Why, What, When, How, Where and Who?
Developing UK Policy on Metering, Billing and Energy Display Devices

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ABSTRACT

The European Directive on Energy End-use Efficiency and Energy Services requires EU member states to ensure that energy consumers have frequent and informative billing, along with meters that reflect consumption accurately and provide information on time of use. There is a lively debate in the UK on what new forms of metering, tariffing and billing are feasible, and on possible environmental and social consequences. The main parties to that debate have been government and the energy regulator, electricity and gas suppliers, consumer bodies, environmental organisations, and manufacturers of meters and metering accessories.

This paper reports on and analyses some of the issues relating to billing, metering and attempts to change consumer behaviour in the UK. It highlights the dispute over the desirability of requiring suppliers to give feedback displays to residential customers in advance of a smart metering rollout, outlining tensions between anticipated benefits to the utilities (from smart metering) and to end-users and the environment (from improved feedback leading to conservation). Definitions, interpretations of the Directive, and the institutional context for feedback and smart metering are analysed in relation to research evidence for energy feedback as a tool for carbon reduction and demand management. The uses and limitations of the research literature in a contested area of policy are discussed.

Introduction

This paper is primarily concerned with issues of communication between energy suppliers and their customers. These issues are considered in relation to a dispute over whether electricity suppliers in Great Britain should be required by government to give real-time display monitors to all customers who ask for one. Advocates of displays have argued that this would start to build energy literacy and achieve much-needed carbon savings within a short time; detractors, that this would be an expensive and unwelcome distraction from the need for a government-backed accelerated rollout of smart meters. Beyond this argument (temporarily resolved), lie questions as to what form feedback to energy users should take in future and what relation this will have to changes in metering.

The paper begins with a consideration of the cases for energy feedback and smart metering and a look at how smart metering is defined. There follows an account of recent policy developments in the UK, including a summary of relevant articles in the 2006 European Energy Services Directive. There follows a reflection on the use of research literature in debates on the future of feedback and metering. The rest of the paper considers questions raised by the smart metering debate and outlines what is being learned.

Why Develop Energy Feedback and Smart Metering?

The argument for feedback is primarily an argument based on educational theory – that feedback is an essential component in learning. It may be used in relatively "shallow" and "deep" ways, according to what is at stake: to achieve goals (first-order), to change goals and strategies (second-order), and to link goals to life purposes (third-order) (Kolb 1984). In the energy context, the first-order goals equate, roughly, to "savings", while the second and third could be linked to transformations in systems of supply and energy services.

Public opinion surveys in the UK over the past few years have shown considerable generalised concern about climate change and energy (e.g. Poortinga et al. 2006), but little evidence of the depth of concern or practical ability that are needed to change behaviour. Feedback has a role, the argument goes, in bridging the gap between concern and action, by giving energy users a sense of efficacy, more important to most people than an abstract sense of moral obligation (Eden, 1993). If individuals can experiment with energy in their homes or workplaces and *see* the consequences of their usage through frequent meter reading, improved billing or some sort of dedicated display, the research literature demonstrates that they increase control over their consumption. The conservation effect varies according to circumstances, but participants in feedback trials have typically reduced their energy consumption by up to 10% when given 'indirect' feedback (processed for them and presented through a bill or statement, or via the web) and between 5 and 15% when they use 'direct' feedback[1] (Darby 2006).

The developing debate on 'smart' meters (broadly speaking, meters that store information and give accurate consumption data at specified intervals to supplier and customer) shows an awareness that improved feedback may also change the relationship between producer and consumer. There are benefits for suppliers if they can incentivise customers to reduce peak-time consumption, and avoid the expense of manual meter reading and of dealing with customer complaints related to estimated bills. From the customer side, there could be energy savings from smart metering if it is accompanied by user-friendly feedback, and also 'non-energy benefits', such as an end to estimated bills and the need to stay at home for the meter reader's visit[2] (Lees 2007). More controversially, there is the possibility of using a smart metering 'hub' as a gateway into the home through which other services can be provided, including direct energy management (e.g. switching off electric water heaters remotely when the power grid is stretched or market prices are high): the prospect of ceding control over consumption does not appeal to all customers.

