

**Smart meters in Great Britain :
the next steps ?**

**Paper 4 : Smart meter contribution to UK goals for
energy saving and carbon reduction**

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Smart Meter Contribution to UK Goals for Energy Saving and Carbon Reduction

Introduction

Our Sustainability First report in March 2006 sought to provide an initial assessment of the likely contribution to energy- and carbon saving in the UK from improved feedback that domestic smart-meters might provide to consumers. Given that a supplier commercial-led case on its own remains unlikely to trigger widescale domestic smart-meter investment in the UK, the scope for energy-demand reduction and carbon-saving remains central to any public-policy case for smart meters.

On the basis of published studies, our considered estimate was that scope for sustained energy-saving from domestic smart-meters for the UK might lie in a relatively conservative range of 1-3%. In terms of carbon saving, a 1 % reduction in energy-use (gas and electricity) has been used as an illustrative assumption of around 8% of the UK's 4.8 MtC domestic carbon goal for 2010¹. With homes accounting for around one-quarter of the UK's total carbon emissions, even at an energy demand reduction of 1%, there could therefore potentially be a material carbon-saving from smart meters.

This section therefore develops our initial assessment of likely domestic energy-saving from smart meters. In particular it seeks to better understand the potential contribution to domestic energy demand-reduction from the introduction of time-related and / or volume-related or seasonal-tariffs. In effect, domestic smart meters could unlock a price-responsive domestic demand-side for both gas and electricity, although, (with possible exception of very recent retail-tariff rises), domestic consumers in general have not proved to be highly sensitive to energy prices.

This exercise does not seek to second-guess the Energy Demand Research Project which will for the first time offer a GB evidence-base about consumer behaviour and energy-use in response to a range of improved feedback and information. Rather, this section explores in a largely qualitative way where the main scope may lie for domestic demand-response, given likely discretionary-load and patterns of appliance- and energy-use in the home. This has not led us to change our initial view of 1-3% for potential energy savings.

¹ Ofgem. Domestic Metering Innovation. February 2006. p.18. Updated household 4.8MtC target from Climate Change Programme. March 2006. See footnote 4 overleaf about need for cautious interpretation of any direct read-across from estimates of end-use energy saving to carbon saving.

Broad Context – UK Carbon Reduction Goals for Billing and Metering

The UK domestic target for CO₂ is to reduce emissions by 20% against a 1990 baseline by 2010².

Within this national goal, the government seeks to reduce household carbon emissions by 4.8MtC pa by 2010³. Of this, the Climate Change Programme Review (March 2006) attributes potential carbon savings of 0.2MtC pa by 2010 to metering and billing. The Energy Review (July 2006) revised this contribution to 0.3MtC by 2010 - rising to 0.4MtC by 2020.

A 1% reduction in energy use was used by Ofgem as an illustrative assumption to represent a 0.36MtC pa saving⁴. In very general terms therefore, a 1% reduction in energy demand from domestic metering and billing could potentially deliver around 8% of the 4.8MtC 2010 annual domestic carbon goal. An average 1% reduction in energy demand achieved by metering and billing (domestic sector only and both fuels) would in principle be able to deliver the July 06 Energy Review carbon-reduction goals of 0.3MtC pa (2010) and 0.4MtC pa (2020).

The Energy White Paper⁵ estimates that proposals for household billing and real-time displays will deliver annual savings of up to 0.4MtC by 2010, in line with the Government's commitment under the Climate Change Programme; and up to 5MtC pa by 2020.

However, it is not evident that the Energy White Paper estimate of delivering a reduction of 0.4 MtC pa by 2010 through metering and billing can be readily achieved.

Proposals in the Energy White Paper to install in-home visual electricity displays⁶ may help to deliver some domestic electricity savings through increased price-awareness, (albeit

² When the draft Climate Change Bill becomes law in 2008, the UK will become subject to legally-binding five-year rolling carbon-reduction targets, within a new carbon budget framework extending fifteen years out, seeking to reduce CO₂ emissions on 1990 levels 60% by 2050. The target trajectory will achieve 'real progress' by 2020 –equating to a CO₂ reduction against a 1990-baseline of 26-32% by 2020. Draft Climate Change Bill. Consultation Document. March 2007

³UK Climate Change Programme. Cmnd 6764. 4.8MtC by 2010. March 06. DTI Energy Review – The Energy Challenge, July 2006.

⁴ Ofgem. Domestic Metering Innovation. February 2006. p.18. para 4.14 ; DTI Energy Review – The Energy Challenge, July 2006 page 47, para 2.42 ; DTI Metering & Billing Consultation. November 2006. RIA p.38, para 5.

These estimates must be taken as broad approximations. Carbon emissions from domestic energy saving will vary, inter alia, with fuel-type (ie electricity or gas) and respective carbon-intensity. Not least, for electricity end-use, carbon intensity will be dependent upon the generation mix. See Market Transformation Programme Briefing Note BNXS01 'Carbon Emission Factors for UK Energy Use' and House of Lords Science and Technology Committee 2nd Report (session 2005-06) and Government Reply for discussion on complexity of calculating the effect of energy end-use on carbon emissions.

