Smart meters : commercial, regulatory and policy drivers

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Appendices

Appendix 1 : Metering market, regulation and technology

1. UK Metering Market

Energy suppliers are responsible for making metering arrangements on behalf of their customers[1], and for making meter-reading arrangements. Suppliers contract with others who provide meter assets, operate meter services (installation, maintenance, repair, replacement etc) and read meters. Data retrieval and processing for billing, and aggregation for settlement may also be undertaken as separate services. Data processes and data flows are subject to common governance arrangements to enable smooth customer switching.[2]

The UK meter sector therefore comprises a number of active players. These include the six large energy suppliers and a number of smaller ones, the fourteen geographic distributors[3] and four gas transporters[4]. A number of stand-alone meter operators are also active. Some existing electricity and gas licensees are developing non-licensed meter businesses, and others, in contrast, have sold or plan to sell their existing meter assets.

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[1] Electricity Supply Licence Condition 7 and Gas Supply Licence Condition 34. Customers can make their own metering arrangements under the Gas Act 1986 and the Electricity Act 1989.

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

[3] Geographic footprint of former Public Electricity Suppliers

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

There are also businesses specialising in meter-data retrieval, processing, billing, CRM and back-office systems.

A growing meter requirement for small-scale renewables and micro-generation at the SME or residential level, needing accurate import / export measurement, is also starting to drive change, and represents a potentially sizeable new market segment.

2. Competition in Metering Provision and Meter Services

The journey to introduce competition in meter asset provision and in meter services began in 1990. The phased introduction of retail supply competition in the 1990s for both electricity and gas[5], meant that metering innovation was driven in the first instance in the industrial and commercial sector, particularly in response to the need for half-hourly meters with full opening of the 100kW retail market in electricity in 1994.

Full retail-market opening in 1998, was followed by full separation of electricity distribution and gas transportation from energy supply. This in turn was accompanied by a move to open meter provision and meter 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 as part of the network infrastructure, and who, subject to an efficiency factor, were able to pass-through meter costs to suppliers.

In the current transition phase, with a gradually unbundling structure, suppliers are now contracting 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) for meter assets and meter operations (installation, maintenance, repair). The current regulatory intention is to move to towards a fully competitive framework for provision of meter assets and meter services where the role of last-resort provider will lapse, in turn prompting Suppliers to make other metering arrangements. For electricity this further step is expected to take place from April 2007, and for gas, the date is yet to be determined [6]. The expectation is that third-party meter operators will become more established in the market and take business from Distributors and National Grid Gas unless they prove cost-competitive.

[5] Electricity - 1990 – 1 MW ; 1994 – 100 kW ; 1998 – full retail competition. Gas - 1996 and 1998/99 – full retail competition.

[6] Distribution Licence Condition 36c and Gas Transporter Licence Condition 8.

Disposal by National Grid of four gas distribution networks and entry of IPGTs is also causing further change within the market.

3. Regulatory Background

Since the late 1990's, there have thus been three regulatory phases :

- **The bundled, Distribution framework** where meter provision sat with Distribution, and all meter charges were directly passed-through to suppliers via Distribution charges (Electricity - pre-March 2005; Gas – pre-March 2002).

- **The current Transition arrangements** where charges for existing and '***basic' new***[7] meter provision can continue to be passed-through by Distributors to suppliers for a fixed period pending full competition of meter provision and operation (Electricity - April 05/07 ; Gas – not yet clarified).

- **A fully Competitive framework**, where provision of ***all new*** meters becomes a non-price controlled activity and is subject to competition (Electricity - April 2007 onwards ; Gas – not yet clarified). [8]

The following are the key features relating to meter provision in the fully competitive framework.[9]

- **Metering Activities -** A supplier has responsibility for making metering arrangements for the customer[10]. These include :
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    - Meter assets [11];
    - Meter services (installation, maintenance, repair, removal[12]);
    - Meter reading - any party may undertake these arrangements for the supplier.
    - Data Collection for Billing (Data retrieval and data processing).
    - Data Aggregation for Settlement.

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7 Defined in the electricity meter price control as 'basic' as at June 2003 – i.e. 'a modern equivalent metering asset' – but not 'smart'.

8 The geographic-based role of Meter Provider of Last Resort, lapses with the onset of full competition in meter provision.

9 Full effect expected – electricity April 2007 ; gas date yet to be confirmed.

10 Electricity Supply Licence Condition 7. Gas Supply Licence Condition 34. Under primary legislation it is also open to gas and electricity customers to make their own metering arrangements.

11 MAP – meter asset provision

12 MOp – meter operations

- **Provision of 'Basic' Meter** - A supplier is free to arrange for any kind of meter to be installed, subject to it conforming to basic safety and accuracy requirements. In regulatory terms, a 'basic' electricity credit meter is defined under the present meter price-control.[13] Similarly for gas.

- **Metering costs reflected in customer prices –** Metering presently represents around 3% of the final supply-price paid by customers. Competition among meter-manufacturers is expected to create downward price pressure to the benefit of meter-providers, and on charges made by meter providers to suppliers. Suppliers reflect the costs of meter-provision in the prices charged to their customers.

- In the competitive retail environment it is a judgement for individual suppliers as to how far they wish to reflect costs, in the final price to consumers. Broadly, with competitive provision of meter assets, meter costs can be recovered by suppliers in prices to consumers in two ways :

    - By sharing costs across a class-of-customer – i.e. all credit customers of a particular supplier contribute to the costs of re-placement credit meters[14]. All pre-payment customers meet the pre-pay meter costs in the pre-payment tariff set by their supplier[15].

    - Customers with a 'non-basic' model of meter, could pay for that meter directly in a specific energy-service or other type of retail-package, into which they may enter with their supplier.

- **Renewal / replacement rate** – there is an implicit meter renewal / replacement rate for both gas and electricity of around 5 % pa – totalling roughly 1 million electricity and 1 million gas meters pa.

- **Financial Exposure -** Long-term financial exposure for the meter-asset rests with the supplier, via a contractual arrangement with the meter provider. Meter providers presently include Distribution Network Operators, National Grid Gas, and, increasingly, a number of third parties.

4. Meters – Key Statistics

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13 'Basic' electricity credit meter as installed at June 2003 – valued at around £7. Under the price control, basic meters continue to count as allowable capital expenditure for the time being and can be added to the regulated Meter Asset Base until transition to competition concludes in 2007. All new meters that are 'non-basic' already fall outside the RAB.

14 Currently around £7 for a 'basic' electricity credit meter.

15 Currently £10-12 allowable cost depending on pre-payment meter type

Ofgem estimate that there are around 49 million gas and electricity meters[16] in Great Britain. Residential gas and non-half hourly electricity meters remain largely owned by National Grid Gas (c.95%) and the Distribution Network Operators (c.90%).

