Smart metering

A REPORT PREPARED FOR CENTRICA

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Executive summary

1.1 INTRODUCTION

Frontier Economics has been engaged by Centrica to provide analysis of the costs and benefits of proposals to introduce smart meters for domestic and business customers within Great Britain. The key objectives of this work were as follows:

- to provide a transparent and structured evaluation of the costs and benefits of introducing Visual Display Units (VDUs) across the electricity domestic sector;
- to produce a transparent and structured evaluation of the costs and benefits of introducing smart meters across the domestic and business sectors; and
- to compare the costs, benefits, risks and rewards of the rollout of smart metering within the current market framework to those within other market frameworks, such as the Regional Franchise Model (RFM).

The main contribution that this study attempts to make is to show how the net benefit associated with a smart meter roll-out may be affected by the way in which the roll-out can be undertaken.

In undertaking this work we have been able to utilise Centrica's knowledge and experience of meter procurement within the existing competitive metering market, as well as its experience of deploying of smart meters within the current industry structure.[1]

1.2 THE CASE FOR VISUAL DISPLAY UNITS

The Government is proposing that from May 2008, where technically feasible, every household having an electricity meter replaced and every household receiving a new connection should be given a real-time electricity VDU free of charge. Analysis undertaken by the Department of Business Enterprise & Regulatory Reform (BERR) purports to show that there will be a total net benefit in the region of £205 million from such a scheme.[2] We consider that this analysis is misleading.

In evaluating the potential benefits of VDUs, it is important to consider the VDU policy and the smart meter policy together.

1 Centrica has already installed 16,000 smart meters in the SME sector and undertook a trial of 50,000 residential AMR (one-way) meters in 2003/04.

2 "Energy Billing and Metering", BERR (August 2007) p21.

- The costs of a VDU *are in addition to* the costs of a smart meter. The type of VDU that is currently available will not be suitable for use as a display device with a smart meter and, therefore, would be rendered redundant on installation of such a meter.
- The benefits of a VDU *are a subset of* the benefits of a smart meter. The only route by which a VDU can generate a potential benefit is via increased customer awareness of the cost of energy consumption, leading to reduced demand, whilst smart meters offer a much wider set of potential benefits. In addition, there is reason to believe that the incentive to reduce consumption that may come from a VDU will be lower than that which would be achieved from a smart meter roll-out.[3]

These two factors mean that a VDU would be stranded in the event that a smart meter was deployed in the same location. Any analysis of the case for VDUs therefore needs to take into account the probability of a smart meter being introduced at a point in time before a positive net benefit is generated.

Using BERR's own estimates of the cost of providing a VDU[4] and the associated benefits[5], the pay-back period for a VDU for a domestic electricity credit customer will be around 9 years.[6] Therefore, given the Government's own aspiration for a roll-out of smart meters to all customers within a 10 year period, few if any VDUs will have been in place long enough to produce a positive net benefit before they are stranded by installation of a smart meter. In addition, for prepayment customers, VDUs are never expected to show net benefits over the life of the asset. Requiring distribution of VDUs to these customers would therefore fail BERR's own test of being financially reasonable and proportionate.

In addition, we consider that the central case estimate of a 3.5% (credit) and 1.75% (prepayment meter) reduction in consumption continuing for 15 years is imprudently high, given the lack of robust evidence to back up such assumptions. A more prudent central case assessment would be for reductions in consumption of 1% (credit) and 0.5% (prepayment). Making these changes would mean that the deployment of a VDU to either a credit or a prepayment customer will not generate a net benefit within the 15 year lifespan assumed by BERR.

Given this analysis, it is evident to us that a general roll-out of VDUs is not likely to be in the public interest. However, since a VDU roll-out could start up to two years before a smart meter roll-out, there are two cases where a limited roll-out

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3 The likelihood that many customers would neither replace batteries when they expire nor update the devices for new tariff information, combined with the absence of reinforcing billing information from suppliers, means that VDUs are unlikely to produce reductions in consumption as large as those from smart meters.

4 BERR's central case cost estimate is £26 to purchase and install, annuitised over seven years at a 10% cost of capital, plus £2.71 per year running costs for seven years. Centrica believes that the upfront costs under-estimate the actual costs that will be incurred in the roll-out, and there may be at least another £14 incurred by suppliers at this time.

5 BERR's central case estimate is for a 3.5% (for credit customers) and 1.75% (for prepayment customers) reduction in energy consumption that will be sustained for a 15 year period.

6 This is based on BERR's central case estimate for credit customers.

of VDUs in this intervening period could be beneficial, providing BERR can substantiate its assumptions about the level of energy reduction that such devices would promote.

- If the Government relaxed its timetable for the roll-out of smart meters so that the new meters were installed on a replacement basis over a 20 year period, there could be a case for issuing VDUs on replacement in the interim period until a smart meter deployment could commence. The customers receiving VDUs in that interim period would not expect to get a smart meter for a further 20 years and therefore, under BERR's central case estimates, would have a VDU long enough to expect to see a net benefit.
- If VDUs could be provided exclusively to those customers that would make the highest savings in their consumption, then their individual payback periods may be reduced sufficiently to provide a net benefit before the introduction of a smart meter. These customers are likely to be:
  - those who actually want such a device and will use it;
  - those who would have most discretionary load to reduce; and
  - those with the largest energy consumptions.

  With the exception of size of energy load, it is not clear that there will be any way of identifying such customers in order to achieve a targeted roll-out. However, it is possible that such customers would self-identify if the devices were provided only on-request with some (nominal) associated charge.

In the event that the Government wishes to see an accelerated roll-out of smart meters, we can only envisage a net loss resulting from a VDU roll-out scheme. Our estimate of the size of this loss is £168m. This is based on the assumption that VDUs are provided on replacement/installation of a new meter and on request for a two-year period prior to the introduction of a smart meter roll-out over a 10-year period.[7]

In addition to this estimate of the net loss to society from the Government's current proposals, we would also note that there are the following additional downsides associated with a focus on a VDU roll-out.

- VDUs can only be applied to a subset of the market.[8] Although this does not affect whether the proposal has a net benefit, it does alter the scale of any benefit and the ability of VDUs to contribute as a policy measure to the 2010 carbon reduction targets. In the event that VDUs will not make a sufficient contribution to this milestone, it may be better to focus on using a smart meter deployment to meet the 2020 targets.

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7 It is assumed that 10% of customers will request a VDU in each of the two years and that the roll out of smart meters will take place on an accelerated 10-year replacement programme.

8 BERR assumes 75% of domestic electricity customers for all meters other than new meter installations where the percentage is 95%.

- Planning for a VDU roll-out programme will take up time and resources that could be better employed on achieving a faster start to a smart meter roll-out.
- In the event of an accelerated smart meter roll-out, the VDU devices would end up being discarded within a short period of time. This could have a detrimental impact on public opinion of the value of investment in such devices.

It is therefore our opinion that, in the event that the Government requires an accelerated roll-out of smart meters, it would not be in society's interest to see a roll-out of VDUs as an interim measure.

1.3 SMART METER ROLL-OUT FOR DOMESTIC AND SMALL BUSINESS CUSTOMERS

In order to produce a transparent and structured evaluation of the costs and benefits of introducing electricity and gas smart meters across the domestic and small business sectors, we have undertaken a detailed Cost Benefit Analysis (CBA) of the introduction of smart meters to these customer groups. This CBA considered the net benefit for "GB plc" and followed HM Treasury's Green Book principles. Our analysis focussed on the incremental costs associated with introducing smart meters to domestic and small business customers, compared to the existing dumb meter programme, over a 20 year period. As such, the analysis takes into account the impact of the timing of the roll-out. It uses data provided by Centrica and collected from other studies recently undertaken in this area.

One of the aims of this study was to understand how the net benefit associated with a smart meter roll-out may be affected by the way in which the roll-out can be undertaken. In order to do this we considered three base case scenarios of how the roll-out could be managed:

- Supplier Hub Model (SHM) (replacement): This scenario involves a roll-out of smart meters using the existing industry framework. Metering would continue to be undertaken competitively by multiple agents. In the event of a smart meter roll-out, each supplier would be responsible for installing a smart meter into each of its customers' premises. The speed of the roll-out would be determined by the requirement to replace dumb meters at the end of their certified life.
- Supplier Hub Model (SHM) (accelerated): This scenario also envisages continuation of the current industry framework. However it assumes that meters will be replaced on an accelerated basis, the base case being that this would happen over 10 years.
- Regional Franchise Model (RFM) (accelerated): This scenario envisages re-integration of the metering functions. In the event of a roll-out of smart meters under this framework, one party would be responsible for installing smart meters into all customers' premises within a defined geographic area. We assume that such reform of the industry would only be undertaken if the roll-out was to be accelerated and, given the increased co-ordination offered by the re-integrated structure, could be undertaken over a shorter time period

than an accelerated roll-out under the Supplier Hub Model. Our base case assumption is that a smart meter roll-out could be undertaken over a seven year period.

To provide structure to the assessment of a smart meter roll-out programme, it is useful to break the analysis down into three stages:

- Is there a net benefit associated with the introduction of smart meters to domestic and small business customers?
- Is there a case for accelerating such a smart meter programme?
- Is there a case for co-ordinating the roll-out of smart meters to achieve cost savings in deployment?

We consider each question in turn.

Case for smart meters

We present a summary of the results of our Cost Benefit Analysis using our base case assumption in Table 1.

	SHM (replacement)	SHM (accelerated)	RFM (accelerated)
Incremental costs	(£4,663m)	(£6,738m)	(£6,109m)
Supplier[9] benefits	£1,889m	£2,994m	£4,804m
'Green' benefits	£2,636m	£3,999m	£4,477m
Other benefits	£192m	£292m	£327m
Total net benefit	**£54m**	**£546m**	**£3,499m**

Table 1: Summary results of CBA (base case) for domestic and small business customers

The results show that, given the scale of the costs and benefits, there is not currently a business case for suppliers to roll-out smart meters to their domestic and small business customers. This result is consistent across both SHM scenarios. In addition, we find that there is still a significant gap between the level of supplier benefits and the cost of the meters and therefore it is not clear that this situation will change in the short to medium term. This does not mean that there are no market segments where there would be a supplier case for a roll-out. However, it does mean that if the Government leaves it to suppliers to decide whether to roll-out smart meters to these customers then, based on current evidence, it appears to be extremely unlikely that this will occur for all customers within the next 10 years.

9 It should be remembered that 'supplier' benefits will be expected to be transferred to customers, given the competitive energy supply market.

The case for a mandated roll-out of smart meters to domestic and small business customers depends on the expected level of 'green' benefits that may be generated by customers altering their energy consumption behaviour. This change in consumption behaviour may be a result of:

- a reduction in the level of gas and electricity consumption in response to better information about the cost of energy consumption; and
- a movement in the timing of electricity consumption from peak to off-peak periods in response to time of use tariffs.

These changes would be expected to generate three potential benefits:

- a reduction in the cost of energy used;
- avoided peak capacity costs; and
- reduced carbon emissions.

Our base case assumes a reduction in consumption of 2% for domestic gas and electricity credit customers, 1% for domestic gas and electricity prepayment customers and 0.25% for gas and electricity small business customers. In addition, we assume 20% of domestic electricity customers will take up a time of use tariff. The carbon reduction associated with each scenario by 2020 is:

- SHM (replacement) – 1.8MtCO_2;
- SHM (accelerated) – 3.2 MtCO_2; and
- RFM (accelerated) - 3.2 MtCO_2.

In order to illustrate the contribution that is made by each source of 'green' benefit, we provide the breakdown for the RFM (accelerated) total 'green' benefit of £4,476.6m in Table 2 below.

	Energy reduction (Gas)	**Energy reduction (Electricity)**	**Peak shift (Electricity)**
Reduction in cost of energy consumed	£1750m	£857m	£27m
Avoided peak capacity	£33m	£625m	£156m
Carbon reduction	£519m	£516m	(£7m)
Total 'green' benefit	**£2,302m**	**£1,998m**	**£177m**

Table 2: Expected level of 'green' benefits (base case) under RFM (accelerated)

Source: Frontier Economics' analysis

These results lead us to make the following observations.

- We consider that our assumptions for the take-up of the time of use tariffs, and the load movement that they would be expected to generate, are conservative. However, the results would indicate that, under current conditions, such a benefit is unlikely to be large enough to make the case for a mandated smart meter roll-out. It is important to recognise that this could change in the future, particularly if a summer peak demand associated with air-conditioning materialised.

- The potential of gas smart meters to deliver significant 'green' benefits should be recognised. Average gas consumption is higher than average electricity consumption and therefore may be expected to result in greater savings for any fixed percentage reduction in consumption.
- The case for a smart meter roll-out, at present, rests on confidence about its ability to deliver a reduction in average consumption. A relatively small change in the average percentage reduction in consumption can lead to a large variation in the size of benefit that such a policy may be expected to generate. Under the base case assumptions, only the RFM (accelerated) scenario shows a net benefit if domestic credit customers' average reduction in consumption drops to 1%.

Therefore, the case for rolling smart meters out to domestic and small business customers now, rests on the expected level of customer and society benefits associated with reductions in consumption. Assuming that the same reductions are achieved by smart meters as those assumed by BERR in its central case for VDUs, a positive net benefit of such a roll-out should arise. If Government considers the achievement of these 'green' benefits to be based on sufficiently robust assumptions, then, if it wishes to see a universal roll-out of smart meters, it will need to mandate that policy.

Case for an accelerated roll-out

If Government decides that a mandated smart meter roll-out is the correct policy, the time period over which smart meters should be introduced needs to be decided.

There are three key benefits to an accelerated roll-out.

- The benefits are received sooner. Clearly, if there are benefits to having a smart meter, the quicker those benefits are received, the greater the value of those benefits within the CBA.
- The time over which the dumb and smart meters will need to be run in parallel will be reduced. This has an associated cost saving as the unit cost associated with managing a diminishing dumb meter stock will rise as the stock of dumb meters falls.
- There may be economies of scale associated with the purchase of a higher number of smart meters per year.

Against these benefits there are additional costs associated with an accelerated roll-out.

- There will be higher levels of stranding of dumb meter assets as more dumb meters are replaced before the end of their economic life.

- The real cost of smart meters has fallen over recent years. If this trend were expected to continue, then the total cost of purchasing the smart meter assets could be higher rather than lower under an accelerated programme.

The analysis that we have undertaken indicates that the benefits of accelerating the roll-out are likely to exceed the costs.

Cost savings from a co-ordinated deployment

There are three potential areas where significant cost savings could arise from undertaking the smart meter roll-out in a co-ordinated manner across the industry. The first is from undertaking the roll-out on a geographic basis, the second is from undertaking the roll-out on a dual fuel basis and the third is from increased supplier cost savings associated with the re-integration of metering services. We discuss each in turn.

There are three key benefits associated with a geographic roll-out.

- There would be a saving in the cost of installation due to the reduction in travel time associated with being able to do a replacement meter programme on a street by street basis.
- There would be a reduction in the cost of managing the dumb meter network during the roll-out period as the density of dumb meters in any remaining area would remain constant. Further, if the dumb meter stock was transferred to the smart meter roll-out provider, then there may well be savings to be made in the intervening period as density will increase compared with the supplier-led approach that is undertaken today.
- A co-ordinated campaign of advertisement and education could be employed in each area in which the roll-out was occurring to maximise both the chance that customers would be in at the time their installation was scheduled (thus saving the costs associated with re-visits) and the chance that they would engage with the process and achieve a reduction in consumption.

The case for a dual-fuel roll-out is also strong.

- There is a lower cost smart metering solution associated with being able to "piggy-back" the gas meter with the electricity meter, resulting both in lower one-off costs associated with the purchase of the equipment and ongoing communications costs associated with the provision of meter reads.
- There is a reduction in the average time to install a meter as only one site visit is required (and therefore a saving is made both in travel time to the property and the time taken to gain access to a meter).
- There is a reduction in undertaking dumb meter reads during the roll-out as both gas and electricity meters can be read at the same time.

It is clearly the case that the geographic benefits could only be achieved by a co-ordinated industry approach to roll-out. However, most of the benefits associated with a dual-fuel roll-out are also only likely to be achieved with a co-ordinated roll-out for the following reasons.

- If the roll-out was the responsibility of individual suppliers, they would only be able to achieve the benefits associated with a dual-fuel roll-out in those cases where they supplied both fuels. This immediately reduces the benefits by over half given that 58% of customers with both a gas and electricity meter still take their supplies from different gas and electricity suppliers.
- In addition, there are strong arguments for why, even for the customers that are on a dual fuel supply, suppliers (and therefore ultimately customers) will not realise the dual fuel savings. First, on installation, we understand that, at present, fitters are not trained to be able to install both gas and electricity meters. The reduced density[10] faced by a supplier, compared with a regional franchisee, means that reorganising its workforce to undertake dual fuel fitting is unlikely to be cost effective. Second, given that a dual fuel supplier has no guarantee that it will not lose one or other of the fuels to an alternative supplier, it will not risk installing the cheaper gas piggy-back solution as this will face a greater risk of being stranded in the event the customer chooses to revert to single fuel supplies.

Certain supplier costs associated with the provision of an energy supply are expected to reduce following the introduction of smart meters. However, the level of reduction will depend on the industry framework that is adopted. In particular, if the current fragmented supplier hub model is retained, it is assumed that costs will still be incurred dealing with the failure of data flows associated with activities such as change of supplier. In the event that these are re-integrated, the cost savings are expected to be greater.

The cost savings associated with a co-ordinated deployment are significant. Utilising information provided by Centrica about the differences in costs generated by the different scenarios, we estimate that the cost of roll-out will be almost £3bn lower if the geographic and dual-fuel cost savings are realised.

Distributional impact

The standard cost benefit analysis considers costs and benefits for society as a whole and does not concern itself with the impacts that a policy may have on particular categories of stakeholders. In order to complete the analysis of a new policy, it is therefore necessary to undertake an assessment of its impact on different stakeholder groups. There are two potential impacts that warrant further consideration:

- Impact on particular groups: Given the nature of the benefits that are expected to arise from smart meters, and the market structure that will deliver them, it is likely that most of the net benefits associated with the policy will accrue to customers. If the policy delivers a net benefit then it is likely that customers will also derive a net benefit. On average both domestic credit and prepayment customers appear likely to derive positive net benefits from the

10 If a supplier has half its customers on dual fuel and supplies one sixth of the market, then the density of dual fuel properties it will face will be one twelfth of that faced by a monopoly roll-out provider.

policy. The case is less clear for small business customers, if the lower reduction in consumption of 0.25% is accepted.