⁵ Meeting the Energy Challenge. A White Paper on Energy. Cmnd. 7124. May 2007. para 2.73. p.65

⁶ For all new and replacement electricity meters from May 2008 (say, 2.5 million meters) and until March 2010 to any household that requests them (say, 5 million meters if 20% of customers)

not for gas). In addition, new measures for improved historical feedback in energy bills may make an additional contribution.

The White Paper estimates that these 'short-term' measures (displays and bills) may reduce emissions by 0.5MtC pa by 2020 : Displays - 0.3 MtC pa by 2020 ; Bills – 0.2 MtC pa by 2020. This may well be feasible.

However, as noted above, a sustained across-the-board 1% pa reduction in domestic energy demand by 2010 (ie both electricity and gas equivalent to around 0.3MtC pa), from these two measures does not seem likely. Not least, displays linked to non-smart meters will be largely electricity only, and also unable to offer variable time-of-use price-information. Moreover, timescales for any smart-meter investment are such that by 2010 smart meters could offer no material contribution to the assumed 2010 level of energy demand or carbon reduction from billing and metering. Counter to the EWP proposal, a view is fairly universally held that in-home visual displays should form an integral part of a smart-meter package. Linked to smart-meters, displays could provide both gas and electricity feedback, and, for electricity, provide variable time-of-use price-information, thereby being more likely to prompt an active consumer response.

Notably, the Energy White Paper makes no specific allowance for a contribution to carbon reduction from domestic smart meter investment. This is despite the EWP expectation that within the next ten years all domestic energy customers will have smart meters with visual displays of real-time information that allows communication between the meter, the energy supplier and the customer. Future government estimates for carbon savings from billing and metering will need to factor in a contribution from smart meters. We would expect the hoped-for Energy White Paper contribution from metering and billing of 0.5 MtC by 2020 to be readily achievable by 2020 on the basis of the relatively modest energy saving of 1-3% from smart meters assumed in our earlier report ⁷.

EU Goals

A number of parallel EU-measures are being introduced. First, in March 2007 at the Spring European Council, EU heads of state agreed a binding target to reduce Europe's greenhouse gas emissions against 1990 levels by at least 20% by 2020, and, subject to wider international agreement, to possibly increase this commitment to 30%. Second, a number of other measures were agreed, including to promote energy efficiency by reducing overall EU-growth in energy consumption by 20% by 2020⁸.

⁷ Ofgem – Domestic Metering Innovation. February 2006 – 1%. Sustainability First. March 2006 – 1-3%

⁸ Presidency Conclusions. Brussels European Council. 8-9 March 2007. 7224/1/07rev1 – 2 May 2007. Commission Action Plan for Energy Efficiency. 2006.

The ESCO Directive⁹ agreed in late-2005 with an implementation-date of May 2008 will be one of the delivery mechanisms, and includes a non-binding provision for member states to achieve a 1% pa energy saving from 2008, with an expectation of a 9% energy saving by 2017. Within the Directive no assumption is attributed to the likely contribution from Article 13 on metering^{10 11}.

The UK Government anticipates that some of their EWP metering and billing proposals will be taken forward in the context of implementing the ESCO Directive. It is however not clear whether the government expects to implement the Directive with respect to domestic customers by its initial EWP proposal for non-smart in-home displays, or, through additional measures to realise the expectation for domestic customers to have smart electricity and gas meters within 10 years. A full evaluation of the costs and benefits of both measures (including the expected carbon savings) will be important, to show that the requirement to offer non-smart in-home displays in the period 2008 to 2010, is compatible with the Government EWP expectation for domestic smart meters in every home within the next 10 years.

Domestic Gas Demand Reduction – What Contribution Might Smart Meters Make?

In 2005, over one-third of primary UK energy consumption was gas. Of total UK gas demand in 2005 - 35% was domestic ; 31% was used in power generation ; 15% was industrial use ; 10 % was commercial use ; and the energy industries ‘own-use’ was 9%.

Natural gas provides 70 % of household energy and represents around 55% of household carbon emissions. Four times more gas than electricity is used in the home (KWh equivalent). Domestic gas-use is extremely seasonal with a winter summer ratio of around 5:1. Domestic gas-use is also highly temperature-dependant.

⁹ Energy End-Use Efficiency and Energy Services Directive. Dir 2006/32/EC. April 2006.

¹⁰ Meetings w European Commission. February 2006.

¹¹ The ESCO Directive neither defines the term meter, nor expands on the phrase ‘individual meters that accurately reflect the final customer’s actual energy consumption and that provide information on actual time of use’.

Article 13 of the Directive says that member states “shall ensure that, in so far as it is technically possible, financially reasonable and proportionate in relation to the potential energy savings, final customers for electricity, natural gas,.....are provided with competitively priced individual meters that accurately reflect the final customer’s actual energy consumption and that provide information on actual time of use. When an existing meter is replaced, such competitively priced individual meters shall always be provided, unless this is technically impossible or not cost-effective in relation to the estimated potential savings in the long term. When a new connection is made in a new building or a building undergoes major renovations as set out in Directive 2002/91/EC, such competitively priced individual meters shall always be provided” – Article 13.1 and that “billing is based on actual energy consumption, and is presented in clear and understandable terms....Billing on the basis of actual consumption shall be performed frequently enough to enable customers to regulate their own energy consumption” – Article 13.2. There are also additional billing-related requirements concerning tariff information and comparative historic consumption data in graphic format.

