Subtask 4
Quantify the potential for existing profile settlement systems to deal with dynamic demand changes resulting from bidding smaller customer demands into markets

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IEA DSM REPORT - EXECUTIVE SUMMARY

TASK XI SUBTASK 4

QUANTIFY THE POTENTIAL FOR EXISTING PROFILE SETTLEMENT SYSTEMS TO DEAL WITH DYNAMIC DEMAND CHANGES RESULTING FROM BIDDING SMALLER CUSTOMER DEMANDS INTO MARKETS

Background

Many countries are concerned that adequate generation capacity may not be developed in liberalised markets. Greater participation of the demand side in the form of Demand Response is vital to address this issue and improve market efficiency.

The domestic, smaller customer sector consumes between 20-40% of electricity in developed countries, and is an obvious and attractive candidate for demand side participation.

The EU Directive on energy end-use efficiency and energy services (ESD) considers the use of "smart metering" to be a driver of Demand Response for smaller customers. It may also be able to contribute to solving some of the issues surrounding profile settlements.

IEA, DSM, Task XI Subtask 2 identified that, other than direct space and water heating, demand shift among smaller customers could also be delivered by reducing thermostat settings on air conditioning and possibly fridges, reducing lighting and inhibiting some domestic appliances. Customer small scale micro generation could also have an important role to play in generating outside normal heat led times and made responsive to Time of Use (TOU) energy pricing.

Profile settlement systems have been developed to enable smaller customers to participate in supply markets without TOU metering. Profile settlements converts smaller customer, total quarterly or annual consumption into a TOU consumption. This enables Suppliers to settle their accounts with generators based on TOU consumption.

This study considers the impact on profile settlements of smaller customers participating in Demand Response and proposes solutions to identified problems.

Objectives

To quantify the potential for existing profile settlement systems to deal with demand profile changes resulting from smaller customers participating in Demand Response

Approach

Profile Settlement systems developed in Netherlands, Spain and UK have been analysed for their potential to accommodate smaller customer, demand profile changes resulting from Demand Response. Factors considered are the numbers of profiles in use, the way they are updated, variables used to modify profile shape to account for seasonal changes and the introduction of embedded micro generation.

Different solutions to accommodating Demand Response in profile settlement systems can influence different actors to motivate customers to participate.

Results

The possibilities available to enable smaller customers to participate in Demand Response within profile settlements have been investigated with the preferred options being to:-

- accept the additional error between measured and calculated demands at Supplier/Generator metering points;
- develop new dynamic profiles for Dynamic Demand Response customers;
- mandate that TOU metering is required for Dynamic Demand Response customers.

The solution recommended by the study is for the additional error introduced into profile settlements to be accepted initially by Suppliers while participating customer numbers increase. In order to accommodate large numbers of customers participating in Demand Response, it is likely that some form of dynamic profiles will be required.

TOU metering has a role to play in motivating Demand Response but is unlikely to replace existing profile settlements systems.

Implications

Detailed studies are needed to determine the take up by customers of Dynamic Demand Response options based on different drivers, demand packages and remote switching override options. An assessment is needed of the impact on profile settlements of different levels of take up and over what time scales. Studies should also be carried out to quantify the potential for developing dynamic profiles to include the remote switching signals sent to different groups of end uses being fed into profile settlements systems. The business model for applying Dynamic TOU Pricing and its extension to Demand Side Bidding for smaller customers needs to be more rigorously evaluated.

Contents

Glossary

AA	Annual Advance
BSC	Balancing and Settlement Code
CHP	Combined Heat and Power
DEFRA	Department of Environment, Food and Rural affairs
DNO	Distribution Network Operator
DSM	Demand Side Management
DR	Demand Response
DSB	Demand Side Bidding
DTI	Department of Trade and Industry
Economy 7	A UK scheme whereby electricity used at night is cheaper
Elexon	The organisation that operates the balancing and settlement system
EEC	Energy Efficiency Commitment
ESCO	Energy Supply Company
EUMF	End Use Monitoring and Feedback
GAAP	Group Average Annual Consumption
GSP	Grid Supply Point
HH	Half Hourly
kW	Kilowatt
KWh	kilowatthour
MW	Megawatt
MWe	Megawattelectric
NETd	Noon Effective Temperature on Day d
NHH	Non Half Hourly
Ofgem	The UK regulator for the energy and gas industry
Party Agents	Parties who have signed the balancing and settlement Code
PV	Photovoltaics
REE	Red Electrica
SSC	Standard settlement configuration
TOU	Time of Use

1 Introduction

Many countries are concerned that adequate generation capacity may not be provided in liberalised markets and consider greater participation of the demand side vital to address the issue and improve market efficiency. Maintaining the balance between supply and demand, and maintaining quality and security of supply are the responsibility of System Operators.

The domestic, smaller customer sector consumes between 20-40% of electricity in developed countries, and is an obvious and attractive candidate for demand side participation. If end use demand of smaller customers can be changed in response to financial and other stimuli, it can be used to reduce the requirement for peak generation capacity, spinning reserve and enable demand participation in balancing and reserve markets.

Time of use (TOU) pricing Dynamic Demand Response and Demand Side Bidding (DSB) are mechanisms for driving energy demand profile shape change by smaller customers. These are already normal pricing, billing and settlement mechanisms for larger customers (>100kW demand and other measures). TOU pricing is used as a motivator to encourage the movement of electricity consumption from higher to lower price periods. TOU pricing information presented to customers can be actual prices in a market or a price related message made up of an energy price and other parameters such as network congestion. The presented prices or signals can also be based on predicted prices for future time periods, such as the next day. Alternatively they can be based on fixed price profiles of charges in the form of previously agreed tariffs. Different notice times for different demand types can be included in order to mitigate the inconvenience to customers when reducing demand. Dynamic TOU pricing can be envisaged, whereby price signals are not fixed in time but are sent to customers indicating, for example, a particularly high price period during part of the following day. Customer responses to the price signals can be to take manual actions to change demand or allow automatic controls to modify demand. However, studies have shown that to be fully effective and sustainable over the long term, demand changes in response to price or System Operator/Supplier requests need to be automatically implemented for smaller customers. Whether or not these automatic switching commands can be overridden by customers is an important consideration in the reliability of delivered demand change, its value and in customer acceptance of the remote controls.

Demand Side Bidding is the formalisation of demand changes motivated by TOU pricing or other stimuli and works by linking the demand changes to contracts between System Operator/Supplier/Aggregator and Customer. Customers are rewarded for making short-term, discrete changes in demand. Rewards are delivered to participating customers by either a reduced price for electricity or by direct payment. Verifying that energy demand has been changed by a customer as a result of DSB implementation requires time of use energy monitoring for larger customers.

Dynamic and Real Time pricing measures result, if successful, in dynamic changes to customer usage profiles and this could impact profile settlement systems used in competitive supply markets.

The important issues to be considered are whether new profiles are needed for profile settlement of smaller customers participating in dynamic demand changes in response to remote signals, the cost of these new profiles and other possible options.

Customer profiles are also used to estimate the real time demand of each Supplier on a continuous basis. Metering systems with added intelligence are likely implementations in the near future for smaller customers. The roles of "Smart" metering and profile settlements need careful evaluation. All these issues determine the viability of smaller customer dynamic demand side participation.

This report describes the profile Settlement systems developed in Netherlands, Spain and UK, together with mechanisms implemented, the number of profiles in use, the way these profiles are kept up to date and what factors are used to modify profile shape on a daily basis to account for seasonal changes, embedded micro generation and demand switching. The compatibility of profile settlements and Dynamic Demand Response is investigated.

2 Profile Settlements

Profile Settlements is a mechanism for enabling electricity suppliers in competitive supply markets to be charged on an equitable basis by generators for electricity they have purchased and supplied to their smaller customers. Financial settlement between Suppliers and Generators uses smaller customer profiles to allocate demand against time for each Supplier at Grid or Group metering points. Grid points have accurate, TOU metering which is read every few minutes. Suppliers pay for the electricity they buy on a time of use basis, normally in half hour or one hour time periods. Smaller customers generally pay for their electricity using a single fixed rate or sometimes a two rate basis. In order to convert smaller customer, total consumption into a time of use consumption which can be aggregated on a TOU basis for each Supplier sharing a common grid metering point, customer consumption profiles are created. Profiles are also used to estimate the real time demand of each Supplier on a continuous basis. These profiles allow the total consumption and time of consumption to be determined for each Supplier by aggregating the smaller customer estimated daily volumes and profiles.

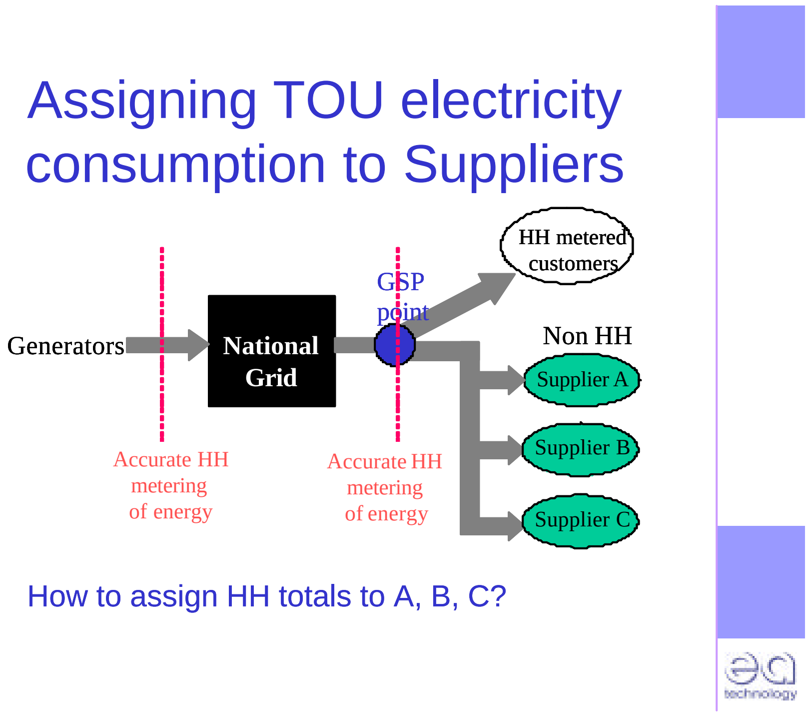


Fig 1 Assigning TOU electricity consumption to Suppliers

From Fig 1 above, the demand against time for the non HH (non-TOU metered) customers can be estimated for each of the three Suppliers, A, B, C. by means of profiles. The total profiled demand plus the TOU metered demand should approximately equal the total metered demand at the GSP.

Individual customer profile processes rely for their accuracy on the collective stability of large numbers of smaller customer demand profiles. This "profile metering" offers some of the benefits of TOU metering but at lower cost. Suppliers are invoiced based on these daily volumes and profiles together with some correction and reconciliation factors. However, the use of "profile metering" (as presently implemented) removes most of the incentive for Suppliers to modify the shape of their smaller customer, energy demand curves.

Profiles can be based on specific customer types, Grid Supply Group profiles or based on the national system profile. The choice among these options depends on the accuracy required in apportioning demand among Suppliers. The more detailed and specific the profiles are, the more accurately the allocation among Suppliers will be. However, it is also more costly to use detailed profiles rather than system or Grid profiles.

The aggregated “profile” demand represents demand against time for large numbers of smaller customers in different categories. Consequently if the demand curve of many smaller customers is modified from the profile shape used for settlements, overall errors will be introduced into the settlement processes. This error is checked at Grid Supply Group metering points where accurate metered values submitted are compared with the summated customer profiles. For settlement Systems using national profiles, checking at Grid points is unnecessary. The size of this error is variable but in general quite small because customer profiles are continuously reviewed in order to minimise this error. The profiled sum error is reconciled, among all Suppliers, against the metered totals at the Grid Supply Group metering points as a result of applying correction factors. If the demand profile shape of large numbers of smaller customers is modified by demand switching, additional errors will be introduced into the settlement process. These dynamic demand change errors could be reduced if new “profiles” were generated in response to the automatic switching of demand. This is provided that customers were not able to or did not override the switching commands or the override was able to be monitored. Being able to accommodate dynamic profiles within settlement systems would remove the need for smaller customer TOU settlement metering, data collection and processing and encourage Suppliers to participate directly in motivating dynamic demand and profile changes. The issues to be resolved therefore are:

- whether Suppliers are prepared to accept more dynamic profiles than are used at present in specific customer profile settlement systems with a probable increase in the error at Grid Supply Group metering points;

- whether Suppliers require new dynamic profiles to be developed and applied to smaller customers, participating in Dynamic Demand Response; and

- whether TOU metering is required for settlements if dynamic demand changes are implemented for smaller customers

The application of Dynamic Demand Response to profile customers should in general reduce supply costs for Suppliers and customers.

3 Motivating Dynamic Demand Profile Change

The most important drivers for motivating smaller customers to accept dynamic demand changes are TOU pricing and environmental concerns. Many forms of TOU pricing exist with the main groupings being Tariff TOU pricing, Dynamic TOU pricing and Real Time TOU pricing with or without remote switching.

Tariff TOU pricing

Tariff TOU pricing is where times and energy prices are essentially fixed for long time periods ahead such as months or years. Tariff TOU prices and times are not able to change when abnormal system peak conditions occur. Customers do not have an incentive to reduce more of their load on the highest peak days than on average days, even though load reductions on these days have substantially higher value. An additional problem with Tariff TOU pricing is that if it is implemented on a voluntary basis, only those customers who can lower their bills by going to TOU rates will select it. This can lead to a revenue loss that has to be recovered in the form of higher average rates for all customers.

Dynamic TOU pricing

Dynamic TOU prices can vary hour by hour but they can also be estimated and provided to customers perhaps 24 hours ahead so as to help them plan demand changes.

Real Time TOU pricing

Customers and their equipment are presented with dynamic prices, near to real time so that demand responses are required to be more or less instantaneous. These demand change motivators, notice periods and response times can be linked to DSB processes which are likely to be based on remote switching of specific demands.

3.1 Implementation Mechanisms

The actual mechanisms for delivering demand changes based on price have various routes to implementation. These can be manual methods where customers actually turn down end uses of energy such as thermostats when high price is indicated or deciding to reschedule the time of use of specific end uses such as washing machines. Automatic methods can also be used where reducing thermostats or disabling the use of specific appliances is carried out based on pre-agreed instructions and remotely controlled by a third party. It is probable that only relatively large demand, end uses would be included in demand response to TOU pricing.

Manual demand change mechanisms have the advantage of simplicity from the point of view of technology requirements and cost of implementation. These requirements are a multi-rate meter and a means of communicating information on current electricity prices to customers. Customers would then be responsible for decided how and when electricity is consumed.

Alternatively, customers could provide a third party, such as the energy Supplier, demand Aggregator or an Energy Service Company (ESCO), with the authority to control certain loads on their behalf particularly when prices are high. This remote switching could incorporate the option for customers to manually override the decisions of the third party.

Customer response to TOU pricing is likely to be both an energy reduction and a demand reduction. The extent to which this happens, and therefore the impact on profile settlements, is not known. It is also not known the extent to which profile shape changes when individual end uses are remotely switched. In order to bid demand as equivalent to reserve generation capacity, it will be necessary to pre-determine (estimate) the demand change potential available to be delivered and the demand change actually delivered by specific switching instructions or price signals.

3.2 Remote or Local Dynamic Control

A critical issue which influences the development of TOU pricing using Tariff, Dynamic and Real Time pricing is whether customers are provided with an option to override the remotely/automatically switched demand signals. If customers have the option not to deliver the demand shift and they exercise it, then the reliability of the potential demand shift is questionable and of less value to System Operators. If the option to override automatic demand shift signals is not provided, then single rate metering is possible and the demand shift becomes more predictable. However, customers are likely to require greater financial incentives to participate in some elements of demand shifting, particularly appliance controls, if an override option is not provided.

Reducing peak demand for very few hours per year has been shown to have a large benefit in terms of reducing system capacity requirements. (IEA, DSM Task XI Subtask 2). This study identified that thermostat reductions of direct space and water heating and air conditioning for a few hours per year could make significant contributions to reducing system peak demand. It also identified that in future, small scale micro generation could be controlled on the basis of TOU pricing to reduce unscheduled peak demands.

The Study also showed that the financial benefits available to motivate smaller customers to participate in TOU pricing, are not great. No definitive studies have been identified which have analysed customer reaction to the disabling of individual appliances for short periods a few times per year and the financial incentives required. No studies have been identified which have analysed the possibility and acceptability of reducing lighting levels again for a few hours a few times per year. These studies need to be carried out together with assessments of the financial incentives needed to obtain customer participation, particularly when no override options are allowed (IEA DSM Task XI Subtask 2).

