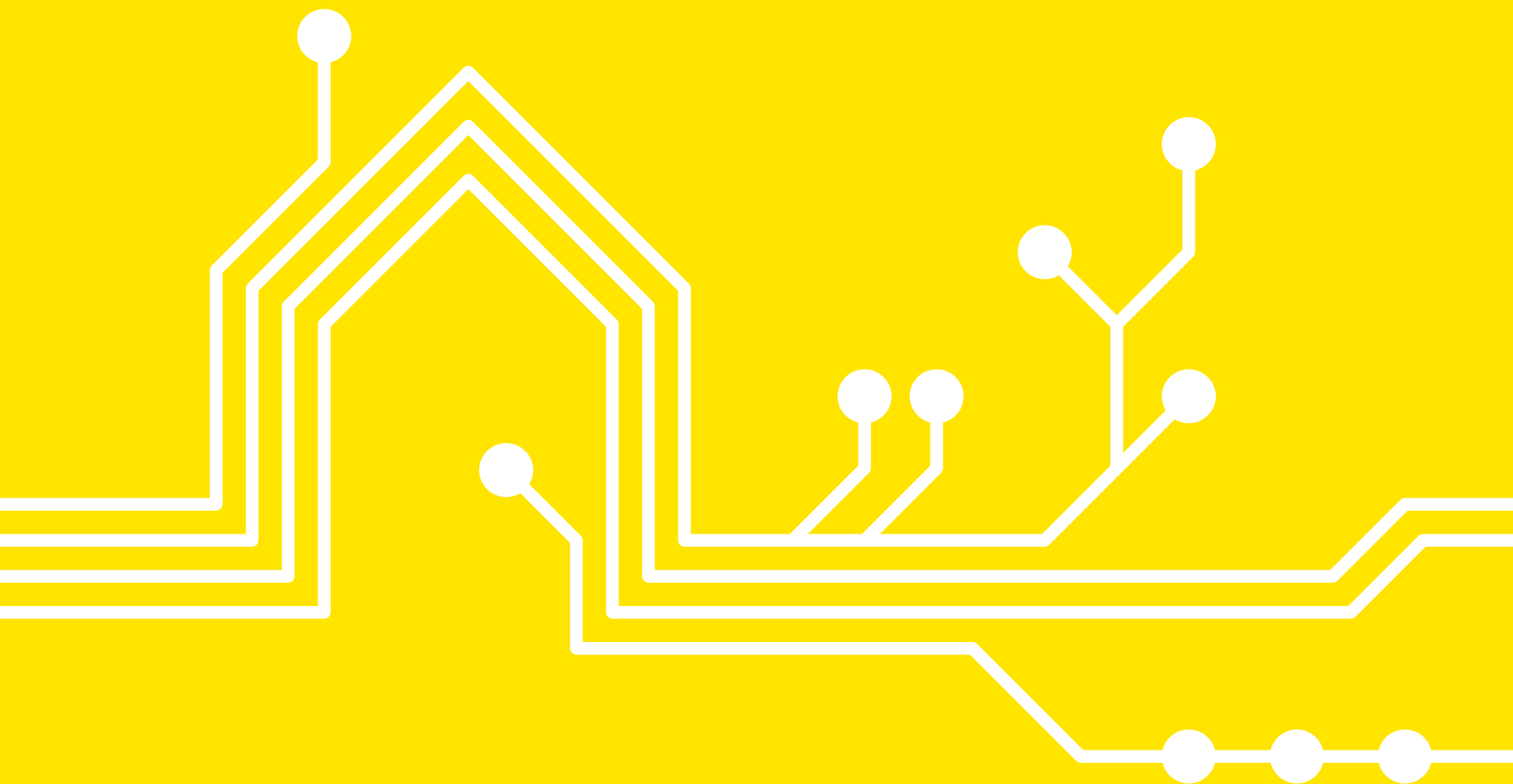


teaching homes to be green: smart homes and the environment

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Green Alliance

Green Alliance is an independent charity. Our mission is to promote sustainable development by ensuring that environmental solutions are a priority in British politics. We work with representatives from the three main political parties, government, business and the NGO sector to encourage new ideas, facilitate dialogue and develop constructive solutions to environmental challenges.

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executive summary

Smart homes crop up far more in conversations about the latest gadgets than they do when talking about energy saving or environmental benefits. But as well as having a place in the futuristic new homes imagined by science fiction, smart technology may help to lower the environmental impact of the homes we live in today. With energy efficiency becoming an increasing preoccupation, smart technology's potential to help will be just as welcome as its ability to make our lives easier.

The government aims to reduce UK carbon dioxide emissions to 60 per cent below 1990 levels by 2050. The domestic sector is responsible for 27 per cent of the UK's emissions, so it is vital that its environmental impacts are addressed as a key contribution to meeting the overall target.¹ Ambitious plans are in place to improve the sustainability of new homes, but improving the environmental performance of existing ones will be more difficult.

Three quarters of the 2050 housing stock is already standing and addressing its environmental impact is as important, if not more so, than improving the sustainability of new homes. But existing homes present greater challenges. Forty three per cent of them have features that are difficult to treat from an energy efficiency point of view, such as solid walls, and even measures that achieve significant improvements have diminishing returns.² Will making homes smarter be the solution?

To answer that question, this report looks at smart features and the impressive claims made about their energy and resource savings. Some companies already promote the environmental benefits of smart features but the area is still relatively unexplored and many claims vary greatly or are hard to verify. This report provides an overview of relevant smart features and explores the nature and extent of their environmental benefits.

It is clear that there are questions to be answered before smart features can be meaningfully incorporated into policy mechanisms that aim to improve the environmental impact of homes. But it is equally clear that smart features do have a role to play in improving the performance of homes and there are already grounds for seeing them as a useful addition to the range of options on offer.

With this in mind, the second half of the report makes recommendations for action. The first recommendation acknowledges the need for a robust evidence base and calls for the government to recognise the environmental potential of smart features and support research to better understand their benefits.

Once that is in place, there are various existing policy mechanisms that can support smart features. The report explores these different mechanisms and the changes that are needed in order for them to recognise and promote the environmental benefits of smart features.

Some smart homes will be the kind imagined by the technology industry, with an extensive home network and a raft of intelligent appliances. But meeting the UK's carbon emission targets requires us to tackle the environmental performance of the draughty, inefficiently heated homes that we live in today. Smart features may have a significant role to play in this decidedly un-futuristic setting and this report aims to shed some light on what that role will be.

summary of recommendations

1. establish the evidence base

We urge the government to recognise the environmental potential of smart features and to commission or support research to establish a robust evidence base for them.

2. get smart electricity meters right

Provide a mandate for smart electricity meters from May 2008 requiring all homes to have one within ten years. Include clear milestones and require the provision of free real time display options to all homes to illustrate consumption.

3. innovate with the way that environmental benefits are assessed

Be innovative and flexible with policy mechanisms in order to recognise and incorporate the environmental benefits of smart features.