Electricity – Around 27 million installed electricity meters. Of these, 22.5 million are domestic meters, of which : 16.2 million are single rate credit ; 3.3 million are multi-tariff (includes Economy 7) ; and 3.5 million pre-payment[17].

Gas – Around 22 million gas meters. 50 % of gas meters are pulse-capable (yellow top). 1.5 million are pre-payment.

Costs of residential meter provision and operation as reflected in the meter price controls presently represent less than 3% of the end-price to consumers of electricity or gas. Ofgem quote a cost to gas and electricity customers of £800 million per annum for meter installation, meter services and meter reading[18].

Around 2.5 million meters (about 5% of the stock) are replaced each year – 1.5 million electricity, and 1 million gas. In addition, there are around 400,000 new meter connections pa.[19] For electricity, this ties into present arrangements for meter certification and depreciation treatment in the present meter price-control. Gas meters do not have a 'certified' life, and replacement rates are implicit in the price control and the Meter Service Agreement between National Grid Gas and suppliers.

5. Residential and SME Meter Stock – Main Characteristics

Despite universal adoption of consumer electronics and new communications technologies in innumerable fields, the UK residential and SME meter stock remains virtually unchanged. There are some 49-million electro-mechanical rotating-disc and basic electronic meters in the UK. These have a successful, century-long history and continue to perform a simple, low-cost and reliable job of accurate measurement of energy used

[16] Domestic Metering Innovation. Ofgem. 20/26. Feb 2006

[17] Ofgem. 2005. SPRU. 2005

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

[19] DTI Smart Meter Working Group. 2001

(electricity) and volume supplied (gas). They are also required to be safe and to have a display[20]. Main drawbacks of these meters include :

- The need for a physical-read by utility - or consumer - to obtain data to generate a bill.
- Inability to record on a time-related basis – i.e. *when* energy was used. In effect, record only at a single rate.
- No capture of historic data.
- No easy-access to meaningful consumption feedback for consumer. Bill remains chief feedback mechanism.
- No means of remote activation / de-activation.

Pre-Payment Meters

There are around 5.9 million pre-payment meters in use in Great Britain representing around 13 % of installed domestic meters.

Gas – 2.1 million gas PPM customers representing around 10% of domestic gas customers. Almost all gas pre-payment meters are Quantum meters, which use smart- card technology [21]. 'Key' technology could be available for gas, but has not been adopted to date.

Electricity – 3.8 million electricity PPM customers representing around 15 % of domestic electricity customers. Of these :

- **Token Meters** - 1.5 million used in nine distribution regions, of which six exclusively.

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[20] **Single Rate Meters -** Most domestic electricity meters operate at single rate. Most meters do not have even a basic communications interface, though more recent basic electronic meters may have an optical data-port, to read, programme or facilitate modular attachments.

Two-Rate Meters and Load Control - Two-rate meters are used with time switches or a radio-teleswitch to accommodate off-peak tariffs, such as Economy 7. The timing device provides rate switching and load-control. Radio Telemeters and Real Time Clocks are later versions, some of which are four-rate and meter electrical heating-load separately from 24-hour circuits. 4.5 million UK electricity customers have multi-rate tariffs. Elexon.

[21] 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.

- **Key Meters** - 1.5 million key meters, used in six distribution regions, of which five exclusively.

- **Smart Cards** - 0.8 million smart cards meters, used in two distribution regions, which also use token meters.

- **Key Pad Meters** – Northern Ireland – 175,000 installed by 2006. Many initially replacing existing Token meters, but now covering c.25 % of residential customer-base.

Token meters have a number of shortcomings, including greater susceptibility to fraud and mis-directed payments, inflexibility in recovery of debts, 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 to the key at the payment service-point, and allow meter reading data to transfer. In this sense, Key meters are 'semi-smart'[22].

Non-Domestic Electricity Customers Below 100kW

Metering systems vary according to energy off-take. Smaller electricity customers tend to have single-rate kWh (1R) meters or multi-rate kWh (2R). Above these demand-levels, or where there is a demand-management dimension, electronic meters have been extensively installed. Most non-domestic electricity meters below 100kW, for example in small-business premises, were not replaced at market opening in 1998. Just as for domestic consumers, these meters do not store data on when energy was used (i.e. they are non-half hourly meters and are 'profiled' by suppliers for settlement purposes) and are manually read, either quarterly or monthly. Throughout this project, we have therefore referred to both domestic and non-domestic electricity credit meters below 100kW in the same terms [23].

The Carbon Trust is presently undertaking a field-trial of around 600 half-hourly advanced meter systems in SME premises, and is due to report in June 2006[24].

Gas Domestic Credit Meters

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

[23] Elexon

[24] Carbon Trust Advanced Metering Field Trial. November 2005.

There are around 20 million gas credit meters in the UK, 95 % of which are owned by National Grid Gas. These are virtually all low-capacity diaphragm meters[25], operating at standard low-pressure, and do not need regular servicing (unlike Industrial and Commercial high-capacity meters operating at higher pressures). Under the gas-meter price-control, suppliers are charged £12.74 pa by National Grid Gas for a standard credit meter, of which £7.57 pa is for meter provision. Interestingly from a meter-market point of view, around 70 % of existing gas meters still measure gas-consumption in cubic feet – i.e. in imperial units - which is then converted to energy-used in order to charge the consumer for the gas used. Technically, under the Weights and Measures Act 1985, imperial measurement is prohibited for all equipment which post-dates 1980.

Non-Domestic Gas Meters

Many SMEs also have low-capacity gas meters of the diaphragm-type of less than 11 standard cubic metres per hour. Capacity is the main cost-driver for any given gas-meter type and above 11 scmh, there are three main types of flow measurement in Industrial and Commercial gas meters : diaphragm, rotary and turbine. Installations connected to high-pressure systems are generally more complex and costly[26]

6. Understanding the Term 'Smart Meter'

Smart metering is a very broadly used term and for which there is no single definition. 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.*

Smart Meter Types

For both electricity and gas, there are two main smart-meter types, typified by their main communications characteristics.

- **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.**

Interval Meter - A two-way meter with an additional capability to store and communicate data both to the customer (in real-time) and to the utility for settlement purposes (half-

[25] U-6 Type – a flow of less than 11 standard cubic metres per hour (scmh).

[26] Operating at pressures >7barg.

hourly data), on actual energy consumption by time-of-use. For billing purposes, this can later be reconciled with real-time tariffs. Interval meters enable real-time pricing at the residential level. Since 1994, Interval meters have been used in the 100kW commercial and industrial electricity sector, but not so far in the UK SME and residential sector. For the utility and industry, Interval meters have a significant data-volume and data-handling dimension, and therefore warrant distinction from simple AMM meters.

Meter Capability - The key distinction between smart-meter types is therefore determined by their communication capability – i.e. whether one-way or two-way - and in the case of two-way communication, by data-storage capability. These basic meter *capabilities* then determine the large range of *functionality* that the meter might offer.

