Implementing Article 13 of the Energy Services Directive and defining the purpose of new metering infrastructures

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Abstract

This paper examines possible responses to Article 13 of the European Directive on energy end-use efficiency and energy services. The Directive requires 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. Stakeholders in the implementation of the Directive include governments, energy suppliers, regulators, consumers and their representatives, environmental NGOs, meter readers and the manufacturers of hardware and software for metering, billing and feedback displays. Utility infrastructures are already changing in some European countries, while plans are being formulated in others. Vendors of the elements in advanced metering infrastructures are busy promoting their wares. Huge investments are at stake when choosing a new socio-technical pathway, and there is much anxiety about becoming locked into a metering/customer relations 'solution' that will not deliver adequate benefits to some stakeholders. There have been intense debates on what is technically and financially feasible, and on the potential environmental and social consequences of different forms of metering, tariffing and billing.

The paper analyses some of the main issues relating to implementation of Article 13 with reference to experience in Europe, particularly the United Kingdom. These issues demonstrate the need for policymakers to define clearly what they want from a metering system in an era of accelerated climate change, in liberalised markets, and with shifts towards more distributed electricity generation.

Introduction

The electricity and gas meter used to be largely ignored when studying European energy systems, but this has changed dramatically in recent years. The first-ever European conference on metering, billing and customer relations, held in 1998, attracted 100 participants. Ten years later, attendance had risen to more than 2,700. Metering and billing had become hot topics, and utilities and policy makers struggled to understand what was technically possible and who might benefit – or lose – from the new developments. Manufacturers and software designers were busy developing and marketing their products, with billions of Euros worth of investment at stake.

This commercial activity is taking place alongside an equally intensive policy debate on how to reduce greenhouse gas emissions quickly and sustainably, while maintaining or improving European employment levels and quality of life along with a commitment to liberalised energy markets. This paper looks at some of the reasoning behind the relatively new policy approach to energy efficiency in relation to energy services and end-user behaviour. It outlines some of the possible definitions of 'smart metering' or advanced metering infrastructures (AMI) and considers their implications, using examples that are mostly drawn from the UK.

EU Energy end-use efficiency and energy services directive
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 measures.
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 …

Source: CEC, 2006

Article 13 of the Energy Services Directive

The overall aims of the ESD are to improve security of supply, mitigate carbon dioxide emissions and create stronger demand-side incentives to reduce emissions. The first paragraph of the preamble sets the scene and states the urgency of moving on efficiency, managed demand and renewable supply. Article 13 of the Directive requires 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. The most relevant extracts are given in the box above.

Notice how the requirements of the Directive, and Article 13, are for provision of better feedback information to energy users, rather than for specific new technologies: encourage meter-reading; provide individual meters reflecting actual consumption and actual time of use; billing that is frequent enough to enable customers to regulate their consumption (rather vague); and provision of prices and consumption on bills along with historic comparisons and (maybe) comparisons with other users. There are escape clauses in the Article, too: 'where appropriate', 'in so far as technically possible, financially reasonable and proportionate in relation to the potential energy savings'… However, Article 13 is a significant development in relating

'efficiency' to energy services and improvement of communications between customer and supplier. It recognises the importance of end-users' behaviour in bringing down energy demand, and the need to improve their understanding (through feedback) of how to manage energy better; at the same time, there is a recognition that new metering and billing technology can make feedback more accessible.

The Directive was issued in April 2006, and Member State governments were required to respond to the Commission, indicating how they would proceed, by May 2008. During this period, technologies that might be enrolled in realising the aims of Article 13 continued to develop. Although they are essentially communication technologies, they are usually referred to under the heading of 'Advanced Metering Infrastructure' (AMI) or 'Smart Metering'. Yet smart metering is not actually mentioned in Article 13. The emphasis is on a process, not a technology or group of technologies. But we need to consider the two together in order to try to understand what is happening now in the energy industries and in attempts to reduce carbon emissions through demand reduction, the development of energy services and the deployment of low- and zero-carbon technologies.