4. use new and existing policy mechanisms to support smart features:

existing mechanisms:

- **home information packs (HIPs)**
Require homes to achieve certain energy and environmental performance ratings before they can be sold and recognise smart features in the assessment process as ways to achieve an improved rating.
- **the code for sustainable homes**
Proceed with proposals to strengthen the building regulations in line with the code for sustainable homes and ensure that the assessment process recognises the environmental benefits of smart features.
- **building regulations**
Apply the energy efficiency aspects of the building regulations to the whole home when extensions are being built or significant refurbishment done.
- **energy efficiency commitment**
Introduce provisions to ensure that suppliers take advantage of the innovation activity element of CERT and use it to trial smart features.
- **energy end use and energy services directive**
Provide a mandate for smart electricity meters from May 2008 requiring all homes to have one within ten years. Include clear milestones and require the provision of free real time display options to all homes to illustrate consumption.

new mechanisms:

- **a strategy for existing stock**
Develop a strategy for improving the environmental performance of existing homes so that they can contribute to reducing domestic carbon emissions.
- **an intelligent buildings rating**
Consider including an intelligent buildings rating in HIPS as smart features develop.

5. start educating the supply chain now

Suppliers should provide training and awareness raising to ensure the availability of dependable installers who understand the technologies and promote their benefits.

1 an introduction to smart homes

What is a smart home?

The Smart Homes Project run by the then Department for Trade and Industry (DTI) defined a smart home as “a dwelling incorporating a communications network that connects the key electrical appliances and services and allows them to be remotely controlled, monitored or accessed.”³

The four key aspects of a smart home are:

- an internal network through which devices talk to each other
- intelligent controls for managing the system
- sensors that collect information
- smart features, such as intelligent heating systems, which respond to information from sensors or user instructions⁴

Features and fundamentals

Discussions about smart homes often focus on the aspects that you can see, such as smart appliances. But the essence of a smart home is its internal network, which appliances and systems link into. A networked home is likely to have unobtrusive consoles in each room through which residents can control the systems in their homes. For example, they could set the bath running upstairs whilst in the kitchen, confident that it will run at their preferred temperature and stop before it is too full. Smart homes also allow residents to communicate with their home remotely, for example by using their mobile phone, so that they can do things like turn the heating on as they head home. The South Korean case study on page 7 provides a useful overview of the features that can already be found in smart homes.

It is important to differentiate between fully networked smart homes and smart features, as the latter can work without a home network. For example, a smart electricity meter can be installed and display information on electricity use to residents, as well as communicate with energy suppliers, without a full home network. A full network would be the next step and allow more sophisticated interaction between appliances. It would enable devices like security alarms and heating controls to interact, so that when a resident comes home and switches the alarm off the heating would know that someone is home and turn on automatically. The features discussed in this report can all operate with or without a home being fully networked.

A variety of communication technologies could end up being the basis of home networks. At present there is no clear leader and different systems on the market use different technologies. As smart homes develop it is assumed that one technology will stand out and become standard over time. There is a great reluctance to prescribe which technology works best in the early stages of development and it is beyond the remit of this report to explore this question.

How is it smart?

The features of a smart home are far more visible than its network and tend to be grouped according to their benefits. BEAMA's⁵ smart homes working group has usefully identified four kinds of smart home; green smart homes, lifestyle smart homes, safe and secure smart homes and assisted living smart homes. These have different sets of features, and the rest of the report goes on to look at the environmental ones in detail.

likely features of a smart home:

green

- smart electricity and gas meters
- smart water meters
- intelligent controls for heating, lighting windows and blinds
- efficient water management
- intelligent, networked appliances

lifestyle

- remotely programmable entertainment equipment
- internet access in all rooms
- 'follow-me' TV and music that moves screens and speakers as occupants move through the house

safe and secure

- automatic whole house lock upon departure
- security alerts by phone
- automatic contacting of emergency services
- panic buttons and motion detectors
- carbon monoxide detection
- intruder activated floodlights
- home delivery ports with access code

health/assisted living

- occupant monitoring using motion sensors
- medication reminders
- health monitoring - e.g. when using the bathroom
- height adjustable kitchen units and sinks
- daily routine reminders

examples of smart appliances

- kitchen web console that suggests recipes
- smart refrigerator that checks stock and re-orders over the internet
- oven and washing machine that turn on remotely
- appliances that trigger a service call if broken

Some features of a smart home have benefits in more than one area. For example, water temperature controls help to save energy and are also useful in protecting resident's health and safety, particularly that of older people.

Overall, a smart home is seen as being more:

- secure
- convenient
- resource efficient
- comfortable due to better temperature control
- responsive to your preferences and the local environment
- adaptive to different life stages, with assisted living for older people

2 smart homes today

Broadband internet and digital TV are seen as the first steps towards smart, networked homes, as they have the potential to be gateways into homes for a wide range of smart applications. Their take up has been rapid; by March 2006, 43 per cent of UK homes had broadband internet connections compared to two years earlier when only 15 per cent did.⁶ The take up of digital television is driven by government policy to switch all TV to digital by 2012 and 77.2 per cent of British homes had digital TV in some form by the end of 2006.⁷

The technology industry sees smart homes as the next big thing and many companies have smart or digital home programmes. But analysts argue that consumers' key concerns are still simple problems, like getting all the computers in a house to link to the same printer.⁸

Other than the most technology literate or the very wealthy, consumers do not yet seem to be demanding the advantages of networked homes. Smart homes are therefore more likely to evolve as people purchase different features that link up to each other over time, rather than through an instant technological upgrade.

Even so, many companies and groups are already looking ahead to fully smart homes. The Automated Home initiative (TAHI) aims to “promote, provide the environment for and launch large scale deployments of ‘smart houses’ and the services...for them so that people can see and experience the benefits the connected home can bring and demand them for themselves.”⁹ Their working groups look at different aspects of smart homes and want to avoid features developing in isolation, as the ability of smart features to communicate and work together through a home network will be essential to their desirability. TAHI has been feeding in to the European level development of a smart homes specification, as well as developing a mark of interoperability.

A number of BEAMA members already produce smart home technology and the association has a smart homes working group. It sets out what a smart home is, what it can offer and the technologies available on a comprehensive website that promotes their members and provides developers and homeowners with information. Such initiatives will be increasingly important to the development of smart homes, as features start to become commonplace.

Smart homes around the world

The smart homes market in most developed countries is similar to that of the UK, with some key exceptions. South Korea is a clear leader in this area and looking at their achievements illustrates the real potential of smart homes.

Smart homes in South Korea¹⁰

Following a financial crisis in the 1990s South Korea invested heavily in developing innovative technology. They have introduced the world to the internet fridge, oven and washing machine and are a laboratory for developing the home of the future. This will help to solve their domestic challenge of dealing with a greying population, as well as providing them with massive export opportunities.

In 2007 the Ministry of Information and Communication will have invested approximately £247 million in supporting the development of original information technology (IT). Part of this will support home networking, which has already received loans to develop 44,000 networked homes. The ultimate aim is to network 10 million homes, with plans to introduce a home network building certification system.

