Department for
Business, Energy
& Industrial Strategy

SMART METER ROLL-OUT

Cost-Benefit Analysis (2019)

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Contents

Executive Summary

To date, the Smart Metering Implementation Programme has overseen the upgrade of over 16.6 million electricity and gas meters, replacing traditional analogue meters with new smart and advanced meters. The programme helps consumers understand and reduce their energy consumption and delivers operational savings for suppliers, networks and other industry participants. Smart meters will unlock a smarter more flexible energy system for homes and businesses across Great Britain and provide a key contribution to the Government's aims to reduce carbon emissions to net zero by 2050.

This document contains the latest assessment of the costs and benefits of the smart meter roll-out based on the most up-to-date, real-world evidence from the programme. Our 2019 cost-benefit analysis (CBA) shows that the programme will continue to deliver significant benefits for households and small businesses in Great Britain, with a total Net Present Value (NPV) of £6bn over the appraisal period. In addition, the updated analysis shows that the programme's business case has now passed the "breakeven" point. In other words, every additional smart meter added to the system is contributing to the positive and growing net benefits of the programme.

While it builds on previous assessments in 2013, 2014 and 2016, there are some differences in the analysis that means direct comparisons should not be drawn to previous CBAs. Since 2016, the programme has further increased the quantity and quality of data it holds on the roll-out. This has enabled the most in-depth assessment of costs and benefits to date, using more real-world data from the smart roll-out and increasing the robustness of the remaining assumptions. In addition, we have thoroughly reviewed the methodologies underpinning the costs and benefits to ensure they are robust. The analysis reflects the latest installation rates and forecasts by energy suppliers, with a new policy framework assumed to be in place from 2021 onwards, which will see smart meters continuing to be installed after the end of 2020. In order to appraise the costs and benefits of one full cycle of smart meter installations, and consistent with HMT Green Book guidance, we have therefore adjusted the appraisal period to cover the years 2013 to 2034 inclusive instead of finishing in 2030 as it did in the 2016 CBA. This ensures we provide an accurate picture of the costs and benefits of the roll-out.

Our 2019 analysis shows an increase in consumer benefits of £2.3bn compared with the 2016 CBA, in part because we are now able to monetise the savings received from the reduced time consumers spend interacting with the energy system (total time savings estimated at £1.4bn). Each individual household is estimated to see a net benefit of £250 over the appraisal period, with estimated total bill savings to households of £5.6bn and carbon emissions reduced by nearly 45 million tonnes of Carbon Dioxide equivalent ($CO2e$). Small businesses will also see significant benefits from the roll-out, for example through the £1.5bn realised through energy consumption reductions over the appraisal period. Smart meters will also play an increasingly important role beyond the end of the appraisal period. For example, the Committee on Climate Change estimates that without a more flexible energy system, which smart meters are a key part of delivering, the costs of reaching net zero emissions in 2050 could be up to £16bn per annum higher.

Supplier benefits have fallen since the 2016 CBA, largely due to changes in the retail energy market that are unrelated to the smart meter roll-out. For example, some consumers now provide meter readings themselves allowing energy suppliers to bank some (but not all) of the efficiency savings that the installation of a smart meter would otherwise bring. However, energy supplier benefits are still expected to amount to £8bn over the appraisal period. Steady state benefits remain broadly similar to the level forecast in 2016, at £1.9bn per annum on average from 2028.

The costs of the smart metering roll-out are largely borne by energy suppliers, predominantly through funding the installation and purchase cost of meters and through funding the national smart metering communications infrastructure run by the Data and Communications Company. Just as with traditional metering, smart meter costs are recovered from energy suppliers' entire customer bases. The 2019 analysis shows that costs in the period to 2030 have reduced slightly when compared with the 2016 CBA (by £300m). The analysis shows that increases in the costs of installations and the DCC have been more than offset by lower asset costs and the fact that as more meters are being installed beyond 2020, costs are incurred later. Once a steady state is reached, costs are around £670m per annum - broadly similar to the level of cost in the 2016 analysis, meaning the roll-out continues to show a good return on investment for domestic and non-domestic consumers and Great Britain as a whole. Overall, from 2028, the programme will be delivering net benefits of around £1.2bn per annum.

Introduction

The costs and benefits of the Smart Metering Implementation Programme (SMIP) have been reviewed several times since the programme began, the most recent of these analyses being published in 2016. During the passage of the Smart Meters Act 2018, the Government committed to publishing this revised cost-benefit analysis (CBA).

Since the last CBA was published, significant progress has been made in delivering the roll-out, with millions of meters installed, technical issues overcome and the move from SMETS1 to SMETS2 largely being completed. During this time, the programme has also received more data from energy suppliers that reflects the reality of the roll-out to date and can be used to validate or adjust the assumptions made in previous analysis.

This CBA aims to quantify all the costs and benefits to the whole of society that will be realised due to the roll-out of smart meters in Great Britain. As both methodologies and data have been thoroughly reviewed, the analysis is presented as a stand-alone piece of work for ease of reading and it follows the latest best practice as set out in HM Treasury's (HMT) Green Book[1]. The analysis looks at the lifetime of the programme, including costs and benefits that have already been incurred as well as estimating those that will be incurred or delivered in the future.

Every effort has been taken to robustly analyse, quantify and monetise each of the individual costs and benefits of the programme. The next chapters will discuss, in turn, background information on the programme, details around the rationale for Government intervention, the assumed future landscape, the realised and projected costs and benefits, as well as consideration of the programme's impact on households and the distribution of costs and benefits incurred. We present the analysis based on a central scenario, but also complete several sensitivity tests in Annex 1 to illustrate the impact that different assumptions and scenarios might have on the presented costs and benefits. Annex 2 presents an analysis of how costs and benefits have changed relative to 2016.

Where possible, the analysis has relied on data and evidence provided by energy suppliers[2] or collected from other sources available to the Department. When forecasting into the future it has been necessary on occasion to make assumptions relating to how costs and benefits might change over time. Where this has been done, it is clearly signalled within the text.

It has also been necessary at times to adjust the data gathered by the Department for Business, Energy & Industrial Strategy (BEIS). Wherever an adjustment has been made we have aimed to reflect a balanced view and clearly stated this within the documentation along with a justification for doing so.

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[1] https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-governent

[2] This data is commercially confidential and is not described in detail within this CBA.

Background and Strategic Overview

Smart meters are a vital upgrade to our national energy infrastructure, not only putting consumers in control of their energy use, but also providing the building blocks of a more flexible and resilient energy system fit for the 21st century. The Government is committed to ensuring that every home and small business in the country is offered a smart meter by the end of 2020 and this is a key priority for BEIS.

Great Britain's smart metering roll-out is being carried out under powers included in the Energy Act 2008[3]. Separately, the EU has set rules in this area that require Member States to roll out intelligent metering systems[4], although a decision to proceed with a roll-out may be subject to a cost-benefit analysis. Where metering systems are rolled out, Member States must ensure that at least 80% of consumers have intelligent electricity metering systems by 2024[5].

The successful delivery of smart metering benefits depends upon coordinated effort from a wide range of organisations. The Smart Metering Implementation Programme is led by BEIS, regulated by the Office of Gas and Electricity Markets (Ofgem), and delivered by energy suppliers. The Government's role includes developing smart metering policy and strategy, providing the right framework against which energy suppliers and network operators can plan, and ensuring benefits are delivered to consumers. Ofgem are responsible for the regulation (including monitoring, reporting and enforcement) of the licence obligations placed on energy suppliers and network operators to deliver smart meters. In due course, the Government's intention is that smart metering should be a self-sustaining system governed by industry and regulated by Ofgem.

Following the Government's announcement in 2008 that it intended to mandate energy suppliers to roll-out smart meters across Great Britain, some energy suppliers began installing smart-type meters on a voluntary basis. In 2011 the Government concluded its policy design confirming the approach chosen for the delivery of smart meters. In the following years, work was carried out to establish the Data and Communication Company (DCC), which provides the national smart metering communications infrastructure to deliver a fully interoperable system. The industry Smart Energy Code (SEC)[6] was also put in place; it establishes a contractual framework, backed up by regulations, between the DCC and its users. In 2013, Government published a timetable under which suppliers are required to take all reasonable steps to roll-out smart meters by the end of 2020.

It is worth noting that the energy retail market has evolved considerably since the start of the roll-out. In particular, we have seen significant market entry of smaller energy suppliers and competition between suppliers has meant that large suppliers have seen their market share reduce as consumers switch to these new smaller energy suppliers. As the smart meter mandate covers all suppliers, regardless of

[3] https://www.legislation.gov.uk/ukpga/2008/32/contents
[4] https://ec.europa.eu/energy/en/topics/markets-and-consumers/smart-grids-and-meters
[5] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CONSIL:PE_10_2019_REV_1 – annex 2.
[6] https://smartenergycodecompany.co.uk/

size, the programme has adapted its engagement and monitoring accordingly over the life of the roll-out to ensure that it covers all of the market.

Rationale for Intervention

Traditional metering allows for a simple record of energy consumption to be collected on an infrequent basis, mainly by manually reading the meter (i.e. by a meter operative visiting the site or consumers submitting meter readings to their supplier). Whilst this allows for energy bills to be issued, there is limited opportunity for consumers or energy suppliers to use this information to manage energy consumption proactively. Smart meters offer a range of intelligent functions, provide consumers with near real-time information on their energy use, and bring an end to estimated billing.

Smart-type metering technology had been available for a number of years, without any significant take-up by energy suppliers prior to the announcement of the Government mandate. These meters had varying functionality and data communication standards. In response, the Government intervened to ensure the interests of consumers were protected and in 2012, a standard for the minimum common functionality of smart meters, known as SMETS1, was defined. This was to ensure a minimum common functionality across smart meters and to stop the variability in the smart-type meters which some energy suppliers were already installing at that time. This was important for ensuring consumers had a consistent experience and also to ensure that these meters could later be enrolled into the national smart metering communications infrastructure and made interoperable between all energy suppliers.

In 2013, the Government set a standard for second-generation smart meters, known as SMETS2. These meters operate on the national smart metering communications infrastructure built by the DCC, which enables communications between all energy suppliers, network operators, other authorised service users (for example price comparison sites) and the smart meter.

Without Government intervention it would have been more likely that there would have been a proliferation of standards and functionality of smart metering equipment, with the focus on securing supplier benefits over those to the consumer or wider energy system. For example, it is unlikely that consumers would all have been offered an In-Home Display or energy efficiency advice, resulting in significantly lower energy savings being realised. There is also a risk that the roll-out could have been slower, more expensive and less secure, as it is unlikely all suppliers would have rolled out smart meters at the same time or to the same specifications, resulting in lower economies of scale for meter manufacturers and higher average costs. In addition, without the Government intervening it is highly unlikely that a centralised communications company would have been established, meaning that smart meters would have been more likely to lose functionality upon switching.

Progress to Date

The programme has made significant progress to date, with around 14.9 million smart and advanced meters operating in smart mode across Great Britain at the end of June 2019. In addition, the programme has reached the following milestones:

- The DCC licence was awarded in 2013, and following the necessary systems design and testing, the national smart metering communications network began offering live services in 2016.
- In 2014, Smart Energy GB was launched and the public-facing campaign to communicate the benefits of smart meters began.
- In July 2016, the Alternative Home Area Network governance arrangements were established, providing a way for suppliers to work together to deliver solutions for more challenging properties (such as high-rise flats).
- In February 2017, BEIS published a toolkit and factsheets on energy efficiency to enable meter installers to give tailored energy efficiency advice during smart meter installation visits, making it easier for householders to adopt energy efficient behaviours.
- The transition to second-generation smart meters began in 2018 and in May 2019, over 1 million of these meters were connected to the national smart metering communications infrastructure.
- In May 2018, the Smart Meters Act 2018 received Royal Assent, extending the Government's right to exercise powers over the roll-out to November 2023.
- Towards the end of 2018, the DCC began progressing work to move first-generation smart meters onto the national smart metering communications infrastructure.
- In June 2019, the New and Replacement Obligation was activated, mandating energy suppliers to take all reasonable steps to install a compliant smart meter where a meter is installed for the first time (for example in new-build properties) or where a meter is replaced.

Analysis of Costs and Benefits

Counterfactual

The counterfactual scenario for smart metering defines a state of the world that we deem most likely to have occurred in the absence of the programme. We subtract the costs and benefits that would have occurred in this version of the world from the assessed costs and benefits of the programme to calculate the additional impact of the roll-out.

Domestic Sector

The counterfactual scenario for smart metering assumes that there would have been no Government intervention in the domestic sector. Despite some suppliers who were keen to take advantage of smart metering as a means of product and service differentiation, the activity from this subset alone would not have the potential to result in any significant penetration of smart meters within the overall population.

It is possible that there would have been a significant number of smart meters rolled out in the absence of Government intervention, however based on the available evidence[7] prior to the announcement of the Government-led programme, we judge this to be unlikely. In deregulated and competitive supply markets such as Great Britain, suppliers or other meter asset owners are reluctant to install their own smart meters without the right commercial incentives and without a technical inter-operability agreement. Without such an agreement, there is a significant risk that meter asset owners could lose a major part of the value of any smart meter they install. This is because there is a high probability that consumers would switch to a different energy supplier at least once over the lifetime of the metering assets; that supplier might not want or be able to use the technology installed earlier, making the smart meter redundant.

It is therefore reasonable to assume a counterfactual world in which there is no smart meter roll-out[8]. This is the assumption underpinning the headline estimates which are presented in this analysis. This is supported by the fact that whilst the technology had been available for several years prior to Government intervention, very few smart meters had been rolled out to domestic customers prior to the announcement of the mandate and those that were would not have supported switching between suppliers. Consequently, our analysis is likely to very slightly overestimate the total benefit of the programme.

We assume that the market would have continued to incur costs associated with the installation of traditional meters due to dilapidation and breakdown, and so these

[7] The 2016 CBA details evidence that in 2012 small suppliers reported that only 75,000 smart-type meters (less than 0.15% of the total metering population) had been installed.
[8] While shifts in public attitudes towards environmental issues could have resulted in higher demand for smart meters in the counterfactual scenario, it would be very difficult to quantify the likelihood or magnitude of this effect.

costs are deducted from the total cost of installing smart meters, in order to isolate the impact of Government intervention.

The counterfactual also assumes that the market would generate some benefits associated with better billing and achieve some level of energy savings (5% of the predicted consumer electricity savings from smart metering are assumed, to 2024) as a result of the Carbon Emissions Reduction Target (CERT) and the delivery of clip-on displays[9]. We deduct these from our final benefits in order to not overestimate the societal benefits delivered by smart metering.

Non-Domestic Sector

A separate counterfactual case has been constructed for the non-domestic sector, which assumes no Government intervention for small non-domestic properties[10].

The non-domestic counterfactual does differ from the domestic counterfactual as it assumes that some costs and benefits would have been realised due to the limited roll-out of smart-type (i.e. advanced) meters that was observed where a positive business case existed for that consumer.

We assume that, from business intelligence obtained ahead of the programme, there would be a positive business case for 50% of non-domestic meters, and that these would be gradually installed across the appraisal period. The roll-out profiles used for the non-domestic counterfactual for electricity and gas meters begins with the number of smart-type meters (entirely advanced meters) in place immediately before the appraisal period and assumes thereafter a linear rate of growth in these installations, until a 50% penetration level is reached in 2034.

Assumed Policy Landscape

There are a number of ongoing workstreams within the SMIP that, when concluded, will have a positive impact on the net present value of the programme. We have analysed the total cost and benefit of the programme assuming they are successfully implemented. We have therefore assumed that all activities in train are delivered successfully and to the latest timetable, including:

- The successful roll-out out of dual-band communications hubs, allowing smart meters to be rolled out to properties that the standard communications hub will not serve.
- SMETS1 meters being enrolled in the DCC meaning that the risk these meters will lose functionality on churn is eliminated.

[9] This assumption is based on the August 2007 consultation on billing and metering. In addition, 3 million (or around 5% of domestic meters covered by the smart metering mandate) real-time displays were installed under CERT: https://www.ofgem.gov.uk/publications-and-updates/final-report-carbon-emissions-reduction-target-cert-2008-2012.

[10] Defined as profile classes 3 and 4 for electricity customers and gas customers with consumption below 732MWh per annum.

- The Alt HAN programme delivers a working technical solution that can be installed from 2021 onwards, delivering smart meters to those properties that the standard and dual-band communications hub solutions are not suitable for.

- The programme maintains its track record of being able to overcome any identified technical issues (such as those being worked on currently in relation to unlocking network benefits).

Were any of these projects delayed it would limit the number of properties that could receive a smart meter and therefore impact on delivery of the roll-out. We have tested the impact of such delays in Annex 1.

Obligation on Suppliers to Install Smart Meters Beyond 2020

For the purposes of this analysis, we assume that the roll-out curve included within the post-2020 consultation's "minded to" position[11] is the central scenario. This roll-out curve requires suitable policies to be in place to be achieved, but for the purpose of this analysis (and consistent with the post-2020 consultation) we make no assumptions as to what those policies are, just that they are sufficient to deliver the level of installations required. The Impact Assessment that is published alongside the post-2020 consultation assesses the impact on the roll-out's costs and benefits if such a policy framework is not implemented[12].

Roll-Out Profile

We have used the latest available data regarding smart meters already installed, alongside energy suppliers' plans for future smart meter installations, to produce the roll-out profile on which this cost-benefit analysis is based.

- For the period up to the end of 2018, this assessment reflects the published actual numbers of smart and advanced meters installed each year[13].

- In early 2019, the thirteen largest energy suppliers[14] were required to provide Ofgem with their roll-out projections for 2019 and 2020, in line with their plans to meet the obligation to take all reasonable steps to install smart meters in all premises by the end of 2020. These plans are based on suppliers' expectations informed by installations undertaken to date, and Ofgem have scrutinised them to ensure that they are both achievable and suitably

[11] The consultation on a proposed post-2020 policy framework is being published alongside this CBA, and is available at https://www.gov.uk/government/consultations/smart-meter-policy-framework-post-2020.
[12] An NPV of £4.3bn is estimated if a post-2020 policy framework is not implemented.
[13] See https://www.gov.uk/government/collections/smart-meters-statistics.
[14] Large energy suppliers are defined as those that supply gas or electricity to at least 250,000 domestic customers; they may also supply non-domestic sites. See https://www.gov.uk/government/collections/smart-meters-statistics.

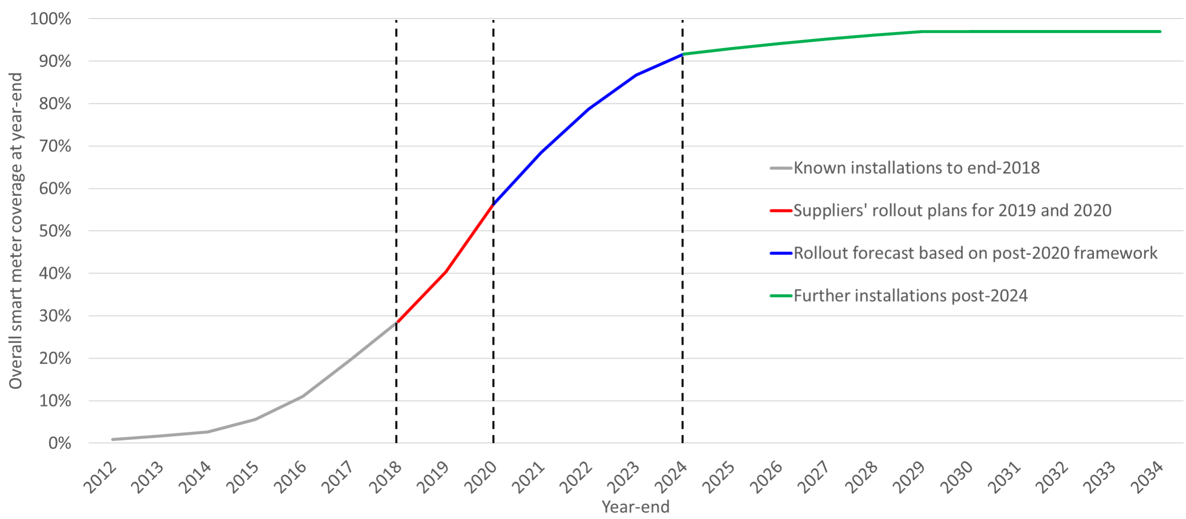
ambitious. We have used these plans as the basis for our expected numbers of installations for all suppliers in 2019 and 2020.

- For the period beyond 2020, the post-2020 consultation sets out a regulatory framework going beyond the all reasonable steps obligation to ensure that suppliers can maintain the roll-out's momentum in order to drive towards market-wide smart meter coverage by 2024. The consultation document sets out the rationale behind this policy change and we model installations during this period based on the assumption that this framework is implemented. Our modelling takes energy suppliers' planned 2019 and 2020 installation rates as the starting point, and then adjusts these in each year post-2020 based on[15]:
  - Expansion of the number of metering points able to receive smart meters, through the availability of solutions such as dual-band communications hubs and Alt HAN.
  - Changes to installer efficiency as time needed to travel between installations increases later in the roll-out.
  - A conservative assumption of reduced productivity to reflect the need to deal with more challenging premises and engage new consumer groups.
  - Possible reductions in the number of installers working on smart meter installations once the majority of installations have been completed.
- Beyond the end of 2024, we assume that additional smart meter installations are limited to new buildings and end-of-service-life replacements. We assume a maximum eventual coverage of 97% to reflect a prudent assumption that installations at up to 3% of metering points may not be possible due to technical and accessibility reasons.

The resulting roll-out expectations, on which our analysis throughout this cost-benefit analysis is based, are presented in the figure below:

[15] These factors are based on lessons learned regarding influences on the roll-out to date, as well as expectations for the period beyond 2020.

Figure 1: The total percentage of metering points (across both electricity and gas in both domestic and non-domestic sectors) that will have smart meters at the end of each year



Metering Point Numbers

We have used data from the BEIS Sub-National Electricity and Gas Consumption Report[16] to provide the actual numbers of meters of each type operating up to 2017 and have then used a variety of data to forecast how these totals are expected to change over the appraisal period.

Domestic electricity metering points are expected to grow in proportion to household growth[17], while domestic gas metering point growth also factors in changes in the proportion of households expected to be connected to the gas grid (as despite a move away from gas central heating, many houses will still cook with gas). We have based our forecasts for growth in the non-domestic sector on the observed year-on-year increases reported in the sub-national statistics to date.

Payment Means

Within our modelling, domestic meter numbers are split between credit and prepayment modes in line with the current proportions of customers who pay by these means[18]. We assume that this split remains constant throughout the appraisal period[19].