Meter Functionality - The attached Chart attempts to capture the variety of functions potentially on offer from the three main meter-types. These range from basic remote meter reading and tamper-detection with one-way communication to remote activation and load shedding, remote tariff-change and time-of-day tariffs with two-way communication and real-time time-of-use tariffs with two-way communication plus data-storage. To some extent, functionality builds incrementally in terms of sophistication and cost.

Suggested Core Capabilities of a Smart Meter

Beyond stating that a smart meter is a device that measures, has a communications interface, and has a reporting system, such a definition may continue to prove elusive. However, the following list captures the core capabilities that are consistently identified as particularly important for a smart meter system :

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

Communications

Communication is intrinsic to advanced metering, allowing meter data to be communicated to a central collection system, and to be processed for billing purposes.

Communications combinations are still evolving with many different fixed, mobile, wireless, narrow-band and broadband communications options available. Many new possibilities – as well as new complexities – present themselves, and each communications choice has pros and cons. Narrow-band technology (i.e. slow speed) is sufficient for meter-data, but many domestic premises now have access to wide-band communications. Reliability and data-accuracy are a recurring theme, whatever the chosen communications technology.

Communications split into three elements : local connectivity to smart technology, customer display, other meters and appliances ; LAN connectivity (Local Area Network) to concentrators, hubs and routers ; WAN connectivity (Wide Area Network) to Broadband, GPRS, Wi-Fi or PLC.

Very broadly speaking, communications from the meter to an *initial* data-collection point can be grouped between 'fixed' and 'wireless' as follows [27]:

Fixed Communications

- **Telephone Landline -** Narrowband / Wideband
    - **PSTN** – Public Service Telephone Network
    - **ISDN** – Integrated Services Digital Network
- **Cable / ADSL** - wideband
- **Power Line Carrier – PLC** – narrowband. Transmits radio-frequency signal via existing electricity distribution wires from meter to data-concentrators sited at very local-level transformers. The data-concentrators aggregate meter-data from groups of, say 20 – 80 meters.
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Wireless Communications – wideband - satellite and terrestrial broadcast.

- **GSM modem with SMS** - Global System for Mobile Communications
- **GPRS -** General Packet Radio
- **UMTS –** Universal Mobile Telecommunications System
- **Radio Network –** narrowband / wideband

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[27] SPRU. 2005. Elexon. 2002.

- **Short-Range** – say up to 100 meter range. This type of technology (such as blue-tooth) is suitable for 'walk-by'-type data-collection and requires the use of a hand-held device to collect the data.

- **Medium-Range** – say up to 8 kms range. Commonly termed **Low Power Radio,** and similar in characteristics to a fixed-network installation. Multiple meters communicate to a base-station located within range. The base-station then passes the data back to the utility. Widely deployed in the USA and elsewhere to support 10 million-plus AMR and AMM meters. [28]

- **Long-Range -** more than 8 kms. The Radio Four Teleswitch system is an example.

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

- **GSM -** Generally, wireless mobile communications such as GSM would allow Suppliers considerable flexibility in targeting particular customer groups, including SMEs, pre-payment or remote residential customers.

- **PLC – LPR** – Fixed installations such as Power Line Carrier, or Low Power Radio, are perhaps well suited to geographic-based smart meter rollout and is being extensively and successfully deployed in Italy, for example. Both are currently lower-cost technologies than mobile. But they are less cost-effective in areas with low population density or low density of smart-meter penetration. Both PLC[29] and LPR[30] are being rolled out elsewhere, and each have their advocates. For both PLC and Radio, planning consents may be needed for communications masts. In some instances, questions arise with both PLC and LPR with respect to reliability of data-transmission, and, with regard to maintenance requirements and costs.

- **WiFi** - Broadband combined with an in-home wireless connection from the meter to home broadband – potentially offers considerable scope going forwards at a

[28] Low Power Radio obviates the need for a wire or GPRS modem in the meter and therefore has the potential to significantly reduce unit costs, although additional circuitry is required to provide Radio Transceiver functionality. LPR could also take data from gas and water meters at relatively little additional unit cost. Technically, it would be feasible to install LPR in the UK. Rough estimates suggest that a national LPR network comprising 20,000 radio collection-points could cost around £70 million including a data-centre, plus an annual operational cost. In discussion, there were both supporters and detractors, not least for reasons of data-transmission reliability.

[29] PLC – e.g. Italy : Sweden – Vattenfall ; Elnat (Eon). Guernsey.

[30] LPR – e.g. USA - California. Sweden – Vattenfall ; Elnat (Eon).

residential-level. However, fully secure systems have yet to be commercially established at the customer-meter interface, and this remains a challenge.

7. Non-Smart 'Facilitation' Options

A number of low-cost options exist which are not smart meters, but which could in effect be used to gradually 'future-proof' the meter stock – i.e. make meters capable of being 'smarted' in the future. One such 'basic-data meter' option under discussion, is a meter with a minimum level of communication capability, either through a pulse or electronic-packet which can later be interfaced to a smart box or external system, to add more functionality or smart features.

- **Pulse Meter** – under this option, all new electricity and gas credit meters could incorporate a basic pulse. The pulsed signal could be activated and relayed from the meter to a separate electronic 'smart' box provided to consumers under commercial arrangements by a supplier. Pulse output represents a very basic option, and suffers a number of significant shortcomings with respect to reliability.

- **Gas Pulse** Meters – 50 % of gas credit meters (yellow top) are already 'pulse-capable', although it is thought that relatively few of these pulse-outputs are in practice serviceable. For safety reasons, a wireless link rather than an electrical connection would enable the pulse to send a signal from the gas to the electricity meter, which could then also be sent to the smart box. This may prove an attractive option for duel fuel packages.

- **Electronic Data Packet** – A slightly more sophisticated alternative to the pulse, might be the option of adding a data-port to basic electronic meters which can periodically transmit absolute data, known as an 'electronic packet'. This would be an optical connection or more commonly, inductive pad (i.e. no wires) that outputs simple ACSII data and opens the way for consumption feedback and display, and as with a pulse meter, once 'smarted' could offer a range of functions, including two-way exchange of data. Electronic packets may also be error prone, just as a simple pulse.

While these basic data meter options may present a low-cost route to future proofing, it is important to understand that they are only initial facilitation measures. They may eventually facilitate some interesting retail-led initiatives by Suppliers, but of themselves are not a route to subsequent mass installation of smart meters. A separate smart-box with consumer electronics *and* a mobile communication system *will still be required*, and so, overall, this remains a full-cost smart-meter option. This option may also require two visits, adding to the overall cost : one to install the basic data meter and possibly a second visit to install a smart box.