Tariff, Dynamic and Real Time TOU pricing are all likely to be viable for direct space and water heating thermostat control. They may also be viable for centrally controlled air conditioning systems, micro generation, saunas and direct electric showers. On their own, remote switching of lighting and appliances is probably not viable, both from the size of the demand per customer and also the inconvenience caused to customers. However, with very effective marketing and the requirement to inhibit demand for only very few hours per year, customers may be persuaded to participate. It may also be possible to inhibit demand for very short times for each customer but apply it in a sequence to a larger population of customers so as to achieve an overall demand reduction for a longer period.

Communication to individual end uses within customer premises in order to activate thermostat setting changes or disable appliances, requires careful consideration because it is a critical element in overall system costing. Communication outside customer premises between System Operator, Supplier/Aggregator and customer can be based on broadcast or cellular radio, power line, pager or telephone media with relatively long response times (minutes) allowed, in order to deliver prices. Communication inside customer premises can take the form of pico cellular radio, power line or twisted pair. It is also possible for controlled end uses to directly receive the external broadcast radio signals. The choice between using the external broadcast communication system to deliver price messages directly to individual end uses or to use a separate but linked internal communication home bus depends on cost and functionality. It also depends on whether other customer services are likely to share the communication system. These could be home security, medical and security alarm monitoring for example. If other services are included in the communication infrastructure in order to share the system and help offset the costs for TOU pricing applications, then separate, internal to the premises communication bus systems are likely to be more flexible and overall, lower in cost.

These gateway linked internal and external communication architectures have been studied extensively for the delivery of wide range of customer services with an overall view presented in IEA, DSM Task 2 report. A typical architecture is shown in Fig 2 where different service providers are shown having exclusive access to individual applications and services inside customer premises. One of these services would be TOU pricing and demand management; another could be appliance, remote diagnostics, etc.

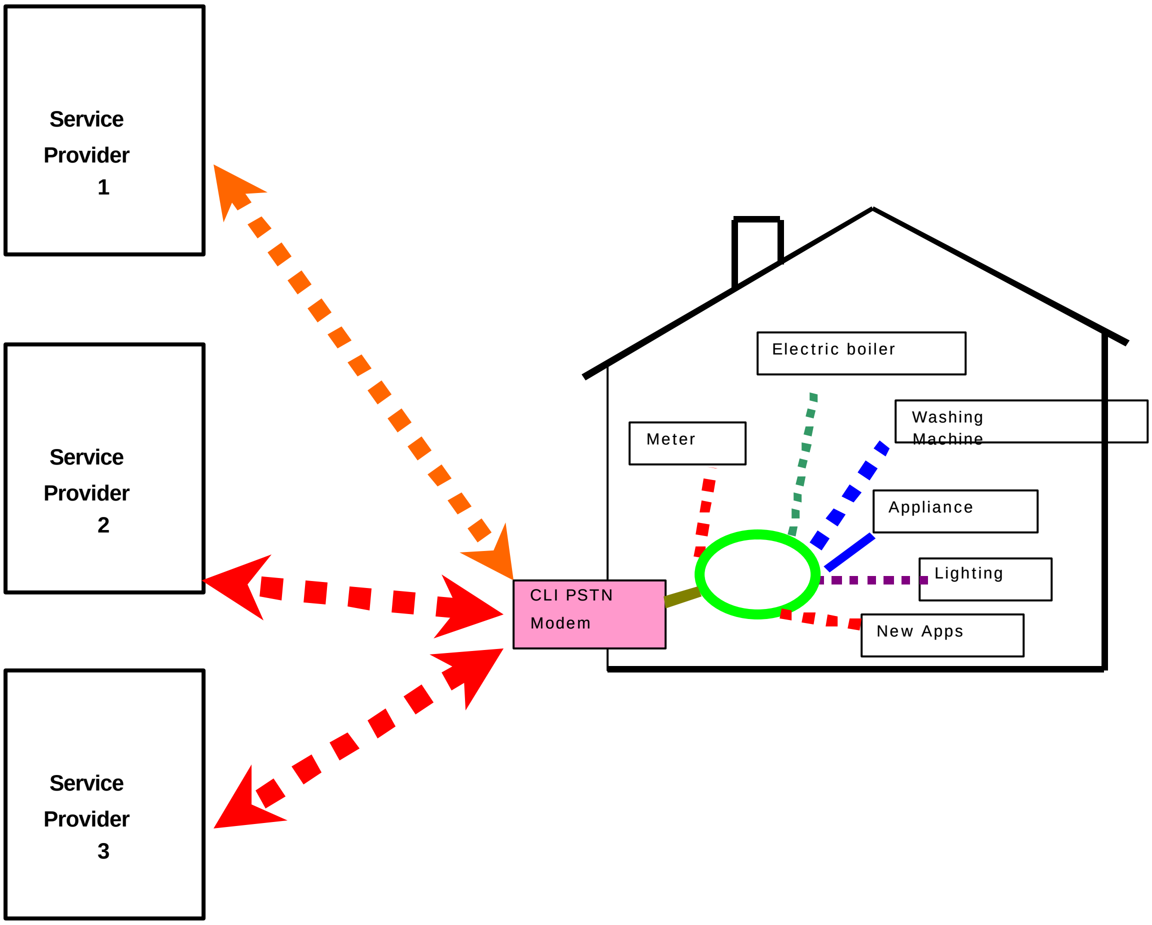


Fig 2 Networked Home Customer Services Infrastructure

Remote demand switching and TOU metering with 2way communication will be common in future in many countries and, if cost effective, may provide an alternative or complementary solution to profile settlements.

3.3 Customer Interest in Demand Response

Demand Response in Spain

Red Electrica carried out customer consultations and an energy survey in Spain during March 2006 on 2000 households to help understand their interest in demand management measures. 70 separate pieces of information were collected. The logo in Fig 3 was used as part of the promotional information given to customers in a bid to encourage participation.

EMERGIE Survey March 2006 REE
Fig 3 Customer willingness to change Energy Demand Use

Customers in general declared their positive attitude to accepting three different kinds of smart control in exchange for an economic premium:

1. Dynamic control without the customer option to override: Premium payment 100 Euro a year. 55% were in favour;

2. Dynamic control with the customer option to override: Premium payment less than100 Euro a year (not defined how much less). 57% were in favour;

3. Non dynamic time of use scheme: Premium reduction on the price of energy (not defined how much). 62% were in favour.

Demand Response in Netherlands

SenterNovem, in the Netherlands, carried out a research project in 2004 to study the potential for demand reductions by small electricity users in Netherlands. (Scan vraagrespons kleinverbruikers elektriciteit, Siderius et al). For domestic and non-domestic profile customers the opinions on the following items were reached by interviews:

1. Demand switching: motivating information related to price reduction: frequency, duration and times of day switching; possibilities to over ride controls (with/without price consequences);

2. Flexible contracts: levels of price reduction for switching off specific appliances, time of day switching; possibilities to over ride (with/without price consequences);

3. Price differentiation: levels of prices and timing and way of providing information and level of price differentiation.

For **domestic profile consumers,** the study concluded that demand switch off could be best conducted during the week on 'offices', between about 0900h and 1600h and also at night for a short period. Customers are quite sceptical about price reductions: the connection charge as such is a major part of the costs in Netherlands and continues to increase. For most domestic customers the option to override the automatic/remote demand switching is important.

There is more interest in flexible contracts with switching only of specific appliances, but there needs to be enough financial advantage. A freezer is the most mentioned appliance for switching, while customers are not much in favour of fridges or washing machines. All want to get informed ahead of any switching. The opinions on the times of switching are diverse: some prefer a specific time or day, some prefer no switch in the morning (0600h-0900 h) or in the late afternoon (1600-1900h). A switch off for a whole day is not acceptable. It is preferred that the price differences would follow a pattern and that specific prices would be applied during agreed periods. Most customers are not willing to follow the prices themselves and react to changes.

For **non-domestic profile customers**, the costs of electricity use are much lower than for gas use in the Netherlands. Often these customers already have a two tariff system, but the price differences have very little impact on the way they organise their business. The non-domestic profile customers in the Small and Medium Enterprises (SMEs) seem to be not interested at all in temporary switch off: they do not want an interruption in their normal process. Related to this, there is also almost no interest in flexible contracts. As electricity costs are not the dominant costs, there is almost no interest in following price differentiations related to time of electricity use. However, in 2003 an experiment was conducted by Openbaar Nutsbedrijf Schiedam (ONS) using real (daily changing) prices and monthly billing based on real electricity use. Smart, remotely readable meters were installed and the households could get price information by teletext. One of the conclusions of the experiment was that a part of the electricity use was manually shifted to periods with lower prices.

For domestic profile customers, the most interesting option for them to participate in Demand Response could be a transparent system of price differentiation related to specific time periods with some form of automatic/ remote switching. Prior to implementation of this option, additional actions will be needed to improve the general opinion among customers regarding Demand Response. Without more and easy insights into disaggregated, real electricity end use it will be hard to get support among customers for this option.

Siderius et al (2004) estimated that there is a theoretical Demand Response potential of about one third of the electricity used by domestic profile customers. Of course the actual amount delivered in practice would be much lower than this. A tentative demand response curve during the day has been developed based on the electricity use of household appliances and the assumed demand for dishwashers, clothes dryers, washing machines and vacuum cleaners, Fig.4.

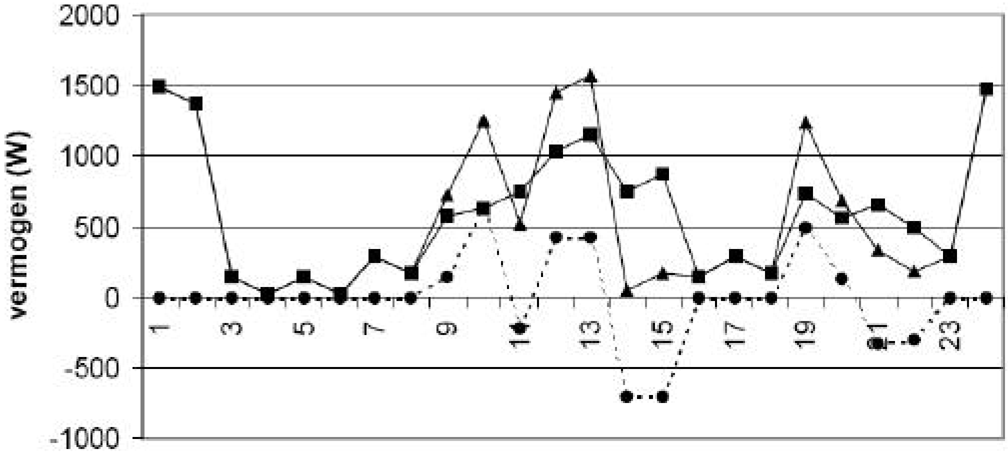


Fig 4 Tentative demand response for households

The line with the triangle is without demand response and that with the block, with demand response. The broken line is the difference.

Using the same assumptions, the potential demand shift for domestic customers is estimated to be around 400-450 W per household. Tentatively this could result in a total demand shift up to 1000 MW for half an hour during a peak period of 1.5 hours.

As a reference the maximum peak in the Netherlands in 2002 was 14500 MW. The potential demand shift for the large electricity users is about 11%.

Demand Response in UK

In order to investigate the barriers to Demand Response at the residential, profile customer level in the UK, three possible ways of implementing it have been considered ranging in complexity. These are:

- Increase the number or dynamic tariffs
- Automatic control of demand by a Supplier/Aggregator
- Energy Service Companies (ESCOs) take on the role in specific geographic areas

Dynamic Tariffs

A meter with different registers for tariffs for different times of the day could be used (for example 6 tariffs). These could either be fixed or varied according to electricity price and the condition of the network. If the times of the tariffs could be varied the top tariff could be a critical price tariff and just used in emergencies. The contract with the consumer could define, for example, that the length of time during each day at the highest price is limited.

Fixed tariffs would require new multi-register meters being fitted and then the billing process for customers would be largely the same as at present (similar to Economy 7 in the UK but with more rates). If the tariffs were to be varied, these signals would need to be sent out by radio, mobile phone, broadband or similar communications. If the tariffs did not change more frequently than every few hours the speed of communication would be low and not an issue. Some means of informing customers of the changing tariffs would be required via a display screen or coloured lights for example. The meter to record the use and rates would be more complex than present meters.

It would need to be agreed between the network company and Supplier whether the network company controlled the switching of tariffs as it does with remote switching of storage heaters in the UK at present or whether it would be controlled by the Supplier.

Automatic/remote control

Switching loads automatically in houses would require separate circuits to groups of end uses or the switching of individual loads using an "in house" communication system. For example the contract between customer and Supplier could guarantee that a washing machine would not be inhibited for more than a defined period. It could also be agreed that a deep freeze could be switched off for 2 hours in the day. Alternatively the demand on some circuits or appliances could be limited at particular times of day. These switches or limits could be changed dynamically or remain at fixed times. Payment could be via:

- A single tariff.
- Different tariffs for non controlled loads and controlled loads (this would require different circuits inside customer premises).
- A fixed charge for usage up to a certain value and then a higher tariff.

Switches or demand limiters which could not be tampered with would be required on specific appliances or circuits. For the times or limits to be dynamic, communications would be required to switch the circuits or appliances. An easy to use methodology would be needed to assess which appliance or circuits to limit or switch. If limits are used, an easy calculation of the value of the limit would be required.

Energy Services Companies to deliver Demand Response

Implementing Demand Response and providing metering and control infrastructure may be best achieved through Energy Service Companies (ESCOs). These ESCOs would perform the demand response aggregation process and, where appropriate, bid the demand into DSB markets. ESCO businesses operate at present in a number of ways:-

- Contract to reduce electricity use by customers and bid demand and local generation into markets. These processes at present are usually based on large industrial customers and include shared savings schemes. A number of UK based ESCO businesses are described in Appendix 3.

- The profit from renewable generation or CHP plant (often community owned) is distributed to the participants via reduced energy costs or through share dividends.

- A CHP plant sells heat via district heating schemes and sells power to a Supplier.

- Heat and/or power are supplied to tenants of a building or cluster of buildings from locally generated power.

For example if a village or definable community created an ESCO (or a Supplier offered the service), it could buy and sell power and offer energy services. Depending on the size of the ESCO, it could either equip customers with half-hourly metering or offer a range of tariffs/prices throughout the day. It would have greater negotiating power with Suppliers, similar to larger customers. Within the ESCO, customers could use microgeneration and Demand Response to reduce peak demand or achieve other targets agreed in the contract. Each customer would need to have a meter to measure import and export of power. Different tariffs or automatic switching could be used to encourage Demand Response. Savings could be returned to participants by a lower price of energy, by providing energy efficiency measures etc. or by a share dividend.

Remote Control of storage heaters

One basic, unobtrusive Demand Response measure applied in the UK and included in the profile settlements system is the remote control of electric storage heaters. This has been in operation for many years with up to 2 million customers involved.

Remote switching for storage heaters can vary the time and length of the heating period in order to flatten the national off peak, load profile. A communication signal is used to switch the two rate meter to the low rate tariff and also switch the heaters. This allows the heaters to be switched on at the lowest cost time for the system. The signal is used to stagger the start of the storage period for some heaters to reduce the peak demand and also enables charging to be carried out in two periods through the night. In order to include this process in the profile settlements system, an estimate of the profile change for these customers has been made using algorithmic profiling which takes account of when the demand is actually switched. This process is called "chunking". The switching signals sent out to switch the demand are also fed into the profile settlements system to modify the profile. More advanced systems vary the heating time according to the weather forecast. The remote switching process is managed by the local network company.

4 Profile Settlements Systems

4.1 Profile Settlements System in Spain

The Spanish market was opened to all customer types on the 1st of January 2003. The market works in hourly settlement periods. In order to allow the billing and settlement of the customers without hourly metering, a profile settlement system was established.

So far the market has not been successful in attracting small electricity customers. From a potential 23 million customers, just 2 million small customers participate in the market through Suppliers. The explanation for this situation is simple. The Spanish regulation provides an integral and regulated tariff system. These tariffs include all the cost components of the electricity supply. The choice of tariffs includes time of use discrimination, but such options have not been taken up by the smaller consumers group. At the moment the price of the regulated tariff is cheaper than the one obtained from the market. Distribution companies (the owners and operators of the distribution networks) are responsible for providing electricity and billing for these customers.

Due to the reduced number of small customers subject to the profile settlement system, the relevance of its accuracy is not hugely important in Spain at the present time. The final settlement of a month in the Spanish market takes eight months. This means that eight months after the end of the month, all the measurements of all the hours of the month must be completed.