- Impact of stranding existing assets: Under an accelerated roll-out scenario, there will be a cost associated with the stranding of the existing metering stock before the end of its expected useful life. Given that metering services tend to be charged to customers on an annual basis over the expected life of the meter, the cost associated with this stranding will rest with industry, rather than customers. The different contractual arrangements that are currently in place between suppliers and meter providers means different industry stakeholders will face different liabilities. It is appropriate that some form of industry-wide solution to stranding is found since parties have acted in good faith in investing in the existing meter asset base and any Government mandated accelerated roll-out would represent a change in policy that was not signalled by Government prior to such investment being made. Failure to recognise this and compensate those affected will be expected to raise the financing costs of the smart meter roll-out.

1.4 SMART METER ROLL-OUT FOR LARGE BUSINESS CUSTOMERS

The definition of large business customers that has been used for this analysis is the one proposed by BERR, namely profile classes 5-8 of the electricity market and non-daily metered gas sites consuming more that 732 MWh[11] per annum. We also use BERR's proposed roll-out of smart meters to this group, namely that it will take place as an accelerated five-year roll-out, starting in 2008. Given the relatively small number of customers involved, we assume that it will be undertaken within the current supplier hub industry framework. In addition, we base the smart meter technology and costs on those that are currently available within the market place.

We summarise the results of this roll-out in Table 3.

	Gas	Electricity	Total
Incremental costs	(£36m)	(£76m)	(£112m)
Supplier benefits	£1m	£62m	£63m
'Green' benefits	£77m	£43m	£119m
Total net benefit	**£41m**	**£28m**	**£70m**

Table 3: Summary results of CBA (base case) for large business customers

These results show that, based on the input assumptions and methodology, there is expected to be a small net benefit associated with the introduction of smart meters to large electricity customers and data loggers to large gas customers. This case is driven primarily by the expected benefits associated with the energy

11 We assume that the cut off point is anticipated to be 732 MWh and not 73,200 kWh, as referenced in BERR (2007) p31.

reduction: even a small reduction in consumption will result in absolute savings that may be expected to exceed the cost of the meters. However, the benefits that accrue to suppliers are not, on average, expected to be sufficient to warrant suppliers undertaking a complete roll-out under their own volition. In the case of gas smart metering, the supplier business case is still a long way from being positive. It is much closer for an electricity smart metering solution.

It is worth comparing two aspects of our results with those that have been presented by BERR. First, the net benefit in our analysis is much smaller than the one predicted by BERR. The main driver of this result is our lower assumption of reduction in average energy consumed. Second, we note that although BERR has calculated a positive net benefit to "Firms" from this policy, we understand that this includes the cost savings associated with avoided peak capacity that BERR assumes accrues to generators and network providers, rather than customers. When the supplier business case is considered in isolation, BERR's analysis would point to the same policy implications as our own: a roll out of smart meters to customers is likely to be in the public interest, but there is currently no supplier business case for the average large business customer. Any comprehensive roll out would therefore have to be mandated in order for it to happen.

2 Introduction

Frontier Economics has been engaged by Centrica to provide analysis of the costs and benefits of proposals to introduce smart meters for domestic and business customers within Great Britain. The key objectives of this work were as follows:

- to provide a transparent and structured evaluation of the costs and benefits of introducing Visual Display Units (VDUs) across the electricity domestic sector;
- to produce a transparent and structured evaluation of the costs and benefits of introducing smart meters across the domestic and business sectors; and
- to compare the costs, benefits, risks and rewards of the rollout of smart metering within the current market framework to those within other market frameworks, such as the Regional Franchise Model (RFM).

In order to undertake this work, we have developed a model that compares the costs and benefits associated with providing smart meter technology to domestic and business customers. In particular, this model provides for comparisons to be made between different roll-out options depending on such factors as the speed of roll-out and on the market framework in place during the period of roll-out. In drawing conclusions from this analysis it should be remembered that many of the input assumptions are uncertain. Undertaking sensitivity analysis of the results is therefore an important element of the work, enabling an evaluation to be made of the likely robustness of any conclusions.

Given our terms of reference, we have considered three particular proposals:

- a roll-out of VDUs to domestic electricity customers;
- a roll-out of smart meters to domestic and small business customers in both the gas and electricity sectors; and
- a roll-out of smart meters to large business customers in both the gas and electricity sectors.[12]

In carrying out this project we have been able to utilise Centrica's knowledge and experience of meter procurement within the existing competitive metering market, as well as its experience of deploying of smart meters within the current industry structure.[13] This version of the report does not contain data that is considered to be commercially sensitive by Centrica. However, all data has been shared on a confidential basis with BERR.

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12 We have used the definition of large business customers provided by BERR, namely profile classes 5-8 of the electricity markets and non-daily gas metered gas sites consuming > 732 MWh per annum.

13 Centrica has already installed 16,000 smart meters in the SME sector and undertook a trial of 50,000 residential AMR (one-way) meters in 2003/04.

This report is structured as follows. We begin by setting out the overall framework for our analysis. This covers the different roll-out options that have been considered and describe the structure of the model that has been used. We then consider each proposal in detail.

- Chapter 4 considers the case for VDUs.
- Chapters 5, 6 and 7 consider the case for a smart meter roll-out to domestic and small business customers. They cover a detailed consideration of the costs and benefits that may be expected to arise under different roll-out scenarios, the base case results and key sensitivities, and an assessment of the distributional impacts that such schemes may result in.
- Chapter 8 considers the case for a roll-out of smart meters for large business customers.

3 Overall analytical framework

3.1 INTRODUCTION

This Chapter sets out the framework that we have used to determine the analysis of the three different proposals for smart meter roll-outs. A key aim of the analysis that we had been asked to undertake was to evaluate the expected impact arising from alternative ways in which the roll-out of smart meters could occur. Therefore, in addition to considering the overall expected net benefit of the different metering options, we were also interested in understanding the expected impact of factors such as the start date of roll-out, the speed of roll-out and the structure of the industry responsible for undertaking the roll-out.

We begin by considering the overall framework used for our analysis before going on to describe the structure of the model we designed to undertake the calculations.

3.2 OVERVIEW OF FRAMEWORK

3.2.1 Objective

There are three particular proposals that we were asked to evaluate:

- a roll out of VDUs to domestic electricity customers;
- a roll-out of smart meters to domestic and small business customers in both the gas and electricity sectors; and
- a roll-out of smart meters to large business customers in both the gas and electricity sectors.[14]

There have been a number of studies that have undertaken assessments of the case for a roll-out of smart meters for customers within Great Britain.[15] In general, these have shown that if the introduction of such technology induces customers to reduce consumption by a large enough percentage (generally involving a sustained reduction in consumption in the region of 1% - 3%) then there will be an expected net benefit for society from such a roll-out.

The main contribution that this study attempts to make is to show how the net benefit associated with a smart meter roll-out may be affected by the way in which the roll-out can be undertaken. In particular, it seeks to estimate the impact that the following factors may have:

14 We have used the definition of large business customers provided by BERR namely profile classes 5-8 of the electricity markets and non-daily gas metered gas sites consuming > 732 MWh per annum.

15 For example, Ofgem (2006), energywatch (2007) and Sustainability First (2007).

- the industry framework in place for the duration of the smart meter roll-out;
- the date by which the roll-out can commence and the duration of the roll-out; and
- the impact that one policy (a VDU roll-out) may have on another policy (a smart meter roll-out).

We discuss each of these in turn.

3.2.2 Industry structure

The current industry structure sets the supplier at the centre of the metering process (we refer to this as the Supplier Hub Model (SHM)). Suppliers are responsible for contracting with different metering agents who have responsibility for ownership and maintenance of the meters and the collection and aggregation of data from the meters. Metering activities are open to competition and different agents are responsible for different meters depending on the supplier of the customer. In the event of a roll-out of smart meters within this current framework, each supplier would be responsible for installing a smart meter into each of its customers' premises.

This fragmented industry structure can be contrasted with an integrated approach to metering services, where one party would be responsible for all metering services associated with the meter stock within a particular geographic area. We refer to this as the Regional Franchise Model (RFM). In the event of a roll-out of smart meters within this framework, one party would be responsible for installing smart meters into all customers' premises within a defined geographic area.

In evaluating the impact on the net benefits of a smart meter roll-out, it is important to understand where the differences between an SHM and RFM will arise. There are two key potential areas where significant cost savings could arise. The first is from undertaking the roll-out on a geographic basis and the second is undertaking the roll-out on a dual fuel basis. We discuss each in turn.

There are three key benefits associated with a geographic roll-out.

- There would be a saving in the cost of installation due to the significant reduction in travel time associated with being able to do a replacement meter programme on a street by street basis.
- There would be a reduction in the cost of managing the dumb meter network during the roll-out period as the density of dumb meters in any remaining area would remain constant. Further, if the dumb meter stock were transferred to the smart meter roll-out provider, then there might well be savings to be made in the intervening period as density for the regional franchisee will increase compared to the density achieved with the supplier-led approach that is undertaken today.
- A co-ordinated campaign of advertisement and education could be employed in each area in which the roll-out was occurring to maximise both the chance

that customers would be in at the time their installation was scheduled (thus saving the costs associated with re-visits) and the chance that they would engage with the policy and achieve a reduction in consumption.

The case for a dual-fuel roll-out is also strong.

- There is a lower cost smart metering solution associated with being able to "piggy-back" the gas meter with the electricity meter, resulting both in lower one-off costs associated with the purchase of the equipment and ongoing communications costs associated with the provision of meter reads.
- There is a reduction in the average time to install a meter as only one site visit is required (and therefore a saving is made both in travel time to the property and the time taken to gain access to a meter).
- If the dumb meter stock is transferred to the franchisee, there is a reduction in undertaking dumb meter reads during the roll-out as both gas and electricity meters can be read at the same time.

It is clearly the case that the geographic benefits could only be achieved by an integrated industry approach to roll-out. However, most of the benefits associated with a dual-fuel roll-out are also only likely to be achieved through an integrated industry structure for the following reasons.

- If the roll-out was the responsibility of individual suppliers, they would only be able to achieve the benefits associated with a dual-fuel roll-out in those cases where they supplied both fuels since it will not be feasible for two different suppliers to access and use a piggy-backed system. This immediately reduces the benefits by over half given that 58% of customers with both a gas and electricity meter still take their supplies from different gas and electricity suppliers.[16]
- In addition, there are strong arguments for why, even for the customers that are on a dual fuel supply, suppliers will not realise the dual fuel savings. First, on installation, we understand that the reduced density[17] faced by a supplier means that it is unlikely to be cost effective to reorganise a workforce to undertake dual fuel fitting. Such reduced density means that it would not operate an installer network based on doing both gas and electricity together, or invest in re-training so that the same fitter could undertake both an electricity and gas installation. Second, given that a dual fuel supplier has no guarantee that he will not lose one or other of the fuels to an alternative supplier, he will not risk installing the cheaper gas piggy-back solution as this will face a greater risk of being stranded in the event the customer chooses to revert to single fuel supplies.

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16 "Domestic Retail Market Report", Ofgem (2007).

17 If a supplier has half its customers on dual fuel and supplies one sixth of the market, then the density of dual fuel properties it will face will be one twelfth of that faced by a monopoly roll-out provider.

3.2.3 Timing

It is also important to consider the impact that the timing of any roll-out may have on the overall size of the net benefit associated with the roll-out. There are two timing variables of interest: the start date of roll-out and the speed of roll-out.

- **Start date of roll-out:** different schemes may be expected to take different periods of time between the policy being made and the proposal being implemented. In addition, determining the start date of any mandated roll-out is a key choice variable: there is a trade-off between waiting for further evidence of the likely benefits of smart meters and the resulting delay in starting the roll-out and receiving the benefits. It is therefore important to consider the impact that the start date of the smart meter roll-out may have on the expected level of net benefit. As part of our base case we assume that a VDU roll-out, or a roll-out of smart meters to large business customers, could commence at the start of 2008. Any mandated smart meter roll-out for domestic and small business customers would not begin until 2010 to reflect the time necessary to adapt the legislative framework and industry systems and processes to enable such a mass roll-out to occur.
- **Speed of roll-out:** in the event that a mandated roll-out is advocated, the speed of that roll-out is also an important choice variable. The roll-out could be undertaken on a replacement basis (and since dumb meters currently have a certified life of up to 20 years, this will determine the maximum period for roll-out). Alternatively an accelerated programme could be mandated. The limit on the speed of any accelerated roll-out would be determined by the logistical constraints associated with trying to roll-out millions of meters per year. It may be expected that a faster roll-out could be achieved under a co-ordinated roll-out compared with a roll-out undertaken under the current industry structure. This is, in part, because under the current supplier hub structure, each individual supplier will need to set up processes to undertake the roll-out to a customer base that will change over the roll-out period, given customer switching. In addition, the fragmentation and complexity of the current systems can be expected to impact on the timetable for such a roll-out. As part of our base case we therefore assume that the limit to the speed at which an accelerated roll-out could be undertaken would be 10 years for the SHM and seven years for the RFM. It is assumed that the roll-out of smart meters for large business customers would happen over a five year period, in line with the current policy expectations.

3.2.4 Joint consideration of policy

Where policy outcomes may be expected to overlap, it is important that those policies are analysed jointly, rather than in isolation. Failure to do this may lead to implementation of a policy that has a positive net benefit when considered in isolation, but results in an overall loss to society when the wider impacts of that policy are taken into account.

The analysis of the joint impact of policies is an important consideration in the case of VDUs and smart meters for domestic electricity customers. In that instance, it is important to evaluate the impact that a VDU roll-out would have on any subsequent roll-out of smart meters.

3.2.5 Base scenarios to be considered

In order to assess how the net benefit associated with a smart meter roll-out will be affected by the way in which the roll-out will be undertaken, we consider the following three base scenarios:

- SHM with smart meters installed on a replacement basis;
- SHM with smart meters installed on an accelerated basis (10 years); and
- RFM with smart meters installed on an accelerated basis (7 years).

A roll-out of smart meters on a replacement basis is not considered for an RFM scenario since it is assumed that this level of industry re-structuring will not be warranted unless the roll-out is to be accelerated. It is assumed that any roll-out of VDUs to domestic electricity customers, or smart meters for large business customers, will be undertaken under the SHM, again given that industry restructuring is unlikely to be warranted for these smaller-scale roll-outs.

3.3 MODEL STRUCTURE

As noted above, in order to produce a transparent and structured evaluation of the costs and benefits of introducing electricity and gas smart meters or VDUs, we have developed a model to undertake a Cost-Benefit Analysis (CBA). This model compares the costs and benefits generated by introducing smart meters, or VDUs, under the different roll-out scenarios described above.

3.3.1 Modelling assumptions

The model has been developed applying the guidance provided by the HM Treasury Green Book and, where appropriate, Defra's guidance relating to projects that have an expected environmental impact.

In order to determine the incremental net benefits of each scenario, and therefore the case for policy change, the model has been built to compare a base case with each of the three scenarios under analysis. The base case assumes that no smart meters will be installed and that the existing stock of 'dumb' meters will continue to be replaced with 'dumb' meters once each asset reaches the end of its useful economic life. The costs and benefits of each scenario are then calculated as increments to the base case, allowing the determination of the net benefit of each scenario over the 'status quo' case.

In line with a standard CBA approach, the model calculates benefits and costs for GB society as a whole, without identifying the recipients of specific benefits or the bearers of specific costs. This discussion is instead addressed by a distribution analysis, which considers the impact of each scenario on the various groups of stakeholders.

The model calculates incremental costs and benefits over a period of 20 years. This is because it is assumed that the impact of smart metering on energy consumption is likely to fade over time, as customers become accustomed to smart meters. Moreover, new energy-savings technologies (e.g. home appliances which do not require to be kept in a stand-by mode) may supersede smart meters in terms of their impact on energy consumption.[18] However, in order to account for the stock of un-depreciated assets at the end of the 20-year-period, the model deducts a terminal asset value.

The CBA net present value has been obtained by discounting incremental benefits and costs at 3.5% (real), the social time preference value, as recommended within the HM Treasury Green Book. However, in order to recognise the fact that industry providers are likely to incur financing costs at a rate of interest higher than the social time preference value, we have allowed for the inclusion of this additional cost of financing ("extra finance cost"). This is calculated as incremental annual rental payments over the life of each asset, to cover one-off meter costs (i.e. purchase, installation and communication costs). Our base assumption for the cost of capital faced by industry is 10%.[19]

Finally, for each model year, meters are assumed to be installed at the start of the year and benefits are assumed to start immediately after a smart meter is installed.

3.3.2 Modelling approach

The calculations in the model can be divided into two groups:

- **Unit benefits and costs:** the first set of calculations is aimed at determining the unit incremental benefits and incremental costs on a per-meter basis. These calculations are independent of the number of meters in the market. Generally, unit benefits are assumed to be meter-specific and do not to vary according to the roll-out scenario chosen[20]. Costs may vary according to the scenario chosen, to take into account potential economies of scale and other savings originating from accelerated and co-ordinated roll-outs. Chapters 5 and 6 provide an in-depth description of the costs and benefits considered in our analysis.
- **Number of meters:** this set of calculations is aimed at determining, for each model year, the number of dumb and smart meters in the market. As well as calculating the number of dumb meters for the base case, the model calculates the number of smart meters being introduced in each year under each roll-out scenario. For each scenario, the model calculates the annual 'flow' of meters, i.e. the number of smart meters being installed in each year,

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18 We have also provided for the functionality to reduce the benefits of smart meters over a quicker time period than the 20-year life of the model, should this sensitivity be required.

19 It could be argued that inclusion of this 'extra finance cost' should only be picked up in the distribution analysis, rather than as part of a CBA, if the CBA is concerned with evaluating the likely net benefit of a policy from society's point of view. However, if the focus is to understand how the policy may impact customers it can be useful to include it as a cost of the scheme. We therefore identify this 'extra finance cost' as a separate cost of the project. This is in contrast to the analysis that BERR has undertaken where such 'extra finance cost' is included implicitly within their amortisation of cost calculation.