Domestic heating and hot water (both gas and electricity) by far outweighs other home energy-use. In 2004, space-heating accounted for 61% of domestic end-use (gas and electricity), water-heating accounted for 23 %, and only c.3% was used in cooking and 13% in lighting and appliances. Space and water heating therefore account for 84% of domestic delivered energy, 68% of carbon emissions and 50% of the energy costs of domestic energy use. The national total for domestic heating and hot water was 450TWh of delivered energy and 29 MtC emissions. Over 80% of this energy was consumed by conventional ‘wet’ heating systems, of which the overwhelming majority was gas (367 TWh). 20 million homes have gas-fired heating systems (c. 90 % of domestic heating systems - less in Scotland)¹².

Working on the earlier estimate that a sustained 1% reduction in energy demand can deliver 8% of the domestic carbon goal to 2010, achieving a 1% reduction in domestic gas demand from improved consumer feedback, be-it by smart meters or other means, would therefore offer a material carbon benefit.

Domestic Gas Demand – Customer Price Response

Since 1990, domestic gas-demand grew on average by between 1-2% pa. Importantly, in each of 2005 and 2006, there was for the first time an observed price-response for domestic gas, where (weather corrected) demand reduced in both years by around 2% on the previous year¹³. This is widely believed to be due to a combination of higher price, anticipation of further price rises, and, significantly, considerable media coverage – both about price and about gas security of supply. Notably, it was not in direct response to higher fuel-bills for winter 2006/07 – which consumers had not yet received¹⁴.

A key question therefore is how to deliver a sustained price-response of the kind noted in 2005 and 2006 for domestic gas-use, and, critically, how to avoid increased gas-use as gas prices start to fall

Unlike for electricity, most price-related response in *domestic* gas will result in an overall reduction in gas demand, rather than simple load-shifting. This is because most domestic gas-use is mainly space-heating, hot-water and some limited cooking, and any price-responsive demand reduction will by its nature not transfer to a different time of day. (Some exceptions eg summer hot-water heating, gas tumble-driers). In contrast, for I&C

¹² Energy Consumption in the UK, 2004. DTI Energy Statistics. MTP Sustainable Products 2006 – Policy Analysis and Projections

¹³ National Grid. Winter 2006/07 Consultation Update. July 2006

¹⁴ We learned of similar observations for electricity in Norway and in the US. In the UK, domestic gas prices rose 45 % real in the period 2004 to 2006. Energy White Paper. P.77 para 2.1.6. 71 % average domestic gas retail price increase (real) from 2003 to end-2006. Ofgem Corporate Strategy and Plan. 2007-2012. 60/07. March 2007. p 3.

gas process-use, consumption may move to a lower-cost time-of-day, and I&C price-responsive peak-shifting will not necessarily result in lower gas-demand overall.

If a price-response for domestic gas-use could be assured going forwards there may be the following benefits : to consumers in lower-bills ; for public policy, in terms of reduced carbon emissions (2% pa for gas could perhaps deliver half the hoped-for 0.5MtC pa from metering and billing by 2020) ; to shippers and suppliers in terms of reduced risk in gas procurement ; to the NTS in more predictability in system-balancing, and possibly, over the very long-term, lower rates than otherwise for investment in gas transmission, distribution pipeline capacity or storage (including LNG).

Potential Benefits to the Gas-Market from a Domestic-Demand Side

There are significant short- and long-run costs to the gas market associated with meeting both daily and seasonal gas peaks - for I&C and domestic demand alike. The potentially high costs to shippers, suppliers and the NTS of meeting daily gas peaks – especially in a prolonged cold snap - and the high costs associated with the significant seasonality of domestic gas-use, is a major incentive to manage peak gas demand.

In theory, gas-industry cost-savings from improved peak-management could relate both to short-term operational and commodity-related costs, as well as longer-term infrastructure investment¹⁵. However, as for electricity, the largely disaggregated GB gas-industry structure produces fragmented incentives for market participants to capture some or all of the potential demand-side benefit.

I&C Gas Sector – Scope for Increased Price-Response

Daily peak-demand management is extremely important in the I&C sector because many shippers, suppliers and large gas-users are directly exposed to short-term gas-prices, including on-the-day commodity prices. Many high-end gas users already have access to interruptible contracts if they choose¹⁶. However, there is likely to be additional untapped demand-side response elsewhere in the I&C gas sector, and which more sophisticated tariffs via advanced and smart metering services could start to unlock. In this context, the Energy White Paper proposal to extend advanced and smart meter services to Non-Daily Metered I&C gas customers within the next five years is very welcome¹⁷.

¹⁵ The scope for improving accuracy through smart-meters in demand estimation in short-term forecasting was raised a number of times. Initial exploration however, did not suggest an immediate benefit. See Annex II to this section.

