Energy Services and ESCos – their benefits and implications for regulation and the consumer

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Executive Summary

A business that sells an energy service adds value to the provision of energy as a commodity by meeting some additional aspect of the customer's needs. This might be by supplying heat, or by selling as much gas and electricity as the customer needs for a fixed monthly fee that is calibrated to the size of their dwelling. In its most developed form, an Energy Services Company (ESCo) provides a commitment to deliver the benefits of energy, such as comfort, or refrigeration, or heat into an industrial process, to a specified level of performance and reliability. This business model is of particular interest to policymakers because an ESCo with a performance contract has a strong incentive to increase the energy efficiency with which it meets its contract, and thereby drive down carbon emissions.

This paper is a contribution to Ofgem's RPI-X@20 Review of energy network regulation, with the aim of identifying changes to network regulation that would stimulate a wider market for energy services, in particular their provision to domestic and small business consumers. The desirability of this development arises from the clear alignment between the goals of the RPI-X@20 Review (which include consumer choice, value for money and transition to a low carbon economy) and the outcomes expected from a flourishing and competitive energy services industry, in terms of:

- better value for money for the consumer through investment in energy efficiency and competitive pressure on conventional energy retail;
- more rapid adoption of new technologies such as heat pumps and micro CHP;
- accelerated network contributions towards a low carbon economy through the inherent incentives of the business model and wider exploitation of opportunities for renewable generation.

The existing UK market for energy services is characterised by three different types of enterprise:

- ESCos operating on a business-to-business basis which have little need of regulatory attention but offer lessons for the other two sectors;
- Local public-private partnerships such as the Woking ESCo which would be economically viable in many more towns and cities given changes to distribution network regulation;
- Limited energy service offers from major energy retailers which are mainly constrained by the consumer's ability to switch contracts easily.

Effect of distribution network regulation on local ESCOs

Network regulation is important to local ESCos because of two techniques they frequently employ to achieve efficiency; firstly the use of Combined Heat and Power plants (CHP) which generate electricity and heat simultaneously from combustion of natural gas, biogas, or biomass, and secondly the supply of heat to customers via a local network of insulated pipes carrying hot water or steam. As heat can only be transmitted over short distances, this type of ESCo must have a concentration of local customers to be viable. Once an ESCo can supply a significant proportion of these customers' electricity needs from its own local generation it should only have to pay for use of that part of the electricity distribution network (typically that within a single town or city) that is actually conveying the locally generated electricity to them. Without this change network charges are excessively

onerous, leading some existing local ESCos to install their own private network. If this was repeated in many locations it would often result in a wasteful duplication of assets.

So a new form of electricity network charge is proposed that reflects the actual cost of this local distribution. It would be a form of "unbundling", but as envisaged in this paper there would be no change in the ownership of network assets, simply a change in the recovery of Distribution Network Operator (DNO) costs through a new local use tariff. A similar argument applies to the use of the gas distribution network where an ESCo has a biogas generator supplying local customers. In the case of heat networks, there are potential benefits from introducing "open access" regulation that will allow competing ESCos to share a network.

If these local use tariffs are suitably framed, they will offer the opportunity for DNOs to gain financially from additional utilisation of a given set of network assets. This should incentivise DNOs in both the electricity and gas sectors to innovate in network management so that the maximum amount of local use can be accommodated.

Adoption of System Operator functions by DNOs

If generation of electricity for local consumption by competing ESCos becomes a significant proportion of electricity use, the DNO will have a more challenging task than at present. In many respects it will be operating a small scale version of the national grid so will be performing System Operator (SO) functions. This implies being responsible for ensuring the continuous balance of supply and demand of electricity that is essential for voltage stability, and for providing fair access to the network for all generators, in addition to the distribution functions of ensuring safety and security of supply. Consideration should be given to regulating it in a similar manner to the national SO.

Enabling domestic energy services by solving the stranded asset problem

At present major energy retailers offer gas boilers on a hire purchase basis, and supply of gas and electricity priced by kWh units. They cannot combine supply of boiler and gas in a single deal, because under present regulation the consumer, having taken delivery of a new gas boiler, could easily change to a cheaper energy-only contract with a different supplier, leaving the original supplier who has invested in the boiler with no repayment for their asset. This issue prevents an energy services supplier offering a package deal under which, for example, the consumer pays a monthly sum which they recognise as acceptable relative to their current outgoings, but a much reduced element of that goes into paying for kWh, and the balance pays for installation and maintenance of a highly efficient heat pump. An illustrative costing of such a deal is provided in Appendix C. The consumer benefits because they are now much less vulnerable to the volatility of kWh prices, and society would benefit from the lower carbon emissions.

This paper proposes that this important problem can be solved through two developments, one regulatory, the other technical. The regulatory change is to require that a supplier taking over an energy services contract which includes assets located on the consumer's premises must take over the ongoing cost of the asset. The ongoing cost will take two forms, each will need appropriate regulation to ensure fairness:

- where the asset is owned by the original supplier, the incoming supplier must make a payment to acquire the asset dependent on age, condition etc;
- where the asset is owned by a leasing company, the incoming supplier must take over the lease.

The technical development proposed is the use of the smart meter infrastructure to capture an inventory of energy related assets on the customer's premises, including their age and performance. This will allow the administration of a change of energy services supplier to be performed efficiently so that the competitiveness of the existing retail energy market is retained. The smart meter system should also be able to provide energy services suppliers with other valuable information such as the energy use patterns of the household and the thermal characteristics of the building. This will enable them to price services accurately and reduce their risks. It is essential that the consumer can use the information collected by the smart meter to obtain quotations for energy services from competing suppliers. This requires regulation of data ownership and access rights.

Automatic Demand Side Management

Demand side management (DSM) is the provision of energy tariffs and metering that allow consumers to benefit from using electricity at times of day when the cost is lower. DSM has not moved forward in the UK for domestic and small business consumers since the introduction of Economy 7 in the 1970's. It is argued that regulators should encourage rapid implementation of a flexible form of automatic DSM, which is currently impeded by absence of the necessary agreement in the industry on a suitable data format. This would allow any electricity supplier including ESCos to transmit a signal to their customers indicating the varying cost of providing electricity to them at different times during the next 24 hours.

Many appliances (ranging from immersion heaters to battery cars) can then be equipped with intelligent controls that respond to this signal by minimising the cost of electricity consumed while meeting their user's needs. This is of particular interest to an energy services business because of their incentive to drive down the cost of energy inputs and match electricity demand to their local generating capacity. It is also of wider benefit in assisting the national electricity generation and distribution system to cope with the variability of wind generation. To accelerate development of tariffs and services, the existing Radio Teleswitch system (which turns storage heaters on and off for some Economy 7 consumers) could be used to transmit this signal in advance of the smart meter rollout.

Once it is possible to transmit this signal via the smart meter network, it can be used by DNOs to manage local network loads. It will therefore contribute to the increased efficiency of network assets needed to support local ESCos and other distributed generation.

1 Introduction

Providing energy to consumers in the form of an energy service which meets their needs for comfort and convenience, rather than simply supplying kWh, is a concept that is attractive to policy makers (as indicated for example by the EU directive on energy services [1]) and potentially valuable to consumers. Within the context provided by Ofgem's RPI-X@20 Review of energy network regulation, this paper begins in Section 2 by summarising the potential benefits of the energy services business model by comparison with the goals of RPI-X@20. Section 3 reviews the UK market for energy services as it exists today, then Section 4 takes the most mature segment of that market and analyses the transaction costs that are the most prominent constraint on its growth. Sections 5 and 6 look at the possible routes for energy service business models that address a mass market to evolve out of the existing structure of the gas and electricity industries. Delineating these evolutionary routes illustrates the innovations that existing and new energy businesses would need to make, and from this analysis possibilities emerge (summarised in Section 7) for Ofgem to shape regulation so that this innovation is encouraged. Section 8 provides conclusions.