Four different profiles have been developed. The customers that do not fall into any of the four following categories are obliged to install hourly, TOU meters:

- **Profile P1:** Applies to low voltage customers (below 1kV) and a maximum consumption power below 15kW.

- **Profile P2:** Applies to low voltage customers (below 1kV) and a maximum consumption power above 15kW. It also applies to high voltage customers (above 1kV and below 36kV) and a maximum consumption power below 450kW.

- **Profile P3:** Applies to low voltage customers (below 1kV) that are subjected to the network access tariff 2.0DHA, which is a two period fixed time of use access tariff. The access tariff represents the cost of using the distribution and transmission lines, and is regulated. All customers that participate in the market pay for the use of the network through a regulated tariff. In order to be eligible for the access tariff 2.0DHA, a two period time of use meter must be installed. The established time periods of tariff 2.0DHA are as follows:

WINTER		SUMMER	
Peak	**Valley**	**Peak**	**Valley**
11-21	0-11 21-24	12-22	0-12 22-24

- **Profile P4:** It is a profile that applies to low voltage customers (below 1kV) that have just switched to the access tariff described in profile P3. The profile only applies temporarily during the period required to install the two period, TOU meter.

Development of profiles

At the beginning of each year, the CNE (regulatory body in the electricity sector) publishes the following:

- An initial value for each profile for the 8760 hours of the year. The value represents the relative weight of each hour in the complete year. The procedure used by the CNE to develop these initial profiles is not public. It is however known that the profiles are static and there is no monitoring involved in their development.

- The forecast load consumption for the complete Spanish system, for each hour of the year.

- The value of three coefficients for each profile. These coefficients are later used to modify the initial profiles. The value of the coefficients remains fixed for the complete year.

The initial profiles are modified monthly by REE (the transmission system operator) following a systematic procedure. The final profiles for each hour of the month must be published five days after the end of each month. This calculation of the final profiles is performed using several formulae that adjust the relative weight of each hour in the year. The only parameters used to modify the profiles are the real country consumption observed in each hour of the month, and the coefficients provided by the CNE at the beginning of the year.

Figures 5 to 8 illustrate the final profiles for two particular days in January 2007.

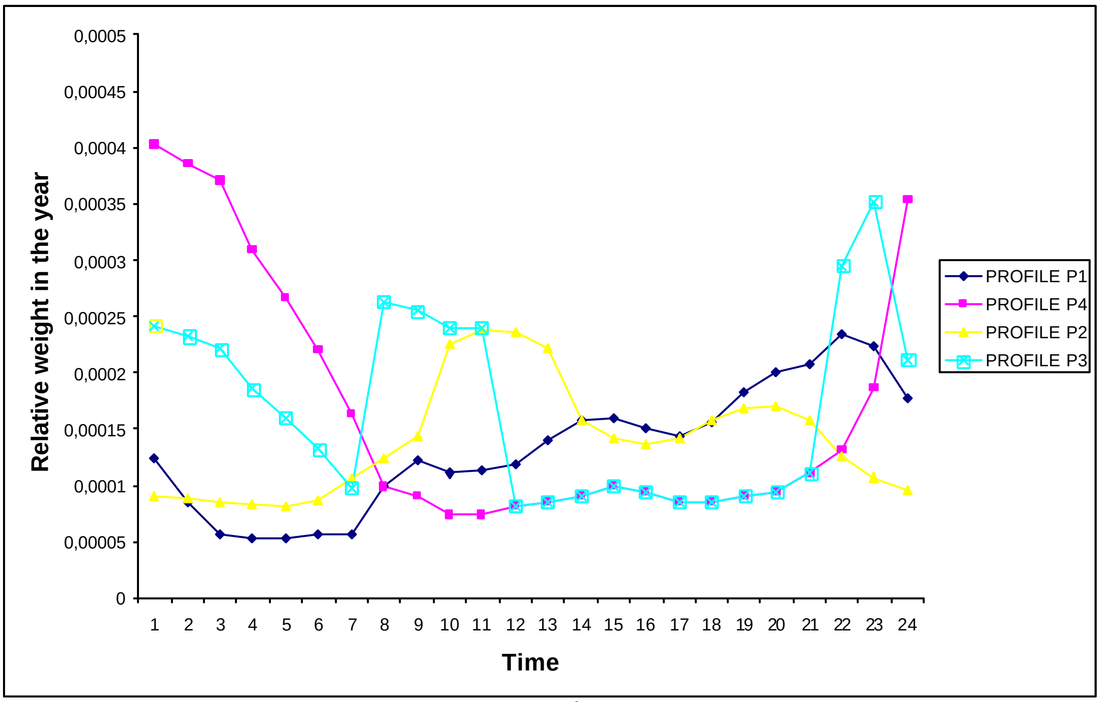


Fig 5 Spa1 Profiles for the 9th of January 2007 (Tuesday)

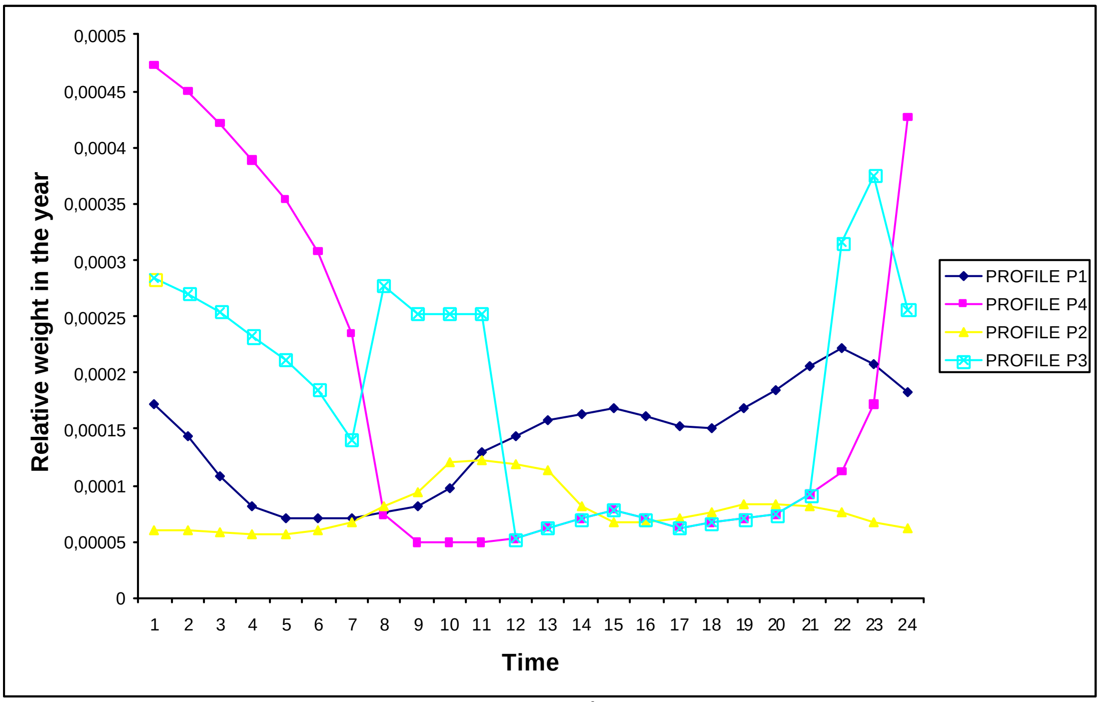


Fig 6 Spa2 Profiles for the 14th of January 2007 (Sunday)

Next two figures present the profiles for two summer days in May:

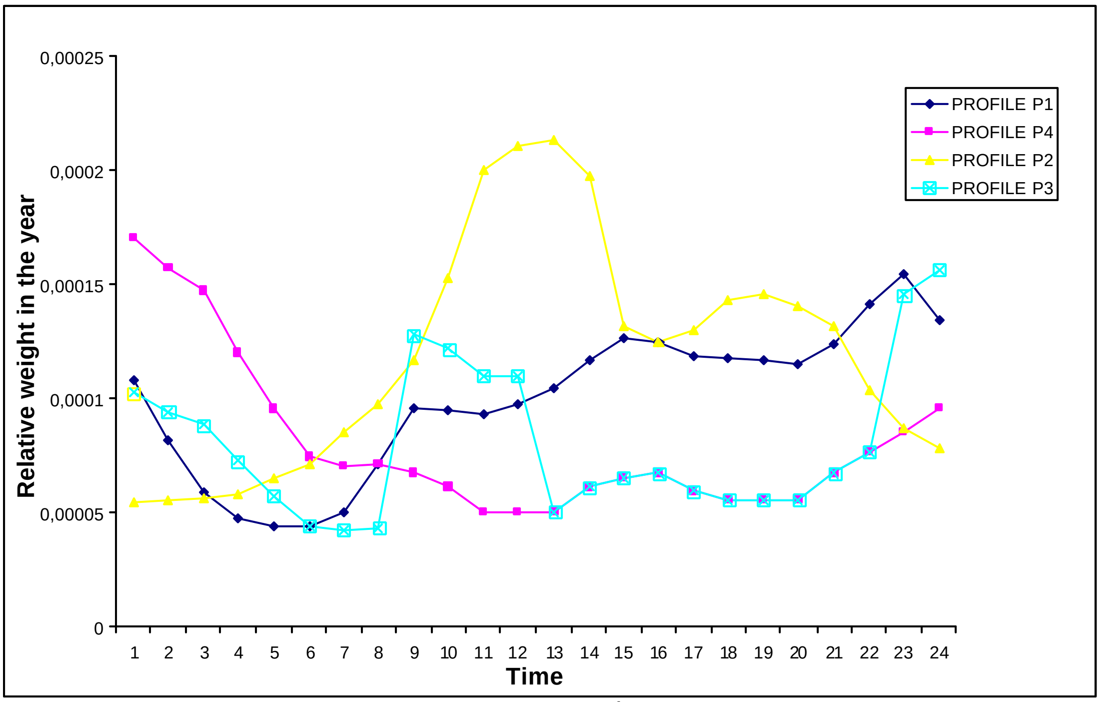


Fig 7 Spa3 Profiles for the 28th of May 2007 (Monday)

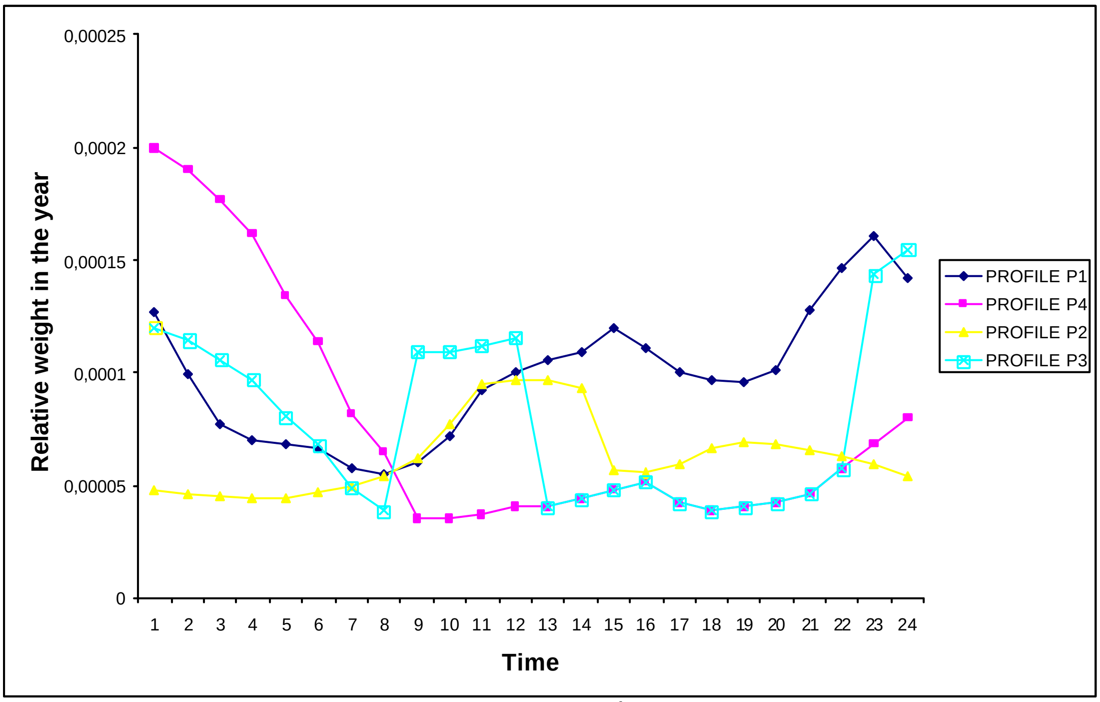


Fig 8 Spa4 Profiles for the 27th of May 2007 (Sunday)

Application of Profile Settlements in Spain

The application of the profiles is simple. Suppliers collect periodically the energy measurement from the non TOU metered customers, and using the profiles published by REE they distribute the consumption hourly following the formula below:

$$E_h = \frac{P_h \cdot E_{period}}{\sum_{i=StartofPeriod}^{EndofPeriod} P_i}$$

E_h = Energy consumed by the customer in the particular hour *h*
E_{period} = Measured energy over a given period
P_h = Final profile for hour *h*
P_i = Final profile for hour *i*

Profiles are used to establish the final settlement. Suppliers must provide the information for all the hours of a particular month, no later than 7 months after the end of the month.

At the present time, the participation of small customers in the market is small, and the relevance of these profiles not very significant. The situation however may change soon, as the Spanish Government is planning the progressive elimination of the "integral tariff". It is likely that by the year 2010, all customers will participate in the market.

4.2 Profile Settlements System in Netherlands

During preparation for the free electricity market, a profile settlement mechanism for smaller customers was developed which included three profiles. The system developed in 2007 and included in the Metering code. These three profiles are: one for domestic customers and two for non-domestic customers. The profiles are set for a period of 3 months and are updated four times a year. The profile correction factors used in the profile system are: tariff correction, climate correction and ‘error’ correction. In practice for the daily correction only, the tariff correction is relevant.

Profile settlements

For smaller customers, these are customers with a maximum demand less than 100kW and not holding a daily, remotely controlled meter, profiles have been developed to facilitate their participation in the electricity supply market. In the period 2002/2003, a group called the “Platform” developed the Profile method for Electricity as a alternative continuous, TOU metering with the purposes of:-

1. determining the specific part that a party with programme responsibility, usually the electricity distributor, delivers to the profile customers using the regional grid;

2. determining the change of Supplier account for profile customers in case there is no meter account known.

This method was later included in the Metering Code that holds a direct relationship with the Electricity Law 1998 (article 31, section 1, sub b). In this code the profiles are included as Annex 14.

At that time (2002/2003) there was no specific measurement data available for Dutch customers from which to develop profiles. Ecofys, the company that assisted with the Platform, developed the profiles for the year 2002 using:

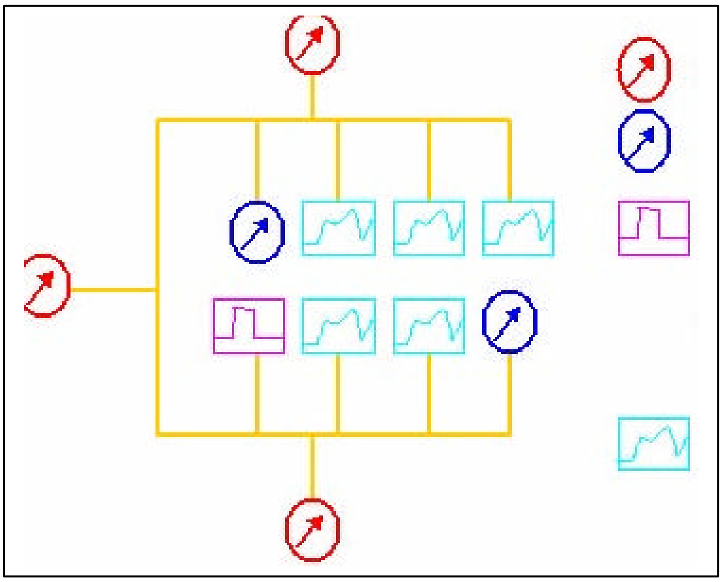
a. Profiles developed by the Electricity Association in the UK;
b. Dutch expertise on profiles;
c. Available Dutch measurements data.

Determination of specific profiles

The total use of electricity from the grid in an area is measured, as well as the use by large customers (as these are continuously measured). Also the assumed profiles for the profile customers in that area are known. There is also a calculated loss of electricity during the distribution. Consequently, the total electricity delivered to the group of profiled customers for each specific electricity Supplier is in formulae form:

Electricity into the grid - Continuously metered customers - Assumed profiles - Calculated grid losses = Use by profile customers

“Use by profile customers” is equivalent to the error function.
This process is illustrated in Fig.9.