[16] https://www.gov.uk/government/collections/sub-national-electricity-consumption-data

[17] https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections/datasets/householdprojectionsforengland

[18] https://www.gov.uk/government/statistical-data-sets/quarterly-domestic-energy-price-stastics

[19] BEIS' Quarterly Domestic Energy Price Statistics show that the proportion of customers paying by prepayment terms has been gradually increasing over recent years (from 14% up to 16% for electricity and from 10% up to 15% for gas between 2005 and 2019). As prepayment smart meters attract slightly higher benefits than credit this assumption that the split remains constant is likely to underestimate the net benefit of the roll-out.

Smart Meter Types

The smart meter roll-out curve depicted above shows the expected total coverage of three distinct types of meter: SMETS1 meters, SMETS2 meters and advanced meters in the non-domestic sector. Where relevant these three meter types are considered separately within our analysis, as they differ in the costs and benefits they provide in certain areas.

For the split between these three meter types up to the end of 2018, we have used known actual installation numbers within our modelling. In line with the SMETS1 end-date, we have then assumed that all domestic smart meter installations will be SMETS2 from March 2019 onwards. In the non-domestic sector, we have used suppliers' forecasts on the number of SMETS2 and advanced meters they expect to install in 2019 and 2020. We then assume that most suppliers will be installing exclusively SMETS2 meters by the end of 2024, with advanced meter installations across the remainder of the market decreasing to minimal levels by 2030.

Enrolment of SMETS1 Meters

To date, the majority of smart meters installed have been SMETS1 meters. Because these meters are not always interoperable when consumers switch supplier, a proportion of these have lost smart services since installation[20]. The Government has recently published two decisions[21] which require the DCC to provide an enrolment service for SMETS1 meters, allowing them to be operated through the DCC's central system.

The provision of this enrolment service (expected to take place during 2019 and 2020) will ensure that SMETS1 meters are interoperable between all energy suppliers, allowing consumers to retain smart services when they switch supplier. Moreover, smart services will be restored to those meters that have lost smart functionality following customer switching. This will ensure that suppliers and consumers with SMETS1 meters can realise the full range of benefits described within the "Benefits" section of this analysis.

Meter Dilapidations

Smart meter failures and dilapidations are rare, and we account for these through the operations and maintenance costs and therefore do not explicitly model the new installations that are required.

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[20] In June 2019, 2.7 million SMETS meters were known to be operating in traditional mode. Smart meters can temporarily operate in traditional mode for a number of reasons, including: (i) customers switching to energy suppliers currently unable to operate the meter in smart mode; (ii) meters being unable to communicate via the wide area network at the point of reporting; (iii) customers having their meter installed in traditional mode; and (iv) installed meters yet to be commissioned (e.g. in new-build premises).

[21] These decisions are available at https://www.gov.uk/government/consultations/enrolment-of-smets1-meter-cohorts-with-the-data-communications-company and https://www.gov.uk/government/consultations/enrolment-of-secure-smets1-meters-in-the-data-communications-company-dcc. BEIS intends to consult on whether DCC should be required to offer an enrolment service for the final SMETS1 meter set, which represents less than 1% of the market, once sufficient information is available.

Underlying General Assumptions

Whilst the assumptions we have used for each area of cost and benefit are set out in the corresponding sections, several general assumptions, discussed below, apply to all costs and benefits unless otherwise stated.

Meter Lifespan

We assume all meters are manufactured in accordance with the Smart Metering Equipment Technical Specifications (SMETS)[22] which states that they must have a lifespan of 15 years. For traditional meters, a lifespan of 20 years is assumed based on advice from experts within BEIS.

Appraisal Period

All costs and benefits are appraised between 2013 and 2034[23]. 2013 was the year that the "all reasonable steps" obligation to install smart meters by 2020 was introduced and as such serves as the starting point for our appraisal.

In determining the end of the appraisal period, we follow Green Book guidance that states that appraisals should be conducted over the lifespan of a policy or asset. Therefore, we attempt to capture the full costs and benefits of one cycle of smart meter installations, each of which has a lifespan of 15 years. Due to the methodology used within our model, we are unable to do this directly. We have chosen to measure the life of the programme from the point the median meter is installed as this means that approximately half of all meters will be reinstalled whereas half will not be appraised over their full lifespan, giving the best approximation for the net benefit of the first cycle of the roll-out. The impact of different appraisal periods is considered in Annex 1 and shows that an extension of 1 year adds around £1bn in net benefit.

Discount Rate and Price Base Year

The analysis uses 2011 as its price base year, to reflect how the programme collects and collates cost and benefit information[24].

In accordance with the HMT Green Book guidance, all figures are presented as 2019 present values and we discount future costs and benefits at a rate of 3.5% per annum. As the appraisal period covers past years, these are not discounted, consistent with the Green Book[25].

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[22] https://www.gov.uk/government/consultations/smart-metering-equipment-technical-specifications-second-version

[23] The 2016 CBA appraised costs and benefits to 2030 rather than 2034. The new roll-out curve necessitates a change in the end-date to properly capture the costs and benefits of the programme.

[24] This is consistent with previous CBAs.

[25] https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-governent – paragraph 5.38.

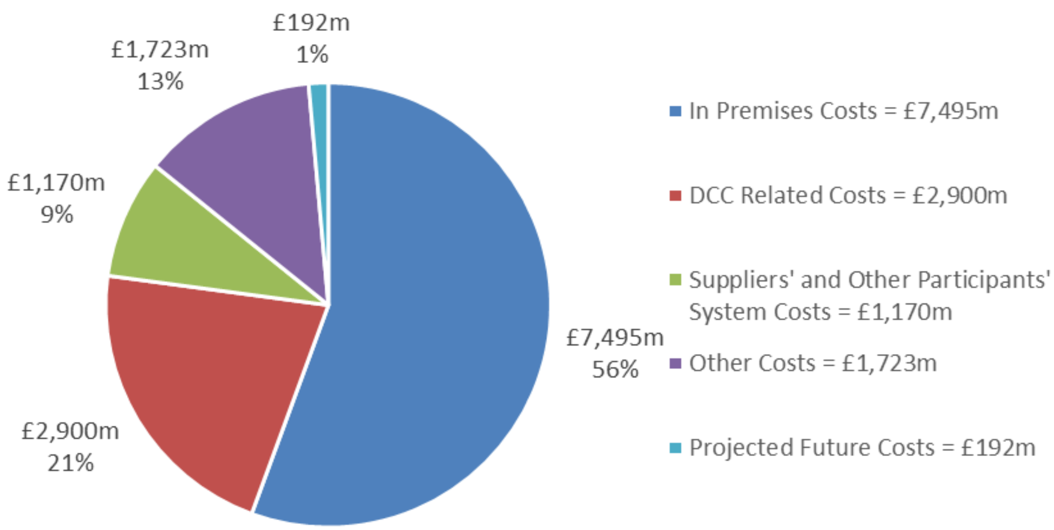
Cost of Capital

We assume a 6% cost of capital across all market participants. This reflects the market data that we have collected, both from firms involved within the smart meter roll-out and from internal analysis of the prevailing cost of capital in the energy supply market.

Analysis of Costs

This section discusses each of the major components of the costs of the roll-out in turn, covering in-premises costs, DCC costs, supplier and other market participants' costs and other costs. The relative proportions of these costs can be seen in the chart below.

Figure 2: Distribution of total costs of the smart meter programme (£m)



The costs discussed in this section include a combination of sunk and future costs. Where possible, we have based our cost estimates on observed data, but necessarily include forward projections given the roll-out is ongoing. The costs of smart metering are largely borne by energy suppliers. Just as with traditional metering, smart meter costs are recovered from energy suppliers' entire customer bases.

In-Premises Costs

Installation Costs

The programme collects information on the cost of smart meter installations through regular[26] statistical returns from suppliers. Costs have been provided for single- and dual-fuel installations for both in-house and third-party installations and include factors such as the costs of training installers, providing tools, managing installers in the field, appointment setting, insurance, legal, van and other back office support costs.

[26] At least annually through Annual Supplier Returns, but also through regular engagement between the programme and stakeholders.

To calculate an average cost per installation, we take data returned by suppliers for installations in 2016, 2017 and 2018 and produce a weighted average based on the number of smart meters installed by those suppliers in those years to reflect the size of the suppliers. Due to the extraordinary nature of 2018 where the SMETS2 roll-out began in earnest and suppliers necessarily incurred higher costs due to factors such as higher levels of training and mentoring being required in order to successfully begin installations of these meter types, we anticipate that 2018 is not reflective of future costs. To make projections post 2018 we forecast from a baseline that is an average of the 2017 and 2018 installation costs to account for likely reduced training and mentoring costs going forward. We then use these figures, coupled with productivity projections (described below) to calculate the overall cost of installations across the roll-out. This is then converted into 2011 prices and divided by the total number of installations to produce a per-meter average cost that can be used in our modelling. As expected, per-meter dual-fuel costs are lower than single-fuel due to the efficiencies that suppliers can exploit in such installations.

When calculating the level of productivity, we use data submitted to both BEIS and Ofgem (through supplier roll-out plans) for the years up to 2020. Beyond that we have no data and therefore rely on judgements from industry experts within the programme to estimate the level of productivity we can reasonably expect to be realised – reaching a maximum of 5 installations per worker per day in 2020 and 2021. This estimation considers factors such as interventions by the programme to help suppliers increase productivity through sharing good practice as well as evidence from third-party installation companies and data collected as part of the programme’s ongoing engagement with energy suppliers. We also account for the fact that productivity will fall in the later years of the roll-out as the number of customers without smart meters reduces and it becomes more challenging for suppliers to reach the final installations, with productivity dropping from 2022 onwards reaching 3 installations per worker per day in 2025 and then maintaining this level thereafter.

The programme also continues to collect information from suppliers for traditional meters (which feed into the counterfactual) and non-domestic meter installation in a similar manner. These costs are shown as a cost per installation in the table below (the dual-fuel cost reflects the cost of installing both the gas and electric meter).

Table 1: Cost of different meter installations

Installation Type	Cost per Installation		
	Smart Meter	**Advanced Meter**	**Traditional Meter**
Electric Only	£88	£136	£53
Gas Only	£88	£136	£54
Dual-Fuel	£143	NA	NA
Retrofit	NA	£68	NA
Electric PPM	NA	NA	£57
Gas PPM	NA	NA	£60

The overall net present value cost associated with domestic and non-domestic installations are approximately £3bn and £170m respectively, giving a total cost of £3.2bn. These figures include the costs of capital incurred from financing the installations over the lifespan of the meter.

Asset Costs

Meter Costs

Through statistical returns from energy suppliers and regular contact with delivery partners the programme has collected information on the costs of smart, advanced and traditional meters. For previous years, we take the reported figures for that year as the values to apply in our model. For future installations, we take the most recent data, based on 2018 asset values, and apply a cost erosion for all assets based on the observed cost developments over time for traditional metering equipment. This decreases the costs of equipment deployed in the home by roughly 1% per annum to the end of the roll-out. We also include a 5% optimism bias to account for potential exchange rate fluctuations and economic risk. The average cost of assets over the roll-out is shown in the table below.

Table 2: Cost of different metering assets

Asset	Cost
Smart meter – electric	£36
Smart meter – gas	£53
Advanced meter – electric, gas and retrofit	£120
Traditional credit meter – electric	£7
Traditional credit meter – gas	£17
Traditional prepayment meter – electric	£43
Traditional prepayment meter – gas	£95

The overall net present value cost associated with metering assets is approximately £1.6bn for domestic assets and -£5m for non-domestic assets (the cost of advanced meters in the counterfactual is higher than the cost of smart meters in the policy scenario, resulting in a net cost saving), giving a total cost of approximately £1.6bn. These figures include the cost of capital incurred from financing the assets over their lifespan. Cost savings are realised in the non-domestic sector as under the counterfactual we assume only advanced meters are installed (due to the market for these meters already firmly established ahead of the programme) whereas in the policy roll-out the majority of these meters are SMETS installations, at significantly lower cost.

Operations and Maintenance

We assume an annual operations and maintenance cost for smart meters of 2.5% of the meter purchase cost. This is incurred largely due to the costs associated with replacing equipment if found to be faulty. This assumption is based on information collected from Meter Asset Providers.

The overall net present value cost associated with operating and maintenance costs is approximately £670m.

Communications Hubs Costs

The cost estimates for communications hubs have been sourced from statistical returns from suppliers for communications hubs installed with SMETS1 meters[27] and from the DCC for SMETS2 communications hubs. The average cost of SMETS1 and SMETS2[28] communications hubs across the roll-out are both £28. In addition, (as outlined in the section below) allowances have been made for dual-band communications hubs that are expected to be deployed in properties where the

[27] There is no specific specification for SMETS1 communications hubs.
[28] Single-band 2.4 GHz.

standard 2.4GHz HAN solution is not suitable. This represents an additional cost above the £28 for relevant SMETS2 installations.

For SMETS1 communications hubs, suppliers use a variety of manufacturers, data and communications providers. Consequently, SMETS1 meters and their communications hubs are not interoperable between all energy suppliers. This will be resolved when all SMETS1 meters are enrolled into the DCC by the end of 2020. For domestic dual-fuel installations where energy is supplied by the same supplier, only one communications hub is needed per premises. For meter installations at properties which have both gas and electric meters but where energy is provided by two different energy suppliers, there is a risk that the second meter installed will not be compatible with the communications hub installed with the first SMETS1 meter. We assume that in two thirds of these properties the two meters are not compatible and therefore two communications hubs are installed, whereas in the remaining third only one communications hub is needed. This assumption is based on data collected by the programme. This gives an average number of communications hubs for properties served by different suppliers for gas and electricity of 1.66. In the non-domestic sector, the same assumptions are made for SMETS1 installations as in the domestic sector, however for AMR installations we assume one communications hub per meter is installed due to technical constraints.

SMETS2 communications hubs are all operated on the national data and communications network run by the DCC. This means that for all SMETS2 installations, even where different suppliers are used for gas and electricity, we assume only one communications hub is installed.

Each communications hub incurs an on-going cost each year per device for maintenance and communication services. For SMETS1 communications hubs, before meters are enrolled into the DCC, we account for the Smart Meter System Operator (SMSO) charges for this service. Once meters are enrolled, we include costs to the DCC based on projections provided by them. All SMETS2 communications hubs incur a charge from the DCC which is modelled based on the actual costs observed to date as well as forward projections provided by the DCC.

Communications hubs for SMETS1 meters are assumed to be financed over the lifetime of the asset. Communications hubs for SMETS2 meters are financed through the DCC and costs are annuitised until the end of DCC's 15-year licence in 2028. We assume that the DCC or another contractor is awarded another 15-year licence starting in 2029 and therefore any communications hubs installed from 2029 onwards as part of a normal asset replacement cycle are annuitised to 2043. The communications hubs for SMETS2 meters have an average cost of capital of 4.2%, which is based on a combination of the observed level set in contracts with the DCC and an expected rate they will be charged going forward (based on intelligence from DCC and an assumption about how future rates will change).

The overall net present value cost associated with communications hub costs is approximately £1.3bn in domestic premises and £80m in non-domestic premises, giving a total cost of £1.4bn (this includes the cost of dual-band communications hubs discussed below).

Dual-Band Communications Hubs

A standard smart metering installation will in most cases include smart gas and electricity meters, an In-Home Display (or similar device in non-domestic premises) and a communications hub. These devices will communicate with each other via a Home Area Network (HAN). The standard 2.4GHz HAN solution specified in the SMETS2 and Communications Hub Technical Specifications is expected to be suitable for at least 70% of premises. In the remaining properties the distance between devices, the location of meters or building fabric and design may prevent the propagation of the 2.4GHz signal. To solve this problem, the Government has worked with industry to implement an 868MHz solution facilitated by dual-band communications hubs.

We have included an uplift to all installations requiring a dual-band communications hub and 868MHz devices to reflect the higher cost incurred relative to the standard 2.4GHz devices. The table below shows this additional cost, as well as the additional cost for compatible gas meters and In-Home Displays (which are captured within the total costs for those assets above).

Table 3: Additional cost of dual-band communications hubs and associated assets

Component	**Additional cost per device**
Dual-band communications hub	£23.00
868MHz Gas meter	£2.00
868MHz In-Home Display	£0.20

The 2.4GHz and 868MHz HAN standards are expected to be suitable for the communications links between all smart metering equipment in approximately 95% of premises. We have taken the assumption based on data from the DCC and industry knowledge within BEIS that once 868MHz equipment is available it will be installed in 25% of properties. In the remaining 5% of premises it is unlikely that the 2.4GHz or 868MHz solutions alone without range-extending equipment will be able to establish a HAN, therefore an Alternative HAN (or “Alt HAN”) solution will be needed. This solution is discussed in more detail below.

In-Home Display Costs

The programme has collected data from energy suppliers on the unit cost of an In-Home Display (IHD) provided with both SMETS1 and SMETS2 meters. A weighted average has been calculated to get an estimate of the average cost of an IHD across all suppliers. We have made a downward adjustment to reflect the fact that several suppliers have purchased IHDs with enhanced functionality above the SMETS specification requirements at an additional cost. However, we have included an allowance to account for approximately 350,000 accessible IHDs that have been purchased, and which cost more than other IHDs. Taking into account these adjustments results in an average cost of £15 for each IHD. Unlike for other assets, the full cost of an IHD is paid in the year of installation and is not financed over the lifetime of the asset. This assumption has been validated with Meter Asset Providers.

Due to the issues of interoperability discussed in the communications hub section, for SMETS1 installations we assume that 1 IHD is installed for every dual-fuel installation but 1.66 are installed for premises where gas and electricity are supplied by separate suppliers. This is the same assumption as for communications hubs. This reflects the fact that IHDs rely on the communications hub to communicate with the meter, and if two communications hubs are required, two In-Home Devices will be as well.

In the non-domestic sector, the offer of an IHD is not mandatory. However, there are regulatory requirements around business consumers' access to their energy consumption data, and a variety of approaches (including offering IHDs) among energy suppliers. The programme is currently reviewing the effectiveness of those approaches. We have therefore allowed for the cost of some form of consumption feedback for non-domestic premises at the same level as an IHD.

The overall net present value cost associated with IHD costs is approximately £600m for domestic premises and £50m for equivalents for non-domestic premises, giving a total cost of £650m.

Financing of Assets

Unless otherwise stated, the installation and asset cost of smart metering equipment discussed above is financed over the lifetime of the asset at a 6% cost of capital.

DCC Costs

The Data and Communications Company (DCC) is a licensed body regulated by Ofgem that provides the shared communications platform needed for the secure transmission of smart meter data and messages. The licence to run the DCC was awarded to Capita Ltd in September 2013. It subsequently signed contracts with a Data Service Provider and three regional Communication Service Providers to establish and operate the necessary data and communications services.

Each year as part of the Price Control regime overseen by Ofgem, the DCC produces a detailed forecast of its costs out to the end of the current licence. We have integrated the elements of the latest costs projection that relate to core smart metering activity into our cost-benefit model. The model applies BEIS assumptions on contract re-procurement and efficiency savings to forecast how these costs are expected to evolve over the entire appraisal period. The resulting cost estimates are split into internal (DCC) and external (DCC Service Provider) costs[29].

[29] The 2008 Smart Meters Act introduced special administration arrangements for Smart Meter Communications licence holders to support the continued provision of smart services until the business is rescued or transferred, benefiting both business and consumers. The programme has recently consulted on supporting licence changes that would allow the costs associated with the

It should be noted that our estimates of DCC costs exclude expected costs that relate to expansion of their services beyond the core smart metering offer, on the basis that any expansion in the scope of the DCC would be assessed on its own merits, and only pursued if there were a positive business case. We have taken this approach because the present analysis is intended to evaluate the costs and benefits of smart metering alone, rather than of the totality of the DCC business. Note, however, that if the DCC is effective at providing a range of ancillary services based on the smart meter platform, this could offer benefits to DCC's smart metering customers because the cost of the DCC's core functionality and fixed costs can be spread across a wider customer base. Because the development of these services is uncertain at this point in time, neither beneficial impacts on costs nor potential wider benefits have been quantified within this analysis.

DCC Internal Costs

These are costs incurred directly by, or directly relating to, the DCC licensee, including staff headcount, overheads, and allowed margin and several of their smaller contracts. A total cost of approximately £540m over the appraisal period is included, containing elements for the initial set-up of services, on-going service provision, as well as potential costs incurred in the re-procurement of DCC services.

As the scope of DCC operations has expanded significantly since the inception of the programme, internal costs have increased over this period. This reflects the fact that DCC staff are now required to support the delivery of several major programmes that are fundamental to delivering full roll-out of smart meters but were not included in the original tender because at that stage the requirements were uncertain. These include delivery of dual-band communications hubs and enrolment of SMETS1 meters. Internal costs are expected to begin decreasing from 2020 onwards, once initial design and development work on these programmes is complete, and this is reflected in our cost estimates.

DCC External Costs

This category consists of costs that are charged to the DCC by the fundamental external service providers for delivering key parts of the smart metering service, including the core contracts for delivery of data and communications services. The total cost associated with DCC's external service providers is approximately £2.4bn over the appraisal period.

The largest element within this cost category relates to the provision of communications services by Communications Service Providers across the three regions (North, Central, and South), which includes the cost of both setting up the communications infrastructure and its ongoing provision. The remaining cost within this category covers other external services commissioned by DCC. These include

appointment of a special administrator to be recouped. The likelihood of having to appoint a special administrator is considered to be very low and the exact circumstances (and hence costs) are highly uncertain. Consequently, these costs have not been included within this CBA. However, a number of illustrative scenarios have been explored in the cost recovery consultation document available at https://smartenergycodecompany.co.uk/latest-news/beis-smip-consultation-on-establishing-a-mechanism-for-recouping-smart-meter-communication-licensee-administration-costs/. In each scenario, the total additional cost is expected to be less than £10m.

set-up and operation of the data services by the Data Service Provider and the development and running of an enrolment solution for SMETS1 meters. Once SMETS1 meters are enrolled, these DCC costs replace energy supplier operational expenditure which was previously forecast to be incurred for the operation of these meters. The provision of these SMETS1 services through the DCC will ensure that all customers can continue to access the benefits of smart services when they change energy supplier.

Alt HAN Costs

A standard smart metering installation will in most circumstances include an electricity meter, gas meter, In-Home Display and a communications hub. These devices will communicate with each other via the home area network (HAN). The presence of a HAN in the home is vital for unlocking key benefits such as energy consumption savings and demand shifting as it not only connects the In-Home Display to the meters, but also allows other smart consumer access devices to be linked into the system.

Standard and dual-band communications hubs are expected to be suitable for the communications links between smart metering equipment in at least 95% of GB premises. Alternative HAN (or “Alt HAN”) is the generic name given to the solution(s) needed to provide a HAN in the remaining premises. Energy suppliers are responsible for developing and delivering Alt HAN solution(s) through the Alt HAN Forum.