South Korea's investment in networking is such that they are increasingly looking beyond the smart home to the smart city. The networked home strategy is now part of a larger project to network entire cities, called U-city, which is being promoted by around £11.5 million worth of subsidies to local government bodies and the construction and housing sectors. Dongtan New Town, Korea's first U-city, is being tested from March 2007 and all 1,010 residential units will be networked from 2008.

Home networks in South Korea are provided by LG Electronics' HomNet product or Samsung's HomeVita. Lotte Castle apartment complex in Seoul is an example of fully networked homes. They have wireless broadband and a HomNet environment that is controlled via TV, a remote control or a keyboard. Cameras relay real time images from other areas of the home and the outdoor playground, DVDs can be copied onto the home's hard drive, gas and electricity use is tracked, a health monitor checks blood pressure, body temperature and heart rate and there are on-screen controls for the washing machine, the microwave, the air conditioner and the oven.

The entire home can be controlled remotely by mobile phone and residents will be notified of any problems, such as the gas being left on, and can get real time images of their home over the phone.

Other networked homes have voice activated controls, refrigerators that can update residents on their contents and mirrors that display their daily appointments, as well as toilets that send health updates to their doctor.

The focus of smart homes in South Korea is to make life easier, rather than environmental benefits. But as the environmental performance of homes becomes increasingly important in Europe, a key export market, these aspects are likely to be developed and highlighted. The UK's pursuit of smart homes will be nowhere near as single minded but it does demonstrate what is possible and provide scope for applying South Korean innovations to our environmental ambitions.

Smart homes in the UK

Smart homes in the UK can be found at extreme ends of the housing spectrum. Wealthy homeowners looking for the latest technology to manage their homes have been installing smart networks and smart applications are also being put into social and sheltered housing because of their healthcare and energy efficiency benefits.

An organisation called Integer has spent over a decade looking at how buildings can be intelligent and green. It has installed smart features and systems in a number of new housing developments because of the environmental benefits that they offer. They have also demonstrated the potential for retrofitting existing homes to make them smarter and to lower their environmental impact.

Getting smart in Elephant and Castle¹¹

The £1.5 billion Elephant and Castle regeneration scheme in central London, to be completed in partnership with developers Lend Lease Europe in 2014, is a low carbon scheme for 6,000 new homes, retail and public use buildings. Smart features will be a key aspect of its efforts to be sustainable along with a district heat and power network.

The specifications for developers include putting smart design into the houses. The aim is to connect the entire development to a network that will enable energy management and smart building technology, as well as the next generation of entertainment and internet connectivity. Smart electricity, heat and water metering are key features of the development.

Sustainable development manager, Tony Moseley, sees the smart features as having huge environmental benefits because lights will turn off automatically when rooms are empty and air conditioning and heating won't be used in areas where they aren't needed. Overall, he aims to utilise the smart features to avoid unnecessary energy use as much as possible, as well as encouraging residents to become more aware of their resource use and to change their behaviour.

The development is particularly progressive because it will provide smart features to both social and private housing. The energy efficiencies and carbon savings offered by the smart features were key factors in Southwark Council's decision to include them, as well as the enhanced community safety that smart features can offer. In addition, the cutting edge communications technology will hopefully make it easier to attract business and residential tenants.

The Elephant and Castle project demonstrates the contribution that smart features and networking can make to the sustainability of housing and it is encouraging to see projects that are leading the way by incorporating smart features in new developments from the start.

The mass housing market is between the extremes of high-end mansions and social housing. The average homebuyer is not demanding smart features and developers have no interest in a home's performance once it is sold, so they have no driver to install energy saving smart features. In a survey looking at the market for smart homes, building contractors felt that they would remain a rarity except in high-end properties. They were also sceptical about the potential of smart retrofitting, believing it will remain a niche area.¹²

In contrast to this pessimism, smart home contractors and manufacturers are very positive, regarding “the forward march of the intelligent home as almost inevitable.”¹³ Academics were also positive in the survey on the market for smart homes but did note that there is little reliable evidence that capital expenditure will be meaningfully offset by household efficiency gains and cost savings.¹⁴ This is a crucial point, as it highlights the continuing scarcity of reliable and consistent evidence about the energy and resource savings that smart features can deliver.

3 smart features with environmental benefits

This section looks in detail at green smart features. They include:

- smart electricity and gas meters
- smart water meters
- intelligent controls for heating, lighting, windows and blinds
- efficient water management

3.1 smart electricity meters

Smart electricity meters are the feature most likely to be commonplace within the next ten years. They will be the test-bed for other smart applications and provide gateways into the home for other uses.

A meter measures energy consumption. Most are ‘dumb’, meaning that they require manual readings. There is no definition of a ‘smart’ meter, although suppliers have agreed a common specification. Generally, smart electricity meters are capable of two-way communication between a home and a supplier. They can measure and record consumption data, often at half hourly intervals, which they transmit to the supplier and store in their memory in order to build up usage patterns and display to residents in the home. The information enables suppliers to provide accurate bills and informs residents about their consumption.¹⁵

The main environmental benefits of smart electricity meters are their potential to:

- reduce consumption
- reduce peak demand
- assist microgeneration

Reducing consumption

Smart electricity meters will be able to record and present consumers with information on how much electricity they use and it is assumed that this will prompt people into reducing their consumption. The data can be presented through a variety of means, including a display unit connected to the meter, through the TV or over the internet. Smart electricity meters will also enable suppliers to provide accurate bills (instead of estimated ones) and this is expected to further raise awareness of energy use and lead to reductions.

The key question is therefore, how much energy can smart electricity meters save? Reducing domestic carbon dioxide emissions is the main reason for the government’s focus on them, but the extent of the reduction offered is still uncertain. Installers frequently say that smart meters will reduce electricity use by 10 per cent, a simple and attractive figure, but in fact the studies behind the figure vary widely.

Various international trials have provided consumers with information on their energy use and assessed whether their consumption fell. Not all of them involved smart electricity meters but all of their findings have been used to make assumptions about the savings they will deliver, even though many trials took place in countries with very different conditions to the UK. The table below sets out the different findings, but its greatly varying results only serve to demonstrate the lack of clarity available on the energy savings that smart electricity meters will deliver.

an overview of energy saving trials around the world¹⁶

trial	reductions in domestic energy use	notes
An International Energy Agency review of trials	10 %	This is an average figure, the individual trial results varied widely
Norway – a trial gave consumers information on energy use	8 – 10 %	Did not involve smart electricity meters, the climate is much colder and all homes had electric heating, which is less common in the UK
Canada	7 – 10 %	The climate is very different
Out of 21 trials that provided consumers with direct feedback on energy use, consumption fell in 15 of them	5 – 14 %	Not all trials involved smart electricity meters, sample sizes and frequency of feedback varied widely and the higher reductions were only achieved when feedback was combined with advice giving
Northern Ireland	3 %	This did not involve fully smart electricity meters and was pre-payment meters only
Norway – the same trial used their results to estimate savings in homes without electric heating	0 – 5 %	
Expected savings in the UK	1 – 3 %	This figure takes into account the varying characteristics of the trials and their contexts

Judith Ward and Gill Owen's review of the above trials takes their specific characteristics and the variety of results into account and concludes with a conservative estimate that the UK can only expect 1 - 3 per cent reduction in domestic energy use from smart electricity meters.¹⁷ They restated this conviction in their final report on their work¹⁸ but noted that, although a one per cent saving sounds small, it would still constitute an eight per cent contribution to the UK's target of reducing domestic carbon emissions by 20 per cent below 1990 levels by 2010.¹⁹

The real key to understanding the potential of smart electricity meters in the UK is the Energy Demand Research Project. This two year project will be underway from late 2007 and will test various methods of providing consumers with feedback on their energy use, including more informative bills, display units to show use and smart electricity meters.

