Smart meters in Great Britain : the next steps ?

Paper 2 : Communications options for gas and electricity smart meters

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Communications Options for Gas and Electricity Smart Meters

A smart meter system communicates meter-data to a data-collection point to be processed for billing purposes. It may also communicate information back to the customer.

Two-way communication – Automated Meter Management – enables communication both from meter-to-supplier and from supplier-to-customer, and permits more functionality at relatively small incremental cost[1]. Two-way communication is necessary for pay-as-you-go and for remote tariff-changes. A capability to store data by timed-intervals, in addition to two-way communication, is needed for suppliers to offer time-of-use or some variable tariffs.

A variety of communications technologies are suited to transmitting meter-data, each with particular characteristics and potential pros and cons. These include dedicated network options on the one hand, such as power line carrier or wireless radio, and, cellular mobile communications on the other. Communications can be narrow-band or broad-band, but narrow-band (ie slow speed) is sufficient for meter-data. Importantly, there is still much learning and debate about how different technology options can best combine together into an overall 'communications architecture'.

Accuracy, consistency and reliability in transmission of meter-data are fundamental whatever the communications technology. Choice of meter-communications is therefore a sizeable risk in procurement and operational terms. A choice which may be fit-for-purpose and cost-effective in one physical environment (eg urban / remote ; high / low-meter density ; indoor / outdoor ; dual-fuel etc) may prove less appropriate in another. The potential for obsolescence is also a factor as next-generation options and combinations emerge.

There is also now considerable international experience in meter-related communications, and there are potentially many valuable lessons for the UK. The Energy Demand Research Project is also likely to provide some useful UK practical experience. Historically, communications have not been a core business activity for energy suppliers or for meter manufacturers. New partnerships with communications specialists are likely to develop and offer new-thinking and expertise.

1 Much meter-communication to date has been one-way (from the meter-to-supplier) offering the means for pedestrian and drive-by AMR (Automated Meter Reading), notably in the United States.

Meter communications can perhaps usefully be considered in three broad tiers :

- **In-home communications** – between meter (or meters or smart-box), home-display, and possibly other appliances. Most likely by means of very low-power short-range radio transceivers (ie combined transmitter and receiver), in the form of an in-built battery-powered micro-chip.

- **Local area-network connectivity (LAN) –** from the meter (or smart-box) within the home to a first link with a concentrator, hub or router which communicates externally beyond the home.

- **Connectivity from LAN to Wide Area Network (WAN)** – Onward transmission from LAN by a variety of fixed or cellular communications.

LAN connection is not needed where a GPRS/GPS modem is inbuilt into a meter and which communicates directly from the meter to the Wide Area Network.

Main Communications Options

Development of a New 'Dedicated Network' – PLC or Radio

Involves creating a permanent communications network from the meter to the Local Area Network (or other initial data-collection point). Currently, the two main 'dedicated network' options are Power Line Carrier and Radio.

Power Line Carrier (PLC)

This involves transmission of a radio-frequency signal from the electricity meter via the existing lower-voltage electricity distribution wires, to enable meter-data to be conveyed from the home to the WAN. There is a long history of low-speed one-way PLC for electricity network control, telemetry and demand-side management. There is also growing two-way PLC experience[2]. Standardised communications protocols and CENELEC standards on frequency bands and voltage limits to prevent interference have been developed[3] [4]. PLC for remote meter management has successfully been rolled out over low and medium voltage networks, most notably in Italy, and also in some parts of Scandinavia (Vattenfall and Elnat) and Guernsey.

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[2] In France, for example, EdF has used two-way PLC to transmit tariff signals to meters for over 20 years.

[3] Sustainable Benefits of Power Line Carrier Systems. Unipede / Eurelectric Task Force. Dec 1998.

[4] High-speed and digital communication over power lines (eg Broadband over Powerlines) poses considerable complexity. Both technical and regulatory developments are very much more recent.

In the UK, power line carrier for domestic metering would involve a number of steps. First, installation (or adaptation) of electricity meters able to transmit and receive a radio signal along the existing electricity distribution wires. The signal would travel from the meter along the wires to data-concentrators sited, perhaps, on neighbourhood electricity transformers. A data-concentrator would aggregate meter-data from groups of, say, 20-150 meters. From these initial data-concentrators, meter-data can be onward transmitted. This could be by PLC, to another electricity transformer or substation - or – could be transmitted wirelessly by medium-range low-power radio – until the point at which the meter data reaches a communication gateway to the WAN. Installation of additional equipment on the distribution network, such as repeaters and controllers would also be required.