In examining options for energy services this paper is informed by the forward-looking analysis provided by Ofgem's LENS project [2] and the review of lessons from fixed line telecoms regulation performed by Pollitt [3]. The description of options is performed from a technical perspective so primarily aims to show what should be feasible and practical – the actual economic viability of a particular option or evolutionary step will depend on many factors, among which fossil fuel prices, the carbon price (as shown by the LENS report) and Government incentives such as the Community Energy Savings Programme (CESP [4]), will have a leading role. Most of the discussion focuses on domestic consumers, but the arguments presented are generally applicable to small and medium enterprises (SMEs).

When considering the interaction between the development of energy services and the regulation of energy networks, the Central Communications Provider (CCP) for the smart metering system (as proposed in the DECC Smart Meter consultation[5]) is included as one of the regulated networks, on the assumption that DECC's preferred option for the Smart Meter system will be adopted. The CCP will be a monopoly provider of a telecommunications network and information system that will link smart meters in every home and business with all the actors in the gas and electricity industries. As it does not yet exist regulation of the CCP is not directly subject to the RPI-X@20 review, but it will have a critical role in the realisation of the "smart grid" that is one of the enabling factors for growth in Energy Service Companies (ESCos).

It will be shown that the sensitivity of energy services businesses to energy network regulation arises mainly from their use of distributed generation of gas and electricity. So changes in regulation that support energy services will also tend to encourage distributed generation operating under conventional business models.

2 The case for energy services

2.1 Alignment of incentives with policy goals

At present the revenue of the enterprises that are central to the energy supply chain (oil majors, electricity and gas utilities, transmission and distribution network operators) is broadly proportional to the amount of energy they deliver, or have the capacity to deliver in the case of network operators. Since this incentive does not favour policy goals for reduction in carbon emissions, national regulators have introduced constraints and alternative incentives. In the UK these include the Carbon Emissions Reduction Target

(CERT) scheme and Renewable Obligation Certificates (ROCs), which oblige electricity companies to invest in efficiency measures such as insulation and procure a proportion of their output from renewable sources. These are effective but are capped to limit the distortion of the normal energy market and result in an ambiguous relationship between suppliers and consumers - as Parag and Darby [6] put it: “Suppliers may well wonder what their primary responsibility is – to supply cheap energy or to achieve emissions reductions?”.

It would be preferable if business models for energy supply could flourish based on economic incentives that are inherently aligned to policy goals and provide a market dynamic that is not bounded by specific regulatory limits. Energy service contracting satisfies these criteria. In the context of the built environment an ideal energy service contract commits the supplier to provide the benefits of energy, such as thermal comfort and light, to a customer at a price which is mainly dependent on the properties of the building and its occupants, and with no or limited dependency on the price of the underlying energy source. It may be compared to buying a train ticket rather than a volume of fuel to put in a car, in order to obtain the benefit of travel. An important aspect of the contract is that performance is monitored (e.g. the achievement of a certain room temperature) and the customer has recourse to some form of rebate if the performance requirements are not satisfied.

Given this contract the energy services supplier is incentivised to provide the energy services as efficiently as possible, which will often involve investment on the customer’s premises, for example in insulation measures and heating or air conditioning equipment, combined with optimised operation and maintenance systems. Typically these will be investments that the customer would not make on their own account, either because they lack the expertise or capital to make them for themselves, or because they prefer to invest their time and money elsewhere. Conventionally the contract between supplier and customer is long term so that the supplier’s risk in making these investments is acceptable (although mechanisms to facilitate short term energy service contracts for domestic consumers are discussed later in the paper). For each contract, profit will be maximised by minimising energy and labour inputs, and extending the life of the capital investment. The supplier will also prefer to procure energy sources with a stable and predictable cost, which makes fossil fuels relatively less attractive, and renewables more attractive, by comparison with the perceptions of a supplier who is readily able to pass on an increased input cost to their customer. As a result reduction of carbon emissions arises directly from the incentive to minimise all energy inputs, and indirectly from the incentive to avoid price volatility.

2.2 Social benefits and innovation

It has also been widely argued that social benefits arise from this model - for example by Steinberger *et al* [7] and Stahel [8]. To the extent that investment is made in heating appliances, insulation, etc. that would not take place under a kWh supply regime, additional jobs are created among building and plumbing trades. The supplier will be monitoring the performance of these investments, so maintenance will be more systematic than when it is dependent on the consumer taking action to recognise and rectify problems. Also, because the contractual commitment is to deliver comfort, vulnerable consumers who have difficulty with the operation of heating systems will be supported. This is not a trivial issue – when Critchley *et al* [9] investigated the effectiveness of improvements to insulation and heating systems implemented to address fuel poverty under the Warm Front programme, they found that 25% of the homes surveyed are persistently cold despite the improvements. Their study reports (*sic*):

> "However, a major residual problem was controlling the central-heating system. A third of all respondents over 60 reported difficulty with programmers, with a majority of these saying they were too complicated; ''I don't understand it,'' ''I'm not very technical – unsure what to do.'' There were three types of response; first leaving the system as originally set, ''I never touch the controls;'' second, asking friends, family members or neighbours to adjust the setting; third, resorting to manual settings, ''My husband switches it on when he gets up.'' However, in [all] these cases, such coping strategies were evidently not successful in securing warm homes."

This is an important finding since the temperature thresholds used by this study to define a cold household were those below which there is increased risk of circulatory and respiratory disease (mean temperatures during winter in living rooms below 18°C or below 16°C in bedrooms). Under a services contract temperatures would be monitored to validate compliance, and the supplier would have an incentive to install easy-to-use and efficient controls. Suitable devices have been the subject of research by Boait & Rylatt [10].

A further benefit arises from those forms of ESCo that operate in a community to exploit opportunities for CHP and renewable heat and electricity generation for local consumption. The Woking ESCo is the best known example, others are discussed later in the paper. The close link between production and consumption provided by these schemes generates a sense of local ownership and political support which helps to overcome the "nimby" factor that can often constrain distributed generation and renewable energy projects. Also the community engagement needed by ESCos to obtain economies of scale can stimulate understanding of, and commitment to, the unavoidable lifestyle changes associated with transition to a low carbon economy.

Finally, a market for services promotes innovation, because the customer is protected from the risks associated with new technology and does not have to acquire the knowledge needed to be a discerning customer of novel equipment. This was recognised by the manufacturers of the first steam engines, who sold them as a service to pump water out of their customer's coal or tin mine and were paid by the gallon. Similarly the telecommunications industry sustains a ferocious pace of innovation by selling consumers easy to use services that hide the extreme complexity needed in their realisation. Thus service provision could accelerate the rate at which households and SMEs adopt technologies such as heat pumps, micro CHP and micro wind, as is recognised by DECC in the Heat and Energy Saving Strategy [11].

2.3 Comparison with RPI-X@20 outcomes

These benefits can now be compared with the outcomes which the RPI-X@20 project aims to promote. Table 1 below summarises the contribution energy services could make to the outcomes cited in RPI-X@20 Working Paper 1 [12]. The table shows a good alignment of outcomes, so the question that then arises is "how can energy networks support the development of energy services?" The next section takes forward this point by reviewing the present state of energy services in the UK and the barriers to further development. Businesses providing energy services that exist today are constrained either in their customer base or their geographical deployment, and they do not always offer the full commitment to the customer's needs that is discussed above. So the policy goal must be to encourage their growth in both coverage and commitment.

