Sustainability *first*

Smart Meters :
Commercial, Policy and Regulatory Drivers

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March 2006

Published by Sustainability First

Sponsored by Ampy, Centrica, EdF Energy, Energy Saving Trust, Energywatch, Eon, IBM Business Consulting, RWE npower, Scottish and Southern Energy

Acknowledgements

We would like to thank our group of sponsors both for their financial support and their contributions of information and comments on the drafts. Thanks are also due to the trustees of Sustainability First – Ted Cantle (Chairman), Phil Barton, John Hobson, Derek Osborn, Trevor Pugh, David Sigsworth - for their support and help throughout. In addition we want to thank all those who gave up time to be interviewed during the research phase and who provided us with information. A full list of interviewees is available in the appendices on the Sustainability First web site. Responsibility for the findings, conclusions and recommendations in this paper rest with us.

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Sustainability First

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Introduction

This report is the result of a project carried out for Sustainability First. The project set out to assess the costs and benefits of smart metering in the UK, to consider the structure and operation of the UK metering market, to assess the UK case for smart meters in the light of international experience, especially on energy saving, and to identify what policy and regulatory changes might be needed to secure wider uptake of smart meters, mainly at the residential level in the UK. It involved comprehensive desk research and structured interviews carried out between October 2005 and March 2006.

Information is most widely available on domestic electricity meters, and in general, this is what the text refers to, unless it is specified that it also refers to gas domestic meters or to meters in the small business sector (SMEs).

This is the main report and it is being published in hard copy and on the Sustainability First web site. Supplementary detailed appendices on : the metering market and technology; smart metering experience and studies; list of interviewees; are available on the Sustainability First web site. www.sustainabilityfirst.org.uk

Executive summary

The UK energy meter stock remains largely electro-mechanical and has not changed significantly in over a century – in marked contrast to many other technologies, which have changed beyond recognition. Advanced metering technology has a thirty year history in the UK but earlier initiatives had all but stalled until being given a new impetus by the EU Energy End-Use Efficiency and Energy Services Directive, the January 2006 Ofgem Consultation and the 2006 Energy Review.

Smart meters are not an end in themselves but are an important gateway :

- For energy suppliers - to improve market operation through better ways of tackling energy management, and, finding new retail opportunities.

- For SMEs and households to achieve energy savings through improved feedback on energy consumption and expenditure; to develop demand-response at an individual level ; and, to develop new scope for micro-generation

Clear pathways are needed to this gateway**.** The Energy Review in particular offers the opportunity to develop firm recommendations and a clear policy road map for the development of smart meters in the UK. Concerted leadership from DTI will be needed, with appropriate support from DEFRA and Ofgem.

Technology

Cost differences between one (AMR) and two way (AMM) communications are not highly material, but the choice of communications medium is significant. There are also differences in operational costs. Some communications technologies are better suited to a targeted approach, and some to geographic installation. Smart meters can perform a huge variety of functions, from remote meter reading to offering real-time tariffs to the consumer. Key smart-meter capabilities are :

- Measures energy consumed **-** both quantity and when (i.e. on a time-interval basis).
- Two-way communication
- Stores interval-data and transfers it remotely to a data collector / utility
- Capable of displaying consumption, tariff and other information.

International experience

International experience suggests that although the overall benefits to society exceed the costs, government or regulatory intervention has been required to facilitate smart metering because suppliers/distributors cannot capture all these benefits Key benefits of smart meters that have led other countries to install them include :

- Reductions in fraud and theft
- Reductions in meter reading costs
- Reductions in prepayment metering costs
- Reductions in peak demand - lower costs and/or better security of supply
- Greater efficiency of electricity wholesale market
- Customers enabled to switch supplier more easily, plus new service offers

Reductions in overall energy demand and in carbon emissions were not identified as major benefits in most of the international examples, because these were not the drivers for smart metering in those countries, and were thus not evaluated. Importantly, a positive cost / benefit assessment in these international examples therefore does not take account of benefits that might accrue in terms of reduced carbon emissions.

Energy saving

The major long term evidence to date on energy-saving is from a Norwegian study based on 'informative-billing' in homes with electric heating – not smart metering – where savings of 4-8% were achieved. A major UK study suggests 3-5% is possible for homes without electric heating. Short-term results with smart prepayment meters in Northern Ireland have shown a 3% energy saving. It therefore seems reasonable to estimate energy savings, on a cautious basis, at around 1-3%. A 3% saving would be £10.50 off an average electricity bill. A 1% saving would equal 8% of the UK's domestic CO2 target.

Smart meter costs and benefits

The choice of communications technology has a significant impact on overall costs. Summary cost information falls in the following ranges :

- Advanced meter +communications (meter only) - £37-80
- Advanced meter + communications + installation and system costs - £70-180

Suppliers could save perhaps 25% on the average of their £20 cost-to-serve per customer. This includes meter reading, service centre costs, billing and payment. However, these averages conceal a wide range of costs – and the benefits do not apply evenly across all customers. There is no 'simple' business case for suppliers to introduce smart meters on a widespread basis - although there is a business case for : prepayment token meters; customers who are costly-to-serve (e.g. debt prone, many meter-read attempts, remote location). In addition, smart-meters may also offer scope for revenue-enhancement for suppliers through development of new services to customers.

Customer benefits fall into three main areas : more accurate billing and payment; better information leading to energy (and money) saving; dynamic market effects through easier switching and new offers from suppliers. There may be further benefits for prepayment and vulnerable customers. However, as cross-subsidies unwind, there may also be winners and losers. Moreover, customers will not necessarily get clear easy-to-use displays, either on the meter, or, elsewhere in the home.

There should be network and security of supply benefits through the opportunities offered by time-of-day pricing, which may lead to peak-demand reductions. But market participants see a lower value in peak-demand reductions in the UK than in many other countries. Smart metering could also enable better valuation of distributed generation .

Assuming cost-recovery over a 15-year period (life of asset) the extra costs per customer per year would be around £8 for the meter, plus £5-10 for operation and maintenance (all nominal values). If 3% energy savings are achieved then, combined with the supplier and network savings, the overall cost-benefit calculation is likely to be positive – at a 1% energy-saving, the cost-benefit calculation may be positive depending upon the level of other customer supplier, network benefits. If the value of carbon savings was costed this would also increase the benefits.

The need for action

Provision of all new energy meters will soon become a competitive, non-price controlled activity. All the incentives for suppliers are to keep metering costs as low as possible and replacement (about 5% a year) is done on a like-for-like non-smart basis. The existence of a number of regulatory barriers means that without intervention, smart metering is unlikely to take off in the UK other than on a small-scale, targeted basis. Key barriers include the requirement for a visual inspection once every 2 years and potential stranding of new meter-assets. The options for regulatory action split broadly into :

- A range of interventions to make the competitive metering market work more effectively to support provision of smart-meters; or
- More major changes in the regulatory arrangements for meter provision, designed to achieve a more systematic rollout over a shorter period.

Options under the competitive framework

In this scenario the supplier would remain responsible for meter asset provision, meter maintenance, and, meter reading. The financial exposure for the meter-asset rests with the supplier. Metering costs will be reflected in prices charged to customers either by customer class or, perhaps, a 'bespoke' package. Minimal interventions would include :

- Remove requirement for a visual inspection every 2 years (easier for electricity than gas)
- Deal with stranding of new assets – through DTI/Ofgem-led supplier agreement for new supplier to take on smart-meter when customers switch.
- DTI/OFGEM would also need to lead an initiative on Interoperability.

These minimal interventions would keep down overall costs of smart metering, leave suppliers in the lead and allow a flexible, targeted, incremental approach, which may be desirable given the communications-technology learning-curve. However, they would produce very low volumes of smart-meters installed, no scale-economies and no pathway to 'critical-mass', which could lead to possible loss of wider benefits overall. Options for further interventions might include :

- New smart-meter duty on suppliers - for new and replacement meters from 2008 (as part of the response to the Energy End-Use Efficiency Directive).
- Set a standard of 'smartness' – e.g. AMM+Interval meters. DTI/ OFGEM would need to lead this initiative and set a timetable.
- Accelerate rate of meter-replacement - e.g. to 10% or more a year.

These further interventions could help to stimulate upgrading of the meter-stock by creating a guaranteed minimum market, whilst maintaining flexibility. All suppliers would face the same requirements so it potentially removes 'first-mover risk'. However, they would lead to extra costs for an uncertain size of benefit, volumes would remain relatively low and overall cost-to-serve during the replacement phase could increase.

Geographic roll-out

For most smart meter rollouts internationally, long-term responsibility for the meter-assets sit with the network and expenditure is recovered via network charges. A mass-roll out could realise logistical and organisational efficiencies, deliver scale-economies and provide a rapid upgrade of meter infrastructure. Full supplier-benefits could be realised and the cost to consumers could be spread over 10-plus years. This does not necessarily mean rebundling – there could be competition for geographic meter licences and meter operation could become subject to competitive provision by 2007 as currently planned.

However, a geographic rollout represents a high cost step for uncertain benefit. The potential technology and implementation risks are transferred to consumers – unless DNOs or Meter Licence Holders are incentivised to take some risk. There is also the risk of early lock-in to technology choices while communications options are still evolving. Key features would include :

- Suppliers would continue to make meter arrangements – but financial exposure would rest with the DNO or Meter Licence Holder.
- DNO / Meter Licence Holder would be required to offer terms to provide meter assets in a geographic area.
- DNO / Meter Licence Holder would be required to replace, say, 20 % pa of existing meter stock with new meters which conform to new 'smart' standard.
- New meter assets could be price-controlled – or not.
- Costs recovered via DNO / MLH charges to suppliers over full asset life – i.e. 10-plus years – enabling pass-through to consumers.

The case for a major trial

A major smart-meter trial would be very valuable but should not hold-up progress. Some of the changes outlined above should be introduced in parallel. A key priority should be to secure better information on the effects of smart meters on energy consumption (electricity and gas if possible) and load shifting and it could trial different forms of customer display and feedback. Empirical evidence on energy saving from a trial would allow fuller evaluation of the cost-benefit case for gas smart-meters. A trial could be funded by allowing EEC credits for smart meters during EEC 2a (2005-08). Depending upon the outcome, smart meters could then be accredited under EEC 2b from 2008.

Conclusion

Under the present commercial, policy and regulatory framework, little is likely to happen to stimulate smart-meter installation, without additional measures. Smart meters offer opportunities for suppliers and for consumers, which risk not being realised. In many other countries detailed assessments have found a positive cost-benefit case for widespread smart meter installation and this review suggests that the cost benefit case for the UK is also likely to be positive, but further work is needed to confirm this. Therefore it would be sensible to start with a number of minimal interventions to enable some progress to be made, alongside a major trial or trials, to help determine the most appropriate further regulatory interventions. These could either be developments of the current competitive framework, or a more systematic geographic rollout.

1. Smart meters in the UK – policy history and context

1.1 Advanced metering in the UK has a thirty-year history, particularly for electricity. From the mid-1980's onwards, the former Electricity Council and a number of the Area Boards, actively explored 'new metering technologies', and initiated major field trials[1]. Subsequently, energy-industry re-structuring and the introduction of retail-competition with associated metering developments, meant that few new metering initiatives took place at the residential and SME-level in the period 1990-98. From 2000 onwards, three significant policy reports were produced on smart metering in the UK, but few notable new policy or regulatory responses emerged.

- **Review of the energy efficiency and other benefits of advanced utility metering** – April 2000. Produced for BEAMA by EA Technology[2]. Wide-ranging and authoritative desk-review of research on metering and energy saving. Inter alia, concluded that improved customer displays and tariff advice were central.

- **DTI Smart Metering Working Group** - made a clear recommendation for pilot studies 'to help determine whether the introduction of smart meters could result in benefits to consumers and companies and also help contribute to the achievement of Government …objectives'[3]. It seems that, in the absence of Treasury and Cabinet Office support, these pilots did not proceed.[4]

- **The New Metering Technology Working Group,** an industry-wide group, convened by Elexon[5], reported at Ofgem's request in May 2002. They concluded that 'policies and decisions must be made now to enable the UK energy industry and their customers to benefit from advanced metering technology'.