For the UK, Power Line Carrier raises a number of distinct commercial and regulatory issues which would arise from the physical development and operation of a new, probably independent, communications network on an electricity distribution network (see below).

Radio Frequency (RF) Networks

Short-Range Radio - operates within a 100 metre range.

Short-range digital radio systems operate standard communications protocols, enabling interoperable 'open-architecture'[5]. Some narrow-band examples are Zigbee, Bluetooth and Z-Wave, each with somewhat different system characteristics. These radio-systems are potentially low-cost[6], and can incorporate a radio (either one- or two-way), memory, and a micro-controller on a small micro-chip. These can be installed when a meter is manufactured (or, possibly, retrofitted), and are battery-operated in a gas meter. These chips work at a low-data rate and low-power, offering potential long battery-life and secure networking.

Wireless short-range radio systems can be arranged in a relatively simple 'star' configuration, suitable for 'walk-by' or 'drive-by' data-collection[7] - or in more complex mesh network arrangements. In a mesh network, the micro-processor can act as a repeater, able to transmit meter-data securely along a line of micro-chips in adjacent meters - including through walls and able to seek out alternative routes if a first route fails - until the signal reaches a main collector. In this way, individual meter data can hop along

5 For example, standard internet protocols could permit use of either PLC or RF in the same meter, depending on which route is available to the meter.

6 Zigbee micro-chip end-device at below US $3. Texas Instruments. Graham Martin. Vice-Chair, ZibBee Alliance. Slides. Metering Europe Conf. Copenhagen. 2006.

7 Widely used in the United States.

a line of, say, one-hundred plus meters. Mesh radio therefore potentially offers similar characteristics and a potentially cost-competitive alternative to power line carrier.

Medium-Range Radio – say up to 8 kms range. Commonly termed Low Power Radio (LPR), and potentially able to provide a networked wireless communications option via base stations. For the UK, LPR would require new electricity meters with transceiver capability and, to achieve UK-wide coverage, a very rough estimate might be for around 20,000 base stations. Base-stations would connect wirelessly to a WAN gateway, and from there to suppliers. LPR is widely deployed in the USA and also in Sweden (Vattenfall) and Denmark (Elnat). Medium-range radio could work in combination with Power Line Carrier or short-range radio.

Long-Range Radio – over 8 kms. One example is the one-way Teleswitch system operated from Droitwich, for remote switching of some Economy 7 meters.

Cellular Mobile Communications – wideband – satellite and terrestrial broadcast.

GPRS / GSM - with SMS – General Packet Radio / Global System for Mobile Communications with SMS messages (Short Messaging Service). Ubiquitous 2-G (second generation) cellular network.

Other than a modem and a SIM-card, there is no need for additional physical infrastructure or other fixed network arrangement. A modem can be installed in the meter at manufacture (or perhaps retrofitted in a data-logger) and is able to communicate direct from the home to the WAN.

With 90 % coverage in the UK, GSM with SMS text-messaging is widely perceived as the front-runner for wireless cellular communications for meters. Entails installing either a smart-box with modem - or a new meter with a modem (most probably the electricity meter, acting as in-home hub). SMS is understood to use the underlying communications infrastructure and is therefore not 2G or 3G dependent - and accordingly does not risk becoming outdated[8].

Cellular mobile communications potentially allow suppliers considerable flexibility in targeting particular customer groups, including commercial and larger SME customers, pre-payment customers or remote residential customers.

[8] Some concerns expressed that 2G may not be maintained by network providers into the long term, and that it therefore could be problematic to embed 2-G sim cards into a meter expecting a 15 year life.

Existing Communications Networks Into the Home

Existing networks into the home offer a communications channel for meter data. Presently involves land-line connection to the meter, with dial-up facility. For example, currently used to provide communications-link for some large industrial and commercial meters.

- **PSTN –** Public Service Telephone Network – narrow-band.
- **ISDN –** Integrated Services Digital Network. Digital data transmission over copper wires (higher speed / better quality than PSTN).
- **ADSL / Cable –** or other wideband connection

WiFi – Potential Use of Home Broadband for Domestic Meter-Data?

