Sustainability first

Smart meters in Great Britain : the next steps ?

Paper 6 : Case studies

Gill Owen and Judith Ward

July 2007

Published by Sustainability First

Sponsored by Accenture, Ampy Metering, Centrica, EdF Energy, Energy Saving Trust, E.ON UK, National Grid, Ofgem, RWE npower, Scottish Power

Case studies of smart metering

California and Pacific Gas and Electric case study

California energy market and regulation

The market is comprised of investor owned, municipal, and cooperative utilities. The major investor owned utilities (IOUs) include Pacific Gas & Electric, Southern California Edison, Southern California Gas Company and San Diego Gas & Electric and account for 80% of the customers. The larger municipal utilities include Los Angeles Department of Water and Power (LADWP) and Sacramento Municipal Utility Department (SMUD).

California led the way in the US in restructuring the electricity industry, starting early in 1998. The three IOUs were required to divest their power generating assets but allowed to retain ownership of the distribution, transmission and supply (retail) functions. Although the IOUs retain ownership of transmission, control of access has been transferred to a non-profit "Independent System Operator" (CAISO).

Direct access for retail (i.e. supply competition) was introduced in 1998, allowing all electricity customers to buy "bundled service" from the utility distribution company or switch to an independent electric service provider (ESP). Less than one percent of residential customers chose alternative providers, mainly green energy, from 1998 to 2000. The power crisis in 2000-2001 (caused by frozen retail rates combined with increased wholesale prices that could not be passed on) caused a crisis for the IOUs and the whole California market. Most new retailers (unable to compete with the price controlled utilities) withdrew from the market and returned their customers to the local default provider utilities. In response, on February 1, 2001, an Act was passed ending the right of customers to direct access. The Legislature authorized the California Department of Water and Power (DWR) to purchase electricity for utility customers with the utilities acting as billing agents for DWR. The suspension of direct access will continue until long-term electricity contracts signed on behalf of the IOUs by the DWR expire. The last of the contracts expires in 2015. There has been some discussion about reinstating direct access before 2015 but no actual proposals to do so to date.

There are four main gas utilities - Pacific Gas and Electric Company (PG&E), Southern California Gas (SoCalGas), San Diego Gas and Electric Company (SDG&E),

Southwest Gas - and several smaller gas utilities. The CPUC regulates the utilities' rates and services. Most of California's 10.5 million gas customers are - "core" - customers, who accounted for approximately 40 percent of the gas delivered by California utilities in 2003. Despite the ability to switch supplier, most residential and small commercial customers still purchase gas directly from the regulated utilities, although most other commercial and industrial customers buy gas from producers or marketers.

The decision to move to smart metering in California was thus taken in a context where virtually all residential and small business customers remain with their local monopoly integrated gas and electricity utility and are likely to continue to do so until well beyond the roll-out is completed.

Smart metering trials

The key driver for smart metering in California is the need to reduce peak demand, particularly after the power cuts experienced in 2001. Peak demand is largely driven by air conditioning use during the summer and a quarter of capacity is used for less than 100 hours a year. The peak energy uses considered most amenable to price response 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 statewide pilot, authorised by the California Public Utilities Commission, (CPUC), involving 2500 residential and small commercial customers, was run in 2003 and 2004 to study demand response to critical peak pricing with smart meters. The Commission also approved demand response marketing and customer education programs.

Some in the trial had automated response (the meter was linked to appliances and could change thermostat settings or switch them off) others were given information about when prices were high. 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 seemed to be important. There was no impact on overall demand – it was merely shifted to off-peak periods. However, Charles River Associates' analysis of 16 other time-of-use programmes found an average conservation effect of 4%.[1]

[1] Charles Rivers Associates. Impact evaluation of the California state-wide pricing pilot. Final Report, March 2005.

Critical Peak tariffs allow the utilities to set higher prices in critical peak periods , on up to 15 days a year. On a normal day the power may be priced at 15 cents per KWH during peak times; at certain times on a critical day that same power may cost as much as $1 per kwh.