[1] Actively supported by the then Electricity Consumers' Council (ECC). 'New Metering Technology'. ECC. Dec. 1985.

Teleswitching : EMEB/BBC installed 50,000 teleswitch units. Today, hundreds of thousands are in use, and are still being purchased.

Mainsborne Signalling : DTI / EMEB / LEB – 2-way communication c.1000 homes in 1982/3.

CALMU - Credit and Load Management Unit Trial. Interim Report 1984 – SEEBoard/ EME & MEB trial of 300 customers : 2-way communication w some teleswitching ; ToD tariffs ; comprehensive customer display ; load management. Succeeded by **EMU** – Energy Management Unit for 500 customers in six Area Boards – multi-rate meters with customer display - received very positive customer feedback. MBA Dissertation. D Lickorish & SEEBoard CALMS report. 1986.

[2] A Review of the Energy Efficiency and Other Benefits of Advanced Utility Metering. A J Wright, J R Formby, S J Holmes. EA Technology. April 2000

[3] DTI Smart Metering Working Group. September 2001

[4] Some trials conducted by suppliers encountered technology problems, creating reticence for wider rollout.

[5] Convened under the Balancing and Settlement Code in Aug 2001.

1.2 In May 2002, Ofgem produced a final Metering Strategy, in expectation that 'Metering competition can deliver significant savings for consumers and encourage the application of innovative metering technologies'. A Metering Innovation Working Group, met intermittently, until 2005. The PIU Study (Feb 2002) and the Energy White Paper (Feb 2003) gave a new policy focus to demand-side and energy efficiency issues, with a succession of follow-on consultations, reviews and policy initiatives[6], but neither addressed smart metering in any detail. The 2002 policy-push on smart meters therefore seemed to have all-but stalled[7], but prospects of higher energy retail-prices, coupled with the risk of failing to meet UK targets for CO_2 reduction in 2010, and new EU-policy developments, have served to re-kindle policy and political interest.

- **Energywatch**, initiated a widely welcomed debate in September 2005 on smart metering [8].

- **In Europe**, EU energy liberalisation legislation requiring full opening of electricity and gas retail markets from July 2007 has served as a catalyst in some member states for residential smart meters, where they are seen as a pre-condition for successful domestic retail competition.

- **The Energy End-Use Efficiency and Energy Services Directive** finally reached political agreement in November 2005, with an implementation date of May 2008. Along with a number of energy-saving measures, 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 for electricity, natural gas,……are provided with competitively priced individual meters that accurately reflect the final customer's actual energy consumption and that provide information on actual time of use. When an existing meter is replaced, such competitively priced individual meters shall always be provided, unless this is technically impossible or not cost-effective in relation to the estimated potential savings in the long term. When a new connection is made in a new building or a building undergoes major renovations as set out in Directive 2002/91/EC, such competitively priced individual meters shall always be provided" – Article 13.1 and that "billing is based on actual energy consumption, and is presented in clear and understandable terms….Billing on the basis of actual consumption shall be performed frequently enough to enable customers to regulate their own energy consumption" – Article 13.2. There are also additional billing-related requirements

[6] Including the Energy Efficiency Implementation Plan (March 2004), the Climate Change Programme Review Consultation (December 2004 - ongoing), the House of Lords Science and Technology Committee Report on Energy Efficiency (July 2005) and the Energy Efficiency Innovation Review -December 2005.

[7] BEAMA have actively and tirelessly continued to make the case for smart meters.

[8] Get Smart. Bringing Meters into the 21st Century. Energywatch. August 2005.

concerning tariff information and comparative historic consumption data in graphic format.[9].

- **DEFRA, DTI and Ofgem will consult in 2006 on UK implementation of the Energy End-Use Efficiency Directive**, and there is likely to be a wide-ranging debate on how this is best carried forward as a requirement in Supply Licences by May 2008, and the role, if any, for smart meters.

- **Domestic Metering Innovation. Ofgem Consultation** - Ofgem has been conducting an exercise to review progress on meter innovation in the context of the competitive regulatory framework for meter provision and meter services. Ofgem issued a consultation in February 2006[10] and a Next Steps document is expected in May 2006.

- **Government Energy Review 2006 -** DTI launched its new Energy Review in January 2006[11]. This questions what more Government could do on the Demand-side, to ensure that carbon emission goals are met, and that homes are adequately and affordably heated.

1.3 This review of the potential for smart metering therefore takes place at a crucial time. In particular, the Ofgem consultation, together with the forthcoming consultation on the Energy End-Use Efficiency Directive, offer a major opportunity to define a clear policy pathway for smart meters, and to enable firm recommendations to feed into the Energy Review, expected to report in summer 2006. Thereafter, strong and continuing leadership by DTI, with appropriate support from Ofgem and DEFRA, will be a fundamental precondition to achieving a coherent policy framework, able to deliver smart-meters at a residential and SME-level in the UK.

[9] Directive 2005 / …/EC of the European Parliament and of the Council on Energy End-Use Efficiency and Energy Services. COM .

[10] Domestic Metering Innovation. 1 February 2006. 20/06

[11] Our Energy Challenge. Securing Clean, Affordable Energy for the Long-Term. DTI. 23 January 2006.

2. Metering market, regulation and technology

2.1 UK metering market and regulation

Energy suppliers are responsible for making metering arrangements on behalf of their customers[12] and can arrange for any type of meter to be installed, subject to it conforming to basic accuracy and safety requirements . Suppliers contract with others who provide meter assets, operate meter services (installation, maintenance, repair, replacement etc) and read meters. Data collection and aggregation for billing may also be undertaken as a separate service. Data processes and data flows are subject to common governance arrangements.[13] The UK meter sector therefore comprises the six large energy suppliers, a number of smaller ones, the fourteen geographic distributors[14], four gas transporters[15] and a number of stand-alone meter operators. Some electricity and gas licensees are developing non-licensed meter businesses, and others are selling their meter assets. A growing meter requirement for small-scale renewables and micro-generation, needing import / export measurement, represents a potentially sizeable new market segment.

The phased introduction of retail supply competition from 1990 meant that metering innovation was driven first in the industrial and commercial sector, in response to the need for half-hourly meters for the 100kW market in electricity. Full retail-market opening in the late 1990s was followed by full separation of electricity distribution and gas transportation from energy supply. This was accompanied by opening meter provision and operation to competition for the residential- and small-business sectors. There has therefore been a move towards a more disaggregated arrangement, from the structure in the late 1990s where electricity Distributors and National Grid Gas owned all the residential and small-business metering assets, and who, subject to an efficiency factor, could pass-through meter costs to suppliers.

In the current transition phase, suppliers can contract with third parties to provide meter assets or meter services, but electricity distributors and National Grid Gas provide a default service (i.e. meter provider of last resort). The current regulatory intention is to move to a fully competitive framework for meter assets and meter services where the role of default-provider will lapse, prompting suppliers to make other metering arrangements. For electricity this is expected to take place from April 2007, and for gas, the date is yet to

[12] Supply Licence Conditions 7 (Ely) and 34 (Gas). Customers can make their own metering arrangements under the Gas Act 1986 and the Electricity Act 1989.

[13] REMA – Review of Electricity Metering Arrangements. RGMA – Review of Gas Metering Arrangements.

[14] Geographic footprint of former Public Electricity Suppliers

[15] National Grid Gas (formerly Transco and Transco Metering Services), and three Independent Gas Transporters.

be determined [16]. The expectation is that third-party meter operators will take business from distributors and National Grid Gas unless they prove cost-competitive.

2.2 Residential and SME meter stock

Despite widespread adoption of consumer electronics and new communications technologies in innumerable fields, the UK residential and SME meter stock remains virtually unchanged. There are around 49 million electro-mechanical and basic electronic gas and electricity meters in the UK – generically all called "basic" meters. These remain largely owned by National Grid Gas (c.95%) and the Distribution Network Operators (c.90%).

Costs of residential meter provision and operation represent less than 3% of the end-price to consumers of electricity or gas – competition has and is expected to continue to exert downward pressure on prices. Ofgem quote a cost to gas and electricity customers of £800 million per annum for meter installation, meter services and meter reading[17]. It is a judgement for suppliers as to how much of the costs of meters is passed on to customers and costs can be recovered either by sharing costs across a class of customer, or smearing costs across all customers, (these two options most commonly used for "basic" meters) or charging individual customers a cost reflective price for their meter (e.g. for a non-basic meter). Long-term financial exposure for the meter asset rests with the supplier.

Basic meters perform a low-cost and reliable job of accurate measurement of energy used (electricity) and volume supplied (gas). Main drawbacks of basic meters include:

- The need for a physical-read to obtain data to generate a bill.
- Inability to record on a time-related basis – i.e. *when* energy was used.
- No easy-access to meaningful consumption feedback for consumer.
- No means of remote activation / de-activation.

There are around 5.9 million pre-payment meters in use in Great Britain representing around 13 % of domestic meters. There are 2.1 million gas PPMs - 10% of domestic gas customers. Almost all gas pre-payment meters are Quantum meters, which use smart- card technology [18]. There are 3.8 million electricity PPMs - 15 % of domestic electricity customers, of which : 1.5 million are token meters; 1.5 million are key meters; 0.8 million are smart card meters. Token meters have a number of shortcomings, including greater

[16] Distribution Licence Conditions 36C and Gas Transporter Licence Conditions 8.

[17] Ofgem Fact sheet 26 'Introducing competition in metering'. March 2003.

[18] Under their meter price control, National Grid Gas charges Suppliers £29.73 pa for a PPM, of which £7.86 pa is for meter provision. Gas pre-payment meter costs are currently quite substantially cross subsidised by charges made for domestic gas credit meters.

susceptibility to fraud and mis-directed payments and high maintenance costs due to the need for site-visits to set tariffs and obtain meter readings. 'Key' meters by contrast, allow transfer of information such as tariff-changes and meter reading data to and from the key at the payment service-point. In this sense, key meters are 'semi-smart'[19].

In Northern Ireland 175,000 keypad electricity prepayment meters have been installed, initially replacing token meters, but now covering c.25 % of residential customers, these have led to costs savings and lower prices for prepayment customers, but the scope for similar savings and benefits in Great Britain is lower because much of the prepayment meter stock is semi-smart as detailed above.

Around 2.5 million meters (about 5% of the stock) are replaced each year. In addition, there are around 400,000 new meter connections pa. [20] For electricity, this ties into present arrangements for meter certification and depreciation treatment in the meter price control. For gas meters, which do not have a 'certified' life, replacement rates are implicit in the price control and the Meter Service Agreement between National Grid Gas and suppliers.

2.3 Smart meters

There is no single definition of smart metering. A smart-meter system comprises an electronic box *and* a communications link. At its most basic, a smart meter *measures electronically how much energy is used, and can communicate this information to another device.* For both electricity and gas, there are two main smart-meter types :

- **AMR – One-Way Communication from the Meter to the Data Collector –** as a minimum enabling **Automated Meter Reading.**
- **AMM - Two-Way Communication between the Meter and the Supplier** - enabling a wider range of functions known as **Automated Meter Management.** A further refinement of the AMM meter is an **Interval Meter -** a two-way meter with a capability to store and communicate consumption data by time-of-use (e.g. half-hourly intervals).

The key distinction between smart-meter types is therefore determined by their communication – i.e. whether one-way or two-way - and data-storage capability. These basic meter *capabilities* then determine the *functionality* that the meter might offer. Functionalities range from basic remote meter reading and tamper-detection to remote activation and load-shedding, remote tariff-change and time-of-day tariffs plus data-

[19] Ofgem. Pre-payment Meters. Consultation on New Powers under the Energy Act 2004 and Update on Recent Developments. February 2005. 32/05.