'Smart metering' definitions and possibilities

Definitions associated with smart and 'advanced' metering continue to evolve. In more negative terms, smart metering means different things to different people. In particular, a 'smart meter' is likely to mean a piece of metering equipment with associated communications technology to an energy professional, but an electricity display panel to many members of the public. There are also many degrees of 'smartness', and language has not yet caught up with this. UK policymakers now have two broad definitions: 'Advanced metering' is their term for automated meter reading (AMR) with one-way communications (from customer to utility), as distinct from 'smart metering' or automated meter management (AMM), with two-way communications. But definition of minimum standards for equipment, and for information to customers, are still under discussion in the UK as in many other European member states. For more on this set of issues, see Darby (2008).

Customer displays are rapidly developing in terms of the range of functions they offer. It is now possible to show both real-time and historic consumption data on a display, as recorded by a traditional 'dumb' or a new 'smart' meter (though less accurately with a dumb meter), to display multi-utility data, and to link to a web interface. Displays can also be used to convey up-to-date information on tariffs, and can be combined with heating or other controls. Information can 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 or mobile phones. There are questions about the relative effectiveness of displays that are dedicated primarily to giving energy information, as opposed to media with several functions such as a PC, mobile phone or TV. People are likely to have to make more of an effort to seek out energy information from multi-purpose media than from, say, an eye-level display in the kitchen or hallway. But different types of display can complement each other in terms of the information and interactivity they offer, and the service they provide.

Many trials of both meters and displays are under way, though few results have been published as yet and many may never be published, for reasons of commercial confidentiality. A map of trials and smart meter rollouts, with outline descriptions, is available at http://maps.google.com/maps/ms?ie=UTF8&hl=en&msa=0&msid=115519311058367534348.0000011362ac6d7d21187. The European Smart Metering Alliance is also producing a report for 2009 that summarises projects throughout Europe and selected project from the USA.

AMI opens up new avenues in terms of information flows, altering relationships between supplier and consumer/microgenerator, and in moving towards smart grids. But some of the claimed benefits from AMI - demand reduction, better load management and carbon reductions - are not assured. They have to be worked for, as they are not the only reasons behind developments in metering. Figure 1 indicates five drivers behind the move to smart metering for electricity. Three of these are particularly related to the utilities (reducing operating costs, improving customer relations and reducing peak loads). Improving feedback, reducing demand and encouraging microgeneration would primarily benefit end-users, government and the environment. (It can also benefit the utilities in a situation in which their emissions are capped.) These four drivers are essentially 'pull' factors for AMI. At the same time, there is a 'push' to develop and market the new AMI technologies, with contracts at stake. But all this is happening while the energy markets are in a state of flux, and no-one can predict the benefits and costs of investing in a particular type of AMI accurately. Decisions need to be made as far as possible on the basis of what is *necessary* to achieve the aims of the ESD and to move beyond them; they ought not to be hijacked by claims of what is *possible* with particular products or services, or by cost-benefit analyses that only apply for limited periods. In order to do this, it is necessary to look at the whole energy system, people and technologies together. Some major issues are raised and discussed below.

Issues raised by Article 13 and AMI

There are some important principles at stake in implementing Article 13, and they have to be considered in relation to the technical possibilities for metering and billing that are opening up. Energy users may well think that they have a right to base their energy-use strategies on accurate evidence rather than on estimates and guesswork. At the same time, they are unlikely to want to pay for new technologies that offer them little apparent benefit. New meters without a clear, useful customer display and/or substantially improved billing might well fall into that category. Looking ahead, the development of smart grids to optimise the use of low-impact electricity will require changes to the transmission, distribution and metering systems but it will also need to improve the information environment for customers, networks and suppliers, to give the kind of feedback loops that enable better management of energy resources. The decision-making processes for these changes has to reflect wider social and environmental considerations. Below, I set out some specific issues raised, and begin to address them.