Reducing peak demand

Smart meters are able to automatically shift between different tariffs throughout the day, with higher prices charged at peak times. This could prompt people to shift their activities, for example, doing their washing during the day when electricity is cheaper. This will become easier as appliances become more intelligent and can be set remotely.

The main benefit of reduced peak demand is the potential to defer or avoid infrastructure investment. Environmentally, shifting demand may also lead to an overall drop in consumption, but experience varies:

- a Californian trial did not see an overall drop in demand
- a Norwegian trial found overall reductions in both the morning and afternoon peak times of 12 and 14 per cent
- a study of 16 trials found a 4 per cent average reduction in overall use²⁰

The energy demand research project mentioned above will also be testing the variable tariffs that smart electricity meters enable and will significantly clarify the reductions in energy use that can be expected in a UK context.

Microgeneration

An additional attraction of smart electricity meters is their ability to monitor and administrate the export of electricity to the grid from homes generating their own energy on site. This will be of increasing value as microgeneration becomes more widespread.

Progress so far

The government aims to see smart electricity meters in all homes within the next ten years (ie by 2017). This ambition was set out in the 2007 energy white paper and was followed by a consultation on metering and billing in the late summer.²¹ The main driver is the reduction in domestic carbon dioxide emissions that smart electricity meters are expected to provide.

In addition, the UK has to comply with the EU Energy End Use Efficiency and Energy Services Directive by May 2008 and it is widely seen as a key opportunity to promote smart meters. As long as it is financially reasonable, the directive requires:

- meters that accurately reflect energy consumption and provide information on time of use
- billing based on actual consumption that is presented simply and frequently enough for customers to regulate energy consumption²²

Smart electricity meters are the obvious way to comply with these requirements. When paired with a display unit they will fulfil the first requirement and they will allow suppliers to meet the second, as consistently accurate and informative bills will only be possible once suppliers can remotely obtain meter readings through smart electricity meters.

Smart electricity meters are also key to the government's vision of a shift in the energy industry to a business model where it becomes profitable for companies to work with their customers to lower energy use.²³ Suppliers will need the information that smart electricity meters provide on how their customers are using energy if they are to work with them to reduce their use.

For these reasons we would like to see the government provide a mandate for a smart electricity meter roll out from May 2008 that requires smart electricity meters in all homes within 10 years. The roll out will not happen immediately, but setting a requirement will be an important first step that will enable energy companies to start making real progress. In the context of smart homes, smart electricity meters are a critical first step in enabling the spread of other smart features.

3.2 smart gas meters

Smart gas meters have had far less focus and have frequently been considered in conjunction with smart electricity meters. Once smart electricity meters are in place the easiest way to provide consumers with consumption information on gas would be for the gas meter to share the electricity meter's display unit. Rolling out smart electricity meters is therefore the crucial first step in getting smart gas meters and dual fuel households will probably be the initial focus.

Three quarters of domestic carbon emissions come from heating and hot water use,²⁴ but this consumption will only register with people when their gas consumption is displayed alongside their electricity use. So smart gas meters, with their ability to raise awareness of consumption and to prompt reduced use, will be needed in order to make real inroads into reducing domestic energy use. They will also help to maximise the potential of other smart features, such as intelligent heating controls. Information on daily gas usage combined with the ability to control it better will have a significant impact on peoples' consciousness of their heating and hot water use. So far though, little research has been done to explore these savings.

3.3 smart water meters

The development of smart water meters has also not progressed as quickly as smart electricity meters, as the debate on whether to universally meter water is still underway. Only a quarter of UK homes are currently metered and a negligible percentage of these have smart water meters.²⁵

The potential environmental benefits of smart water meters are their ability to:

- reduce consumption
- reduce peak demand
- detect leaks and increase efficiency

Metering trials conducted since 1970 have consistently resulted in water use falling by 5 - 21 per cent. It is generally assumed that water meters can reduce demand by an average of ten per cent by making people more aware of how much water they use.²⁶ Smart water meters have the added benefits of being able to provide more detailed information on consumption and presenting it in a more user-friendly way, as well as enabling variable charging to reduce peak demand.

The size of the UK's water system (number of reservoirs and pipes) is determined by peak demand in the summer, but it is driven by a small percentage of the population

with very high consumption. Their use requires higher capital investment in infrastructure, with the associated environmental impacts, and the costs are passed on to the whole population. It would be preferable to introduce a higher tariff in summer which would be applied above a certain level of use. People would therefore pay more for discretionary use (e.g. excessively watering gardens or filling paddling pools every day), which is likely to reduce overall demand. Smart meters would be required for this, as 'dumb' ones would not be able to assess consumption patterns against the seasons and differentiate between discretionary and necessary use if, for example, consumption is high because of large family.

Smart water meters can also detect leaks in homes by measuring flow rate. Current estimates suggest that one third of water leaks are in domestic properties, where customers are responsible for them. A smart water meter could highlight them and prevent ongoing wastage once the leaks are mended.

Progress so far

Water companies have been looking at water meters more thoroughly due to increasingly frequent water shortages and the potential for smart water meters to help reduce capital investment requirements is a further incentive. The Environment Agency aims for 70 per cent of homes to have water meters by 2030²⁷ and the water industry is in general agreement with this. If they are to go for water meters on this scale it makes sense to go straight to smart ones, although not all will. Companies are also mindful of the EU Energy End Use Efficiency and Energy Services Directive and the possibility that similar metering and billing requirements will be placed on them, which makes smart meters yet more attractive.

Work is underway on developing a common data specification for smart water meters but the regulator, Ofwat, needs to be confident that meters will deliver a ten per cent reduction in water demand to justify passing the costs of smart meters on to consumers. This highlights the need for more consistent and sustained research to confirm the data.

And even with sound evidence of a ten per cent drop in consumption from a trial, unexpected weather may still change peoples' behaviour. They may be willing to pay far more for water to maintain their gardens during a very hot summer, despite more expensive variable tariffs, than a trial that took place in a mild summer may suggest. Suppliers need to have confidence that consumption will fall, whatever the weather, as it will influence decisions about whether to invest in additional water supply capacity.

Progress is required to confirm the extent of the savings that smart water meters offer and to address the complexities created by uncertainty about peoples' behaviour. But they will be the missing piece that will provide households with a full picture of their resource use alongside smart electricity and gas meters.

3.4 intelligent heating controls

Intelligent heating controls (which can also control cooling, such as air conditioning) can be seen as a step beyond smart meters. Smart meters make people aware of their energy use, while intelligent heating controls allow residents to refine their energy use to heat and cool their home in the most efficient way possible.