Around 50% of UK homes (13 million) presently have a broadband connection[9].

In the future, it may become feasible to make use of household broadband connections to the internet, to send meter data directly from the home-internet to a supplier and also to send back meter-related information from the supplier to the customer (this latter already occurs).

One potential means may be by use of WiFi. This uses short-range radio technology to provide wireless connectivity for consumer electronics and computing devices within a Local Area Network. In the future, WiFi could offer scope for a wireless connection from the meter to the home-computer router to provide internet access. However, a number of issues will need to be resolved, before commercial WiFi arrangements are established for meter data. Issues include ensuring a secure WiFi connection and a strong uninterrupted signal between meter and router (ie not open to disturbance, either intentional or inadvertent), satisfactory encryption, and clarity with respect to responsibilities in the event of problems with data-transmission. Lastly, WiFi power-consumption is higher in comparison to other low-bandwidth standards such as Zigbee and Bluetooth and may therefore impact on battery-life (for gas meters at least).

[9] Ofcom. April 2007

Some Wider Communications Considerations

Dedicated Networks – Wider Issues

In the UK, there is little practical experience of either PLC or Radio with which to compare the likely benefits and short-comings, including the potential costs, of a possible 'dedicated network' approach to meter communications. Any dedicated network will :

- Entail investment in a fixed infrastructure and will incur ongoing operational and maintenance costs.
- Could be PLC or radio – or in combination.
- Include an arrangement of repeaters, concentrators (collectors), antennae and towers to transmit meter-data to a point where it connects with the Wide Area Network.
- Require some common regulated frameworks and industry-wide governance arrangements (see below).

Both PLC and Radio have supporters and detractors, in particular with regard to :

- **Reliability in data transmission**, and arrangements with respect to network down-time.
- **Costs –** PLC and Radio seem generally assumed to offer comparable costs. However, in practice relatively little cost information is available. The Energy Demand Research Project may be helpful in improving knowledge of costs, as might the earlier 2002 British Gas radio meter pilot. For Radio, other recent RF network roll-outs in the UK may also offer some possible cost comparisons. For PLC, albeit non-UK specific, overseas examples may offer an initial source of cost-data.
- **Cost Comparison of Fixed Network against Mobile Communications** - PLC and Radio are generally believed to offer a lower operational cost than mobile communications[10]. However, any cost-comparison needs to take full account of both the initial capital and development cost as well as the ongoing operational cost of running and maintaining a fixed network. The costs of fixed networks for meter communications need much better understanding and could perhaps be higher than anticipated. By contrast, and over time, the costs of mobile communications, and in particular the cost of a modem, look set to decline against those of fixed networks (see below).

[10] See Paper 3 - 'Costs of Smart Meters'

Mobile Communications – Wider Issues

- **Modem Costs –** Capital cost of a modem is presently around £20-30, but there is some anticipation that costs could reduce in a few years hence – around £10 is cited, but this may prove optimistic. There are requirements on technical standards in adopting low-cost communications micro-chips – which necessitate both international and UK approvals. These could be time-consuming and expensive to secure, although it may be possible for meter manufacturers to make joint-applications.

- **SMS text costs** - At 3-8p per text, the costs of SMS texts were judged potentially expensive against likely network set-up and running costs assumed for PLC and Radio. The per-text charge by mobile operators is volume-related, and part-defrays the modem cost. Communications operators presently appear to show relatively limited interest in mobile communications for meters because in contrast to their usual text traffic volumes, meter-traffic looks extremely low. Apparently, around one billion texts are sent in the UK each day. By contrast, texts from energy meters may number around 25 million per week (ie one text per household per week).

- **SIM cards in meters -** The modem for the meter will have a SIM-card. This is most likely to be in the electricity meter where the electricity meter acts as the communications-hub[11]. In discussion, a number of uncertainties were raised about handling the SIM-card where a customer switches supplier. It seems that arrangements will be needed either to :

    - Leave the SIM in place but ensure re-routing of a customer's meter-data to the new supplier.

    - Or, less likely, change the SIM card in-situ. In practice there are disadvantages to doing this, including :

        - Risk of data-loss or SIM-damage.
        - Potentially breaking the meter-seals. For an electricity meter this may require a qualified electrician. For a gas meter, a CORGI-qualified operative.

