carbon trading might work at the grass roots level. Three major conclusions emerge.

Firstly it is clear that when they are given access to user friendly devices to monitor their energy consumption, people will usually act positively to reduce it.

Secondly, this behaviour is more likely to become the norm when they are offered appropriate incentives to reduce their energy consumption. The key is to create a range of appropriate incentives, one of which might be a variant of personal carbon trading.

Thirdly, incentives do not have to be exclusively financial or material. Peer pressure and a spirit of friendly competition should not be underestimated. A Facebook App encouraged users comfortable with social media to communicate with their friends about reducing their energy consumption.

What users said

The Living Lab in Bristol lies 3000kms away from the Living Lab in Plovdiv. However, the geographical distance made very little difference to their reactions to involvement in DEHEMS.

“I think I am doing things better. I think I’m looking at some of the appliances in my house which I would not ordinarily look at because I notice them on screen and if you didn’t have something to see that you wouldn’t be able to do something about it.” Was the comment of one of the participants in the Birmingham Living Lab.

Those comments were echoed by one of the members of the Living Lab in Plovdiv. “Beshe mnogo lesno da namalim znachitelno potreblenieto na energija sled kato vidjahme kolko izpoluva vsjeki ot uredite.” (*This translates as, We found it quite easy to reduce our energy consumption once we could see how much each appliance used.)*

One of the key motivators for all participants concern over the rising cost of energy and the need. One of the Manchester participants summed it up like this, “Energy prices are going through the roof, so anything that helps us to cut down the amount we use saves money. That pleases everybody.”

Another common theme concerned the benefits to be gained by comparing energy consumption with other people. In the case of one participant from Birmingham this led on to comparisons with technologies that were not even part of DEHEMS; wood burning stoves. “We have become a more eco-conscious family, this is fascinating. We are comparing the use of wood- burning energy with others. This system is helping/enabling that comparison.”

A Facebook App proved to be popular with some of the users. “This was extremely useful and quite motivating,” commented one of the Manchester users. This was echoed by another Facebook user in Bristol who said, “I use Facebook a lot, so didn't have to go to a separate web site to see DEHEMS data. Also, seeing the consumptions of people I know made the experience more real”.

Things we have learnt

One key lesson that emerges from the DEHEMS project is that when people are given access to information about their energy usage in a way which makes sense to them, they will often change their consumption patterns very dramatically. All the DEHEMS households grouped in Living Labs wanted to reduce their energy consumption. DEHEMS made that possible by developing and integrating some very innovative technologies which enabled the users to see how much energy they were using down to the appliance level.

In ICT projects like DEHEMS priority must be given to enhancing the user experience. The golden rule is to keep things simple. Ideally the equipment should be 'plug and play.' Where it isn't, an efficient installation service and a help desk should be provided in order to maintain enthusiasm for the project. Once the initial installation has taken place users need to be able to use it with confidence.

Grouping users in Living Labs can be very effective in developing ICT products. We feel that the DEHEMS results have been dramatically improved by the direct engagement of users in the development of the technologies and their associated services. User engagement in the creation of innovative ICT services has two very positive

outcomes. Firstly it helps ensure that the proposed service meets user needs and secondly it leaves users with an enhanced sense of ownership.

Implications for Policy Makers

The DEHEMS results do have clear implications for policy makers. Users need to have access to the tools which enable them to easily monitor and control their energy consumption. These tools already exist as far as electricity consumption is concerned. Measuring gas consumption is more problematic without the fitting of replacement meters, the problem being that most of the bolt-on systems currently available usually measure accumulated as opposed to realtime consumption.

Smart meters are intelligent gas and electricity meters that are being installed as replacements for existing meters. They can communicate energy usage back to the energy supply company, as well as giving consumers up-to-the-minute details of how much energy they are using.

Policy makers need to decide whether or not to promote the replacement of existing meters with smart meters. If the decision is made to move towards smart meters consequential decisions will have to be made on how they will be supplied and how they will be paid for.

The Future

The DEHEMS project has formally come to an end but the research undertaken during the project continues to have an impact.