At national level, smarter metering is seen as a possible way of developing supplier-customer partnerships to reduce emissions, through better energy management by the consumer and better load control by the supplier. If that proves to be the case, then something exciting will be happening, with new technology catalysing changes in behaviour on both sides of the meter. But introduction of new technology is rarely straightforward; there is always the danger that the technology itself takes centre stage in the early stages of change while social and behavioural considerations are sidelined. Before looking at what has happened, it is worth thinking about what "smart metering" might mean to different actors and why this matters.

[1] The term 'direct' is used here to describe feedback that is available to the end-user in real time, through the meter or a dedicated display.
[2] Meters are usually indoors in the UK.

What Does "Smart Metering" Mean?

There is no one accepted definition as yet, but a useful starting point is the definition of a smart metering system, as set out by the UK Industry Metering Advisory Group and shown below. The items that are most significant from the point of view of energy conservation and own-generation are in italic.

> A smart metering system provides a level of service above and beyond measurement of consumption… significant additional functionality for suppliers and end use customers. The guideline is based on a fundamental set of capabilities (A,B,C) plus a range of optional functions that a smart system could include... The guideline allows for a number of technology solutions including single unit, multiple units and communications options…
>
> A Measures consumption over representative periods to legal metrology requirements
>
> B Stores measured data for multiple time periods
>
> *C Allows ready access to this data by consumers as well as by suppliers or their agents and at least one of the following functions:*
>
> *i. Provides analysis of the data and a local display of the data in a meaningful form to the consumer or as part of a smart housing solution.*
>
> *ii. Transfers consumption data to the supplier or his agent for the purposes of accurate billing* without requiring access to the home.
>
> iii. Provides a payment facility for one or more supplies.
>
> iv. Measures and records information as to continuity and quality of the supply, and provides this and other data to the Distribution Network Operator for purposes of system operation, planning, and loss assessment.
>
> *v. Permits remote control (e.g. interruption and restoration) of specific consumer circuits or equipment for the purposes of agreed load management.*
>
> *vi. Allows display of price signals for different time periods as part of a cost reflective tariff for the purposes of demand response.*
>
> vii. Allows for remote change of tariff, debt or other rates for utility charging without requiring access to the home.
>
> *and, where a consumer has micro generation equipment installed:*
>
> *• Provides a facility to measure energy export and/or generation, where required for official purposes.*
>
> (IMAG, 2006)

According to this definition, the system must provide "ready access" to consumption data for the consumer but it does not have to be in the form of a "local" (in-home) display. It could be part of a 'smart housing solution', i.e., largely automated. The system could permit remote control of equipment by the supplier: again, the householder does not have to be aware of what is going on. But by the time the IMAG definition was coined, the British public was coming to be aware of a 'smart meter' as a display panel that would show them the cost of their daily

electricity use and help them to conserve. There are many examples of this usage, such as this report from the BBC:

> There are growing calls for gas and electricity meters to be dusted off, brought out from the cupboard underneath the stairs, and given pride of place in people's living rooms and kitchens. Advocates of so-called "smart meters" say the information provided by the devices can revolutionise the way households consume energy, and can reduce demand by up to 10%. (BBC news channel, 18 May 2006, http://news.bbc.co.uk/1/hi/sci/tech/4754109.stm, accessed May 2008).

This usage of "smart meter" has worked its way into the debate, but is only accepted up to a point by those who will be responsible for implementing any smart metering solutions. For example, the Energy Retail Association has adopted a definition in their Smart Metering Operational Framework specification that includes capability for "two-way communication with Local Devices. This will deliver consumption information to customers and suppliers at a flexible and configurable level of detail... [and] Electronic storage and display of data, including tariff and consumption" (SRSM 2007, pp8-9). The commitment to some form of display is there, but what form the display might take is left open – something that may have important implications for the quality of feedback.