20 The exceptions relate to some of the supplier benefits. These are discussed in Chapter 1.

and the 'stock' of meters, i.e. the cumulative number of smart meters in the market. The number of dumb and smart meters in the market is mainly a function of the speed of meter replacement.

Figure 1 illustrates the modelling approach used. In order to derive total costs and benefits for each scenario, unit benefits and costs are multiplied by the number of meters in each year. One-off costs, i.e. costs that are incurred only once when a new meter is installed, are multiplied by the annual 'flow' of meters. Annual costs, i.e. costs that are incurred for each meter on an annual basis, as well as benefits, are multiplied by the 'stock' of smart meters in each model year.

One-off costs include purchase costs, installation costs and system costs (necessary to upgrade the existing system). Annual costs include part of communication costs, maintenance and dumb meter reading costs. All benefits are assumed to be generated on an annual basis, making the overall level of benefits in each year dependent on the total 'stock' of smart meters in the market.

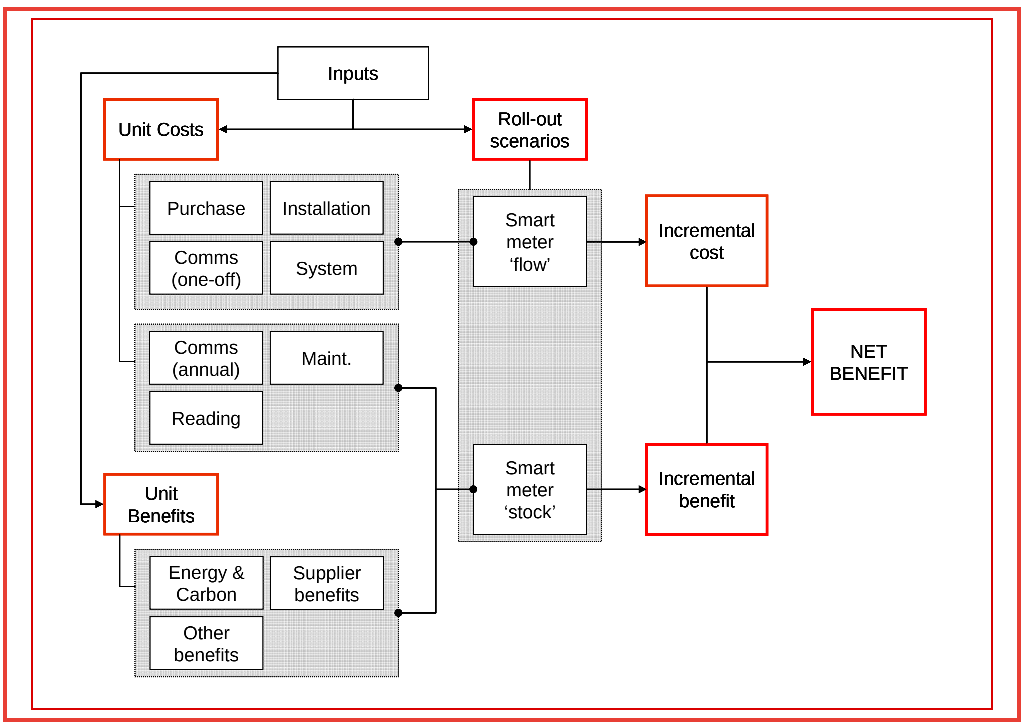

Figure 1: Modelling approach

The incremental costs and benefits of each scenario are then compared to identify the net benefit of each option and calculate its cost/benefit ratio. A cost/benefit ratio greater than 1 indicates a positive net benefit and it implies that the option considered, based on the underlying input assumptions and methodology, may be expected to be justified from a societal point of view.

In addition to allowing the input of costs, benefits and roll-out scenarios, the model provides the user with the flexibility to customise each scenario, by varying parameters such as the speed of meter replacement and the assumptions related to the energy reduction expected from the introduction of smart meters.

The model also allows the user to choose the start year for the smart meter roll-out scenario. This feature lets the user determine the impact of different timings of the smart meters roll-out, as well as allowing the modelling of the joint net impact of the introduction of VDUs for a period before the deployment of smart meters.

Gas and electricity smart meters are modelled separately. However, care must be taken when interpreting the results of each roll-out separately: many of the input assumptions on both costs and benefits are based on the assumption that both energy meters are smart. In order to estimate the effect of a smart meter roll-out on either the electricity or gas sector in isolation, it would be necessary to update the input assumptions to reflect this.

4 Visual Display Units

4.1 INTRODUCTION

The Government is proposing that from May 2008, where technically feasible, suppliers will have to provide a real-time electricity visual display unit (VDU) to every household having an electricity meter replaced or receiving a new connection. In addition, suppliers would be required to provide a VDU to any other customer that requests one (again, where installation is technically feasible).

Analysis undertaken by the Department of Business Enterprise & Regulatory Reform (BERR) purports to show that there will be a total net benefit in the region of £205 million from such a scheme.[21] We consider that this analysis is misleading as it is based on treating VDUs as a stand-alone policy. Using BERR's own estimates of the costs and benefits of VDUs, we find that such a policy is unlikely to have a net benefit if it is assumed that smart meters may also be rolled-out to domestic customers within a ten year period, as envisaged within BERR's recent consultation document.[22] Further, if the large reductions in average consumption that have been assumed by BERR fail to materialise, a policy of rolling out VDUs would fail to show an expected net benefit even in the absence of a smart meter roll out.

4.2 COSTS AND BENEFITS

A VDU is a real-time electricity visual display unit that can provide information about the cost of electricity usage, in real time, on a device that is separate from the meter. Currently, there is only a VDU for electricity meters and, even for those, there are a proportion of meters (approximately 25%) for which this solution will not work. This section describes the level and type of costs and benefits associated with VDUs that have been used within our analysis. We compare these assumptions with those used by BERR.

4.2.1 Costs associated with VDUs

The costs associated with VDUs relate to:

- initial purchase cost;
- installation cost;
- other one off costs; and
- ongoing annual costs.

We compare the base level assumptions that we have used, with those assumed by BERR, in Table 4 below.

21 "Energy Billing and Metering", BERR (August 2007) p21.

22 "Energy Billing and Metering", BERR (August 2007).

	BERR	Frontier
Initial purchase cost	£15.00 (plus "extra finance cost")	£15.00
Installation	£11.00 (plus "extra finance cost")	£11.00
Other on-off costs	£0.00	£14.44[23]
Ongoing annual costs	£2.71 (for 7 years)	£0.27[24] (for 15 years)

Table 4: Costs of VDUs

Source: BERR, Centrica

We have used the same base case estimate of the purchase and installation cost of a VDU as BERR. However, whereas BERR assumes that these costs are amortised over seven years at a 10% cost of capital, our base case scenario assumes that all costs are incurred at the time of installation. Since the 10% cost of capital is higher than the social discount rate of 3.5%, BERR's purchase and installation cost is approximately £7 higher, in NPV terms, than the cost assumed in our base case.

In contrast, Centrica considered that the BERR analysis under-estimated the one-off costs that would be incurred by a supplier in the event of a VDU roll-out. Centrica estimated that these would total £14.44 per customer, and would primarily be composed of additional customer service costs associated with dealing with customers that would not understand how the VDU operated, together with the cost of one replacement battery for each VDU.

The ongoing costs associated with the operation of the VDU are higher under BERR's base case assumption, but will persist only for a period of seven years. Centrica estimated the ongoing costs to be lower, based on a proportion of customers contacting their supplier about their VDUs each year, but assumed these would continue indefinitely.

The combination of these different assumptions means that our analysis has slightly lower overall costs associated with a VDU roll-out than BERR's. The difference in lifetime cost of a VDU in NPV terms is £51 (based on BERR's assumptions) and £44 (based on Centrica's assumptions).

4.2.2 Benefits associated with VDUs

The benefits of VDUs are assumed to be the result of lower average electricity consumption brought about by increased awareness of the cost of that consumption in real time. Therefore, there are two questions that need to be answered:

23 Based on information provided by Centrica.

24 Based on information provided by Centrica.

- What level of reduction in consumption should be assumed?
- How should this be valued?

We consider each in turn.

Level of energy reduction

It is necessary to consider both the level of energy reduction that can be expected, and the length of time for which it is predicted to persist. As there have only been limited trials of VDUs to date, there is limited evidence on which to base an estimate.

BERR quote a literature review carried out by Sarah Darby for Defra in 2006.[25] This review examines a number of ways in which feedback can reduce energy consumption. For real-time displays, Sarah Darby claims that "savings are typically of the order of 10% for relatively simple displays."[26] However, the only study for electricity VDUs, quoted by Sarah Darby, that has been carried out within the last 25 years was conducted in Ontario in 2006. Although this study found that customers reduced electricity consumption by an average of 6.5% after fitting a VDU for the duration of the study, the study lasted only 15 months and was based on the consumption patterns of 382 electricity customers fitted with VDUs and a control group of a further 42 customers.[27]

Given this exceedingly limited evidence base, we consider that it is prudent to consider a small level of energy reduction from such devices, particularly if this reduction is then projected to persist over a sustained period of time. [28] We have therefore used a base case assumption of a 1% electricity reduction for credit customers and 0.5% reduction for prepayment customers that lasts for 15 years.[29] This compares with BERR's assumption of an average reduction in electricity consumption of 3.5% for credit customers and 1.75% for prepayment meter customers for 15 years.[30]

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25 Sarah Darby (2006) "The effectiveness of feedback on energy consumption"

26 Sarah Darby (2006), p11.

27 "The Impact of Real-Time Feedback on Residential Energy Consumption: The Hydro One Pilot", Dean Mountain (2006).

28 There is much "informal" evidence that customers either refuse to take such devices when they are offered, or they take them but put them in a drawer soon after receipt. Suppliers involved in less successful trials have not always chosen to make their results public.

29 BERR also assumes that prepayment customers will experience half the energy reduction of credit customers, as they are expected to have greater awareness of their energy consumption habits at present.

30 Although BERR assumes that the lifespan of a VDU will be seven years, its analysis assumes that the 3.5% reduction in consumption will persist for 15 years.

Value of reduced energy consumption

In addition to determining the level of reduction in energy consumed, it is also necessary to value this benefit for the purpose of the CBA. We discuss how this has been done in detail in Chapter 6 when discussing the calculation of the benefits of smart meters. However, in summary, we calculate three benefits associated with the reduction of consumption: reduced cost of energy use; avoided peak capacity costs and reduced carbon emissions. We discuss each of these in turn, highlighting any differences in our approach with that used by BERR.

- **Reduced cost of energy use:** We base our estimate of the reduced cost of energy use by multiplying the reduction in consumption achieved by those domestic electricity customers with VDUs by the average price of energy. The electricity prices are derived from Elexon's Market Index Prices for 2006. In addition, to avoid potential double counting of benefits from the cost of carbon included within the generation price, 50% of the cost of carbon emissions is subtracted from the energy cost saving.[31] This is a more accurate estimate of this benefit than the one used by BERR which simply estimates the saving to be 35% of the average retail bill, as an approximation of the generation costs.[32]
- **Avoided peak capacity costs:** A reduction in overall consumption will also result in a reduction in peak demand. Given that it is peak demand that determines required network system capacity, there should be a reduction in network capacity costs. We estimated these using the values for peak capacity assumed by Ofgem.[33] We understand that in its analysis of VDU benefits, BERR did not seek to put a value on this benefit.
- **Reduced carbon emissions:** There is assumed to be a benefit to society from a reduction in carbon emissions from the reduced energy consumption. We have estimated the carbon savings based on the carbon intensity of the marginal plant generating at peak and off-peak times. On average, this implies an average carbon intensity of 0.64 tCO_2/MWh. BERR uses a lower value of 0.43 tCO_2/MWh. This is likely to be an average carbon intensity of all electricity generation, rather than an estimate of the marginal plant that would be avoided in the event of an energy reduction. This is likely to underestimate the benefit as infra-marginal baseload plant, such as renewables or nuclear, are typically low or zero emitters of carbon, whilst marginal plant such as coal or gas are relatively high emitters. Consequently the marginal emissions factor is higher than the average emissions factor. To value the

31 The basis for this adjustment is discussed in Chapter 6.

32 However, we note that this approach is more appropriate than taking any higher proportion of the bill, as is the case in BERR's analysis of the large business customer case.

33 "Domestic Innovative Metering, Ofgem's high level cost benefit analysis – supporting documentation", Ofgem (2006).

benefit of reduced carbon, we have used DEFRA's social cost of carbon value of £70 per tonne (in 2000 prices).[34]

4.2.3 Roll out options

The Government's proposals suggest that VDUs should be provided to any customer that requests one over the course of two years, with VDUs also being provided to all electricity customers at replacement or new installation of their electricity meter. In each case, VDUs only need to be provided where technically feasible.

- BERR assumes that 25% of customers will request VDUs over the first two years of a roll-out programme. It further assumes that it will be technically feasible to fit such VDUs in 75% of cases for all existing and replacement meters and in 95% of all cases where the meter is new. The assumptions contained within BERR's model means there would be 5.4m VDUs installed after two years, increasing by a further 280,000 per year after that. It should be noted that there appears to be a discrepancy between BERR's analysis of the way in which the roll out of VDUs may occur and the policy that is described in the text. In particular, whereas the policy talks about a complete roll-out of VDUs to those customers having old meters replaced or new meters installed, BERR's model is based on roll-out only to those customers that request one (with an assumption that 25% of such customers will request VDUs).
- Our base case scenario considers the impact of rolling out VDUs over a two year period. In this time, we assume that 20% of customers will request a VDU and that VDUs will be provided to all new customers and existing customers on meter replacement. For both replacement and new meters, we assume it will be possible to install VDUs in 75% of cases. This means that a total of 5.8m VDUs would have been installed after two years. We assume that no further VDUs are installed after this point in time.

4.3 ASSESSMENT OF CASE FOR VDUS

We have examined the case for VDUs in two stages. The first stage takes VDUs in isolation and considers the benefits of introducing VDUs in the absence of any smart meter roll-out. The second stage considers how that analysis would change if smart meters were to be rolled out shortly after VDUs.

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34 We recognise that, in reality, the effect on carbon emissions is more complex than this. In the shorter term, as the power sector is within the EU ETS, there will be no direct emissions saving from a reduction in electricity consumption. However, benefits will be felt by all entities within the EU ETS that can now choose to buy allowances as a cheaper option than incremental abatement. In the medium / longer term, reductions in electricity consumption may be expected to facilitate equivalent reductions in total allowed carbon emissions. The corresponding adjustment to be made to generation costs suffers similar complexity and uncertainty. Assuming that this benefit should be reduced by 50% of the value of the carbon benefit is a simple adjustment based on the fact that prices are likely to have been influenced by relevant allowance prices and these were much lower than Defra's estimate of social cost of carbon.

4.3.1 VDUs – standalone case

A summary of the overall costs and benefits associated with BERR's base case and ours is presented in Table 5.[35]

	BERR analysis	Frontier analysis
Total costs	(£475m)	(£255m)
Energy saving benefits	£497m	£139m
Carbon benefits	£182m	£54m
Overall NPV	**£204m**	**(£62m)**

Table 5: NPV of costs and benefits associated with rolling out VDUs

Source: BERR, Frontier Economics

BERR's overall analysis shows a positive net benefit to the VDU roll-out, primarily due to its higher assumption about the potential for reduction in energy consumption that will follow the installation of VDUs. In particular, BERR's analysis predicts that VDUs associated with credit meters have net benefits (in NPV terms) over periods greater than nine years. However, using BERR's own base assumptions, its provision of VDUs for prepayment meter customers has a negative net benefit: the lower energy reductions that are assumed for these customers are not sufficient to offset the costs.

Undertaking the analysis based on our base case assumptions, there is a net loss associated with a VDU roll-out, which we estimate to be around -£62 million across both credit and prepayment customers. Although the costs of the roll-out are lower than those assumed by BERR, and the valuation of any reduction in consumption higher, the lower estimate of the level of reduction in consumption results in the net loss from such a policy. However, it should be noted that a relatively small increase in the assumed energy reductions from 1% to 1.3% for credit customers and from 0.5% to 0.65% for prepayment customers, would be sufficient for VDUs to have overall net benefits on a standalone basis.

BERR's central case forecast for annual emission savings in 2020 associated with provision of VDUs to electricity customers was 0.55MtCO_2. Our base case assumption would provide for 0.27 MtCO_2 by this date. This lower estimate is primarily a function of the lower assumed reduction in consumption that such a device would be expected to generate.

4.3.2 VDUs and smart meters

In evaluating the potential benefits of VDUs, it is important to consider the VDU policy and the smart meter policy together.

35 When undertaking the comparison it is important to remember that the BERR analysis assumes that VDUs will continue to be installed on a new and replacement basis after the initial two year roll-out. This results in a greater overall level of cost and benefit to reflect the increased meter numbers.

- The costs of a VDU *are in addition to* the costs of a smart meter. We understand that the type of VDU that is currently available will not be suitable for use as a display device with a smart meter and, therefore, would be rendered redundant on installation of such a meter.
- The benefits of a VDU *are a subset of* the benefits of a smart meter. The only route by which a VDU can generate a potential benefit is via increased customer awareness of the cost of energy consumption, leading to reduced demand, whilst smart meters offer a much wider set of potential benefits. In addition, there is reason to believe that the incentive to reduce consumption that may come from a VDU will be lower than that which would be achieved from a smart meter roll-out.[36]

These two factors mean that a VDU would be stranded in the event that a smart meter was deployed in the same location. Any analysis of the case for VDUs therefore needs to take into account the probability of a smart meter being introduced at a point in time before a positive net benefit is generated.

When considering how smart meters will affect the case for VDUs it is therefore important to estimate how long a VDU will be expected to be in place before being replaced by a smart meter? In the analysis described above, BERR's analysis requires VDUs to be in place alongside credit meters for around nine years before they will be expected to result in a positive net benefit. Therefore, any roll out that on average replaces VDUs for credit customers before they have been in place for a period of nine years will be expected to result in a net loss.