¹⁶ Ofgem indicate real wholesale gas prices rose 109% from 2003 to end-2006. 'Role of Demand-Side Response in Balancing the Gas Market'. 05/06. Global Insight. 2005. Report for DTI. Suggests that possible winter peak-day demand response from very high-users may offer an additional 6-9% of winter peak-day demand-response.

¹⁷ Energy White Paper. P55. para 2.33. See also 'Advanced Meters for SMEs. Carbon and Cost-Savings'. The Carbon Trust. May 2007, which found demand reduction benefits from smart-meters coupled with advice for the larger SME sector, including for gas.

Domestic Gas Sector - Commercial Incentives for Variable Tariffs

Commercial Incentives to Offer Domestic Customers Time-of-Use Tariffs –

By contrast however, there appears little equivalent push among gas-market actors to capture the potential commercial benefits of peak-demand reduction in respect of the domestic gas sector - either daily or seasonal. One element of this may be that much gas procurement by shippers and suppliers for domestic customers ties into long-term contracts. Another key element is that commercial arrangements and pricing for gas-market balancing are daily, rather than within-day half-hourly pricing as for electricity. This reflects the comparative flexibility of gas as a fuel in terms of the availability of short-term storage (eg line-pack, gas-monitors), in contrast to electricity which cannot be stored. For gas, without a marginal *within-day* pricing system reflecting the real-time commercial costs of balancing gas-demand, there is no obvious commercial driver for suppliers to offer domestic gas customers *within-day time-of-use* tariffs to deliver greater efficiency in peak-demand management.

Commercial Incentives to offer Domestic Customers Other Variable Tariffs

However, other variable retail-tariffs may be more relevant to assist suppliers in achieving improved peak-demand management for the domestic gas-sector.

- **Block or Volume Gas Tariffs** - could offer a strong demand-reduction incentive for the domestic sector by charging more for higher-usage. Not least, average gas-demand is around one-third less than peak-demand, and so block tariffs could prove very effective in a cold snap when the system was under pressure. Equally however, could prove controversial, especially in winter.
- **Seasonal Gas Tariffs** - could influence domestic gas-usage. However, retail tariffs would need to be extremely high in winter to influence customer behaviour, and again this could prove controversial. Moreover, introduction of lower summer tariffs risk a perverse effect, potentially encouraging higher summer gas-use. This in turn implies that the summer-part of a seasonal tariff should remain at least at current levels. Seasonal gas tariffs could in practice produce a beneficial effect for shippers and suppliers in the spring and autumn periods, when gas demand is at its most unpredictable due to temperature variation.
- **Smart Meters and Variable Tariffs** - Gas smart-meters would be needed to offer time-of-use tariffs (but as we have seen, not likely for gas) or, more likely, for seasonal tariffs. Gas smart-meters are not a pre-requisite for block or volume tariffs. However, it seems very likely if there was large-scale adoption of either seasonal or block tariffs for gas, especially for domestic customers, that considerations about transparency and accuracy would work in support of installation of gas smart-meters.

- **Time-of-Use Tariffs for Domestic Electricity** - A significant proportion of industrial gas demand – and almost one-third of total gas demand - is used in power generation. This suggests that time-of-use tariffs *for domestic electricity consumers*, where gas-fired power generation is the marginal generating plant, could be an effective means of delivering some gas peak-demand reduction, especially at winter-peak.

Other Non-Tariff Related Measures Which May Also Help to Achieve a Sustained Reduction in Domestic Gas Demand

Domestic Gas Boilers – Scope for Reducing Gas Demand – In most homes, the main point of gas-use is the domestic boiler. New boilers are increasingly efficient, and also increasingly, many room-radiators have individual thermostats. Hot-water tanks for non-combi-boilers are generally better-insulated. Nevertheless, the Market Transformation Programme stress the continued importance of persuading households to use controls properly. MTP estimates at 14TWh pa the energy savings ‘foregone’ as a result of ignoring or abusing existing heating controls. Moreover, a one-degree centigrade thermostat turn-down is believed to reduce domestic gas-use by potentially as much as 10%¹⁸. Around 1.4m domestic boilers are replaced each year, and of these, half also involve heating-control upgrade. If a main public policy goal is domestic gas demand-reduction, energy management measures directed at boiler-controls may prove effective. Some examples we came across were :

- **Third-party remote / smart switching of gas-boiler or hot-water thermostats** - In particular, could be effective for gas-industry ‘peak-day’ management. However, we learned of experience to suggest that some customers may be reluctant to lose direct control of the boiler thermostat. Accordingly remote-switching - or other forms of smart-control - may need to overcome a degree of customer-resistance to become an effective tool for reducing overall gas-demand in a sustained way.
- **Customer remote control of gas-boiler or hot-water thermostats** – Customer-initiated GSM text messaging to ‘smart’ boiler thermostat enables customer remote control of home-heating and thermostat when away from home.
- **Prominent, user-friendly display-panels for gas-boiler controls** - Comparatively modest changes to boiler-control displays could make a material difference in reducing domestic gas-use by encouraging a thermostat down-turn, without other major intervention. Not least, improvements to display-panels for boiler-controls could be relatively low-cost and simple to achieve. One example might be clear external and internal temperature sensors, coupled with warning-lights aimed at encouraging manual turn-down of the boiler thermostat¹⁹. Other user-friendly adaptations would be to make it easier to adjust the boiler time-switch : many households leave boilers on

¹⁸ Market Transformation Programme. Sustainable Products 2006 : Policy Analysis and Projections. P54. Also, Energy Saving Trust. Website.