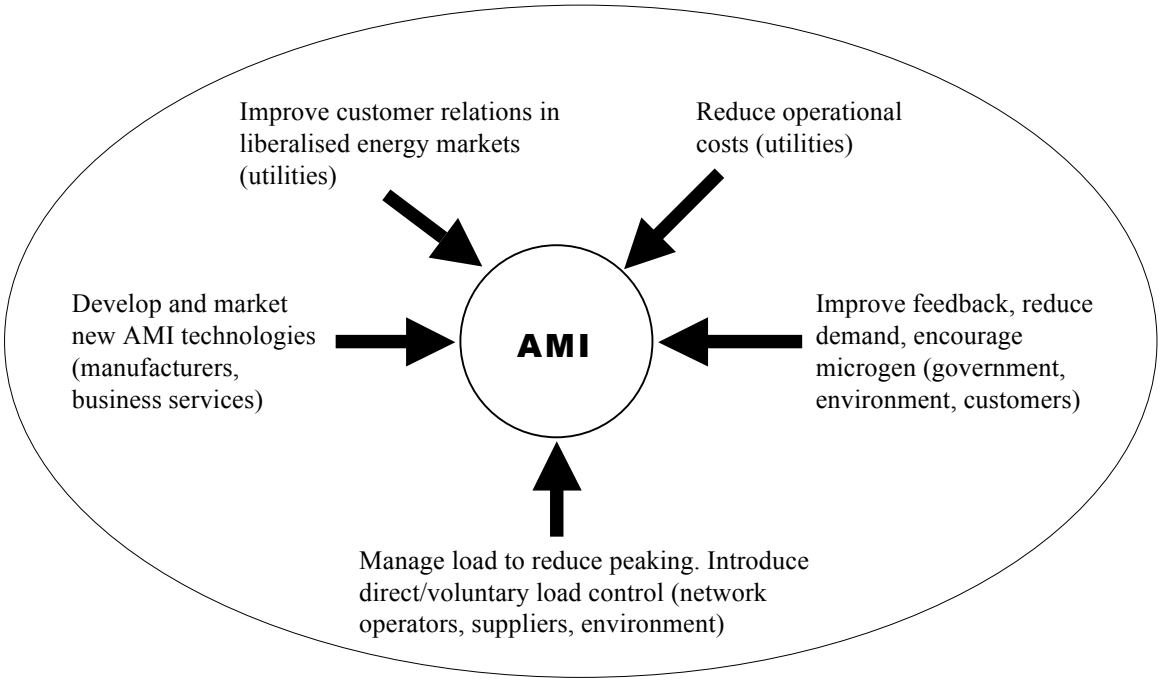

Figure 1. Some drivers of Automated Metering Infrastructure

HOW COMPLEX DOES METERING NEED TO BE, FOR DEMAND REDUCTION, LOAD MANAGEMENT AND DISTRIBUTED GENERATION?

The 'smart metering' case for social and environmental benefits arising from demand reduction rests on the evidence that improving feedback to end-users typically leads to lower consumption, and on the argument that feedback is an essential component in experiential learning (Darby 2006, Fischer 2007, Kolb 1984)[1]. If smart metering improves feedback, then there will be benefits from reductions in energy bills and in greenhouse gas emissions.

For smart metering to improve feedback, though, it has to provide an improved channel for it. In the past, feedback on gas and electricity usage has been provided in two ways: the old 'dumb' meter (which only shows a single number or a series of dials); and the bill or statement (often infrequent and/or unhelpful in that it includes estimated readings, or equalises payments through the seasons of the year). This is inadequate for energy management purposes, and also inadequate for customers who are generating their own electricity.

Automated meter reading (AMR) allows for an end to estimated bills, and offers the prospect of frequent, accurate billing along with comparisons to other periods of time and other end-users. Norwegian trials (Wilhite and Ling 1995; Wilhite et al. 1999) contributed to the move towards informative billing in Scandinavia and to the current adoption of AMR in Sweden.