Using our base case assumptions, we can estimate the impact that a roll-out of VDUs might have on the case for a smart meter roll out. To do this we assume that there will be a two year roll-out of VDUs, followed by an accelerated roll-out of smart meters. Once a customer with a VDU receives a smart meter, the benefits associated with the VDU are assumed to cease, as equivalent information will be provided by the smart meter. Table 6 shows the impact that rolling out smart meters would have on the case for VDUs, based on our analysis. It shows that a ten year roll out of smart meters would increase the net losses associated with VDUs from £62m to £168m. If the accelerated roll-out of smart meters was to take seven years, the net loss would increase to £188m. In each case the costs of distributing VDUs remain constant but the benefits attributable to VDUs fall as they are eliminated sooner following the faster installation of the smart meters.

36 The likelihood that many customers would neither replace batteries when they expire nor update the devices for new tariff information, combined with the absence of reinforcing billing information from suppliers, means that VDUs are unlikely to produce as large reductions in consumption as smart meters.

	Ten year smart meter roll out	Seven year smart meter roll out
Total costs of VDUs	(£255m)	(£255m)
Energy saving benefits of VDUs	£63m	£49m
Carbon benefits of VDUs	£23m	£18m
Overall NPV of VDU roll-out	**(£168m)**	**(£188m)**

Table 6: NPV of costs and benefits of VDU roll-out followed by smart meter roll out

Source: BERR, Frontier Economics

4.4 POLICY IMPLICATIONS

Although there are some differences in the input assumptions that underpin both our analysis and that undertaken by BERR, we consider that similar policy implications arise, whichever set of inputs is used.

- Even ignoring any possible roll out of smart meters, VDUs are not expected to have net benefits for prepayment meter customers. Requiring distribution of VDUs to these customers would therefore fail a test of being financially reasonable and proportionate. We would also conclude, based on prudent energy reduction assumptions, that this is the case for credit customers.
- The second implication is that a widespread roll-out of VDUs is even less likely to be in the public interest if it is quickly followed by a roll out of smart meters, even when higher assumptions of energy reduction are applied. Based on BERR's estimates, VDUs need to be in place for at least nine years for credit customers before they can be expected to have net benefits. Most VDUs would be replaced within this timeframe in the event of an accelerated smart meter roll out.

However, since a VDU roll-out could start up to two years before a smart meter roll-out, there are two cases where a limited roll-out of VDUs in this intervening period could be beneficial, but only if BERR is confident in its assumptions about the level of energy reduction that such devices would promote.

- If the Government relaxed its timetable for the roll-out of smart meters so that the new meters were installed on a replacement basis over a 20 year period, there could be a case for issuing VDUs to credit customers on replacement in the period until a smart meter deployment could commence. The customers receiving VDUs in that interim period would not expect to get a smart meter for a further 20 years and, therefore, under BERR's central case estimates, would have a VDU long enough to expect to see a net benefit.

- Alternatively, if VDUs could be provided exclusively to those customers that would make the highest savings in their consumption, then their individual payback periods may be reduced sufficiently to provide a net benefit before the introduction of a smart meter, even under an accelerated roll out. These customers are likely to be:
  - those who actually want such a device and will use it;
  - those who would have most discretionary load to reduce; and
  - those with the largest energy consumptions.

  With the exception of size of energy load, it is not clear that there will be any way of identifying such customers in order to achieve such a targeted roll-out. However, it is possible that such customers would self-identify if the devices were provided only on-request with some (nominal) associated charge.

Although we recognise these particular cases where a case could be made for VDUs, we would note that there are the following additional downsides associated with a focus on a VDU roll-out.

- VDUs can only be applied to a subset of the market: they only impact on a proportion of domestic electricity customers for whom the solution is technically feasible. Although this does not affect whether the proposal has a net benefit, it does alter the scale of any benefit and the ability of VDUs to contribute as a policy measure to the 2010 carbon reduction targets. In the event that VDUs will not make a sufficient contribution to this milestone, it may be better to focus on using a smart meter deployment to meet the 2020 targets.
- Planning for a VDU roll-out programme will take up time and resources that could be better employed on achieving a faster start to a smart meter roll-out.
- In the event of an accelerated smart meter roll-out, the VDU devices would end up being discarded within a short period of time. This could have a detrimental impact on public opinion of the value of investment in such devices.

It is therefore our opinion that, in the event that the Government requires an accelerated roll-out of smart meters, it would not be in society's interest to see a roll-out of VDUs as an interim measure.

5 Costs of smart meters for domestic and small business customers

5.1 INTRODUCTION

The next three Chapters consider the case for a smart meter roll-out to domestic and small business customers. This Chapter considers the costs associated with the roll-out and presents the assumptions underpinning the inputs used in the modelling. Chapter 6 illustrates the benefits associated with the roll-out and Chapter 7 presents the result of the cost-benefit analysis of the various scenarios.

As described in Chapter 3, the calculation of the incremental costs associated with each roll-out scenario is based on a comparison between the smart meter roll-out and the option of continuing to install dumb meters at the time of asset replacement (the "status quo" option). Therefore, we begin the description of the input costs associated with a dumb meter roll-out, before considering the costs associated with each smart meter roll-out scenario.

5.2 DUMB METER COSTS

Centrica has provided us with meter and installation cost assumptions for gas and electricity meters that have been used to model the "status quo". These have been removed from this version of the report on the basis that they contain commercially sensitive information. The maintenance costs are based on the assumption, used in Ofgem (2006), that annual maintenance costs are equal to 1% of the cost of the meter. In the "status quo" scenario, the existing stock of dumb meters is maintained in its steady state by replacing only those assets that have reached the end of their useful economic life with identical dumb meters. Meter asset life is assumed to be 20 years for all cases other than gas prepayment meters where a 15 year asset life is assumed.

The only costs that are incurred for existing 'dumb' meters are those associated with their purchase, installation and maintenance. No other costs are assumed to arise in this scenario as communication and system costs are assumed to be entirely incremental in the smart meter roll-out scenarios and reading costs are considered separately under supplier benefits.

5.3 SMART METER COSTS

Before it is possible to determine the costs associated with the smart meter, it is necessary to consider what specification of smart meter is to be assumed. Since we are primarily interested in the impact that the roll-out scenario has on the overall net benefit of the policy, the actual meter design is of second-order interest to this study. We have therefore based the analysis on a relatively high specification of smart meter, allowing the following basic functionality:

- separate visual display;
- remote meter read;

- storage of half-hourly / daily consumption data;
- capable of recording imported and exported units of electricity separately;
- remote connect / disconnect; and
- remote switch between credit/prepayment functionality.

Perhaps the most controversial issue is the inclusion of a smart gas meter that will be capable of being switched remotely between credit and prepayment functionality: it is not yet clear whether, at current prices, it would be cost effective to install these meters as standard.

Due to a lack of available information, we have not attempted to evaluate the different costs associated with different communication systems to estimate what the "GB optimal" solution is likely to be. Instead the analysis is based simply on a complete roll-out of a GSM solution, on the assumption that there will be a single communications solution rolled-out in any geographic area

We set out the base case cost assumptions of this meter and communication option in the rest of this Chapter.

Purchase costs

Table 7 and Table 8 provide a summary, for gas and electricity, of the purchase cost assumptions for each type of smart meter under each smart meter roll-out scenario. In all cases the smart meters are assumed to have an asset life of 15 years.

Gas Purchase costs	**SHM (Replacement)**	**SHM (Accelerated)**	**RFM (Accelerated)**
Domestic – Prepay	£103.39	£93.05	£73.05
Domestic – Credit	£103.39	£93.05	£73.05
Business - Small	£103.39	£93.05	£73.05

Table 7: Smart meter purchase costs - Gas

Source: Centrica

Electricity Purchase costs	**SHM (Replacement)**	**SHM (Accelerated)**	**RFM (Accelerated)**
Domestic – Prepay	£79.62	£71.66	£71.66
Domestic – Credit	£79.62	£71.66	£71.66
Business - Small	£79.62	£71.66	£71.66

Table 8: Smart meter purchase costs - Electricity

Source: Centrica

Centrica provided the base assumptions for the smart meter costs, based on discussions it has had with meter providers. The difference between the meter costs for the replacement and accelerated scenarios is based on the fact that greater economies of scale will be achieved with an accelerated roll-out. For example, a doubling of replacement rates will occur if the accelerated roll-out were to happen over 10 years, compared with a replacement programme over 20 years. We have assumed that this 100% annual increase in meter volumes will result in a 10% saving on the purchase cost of the meters.

In addition, a further saving on the gas meter is assumed for the RFM (accelerated) scenario. This is to reflect the fact that the roll-out will take place on a dual fuel basis. This allows the gas meter to piggy-back off the electricity meter, leading to a saving on the cost of a modem within the gas meter. Centrica has estimated that this would reduce the cost of the gas meter by £20 per meter.

The costs that are presented here are assumed to be those that would be obtained in 2008. The costs of smart meters have reduced substantially in recent years and therefore it seems prudent to assume that there may continue to be reductions in the real cost of these meters for some years to come. We have therefore assumed as part of our base case that the purchase cost for gas and electricity smart meters will decrease in real terms over the first five years of the model by 5% per annum. This implies that, in 2013, the smart meter purchase costs will be £80 for a smart gas meter and £50 for a smart electricity meter.

Installation costs

Table 9 and Table 10 provide a summary, for gas and electricity, of the installation cost assumptions for each type of meter under each smart meter roll-out scenario.

Gas installation costs	**SHM (Replacement)**	**SHM (Accelerated)**	**RFM (Accelerated)**
Domestic – Prepay	£18.98	£16.87	£12.78
Domestic – Credit	£17.55	£15.75	£12.78
Business - Small	£20.00	£18.00	£12.50

Table 9: Smart meter installation costs - Gas

Source: Centrica, Frontier

Electricity installation costs	**SHM (Replacement)**	**SHM (Accelerated)**	**RFM (Accelerated)**
Domestic – Prepay	£18.62	£16.73	£12.78
Domestic – Credit	£17.82	£15.79	£12.78
Business - Small	£20.00	£18.00	£12.50

Table 10: Smart meter installation costs - Electricity

Source: Centrica, Frontier

It can be seen that the installation costs are assumed to vary by roll-out scenario. These variations are driven by differences in assumption about the time taken to undertake an installation. Average time taken to complete each installation may be expected to vary by scenario because of differences in customer density (which impacts on travel time between properties) and access rates.

Our travel time estimates have been derived from a detailed operational model commissioned by Centrica as part of its meter procurement programme. This model calculates average travel times for the country as a whole, based on postcode level data about customer density. The model also reflects the impact of "no access" visits. We have used this model to predict average travel times based on the customer density achieved at current levels of installation, and the lower times that would be achievable with a higher density under an accelerated roll out. Full details of the inputs provided by this model have not been included in this report as they are commercially sensitive to Centrica. However, they have been shared with BERR on a confidential basis.

Under the RFM (accelerated) scenario, we have assumed that a further step change in travel times would be available. Rather than travelling for several minutes between appointments, as at present, a street by street roll out would allow significantly reduced travel time. Further, it is likely that a higher access rate would be achievable as a street by street roll out would allow for greater publicity and for better coordination (e.g. households arranging access with neighbours). The actual time taken to install a smart meter is based on the same assumption in each of the three models. However, the differences in travel time mean that installation costs are assumed to be lower under an accelerated supplier hub model than under a rollout on replacement supplier hub scenario, and lower still under a regional franchise model.

The savings that we estimate are available from moving to an RFM roll-out are likely to be a conservative estimate. As well as the savings from reduced travel time, there are potential benefits from moving to a dual skilled workforce where a single meter installer is able to fit both gas and electricity meters. The main advantage from this is that once access is gained for one fuel, there is no need for a second visit for the second fuel. There is therefore a saving in terms of reduced travel time between unsuccessful appointments. Centrica's experience is that this would be unlikely to be achievable without moving to a RFM due to the operational difficulties of operating a single fuel workforce at low densities.

Maintenance costs

Table 11 and Table 12 provide a summary, for gas and electricity, of the maintenance cost assumptions for each type of meter under each smart meter roll-out scenario, in 2008. These costs are assumed to be incurred on an annual basis and, as for the 'dumb' meters, they are assumed to be driven by the purchase cost of the meter. Using the same assumption as Ofgem (2006), annual maintenance costs for smart meters are assumed to be 2.5% of the meter's purchase cost.

Gas annual maintenance costs	SHM (Replacement)	SHM (Accelerated)	RFM (Accelerated)
Domestic – Prepay	£2.58	£2.33	£1.83
Domestic – Credit	£2.58	£2.33	£1.83
Business - Small	£2.58	£2.33	£1.83

Table 11: Smart meter annual maintenance costs - Gas

Source: Centrica, Ofgem

Electricity annual maintenance costs	SHM (Replacement)	SHM (Accelerated)	RFM (Accelerated)
Domestic – Prepay	£1.99	£1.79	£1.79
Domestic – Credit	£1.99	£1.79	£1.79
Business - Small	£1.99	£1.79	£1.79

Table 12: Smart meter annual maintenance costs - Electricity

Source: Centrica, Ofgem

Communication costs

As noted above, we assume that a single, GSM, communications network will be roll-out in each geographic area. Table 13 and Table 14 provide a summary, for gas and electricity, of the additional annual communication cost charges assumed for each type of meter and roll-out scenario, based on a GSM communication solution. The cost of the modem is already assumed to be within the purchase cost of the meter.

Gas annual comms costs	SHM (Replacement)	SHM (Accelerated)	RFM (Accelerated)
Domestic – Prepay	£4.00	£4.00	£0.00
Domestic – Credit	£4.00	£4.00	£0.00
Business - Small	£4.00	£4.00	£0.00

Table 13: Smart meter annual comms costs - Gas

Source: Centrica

Electricity annual comms costs	SHM (Replacement)	SHM (Accelerated)	RFM (Accelerated)
Domestic – Prepay	£4.00	£4.00	£4.00
Domestic – Credit	£4.00	£4.00	£4.00
Business - Small	£4.00	£4.00	£4.00

Table 14: Smart meter annual comms costs - Electricity

Source: Centrica

Based on discussions Centrica has had with telecom providers, it has been assumed that there will be no one-off communication cost associated with purchasing a SIM card. Instead the telecom provider will recover the fixed cost of providing the SIM card through annual data traffic charges. In order to calculate the cost, it has been assumed that each meter will have at least 12 meter reads per year, with a greater frequency of reads for those customers that are assumed to take up a more sophisticated time of use tariff (as discussed in Chapter 6 below).

The only difference in the cost between the scenarios is for the RFM (accelerated) scenario. Since this is assumed to involve a dual fuel roll-out with a smart gas meter piggy-backing on the smart electricity meter, there will be no incremental annual communication charge for the gas meter.

System costs

The mass roll-out of smart meters is assumed to require a sizeable investment to implement the policy and adapt the current systems in order to exploit the functionality and outputs associated with smart meters. It is anticipated that these costs will need to be born by the industry in preparation to the roll-out of smart meters and therefore they are assumed to involve a one-off up-front cost.

The level of these costs is subject to great uncertainty and we are not aware of any detailed quantification of these costs. However, Centrica has undertaken an initial assessment to try and quantify how these costs may vary depending on the speed of roll-out and industry framework. These are presented in Table 15.

One-off implementation and system costs	SHM (Replacement)	SHM (Accelerated)	RFM (Accelerated)
Net present value	£300m	£400m	£700m

Table 15: Net present value of implementation and system costs: Gas and Electricity

Source: Centrica

Stranding costs

In the event of an accelerated smart meter roll-out, existing dumb meter assets may be replaced before the end of their useful economic life. This results in an economic cost of stranding associated with the removal of an asset that would have been able to continue to provide meter reads for the remainder of its certified life. We do not include an explicit cost associated with the stranded cost of dumb meter asset within our model. However, since our cost-benefit analysis is based on comparing the roll-out of smart meters with the "status quo" benchmark, the economic value of stranding dumb meters before the end of their useful life is captured within the model.

Suppliers may also be liable for contractual charges if they strand meters early. However, these charges are treated as a purely distributional issue, representing the transfer of a payment between industry parties for assuming the cost associated with obsolescence of the asset. These costs are only considered as part of the distributional analysis.

6 Benefits of smart meters for domestic and small business customers

6.1 INTRODUCTION

In Chapter 5, we described the functionality of the "smart" meter that we have assumed for domestic and small business customers. Given such functionality, a set of benefits are assumed to arise following the installation of such a meter. We consider the quantification of these benefits within this Chapter. We divide them into three categories: supplier benefits, "green" benefits and other benefits.

It should be noted that, with the exception of a proportion of the supplier benefits, the level of benefits per smart meter installed is generally invariant to the roll-out methodology. Therefore, the key difference in overall benefit levels associated with each roll-out methodology is in the speed with which the roll-out happens: the faster the roll-out the quicker the benefits are received and the larger they may be.

6.2 SUPPLIER BENEFITS

Certain costs associated with provision of an energy supply are expected to reduce following the introduction of smart meters. These cost reductions are grouped under the heading of supplier benefits. We have based our estimates of these benefits on information provided to us by Centrica on a confidential basis. This information has been used to estimate the scale of industry supplier benefits that may result. These benefits have been quantified on the basis that there is a mandated dual fuel roll out of smart meters. In the event that only a proportion of customers have smart meters, or they are only applied to either gas or electricity meters, the per meter benefits would be lower.

Meter read costs

One of the key benefits that would be expected to arise from the introduction of smart meters is a reduction in meter reading costs, given that these meters can be read remotely at low incremental cost. Such a benefit may be significantly eroded in the event that smart meters continue to have to be visually inspected every two years.[37] Given that a derogation from this requirement is currently being sought for smart meters, we assume for the purpose of our analysis that there is no such requirement.

Although the costs of meter reading will be lower once all meters can be read remotely, for the period of the roll-out there will be an increasing unit cost of dumb meter reads. This is associated with the lower density of such meters and therefore the increase in distance between each dumb meter, leading to higher

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37 This was recognised by Ofgem in its 2006 investigation into smart meters and prompted the supply licence condition change that allows for a derogation of this requirement if permitted by the Health and Safety Executive.

travel costs and, hence, higher cost per read. This will be affected both by the speed of roll-out (and therefore the length of time that the dumb and smart meters will have to run in parallel) and by the method of roll-out (a geographic roll-out under the RFM assumption will mean that the density of dumb meters in any region does not drop to the same extent as it would under the SHM.