Based on the outcome of the pilot, the CPUC agreed to statewide installation of smart meters for all small commercial and residential IOU customers by 2011, with cost recovery 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 advanced metering for all of its customers below 200 kW has been estimated at $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. (CPUC web site)

Pacific Gas and Electric

Pacific Gas and Electric's (PG&E) programme is typical of that now being undertaken by all the California gas and electricity utilities. PG&E's installation of 9.3 million smart meters for its 5.1 million electricity and 4.2 million gas customers began in autumn 2006 and is scheduled to finish in 2011.[2]

The SmartMeter™ system consists of a new electricity smart meter and an add-on device fitted to the existing gas meter. Data is sent from the gas meter to the electricity meter by low power radio and on from the electricity meter to PG&E by power line carrier. Gas usage data is sent from the gas meter to the electricity meter daily. The electricity meter captures electricity use data on an hourly basis, then gas and electricity data are sent to PG&E on a daily basis. Consumer visual displays are not being provided, but in the future, customers will have the ability to monitor their hourly electricity usage and daily gas usage via the Internet.

The main benefits for PG&E will come from an end to meter reading; better price signals which will reduce PG&E's need to purchase power to meet demand at the most critical times and help avoid strain on the power grid; better pinpointing of outage size and location. The latter will enable PG&E to send crews directly to suspected trouble spots, in contrast to current practice of crews sometimes having to patrol entire circuits until problems are located.

---

[2] For more information about Pacific Gas and Electric Company's SmartMeter™, visit www.pge.com/smartmeter or www.pge.com/new

Because the system records electricity usage every hour, PG&E will be able to vary electricity prices by season and time of day. It envisages a number of different time of use and time of day offers, although these will have to be approved by the CPUC. The CPUC has already approved PG&E's proposal to offer customers a Critical Peak Pricing (CPP) option. Residential customers who voluntarily enrol in the CPP program will receive a price reduction of nearly 3 cents per kilowatt hour from 1 June to 30 September during non-CPP events. During a CPP event, enrolled residential customers would pay a 60 cent per kWh surcharge in addition to their standard price for energy used between 2 and 7 p.m. Enrolled business customers would pay a 75 cent per kWh surcharge for energy used between 2 and 6 p.m. The number of CPP events will be limited to no more than 15 per year, from 1 May to 31 October. PG&E estimates that only about 15 percent of PG&E customers will need to enrol in CPP for the smart meter programme to offset 10 percent of its projected cost.

PG&E's investment is estimated to be $1.74 billion, consisting of $1.41 billion of capital and $330 million revenue. To fund the deployment, PG&E will be allowed by the CPUC to increase rates. For the average residential customer with both gas and electricity, the increase ranges from 49 to 99 cents per month for the first five years, or about 1 percent. Thereafter the rate increase will decline and it is projected that eventually rates will fall to reflect savings generated by the programme – but actual rates beyond the first 5 years will be determined nearer the time by the CPUC. The CPUC has also approved funding for a retraining budget for meter readers who will be made redundant.

Netherlands and Oxxio case study

Netherlands retail market

The Dutch energy retail market was liberalised in 2001 – initially only to allow new entrants to offer green electricity and a number of new suppliers entered the market.. Almost 37% of consumers opted for green electricity, helped by tax incentives to do so, although most did so by switching to a green tariff offered by their incumbent supplier rather than switching supplier.[3]

On 1 July 2004, the supply market for gas and electricity was fully liberalised. Since full liberalisation, energy tariffs are no longer determined by the energy retailer . The three largest suppliers have a market share exceeding 80% for both electricity and gas. In addition, there are approximately 20 independent suppliers.

Energy switching rates have been relatively low - - around 5% for electricity and 3% for gas in the first year of full liberalisation. Consumer perception that the savings from switching suppliers are limited may explain the low switching rates. However, surveys carried out by the energy regulator in 2005 show that a household with an average energy consumption can save up to €100 per annum by switching to the cheapest supplier.[4]

[3] Directie Toezicht Energie (DTE – Netherlands Office of Energy Regulation) web site www.dte.nl
[4] DTE, 2005 Annual Report, Office of the Energy Regulator, Netherlands.

Smart meters in the Netherlands

In 2005, SenterNovem, on behalf of the Ministry of Economic Affairs, co-ordinated a study into the potential for smart meters for residential customers in the Netherlands. A key driver of government interest is 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 by KEMA(the Dutch energy sector's research body).