8. Easy Access Visual Displays

DEFRA, NGOs (Energy Saving Trust, energy watch, the Carbon Trust and the Association for the Conservation of Energy) stressed that improved consumption and expenditure feedback to create better awareness of energy use, is potentially one of the most important 'gains' from a move to smart-metering[31]. There are a number of different ways in which consumers could obtain improved feedback via a display. It is therefore important to note that :

- Smart meters may well be positioned outside or out-of-sight. This is common in the 100kW Industrial and Commercial market. 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 prominent 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 on their energy consumption and expenditure.

- 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, successfully 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.

9. Basic Visual Displays of Consumption Feedback Without a Smart Meter

A number of non-smart separate consumer 'clip-on' devices are coming onto the market [32] that provide a clear visual display, generated from a signal from the *existing* non-smart

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[31] 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.

[32] such as RWEnpower's Electrisave

meter. At around £–50-70, the unit cost is currently not trivial, but could come down with volume. The device needs physically calibrating with the correct tariff, but information from Canada [33] suggests that such basic monitors can be an effective tool in increasing awareness of energy use at a cost of Canadian $100. Other, more basic, plug-in electronic devices are also available which give expenditure information for individual appliances, retailing at under £10. In Denmark [34], the Danish Electricity Saving Trust has developed a number of such devices, including a power-saving plug, which reduces 'stand-by' consumption on appliances such as televisions and DVDs [35]

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

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

[35]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)

Chart to Show Potential Functionality of Different Types of Meter

This Chart lists a theoretical range of functionalities that could be available via the main meter-types. In practice, the range of functionality of the meter depends first on the meter communications capability (one-way or two-way) and, second, on data-storage capability. Functions build incrementally in terms of sophistication and cost. Only the most expensive two-way interval meters would be able to offer all of these functions.

Key

- **Capability**

o **No Capability**

	Electro-Mechanica l / Basic Electronic	**AMR – One-Way Communicatio n from Meter → Meter Operator**	**AMM – Two-Way Communicatio n**	**AMM +INTERVAL Two-Way Communication with Stored (egg half-hourly) Information (Interval Meter)**
Accurate Measurement	•	•	•	•
Accurate Measurement for Time of Day	Only via Profiles	Only via Profiles	•	•
Clear, Easy-Access Electronic Display – (only useful where the meter is located within the home, or, there is a remote unit, separate to the meter)	o No – but some 'in-home' devices can give basic price info	o only if specified	o only if specified	o only if specified
Facility for Supplier to send messages – e.g. on energy efficiency	o	o	• Would need Easy-Access Display	• Would need Easy-Access Display

	Electro-Mechanical / Basic Electronic	**AMR –** **One-Way Communication from Meter → Meter Operator**	**AMM –** **Two-Way Communication**	**AMM +INTERVAL** **Two-Way Communication with Stored (e.g. half-hourly) Information (Interval Meter)**
Access to Account via Internet	Basic account info only	Basic account info only	Basic account info only	• Time of Use Data
Simple Data Capability	• 50 % gas meters have	• as a minimum	n/a	n/a
Dual Fuel Capability – i.e. whether possible to read both electricity and gas meters in a single meter-reading exercise.	o	• via data input	• via data input	• via a data input
Accurate Non-Estimated Bills - on any billing frequency, without a visit	o	•	•	•
Enables Offer of Variable Direct Debit	o	•	•	•
Tamper Detection Without Visit	o	• PLC– not necessarily for each meter – but for groups of meters at a data concentrator	Possibility	•

	Electro-Mechanical / Basic Electronic	**AMR – One-Way Communication from Meter → Meter Operator**	**AMM – Two-Way Communication**	**AMM +INTERVAL Two-Way Communication with Stored (e.g. half-hourly) Information (Interval Meter)**
Switch Supplier Without Visit - to read meter, change customer ID etc	•	• Provided visit not needed for ID change – some mobile comms may require.	•	•
Tariff Change Without Visit – where meter displays price information as well as energy used.	o	o	•	•
Switch between Credit and PPM without a visit	o	o	If specified (will be added cost)	If specified (will be added cost)
Pay as U Go	PPM - Smart Card and Key – can change tariff without visit. Not Token.	Not unless a PPM smart-meter	If specified. May need separate in-home display to show remaining credit	• If specified. May need separate in-home display to show remaining credit.
Time-of-Day Tariffs – meter able to transmit information (consumption, cost) relating to energy used in different time-periods.	o Economy 7	• Potentially – but complex & costly	•	•

Time-of-Use Tariffs – real-time price information	o	o	o	•
	Electro-Mechanical / Basic Electronic	**AMR – One-Way Communication from Meter → Meter Operator**	**AMM – Two-Way Communication**	**AMM +INTERVAL Two-Way Communication with Stored (e.g. half-hourly) Information (Interval Meter)**
Allow Remote Software Upgrades	o	o	•	•
Remote Disconnection / Load Limiting Facility (not credit gas meters on safety grounds)	o	o	If specified. Gas disconnect only, not remote reconnect.	If specified. Gas disconnect only, not remote reconnect.
Remote Load Switching / Downturn	Economy 7 plus existing Teleswitch, Time switch and Radio-Teleswitch	Economy 7 plus existing Teleswitch, Time switch and Radio-Teleswitch	• not gas	• • not gas
Micro Generation - Import / Export Measurement	o	o	• But not ToD	•
Asset Life	15-30 years	? 15 years	15 years	15 years
Cost Range	£7 depending on functionality	c. £40 - plus addtl functionality plus comms	c. £40 – 60 plus addtl functionality plus comms	c. £40 – 60 plus addtl functionality plus comms

Appendix 2 – Smart metering experience and studies

1. Review of evidence on energy saving

A key document is a report produced by EA Technology (Wright et al, 2000) for BEAMA into the energy efficiency, carbon dioxide reduction and other benefits of advanced utility metering. It is information in this report that many others (see below) have been using in support of their estimates of the energy saving potential.

1.1 EA Technology paper (Wright et al, 2000[36])

Wright et al identify eight separate techniques that have been 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 gateway to the home for load control and other services. They note that four of these (e.g. mainly to with improvements to billing information and energy advice) were achieved with no change to metering, since all the information is based on billing data and in one case a questionnaire. The main evidence in the report is from Norway where savings of up to 10% were achieved, but these were 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."

In the report summary Wright et al (2000) suggest that savings may be 3-5% in the UK for UK homes without electric heating, and likely to be slightly higher for those with electric storage heating. The report also says that the carbon benefits of load shifting would be very small – around 0.3%.

1.2 DTI smart metering working group report (2001)

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

The DTI smart metering paper quotes 5-10% savings and references these back to the EA Technology paper.

1.3 CSE (Towards effective energy information. Improving consumer feedback on energy consumption, 2003)

CSE base their estimate of 5-10% savings on the reviews by Darby and Wright et al. They also examined some of the original studies however, and point out that few of them were longitudinal so evidence of a sustained effect is thin. The best in this respect is Norway (Wilhite et al[37]) 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). (But note that these homes had electric heating)

1.4 Sarah Darby paper (Making it obvious : designing feedback into energy consumption. 2001)

A review of 38 feedback studies carried out over a period of 25 years (1975-2000) Of 21 studies that involved what Darby terms direct feedback (includes smart meters but 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 all 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). However, some analysis of some of the studies is undertaken.