The range of available customer displays is, of course, growing all the time, from the basic real-time digital electricity display (first generation) to a display that shows historic/cumulative data as well (second generation), to one that communicates with a web interface and may show multi-utility data (third generation). Information may be conveyed in non-digital ways, for example through different coloured lights or through analogue shapes; and it may be accessed via non-dedicated media such as digital TV. As yet, we do not know much about the relative effectiveness of such types of display in different contexts. However, as mentioned above, 'direct' feedback seems to offer more potential for energy conservation than 'indirect' feedback which has been processed and presented through a medium that customers have to make a special effort to see (Darby 2006).

There are issues about what a display technology means in terms of environmental impact: what is the embodied and in-use energy consumption? Does it have batteries? Does it have dual-fuel capability? Tying down meanings requires constant vigilance, whether these are in policy documents or public debate, and the energy suppliers are careful to keep their options open. The government consultation document sent out in August 2007 reminded readers that

> 'the Government set out its expectation that, over the next ten years, all gas and electricity customers will be given smart meters with separate visual displays *or potentially other ways of providing real-time information*, if they are shown to be effective, that allow communication between the meter, the energy supplier and the customer' (BERR 2007, p.6).

Metering and Feedback Considerations in Recent UK Energy Policy

Advanced metering was already being discussed in the late 1970s, within the memories of senior executives in the utilities today. A combination of cheap fuel and organisational inertia then kept the subject dormant for many years, until it was revived in the 1990s. Marvin et al.

(1999) gave an account of the renewed interest in smart metering, concluding that 'support for the installation of environmental applications [i.e., the potential to manage and/or reduce load more effectively]… requires a powerful shift in the regulatory and institutional frameworks within which utilities and manufacturers are configuring the functionalities of smart meters. The challenge for public policy is to ensure that these … opportunities are not foreclosed as utility competition develops…A context needs to be created in which utilities, manufacturers and communications companies, can be supplemented with the "missing voices" of regulators and user groups, such as environmental and community organizations.' They pointed out the need to avoid technical development pathways that might lock users into particular relations with their utilities, without fully assessing user needs beforehand.

In 2001, the Department of Trade and Industry established a Smart Metering Working Group which recommended that pilot studies should be set up to establish how far smart metering could contribute to social, environmental and security of supply objectives. Little happened, however, until the 2003 Energy White Paper[3] recognised that the metering system would need restructuring to support distributed generation. However, there is only one reference to new metering technology being able to make demand "more flexible", and none at all to informative billing or customer displays as a means of education and energy savings (DTI 2003).

Energy White Papers are normally few and far between – perhaps one a decade – but the 2003 White Paper was followed in 2006 by a Review and, in 2007, by a second White Paper. Smart metering and the need to improve feedback figure much more prominently in the two later documents, reflecting the pace of technological developments and the growing buzz about what changes in metering might achieve for utilities and how feedback might assist in meeting carbon reduction objectives. Smart metering is described in the Review as an 'energy efficiency measure', with a recognition that 'current metering and billing arrangements provide little in the way of incentive for householders to think about how they use energy and the consequences their energy use has on climate change'. Under the heading of 'Increasing awareness and information in all sectors of society', there are sections of the Review devoted to improved billing, to real-time electricity displays for households and to smart metering. The review announces a major set of government- and utility-funded trials[4] to explore the benefits of smart metering and to test its effectiveness '*in comparison with cheaper options such as improved billing and real-time displays*'. This distinction is significant. At the time, the definition of a smart meter did not necessarily include a display for the end-user (in Italy, the only European country with smart meters at the time, none of the meters had associated displays).