- A number of possible ways were mooted about how to address SIM-card issues, including :

    - **Leave the SIM in place but make arrangements for electronic re-routing of a customer's meter data to the new supplier** – Securely embedding the modem and SIM-card within the main meter casing when it is manufactured, with an expectation that the modem and SIM will last the full meter-life, say, fifteen years. This will necessitate some kind of administrative process to manage re-routing of the SIM card information. One approach might be

[11] An independent, non-linked, gas smart meter would require its own modem and SIM.

meter-data agents managing the electronic transfer of customer-data – including possible payment of network access charges to the new supplier (or their agent). This may resemble present arrangements for the Pre-Payment Meter Information Provider, which enables pre-payment customers to switch supplier while allowing the pre-payment meter to stay on the wall. This potential agency role for smart-meter data-transfer is becoming termed a Smart Meter Information Provider (SMIP).

  - **Adapt the meter to permit straight-forward SIM-change** - Identifying cost-effective and practical ways to manufacture a meter to securely house the modem and SIM-card outside the main meter casing. The aim would be to enable the SIM to be readily exchanged without entailing a specialised home-visit, while nevertheless protecting the modem and SIM from potential damage, loss or theft. Without this, a specialised home visit to change a SIM-card would become an added cost for each customer switch.

Communications – Industry-Wide Frameworks and Governance Arrangements.

In today's non-smart meter world, existing industry-wide agreements and governance arrangements determine the handling of meter-data flows when a domestic customer switches supplier [12].

These agreements took many years to develop, and whatever communications technologies are employed for smart meters in the future, when a customer switches supplier it will be important to adapt and build on existing meter-related governance frameworks to ensure interoperability at least cost. Opting to build on present agreements, and to continue to communicate via the present arrangements for existing data-flows, could obviate the need for early or expensive replacement of existing billing systems.

Some additional communications-related governance considerations are as follows :

- **For 'dedicated-networks' - PLC or Radio** - interoperability will entail some basic requirements, including agreements which ensure :

  - Transparent, non-discriminatory network access for all suppliers. This will be important where existing dual-fuel customers switch only one fuel (see below).
  - The basis for network charging (access and use-of-network)
  - Clarity on liabilities in the event of data-loss, or network down-time.
  - Governance arrangements in respect of access to customer data.

[12] Meter Registration Agreement (electricity) and Supply Point Administration Agreement (gas).

- **For Power Line Carrier via DNO Networks** – additional considerations would include :

    - Full and transparent business separation between DNO activity and all meter-communications related activity.
    - Meter-communications (incl any infrastructure) to be charged on a fully cost-reflective basis – ie no hidden subsidies.
    - Transparent and non-discriminatory terms and responsibilities to ensure confidence among competing suppliers that a DNO does not favour its own supplier.
    - DNO licence change may be needed to ***require*** DNOs to make available their networks for meter communications (some DNOs may otherwise be reluctant to offer this).
    - Scope for third-parties to develop and maintain communications infrastructure on a DNO network.

- **For Cellular Mobile Communications in Respect of SIM-Cards –** If meters which contain a modem are to be interoperable where a customer switches supplier, a cross-industry agreement would be needed for treatment of SIM-cards (see above).

- If SIM-cards remain in situ, then industry-wide administrative arrangements will need to provide electronic re-routing of the meter-data to the new supplier, building on existing MRA (electricity) and SPAA (gas) meter-data flow arrangements. There would also need to be governance arrangements regarding third-party access to customer data. The Netherlands are understood to be considering appointing a universal 'middle-ware' data-agent[13].

Electricity and Gas Meters – Communications Considerations

- Communications choices for gas and electricity meters can be wholly independent of each other – or in combination.

- **Electricity -** Meter-communications beyond the home will most-likely be driven from the electricity meter (or, perhaps from a smart-box). This makes it likely that smarting of the electricity meter will either precede - or at least be in tandem with - smarting the gas meter – rather than vice-verse.

- **Electricity Meters –** could be linked to either a fixed-network (PLC or Radio) or to mobile communications. Short-range radio-connection to an in-home smart-box or

[13] Nuon slides. Metering Europe. Copenhagen. October 2006.

perhaps eventually to home-internet would also be possible. Any communications arrangement from the electricity meter can be mains-connected.