Intelligent heating controls have two key areas of environmental benefit:

- 1** improved control:
 - set time and area preferences, e.g. keeping bedrooms cooler than the rest of the house
 - control heating remotely and automatically turn it off when a house is empty
- 2** improved efficiency:
 - adjust when the heating switches on throughout the year and respond to outside temperature changes on a daily basis
 - detect occupancy levels to turn heat off in unoccupied areas
 - monitor temperature with a sensor in every room, not just one for the whole house
 - enable more efficient boiler operation

Enabling households to interact more closely with their heating controls, particularly when combined with information from smart meters, will help to raise awareness of energy use and prompt reductions, although this will rely on residents being motivated to engage with the system. But intelligent controls can also deliver energy savings independently of resident involvement by improving the efficiency of the way that heating systems operate. Further benefits will be the ability to integrate and optimise the efficiencies of low carbon systems like solar hot water heating.

Firm evidence on the expected energy savings is hard to obtain. Much of the industry does not have any evidence, as energy efficiency is not yet a selling point for their customers. Control systems in commercial buildings have delivered up to 30 per cent savings, but this is not expected in a domestic setting where systems are smaller and individuals have far greater control over the settings. Research is currently underway to clarify what the expected savings are likely to be. Once this is clearer, controls have the potential to become a serious option for improving a home's energy efficiency, especially in existing homes where easier energy efficiency options may not be feasible or in homes where the easier options have already been implemented. They can be retrofitted with minimal disruption and will also become more attractive as people become familiar with other intelligent applications, like smart meters.

3.5 intelligent lighting controls

The amount of electricity used to light UK homes has nearly doubled since 1970.²⁸ The phase out of incandescent light bulbs will help to address this and intelligent lighting controls can offer further energy savings.

The environmental benefits of lighting controls include their ability to:

- have lights turn on and off automatically when people enter or leave a room
- respond to night time movement, to avoid leaving lights on all night
- adjust lights in response to daylight levels

Companies focussing on the energy saving potential of intelligent lighting controls maintain that they can reduce the energy used for lighting by between 30 and 45 per cent, but few companies have any data on this.²⁹ And with controls often focussing on dimmers and mood lighting for each room, much of which is not strictly necessary and often uses energy intensive halogen bulbs, there is a danger of them increasing energy use. As systems begin to incorporate low energy light bulbs

this risk will decrease and if, in future, controls are linked to a display of energy use, people will become more aware of how their lighting preferences affect their overall energy use. Energy savings will vary between homes because of different preferences, but certain aspects will deliver guaranteed savings with minimal resident interaction.

Lighting control systems are currently more common than intelligent heating systems and will become more widespread as the incentives for smart features improve and controls start to be offered as part of a package.

3.6 solar gain and cooling controls

These relate to windows and awnings. Awnings can be set to go up and down in relation to direct sunlight in order to warm rooms with maximum sunlight exposure in winter and to prevent rooms overheating in the summer. Window glass can have a function that switches them from clear to opaque to manage the amount of direct sunlight hitting a room to optimise room temperature. Windows can also be set to open and shut in relation to internal and external temperatures.

There is no real data on the energy savings that these controls offer, but they can have a useful contribution to lowering a home's environmental impact.

3.7 water efficiency features

These include hands free taps that switch on and off in response to movement, reducing wastage, although they are rare in a domestic setting. Recent developments also include digital showers which have a 'warm up' function to prevent wastage while the flow warms up, can change flow rates and can automatically turn the shower off after a set period of time. These functions can be used to change habits and save water.

Grey water recycling is becoming more common in homes and intelligent controls can measure the amount of water being collected and used and automatically add the required amount of disinfectant to the process.³⁰

The market for domestic water efficiency features is currently small but this may gradually change as the code for sustainable homes is applied to building regulations and developers look to make more water efficiency improvements (see chapter 6).

3.8 possible tensions

It is easy to assume from the above that smart features offer guaranteed environmental benefits if used to their full potential. But smart features can also increase the environmental footprint of a home. As discussed, intelligent lighting controls have the potential to increase energy use because of their 'lifestyle' aspects. The mainstream press about smart homes focuses on their improved entertainment offerings and they have been the motivation for many of the high-end installations, with things like heating controls added in as extras. But smart entertainment options include things like follow-me TV, which moves from room to room as occupants move around their house and therefore requires the installation of numerous energy intensive plasma screens.

Academics and those in the industry who are looking at smart applications from an environmental angle have been working to highlight this tension. The smart homes trade association, CEDIA,³¹ has been receptive to the agenda and are aware that energy consumption will be an increasing factor in consumer decision-making. They

make the point that energy savings from smart features will go some way towards offsetting any increased energy use in other areas, but they are also keen to position their technologies as solutions to climate change, not contributors to the problem. As the environmental benefits of smart features become more desirable, manufacturers of the more energy intensive smart applications are likely to seek ways of reducing their energy consumption in order to remain attractive to consumers.

4 policy context

Smart features clearly have a role to play in improving the environmental performance of homes, but the evidence base is not yet robust enough. As a result, there are no real incentives to pursue them and the market remains very small. We would like to see their benefits clarified; how do they deliver environmental benefits? In what circumstances are they most effective? And what contribution can they make to achieving environmental goals? Once this gap is addressed smart features can have a higher profile in efforts to tackle the environmental performance of UK homes, both new and existing, and be more meaningfully incorporated into existing policy mechanisms.

Why look at smart technology

The energy performance of existing homes is a key reason to look at smart features more closely. The UK target is to reduce carbon emissions by 60 per cent below 1990 levels by 2050. And with the domestic sector accounting for 27 per cent of the UK's carbon dioxide emissions, reducing emissions from homes will be essential to this effort.³² Zero carbon homes, stronger building regulations and the code for sustainable homes are key approaches, but they only apply to new homes. To have a realistic chance of reducing domestic emissions by 60 per cent the energy performance of existing homes has to be addressed as well.

But existing homes have had very little attention, despite the fact that two thirds of 2050's housing stock is already built.³³ Communities and Local Government (CLG) is reviewing the sustainability of existing buildings, but Gordon Brown (as Chancellor) only addressed the issue in March 2007, saying "I announced that within ten years all new homes would have to be zero carbon...But new homes are only a small percentage of the total...Over the next decade my aim is that every home for which it is practically possible will become low carbon."³⁴ It is this prospect that excites proponents of smart homes.

If incentives are introduced to improve the environmental performance of existing homes the demand for smart features is likely to grow. Forty three per cent of UK homes have at least one 'hard to treat' feature, such as solid walls.³⁵ This leaves a large percentage of homes unable to take easy, subsidised options like cavity wall insulation. Many homes also face planning permission barriers or conservation area restrictions. Homeowners in such situations do not currently need to seek alternatives, as there is no onus on them to improve their home's environmental performance. But if they have incentives to improve their efficiency, smart features will become attractive additions to the range of energy efficiency options available.