The way we have modelled the impact of density of unit meter read costs has been informed by discussions with Centrica and their understanding of the costs of meter reads. In particular, it has been assumed that the variation of the unit cost of reading a dumb meter is inversely proportional to the square root of the number of meters installed at any given time. The relationship that has been used is described by the following formula:[38]

$$C = \frac{k}{\sqrt{N}}$$

where C is the unit cost of reading a dumb meter, N is the number of installed dumb meter and k is a constant, which determines the position of the curve.

Centrica provided an estimate of the average cost of reading a domestic customer's dumb meter. This was used as our base for the cost of a dumb meter read under the SHM at a level of density equivalent to a supplier of Centrica's size. We have then used Centrica's assumptions about the level of variable cost within this figure, and the proportion of this variable cost that can be expected to be linked to density. This provided us with an estimate of the percentage of meter reading costs that are variable with customer density. Using these assumptions, estimates can be made of unit meter read costs under each of the SHM and RFM scenarios both at the start of the roll-out, and then as the dumb meter density changes over the course of the roll-out.

Customer service benefits

Centrica anticipates that many of its customer service costs will be reduced following a full roll-out of smart meters. It is assumed that the level of reduction will depend on the industry framework that is adopted. In particular, if the current fragmented supplier hub model is retained, it is assumed that costs will still be incurred dealing with the failure of data flows associated with activities such as change of supplier. In the event that these are re-integrated within a RFM type approach, the cost savings are expected to be greater. For those customer service costs that will continue to be affected by the industry framework, it has been assumed that the saving under a supplier hub roll-out is half the size of those achieved under a RFM.

The customer service savings are assumed to be generated from the following activities.

- **Reduction in back office costs:**
  - a reduction in costs associated with the elimination of estimated bills;

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38 This is because dumb meters are assumed to be randomly distributed on a bi-dimensional surface.

- an end to estimated reads at change of supplier;
- a reduction in "exceptions" generated by a failure of data transfers between agents; and
- less customer contact associated with inaccurate calculation of customers' regular payment scheme arrangements.

- **Call centre savings:** a large proportion of customer service contacts arise from issues with billing or change of supplier and these should reduce in line with the reduction in back office costs.
- **Debt management costs:**
  - the ability of smart meters to be remotely switched between "credit" and "pay as you go" mode will greatly reduce the costs associated with meter exchanges;
  - there should be an opportunity to reduce the costs associated with "dumb" debt processes (e.g. in avoidance of the use of magnetic cards[39] as a form of debt management for credit customers); and
  - there will be lower costs associated with managing prepayment meter customers (e.g. in the provision of the electronic credit keys).

Centrica has carried out an evaluation of these benefits against its own cost base and these benefits have been applied against the entire asset base on a pro rata basis. These calculations are commercially sensitive and have thus not been included in this report. However, they have been shared on a confidential basis with BERR.

6.3 GREEN BENEFITS

Under the heading of "green" benefits we include those benefits that will be driven by changes in consumers' expected consumption behaviour. There are two potential sources of change in consumption behaviour that may arise from the introduction of smart metering:

- a reduction in average consumption; and
- a movement in the timing of consumption from peak to off-peak periods.

These potential changes in consumption behaviour may then each result in three potential benefits:

- a reduction in the cost of energy used;
- avoided peak capacity costs; and
- reduced carbon emissions.

[39] These allow customers to repay debt on a weekly basis through payment centres such as the Post Office network.

This is illustrated in Table 16 below.

	Benefit		
Change in energy consumption	Reduced cost of energy use	Avoided peak capacity costs	Reduced carbon emissions
Reduction in average consumption	✓	✓	✓
Load shifting from peak to off-peak periods	✓	✓	✓

Table 16 Illustrative example of changes in energy consumption and resulting benefits

In this section we first describe the assumptions underlying the two ways in which energy consumption behaviour might change, before describing how we have modelled the resulting benefits that would arise from such changes.

6.3.1 Reduction in average consumption

The replacement of dumb meters with smart meters is expected to lead consumers to reduce their consumption as they become more informed about the cost of their consumption in real time. This response includes similar reductions in energy use during both peak and off-peak periods. A stylised example of an average energy reduction across a day is illustrated in Figure 2 below.

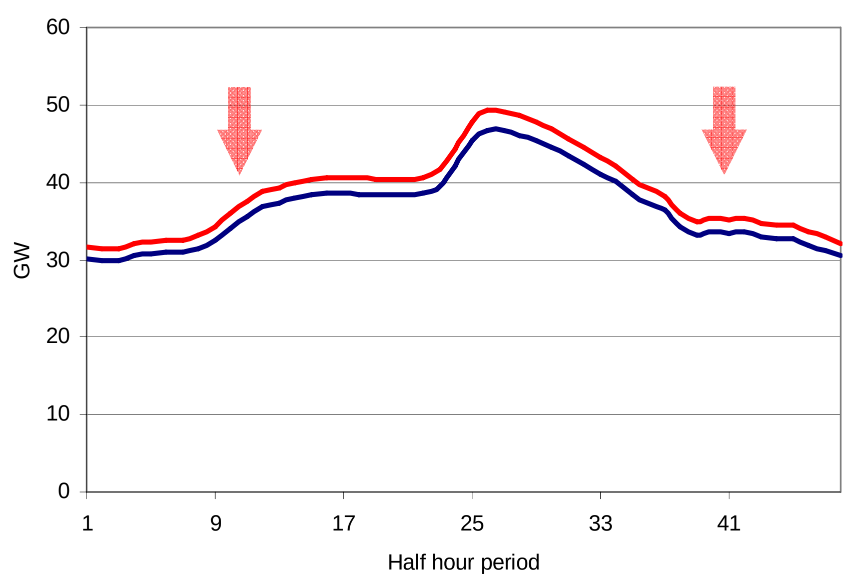

Figure 2 Stylised example of market energy reduction across a sample daily load

The scale of the reduction in consumption likely to result from the introduction of smart meters is uncertain. A review of the available literature was recently carried out for DEFRA (Darby (2006)[40]). It concluded that "direct feedback" to the consumer (i.e. obtained either from a meter or an associated display monitor) is capable of yielding energy savings of between 5% and 15%. Considering a wider range of studies, the range of estimates found for energy savings as a result of the introduction of smart meters goes from 0% to 15%.[41]

However, the trials and studies that form the basis of these estimates were generally small, often involving voluntary participants (which may not reflect the broader population) and generally do not confirm whether these effects persist in the longer term. It is also the case that almost all the studies undertaken to date focus on electricity smart meters. There are far fewer studies that consider whether similar reductions for gas will be achieved following the introduction of smart gas meters.[42]

This lack of certainty about the extent of energy reduction led to the establishment of first large-scale trials of smart meters in Great Britain[43]. Under the trial, meters are being fitted in around 15,000 British homes to provide feedback on whether they help customers improve household energy efficiency. A further 8,000 homes will receive VDUs. The trials will be administered by Ofgem over the next two years with a final report expected in 2010.

In the absence of information from the trials to provide more certainty about the level of consumption reduction that should be assumed, we consider it prudent to assume much more conservative consumption reduction estimates than those proposed in Darby (2006). We base our central case on the Sustainability First estimate that "smart meters, as part of a package of energy saving initiatives, might produce a 1-3% energy saving in the domestic sector."[44] In particular, our base assumption is that there will be a 2% reduction in demand for domestic credit customers, and a 1% reduction for domestic prepayment meter customers. The lower estimate for prepayment meter customers reflects the fact that they already have a much more accurate idea of the amount that they pay for their energy use. Small business customers are expected to reduce their consumption

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40 "The effectiveness of feedback on energy consumption. A review for DEFRA of the literature on metering, billing and direct displays", Darby S, Environmental Change Institute, University of Oxford (2006).

41 For example, reviews have been included within "Smart Meters – Costs and Consumer Benefits", energywatch (July 2007); "The Effectiveness of Feedback on Energy Consumption", Environmental Change Institute (April 2006); Sustainability First (2007); and Ofgem (2006).

42 A further issue may arise because most smart meter trials have only considered electricity consumption. There is evidence that electricity consumption (for example, lighting, televisions, computers) also provides a significant source of indirect heating and that savings in electricity consumption are often partially offset by a corresponding increase in gas consumption heating. This is known as the Heat Replacement Effect. However, as a base case assumption we assumed that the observed results already net of any heating uplift effect.

43 Ofgem Press Release R/31 Thursday July 12, 2007, First trials for smart energy meters in Britain are to begin, http://www.ofgem.gov.uk/Media/PressRel/Documents1/ofgem31%20_2_.pdf

44 Sustainability First (2007) p5.

by 0.25%. This lower reduction is based on the fact that small business energy demand may be expected to have lower levels of discretionary load than domestic customers. These reductions are assumed to apply to both gas and electricity customers and are net reductions in consumption, after taking into account any net increase in energy use by the smart meter itself.

6.3.2 Load shifting from peak to off-peak periods

Smart meters provide the functionality to record consumption over more discrete time periods. This will allow suppliers to offer tariffs that may provide pricing structures to incentivise consumers to move consumption from peak to off-peak periods. These could take the form of static time of use type pricing, such as the existing economy 7 tariff, or could be more dynamic pricing such as critical peak pricing associated with a much higher peak price over a small proportion of hours in the year, the precise timing of which may be determined at short notice. Although such tariffs may have relatively low take-up if they are not compulsory, they still offer the potential for material benefits as a reduction in peak capacity will reduce the requirement for peak generation and network capacity. This has been a key driver in smart meter roll-outs in other countries.

A stylised example of within-day load shifting is presented in Figure 3.

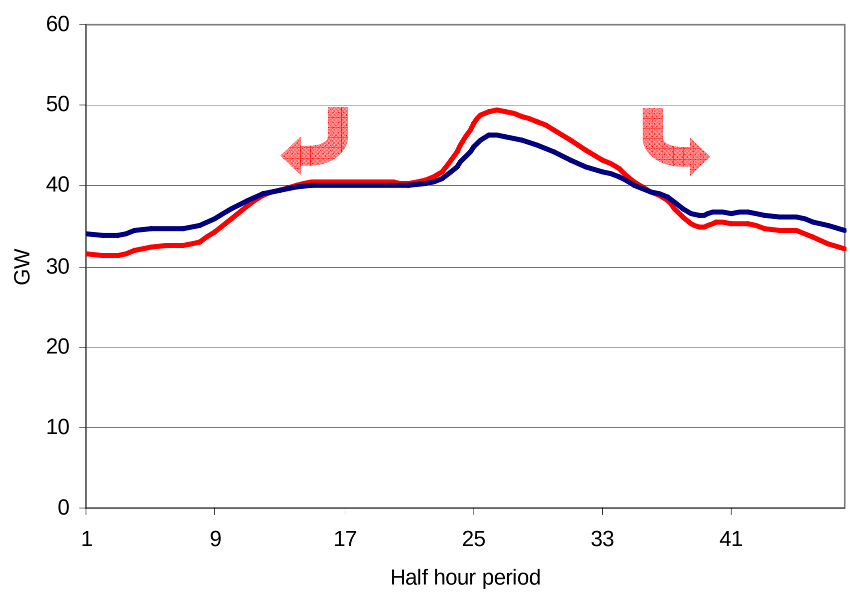

Figure 3 Stylised example of market load shifting across a sample daily load

For the purpose of the cost benefit modelling, we have considered two types of tariff structure that could be introduced.

- **A static Time-of-Use (ToU) tariff:** This type of tariff assumes a peak and an off-peak period with prices and durations fixed, ex ante, for a period of a year. As such, the tariff is similar to the current Economy 7 tariffs. We have assumed that the peak price is 1.7 times the level of the off-peak price[45] and that peak periods last for 30%[46] of the year.

- **A semi-dynamic Critical Peak Pricing (CPP) tariff:** This tariff would be characterised by having much higher peak to off-peak prices over a smaller proportion of the year/day. This might operate in a manner similar to that of the Tempo tariff in France, whereby the periods vary depending on *anticipated* high-demand days of the year (set 24 hours in advance and notified to the customer through a message sent to the meter). Although the price does not respond to the actual demand on those days, it is a more dynamic method of pricing than a static ToU tariff. As a base case we assume that the peak price would last for 1% of the year, and would be based on a price that was 2.6[47] times higher than the off-peak price.[48]

We assume that the introduction of such tariffs, and the resulting movement in demand from peak to off-peak prices, is only possible for domestic[49] electricity customers, not already on Economy 7 tariffs. The calculation of the level of energy moved from peak to off-peak periods as a result of the introduction of these tariffs is presented in Appendix 1 of this report.

We do not consider that similar tariffs will be introduced in the gas sector for the following reasons:

- settlement of gas is undertaken on a daily, rather than half-hourly, basis; and
- although daily or seasonal tariffs may still be theoretically offered to domestic and small business customers, the fact that there is less discretionary load associated with gas demand[50] (and therefore less option for movement of demand over time) as they are not expected to be very popular.

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45 This is a relatively conservative assumption about price differentials. A move to fully cost-reflective pricing (based on the differences in wholesale energy costs during peak/off-peak periods) would imply a greater increase in the price ratio.

46 Since we did not have information on half hourly consumption for these customers, the peak period was based on assuming a domestic load factor of 35% and defining 'peak' as the time during which consumption is higher than average annual consumption.

47 This price ratio reflects the ratio between energy purchase costs in the peak 1% compared with the remaining 99% in 2006.

48 Other forms of pricing may be theoretically possible with smart metering, such as dynamic real time pricing which adjusts prices in real time, rather than pre-determined time periods. However these were not considered in the modelling.

49 Studies have found that price responsiveness is significantly less for small and medium business customers than it is for residential customers, therefore, in order to be prudent in our assumption, we do not assume any response.

50 Domestic gas is mostly used for space heating (61%), hot water (23%) and, to a lesser extent, cooking (3%) according to "Smart Meters in Great Britain: the next steps? Paper 4: Smart meter contribution to UK goals for energy saving and carbon reduction", Gill Owen and Judith Ward, (July 2007).

We assume that these tariffs would not be compulsory, and therefore customer take-up would be expected to fall short of 100% of customers. However, we expect that tariff differentiation is something that suppliers will be interested in offering and therefore a material take-up of such tariffs could be expected. Our base assumption is that 15% of customers, not already on Economy 7 tariffs, will take up the ToU tariff, whilst 5% of customers may take up a CPP tariff. These proportions can be varied within the model. We discuss the Settlement System implications associated with the introduction of such tariffs within Appendix 2 of this report. We assume that the cost of updating Settlement in order for such tariffs to be allowed is included within the one-off system costs that have been allowed within our cost assumption.

6.3.3 Reduced cost of energy use

Having described where the changes in behaviour come from, we now go on to consider how the benefits from these changes in behaviour are calculated. The first of these is the reduced cost of energy use.

Reduction in energy consumption

In order to quantify the benefit associated with reduced cost of energy use following a reduction in energy consumption, we calculate the reduction in the total quantity of energy consumed for each profile class in the gas and electricity sectors. Specifically we:

- determine average energy consumption by meter (by customer profile class);
- adjust for line losses/energy losses to account for the difference between consumption and electricity generation/gas production; and
- apply assumed percentage reduction in consumption.

This change in consumption is then multiplied by the average price of energy to determine the benefit per meter[51]. The electricity prices are derived from Elexon's Market Index Prices for 2006, whilst the gas prices are sourced from National Grid SAP prices for the gas year 2005/06.

The energy costs used to quantify the savings will reflect not only fuel/operating costs, but also generation capacity costs (particularly during peak periods, when prices tend to exceed short run marginal cost) and, in the case of electricity, some pass-through of carbon costs. In order to avoid double counting of benefits, 50% of the cost of carbon emissions (described below) is subtracted from the energy cost savings to account for the carbon cost pass-through. [52][53]

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51 This can be expected to be more accurate than the approach used by BERR which is based on assuming that generation costs are a (35%) portion of the average bill.

52 Numerous studies of the initial stages of the EU ETS have estimated the level of carbon cost "pass-through" at between 40-70%, hence 50% represents a reasonable mid-point:. For example, see "CO_2 price dynamics. A follow-up analysis of the implications of EU emissions trading for the price of electricity" Sijm, J.P.M.; Donkelaar, M; Hers, J.S.; Scheepers, M.J.J.; Chen, Y. (2006), ECN Policy Studies , ECN-C--06-015.

Load shifting from peak to off-peak periods

A movement of consumption from peak to off-peak periods will reduce the average cost per unit of energy consumed, since the average cost of energy during peak hours is more expensive than during off-peak hours. This is because the fixed cost of a capital investment is spread over fewer hours of the year when that peak capacity is required. "Peakier" load (i.e. a lower load factor) requires more capacity over fewer hours, and this increases the cost of meeting a given level of total demand. This will reduce the total cost of energy supply, for a given level of consumption. An example of the relationship between energy costs (represented by the wholesale pool price) and market energy demand is presented in Figure 4.