¹⁹ Energy demand for space-heating is very sensitive to the difference between indoor and outdoor temperatures, and a 1 degree celsius increase may lead to a 13% increase in consumption. ‘Improving Domestic Energy Efficiency – A Technical Overview. IDG/EES/WP13. Defra. 2003.

all-day even when they are not at home ; and many do not adjust the boiler on-off hours as the seasons change. Importantly, in-home displays which link to a non-smart mechanical gas-meter are not presently feasible. However, improved display-panels for boiler controls, even translating into very general cash-terms the amount of gas being used by the boiler, could perhaps serve as a very rough proxy for the gas-meter in terms of improving customer feedback.

Sustained Feedback - The main determinant of household-spend on energy consumption is real disposable income spent on fuel – with a range of 2% to 6% of disposable income from the most- to least-wealthy. 50 % of gas customers presently pay their bills by monthly direct-debit. By contrast, pre-payment customers demonstrate a very sophisticated awareness of their day-to-day gas-use, anticipating when a pre-pay meter needs a cash top-up. Improved data-accuracy and feedback to other gas-customers brought about through smart meters - which would enable accurate bills and variable direct debit arrangements – together with possible block or seasonal tariffs - could improve awareness of household gas usage.

The Potential for Gas-Smart Meters in Reducing Domestic Gas-Demand – Conclusion

As outlined above, media-coverage *together with* anticipation of higher fuel-prices, may have prompted recent GB domestic gas-demand reductions, but these are unlikely to be sustained. A combination of measures will be needed to achieve sufficient consumer engagement to bring about a sustained reduction in gas demand. These are likely to include gas-smart meters, possibly offering block or seasonal tariffs and visual feedback via displays or other means, smarter display panels for gas-boiler controls, advice, media-support and other feedback.

Potential Price-Responsiveness of Domestic Electricity-Load

Introduction

Both Ofgem and our earlier report²⁰ touched briefly upon the potential benefit from electricity smart meters to enable a genuinely inter-active demand-side in the GB electricity market, able to respond to the marginal price of balancing the electricity system in real-time.

Widespread electricity demand-reduction at peak could in principle offer : short-run benefits in terms of improving flexibility in system security and system operation - with attendant cost-savings and potential price-benefits ; and, possibly, long-run benefits in terms of a lower-rate of capacity investment (potentially both generation and transmission).

Prospectively, for a variety of reasons in the GB context, these benefits appear relatively modest and difficult to capture. As noted above for gas, the largely non-vertically integrated nature of the GB electricity market produces fragmented incentives for market participants in respect of the potential demand-side benefits. Not least, GB transmission and distribution networks are already well-incentivised through existing regulatory arrangements with respect to some of the benefits claimed elsewhere for smart meter investment - such as improved loss-management, network diagnostics and response-times for lost-supplies at remote locations.

I&C Sector - Scope for Price-Responsiveness

65% of total electricity consumption is in the I&C sector. The I&C sector may well therefore offer greater potential than the domestic sector for demand-response via time-of-use-tariffs. The Energy White Paper proposal that suppliers should extend advanced and smart metering services in this sector to firms with electricity meter profile-classes 5 to 8 is therefore welcome (ie below the present 100kW half-hourly meter threshold). This new measure, in tandem with the proposed Carbon Reduction Commitment and the new requirement to display Energy Performance Certificates in larger public buildings should ensure widespread advanced and smart-meter services penetration into the I&C sector over the next five years, providing scope for these customers to be offered time-of-use or variable tariffs²¹.

²⁰ Ofgem. Domestic Metering Innovation. February 2006; Sustainability First – Smart Meters : Commercial, Policy and Regulatory Drivers. March 2006.

²¹ Ofgem – from 2003 to end-2006, 93% wholesale electricity price increase (real).

Domestic Sector – Scope for Price-Responsiveness

In 2005–06, GB domestic electricity demand fell by 0.2%²² while domestic electricity retail prices rose 29% real in the period 2004 to 2006²³. Given that domestic electricity demand continued to grow at over 1% pa during this period, this suggests a domestic electricity price response, albeit apparently modest. The Energy Demand Research Project will of course help to develop a GB evidence-base for demand-reduction behaviour in response to more variable tariffs. In the meantime, this section seeks to explore in a qualitative way what impact, if any, the introduction of domestic time-of-use tariffs could potentially bring to the demand-side.