"The highest savings – in the region of 20% - were achieved by using a table-top interactive cost- and power- display unit; a smartcard meter for prepayment of electricity (coinciding with a change from group to individual metering); and an indicator showing the cumulative cost of operating an electric cooker. In the absence of a special display or a PC display, the feedback was supplied by the reading of standard household meters, sometimes accompanied by the keeping of a chart or diary of energy use….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), indicating the potential for feedback to be incorporated into advice programmes on a regular basis."

[37] Wilhite, H et al. Advances in the use of consumption feedback in energy billing : the experiences of a Norwegian energy utility. University of Oslo, 1999.

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…"

1.5 Evidence from more recent use of smart metering

There would appear to be limited evidence from recent use of smart metering to quantify energy savings. The major smart metering initiatives (Italy, Ontario, Victoria, Sweden and California) are all too recent to have produced any data. . The best data are from the California state-wide pilot which found significant impacts on peak demand in response to pricing signals, but no reduction in energy use overall. In Northern Ireland (keypad prepayment meters) savings of 3% were found over a relatively short period but further evaluation is underway and so more evidence should be available around March/April 2006.

Further recent evidence comes from a major International Energy Agency study[38] 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.

1.6 Powergen consumption information trial

Powergen have launched a trial to test domestic consumers' reaction to information about their energy consumption. The trial is designed to see if savings seen in overseas trials can be demonstrated in the UK

The trial consists of a set of 3000 selected domestic customers, who, each quarter, will receive an energy statement following the production of their regular bill or statement. The energy statement shows in graph form how their consumption has changed since the same period of the previous year (in total and in average use per day). The statement includes a hotline number direct to the Powergen Energy Efficiency team, and tips and pointers about energy consumption. The trial was launched in August 2005, with the first statements going out in mid-September.

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

Customers were selected across the UK from the Powergen customer base. An additional 3000 customers (Control 1), chosen using the same criteria as the main group, were just told that Powergen would be looking at their consumption. This was to test the 'placebo' effect of customers being contacted about their energy use. A further 3000 accounts have been flagged but not contacted (Control 2), to be used as the baseline. Customers were selected across the four main payment types to test a broad range of customers: Monthly Direct Debit, Quarterly Cash (On Demand), Regular Cash Payment and Prepayment Meter. There is a fairly equal split across gas and electricity, with some dual fuel and also a small number of internet self-serve customers.

The trial was designed in conjunction with Ofgem and the Centre for Sustainable Energy. Sarah Darby of the Environmental Change Institute, Oxford University, acted as external consultant. Regular reports will be run each quarter to monitor how the energy consumption of the selected customers has changed relative to each other. The trial will run for 2 years, with a report issued each quarter.

1.7 RWE Npower trial of Electrisave

The Electrisave device consists of a small wireless transmitter which is attached to an electricity meter and a customer display unit that can be placed anywhere in the house. The units cost £50-70 depending upon volume bought. Once programmed with the tariff rates the display unit can show the customer how much electricity (in units and pence) is being consumed at any time and how much has been consumed over various periods. Npower have trialled the unit with staff and have now recruited 500 customers to try it out. The effects on consumption will be monitored.

1.8 The Application Home Initiative (TAHI)

TAHI was a trial of energy and water consumption information via broadband to a set-top box and TV display, by Severn Trent.[39] There was very low take-up of this trial offer – even with the incentive of a free broadband connection and digital set-top box for a year. 1500 households were made the offer but only 50 volunteered and of these only 20 were deemed suitable for the trial. However, there was no incentive that they could save money on bills through time of use tariffs (though presumably they might have been able to save by reducing overall use through the better information).

1.9 Conclusions

[39] Home economics. Utility Week, 9 September 2005, p.23

Evidence is mostly based on small-scale trials and few have been longitudinal – so they do not show whether the response is likely to last. The Northern Ireland example (see Appendix on international experience) shows reductions of 3% but evidence from a longer term study will be needed to see if this is maintained. . The Hydro One project (see below) 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 context the Powergen consumption information trial and the npower Electrisave trials should also provide some useful UK evidence on the usefulness of information.

The major long term evidence is from Norway and this involved informative billing rather than smart meters and homes using electric heating (4-8% saving). In the UK the scope for major savings on electricity is lower than many other places due to limited use of electric heating and virtually no air conditioning. It therefore seems likely that the average response via behavioural changes will be less than 5%,. There may be more scope to reduce gas use with smart metering (heating and hot water uses) but virtually all trials and studies have only looked at electricity. . However, if the information from smart metering encourages more households to invest in energy saving measures and/or micro-generation then the impact on energy use and emissions could be greater. Furthermore it is worth putting this in context – even a 1% reduction in energy use would equate to about 8% of the domestic sector carbon savings target. If average savings did amount to 4-5%, then the contribution to the domestic sector carbon saving target could be substantial.

Finally it is also worth noting that all the above relates to the household sector. In the commercial and industrial sector the issues are likely to be different. Work by the Carbon Trust[40] 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 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.

2. International experience

Much of the international experience (especially in the US) is with AMR only. Much of this was developed many years ago and driven by a tradition of monthly billing and hence a strong business case to cut meter reading costs. AMR has been used by many utilities to enable them to read meters from a van driving by houses, obviating the need to get into

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

the property. Typically this involves a small battery powered radio transmitter being fitted to the gas meter. As the van drives past it sends a signal to the meter and the meter sends data back to the van for onward transmission to the utility. We have assumed that 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, customers and public benefits) are from AMM

The focus below therefore is on those examples that are AMM (with or without interval metering).

Note also that all of the examples that follow are for electricity. The only examples of use of advanced metering for gas are in the US and are mostly AMR.

2.1 Northern Ireland keypad meters

The Northern Ireland experience is clearly within the UK but is included here as it provides an interesting case study. Northern Ireland Electricity (NIE) remains the only supplier to the residential market, but full retail competition will begin in 2007. NIE remains vertically integrated through supply, distribution, transmission and electricity purchasing and this includes metering responsibility. There is some competition in the wholesale market and for industrial and commercial customers.