The costs associated with delivery of the Alt HAN solution are recovered from energy suppliers as a pass-through cost via the DCC’s charging mechanism. Given the maturity of the programme and the progress made to date, the costs of the Alt HAN solution(s) have been isolated from DCC’s wider costs as the DCC has no control over these, and they are instead managed by energy suppliers through the Alt HAN Forum. This allows us to reflect the full costs for Alt HAN that can be reasonably expected to be incurred by the Alt HAN Forum, including those not yet reflected in DCC’s charging statements.

The costs associated with delivering the Alt HAN solution are:

- The costs associated with the organisational set-up and running of the Alt HAN arrangements, including procurement, business support and staffing costs.
- The costs of procuring and designing the technological solution(s).
- The per-unit cost of any devices required.
- The cost to implement the solution, including any incremental installation cost incurred over and above what is assumed for a standard smart meter installation and any additional energy costs for the solution.
- Optimism bias to reflect the inherent risks in pricing a technology still in the design phase.

The total present value cost of the Alt HAN solution based on data provided by Alt HAN Co. is approximately £290m.

Energy Suppliers' and Others' IT System Costs

The section below captures the additional IT costs that suppliers and industry are expected to incur in order to maximise their ability to realise the benefits of the smart meter roll-out. Given IT upgrades are a common aspect of any business, we have attempted to isolate the additional investment brought about purely due to the requirements of the roll-out.

Supplier and Industry IT Capital Expenditure

In 2010, the programme issued a request for information (RFI) to relevant industry stakeholders to obtain information for a range of IT system related costs. Through this RFI the programme received a range of figures for large supplier IT costs which were analysed to find an average cost per supplier that we could have confidence in.

Figures for small suppliers are included as provided at the time, as well as responses from other industry participants including network operators and existing industry agents.

Since the original 2010 RFI, the structure of the energy market has changed significantly, with the entry and expansion of a number of independent suppliers. The IT cost estimates for small suppliers have been updated based on evidence collected on the cost of DCC services that small suppliers are expected to procure from third parties.

We modelled the vast majority of IT investment to be carried out upfront, ahead of the time the DCC commenced its service provision. A small incremental investment is assumed to be incurred in 2021 for the additional function of registration being added as a DCC service. We have also included a cost allowance to reflect further incremental investment in 2021 supporting the provision of data aggregation services by the DCC.

An allowance has been included to cover the costs suppliers are expected to incur to enrol SMETS1 meters in the DCC. This includes the IT changes that suppliers will need to make in order to operate gained SMETS1 meters via the DCC and the business changes that will be required to ensure their customer service operations can support the various meter types that their customers have. These costs were analysed and are described in the consultations on the enrolment of SMETS1 meters.

All capital expenditure is annuitised over 5 years, resulting in a present value cost of approximately £550m.

Supplier and Industry IT Operational Expenditure

For modelling large suppliers' IT operational expenditure, we use an industry standard figure of 15% of total IT capex to estimate initial operational expenditure for smart metering IT, except where more specific evidence has been available. This initial figure is reduced gradually to 5% by 2030. This is in line with best practice IT application and infrastructure management where on-going performance improvement is a key feature of contracts and has been observed in IT systems of comparable scale and complexity.

Cost estimates for supplier operational expenditure are based on the 2010 RFI, referred to above, reflecting operational expenditure arising from changes to IT systems as a result of the refined technical architecture. Similarly, for other industry participants' IT operational expenditure, we have used the responses received to the 2010 RFI. We have verified these values with suppliers through our ongoing engagements and are confident that they remain robust.

For smaller suppliers, operational expenditure estimates are based on information collected from DCC adaptor service providers in 2015. These operational costs include a fixed annual service charge and per-meter service charges that suppliers are expected to pay as part of their contracts with adaptor service providers.

The resulting overall present value cost estimates for suppliers' and other industry participants' IT operational expenditure are approximately £620m.

Other Costs

Energy

Smart meters, communications hubs, and In-Home Displays all consume energy. In total, we assume that a typical smart metering system (consisting of a meter, a communications hub, and an In-Home Display) consumes 2.6W[30] more power than a comparable traditional metering system. This calculation captures the cost of unmetered energy only and therefore excludes the cost to run an In-Home Display, which is a plug-in device and therefore metered. We also include the forecast energy consumption costs that are associated with the equipment necessary to establish a HAN in premises that require the Alt HAN solution. The value of the energy consumed is taken from the Green Book[31].

The total present value cost of this additional energy consumption over the appraisal period is approximately £660m.

Organisational Costs

There is a variety of legal, institutional and organisational set-up costs for the smart meter roll-out across both the energy industry and Government that have not been captured elsewhere. Total present value costs in this area are approximately £280m,

[30] The energy consumption by an IHD is included in this figure but excluded from the total cost calculations. As IHDs are plugged in (i.e. not behind the meter) the energy cost will be passed on like any other appliance, and so the energy savings will pick up a net figure. The total annual consumption by smart metering assets is approximately 18KWh.

[31] https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

which includes legal, contractual and trial/testing costs across the industry (around £70m), data protection and security assurance costs (around £60m) along with governance costs within both industry and Government (around £150m). These costs are based on observed data where possible, and for future costs we use our most robust projections based on expertise within the programme.

Pavement Reading Inefficiency

As more traditional meters are replaced with smart meters, the geographical density of the remaining traditional meters decreases. Therefore, it becomes more time-consuming to read these traditional meters (for example, because travel times between meters needing to be read increase or because meter readers are in a particular area for a shorter time period, making revisits to premises where access was not possible more difficult). We have calculated the cost of this increasing inefficiency by applying an uplift to traditional meter reading costs. The size of this uplift is capped at twice the existing meter reading cost of £3.65 (see Avoided Site Visits), based on responses to an RFI to suppliers in 2013. This results in a maximum increase of £7.30 and an annual cost of meter reading of £10.95. These reads are treated as an additional cost per meter and the costs are spread across the roll-out.

The total present value cost of these pavement reading inefficiencies is approximately £250m, with £260m accruing to the domestic sector and a cost saving of £10m for the non-domestic sector. This cost saving is realised because the additional cost of reading the higher number of traditional meters under the counterfactual roll-out (50% remaining at the end of the appraisal period) exceeds that of the policy scenario.

Costs Associated with Consumer Engagement Activities

The roll-out mandate requires that a programme of centralised marketing activities around specific consumer engagement objectives[32] undertaken by a specialised delivery body be carried out. Smart Energy GB was established in 2013 in order to fulfil this role and is funded by larger suppliers[33], with smaller suppliers contributing to the body's fixed costs.

With Smart Energy GB facilitating a GB-wide consumer engagement campaign, there is a reduction in overall marketing costs as it allows for the exploitation of economies of scale. Part of Smart Energy GB's purpose has been supporting suppliers' own communications by developing standardised communications material, messaging and a common brand, and providing independent reassurance about privacy and safety, among other things. Over the past two years, its activities have increasingly been focused on increasing the willingness of consumers to seek or accept an installation, thereby reducing the need for multi-channel outreach by suppliers and repeat site visits.

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[32] Condition 45.10 of the standard electricity supply licence, and 39.9 of the standard gas supply licence.
[33] Those with over 250,000 customers.

The total present value cost of Smart Energy GB's spending activity is £230m. This is based on actual (to 2019) and forecast budgets provided to BEIS by Smart Energy GB and includes spending from 2013 out to 2021.

In this assessment we do not make a specific provision for individual supplier marketing costs. Given suppliers fund marketing costs through the central delivery body, they would not be required to undertake further marketing activity to demonstrate compliance with their all reasonable steps obligation. In addition, any supplier marketing activity that features smart metering will have direct benefits to them, such as improved brand recognition and increased customer retention and acquisition. Any additional marketing costs are therefore not a core requirement of the smart metering roll-out, and we assume that any additional marketing spend that does feature smart metering by suppliers is undertaken as rational profit maximising activity to deliver these private benefits. We therefore do not capture any additional marketing costs within our analysis.

Disposal

When meters reach the end of their lifetimes, there is a cost from having to dispose of them. For traditional gas meters, this includes the cost of disposing of the mercury that they contain.

These are not new costs, as they would eventually have been incurred under business-as-usual traditional meter replacement programmes. However, the smart meter roll-out means that more meters are disposed of earlier than they would otherwise be, and the cost of this disposal therefore attracts less discounting that it otherwise would. To reflect this additional cost over and above the costs that would have been incurred in the counterfactual, we have assumed a cost of £1 per traditional meter that is replaced. We also apply this £1 cost to smart meters that are required to be replaced.

Total present value costs of meter disposal amount to approximately £20m.

Projected Future Costs

Whilst many aspects of the programme are now settled and costs are clear, there are several cost areas where there remains some uncertainty about the post-2020 policy landscape or we have made specific assumptions in other published analysis that is not captured elsewhere in the CBA. In order to ensure the CBA is fully reflective of these potential costs, we have included them here.

Costs of Enrolment and Adoption of SMETS1 Meters

The Government announced its intention to enrol 4 of the 6 SMETS1 meter cohorts into the DCC in October 2018[34] and the 5th cohort in May 2019[35]. This means over 99% of all SMETS1 meters and the costs of enrolment are included in the DCC and IT costs described above. The decision relating to the final cohort of meters has not yet been taken, and we have therefore included a contingency to cover the additional cost of enrolling the remaining cohort of SMETS1 meters into the DCC, based on the average cost of the cohorts where the decision to enrol has already been taken.

In addition, we have included a prudent allowance to cover the potential cost of replacing a small number of SMETS1 meters that may fail to successfully enrol into the DCC with a SMETS2 meter. This cost allowance is contained primarily within the asset and installation cost areas described above.

Enduring Change of Supplier

In January 2019[36], BEIS consulted on proposed changes to the supplier processes involved when a change of supplier is instigated. This enduring change of supplier mechanism would consolidate the role of the DCC in the process and ensure that change of supplier events are robust and secure for both suppliers and consumers. As this programme of work is still in its early stages, it is not yet possible to incorporate the full costs as these are not captured within the DCC's budgets. Therefore, we have included a contingency to cover additional costs of the enduring change of supplier programme that are predicted to fall on both the DCC and suppliers.

Ongoing Marketing Costs

The current Smart Energy GB budget is only agreed until 2020, however with the roll-out now expected to continue until 2024, it is expected that some form of ongoing coordinated, national communications provision will be required. We therefore include a contingency to account for potential continuing marketing costs post 2020, as well as costs that will reflect an increased role for Smart Energy GB in the non-domestic sector.

Alt HAN Costs

Given the nature of the Alt HAN project, which is delivering a novel and untested technical solution to establishing a HAN in the hardest-to-reach properties, we have included a cost allowance to reflect the risk of future increases in the cost of providing the solution.

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[34] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/745717/Govt_Response_to_Consultation_on_SMETS1_Enrolment.pdf

[35] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/803966/smip-dcc-enrolment-govt-response.pdf

[36] https://smartenergycodecompany.co.uk/latest-news/beis-consultation-introduction-new-dcc-licence-condition-relating-enduring-change-supplier-arrangements/

Total Potential Future Costs

In total, we include approximately £190m to reflect these potential future costs.

Total Costs

The total costs of the programme over the appraisal period are estimated to be £13.4bn, with £13.1bn attributable to domestic premises and £360m to non-domestic premises. The table below summarises the total undiscounted costs in each year of the roll-out.

Table 4: Annual undiscounted costs of the smart meter roll-out

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Cost (£m)	86	89	260	442	564	771	909	964	976	1,046	1,055

Year	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Cost (£m)	1,072	1,033	952	975	763	729	708	657	633	612	594

As discussed in the Executive Summary, the difference in appraisal periods means that figures presented in this CBA cannot readily be compared with figures within the 2016 CBA. Nonetheless, the table below illustrates the total undiscounted costs for each CBA to each appraisal period end-date and is the most reliable comparison of costs possible. In general, costs are lower due to the fact that the earlier years of the roll-out incur fewer installations. Once the roll-out reaches completion costs are almost identical; for example, undiscounted costs between 2028 and 2030 in the 2016 CBA are 1% higher than in the 2019 CBA (£2,218m compared to £2,199m).

Table 5: Total undiscounted costs in 2016 and 2019 CBA documents

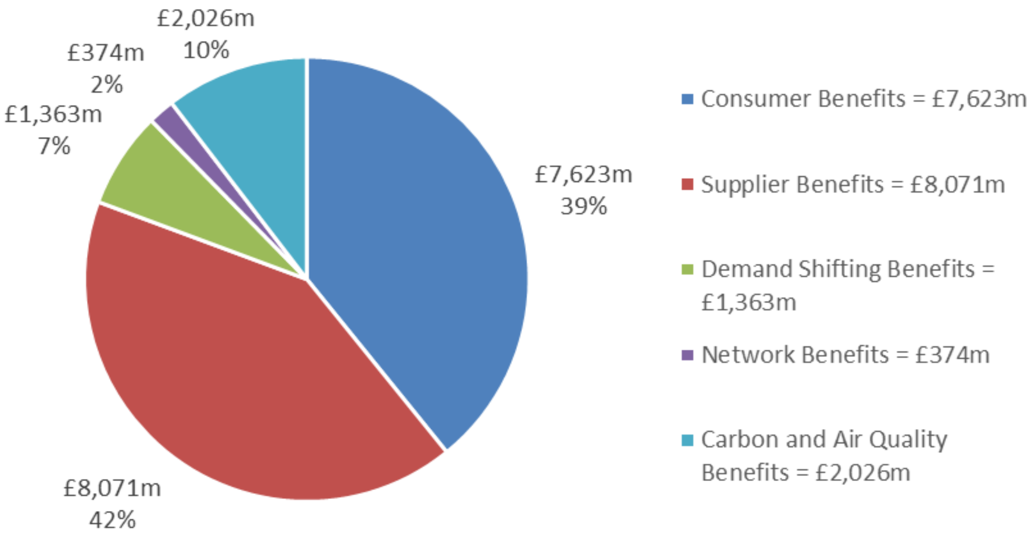
	Costs to 2030	Costs to 2034
2016 CBA	£13.7bn	£16.3bn[37]
2019 CBA	£13.4bn	£15.9bn

[37] The 2016 CBA did not analyse costs to 2034 so we have retrospectively calculated this figure.

Analysis of Benefits

This section will discuss each of the major components of the benefits the roll-out delivers, covering customer benefits (including energy savings), supplier benefits, demand-shifting benefits, network benefits, environmental benefits and unquantified benefits in turn. The relative proportions of the quantified benefits can be seen in the chart below.

Figure 3: Distribution of total benefits of the smart meter programme (£m)



Customer Benefits

Energy Savings

The smart meter roll-out delivers significant benefits in the form of energy reductions driven by changes in consumers' energy consumption behaviour. There are four main levers that contribute to the realisation of these benefits[38]:

- Direct feedback – real-time consumption data through In-Home Displays (that are offered to all domestic smart metered households), smart phones, online services or other platforms.
- Indirect feedback – aggregated or non-real-time feedback, e.g. accurate bills and historic or comparative information on bills.

[38] https://www.gov.uk/government/consultations/smart-meter-consumer-engagement-strategy

- Advice and guidance – on energy and energy reduction, e.g. advice that installers are required to offer during installations or applications and services that can help interpret data and point towards better choices.
- Motivational campaigns – designed to raise energy literacy and motivation to reduce energy consumption. Smart Energy GB, the national communications campaign supporting the roll-out, has an objective to this effect[39].

Evidence Base

There is a substantial evidence base demonstrating that feedback enabled by smart metering leads, on average, to a reduction in energy demand.

Many feedback trials and pilots have been conducted across the world. A series of large-scale international studies have reviewed these and consistently found that feedback – and particularly real-time feedback – can result in significant reductions in energy consumption[40]. A recent example is a January 2019 review by VaasaETT for the European Smart Metering Industry Group (ESMIG)[41]. The review found that, across 130 electricity and gas pilots including 709 samples and involving around 5.5 million residential customers, feedback trials found an average reduction of 5.4% in electricity consumption and 3.9% gas consumption. Real-time feedback led to the highest savings: an average of 7.9% in electricity consumption and 9.6% in gas consumption.

The most relevant and important sources for this CBA are studies in the GB context. This includes the 2011 Energy Demand Research Project (EDRP) which was undertaken to understand GB consumers' responses to a range of forms of feedback, including smart meter-based interventions. The EDRP trials most closely comparable to the GB smart meter roll-out found electricity reductions of 2% to 4%, and these savings were sustained for the duration of the trials (which ran for up to 2 years). Reductions of around 3% were observed in gas consumption.

In 2015, the Government published the findings of the Early Learning Project (ELP)[42]. This included an independent synthesis report which summarised and analysed evidence from two ELP research projects exploring how GB consumers who received smart meters between 2011 and early 2013 engaged with smart metering and GB and international evidence on smart metering and energy feedback. The ELP included a statistical study which quantified the impact of early smart-type meter installations in 2011 on household energy consumption in the year following installation. The study found a reduction in electricity consumption of 1.6-

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[39] https://www.smartenergygb.org/en/-/media/SmartEnergy/essential-documents/essential-documents/english/Engagement-Plan-and-Budget-2019.ashx

[40] For example: Darby, The Effectiveness of Feedback on Energy Consumption; Erhardt-Martinez, Donnelly, Laitner, Advanced Metering Initiatives and Residential Feedback Programs: A Meta-Review for Household Electricity-Saving Opportunities; ACCEE, Results from Recent Real-Time Feedback Studies, available at http://www.aceee.org/research-report/b122; Fischer, Feedback on Household Energy Consumption: a Tool for Saving Energy?; and ESMIG, The Potential of Smart Meter Enabled Programs to Increase Energy and Systems Efficiency.

[41] https://esmig.eu/resource/report-role-data-consumer-centric-energy

[42] https://www.gov.uk/government/publications/smart-metering-early-learning-project-and-small-scale-behaviour-trials

2.8% and in gas consumption of 0.9-2.1% (95% confidence intervals). The synthesis report concluded that there was scope to improve on this through effective consumer engagement, and it was realistic to expect durable savings of 3% based on the evidence to date and potential improvements identified.

Since the ELP, BEIS has collected and reviewed evidence from energy suppliers, finding that consumption reductions are being achieved and sustained in line with the programme's original expectations (2.8% in electricity for credit and prepay customers, 2.0% in gas for credit customers and 0.5% in gas for prepay customers) or higher (3.5% for electricity and 2.6% for gas credit) amongst customers of suppliers with more mature and sophisticated consumer engagement approaches, which supports the ELP's conclusion.

Assumptions

Based on the available evidence, we assume that gross average reductions in demand per household will be:

- 3.0% for electricity (credit and prepayment).
- 2.2% for gas credit and 0.5% for gas prepayment.

These figures assume that around one third of all energy customers will meet the higher reductions which customers of suppliers with more mature and sophisticated engagement approaches currently achieve, with the remaining two thirds reducing their energy consumption in line with the programme's original expectations[43]. The one-third assumption is based on the observed savings for customers achieving the higher rates, extrapolated across the relevant proportion of the market. This approach is further justified by the fact that we know compliance with suppliers offering energy efficiency advice has increased since the customers included in the original studies had their meters installed, coupled with the fact that we know that the methodologies of several suppliers will have underestimated the energy savings attributable to smart meters. In addition, the programme has put in place a policy framework to deliver higher quality energy efficiency advice, which should drive higher energy savings, and meets regularly with energy suppliers to ensure delivery against these policies. We will continue to monitor existing evidence in this area.

For non-domestic consumers, we assume that smart/advanced meters will result in gross average reductions in demand of:

- 2.8% for electricity.
- 4.5% for gas.

These assumptions are in line with the reductions observed in trials specifically conducted with non-domestic consumers by the Carbon Trust. These controlled trials, published in 2007, involved the installation of advanced metering in 538 SME sites[44]. We also have no evidence to suggest that these estimates are out of date,

[43] 2.8% for electricity and 2.0% for gas for credit customers.
[44] https://www.carbontrust.com/resources/reports/technology/advanced-metering-for-smes/

especially given that the evidence on the domestic sector reinforces the early evidence rather than contradicting it.

Calculating the Benefit

To calculate a per-meter figure for the amount of energy saved, we multiply the savings assumptions above by the amount of energy consumed by the average household in a given year sourced from BEIS energy and emissions projections[45]. As the amount of energy households consume is forecast to increase over the appraisal period, so the quantum of energy saved per meter also increases. To calculate the total benefit per year we multiply the per-meter energy saving by the total number of smart and advanced meters installed and then multiply this total energy reduction by the long-run cost of energy for that year taken from the Green Book[46]. We calculate this value for each year and then discount and sum across the appraisal period to calculate the total value of energy saved[47] as a result of the programme.

The table below shows the benefit calculation for 2020 for domestic credit customers.

Table 6: Value of domestic energy consumption reductions (credit meters only) in 2020

	Electricity	Gas
Per meter consumption (kWh) – A	3,704	13,785
Average energy saving – B	3.0%	2.2%
Per meter energy reduction (kWh) – C (A*B)	112	302
Projected number of smart meters installed – D	13.6m	11.0m
Total energy reduction (GWh) – E (C*D)	1,525	3,339
Long-run variable cost of energy (2011 prices, pence per kWh) – F	10.4	1.8
Total value of energy reduction – G (E*F)	£159m	£61m

The total present value benefit from reduced energy consumption over the whole appraisal period is approximately £6.2bn.

The total benefit available to credit customers and prepayment customers is £4.1bn and £600m respectively (note the difference is largely driven by the lower market share of PPM customers) and the benefit to non-domestic customers is £1.5bn.

45 https://www.gov.uk/government/collections/energy-and-emissions-projections
46 https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal
47 Note that this cost-benefit analysis remains valid in the context of the energy price cap.

Time Savings

Smart meters reduce the amount of time that consumers spend interacting with the energy system. For example, smart customers are no longer required to submit meter readings to suppliers to ensure accurate bills and have more options for topping up prepayment meters that do not require them to leave their home. These time savings are a benefit to consumers.

Evidence Base

The programme undertook research with Kantar to gather data from consumers and develop an evidence base around the following areas:

- Time spent by consumers reading traditional meters.
- Time spent by consumers submitting their readings to their energy supplier.
- Time spent by prepayment (PPM) consumers travelling to their local shop to top up their prepayment key.
- Time spent in contact with their energy supplier in order to query a bill or make a complaint (including via phone, email, online chat etc.).

The programme also gathered data from the six largest energy suppliers via a request for information to corroborate the total number of readings that had been submitted in the past year, as well as the total number of bill queries and customers, split by electricity and gas.

A request for information was also sent to operators of the prepayment infrastructure to confirm the number of vends that had been made by consumers annually.

Methodological Approach

The methodology uses the collected data described above in order to calculate a per-meter time saving. The results are set out in the following table.