Table 1. Alignment of outcomes between RPI-X@20 and energy services

Desired outcome promoted by RPI-X@20	**Outcome potentially delivered by competitive provision of energy services**
Energy networks of the future should focus on the needs of existing and future consumers. This means providing value for money in delivering identified outcomes, providing choice to consumers where appropriate, and delivering appropriate quality of service to different customer groups.	• Real needs satisfied (comfort, light) rather than kWh. • Value for money through investment in energy efficiency measures. • Choice as an alternative to consumer buying kWh and heating equipment etc. as separate purchases. • Quality of service assured through tailored offerings to consumers and commitment to real needs.
Energy networks of the future should play a full role in delivering secure, sustainable supplies of energy (incorporating security of supply, environmental and social requirements) and the transition to a low carbon economy	• Energy efficiency incentive supports security and sustainability, and reduces carbon emissions. • Preference for non-volatile and local sources favours renewable energy. • Linkage between local generation and consumption supports transition to a low carbon economy. • Adoption of new technology (e.g. heat pumps, micro CHP, solar energy capture, intelligent control systems) made easier for the consumer.

3 Energy services in the UK today

3.1 Business-to-business ESCos

The enterprises operating today that offer energy services corresponding in whole or in part to the concept described above fall into 3 main groups. The first of these comprise true ESCOs that are subsidiaries of large international control companies, oil companies, or utilities, that offer comprehensive energy services targeted at medium and large scale businesses and public sector organisations. Their services are procured as an aspect of outsourcing of non core activity. These customer organisations have the management resources to negotiate the complex and typically long term contracts required which capture the commitments needed on either side. Bertoldi *et al* [13], in a pan-European survey of ESCos, say of this form of services business “The UK, due to its large experience in project financing, the innovative spirit of enterprises and the favourable market structure, has developed a flourishing ESCo industry”. So arguably this sector needs no change to the regulatory regime, and could provide a basis for growth into the domestic and small business markets. However, there are useful lessons from the business model of these ESCos and their relatively limited customer base which are examined in Section 4.

3.2 Retail energy suppliers

The next group are the major retail gas and electricity suppliers. These do not offer the domestic or small business customer anything approaching an ideal energy services contract, but some of their mainstream products provide substantial building blocks towards that goal, such as maintenance contracts that for a fixed fee commit to rectifying all faults in a domestic heating system within a specified time period, and home energy assessments that match estimated savings with the cost of hire purchase of insulation or appliances (though the supplier does not take on the risk that savings will not be achieved). They have experimented in a limited way with energy supply as a service; the best example is the E.on Staywarm contract [14] offered to people over 60 which supplies electricity and gas for a fixed monthly fee reviewed every 12 months. The company reserves the right to transfer customers to a conventional kWh-based deal if their usage becomes excessive, and this has happed to about 10% of customers [15].

There are a number of reasons why these fragmentary offers are not bundled into a proper energy services deal for the domestic market:

- Consumers' right to switch gas and electricity suppliers at short notice deters inclusion of long term investments in the same contract.
- There are obvious risks to suppliers from reckless behaviour by customers, as the E.on experience demonstrates.
- The absence of a strong commercial incentive.

A combination of technical innovation and regulatory changes that could overcome all these barriers is discussed in Section 5.

3.3 Local ESCos

The third group of existing ESCos are those arising from local authority or community initiatives operating in a restricted area, often on the basis of some form of public-private partnership. They typically offer at least some of their customers both electricity and heat in the form of hot water pumped through a local network of insulated pipes. The heat comes from a combined heat and power plant (CHP) which burns a fossil fuel or biomass to produce heat and generate electricity. Their business case is based on fact that it is inherently more efficient to produce both together than separately. The critical role of the local authority or community organisation is to identify and attract customers for the heat that are located close together so that the cost of installing the heat network is affordable. It is also desirable to have a year-round demand for heat to keep the CHP operating – swimming pools and hospitals are ideal for this purpose.

Once a local authority has a CHP system operational, savings from their previous running costs have been re-invested in other energy efficiency and energy producing measures such as insulation and photovoltaic plants, drawing in customers who may not be on the original heat network. However these ESCos are subject to the same constraints as the major retailers in their ability to offer domestic customers a comprehensive performance commitment in their contracts. They have not proliferated because financially they are only just viable, and arguably operate currently with an element of subsidy [3]. This will change as the cost of carbon rises as shown by the LENS report.

If a local ESCo of this form is successful and acquires a balanced portfolio of electricity generating assets and electricity consumers it starts to satisfy some of the technical requirements for operation as a micro grid. The critical test is whether the generators are capable of meeting a significant proportion of the consumers' load continuously throughout the year, with a level of reliability consistent with statutory requirements. Once this threshold is passed, it becomes onerous for the ESCo to pay network charges that reflect the cost of delivering the peak electrical load from the national network. Some ESCos such as Woking have installed their own "private wire" electricity distribution network to avoid this cost. This leads to the case for unbundling of local networks as presented in [3] and further discussed in Section 6.

4 Lessons from existing business-to-business ESCos

The economics of energy service contracting have been analysed in detail by Sorrell [16], based on a study of the UK ESCos in the first group described above. He summarises energy service contracting as being viable "where the expected reduction in the production cost of supplying energy services can more than offset the transaction cost of negotiating and managing the relationship with the energy service provider". The reduction in production costs arises from measures provided by the ESCo such as CHP, heat pumps and heat networks which meet the customer's requirements for comfort, lighting, etc. at lower cost than their existing facilities and contracts for supply of kWh. The transaction cost is driven by four factors:

- Asset specificity i.e. the extent to which the ESCo's investment is specific to a particular customer because it is on his premises, or tailored to his needs, or would not have any value elsewhere. Examples of investments that are highly specific include the initial audit of a customer's existing heating appliances, installation of temperature measurement sensors to validate contract performance, and improved building insulation.
- Task complexity i.e. the degree of difficulty and cost in drawing up and monitoring the terms and conditions of the contract. This will depend on the number of different end uses of energy covered by the contract, and the range of performance parameters that must be specified. For example a major customer such as a hospital may hire consultants to draw up a specification of the performance requirements for the contract, while the supplier will need to conduct a detailed audit of the customer's energy use. The supplier may also need to investigate and understand the sensitivity of the customer's energy use to local weather conditions.
- Competitiveness of the market in which the transaction occurs. This tends to affect the transaction cost as seen by the buyer - if they are committing to a long contract term during which their comfort or their business depends on the supplier's performance, they will be very careful about the terms of the contract and the reputation of the supplier. If they have the opportunity to readily compare prices and change suppliers at any time, then the decision to purchase is easier and the transaction cost lower.
- Institutional context. This refers to the existence of industry wide measures that reduce risk for both parties, such as standardised specifications, procurement protocols and contracts, and accreditation schemes for suppliers. It also covers the extent to which a particular form of energy service is widely advertised and understood by potential customers – clearly niche products will have higher transaction cost.

When these four factors are considered in the context of domestic energy services, the scope for reduction in transaction cost is evident:

- Asset specificity can be reduced by heat networks, which keep equipment out of the consumer's home, and is clearly less for some forms of housing such as blocks of flats or student halls, where the heating appliances and physical layout are standardised over multiple dwellings allowing the supplier's analysis, design, and planning costs to be spread over many customers. Alternatively, the cost of energy audits and compliance monitoring could be reduced if they can be performed through the smart metering infrastructure.
- The task complexity associated with negotiating a contract for an individual consumer is reduced when economies of scale can be achieved by the supplier through engagement with whole communities. The supplier's audit task would also be greatly simplified if they had access to well structured records of the customer's historic energy consumption and an inventory of the heating or cooling appliances in use – again these records could be provided by the smart metering system as discussed further in Appendix B.
- Competitiveness can be increased by finding a mechanism that allows consumers to easily obtain and accept competitive quotations for services, while protecting suppliers from stranded assets.
- Institutional context could be improved through trials and pilot projects that improve the industry's understanding of the services business model, and allow standard contract terms and procedures to emerge. It can also be addressed by regulatory initiatives such as RPI-X@20 and CESP.