NIE's experience with smart meters relates solely to pre-payment and began in 2000. The key driver was problems with the former pre-payment system (Powercard) that had high costs (token management, need to visit to change tariffs, vulnerable to fraud/theft, requirement to track and reconcile usage and billing) and high levels of customer dissatisfaction (costs, breakdowns). These concerns and pressure from Ofreg and consumer groups encouraged NIE to look for a solution. Ofreg was also concerned to ensure that prepayment customers had smarter meters before the market is opened to make it easier for them to participate. NIE chose the Liberty keypad meter manufactured by Polymeters response International (PRI – based in Winchester) – a meter that is widely used in South Africa. Key features are :

- Prepayment keypad meter, with in-home display (essentially AMM + interval)
- Keypad meter costs about £60 plus £20 installation. (100,000 units)
- £15 of cost (same as older PPMs) goes into the RAB of T&D – the remainder of the additional cost (£45) remains with the supply business and is recovered via the supply price control (but NIE say the meter reduces costs such that they can offer

customers using the keypad a cost reflective tariff that is 2.5% below quarterly credit – compared to 4% lower for direct debit)

For NIE the main benefits are reductions in bad debts, meters reading costs, call centre costs, billing and debt management costs, call out costs. For customers the main benefit is the 2.5% discount. Standing charges are the same as for credit customers. Credit can be obtained either from agents (such as pay point) or by telephone using a debit card. The keypad does not involve anything being inserted into the meter – the customer just types in a number to activate the credit. So it cuts out a lot of the problems (and costs) associated with tokens/keys/cards that can be damaged or lost. The keypad meter has a conveniently placed customer display that enables them to monitor consumption, credit available etc.

Compared to 80,000 prepayment customers on the Powercard system, NIE had 160,000 Keypad customers by mid- 2005. It has a target (under the price control) of 175,000 (25% of all residential electricity customers) by 2007 but this is likely to be achieved in 2006. So the keypad system has dramatically increased the size of the prepayment market and has proved very popular with customers.

An initial trial of 200 households found an average 10% energy saving. However, these were all prepayment meter customers moving from old to new prepayment. Follow up research on a broader sample (ex-credit as well as prepayment) of 100 customers found an average 3% saving. These savings were based on time of day tariffs (4 time periods) that gave customers a strong incentive to save at peak times (there was an average 10% reduction in use at peak times). However these trials were over fairly short periods. NIE are doing further research with the University of Ulster over a longer period to assess the longer term effect – this will finish March 2006.

2.2 California

The Californian market consists of investor owner utilities (IOUs) regulated by the California Public Utilities Commission (CPUC) and private generating companies. Other key players are the California Energy Commission (CEC) and California Power Authority (CPA). The IOUs are mainly vertically integrated and have the metering responsibility in their area.

The key driver for smart metering in California is the need to reduce peak demand, particularly after the serious power cuts experienced in 2001. Peak demand is largely driven by air conditioning use during the summer. One quarter of capacity is used for less than 100 hours a year. The top peak energy uses that are considered amenable to price responsive demand targets are : commercial air conditioning; residential air conditioning;

commercial lighting; residential miscellaneous; agriculture and water pumping. The residential load contributes 25% to peak demand on a cool day and just over 30% on a hot critical peak day.

A state-wide pilot, authorised by the 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[41] of 16 other time of use and CPP programs found an average conservation effect of 4%. Another potential benefit of reducing peak demand that has been considered in California is the effect on energy market prices as relatively small changes in load can produce lower market clearing prices and lower volatility.

Based on the outcome of the pilot, and an agreement between the CPUC, CPA and CEC on an Energy Action Plan for the state, the CPUC has agreed to state-wide installation of smart meters for all small commercial and residential IOU customers by mid-2006, with cost recovery agreed based upon plans submitted by the IOUs. Agreement on cost recovery was required because the benefits to the utilities (in terms of savings on operational costs) would be significantly lower than the costs of introducing smart metering. For example, in the case of Pacific Gas and Electric (PG&E), over a 15 year period, the NPV of costs to deploy an advanced metering infrastructure and meters for all of its customers below 200 kW have been estimated at approximately $1.8 billion, whereas the corresponding operational benefits (excluding demand response benefits) are approximately $0.8 billion. However, the state-wide pilot helped to establish that when the societal benefits are added, the cost benefit case is positive due to the value of the reduction in peak demand.

Critical Peak Pricing tariffs will allow the utilities to decide, on up to 15 days a year, when the poweris too short and let customers decide how much power they want to buy. On a normal day the power may be priced at 15 cents per KWH during peak times; on a critical day that same power may cost as much as $1, more than six times the normal peak price. In July 2005, extreme temperatures in the Southwest States coupled with 2,000MW missing on the network as a consequence of some local power plants tripping brought a Californian Independent System Operator very close to a major crisis. The "stage II" alert issued by the California operator prompted several utilities to invoke demand-response

[41] Charles Rivers Associates. Impact evaluation of the California statewide pricing pilot. Final Report, March 2005.

programs to reduce load. Thousands of customers, including both large and small customers, reduced their energy usage, and a crisis was avoided. (CapGemini, 2005[42])

2.3 Ontario, Canada

Ontario Energy Board licences all participants in the electricity market including generators, transmitters, distributors, wholesalers, retailers. Ontario's competitive electricity market opened on May 1, 2002. The former Ontario Hydro was broken into five separate, independent companies that remain wholly owned by the Ontario Government. Three are The Independent Electricity System Operator (IESO), The Electrical Safety Authority, the Ontario Electricity Financial Corporation. Two of the successor companies, Ontario Power Generation Inc. (OPG) and Hydro One Networks Inc. (HON) are commercial entities. Ontario Power Generation (OPG) generates electricity and competes with other generating companies in the new marketplace. Hydro One Inc. transmits and distributes electricity through its subsidiary, Hydro One Networks Inc. Hydro One owns and operates Ontario's high-voltage transmission network that delivers electricity to large industrial customers and municipal utilities, and a 122,000 kilometre low-voltage distribution system that serves about 1.2 million end-use customers and smaller municipal utilities in the province., Customers can stay with their local utility on a regulated price or switch to another supplier. The integrated utilities retain metering responsibility in their distribution businesses.

The driver for smart metering in Ontario was problems with peak demand creating the need for expensive imports. In July 2004, the Minister of Energy asked the OEB to develop a plan to achieve the Government of Ontario's smart meter targets for electricity: 800,000 smart meters installed by December 2007 and installation of smart meters for all Ontario customers by December 2010.[43] Key features are :

- Ontario Energy Board has specified minimum standards but not specific technology, so costs are estimates
- Cost recovery via distribution charges
- Total capital costs to 2010 estimated at CAN $1 billion for meters (CAN $4.5 million meters), communications, installation and distributor system charges
- Net increase in annual operating costs once installation complete estimated at CAN$50 million
- Cumulative capital and operating costs estimated as requiring an extra CAN $3-4 on monthly charges

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[42] Cap Gemini. Smart metering : the holy grail of demand side management ? 2005.
[43] Ontario Energy Board. Smart meter implementation summary, 2005.