Table 7: Time saved by meter type per year

Meter Type	Total Minutes Saved per Year
Electric Credit	14.7
Gas Credit	17.8
Electric PPM	101.3
Gas PPM	97.2

These estimates take into account behaviours of consumers observed in the research and evidence collected by BEIS through its wider market intelligence. For example, the research investigated circumstances where consumers would usually top up their prepayment gas and electric meter together or separately and an adjustment was made to account for this. We also reflect evidence from the 2017 Smart Meter Customer Experience Study[48], carried out with customers of two energy suppliers for BEIS by Ipsos Mori, which found that after having a smart meter installed around a quarter (26%) of prepayment customers still chose to top up at a shop rather than remotely. In order to not overestimate the benefits, we have adjusted for factors such as these in our analysis – for example we have reduced the total time savings for prepayment customers that were identified in Kantar survey by 50% to account for the levels of behaviour change identified by Ipsos Mori and that the study involved customers of only two energy suppliers and therefore may not represent the rest of the market. This is a conservative assumption as we might expect to see the proportion of customers who still top up in shops decline as remote top-up becomes normalised.

We also include a benefit from the time saved by customers switching from credit to prepayment tariffs. Previously such switches would require a visit from the supplier to install a meter compatible with the relevant tariff type, but smart meters enable this to be done remotely, saving the customer time from not having to be home to meet the engineer. Energy suppliers provide data on the changes in the number of prepayment customers (and therefore the number of installations of traditional prepayment meters and re-installations of credit meters that would be performed annually in the counterfactual) in the Ofgem Supplier Social Obligations Annual Report[49].

Time Cost of Installations

The analysis also takes account of the fact that there are time costs associated with having a meter installed in both the policy and counterfactual scenarios. The following is considered in our assessment of the benefits:

- There is a time cost to consumers of having their smart meter installed.
- In the counterfactual, there is a time cost that occurs due to end-of-service-life replacements of traditional meters.

In taking these costs off the time savings benefits, we assume that the time required from the consumer is the same for both of the above activities and use the average length of a smart installation as a proxy (varying for single- and dual-fuel installations). We make this assumption since for the majority of the time during which the installation is happening, the consumer will not be required to be engaged in the process. The time cost therefore proxies the time spent preparing the property for the installer (i.e. clearing items from in front of the meter), letting the installer into the property, dealing with any issues that arise during the installation and then letting the installer out again. The fact that the time taken to install a smart meter is typically

[48] https://www.gov.uk/government/publications/smart-meter-customer-experience-study-2016-18
[49] https://www.ofgem.gov.uk/about-us/how-we-work/working-consumers/protecting-and-empowering-consumers-vulnerable-situations/consumer-vulnerability-strategy/consumer-vulnerability-strategy-reporting-progress

longer than to install a traditional meter is not considered due to the fact that we assume this additional time is not spent with the customer engaged with the process.

Despite the fact we assume the same time cost for a smart and traditional installation, there are more smart installations under the roll-out than there would be traditional installations in the counterfactual. Therefore, the total time cost incurred in the counterfactual is netted from the time cost incurred under the roll-out to give the overall time cost that is incurred by consumers.

Valuation Approach

In order to monetise these time savings, we use Department for Transport WebTAG guidance[50] on time valuation. This is the most robust and well evidenced methodology for valuing time available.

We have chosen a conservative assumption on the value of time, by applying the WebTAG value for non-working/leisure time of £4.67 (2011 prices) to the whole population, which was the lowest value we considered as well as the most robust. Other options that were considered included the average wage and data from the Office for National Statistics on the value of household tasks, both of which were deemed to be less robust; the former because time spent on the activities described above is unlikely to be work time, the latter because the source provides the value of time spent on a task based on the cost of employing someone else to it, and we do not believe it is credible to assume that someone would be paid to submit meter readings, top up PPM meters, remain at home for the installer visit etc.

Results

In this analysis we consider time savings to the domestic sector only, as we did not collect data from non-domestic customers.

The amount of time saved annually per meter is substantially higher for prepayment customers than for credit customers. This is driven solely by the time taken to visit a shop to top up the prepayment key in combination with prepayment customers topping up on average around 37-38 times a year. However, the total time saved that accrues to credit and prepayment meters is relatively similar due to the higher volume of credit meters compared to prepayment.

[50] https://www.gov.uk/government/publications/tag-data-book

Table 8: Total value of time savings

Source of Time Savings	Credit		Prepayment	
	Electricity	Gas	Electricity	Gas
Submitting meter readings	£320m	£330m	NA	NA
Topping up prepayment meters	NA	NA	£470m	£330m
Avoided installations of traditional meters	£180m		£70m	
Installation of smart meters under the roll-out[51]	-£260m		-£70m	
Subtotal	£580m		£800m	
Total	£1.4bn			

The total present value consumer time savings benefit is approximately £1.4bn, as illustrated in the table above. The total benefit available to prepayment customers and credit customers is £800m and £580m respectively.

We have not quantified any time savings that accrue to non-domestic premises.

Supplier Benefits

Avoided Site Visits

Energy suppliers will avoid costs from not having to send meter reading operatives to properties in order to obtain a meter reading or inspect a meter for safety purposes. The former will not be required for smart meters, while safety inspections will be carried out independently of meter readings.

Using data from energy suppliers on the volume of meter reading/inspection visits and the overall expenditure on these, we can track the unit cost of a meter read visit and the average frequency with which these visits occur. We can then multiply these two factors together to get an average cost per meter per year for each energy supplier. The average figure across the suppliers is then obtained by weighting these values by market share. Table 9 gives the costs and frequencies for each of these categories.

[51] Negative saving represents a time cost of meter installations.

Table 9: Avoided meter reading and inspection visits – average costs and frequencies

	Cost / Benefit	Cost per visit	Frequency	Total cost per meter per year	Applied to
Cyclic meter readings	Benefit	£2.15	1.7 visits p.a.	£3.65	All credit meters
Non-cyclic (special) meter readings	Benefit	£10	5% of meters p.a.	£0.50	All credit meters
Non-cyclic (special) safety inspections	Benefit	£10.50	5% of meters p.a.	£0.53	All meters
Smart meters: low risk customers (90%)	Cost	£2.15	Every five years (20% of meters p.a.)	£0.39	All meters
Smart meters: high risk customers (10%)	Cost	£10.50	Every two years (50% of meters p.a.)	£0.53	All meters

For cyclic meter readings, the advent of the smart meter roll-out was a critical factor in the review – convened and chaired by SMIP – and subsequent removal by Ofgem of the SLC12 obligation[52], which has enabled the move to less frequent but risk-based inspections. To reflect this, we have made an adjustment to the frequency of visits that suppliers make to traditional meters to reflect the fact that because of the roll-out suppliers are reading traditional meters less per year than they would have been in the counterfactual. The value for avoided cyclic meter reading costs is also used for the pavement reading inefficiency calculation (as discussed in the costs section).

For traditional meters, regular safety inspections are typically carried out alongside cyclic meter readings (so there are no additional costs) and special safety inspections carried out alone. For smart meters, since no cyclic reading is involved, safety inspections are carried out independently. Smart meter inspections are typically carried out on a risk-based basis, in line with Health and Safety Executive recommendations. It is assumed that suppliers will adopt a read frequency according to whether the customer is considered at low or high risk of vulnerability, as set out in Table 9. Inspection costs are assumed to be the same as those for traditional meter regular reads and special safety inspections reported in statistical returns from suppliers. The costs of separate safety inspections for smart meters reduce the overall benefit by around £50m.

[52] https://www.ofgem.gov.uk/ofgem-publications/97556/reformingsuppliersmeterinspectionobligationsfinalproposals-pdf

The total benefit from avoided meter readings and inspection visits is approximately £2.3bn, of which £2.2bn accrues in relation to the domestic sector and £120m in relation to the non-domestic sector.

Customer Switching

Suppliers benefit from reduced costs of handling the customer switching process by:

- Smart meters providing automated meter readings upon change of supplier.
- The DCC taking on centralised registration services from 2022.
- The reductions in supplier costs as a result of additional DCC data services from 2022.

For the first of these categories, the benefit accrues from smart meters providing automated reads thus avoiding the cost to suppliers of obtaining an actual meter reading when a customer switches (either through sending a meter reader or by requesting a read to be submitted by the customer), and in investigating any exceptions to this. Data from suppliers provides information on the costs incurred in obtaining a change of supplier reading for traditional meters, which represent the maximum costs that can be avoided and account for the incidence of switching in the year the data was submitted (2018). Maximum cost savings are assumed to only be achieved from the point at which the DCC communication network was fully operational (2017); for years prior to this, the figure is adjusted down to reflect the gradual development of the network. Non-domestic meters are treated in the same way as domestic meters, except if they are advanced meters – since these are not connected to the DCC communications network, only the minimum cost saving is achieved. This benefit area is worth £0.67 per meter per year from 2017 onwards, totalling approximately £430m over the appraisal period.

For centralised registration, from 2022 the DCC will administer a database of each meter point, including the customer and supplier names. We received information on the costs of interacting with a variety of agents in order to obtain and investigate this information via a request for information to industry in 2010. We have no evidence to suggest these figures are not still robust. The benefits associated with avoiding these costs are worth £0.63 per meter per year from 2022 onwards, representing approximately £340m over the appraisal period.

For data services, a benefit accrues from the reduced processing and data retrieval costs for market-wide settlement, as well as from the anticipated extension of DCC's role in centralising data aggregation and processing (removing the need to pay agents for this). The total benefits are captured as avoided costs of £0.91 per meter per year from 2022 onwards, totalling approximately £480m over the appraisal period, also obtained from the 2010 request for information. The associated additional IT costs for this, and for registration, are included in the analysis.

The value of time savings to the domestic consumer from not having to provide meter readings for the purpose of switching supplier are detailed in the section on time savings benefits, and are not counted again here.

The total switching benefit is approximately £1.2bn, of which £60m accrues to the non-domestic sector.

Inbound Customer Calls

There are reduced costs to energy suppliers from handling customer billing enquiries from smart meter customers. Since smart meters are expected to result in an end of estimated bills for consumers, the volume of these type of enquiries is falling. This reduces the cost of the two components of total call handling costs to suppliers: inbound enquiries (i.e. the direct cost of dealing with a customer call) and customer service overheads (i.e. fixed costs such as rent of buildings and IT systems). Overheads are assumed to represent 15% of overall customer call costs for traditional meters (based on BEIS industry knowledge) and therefore decline alongside the costs of inbound inquiries.

We collect data on actual costs from suppliers that allows us to calculate the reductions in costs for suppliers from these lower call volumes. To do this, we establish the difference in cost per meter between that of traditional meter customers and smart meter customers, accounting for both the volume and cost of calls. This per-meter cost is then applied to the number of smart meters installed in any given year to calculate the total benefit. Data collected from energy suppliers shows that volumes of calls from households with smart meters are around 60% lower than those with traditional meters. This data also identified a higher cost per call for smart meter customers than for traditional meter customers, which is explained by the fact that initially suppliers receive more complex calls following installation and call centre staff are less familiar with the issues raised. We assume that this cost will fall to the same level as traditional customers, as smart meter customers (and call centre operatives) adjust to their meters. This fall in per-call cost is assumed to occur from the second year after the installation. For the overhead cost component, the decline is more gradual, reflecting the extra time required for suppliers to adjust their resources.

The combined impact of these changes is a reduction in the cost of call handling for suppliers of £1.91 per meter per year. The total benefit from reduced customer calls is approximately £1.2bn, of which £60m accrues to the non-domestic sector.

Prepayment Cost to Serve

Smart meters bring savings in the costs that energy suppliers incur in serving customers with prepayment meters (PPM). The cost for a supplier to serve a typical prepayment customer is higher than for a direct debit or standard credit customer because:

- Prepayment meters are more expensive to buy and service.
- The traditional prepayment system requires a specialised back-office administration to manage and reconcile the allocation of payments from customers to energy suppliers, as well the operations and maintenance of a number of physical Payzone and PayPoint top-up locations.

Smart meters bring about considerable cost savings to suppliers because:

- They enable remote switching between credit and prepayment mode whereas with traditional metering, switching would require a site visit to replace a credit to prepayment meter and vice versa. The installation visit to fit a PPM is avoided once smart meters are installed, which is significant given that Ofgem reported a total of approximately 300,000 PPM installations[53] in 2018.
- Smart meters in prepayment mode require less maintenance and service than traditional meters since there is less mechanical interaction.
- Savings on the prepayment infrastructure could be achieved through the streamlining of the credit upload system for smart prepayment as new payment approaches become possible, such as remote top-up.
- There are unquantified benefits such as:
  - An enhanced ability for consumers to forward-plan and make use of smart meter data to inform their consumption and spending patterns.
  - The ability for the customer to take comfort and find peace of mind in knowing more about the energy they are using and when they are likely to need to top up their meter.
  - Time savings made once prepayment customers make the switch to smart, which are discussed above and are not counted again here.

For this assessment we assume that the additional cost to serve PPM customers relative to a direct debit customer is £26 for electricity and £40 for gas. We have derived this estimate using data from the Competition and Markets Authority report[54] on their analysis of costs varying by payment type, which is broadly within the range estimated by Ofgem in their Energy Supply Probe[55]. We have also assessed this against data we have received from energy suppliers which supports the assumptions we have used in our analysis.

Based on data from suppliers, we calculate that smart meters result in a 40% reduction in the difference in cost to serve for gas, while for electricity there is a 33% reduction. This means savings of £16 per year per gas PPM customer and £9 per year per electricity PPM customer.

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53 https://www.ofgem.gov.uk/publications-and-updates/vulnerable-consumers-energy-market-2018
54 https://assets.publishing.service.gov.uk/media/56ebdf3440f0b6038800000c/Appendix_3.6_-_Analysis_of_costs_by_payment_method.pdf
55 https://www.ofgem.gov.uk/gas/retail-market/market-review-and-reform/retail-market-review/energy-supply-probe

The analysis maintains a portion of the ongoing costs associated with the traditional prepayment infrastructure. It is necessary to include these costs for the following reasons:

- Suppliers have obligations to offer cash as a payment option for prepayment customers.
- Fixed standing charges are a component of the suppliers' contracts with Prepayment Meter Infrastructure Providers (PPMIPs) and National Service Providers (NSPs).

The present value of the prepayment cost to serve reduction benefit is approximately £1.1bn. This accrues solely to the domestic sector as we do not assume any prepayment meters in non-domestic premises.

Debt Handling

Smart metering helps to avoid or reduce the impact of debt – both on the consumer and the energy supplier – in three key ways:

More Frequent Billing

Most consumers on standard credit tariffs (i.e. those not paying by direct debit or prepayment) pay for their energy usage in arrears based on infrequent manual meter readings or estimates. Many energy suppliers currently choose to bill these customers only on a quarterly basis, which can lead to substantial arrears (up to 4 months for bills paid on-time) between energy usage and the corresponding payments. Smart meters provide suppliers with more frequent, accurate usage information, allowing them to invoice customers on a monthly basis (where a customer chooses this option) without needing to rely on potentially inaccurate usage estimates. This means that suppliers will receive payments closer to the time at which they incur expenditure for the energy that is used. We have calculated the amount of interest that suppliers are required to pay for the capital needed to cover this expenditure under monthly and quarterly billing – the difference between the two gives the benefit offered by smart meters in this area.

Earlier Identification of Debt Build-Up and Faster Follow-Up Action

Information about energy consumption and cost implications communicated through the In-Home Display can help consumers avoid or better manage debt build-up. In addition, more frequent, accurate billing can help energy suppliers to spot customers at risk of getting into debt more quickly and enable them to discuss and agree reactive measures. In this way, the availability of more and better usage data can better inform energy suppliers' existing debt management processes. This might include offering energy efficiency advice to reduce energy expenditure or developing a debt repayment plan based on the customer's individual circumstances. Furthermore, remote access connectivity can enable follow-up mitigative/ preventative action (e.g. switching customers to prepayment terms or implementing debt repayment tariffs) to be enacted more quickly. We have used data on average days sales outstanding to estimate the typical duration over which customers in arrears build up debt before follow-up action is taken. We have then assumed[56] that the combined effect of the above factors can reduce these timescales by around two weeks on average. This reduces the amount of debt that energy suppliers are owed, delivering savings on the cost of capital they incur.

Reduced Bad Debt Charges and Final Debt Write-Off

As a result of being able to bill customers more regularly, suppliers should be able to spot the build-up of unsustainable levels of debt more quickly and thereby reduce the amount of debt that needs to be written off. While this reduction in bad debt cannot be directly claimed as a benefit as it represents an economic transfer between consumers and suppliers[57], the ability to access the owed capital in line with typical debt repayment timescales rather than having to recover it through tax deductibles or other means at a later date does offer benefit to suppliers.

Results

As described above, we estimate that each of these benefits can enable energy suppliers to reduce the amount of consumer debt that they hold and/or write-off[58], which reduces suppliers' working capital requirements. Since the provision of this working capital is not free (it could be utilised elsewhere and therefore carries opportunity costs), reductions in working capital requirements equate to an operational cost saving that suppliers can realise and consequently pass on to consumers. Based on an analysis of the energy market[59], we assume a cost of capital of 6% per annum within all our calculations in this benefit area.

Management of debt also requires administrative work communicating with debtors, arranging payment terms and collecting debts. With smart meters, smaller debt books and faster repayment times due to the three benefit areas described above are expected to reduce these administrative burdens, decreasing suppliers' operational costs. We expect the number and complexity of suppliers' debt management actions to decrease roughly in line with the total debt held, so we have applied the debt book reductions calculated above to energy suppliers' reported debt management costs (excluding overheads and fixed costs).

Bringing all the elements described above together, we estimate the total benefit per domestic credit smart meter to be £1.8 for electricity and £1.6 for gas. In the non-domestic sector, higher average bills mean that these figures increase to £4.7 and £1.8 respectively. The overall present value benefit associated with better debt management is approximately £1.1bn.

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[56] This is an assumption based on the debt management processes discussed in the Competition and Markets Authority's Energy Market Investigation, available at https://www.gov.uk/cma-cases/energy-market-investigation#final-report.

[57] Across all suppliers, this reduction in bad debt is potentially worth up to £60m per year, which would accrue to suppliers. However, this represents a transfer from each supplier's customer-base, so is not included within our analysis of economic benefits.

[58] We have quantified these impacts based on analysis of energy suppliers' published accounts and evidence provided regarding their debt management costs.

[59] Internal BEIS analysis based on available market sources.

Reduced Theft

The introduction of smart metering has improved energy suppliers' ability to detect and manage energy theft. More granular data on consumption will help alert suppliers to patterns of behaviour that could be indicative of theft, enabling them to better target their enforcement activity, reducing the amount of energy theft incurred. Estimating theft on the network is problematic by nature and levels of theft are inherently difficult to quantify.

Detailed analysis that was carried out by industry in 2010 suggested that levels of theft for gas and electricity attributable to domestic and smaller non-domestic customers come to 1.6TWh and 5.5TWh per annum respectively. Using data on domestic retail energy prices published by BEIS[60], this translates to a retail value of about £240 million each. This was then corroborated in Ofgem's consultation response to their Impact Assessment on tackling gas theft[61] and in Ofgem's strategy consultation for the RIIO-ED1 electricity distribution price control[62], which in 2012 estimated the value of gas and electricity theft to be between £220m-£400m and £400m per year respectively. We have no evidence to suggest that these values are significantly different in 2019.

In our central scenario we make the conservative assumption that the monetised benefits of reduced theft are equal to 10% of the value of the total theft. This assumption measures the reduction in resources deployed by industry to detect and stop theft occurring, as well as the wider costs to companies that theft can cause. It is not intended as a measure of the total value of the reduction in theft itself, as in economic terms this is simply a transfer from consumers to suppliers. There is some evidence from industry to suggest that smart meters could reduce the incidence of energy theft by as much as 20-33%, which we feel supports our conclusion of a prudent 10% estimate for the societal value this brings.

This overall level of energy theft saving is then converted into an effective saving per smart and advanced meter which then accumulates as the roll-out progresses. Advanced meters are implicitly assumed to provide the same benefits as smart meters in our analysis, as they provide remote access and half-hourly reads, which is the minimum functionality required for suppliers to be better able to detect theft.

The overall reduction in energy theft is then updated in future years in accordance with the changes in the long-run variable cost of energy supply, which forms part of the Green Book guidance. This results in a present value total benefit of approximately £260m.

Avoided Losses

The difference between the electricity entering and leaving the transmission and distribution network is known as transmission and distribution losses. There are two distinct types of losses – technical losses, which arise for physical reasons, and non-

[60] https://www.gov.uk/government/collections/domestic-energy-prices
[61] https://www.ofgem.gov.uk/ofgem-publications/39164/gas-theft-ia2pdf
[62] https://www.ofgem.gov.uk/publications-and-updates/strategy-decision-riio-ed1-overview

technical losses, which incorporate measurement errors, recording errors, timing differences and theft (covered above). These are then weighted by the roll-out profile in order to derive a profile of benefits accruing from avoided losses.

Smart meters reduce losses and provide benefits by:

- Reducing the total amount of electricity being transported across the distribution network as a result of consumers reducing their energy consumption.
- Reducing consumption at peak times as a result of changes in consumption patterns following the increase in uptake of time-of-use tariffs.
- Providing Distribution Network Operators with detailed information that can enable them to better manage load factors through active network management.
- Providing more accurate data for settlement purposes.

Our estimates of losses are informed by an assessment of the range of possible benefits by Mott MacDonald conducted in 2007, which suggests that smart meters facilitate some reduction in losses and that the benefits per meter per year will be £0.5 for electricity and £0.1 to £0.2 for gas. We have not identified more recent evidence that suggests these assumptions are now incorrect. The benefits from avoided losses accrue in both the domestic and non-domestic sectors and are realised in line with the roll-out profile. The associated total present value benefits are approximately £540m and £110m respectively, giving a total benefit of £650m.

Remote Change of Tariff

For traditional meters, in order to switch a consumer from a single rate tariff to a multiple rate tariff (e.g. standard to Economy 7) or vice versa, a visit is required to adjust/change the meter. For smart meters, this visit will no longer be needed, as this action can be carried out remotely. This benefit area captures the avoided costs from energy suppliers not having to carry out that visit.

We collect data from suppliers on the costs they incur for these visits that allows us to calculate the average cost per visit (£74) and the proportion of meters visited for the purposes of tariff change per year (0.4%). We can then use these figures to calculate the total cost to industry from making these visits, and then calculate the average cost per meter by dividing this total figure by the number of meters to give a potential saving of £0.26 per meter per annum.

The total change of tariff benefit is approximately £170m, of which £160m accrues in relation to the domestic sector and £10m in relation to the non-domestic sector.

Demand-Shifting Benefits

Smart meters will enable incentives for consumers to shift demand away from peak time towards off-peak or towards periods when cheap, low-carbon generation is available, therefore bringing significant benefits to the electricity system.