Going beyond AMR, AMM offers two-way communication between customer/microgenerator and supplier and has the potential for a huge increase in the frequency of accurate information travelling in both directions. This can be displayed to the customer in a variety of digital/graphical/analogue or ambient formats.

Electricity load management can be carried out through time-of-use tariffs and voluntary agreements between customer and supplier, such as the EdF 'Tempo' tariff. More sophisticated arrangements, moving closer to real-time pricing, become possible once interval metering is in place, giving a record of consumption (and own-generation) in 30- or 15-minute time slots. Electricity suppliers could control end-uses directly in order to manage load, using a smart meter as the communications hub; but they can also do this through technologies such as the Programmable Communicating Thermostat, without AMM and without the customers needing to do anything apart from give consent.

Some of the potential feedback and load management benefits claimed for smart metering can be made available in ways that are simpler than full-scale AMM. Most of the research literature on feedback deals with the impact of written or electronic feedback, implemented before smart meters were available. For example, organisations such as 'CO_2online' demonstrate continuing energy savings by combining feedback from own-meter-readings with skilled advice. This is likely to attract people who already have some motivation to save energy, and there is a growing number of examples of feedback mechanisms such as websites that are being used by motivated customers. The challenge is to extend this group by offering attractive and effective services, with outcomes that the users can verify for themselves. Given the complexities and long timescales for moving ahead with AMI, smaller-scale incremental changes also need consideration. In the UK, for example, there was a heated debate about whether utilities should supply free 'clip-on' electricity real-time displays to any customers who request them, as it will be many years before AMI can be rolled out across the entire population. (This government proposal was defeated in its early form, but may be revived.) Large-scale trials of a whole range of different feedback modes are under way,

1. There are further environmental benefits from cutting peak electricity loads, especially if peak demand is normally met by high-carbon generation.

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with and without smart meters. While the consensus seems to be that AMI is necessary for all the functions needed in a 21st century electricity system (and, probably, 21st century gas and heating systems), there is a danger of over-complexity increasing the costs, lengthening the implementation time, and standing in the way of some of the potential benefits. There is also a need to minimise consumption by the metering system itself.

WHO CONTROLS END-USES?

AMI changes the relationship between supplier and customer because it changes the type and scale of information flowing between them, and can enable the supplier to control specific end-uses. This needs to be taken into account explicitly in the debate over possible future technological pathways (Marvin et al., 1999). AMI can also change the nature of the supply business. In addition to enabling more distributed generation and encouraging energy-efficiency solutions, smart metering 'hubs' can be used as gateways into a building, through which other services can be provided, such as security and retailing. These will not necessarily reduce consumption and could increase it. As Wilhite (2007) has pointed out, new technologies create potentials for change rather than determining new patterns of consumption.

There is the exciting prospect of new technology catalysing changes in behaviour on both sides of the meter. But there is the accompanying risk that the technology itself takes centre stage in the early stages of change, while social and behavioural considerations are sidelined. The issue of control is high on the list of these considerations. When utilities have invested so much in huge new metering systems, how much control are they going to want to cede to others? A review by King and Delurey (2005) indicates how feedback systems designed to achieve load management produce a smaller conservation effect that those designed for overall demand reduction, and more recent trials of variable pricing with feedback broadly support this finding.

The tension between peak and overall reductions exists at other levels, too. For example, a recent study of the use of programmable communicating thermostats in the USA shows how automated control of thermostats gives more reliable demand reduction during critical peak periods, but does not produce as large a conservation effect throughout the year as improved information combined with manually-operated thermostats, and the increased customer awareness and involvement that go with manual control (Klos et al., 2008). The general message is that automation will tend to support the utility's interests most strongly, while education/ awareness will tend to be best for the customer and for the environment in the longer term. There is plenty of research still to be done on the optimum designs for feedback for both demand reduction and load management, as well as on where, when and how automation is most appropriate. Some people will be happy for their utility to control some of their end-uses, e.g. remotely switching off electric water heaters, or even space heating, when the power grid is stretched or market prices are high. But the prospect of ceding control over consumption (and comfort) does not appeal to all customers (see Abaravicius et al, 2005, for a Swedish trial of direct load control). Compromises are of course possible, such as manual overrides, special tariffs and negotiated lists of end-uses for direct control. It seems likely that suppliers who can increase the trust of their customers by developing good feedback arrangements may then be in a better position to ask for a measure of direct load control if they feel that they need it.