[20] DTI Smart Meter Working Group. 2001

storage. The following list captures the core capabilities that are consistently identified as particularly important for a smart meter system :

- Measures energy consumed - quantity and when (a time-interval basis)
- Records 'billing-level' readings
- Two-way communication
- Stores interval-data and transfers it remotely to a data collector / utility
- Capable of storing and displaying consumption and tariff information

Communications combinations are still evolving with fixed, mobile, wireless, narrow-band and broadband options available. Reliability and data-accuracy are a recurring theme, whatever the chosen communications technology. Broadly speaking, communications from the meter to an *initial* data-collection point can be grouped between :

- fixed - e.g. telephone landline - PSTN, ISTN, Cable/ADSL ; or the electricity distribution wires - Power Line Carrier (PLC)
- wireless – e.g. GSM (system used by mobile phones); various forms of radio communications such as GPRS and Low Power Radio(LPR)

Different communications technologies seem best suited to different needs as follows.

- **GSM -** would allow Suppliers considerable flexibility in targeting particular customer groups, including SMEs, pre-payment or remote residential customers.
- **PLC – LPR** – are well suited to geographic-based smart meter rollout and are being extensively and successfully deployed in Italy and Scandinavia, for example.

In a number of countries where smart meters are being installed a range of communications technologies are being deployed to meet different needs, and many valuable lessons are being learned.

2.4 Basic data meters

A number of low-cost options exist which are not smart meters, but which could make meters capable of being 'smarted' in the future. These are basic data meters with a minimum level of communication capability, through a pulse or electronic packet that can later be interfaced to a smart box or external system, to add more functionality. These basic data meters suffer from shortcomings related to reliability and while they may facilitate some retail-led initiatives by suppliers, a separate smart-box with consumer electronics *and* a mobile communication system *will still be required.* This option may therefore require two visits for installation, adding to the overall cost.

2.5 The importance of visual displays

DEFRA, Energy Saving Trust, energywatch, the Carbon Trust and the Association for the Conservation of Energy stressed that improved consumption feedback to create better awareness of energy use and carbon emissions, is potentially one of the most important 'gains' from a move to smart metering[21]. It is therefore important to note :

- Meters may well be positioned out-of-sight. Most household meters are in under-stair or external cupboards.
- Smart meters will not necessarily have a user-friendly consumer display showing usage, expenditure and tariffs, unless part of a meter specification. A separate consumer-display elsewhere in the home, wireless-linked to a smart meter is possible, but would add to costs.
- Even with smart meters, billing may well remain the main channel for providing consumers with feedback.
- Only two-way interval meters have the capability to display real-time time-of-use prices, to which consumers can actively respond.
- Consumers may choose a tariff package from their supplier, linking time-of-day with different tariffs, obviating the need for a display.
- Consumers could obtain data via other means – for example via the internet, interactive TV or mobile phone – provided they have a smart-meter which links to an external communications medium.
- Consumers could find consumption-breakdown between lighting and other electrical circuits of interest. However, separate measurement devices on each internal circuit would be needed to achieve this.

2.6 Basic visual displays without a smart meter

A number of non-smart 'clip-on' devices are coming onto the market [22], which provide a clear visual display, generated from a signal from the *existing* non-smart meter. At £–50 or more, the unit cost is currently not trivial, but could come down with volume. The consumer needs to programme the device but information from Canada [23] suggests they can be an effective tool in increasing awareness of energy use. Other, more basic, plug-in electronic devices give expenditure information for individual appliances, and retail at under £10. The Danish Electricity Saving Trust[24], has developed a power-saving plug which reduces 'stand-by' consumption on appliances such as televisions and DVDs [25]

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[21] Twenty years ago, ECC Survey, 1985 concluded : 'without detailed cost information for consumers most of the benefits of these systems will be lost as consumers would not be able to plan their electricity consumption in the most energy and cost-efficient manner.

[22] such as RWEnpower's Electrisave

[23] HydroOne pilot of 500 homes. Ontario. Sept 05

[24] Danish Electricity Saving Trust – ElSparefonden – www.sparEl.dk

[25]DEFRA estimate that in the UK, appliances on stand-by use around 7 TWh pa. An Energy Saving Trust survey suggests that the average UK household has up to twelve devices on charge or on stand-by at any one time. (news.bbc.co.uk/1/hi/sci/tech/4620350.stm - 22 January 2006)

3. Smart metering experience and studies

This section outlines the key lessons from international experience with smart meters and the evidence from this experience and other studies on the impacts of smart metering on overall energy use and peak demand.

3. 1 International experience

Much of the international experience (especially in the US) is with AMR only, was developed many years ago and driven by a tradition of monthly billing and hence a strong business case to cut meter reading costs. The AMR systems used in the US have mainly involved fitting a small communications device to the meter to enable the utility to read meters from a van driving by houses, obviating the need to get into the property. This will be of limited interest in the UK context given that :

- the relative costs of AMM and AMR are now closer
- quarterly billing (and only once every 2 years meter reading requirement) reduces the business case for AMR on its own
- the main potential benefits (for the energy industry, and especially for customers and public benefits) are from AMM

The focus therefore is on those examples that are AMM (with or without interval metering). Note also that all of the examples are for electricity. The only examples of use of advanced metering for gas are in the US and have tended all to be AMR. The international examples examined for this report are therefore : California (US) Italy, Netherlands, Northern Ireland, Ontario (Canada), Sweden, Victoria (Australia)

Generally, in most of the international examples, the benefits for the energy suppliers/distributors (whoever has the metering responsibility) do not add up on their own to a business case for smart metering. The exceptions to this are :

- Italy, where particular circumstances made it sensible for ENEL (although even there the regulator has allowed some cost recovery) to do smart metering (fraud/theft, advent of competition)
- Sweden, where monthly meter reading created a business case for AMR (they have now moved on to AMM in many cases as the incremental costs relative to the extra benefits make this sensible).
- Northern Ireland, where the form of prepayment metering used was high cost, thus justifying a smart metering rollout, but only of prepayment meters.

In Victoria, Ontario, California and the Netherlands the assessment is that the benefits exceed the costs when societal benefits or economy wide benefits are taken into account. The direct benefits to energy suppliers/distributors do not exceed the costs and the assessment is that they would not be able to capture the benefits hence the need for regulatory or government intervention.

The main societal or economy wide benefits identified are :

- reductions in peak demand leading to better security of supply - less risk of blackouts (California, Ontario, Victoria, Italy)
- reductions in peak demand leading to lower costs due to less need for peaking plant and power imports and avoided investment in distribution and transmission network upgrades (California, Ontario, Victoria)
- improved balance between supply and demand leading to greater efficiency of operation of the electricity wholesale market (Victoria)
- customers enabled to switch supplier more easily, plus new service offers made possible by smart meters (Netherlands, Victoria, Sweden)
- environmental benefits from reduced power demand (Sweden)

Note that reductions in overall demand and carbon emissions reductions have not been identified as major benefits in most of the international examples - although they are mentioned as potential benefits in Victoria. This would appear to be mainly because these have not been drivers for smart metering and therefore have not been assessed. It is interesting to note therefore, that in each of these countries, a positive cost/benefit case has been established without taking into account any benefits that might accrue in terms of reduced carbon emissions.

3.2 Studies of the impact of smart metering on energy saving

It is generally assumed that smart metering, by providing more information to consumers, will encourage more efficient use. There have been a number of trials and research studies of smart metering and other methods of providing improved information to consumers and these were reviewed for this report. The two key research reports are Wright et al (2000[26]) and Darby (2001) - these are the basis of the figures for potential energy savings due to smart meters quoted in some of the other main reports on smart metering and informative billing (DTI, 2001, CSE, 2003, Energywatch, 2005). Both Wright et al and Darby review a number of studies in the UK and overseas.

Wright et al identify eight separate techniques used to improve information and lead to energy savings in a number of countries. These include improved billing information, customer displays, load control via the meter, and use of the meter as a communications

[26] Wright et al. A review of the energy efficiency and other benefits of advanced utility metering. EA Technology, 2000

gateway to the home for load control and other services. They note that four of these (mainly improvements to billing information and energy advice) were achieved with no change to metering. The main evidence is from Norway (Wilhite et al) where the saving was on average 4% three years after consumption information was introduced compared to a 4% increase in households in general (so equates to an 8% fall).where savings of up to 10% were achieved. Note that in this case that this was due to more informative bills – not smart meters with displays – and in all-electric homes.

Commenting on the applicability to the UK, Wright et al conclude "it is not possible to say how much energy would be saved. Better billing feedback produced savings of up to 10% in electrically heated homes in cold climates, mainly using simple manual methods. In the absence of electric space heating smaller savings are likely, but some of the automatic measures here could produce new types of saving - for example in refrigeration - which would not be possible manually. Load shifting is easier than load reduction, so cost savings are easier to achieve than energy savings, but both would probably lie in the 0-5% range for a home without electric heating."

Darby (2001[27]) reviewed 38 feedback studies that had been carried out over a period of 25 years (1975-2000) Of 21 studies that involved what Darby terms direct feedback (includes smart meters but also other things such as better displays, use of TV/internet, prepayment meters) the majority (15) showed savings in the range of 5-14%. As Darby points out "A number of difficulties arise in comparing, and even categorising, these studies: all contain a different mix of elements such as sample size (from three to 2,000), housing type, additional interventions such as insulation or the provision of financial incentives to save, and feedback frequency and duration." The paper does not seek to separate out the results according to these or other variables such as : low income or a cross section of households; prepayment or credit payment; fuel use (e.g. whether feedback on electricity use was in electrically heated houses).

Direct feedback in conjunction with some form of advice or information gave savings in the region of 10% in four programmes aimed at low-income households (with constant or improved levels of comfort. Darby concludes that "Feedback is a necessary but not always a sufficient condition for savings and awareness. It should not be treated in isolation: this is also a clear lesson from this review. The range of savings, as well as the accompanying detail, shows the importance of factors such as the condition of housing, personal contact with a trustworthy advisor when needed…"

More recent evidence comes from Northern Ireland and Ontario. The Northern Ireland example shows energy savings of 3% but evidence from a longer-term study (due later in 2006) will be needed to see if this is maintained. The Hydro One project in Ontario in 2005 found a 7-10% saving effect over one year and this is interesting as it shows the value of customer displays, that could be provided without full smart metering. In this

[27] Darby, S. Making it obvious : designing feedback into energy consumption. Oxford University, 2001

context the Powergen consumption information trial and the npower Electrisave trials should also provide some useful UK evidence on the usefulness of information.

Further recent evidence comes from a major International Energy Agency study[28] of trials in a number of IEA countries into feeding back energy end use information to smaller customers using a range of methodologies, including smart metering, better billing etc. The study found average energy savings of around 10% although as with previous reviews, a very wide range was found.

To sum up therefore, most trials and studies to date have examined effects on electricity use only and in homes with electric heating, whereas most UK homes have gas heating. In the UK there may be more scope to reduce gas use with smart metering (heating and hot water uses). Many of the studies include time of use pricing, and the provision of other measures (e.g. installation of energy saving measures, advice) alongside smart metering. Another point to note is that few studies have been longitudinal so it is not clear whether demand reduction effects are only short-lived. This all suggests that there is the need to get further good, long term evidence, before a real assessment of the energy saving potential is made. In the meantime, based on the available evidence, and taking a cautious view, it is reasonable to assume that some energy saving will result but that it could be as low as 1% and for electricity it would be unlikely to be much more than around 3% Smart meters for gas might well produce higher savings but there is not enough evidence on which to make an estimate.

The evidence does suggest that the energy saving and environmental effects of smart metering should be greater if :

- clear, well positioned and easy to understand customer displays are provided
- time-of-day or time-of-use tariffs are introduced alongside smart meters
- information from smart metering is reinforced by other action – e.g. offers of energy saving measures/packages, advice on behavioural changes, offers of micro-generation packages

Smart metering thus could have a role to play in an overall energy saving strategy that also encompasses these other measures.