The validity of this analysis is illustrated by the form of existing local ESCos; they generally employ heat networks, and their transaction cost is partly met by local authorities or community associations on behalf of groups of consumers.

5 Possible development of energy services from retail suppliers

Of the three present constraints on energy services from retail suppliers identified in 3.2, the absence of a commercial incentive is clearly the most significant. This could change through an accumulation of several factors:

- micro CHP reaching a mass market;
- recognition of the efficiency savings from heat pumps;
- availability of feed in tariffs for renewable micro generators;
- rising carbon prices;
- regulatory incentives from CERT and CESP.

5.1 Micro CHP

Micro CHP units (as shown in Fig.1) replace a conventional domestic gas boiler and generate electricity when heat is needed. They offer the same fundamental improvement in thermodynamic efficiency that has motivated the local authority ESCos, but at the scale of a single house or small business premises. As a technology they have proved challenging to develop, but it seems likely that Whispergen (who are partnered with E.on) and Ceres Power (partnered with British Gas) will have viable products by late 2010 or during 2011 that are backed up by large scale manufacturing and field support. Trials of the Whispergen product by Carbon Trust [17] and Boait *et al* [18] have shown that for larger and older homes with above average heat load they save carbon emissions and pay back the additional cost over a conventional boiler in about 3 years.

Each micro CHP unit has a generator rated at about 1kW, so 1 million would provide generating capacity of 1GW which would be a useful contribution at the national scale. Also, since domestic heat demand is higher in the evening and in winter, there is potential for them to generate electricity exactly when demand is highest i.e. early evenings in winter. The value of this generation will increase as the volatility of wholesale electricity prices increases, driven by the rising proportion of wind generation in the UK fuel mix. Poyry [19] predict that peak prices could rise to £1300/MWh in 2020. They also point out that the UK market does not favour investment in conventional peaking plant[2] that would exploit the opportunities presented by wind deficiencies and mitigate price peaks, because of the high risks involved.

Figure 1. Whispergen micro CHP unit

So micro CHP presents a serious commercial opportunity to provide new technology as an energy service to the consumer, which at the same time meets a demand for peaking plant in the UK electricity market. The question then arises, why can't the supplier just sell the micro CHP to the consumer as a capital asset for their home just like a conventional boiler? The answer is that of course they can, but there are two important advantages from selling the technology as a service:

- the UK market for heating appliances is notoriously conservative as shown by the late adoption of condensing boilers by comparison with other European countries [20] - selling a service protects the consumer from technical risk and encourages uptake as demonstrated by the telecoms industry;
- to ensure as far as possible that each micro CHP is generating high value electricity at the time of peak demand, the supplier will require a degree of remote control over the operation of the unit - this could only happen with the consent of the consumer, which is much more likely to be given in the context of a services contract that inherently demands mutual trust and provides equitable sharing of risk.

[2] Peaking plants are electricity generators capable of starting quickly and running for limited periods to meet surges in demand.

This remote control of domestic micro CHP is a form of automatic Demand Side Management (DSM) and is an example of “smart grids” in practice. The methods by which it may be exercised have their own issues which are discussed in Appendix A. The other key technical precondition for this business model is smart metering, since it is essential that the time when the micro CHP generator is running is recorded so that the full value of its output can be credited in the balancing and settlement process[3]. Adoption of automatic DSM should be also be accelerated by the arrival of battery and plug-in hybrid cars, whose owners will be very interested in charging their vehicles at favourable tariffs, but will not want the nuisance of manually switching the charger on and off to pick out times when low cost electricity is available[4].

5.2 Heat pumps

A heat pump converts electricity to heat in a way that allows 1kWh of electricity to produce between 3 and 5kWh of heat. So using electricity costing 10p per kWh unit, heat is supplied for 2.5p per unit which undercuts gas at about 3.5p per unit. This massive improvement in efficiency compared to conventional electrical heating presents an opportunity for retailers to offer it as a service where the reduction in the running costs of an electrically-heated home could amply repay capital investment in a heat pump and the transaction costs (if the latter were reduced using the methods described later). An illustrative costing of an energy service on this basis is set out in Appendix C. Because this is an unfamiliar technology in the UK, and requires some specialist skills in installation design and maintenance, it is an ideal candidate for an energy service that provides a performance commitment (i.e. guaranteed heating comfort) to give confidence to the customer. A large reduction in carbon emissions is also achieved similar to the efficiency improvement making this a very desirable technology from a regulatory perspective.

5.3 Feed-In Tariffs and mitigation of supplier risks

The introduction of Feed-In Tariffs[5] (FITs) for renewable microgeneration in the DECC Low Carbon Transition Plan will improve the commercial attractiveness of including photovoltaic (PV) and wind generators in a services package, particularly for new build where property developers may welcome the opportunity to outsource part of the obligation to meet zero carbon building regulations [21]. For example, a PV installation costing £15,000 at new build will generate a return of £950 per annum. If FITs are extended to renewable heat this will improve the business case for solar thermal panels.

So, with a significant commercial incentive in place the remaining barriers to domestic energy services contracts are likely to be the problem of short term contracts and the risk of unreasonable energy use by the consumer as experienced by E.on. A combination of technical and regulatory measures that address the first of these issues by allowing consumers to change service contracts easily, while ensuring suppliers are not left with stranded assets, is detailed in Appendix B. In summary, it is proposed that the smart meter infrastructure is used to capture an asset inventory as well as energy use data. Given appropriate regulation of data ownership, the consumer should be able to request a quotation from a new services supplier based on their assets and energy use. Then if the consumer changes suppliers, the outgoing supplier either receives a regulated transfer

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[3] This is the procedure operated by the electricity industry to match payments for generation with charges for demand taking into account the variation in the cost of electricity during each day.
[4] When a substantial proportion of electricity is generated from wind, the time when electricity is cheapest will vary from day to day.
[5] Feed In Tariffs are payments per kWh to small renewable electricity generators (such as roof mounted photovoltaic panels and micro wind turbines) which increase the incentive to install them.

price for the assets from the new supplier, or the new supplier takes over the leasing charge if the assets are leased.

The risk of unreasonable behaviour by the consumer is capable of being managed to some extent by careful marketing and contract terms as E.on have shown. The telecoms industry has an exactly analogous problem with excessive downloads over domestic broadband, which has been handled in this way. However, if energy services are to be extended beyond 60-year olds technical measures may be needed to mitigate the risk of reckless use of energy. The heating controls described in [10] address this point by recognising an abnormal heat load.

If energy services from large retailers do become popular, then the rising amount of microgeneration may start to have an impact on the voltage regulation and other technical parameters of local distribution networks. This is not likely to happen for some time – 500 micro CHP units in a housing development near Manchester have operated successfully without any need for network changes [22]. As distributed generation grows, DNOs will have to take into account all generators present on each local network which may mean some constraints have to be fed back to retailers. This issue is more material for the local ESCos so is discussed further in the next section.

6 Possible development of local ESCos

6.1 Innovation in CHP

The new technology that should assist the viability of local ESCos is biomass and waste CHP. Techniques for gasification of the fuel have now been developed which make container-sized plants reliable and easy to operate [23]. With FITs enhancing the value of the electricity and heat, the economics of local CHP using this fuel will escape the volatility in the "spark spread[6]" between natural gas and electricity which has been one of the factors discouraging community scale gas-fired CHP. If CHP is combined with suitable heat-driven refrigeration plant (as Woking have demonstrated [24]) then the whole system can supply air conditioning in summer as well as heat in winter. This arrangement (sometimes known as trigeneration) keeps the CHP plant running efficiently all year round and supports a comprehensive commitment to comfort in the services contract.