Time of Use Domestic Electricity Tariffs (ToU)

The term Time-of-Use (ToU) tariff is used in this section in the sense of a tariff for different banded times-of-use. In the UK, the term time-of-use is seemingly used somewhat interchangeably with time-of-day, but the preferred term in this report is Time-of-Use. A major report prepared for the US Environmental Protection Agency offers three helpful definitions of time-varying tariffs²⁴ :

- **Time-of-Use (ToU) tariffs - have different per-unit prices for usage during different blocks of time.** Definition of ToU periods will differ dependent upon on the timing of peak system demands over the day, week or year and may be year-round, or seasonal. For the future, banded ToU tariffs are the time-varying tariff most likely to be offered to domestic customers in the UK.
- **Critical Peak Pricing** tariffs - have high per-unit rates for usage during periods designated ‘critical peak periods’ by the utility, Unlike ToU blocks, the days in which critical peaks occur are not designated in the tariff, but notified, sometimes at short notice, perhaps for a limited number of days in the year.
- **Real-Time Pricing** tariffs – reflect the wholesale price of electricity and therefore not a fixed-tariff (as per ToU tariffs) but vary continuously over time. For the UK, the nearest approximation is the half-hourly system balancing price for electricity.

²² National Grid

²³ Energy White Paper. P.77, para 2.1.6. Ofgem – from 2003 to end-2006 45 % retail electricity price increase (real).

²⁴ A Survey of Time-of-Use (ToU) Pricing and Demand Response (DR) Programs. Report prepared for US Environmental Protection Agency by Energy and Environmental Economics, Inc. CA. July 2006. pp 13-14.

Domestic Electricity Load-Shifting

- **Domestic Electricity Load Shifting – Carbon Benefit** - The NIE Keypad ‘Powershift’ Time-of-Use trial suggests that wider adoption in GB of ToU tariffs could achieve some load-shifting, but not necessarily significant overall electricity demand reduction²⁵. Electricity load-shifting may offer some carbon benefit, subject to the marginal generating plant, but, possibly, relatively little impact by way of reduced electricity demand overall. This is in contrast to gas, where (if it can be appropriately incentivised) domestic gas-peak shifting could potentially reduce overall gas demand, with an associated carbon benefit.
- **Domestic Electricity Load-Shifting – Customer Benefit** – The Keypad ToU tariff experience indicates that electricity ToU tariffs could offer some worthwhile customer price-benefit. In practice, households spend proportionately more on electricity than gas because unit-for-unit electricity is a more expensive fuel, (albeit gas-usage is four-times higher than electricity usage (in KWh equivalent)). In round terms, electricity represents c. 45% of household fuel-spend and gas c.55%. Electricity time-of-use tariffs may therefore offer a consumer cash-saving, provided there are sufficient high-use appliances in the home which offer the potential for ‘discretionary load’. We consider this below.

Domestic Appliances - Discretionary and Non-Discretionary Loads²⁶.

UK domestic electricity consumption represents around one-third of total UK electricity end-use (c. 116 TWh in 2005). Domestic electricity demand continues to grow at around 1.5 % pa. Of UK domestic electricity consumption, of the order of 70 %²⁷ is consumed by domestic electrical appliances including lighting, and c.30 % consumed by electric space-heating and cooking. Together, lights and appliances comprise over 20% of household carbon emissions.

Electricity has a higher emission factor than gas (ie a higher carbon-intensity). Unlike gas, electricity demand reduction and carbon reduction depend upon the carbon intensity of the electricity generated. It is therefore difficult to attribute a given-level of carbon-saving to a particular level of electricity-saving.

²⁵ Small NIE ToU trial in 2004 of 200 Keypad customers - of whom half on a 4-band 3-rate ToU (Powershift) tariff. Evidence of 10 % reduction at evening peak when a significant price-signal applied (60% above standard Keypad tariff). Findings inconclusive on whether an active or passive price-response, because Keypad ‘control’ group also used less electricity at evening peak. Average annual cash-saving of 1.5% due to demand shift. (Annual consumption 3.5% below average domestic credit customer (possibly a general pre-pay effect)). Of note, trial also found that on average Powershift customers had reduced peak-demand usage and lower electricity bills, but that their average total electricity-use may have slightly increased. In effect, Powershift consumers saved money but not energy. Since 2005, Powershift generally offered by NIE, though take-up modest. See Appendix on Smart Meter Case Studies.

²⁶ Main source for domestic electrical load information in this section is Market Transformation Programme - Sustainable Products 2006 : Policy Analysis and Information. However, material in this section draws from other sources, some of which are not necessarily directly comparable. Numbers in this section should therefore be regarded as broadly illustrative.

²⁷ 80 TWh in 2005

Some appliance-use can be ‘discretionary load’ – ie able to respond to time-of-use tariffs – and some ‘non-discretionary load’ – ie unlikely to respond to time-of-use tariffs. The following section offers some initial thinking on what domestic electrical appliance-use could in practice respond to ToU tariffs offered via smart electricity-meters (see Chart).