The general prominence of smart features as environmental solutions will also grow once easier measures have been widely implemented. The interim report from CLG's review of existing buildings notes that improving homes has "diminishing marginal results in terms of incremental carbon saving...once the cheapest (and usually

easiest) measures have been fitted (e.g. cavity wall insulation and loft insulation).”³⁶ New solutions will be required if the government wants homes to continuously improve environmental performance, and smart features are likely to fit the bill.

What of the cost?

The CLG review does raise the issue of cost, noting that “further improvements to the energy performance of a property becomes relatively more expensive.”³⁷ Even as the cost of smart features falls, options like insulation will always be cheaper. But the cost of smart features will be balanced against the incentives available and any requirements to improve environmental performance that builders or homeowners become subject to. Costs will also fall if energy suppliers start to subsidise smart options more frequently as part of their commitments to improving domestic energy efficiency.

It is also important to note that the market for smart homes and features has much stronger drivers than environmental benefit. Technology, electronics and communications companies all want to promote smart, networked homes and they will drive the market, along with consumers’ never ending desire for the latest gadget. The demand for environmental smart features may grow by association, as people put home networks in place and look to plug in the different features on offer. As smart features become more common people may also start demanding them in new homes, prompting developers to include them and significantly increasing their market.

5 recommendations for action

For the potential benefits of smart features to be realised a number of steps need to be taken. Below, we discuss our recommendations for action.

summary of recommendations

1. establish the evidence base
2. get smart electricity meters right
3. innovate with the way that environmental benefits are assessed
4. use new and existing policy mechanisms to support smart features:
 - existing mechanisms:
 - home information packs
 - the code for sustainable homes
 - building regulations
 - energy efficiency commitment
 - energy end use and energy services directive
 - new mechanisms:
 - a strategy for existing stock
 - an intelligent buildings rating
5. start educating the supply chain now

1 establish the evidence base

The key barrier to a greater profile for smart features in energy and resource efficiency discussions is the lack of a robust evidence base about the benefits they will deliver. They clearly have a role to play in lowering the impact of homes but their benefits need to be better quantified and understood. This is essential if smart features are to be recognised as environmental solutions.

Progress is already being made for some features, with the government and energy suppliers working on large scale trials of smart electricity meters. This is a crucial first step because, as we argue below, smart meters will be critical to the success of smart features in general. Various demonstrations of smart homes or specific features have been carried out by individual companies, put into test homes or explored in a commercial context. But the environmental benefits of smart technology in a UK domestic setting has rarely been a focus of research and studies have not been brought together.

For this reason, further research and trials to clarify the environmental benefits of smart features in a domestic context are needed. Initiatives like the BEAMA smart homes working group acknowledge this when stating their desire to get the different technologies in a test house to monitor their performance over time. Sustained and thorough research in a UK context is central to taking advantage of the environmental benefits that smart features offer.

Existing avenues

Some useful opportunities for research do already exist, although they alone will not be enough to provide the necessary evidence base. The first opportunity lies with the energy efficiency commitment (EEC), which will become known as the carbon emission reduction target (CERT) from 2008. Under CERT, suppliers will be able to meet a portion of their commitment through innovation activity. These will be newer energy efficiency measures where it is necessary to explore and confirm their carbon emission reductions and where savings are dependent on behavioural change. Suppliers will not be penalised if the measures fail to deliver the expected savings and, once their carbon savings are established, the measures in question can be added to the general range of measures recognised by CERT.³⁸ This will be ideal for exploring the energy efficiency benefits of smart features and we strongly encourage energy companies to take advantage of this aspect of CERT to undertake trials of smart features.

The second opportunity is the Technology Strategy Board's (TSB) low impact buildings innovation platform. The TSB is an arm's length non-departmental public body that works with UK science and industry to develop leadership and markets in sectors that can respond to societal challenges. It also helps sectors develop in order to meet the challenges set by government policy. Lowering the environmental impact of buildings is a key challenge and, with a strong building sector in the UK, is an area that the TSB has chosen to focus on.

Their work recognises smart features and smart homes as ways to lower the impact of buildings, but it has also identified the barriers that they face. When examining the current status of possible solutions, all of the smart features listed fell into the 'needs improvement' or 'needs demonstrating' area, and full smart home demonstrators fell into the 'not available section'.³⁹ Whilst the TSB's work will provide some support for addressing these gaps, we would like to see central

government recognise the need to explore the contribution that smart features can make to environmental goals.

Funding for smart technology demonstration projects could also be accessed through the environmental transformation fund, which is a Defra/ BERR source of funding for projects that innovate and support the development of low carbon technologies and remove barriers to energy efficiency. Low carbon buildings is an area that the fund will support projects in.

We urge the government to recognise the environmental potential of smart features and to commission or support research to establish a robust evidence base for them.

2 get smart electricity meters right

Smart electricity meters are a crucial first step towards smarter homes. They will have a key role in familiarising people with smart technology and the ways it can help them to lower their environmental impact. They will also enable a variety of other smart features, such as smarter gas meters. This is key to tackling the impact of UK homes, as three quarters of domestic carbon emissions come from heating and hot water use.⁴⁰ In the longer term, there is potential for smart electricity and gas meters to link up with water meters, which will then provide a complete picture of a home's resource use.

The consumption information provided by smart utility meters will also enhance the effectiveness of other features, such as intelligent controls. People will be able to decide on settings for their smart heating systems based on detailed consumption information that will help to identify areas for saving and allow people to monitor the impact of their settings.

Smart electricity meters are therefore crucial to whether homes become more intelligent. The government aims to see them in all homes within the next ten years (ie by 2017)⁴¹ but much more clarity is needed about how this will be achieved. We would like the government to set a mandate in May 2008 requiring all homes to have smart electricity meters within 10 years, as this will allow energy companies to start addressing the communications and logistical challenges of a roll out. To ensure that progress is made as soon as reasonably possible, the mandate should include clear milestones against which progress can be measured.

We would like to see the roll out require suppliers to offer consumers a range of real time display options, free of charge, in addition to the smart meter. The current Energy Demand Research Project will provide useful evidence to inform decisions as to what the most effective range of display options will be.

Provide a mandate for smart electricity meters from May 2008 requiring all homes to have one within ten years. Include clear milestones and require the provision of free real time display options to all homes to illustrate consumption.

3 innovate with the way that environmental benefits are assessed

Smart features are unique in their delivery of environmental benefits, as they are influenced by the way that residents engage with them. Cavity wall insulation will deliver a quantifiable amount of energy saving regardless of occupant behaviour. Intelligent heating controls, for example, will not, as their benefits depend on the settings that residents decide on.

Many smart features will deliver a certain level of environmental benefit regardless of resident activity. In addition, if people install smart features because they are required to improve the environmental performance of their home, they will have a pressing incentive to make the most of the benefits that smart features can offer.

But the impact of residents' behaviour still needs to be addressed when seeking to incorporate smart features into existing policy mechanisms and assessments. Many of the policies discussed below use a set of assumptions that are inappropriate for smart features. These assumptions will need to be rethought once there is clarity on the benefits of smart features and they start to have a higher profile in efforts to improve the environmental performance of homes.