Smart meters are a key enabler of large-scale domestic demand shifting. They are necessary in order to unlock large-scale benefits from demand shifting, but they are not sufficient to achieve this: additional effort will be required to unlock these benefits in full, such as Ofgem's half-hourly settlement programme and the implementation of the smart systems and flexibility plan. As Ofgem outline in their Business Case for market-wide settlement reform, smart meters enable half-hourly settlement by recording the amount of energy consumed or exported within every half hour of the day, and by allowing two-way communications. This provides an opportunity to make the settlement process more accurate and timely, a necessary condition for new products and services – such as time-of-use tariffs and smart appliances – to incentivise and enable consumers to shift consumption[63].

Due to the additional policy interventions that will be required in order to fully realise the benefits of demand shifting, we are acutely aware of the problem of attributing the benefits we assess in this CBA. We will take forward work to consider the proper attribution of demand shifting benefits between the different components of the system in the future, working with relevant stakeholders across Government, but include the benefits in their totality within the headline figures of this CBA given the significant role smart meters play.

We include all forms of smart tariffs in our analysis, as market intelligence suggests that more dynamic tariffs will become more prevalent in the market soon (and have existed in some form since February 2018). The load shifting that is incentivised by smart tariffs and delivered through load control can create a range of benefits:

- The electricity system must be able to meet the highest demand on any given day. Demand-side response reduces peak demand and smooths demand throughout the day. This leads to less investment in new generation being required because the system will require less capacity to deal with the maximum level of demand during the day.
- A more even distribution of demand across the day can lower the average cost of energy generation, as plants are utilised in ascending order of short-run marginal costs. If peak demand is reduced, plants with higher short-run marginal costs might not need to be utilised and hence average cost of generation could decrease.

[63] We recognise that additional policy interventions will be required to unlock the full potential of demand shifting, but as smart meters are a pre-requisite, we include the full amount of benefit in this CBA as an indication of the value to society that smart meters will bring.

- As demand smooths over the day, existing GB energy generation capacity will be used more efficiently, for example reducing curtailment of renewables.
- Distribution and transmission networks also benefit from lower peak demand. Long-term capacity investment in transmission and distribution networks can be reduced, as peak loads will be lower than in the counterfactual.
- Less demand at peak times also reduces greenhouse gas emissions, as the generation mix at peak times is usually more carbon intensive than during off-peak times.

Our analysis aims to capture as many of these benefits as possible. The next section sets out the modelling approach and assumptions and is then followed by a presentation of the results and a discussion of the unquantified benefits.

Modelling Approach and Assumptions

The BEIS "Dynamic Dispatch Model" (DDM)[64] was used to assess the benefits of demand shifting as enabled by smart meters. The DDM is a comprehensive, fully integrated power market model covering the GB power market over the medium-to-long term. The model analyses electricity dispatch decisions from GB power generators and investment decisions in generating capacity from 2010 through to 2050. It can show the impact of policy decisions on generation, capacity, costs, prices, security of supply and carbon emissions. Costs and benefits are derived by comparing a counterfactual run with a scenario run. If overall system costs to society are larger in the counterfactual than in the scenario run, there is a net benefit. For this CBA, we compared a *demand shifting enabled* smart meter scenario with a *no demand shifting* counterfactual.

The counterfactual did not assume any level of demand shifting. The smart meter scenario assumed an increase in demand shifting uptake over time, with 1% of total demand assumed to be flexible in 2020 rising to 15% in 2034. This is based on an assumed uptake of time-of-use tariffs of 3% (2020) to 25% (2034) and load shifted for the average time-of-use household increasing from 30% (2020) to 60% (2034). A proportion of non-domestic demand estimated to be eligible for smart metering is also allowed to shift following the same assumptions[65].

The level of demand assumed for every year is consistent with BEIS assumptions for the Clean Growth Strategy[66] and assumes an increased demand from electric vehicles and heat pumps, especially after 2035. Every half-hour of flexible domestic demand and flexible demand from non-domestic consumers that qualify for smart meters can shift four hours earlier or later (shifting window of 8 hours). For electric vehicles and heat pumps, other shifting assumptions are used to reflect the specific nature of these products[67].

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[64] https://www.gov.uk/government/publications/dynamic-dispatch-model-ddm
[65] For non-domestic demand we assumed a different load curve than for domestic demand.
[66] https://www.gov.uk/government/publications/clean-growth-strategy
[67] Domestic electric vehicles can shift their demand only forwards and only between 4pm – 10pm for a maximum of 8 hours.

Results

Overall, the modelling results showed that the level of demand shifting that is enabled by smart meters provides a net benefit to society, with a net present value of £1.4bn to 2034. Of this, the DDM estimates that approximately £1.1bn is attributed to the domestic sector and £230m to the non-domestic sector. However, these figures are only an approximation due to the way the DDM calculates benefits, with the order in which certain aspects of demand are allowed to shift having a significant impact on the quantum of benefit ascribed to them. Were the analysis to "turn on" non-domestic demand before domestic, the relative benefit attributed to non-domestic demand would appear larger, even though the total NPV would remain the same.

Unquantified Benefits of Demand-Shifting

We were not able to quantify all benefits of demand-shifting and discuss these unquantified benefits briefly here. Due to this, the presented NPV is likely an underestimate of the total benefits of demand shifting.

- The DDM only captures costs and benefits of the transmission network, not the distribution network. At present, we are not able to include a robust estimate of distribution network benefits of demand shifting in this analysis, but these could be significant.

- The DDM models demand shifting by smoothing demand over the whole day. This means that benefits of demand-side response in system operation, where it would play a role in the balancing or ancillary services markets is not captured by the model at present.

- Wind profiles used in the DDM are assumed to be flat over 24 hours. Three different strengths of wind are assumed and modelled, but no in-day variation is assumed. This will omit benefits of demand-shifting from avoided curtailment costs, as our data suggests that one third of days in a year feature non-flat wind profiles. Currently, we are unable to model this robustly, but early model runs suggest that the benefits would be significantly higher if we could.

Network Benefits

Smart meters offer benefits to the Distribution Network Operators (DNOs) who manage the infrastructure used for electricity distribution. Such benefits come from the increased data that network operators will have available, allowing them to identify faults in the network, restore electricity supply more quickly when outages occur and take better informed investment decisions.

In 2016, PA Consulting conducted an in-depth investigation for BEIS into the potential impact of smart meters in this area, including evidence published by BEIS, the Energy Networks Association, individual DNOs and Ofgem, as well as international studies.

This was used to identify a range of network benefits that could be realised using smart metering data (including alerts) in the 2016 CBA. Data from Ofgem and DNO business plans was then used to quantify these benefits for the RIIO-ED1 price control period (2015-23)[68], with further benefits uplifts being applied for RIIO-ED2 (2023-31) to reflect the view that benefits during ED2 will be higher (for example in light of an expected increase in the deployment of low-carbon technologies). We have confidence that this detailed study still represents the best available evidence base on how smart meters can benefit network operators and therefore have used it as the basis for our assessment of network benefits for the present analysis. We have updated assumptions where new information has come to light since 2016 that is relevant.

Our regular discussions with individual DNOs have revealed that smart meter data will play a key role in their transition to becoming Distribution Systems Operators. For example, gaining information about the demand requirements of electric vehicle owners both in terms of volume and time-of-use will be particularly important, as will the ability to measure low-voltage generation. These benefits have not been quantified within this analysis.

Better-Informed Decisions for Electricity Network Investment

Having more detailed historical information from smart meters allows DNOs to more effectively target network reinforcement and plan new connections.

These benefits depend on DNOs having access to historical smart meter data, which can be obtained through DCC systems for both SMETS2 meters and SMETS1 meters that have been enrolled in the DCC. We assume that 60% coverage is required to give sufficient network visibility for these benefits to be realised, and we allow enrolled SMETS1 meters to contribute to this coverage requirement for these benefit areas.

The individual elements of investment decision benefits are as follows:

Better-Informed Decisions Regarding Network Reinforcement

Historical smart meter data allows DNOs to identify areas in the existing network which are at risk and might require reinforcement more easily. This will result in investment for network reinforcement being better directed. This will be particularly useful for low-voltage networks, as existing systems cannot provide the level of detailed information available from smart meters.

Our analysis uses the actual annual investment requirement figure from the fifth Distribution Price Control Review (DPCR5)[69] as the baseline for annual investment

[68] https://www.ofgem.gov.uk/network-regulation-riio-model/current-network-price-controls-riio-1/riio-ed1-network-price-control
[69] https://www.ofgem.gov.uk/electricity/distribution-networks/network-price-controls/distribution-price-control-review-dpcr-5

spending. The Energy Networks Association's cost-benefit analysis[70] on the implications of smart metering for DNOs indicated that the availability of better information from smart meters offers the potential to reduce required investment by 5% to 10%. We have adopted this assumption, assuming savings of 5% during RIIO-ED1 (2015 to 2023, but only once the 60% coverage threshold has been reached), rising to 10% for RIIO-ED2 (2023 to 2031) and beyond. This reflects the expectation that the benefits from smart metering will increase over time, for example due to the deployment of more low-carbon technologies.

We further reflect this expectation through the assumption that these traditional investment benefits will be replaced by benefits associated with active network management from the middle of RIIO-ED2 onwards. Active network management involves the use of advanced systems management software to analyse data from smart meters and other sources in order to optimise the use of existing network capacity and reduce the need for network reinforcement. Based on a review of DNOs' published smart metering strategy papers[71], we conservatively assume that active network management will deliver a one-third uplift over the traditional reinforcement benefits calculated above for the latter half of the RIIO-ED2 period and beyond.

In total, the present value benefit associated with network reinforcement investment is approximately £170m.

Reduced Cost to Serve New Connections

Smart meters enable DNOs to optimise network design requirements, minimising the costs of connecting new sites to the existing network.

These benefits have been estimated by multiplying the actual annual investment for new connections (from DPCR5) by the cost savings assumptions of 5% during RIIO-ED1 and 10% during RIIO-ED2 and beyond as above.

The total present value benefit associated with new connections is approximately £40m.

Outage Detection and Management for Network Operators

The availability of detailed information from smart meters should allow DNOs to detect outages more quickly and accurately and to resolve them more efficiently. DNOs already have remote monitoring systems in place covering large parts of the high-voltage network, so we assume that benefits are realised only for faults on either the low-voltage network or 10% of the high-voltage network.

Benefits in this area depend on the "last-gasp" functionality (i.e. sending a message notifying the network that power has failed) provided by SMETS2 meters and require sufficient geographical coverage to provide the network visibility needed to reliably identify the location and scope of an outage. For this reason, we assume these benefits to be realised only once 60% of all meters are SMETS2 meters. We assume

[70] http://www.energynetworks.org/electricity/futures/smart-meters.html
[71] These can be found on DNOs' websites.

that SMETS1 meters do not contribute towards this benefit area, even once enrolled in the DCC.

The individual elements of outage management benefits are as follows:

Earlier Fault Notification

This captures the consumer benefit from the reduction in the average length of an outage because smart meters provide DNOs with earlier notification of outages.

With traditional metering systems, DNOs rely on customers calling in to report outages and require calls/notifications from two customers to classify an outage as a network fault. On average, the time required for two customers to become aware of the problem, locate the DNO's phone number/website, and call the DNO/log the outage is estimated to take 7 minutes. With smart meters, current performance of CSP systems and notification processes suggests this timescale can be reduced by 5 minutes on average. We monetise this 5-minute reduction using the average Customer Minutes Lost (CML) price incentive for the RIIO-ED1 regulatory period, running from April 2015 to 2023. The CML incentive rate reflects end customers' willingness to pay for quality of supply improvements with regards to a reduction in minutes lost.

The present value benefit from earlier fault notification is approximately £40m. This reflects the value that consumers place on the improved quality of supply.

Faster Restoration of Supply

Outage notifications from smart meters provide DNOs with information on the nature, location and scope of an outage. Once there is sufficient SMETS2 coverage, this will enable them to reduce the time it takes to resolve a fault once they have become aware of it, reducing Customer Minutes Lost (CML).

International evidence suggests that potential reductions in CML range from 5% to 35%. We have therefore applied a 20% reduction factor (as the mid-point in the range) to the total CML due to faults on the low-voltage network and the part of the high-voltage network that is not currently remotely monitored. This has then been multiplied by the CML price incentive as above.

This gives a total present value benefit from faster restoration of supply of approximately £90m.

Reduction in Operational Costs to Fix Faults

Information on the exact location and scope of an outage allows DNOs to deploy fault resolution teams in a more targeted manner and avoid instances where they return to the depot only to have to be redeployed because a nested fault was not fully resolved. It will also reduce the need for unnecessary visits, where the outage is the result of a fault in the premises rather than with the distribution network. These instances will provide operational cost savings for DNOs.

We have estimated the operational savings associated with deploying teams in a more targeted manner and reducing redeployment at £50 per fault. This is towards the lower end of the estimated savings reported in DNO Smart Metering Strategy papers. This value has then been multiplied by the number of customer interruptions on the low-voltage and high-voltage parts of the network not covered by monitoring equipment to estimate the total value.

The present value benefit from the reduction in costs to fix faults is approximately £20m.

Reduction in Calls to Fault and Emergency Lines

In the long-term, customers will be confident that networks are already aware of outages due to smart meter information. In the short-term we envisage a reduction in the number of calls that need to be answered by DNOs through the introduction of automated messages that inform callers of the geographic scope and expected restoration time, facilitated by more accurate information from smart meters.

To estimate this benefit, we have applied a 10% reduction to DNOs' call centre costs from the point 60% SMETS2 coverage is reached. This is a conservative assumption relative to international evidence, which suggests that substantially higher reductions in call volumes could be deliverable.

This gives a present value benefit from a reduction in call volumes of approximately £20m.

Results

In total, the six benefit areas described above give an overall network-related benefits total of approximately £370m in present value terms; £260m of this is accruable to DNOs, while £110m is consumer benefit accruing from earlier fault notifications, faster supply restoration and an improved application process for new connections.

Outage detection and management benefits are split between the domestic and non-domestic sectors in proportion to the size of these customer-bases. By contrast, better-informed investment decisions benefits are realised across the entire electricity network infrastructure, so we have decided to allocate them to the domestic sector only to avoid any risk of double-counting. This means that £360m of the total pot of network-related benefits is attributed to the domestic sector, while the remaining £10m is ascribed to the non-domestic sector.

Unquantified Benefits

There are several areas where smart metering could provide additional benefits to DNOs that it has not been possible to fully quantify in this assessment due to a lack of evidence at this point. These include:

- Improved asset management – Smart meters provide asset management engineers with information (including on issues such as variation in load and duration of overloading) that can be used to optimise performance, manage risks, and minimise costs associated with asset maintenance.

- Vegetation management – DNOs incur regular costs for managing vegetation, such as cutting trees and branches that are close to overhead lines. This helps to maintain the effectiveness of the power network, reduce outages and manage fire hazards. With smart metering data, DNOs may be able to better target their vegetation management activities based on information on outages, which could provide costs savings.

- Regulatory and reporting requirements – Smart meters increase the volume and quality of network data, which in turn should improve efficiency and accuracy of regulatory reporting and subsequent DNO allowance setting. This benefit will be realised by customers rather than DNOs.

- Cyber security and data protection – In the future grid environment, it is likely that network operators will need to communicate and exchange data with a range of third parties. The use of existing smart metering infrastructure to support these communications could mitigate security risks by providing systems which are already secure.

Carbon and Air Quality Benefits

Avoided Costs of Carbon from Energy Savings

We have valued the avoided costs of carbon emissions resulting from energy savings in line with the relevant Green Book Supplementary guidance[72].

For electricity, reductions in energy use will mean the UK purchasing fewer (or selling more) allowances from the current EU ETS. We estimate a reduction in traded carbon emissions of 11.2 million tonnes, which accounts for a monetary benefit of approximately £320m.

For gas, the value of carbon savings from a reduction in gas consumption uses the non-traded carbon prices under the Government's carbon valuation methodology. We estimate a reduction in non-traded carbon emissions of 23.2 million tonnes, which accounts for a monetary benefit of approximately £1.3bn.

Air Quality Benefits

Air quality can impact on human health, productivity, wellbeing and the environment. In line with guidance from the Department for Environment, Food and Rural Affairs[73], a benefit reflecting air quality improvements from reduced emission of pollutants as a result of energy savings is estimated. Air quality improvements are estimated to deliver present value benefits of approximately £390m.

[72] https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2018
[73] https://www.gov.uk/guidance/air-quality-economic-analysis

Unquantified Benefits

Whilst every effort has been taken to quantify all the benefits associated with the smart meter roll-out, in some instances this has not been possible. Some of these unquantified benefits have been discussed in the relevant sections above. In addition, the benefits identified below are all areas that we would expect to be significant were quantification possible, but for which there is not enough data available to either quantify or monetise the impact. Instead, we present a qualitative description of how each benefit is expected to be realised.

Enabling a Smart Energy Future

The recent report by the Committee on Climate Change (CCC)[74] recommended that the UK aims to reduce net carbon emissions to zero by 2050, a recommendation that was accepted by the Government in June 2019[75]. In their report, the CCC highlight the need for smarter energy systems in the future, without which the increase in technologies such as electric vehicles and hybrid heat pumps will not deliver their full potential carbon reductions. Smart meters are a key enabler of these wider systems through providing real-time price signals into the home. Whilst we capture the benefits of demand shifting unlocked by smart meters, there remain significant future benefits that are not quantified within the analysis and we would expect the annual benefit to increase in size beyond the appraisal period as we head toward 2050.

Without widespread deployment of smart meters, it becomes significantly more challenging to meet the target of net zero emissions by 2050. For example, the CCC estimates that without a flexible energy system, which smart meters are a key part of unlocking, the costs of delivering net zero emissions by 2050 could be up to £16bn per annum higher[76].

Competition Benefits

The Competition and Markets Authority reported in 2016 that the domestic energy supply market was not as competitive as it could be, with a resulting consumer detriment of £1.4bn per annum. The roll-out of smart meters will have a positive impact on competition within the energy sector, helping to reduce this detriment. This will be achieved through a number of factors, such as the increase in data available to consumers, more accurate consumption data and an end to estimated bills driving customer engagement. This should lead to higher switching rates and more competition between energy suppliers.

In addition, the promise of a smarter energy market facilitated by the roll-out may have encouraged new suppliers into the market, attracted by the lower operating costs and market opportunities that are now available. The potential for smart meters to contribute to improved competition within the energy market was recognised in the

[74] https://www.theccc.org.uk/publication/net-zero-the-uks-contribution-to-stopping-global-warming/
[75] https://www.gov.uk/government/news/uk-becomes-first-major-economy-to-pass-net-zero-emissions-law
[76] https://www.theccc.org.uk/wp-content/uploads/2018/06/Imperial-College-2018-Analysis-of-Alternative-UK-Heat-Decarbonisation-Pathways.pdf

Domestic Gas and Electricity (Tariff Cap) Act 2018[77] which stated that when the regulator considers removing the cap it must consider as part of its assessment of competition in the market the extent to which the roll-out is complete.

Overall, we would expect increases in competition facilitated by the roll-out to reduce the average price paid by consumers and lead to an increase in innovative offers from suppliers. However, it has not been possible to quantify this benefit as isolating the impact of smart meters on competition relative to other factors (such as Ofgem's faster switching programme and new suppliers entering the market and gaining significant market share) has not been possible. However, given the identified customer detriment of £1.4bn per annum that exists, the potential benefit that smart meters can unlock in this area is significant.

Erroneous Transfers

Erroneous transfers occur where the incorrect meter point is chosen as part of a change of supplier event. It can impact the old supplier, new supplier, the customer who wanted to change supplier and the unsuspecting customer whose meter point has been used. Erroneous transfers can take considerable time and effort for both impacted suppliers to resolve, and regularly causes customer detriment.

There is a benefit from smart meters in this area as smart meters enable a "CIN check". A CIN check is delivered via the DCC service which enables a supplier to send the consumer a unique number (the CIN), which is displayed on their In-Home Display. The customer can then provide this to the supplier to tally it against the CIN returned to them as part of the service response. The CIN check therefore allows suppliers to confirm that the correct meter has been selected before the change of supplier event begins, thus avoiding the risk that the wrong meter being chosen. Each of these avoided events could potentially bring significant benefits.

Whilst erroneous transfers could happen in up to 1% of change of supplier events, we have not quantified this benefit as we do not have access to robust estimates of the cost to suppliers and there is currently a lack of data as to how often CIN checks are being used in change of supplier events.

Safety Benefits

Gas Safety

According to the Gas Safe Register website, 1 in 6 homes has a dangerous gas appliance.

Under the Gas Safety (Installation and Use) Regulations 1998, gas engineers carrying out any gas work that become aware of a gas appliance that cannot be used without constituting a danger to any person are required to take all reasonably practicable steps to inform the customer. The scale of the smart meter programme, and the policy intent to offer a smart meter to every home in Great Britain, means that many of these appliances or network assets will be encountered and visually

[77] http://www.legislation.gov.uk/ukpga/2018/21/contents/enacted

inspected more quickly than they may have been otherwise, thereby improving consumer safety overall.

Industry Collaboration

The programme has brought industry parties together via governance groups which has improved collaboration across the industry. Key outputs from safety-related groups include improved processes, communications and quality and consistency of reporting of potentially dangerous occurrences followed by industry-wide actions and lessons learned taken off the back of these incidents. For example:

- A monitoring regime was established to track safety incidents, providing for the first time a more comprehensive industry-wide view of safety incidents and prompting industry-wide actions to be taken to reduce them.
- An escalations list has been set up that gives suppliers and network operators direct contact details of other industry stakeholders to ensure rapid action/ communication of serious safety incidents between parties.
- Information sharing between industry participants to improve best practice sharing related to safety management issues.

Priority Services Register

The volume of activity being undertaken by suppliers as a result of the programme has also helped energy suppliers to identify customers that would potentially benefit from being on the Priority Service Register. The volume of activity being undertaken is assumed to be raising awareness of this and helping suppliers refresh records where necessary, giving eligible consumers access to various rights including a free annual gas safety check.

Comfort Taking

Smart meters give people a better understanding of their energy use, which is expected to lead to reductions in overall consumption as discussed in the consumer benefit section above. However, whilst it is possible to measure reductions in energy consumption, consumers may also change how they use their energy to deliver higher personal benefit. For example, consumers may realise that they can substitute energy spent lighting their home for energy spent heating it, resulting in no change in consumption but the consumer still benefitting as they are using their energy to better suit their personal needs. It has not been possible to quantify this benefit due to the difficulties in measuring behavioural change in the home, which would not be visible in the data that energy suppliers or BEIS collect.

Smart Export Guarantee

Smart meters can measure the time and amount of electricity exported to the grid from on-site renewables and other sources such as battery storage or electric vehicles. This helps support development of innovative smart “time of export” tariffs that reward consumers for exporting at times of system need. The Government’s proposed “Smart Export Guarantee”[78] builds on the functionality provided by smart metering, allowing more consumers to benefit from location- and time-specific electricity prices.