Electricity into the grid Minus Continuously metered customers Minus Assumed profiles Minus Calculated grid losses = Use by profile customers

Fig 9 Calculation of the electricity use by profile consumers

Another way of representing this system in presented in Fig.10. Here we start with the summation of assumed profile use for each of the 3 main profile groups (PU 1-3). This results in the total electricity use for the profile customers. Also known is the total electricity delivered as this is the total electricity measured minus the total of the continuously metered customers. The difference between these two is the ‘error’ in the calculation of the assumed profiles. This error is distributed to each of the three profile groups, based on their contribution of the sum of the assumed profile uses. The **total profiled consumption** is calculated as the sum of all assumed profiled consumption in the administrator’s grid multiplied by the ‘error’ (metering correction factor; MCF).

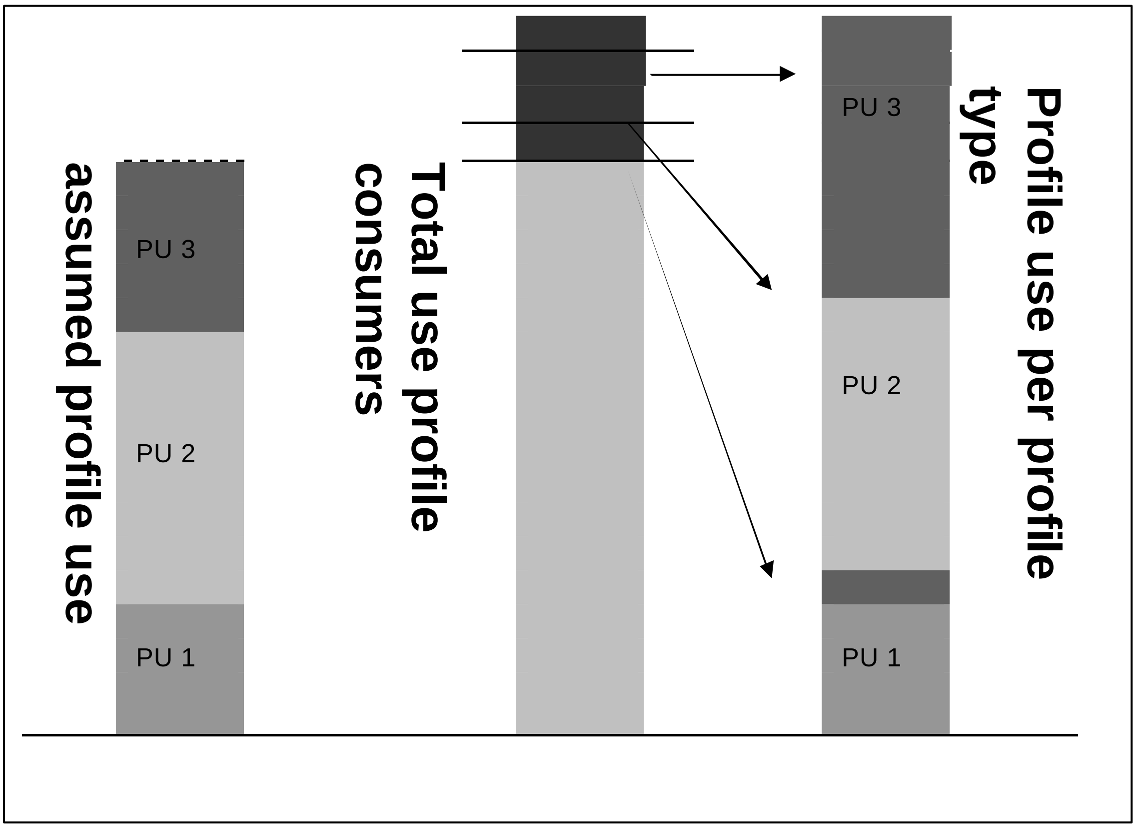


Fig 10 Error in calculating the profile use per profile type

Switching Supplier
Profile customers are free to choose an electricity Supplier. At the present time, if a profile customer switches to another Supplier, there should be a meter account taken. In case this does not happen, the profile method is use to set the electricity used in the period from the meter account known and the date of change.

Development of profiles
There are 3 main groups of profiles in the Netherlands, depending on the grid connection:

- E1: connection of 3x25 Ampere or less
- E2: connection between 3x25 Ampere and 3x80 Ampere
- E3: connection of 3x80 Ampere or higher and no continue measuring

Each group is subdivided in more specific groups, resulting in a total of 9 profiles.

Table 1 gives an overview of these profiles which are described in more detail in the following section. As a rule, households have an E1 profile while non-domestic customers have an E2 or E3 profile, depending on their electricity us.

Table 1 Electricity profiles for small customers in the Netherlands

Code	Characteristics
E1	connection of 3x25 Ampere or less
	E1A: single tariff
	E1B: two tariffs: day/night (2300-0700h)
	E1C: two tariffs: day/evening (2100-0700h)
E2	connection between 3x25 Ampere and 3x80 Ampere
	E2A: single tariff
	E2B: two tariffs
E3	connection of 3x80 Ampere or higher and no continue measuring
	E3A: connection time (PBT) <= 2 000 hours
	E3B: connection time (PBT) >2 000 hours and <= 3 000 hours
	E3C: connection time (PBT) >3 000 hours and <= 5 000 hours
	E3D: connection time (PBT) > 5 000 hours

Every three months the grid administrator prepares a proposal for the profiles that will be used in the next quarter of a year. This proposal is judged in a committee that decides on the set of profiles.

Load profile data is based on actual 15 minutes demand data.

The number of profile customers is estimated to be around 7 million. More detailed data seems to be not available.

Factors used to modify profile shape on a daily basis

The basis of the standard profiles is the profile fractions. A profile fraction is the 15 minutes demand of a standard annual electricity user and is in 9 digit form (8 data after the comma).

For the **assumed profiled consumption** the profile fraction is multiplied by:

a. The tariff correction factor;
b. The climate correction factor.
c. Sum of standard annual consumption of all customers per programme-responsible party in a profile category and in a specific tariff category.

Consequently there are two factors in principle which are used to modify the profiled consumption. The **climate correction factor** is a climate-dependent multiplier that can vary between profile categories in order to correct the various profiles for climate influences. Since the introduction of the profiles in The Netherlands the climate correction factor, for electricity, has been set equal to 1.

In the Netherlands, profile customers can opt for a two-tariff system for electricity; a normal or peak hours tariff and a low (night or evening) tariff. To take this into account the **tariff correction factor** is used. This factor is a multiplier used per programme-responsible party (PRP) and per profile category. This is applied if one or more tariff subcategories with both peak and off-peak hours are applicable within a single profile category. This correction factor is in 4 digits (3 data after the comma).

4.3 Profile Settlements System in UK

In order to remove the need for half-hourly metering for smaller customers (i.e. those with a maximum demand less 100kW), a number of load profiles have been developed in order to facilitate the introduction of electricity supply market competition for these customers. It was decided that eight different profiles (referred to as profile classes) would be required, each providing the daily time based consumption pattern of electricity over a period of one year for an average customer within each profile class. The eight generic Profile Classes, that represent large populations of similar customers, are shown in Table 2. There are two profiles for domestic customers and six for non-domestic customers. The non-domestic customer profiles comprise two, where customer demand is unrestricted (i.e. there is no maximum demand element), with the remainder classified according to customer peak load factor, defined as the ratio of the annual energy consumption over the amount of energy that would have been consumed if the maximum demand had been maintained throughout the whole period.

$$\text{Peak load factor (\%)} = \frac{\text{annual energy consumption}}{\text{maximum demand x no. of hours in year}} \cdot 100$$

Table 2 Description of Profile Classes

Profile Class	Customer Type
1	Domestic Unrestricted
2	Domestic Economy 7
3	Non Domestic Unrestricted
4	Non Domestic Economy 7
5	Non Domestic Maximum Demand (peak LF < 20%)
6	Non Domestic Maximum Demand (20% < peak LF < 30%)
7	Non Domestic Maximum Demand (30% < peak LF < 40%)
8	Non Domestic Maximum Demand (peak LF > 40%)

Typical load profile shapes for a winter weekday are shown in Fig 11.

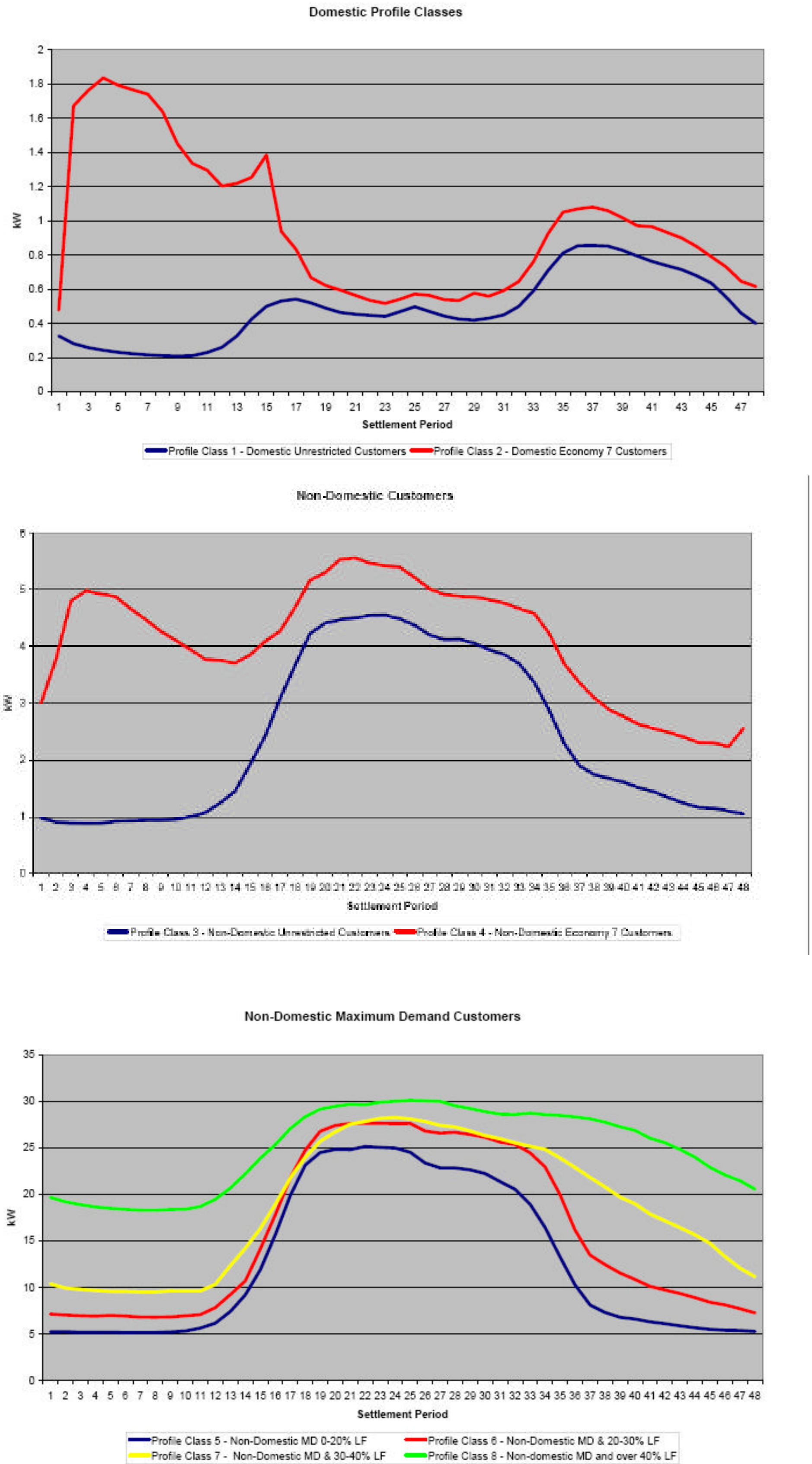


Fig 11 Example load profile shapes (winter weekday)

The following sections provide an overview of how profiles are developed and the factors used to modify the profile shape on a daily basis to account for seasonal changes.

Development of profiles

Load profile data is based on actual half-hourly demand data from a representative sample of customers. The customers are selected using a stratified sampling technique, whereby customers are grouped into relatively homogeneous sub-groups, or strata, and random sampling then applied within each stratum. The aim is therefore, to select a sample of customers that are representative of the distribution of the population as a whole. Using this approach, it is possible to produce a weighted mean, based on the percentage of customers within each stratum (or sub-group) for the population as a whole, which has less variability that the arithmetic mean of a simple random sample of the population. As a result, the sample size can be significantly reduced.

For example, a typical stratification for domestic customers would be:

- Stratum 1: Customers who consume less than 3,000 kWh per year
- Stratum 2: Customers who consume between 3,000 kWh and 7,500 kWh per year
- Stratum 3: Customers who consume over 7,500 kWh per year

The samples are determined and analysed according to Grid Supply Point (GSP[1]) group, which refers to the GSPs within a specific region, of which there are 12 in England and Wales and a further 2 in Scotland.

The weighted mean demand for a settlement period for the sample of customers within a profile class for a particular GSP group is therefore determined using the following equation:

$$\text{Weighted average demand in settlement period h1} = \sum_{x=1}^{x} \left(\frac{\sum_{i=1}^{n_{Sx}} D_{Sx,h1,i}}{n_{Sx}} \cdot \frac{N_{Sx}}{N} \right)$$

Where

N = number of customers within the profile class within the GSP group population

N_{SX} = number of customers within Stratum X within the GSP group population

n_{SX} = number of customers within Stratum X in the sample

D_{SX} = demand of customer i within Stratum X, during settlement period h1.

According to the Balancing and Settlement Code the Profile Administrator has the responsibility to:

- Create and maintain a load research sample using customer information provided to it by Suppliers and to carry out a programme of load research in order to collect half-hourly demand data from customers;
- Analyse data collected through the load research programme and from other sources approved from time to time by the Panel; and
- Derive sets of Regression Coefficients for each Profile Class.

[1] A GSP is a sub-station where the Distribution system is connected to the Transmission system

Suppliers have an obligation to provide the Profile Administrator with enough customer details for the profile administrator to select customers to sample for determining profiles.

Size of samples for profiles
The profile administrator aims to sample 2500 of the 25 million customers in the UK to keep the profiles up to date. In December 2005 the Profile Administrator was struggling to recruit enough participants to log demand to update profiles and reported that customers were leaving the logging scheme at 7.5% per annum. The table below shows the number of samples needed and logged for each profile class in January 2006.

Table 3 Existing Sample Figures

Table 1 – Existing Sample Figures

Profile Class	Installed Sample	Minimum Required Data	Average Collected Data
1	697	500	454
2	562	450	372
3	362	300	277
4	286	250	221
5	178	180	136
6	113	100	90
7	107	100	81
8	204	180	144

In addition the equipment used to log demand is 10-20 years old and there is an increasing risk of its failure. In 2006, it was therefore proposed that investment should be made to install, modern half-hourly meters at a cost of £600 000.

Regression analysis
Regression analysis is used to determine the regression co-efficients used to estimate from the energy use, the demand of a particular customer for a particular settlement period on any given day. There are fifteen basic regression types representing five seasons and three day types, as summarised in Table 4.

Table 4 Regression Types

Seasons:	Winter Spring Summer High Summer Autumn
Day types:	Weekdays Saturdays Sundays

Regressions are performed on a half-hourly basis within each of these fifteen day types using a number of variables, a brief description of which is provided below in Section 0. The output of this process is the regression co-efficients for each profile class according to season, day type and half-hour settlement period, an example of which is given in Table 5.

Table 5 Example Regression Coefficients

Profile	Season	Day Type	Period	Temp	Sunset	Sunset Sq.	Mon	Wed	Thu	Fri	Constant
1	Autumn	Weekday	1	-1.33E-03	-3.11E-05	4.66E-06	7.49E-03	-3.99E-05	-1.60E-03	1.04E-03	0.322

Regression Variables

Three types of regression variables are used to modify the profile shape on a daily basis to account for seasonal changes etc. These are described below.