It is also worth noting that all the above relates to the household sector. Work by the Carbon Trust[29] suggests that there may be considerable potential for energy savings in the business sector through greater use of smart metering and associated services. Early results from their trial of advanced metering plus professional advice on energy saving

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[28] Smaller Customer Energy Saving by End Use Monitoring and Feedback. IEA, 2005 (unpublished)

[29] The Carbon Trust's advanced metering project. Metering International, Issue 3, 2005 and Carbon Trust presentation to Ofgem seminar, 02.03.06

options in 575 SME premises have shown savings of 5% on average. In several of the countries that are rolling our major smart metering programmes, they are doing so for larger energy users first, partly because delivery is easier to fewer larger users but also because the greatest potential (albeit mainly for load shifting rather than reduction) exists in those sectors.

3.3 Evidence on peak demand reductions

There are three main potential benefits from peak demand reductions. Firstly, cost saving – if it reduces need to upgrade networks or construct new power stations Secondly, improvements in security of supply, as blackouts can be avoided and reliance on fuel imports reduced. Thirdly, possible emissions reductions, but these depend upon what is the marginal generating plant and so could vary quite significantly, subject to coal or gas-burn at peak. Wright et al (2000) said that the carbon benefits of load shifting in the UK would be very small – around 0.3%. The main driver for peak demand reductions has been to improve security of supply but also to some extent to secure cost savings. Potential emission reductions have not been an important driver. While smart-metering could achieve some load-shifting, the UK has already achieved a substantial load-shift to off-peak periods through off-peak tariffs which have been available for electricity, and particularly for some forms of electric space-heating in the UK, since the 1970s, and have been used in conjunction with automatic teleswitching of appliances or the use of simple timers. However, the ability to use smart-meters to offer a new range of time-of-use tariffs and some additional automatic switching-on and off of appliances, or providing messages to consumers to switch off in expensive periods, has opened up new possibilities.

In California, which is a key source of evidence of smart metering impact on peak demand, the serious power cuts experienced in 2001 acted as a spur to the use of smart metering. A statewide pilot, authorised by the California Public Utilities Commission (CPUC), involving 2500 residential and small commercial customers, was run in 2003 and 2004 to study demand response to critical peak pricing with smart meters. Some in the trial had automated response (the meter was linked to appliances and could change thermostat settings or switch off) others were given information about when prices were high for them to respond. The effects ranged from 27% reductions (with automated response at the highest critical peak prices) to more typical 5-10% reductions without automated response. One group of households was just given information about peak periods without a price signal and no discernible response was found in these cases – so the price signal seems to be important. However, there was no impact on overall demand – it was merely shifted to off-peak periods. However, Charles River Associates' analysis of 16 other time of use and CPP programs found an average conservation effect of 4%. A large-scale trial of smart metering with time of use tariffs and automated response in Norway (1200 customers over 3 years, 2001-04) found reductions in morning peak loads of around 12% and of afternoon peak loads of 14% (Crossley, 2005).

A recent study by the IEA[30] identified thermostat reductions of direct space and water heating and air conditioning for a few hours per year are able to make significant contributions to reducing system peak demands. It also identified that small-scale micro generation could easily be controlled on the basis of TOU pricing to reduce unscheduled peak demands. Results of field trials of dynamic pricing identified that automatic intervention is preferred by customers for shifting demand rather than requiring manual actions.

However, the UK differs from many other countries where peak demand has been a key driver for smart metering because fewer than 10% of households use electricity for heating and there is virtually no air conditioning in households. The household potential will be mainly to switch washing machines, dishwashers and tumble driers to off-peak, because many appliances need to be used when the need arises and so cannot be shifted to off-peak. The main potential may be in the commercial sector where load shifting could be very significant due to use of air conditioning and refrigeration. Thus although there is some very good international evidence on load shifting, it probably has limited relevance to the UK. There are two areas where further work will be beneficial in the UK context. First, on the potential effect of more clearly differentiated tariffs on residential appliance-use in the UK. Second, modeling of the likely medium-term impact upon UK carbon emissions to result from peak lopping and other potential changes to the shape of the daily load-curve.

[30] Time of Use Pricing for Demand Management Delivery. IEA, 2005 unpublished

4 Costs and benefits of smart meters

This section first looks at the likely capital and installation costs of smart meters. It concludes with an illustrative overview of the overall cost-benefit position.

4.1 Smart meter costs compared with basic meters

Costs can vary considerably depending upon volume and technology assumptions, and there are a number of ways of assessing these. For commercial reasons, much cost information provided to this study was broadly generic, and accordingly the costs below reflect a synthesis of two main sources of information : known costs where smart metering has been introduced overseas; likely costs in the UK, based on certain volume and technology assumptions. However, the figures come with a significant health warning – there are some very different views about the reasonableness of some costs amongst different parties (meter manufacturers, energy suppliers etc) – in particular divergent views about installation and operational/maintenance costs. It should also be noted that the costs are for electricity smart meters only. A number of costs may be higher for gas smart meters – notably a contactor to connect and disconnect supply, due to safety issues.

4.1.2 Basic meter

Costs around £7-8 plus installation costs[31]

4.1.3 Basic data meter

Would add about £1-3 to cost of basic meter. However, the data capability does not add any smart functionality and the need to visit at a later date to add a "smart box" would mean two lots of installation charges.

4.1.4 Advanced meters

There is no significant difference between the unit cost of AMR and AMM meters [32]. The costs which follow are therefore only for AMM, given the greater functionality that this will provide. The choice of communications technology has a significant impact on costs. Power line carrier (PLC), fixed network radio and low power radio (LPR) tend currently to be significantly cheaper than GSM. The use of fixed telephone lines tends to be considered too expensive compared to other options.

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[31] 2005-07 Electricity Meter Price Control – Allowable capital cost for a 'basic' meter, as at June 2003

[32] The form of AMR used extensively in parts of the US - where meters are fitted with a simple transmitter that can send a signal to a van for drive-by readings – may have lower costs.

The figures below are based on a number of different sources in the UK and international experience, assume a reasonable volume purchase (at least 300,000 plus) and are for single-phase credit electricity meters.

- **Cost of base meter** – includes more functions than a basic meter and has appropriate software – around £15-17.
- **Costs of specific functionality –** for example - an interval / data storage (enabling time-of-use) facility; a facility to operate in prepay mode (using keypad or smart card for prepayment); a contactor to connect and disconnect supply; a customer display on the meter itself. Each additional function could add £5-7, but if part of a single meter specification, unit costs may be lower.
- **Micro-generation-** the ability to meter micro-generation at the customer's premises – i.e. to charge one rate for electricity supplied by the utility and credit the customer with a different rate for the electricity exported might also add between £1-7 depending upon the technology requirements.
- **Choice of communications medium** Power line carrier or fixed line radio - £17-20 (including data concentrator); low power radio £12 - £15 (excluding the cost of some form of handheld data collection unit); GSM - £35-40.

4.1.5 Potential cost ranges for advanced meters

Meter plus communications :

- AMM + PLC - £37-62
- AMM+LPR - £32-57
- AMM + GSM - £54-80

Plus :

- **Installation Costs** should not vary according to the type of meter (although GSM/LPR antenna positioning might cause some additional site costs) but will vary with volume installed and whether meters are being rolled out on a geographic basis or more selectively. Post-installation checks and fault handling are assumed to be included in installation-related costs. £20-30 per meter.
- **Data infrastructure/systems** - that need to be set up within the utility. These will vary significantly in terms of cost per meter, depending upon volume, as there will be a high level of set up costs associated even with a small volume of meters installed. £15-25 per meter.
- **Separate customer display** – connected by PLC or wireless to the smart meter but conveniently located for customer use (e.g. kitchen). Compared to a display on the meter itself(£5-7) this could add a further £28-45 to the cost.

Total potential capital cost ranges :

- AMM + PLC or LPR - £70-115 (£98-160 including separate display)
- AMM + GSM - £95-135 (£123-180 including separate display)

To the above costs need to be added :

- **Ongoing operational costs / maintenance** - including costs of maintaining communications infrastructure - could be £5-10 per meter.[33]
- **Stranding costs** – the costs of compensating meter asset owners for early removal of functioning meters would also need to be added if smart meters were to be installed under an accelerated replacement or rollout over a short period. This could add a further £15-17 to capital costs (Ofgem estimate).

4.1.6 Assuming a meter price of £120 installed, and an asset life of 15 years this gives a simple annualised cost per meter of £8, plus operating and maintenance costs of £5-10, making a total of £13-18, excluding stranding costs which would be limited at these volume assumptions. These are all nominal values – depending upon discount rates applied the NPV will clearly vary. (for comparison in California the assumed extra cost per customer per year is US$24; in Ontario CAN$36-48) Meter unit costs would fall considerably with larger volumes – by up to one-third – communication, system and installation costs would all fall with increasing volume. However, stranding costs would the also need to be factored into the costs of a major programme.

4.2 Supplier costs that may be impacted by smart metering

To assess whether the costs of smart meters are exceeded by the benefits of introducing them, it is useful first of all to examine the costs incurred by suppliers in metering and billing customers, plus the costs of the supplier switching process.

4.2.1 Quantified costs[34] :

- **Meter reading** - costs £6 per annum average to read a meter x 45 million customers = £270 million

[33] Some estimates suggests costs could be lower at £2-3 per year but others that they may be higher, particularly in the early days of a large scale deployment, due to problems with manufacturing, installation, communications, customer misuse, programming error etc.

[34] Assumptions : 20 million households have gas; 25 million households (i.e. all) have electricity. No account taken of any cost savings from dual fuel.

- **Call centre activity** - Average £10 per customer x 45 million customers = £450 million

- **Billing** costs - £4 per customer average x 45 million = £180 million

- **Supplier switching** process Logica estimate £100 million per annum for mis-billing and data integrity problems associated with supplier switching (but it is suggested Ofgem estimate this at between £100-200 million)

- **Gas prepayment meters call outs** (Transco undertake 1 million visits a year due to problems at a cost of £50 a visit) - £50 million

- **Lost revenue due to fraud/theft/bad debt** – Some estimates suggest that around 2% of turnover is currently written off due to bad debt (this would be £284 million if applied to gas and electricity domestic sector) Ofgem estimates the cost of theft at £100 million.

So the total cost of the above is in the range of £1.1 billion - £1.4 billion

4.2.2 Plus the following more uncertain costs :

- **Switching between credit and prepayment**. A gas prepayment meter costs around £130 and an electricity prepayment meter around £55, plus an installation/switch cost of £50. Possibly about 10% (600,000) of the prepayment meter population changes each year, so these costs could be substantial.
- **Costs of site visits** to change tariffs for token electricity prepayment meters (1.5 million meters). Most of these are included in meter reading costs as done at the same time, but there may be a cost of around £10 million for special visits.

4.3 Potential benefits of smart metering

The main beneficiaries will be suppliers; network operators; customers. In addition there are potential public benefits (environment, security of supply, contribution to fuel poverty targets), but caution is needed to avoid double counting of benefits.

4.4 Supplier benefits

For suppliers a major attraction of smart meters could be the potential to reduce some of the above costs. However, smart meters could be more useful to suppliers if they also opened up the potential for increased revenue. This section divides potential benefits to suppliers of smart metering into : cost reductions; revenue enhancements.

4.4.1 Scope for cost reductions for suppliers :

- **Meter reading** – Suppliers are required to make a visual meter check once every two years, although they read most meters more frequently. An actual reading is required once every 14 months for settlement purposes, although 'customer own reading' is an acceptable alternative to a meter reader visit. However the quality of returned data is lower than that from a meter reader. Costs are very high for some customers where access requires repeat attempts (about one third of meter reading costs are due to hard to read meters). Smart meters would eliminate the need for a manual read, although if suppliers are still required to inspect meters once every two years then the cost savings will be lower. It is also important to note that the average cost-per-meter-read of those basic meters left will increase if smart meters are not introduced in a geographic rollout.

- **Call centre activity** – Smart metering should significantly reduce call centre activity due to the elimination of estimated bills and the need for customers to read meters. Costs are not evenly distributed amongst customers – they are small for the bulk of customers who never or rarely call but very high for some customers.