WHO CONTROLS INFORMATION AND ACCOUNTING?

There are some large-scale issues to be addressed here. Who should own and operate the equipment and software for recording and displaying data? How well are energy suppliers equipped to gather and manage data on the huge scale that is now possible? – do they need to contract it out to one or more intermediaries, as is now being proposed for the UK? When consumers decide to become microgenerators, with new metering requirements, will they have full access to all their data and be able to sell any surplus power to the grid at a fair price? What safeguards are needed to keep detailed data on patterns of energy use confidential? And if suppliers make a shift from selling commodities (kWh, cubic meters of gas, or units of heat) to selling energy services, does that undermine the whole case for detailed feedback on end-uses?

In the new era of energy and carbon accounting, there are questions surrounding accreditation for emissions reductions. For example, if a customer is prompted by improved feedback to install insulation with the help of a discount from the supplier, should the supplier claim credit for any "savings" that result from providing the feedback, the insulation, or both?

In order to optimise the impact of more advanced metering, then, there is a need for minimum standards for information for end-users – standards that are more specific than the requirements of Article 13 – and also for guidance on data access, data protection and accreditation. These would form a framework within which there can be innovation and competition on feedback provision to customers, allowing for interoperability between different suppliers and systems.

STAKEHOLDERS IN THE IMPLEMENTATION OF ARTICLE 13 – WHO MIGHT WIN OR LOSE?

Stakeholders in the implementation of the Directive include governments, energy suppliers, regulators, consumer bodies, environmental NGOs, and the manufacturers of hardware and software for metering, billing and feedback displays. These have overlapping but different interests, which are better served by some combinations of technologies than others, as indicated in Table 1. For example, there are benefits for electricity suppliers if they can incentivise customers to reduce peak-time consumption, and for all suppliers if they can avoid the expense of manual meter reading and of dealing with customer complaints related to estimated bills. (Meter readers, of course, lose out on any solution that involves automated meter reading; something that is rarely discussed.) 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 having to wait at home for the arrival of the meter reader (Lees 2007).

The cost-benefit accounting that surrounds the implementation of AMI is also far from straightforward. Even the definitions are complex, with a range of options from low-cost retrofits to high-specification, all-new solutions (e.g. Siderius and Dijkstra 2006; Owen and Ward 2006; Mott Macdonald 2007). It is difficult enough to estimate the costs of a wholesale rollout of smart meters, especially in a liberalised market, but harder

Table 1. A summary of possible stakeholder benefits from different implementations of Article 13

	Government (improved energy security)	Environment (demand reduction)	Customers (lower bills+ more control)	Suppliers (operational savings +load management)	Small-scale generators	Manufacturers of meters and associated technologies
Informative bills (with AMR)	X	X	XX	X (OS)	**X**	X
AMR or AMM, no displays	X			X (OS)	X	X
Displays, no AMM	X	X	XX		X	X
AMM and online information	X	X	XX	XX(?LM)	X	X
AMM and dedicated displays	X	X	XX	XX(?LM)	X	X
AMM and direct load control	X	?	X (more control)	XX	X	X

still to quantify the benefits, especially those that are social and environmental. It is no accident that the first nationwide rollout of AMI was in Italy, where it took place in a near-monopoly situation with the principal objective of reducing fraud and theft. This rollout has been relatively straightforward. As yet, there are no customer displays associated with the smart meters, so the interface between customer and supplier has not changed markedly, although it has become easier to limit customer loads, and to carry out remote connection and disconnection. In the Netherlands, by contrast, it was necessary to include estimated social and environmental benefits in order to make the business case for AMI, the supply market was more complex, and the rollout began but has been halted, while further decisions are made about how best to proceed. The need for customer display interfaces has been recognised, but choice of design is being left to suppliers, as part of their offer to attract and retain customers.