- **Electric space and water heating** – Less than 10 % of GB space and water heating appliances are electric²⁸. Of this, virtually all (90%) of GB electric space and water heating is already Economy 7 off-peak – and therefore no additional price-response will be achievable through electricity ToU tariffs. **Electric Showers** – Usage increasing (possibly 4% of domestic electrical appliance end-use) and could be price-responsive. **Air conditioning** - For the future, there may be a growth in mobile domestic air-conditioning – which, as demonstrated elsewhere, could be price responsive.
- **Cooking** – 14.5TWh for both gas and electricity in 2005. **Ovens** – 60 % are electric; 40% are gas. **Hobs** – 46 % are electric ; 54% are gas. Very little price-responsive load for either fuel. **Kettles** – 97% kettle-ownership among UK households. UK unique in its prevalence of 2-3 kW electric kettles. Kettles estimated to use 4.2 TWh pa (5% of annual domestic electrical appliance load). Kettle-use shapes electricity demand (including peaks) on a daily basis by contributing to so-called instant ‘TV pick-ups’. Kettle-use however is not likely to be price-responsive, but new, potentially more energy-efficient, domestic water-boilers are becoming available.
- **Wet Appliances** – represent around 17 % of domestic electrical appliance-use (13.5 TWh pa in 2005). Main source of potential domestic appliance discretionary load – washing machines, dishwashers and tumble-driers.
- **Cold Appliances** - cold-appliances represent around 21 % of domestic electrical appliance-use (16 TWh pa in 2005). Fridges and freezers do not presently offer discretionary-load, but could offer frequency-driven demand-response in the future²⁹.

Generally, both wet and cold appliances have become more efficient via labelling – but some white-goods are increasing in their size and energy-use. Together, wet and cold appliances in 2005 represented around 38% of domestic electrical appliance load and around 16% of domestic carbon-dioxide emissions.

- **Lighting** - represents c 22 % of domestic electric appliance-load – and rising (c 18 TWh pa in 2005). Represents c. 2MtC or 6% of domestic carbon-dioxide emissions. At the margin, some unnecessary lights may be turned-off in response to high ToU tariffs, but far more material is the recent announcement to phase out tungsten-

²⁸ 1.9million homes have electric heating.

²⁹ Dynamic Demand – for the future, fridges and freezers could have new in-built frequency responsive load-control devices – www.RLtec.com and www.dynamicdemand.co.uk.

filament light-bulbs for domestic-use by 2011, and which presently represent 80% of all domestic lights. Interestingly, after 2011, once new energy-efficient CFLs (compact fluorescent lamps) which use only one-fifth of the power of an equivalent old-style bulb become prevalent, impact from ToU tariffs in prompting lights to be turned-off is likely to become increasingly modest.

- **Electronic / Digital and Brown Goods** – represents c.22 % of domestic electrical appliance use in 2005 (c.17.3 TWh pa and 2 MtC). Non-discretionary load. If business-as-usual, Market Transformation Programme estimates brown-goods consumption could double by 2020 to around 37 TWh pa. Energy White Paper indicates active area for more energy efficient product standards. Without further intervention, consumption of digital set-top boxes could triple by 2020. Flat-screens (LCD / Plasma) use 3-4 more times electricity than same-size cathode ray. **Chargers / External Power Supplies** - phones / tools – represented 3.4TWh pa in 2005 (say c.3% of appliance-load) - and rising. May consume 2 or more watts in no-load mode, but with new product standards could reduce to 0.5 watts.
- **Home Computers** – represents c 10 % of domestic electrical appliance load in 2005 (7.9 TWh). Largely non-discretionary load.
- **Miscellaneous** - Ironing, vacuuming, boiler pump. Some discretionary- load.
- **Stand-By** – estimated 6-10 % of annual household electricity demand³⁰. Some discretionary element to stand-by load. However, product standards will begin to address for electronic goods and chargers. By 2010, MTP indicate aim is to achieve 1.7 watt average standby consumption. An IEA 1-watt campaign and EU Code is also in prospect for 2010.

The Potential for Electricity-Smart Meters in Reducing Domestic Electricity-Demand – Conclusion

Smart electricity meters, by enabling improved price-awareness – or by offering Time of Use (ToU) tariffs – could deliver :

- **Load-Shifting / Lower Rate of Peak-Demand Growth** – The variety of appliances with discretionary load is perhaps relatively limited, albeit some of these appliances are high-use. Domestic electricity price-response will be mainly via wet-appliances including tumble-driers, as well as electric showers, battery chargers, a modest amount of lighting (more modest post-2011) and possibly, for the future, domestic air-

³⁰ Eg Combined TV/DVD – one third to one quarter of power used in standby – 12.5 watts in ‘on’ mode; 3.2 watts stand-by. ‘Suspecting Standby ? Domestic levels and the potential for household level reductions in UK’. J Vowles, B Boardman & K Lane. Environmental Change Institute. University of Oxford. 2000. MSc study of electronic appliances in 32 households.

conditioning. Wet appliances, together with these other appliances, may therefore offer a possible discretionary-load of around 20-25 % of all domestic electrical appliance use. This could equate roughly to around 16 TWh pa or potentially some 2 MtC. Of this, it is hard to anticipate how much load would shift in practice. The NIE Timeshift trial suggests a 10 % reduction at evening peak when a significant price-signal was applied ³¹.