6.2 Unbundling of electricity distribution

Once a local ESCo has a significant level of reliable electricity generation capacity then they should be able to benefit from unbundling of the local distribution network, as introduced in section 3. Since competition between ESCos is likely and desirable, and of course some (probably a majority) of consumers will wish to continue to procure kWh and their own heating appliances in the conventional manner, unbundling must be on the basis of continuing shared use of the local network. This is a material difference from local loop unbundling in the telecoms industry, where the local loop often (but not always) comprises a discrete physical connection in the form of a copper or fibre optic cable from the telephone exchange to the consumer's premises.

So the key parameters in the contract between the DNO and the ESCo must be:

- the geographic coverage of the unbundled network,

[6] The spark spread is the difference between the wholesale price of electricity per kWh and the cost of electricity when generated by natural gas (which has its own wholesale price per kWh)

- the peak expected electrical load from the ESCo's customers that are within the coverage area (the "peak load"),
- the electrical load from the ESCo's customers within the coverage area that will always be supplied by the ESCo's generators within the coverage area (the "carried load").

The network charge for delivering the electrical load represented by the difference between the "peak load" and "carried load" should be calculated in accordance with existing bundled tariffs, because this is electricity that is being delivered from the national network in the conventional manner. The "carried load" should be charged using an unbundled tariff which reflects only a contribution to the cost of the distribution assets within the coverage area, proportionate to the amount of reliable power carried. Given the limited area involved the tariff might for simplicity be based on MW-mile units i.e. the cost of transporting a MW of electrical power over a mile of distribution network [25]. However, this is only one option from the variety of transmission tariff schemes covered in the academic literature and employed on the ground – the topic requires more investigation than can be undertaken here.

The advantage of this structure is that the ESCo should be able to benefit from the reduced cost of the unbundled tariff as soon as they have a sufficient amount of sustained generating capacity to exceed some threshold (say 5% of the electrical load in the coverage area). They do not have to make the level of investment needed for a fully (or nearly) self-sufficient microgrid. It nicely complements the proposal in [2] that nodal pricing[7] be introduced so that the wholesale price of electricity at each location in the UK reflects more accurately the local balance of supply and demand, since this will increase the attractiveness of unbundled tariffs where local generation will be most useful. Retailers offering an energy services contract as discussed in Section 5 could also benefit from unbundled tariffs where they have a local concentration of microgeneration.

Clearly local ESCos will then have an economic interest in increasing the proportion of "carried load" relative to "peak load", since this will both reduce their network charges and reduce the amount of electricity they are obliged to buy-in on the wholesale market. To do this they will need to encourage their customers to match their demand to times when the ESCo's generators are running. This is another example of the need for DSM as discussed in Appendix A. There is of course a wider interest in the success of DSM in this local application, just as there is for national scale electricity supply, because it increases the efficiency with which network and generation assets are used, and improves the ability of the national system to withstand the intermittency of wind generation.

If the local use tariffs from DNOs are suitably framed, they will offer the opportunity for DNOs to gain financially from additional utilisation of a given set of network assets. This should incentivise DNOs in both the electricity and gas sectors to innovate in network management so that the maximum amount of local use can be accommodated.

These changes should ensure that local ESCos are potentially economically viable wherever there is a suitable concentration of thermal and electrical load, and a supply of biomass or waste. They will be interested in opportunities to increase the reliability of their electrical supply to increase their "carried load", so they will find local small hydroelectric schemes attractive as a constant source of power, and may also contract with local industrial or commercial enterprises that have standby generators. These standby generators have to be exercised, so could be engaged by the ESCo to run when their CHP plant needs maintenance or other deficits arise. If successful ESCos will tend to grow their

[7] Nodal pricing is a method for determining a price for electricity anywhere in a network which takes account of the varying cost of its generation at different locations and the limitations and losses of transmission lines.

geographic coverage, and will be aided in their ability to gain domestic customers by the technical and regulatory measures described in Appendix B. As geographic coverage overlaps this should lead to competition between local ESCos, and with energy services from national retailers. Figure 2 aims to illustrate this scenario.

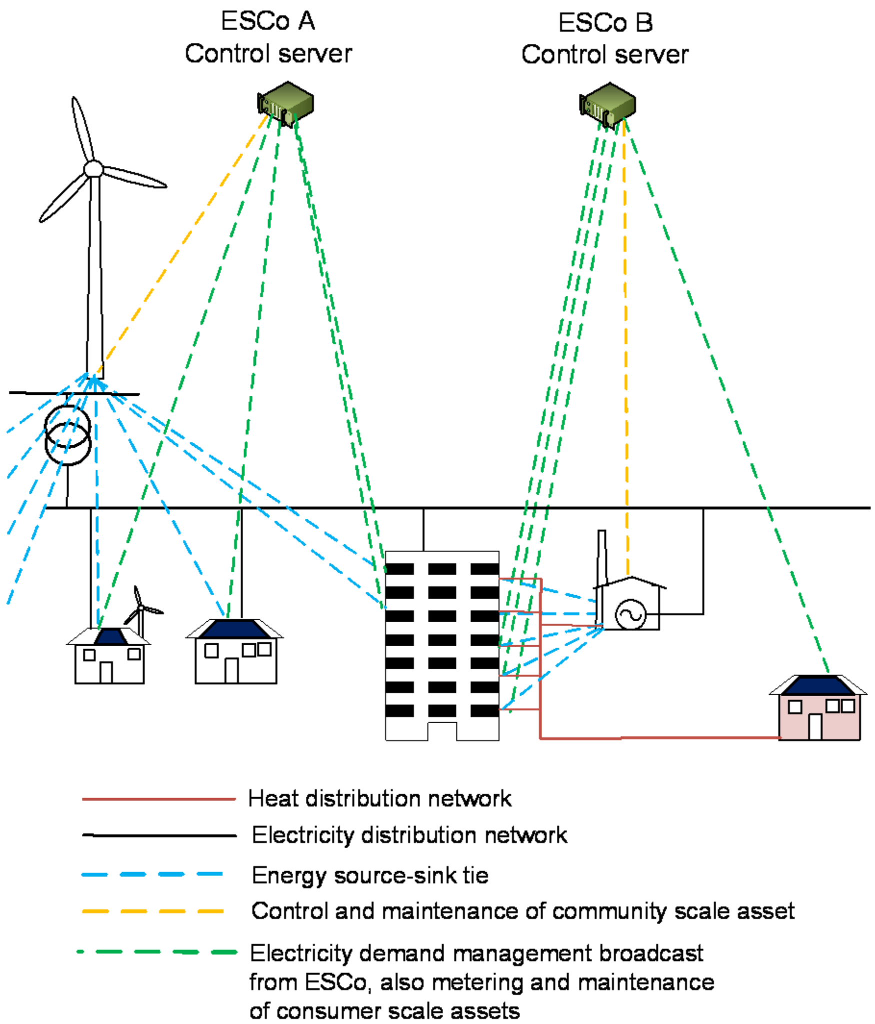

Fig. 2. Networks and linkages of the ESCo technical and business model

6.3 System Operator role for DNOs

It is evident that the DNO will have a challenging role in managing this more complex usage pattern and tariff regime for their network. They will need to monitor the compliance of their ESCo customers with their commitments and also supervise the aggregate loading and other parameters of the network in a more fine-grained way than is necessary when there is no distributed generation. The CCP should be able to assist in this with data from smart meters. In essence they will become a System Operator[8] (SO) on a regional and local scale once the amount of local generation starts to approach that drawn from the national grid, and arguably should have similar powers and constraints to those applied to the national SO.

[8] A System Operator is responsible for ensuring the continuous balance of supply and demand of electricity that is essential for voltage stability, for safe operation of the transmission network, and for providing fair access to the network.