The Senter Novem study concluded that the Government should define functionality to facilitate large-scale introduction of smart metering. For the cost benefit analysis the assumptions were a 10 year transition period, in-house customer display, two way communication, both gas and electricity meters converted. The costs would be spread over a 30 year period and the assumed internal rate of return was 7%. They also assumed a 2% energy saving and reductions in electricity and gas prices due to improved competition (€0.0025/kWh for electricity and € 0.0050/m3 for gas) . The cost benefit analysis (meters for 7 million households) produces a positive outcome of €1.2 billion with the following main costs and benefits:

Table : Costs and benefits of smart meters in the Netherlands[5]

Costs :	
Purchase and installation of smart meters	€798M
Monthly billing energy consumption by supplier	€437M
Data infrastructure via PLC/internet/GSM	€354M
Benefits :	
Easier switching – more price competition – price reduction	€1,353M
Less complaining via call centre	€927M

The Dutch ministry of Economic affairs is planning to make smart meters obligatory with a 6 year roll-out starting in 2009. 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.

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

A national Technical Agreement between market participants is expected to be finalised in April 2007, which includes the standardisation of the communication protocol.

Energy market players in the Netherlands currently installing smart meters include Continuon (distribution and retail company), Eneco and Oxxio (see case study below). Continuon are doing a project using Power Line Carrier, to install either just electricity smart meters or combined electricity and gas smart meters (gas piggybacking on the electricity meter) with approximately 30,000 households. Eneco has initiated a GPRS based solution with an in-house display - approximately 1000 meters have been installed.

Oxxio

Oxxio – at that time operating under the name Energiebedrijf.com – was one of the new entrants to the Dutch market in 2001. Oxxio has since become that nation's largest independent energy supplier, with nearly 600,000 customers (550,000 residential , 50,000 small business customers).

Oxxio owns no distribution or generation assets, buying electricity from wholesalers and reselling to its customers. Because the distribution companies owned the metering technology and data, Oxxio was dependent on them for the information it used to generate its customers' bills. At times the information was provided late or not at all, forcing Oxxio to use "estimated" readings on its bills. This was inefficient, costly and time consuming for Oxxio, and generated ill-will among customers. Oxxio wanted to become independent of the distribution companies for the information it uses to generate its customers' bills.

Oxxio metering

To enter the metering business, Oxxio teamed with IBM to launch the Oxxio Metering subsidiary to own the meters, the meter-reading technology, and the metering data. After developing the business case for, and operational model of, the company, IBM implemented the metering and data-management infrastructure required to run the new company. Oxxio outsourced infrastructure management and operation of the company to IBM.

Oxxio Metering uses "smart" meters that upload their data to the main data management systems of the company. As Oxxio does not own the distribution network PLC was not an option for data transfer. Instead a wireless data communication module is used to gather data from the meters and send it directly to Oxxio's central control facility. The customer's existing non-smart gas meter is replaced by a new gas meter with an RF (LPR) communication interface (currently Radian RF over 433 MHz). The RF interface communicates with the GPRS communication modules connected to the electricity meter. The data (hourly consumption profile) of the gas meters is stored on the gas meter and transmitted to the communication module on the electricity meter on a daily basis. The communication module on the electricity meter then transmits data from both the gas and electricity meters to Oxxio. Downstream data transfer works the same way, with information and commands sent wirelessly to the communication module and then on to the gas and electricity meters, all in real-time.

Costs for the package of electricity meter, gas meter and GPRS/RF module is approx 250 EUR. Battery lifetime is expected to be 12-15 years, assuming daily usage of RF communications. Oxxio's business case assumes a battery replacement by the meter operator after 12 years. Installation costs are around 65 euros for the gas meter and 67 euros for the electricity meter. One person installs both meters on a single visit but as it takes significantly longer to install two meters than just one, both charges are applied for dual fuel applications.[6]

At this stage Oxxio have decided to provide customer information over the Internet rather than a customer display unit. Customers can obtain an up-to-date profile of both their electricity and gas consumption via the Internet. This was done partly because it was easier to realize but also because they wanted to attract customers to the website and using this method enable them to extend the services with data analysis and advice on energy behaviour. So far however, most consumers go to the web site just to check their bills and only a small proportion actually look at the consumption profiles. Oxxio is looking into additional devices to connect to the meter, including the possibility of an in-home display.