Temperature

The effect of temperature on demand is correlated using noon effective temperature, which is designed to take account of residual heat within the fabric of buildings. It is a weighted average of the noon temperature on the three days up to and including the relevant settlement day. It is calculated using the following formula:

Noon Effective Temperature on day d (NET_d) = $0.57 \times T_d + 0.28 \times T_{d-1} + 0.15 \times T_{d-2}$

Where
T = the noon temperature

Sunset variables

Two sunset variables are used; these are generally referred to as 'the sunset variable' and the 'sunset variable squared'. The sunset variable is defined as the number of minutes before or after 18:00 that sunset occurs (i.e. a positive or negative value) to allow for the effect of sunset on the time that lighting is switched on. The sunset variable squared provides a positive value across the year to reflect and seasonal variations.

Week-day variables

A number of dummy variables are used, expressed as 1s and 0s, to reflect the effect that day type has on the pattern of energy consumption. For example, the winter heating load in a non-domestic property will typically be higher on a Monday, due to the fact that such buildings are generally unoccupied over the weekend. Tuesday is taken to be the 'standard day'. For other days a dummy variable is applied, for example, if the day is a Monday, the Monday variable is set to 1 and for all other day types it is set to zero.

Economy 7 customers

Estimating the demand of Economy 7, off peak storage heating, customers is a little more complex than that described above, an additional two steps of data processing are required. Firstly, the total load is apportioned between switched load and base load, as indicated in Fig 12, based on sample customer data. Secondly, the Economy 7 switched load profile undergoes a procedure referred to as algorithmic profiling, which is a technique that allows the switched load to be assigned to time periods other than the standard Economy 7 storage heating period of 00:30 to 07:30

as shown in Fig 13. This enables Suppliers to switch heating loads at other times or have split charging periods. The assumption behind algorithmic profiling is that the day to day total consumption of the switched loads (i.e. the heating loads) is similar, irrespective of the actual switching times.

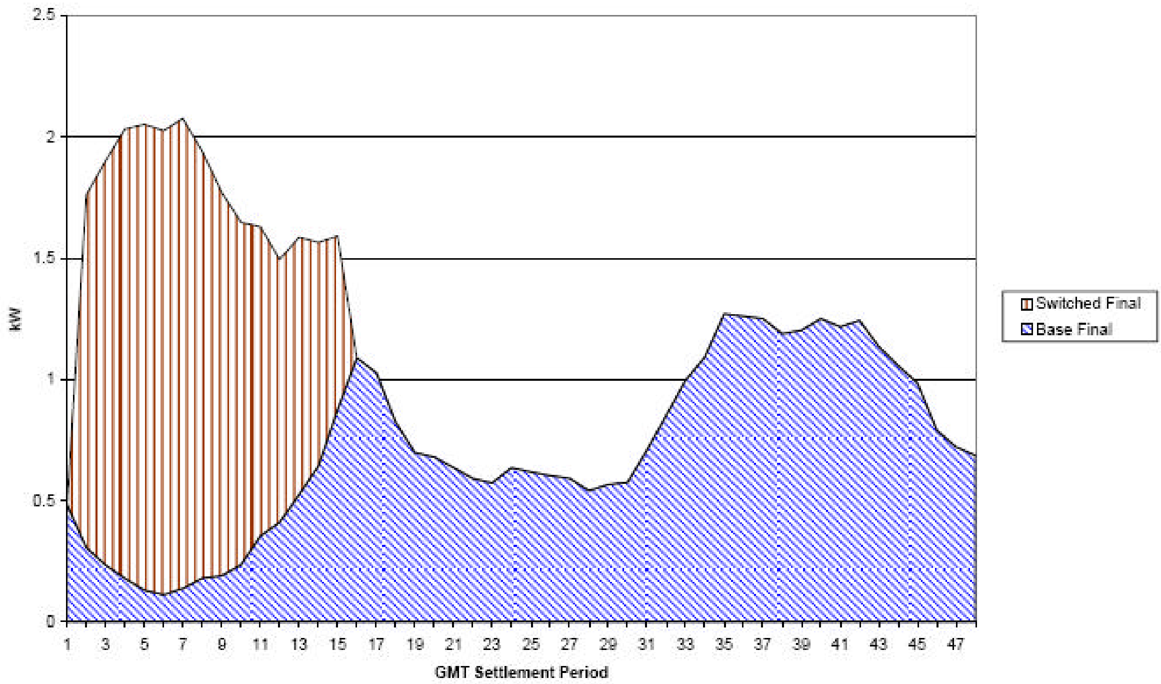


Fig 12 Economy 7 profile split into switched load and base load

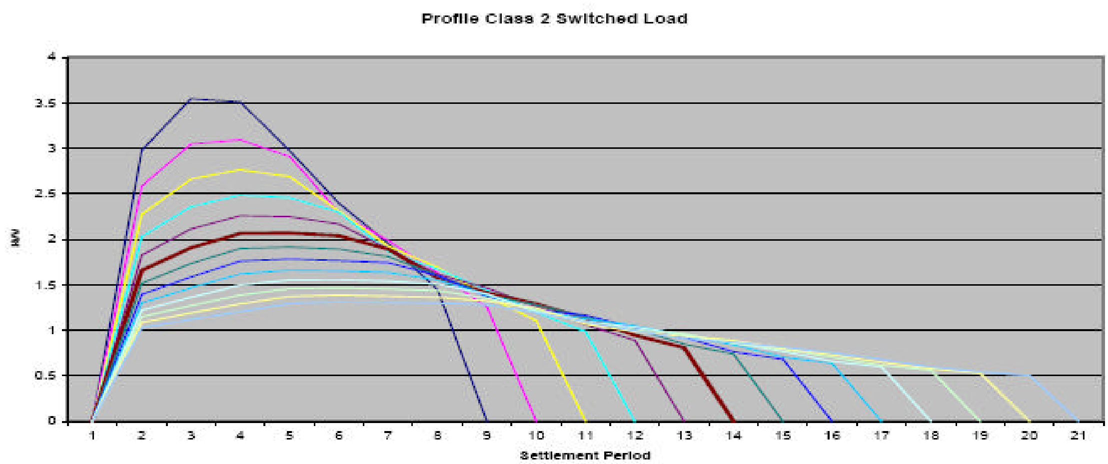


Fig 13 Algorithmic profiling of the Economy 7 switched load

This process is referred to as "chunking" and is used to ensure that the profile co-efficients for the switched load and base load are combined in the correct proportions. It is essentially a process to allocate an amount of energy to a particular time period.

Application of profile settlements in UK

The operation of the settlement system for non half-hourly (nhh) metered customers is undertaken by Elexon and various Party Agents. The amount of energy used by a non half-hourly metered customer in each half-hourly settlement period is determined by allocating a customer's total energy consumption according to the pattern dictated by their load profile. This is done by applying the appropriate regression co-efficients (i.e. according to Profile Class and GSP) to the appropriate out-turn regression variables. However, these values need to be scaled to take account of the amount of energy consumed by a particular customer relative to the average for all customers within that Profile Class and GSP.

The process can be summarised as follows:

1. Consider customer C that consumed M units of electricity over time interval, t. This is referred to as the Meter Advance.

2. Determine kW consumption for an "average" customer in each settlement period, by applying the appropriate regression co-efficients to the outturn regression variables for each half-hourly settlement period over time interval, t.

3. Calculate the total energy consumed by an "average" customer over the time interval t, by summing the average kW values determined in step 1.

4. Determine the proportion of annual energy consumed by an "average customer" over the time interval by dividing the total energy consumed by an "average" customer over time interval t (determined in step 2) by the annual consumption of an "average" customer, calculated using the ten-year average NETs and sunset variables. This is referred to as the Group Average Annual Consumption (GAAC).

5. The annual energy consumption of customer C is therefore determined by dividing the meter advance M by the proportion of annual energy consumed over the time interval (i.e. value determined in step 4). This is referred to as the customer's Annualised Advance (AA).

6. The energy used by customer C in each half-hourly settlement period is therefore determined by scaling the values (determined in Step 2) by the ratio AA to GAAC.

These calculations are performed at the level of GSP Group, so that for each half-hourly settlement period, the amount of electricity consumed by the customers of a given electricity Supplier is estimated from the sum of the actual consumptions of all their customers with half-hourly metering plus the estimated consumption of all their nhh, profiled, customers. The total metered demand for the GSP Group is then compared with the sum of the 'takes' of all the Suppliers active within that Group. The difference between these two values is referred to as the GSP Group Correction Factor, and represents the errors arising as a result of the profiling process. The error is then corrected at each GSP Group by apportioning it to each relevant Supplier in proportion to their demand of the nhh metered customers.

5 Demand Response and Profile Settlements

5.1 Settlement with Tariff TOU Pricing

Demand profiles of customers will change as a result of applying demand response motivating tariffs and controls. New profiles will be required for a Supplier to gain benefit from the delivery of Demand Response. The actual demand response will be uncertain if customers have control of power usage and may choose to use power at times of high price. The change in profile shape may be mixed and possibly reduce over time. With remotely variable tariffs, Suppliers could increase the price differential to encourage customers to continue to smooth their demand profile.

In the first year of a Demand Response motivator scheme, profiles could be estimated by considering the impact on existing profiles of moving the use of appliances such as washing machines, dishwashers etc. or simply by assuming a percentage reduction in peak demand. If logging devices (with the agreement of customers) were installed with the meters after the first year, profiles could be improved. It is not believed that the additional (incremental) cost associated with the provision of this logging equipment would be significant to the overall cost given the requirement for new meters and communication.

5.2 Size of each Grid Supply Point Group and error in settlement

Each GSP Group in the UK is a distribution network operator licence area (i.e. the network that it feeds is maintained and controlled by one distribution network operator under one license). Although the sizes of GSP Groups vary, each has around 2GVA of peak demand and around 2 million customers.

It is believed that the GSP Group Correction Factor is typically less than 10%[2], although errors can occasionally be larger than these at weekends when customer demand is more variable.

Although no work has been done to estimate the potential impact of dynamic demand management on the magnitude of the GSP Group Correction Factor, an analogy can be drawn with similar work done with regards to the impact of micro-generation on the profile settlement process. A recent study suggests[i] that a penetration of 33,000 micro CHP installations of approximately 1kW capacity each would introduce significant errors into the Settlement Process. Therefore, assuming dynamic demand management options result in a change in the demand profiles of domestic customers of a similar magnitude to that caused by micro-CHP, it would appear that GSP Group Correction Factors would be significantly affected by dynamic demand management involving a relatively low (a few 10s of thousands) of customers.

Demand Response driven profile change would need to deliver hundreds of MW of capacity equivalent in order to be effective as part of the provision of system capacity. The larger the contribution Demand Response makes to providing capacity, the larger will be the error between profile calculated and measured demands unless new profiles are developed. However, demand response motivating mechanisms and customer response to them would be installed over an extended time scale so that Group Correction Factors could be monitored for the impact of Demand Response and decisions made regarding possible modification to profiles or use of TOU metering.

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[2] Information provided by Elexon

5.3 Dynamic profiles

In theory, a series of 'generic' DSB profiles could be produced to reflect the change to demand profile resulting from specific actions, in a similar way to that used for properties with micro-generation technologies.

Thus, the consumption would be settled according to the meter advance using the standard settlement profile, with the Demand Response action treated separately, as highlighted in Fig.14.

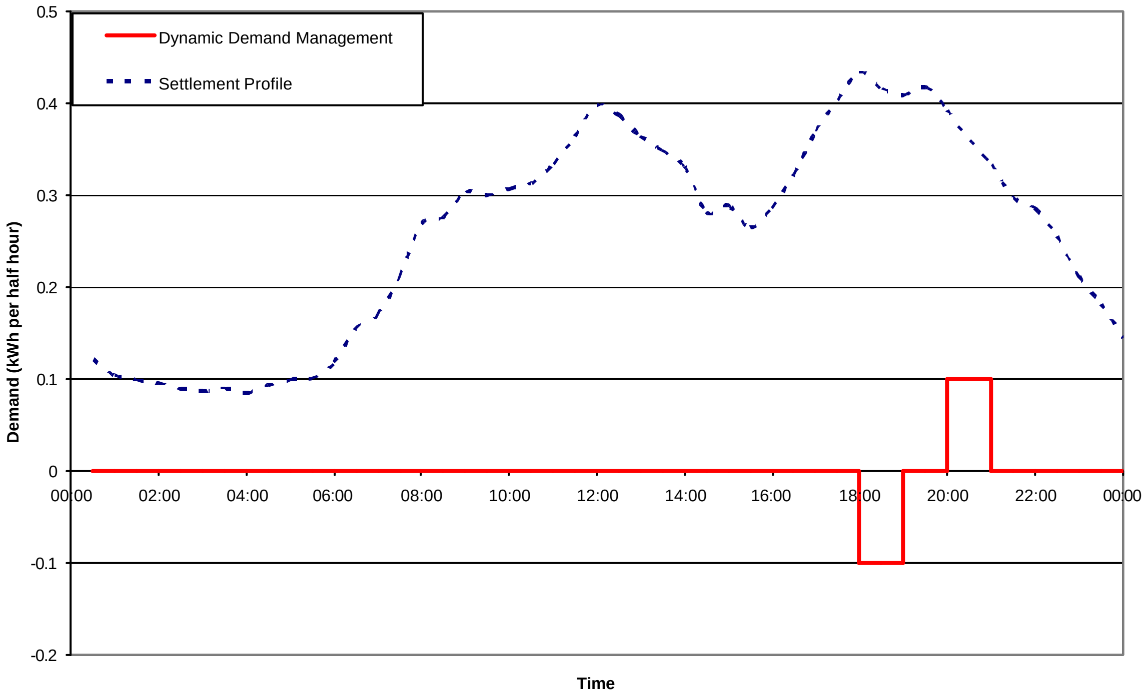

Fig 14 Dynamic demand profiles

In this example, the 100Wh of demand (i.e. 100 W over 1 hour is shifted from 18:00 to 20:00, as represented by the red line in Fig14 above. The dotted blue line is a representation of the energy consumption of the house with no dynamic demand management according to the standard settlement profile. Thus, the red line represents the 'adjustment' that needs to be made to the settlement process to reflect the dynamic demand management actions undertaken. With this approach, any dynamic demand actions can be attributed to specific customers and/or their Suppliers within the settlement process. However, the inability to directly measure 'non-consumption' may require the use of statistical techniques to quantify the 'kWh' demand shifted.

With this option, dynamic demand profiles would need to be developed in order to reflect the specific changes to demand that occur as a result of demand side actions. In the interim, simple profiles could be used in much the same way that the initial profiles for export from micro-generation technologies were developed in the UK under P81. However, the approach for Demand Response is more complicated than that currently applied under P81. In particular, there is a requirement for the profiles to be adjusted on a day to day basis, according to when and if the demand management actions are undertaken. The role of constructing the profiles could be undertaken by Elexon, or alternatively by a 'certified' third party.

Suppliers not directly involved in Dynamic Demand management would require reassurance that they were not adversely affect by the new profiles, although comparison of the GSP Group correction factors on days with and without demand management should provide a useful guide to the accuracy of the profiles.

This approach is not dissimilar to that currently being proposed for the settlement of energy consumed by un-metered street lighting in the UK. At the present time, the energy consumed by street lights is estimated by local distribution network operators, based on the number and wattage of the lights. Daily profiles are generated based on sunset and sunrise times. The advent of central management systems to dynamically adjust the time that lights are switched on and off and/or dim lights according to actual conditions, has resulted in the development of a proposed modification to the settlement process. This allows authorised or 'certified' third parties to submit 'dynamic' profiles according to the switching regimes applied.

5.4 Multi-register metering

Rather than use dynamic profiles, it should be possible within the current metering and settlement system for Suppliers to use multi-register meters to identify energy consumed during times of demand management. For example, consider a meter with two registers, with one (the normal register), recording energy consumed during 'normal' periods, i.e. those without dynamic demand management. The second register is then used to record how much energy is consumed during specific periods of demand management, the timing of which would be dynamically controlled. Although, this could enable customers to manually manage their demand, it is more probable that Suppliers would control load remotely to coincide with the activation of the 'high' rate register. A 'chunking' process as used in the UK and described in Section 3, would then be required to allocate the energy consumed to the appropriate time period.

Multi-register meters are already in use for customers with economy 7 and other 'seasonal time of day' tariffs. However, with the exception of radio-teleswitching for storage heater loads in the UK, the timing of the periods is fixed.

Therefore, any Supplier adopting this approach would be required to provide an interface to the settlement process to ensure that the dynamic switching regime sent to customer demands is captured, as is currently done for radio-teleswitching.

A limitation to this approach, which arises due to the way that the settlement process operates, is that such dynamic switching of loads is restricted to the half-hourly settlement intervals, i.e. switching can only take place on the 'half-hour'. Thus the use of multi-register meters would only be effective for half-hourly blocks of Demand Response.