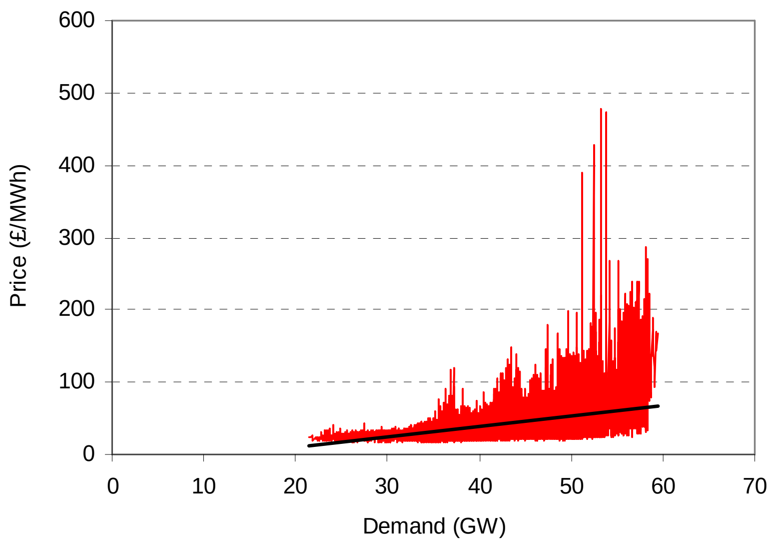

Figure 4 Relationship between electricity load and cost

Source Elexon Market Price Index (2005) charted against NationalGrid Market Demand Data (2005) for corresponding periods

In order to quantify the benefit associated with reduced cost of energy use, the reduction in peak consumption resulting from the load shifting is multiplied by the peak energy price, while the increase in off-peak consumption (which is an equivalent volume) is multiplied by the off-peak energy price. The peak energy

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[53] We recognise that, in reality, the effect on carbon emissions is more complex than this. In the shorter term, as the power sector is within the EU ETS, there will be no direct emissions saving from a reduction in electricity consumption. However, benefits will be felt by all entities within the EU ETS that can now choose to buy allowances as a cheaper option than incremental abatement. In the medium / longer term, reductions in electricity consumption may be expected to facilitate equivalent reductions in total allowed carbon emissions. The corresponding adjustment to be made to generation costs suffers similar complexity and uncertainty. Assuming that this benefit should be reduced by 50% of the value of the carbon benefit is a simple adjustment based on the fact that prices are likely to have been influenced by relevant allowance prices and these were much lower than Defra's estimate of social cost of carbon.

price is calculated as the average price of those periods when market demand exceeds average market demand[54]. The net effect is a reduction in the average cost of energy consumed, since off-peak energy costs less.

6.3.4 Avoided peak network capacity costs

A reduction in the total quantity of energy consumed, or a shift in consumption from peak to off-peak periods, will each result in a reduction in the coincident peak demand. Given that it is generally peak demand that determines required system network capacity (as opposed to total energy consumption) this will reduce future capacity requirements and costs. Strictly speaking, existing capacity is already a sunk cost, and any reduction in peak demand will not reduce this cost. However, since energy demand is growing over time, any reduction in coincident peak demand in future years will reduce further capacity cost expenditure.

To estimate the value of avoided capacity costs, the reductions in peak demand, from both the reduction in total energy consumed and the load shifting, were multiplied by the estimated value of avoided system capacity cost.

Reductions in peak demand for electricity were valued at £70/kW/year based on:

- £20/kW/year for transmission[55]; and
- £50/kW/year for distribution[56].

The avoided capital cost of generation is not included since capital costs are ultimately reflected in the wholesale energy cost.

The costs of avoided capacity for gas are far lower than for electricity since the capital costs are far lower. Reductions in peak demand for gas were valued at £0.40/kW/year based on:

- £0.10/kW/year for storage[57]
- £0.15/kW/year for transmission[58]; and
- £0.15/kW/year for distribution[59].

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54 In order to calculate this price, we have assumed an average load factor of 65% (taken from National Grid's Market Demand Data (2005)). Using this assumption, 51% of all hours will be defined as "peak" hours. This is the approach adopted in "Review and Potential of Demand Response Measures", Ranci P, Potoschnig A, Settimio E, Frontini S and Prandini A, Presentation to SESSA Conference: Investment for Sustainability, (2005).

55 Based on the average construction costs of reinforcement trans lines in Scotland 3.6GW costing £804m discounted over 15 years at 6%, pg 84 Technical evaluation of Transmission Network Reinforcement Expenditure, Sinclair Knight Merz, (2004)

56 Ofgem assumption, Domestic Innovative Metering, Ofgem's high level cost benefit analysis – supporting documentation, 10 March 2006, summarised in Ofgem's consultation paper – Domestic Metering Innovation: 20/06 – February 2006 (Chapter 4)

57 Ofgem assumption, Domestic Innovative Metering, Ofgem's high level cost benefit analysis – supporting documentation, 10 March 2006, Based on NGC prices

58 Appendices pg 10, Ten Year Forecast, National Grid; Statutory Capex requirement, pg 62 Transco price control review 2001

6.3.5 Reduced carbon emissions

In addition to the energy and capacity benefits, there may also be a benefit to society from a reduction in carbon caused by the reduction in generation. This section considers the calculation of the benefit associated with a reduction of carbon emissions that can be expected to result from the change in consumption patterns. As we discuss below, the effects of reduced consumption and load shifting on carbon emissions are potentially conflicting.

Reduction in emissions due to lower total energy consumption

The basis for calculating carbon emissions reductions is, essentially, the reduction in energy demand multiplied by the emissions factor of the marginal units of consumption. In the case of gas, the marginal emissions factor is equal to the average emissions factor, since each unit of gas is homogenous. In line with the policy of Defra, we use an emissions factor for gas of $0.19tCO_2/MWh$.[60]

In the case of electricity, emissions factors vary by plant. Infra-marginal baseload plant, such as renewables or nuclear, are typically low or zero emitters. Marginal plant, such as gas or coal plant, are relatively higher emitters. Consequently, the marginal emissions factor is higher than the average emissions factor[61]. We have calculated the marginal emissions factors for peak and off-peak periods separately and then calculated a weighted average, as follows:

- The emissions factors are calculated to be $0.45tCO_2/MWh$[62] for CCGT gas plant and $0.88tCO_2/MWh$[63] for coal plant.
- The relative difference between the marginal cost of operation of the marginal plant between the peak and off-peak period is then derived:
  - Gas is assumed to operate as the marginal plant 80% of the time during peak periods, and coal 20% of the time (due to the relatively higher marginal cost of gas). Given the emissions factors for gas and coal plant calculated above, a peak marginal emissions factor of $0.54tCO_2/MWh$ is derived.
  - Coal is assumed to operate as the marginal plant 80% of the time during off-peak peak periods, and gas 20% of the time. This results in an off-peak marginal emissions factor of $0.79tCO_2/MWh$.

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59 Ofgem assumption, Domestic Innovative Metering, Ofgem's high level cost benefit analysis – supporting documentation, 10 March 2006: Based on transmission price

60 Batey, M and Pout, C, DEFRA, Delivered Energy Emission Factors for 2003

61 This is why we do not consider that the emission factor 0.43 tCO_2/MWh, assumed to be an average carbon intensity of all generation capacity, is appropriate.

62 This is based on average plant efficiency of 41% and CO_2 content of gas of $0.19tCO_2/MWh$ thermal.

63 This is based on average plant efficiency of 36% and CO_2 content of coal of $0.32tCO_2/MWh$ thermal.

This provides a volume weighted average marginal emissions factor of 0.64tCO_2/MWh, which is similar to the emissions factor for electricity displaced from the grid (0.568tCO_2/MWh)[64].

Application of the volume weighted average marginal emissions factor to the level of assumed reduction in consumption provides an estimate of the CO_2 emissions savings due to reduced energy consumption. To estimate the value of these emissions savings, this is multiplied by DEFRA's social cost of carbon: this was set at £70/tC in 2000 in 2000 prices with a £1/year increase in subsequent years. This provides a price for CO_2 of £25.41/tCO_2[65][66] in 2007[67].

Change in the average emissions due to load shifting

Since emissions factors vary by plant, the marginal emissions factor also differs by peak and off-peak periods. The impact on carbon emissions following a shift in consumption from peak to off-peak periods could in principle be either positive or negative depending on the composition of the generation merit order.

At present, coal, which has a higher emissions factor, is more frequently the marginal plant during off-peak periods, given current fuel and carbon price conditions. Gas, which has a lower emissions factor, is more frequently the marginal plant during peak periods. Therefore, at present, any shift in consumption from peak to off-peak periods will actually increase average emissions for a given level of total consumption. This may change in future if the fuel and carbon costs adjust such that coal and gas reverse in the merit order. We consider this as a sensitivity in the CBA.

6.4 OTHER BENEFITS

Most benefits that are expected to result from the introduction of smart meters will fall under one of the two headings above. However, there are three further benefits that we have included within the CBA.[68] These were taken from Ofgem's (2006) CBA of smart meters for domestic customers.

- **Electricity outages and restorations:** Smart meters may be used by electricity network companies to track outages more quickly and more accurately. Ofgem assumed that this could lead to a reduction in customer

64 Batey, M and Pout, C, DEFRA, Delivered Energy Emission Factors for 2003

65 1 tonne of carbon, atomic weight 12, produces 44/12 tonnes CO_2, molecular weight 44.

66 An alternative would be to multiply by market prices for carbon (eg under the EU ETS) however this would become partly circular, since the price of carbon is partly a function of the targets set, which are simply a result of government policy.

67 This is slightly higher than BERR's latest assumption (provided in the note "Potential Changes to RTD model") of the cost of CO_2 of £24.81/t in 2008. However, the rate of increase assumed in our model is approximately 1.4% per year, compared with BERR's assumption of a 2% increase per year. These differences do not have a material impact on the results.

68 We recognise that there are likely to be further benefits that we have not attempted to quantify within this analysis. For example, a smart meter that could record export as well as import energy flows could be expected to promote the use of microgeneration plant.

minutes lost of 10%. This translated into a benefit of £0.05 per electricity meter per year.

- **Reduced theft:** Large scale implementation of smart metering would reveal existing theft (both tampering and by-pass), the frequency of accurate meter reads may serve to identify theft and the functionality of the meter may be able to monitor and communicate theft. Ofgem assumed that there would be a 25% reduction in theft following the introduction of smart meters. This translates into annual benefits of between £0.27 per gas prepayment meter and £0.61 per electricity credit meter.
- **Reduced technical losses:** Having a complete demand profile for any given node on both the electricity and gas networks should allow network operators to reduce the level of technical losses. Based on a 1% reduction in technical losses, Ofgem estimated this benefit as £0.08 per electricity meter and £0.03 per gas meter.

7 Results of smart meter CBA for domestic and small business customers

7.1 INTRODUCTION

This Chapter presents the results of the cost benefit analysis undertaken for domestic and small business customers, together with a consideration of some of the key sensitivities that underlie the results.

In order to provide a structure to the assessment of a smart meter roll-out programme, it is useful to break the analysis down into three stages:

- Is there a net benefit associated with the introduction of smart meters to domestic and small business customers?
- Is there a case for accelerating such a smart meter roll-out programme?
- Is there a case for co-ordinating the roll-out of smart meters to achieve cost savings in deployment?

We consider each question in turn, presenting the results of the cost benefit analysis for each of the roll-out scenarios considered.

7.2 NET BENEFIT ASSESSMENT

We present in Table 17 a summary of the costs and benefits for a roll-out of smart meters to domestic and small business customers in the gas and electricity sectors under our base case assumptions. All base case scenarios assume that the actual roll-out of smart meters will commence two years after the decision to introduce smart meters is taken, allowing time for industry to prepare for a comprehensive roll-out of smart meters. Under the SHM (replacement) scenario, meters will be rolled-out on a replacement basis in 20 years. Under the SHM (accelerated) scenario, the replacement of all dumb meters is expected to be completed within 10 years and, under the RFM (accelerated) model all meters in the industry will be smart meters within a seven year period. All values are presented in 2007 prices.

	SHM (replacement)	SHM (accelerated)	RFM (accelerated)
Incremental costs			
Purchase	(£2,170m)	(£2,670m)	(£2,702m)
Installation	(£54m)	(£166m)	(£71m)
Maintenance	(£507m)	(£683m)	(£671m)
Communication	(£1,404m)	(£2,239m)	(£1,433m)
Other system and implementation	(£300m)	(£400m)	(£700m)
Extra finance cost	(£983m)	(£1,045m)	(£992m)
Terminal Asset Value	£756m	£465m	£460m
Total incremental cost	**(£4,663m)**	**(£6,738m)**	**(£6,109m)**
Benefits – Supplier and Network			
Supplier legacy meter reads	£925m	£1,558m	£2,016m
Supplier – other benefits	£964m	£1,435m	£2,789m
Total Supplier benefits	***£1,889m***	***£2,994m***	***£4,804m***
Other Network benefits	£192m	£292m	£327m
Total Supplier and Network benefits	**£2,081m**	**£3,286m**	**£5,132m**
Benefits – Green			
Energy savings	£1,549m	£2,349m	£2,634m
Lower demand	*£1,533m*	*£2,324m*	*£2,607m*
Load shifting	*£16m*	*£24m*	*£27m*
Avoided peak capacity	£473m	£727m	£815m
Lower demand	*£382m*	*£587m*	*£658m*
Load shifting	*£91m*	*£140m*	*£156m*
Carbon savings	£614m	£924m	£1,028m
Lower demand	*£618m*	*£930m*	*£1,035m*
Load shifting	*(£4m)*	*(£7m)*	*(£7m)*
Total Green benefits	**£2,636m**	**£3,999m**	**£4,477m**
CBA Summary			
Incremental costs	(£4,663m)	(£6,738m)	(£6,109m)
Supplier and network benefits	£2,081m	£3,286m	£5,132m
Green benefits	£2,636m	£3,999m	£4,477m
Total net benefit	**£54m**	**£546m**	**£3,499m**
CBA ratio	**1 to 1.0**	**1 to 1.1**	**1 to 1.6**

Table 17: Results of CBA (base case) for domestic and small business customers

Source: Frontier analysis

Results of smart meter CBA for domestic and small business customers

The carbon reduction associated with each scenario by 2020 is:

- SHM (replacement) – 1.8MtCO_2;
- SHM (accelerated) – 3.2 MtCO_2; and
- RFM (accelerated) - 3.2 MtCO_2.

The positive net benefits shown in this table would indicate that, given the base case input assumptions and methodology, a roll-out of smart meters may be in society's interest. In addition we also observe the following:

- the gap between the costs that would be incurred by suppliers and the benefits that would accrue to suppliers means that a roll-out of smart meters is unlikely to happen if it is not mandated by Government;
- a decision to mandate a smart meter roll-out will depend on the confidence that such a policy will deliver the level of 'green' benefits that have been assumed;
- acceleration of the roll-out appears to increase the size of the net benefit; and
- if a mandated roll-out of smart meters was required, the highest net benefit would be expected to be achieved through an accelerated co-ordinated roll-out approach, as envisaged under the RFM (accelerated) model.

We discuss these points in more detail in the rest of this section, and undertake sensitivity analysis on the results where this is instructive.

Supplier business case

The results show that, based on current assumptions, it is extremely unlikely that it would be in suppliers' interest to roll-out smart meters to all domestic and small business customers. This result is consistent across the SHM for both the replacement and accelerated scenarios.[69] In addition, the current gap between costs and benefits is so large, it would only be bridged in the event of an increase in supplier specific benefits of over 100%, or a reduction in costs of an equivalent magnitude.

This does not mean that there are no market segments where there would be a supplier case for roll-out (for example, where customers have hard-to-read meters or have a higher probability of falling into debt). However, it does mean that if the Government leaves it to suppliers to decide whether to roll-out smart meters to these customers, it appears to be extremely unlikely that this will occur for all customers within the next 10 years.

69 It is not appropriate to consider the supplier business case in the context of a RFM on the basis that the industry reform would not be expected to occur if a smart meter roll-out was not mandated.

Case for mandated roll-out

The case for a mandated roll-out of smart meters to domestic and small business customers depends on the expected level of 'green' benefits that may be generated by customers altering their energy consumption behaviour. As we discussed in Chapter 6, the change in consumption behaviour may be a result of:

- a reduction in the level of gas and electricity consumption in response to better information about the cost of energy consumption; and
- a movement in the timing of electricity consumption from peak to off-peak periods in response to time of use tariffs.

These changes would be expected to generate three potential benefits:

- a reduction in the cost of energy used;
- avoided peak capacity costs; and
- reduced carbon emissions.

Our base case assumes a reduction in consumption of 2% for domestic gas and electricity credit customers, 1% for domestic gas and electricity prepayment customers and 0.25% for gas and electricity small business customers. In addition, 20% of domestic electricity customers are expected to take up a time of use tariff, the parameters of which are set out in Table 18 and were described in detail in Chapter 6.

	Time of Use tariff	**Critical Peak Pricing tariff**
% of customers choosing tariff	15%	5%
Peak/Off-peak price ratio	1.68 to 1	2.56 to 1
Peak period as % of all hours	30%	1%
% of peak period load shifted to off-peak	5%	5%

Table 18: Time of use pricing assumption (domestic electricity customers)

Source: Frontier Economics

In order to illustrate the contribution that is made by each source of green benefit, we provide the breakdown for the RFM (accelerated) total green benefit of £4,477m in Table 19 below.

	Energy reduction (Gas)	Energy reduction (Electricity)	Peak shift (Electricity)
Reduction in cost of energy consumed	£1750m	£857m	£27m
Avoided peak capacity	£33m	£625m	£156m
Carbon reduction	£519m	£516m	(£7m)
Total 'green' benefit	**£2,302m**	**£1,998m**	**£176m**

Table 19: Expected level of 'green' benefits (base case) under RFM (accelerated)

Source: Frontier Economics' analysis

These results lead us to make the following observations.

- We consider that our assumptions for the take-up of the ToU and CPP tariffs, and the load movement that they would be expected to generate, are conservative. However, the results would indicate that, under current conditions, such a benefit is unlikely to be large enough to make the case for a mandated smart meter roll-out. It is important to recognise that this could change in the future, particularly if a summer peak demand associated with air-conditioning materialised. Indeed, it is the benefits associated with movement of demand, rather than an absolute reduction, that have driven the case for a smart meter roll-out in other countries such as the United States and Australia. We also note that the increase in carbon associated with these tariffs is a function of the current generation conditions and may change in future if coal and gas reverse in the merit order.
- The potential of gas smart meters to deliver significant 'green' benefits should be recognised. Average gas consumption is higher than average electricity consumption and therefore may be expected to result in greater savings for any fixed percentage reduction in consumption. However, as we recognised in Chapter 6, there is less evidence about what, if any, reduction in consumption may be achieved in response to gas smart metering. If the reduction is lower than in electricity (perhaps because there is less discretionary load associated with gas consumption) then the benefit may be lower.
- The case for a smart meter roll-out, at present, rests on confidence about its ability to deliver a reduction in average consumption. We consider the sensitivity of the results to the level of expected reduction below, using the alternative energy reduction assumptions contained in Table 20.

	Low case	Base case	High case
Domestic credit	-1.00%	-2.00%	-3.00%
Domestic prepayment	-0.50%	-1.00%	-1.50%
Small business	-0.00%	-0.25%	-1.00%

Table 20: Energy reduction sensitivity analysis assumptions

Source: Frontier Economics

The impact of these sensitivities on the level of benefits is presented in Table 21.