The use of the smart metering system will avoid the cost of installing export meters in premises that export energy to the wider system. Given the uncertainties surrounding the number of premises the smart export guarantee will impact, it has not been possible to estimate an annual cost saving.

Value of Data

The data that smart meters produce has value to the consumer, supplier and third parties such as academics and businesses. Once a meter is settled on a half-hourly basis, meter readings will be extracted over 17,500 times per annum compared to the current situation of, at most, 12 times. In addition, customers will be able to access information on their electricity use in near-real-time through their In-Home Display. This data, subject to proper permissions being granted, can be collated and used to unlock potential benefits both for the domestic and non-domestic sectors beyond those quantified benefits, especially if customers allow other third parties access.

Examples of the potential value from the use of smart meter data come from the Department’s Non-Domestic Smart Energy Management Innovation Competition (NDSEMIC) which is piloting innovations such as apps and online platforms which convert smart meter data into tailored, actionable insights for SMEs. Emerging case studies from this competition have shown the value businesses place on data coming from their smart meter; for example, one firm took steps to improve ventilation after engagement with their data showed that regularly cleaning their ventilation system helped reduce energy use, and another found that they were able to take better informed investment decisions. Smart meter data was even used to run energy-based activities with pupils in schools, which was identified as helping to improve their understanding of how to use graphs and handle data.

Energy consumption data collected by smart meters can also be used to provide a range of innovative energy saving products, services and interventions for households, with the potential to deliver additional benefits. To drive innovation in this area and secure further evidence on potential impacts, the Department has launched the Smart Energy Savings (SENS)[79] and Smart Meter Enabled Thermal Efficiency Ratings (SMETER)[80] competitions. These projects will develop and test new ways of using smart meter data to assess building performance and deliver feedback and advice to consumers to support them in managing their energy consumption.

In addition to examples like this, smart meter data could be of immense value to the academic sector, unlocking the ability to undertake more interesting and detailed

[78] https://www.gov.uk/government/consultations/the-future-for-small-scale-low-carbon-generation
[79] https://www.gov.uk/government/publications/smart-energy-savings-sens-competition
[80] https://www.gov.uk/guidance/innovations-in-the-built-environment#smart-meter-enabled-thermal-efficiency-ratings-smeter-innovation-programme

investigations of energy use and ways to improve the energy market and wider ecosystem in the future.

Smart meter data can also be used to allow better quality care for people in need. With the consumer's consent, data from smart meters can be used to identify energy usage patterns that could be associated with health conditions such as dementia or depression. Where they have the individual's consent, a patient's carer or the NHS can be notified where intervention may be required. This could also be used as a clinical decision-support tool. For example, a project led by Mersey Care NHS Foundation Trust and Liverpool John Moores University is currently exploring how new tools which make use of real-time consumption data and AI can support patients to live more safely at home, maintaining their independence for as long as possible and cutting care costs.

Total Benefits

The total benefits of the programme over the appraisal period are estimated to be £19.5bn, with £16.9bn accruing to domestic premises and £2.6bn to non-domestic premises. The table below summarises the total undiscounted benefits in each year of the roll-out.

Table 10: Annual undiscounted benefits of the smart meter roll-out

Year	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Benefit (£m)	18	27	57	115	219	390	550	773	957	1,169	1,342

Year	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**
Benefit (£m)	1,496	1,696	1,745	1,736	1,824	1,886	1,949	1,830	1,934	1,983	2,017

Summary of Costs and Benefits

Overall, the programme incurs costs of £13.5bn but delivers benefits of £19.5bn, yielding a net benefit of £6bn. This is summarised in the table below.

Table 11: Summary of costs and benefits and total NPV (all figures in £m)

Total Costs	**13,480**	**Total Benefits**	**19,457**
In Premises Costs	*7,495*	*Consumer Benefits*	*7,623*
Installation of Meters	3,208	Energy Savings	6,247
Meters & IHDs	2,201	Time Savings	1,376
Communications Hubs Capital Costs	1,110		
Operations and Maintenance of Meters	666	*Supplier Benefits*	*8,071*
Communications Hubs Operations Costs	310	Avoided Site Visits	2,327
		Customer Switching	1,249
DCC Related Costs	*2,900*	Customer Calls	1,242
DCC Licensee Costs	539	Avoided PPM Premium	1,119
External Service Provider Costs	2,361	Debt Handling	1,051
		Reduced Theft and Losses	913
Suppliers' and Other Participants' System Costs	*1,170*	Remote Change of Tariff	171
Supplier Capital Costs	494		
Supplier Operating Costs	346	*Demand Shifting Benefits*	*1,363*
Industry Capital Costs	57		
Industry Operating Costs	118	*Network Benefits*	*374*
DCC Adaptor Services	156	Better Informed Investment Decisions	209
		Outage Detection and Management	166
Other Costs	*1,723*		
Energy Consumption by Smart Metering Assets	659	*Carbon and Air Quality Benefits*	*2,026*
Organisational Costs	280	Reduced GHG Emissions	1,633
Alt HAN Direct Costs	288	Air Quality Impact	394
Pavement Reading Inefficiency	248		
Smart Energy GB Costs	230	**Net Present Value**	**5,977**
Disposal Costs	18		
Projected Future Costs	*192*		

Overall the roll-out delivers a benefit-to-cost ratio (BCR) of 1.44, reflecting lifetime costs and benefits. As with any infrastructure investment programme, the roll-out incurs up-front set-up costs (such as establishing the DCC and Alt HAN programme, Government programme costs and investments from suppliers in IT and other system costs). Once these costs are no longer being incurred, the total annual cost of running the smart metering system fall to an estimated £670m per annum on average with estimated benefits of £1.9bn per annum on average (undiscounted). Therefore, the ongoing BCR of the smart meter roll-out increases to 2.86.

We have also calculated the marginal cost and benefit of a smart meter installation. Over its lifetime, a domestic smart meter will incur costs of slightly over £400 but deliver benefits of nearly £750. For a non-domestic smart meter, marginal costs are slightly higher at around £470, largely driven by the fact that advanced meters have a higher cost than smart meters. Offsetting this increased marginal cost, however, are significantly higher marginal benefits of over £2,200, due to higher energy consumption reductions (both in terms of the percentage reduction and baseline consumption figures).

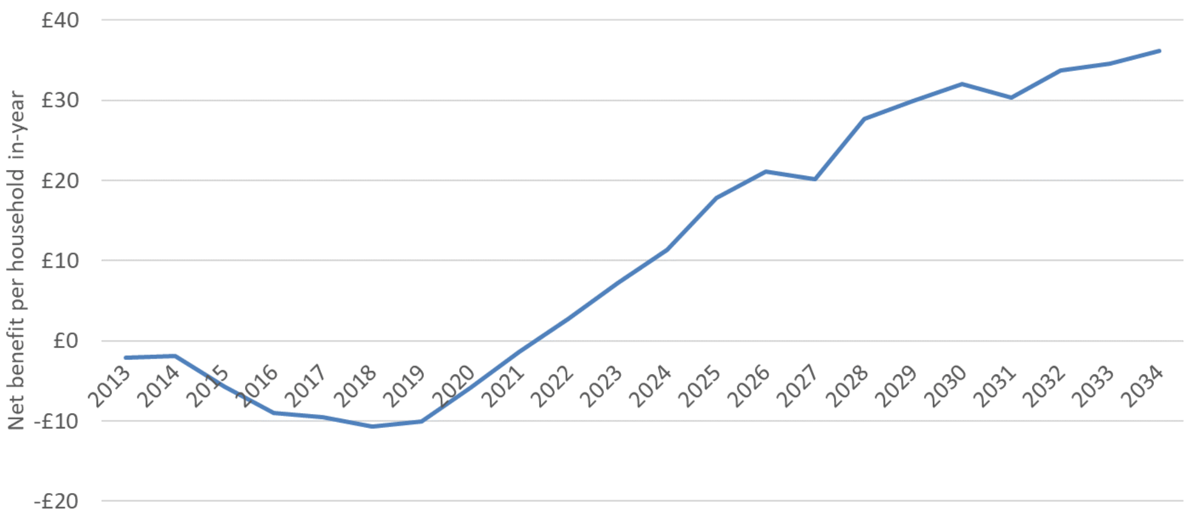
Household Impact

This chapter considers the impact that the smart meter roll-out will have on households within Great Britain.

Net Benefit per Household

The graph below demonstrates the net benefit that each household in Great Britain is expected to realise as a result of the smart meter roll-out. These figures are inclusive of all benefits such as time savings (£1.4bn benefit to 2034), carbon reductions (estimated as 34.4m tonnes) and air quality benefits (valued at £390m to 2034), as well as the bill savings that smart meters deliver through lower average energy consumption and price reductions for periods where suppliers' costs are lower. The net benefit per household is therefore the most accurate measure of the impact that the roll-out will have for consumers as a whole.

Figure 4: Net benefit per household (nominal prices)

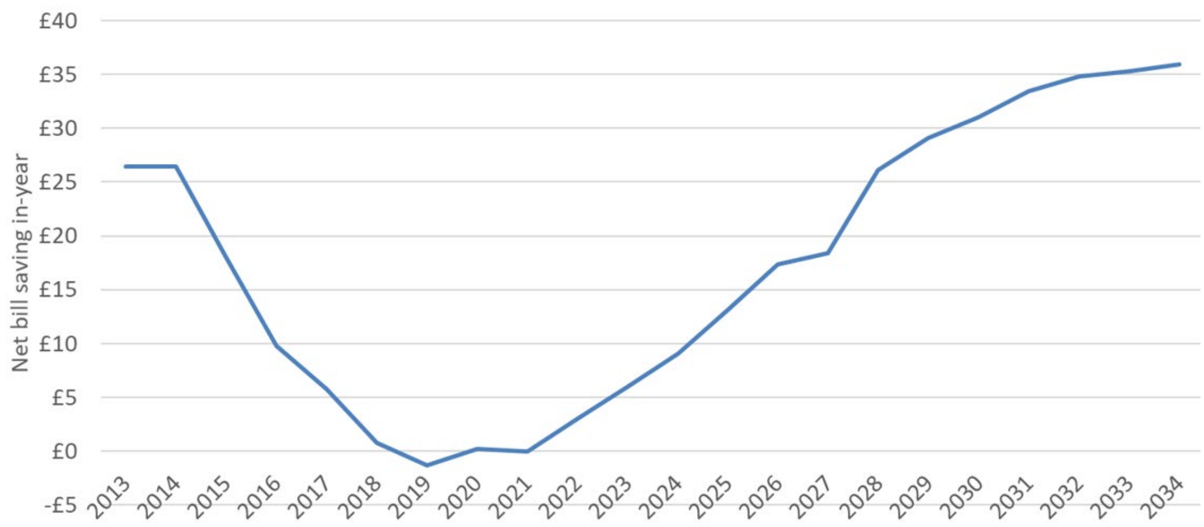


As the graph demonstrates, from 2022 the smart meter roll-out delivers a net benefit to households within GB, and by 2034 the average household will be benefitting by over £36. Over the entire appraisal period, the average household is expected to see a cumulative total net benefit of nearly £250 compared to the counterfactual scenario where the smart meter roll-out was not implemented. This demonstrates that whilst, in common with lots of infrastructure projects, there are net costs to households in the early years of the appraisal period (reaching a maximum of nearly £11 in 2018), these costs are more than offset in the medium-to-long run. Looking across the appraisal period, it is in 2026 that the cumulative benefits from smart meters start to outweigh the costs, and from that year onwards the total benefit smart meters deliver continues to grow in perpetuity.

Bill Impact

As some of the benefits that we measure within our assessment are non-monetary, we have used the BEIS prices and bills model as a basis to estimate the impact that the smart meter roll-out is expected to have on household bills. The graph below shows the estimated average savings that customers with smart meters are expected to realise as a result of the roll-out.

Figure 5: Bill impacts for households with a smart meter (2012 prices)



The earlier a household receives a smart meter, the greater the level of benefit they are expected to realise will be. For example, a dual-fuel household that received a smart meter at the start of the roll-out in 2013 is expected to have bill savings of nearly £380 over the appraisal period, whereas a household that has a smart meter installed in 2020 is expected to realise bill savings of £290 between 2020 and 2034.

Distributional Analysis

The Government is subject to the Public Sector Equality Duty under Section 149 of the Equality Act 2010. This requires public bodies to have due regard to the need to eliminate discrimination, advance equality of opportunity and foster good relations between different people when carrying out their activities. Advancing equality of opportunity includes having due regard to the need to remove or minimise disadvantages, take steps to meet the needs of persons sharing a protected characteristic and encouraging their participation in activities where their participation is disproportionately low. The Public Sector Equality Duty sets out the following protected characteristics:

- Age.
- Disability.
- Gender reassignment.
- Pregnancy and maternity.
- Race (including ethnic or national origins, colour, or nationality).
- Religion or belief.
- Sex.
- Sexual orientation.

From its inception, the Smart Metering Implementation Programme was designed with consumers at its heart and took steps to ensure that all consumers could benefit. This intent to be inclusive by design was underpinned and followed by research which led to specific requirements on accessibility and consumer protection in the regulatory framework for the smart meter roll-out. The experience of groups who might encounter barriers in realising the benefits of smart metering is monitored as part of the programme's evaluation activities.

Availability to All

A key tenet of the programme's delivery plans is that the benefits of smart metering, detailed within this document, should be available to *all* consumers who receive a direct energy supply, irrespective of their individual circumstances. To achieve this, the programme has implemented legislation to oblige energy suppliers to take "all reasonable steps" to ensure that a smart meter is installed in all domestic and small business customers' premises by the end of 2020.

Delivery of a dual-band solution and communications hub and work on the Alt HAN solution are just two examples of the programme taking steps to implement solutions that ensure as many households as possible can receive the full smart meter experience and realise the associated benefits.

Accessibility

In order to maximise the benefits of smart metering, it is important that information about smart meters and how to use the data they provide is made available and accessible to all, irrespective of any disability or impairment. Section 29 of the Equality Act 2010 requires that information is provided in an accessible format where to not do so would put a disabled person at a disadvantage.

To promote a good standard of service by suppliers and to safeguard consumers' interests, the programme worked with Ofgem and suppliers to develop a Code of Practice[81], part of which requires energy suppliers to ensure that their communication materials are available in a suitable format and tailored for groups with specific needs. The code also requires energy suppliers to ensure that their installers are trained to identify potential cases of vulnerability and respond to the needs of vulnerable consumers. Ofgem is responsible for monitoring and enforcement of supplier compliance with the code. Energy suppliers are required to collect post-installation customer surveys – relating to the key elements of the code, including the offer and demonstration of IHDs, the provision of tailored energy efficiency advice and taking into account vulnerability – and submit the results to Ofgem and BEIS. BEIS work closely with Ofgem to support these compliance monitoring activities and engage regularly with energy suppliers in relation to the code. While the code's requirements do add to the average installation cost[82], these additional costs are judged to represent good value as they improve the consumer experience and support consumers in realising smart metering benefits.

Energy suppliers are also required to ensure that they offer IHDs that meet accessibility needs, including for consumers with impaired sight, dexterity and memory. A number of IHD manufacturers are developing versions of their IHDs that meet accessibility needs. This includes an Accessible In-Home Display for blind and partially sighted customers that has been developed in partnership between Energy UK, the Royal National Institute of Blind People and geo. The roll-out of these devices will ensure that consumers have access to the full range of smart metering benefits.

Maximising Understanding

The near real-time data displayed on IHDs and the historical data captured by the smart meter are key enablers of consumer benefits. Therefore, it is not sufficient to merely ensure that smart meter data is accessible to consumers; it is also necessary to ensure that all consumers understand and act on this information in order to

[81] https://www.ofgem.gov.uk/ofgem-publications/57316/smartmeteringinstallationcodeofpractice-pdf
[82] These added costs are factored into the installation costs used within our analysis.

reduce energy usage, save money on bills and/or make informed choices about their energy tariff.

For most consumers, the first point-of-contact with smart metering information will be during the installation, so this provides a vital opportunity to engage the consumer and help them understand how this information can help them to save money. For this reason, suppliers are required to provide a demonstration of how the IHD works as well as energy efficiency advice at installation. The programme, together with Ipsos MORI and the Energy Saving Trust, developed a toolkit[83] in 2016 to advise on how this advice can be effectively tailored to be of specific relevance to each consumer. Vulnerable consumers were specifically included in the development and testing of this toolkit.

In addition, energy suppliers were required by their licence to establish a central delivery body (now known as Smart Energy GB), the objectives of which are also set out under licence. Smart Energy GB has a clear objective to assist consumers with low incomes and those who may face additional barriers in being able to realise the benefits of smart metering. As part of this, Smart Energy GB runs a partnership programme which works with National Energy Action, Energy Action Scotland and the Charities Aid Foundation to deliver funding, support and training for regional and local partners to work in communities raising awareness and understanding of smart meters amongst harder-to-reach audiences[84].

Research undertaken by BEIS and others has demonstrated that some vulnerable consumers will need further support if they are to realise the full benefits of smart metering. In light of this, BEIS led a project working with energy suppliers, Ofgem and consumer groups to develop a framework for the provision of smart metering support. This framework is designed to ensure that customer journeys work well for all consumers, meet their expectations and give them the confidence and ability to use their smart metering systems to manage their energy appropriately. The framework[85] was agreed in October 2017 and is composed of eight principles for suppliers to follow, including:

- At least one proactive contact with all consumers after their installation, alerting them to sources of smart metering support.
- Making a dedicated point-of-contact available for all consumers who require further support or information regarding smart metering.
- Establishing relationships with local and community providers of smart metering support and actively referring consumers to them for further support where a need is identified.

[83] https://www.gov.uk/government/publications/best-practice-guidance-for-the-delivery-of-energy-efficiency-advice-to-households-during-smart-meter-installation-visits
[84] Further information about this partnership programme can be found at https://www.nea.org.uk/smartenergygb/.
[85] https://www.nea.org.uk/smartenergygb/consumer-reference-group/

The Department's 2018 Customer Experience Study found that the experiences of groups who are more likely to be in vulnerable circumstances were broadly consistent with those of non-vulnerable consumers, and in some cases were better. For example, low income groups were generally more satisfied with the supporting materials provided alongside the installation: consumers with incomes lower than £16,000 were more satisfied than higher income groups (81% vs. 75% for those with an income over £30,000)[86]. Another example is that social renters showed higher levels of satisfaction with their smart meters (84% vs. 72% for owner-occupiers) a year after installation.

However, the study also identified some groups as requiring further support on how to realise benefits. Consumers aged over 65, for example, were less likely to recall being given a full demonstration of their IHD and whilst they were more likely to say they were satisfied with the energy efficiency advice they received, they were less likely to say that their understanding of their energy use had improved[87]. In 2019, the funding and support available through Smart Energy GB's partnership programme is targeted at partners who reach people over the age of 65. This work builds on a programme of activity undertaken in 2018, designed to support people over the age of 60 with no personal internet access, people over the age of 65, those on a low income and individuals who are severely and profoundly deaf.

Protecting Customers

While the installation visit provides an important opportunity to promote energy saving behaviour, consumers must be protected from unwelcome sales and marketing at home. The Installation Code of Practice requires energy suppliers to meet certain standards around the installation visit, including requiring prior customer consent to carry out any face-to-face marketing and not concluding any sales during a domestic installation visit.

Ofgem publishes a Customer Vulnerability Strategy, which stipulates a range of rules and principles that suppliers must follow to protect vulnerable customers. These clarify that the same safeguards as for traditional metering remain in place for consumers with smart meters. In particular, suppliers must take all reasonable steps to ascertain a customer's ability to pay when calculating debt repayment tariffs and should only consider disconnections as a very last resort. Suppliers' licence conditions also prohibit them from knowingly disconnecting any customer who is of a pensionable age or who solely lives with people that are of a pensionable age or under 18 during the winter months. Additionally, they must take all reasonable steps to avoid disconnecting those that are disabled or chronically sick during winter. Many suppliers have further pledged to never knowingly disconnect any vulnerable

[86] Ipsos MORI, 2017 Smart Meter Customer Experience Study (BEIS, 2018): https://www.gov.uk/government/publications/smart-meter-customer-experience-study-2016-18.

[87] Those surveyed who were in the 65+ age group were: less likely to recall being shown through each screen of the IHD (72% vs. 77% average); more satisfied than lower age groups with energy efficiency advice (83% vs. 74% for 18-34 and 77% for 45-59); and less likely to say their understanding of their energy use had improved (43% vs. 62% for those below 45 years old, or 57% of those below 65 years).

customer at any time of the year. This is reflected in Ofgem statistics[88], which show that domestic disconnections have fallen substantially, with only 17 in total taking place during 2017.

Ofgem recently ran a call for evidence[89] focussed on the possible risks of prepayment customers self-disconnecting, which occurs when they go off-supply due to a lack of credit on their meter. This can result in increased vulnerability, placing consumers at risk. Smart meters can be beneficial in mitigating these risks, as the flow of data they provide enables suppliers to spot such instances more quickly, allowing them to identify vulnerable customers who might be at risk. During the “Beast from the East” in 2018, one energy supplier made use of the remote functionalities provided by smart meters to remotely top up all their customers who were off-supply in order to ensure that they would be able to heat their premises.

In addition, a number of general obligations apply to suppliers in relation to their interactions with vulnerable consumers, which are also applicable to the context of the smart meter roll-out:

- Energy companies are required by Ofgem to provide non-financial support to consumers in vulnerable circumstances via Priority Services Registers. Suppliers must take all reasonable steps to identify consumers who may benefits from these services.

- In August 2017, Ofgem confirmed the addition of a new vulnerability principle to the domestic Standards of Conduct that clarifies to suppliers that, in order to uphold their obligation to treat all domestic customers fairly, they need to make an extra effort to identify and respond to the needs of those in vulnerable situations.

Prepayment Customers

Prepayment consumers are more likely to be in vulnerable circumstances. Estimates[90] suggest that prepayment customers are more likely to be on low incomes and around 22% of prepayment customers in England are fuel poor, compared to 7% of direct debit customers and 16% of standard credit customers. Prepayment customers are also more likely to be disabled, with around a fifth having a physical or mental impairment, and are more likely to be in the C2DE social economic groupings.

[88] https://www.ofgem.gov.uk/about-us/how-we-work/working-consumers/protecting-and-empowering-consumers-vulnerable-situations/consumer-vulnerability-strategy/consumer-vulnerability-strategy-reporting-progress
[89] https://www.ofgem.gov.uk/publications-and-updates/prepayment-self-disconnection-and-self-rationing-call-evidence
[90] All data here from https://www.ofgem.gov.uk/publications-and-updates/consumer-vulnerability-strategy-progress-report.