Since the local distribution network will now be operating at a higher level of loading it is likely that “hot spots” will emerge – line segments or transformers that are approaching their limits. Active network management techniques will allow safe operation closer to limits than has been possible in the past, but ultimately the DNO may need to constrain their customers’ power flows. This is a further example of the need for DSM. Methods for reconciliation of the DSM goals of DNOs with those of ESCos and large retailers of energy services are discussed in Appendix A.

Over time it is possible with this scenario that the capabilities of DNOs to perform the SO function will grow to the point that the role of the national SO can be delivered by co-operation between the Transmission Operator and the DNOs. This could be helpful from a regulatory perspective by introducing an element of competition to the SO function.

6.4 Gas and heat networks

A final question to be considered in this section is whether similar reasoning applies to gas and heat networks. Developments in biogas production suggest this is definitely the case for gas. The German town of Lunen [26] is building a gas pipe network to distribute 6.8MW of locally generated biogas to 12 separate CHP units as part of an exemplary ESCo operation. In effect this reduces the size of the heat network that would otherwise be required for the town – the gas pipes have fewer losses and are cheaper to install than insulated pipes carrying hot water or steam. So an unbundled tariff for use of the local gas network could be an attractive option to an ESCo with gas generating capacity. The tariff should probably be structured for shared use of the pipes as proposed for electricity. While large scale biogas production currently tends to occur in areas where there are pig or poultry farms, there are also proposals to produce biogas from farmed seaweed [27], which as an energy crop would not compete with food production. This could be of interest to ESCos in coastal towns, giving them all the operational flexibility of gas fired heat and electricity generation from a renewable source.

There are relatively few heat networks in the UK at present compared to other European countries - the Sheffield network is the largest, but Leicester is planning a substantial expansion of its existing network [28] and the London Development Agency is promoting a scheme in the Thames Gateway [29]. Given the progression towards competition between ESCos an “open access” regulatory regime for heat networks such as that introduced in Sweden would seem desirable, but given the limited nature of UK experience (and the lower level of winter heat demand in the UK by comparison with northern Europe) it needs to be framed in a way which does not increase (and preferably reduces) the commercial risk for the body that makes the initial investment so that the growth currently taking place is not stifled. The objective in regulating heat networks would be to create a market in heat within urban areas which would attract participation by large electricity generating plants and other industries with waste heat, thereby strengthening the wider market for energy services.

7 Interaction between regulatory change and technical innovation

The discussion in the last two sections has illustrated the intricate relationship between regulatory change and the practical deployment on a large scale of technical or operational innovations that would otherwise remain niche solutions with limited application. Table 2 aims to summarise this relationship for development of energy services, by taking each of the actors in the electricity and gas industries and identifying the regulatory changes relevant to them (some of which such as FITs are already in train) and the related innovations allowing them to provide their element of the services value chain. Regulatory changes that are options for consideration under RPI-X@20 are underlined.

Table 2. Regulatory change and services innovation in the electricity and gas industries

Industry segment	**Regulatory change**	**Innovation**
Retail electricity and gas suppliers	• R&D incentives • Introduction of smart meters • CESP • FITs • Asset value transfer payments for domestic services contracts	• Smart metering • Micro CHP • Micro renewable generators (wind, PV, hydro) • DSM • Intelligent heating controls • Automated due diligence for transfer of services contracts
Electricity Distribution Network Operators	• R&D incentives • Nodal pricing • Local wire unbundling • Local SO powers and constraints	• Active network management • DSM • SO functions
Gas Distribution Network Operators	• Local pipe unbundling	• Biogas feed-in
Heat Network Operators	• Open access	• Waste heat feed-in
Electricity Transmission and System Operator	• R&D incentives • Nodal pricing	• DSM
Central Communications Provider	• Initial vesting of CSP • Include heat metering • Extend data management to include asset inventory	• Smart metering • DSM • Integration of building energy management with metering • Automated due diligence for transfer of services contracts
Electricity and gas generators	• Local wire & pipe unbundling	• Participation in local ESCos

The long term effects on the industry that could be expected from a vibrant energy services market and the changes to networks underlined in Table 2 can be summarised as:

- Distribution networks (both electricity and gas) become more innovative in order to attract local ESCos and the revenue they bring.
- System Operator functions become more dispersed leading to the Transmission Operator and DNOs managing the national system jointly on the basis of peer-to-peer co-ordination, with an element of competition that should stimulate innovation.
- More distributed generation in the south and west (and any area affected by network constraints) as the value of electricity generation in these locations is fully exposed.
- Heat networks develop and extend to capture waste heat from industrial processes and electricity generators.
- Competition at retail level between energy services offers and conventional sale of kWh drives innovation and improves value for money for the consumer.

8 Conclusions

This paper has argued that businesses offering energy services can make a substantial contribution to realisation of the outcomes sought by the RPI-X@20 Review. They do this through two particular aspects of the business model:

- by identifying opportunities to produce and deliver heat and electricity simultaneously in a way that is more efficient than producing either on their own;
- by entering into a more intimate relationship with their customers than is necessary for supply of kWh, so that they can identify and deliver their actual energy-related needs.

Because heat cannot be transmitted very far, an energy services business must unavoidably involve investments that are close to the customer, either within their premises as in the case of micro CHP, heat pumps and insulation, or in the local area, where district heat networks are installed. This makes the business model inherently different from the sale of kWh which has been based on very large plants obtaining economies of scale in the delivery of a commodity. It is not surprising therefore that service businesses will flourish best under a somewhat different regulatory regime to that which supports commodity kWh. In the context of RPI-X@20, the critical changes are those which allow an energy services business to only pay for the segments of local electricity, gas, and heat networks that it is actually using. Although the current proportion of costs attributable to distribution may only be about 18% [3], a viable services business needs the savings from its reduced use of transmission and distribution, combined with the thermodynamic efficiencies of CHP, to offset the loss of economy of scale compared to big generators, and the extra transaction costs of the close customer relationship.

It has also been argued that two technical and commercial innovations are needed for a strong energy services industry, which will probably require regulatory intervention to establish, although not necessarily under RPI-X@20. The first of these is a comprehensive automatic DSM mechanism usable by all consumers. It is important to an energy services business because matching the production of both heat and electricity to demand is even more challenging than just matching one of them. So the ability to dynamically shift the customer's demand is valuable, and the consent of the customer to allow this within agreed parameters flows naturally from their close relationship with the supplier. The involvement of the regulator is likely to be needed because common standards will have to be adopted across the electricity industry, and the benefits of DSM, while accessible to many industry actors, may not automatically coincide with costs.

The second innovation is automation of the process of setting up an energy services contract, so that transaction costs are reduced to a level compatible with domestic consumers, and competition is facilitated. The key regulatory action is to set rules for the residual value of a supplier's assets to be covered by a transfer payment or lease when the consumer moves to a new supplier. This will enable attractive energy services deals to be offered along the lines set out in Appendix C. These rules need to be supported by an inventory of the assets and their performance which should preferably be captured and maintained by the Central Communications Provider via the smart metering system.

However, even if these regulatory changes and innovations take place, the resulting energy services must be taken up on a sufficient scale to achieve RPI-X@20 Review outcomes. We argue that this will occur, driven by four groups of customers:

- consumers who feel strongly about climate change and volatile energy prices, but want someone to deal with them on their behalf;
- new build, where outsourcing the challenging requirements of building regulations will be attractive;
- relatively homogenous communities such as social housing and university halls of residence, whose occupants generally expect comfort to be part of the accommodation package;
- owners of battery and plug-in hybrid cars, who will be open to novel forms of contract that meet their needs.