Be innovative and flexible with policy mechanisms in order to recognise and incorporate the environmental benefits of smart features.

4 use new and existing policy mechanisms to support smart features

Various policy mechanisms already exist that could support smart features, particularly once their benefits are better understood. These will help to raise the profile of smart features and firmly place them in the range of options available for lowering the environmental impact of homes. Some new approaches will also help to support smart features.

The existing policy mechanisms discussed are:

- home information packs
- the code for sustainable homes
- building regulations
- energy efficiency commitment
- energy end-use efficiency and energy services directive

The new mechanisms discussed are:

- a strategy for existing stock
- an intelligent buildings rating

Home Information Packs (HIPs)

HIPs are mandatory when selling homes with three or more bedrooms and a roll out to the rest of the market is expected at some point. HIPs are prepared by sellers for homebuyers and include an energy performance rating, based on the fuel costs of running a home, and an environmental impact rating, based on carbon dioxide emissions. Both ratings will be familiar to people, as they are the same design as the energy efficiency ratings seen on white goods. The assessment process will set

out the running costs of a home and the intention is to make low impact, energy efficient homes more desirable because of their lower running costs. Homes will receive ratings from A (most efficient) to G (least efficient) with specific aspects of the homes, such as the walls or roof, rated separately and the running costs broken down into heating, lighting etc. The assessment will include recommended measures to improve energy efficiency and the expected cost savings.

Sellers do not have to achieve a certain rating in order to sell their home, but this could change and would be a key way to incentivise environmental improvements. Alternatively, purchasers could be required to implement a certain number of the assessment's recommendations within two years of purchase. This would increase the market for a wide variety of energy saving options and, with a solid evidence base in place, smart features will be a useful addition to the range of options available to homeowners.

Smart features and HIPs

Smart meters are likely to assist the rating process, as they will be measuring, recording and displaying a home's resource use. But if smart features are to become a viable option for homeowners looking to improve their rating, the assessment process will have to recognise them as ways of improving environmental performance.

CLG did consider including smart features in the assessment process but they settled on measures that deliver guaranteed levels of energy saving, whereas definitive values can not yet be assigned to smart features. This is a fast changing area though and the list of features included can change. Further research will strengthen the case for smart features and other features will have to be included once conventional options like wall insulation become more widespread.

The assumptions behind the energy ratings present a more fundamental barrier, as they assume certain conditions in a home in order to compare the energy savings delivered by different options. But smart features deliver savings in a different way. Rather than assuming that a home is heated to 18°C for 16 hours per day on a weekend (as the assessment does) and then comparing savings, the benefit of smart features is that a whole home would not be heated unnecessarily if only a few rooms are in use, or if people are not even at home. The impact of behaviour change on the savings delivered will also need to be considered.

The assessment process will therefore have to become more flexible so that it can recognise the environmental benefits of smart features. But it is crucial that it does, as the assessments in HIPs are one of the few mechanisms that cover new and existing homes, where smart features have a lot to offer.

Require homes to achieve certain energy and environmental performance ratings before they can be sold and recognise smart features in the assessment process as ways to achieve an improved rating.

Code for sustainable homes

The code came into effect in April 2007 and sets national standards for the sustainability of new homes. It has six levels, with minimum standards of energy and water efficiency that have to be achieved at each level, as well as a range of additional points that can be gained for other sustainability measures. The code covers:

- energy/carbon performance
- water use
- materials
- surface water run off
- waste
- pollution
- health and well being
- management
- ecology

After a positive response to the CLG's proposal to make a code rating mandatory from 2008, they are consulting on further details. Developers can have their homes assessed against the code and inform purchasers of the level achieved. Alternatively, purchasers will be informed that their home only meets building regulations standard and effectively has a zero rating against the code. This aims to raise awareness of a home's environmental features among consumers and make sustainability a greater factor in decision-making. To avoid confusion, the rating will be linked with the energy performance assessment of new homes and is likely to be presented in HIPs.

Homes will not be required to meet a certain level of the code. But the government's 2006/07 consultation, *Building a greener future: towards zero carbon development* proposes strengthening the building regulations in line with the code so that, over time, new homes automatically reach ever higher levels of the code just by meeting building regulations.

The consultation suggests strengthening the building regulations to achieve a:

- 25 per cent improvement by 2010 = all new homes meet code level 3
- 44 per cent improvement by 2013 = all new homes meet code level 4
- zero carbon by 2016 = all new homes meet code level 6⁴²

Is the code smart?

Smart features are not singled out in the code's assessment as a way of gaining additional points, but this could change when the savings delivered by smart features become clearer.

The real opportunity for smart features in relation to the code lies in the minimum energy and water efficiency standards at each level. As the building regulations get tougher and higher standards of the code have to be met it will get increasingly challenging to build homes that meet the minimum requirements for each level. Once house builders have included the easier options for improving energy and water efficiency they will be looking for solutions that enable them to deliver the further improvements that they require. Smart home proponents believe that they will be able to offer the final set of savings that house builders will be looking for.

This view is also reflected in the Technology Strategy Board's motivation for looking at smart features, as they are aware that the building industry will need support in meeting the challenges presented by these policy proposals. As with the energy and environmental assessments of homes discussed above, the code will have to display flexibility in incorporating smart features into the process and recognising their benefits. But it is vital that it does, as smart features will have an increasingly important role to play the higher the level of the code that builders have to meet.

Work on this area is already underway. The Centre of Excellence for Intelligence in Buildings has set up a homes and communities taskforce whose initial focus is an examination of how smart features can contribute to meeting different levels of the code and it will be reporting on its initial findings in March 2008.⁴³

Proceed with proposals to strengthen the building regulations in line with the code for sustainable homes and ensure that the assessment process recognises the environmental benefits of smart features.

Building regulations

Merging the building regulations with the code for sustainable homes provides a significant opportunity for the take up of smart features, but these developments will only cover new homes. There are also opportunities for using the regulations to improve the energy performance of existing stock. Amendments to the Sustainable and Secure Buildings Act allow CLG to require homes that are changing occupancy or doing large scale building work to bring the rest of the home up to the building regulations standard on conserving fuel and power.⁴⁴ So far, CLG has not chosen to enact this.

Other suggestions include requiring homeowners building extensions or doing significant refurbishment to bring the rest of their home up to a certain energy efficiency standard (based on the code or the energy performance assessment in HIPs). This would guarantee whole-home improvements in energy efficiency and smart features will be a good solution in homes where that is a challenge.

Apply the energy efficiency aspects of the building regulations to the whole home when extensions are being built or significant refurbishment done.

Energy efficiency commitment (EEC)

EEC requires all energy suppliers with over 50,000 customers to deliver energy savings in their customer's homes. This contributes to carbon emission reduction targets by improving the energy performance of existing homes. Suppliers are given an energy saving target proportionate to their customer base and are currently working to EEC phase 2 targets.