The OEB has left distributors free to choose which technology to use as long as it meets the functionality specification. The standard requires two way communication (AMM + interval meter) but the summary of the OEB's proposals notes " two-way communication is not, in itself, sufficient to provide functions such as customer display, integration with load control systems, interface to smart thermostats, voltage monitoring, earlier payment, load limiting and remote cut-off. These functions depend on the availability of ancillary devices at additional cost. In order to improve interoperability and the development of ancillary devices, the Board proposes a requirement that smart meter systems have an open network interface at the connection to the wide area network." This would then allow others (e.g. retailers and ESCOs) to offer these additional services to customers.

The Board proposes a basic smart metering system that would measure how much electricity a customer uses each hour of the day. Through wireless communication or other technologies, the data would be transferred daily to the local electricity distributor. The distributor would use that data to charge customers an energy price that varies depending on when the electricity was consumed. Customers would have access to data by telephone or Internet the following day. Distributors would transmit customer consumption data to retailers for those customers who had signed with retailers.

Customers with peak electricity demand between 50 and 200 kW will get a smart meter capable of reading demand (which is required to compute demand charges applicable to those customers). General service and industrial customers with over 200 kW of peak demand (maximum electricity use at any point in the month) will get interval meters that measure consumption in 15- minute intervals. Large customers that have peak demands over 200 kW will get new meters first. For all other customers, the Board proposes a two-phased plan that focuses on the large urban distribution companies until the end of 2007 and the remainder of the province starting in 2008. The meters recommended for residential and small commercial customers are not interval meters and their readings are not collected over dedicated telephone lines. Rather, a full range of public and private Wide Area Network (WAN) infrastructure communication media is available for mass-deployed systems including wireless radio frequency, power line carrier, and shared telephone transmission to send information to and from the meter. The Board proposes that customers have daily access to their consumption data for the previous day via the Internet or telephone or, for an additional fee, with an in-home customer display. Historical consumption data will also be available. Customers will have information on how much energy they consume during different hours and different days.

The OEB's view is that the combination of a smart meter and a "smart" price plan will give customers the incentive and the ability to control their energy costs through moving usage to off-peak periods or lowering energy use during peak periods. It envisages that customers will be able do this manually, or by using automatic control devices that they purchase and install themselves, or via a contract with an energy services company to control devices automatically based on price or demand level over the system. The Board is encouraging distributors to carry out an initial set of pilot programs using dedicated conservation and demand-management funds during 2005 to gain useful information about the installation and operation of smart meter systems before making final decisions on the particular system that they intend to choose. The Board expects distributors who have held pilot projects to share lessons learned with other distributors.

The implementation plan proposes that the capital and operating costs of the smart meter system be included in a distributor's delivery rates that are charged to all customers in a particular rate class, whether or not they have a smart meter. In addition, it proposes that the costs related to old meters and other distributor assets that are made obsolete by the introduction of smart meters continue to be included in distribution charges.

2.4 Ontario – Hydro One customer display trial

Between July 2004 and September 2005 Hydro One equipped 500 homes with a low-cost, indoor energy monitor in the largest such study ever completed in Canada. The technology wirelessly transmits data from a building's outside meter to a portable indoor display, allowing homeowners to directly see how much electricity they are consuming on a "live" basis. The displays cost less than $100 (£45) per home and can be self-installed and so are a much cheaper option than smart meters, although clearly they do not have the full functionality of smart meters The results were compared to the same seasons and months in the previous year. Hydro One found that participants in the project reduced their energy use by between 7 per cent and 10 per cent.

The data from the project are being analysed and documented by McMaster University's Institute of Energy Studies, and a final report is expected during 2006. The results will also be filed with the Ontario Energy Board.

2.5 Victoria, Australia

In Australia energy markets are established at state level and decisions are also taken at state level about whether to privatise or liberalise the market. The industry was privatised in Victoria in the late 1990s and there has been full retail competition since 2002. The gas and electricity supply and distribution businesses have been regulated at state level (in Victoria by the Essential Services Commission); whilst transmission and generation have been regulated at federal level by the Australian Competition and Consumer Commission (ACCC). However, in June 2004 the Federal government passed legislation to establish a single Australian Energy Regulator, which will be part of the ACCC and will eventually regulate all energy businesses in Australia. For the moment the electricity market in Victoria is still regulated by the Essential Services Commission and it is the ESC that has decided to mandate a targeted rollout of interval meters.

The key driver for smart meters in Victoria is problems with peak demand, particularly in the summer period due to growing use of air conditioning. The ESC considers that cost-reflective pricing is needed for consumers and the economy as a whole to realise the potential benefits of the electricity industry reforms and that interval meters have crucial role to play in creating the technological platform to deliver the economic and social benefits of :

- effective electricity competition
- improved energy efficiency and conservation
- market efficiency through more demand management
- technological innovation and advancement in the energy market
- greater customer empowerment and self-reliance
- the improved security of supply associated with smoothing the load profile.

The ESC believes that the responses of electricity demand to cost-related prices should contribute to:

- smoothing the peaks in the electricity load profile, thus reducing the volatility of energy prices
- improving the efficiency of the operation of the electricity wholesale market
- improving the balance between supply and demand in the wholesale market
- lowering the cost of energy by delaying investments in new infrastructure to satisfy the future growth of, and peaks in, the demand for electricity.

These potential improvements in wholesale market efficiency are particularly relevant for Australia's wholesale market, which has weather driven needle peaks in demand and relatively low forecast reserve plant margins.

The ESC has decided to mandate a rollout of AMM + interval meters and has specified minimum standards (but not the actual meters).[44] The decision was predicated on its following assessments:

- Market forces alone would fail to deliver a timely interval meter rollout on a scale sufficient to provide economies in meter manufacture, installation and reading.
- Regulatory intervention would be required to achieve the economic benefits that would result from a more timely and larger scale rollout.
- Based on the Commission's cost–benefit analysis, a net economic benefit would arise

[44] Essential Services Commission. Mandatory rollout of interval meters for electricity customers. Final Decision.July 2004

from a timely, mandatory rollout of interval meters.
• The current cost increment between accumulation and interval meters is expected to fall over time.

The Commission's final decision is for interval meters to be installed :

• by 2008 for all large customers (greater than 160 MWh per year), commencing in 2006
• by 2011 for all small business and large residential customers (those consuming less than 160 MWh per year but more than 20 MWh per year) with off-peak metering or three-phase metering, commencing in 2006
• by 2013 for all small business and residential customers(those consuming less than 20 MWh per year) with off-peak metering or three-phase metering, commencing in 2006
• on a new and replacement basis for all small business and residential customers with single-phase, non-off-peak metering, commencing in 2008.

In the seven years from 2006, up to one million large customers and customers with electric water heating will have their accumulation meters upgraded to interval meters. Over an extended period, when a new or replacement meter is required, all remaining meters (around 1.3 million) would be upgraded.