They are researching whether to offer time of use or time of day tariffs. Their initial view is that these may be mainly useful for commercial customers. They are assessing the potential benefits of such tariffs in terms of forecasting, monitoring correction factors and use for annual settlement of profile customers.

The benefits of the smart meters are seen as :

- reduced overall "meter-to-cash" costs by 50 percent
- control of the metering data ensures accurate and timely billing, reducing errors and late or inaccurate billing cycles
- Replacing billing estimates with real-time usage-based billing improves Oxxio's internal process efficiency and increase customer satisfaction
- Advanced features like load profiling provide competitive differentiation, increase customer retention and promote conservation

37, 000 customers already have smart meters installed, of which 85% are dual fuel. Over 75, 000 metering contracts have been agreed and the rest of these meters are currently being installed . Oxxio plans to install over 100, 000 smart meters in 2007. Smart meters are fitted as part of a three year contract with the customer. Customers get one bill for gas and electricity, although the charges for each fuel are itemised separately. The metering contract is a separate contract from the contract for gas and electricity supply. If the

[6] Personal communication with Oxxio.

customer switches supplier, the customer can maintain the metering contract with Oxxio, or can terminate the metering contract. In the latter case the meter can be either transferred to the new metering company, or be replaced and returned by the new company. If the customer wishes to terminate a metering contract within 3 years, a termination fee will be charged.[7]

At present no other companies in the Netherlands use smart meters so the question of how Oxxio would handle smart meters installed by other companies for customers who switch to them has not arisen. Their current view is that they would aim to make use of the data from the existing meter, through an agreement that the existing metering company provides the data to them.

Northern Ireland Key pad meters case study

Key pad meters – background

Northern Ireland Electricity (NIE) remains the only supplier to the residential market, in Northern Ireland, but full retail competition will begin in November 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 retail competition for industrial and commercial customers.

NIE's experience with pre-payment smart meters 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
- Keypad meter costs about £85 , including installation. (100,000 units)
- A proportion of cost (cost of base asset – i.e. standard domestic meter) is carried by NIE's networks business – the remainder of the additional cost remains with the supply business and is recovered via the supply price control (but NIE say the

[7] Personal communication with Oxxio.

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). From 1 April, keypad meter investment will transfer from NIE Supply to the T&D business. The full costs will be captured in the T&D RAB.

The Keypad meter does not incorporate a two way communication module within the meter. Communication between the meter and the supplier and vice versa (credit activation, meter readings etc) is via the customer inserted vend code, obtained when the customer buys credit either from agents (such as pay point) or by telephone using a debit card. In effect, therefore, the keypad meter operates in a similar way to the key and smart card (including Quantum) prepayment meters used in Great Britain. The main difference between the GB meters and the NI Keypad is that the latter does not involve anything being inserted into the meter – the customer types in a 20 digit code 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. Another difference is that the keypad meter has a conveniently placed customer display that enables them to monitor consumption, credit available etc.

For NIE the main benefits are: increased customer satisfaction, reductions in bad debts, meter reading costs, call centre costs, billing and debt management costs, call out costs, no requirement to recalibrate meters following tariff changes (this is done automatically via a code which is encrypted into the customer's next vend).

For customers the main benefits are:

- 2.5% discount off the standard credit tariff (direct debit customers get 4% off the standard credit tariff)
- There are no standing charges for the majority of customers. Standing charges are only applied to off peak tariffs and Economy 7 keypad standing charges are the same as for credit customers.
- Keypad meters provide customers with a means of budgeting for their electricity
- Keypad meters provide 'friendly credit' – customers cannot be disconnected between 4pm – 8am on weekdays and all weekend.
- The display provides information which is readily accessible to customers on: remaining credit, previous (days, weeks, months) costs, unit rates and number of units used at each rate, current load, maximum demand and time and total units

Compared to 80,000 prepayment customers on the Powercard system, NIE had 190,000 Keypad customers by early 2007, with new connections continuing at the rate of 2000 per month without any promotion. It had a target (under the price control) of 175,000 (25% of all residential electricity customers) by 2007. So the Keypad system has dramatically increased the size of the prepayment market and has proved very popular with customers. There are approx 1620 outlets to purchase electricity (through Paypoint and Payzone) and

24/7 vending ability via an IVR telephone facility. Although customers can top up their credit by telephone more than 90% use Paypoint or Payzone.[8]

Energy usage by Keypad customers

An initial trial of 200 households found an average 10% energy saving, compared to usage in the previous year. 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. NIE are just embarking on new research with University of Ulster Psychology Department looking at the use of real time and historical consumption feedback on keypad messages linked the provision of energy saving advice (with the EST Advice Centre in NI) – however this won't report for 2 years.