By the time of the 2007 White Paper, momentum had built behind the drive for both smart metering and improved feedback. The summary states that

> We will empower consumers to make more informed energy choices by requiring the provision of clearer information on bills and more advice about energy efficiency. We will launch an on-line CO_2 calculator which will enable households to know how their everyday activities contribute to emissions. We are also undertaking trials of smart meters and real time displays which enable people to track their energy use conveniently in their homes. Subject to the results of these trials we intend to work with energy companies to roll these out to households over the next 10 years. In the meantime, *real time displays will be*

[3] A White Paper is a statement of government intent, the precursor to a Bill.
[4] These trials began in the autumn of 2007; final results are expected in 2010.

provided with any new meters fitted from 2008. Because it will take a number of years before a new meter and display can be rolled out to every household, we have decided that between 2008-2010, real time displays will be available free of charge to any household that requests one. (DTI 2007)

Two points were particularly contentious: the vagueness of the undertaking[5] to roll out smart meters to households within 10 years, and the specific requirement for utilities to provide real-time displays (in practice, for electricity only) to all households on request. A storm of opposition broke out, from the utilities and also from less predictable sources such as the energy consumer watchdog and a number of environmental organisations. The government consultation exercise which closed on October 31st 2007 attracted an unusual number of passionately-argued submissions (see BERR 2007 for the consultation document and responses). The outcome of the consultation was announced at the end of April 2008, some months later than had been expected. Before revealing what the outcome was, the remainder of this paper attempts to unpack some of the elements in the debate. One of the most significant was the need to comply with European legislation.

The European Energy Services Directive in Relation to Customer Information

The European Commission issued the Energy End-use Efficiency and Energy Services Directive (usually referred to as the Energy Services Directive) in April 2006, with the requirement that all Member States of the European Union should implement it by May 17th 2008. The preamble to the Directive requires Member States to adopt targets to promote end-use efficiency for reasons of security of supply and in order to reduce carbon emissions. The stated aim is 'not only to continue to promote the supply side of energy services, but also to create stronger incentives for the demand side' (EC 2006 preamble, para 7).

The part of the Directive most relevant to this paper is Article 13, which deals with metering and billing with a view to customers having the information to make better-informed decisions in regulating their energy consumption (see below). The Directive does not, at any point, state that meters have to have *separate*, easily-visible or interactive displays, although these could convey information to customers more directly than a bill or statement. Indeed, it mirrors the commonplace confusion between 'smart meter' and 'display' that is discussed later in this paper.

[5] It is commonly described in policy documents as a 'vision'.

EU Energy End-Use Efficiency and Energy Services Directive (2005)

Preamble

- In defining energy efficiency improvement measures, account should be taken of efficiency gains obtained through the widespread use of cost-effective … innovations, e.g., electronic metering…
- to enable final consumers to make better-informed decisions … they should be provided with a reasonable amount of information … consumers should be actively encouraged to check their own meter readings regularly.

Article 1

The purpose of this Directive is to enhance the cost-effective improvement of energy end-use efficiency in the Member States.

(a) providing the necessary indicative targets as well as mechanisms, incentives and institutional, financial and legal frameworks to remove existing market barriers and imperfections that impede the efficient end use of energy;

(b) creating the conditions for the development and promotion of a market for energy services and for the delivery of other energy efficiency improvement.

Article 11

… Member States may establish a fund… to subsidise the delivery of energy efficiency improvement programmes and … measures… These shall include the promotion of energy auditing … and, where appropriate, improved metering and informative billing.

Article 13

Member States shall ensure that, in so far as it is technically possible, financially reasonable and proportionate in relation to the potential energy savings, final customers … are provided with competitively priced individual meters that accurately reflect actual energy consumption and that provide information on actual time of use.