	SHM (replacement)		SHM (accelerated)		RFM (accelerated)	
	Low	High	Low	High	Low	High
Incremental benefit	£2,488m	£5,094m	£3,749m	£7,702m	£5,379m	£9,805m
Net benefit	(£1,249m)	£1,359m	(£1,430m)	£2,522m	£1,286m	£5,712m
Cost/Benefit ratio	1 to 0.67	1 to 1.36	1 to 0.72	1 to 1.49	1 to 1.3	1 to 2.4

Table 21: Impact of variation of assumption on energy reduction

Source: Frontier Economics' analysis

It can be seen that a relatively small change in the average percentage reduction in consumption can lead to a large variation in the size of benefit that such a policy may be expected to generate. If smart meters only generate a sustained reduction of average consumption at the level assumed under the low case sensitivity, then the only scenario showing a positive level of net benefit is the RFM (accelerated) given that is estimated to achieve the roll-out at the lowest cost.

Since there is considerable uncertainty about the level of expected consumption reduction, there may be a case for delaying the roll-out of smart meters until the current GB metering trials are more advanced or complete, or further information has emerged from the other countries where smart meters have already been introduced (such as Italy and Canada (Ontario)). However, there is also a potential cost associated with waiting, given that there will be a delay in the receipt of benefits. Table 22 illustrates the impact of a one-year postponement in the introduction of a smart meter roll-out.

	SHM (replacement)		SHM (accelerated)		RFM (accelerated)	
	Year 3	Year 4	Year 3	Year 4	Year 3	Year 4
Net benefit	£54m	£20m	£546m	£474m	£3,499m	£3,253m
Cost/Benefit ratio	1 to 1.0	1 to 1.0	1 to 1.1	1 to 1.1	1 to 1.8	1 to 1.8

Table 22: Impact of a one-year delay in a smart meter roll-out

Source: Frontier Economics' analysis

The results show that postponing the introduction of smart meters by one year does not alter the cost-benefit ratio of each scenario significantly, although, under the RFM the absolute reduction is material at £246m. It should also be noted that this analysis may be expected to underestimate the cost of delay since it ignores the impact that uncertainty about Government policy is having on the market. In particular, such uncertainty can be expected to drive up the required return of meter owners and operators.

It is a question for Government whether it considers that there is already sufficient evidence to support a mandated roll-out of smart meters, or whether the uncertainty is such that it warrants a delay in implementing such a policy to wait for more information.

7.3 CASE FOR AN ACCELERATED ROLL-OUT

If the Government decides that a mandated smart meter roll-out is the correct policy, the time period over which smart meters should be introduced needs to be decided. We noted in Chapter 3 that there are likely to be three key benefits to an accelerated roll-out:

- the benefits of switching to smart meters are received sooner;
- the time over which 'dumb' and smart meters will need to be run in parallel will be reduced; and
- there may be economies of scale associated with the purchase of a higher number of smart meters per year.

Against these benefits, there may be additional costs associated with an accelerated roll out:

- there will be higher levels of stranding of 'dumb' meter assets as more 'dumb' meters are replaced before the end of their economic life; and
- if real meter costs continue to fall, the NPV of the total cost of purchasing smart meter assets could be higher, not lower, under an accelerated programme.

The SHM (replacement) and the SHM (accelerated) scenarios illustrate the net impact of the benefits and cost associated with acceleration. In aggregate, the impact of undertaking the roll-out in 10 years instead of 20 years is summarised in Table 23.

	SHM (replacement)	SHM (accelerated)
Incremental costs	(£4,663m)	(£6,738m)
Incremental benefits	£4,717m	£7,284m
Total net benefit	£54m	£546m
Cost/Benefit ratio	1 to 1.0	1 to 1.1

Table 23: Impact of speed of roll-out

Source: Frontier Economics' analysis

It can be seen that the net benefit of the accelerated scenario is about ten times higher than the net benefit obtained under the standard replacement solution. In order to assess the robustness of this result, we test the sensitivity of this result to the assumption about economies of scale in meter purchase that may be achieved under the accelerated roll-out.

Our base case assumption is that meter purchase costs will be 10% lower under an accelerated roll-out compared with a replacement roll-out given that approximately twice as many meters will be bought in any year under such an assumption. If the reduction in purchase costs were only 5%, total costs under the accelerated scenario would rise by £296m. Clearly the net benefit associated with acceleration is sensitive to the achievement of economies of scale in meter purchase.

It should be noted that, while an accelerated roll-out delivers higher net benefits than a standard roll-out based on replacement, it would also lead to the stranding of part of the existing meter asset base. We discuss the implications of this within the distribution analysis below.

7.4 CASE FOR CO-ORDINATED ROLL-OUT

In the previous section we have shown that, under our base case assumptions, an accelerated smart meter roll-out would generate a higher net benefit than a roll-out based on the replacement of existing meters when they reach the end of their certified life. Our base case results showed that it may be possible to achieve even higher savings if the deployment of smart meters was undertaken in a co-ordinated manner across the industry: the net benefit associated with the SHM (accelerated) was £546m compared with £3,499m from the RFM (accelerated), a difference of £2,953m. The majority of this difference in net benefit is a result of three factors:

- roll-out of the solution on a dual-fuel basis allowing a cheaper solution for gas smart metering;
- re-integration of many of the metering processes resulting in fewer instances of failure of the systems resulting in higher supplier benefits; and
- co-ordination of the roll-out on a geographic basis involving lower cost of installation and lower costs of reading the legacy dumb meters.

The cost savings associated with being able to install a dual fuel solution allowing the smart gas meter to "piggy-back" on the communications functionality of the smart electricity meter comes from two sources: a one off £20 reduction[70] in the cost of the gas meter and an on-going communication cost saving of £4 per year. The £20 gas meter cost differential impacts on the maintenance cost, the extra finance cost allowance and the terminal value (since all of these are also related to

70 This £20 differential is the difference between the meter costs in 2008. Because a real reduction in prices of 5% per year is then applied for the first five years, the absolute differential is lower in the subsequent years.

the purchase cost of the meter) as well as the purchase cost itself. The sum of these impacts has a net present value of £643m. The on-going communication cost saving has an even bigger net benefit of £1,060m, given that the saving is achieved annually for every gas meter that is installed.[71]

The next most important driver of this result is the level of supplier benefits that are expected to occur as a result of a re-integration of metering services. If the supplier benefits were equivalent under the SHM (accelerated) model as they were under the RFM (accelerated) then the benefits would be £1,053m higher.

The two other sources of cost saving under the RFM are the saving in legacy meter reads and the installation costs. As shown in Chapter 6, the unit cost of reading 'dumb' meters increases as the density of dumb meters in the market decreases. A geographically co-ordinated roll-out allows suppliers to reduce the extent of this problem, as, while smart meter installation is concentrated in one area, the density of 'dumb' meters in the other areas is maintained, allowing the minimisation of travel time. This results in assumed savings of £456m under the RFM. Installation cost savings are lower at £95m, partly because we have not sought to additionally quantify the benefits associated with a dual fuel roll-out as part of this work.

The case for co-ordination clearly depends on three main impacts: a cheaper dual fuel solution that would not be available without industry co-ordination; higher supplier benefits associated with re-integration of metering services and reduced cost of legacy meter management. Each of these has the potential to achieve large savings in the cost of a smart meter roll-out and, by itself, potentially could justify restructuring the industry to provide for the meter roll-out.

7.5 DISTRIBUTION ASSESSMENT

The standard cost benefit analysis considers costs and benefits for society as a whole and does not concern itself with the impacts that a policy may have on particular categories of stakeholders. In order to complete the analysis of a new policy, it will therefore be necessary to undertake an assessment of its impact on different stakeholder groups. While all stakeholders should be taken into account in such an assessment, this analysis focuses mainly on those groups that may be expected to be adversely affected by the policy.

In the case of a policy involving the introduction of smart meters to domestic and small business customers, most of the net benefits associated with the policy will be expected to be passed through to customers. Supplier costs and benefits will also predominantly find their way through to customers, given the competitive retail market for energy. Certain network benefits may be shared between customers and network providers through the operation of the price control mechanism, whilst benefits associated with reduction in consumption will

71 It should be noted that in order to obtain the benefits from piggy-backing the gas meter on the electricity meter, the timing of the gas smart meter installation would be dependent on the timing of the electricity meter installation.

be directly received by customers in the form of lower energy costs and society in the form of lower carbon emissions.

There are two potential impacts that we consider need to be specifically considered within the distributional analysis.

- Impact on particular customer groups: as costs and benefits are generally passed on to final consumers, the distributional analysis should consider how they may be affected by this policy. While the policy appears to have an overall positive NPV, different customer groups may be affected in different ways.
- Impact of stranding existing assets: under an accelerated roll-out scenario, there will be a cost associated with the stranding of the existing metering stock before the end of its expected useful life. Consideration of the parties that will be affected by this cost warrants consideration.

We address each of these issues in turn.

7.5.1 Customer impact

As noted above, given the nature of the benefits that are expected to arise from smart meters, and the market structure that will deliver them, it is likely that most of the net benefits associated with the policy will accrue to customers. If the policy delivers a net benefit then it is likely that customers will also derive a net benefit without further need for intervention.

The question that needs to be addressed is whether this net benefit can be expected to be realised by all customers, or whether there are specific sub-groups that may fail to benefit. In this context we consider two particular groups: prepayment meter customers and small business customers.[72]

Prepayment meter customers

In Chapter 4 we saw that, even under BERR's own base case assumptions, prepayment meter customers may not be expected to benefit from a roll out of VDUs. This is because their reduction in energy consumption may be expected to be lower than that of credit customers, given that they already tend to be more aware about the cost of their consumption. It is therefore important to understand the impact that a smart meter roll-out may have on this customer group.

At present, prepayment meters have a higher purchase cost than credit meters, part of which is recovered from customers in the form of higher charges. However, with the introduction of smart meters, the same meter could be used for both prepayment and credit customers, with any switch between the two functionalities being undertaken remotely at much lower cost than today. It is

72 In the event of the introduction of time of use pricing, there may also be some concern about those customers who have to consume energy disproportionately at peak times. Such customers may include the elderly or those with young children. However, since we consider only modest uptake of voluntary time of use tariffs we do not consider that this will be significant.

therefore the case that the incremental costs associated with providing a smart meter solution to prepayment customers is less than it is to provide a smart meter solution to credit customers. It is this effect that keeps the net benefit to prepayment meter customers positive under a smart meter roll-out, even though they will be expected to reduce their consumption by less. We show this in Table 24.[73]

Net benefit	SHM (replacement)	SHM (accelerated)	RFM (accelerated)
Domestic – credit	£9m	£619m	£3,083m
Domestic - prepayment	£260m	£240m	£773m
Small business	(£215m)	(£312m)	(£357m)

Table 24: Results of CBA (base case) for gas and electricity customers by payment type

Source: Frontier Economics' analysis

Given that there are over four times as many credit customers as prepayment customers, the prepayment meter case is actually stronger than the case for either credit customers or small business customers under both of the SHMs. To the extent that current prepayment meter tariffs do not reflect the full extra costs of the prepayment meters, this analysis may overstate the benefits that will be expected to accrue directly to prepayment customers. However, a simpler metering solution for these customers may also lead to an increase in competition to supply them, with significant resulting benefits for prepayment customers.

Small business customers

Table 24 shows that small business customers may be least likely to benefit from the smart meter roll-out. This result is generated by the fact that they are assumed to reduce consumption by only 0.25% in response to the additional information provided by the smart meter. Although, as we will see in Chapter 8, such a small reduction in average consumption may still generate sufficient savings when average consumption is at the level of a large business customer, it is less likely to be sufficient in the case of small business customers.

7.5.2 Stranding costs

If an accelerated smart meter roll-out is undertaken, this will result in a cost associated with the premature stranding of the existing dumb meter stock. This cost is associated with the removal of an asset that would otherwise have been able to continue to generate a net benefit for the remainder of its certified life.

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73 The split of costs and benefits between these different customer groups should be treated with some caution, given difficulties in allocating costs and benefits between these customer groups. In particular, no attempt has been made to assign the up front system costs between these customer groups in a cost reflective way.

In addition to this economic cost of stranding, different stakeholders may be liable for additional costs associated with the dumb meter assets. We refer to these as additional contractual liabilities. Although these should not impact on consideration of the CBA for smart meters, it is important to understand their impact in the distributional analysis.

At present, a meter owner is likely to charge a supplier an annual rental on each installed meter. The supplier will then pass this cost on to customers over the expected life of the meter. Any accelerated roll out of smart meters would involve removing some dumb meters before the end of their lives, and therefore before the full cost of installing and purchasing the existing dumb meter has been recovered from customers. The liability from the stranded meter costs will therefore lie with either the supplier, or the meter owner, depending on the contractual framework that is in place between them. The likely contractual position depends on the type of meter and the meter owner.

- Most legacy electricity meters are provided by the distribution network operators (DNOs). If a meter is removed early, the supplier ceases paying an annual rental but the DNO receives no form of compensation for the fact that they may not have received the full value of the meter in rental payments by that date. Consequently, suppliers who are still contracted with DNOs face no stranding risk for their electricity legacy meters; the entire stranding cost would be borne in the first instance by DNOs.
- In the case of the legacy gas meters the situation is more complicated, given the ongoing Competition Act investigation into National Grid Gas' metering service agreements. As the contract currently stands, most suppliers have assumed some of the stranding risk associated with the removal of existing assets.
- In the cases where suppliers have entered into competitive metering contracts with Commercial Meter Operators (CMOs), the liability for stranding may have been transferred from the owner to the supplier.

In the event of an accelerated smart meter roll-out, it is therefore the case that different stakeholders will face different liabilities.

Policy implications of stranding

It is appropriate that some form of industry-wide solution to stranding is found. Parties have acted in good faith in investing in the existing meter asset base. Any Government-mandated roll-out would represent a change in policy that was not signalled by Government prior to such investment being made. Failure to recognise this and compensate those affected will be expected to raise the financing costs of any future smart meter roll-out. Such an increase is future metering costs could well outweigh the cost of compensating existing industry stakeholders. This points to the need for an industry-wide solution to deal with stranding costs equitably.

Stranding has generally not been an issue in other countries where there has been a mandated smart meter roll-out given that metering is almost universally a network activity. In such cases the unrecovered cost of the dumb meter assets has remained within the Regulated Asset Base of the network company and has continued to be remunerated by customers through network charges.

There are a number of alternative schemes that could address meter stranding. One of the most transparent would be to establish an industry-wide fund that would cover the cost of stranding. The cost of this fund would be spread evenly across customers in the form of a levy. This is similar to the way in which the additional costs associated with renewable generation were recovered from customers at the time of electricity sector liberalisation.

8 Large business cost benefit analysis

8.1 INTRODUCTION

This Chapter presents the cost benefit analysis of the introduction of smart meters for large business gas and electricity customers. Where possible, it also compares our results with the analysis carried out by BERR within its Energy and Billing (2006) consultation document.

The definition of large business customers that has been used, is the one proposed by BERR, namely profile classes 5-8 of the electricity market and non-daily metered gas sites consuming more than 732 MWh[74] per annum. The number of meters included within this definition of large business customers is shown in Table 25 and Table 26.

Type	Group	Description	Number of meters
Type 7	Class 5	0-20% Load factor	38,006
Type 8	Class 6	20-30% Load factor	53,668
Type 9	Class 7	30-40% Load factor	27,545
Type 10	Class 8	>40% Load factor	35,009

Table 25: Large business customers: Electricity

Source: The Carbon Trust

Type	Group	Description	Number of meters
Type 4	Non-daily 2	732 – 2196 MWh	26,600
Type 5	Non-daily 3	2196 – 5860 MWh	7,700
Type 6	Non-daily 4	> 5860 MWh	3,100

Table 26: Large business customers: Gas

Source: The Carbon Trust

Some of these customers will already have had a smart meter solution installed, where there has been a positive supplier/customer business case to do so. Since the supplier business case is often driven by factors such as the location of the premises (and therefore the cost of providing manual meter reads) rather than the size of the customer's load, it is not possible to make an assumption that it is

74 We assume that the cut off point is anticipated to be 732 MWh and not 73,200 kWh, as referenced in BERR (2007) p31.

the largest of these customers that already have a smart meter installed. We therefore undertake the CBA on the basis of the full customer base. However, this may be expected to overstate the case for installing smart meters to those large business customers that currently do not have them.

Given the roll-out of smart meters to large business customers envisaged in BERR's consultation document,[75] our analysis is based on an accelerated five-year roll-out, starting in 2008. Given the relatively small number of customers involved, we assume that the roll-out will be undertaken within the current supplier hub industry framework.

8.2 COSTS

As with our CBA for domestic and small business customers, the analysis that we undertake is based on estimating the incremental costs associated with the proposed smart meter policy compared with the status quo solution of continuing with dumb meter technology. Given that the current preferred policy will require a roll-out of smart meters starting very soon, it is appropriate to base the smart meter technology and costs on those that are currently available within the market place. We have therefore based the analysis on the solution that Centrica currently installs for these customer groups. This information is commercially sensitive to Centrica and has not been included in this report,. However, it has been shared with BERR on a confidential basis.

For gas, Centrica's solution involves the installation of a data logger that is retrofitted to existing dumb gas meters, rather than a new smart meter. It is therefore the case that the existing dumb meter remains in place and the costs associated with the dumb meter purchase, installation and maintenance will still be incurred. Because of our incremental cost approach, they do not need to be considered within the analysis. It should also be noted that we have included the additional communication costs associated with smart meters within the meter reading costs. For large business electricity customers, the solution is expected to be a complete smart meter.

BERR's estimates of the costs associated with these customers are presented in Table 27 for gas and Table 28 for electricity for comparison.