Hildebrand Technology, one of the DEHEMS partners have set up Energyhive, www.energyhive.co.uk, a network which works with individuals and organisations keen to reduce their energy consumption. This includes a major deployment with smart grids Australia as well as a district heating initiative in Camden, London.

In conjunction with Manchester City Council, Hildebrand is the technical partner in a new European Commission funded project from December 2010, exploring issues of databases and Cloud computing. This is the practice of using a network of remote servers hosted on the internet to store, manage, and process data, rather than a local server. The project will involve building on and adapting the Smart Environment Application created during DEHEMS and adding it to the EPIC (European Platform for Intelligent Cities) platform to provide a service that can be used across Europe to help cities achieve their carbon reduction targets. As well as looking at other Cloud services, these targets will be achieved by supporting households in reducing their energy usage through better analysis and management of their energy consumption.

Recognising the potential for a commercial energy management monitoring solutions, Clicks and Links developed and implemented the Greenica product (www.greenica.net) in 2009/2010.

Greenica is a completely supplier independent allowing any household or small business to start monitoring their electricity in real-time within a couple of minutes.

With the strapline "making energy visible", Greenica has been deployed by including lessons learned and successes of the various cycles of DEHEMS. Clicks and Links is continuing to commercially exploit and further develop the data collecting equipment and the online dashboard concept.

SMARTER is a web-based initiative where, via an online dashboard, users (both households and SMEs) with energy monitoring equipment can, in real-time display energy usage, both as total kWh per location or reported on an individual appliance level. SMARTER has been successfully implemented into 56 small businesses (SMEs) and 282 homes in the city of Manchester.

In Birmingham, Family Housing Association are exploring the potential & viability of using smart meter / DEHEMS –type technology in residents homes as standard – as a result of seeing the positive impact it can have on residents use of energy & how it can help reduce consumption and bills.

Further details of how DEHEMS partners are developing future work based on DEHEMS can be found on the DEHEMS website.

We are confident that the work that was kick started in DEHEMS will soon become part of the mainstream. People will take their ability to measure energy consumption and modify their behaviour to reduce their carbon footprint and save money for granted.

Informative Links

www.dehems.eu

www.dehems.org/demo.html

www.dehems.eu/reports

http://ec.europa.eu/information_society/activities/livinglabs/index_en.htm

www.ics.uci.edu/~wscacchi/Papers/SE-Encyc/Socio-Technical-Design.pdf

http://en.wikipedia.org/wiki/Living_lab

www.hildebrand.co.uk

www.greenica.net/opencms/opencms/

manchesterismyplanet.com/behavioural-change/the-changing-behaviour-project/behavioural-change-toolkit

www.ami-communities.eu/drupal/node/28

www.ibm.com/smarterplanet/uk/en/smart_grid/ideas/index.html?re=spf

http://tinyurl.com/5utw9zb Literature review for the Energy Demand Research Project, Environmental Change Institute, University of Oxford

Acknowledgements

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List of Partners

The project partnership includes a mix of European local authorities, private business and universities.

United Kingdom: Manchester City Council, Birmingham City Council; Bristol City Council; Clicks and Links Ltd; Coventry University; Hildebrand Technology Ltd; University of Salford

Bulgaria: Ivanovo Municipality; Energy Agency Plovdiv; University of Rousse

Romania: Institute e-Austria Timisoara; Technical University of Cluj-Napoca

Project Results

The project results, including the code used to create the system along with other information, materials and knowledge is available for other researchers to access. Identifying information has been removed and all data is anonymised. As well as the library of project reports, code and data are available in the following areas:

- Carbon Trading / Energy Team Challenge - the code used to create the website
- Dashboard - the code used
- Semantic web and appliance ontology
- Database benchmarking framework for sensor-data storage
- DEHEMS generated processed data for analysis
- Thermal model identification
- Hypertable Distributed DBMS

Details are in the Project's Final Report (D1.3) www.dehems.eu/reports. The website and the repositories will be maintained for two years (2013).