MOVING TOWARD IMPLEMENTATION OF ARTICLE 13 – SOME REFLECTIONS ON THE UK EXPERIENCE

The UK shares many issues with the other member states of the EU, but is relatively isolated geographically, with only a small interconnector to the grids of continental Europe. It has the most highly-deregulated energy markets in Europe. This second difference makes the introduction of advanced or smart metering particularly problematic, in a market where suppliers rather than district network operators effectively own the meters and procure metering services for their customers. To add to this complexity, the metering market itself was recently unbundled, and reversing this will require a good deal of legal work (Frontier Economics 2008).

An Energy White Paper[2] in 2003 recognised that the metering system would need restructuring to support distributed generation, and that new metering technology might be able to make demand "more flexible" (DTI 2003). Only four years later, a further White Paper gave far more prominence to metering and the need to improve feedback, reflecting the pace of technological development, the growing interest in what AMI might achieve for utilities, and the expectation that improved feedback could assist in meeting emissions targets. The summary stated 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 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 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)

The requirement for utilities to provide real-time displays (for electricity) to all households on request was not realised, though. Opposition from an unlikely coalition of utilities,

2. A White Paper is a statement of government intent, the precursor to a Bill.

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consumer bodies and environmental organisations (mostly on the grounds that displays would be an unnecessary distraction from moving to full-scale AMI) led to a shift in policy. In April 2008, the government 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[3];
- 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; and
- complete further economic assessment work and consultation to finalise the policy position in respect of smart metering for small businesses and domestic consumers.

This was a cautious response, but in November 2008 the government went further and announced that there would be a full-scale rollout of 'smart meters' for both electricity and gas by 2020. This was seen as both a conservation measure and a complement to the new feed-in tariff for distributed energy. However, there is still a long way to travel. Further economic and legal assessment is still under way, along with government-backed trials that are being conducted by four of the major suppliers and managed by the energy regulator. These are testing the impact on household consumption of various combinations of improved billing and information, displays, smart meters and financial incentives. The trials are also an opportunity to build up experience of the practical details of rolling out and using the new technologies. Final results are expected late in 2010.

Extending smart metering for both gas and electricity to all UK customers[4] will be the largest exercise of its kind in the world to date, and defining what is needed for a new infrastructure is a major challenge. To give a few examples:

- Great Britain has a higher rate of supplier switching than rest of Europe – some 4 million customers in 2008. This shows the necessity for new metering technologies to be interoperable, so that customers do not have to change meters (or feedback arrangements) when they change gupplier.
- 2.3 m (12%) of gas customers in Great Britain have prepayment meters. Prepayment capability is expensive for gas; should all new meters have it?
- In Northern Ireland, electricity prepayment customers rose from 10% to 25%+ of the population when 'semi-smart' prepayment meters were introduced, and when tariffs were altered so that prepayment no longer involved higher unit costs. This change to prepayment had a conservation effect in itself (Boyd, 2008). Should there be a move towards prepayment generally, in the rest of the UK?
- AMI could facilitate a move from a measures-based energy efficiency supplier obligation (the Carbon Emission Reduction Target) to an outcome-based system, in which suppliers have to demonstrate actual reductions in demand. Less controversially, it could also be used to measure the impact of interventions such as the CERT more systematically.
- The Smart Metering Operational Framework commissioned by the energy suppliers (Engage Consulting 2007), raised questions about how many benefits (and whose benefits) could be realised from the suppliers' favoured specification, and from less expensive solutions such as retrofits for existing meters (Mott MacDonald 2007). Work on estimating costs and benefits of various options continues (e.g. BERR 2008).
- There are concerns about the confidentiality of data from interval metering ('A Spy in Every Home', shouted one headline). Provisions for data protection/ customer confidentiality have to be worked out and costed.
- While it is accepted that a 'smart meter' includes a customer display, and there are moves towards a minimum specification for data and presentation, the issue of what constitutes an acceptable display (one that optimises environmental and social benefits) is not settled.
- There is estimate of 5.8 W for the in-use power demand of a smart meter, communications and display (BERR, 2008), but there is no standard yet for maximum allowable embodied energy and in-use demand.
- An AMI means a huge increase in the quantity of data, which utilities may not be best equipped to deal with. A vast data collection and management operation will be needed.