- … Billing on the basis of actual consumption shall be performed frequently enough to enable customers to regulate their own energy consumption.
- Member States shall ensure that, where appropriate, the following information is made available to final customers in clear and understandable terms … in or with their bills…:

Current actual prices and actual consumption of energy;

Comparisons of the final customer's current energy consumption with consumption for the same period in the previous year, preferably in graphical form;

Wherever possible and useful, comparisons with an average normalised or benchmarked user of energy of the same user category …

The Use of Research Literature in Specifying Smart Metering Systems

Throughout this debate, the available research has been combed to in order to bolster competing points of view and to look for a way forward. As discussed above, there is a theoretical case for feedback as an educational tool, and there is also an empirical evidence base

(Wood and Newborough 2003; Darby 2006). There are not many large-scale "real life" trials of feedback, carried out rigorously in ecological conditions; but two that stand out for thoroughness are the trials of informative billing carried out in Norway (Wilhite and Ling 1995) and trials of real-time electricity displays in Ontario, Newfoundland and British Columbia (Mountain 2006 and 2007). Both show persistent savings resulting from better feedback; the Canadian studies also demonstrate the importance of situational factors such as electricity price, climate, and education. It is worth stressing that little domestic energy feedback to date has relied on smart metering: it has mostly occurred in conjunction with old-style "dumb" meters. The essential change associated with energy conservation has been visibility of energy use where it was previously invisible. The feedback-based case for smart metering is that smart metering can be used to *improve* feedback to consumers; not that it is *necessary* for feedback to occur (except sometimes where more frequent and accurate billing is concerned).

Smart metering offers technological solutions to problems of meter reading and billing for gas and electricity, as well as electrical load control. These have their own literatures – demand response[6], engineering, economics. But smart metering cannot be specified satisfactorily from any single standpoint: there are too many questions from too many directions. How is control of supply, consumption and information to be divided between utilities and energy end-users? Who should own and operate existing and emerging solutions for recording and displaying data? More broadly, how are the complex infrastructures of supply and demand to be organised if they are adapted to accommodate advanced metering, and what will this mean for the role of energy supplier? What happens when consumers become microgenerators, with new metering requirements? In accounting terms, if a customer installs insulation with the help of the supplier, as a result of learning more about gas consumption during the winter months through improved feedback, should the supplier claim credit for any "savings" from providing the feedback, the insulation, or both? And what happens if energy suppliers need to negotiate their way into a future where they are no longer selling energy-as-commodity, but energy services? Smart metering is a classic topic for "post-normal" science – science that is "constrained by uncertainty, urgency, high stakes and public values" (Tainter et al. 2006).

Timescales

If direct feedback on electricity consumption is effective in giving energy savings and in developing energy literacy for the long term, then why delay in making it available? Overall delivered energy to homes in the UK remained roughly stable between 1996 and 2006 while electricity consumption rose by 8% over that period (DTI 2007a). This has happened in spite of considerable efforts to improve end-use efficiency through "soft" and "hard" measures. The growth in consumer electronics continues, in particular; and the number of households is also growing at approximately 1% per year. There is a pressing need to halt and then reverse the growth in carbon emissions from the residential sector.

Energy policy in the UK is divided between two government departments. The Department for Business, Enterprise and Regulatory Reform (BERR) is responsible for ensuring secure, diverse and sustainable suppliers of energy at competitive prices, while the Department of Environment, Food and Rural affairs (DEFRA) is in charge of climate policy, biomass, energy from waste and combined heat and power. DEFRA pressed for rapid deployment of real-time

[6] Demand response has not figured much in UK policy to date, partly because of relatively large supply margins and partly because of the nature of peak demand.

displays, while BERR has been more inclined to back the supply industry in its resistance to this as an unnecessary distraction from the main business of smart metering. All parties say that they are not anti-display; but if displays were only to be issued to householders in conjunction with smart meters, then many would have a long wait[7]. A full rollout of smart meters is likely to take around 10 years to complete, allowing for two or three years to sort out specifications and legal issues at the outset.

In the meantime, a major set of government-backed trials is under way, conducted by four of the major suppliers and managed by Ofgem. These are testing the impact on household consumption of various combinations of improved billing and information, displays, smart meters and financial incentives. Final results are expected in 2010 – too late to assist in some of the decisions that have to be made on the future of metering, although lessons are already being learned on the practicalities of rolling out the new technologies.