Much domestic electricity-use (fridges, freezers, lighting, brown-goods) – perhaps around 70-80% of domestic electric appliance load – however will remain non-discretionary and non-price-responsive. Virtually all electric-space and water heating is already off-peak, and would not offer additional responsive-load.

The extent of carbon-saving from load-shifting will anyway depend upon the marginal generating plant. However, despite possibly modest carbon-benefits from domestic electricity load-shifting, the price benefits to consumers from ToU tariffs could prove well-worthwhile, not least because in comparison with gas, electricity is a high-cost fuel. ToU tariffs could perhaps also lead to a lower-than-otherwise rate of electricity peak-demand growth, possibly with attendant long-run generator and network investment benefits.

- **Demand-Reduction / Lower Rate of Overall Demand Growth** – Electricity ToU tariffs are not likely to lead to significant scope for overall electricity demand-reduction or even to a lower rate overall for domestic electricity demand growth.

Main scope for demand-reduction would come from a small amount of discretionary-load such as reduced stand-by (stand-by anyway to become regulated for some appliances and electronic goods). Most domestic electricity demand-reduction is likely to come from efficiency improvements in non-discretionary load such as increased penetration of energy-efficient lighting and new product standards – and possible new flat-screen technology post-2015.

Appliance Product Standards and Building Regulations – likely to prove a more powerful tool to achieve sustained electricity demand reduction than ToU tariffs offered through electricity smart meters. The Eco-Design Directive, Improved Product Standards indicated in the Energy White Paper, the Code for New Sustainable Homes and associated revisions to the Building Regulations will over time have an incremental effect, albeit take time to put in place. ToU-pricing may offer a useful re-inforcement.

³¹ Northern Ireland Electricity suggest that around 15 % of total domestic electrical appliance load may be discretionary (ie price responsive), with a further 15% offering a possible opportunity for discretionary load. NIE slides. Utilities Metering Forum. March 2007. Against this, a 10 % demand reduction at peak would imply a potentially very active price-response from discretionary-load (possibly as much as half). For the California Energy Commission, a study on Demand Response by Brattle Group study (May 2007), suggests that a peak-load reduction as high as 10% would only likely to be achievable where dynamic pricing is the default tariff for all customers, offering an assumed participation-level of 80% of customers.

Electricity Smart Meters coupled with advice and sustained media-coverage – will help to engage individuals through providing long-term sustained feedback. ToU tariffs will achieve some load-shifting and potentially a lower rate of peak-demand growth. Some limited overall electricity demand reduction could also be achieved through ToU tariffs, but scope appears relatively modest. A key benefit from ToU tariffs is likely to be for consumers in reduced bills – rather than for lower energy or carbon. Additionally, improved price-feedback through ToU tariffs may help, inter alia, to influence appliance-purchase decisions in favour of higher energy efficiency ratings. In reality however, much electricity demand-reduction going forwards will be achieved through concerted efforts in appliance and product regulation and through higher standards for domestic building regulations.

ANNEX II

Demand Estimation in Short-Term Gas Forecasting – Scope for Greater Accuracy from Smart Meters ?

Other than Daily Meters and the small number of installed AMR meters in the commercial sector, GB gas meters presently have no facility to store or to actively communicate data about the volume of gas used in a given time-period.

Around 60% of Local Distribution Zone gas-demand is domestic³² and accuracy in short-term domestic gas-demand forecasts³³ is important for two key reasons. First, short-term domestic demand estimates are fed into forecasts which support short-term balancing actions by the system operator. Second, and separately, through Gemini/Xoserve, they also feed post-event, into the reconciliation and attribution process for charges made by the gas transporter to shippers for commodity and energy imbalance.

The short-term forecasts of domestic gas-demand derive from historic meter-data to provide an estimated Annual Quantity for each meter supply point (ie for each meter). This AQ value is allocated to an End User Category (in effect, to a deemed profile), and is weather-corrected within each LDZ. Additionally, for all non-daily metered customers over 73,200 kWh pa (ie non-domestic customers), an annual load-factor is applied to the AQ to give an estimate of peak-demand for that customer.

Under the Uniform Network Code, these short-term demand-estimation methodologies are kept under review, including the models used in respect of the End User Categories. In addition, recent Ofgem reviews³⁴ suggest that current gas-demand estimation and forecasting methodologies are relatively robust, and that the additional accuracy which smart meters could eventually offer, for example in improvements in reconciliation of shipper transportation charges, is not presently a pressing concern.

However, if, in years to come, there was widespread use of residential smart gas-meters then the industry could well wish to review the present profiled approach to reconciliation and final settlement of commodity contracts between shippers and suppliers, and between shippers and the NTS. Such bottom-up potential change, as for electricity settlement, presently seems a good many years off.

³² Report for Ofgem by Frontier Economics on National Grid Gas Demand Forecasting Methodology. June 2006.

³³ Ie not the models for long-term forecasts ie for Ten Year Statement and annual or peak-demand forecasts

³⁴ Ofgem Review of Reconciliation by Difference . March 2006 ; Frontier Economics.

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