Just as mobile phone use began with plumbers and salesman, and became widespread as the usefulness of this service was recognised, so energy services may spread from these early adopters to the wider community. The RPI-X@20 review should sustain this possibility.

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Appendix A Demand Side Management

The economic benefit of automatic demand side management (DSM) has been recognised since Economy 7 was introduced in the 1970's to lower the price of electricity consumed overnight. Ideally an electricity supplier should be able to communicate to their customers at, say, midnight, a cost profile for the coming day. This profile will vary from day to day depending on the weather[9], time of year, and the likely response to it[10]. Note that the cost indicated is not necessarily related to the price paid by the customer, particularly in the context of a services contract. Given a suitable intelligent control device, a customer's appliances could then choose to operate at a time which represented a best compromise between the needs of the household and the cost of electricity. This control mechanism is recognised as one of the key building blocks of a smart grid[11] and should feature in the vision and roadmap for the UK smart grid promised by DECC[12] for later this year. Figure A1 illustrates a possible shape of such a cost profile – it will tend to follow the normal daily UK demand profile (the vertical axis represents variation from mean cost).

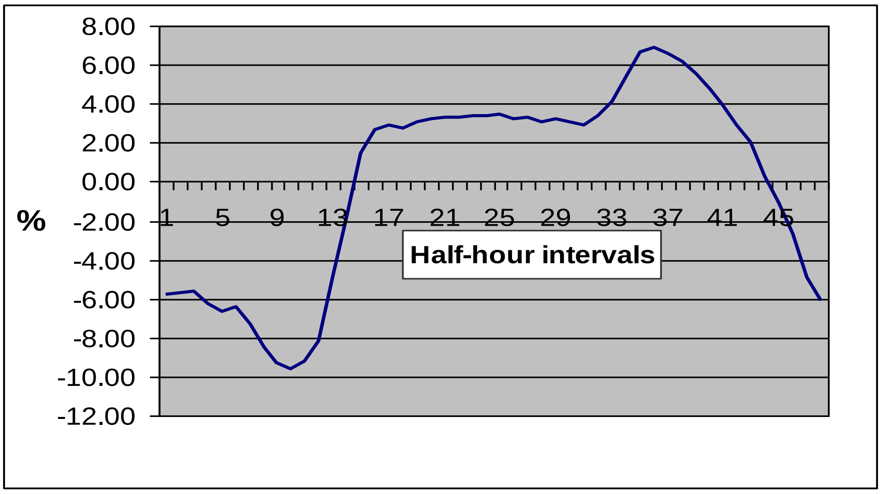

Figure A1. Daily cost profile for demand management

The response to such a cost profile need not be limited to time shifting of electricity demand from appliances such as immersion heaters and tumble driers; it should also include micro CHP units and cars with plug-in hybrid or battery-only power trains. A control device with access to the cost profile and ability to make small adjustments to the room thermostat can shift the time at which electricity generation occurs from a micro CHP unit so that the value of that electricity is maximised, without affecting the consumer's comfort. [10, 30]. Similarly an intelligent device controlling the charging of a car battery could choose least cost times to take the energy required for the user's expected travel needs, and also, given an appropriate contract between the user and the electricity supplier, actually return energy to the grid when cost peaks occur (although the losses involved in the battery charge/discharge cycle will make this unattractive on a routine basis).

However, there is no consensus in the UK industry at present on the precise technical method by which this signal should be delivered, or on the exact nature of the signal itself. The ERA response to the DECC Smart meter consultation [31] plays down the ability of the

[9] This dependence will increase as the proportion of renewable generation increases.
[10] The response will reflect the elasticity of demand for electricity which will vary e.g. due to varying needs for travel by electric cars.
[11] DECC Low Carbon Strategy Box 10 Page 71
[12] DECC Low Carbon Strategy Page 72

proposed smart meter rollout to perform DSM, and defers to the prospective DECC smart grid roadmap for direction. There are a number of international standardisation initiatives in progress covering the communications aspects of DSM, notably the International Electrotechnical Commission's Smart Grid portal [32] and the EU's Openmeter programme [33]. Major equipment manufacturers such as Cisco are also seeking to influence the industry with their own vision [34]. There is clearly going to be some competition between standards similar to that for DVD formats (Blu-ray vs. HD DVD).

Fortunately for regulators, the medium for DSM is less important than the message, i.e. the actual cost dependent signal. The calculation and presentation of this signal needs to be standardised for the UK using a regulated method so that when a consumer switches suppliers their control units will respond rationally to the signal from the new supplier. It will also be necessary to ensure System Operators (i.e. including DNOs as they take on this role with increasing distributed generation) can influence the shape of the signal to deal with balancing issues such as TV pickup[13], while DNOs should be able to use the signal to prevent local network overload conditions.

In order to stimulate the development of all aspects of DSM, the existing Radio Teleswitch system [35] could be used to broadcast a limited number of cost profiles in advance of the smart meter rollout. This system currently allows the time at which electricity is supplied to domestic storage heaters under the Economy 7 scheme to be varied, using a radio signal embedded in the BBC Radio 4 long wave broadcast that is picked up by a receiver unit installed with the Economy 7 meter (see Figure A2 – the teleswitch is the box to the right of the meter). It was developed in the 1980's to avoid the surge in electrical load that was occurring at the 1 am start of the Economy 7 period, and is fitted to the majority of homes with storage heating. The broadcast is still used by National Grid as a balancing technique. But when a consumer with one of these devices in their home switches electricity suppliers, the new supplier does not usually know whether one is fitted, so cannot get the full financial saving it should provide in the settlement process.

This simple and low cost (but under-used) technology could be exploited immediately to allow automatic appliance controls to be developed and used by any consumer with half-hour metering (which already includes many small businesses). Since it does not have the capacity to carry a signal for every supplier and distribution zone in the country, the available capacity should be allocated on a competitive basis to suppliers who have credible plans to make use of it.

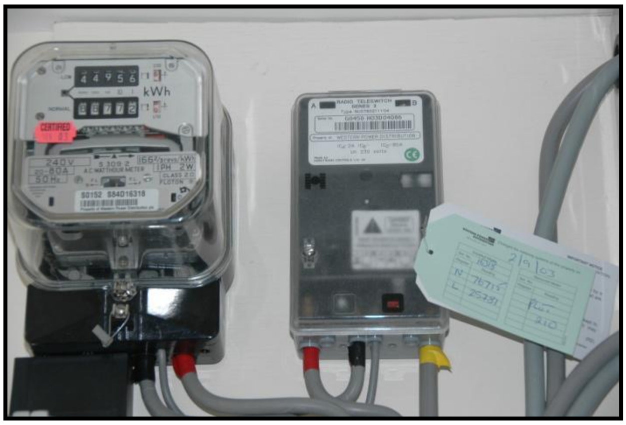

Figure A2. A radio teleswitch

[13] "TV pickup" is the surge in electricity demand caused by mass use of electric kettles when a very popular programme or sporting event pauses or ends.

Appendix B Technology and regulation to reduce transaction costs and increase competition in energy services

This Appendix aims to provide further detail suggesting how the smart meter infrastructure might be exploited to facilitate retail energy service contracts with a performance commitment.

Most homes in the UK contain some form of control unit that determines when space heating and hot water are provided, and thermostats that regulate room and water temperature. Time and temperature settings are normally configured manually by users. Here we conceive a much more sophisticated version of this control unit which combines automated heating control with energy metering and at the same time acts as a semi-autonomous agent mediating between the ESCo and the consumer, thereby reducing transaction cost and risk for both parties and promoting competition. This requires a range of supervisory, control, and data collection functions to be performed using the information processing resources of the smart meter system and the Central Communications Provider. These functions can be divided into those which reduce the supplier's risk, others which reduce the consumer's risk, and some which are beneficial to both parties. Table 1 lists and classifies the functions accordingly.