The programme's Customer Experience Study[91] in November 2018 showed that smart metering is transforming the prepayment customer experience for the better – smart prepayment customers are especially likely to be satisfied with their smart meters, with eight-in-ten respondents satisfied around a year following installation. Smart prepayment respondents were also more likely to recommend smart meters, with six-in-ten giving the maximum score of 10 out of 10 when asked how likely they would be to recommend a smart meter to friends and family and only 5% giving a score of 4 or below. In addition, almost nine-in-ten said topping-up had become easier with a smart meter. Prepayment meters also deliver higher levels of benefit due to the savings associated with the prepayment infrastructure discussed above as well as the higher time savings that accrue to prepayment customers compared to standard credit and direct debit customers.

Additional Impacts

In light of the provisions put in place, we expect vulnerable consumers to be able to realise the full benefits of smart metering. In addition, BEIS consumer research has shown a number of other benefits that we expect to be available to these consumers, including:

- Improved budgeting and peace-of-mind, particularly for prepayment consumers.
- Increased convenience and reassurance from avoided need to read (often inconveniently positioned) meters or allow meter readers into the property.
- Possibility for "comfort taking" (i.e. enabling consumers to have the confidence to spend more to achieve appropriate levels of comfort) owing to better understanding of energy spending through greater access to data and real-time energy use.

Furthermore, we expect that smart meters will enhance the ability of consumers in vulnerable groups to identify cheaper tariffs that enable appropriate heating of homes to be afforded.

The activities described above illustrate how the programme is actively monitoring this area, both through discussions with energy suppliers and Smart Energy GB and also via a programme of research designed to shed light on any emerging issues which the programme can seek to address.

[91] https://www.gov.uk/government/publications/smart-meter-customer-experience-study-2016-18

Annex 1 – Sensitivity Tests

As part of our analysis, we have undertaken a series of sensitivity tests. Some of these are in response to recommendations from the National Audit Office (NAO), others to highlight the impact that changing key assumptions could have on the final NPV. The sensitivity tests we have undertaken are:

<u>Sensitivity tests that impact both costs and benefits</u>

- Impact of removing the 2020 deadline (in response to the NAO recommendations).
- Impact of delaying the completion of the roll-out.
- Impact of changing the percentage of smart-type meters installed in the non-domestic sector in the counterfactual.
- Impact of changing the assumed cost of capital.
- Impact of alternative appraisal periods.
- Impact of considering only future costs and benefits.

<u>Sensitivity tests that impact costs</u>

- Impact of different productivity assumptions for installation costs.

<u>Sensitivity tests that impact benefits</u>

- Impact of different values for energy saved.
- Impact of different values of time for time savings.
- Impact of different site visit assumptions.
- Impact of different customer switching rates on switching benefits.
- Impact of different levels of demand shifting.

We also conduct a breakeven analysis to assess how many meters need to be installed to reach an NPV of zero, after which each additional meter installed adds to the net benefit.

Sensitivity Tests that Impact Both Costs and Benefits

The following sensitivity tests assess the impact of changes to the underlying assumptions, specifically around the roll-out curve.

Impact of 2020 Deadline

As part of their review of the smart meter roll-out in 2018, the NAO recommended that the Department assess the costs and benefits of retaining the 2020 deadline for suppliers to take all reasonable steps to install smart meters in relevant properties by the end of that year, rather than proceeding with the roll-out at a slower pace. To address that recommendation, the analysis below considers the effects of removing the 2020 mandate and replacing it with an obligation to take all reasonable steps to install smart meters in relevant properties by the end of 2023, as suggested by Citizens Advice[92]. In this scenario, it is difficult to anticipate exactly what levels of smart meter installations would be undertaken by energy suppliers. For this reason, we model a range of possible outcomes:

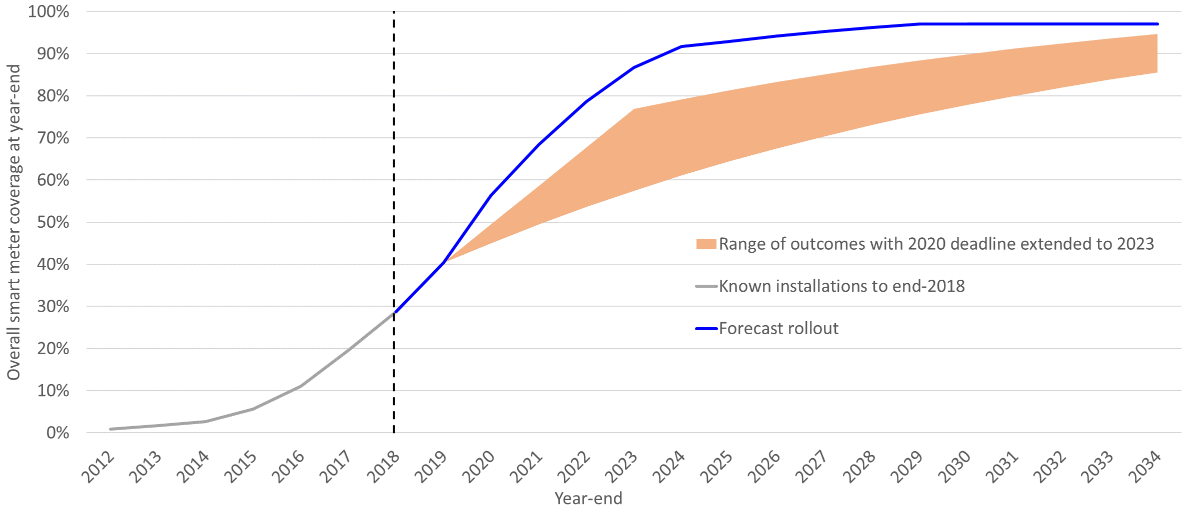
- As a minimum, suppliers would install at least those meters that they are obligated to under the New and Replacement Obligation – namely installing SMETS2 meters when connecting any new metering point or replacing a traditional meter.
- Any installations beyond this minimum would be optional for consumers, meaning that we could not be confident that the momentum of the roll-out would be maintained. However, as a maximum we consider the coverage that would be delivered if 2018 installation rates were maintained[93]. After 2023, only new and replacement installations would take place.

We would therefore expect extending the existing 2020 deadline to 2023 to result in smart meter coverage falling somewhere within the orange-shaded region in the following chart:

[92] https://www.citizensadvice.org.uk/about-us/how-citizens-advice-works/media/press-releases/citizens-advice-responds-to-latest-smart-meter-installation-figures/

[93] Experience of the existing “all reasonable steps” obligation to date has suggested that any further acceleration in installation rates is unlikely to be delivered under this option.

Figure 6: Potential impact of the removal of the 2020 deadline and its replacement with a new 2023 deadline

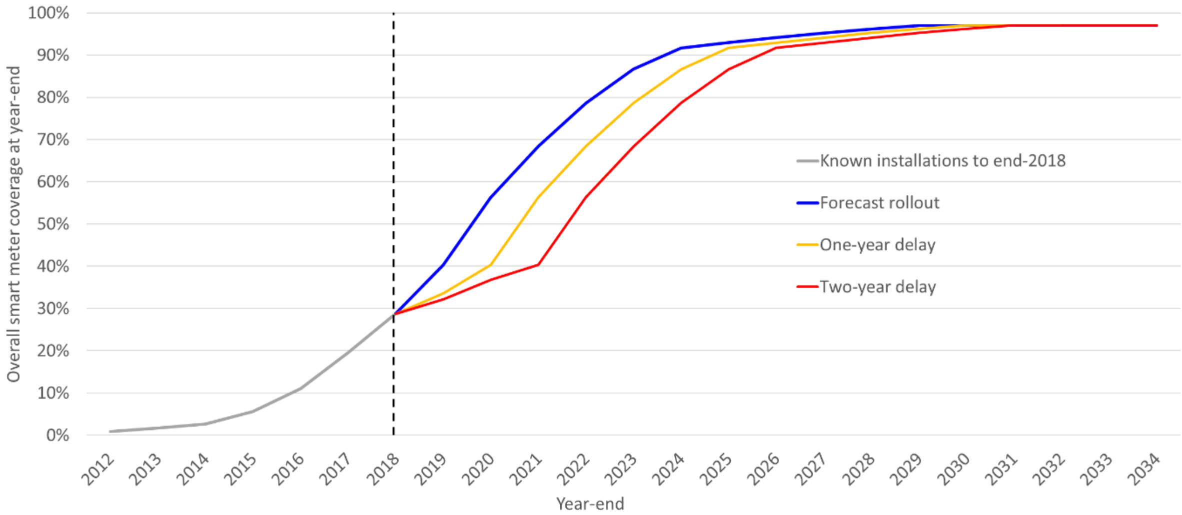


This shows that extending the deadline out to 2023 could, in the worst case, result in smart meter coverage only reaching 86% by 2034. This extension would be expected to reduce the NPV by between approximately £1.0bn to £2.3bn.

Impact of Delays

Our central roll-out forecasts for the period 2021-24 are based on the installation rates that we expect energy suppliers to be able to achieve under the proposed post-2020 policy framework. This policy framework is expected to deliver overall smart meter coverage of over 90% by the end of 2024. Whilst we believe that the roll-out curve assumed in the analysis is achievable, we have also modelled the impact that delays of one or two years would have. To understand the potential impact of such delays, we consider the following alternative roll-out profiles, which effectively shift the post-2020 installation curve to the right:

Figure 7: Potential impact of delays on the smart meter roll-out[94]



With a one-year delay (yellow line), coverage in 2024 would fall to 87% and the NPV would be reduced by approximately £490m. A longer delay of two years (red line) would have a greater impact, reducing coverage in 2024 to 79% and leading to a fall in NPV of approximately £1.0bn.

Non-Domestic Roll-Out Counterfactual

The non-domestic counterfactual assumes that 50% of metering points (both gas and electricity) would have been replaced with smart-type meters in the absence of the programme's mandate. However, the observed uptake of gas smart-type meters has been significantly lower than that of electricity, implying that the 50% threshold may be too high. Reducing this to 40% for gas would see the NPV increase by approximately £90m, whilst doing likewise for electricity would increase the NPV by approximately £50m.

Cost of Capital

Throughout this analysis, we have used a figure of 6% for the cost of capital for energy suppliers (based on a review of current rates across the energy sector). This impacts upon several areas of our analysis:

- Metering asset and installation costs, which are annuitized at this rate across the lifespan of the meter.
- Industry IT costs, which are annuitized over a five-year period.
- Debt handling benefits, which accrue to energy suppliers as the cost of capital that they avoid by reducing the size of their debt books.

[94] These are illustrative roll-out profiles designed to test the potential impact of various delays. They are not intended to represent expected roll-out behaviour.

As cost of capital can vary based on the state of the market and the wider economy, it is prudent to assess the impact on our analysis of alternative cost of capital assumptions. For this reason, we have tested a range of assumptions from 3% up to 10% - the resulting NPV impacts are indicated in the table below:

Table 12: Estimated impact of different cost of capital assumptions on final NPV

Cost of capital	3%	4%	5%	7%	8%	9%	10%
NPV impact	+£540m	+£370m	+£190m	-£200m	-£410m	-£600m	-£850m

Appraisal Period

We have considered several different appraisal periods for this analysis, each of which would have considerably altered the final NPV. The table below demonstrates the impact that different lengths of appraisal period would deliver. We have chosen to show the impact of 2035, 2038 and 2040 end-dates for the appraisal period to demonstrate a range of possibilities. We include 2038 as this year represents 15 years after the proposed end of the programme in 2024 so would see all meters installed under the proposed obligation appraised for their full lifespan.

Table 13: Impact of different appraisal period end-dates on total NPV

Year	**Change in NPV**
2035	+£1.0bn
2038	+£4.0bn
2040	+£6.1bn

Excluding Sunk Costs and Benefits

This analysis includes all costs and benefits of the programme and therefore captures a significant number of sunk costs and benefits. A more accurate view of the benefits that the programme will deliver into the future can be gained by excluding these sunk costs and benefits, instead appraising over the period 2019-2034. To do so would increase the NPV by approximately £1.4bn, to a final NPV of £7.4bn.

Costs

As we rely on collected data for most of our cost estimates, the scope for sensitivity tests is limited. However, our estimates for installation costs are reliant on an assumed productivity profile beyond 2020, and we test the sensitivity of this assumption below.

Installation Costs

Our analysis of installation costs necessarily assumes a profile for productivity beyond 2020. This profile is based on the successful completion of key workstreams within the programme both unlocking additional properties (such as the successful delivery of an Alt HAN solution) and driving up installer productivity (for example, through best practice sharing and benchmarking among energy suppliers). Whilst we are confident that the assumed profile can be met based on observed performance, feedback from suppliers and known policy interventions that will drive an increase in productivity, we nevertheless test the impact of a possible deviation from those expectations.

In a scenario where productivity is overestimated in our model, we have assumed a profile where there are no additional improvements in productivity beyond the observed average level based on the data provided by suppliers. This leads to a 20% lower productivity in 2020, which adds £11 to single-fuel installations and £15 to dual-fuel installations and reduces NPV by £580m.

In a scenario where productivity is underestimated in our model, we have increased the level of productivity to the maximum level forecast to Ofgem by a single supplier, which is a 20% higher productivity in 2020 than in our model. This reduces single- and dual-fuel installation costs by £4 on average and increases the NPV by approximately £190m.

Benefits

The following sensitivity tests assess the impact of changing assumptions within different benefits categories.

Energy Savings

Our analysis assumes roughly one in three smart meter customers are able to realise energy savings that are consistent with those observed by BEIS of customers of higher-performing suppliers. This gives average energy savings rates of 3% for electricity (credit and PPM customers) and 2.2% for gas (credit customers only).

The data we currently hold comes predominantly from the largest suppliers, and necessarily covers a time period where factors such as the provision of energy efficiency advice were delivered less consistently than they are now. There is therefore reason to believe that in future, customers may realise higher savings than those assumed in this CBA. If two thirds of customers are able to realise the level of savings that customers of the highest performing suppliers have achieved, then the average energy savings would increase to 3.3% for electricity (credit and PPM customers) and 2.4% for gas (credit customers only). This would increase the NPV by approximately £590m (£440m from reduced energy consumption and £150m from carbon and air quality benefits).

Conversely, we have also conducted a sensitivity test that assumes the observed average rate of savings in 2016 is maintained with no improvements made by industry. This results in average savings of 2.8% for electricity (credit and PPM customers) and 2.0% for gas (credit customers only). This would decrease the NPV by approximately £530m.

Customer Time Savings

Our analysis uses the Department for Transport value of non-commuting leisure time as the best proxy for the value of customer time saved by no longer having to submit meter readings or engage with the prepayment metering system. It is a conservative assumption, as this value was the lowest that we considered in our review of the literature, and as it is not directly linked to the specific task of reading an energy meter and submitting this reading.

The highest value of time we considered using was the average wage value of £11.41 per hour (2019 average wage in 2011 prices). We consider this to be a plausible maximum rate for the value of time, as economic theory suggests that a person's wage rate represents the opportunity cost of labour; i.e. if they were not engaged in activity related to their energy meter they would be able to engage in paid employment instead and earn a wage. Were we to have used the average wage rate in our analysis, the total NPV would have increased by approximately £2.0bn.

We also do not include any time savings for the non-domestic sector as the results of the research conducted focussed purely on households and not businesses. However, if we were to assume that businesses save the same amount of time per meter as households, and that this time is valued at the average wage rate (as in the non-domestic sector the activity foregone is productive rather than leisure time), then the value of these time savings would add approximately £120m to the NPV.

Avoided Site Visits

Given the changes to the market in recent years, it has proved difficult to effectively estimate the number of meter readings per meter per year that would take place in the counterfactual. Data returned from suppliers suggests a value of 1.4, but this will have been impacted by the introduction of smart meters allowing suppliers to reduce the frequency of meter reads. The 2016 CBA assumed a level of 2 reads per meter per year, based on assumptions from the Mott McDonald report in 2007, at a time when the roll-out had not begun and therefore no effect could be attributed to smart metering.

In our analysis, we chose the midpoint of these two points as our best estimate for the counterfactual number of meter readings. However, had we used the values of 2 or 1.4, then the NPV would have been approximately £320m higher or lower respectively.

Customer Switching

The cost savings from obtaining a change of supplier meter reading are based on data for 2018. By using this, we have implicitly assumed that the rate of switching would remain at that observed in 2018 for the remainder of the appraisal period.

However, the rate of switching over the past few years has been increasing, by around one percentage point per year[95], to reach 19% of customers in 2018. If this trend were to continue for a further year (thus reaching 20% in 2019), the NPV would increase by £30m – future increases in the switching rates would also increase the estimated cost savings. If the switching rate were to continue to rise by one percentage point per year to 2034, then the assumed switching rate would be 35% by the end of the appraisal period and the total increase in NPV would be approximately £220m.

Customer Calls

In our analysis, we assumed that smart meter call costs reduced to those of traditional meters from the second year following installation, in line with the experience of suppliers in the roll-out thus far. Were costs to fall more gradually, for example, as the central scenario for 50% of customers but from year three for the remaining 50% of customers, then the NPV would reduce by approximately £15m.

Demand Shifting

There is significant uncertainty around the uptake of time-of-use tariffs over the appraisal period, since this is an emerging market and we do not yet have enough data on customer behaviour to draw firm conclusions. The assumptions used in our analysis assume a modest uptake of 19% of households on a time-of-use tariff by 2030, resulting in total demand that can be shifted increasing from 1% in 2020 to 15% in 2034. We have also modelled a scenario where only 9% of households are on a time-of-use tariff by 2030, with the resulting reduction in total demand that can be shifted to just 7% in 2034. This would reduce the overall NPV by approximately £230m.

Breakeven Analysis

In order to achieve breakeven, after which the benefits accrued begin to exceed the total costs of the roll-out, our analysis shows that total smart meter coverage of 32.5% is required. This level of coverage has already been achieved during 2019, which means that the benefits delivered by the meters already on-the-wall are sufficient to pay for the total fixed and already incurred costs of the roll-out across the appraisal period. Therefore, all meters installed from now on will provide a positive net benefit to society.

[95] https://www.gov.uk/government/statistical-data-sets/quarterly-domestic-energy-switching-statistics

Annex 2 – Changes Relative to 2016 CBA

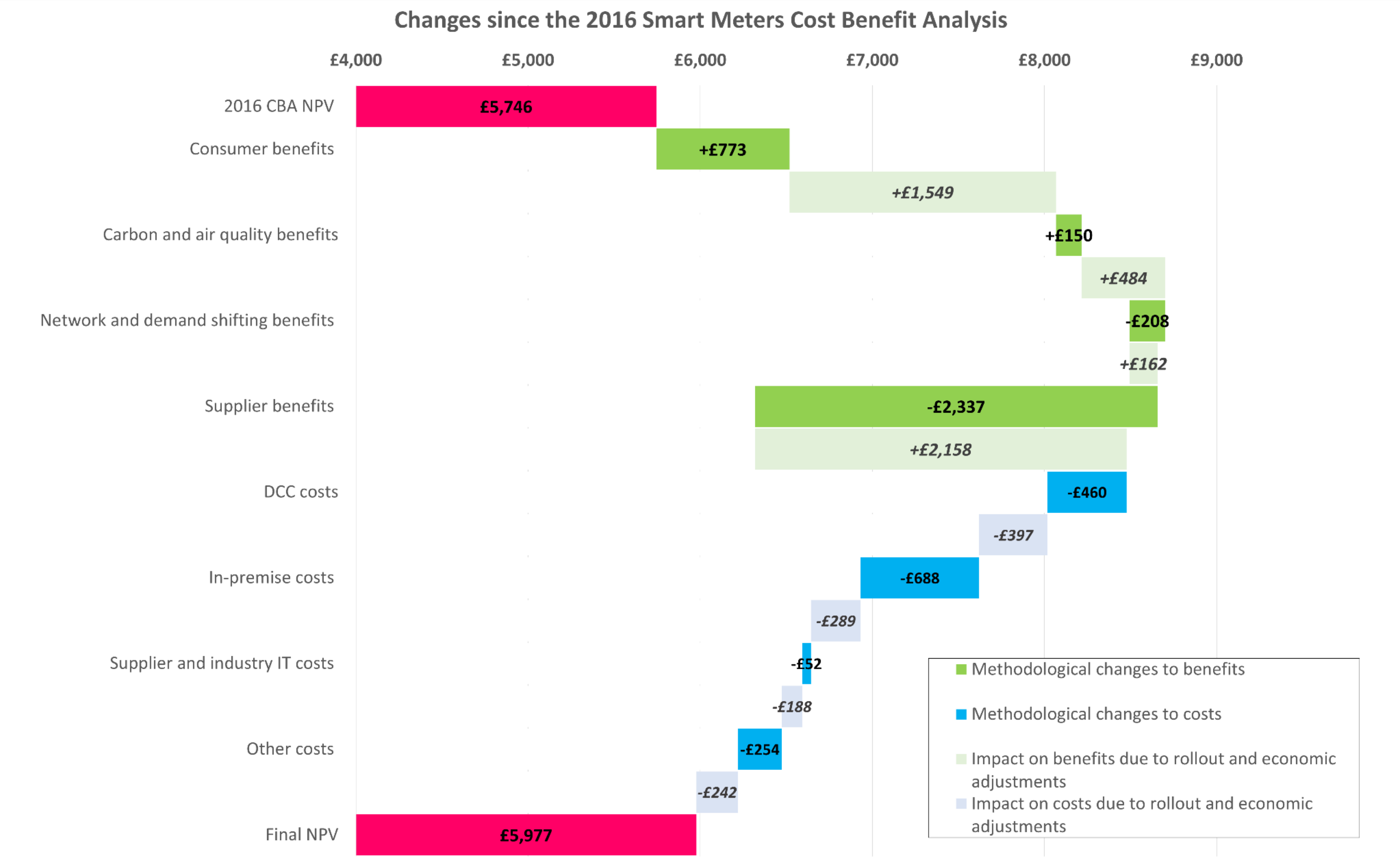
This Annex summarises the changes that we have made to the CBA relative to the 2016 analysis, including the reasons for why these changes have been made. In general, these changes have come about due to one or more of the following factors:

- The programme having access to new or improved data.
- Changes to the retail energy market (most of the time unrelated to smart metering), resulting in the counterfactual changing.
- Methodology reviews resulting in more robust ways of estimating outputs.

Waterfall Chart

The waterfall chart below shows the changes that have occurred to each individual component of the CBA relative to the 2016 document. The dark bars represent the changes that would occur were we to run the analysis with our new data and methodologies but based on the underlying assumptions used in the 2016 CBA. The lighter bars show the impact of the economic adjustments we have made within the analysis, such as updating the roll-out curve, extending the appraisal period to 2034 and updating the present value base year from 2016 to 2019.