The ESC produced a cost model to enable them to assess costs and benefits. The costs modelled were : meters and associated capital equipment; installation; maintenance; meter reading and data management. Costs vary according to specifications and quantities – e.g. AU$124 (£52) for a single-phase off-peak meter where more than 200,000 units are supplied, but $149 where less than 30,000 are supplied. Installation costs also vary with quantity from $50 at the lower volume end down to $35 at the higher volume end. Total cost for 200,000 meters is $159 per meter (£64) Metering data services are assumed to cost $20 a year per meter. Maintenance costs are assumed at 2.5% of the meter cost per year.

2.6 Italy

ENEL is state owned, vertically integrated (generation, transmission, distribution and supply) and the major electricity company in Italy with 85% of the supply market and are the only supplier to the residential sector – this sector of the market does not open to competition until 2007.

Four drivers encouraged ENEL to embark upon a major programme to replace all their residential meters with smart meters over a 5 year period from 2001. Firstly, serious problems of fraud, theft and bad debts that led to significant losses in revenue. Secondly, the need to make many visits to premises both to deal with theft/fraud/debts and also to change load allowances (typically households contract for one of two levels of load and they decide to change this has to be done via a home visit). Thirdly to prepare themselves for the competitive market, including to offer customers new services. These three were the main drivers. Fourthly, there was the need to deal with peak demand problems particularly following some severe blackouts in 2003.

The meters installed are AMM + interval meter - ENEL have chosen a specific technology to meet its requirements. Installation has been driven by a clear business case for ENEL with the regulator allowing some cost recovery. The cost is 2.1 billion euros to replace 30 million meters over 5 years starting in 2001, representing a cost of 100 euros per meter in total – meter (40); installation(40); communication (10); central systems (10) ENEL estimate that smart meters will save them 500 million euros a year through better revenue protection and reduced costs.

Alongside the meters, ENEL have introduced time of use tariffs (in 2005) and they are also considering introducing remote control of appliances. The technology chosen also enable them to provide reduced power supplies (e.g. enough for lights only) as an alternative to disconnection – and this can be done remotely. The communications technology is power line carrier between the meter and transformers and then GSM/fixed line to data centres.

2.7 Sweden

Competition was introduced in 1999.Three major companies – Vatenfall, Fortum, and Sydkraft – have a combined market share of 50% and around 1 million customers each. There are almost 200 smaller companies, many of them municipally owned. Distribution companies own the meters and do the meter reading. The key driver in Sweden for smart metering was a decision in 2003 by the Swedish Energy Authority (STEM) to require monthly meter readings for all electricity consumers. This came about due to problems with billing following the introduction of competition. An assessment carried out by STEM prior to this change had concluded that more frequent meter reading would benefit the Swedish economy by 600 million Swedish kroner per year, due to reduced energy consumption and reductions in electricity companies' costs. The costs were estimated at 10 billion Swedish kroner. Costs are passed through to the consumer.

The energy companies responded to this requirement by introducing smart metering to cut meter reading costs. Initially most meters were AMR only, but now many are installing or considering installing AMM + interval meters. Another factor in Sweden is that many households have 3 phase meters rather than the single phase ones used in the UK. So basic meters cost more than in the UK (around £25 compared to £7) thus lowering the capital cost differential with a smart meter.

2.8 Netherlands

In the Netherlands competition for small customers began in July 2004 (though competition for green energy supply contracts has been available since 2001) Currently 3 large suppliers have 90% of the market and there are 10 suppliers in total. A consumer survey by Consumentenbond (Dutch consumers' association) found 14% had switched by the end of 2004 (including 8% who had switched to green energy since 2001) Switching since market opening in July 2004 was around 6%.

SenterNovem (the Dutch Energy Agency) has co-ordinated a study into the potential for smart meters for residential customers in the Netherlands. A key driver of government interest seems to be the potential for smart meters to enable customers to switch supplier more easily (and to be more interested in doing so in response to new service offers made possible by smart meters) thus stimulating more competition and hence lower prices. The study involved consultation with market players, a review of the need for standardisation and a cost benefit analysis. It asked KEMA(the Dutch energy sector's research body) to do the cost benefit analysis. Senter Novem has submitted its recommendations on smart metering to the Dutch Ministry of Economic Affairs. A number of pilot schemes to introduce smart meters are now underway, including one run by one of the major market players, NUON. It has been agreed that, to avoid stranding issues, when customers switch suppliers, the new supplier has to take on the old supplier's smart meter.

The Senter Novem study concluded that the Government should produce a definition of functionality that would then enable the market to develop standardisation. It noted that standardisation is essential but not the only condition for large scale introduction of smart metering. For the cost benefit analysis the parameters were a 10 year transition period, AMM, in-house customer display, gas and electricity meters with a mixed data infrastructure (40% PLC, 40% internet, 20% GSM), with the financial parameters being a 30 year period and an internal rate of return of 7%. They also assumed a 2% energy saving and perhaps most interestingly, reductions in electricity and gas prices due to improved competition (EUR 0.0025/kWh for electricity and EUR 0.0050/m3 for gas) . The resultant costs benefit analysis (meters for 7 million households) produces a positive outcome of 1.2 billion EUR with the following main costs and benefits :

Costs :

Purchase and installation of smart meters	798MEUR
Monthly billing energy consumption by supplier	437MEUR
Data infrastructure via PLC/internet/GSM	354MEUR

Benefits :

Easier switching – more price competition – price reduction 1,353MEUR
Less complaining via call centre 927MEUR

(Source : Senter Novem power point[45])

[45] Aldo Dijkstra. Cost benefit analysis for smart metering infrastructure for residential customers in the Netherlands. Senter Novem, 2005.

Appendix 3 : List of interviewees and those who provided information

Ampy – Jonathan Elmer

Association for the Conservation of Energy (ACE) – Jacky Pett

Accenture – Simon Coombs

BEAMA – Howard Porter, John Parsons, Bob Lowe (Horstman)

Bayard Capital - Cathy Zoi

Carbon Trust – Harry Morrison, Kofi Atuah

Centrica – Jill Harrison, Petter Allisson

CSE - William Baker

DEFRA - Paul Chambers, Carsten Rohr, Steven Daniels

DTI - Bryan Payne, Chris Bryant, Geoff Hatherick, Liz McDonnell

EA Technology – Linda Hull

EDF – Derek Lickorish, Ashley Pocock, Denis Linford, Roger Barnard

Energy Futures Australia – David Crossley

Energy Retailers Association – Duncan Sedgwick

Energy Saving Trust (EST) – Brian Samuel, Matthew Percy

Energywatch - Ed Reed

EON – Bryan Seabourne, Don Leiper

IBM – Colin Sawyer, Jeremy Willsmore

Iskraemco - Alan Anderson, Alan Jones

Micro Power Council - Dave Sowden

National Grid – Eric Fowler

NEA - William Gillis, Joanne Carr

Ofgem - Philip Davies, Mark Baldock , John Scott , John Wybrew

RWE npower – Laurence Poel, John Stewart, Jane Franklin, John Gilbert, Jonathan Woodthorpe

Scottish and Southern Energy (SSE) – Keith Maclean