EEC 1 ran from 2002 – 2005 and suppliers exceeded the required savings

EEC 2 is running from 2005 – 2008 with a target more than double that of EEC 1

EEC 3 will run from 2008 – 2011 and will change to a carbon emission reduction target

EEC3 will become known as the carbon emission reduction target (CERT) from 2008 and will require a further doubling of EEC2 targets. EEC credits various

energy efficiency measures with delivering certain amounts of carbon emission reductions and the measures covered by CERT have already been finalised. Smart heating controls are included, but the clear winners are still options like cavity wall insulation. This has been the method of choice for meeting EEC targets so far and, given the savings it delivers, its low cost and the 10 million homes still without it, it is likely to remain so for some time.

CERT does however provide some opportunity for smart features, as discussed above. Suppliers will be allowed to meet a limited portion of their commitment through 'innovation activity' that explores measures whose carbon savings are still uncertain, and where savings depend on behavioural change. Suppliers will not be penalised if they fail to deliver the expected savings and once carbon savings are established, the measures in question can be added to the general range of measures recognised by EEC/CERT.⁴⁵ This mechanism is ideal for exploring smart features, as many of them involve behaviour change and require further research to better understand the savings they will deliver.

The future of CERT up to 2020 also provides a strong driver for smart meters. The government envisages energy companies working with customers to reduce energy use, with a new business model that makes this a profitable activity. But suppliers will only be able to achieve this if they have the frequent and accurate data on how their customers use energy that smart electricity meters will provide. Without them, energy companies will not be able to evolve into the energy service companies envisaged by government.

Introduce provisions to ensure that suppliers take advantage of the innovation activity element of CERT and use it to trial smart features.

Energy end-use efficiency and energy services directive

This EU directive was agreed in November 2005 and has to be implemented by 2008. As long as it is financially reasonable, it requires:

- the installation of meters (new or replacement) that accurately reflect energy consumption and provide information on time of use
- billing based on actual consumption that is presented simply and frequently enough for customers to regulate energy consumption⁴⁶

The directive is an ideal opportunity to promote smart electricity meters, as they are the only solution that will allow both increased information on energy use for consumers while enabling suppliers to provide accurate bills. Smart electricity meters are also crucial to the future of smart homes in general, so we would like to see the government seize the opportunity presented by this directive and provide a mandate for a smart electricity meter roll out starting from May 2008, with a requirement for smart electricity meters in all homes within 10 years. The roll out will not happen immediately, but it is a critical first step that will enable energy companies to start making real progress.

Provide a mandate for smart electricity meters from May 2008 requiring all homes to have one within ten years. Include clear milestones and require the provision of free real time display options to all homes to illustrate consumption.

A strategy for existing stock

As discussed throughout this report, we believe that smart features can make a useful contribution to lowering the environmental impact of existing homes, because of the challenges they present to many of the easier, more conventional options. The code for sustainable homes provides a comprehensive approach to environmental impacts for new homes and the same thoroughness would be welcomed when looking at existing homes.

It would be helpful to bring the various policy mechanisms that can incentivise environmental improvements in existing homes into a comprehensive strategy. CLG's review of the sustainability of existing stock may be a precursor to this, but existing homes will need to be addressed in a more strategic way if they are to make a real contribution to the UK's carbon reduction targets. And a coherent strategy is required if Gordon Brown's ambition of all homes becoming zero carbon over the next decade is to be realised.⁴⁷

Develop a strategy for improving the environmental performance of existing homes so that they can contribute to reducing domestic carbon emissions.

An intelligent buildings rating

TAHI is exploring the idea of an intelligent buildings rating and the Building Research Establishment (BRE) is also working with BERR to develop one. Some countries already have this, such as Japan and South Korea, but they assess the number of smart features in a building, rather than the business and lifestyle improvements that the technologies support. BRE aims to focus more on what smart homes enable.⁴⁸ As smart features in homes become more common a smart rating could be included in HIPS. It would make a home's intelligence an increasingly key feature in decisions, in the same way that existing policies aim to raise awareness of a home's environmental performance.

Consider including an intelligent buildings rating in HIPS as smart features develop.

5 start educating the supply chain now

Even with a good evidence base and policy mechanisms that support smart features, lack of knowledge in the supply chain may be a barrier to their development. Most smart feature suppliers are ready and waiting for the market to grow, but a lot of them have concerns about installers. The features may be new and smart but traditional professionals, such as plumbers and electricians, will still be installing many of them. Plumbers consistently advised homeowners against condensing boilers until legislation made them a requirement and plumbers had to start installing them. If homeowners are discussing their options with plumbers and electricians they may not be made aware of smart options and, even if they request them, they may be persuaded against them.

Suppliers should provide training and awareness raising to ensure the availability of dependable installers who understand the technologies and promote their benefits.

6 conclusion

Smart features have the potential to reduce the environmental footprint of UK homes, but there is some way to go before they become obvious choices and common features in homes. Smart entertainment features are likely to spread faster due to the strength of the industries, advertising and consumer desires associated with them.

But the environmental performance of homes is a growing concern and the benefits offered by smart features should be welcomed. As this report argues, smart features have a lot to offer both new homes and existing homes. They can offer the additional improvements that will be required as the environmental standards for new homes become increasingly stringent. And they can also help to improve the performance of existing homes, particularly in cases unsuited to easier, conventional methods.

A robust evidence base is needed to support smart features and to clarify the benefits that they can deliver. The crucial first step towards smarter homes also needs to be taken, with the roll out of smart electricity meters. As progress is made in these two areas, it will become easier to make the case for including smart features in existing policy mechanisms that promote environmental improvements in homes. Policy makers will have to be open minded and innovative when seeking to accommodate smart features into existing mechanisms, but their inclusion is vital. Smart features are useful additions to the existing range of energy and resource efficiency options available because they offer different benefits to existing options and engage residents in the process of delivering them.

Smart features are unlikely to become as ubiquitous in UK homes as they are in South Korea but they will become more common, as policy develops and some degree of responsibility for a home's performance shifts to its owner. Our homes may not be transformed into the kind seen in films and gadget magazines, in fact, they will probably look much the same. But behind the scenes they will be getting smarter and, as a result, greener.

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This report steps back from futuristic visions of smart homes to look at what smart technology can offer us in the homes that we live in today. The domestic sector is responsible for twenty seven per cent of the UK's carbon dioxide emissions, so our homes have to be part of efforts to meet the UK's ambitious carbon dioxide reduction targets. Smart features can help to address this challenge and *teaching homes to be green: smart homes and the environment* explores the potential for homes to become greener by getting smarter.

With their new and different benefits, features such as smart electricity meters or intelligent heating controls have great potential to improve a home's environmental performance. They can run homes more efficiently and help to change behaviour by providing residents with a complete picture of their energy and resource use. But this potential needs to be explored and the benefits of smart features better understood. As research takes place and a robust evidence base develops, various policy mechanisms already exist that can help to support the development and spread of smart features.

For homes to significantly lower their environmental impacts we will need as many options as possible and smart features should be part of our approach. They may not transform our homes into the kind imagined by science fiction but behind the scenes they will be getting smarter and, as a result, greener.

“Smart features clearly have a role to play in lowering the impact of homes, but their benefits need to be better understood. This is essential if they are to be recognised as environmental solutions.”