5.5 Demand Response Businesses

The organisations motivating smaller customers to participate in dynamic demand management can be classified according to the main contracting party or organisation involved in 'purchasing' the demand response.

- System Operator led schemes, whereby the System Operator contracts directly with customers for demand response to assist with maintaining the quality and security of the electricity supply system; (The actual contracting position of System Operators in terms of actually purchasing balancing capacity or Demand Response is different in different countries);

- Supplier led schemes, whereby the Supplier actively manages the demand of its customers (or encourages its customers to do so) in order to reduce the cost of wholesale energy purchases;

- Third Party led schemes, whereby an intermediary contracts with customers for demand response which is then sold on to either the System Operator or traded in much the same way that the output from generators is traded; and

- Energy Service Company led schemes, whereby the Energy Service Company buys and sells power from a Supplier via a single meter interface whilst actively managing the demand of its customers to ensure a favourable price is obtained from the Supplier.

The impact of each of these on profile settlements is highlighted below.

System Operator Led Schemes
In this case, customers are aggregated by the System Operator in order to assist with maintaining the quality and security of the electricity network. As highlighted in IEA DSM Subtask 2 and 3 reports, the use of profile settlements may not necessarily be a barrier to the implementation of this type of dynamic demand management.

It is reasonable to assume that individual customers take the same amount of energy over the day both with and without dynamic demand management (with demand simply moved from one time of the day to another)[3]. Therefore, when the quarterly meter readings split into the half-hourly values based on profile coefficients, the resulting values will be the same whether or not dynamic demand management had taken place, thus there is no impact on the contracted position of Suppliers.

There would, however, be a impact in terms of the size of the GSP Group Correction Factor at times when demand had been actively managed, reflecting the deviation in consumption away from the typical profile. This could leave Suppliers in a position where they may have purchased more electricity to cover the anticipated demand of their customers than was actually required, once the GSP Group Correction Factor has been taken into consideration. Thus, Suppliers may require to be financially compensated for the Demand Response actions undertaken by System Operators. However, any savings made by the System Operator in terms of the costs of maintaining the quality and security of the electricity system through the use of Demand Response would be passed on in the form of reduced Balancing Services Use of System (BSUoS) charges levied on all Suppliers and Generators.

Supplier Led Schemes
Profile settlement systems at present do not allow Suppliers and/or their customers to benefit from actions taken to reduce demand, for example when electricity prices are high, although doing so would clearly be of benefit. One solution would be to move to half-hourly metering and settlement as currently applied to customers with

[3] This assumption would seem reasonable for shifting appliance energy consumption and for heating and air-conditioning loads shifted over relatively short time frames.

demands over 100kW. Suppliers would be charged for the actual amount of electricity consumed by their customers, rather than that determined by profiles. It would then be up to Suppliers to determine how best to implement Demand Response with their customers; options could include:

- Time of Use (TOU) tariffs, so that customers are charged the 'true' cost of electricity, and it would be up to the customer to determine whether and how to manage their demand in response to the price signals provided. However, little is known about customer response to such tariffs over the long term, although the Energy Reduction Pilot Trials being carried out in the UK may provide some results in this area;

- Single rate tariff, but with the Supplier having automatic control of certain customer loads to ensure that specific demand reductions are applied. Otherwise the Supplier risks exposure to high electricity prices in the market without being able to pass these onto to its customers. Under this arrangement, it would seem unlikely that Suppliers would be willing to offer customers the option to manually over-ride the actions taken by the Supplier to reduce demands.

Both these options require meters capable of storing half-hourly meter data as well as two-way communication. However, the major barrier to half-hourly metering for the domestic sector seems to lie with the cost of collecting the meter data and entering it into the Settlements process, rather than the actual technology costs. As a result, there seems to be a general consensus that it is not cost effective to settle using smart meters for domestic properties in the half-hourly market.

For example, a Supplier in the UK typically charges a customer a monthly fee for half-hourly data collection and aggregation, which can vary from between £18 per month to £50 per month, although most charges are at the lower end of this range, whereas the fee for non-half hourly metering would be in the range £15 to £20 per annum. However, these prices per customer could reduce significantly if many millions of customers were involved.

One option being explored by a consortium comprising a UK Energy Supplier, a meter manufacturer and a metering association is the use of half-hourly meters to collect actual consumption data which is used in parallel to the Profile Settlement process to correct the difference between actual energy flows and profiled energy flows. The main application is to ensure that customers with micro-generation benefit from the change in their consumption profile, which can be particularly valuable at times of peak prices.

Other options for Suppliers to capture the value of Dynamic Demand Response actions include;

- The use of dynamic profiles; and
- The use of multi-register meters with dynamic switching regimes.

Third Party Led Schemes

Third party led schemes are possibly the most complicated mechanism for implementing Dynamic Demand Response in terms of the impact on the profile settlement process. 'Proof' is required that the demand is available for 'turndown' before it can be sold, and similarly 'proof' is required that the demand change was actually delivered. For larger customers, real-time metering provides valuable information on customer demand in real time, whilst minute-by-minute measurements provides a direct measure of the level of demand reduction delivered. Neither of the metering options is realistic for large numbers of small customers due to the costs involved.

While the value of the demand side response can be captured via the use of dynamic profiles, there will be a need to ensure Suppliers are charged for the energy that customers would have consumed without dynamic demand management. Otherwise any financial benefits of dynamic demand management actions could be passed onto Suppliers via the GSP correction factor. This requires the third party or 'aggregator' to ensure that dynamic demand management actions are linked to specific MPANs. (The MPANS is the unique customer meter reference number in UK). Currently, information on MPANs (i.e. the MPAN for a particular address and information on who the supplier is for a particular MPAN) is only available to suppliers and non-domestic customers. However, it would seem entirely reasonable for this information to be made available to registered Third Party Aggregators

Energy Service Company Led Schemes

Although ESCOs exist in the UK, the vast majority of these operate in one of the following ways:

- The profit from renewable generation or CHP plant (often community owned) is distributed to the participants via energy efficiency measures or through share dividends;
- A CHP plant sells heat via district heating schemes and sells power to a supplier;
- Heat and/or power is supplied to tenants of a building or cluster of buildings from locally generated power generally with one meter for power imported from the network.

Some examples of ESCOs in the UK are provided in Appendix A.

Thus, a village or definable community could create an ESCO (or a Supplier could offer the service) to buy and sell energy with a Supplier from a single meter interface. Depending on the size of the ESCO, it could either use half-hourly metering or a range of tariffs throughout the day for its customer. It would have greater negotiating power like a larger customer. Within the ESCO, customers could use micro generation and demand side management to reduce peak demand or achieve other targets agreed in the contract. Each customer would need to have a meter to measure import and export of power. Different tariffs or automatic switching could be used to ensure demand management was implemented. Savings could be returned to participants by low a lower price of energy, by providing energy efficiency measures etc. or by a share dividend.

The ESCO could be considered like a larger user of power as far as profile settlements is concerned. This still may require a new profile if half hourly metering is not used. However the Supplier and ESCO could agree a profile to aim to achieve and the ESCO could be penalised for a significant deviation from it if.

The cost of installing the equipment required would fall to the ESCO rather than the Supplier and therefore the risk to the Supplier would be minimised. As the ESCO is installing the equipment, it is in their interest to maximise the return by achieving the Demand Response and peak reduction agreed. Whether such a scheme is viable depends on whether the ESCO could achieve sufficient benefit to cover the cost of controls, micro generation or half-hourly metering.

5.6 Profile Development

No new profiles have been produced in the UK since the introduction of the profiling system in 1988. However, some significant changes have been made to the settlement system to encourage the use of micro-generation technologies. In particular, an amendment to the rules that set out the settlement process[4] was introduced so that domestic customers were no longer required to have half-hourly metering for any electricity exported. More specifically, it allows electricity Suppliers to ensure that any such exports are accounted for within the settlement process. This process can be considered to be similar to that of Dynamic Demand Response. Prior to this amendment, any electricity exported without half-hourly metering was treated as 'spill', with the benefit being distributed among all Suppliers within the GSP Group through the apportioning of the GSP Group Correction Factor.

These new arrangements have established a series of export profiles for each of the various micro-generation technologies (i.e. wind, hydro, PV, micro-CHP). These are referred to as standard settlement configurations (SSCs), and work on the principle of allocating the export to specific time periods.

In the Netherlands, the existing system of normal and evening/night tariff is taken into account in the profile settlement system by means of the tariff correction factor. The customers with a single tariff have on average lower electricity use than those with two tariffs (in 2003: 2865 kWh versus 3860 kWh).

At the present time, the price for electricity for profile customers comprises ¼ for production costs, ¼ for distribution costs and ½ for VAT and energy taxes. Consequently, only half of the electricity price is related to direct costs that could be influenced by a Supplier or an ESCO. In a 2004 study (Siderius et all) it is stated that profile customers will need new contracts (additional to those that are now operational with a lower cost evening/night tariff) if they are to get financial advantage from Demand Response. Three options were proposed:

a) price differentiation or variable pricing
b) maximum power cut off (Demand Limiter)
c) contract for remote switching of demand

The study concluded that the existing system of profile settlements is a barrier to tailor made electricity supply. Based on interviews with key players Siderius et all concluded that:

- Electricity Suppliers have no active policy for Demand Response participation by profile customers;
- Electricity Suppliers give priority to improving the administrative system and the billing in the free electricity market;
- Electricity Suppliers are reluctant to invest in Demand Response as it is not clear who should invest in new infrastructure and who would get the future benefits;

[4] Referred to as modification P81, which was introduced in September 2003

- Not only the Suppliers and their branch organisations, but also customer organisations hold the opinion that profiled customers are not interested in new services related to Demand Response;

- Reasons for this lack of interest are caused by the fact that customers have no or minimum insight into:

  - Their electricity use over time;
  - The tariff components and the way these could be influenced
  - The way they could change their usage and gain financial advantages.

6 Future Metering Systems

TOU metering has the potential to remove the problem of Dynamic Demand Response for smaller customers in terms of profile settlements. However, profiles are also used to determine supplier demand in near real time and TOU customer metering is not able to do this unless high speed remote data collection and processing are also included. This is not really a feasible option in the foreseeable future. Consequently, even if TOU metering were installed at smaller customer premises for a variety of reasons, some form of profile settlements system may still be required.

6.1 Future metering systems

Currently the Spanish legislation obliges the installation of advanced TOU meters to customers consuming more than 450kW of peak power.

The installation of advanced meters in the small customer segment is not yet a requirement. There is, however, one distribution company (ENEL-Viesgo) that operates in the north of Spain, that has decided to replace the standard meters of all their 600,000 domestic customers. They started the replacement during the year 2006, and at present time (July 2007), around 100,000 new meters have been installed. The new meters allow the remote metering of hourly consumption. At the present time, no special TOU tariffs are being applied and for billing purposes the total energy consumed every two months is used. This shows that the non demand side management related benefits (improved operation costs and procedures), can justify the installation of the advanced meters. However, ENEL-Viesgo expects to make the most from the meters in the coming years, when TOU tariffs are introduced.

Several pilot installations have also been developed in the residential segment. They were funded by the Government using income from the integral tariff for the year 2005. An initial budget of €10M was planned, allocating €30 per metering point. In reality, a very small part of that amount was used and around 5000 meters have been installed by the rest of the distribution companies. The main aim of the pilot installations is to evaluate the technical viability of the systems. The experimental remote data collection is also used for internal policy research within utilities. However, participating customers are still supplied and billed using a fixed tariff. Most of the installed meters are not located inside the household. They are located in the basement of apartment buildings and customers cannot easily access the recorded information.

Use of Power Limiters to control system peak

The meters that have been installed allow the remote modification of the maximum power that a customer can consume. This can be extremely beneficial as according to a survey performed by REE, more than 50% of the residential customers in Spain do not own a power limiter. Power limiters are small relays that trip when the power consumed in a household exceeds a preset threshold. When the relay trips, the complete household loses the supply. Customers must then disconnect some loads and manually reconnect the relay. The possibility to remotely modify the setting of the relays is very attractive from a network operator point of view and could potentially reduce network congestion problems in a very simple way.

Government plans for smart meters in Spain

The Spanish Government is clear and plans to progressively force the installation of smart meters in every household. The royal decree 809/2006 states that starting from the 1st of July 2007, every new meter installed in the residential sector must allow the hourly measurement of the consumption, remote metering, and the remote modification of the supply conditions. It is very likely that a similar decree forcing the change of all the existing domestic meters will follow soon. Distribution companies are not completely happy with this decision and the date will probably be postponed. The main argument is that the main functionalities of the meters are still unclear and require careful examination. A specific measuring protocol is still to be developed and the possibilities for introducing particular demand side management functions and programs should be further considered.

If Government plans go ahead, it is likely that the elimination of the "integral tariff" and the installation of smart meters will be coincident in time. Even if advanced demand response and demand side management programs are put in place, the existence of TOU meters and advanced communication infrastructure will reduce the relevance of the profiles used for settlement, eliminating the need for extensive work on profile development.

Vision of REE

The operation of the transmission network in Spain is becoming challenging. Peak demand increases year by year, especially in some particular regions. The penetration of wind generation is also increasing, and the permission to build new transmission infrastructures is increasingly difficult to obtain. For these reasons, the main interest of REE is related with the initiatives that provide dynamic changes to the aggregated load shape. Remote appliance switching, together with critical peak pricing, could be an attractive solution. REE believes that, if these types of demand response initiatives are implemented, they will be associated with smart metering and two-way communication systems. These issues are also being addressed in many other countries.

6.2 Future Metering Systems in Netherlands

The Ministry of Economic Affairs in the Netherlands is in favour of "smart" meters for all users in the Netherlands and is about to finalise the legislation process to put this in place. The proposed law seeks to achieve complete "smart" meter roll-out within six years from its start date, which is expected in early 2008. Additionally the Ministry wants to optimise the process and to be able to take advantage of all the benefits. The "smart" meter is assumed to be an important element in facilitating competition. Therefore 'customer lock-in' should be avoided and the technology should not become a barrier to customers switching Supplier, either physically or administratively.

The ownership of the meters will in future be with independent, non-competitive, regulated network operators. In the Netherlands the network operators – of which there are four main ones, Eneco, Continuon, Essent and Delta– will be responsible for the roll-out of "smart meters", and will own the meters.

In addition, in the case of new connections, new builds and other changes, such as end of lifetime or meter pooling, the installation of "smart" meters by the network operators will be compulsory.

The management of metering data will be with the competitive Suppliers. However, who will be also responsible for all customer related processes.

It is foreseen that the "smart" meter will become the central 'hub' for demand and supply, and an optimal facilitator for energy management. The "smart" meter will provide an extra gateway into the home and the data should be available – subject to the usual privacy requirements – to all those who want to utilise it. These are the network operator and the Supplier, but there are also third parties such as smart home application service providers.

The metering process and infrastructure are also required to facilitate energy savings in an optimal way the energy savings. The availability of metering data is crucial in this respect. For this reason the government is mandating a standardisation process. The proposed functionalities of the "smart" meter are the following:

- Ability to remotely read how much energy has been consumed or how much put back into the system in cases of individual (decentralised) generation;
- Ability to remotely connect and disconnect the customer supply;
- Ability to remotely read the meter and monitor power quality;
- Ability for an online interaction between customers and Suppliers;
- Ability for real time response of controllers in energy systems.

These in turn give rise to potential applications such as peak load shaping, fraud detection, decentralised energy generation and better distribution system management by the network operator. All of these are important and enhance the operation of the energy market.

Metering and Energy Services Directive

The Ministry of Economic Affairs is finalising the legislation process for smart metering for profile consumers. The main starting point of this process is the EU Directive on energy end-use efficiency and energy services (ESD). Appendix 3 describes the main elements from this directive related to metering. Additionally the Ministry wants to optimise the process and to be able to take advantage of all the benefits, and accordingly they foresee a complete roll-out to all customers.

Nevertheless, the cost of processing TOU consumption information for such large numbers of small customers could be too expensive for Supplier settlements. Profile settlement based on representative samples of customers may be a more attractive option and easy to achieve when all the population can provide hourly data, or probably better, with random sampling of the consumption of each customer.

The process could be complemented or substituted by direct control of some appliance functions by a central smart device, meter or other, which could be more or less dynamic.

6.3 Future Metering Systems in UK

In February 2006, the UK Energy Regulator, Ofgem produced a consultation document on domestic metering in the UK as to how smarter forms of metering could be used to improve customer services, increase energy efficiency, maintain security of supply, tackle climate change and reduce fuel poverty.