This list is perhaps best read in conjunction with Figure 1. In tackling these issues, government and the regulator are not only addressing technical or economic problems, but must adjudicate between stakeholders and decide what is going to be necessary to achieve their more strategic aims.

Summary and conclusions

Article 13 of the ESD came into being at the same time as a resurgence of activity in the development of 'smart metering'. The intense interest in smart metering, allied with debates on demand reduction and customer relations, has meant that end-user behaviour is more prominent in policy discussions than before. However, socio-technical considerations are often subordinate to technical matters that are more easily described and quantified. Yet the type and quality of communications between utility and customer will have quantifiable impacts on overall consumption, on load management and on customer retention.

From the state of the policy debate, it is clear that AMI is now expected to play a key part in the transition to a lower-carbon economy, in line with national, European and international targets; and it is in the interest of utilities as well as

3. Although estimates and non-graphic presentations will still be allowed.

4. Half-hourly metering has been in place for the largest customers for some time; in May 2008, the Government decided to mandate smart metering for customers using more than 732 MWh/yr gas and with electricity profiles 5-8.

other stakeholders to argue that this is the case, because of their anticipated operational savings. This account of some of the issues relating to implementation of Article 13 demonstrates the need for policymakers to define clearly what they want from any changes in metering and billing. The utilities and energy networks have relatively clear-cut benefits in view, as indicated in Figure 1; but maximising their gains could mean compromising environmental and social benefits from reduced consumption and moves to more distributed generation, especially when energy markets are not designed to encourage suppliers to move away from volume sales of kWh.

The relationship between load management and demand reduction objectives raises important questions for research. Managing electrical load more effectively, to reduce peak demand, is worthwhile in itself from an environmental standpoint. However, if this is the principal aim of a metering-and-feedback system, overall demand reduction could suffer.

The development of new energy-related communication technologies has thrown up many other issues that still need to be tested and, if possible, resolved. For example, how elaborate does the infrastructure need to be in order to give adequate feedback to energy users to promote and sustain reductions in demand? Who will control different elements of the any new communications technologies introduced to supplement metering? Who should have ownership of, and access to, the new information made available? How might the costs and benefits of different technical options be distributed? What are the non-economic, or even the non-energy, costs and benefits of different options – and what difference do these make to the calculations?

This paper has illustrated how the policy debate has moved a long way from the initial ambition of the ESD to encourage customers to read their own meters and to provide them with 'reasonable information'. Indeed, the ESD is only one driver for change in the metering infrastructure: there is a massive push for AMI from commercial interests in metering, throughout the world. AMI *can* form part of a transformation to lower-impact energy systems, but it is not a foregone conclusion.

What sort of recommendations emerge from these considerations? First, I suggest that there needs to be a focus on developing standards that support effective feedback and that will help in building a strong customer 'pull' for better feedback. Second, energy users must have a right to their metering data, as part of a change in relationship between (active) supplier and (passive) consumer, and there must be agreed, widely-accepted standards for data protection. Research is also needed into balancing supplier and customer needs when it comes to controlling electricity loads. There are growing marketing pressures behind home automation, but as yet there is little evidence to support it in terms of demand reduction, or to indicate in which circumstances it might be deployed effectively. Finally, in order to realise the aims of the ESD and, eventually, to move beyond them, AMI needs to be implemented in energy markets that are regulated with incentives to reduce volume sales as well as peak electricity loads.

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