- **Billing and payment and other miscellaneous costs of serving customers** - Costs particularly high for some prepayment meter customers who buy credit frequently – e.g. more than once a week (transaction costs for use of Paypoint) Smart metering would eliminate estimated bills, but prepayment meter customers might still buy credit frequently.

- **Opportunity to seek a lower cost payment infrastructure for prepayment.**

- **Supplier switching costs** - process will be simplified. Smart meters should enable more accurate and efficient data processes and transfers

- **Switching between credit and prepayment** –Smart meters can enable this to be done remotely (at some extra cost - £5-7 per electricity meter but more for gas due to safety requirements), avoiding the need to change meters.

- **Fewer call-outs** - Cost savings would result from smarter prepayment meters with fewer problems leading to call outs

- **Switch-over to remote application –** There would be no need to visit to change tariffs or read meters for the token electricity prepayment meters (1.5

million) The business case for changing these is strong but the main issue inhibiting action at present is which technology to choose [35].

- **Bad debt reduction /better detection of fraud/theft** – due to elimination of estimated bills, scope for more frequent billing and automated detection of theft (sensitivity of detection varies with technology). Hence potential reductions in revenue lost

- **Load management/electricity purchasing** – better data potentially enables better management of power purchase agreements.

It is difficult to quantify what these cost savings might add up to, but discussions with suppliers suggest it is reasonable to assume that at least 15-25% of supplier costs outlined above might be saved from the introduction of smart metering.

4.4.2 Revenue enhancements for suppliers :

In addition to scope for cost saving, there are also a number of ways in which suppliers could improve their present revenues through smart meters. For example :

- **Improved use of** working capital– the gap between reading meter, billing and collecting money all shortens – hence a cash flow benefit as money comes in faster in relation to costs incurred

- **New retail packages -** Ability to offer customers new packages – e.g. time of use tariffs ; energy services micro-generation

- **Dual-fuel and multi-utility-** Ability to meter more than one service and so offer dual fuel and multi-utility packages – e.g. gas and water – via links between the meter

- **Wider scope for Pay-as-You-Go** - More ability to use pay as you go because it becomes more attractive– e.g. for students, houses in multiple occupation, properties where tenants change frequently, some SMEs. This could be categorised as cost reduction (reducing debt problems), but the main benefit may be revenue enhancement from better cash flow and possibly the willingness of customers to pay more for a better pay as you go service.

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[35] Virtually all 2.1 million gas PPMs are Quantum (smart card technology) . Key (1.5 million) and Smart Card (0.8 million) electricity meters can have their tariffs changed remotely and send meter readings remotely through the transfer of information when the customer charges the key/card with credit. So these meters are "semi smart" already and hence there is not such cost-saving potential

Overall, although potential cost savings could be significant, as all suppliers face similar costs they can therefore be passed on to customers. This arguably reduces the incentive to install smart meters to cut these costs. It should also be noted that, either existing systems will need to be modified to accommodate smart meters, or new systems will need to be created and existing meters migrated over, or old and new systems will need to be run in parallel. Each of these options will result in some degree of inefficiency and extra cost that would offset the cost savings to suppliers during the deployment/roll-out period. It is only when smart metering rollout is completed that suppliers will achieve the full cost savings potential. Thus the scope for revenue enhancement may become an equally important driver. However it has not been possible to quantify the revenue enhancements. Finally it is worth noting that suppliers may lose revenue if smart metering reduces total energy demand and this may act as a disincentive.

4.4.3 Supplier benefits – conclusion

The above analysis suggests that supplier annual cost savings might be about £5 on average per smart meter installed, compared to a cost of £13-18. Therefore there is currently no business case for suppliers to introduce smart meters on a widespread basis. Suppliers who installed smart meters would risk raising their costs and placing themselves at a disadvantage compared to their competitors. It would also not be easy for suppliers to capture the benefits that are dispersed amongst other market actors (potential new entrants, network operators, customers, public benefits – environmental and social). Nevertheless there is a business case for suppliers to introduce smart meters to some segments of the market :

- **Token pre-payment meters**

- **Other pre-payment meter customers who are costly to serve** (buy credit frequently, in debt, frequently lose payment keys etc) and possibly particularly gas prepayment customers

- **Credit customers who are costly to serve** - e.g. where it takes several attempts to get a meter reading; customers in remote areas; debt prone/late paying customers; properties with frequent tenancy changes; having to install and then take out pre-payment meters and vice versa (these may be small business as well as household customers).

- **Customers willing to pay for a smart meter because they value the services it may offer -** may be a large group in the business sector but probably more limited amongst households.

4.5 Customer benefits

Customer benefits could come in three main ways : improvements in billing accuracy and payment arrangements; better information - enabling energy saving (and hence money saving); dynamic market effects.

4.5.1 Improvements in billing accuracy and payment arrangements :

- **More accurate billing** – avoid under (risk of debt) and over (cash flow) paying.
- **No meter reading** – no need to let people into the house
- **More payment options** – e.g. variable direct-debit based on actual use might suit some – and could also encourage energy saving.
- These benefits are difficult to quantify or price. It is assumed that on average they would be small, although some customers might value them more highly.

4.5.2 Energy saving :

- **More information provided via a conveniently sited display (**e.g. in kitchen) or via the internet or mobile phone messages could enable behavioural change and encourage investment in energy saving measures, that could lead to lower bills. This could involve absolute reductions in use (energy saving) or shifting use to off-peak times (via time of use pricing).
- **Smart meters with two-way communications could be used to send messages** – e.g., energy saving tips, information about EEC grants etc.
- To quantify these benefits- on an average electricity bill of £350 a 1% reduction in demand would produce a saving of £3.50 a year. A 3% saving (achieved in the Northern Ireland key-pad trial to date) would equal around £10.50 a year.

4.5.3 Dynamic market effects :

- **Problem-reduced switching** (from better data flows) could make customers more likely to switch with a potential dynamic effect on the market. If more customers switch, suppliers might have to offer better loyalty deals to customers who stay. And lower costs through smart meters may enable suppliers to offer better deals. So smart metering could potentially help to reduce prices for all customers. But this assumes that profits are high enough to facilitate this and/or that suppliers' costs will fall and they will share these savings with customers.
- **New offers from suppliers** – e.g. time of use tariffs; energy services packages; micro-generation packages; more dual fuel packages – smart metering could help to facilitate these and make them more attractive to customers and suppliers. These new offers could also help to induce more switching with further price effects.

- **Smart meters might also facilitate market entry by new suppliers by lowering costs.** Problems with billing and collection of money are considered at least partly responsible for the failure of some smaller market entrants (Independent Energy, Alliance) – smarter metering would help overcome these problems. However, being obliged to take on responsibility for an expensive smart meter asset might discourage some entrants.
- These benefits are difficult to quantify but could be substantial (they have been considered in the cost benefit case in the Netherlands and to some extent in Victoria)

4.6 Pre-payment meter customer benefits

There are also some potential additional benefits for prepay customers.

- **An end to the stigma of prepayment** – it could become just another choice of payment method like prepay mobile phones.
- **Improvements in ways of buying pre-pay credit** – for example, by phone or over the Internet.
- **Suppliers may be willing to make emergency credit more flexible -**as in Northern Ireland. Another option might be soft disconnection – e.g. reducing load so customer could just use lights and fridge (for example) until credit topped up

4.7 Vulnerable customer benefits

There are also some potential additional benefits for vulnerable customers.

- **Time-of-use and time-of-day tariffs -** Some vulnerable customers may benefit particularly from such tariffs as many of them are at home in the daytime (elderly, some disabled, unemployed) and thus would be able to use appliances off-peak. Suppliers might consider a new "home-all-day-tariff" for this market.
- **An accessible customer display and prepayment meters that do not require cards/keys to be inserted**, or numbers typed-in, could be useful for elderly and disabled people who have problems with inaccessible meters.
- **Instant credit by telephone** over the Internet etc to pay as you go meters would be useful as carers and family members could do this remotely for elderly and disabled people.
- **Special services for vulnerable customers** - Suppliers might also offer special services, such as monitoring whether vulnerable households are using enough energy. This could enable notification to be sent to someone else if need be (e.g. a carer) – as a development of priority register services.

4.8 Customer risks and downsides

Smart metering may provide a number of benefits to customers but it is also important to consider any risks and downsides.

- There is no guarantee that customers would get conveniently sited displays as smart meters with them will cost more than those without. Displays will need to be relatively simple to use – many customers have problems using central heating controls and so might have problems with displays.

- On the other hand not all customers will want more information or want it in the form of in-house display units. Information might be provided via smart meters in other ways – e.g. via the Internet or to mobile phones.

- Displays can be provided without smart metering – e.g. via devices such as the Electrisave unit being trialled with some customers by npower. Although note that at present these devices are fairly expensive – around £50-70 each.

- Improved information (albeit not so immediate or detailed) could be provided on bills without smart metering – the Norwegian study (1989) was based on more informative billing albeit wrongly frequently cited as evidence of the savings potential of smart meters. A Powergen consumption information trial is currently assessing the impact of more informative billing.

- Prepayment customers will not necessarily see savings, even if new smart prepayment meters reduce suppliers' costs. This is because many suppliers have already equalised their PPM tariffs with credit meter tariffs, so these PPM customers are being cross subsidised. In these cases, suppliers will be more likely to keep the benefit of the reduction in costs or use it to reduce prices to other customers if they need to do so to remain competitive.

- There are lots of cross subsidies in the non-half hourly profile system – these could be unwound with smart metering creating winners and losers.

Some further concerns may be raised by consumer/fuel poverty groups :

- That some vulnerable customers may switch-off too much.
- Suppliers could use smart meters to introduce a range of tariffs that customers might find confusing – some find telephone tariffs confusing for example.
- "Big brother" aspects of direct load-control should this be used (although as some people are used to this with storage heaters may be less of an issue)

- Concerns, because of the potential for self-disconnection, that people will be forced onto PPMs by being offered credit meters on disadvantageous terms .

4.9 Benefits for distribution/transmission network owners/operators

- Potentially some benefits through better demand response (i.e. time of use tariffs) that leads to avoided peak capacity investment and thus more economic use of networks. The GB networks are already well incentivised to manage losses and to prioritise network investment, and while potential additional savings may be available via the additional information that smart meters could provide, the initial benefit may not be significant.
- Metering could facilitate separate import and export prices for customers with on-site generation. It may help distributors to clarify the value of distributed generation and make more effective use of it to optimise network management.

Overall, both suppliers and the distribution/transmission businesses see the benefits here as relatively small – perhaps worth around £1-2 per meter per year on average.

4.10 Security of supply benefits

Smart metering could help to boost security of supply :

- Through interval metering and time of use tariffs it could stimulate better demand response – demand reduction at peaks can become a resource. This may apply particularly to business customers who are willing to shift load to save money.
- By metering import and export, smart meters could help facilitate the growth of micro-generation, which could also help with security of supply.
- It has not been possible to quantify this benefit.

4.11 Carbon reduction

This could come about through :

- Energy saving – if smart meters encourage consumers to use less energy in total.
- Load shifting – if consumers respond to time of use or time of day tariffs by shifting their use to off-peak times. In this case the effect would depend upon the carbon intensity of the marginal plant.
- A 1% reduction in energy use would equate to about 8% of the domestic sector carbon savings target.

4.12 Gas metering

It would be possible to cut the costs of 'dual-fuel' smart metering for gas and electricity by not installing a smart gas meter but fitting a data logger/communication device to an existing gas meter that could send information to a smart electricity meter. The smart electricity meter would then act as the smart meter for both fuels, with a similar range of functionalities subject to costs and some technical issues specific to gas. This single smart meter option could support fuel purchase from different suppliers for gas and electricity although this would require some supplier protocols to be agreed. It would also be possible to do the same for water, although this might raise technical issues where water meters have been installed underground.