- **Gas -** The single biggest communications-constraint for gas is that for safety reasons all initial communication from the meter must be wireless and therefore battery-powered. In practice, this could be either low-power radio short-hop within the home, or, a GPRS/GSM modem. Either way, the requirement for wireless communication from the gas meter does not constrain wider communications choices beyond the home.

- Elsewhere, we have indicated that for gas meters, battery-life and battery-cost need not determine communications choice. Current battery technology will equally well support for at least 10-years the necessary volume of GPRS / GSM and SMS data transmissions, or pulse transmissions by short-range low-power radio.

- **Stand-alone Gas Meters** – To some extent the communications choice for gas will be driven by whether the gas smart-meter is treated wholly independently of the electricity meter. If yes, communications will be by GPRS / GSM and SMS.

- **In-Home Radio Link of Gas and Electricity Meters** – The gas meter can be linked wirelessly by short-range radio to the electricity meter - or other in-home smart-box. A gas meter is not likely to play the role of in-home hub, given that it is not mains-connected.

- Gas meters are often located out-of-doors, which compared with the location of many electricity meters may be a less conducive physical environment for comparatively sensitive and expensive electronic equipment. However, external location of gas meters lends itself well to basic walk-by or drive-by meter-reads.

Dual Fuel

- In practice, electricity meters will probably be smarted independently of gas meters – but it seems probable, initially at least, that many gas meters will be smarted at the same time as electricity meters as part of a dual-fuel package.

- In high density flats both gas and electricity meters may be grouped together in basements – and dedicated network solutions may prove particularly suitable.

Customer-Switching, Communications and Governance

- Existing MRA or SPAA arrangements are likely to continue to apply for meter data flows.

- In communications terms, if an existing dual-fuel customer switches supplier, then electricity and gas meters which are wholly independent of each other for their communications, may offer most flexibility.

- Where a gas-meter is linked in communications terms to the electricity meter, and the customer switches a single fuel, then governance arrangements would be needed to allow for the gas meter-data to continue to be routed via the electricity meter and out to the Wide Area Network.

Geographic and Locational Characteristics – Communications Considerations

Regional / local considerations – Regional or local approaches to communications might prove best able to accommodate different geographies (remote, suburban, urban) and diversity of housing mix and existing meter location (old / new ; high/low density; different tenure ; prevailing mix of indoor / outdoor meters). Unlike in Italy, in Scandinavia, Netherlands and Ontario, energy utilities are opting for local (ie not universal) approaches to communications – ie installing a mix of low-power radio, power-line carrier and mobile communications, dependent upon local considerations.

Possible regional / local partners - There may be existing regional / local partners with whom likely metering communications could be linked. For example in the UK, some local authorities are contemplating installing WiMax, to offer alternative 'last-mile' broadband access[14]. Other potential local partners might include water companies for example who are set to roll-out water meters by geographic area (albeit not necessarily 'smart' initially) ; the government is promoting development of sustainable communities and contemplating new Eco-towns. It will be helpful to consider how communications for utility metering might link to separate geographic initiatives of this kind.

Incremental Approach – Meter communications could be least-regrets and incremental. Potentially, communications could be very local by simply starting with pedestrian reads – by post-men, refuse-collectors or others - through possible partnerships with Royal Mail, local authorities or TV detector vans. It would be possible to install concentrators incrementally, eventually building to Wide Area Network coverage over time, allowing a capability to feed back to customer in a variety of ways – especially via the internet[15]. An incremental communications model would probably entail some form of coordination via a meter-data agent to enable some limited two-way communication from the supplier to the customer.

[14] Examples of WiMax / local authority trials – Pipex in Milton Keynes ; Pipex and Intel for Warwick District Council.
[15] For example, Edelia – EdF metering subsidiary

Overall Conclusion on Meter Communications

Cost Comparisons – Far better understanding and more detailed cost-comparisons are needed for the UK context of the likely full life-time costs of the main communications options : Power Line Carrier, Radio and cellular mobile.

Retention of Future Flexibility and Adaptability in Meter Communications – It seems unlikely that one single meter communications choice will prevail for all of the UK – either initially or for the future.

Evolving options in communications - and the complexity of how these options might link together in different 'architectures' - mean that lock-in to a single uniform approach to meter-communications for all of the UK could prove inappropriate. Future flexibility and adaptability remain important principles in an environment which is extremely dynamic in both technical and cost terms.