Keypad customers do have lower consumption than consumers in general. In 2005/06 on average, keypad customers consumed 3930kWh pa, 6.4% less than the NI total average domestic consumption (including keypad) of 4200kWh pa.

Powershift tariff

NIE developed and offer a 'time of use' keypad meter product called 'Keypad Powershift' which is promoted to Keypad customers as a potential means of saving money on their electricity bills. It uses a price message to encourage customers to avoid the peak times. Customers who want to switch to the Powershift tariff call the customer help line to register and are given a (60 digit) code to enter into their meter when they next buy a top-up of credit. NIE does not have to visit to switch the meter. If the customer does not think they are making a saving they can ask to switch back to the standard Keypad tariff, which again is activated via a vend code.

The time periods are :

Weekdays (Monday-Friday) :

Midnight to 8am – green (low)
8am-4pm – amber (medium)
4pm-7pm – red (high)
7pm-midnight – amber (medium)

[8] Personal communication with NIE

Saturdays and Sundays :

Midnight – 8am – green (low)
8am-7pm – amber (medium) 7pm-midnight – green (low)

The applicable rates (including VAT) are :

6.56p/kWh - low (40% lower than standard keypad)
9.84p/kWh - medium (10% lower than standard keypad)
17.50p/kWh - high (60% above standard keypad) .

The low and medium rates are lower than the standard Keypad (10.94p) rate, but the high rate is significantly higher than the standard Keypad rate. For comparison the standard credit rate is 11.02p.[9]

The promotional leaflet on Keypad Powershift advises customers to avoid using certain appliances (e.g. washing machines, tumble dryers, showers) during the peak period. It also provides some information on the savings that people can make if they switch the use of certain appliances to the off-peak periods as compared to the standard rate :

Appliance	Standard rate	Amber	Green
Tumble dryer (4 times a week)	£1.60	£1.45	£1.00
Washing machine (4 times week)	£1.00	£0.90	£0.60
Electric shower(20 a week)	£1.50	£1.35	£0.95

(leaflet in the process of being revised to reflect tariff changes)

Powershift tariff trial results

The Keypad Powershift trial was undertaken with 200 customers from October 2003 to September 2004.[10] 100 customers ("Price Message Group") were given the Keypad time of day (Todd) time bands and tariffs(4 time bands 3 rates). They were compared to a control group of 100 customers who had a flat rate tariff (as per normal keypad customers). In the case of the control group the ToD bands were used to enable comparison of consumption within the same time bands as the price message group (i.e. did the price message encourage switching or do keypad customers have a different consumption profile from the majority of customers).

[9] All data from NIE presentations and personal communications.
[10] NIE Time of day trail report. April 2005

Average consumption in the 1 year trial period :

- Control Group 4098 kWh
- Price Message Group 4163 kWh

Therefore the Price Message Group's (PMG) average consumption was 2% more than the Control Group (CG)

% consumption per rate :

	PMG	CG
high rate	15%	17%
medium rate	61%	60%
low rate	25%	24%

The average annual PMG spend was £371.98 compared to 393.54 by the control group on the standard keypad tariff. But if the control group had had the time of day price bands applied to their usage pattern, they would have paid £377.60. This may suggest that that much of the saving for the PMG was passive (i.e. reflecting lower use at peak periods by keypad customers in general) rather than an active response to the price signal.

As the above figures demonstrate, NIE observed slightly increased usage overall amongst the PMG relative to a standard keypad meter customer, however, with lower consumption at peak periods. Consumers saved money but not energy.

Current status of Powershift

There was a positive customer reaction to the Powershift concept and NIE started recruiting more customers in October 2005 via a small direct mail campaign. Currently 1000 customers are on the Powershift tariff. NIE intend to undertake some additional research with current Powershift customers to assess whether the response to the price message is sustained before a further promotion is rolled out.[11]

[11] NIE personal communication