4.13 Conclusions on costs and benefits

In conclusion, if smart metering is left to the market, it is likely to happen only on a relatively small-scale basis over the short to medium term, because the costs exceed the benefits that would accrue directly to suppliers, or that they could capture from network operators. The other major potential benefits – to customers and the public benefits of reduced environmental impact and security of supply – are more difficult to quantify, although where this has been done in other countries, the benefits have been found to exceed the costs. However, the largest benefit that has been assessed in most international examples comes from reductions in peak demand - and it does not appear that this is so valuable in the UK. This means therefore that the benefits to customers and the environment become key to whether the cost benefit case is positive.

The dynamic market benefits could be significant and the work in the Netherlands to quantify this is interesting, albeit that the market is less developed there and so is likely to offer more scope than in the UK. However, it has not been possible to quantify this benefit as there are a number of uncertainties around it.

If smart meters lead to energy saving this will benefit both customers and the environment. Based on the evidence available to date, a reasonable assumption would be a 1-3% reduction. Customers may also be willing to load shift in response to differential tariffs – a 1% reduction is assumed. At the 3% level, when added to load shifting, supplier and network benefits this is broadly equivalent to the installed costs of smart metering (£13-18 costs and £14-23 benefits), although supplier benefits would be lower whilst they have to run smart and basic meter systems in parallel. Further work on network benefits may lead to higher estimates of their value. If the public benefits, such as carbon savings and security of supply are counted then the benefits would also increase and if average energy savings amounted to 5% or higher (the level seen in some trials), then the contribution to the domestic sector carbon saving target could be significant. More work is needed on the potential carbon savings from possible load shifting.

Summary of costs and benefits – electricity meters only

Significant uncertainty attaches to analysis of costs and benefits. This summary is for illustrative purposes. All costs and benefits are nominal (non discounted) values.

Capital and operating costs of smart meters

Capital cost of each AMM-Interval Meter installed	+/- £120 per meter (range £70 - £180)
Cost per meter per customer pa (annualised over 15 year life)	£8 per customer pa
Annual maintenance / operational costs	£5-10 pa
	Total nominal cost per customer £13 – 18 pa
Benefits of smart electricity meters :	
Potential supplier benefits at end of 100% roll-out	**£125 million pa (£5 per customer**
Potential benefits to customers	
1 - 3% pa energy saving/load reduction - average electricity bill £350	£3.50 -£10.50 per annum
Possible 1% load shifting (in addition to load reduction) due to time of use tariffs	£3.50 per annum
Accurate bills / scope for better budgeting	Estimate £1 per customer pa
More dynamic market / improved service / loyalty & retention offerings	Estimate £1 per customer pa
Total potential customer benefits	**£8-16.00 a year**
Network Benefits (cost savings on upgrading)	**£1-2 per annum per meter**
Total benefits (excluding any value for carbon)	**£14-23 per year**

5. Regulation and policy – options for change

Ofgem published their major consultation on Domestic Metering Innovation on 1 February 2006. This is a very welcome step in re-visiting the regulatory drivers for smart meters in the UK, although Ofgem should extend their review to cover smart meters for SMEs in addition to the household sector. The following section addresses the six specific options posed by Ofgem in their consultation and considers some further options for policy and regulatory change.

5.1 Prospects for smart meter installation under present framework

There are a number of features of the present competitive framework that are inhibiting smart meter installation. These include :

- **Lack of a clear supplier business case** – Metering is a supplier responsibility but the cost-benefit analysis suggests there is not a clear business case for suppliers to install smart meters on a widespread basis, (although there is a case for certain groups of customers). There are benefits to other market participants – customers, network owners and operators. However in the case of these other benefits suppliers either cannot easily capture them, or the benefits are uncertain or unproven.

- **The requirement for a visual inspection once every 2 years -** This obligation is largely for tampering and safety reasons[36]. Where premises are hard-to-access, this can become a high-cost activity for suppliers. This limits the cost savings that could be achieved through smart metering.

- **28-day rule** – Consumers can switch supplier, subject to 28 days notice. A significant issue therefore arises about where long-term financial responsibility for a higher-cost meter-asset might sit. This was the single most important regulatory risk identified in discussion by suppliers and others under present regulatory arrangements. The more sophisticated and higher-cost the meter, the greater a supplier's potential exposure.

- **Regulatory incentives and competitive pressures for cost-reduction -** Around 5% pa - i.e. roughly 1 million gas and 1 million electricity meters - are renewed or replaced each year. However, meter renewal and replacement is incentivised on a largely like-for-like or equivalent-cost basis, rather than on a technology-upgrade or improvement basis. Credit smart-meters currently cost ten-times or more than current basic electro-mechanical or electronic models[37]. This continues a long trend in which past and

[36] Electricity and Gas Supply Licences - Condition 17 and HSE requirement for gas.

[37] Assume around £120 per meter-installed at current rates for an AMM+interval electricity credit meter.

present regulatory drivers, either via meter price-controls or via competition, are largely focused on cost- and price- reduction.

Together, these four factors have combined to create inertia in terms of any significant meter-stock upgrade or technological change, even so far as modest steps towards future proofing are concerned.

A number of suppliers are presently considering 'retail-led' smart meter initiatives, although it is likely that these will be limited to groups of customers who are costly to serve (e.g. some prepayment customers, the debt prone, hard-to-read). However, significant deployment of smart meters is likely to require additional regulatory or policy interventions. These essentially fall into two broad approaches :

- Various changes to facilitate smart metering within a broadly competitive framework - Section 5.2 below.

or

- Adoption of a more structured large-scale geographic rollout - Section 5.3 below.

There is also a possible 'facilitation' or "basic future proofing" route, but this has significant shortcomings - Section 5.4 below.

5.2 Competitive framework for meter provision

5.2.1 First-stage minimal interventions

The following are minimal interventions that might be adopted to tackle some of the current disincentives to smart meter installation

- **Remove or reduce the requirement for a visual check once every 2 years.** This would permit suppliers to reduce their overall cost-to-serve. Clearly this would need to be subject to the meter having an adequate capability for communicating tampering to the meter asset provider. For gas, any such change would require agreement of the Health and Safety Executive.

- **Tackle stranding of new meter assets due to the 28-day rule**. Within the present framework, the only available solution is for the supplier to charge the customer who switches for the 'stranded' smart-meter. The regulations surrounding the 28-day rule do allow suppliers to offer contracts that include termination fees, subject to reasonableness, should customers switch supplier within a period of, say, two years.

However, this option has not been used to date and it would only work with active customer demand for smart-meters. Two other possible options would be:

- o A new requirement on suppliers where they win a new customer, to take on and support the contract for the existing meter asset for a specified period (probably linked to asset life).

or

- o Some other form of adaptation of the 28-day rule.

- **Establish interoperability protocols** Data formats are already prescribed under REMA / RGMA but new technical protocols to achieve interoperability will be needed to reduce the scope for needless asset stranding or obsolescence. These will give greater confidence to the market in its technology choices. Standardisation need not be unduly prescriptive, or stifle innovation. These protocols could be left to the industry to agree, but progress will be swifter and the outcomes more fair to all parties and effective if overseen by Ofgem to an agreed timetable. This is an area that will benefit from strong leadership by Ofgem. The interoperability initiative should cover compatibility in three key areas : equipment ; data formats for key items of data ; and communications. Electricity and gas protocols may eventually need aligning, not least to support dual-fuel initiatives.

Removal of these three 'first-base' regulatory obstacles within the existing competitive framework, will enable more smart-meter installation than at present. For example, these first-base changes should create sufficient incentive for suppliers to install smart-meters where there is a clear-cut business case. That is, for certain categories of high-cost-to-serve customers (e.g. hard-to-access, very mobile, some pre-payment (especially token pre-payment), or SMEs, or other consumers at the high-consumption end).

5.2.1.1 Advantages of making minimal interventions but otherwise leaving the deployment of smart meters up to suppliers :

- Scope for incremental, flexible and targeted approach. This may be desirable in both policy and risk-terms, given current unknowns in terms of the overall benefit case and uncertainties surrounding both unit-costs and communications technology choice.

- Leaves supplier firmly in the lead to innovate and to target specific highest-cost-to-serve customer segments, or customers with short pay-backs, for example :

    - o **Retail-led -** innovative / marketing-led packages to customers, for example involving multi-rate or time-of-day tariffs or consumers with high-end consumption, including many SMEs. Likely to prove most appropriate framework for SMEs with larger consumption

  - **Business-case led** - where there is a clear cost-saving case for suppliers to install a smart-meter, for example :hard-to-access premises; very mobile consumers; debt-prone customers; **s**ome pre-payment customers – especially those with token pre-payment meters.

- Targeting high-cost customers, should enable suppliers to reduce average cost-to-serve across customer base i.e. to reduce subsidy to higher-cost customers from existing low-cost-to-serve customers. Ultimately, this may help suppliers to offer more attractive tariffs to retain the loyalty of low-cost-to-serve customers.

- The overall amount spent by suppliers on smart metering will be fairly low, as too will be the corresponding impact on customers. Indeed, the costs may only be borne by certain groups of customers – e.g. SMEs. Moreover, if such meters are installed in response to a clear business case, supplier cost-savings should counter-balance their higher expenditure.

5.2.1.2 Disadvantages of making only these minimal interventions :

- Volumes likely to remain extremely low. Even at, say, 30,000 per supplier pa, unlikely to exceed 200,000 pa – i.e. less than 1% of the total meter stock pa. Potential supplier cost-savings (reduced meter reading and call-centre costs, lower back-office costs) cannot be realised at these low volumes.

- Highly unlikely to deliver volume or systematic pathway to achieve a tipping point / critical mass, ultimately necessary to achieve rapid reduction in smart-meter costs. Unlikely to produce real scale economies in lowering initial capital expenditure commitment – or in lowering supplier cost-to-serve costs significantly.

- Possible welfare loss – without critical mass, unlikely to achieve potential of wider benefits of greater efficiency in retail market operation, or, 'public' benefits of energy saving or carbon-saving.

- Suppliers may put 'toe-in-water' - but without critical mass, ongoing doubts about high-costs and uncertain technology-choice could cause present inertia to persist.

5.2.2 Enable the customer to contract for a smart meter

The Ofgem consultation suggests that one 'more radical' option to promote innovation is to put the customer, rather than the supplier, at the centre of the decision of what sort of meter to install. Under this option, a customer could either own the meter, or contract directly with a meter provider for the meter, or contract through the supplier with a meter operator. In practice this option is already open to customers under the Electricity and Gas Acts, but to date there has been no take-up[38]. For all the reasons outlined in the preceding paragraphs, it is extremely hard to see that this option, even if well publicised, and even if geared to SMEs, could make anything other than a very minor difference at the margin.

5.2.3 Further regulatory interventions within competitive market framework

Interventions that are designed to secure volume installation of smart meters will impose more costs on consumers and, clear evidence of the benefits would therefore be required. The following additional regulatory interventions may be a way of securing more smart-meter installation under the competitive market framework.

5.2.3.1 A smart metering duty on suppliers.

The 5% of meters being replaced each year, continue largely to be replaced, for both gas and electricity, with a basic non-smart meters. In practice, this means that in 2006 alone, almost one million additional 'basic' electricity meters with a twenty-year asset-life will be installed across the UK. **A new duty would require suppliers[39], in making meter arrangements on behalf of customers with a single-phase electricity meter, to ensure that a meter of a specified smart-standard is installed, whenever an old meter is renewed or a new meter installed.** The duty would take effect from a specified date. An appropriate target date might coincide with UK implementation of the Energy End-Use Efficiency and Energy Services Directive in May 2008.

Given that the 5% replacement rate is implicit but not required it might be necessary to ***require*** 5% of meters to be replaced each year to avoid the risk of a new standard reducing the incentive on suppliers to replace meters.

Key benefits of a smart metering duty on suppliers would be :

- Embarks down pathway of systematic uprating of meter stock.
- All suppliers would face the same requirement – largely removing 'first mover' risks[40]. This could allow suppliers to spread the additional costs across all their customers - as noted above, amounting very roughly to £8 per customer pa.

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38 In their consultation 'The Proposed Restructuring of National Grid Transco's Metering Business – March 2005 – Ofgem point out the considerable complexity around potential arrangements relating to Gas Act meter owners.