Figure 8: Waterfall chart showing changes from 2016 to 2019 CBA



Changes in Costs

Once steady state is reached, ongoing costs are around £670m per annum, which is in line with those in the 2016 CBA. In terms of costs across the appraisal period, the majority of cost changes are due to changes in the appraisal period (which now ends in 2034 rather than 2030) and present value base year (which is now 2019 rather than 2016). On a like-for-like basis (2016 present value, 2013-30 appraisal period), costs have decreased by £330m, reflecting the fact that undiscounted costs to 2030 have decreased by £300m (from £13.7bn to £13.4bn) and are incurred later, reducing their present value as they are subject to higher discounting on average.

Installation Costs

The 2016 CBA estimate for smart meter installation costs was based on projections to 2020 provided by a number of energy suppliers and meter operators. These costs have been updated to reflect new evidence collected on current installation costs. Additionally, our new analytical assessment incorporates cost estimates for the proportion of the roll-out which is now expected to occur post 2020.

Installation costs have increased compared to the 2016 CBA, primarily due to the more gradual increase in the roll-out meaning that the expected productivity gains from a higher volume of installations have been delayed. The productivity gains are now assumed to be achieved in later years. We have also replaced the 2016 installation cost estimates with real data gathered from energy suppliers and meter operators, which are higher than previously assumed.

Since the 2016 CBA, the programme has collected new evidence on traditional meter installation costs from statistical returns from energy suppliers. This evidence indicates that costs for traditional meter installation have increased. However, a portion of the traditional meter installation cost increase is driven by the smart meter roll-out, as any remaining traditional meter installations would incur inefficiencies due to lower volumes. The full cost increase has been reflected in the policy scenario. However, not all of this cost increase would have been observed in the counterfactual as traditional meter installations would have continued at scale in this scenario, so inefficiencies would not have been observed. Therefore, only a portion of the traditional meter installation cost increase is applied to the counterfactual.

Total net installation costs have increased relative to the 2016 CBA by approximately £1.1bn (this figure – as with all values presented in this Annex – is based on the 2016 roll-out curve; in reality the increase is significantly lower as discussed above).

Meter, In-Home Display and Operations and Maintenance Costs

Meter Costs

The programme has collected new evidence on the asset costs of smart, advanced and traditional meters from statistical returns from energy suppliers and through regular contact with delivery partners. This showed that the cost of smart meter assets has reduced from the 2016 CBA value, driven by a more competitive market and lower production costs.

In-Home Display Costs

The cost of IHDs has not changed relative to the 2016 CBA but we have now included an allowance for the provision of a limited number of accessible devices, which are currently more expensive than traditional IHDs as they include additional features such as speech functions and are produced in smaller volume. This increases the average cost from £14.70 to £15 per IHD.

Operations and Maintenance Costs

We have not changed the assumptions we use in relation to operations and maintenance costs of the smart meter asset itself from the 2016 CBA. These remain at 2.5% of the smart meter asset cost and this figure has been tested with industry and agreed as a reasonable estimate.

Combined Impact

The combined changes in meter, In-Home Display and operations and maintenance costs is a reduction of approximately £570m relative to the 2016 CBA.

Communications Hubs Costs

The programme has collected new cost evidence from energy suppliers for communications hubs installed with SMETS1 meters and from the DCC for SMETS2 communications hubs.

For meter installations at properties which have gas and electricity meters but where energy is provided by two different energy suppliers, the analysis has been updated to take account of the lack of interoperability of SMETS1 communications hubs before they are enrolled into the DCC. The new assumption is that there are 1.66 communications hubs at these premises, instead of 1 communications hub per premises as assumed in the 2016 CBA. This assumption is based on evidence from statistical returns from energy suppliers.

The cost of capital for SMETS2 communications hubs has been reduced compared to the 2016 CBA from 6% to 4.2%, based on the observed rates set in contracts with the DCC and an estimated future rate.

This analysis has also been updated to reflect the different operational expenditure expected for SMETS1 communications hubs before and after they are enrolled into the DCC. The SMETS2 communications hub operational expenditure has been separated from SMETS1 communications hubs to reflect their lower ongoing cost.

Based on latest evidence on the cost of dual-band communications hubs provided by DCC, the additional cost over a single-band communications hub per device has been updated from £2 to £23. However, the proportion of premises that are expected to be fitted with a dual-band communications hub has reduced from an assumed 50% to 25% based on the current assumed level of HAN coverage.

The impact of the capital expenditure on communications hubs is a reduction in total costs of approximately £210m relative to the 2016 CBA.

DCC Costs

Costs incurred by the DCC in setting up and running the data and communications services needed for the successful delivery of the smart meter roll-out have increased primarily due to a broadening of the scope of activities coming under DCC’s purview. In particular, we now include within this category the cost of the external service provider contracts that DCC has signed to deliver an enrolment service to enable SMETS1 meters to retain smart services when customers switch supplier. Previously, these costs were included within operational expenditure incurred by suppliers and their magnitude was known with considerably less certainty. Similarly, the costs associated with developing and testing dual-band communications hubs have increased both with the greater certainty around the challenges that they are required to address that we now have and due to increased foreign exchange costs.

All these increases in scope have necessitated higher DCC staff headcounts, driving increases in internal costs as well, which are reflected in the new figures.

These changes in scope increase the total cost by approximately £460m[96].

Increases in operational expenditure associated with communications hubs, which was presented within this section of the 2016 CBA, contribute a further cost increase of approximately £360m.

Supplier and Industry Capital Expenditure

An additional supplier cost has been included compared to the 2016 CBA to reflect the costs suppliers are expected to incur to enrol SMETS1 meters into the DCC. These costs are consistent with the analysis contained within the consultation responses[97] on the enrolment of SMETS1 meters. These include costs for IT change, firmware upgrades, testing and migration.

Additionally, based on new evidence from energy suppliers, supplier IT capital expenditure is annuitised over 5 years rather than the 15 years assumed in the 2016 CBA and the cost of capital has been reduced from 10% to 6%. This increases costs in the short-term but reduces total IT capital expenditure over the whole appraisal period due to lower interest charges.

These combined have led to a reduction in costs of approximately £50m relative to the 2016 CBA.

Organisational and Industry Set-Up Costs

There have been no changes to assumptions associated with the initial legal, institutional and organisational set-up of the smart meter roll-out across either the energy industry or Government.

Other Costs

Disposal Costs

Our assumptions around the cost of disposing of traditional metering equipment remain unchanged from those used in the 2016 CBA.

[96] Much of this cost increase was already identified in the National Audit Office's report on "Rolling out smart meters", published in January 2019. This identified DCC cost increases of £300m out to 2025, with a further £80m increase expected to 2030. Our current analysis shows that these cost estimates have increased by a further £77m (in comparable terms, using 2011 prices and 2016 present values). This is due to a combination of factors, including the integration of some core testing operations within the DCC and greater certainty on some costs associated with SMETS1 enrolment than was available in the end-2017/18 data on which the National Audit Office's analysis was based.

[97] https://www.gov.uk/government/consultations/enrolment-of-smets1-meter-cohorts-with-the-data-communications-company and https://www.gov.uk/government/consultations/enrolment-of-secure-smets1-meters-in-the-data-communications-company-dcc.

Energy Consumption by Smart Metering Equipment

In addition to updating the value of energy consumed by meters to be consistent with the values published in the Green Book supplementary guidance[98], we have updated the methodology to include and monetise energy costs associated with the technologies that are likely to be used as part of the Alt HAN solution. This did not form part of the 2016 analysis.

We now include costs associated with consumption of energy by IHDs within the overall assessment of energy savings. These costs are therefore removed from this section of the CBA.

Pavement Reading Inefficiency

The cost of meter reading used to derive the additional cost attributable to pavement reading inefficiency has been updated in line with the changes to the cost of avoided meter readings (see avoided site visits).

Combined Impact

Overall, these changes have reduced total costs by approximately £250m.

Alt HAN Costs

This is a new cost item for the 2019 CBA, as the regulatory framework necessary to enable energy suppliers to work collaboratively to develop an Alt HAN solution only came into force in July 2016.

Since then, the Alt HAN programme has progressed and has access to firmer cost estimates as it proceeds through the procurement process. Costs presented within this CBA include significant levels of optimism bias for this area, to reflect remaining uncertainty around the final cost.

The latest estimate of the cost of Alt HAN is approximately £290m.

Smart Energy GB Costs

Our analysis includes the latest cost estimates provided to the Department by Smart Energy GB, reflecting the costs set out in their published budgets, which have been agreed by energy suppliers. Future forecasts provided by Smart Energy GB beyond 2021 have been included in the analysis' projection of future costs, as these are yet to be agreed with energy suppliers.

Smart Energy GB costs have increased by approximately £30m out to 2021 relative to the 2016 CBA.

Projected Future Costs

These costs were not included in the 2016 CBA and increase total costs by approximately £180m.

[98] https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

Changes in Benefits

Annual steady-state benefits are around £1.9bn, which is in line with those in the 2016 CBA. Across the full appraisal period, changes to the appraisal period (which now ends in 2034 rather than 2030), the present value base year (which is now 2019 rather than 2016) and the fact that we have been able to quantify a new area of consumer benefit are key drivers of the increase in total benefit. On a like-for-like basis (2016 present value, 2013-30 appraisal period) benefits are £3.5bn lower than in the 2016 CBA, due in part to the more gradual roll-out profile. That same profile drives the extension of the appraisal period, which in turn increases net benefits as the costs and the benefits of a greater number of those meters installed later get appraised over their full lifetime.

Energy Savings

The energy savings assumptions have been reviewed to take account of (i) evidence on observed energy consumption reductions, (ii) long-run variable cost of energy projections, and (iii) new projections of household energy consumption.

(i) In the 2016 CBA we assumed that consumers would realise electricity savings of 2.8% (credit and prepayment) and gas savings of 2.0% (credit only), based on large-scale GB trials, international pilots and early evidence from the roll-out. In light of new evidence from energy suppliers on observed energy reductions among their customers, and the conclusions of BEIS' Early Learning Project[99], we now estimate gross average reductions in demand per household of:

- 3.0% for electricity (credit and prepayment).
- 2.2% for gas credit and 0.5% for gas prepayment.

These figures assume that around one third of all energy customers will meet the reductions which evidence shows customers of high-performing energy suppliers can achieve, with the remaining two thirds reducing their energy consumption in line with the programme's original expectations. We are confident that these reductions will continue to be realised through BEIS' existing policy framework and proactive engagement with industry, and through energy suppliers improving the energy efficiency advice they provide to their customers.

(ii) New projections of the long-run variable cost of energy have been integrated into the module, as per HMT Green Book guidance[100]. These are used to value the energy reductions that occur as a result of smart metering. A sustained drop in the cost of energy in the early years of the appraisal period compared to what was projected in 2016 has resulted in a significant drop in the value of energy savings in these years.

(iii) New projections of household energy consumption have been incorporated (which now include observed data to 2017). These take account of smart meters' position in the policy hierarchy, so the energy savings resulting from the programme alone can be identified. The electricity consumption projections generally show a reduction compared with the 2016 CBA, whereas the gas consumption projections have broadly increased. This is the result of

[99] BEIS' Early Learning Project included the conclusion that "…through effective consumer engagement, and it is realistic to expect durable energy savings of 3% based on evidence from the research literature and trials worldwide, the Early Learning Project findings and the potential improvements identified".
[100] https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

revisions to both the projections of final energy demand and to other policies' savings. The energy consumption baseline for non-domestic meters is unchanged.

In total, benefits accruing from energy savings have decreased by approximately £310m relative to the 2016 CBA.

Time Savings

Consumer time savings is a new area of quantified benefit for the 2019 CBA. In comparable terms to the 2016 CBA, this area contributes an additional £1.1bn of benefit[101].

Avoided Site Visits

For this analysis, we have used observed data on the cost and volumes of meter readings and safety inspections for traditional meters, collected directly by the programme from large energy suppliers, for each year from 2012 to 2018. For avoided meter readings, this data has consistently shown an average cost of reading a meter per year of approximately £3. This contrasts with the £5-8 per traditional meter figure obtained via a Mott McDonald study in 2007[102], with the value used in the 2016 CBA of £6 per meter at the lower end of this range.

The 2017 and 2018 datasets provided by energy suppliers disaggregate the cost per meter figure into the cost per reading and the frequency of readings. The data identified a cost per traditional credit meter reading of £2.15, a reduction from the £3 figure assumed to drive the overall cost in 2007. The data also identified a frequency of around 1.4 supplier meter readings per traditional credit meter per year, a reduction on the 2 readings per year figure that was assumed in 2007. It is considered that the roll-out has contributed to this reduction of 0.6 readings per meter per annum – not least through the influence it had on the removal of the SLC12 obligation[103] on energy suppliers to read a customer's meter at least every 2 years in order to conduct a safety inspection. Since the extent of the smart meter contribution is difficult to separate from the effects of other industry developments (for example, increased digitisation and competition driving down operational costs), we have assumed that half of the reduction would have occurred in the absence of the programme. The resulting avoided meter reading frequency of 1.7 is therefore used in this CBA. The overall avoided cost of meter reading activity is therefore £3.65 per meter per annum.

These updates have led to a reduction in benefits of approximately £1.1bn relative to the 2016 CBA.

Inbound Contacts

We have used data collected by the programme on costs and volumes of billing enquiries handled by large energy suppliers in 2018, for each of traditional meter and smart meter customers. From this, we have been able to derive a difference in the cost per call and volume of calls between the two groups. This replaces data used in the 2016 CBA, from the 2007 Mott McDonald study, which displayed higher costs of call handling for traditional meter customers (£7.89, compared to £3.36 now), but a lower reduction in call volumes from smart customers (around 30%, compared with around 60% now).

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[101] This figure is in terms comparable to the 2016 CBA. The total value of this new quantified benefit within this new analysis is £1.4bn.

[102] https://webarchive.nationalarchives.gov.uk/+/http:/www.berr.gov.uk/files/file45997.pdf

[103] https://www.ofgem.gov.uk/ofgem-publications/97556/reformingsuppliersmeterinspectionobligationsfinalproposals-pdf

Taken together, these updates have led to a reduction in benefits of approximately £190m relative to the 2016 CBA.

Lower Cost to Serve Prepayment Customers

The assumptions which underpin the prepayment cost to serve reduction benefit have changed to reflect new evidence that has become available to the programme since the 2016 CBA.

Notably, this includes new information and data which is collected annually by the programme from energy suppliers. This data has led us to refine and revise some of the assumptions around the cost to serve traditional electricity prepayment meters and as a result has produced a lower saving. The two main changes have been a downward revision in the cost to serve traditional electricity PPM from £30 to £26, and a reduction in the percentage of this saving that we attribute to smart meters from 40% to 33%. The decision to make these changes has been informed by the Competition and Markets Authority's report into the cost to serve variance by payment method and data from suppliers on the difference in cost to serve smart and traditional prepayment customers.

Overall this has reduced the total benefits by approximately £150m relative to the 2016 CBA.

Debt Handling

For this analysis, we conducted a new bottom-up assessment of the benefits that energy suppliers derive from improved debt handling capabilities through smart metering. As this is based largely on the costs that suppliers avoid by reclaiming capital earlier, the fall in assumed cost of capital within the energy sector from 10% to 6% since 2016 means that our per-meter debt handling benefit estimate is now around 31p lower than previously.

The overall impact is a reduction in benefits of approximately £190m relative to the 2016 CBA.

Customer Switching

Data has been collected by the programme from the large energy suppliers on the cost of obtaining a meter reading when a customer changes supplier. This replaces data obtained from a request for information from suppliers in 2010 and has reduced the per-customer cost saving by around £0.95. Updated timelines for Ofgem's switching programme have additionally been incorporated, postponing by one year the additional cost savings expected from DCC's management of the centralised registration service.

The impact is a reduction in benefits of approximately £590m relative to the 2016 CBA.

Theft and Losses

Our assumptions around the reduction in theft and distribution network losses remain unchanged from those used in the 2016 CBA.

Change of Tariff

This is a new benefit area for the 2019 CBA, worth £140m in terms comparable to the 2016 CBA.

Remote Disconnections

Data from Ofgem shows that there have been significant reductions in the number of households disconnected from supply as a result of debt in recent years. Data for the 2016 CBA was gathered in the 2007 Mott McDonald report, in a year that saw nearly 8,500 disconnections of supply[104]. The same data source shows that in 2017 just 17 disconnections occurred, and no smart meters have ever been disconnected. We have therefore removed this benefit from the CBA.

This reduces total benefits by approximately £230m relative to the 2016 CBA.

Microgeneration

The 2016 CBA estimated the cost saving that smart meters would deliver for customers who generate their own electricity, for example through solar panels, and export this electricity to the market. Since then, the Department's subsidy scheme for microgeneration, feed-in tariffs, has been replaced by the Smart Export Guarantee. Whilst this new scheme mandates the use of a smart meter when exporting to the grid, there is no reliable estimate for the number of households that will be impacted by the scheme. It has therefore not been possible to estimate the potential benefit and we have removed this from the CBA.

The removal of this benefit reduces the NPV by approximately £60m compared to the 2016 CBA.

Network Benefits

Our analysis of network benefits is largely based on a detailed study, undertaken by PA Consulting, which was commissioned for the 2016 CBA. We have removed the benefits linked to investigation of voltage complaints, because DNOs' experience has shown that existing smart meter specifications do not provide sufficiently robust voltage information to deliver these. In addition, we have made several small updates to some of the data underpinning each benefit area, but aside from those changes this analysis and its results are very similar to those in the 2016 CBA.

The changes above have reduced benefits by approximately £80m relative to the 2016 CBA.

Demand Shifting (formerly Time-of-Use)

Our methodology for measuring the benefits from consumers shifting demand to off-peak times through time-of-use tariffs has changed fundamentally since the 2016 CBA and now utilises the BEIS Dynamic Dispatch Model[105]. Assumptions feeding into the methodology have also changed, assuming a later and slower uptake of time-of-use tariffs relative to the assumptions used in 2016, which estimated that by the end of 2018, 20% of customers would be using a time-of-use tariff.

Overall, demand shifting benefits have reduced by approximately £120m relative to the time-of-use benefits included in the 2016 CBA.

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[104] https://www.ofgem.gov.uk/about-us/how-we-work/working-consumers/protecting-and-empowering-consumers-vulnerable-situations/consumer-vulnerability-strategy/consumer-vulnerability-strategy-reporting-progress

[105] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/65709/5425-decc-dynamic-dispatch-model-ddm.pdf

Carbon and Environmental Benefits

Our assumptions around carbon and environmental impacts have been updated according to Government guidelines, using the most recent carbon values and the most recent air quality damage costs. As air quality damage costs have increased significantly since 2016, our estimate of total carbon and air quality benefits has increased accordingly, by approximately £150m relative to the 2016 CBA.

Changes to Underlying General Assumptions

When we consider the changes to individual costs and benefits, as above, it is possible to isolate the impact of the particular changes we have made relative to the other changes we have made to our modelling. Therefore, the order in which we present these changes does not matter; the impact of introducing time saving benefits and removing remote disconnection benefits is the same no matter how it is done. The same cannot be said for the underlying general assumptions, however. Were we to update the present value base year before we change the roll-out curve, the impact of each change when considered in isolation would be different each time. Likewise, had we changed the underlying assumptions before we made the methodological changes to costs and benefits detailed above, the scale of each change would be different.

In order to make the impact of each change clear, we have therefore introduced all the changes to costs and benefits before we model the impact of changing the underlying general assumptions. We then introduce each change to the underlying general assumptions in turn, so by the time we consider the impact of extending the appraisal period to 2034, all other changes to the costs and benefits, roll-out, present value base year and counterfactual have already been taken into account.

Roll-Out Profile

The roll-out to date has already delivered substantial numbers of smart meter installations, building a strong foundation for an enduring smart system. However, a variety of challenges have restricted the pace of these installations, as a result of which we have revised the roll-out profile used within this analysis. The data used in this CBA reflects the latest actual installation figures available through official statistics, the latest installation forecasts submitted by energy suppliers and the most up-to-date policy position. Compared to the 2016 analysis, we now assume a more gradual roll-out, although market-wide coverage levels are still attained before the end of the appraisal period.

This more gradual roll-out means that the average meter will be installed later and hence benefits will begin being accrued later. In the long-term, the full range of smart metering benefits will still be delivered, but the fact that these begin later means that they attract more discounting within our analysis, thereby reducing our NPV figure. We have also updated how these smart meter installations are split between SMETS1, SMETS2 and AMR (in the non-domestic sector only) meters based on the latest observed installation volumes and energy supplier forecasts.

This has reduced the NPV by approximately £170m.

The total number of metering points within scope for smart metering also impacts upon our analysis. By 2030, we are now forecasting this total number to be almost 2.5 million lower than was forecast in 2016. This is primarily due to reductions in the latest household growth forecasts and lower current numbers of non-domestic gas meters than expected.

This means that there will be fewer meters accruing benefits by the end of the appraisal period, driving an approximate reduction in NPV of £270m.

The combined impact of these two changes is to reduce the NPV by approximately £450m.

Non-Domestic Counterfactual Roll-Out

In the 2016 CBA, it was assumed that a smart-type (i.e. SMETS or AMR) meter would have been installed at 50% of the business metering points in scope of the roll-out under business-as-usual arrangements by the end of the appraisal period (2030), and that the rate of these installations would grow linearly from zero in 2012. However, BEIS statistics[106] show a large number of (mainly electricity) advanced meters which were installed prior to 2013 and are not considered to have been brought about by the programme (but are eligible for the mandate). This number now represents the starting point (2012) of the non-domestic counterfactual roll-out, with a linear growth applied from that point to a 50% threshold reached in 2034 (rather than 2030 in the 2016 CBA, to reflect the updated appraisal period). Whilst this has been applied for both fuels, the main impact is on electricity, where the counterfactual now starts at 18% coverage.

A cap has also been introduced, such that the counterfactual roll-out cannot exceed the policy roll-out – this has reduced the gas counterfactual roll-out between 2012 and 2016 in line with the lower policy roll-out and therefore implicitly assumes that the programme had no impact on non-domestic gas installations until 2017.

The impact of these changes on the NPV is to increase it by approximately £25m.

Present Value

We have updated the present value base year from 2016 to 2019 to reflect the year this appraisal was conducted in. We have also reduced the discount rate applied to costs and benefits from 2013 to 2018 from 3.5% to 0%, as the Green Book states that past costs and benefits should not be discounted[107].

This has increased the NPV by approximately £430m.

Appraisal Period

The appraisal period has been extended from 2030 to 2034. Changes to the roll-out profile since the 2016 CBA, which used an appraisal period of 2013 to 2030, mean that in order to appraise the median meter over its full lifespan (as described in the main body of the text) the appropriate end-date is now 2034.

This change has increased the NPV by approximately £3.3bn. It is worth noting that this change increases both costs and benefits compared to the 2016 analysis.

[106] https://www.gov.uk/government/statistics/statistical-release-and-data-smart-meters-great-britain-quarter-1-2019

[107] https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-governent – paragraph 5.38.

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