The response from Ofgem in June 2006 made the following decisions:

- The UK would maintain competition in the metering sector and not rebundle it into the network operations;

- Ofgem will not mandate the installation of "smart" meters although Ofgem noted that the UK government may consider legislation necessary to comply with the 'End Use Energy Efficiency and Energy Services' EU Directive to be implemented by May 2008. Some interpretations of the directive take it to mean that member states must implement time-of-use metering for the domestic sector if technically and economically feasible;

- Ofgem welcomed the announcement by the UK government on “smart” metering trials and have co-operated with DEFRA (Department of Energy, Food and Rural Affairs) and the DTI (Department of Trade and Industry) in terms of their management.

Ofgem sees its role as:

- Unblocking technical and commercial obstacles to Suppliers proceeding more quickly and more ambitiously with their investment plans particularly on issues such as interoperability of metering applications;

- Chairing a working group to agree technical standards for “smart” meters both domestic and small commercial and including prepayment meters. The group includes Suppliers, Distribution Network Operators and customer representatives;

- Ensuring Suppliers' gas and electricity licences are amended so that any necessary conditions on metering are appropriate for the developing metering services market;

- Committed to resolving health and safety concerns potentially allowing remote diagnostics of meters rather than insisting on the present 2 yearly visual inspection;

- Supporting work to gather more evidence on customer Demand Response and working with government to manage the trials they are funding.

£10 million has been provided by government to co-finance with energy Suppliers trials of different “smart” metering and improved information services for customers to measure their effectiveness particularly in terms of saving energy.

- Clarifying the steps that need to be followed to receive Energy Efficiency Commitment (ECC) accreditation;

  The Energy Efficiency Commitment sets targets for energy Suppliers to deliver energy savings to households and is administered by Ofgem. To encourage the use of “smart” meters in these schemes, EEC accreditation can be claimed for smart meters and associated feedback devices (to be succeeded by CERT, Carbon Emissions Reduction Targets, EWP May 2007). There are further developments planned for the next phase of the EEC, which will run from April 2008 until March 2011. The government is considering making EEC more flexible by allowing the inclusion of microgeneration and measures that help reduce consumption such as “smart” metering;

- Reviewing the price controls on basic gas and electricity domestic metering to ensure that they send the right signals to Suppliers and investors, while protecting customers. Ofgem have issued a consultation paper on the subject and will report on whether they will remove the regulation on meter price in the near future.

- Working with Elexon (who manage the balancing and settlement process in the UK) to ensure that electricity settlement rules are adapted to the needs of "smart" metering. If "smart" meters are to be deployed in large numbers for residential and smaller commercial electricity customers, Elexon have initiated a project to determine what changes are required to their systems and processes to facilitate wide-spread use of "smart" metering. Ofgem will ensure that the interoperability work takes into account progress in this area. Among the issues on Elexon's agenda are the following:

- Access to the half hourly market - more smaller commercial customers might install half hourly meters if it was less onerous and expensive to operate in the market. Elexon is reviewing whether it can reduce some of these requirements for smaller customers.

- Systems – when introducing smart meters that record half hourly data, Suppliers will need to ensure their agents can submit reliable data, which may impact on their accreditation and system certification. There may also be a need to upgrade the settlement system to process increasing amounts of half hourly data.

- Contractual arrangements - the introduction of "smart" meters is likely to require a number of contractual agreements between different parties. It is important that such agreements are aligned with the requirements of settlement especially as they may include parties that have not signed up to and are not included in the Balancing and Settlement Code at present.

- In all of these areas of work, ensuring that the needs of prepayment meter customers and microgeneration are being addressed.

Energy Reduction Pilot Trials

As mentioned above, one government initiative is the co-funding of trials of "smart" metering and other measures that may encourage energy efficient behaviour, in order to evaluate their effectiveness. The invitation to tender identified four main areas that overall the trials should cover:-

1. Methods to encourage energy efficient behaviour without "smart" metering. For example:
    a. Provide additional information on bills (e.g. historical or comparative).
    b. Visual display units that work off existing basic energy meters to give an instantaneous reading of energy use and cost to the customer
    c. Other innovative approaches to encourage customer to become more energy efficient.

2. The use of "smart" meters that can be read remotely is to form the basis of better feedback to customers through enhanced billing information.

3. The use of "smart" meters that, in addition to being read remotely can offer information about consumption and cost of energy over different periods of time in the home through different forms of visual displays.

4. The use of "smart" meters that, in addition to being read remotely also provide energy consumption over different time periods and result in *"time of day"* or *"real time"* tariff offers to customers.

It is only the third and fourth areas that could be used to encourage demand response. The nature of the trials and the preliminary result have not yet been published.

7 Cost and Benefit Issues for Dynamic Demand Response and Profile Settlements

Costs of profile and metered settlements systems

Although the running costs for settlement is low for non-half hourly metered customers, in the UK, the annual cost of maintenance of the profiles is around €1.8million and each additional profile would increase the cost by around 5 to 10%. The costs associated with establishing a new profile have been estimated to be in the range €140,000 to €700,000. This represents the initial costs of setting up the profiles, but does not include the maintenance costs required to cover the continuous monitoring of the sample customers and updating the profiles. This is estimated to be in the range €80,000 to €170,000 per profile per annum.

For a new profile to be developed, the Balancing and Settlement Code (BSC) panel need to be convinced that there are sufficient customers with a significant difference to existing profiles for the new profile to be justified. Once the BSC Panel are convinced there is a need for new profile all BSC parties bear the cost.

Costs of the half-hourly and non-half hourly settlement systems

The rationale for using demand profiles for smaller customer in the UK is that it has not been cost effective to use half-hourly metering settlement. The costs of different systems and the customer demand thresholds for their viability are listed below. Any Demand Response system must also fit into this economic framework.

Half-hourly metering system

It is estimated to cost about €460/year per customer to operate a half-hourly metering system for larger customers in the UK and its cost effectiveness for smaller customers is questionable. However the cost per customer would reduce significantly if millions of smaller customers were involved.

Generators with a capacity of more than 30kW should be half-hourly metered. However those of less than 100kW are not required to submit information within the daily settlement timescale and so do not need communication links to the central systems. Metering for these generators must conform to defined standards and protocols, known as Code 6. This means that the meters must be able to store data for up to 20, 100, 250 or 450 days depending on whether they are associated with manual meter readings at intervals of fortnightly, quarterly, six monthly or annually, respectively. These type of meters cost around €150 whereas those that download data daily cost around €220 with an additional cost of €220 to €420 for communications equipment.

8 Potential Mechanisms for Dynamic Demand Response and Settlements

The financial savings resulting from enabling individual smaller customers to participate in Demand Response are not large. Consequently, any mechanisms that enable their participation in demand markets need to be relatively low cost. Chapter 3 showed that there is a potential demand shift of 400 to 450 watts per customer, on average available for Demand Response. In order to deliver Demand Response infrastructure for smaller customers, the identified options need to be quantified and compared. The comparison needs to be on the basis of delivering an acceptable accuracy of financial settlements among Suppliers at an acceptable cost and any additional costs offset by benefits of Demand Response to customers, System Operators, Suppliers and Aggregators.

The options available for smaller customer Dynamic Demand Response participation infrastructure in terms of profile settlements are:-

- Allow dynamic demand changes to result in additional error at GSP Groups, at least initially. The resulting error is likely to be such as to reduce supply costs to Suppliers.

- Develop new dynamic profiles for Dynamic Demand Response customers. This could involve including the demand switching signals, which are sent to specific blocks of customer demands by Aggregators, being fed into profile settlements systems.

- Mandate that TOU metering is required for Dynamic Demand Response customers. This would involve TOU metering plus data collection/processing. If TOU metering is used without high speed remote reading, TOU data could be used in reconciliation process following initial settlements using profiles. Profiles would also be used to determine individual Supplier demands in real time.

8.1 Accept Error at Group Metering Points

This option is for Suppliers to accept, at least initially, an increased error at GSP Group Metering points. With this arrangement individual Suppliers would not receive specific benefits from the dynamic demand changes. System Operators and groups of Suppliers at metering points obtain benefit.

This is the lowest implementation cost solution and in the short term or where there is limited participation in Demand Response by groups of customers, it would result in only a very small additional error. Dynamic Demand Response based on this approach would allow detailed monitoring to be carried out among the groups of participating customers in order to collect data which could ultimately be used to improve profile accuracy.

8.2 Develop New Dynamic Profiles

Each switching or pricing signal instruction sent to customers or demands has a value in terms of delivered demand change. This demand change could be of value to System Operators but also to Suppliers in balancing contracts if it is targeted at customers associated with specific Suppliers. The issue is to quantify the demand change in any specific hour or half hour period as a result of sending out specific demand change motivator signals to specific groups of customers. If this can be done by modelling and empirical trial results then the profiles used in settlements could be modified to include the dynamic demand changes.

This process would enable both Suppliers and System Operators to obtain benefit from the dynamic demand changes initiated by them or by ESCOs as a contractor to either. However, there will be a significant cost in quantifying the actual demand change delivered by groups of customers in response to a motivating instruction at different times. There will also be a cost for integrating the demand change instructions and their confirmation into the settlements processes. This is done already for storage heater switching in the UK where the customer profile is changed dynamically based on the specific times of switching the storage demand. Whether this “chunking” process can be applied to other smaller customer demands remains an open question.

8.3 Mandate that TOU Metering is required for Dynamic Demand Response Customers

If TOU metering with remote reading is required to be installed at smaller customer premises together with high speed data communication as a prerequisite for participation in Dynamic Demand Response, and the TOU data used for settlements, then this effectively removes the profile system for settling Supplier energy accounts. This is likely to be an expensive option but should be evaluated by countries considering setting up new profile settlement systems. If remote meter reading is not used and the metered TOU data collected at manual meter reading times, then profile settlements could be used and the TOU data fed into the reconciliation process for profiled customers. Customers would be billed on the basis of TOU metering but initial settlements would be carried out using profiles. This would reduce the data processing costs. New profiles may be needed for these customers in response to their resulting demand changes based on TOU pricing.

Customer profiles are also used to estimate the real time demand of Suppliers on a continuous basis in order to validate their demand balance position against agreed contracts. This process would be difficult to replace with TOU metering because of the delay in obtaining the meter advance readings even with remote meter reading.

9 Conclusions

The objectives of delivering smaller customer Demand Response are to save energy and assist System Operation and Network capacity constraints. The impact on profile settlements resulting from these demand changes is influenced in part by what motivators are used to deliver them.

9.1 Option 1 (Energy End Use Feedback)

If the Demand Response is delivered by means of presenting end use information and general costs to customers, then the customer profile may not change much in shape but only in amplitude. The volume error will be included in profile settlements reconciliation processes based on normal meter reading. IEA DSM Task XI Subtask 1 report showed that TOU pricing and metering on their own may not be able to provide sufficiently specific energy end use information to customers to motivate them to save energy. Customer interviews were considered a better option for motivating energy saving.

9.2 Option 2 (Tariff TOU pricing and manual response)

If the demand changes are delivered by Tariff TOU pricing alone then it is likely that peak demand will be reduced and therefore profile shape changed. If the TOU pricing is based on fixed times and prices and manual actions required by customers to modify demand then some customers will modify their end use behaviour to save money. The customer profile shape change resulting from fixed TOU tariff times and prices is likely to be a flattening of the profile. However, this change is a result of manual actions by customers, so that the actual amount of change is likely to vary significantly. The overall impact on profile settlements could be significant if a large percentage of customers opted for this metering arrangement and were prepared to alter their behaviour over the long term. TOU metering, presently being installed in some countries for demand shift purposes, could be used instead of profile settlements for settling Supplier accounts. However, this is an expensive option, particularly because of data handling costs, and profile settlements may still be required in order to calculate real time Supplier demand. New customer profiles could be developed for Tariff TOU metered customers based on measured results over a period of time.

9.3 Option 3 (Dynamic TOU pricing and remote switching demand)

If Dynamic TOU Pricing or even critical peak pricing together with remote switching of end uses and varying times and prices is used to deliver Demand Response, there will be a significant impact on customer profiles. The impact on customer profiles and its predictability will be significantly influenced by whether a demand switch override option is allowed for customers. With an option allowed, the results of this process in terms of Demand Response could be similar to that for TOU metering alone although the price signal may dissuade customers from exercising the override option. If the override option is not allowed then the demand change will be more predictable. The impact of option 3 will result in flattening of the customer demand curve which would have an impact on profile settlements if widely implemented.

Again, TOU metering could be used for Supplier settlements but it requires a large amount of data processing. Profile settlements may still be required in order to calculate real time Supplier demand. New profiles could be developed for these TOU metered plus remote switching customers with the remote demand switching signals be fed into profile settlement systems in order to dynamically modify profiles. This assumes that use of the override option by customers is rare or could be predicted.

9.4 Preferred Options

Based on the effectiveness of the different demand change options and the issues of profile error, it is possible to identify a preferred strategy with which to move forward and introduce Demand Response for smaller customers.

End use monitoring and feedback (option 1) should have minimal impact on profile settlements. Consequently it can be used to save energy and should be implemented now. However, collecting or estimating end use energy consumption is not easy and probably requires “very smart” meters in order to do it with any degree of accuracy. Customer interviews were recommended as the preferred methodology for collecting and presenting disaggregated demand information to customers, IEA DSM Task XI Subtask 1 report.

Tariff Time of Use Pricing (option 2) and Dynamic Time of Use Pricing (option 3) will have an impact on profile settlements if widely applied.

The proposed way forward for these demand response motivating mechanisms is to monitor their impact in field trials and real but limited implementations. If the profile settlement error becomes unacceptable then new, dynamic profiles may be needed to reduce it. This would be technically possible.

It is very important to quantify what energy saving and Demand Response benefits the different information provision, pricing and metering options can deliver before wide scale deployment of TOU metering is implemented. It should be noted that the effects and benefits obtained from relatively fixed TOU tariffs and dynamic programs are different. The first case provides a sustained benefit, modifying the long term shape of the profile, and the second one a short term effect. The economic benefits obtained from the implementation of both types of demand management programs represent the avoided costs, which are different in both situations (higher in the dynamic ones). The consolidated effect of both program types does not necessarily need to be perverse.

In order to implement Dynamic, TOU Pricing and remote switching of end uses, a significant communication infrastructure is required. This infrastructure includes provision of communication with end uses of energy, inside customer premises. It is likely to be a number of years before this infrastructure becomes available on a wide scale. One way communication would be sufficient for this end use switching (inhibiting demand). Dynamic TOU Pricing could be applied without remote switching but would be more difficult to obtain customer acceptance. In countries like Spain, it is likely that dynamic demand response initiatives in the domestic sector will come together with the availability of advanced metering and communication infrastructures.

The ESCO route to delivering Demand Response may be the most attractive in moving forward. This is especially true if the settlements error resulting from demand Response is accepted at least initially by Suppliers. In this case there would be very little incentive for Suppliers to invest in smaller customer Demand Response.

10 Recommendations

Detailed studies are needed to determine the take up by customers of Dynamic Demand Response options based on different drivers, packages and remote switching override options. An assessment is needed of the impact on profile settlements of different levels of take up and over what time scales

EUMF is unlikely to significantly impact profile settlements. The route to delivery of disaggregated energy use information presentation needs to be clearly defined because, in order to be very effective, specific end use data is required. General end use information based on refined national statistics should be provided now to customers.

Field trials of different TOU metering and remote switching control options should be carried out to estimate their impact on profile settlements. Studies should also be carried out to quantify the potential for developing dynamic profiles which include the remote switching signals sent to different groups of end uses being fed into the profile settlements systems.

Even if all domestic customers are fitted with TOU meters with communication capabilities, the massive amount of data managed by the metering and communication system could prove impractical for settlement systems. If this situation occurs, each customer could be metered using just a statistically valid number of days per week which would reduce the size of the databases and the communication flow.

The option of using recently read TOU meters instead of profile settlements should be evaluated.

The business model for applying Dynamic TOU Pricing and its extension to Demand Side Bidding for smaller customers needs to be more rigorously evaluated especially via the Energy Service Company route.