39 Via a standard licence modification to supply licences.

40 Some disparities in purchasing power and market influence would nevertheless persist.

- In practice, suppliers will also realise potential cost-savings (an end to meter-reading), and so can be expected not to pass-through costs in full.

- Creates a guaranteed market for 1 million smart electricity meters pa, in addition to any additional retail-led initiatives by suppliers. While this may not achieve 'critical mass' in terms of scale-economies (for any of meter-unit, communications or installation costs), it could gradually start to make a cumulative difference.

- The 5 % pa volume could be delivered flexibly – i.e. geographically, or by customer-segments, or, on an asset-retirement basis. Within the constraint of the required standard, suppliers and customers would be free to opt for the most appropriate mix for them of meter-functionality and communications systems.

However, there are also some potential disadvantages of a 5% replacement rate :

- Very slow (20-year) route to a universal rollout of smart meters.

- Although an increase in volume over the supplier-driven route, may still be insufficient to deliver scale-economies, either operationally or in capital-cost terms.

- Low volume may actually increase some costs – for example by increasing the average cost per meter-read, where old meter stock remains in situ, or, forcing multiple back-office costs for a prolonged period of running two or more systems.

- Risk of committing to additional expenditure per customer without guarantee of equivalent customer benefit.

5.2.3.2 Set a smart meter standard

The smart-meter duty on suppliers would require an appropriate standard of 'smart-meter' functionality to be established. The common standard should be agreed by an expert group (involving energy suppliers, the metering industry, consumer representatives and other appropriate experts), led by DTI and supported by Ofgem. Leadership of DTI and Ofgem will be crucial to securing an agreed standard in what is a complex area with many different views. This group should report direct to a minister as a work stream flowing from the Energy Review. Agreeing a target date for the supplier smart-meter duty should not wait until a standard is agreed. By setting a target date for the duty, this will establish a deadline for agreement of the smart-meter standard and avoid the risk of protracted technical discussion causing delay.

5.2.3.4 Accelerate meter replacement

To achieve volume more rapidly, an additional step would be to accelerate the meter replacement rate from 5%. This could be done by placing an obligation upon suppliers for replacement of, say, at least 10 % of the current single-phase electricity meter stock each year. The main benefits of accelerating the replacement rate would be :

- Through increasing volume, suppliers should start to realise potential cost-savings (fewer meter readings, fewer visual checks, better bill data etc) - and so may be expected not to pass-through the full costs to customers.

- Commitment to a 10-year smart-meter programme, installing 2 million meters pa, could start to give traction to scale-economies – in meter installation programmes, in unit costs of meters, in communications systems and in back-office systems.

- At 10 %, more cost-effective potential will emerge for geographic solutions, possibly deploying lower-cost geographic based communications systems such as Power Line Carrier or Low Power Radio networks.

The main disadvantages would be :

- Significant additional costs to consumers with uncertain benefits.

- 10% rate may still not be sufficient to produce real scale-economies in capital expenditure or in lowering supplier costs.

- Potentially, faster stranding of existing 'legacy' assets –for electricity could lead to a more rapidly reducing return on DNOs existing price-controlled meter asset-base and for gas could lead to considerable exposures, potentially for suppliers.[41]

5.2.3.5 Establish a formal multi-party agreement

At an accelerated replacement rate (and possibly at the 5% replacement rate) some sort of formal multi-party agreement would be needed between suppliers and meter providers to ensure smooth operation of the market. Any such agreement would need to define procedures for dealing with meter assets when a customer switches supplier (stranded

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[41] Under 2005-2010 Distribution Price Control, unforeseen stranding of existing meter-assets could potentially allow re-opening of D-price control. Separately for gas, treatment of legacy domestic credit meter gas assets is covered in NGC's Meter Service Agreements, and includes potential charges to suppliers for premature replacement. This could prove very costly, and persist as a deterrent to new smart-meter investment. The position differs for non-domestic gas meters, where the stranding exposure sits with the meter provider

assets and contracts), and ongoing relationships between suppliers, meter asset providers, meter operators and data-flows. Ofgem would need to take this forward by building on the REMA and RGMA procedures. The Energy Retail Association has also recently started to consider these issues.

5.2.3.6 Settlement

At an accelerated replacement rate, particularly if there is a significant shift to actual time-of-use tariffs, settlement issues at low levels of demand seen at an individual domestic-level will need wider consideration. Elexon has started to consider how to ensure that settlement rules do not impede developments at this level.

In effect, the combination of a new smart-meter standard and an accelerated replacement rate would ensure a pathway, albeit very long-term, towards systematic uprating of the national meter-stock.

5.3 Alternative approach to smart meter installation – geographic roll out

In most overseas examples seen so far of universal smart-meter installation, responsibility for the meter assets have sat with the network provider. Expenditure has been recovered from consumers via network charges, or via price-controlled supply prices[42].

The UK could choose to adopt a similar approach through the transfer of electricity meter assets to geographic DNOs or to Geographic Meter Licence Holders, who would then be required to upgrade all meters to smart-meters in their geographic area over a fairly short period (say five years or less). The creation of a geographic meter licence would enable third parties, as well as incumbent DNOs, to tender for a geographic-area licence, thus providing a greater element of competition into the scheme. This arrangement would have the effect of transferring long-term responsibility for the meter-asset to the DNO or Meter Licence Holder, irrespective of whether a consumer switches supplier. It would remove the financial risk of potential stranding of new smart-meter assets away from the supplier. Meter charges made to the supplier by the DNO or by the Meter Licence Holder, could pass-through to consumers via the supply price.

[42] In some, but not all overseas examples, supply and network businesses may be bundled. Similarly, the market may not offer full supply competition.

5.3.1 Geographic rollout – efficiency arguments

A mass rollout could realise logistical and organisational efficiencies and deliver scale-economies, in a way not likely to be achieved at low-volumes, because at volume one could expect to see :

- **Meter-unit costs** reducing significantly, potentially by around one-third, depending on volume.
- **Lower communications costs** e.g. Power Line Carrier or Low Power Radio – currently estimated to be less than half the cost of mobile equivalent. These also could significantly reduce meter unit costs by eliminating the need for a modem.
- **Average installation costs** in a systematic mass-roll out would also be lower
- **Supplier benefits** (reduced meter-reading and call-centre costs) could expect to be fully realised at volume.

5.3.2 Geographic rollout - main benefits

- Possibly most practical option to deliver systematic and rapid, (say 5-year) upgrade of the national meter infrastructure.
- Significant organisational efficiency benefits and scale economies (see above).
- Facilitates technological and planning synergies with distribution. For example, and subject to any regulatory constraints, communications synergies for Power Line Carrier or Low Power Radio by using existing DNO communications infrastructure, including equipment and buildings. Also permits scope to co-ordinate maintenance schedules through optimisation of physical connection with DNO assets.
- Any universal rollout could be carried out either geographically or to customer segments (e.g. largest first). It could utilise either wholly geographic-based communication systems (Power Line Carrier or Low Power Radio), or targeted wireless communications in combination. Gives regulatory confidence, because eliminates supplier risks and could enable costs to be fully re-coverable.
- Shifts long-term responsibility and financial exposure for the meter away from the supplier to the geographic DNO or Meter Licence Holder[43] and therefore averts potential wasteful stranding of smart meter assets. In particular, small new-entrant suppliers will be free of very large financial exposure for expensive meter assets.

[43] See following section

- Cost to customer could be spread over 10-15 years or more - appropriate to infrastructure assets with a long-life.

- Allows cost transparency through published charges

- Makes multi-party agreements potentially more straightforward than in a competitive framework. Geographic DNO or Meter Licence Holder retains responsibility for meter irrespective of whether customer switches supplier. Likely to make switching supplier less complex and bureaucratic in back-office terms.

- Provides quick path to obtaining load-management capabilities.

- Geographic rollout could potentially be deployed solely to install and remunerate a communications network – PLC or Low Power Radio – leaving smart-meter provision to suppliers. Without the communications element, financial exposure for suppliers from smart-meter capital costs would be considerably lower. Communications costs would transfer to the DNO or Meter Licence Holder.

5.3.3 Geographic rollout – main shortcomings

- Expensive. A big step.

- May meet consumer resistance – for example in respect of increased costs or access for installation.

- Transfers technology-risk and other risk to customer, for uncertain benefit. Cost pass-through will not necessarily best serve suppliers or customers in sustaining pressure to drive down prices for meter provision.

- Foregoes the flexibility of an incremental or targeted approach of the competitive market model.

- Potential loss of direct customer-contact with utilities - and supplier-customer engagement in particular.

- Likely to lead to early lock-in to volume technology choices with attendant risk – especially on the communications side which is potentially still evolving at the individual householder level.

- New smart meter assets likely to earn only regulated returns (or slightly above), whereas meter providers might reasonably expect to earn higher returns on high-tech assets, which have potential risk of obsolescence etc. If DNOs / Meter Licence Holders sought above-regulated returns, they would need to take some of the risk.

- Re-introduction of a price control and subjecting smart meter assets to regulated returns could prove burdensome. Some form of light-touch regulation may be possible – provided suitable efficiency incentives were in place.

- Existing third-party meter providers have entered the market in good faith, and their contracts may be put in jeopardy by retrospective regulation. This would need satisfactory resolution.

- Similarly, some DNOs currently plan to exit the metering business, where this presently no longer sits with their overall business strategy.

- Geographic licence holders would need to take over the assets of independent DNOs and GTs.

- Potential industrial relations issues, including job losses.

- Potential to curtail competition in meter-asset ownership, and thereby reduced cost pressures on provision of new meter assets. This could in part be addressed by a requirement for economical and cost-effective procurement of meter assets.

- Proposal for a meter licence could meet resistance as running counter to competition in meter-asset provision and bureaucratic in terms of a potential new price-control.

5.3.4 Geographic roll-out approach – key features and requirements

The substantial costs and risks involved in a mass programme mean that there would be significant regulatory, consumer and supplier pressure for cost transparency and non-discrimination. Key features and likely responsibilities would therefore include :

- **Suppliers continuing to make meter arrangements for customers**

- **Distributor / Meter Licence Holder would be required to offer terms for providing meter assets in a geographic area.**

- **Meter renewal –** requirement on DNO / Meter Licence Holder to replace, say, 20 % of meter stock pa with new meters conforming to a specified 'smart'- standard.

- **Procurement** – As an efficiency safeguard, a duty for economical and cost-effective asset-procurement could be placed on DNOs / Meter Licence Holders.

- **Meter charges** to suppliers published and separately identified as meter provision and meter operation.

- **Costs –** to be recovered via charges made by Distributor / Meter Licence Holder Charges to Suppliers, with full pass-through by suppliers to consumers. Cost-recovery from consumers could be over full asset-life – i.e. 10-plus years.

- **Meter assets** – could sit either within a regulated asset base and earn a regulated return alongside existing meter assets, via price-controlled charges. Or, meter assets could be non-price controlled, earn non-regulated returns reflecting any reasonable risk and be subject to ex-post regulation to prevent excess returns.

- **Transparency and non-discrimination -** strict enforcement of regulatory ring-fence between meter assets and distribution assets[44]. Clear cost-separation for any use of DNO hardware / assets for mass communications rollout, including clarity on inter-business charging.

- **Meter operation** to become subject to competitive provision in 2007 as planned, subject to there being a viable 'stand-alone' business model.

These steps could be achieved by modifying standard licence conditions, subject to majority agreement by current licence holders.

A Meter Licence could be achieved by Order of the Secretary of State[45]. Duties for Meter Licence Holders could be fairly narrowly drawn as above in terms of a specific duty to deliver a national smart meter roll-out by a given date, which could lapse after a period, once this task was concluded.

5.4 'Facilitation' or basic future proofing option.

5.4.1 Facilitation approach – key features and requirements

A number of low-cost "basic data meter" options exist. These are not smart meters but could be used to gradually 'future-proof' the meter stock – i.e. make meters capable of being smarted at some point in the future. Chief features would include :

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[44] And for those businesses retaining both supply and distribution interests, strict separation with respect to meter data.