Cost category	'Dumb' meter	Smart meter
Purchase	£17.00	£247.00
Installation	£25.00	£136.00
System costs	-	£25.00
Maintenance (per year)	£0.17	£6.18
Reading (per year)	£15.00	£4.15

Table 27: BERR's meter cost assumptions for large business customers: Gas

Source: BERR

75 "Energy Billing and Metering", BERR (August 2007)

Cost category	'Dumb' meter	Smart meter
Purchase	£7.00	£247.00
Installation	£20.00	£136.00
System costs	-	£20.00
Maintenance (per year)	£0.07	£6.18
Reading (per year)	£15.00	£4.15

Table 28: BERR's meter cost assumptions for large business customers: Electricity

Source: BERR

BERR's estimates of the purchase and installation costs for smart meters are higher than the levels assumed by Centrica. Conversely, dumb meter costs are assumed to be lower. All of these costs (plus system costs) are annuitised over the life of the meter (20 years for dumb meters, 15 years for smart meters) at a 10% cost of capital. In contrast, as discussed in Chapter 3, we calculate "extra finance cost" as a separate, explicit, calculation. BERR assumes that maintenance costs will rise under smart meters (from 1% of dumb meter assets costs to 2.5% of smart meter asset costs p.a.) but reading costs will fall as manual reads will no longer be required.[76]

8.3 BENEFITS

In assessing the benefits that can be expected to arise from installation of smart meters to business customers, we limit consideration to two areas:

- supplier benefits; and
- 'green' benefits.

Supplier benefits

There are three sources of supplier benefit that are expected to result from the introduction of smart meters to this customer group.

- Meter reading costs: It would be expected that the cost of reading meters would reduce as remote meter readings could be taken. This is the case for the smart electricity meters where annual meter read costs are expected to fall. However, in the case of the gas smart data logger, based on its experience, Centrica expected there to be a small rise in the cost of meter reading after it has been installed. BERR estimate a £10.85 per meter per year saving for both electricity and gas customers.

76 BERR assumes that four meter reads will be taken per year, at a cost of 10p per read, but the must inspect obligation will remain, necessitating one visit every two years at a cost of £7.50. Our base case assumptions assumes that the must inspect obligation is relaxed and that meters are read on a monthly basis, given that these customers are all on monthly read tariffs.

- Call centre costs: Centrica has estimated that there should be a saving greater than BERR's estimate of £1.10 for both gas and electricity customers from a reduction in call centre costs.
- Reduction in bad debt: Centrica has estimated that there is expected to be an annual saving for electricity customers due to measures to reduce the incidence of bad debt. No such saving is assumed for gas customers given the reduced functionality of the smart meter solution. BERR does not include this benefit within its analysis.

Green benefits

We have described the different ways in which 'green' benefits may arise from the introduction of smart meters in Chapter 6. For large business customers we have only considered benefits that may arise from a reduction in energy consumed.

BERR has assumed that the introduction of smart meters will lead to high reductions in average consumption. In particular, electricity customers are expected to reduce average consumption by 2.8% and gas customers to reduce average consumption by 4.5%. These estimates are based on reported reductions from the Carbon Trust study of smart meters in SMEs.[77]

We do not consider it prudent to use these assumptions of energy reductions. In particular, participants in the Carbon Trust study were self-selecting volunteers and received additional advice on energy conservation techniques over the course of the study. The consortia running the trials provided energy saving recommendations and tracked the extent to which their recommendations were implemented. There is a risk, therefore, that the results are unlikely to be representative of the overall level of energy reduction that could be achieved by a more widespread roll out of smart meters which would not necessarily include energy advice.

In carrying out this analysis, we have assumed that rolling out smart meters to large business customers leads to a one-off reduction in energy consumption equal to 0.25%. Nonetheless, the customers belonging to this category tend to consume large amount of energy, implying that even small reductions in consumption lead to large energy and carbon benefits.

This difference in base case assumption about the likely reduction in average energy consumption is the biggest contributor to the different CBA results calculated for this customer group. However, there are some additional differences in the calculation of these benefits that should be recognised.

- As discussed in Chapter 6, there are three benefits that may be expected to result from a reduction in energy consumption: a reduction in the cost of energy consumed, avoided peak capacity costs and reduced carbon emissions. There are some differences between our approach and BERR's approach in the way these have been estimated.

77 "Advanced Metering for SMEs", Carbon Trust (May 2007).

- Cost of energy consumed: We understand that BERR has based its estimate of the savings on the full retail price of the relevant fuel. Our approach is to value this based on the average price of energy. We consider that BERR's approach will lead to a significant over-estimate of the benefit as network and supply costs will not be avoided as a result of a reduction in the average consumption.
- Avoided peak capacity: BERR assumes that peak reduction will fall by less than its assumed reduction in average consumption. Therefore, for electricity, BERR assumes that smart meters will lead to a 2.5% reduction in the annual average peak capacity required, whilst for gas, smart meters are assumed to lead to a 3% reduction in required peak capacity. We assume that the reduction in peak capacity will be 0.25%, equal to our assumption of average reduction in energy. We both assume the same value of peak capacity for gas (£0.40/kW). For electricity we assume the same value for the avoided electricity network costs (£70/kW) but BERR additionally include a further benefit of £110/kW for avoided generation capacity costs. We consider that this is likely to double count the benefits as generation capital costs are largely reflected in the wholesale energy cost (or, in the case of BERR's analysis, the final retail price) and therefore will be within the calculation of reduced energy costs, as described above.
- Carbon emissions: BERR values carbon savings based on an average intensity of carbon emissions of 0.096 tC/MWh, whilst our analysis uses an average intensity of 0.176 tC/MWh[78]. As explained in Chapter 6, our analysis considers carbon emissions from the marginal plant, while BERR's may be based on an average carbon intensity including baseload nuclear and renewable plants. This means that, for any given level of energy reduction, our analysis will predict greater carbon benefits. However, since part of this benefit is likely to be reflected in the generation wholesale costs, and is therefore included within the calculation of reduced energy costs, we deduct 50% of the cost of carbon emissions from the energy cost savings to account for the carbon cost pass-through to avoid double counting. We do not believe that BERR makes a similar adjustment.

- BERR assumed that there is a lag of approximately 6 months between installation and when the benefits are realised. Our model assumes that these benefits will commence when the meter is installed.
- BERR's base case involves a reduction in the quantum of benefits over time to account for overlap with other Government carbon reduction schemes. No benefits are assumed after a 15 year period. We assume that benefits continue for the 20 year period of the analysis and are not profiled over time. Our base assumption of a 0.25% reduction reflects this approach.

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78 This is the value of 0.64 $t/CO_2/MWh$ reported in Chapter 1 converted to t/C/MWh using the conversion factor 44/12.

8.4 RESULTS OF COST BENEFIT ANALYSIS

We present our results for the CBA for large business customers in Table 29.

	Gas	Electricity	Total
Incremental costs			
Purchase	(£23m)	(£39m)	(£63m)
Installation	(£12m)	(£18m)	(£31m)
Maintenance	(£3m)	(£10m)	(£13m)
Extra finance cost	(£1m)	(£13m)	(£14m)
Terminal Asset Value	£3m	£6m	£8m
Total incremental cost	**(£36m)**	**(£76m)**	**(£112m)**
Benefits – Supplier			
Supplier legacy meter reads	(£0.4m)	£47m	£47m
Supplier – other benefits	£1.3m	£15m	£16m
Total Supplier benefits	**£0.9m**	**£62m**	**£63m**
Benefits – Green			
Energy savings	£62m	£21m	£83m
Avoided peak capacity	£1m	£11m	£11m
Carbon savings	£13m	£11m	£24m
Total Green benefits	**£77m**	**£43m**	**£119m**
CBA Summary			
Incremental costs	(£32m)	(£76m)	(£112m)
Supplier benefits	£1m	£62m	£63m
Green benefits	£77m	£43m	£119m
Total net benefit	**£41m**	**£28m**	**£70m**
CBA ratio	**1 to 2.1**	**1 to 1.3**	**1 to 1.6**

Table 29: Results of CBA (base case) for large business customers

Source: Frontier analysis

These results would show that, based on the input assumptions and methodology, there is expected to be a small net benefit associated with the introduction of smart meters to large electricity customers and smart data loggers to large gas customers. This case is driven primarily by the expected benefits associated with the energy reduction: even a small reduction in consumption will result in absolute savings that may be expected to exceed the cost of the meters. However, the benefits that accrue to suppliers are not, on average, expected to be sufficient to warrant suppliers to undertake a complete roll-out under their own volition although the case would currently appear to be considerably closer for an electricity smart metering solution than for gas data logger solution.

We summarise the results of BERR's analysis in Table 30.

	Gas	**Electricity**	**Total**
Net "Firms" costs	£79m	£107m	£185m
Energy savings	£415m	£163m	£578m
Carbon savings	£118m	£35m	£152m
Net benefits	**£611m**	**£305m**	**£916m**

Table 30: BERR Cost benefit analysis of smart meters for large business customers

Source: Amanda Greenwood "ERA explanation of BERR's Impact Assessment for Smart Meters for Business"

It can be seen that the scale of net benefits assumed is 10 times the size of the net benefit estimated using our base case results. This is also reflected in the assumed level of carbon reduction that will result from this policy. Whereas BERR estimates that it will result in a saving of 0.51MtCO_2, our base case assumes that the reduction will only be expected to deliver 0.074Mt$C0_2$. This reflects the much more conservative assumptions regarding the extent of energy reduction that we have assumed.

In addition, we note that although BERR has calculated a positive net benefit to "Firms" from this policy, we understand that this includes the cost savings associated with avoided peak capacity that BERR assumes accrues to generators and network providers. We would challenge the assumption that this is retained by firms, rather than being passed through to customers through the operation of the competitive generation and supply markets, or through regulation of the network businesses. In any case, when the supplier business case is considered in isolation, BERR's analysis would point to the same policy implications as our own: a roll out of smart meters to customers is likely to be in the public interest, but there is currently no supplier business case for the average large business customer. Any comprehensive roll out would therefore have to be mandated in order for it to happen.

Annexe 1: Calculation of load shift in response to ToU tariffs

This section sets out how we have determined the level of movement in consumption from peak to off-peak periods, given the introduction of the time of use tariffs described in Section 6.3.2 above.

First an estimate must be made of the level of energy consumed in the peak period and the off-peak period (the periods being defined by the particular tariff), prior to any price differential being introduced. This needs to be estimated as we did not have access to actual consumption data by profile:

- peak demand (kW) is estimated as average consumption (MWh) divided by the load factor, divided by 8760 (hours of the year);
- **average peak consumption** is then estimated as the average between the peak demand calculated above (kW multiplied by 8760) and the average consumption (MWh); and
- **average off-peak consumption** is calculated from the difference between total consumption (derived from the average) and total peak consumption (derived above).

Based on the market load factors for all profiles, the peak to off-peak demand ratio is calculated as 179% for electricity, 148% for gas.

Second, in order to calculate how consumption will move from peak to off-peak periods following the introduction of the Time of Use and Critical Peak Price tariffs, we then need to assume an elasticity of substitution between peak and off-peak periods. The elasticity of substitution represents the percentage change in the ratio of electricity consumption in peak/off-peak periods that occurs in response to a given percentage change in the relative price between those periods.

$$\sigma = - [\% \Delta (Q_p/Q_o)] / [\% \Delta (P_p/P_o)]$$

where σ is the elasticity of substitution, Q_p and Q_o are peak and off-peak usage, and P_p and P_o are peak and off-peak prices, respectively.

In terms of an appropriate assumption regarding substitution elasticities, various studies have found that the elasticity of substitution between peak and off-peak periods for electricity consumption is in the region of 13%.[79] The Essential Services Commission of Victoria, Australia conducted a review of the relevant literature on elasticity, including results of numerous trials around the US.[80] For example, EPRI (formerly the Electric Power Research Institute) researchers

79 Various academic studies collated by Public Utilities Fortnightly in an article titled "Predicting California Demand Response", July 2003. Further desktop research corroborates the range found in this article.

80 ESC Position Paper, Installing Interval Meters for Electricity Customers – Costs and Benefits, November 2002

found that trial results were remarkably consistent across a number of US experiments in the early eighties, once adjustments were made for a variety of conditioning factors such as weather and demographic and appliance ownership characteristics. More recent trials have found similar results. The estimated elasticity of substitution varied with:

- Major appliances: Households that had no major electric appliances had an elasticity of substitution of 0.07. Households with all major electric appliances had an elasticity of substitution of 0.21; and
- Climate: elasticity of substitution was 25% higher in the hottest climate than in the coolest climate for typical households, and nearly double in the hottest climate for households with air conditioning. The lower range of these estimates would be more applicable to the UK climate.

Across these variable scenarios, the elasticity of substitution between peak and off peak usage ranged from 0.06 to 0.33.

The assumption we have used in our base case for the elasticity of substitution is 0.05. This estimate of reduction in consumption is conservative, given studies that have been undertaken in this area. This is consistent with the fact that Great Britain has a relatively mild climate with, at present, minimal use of air-conditioners. We assume the same elasticity of substitution for both of the time of use tariffs that we consider.

Few studies were found on the price elasticity of demand for small business customers, but these studies found that price responsiveness is significantly less for small and medium business customers than it is for residential customers. We therefore do not assume that business customers will take up time of use tariffs.

Third, we apply the elasticity of substitution to calculate the new peak to off-peak demand ratio:

- Initial Peak to Off-peak ***price*** ratio = 100% (flat tariffs);
- New Peak to Off-peak ***price*** ratio = 150% (using the implied differential assumed for the ToU tariff);
- implied increase in ***price*** ratio = 50%;
- this is then multiplied by the elasticity of substitution (5%[81]) = 2.5% reduction in the Peak to Off-peak ***demand*** ratio;
- Initial Peak to Off-peak demand ratio = 179% x reduction of 2.5%;
- New Peak to Off-Peak demand ratio = **175%**.

This ratio is then used to calculate the new peak/off-peak consumption, and hence (a) the implied *volume* shift from peak to off-peak consumption and (b) the reduction in peak demand, in terms of kW.

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81 Strictly speaking, the elasticity of substitution is a negative (ie a reduction in peak demand for a relative increase in peak prices, but for simplicity it is referred to in the modelling as a positive number and the calculation is adjusted accordingly.

Annexe 2: Smart meters and settlement

Smart meters open the way for suppliers to offer a greater variety of gas and electricity tariffs based on time of use pricing. This could potentially lead to net benefits by encouraging customers to shift demand from times when energy is expensive to times when energy is cheaper and by limiting the need for costly investment in peak capacity. However, these tariffs will only be offered by suppliers on a wide scale if changes are made to settlement.

This annexe sets out a range of options for settlement in the future which combine greater pricing flexibility with more or less extensive changes to the current settlement system.

Implications of the current settlement framework

Using load profiles makes settlement cheaper as the exact amount of energy used by each customer in each time period does not have to be recorded. However, they bring several drawbacks.

- **Customers do not pay according to the time at which they actually consume energy.** Load profiles reflect average consumption patterns across a group of customers. If some customers consume a higher proportion of their energy at more expensive times, this is not reflected in the average prices they pay. This means there are cross-subsidies between customers. Further, customers may not use energy efficiently if they do not face the true costs of consumption.
- **The number of tariff categories available is limited to the number of profiles.** Suppliers have to pay for energy based on the profile to which their customer is assigned. Therefore, although a supplier could offer time of day tariffs once a smart meter was installed to record consumption on this basis, unless the half hourly data were used for settlement, the supplier would potentially be exposed to additional price risk associated with having to settle on a different load profile from the one on which it was charging.
- **It is hard to introduce new profiles.** Load profiles are currently based on historic data. It takes one complete year to collect all the information needed to estimate a load profile, plus a further year to analyse it. The load profiles in use today are therefore based on information collected two years ago. Using the same system, any new profile would also take two years to introduce. This limits the speed at which tariffs can be introduced and makes experimenting with new tariffs hard.
- **Tariffs can only reflect average prices, not real-time prices.** Using load profiles gives very little scope to reflect real time prices and therefore to encourage reductions in consumption during the highest price peak periods, the precise timing of which will be unknown in advance.

Options for reforming settlement

There are two broad options for reforming settlement:

- move to some form of half-hourly settlement (daily for gas) for all customers; or
- extend the use of load profiles, possibly with real-time estimation of load profiles.

Half-hourly settlement

Using half-hourly settlement (daily for gas) for all customers would give suppliers extensive freedom to experiment and introduce new tariffs. Suppliers would be able to compete with each other by offering cheaper average electricity prices to customers who were prepared to accept more expensive prices at peak times. It therefore offers the greatest scope for achieving savings from shifting consumption patterns. However, the costs, in terms of data handling, data retrieval from meters and system reform, could be substantial.

The costs – particularly data retrieval costs - could be restricted by lengthening the time period for entering half hourly data into the settlement system. At present, all data for customers with interval meters is collected and added to settlement databases within a few days. Extending the deadline would reduce the number of times that each meter needs to be polled each year, and therefore potentially reduce costs. However, such an option is still likely to involve significant costs of reform.

Load profiles

Some extensions to the current settlement system are possible, whilst retaining the use of load profiles. The most straightforward extension is to include more static load profiles to reflect more time of day tariffs. This would be relatively inexpensive, but would take time (at least two years to record sufficient data before the new profiles can be introduced) and would use only a small part of the smart meter's capability (i.e. recording total consumption in each tariff band). Further, the load profiles would be static and suppliers would not be able to change the structure of their tariffs (e.g. the time at which peak or off peak bands start) as the load profiles would have been estimated on a different basis. Finally, using static load profiles does not allow any form of dynamic, critical peak pricing.

The more significant extension would be to use dynamic load profiles. This would involve collecting real-time data at regular intervals from a sample of customers on any individual tariff. The profile of these customers would be assumed to apply to all customers on that tariff. This allows greater flexibility to introduce critical peak pricing, by assuming that all customers experience the same fall in consumption as the sampled customers. At the same time, it makes data collection for other customers easier and cheaper as only the total quantity of electricity consumed during the peak and off period needs to be retrieved, not the full half-hourly dataset.

Using dynamic load profiles also makes the introduction of new profiles easier and faster as no historic consumption data is required. However, dynamic profiles still provide less flexibility than full half-hourly settlement. The number of profiles is limited by the need to recruit and retain a sample of customers on a particular tariff, while increasing the number of profiles will make settlement more expensive and costly. In addition, suppliers are likely to have to agree to use common profiles (e.g. using the same days for critical peak pricing) which would reduce the opportunity for innovation in tariffs and energy savings.

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