Rolling Out Smart Metering and Displays – Ownership and Geography

Introducing advanced metering is a daunting prospect in a market where suppliers, not district network operators, effectively own the meters and procure metering services for their customers. To add to this complexity, the metering market itself has recently been unbundled. Rebundling it would make rollout easier, but would also require a good deal of legal work (Frontier Economics 2008). The ability of consumers to switch supplier at short notice also means that any smart meters have to be fully interoperable with each other.

Sending displays to every householder who asks for one (as proposed in the White Paper) is fairly simple, as long as the householder is made responsible for installation. But installing smart meters, when a supplier's customers may live anywhere in the country, would be massively more expensive and cumbersome than rolling them out street by street in a given area, as would have been the case pre-liberalisation. Short of re-instituting regional suppliers, a plan for cooperation between the utilities to allow for geographical rollout will be needed. The pressure on government to give a clear lead on the basis on which smart metering can proceed has grown, not least because of these intractable issues surrounding the ownership and operation of meters and the associated communications.

The Outcome of Consultation: A Step on the Road to Smarter Metering?

The government maintained the position set out in the 2007 White Paper for many months: that electricity display monitors were to be provided with all new and replacement meters and sent to all customers who requested one. However, at the end of April 2008 it announced that, following the consultation exercise and as an implementation of Article 13 of the Energy End-Use Efficiency and Energy Services Directive, it would

- require historical consumption data to be provided on all domestic customers' electricity and gas bills and statements[8];

[7] However, one major supplier is now offering an electricity tariff that incentivises conservation, in conjunction with a real-time display.

[8] although estimates and non-graphic presentations will still be allowed.

- request electricity suppliers to provide on a voluntary basis real-time display devices to particular customer segments (but not pursue proposals for provision of such devices when a meter is replaced or newly-installed or for provision 'on-request);
- require electricity and gas suppliers to provide smart meters to all business customers above a certain usage threshold by 2013;
- complete further economic assessment work and consultation to finalise policy position in respect of smart metering for small businesses and domestic consumers.

Summary and Conclusions

The rapid and intense revival of interest in smart metering has brought behavioural and relational considerations into the debate on the future of energy utilities in a new way. The type and quality of communications between utility and customer will have an impact on overall consumption, on load management and on customer retention. Not only that, but advanced metering and the associated communications are expected to play a key part in the transition to a lower-carbon economy, in line with national, European and international targets. Energy utilities operating in the UK have recently moved faster in the direction of smart metering than ever before, and are having to consider redefining their relationship with their customers and developing new business models.

Smart metering and the call for improved feedback have posed technical and organisational challenges to both utilities and policymakers in the UK. One of the main debates has been between advocates of stand-alone displays showing electricity usage for the residential sector (limited in capability but expected to yield early carbon savings), and those who claimed that such displays would be an unwelcome distraction from a government-mandated rollout of smart meters. The clamour for a clear government lead has built up, as the need to cut through the complexities of a highly-liberalised market has become increasingly clear. Even an accelerated rollout of smart meters is likely to take seven years, after preparation that may well take two to three years.

Both sides in the dispute over displays have moved some distance over the past year in understanding the issues, if not always in terms of changing their original objectives; many of those involved are learning in an unprecedented way about aspects of the energy industry that they often ignore and sidelined, through focusing on metering and conservation issues. But the dispute has been in some ways a surrogate for a wider disagreement between those who prioritise a process (feedback) in their thinking, and those who prioritise a technology or set of technologies. This persists. Meanwhile, microgenerators pose a separate but related set of challenges to energy infrastructures.

Displays emerge from this debate as a catalyst: they have concentrated attention on the potential for better feedback between agents in energy systems, for developing energy literacy, and for an overhaul of customer/utility relations. They are bringing together behavioural and technical considerations in energy systems in a way that is both complicating and informing the experiment on which the supply industry, government and end-users have embarked.

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