[45] Utilities Act 2000 amending s.56A Electricity Act 1989. Upon application by the Authority to make activities licensable.

- Suppliers' continued responsibility for making metering arrangements for the customer, and contracting with any party to provide meter assets and meter services.

- New requirement placed upon suppliers to ensure that all new meters at the point of meter replacement or new installation met this very basic data capability. An industry technical standard would be needed[46].

- Where a customer switches supplier, this basic-data meter would need to remain in situ. This could either be done as in the competitive framework, with responsibility transferring to the new supplier. Or, this could be done via the DNO or Meter Licence Holder alternatives above.

- With an increasing number of these basic-data meters in situ, it would become increasingly open to suppliers to offer 'smarting' options to targeted customers. For most credit customers, the much higher costs of smarting the meter, would be recovered from individual customers, via tariffs.

5.4.2 Facilitation approach – main benefits

- Offers a low initial cost modest insurance policy for the future.

- 'Regulated' part of meter i.e. measurement aspect reduced to necessary minimum – leaving suppliers to innovate on the consumer-electronics.

- Could either be incremental – or national rollout.

5.4.3 Facilitation approach – main shortcomings

- Does not deliver smart-meters – only facilitates option.

- Potentially a high-cost option overall. Will eventually need some form of added (high-cost) electronic device to read / transmit data.

- If part of a systematic future-proofing programme (rather than a targeted retail initiative), installation may involve two separate visits – one for basic meter replacement and one for smart box installation.

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[46] Including on whether a pulse, or, a slightly more sophisticated electronic alternative in the form of an optical data-port on the meter which can periodically transmit absolute data, termed 'electronic packet'. Both electronic data packets and simple pulse may prove error-prone in terms of data integrity.

- **'**One-size fits all approach' – so would entail achieving basic agreement among industry and would need strong leadership.

5.5 Further policy considerations

This final section examines some further policy considerations in relation to prepayment meters (with implications for fuel poverty), energy saving and gas meters.

5.5.1 Pre-Payment

- **Replacement of token pre-payment meters -** Electricity Token Pre-Payment meters offer by far the strongest business-case on cost-benefit grounds for early-replacement by smart meters. It is quite likely that suppliers will replace these anyway but one outstanding risk is possible inertia due to uncertainty over technology choice. To address this, perhaps within the context of the Energy Review, the Government and Ofgem could consider setting a target date for replacement of token pre-payment meters by newer smart meters with certain functionalities, whilst leaving actual technology choice to suppliers.

- **Other pre-payment meters –** Pre-pay customers currently pay on average £50 pa more than credit customers. Over the long term, smart meters that can be switched between credit and prepayment more easily and eliminating some other current costs of prepayment may help to reduce this cost-differential and make a significant contribution towards eliminating fuel poverty for some households. In Northern Ireland newer forms of prepayment have significantly reduced costs, and these savings are being passed through to prepayment customers in the form of lower charges. However, in the GB context smarting the pre-payment stock would not necessarily reduce pre-pay costs significantly as most meters are semi-smart, although they may provide other benefits to prepayment customers (feedback on use and scope to save money through load shifting). However, if the accelerated replacement rate or geographic roll-out option were to be pursued, then an option could be to prioritise the prepayment meter stock by s**etting a target date for replacing all prepayment meters with smart pre-payment meters.**

5.5.2 Energy saving

There is a lack of UK-specific evidence on behavioural impacts on consumers of better consumption- and energy-expenditure feedback, and the extent to which this translates into real and sustained reductions in energy use and also reductions in carbon emissions. If there was hard evidence that smart meters would lead to significant energy savings by customers in the UK, then this would make the overall cost-benefit of introducing them more clearly positive. Such a positive cost-benefit position would not however, on its own, guarantee that smart meters would be installed in a competitive market framework as this would depend upon the suppliers' ability to capture some of this benefit to defray the costs, rather than it just accruing to the customer.

Importantly, such a positive cost-benefit case could justify government or regulatory intervention to secure smart meter installation, sooner rather than later. It could help to tilt the balance towards accelerated replacement under the competitive framework, or to make the case for a geographic rollout.

Securing better information on the likely effects on energy consumption should therefore be a key priority. It therefore would seem sensible to initiate a long-term large-scale trial specifically to evaluate these behavioural effects comprehensively, to avoid the risk of being no further forward in years-to-come in properly evaluated and costed long-term policy decisions about the overall 'public' benefits of smart-meters[47] .

5.5.3 Proposal for a major trial of smart meters in the UK

It is important to state first of all that a trial should not hold up progress on some of the options outlined above. At least the minor changes to regulation within the competitive framework should take place in parallel. A major trial designed to test energy saving potential and other 'public' benefits of smart meters will help to determine whether there is a case for some of the more substantial options. Trials of course will also provide the opportunity to pilot different meters and communications technologies, but that is a secondary benefit.

Trials should be run by suppliers either on their own or with DNOs. Ofgem, DTI and DEFRA should be involved in establishing the criteria for trials and to get industry agreement on sharing information from them. Major players such as the Energy Saving Trust and energywatch should also be involved from the outset in design and implementation plans. Trials need to be large enough to produce valid results. This will mean at least several thousand households to test a number of factors. Trials will also need to run for long enough to avoid the risk of results being distorted by relying on short-term effects – this suggests probably two years. There are a number of things that trials could test. To achieve statistically valid numbers it will not be possible to test everything but the following list illustrates some of the variables that could be used.

- Credit and prepayment customers.

[47] Trials were recommended by DTI and Elexon in 2001 – but the recommendations were not implemented. A number of suppliers have indicated that they are considering commercial pilots, but our understanding is that these are largely relatively small-scale evaluations of technologies and communications systems.

- It might be particularly useful to target some trials in social housing as this would enable blocks of properties to be rolled-out by geographic area.

- Importance of siting of a visual-display – could try meters with a display included as opposed to a separate display somewhere more prominent.

- Customer responses to different forms of display – different presentations of information.

- No customer display in the home but information available via the internet, SMS etc.

- Metering with and without time-of-day and time-of-use pricing.

- Metering on its own and with other energy saving actions – e.g. advice, subsidies for energy saving measures

To help fund the trial it is proposed that suppliers should be able to claim EEC credits within EEC 2.

EEC-funded trial – DEFRA should therefore take immediate steps to set up a major trial to run during 2007 to assess smart-meter impacts on energy use and quantify energy saving potential. EEC credits should be allowed for smart meters within EEC 2a (2005-08) to help fund these trials. DEFRA should lead, but in developing the precise scope of what needs evaluation and how, should work closely with suppliers, DTI, Ofgem, the Energy Saving Trust, consumer and fuel-poverty bodies and relevant academics.

5.5.4 Changes to EEC 2b from 2008

Depending upon the outcome of the trials, it may then be appropriate to allow smart meters to become an allowed item under EEC 2b. Smart prepayment meters might also be accredited under a new 'Social Obligation' on Suppliers if this is established**.** The idea of a revising the Priority Group part of the Energy Efficiency Commitment from 2008, to focus more on contributing to fuel poverty goals is under discussion in the Government's Fuel Poverty Advisory Group and elsewhere. 'Smarting' the pre-payment meter stock could be included as eligible supplier expenditure if it is found that such meters could benefit these customers

5.5.5 Gas meters

For reasons outlined earlier, this report has focused mainly on the potential for electricity smart meters, rather than for gas. However, there remains a separate need to consider upgrading the gas meter stock, as for electricity. The potential for smart meters for gas as well as electricity could be substantial particularly in view of UK circumstances where nearly 90% of households have gas and electricity and dual fuel contracts are increasing. Further substantive work is needed on gas, and cannot be addressed in any detail here. However, the following points are in need of early consideration in respect of gas.

- The first benefits for smarting gas credit-meters are supplier benefits and relate mainly to improved customer-service management and back-office management.

- Any energy-saving benefits are likely to arise from better customer feedback and potential thermostat turndown. Possible benefits to the network of Time-of-Day or Time-of-Use tariffs currently seem to have potentially less application for gas, partly because the gas system is balanced on a twenty-four hour 'within-day' basis, and not half-hourly as for electricity. There are also potential gas-pressure and safety issues.

- The full gas pre-payment meter stock (2.1 million meters) should be considered for replacement as a priority measure – see pre-payment section above[48].

- Dual fuel packages are likely to be the main initial and market-led driver for smarting gas-meters in the competitive framework for meter provision. Potentially, once a smart electricity meter is installed, the gas meter can be 'smarted' relatively simply via a basic data packet attached via an optical data port. (Adequate meter transfer arrangements would be needed for consumers who subsequently change one fuel supplier - but not both).

- Eventually, just as for electricity, the only way to achieve systematic uprating and improvement of the full gas-meter stock would be via a requirement for a smart-meter standard. The benefit case would first need full evaluation, in terms of potential for overall energy and carbon savings.

- It is probable that a smart-meter requirement for electricity could also stimulate smarting of gas meters. Suppliers may well be prompted to offer dual-fuel smart packages whenever a new electricity smart-meter is installed, offering to smart the gas meter, and potentially even the water meter, at the same time. Moves towards compulsory water metering might enhance the prospects for such multi-utility smart metering.

- With empirical evidence on energy saving gained from any trials, a fuller evaluation of the cost-benefit case for requiring smart meters for gas should be possible. Safety issues would need to be factored in.

[48] Eventual unwinding of present sizeable cross-subsidies of gas pre-payment costs, will improve the cost-benefit case for smarting gas pre-payment meters.

6. Conclusions

Except where stated, this section applies to electricity meters.

Under the present commercial, policy and regulatory framework for meter provision, little is likely to happen to stimulate smart-meter installation, without additional measures. Smart meters offer opportunities both for suppliers and for consumers – and which risk not being realised and are a potentially important gateway. They are a gateway for suppliers to improve market operation, both by identifying better ways to tackle their existing customer-service activities and by offering scope for new retail opportunities. They are a gateway for SMEs and households to achieve energy savings through improved feedback on consumption and expenditure, and, by beginning to enable demand-response at an individual level. They are also a gateway for micro-generation. However, no commonly understood pathway – or pathways – currently exist to arrive at this gateway.

The uncertainties about the full cost benefit case, suggest that the pathways chosen should enable some action to start quickly, whilst enabling more information to be gained, within a reasonably short timescale, to facilitate a decision on what further action is warranted. This suggests the following two possible pathways :

- **Pathway 1** - As soon as possible remove the basic regulatory barriers identified in xxx above to allow smart meter installation to begin to take place within the present competitive framework for meter provision. In addition, proceed with a large-scale trial in 2007 and 2008. Removal of basic regulatory barriers should allow suppliers to proceed with a number of retail-led initiatives. Subject to the outcome of the trial particularly on the extent of energy and carbon savings to be achieved with smart meters, and the extent of progress through retailer initiatives, come to a decision at the end of 2008, on :
-
    - whether to set a smart meter standard;
    - whether to proceed with adopting a specified replacement rate (e.g. 10% pa) to the smart meter standard within a competitive framework

    or
    - whether the potential energy-saving and carbon benefits are such that a universal geographic rollout within a shorter timescale could be warranted.

- **Pathway 2 -** Remove basic regulatory barriers and embark on a major trial.. In addition, start work immediately on a smart meter standard to be agreed and adopted by May 2008 (the implementation date of Energy End-Use Efficiency Directive) to apply to all new and replacement meters installed from that date. Subject to the extent of energy and carbon-saving potential indicated by the trial, determine a specified replacement rate within a competitive framework, or, decide upon a geographic rollout.

In addition to consideration of these pathways, the following of our proposals should be adopted.

- **Prepayment** – all electricity token prepayment meters to be replaced with smart meters. All other electricity and gas pre-payment meters to be considered for replacement, with support via EEC if necessary (paragraph 5.5.1 above).

- **Gas smart meters** – more work will be needed (paragraph 5.5.5 above).

- **Carbon saving** – more work will be needed (paragraphs 4.11, 4.13, 5.5.2 above).