Table B1. Control functions useful for competitive retail energy services

Function	Reduces supplier risk	Reduces consumer risk	Comments
Automatic time settings so that heat is only provided when the occupants of the home are present and need it.	✓		Also convenient for consumer.
Automatic temperature settings.	✓		Some consumer control necessary.
Limit reckless use of heating (e.g. with windows open).	✓	✓	Consumer avoids contract surcharges
Provide feedback on energy consumption.	✓	✓	Consumer benefits from efficiency when contract renewed.
Record and display achievement of comfort levels (i.e. contract compliance by supplier).		✓	
Recognise new energy capture or conversion devices and bring under management.		✓	Allows consumer to "plug & play" their own devices e.g. solar thermal.
Monitor efficiency and performance of all energy capture and conversion devices under management.	✓	✓	Consumer avoids loss of comfort due to equipment failure.
Exploit thermal capacity of the building to optimise timing of energy use.	✓		Facilitates demand side management.
Manage electrical load and generation in response to demand side management	✓		
Capability to submit an inventory of energy equipment and metering history to an alternative ESCo via CCP.		✓	Allows consumer to change ESCos easily – see text.

Because a control unit with this specification supervises all aspects of the supplier-customer relationship, it could allow an ESCo business model to be maintained in a market with open competition and short term contracts. This might operate with the following rules and processes:

- The service provided by the ESCo meets all the heating/cooling and electricity needs of the consumer.

- The control unit is aware of the type, age, and performance of all the energy conversion units (boilers, micro CHP, air conditioning units, heat pumps, solar panels, etc) under its supervision. It is assumed at this point they have been provided under the consumer's current ESCo contract. The control unit also maintains records of energy consumption and the thermal parameters it has calculated for the building such as thermal capacity and heat loss.

- The consumer would be able to ask the unit to submit this data in summary form, to an alternative ESCo to obtain a quotation.

- The alternative ESCo would provide a quotation of an ongoing tariff to the consumer taking into account the cost of buying out the energy conversion assets, according to standard rules agreed between the industry and the regulator (e.g. £x per kW of rated heat output per year of life for a gas boiler with y% efficiency). Where the assets are owned by a leasing company the cost would be the leasing charge. This ensures that asset stranding does not occur.

- If the consumer accepts this offer, the alternative ESCo pays the original ESCo the buyout price and the contract transfers. The control unit re-affiliates to the new ESCo for the purpose of routine reporting and billing.

Here the control unit has facilitated competition by acting as a trusted source of information and by automating an otherwise complex transaction, of a kind which is commonplace today in outsourcing contracts, but is carried out with laborious "due diligence". This market model will bring into play some other useful incentives in that any wasteful (or efficient) behaviour by the consumer will be visible in the records so the alternative ESCo will be able to price this into their offer, while ESCos will seek to arbitrage the asset buyout price by obtaining energy conversion equipment at volume discount prices and with high efficiency.

A critical point is the ownership of the data captured by the control unit. Since it is functionally an extension of the smart meter preferably all the data including metering data should be treated in the same way. It will be quite unacceptable for the incumbent ESCo or retail supplier to consider it their intellectual property and then use this ownership to prevent its release to a competitor. A possible approach would be for the CCP to own the data, with comprehensive access rights (and confidentiality commitments) to the consumer, access rights to the incumbent supplier or ESCo, and limited access rights to an ESCo or supplier who has been invited by the consumer to provide a quotation.

The rules of the market should allow consumers to provide their own energy capture assets. For example, if a consumer thinks their house presents an opportunity for a micro-wind generator, and their ESCo is not interested in making the investment, then it would be open to them to install it on their own account. The control unit would recognise and characterise it, and then they could invite their current and alternative ESCos to price up a service including this asset. They would have the option to either receive the asset buyout price, or retain ownership of the asset, and benefit accordingly from revised terms in their service contract.

The transactions described above would be sufficient for retail energy services as described in section 5, but need to be extended to support local ESCos as described in section 6. Some possible market processes and rules for this context might be:

- ESCo customers, both domestic and commercial, may group themselves together and seek a collective deal with an ESCo using the aggregated data from their control units. They would expect to extract some of the benefits of economy of scale - for example all the consumers in a block of flats could be supplied by a CHP unit provided by the ESCo. Alternatively they may choose to procure and operate their own CHP asset and invite ESCos to build it into the deal.

- Where an ESCo provides a community asset, such as the CHP unit in the example, they can “tie” customers to that asset (up to the limit of its capacity) such that if a customer seeks to change to a new supplier their share of the CHP asset value or lease would be included automatically in the asset buyout price.

- A new supplier taking over a customer who is tied into a community asset would have the option of having the customer’s energy needs continuing to be met by the existing asset (the CHP in the example). In this case the new supplier would pay the old supplier a regulated running cost fee as well as buying or leasing the share of the asset. This will ensure that inefficient ESCos can always lose customers.

- Once a new ESCo has a majority of the tied customers on an asset it will be deemed to have taken the asset over for the purposes of assuring operation and maintenance on behalf of the customer base (though of course these activities might be subcontracted). To support this kind of transaction the CHP unit would also have a trusted control unit that would provide a summary of its performance to a new ESCo.

The technical feasibility of a control unit with many of the features in Table A1 has been demonstrated [10], and it has always been part of the vision and justification for the UK smart meter rollout that it should support innovation of this kind. The challenge for regulators and the energy industry is to develop the detailed rules for transfer of assets and/or leases between ESCos. To ensure there is always competition between ESCos and conventional kWh retail, it must be possible for the consumer to buy themselves out of a services deal that has involved capital investment, by paying the residual asset price or leasing charge themselves. They would then be able to take on any conventional kWh supply contract.

Appendix C Provision of an energy service using heat pump technology

This appendix provides an example of how a new technology with high capital cost could be converted into an affordable and attractive energy service. Consider a 3 bedroom home or flat currently equipped with storage heaters on Economy 7, with an annual heating load of 15000 kWh. The family pays 10p per unit for daytime electricity, and 5p per unit for Economy 7 electricity. Two thirds of their heat load is met by the cheap electricity, so their current annual cost is 10,000*5p + 5,000*10p = £1000.

A heat pump with a Coefficient of Performance (CoP) of 4 requires only a quarter of the electricity units to provide the same amount of heat. However, more of the units will be day units since a simple heat pump system does not include much thermal storage. So this home would require 15000/4 = 3750 kWh per year, of which 80% would be day electricity and 20% Economy 7. The resulting annual cost would be 750*5p + 3000*10p = £337.50

The saving in electricity cost per annum is therefore £1000 - £337.50 = £662.5. The cost of installing an air source heat pump system would be about £5000. So the simple payback time is £5000/£662.5 = 7.5 years. However, if the heat pump was sold as a service, with guaranteed room temperature levels (subject to reasonable conditions) this would be of interest to a family irritated by the tendency of storage heaters to overheat their home in the morning and leave them cold in the evening. The ability of the heat pump to provide cooling in summer would also be very attractive. So they would be willing to invest £1500 as an initial service charge to modernise their home, and continue to pay £1000 per annum if given confidence that this figure is not going to increase dramatically in future. This reduces the payback time to the supplier to 5.3 years, which should be sufficiently inside the operational lifetime of the equipment (say 10 years) to support financing costs. It would probably be sensible for the service to charge air conditioning usage only at a kWh rate to avoid the supplier's risk associated with this feature - consumers would recognise and accept this as a "premium" service.

This combination of an upfront payment combined with a stable running cost for a service providing new technology is well understood by consumers from mobile phone deals. As long as there is no risk of stranded assets, this kind of contract should be attractive to energy retailers, once they have acquired the telco skills of specifying, buying, and managing domestic equipment in bulk to drive down costs.