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Appendix 1

Definitions for the Netherlands

Metering

metering code
The metering code defines the conduct agreed between grid administrators and connected parties regarding the metering of data relating to the transmission of electricity and the exchange of metering data. The Electricity Act (1998) stipulates that the joint grid administrators must submit proposals to the Office of Energy Regulation (DTe) detailing a tariff structure and a set of technical conditions (regulations) for grid administration. The Metering Code is one of these technical regulations. DTe has evaluated and adopted the Metering Code proposal submitted by the grid administrators. The metering Code contains conditions for the design and management of metering devices. The Metering Code provides guidelines for:

- the metering of data for electricity transmission and supply;
- the exchange of metering data;
- administrative details of metering devices.

metering responsibility
The responsibility of the connected party for the presence on the grid connection of a metering device required pursuant to Chapter 2 of the Electricity Metering Code, metering devices for the power generated by the connected party itself, and metering devices in the context of the Electricity Production (Environmental Quality) Act (in Dutch: Wet Milieukwaliteit Elektriciteitsproductie), as well as for the correct and timely determination and reporting of the measurement data referred to in Article 1.1.1 of the Electricity Metering Code pursuant to Chapter 3 of the Electricity Metering Code.

metering company
The management of metering devices and the data collection is carried out by an authorised certified metering company. The connected party is free to choose any metering company it prefers. Grid administrators can act as authorised metering companies, too, provided that they meet the requirements listed in the Metering Code and have been authorised by the Committee for Authorisation and Supervision.

Register of Acknowledged Parties Having Electricity Metering Responsibility
In accordance with the Electricity Metering Code and the Gas Metering Code (both based on the Electricity Act of 1998), metering activities may only be outsourced to parties that have been authorised by TenneT to perform such activities. In order to make this information accessible to the public, TenneT publishes a register of recognised programme responsible parties and parties responsible for metering electricity and gas consumption. To ensure that these registers remain transparent, TenneT also publishes the date of initial recognition and the date of termination of recognition (where relevant), as prescribed by the Metering Code.

MR register electricity
According to the Netherlands Electricity Act 1998, the responsibility for having an electricity meter on hand that complies with the relevant statutory regulations – more in particular, those as per the Electricity Measuring Code that is anchored in the said Act – rests with the business in question. The Electricity Measuring Code stipulates

that work to be carried out on the strength of the Code may only be contracted out to TenneT-acknowledged companies.

Profiles

profile category (PC)
One of the categories listed in Annex 14 of the Metering Code which is used to classify grid connections on the basis of characteristics to be determined objectively, e.g. tariff category, connection value, contracted transmission capacity and operating time. A specific series of characteristic profile fractions is determined for each of these categories.

assumed profiled consumption
The profile fraction multiplied by the tariff correction factor, the climate correction factor and the sum of the standard annual consumption of all customers per programme-responsible party in a profile category and in a certain tariff category.

total assumed profiled consumption
The sum of all assumed profiled consumption in the administrator's grid.

climate correction factor
A climate-dependent multiplier that can vary between profile categories in order to correct the various profiles for climate influences. Currently the climate correction factor is equal to 1.

Tariff

Tariff Code
The 1998 Electricity Act stipulates that the joint grid administrators shall submit to the director of the Office of Energy Regulation (DTe) a proposal concerning the tariff structures. For that purpose the Tariff Code describes the tariff components and the method of calculating the tariffs of the services to be supplied by the grid administrators, i.e. the connection service, the transmission services and the system services.

tariff correction factor
A multiplier used per programme-responsible party (PRP) and per profile category if one or more tariff subcategories with both peak and off-peak hours are applicable within a single profile category.

tariff period
A consecutive period of peak or off-peak hours.

tariff structure
The tariff components and the method of calculating the tariffs.

tariff category
One of the categories listed in Article 3.7.1 of the Tariff Code. Within category F, the subcategories single tariff, evening tariff and night tariff are distinguished.

periodic tariff for connection service
A periodic fee to be paid by a customer to cover the costs of maintaining a connection.

system services tariff
The tariff which the grid administrator of the national high-voltage grid (i.e. the TSO) charges parties connected to the Netherlands electricity grid and parties with programme responsibility in order to cover the costs of the system services.

normal tariff
The tariff, expressed in ct/kWh, charged for use of the grid during certain hours determined in advance by the regional grid administrator, during which the average load of the grid is generally higher.

evening tariff
The tariff category referred to in Article 3.7.14 of the Tariff Code, whereby the metering device separately records the consumption via a grid connection during off-peak hours and during peak hours and the connected party is invoiced accordingly. The transition from peak hours to off-peak hours occurs at around 9 p.m. and from off-peak hours to peak hours at around 7 a.m.

low tariff
The tariff, expressed in ct/kWh and determined in advance by the regional grid administrator, charged for use of the grid during certain hours when the grid load is generally lower than average.

night tariff
The tariff category, as referred to in Article 3.7.14 of the Tariff Code, whereby the metering device separately records the consumption on a grid connection during off-peak hours and during peak hours and the connected party is invoiced accordingly. The transition from peak hours to off-peak hours occurs at around 11 p.m. and from off-peak hours to peak hours at around 7 a.m.

peak hours
Hours of the day during which the normal tariff is applicable.

off-peak hours
Hours of the day when the low tariff is applicable.

General

electricity grid
A network of overhead connections, underground cables, transformers and switching and distribution stations and other devices via which electricity is transmitted. The electricity grid can be subdivided into a main transmission grid (TenneT) with voltages of 380 kV and 220 kV, a transmission grid with voltages of 150 kV, 110 kV and 50 kV and a distribution grid with voltages of 25 kV, 20 kV, 10 kV and 380/220 V.

According to DTe: One or more connections for the transmission of electricity and the related transformer, switching and distribution stations, substations and other equipment, except insofar as these connections and this equipment are located within the installation of a producer or a customer.

Electricity Act
The Electricity Act forms the framework for the operation of the Netherlands electricity market, against the background of European legislation. The Electricity Act

aims for free market operation in the generation, import, export and supply of electricity and for non-discriminatory access to the electricity grids.

The Electricity Act of 1998 contains clear conditions and rules which must ensure that the electricity supply system will continue to function properly. The Act stipulates, among other things, that the joint grid administrators must present a proposal for the tariff structure and the technical conditions to the director of DTe, the Office for Energy Regulation, for his approval.

programme responsibility
The responsibility of customers, not being protected customers and licence holders, to draw up or to have drawn up Energy Programmes relating to the production, transmission and consumption of electricity, to announce them to the grid administrators and to act in accordance with these Energy Programmes, taking into account the conditions laid down in Article 26 of the Electricity Act.

programme responsibility register (PR register)

A register set up and managed by the system operator, which contains the names, addresses, telephone and fax numbers as well as the data for the purpose of automated communication of the natural persons or legal entities which have been recognised by the system operator as parties with programme responsibility (PRPs

protected customer
A customer who has a connection to a grid with a total maximum transmitting power of more than 3*80 A and an available electrical capacity of no more than 2 MW per connection during the period until 31 December 2001, or a total maximum transmission power of no more than 3*80 A during the period until 31 December 2006.

Source for English descriptions:
http://www.tennet.org/english/tennet/terms_definitions.aspx

Dutch English translations:

Dutch	**English**
Dienst Toezicht elektriciteit (DTe)	Office of Energy Regulation
Nederlandse Mededingingsauthoriteit (NMa)	Netherlands Competition Authority
Landelijk netbeheer elektriciteit (hoogspanningsnet) annex Systeem Operator (TenneT)	Manager of the National Electricity Grid (High-Voltage grid) and System Operator (Tennet)
Netbeheerder elektriciteit	Electricity grid manager
Vergunninghouder elektriciteit	electricity licence holder
Meetcode Elektriciteit	Metering Code Electricity
Meetverantwoordelijkheid	Metering responsibility
Profielcategorie (PC)	Profile category (PC)
Programmaverantwoordelijke	Programme resonsibility

Appendix 2

Directive on energy end-use efficiency and energy services (ESD) 2006/32/EC of 5 April 2006, section Metering

Article 13 Metering and informative billing of energy consumption

1. 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, district heating and/or cooling and domestic hot water 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.

2. Member States shall ensure that, where appropriate, billing performed by energy distributors, distribution system operators and retail energy sales companies is based on actual energy consumption, and is presented in clear and understandable terms. Appropriate information shall be made available with the bill to provide final customers with a comprehensive account of current energy costs. Billing on the basis of actual consumption shall be performed frequently enough to enable customers to regulate their own energy consumption.

3. Member States shall ensure that, where appropriate, the following information is made available to final customers in clear and understandable terms by energy distributors, distribution system operators or retail energy sales companies in or with their bills, contracts, transactions, and/or receipts at distribution stations:

   a. current actual prices and actual consumption of energy;
   b. comparisons of the final customer's current energy consumption with consumption for the same period in the previous year, preferably in graphic form;
   c. wherever possible and useful, comparisons with an average normalised or benchmarked user of energy in the same user category;
   d. contact information for consumers' organisations, energy agencies or similar bodies, including website addresses, from which information may be obtained on available energy efficiency improvement measures, comparative end-user profiles and/or objective technical specifications for energy-using equipment.

Appendix 3

Examples of ESCOs in UK

Gigha Renewable Energy limited

Gigha is an island off the west coast of Scotland that is owned by the community through the Island of Gigha Heritage Trust. Three 225kW wind turbines have been erected by the Island of Gigha Heritage Trust. Part of the profit from the electricity sold to a supplier will be invested in energy saving measures in the housing stock on the island owned by the Island of Gigha Heritage Trust.

Southampton District Heating Scheme

Using conventional CHP and a geothermal borehole the Southampton District Heating scheme provides low cost heat to domestic and commercial buildings, a hospital and a school. The electricity is sold to a supplier through a long term contract. The majority of the company is privately owned but the city council have a stake in the company. Profit made by the company has allowed the district heating scheme to expand.

St Pancras Housing Association

The heat and power of 2 blocks of flats, a community centre, a few commercial units and the head quarters of St Pancras Housing Association are provided by CHP units. The blocks of flats were already managed by a services company and the heat consumption of the flats included in the rent. When the CHP was installed St Pancras Housing Association took over reading the meters and organising payment for electricity. The scheme therefore does not involve the trading energy outside the Housing Association.

Woking Borough Council

Woking Borough Council set up a company, 19% of which is owned by the Council to develop renewable energy schemes. Through a series of private wires developments, the capital cost is decreased and return for renewable power increased by reducing distribution and other charges. Heating and cooling networks have also been introduced. Power is traded between communally owned private wires networks using the public distribution system and this enables the power and generation to be matched as the demand moves from domestic, to transport, to commercial areas. Costs for using the distribution system are kept low by the fact that the sites and generators are small enough to be licence exempt suppliers.

Licence exemption

Licence exemption is a concession within the balancing and settlement code to allow small generators to transport small amount of power across the public network from one site to another, possibly private wires networks. This power is effectively ‘under the radar’ of the balancing and settlement process and thus avoids the charges associated with it however there are severe restrictions on how this can operate. There are two criteria relevant to DSM for licence exempt operation:

- The total power supplied (licensable or non-licensable) is restricted to 5MW with 2.5 MW supplied to domestic customers on multiply sites owned by the same supplier. Standby or ‘top up’ supplies are not exempt. Any power not supplied by the site owner must be supplied by a licensed supplier thus two license exempt suppliers cannot trade power.

- Alternatively on-site supply is exempt where the generator is connected, the power supplied is limited to 1MWe domestic and 100MW in total but this is limited to one site.

The transport between sites also depends on a licensed supplier. By managing load on more than one site the total could be kept within the limits of the local generation. This method could therefore encourage DSM especially if size limit is raised for the transport of power between sites or two license exempt suppliers are allowed to trade power.

Review of the licence exempt criteria were part of the UK Government's 'Distributed Generation Call for Evidence for the Review of Barriers and Incentives to Distributed Electricity Generation including Combined Heat and Power', the conclusions of which were fed into the Energy White Paper, published in May 2007.

Conclusions

In none of these schemes does the ESCO actively encourage demand side management and does not enter the electricity trading market or balancing system. Even large schemes such as Woking Borough Council has largely by-passed the central power trading by installing private wires. Different small private wires schemes within Woking buy and sell power using the public distribution network however they must keep within the 'licence exempt' suppliers criteria. Although the renewable power installed aims to match the load profile the scheme does not use DSM.

Appendix 4

Overview of the International Energy Agency (IEA)
and the IEA Demand-Side Management Programme

The International Energy Agency
The International Energy Agency (IEA), established in 1974, is an intergovernmental body committed to advancing security of energy supply, economic growth, and environmental sustainability. The policy goals of the IEA include:

- diversity, efficiency, and flexibility within the energy sector,
- the ability to respond promptly and flexibly to energy emergencies,
- environmentally-sustainable provision and use of energy
- development and use of more environmentally-acceptable energy sources,
- improved energy-efficiency,
- research, development and market deployment of new and improved energy technologies, and
- undistorted energy prices
- free and open trade
- co-operation among all energy market participants.

To achieve those goals, the IEA carries out a comprehensive program of energy cooperation and serves as an energy forum for its 26 member counties.

Based in Paris, the IEA is an autonomous entity linked with the Organization for Economic Cooperation and Development (OECD). The main decision-making body is the Governing Board, composed of senior energy officials from each Member Country. A Secretariat, with a staff of energy experts drawn from Member countries and headed by an Executive Director, supports the work of the Governing Board and subordinate bodies.

As part of its program, the IEA provides a framework for more than 40 international collaborative energy research, development and demonstration projects, known as Implementing Agreements, of which the DSM Programme is one. These operate under the IEA's Energy Technology Collaboration Programme which is guided by the Committee on Energy Research and Technology (CERT). In addition, five Working Parties (in Energy Efficiency, End Use, Fossil Fuels, Renewable Energy and Fusion Power) monitor the various collaborative energy agreements, identify new areas for cooperation and advise the CERT on policy matters.

IEA Demand Side Management Programme
The Demand-Side Management (DSM) Programme, which was initiated in 1993, deals with a variety of strategies to reduce energy demand. The following 18 member countries and the European Commission have been working to identify and promote opportunities for DSM:

Australia	Italy
Austria	Japan
Belgium	Korea
Canada	The Netherlands
Denmark	Norway
Finland	Spain
France	Sweden
Greece	United States
India	United Kingdom

Programme Vision: In order to create more reliable and more sustainable energy systems and markets, demand side measures should be the first considered and actively incorporated into energy policies and business strategies.

Programme Mission: To deliver to our stakeholders useful information and effective guidance for crafting and implementing DSM policies and measures, as well as technologies and applications that facilitate energy system operations or needed market transformations.

The Programme's work is organized into two clusters:

- The load shape cluster, and
- The load level cluster.

The 'load shape" cluster includes Tasks that seek to impact the shape of the load curve over very short (minutes -hours-day) to longer (days-week-season) time periods. The "load level" cluster includes Tasks that seek to shift the load curve to lower demand levels or shift loads from one energy system to another.

A total of 17 projects or "Tasks" have been initiated since the beginning of the DSM Programme. The overall program is monitored by an Executive Committee consisting of representatives from each contracting party to the Implementing Agreement. The leadership and management of the individual Tasks are the responsibility of Operating Agents. These Tasks and their respective Operating Agents are:

Task 1 International Database on Demand-Side Management &
Evaluation Guidebook on the Impact of DSM and EE for Kyoto's GHG Targets - *Completed*
Harry Vreuls, NOVEM, the Netherlands

Task 2 Communications Technologies for Demand-Side Management - *Completed*
Richard Formby, EA Technology, United Kingdom

Task 3 Cooperative Procurement of Innovative Technologies for Demand-Side Management – *Completed*
Dr. Hans Westling, Promandat AB, Sweden

Task 4 Development of Improved Methods for Integrating Demand-Side Management into Resource Planning - *Completed*
Grayson Heffner, EPRI, United States

Task 5 Techniques for Implementation of Demand-Side Management Technology in the Marketplace - *Completed*
Juan Comas, FECSA, Spain

Task 6 DSM and Energy Efficiency in Changing Electricity Business Environments – *Completed*
David Crossley, Energy Futures, Australia Pty. Ltd., Australia

Task 7 International Collaboration on Market Transformation - *Completed*
Verney Ryan, BRE, United Kingdom

Task 8 Demand-Side Bidding in a Competitive Electricity Market - *Completed*
Linda Hull, EA Technology Ltd, United Kingdom

Task 9 The Role of Municipalities in a Liberalised System *Completed*
Martin Cahn, Energie Cites, France

Task 10 Performance Contracting *Completed*
Dr. Hans Westling, Promandat AB, Sweden

Task 11 Time of Use Pricing and Energy Use for Demand Management Delivery
Richard Formby, EA Technology Ltd, United Kingdom

Task 12 Energy Standards
To be determined

Task 13 Demand Response Resources - *Completed*
Ross Malme, RETX, United States

Task 14 White Certificates – *Completed*
Antonio Capozza, CESI, Italy

Task 15 Network-Driven DSM
David Crossley, Energy Futures Australia Pty. Ltd, Australia

Task 16 Competitive Energy Services
Jan W. Bleyl, Graz Energy Agency, Austria

Task 17 Integration of Demand Side Management, Distributed Generation, Renewable Energy Sources and Energy Storages
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