Energy efficiency:
An infrastructure priority

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Executive Summary

There is a strong case for Government to make home energy efficiency an infrastructure investment priority and to develop an infrastructure programme to deliver it.

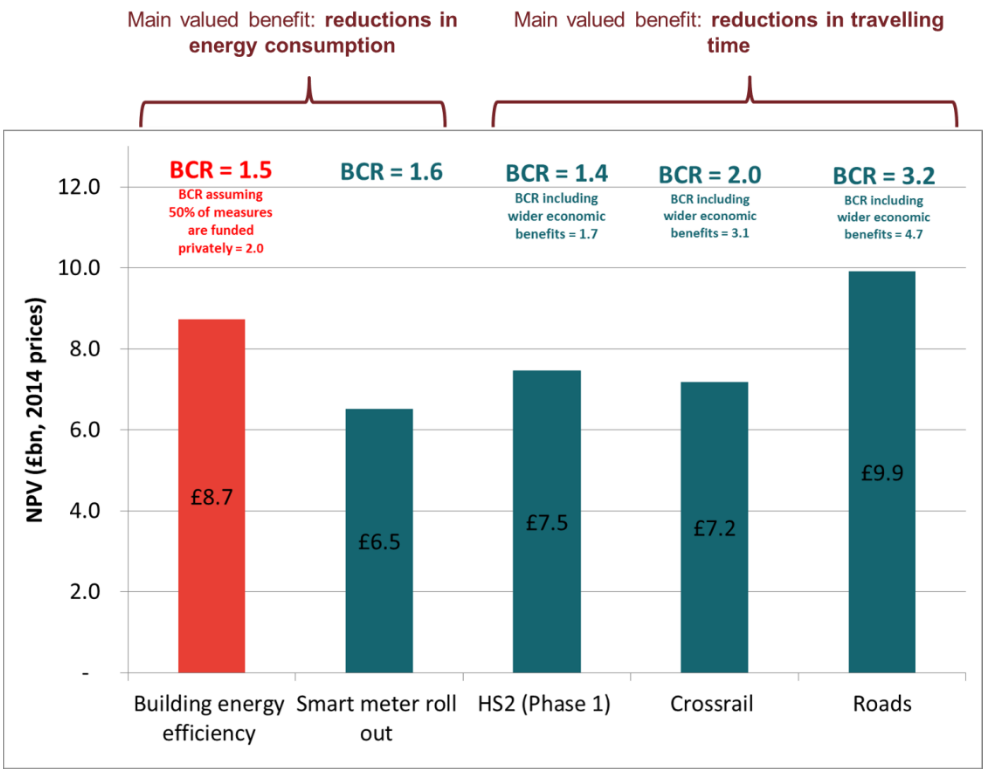
- **Energy efficiency investments constitute infrastructure**. Domestic energy efficiency investments can free up energy sector capacity just as effectively as delivering new generation plant, networks or storage would. Energy efficiency investments provide public services, by reducing carbon emissions and improving health and wellbeing. They also provide option value in the face of uncertainty over future energy sector conditions (e.g. uncertainty over future fuel prices)[1]. An energy efficiency programme would meet the criteria HM Treasury apply for determining their top 40 infrastructure requirements. It would also fit with the eight characteristics of infrastructure identified in HM Treasury's valuation guidance. In addition, classifying energy efficiency as infrastructure is consistent with the way energy efficiency is considered by a range of international organisations, such as the European Investment Bank and the International Energy Agency (IEA).

- **Energy efficiency investments provide value for money.** Our analysis of Government Impact Assessments shows that they have comparable benefits to other major infrastructure investments. In fact, a programme to make British buildings more energy efficient would generate £8.7 billion of net benefits. This is comparable to benefits delivered by the first phase of HS2, Crossrail, smart meter roll out, or investment in new roads (Figure 1). This finding holds, even without quantifying many of the key social benefits of energy efficiency measures (for example health and wellbeing improvements).

- **An infrastructure programme to deliver energy efficiency measures can overcome key barriers to delivery.** The market failures around energy efficiency provide a strong case for Government intervention. As part of a broad energy efficiency programme there are benefits to delivering a coordinated area-based scheme under a directly funded approach. This could be used to target the consumers who would benefit the most.

1 The incremental nature of energy efficiencies investments means that strategies can be changed as new information comes to light. This flexibility is not possible with more lumpy capital investments (for example nuclear power plants).

Figure 1. Summary of infrastructure scheme assessments



Source: Frontier Economics, based on sources detailed Box 1 on page 17. The NPV is the present value of the difference between the stream of costs and benefits of each scheme. The BCRs represent the ratio of societal benefits to Government costs (In line with Webtag guidance). The NPV figures do not include wider economic benefits. The base year for the present values varies between 2010 and 2013.

- **There is widespread support for making energy efficiency an infrastructure priority.** Making energy efficiency a public infrastructure priority is supported by leading UK business associations and businesses, including the CBI. It is also supported by core cities. Area-based programmes carried out by core cities are a natural fit with Government's aims to encourage resurgent cities and to support further devolution.

1 Introduction

This Government has identified productivity as one of the major economic challenges of our time. And it has recognised that investment in infrastructure is central to increasing the UK's productivity[2].

When thinking of infrastructure, it is often the major construction projects that come to mind –road and rail upgrades or investments in large new energy sector assets, like nuclear power stations or gas storage facilities.

But are we missing something by focussing on the big and visible projects? Are there alternative infrastructure investments that could provide greater benefits to the UK?

This report makes the case for classifying domestic energy efficiency as an infrastructure priority.

- Though less visible, domestic energy efficiency investments have many characteristics in common with supply side energy sector investments. In Section 2 we explain why domestic energy efficiency investments constitute infrastructure.

- Energy efficiency is a highly cost-effective way of meeting Government energy and climate change goals. Putting energy efficiency on a common footing with other major investment decisions allows a discussion on investment priorities. Section 3 assesses whether domestic energy efficiency investments provide value for money for the nation, when compared to other infrastructure investments.

- Thinking of energy efficiency as infrastructure will provide insights on how to overcome the market and policy failures that have prevented its widespread delivery. Section 4 describes the implications this has for delivery of energy efficiency.

- Based on this analysis, we conclude in Section 5 that there is a strong case for making domestic energy efficiency investments an infrastructure priority.

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2 HM Treasury (2015), *Fixing the Foundations*

2 Energy efficiency is infrastructure

Roads, railways, broadband networks, and energy supply investments are well understood to be infrastructure. Their importance to the UK economy is widely recognised[3].

Though less visible, domestic energy efficiency investments have many characteristics in common with supply side energy sector investments. But do they constitute infrastructure?

In this section, we review definitions of infrastructure in the literature, and assess how well domestic energy efficiency fits with them.

We conclude that domestic energy efficiency constitutes infrastructure investment.

- **Domestic energy efficiency investments free up energy capacity for other uses, just as investment in new generation or network capacity would. In this way, they increase inputs to the production of goods and services across the economy.**
- **These investments also provide public services, by reducing carbon emissions and improving health and wellbeing.**

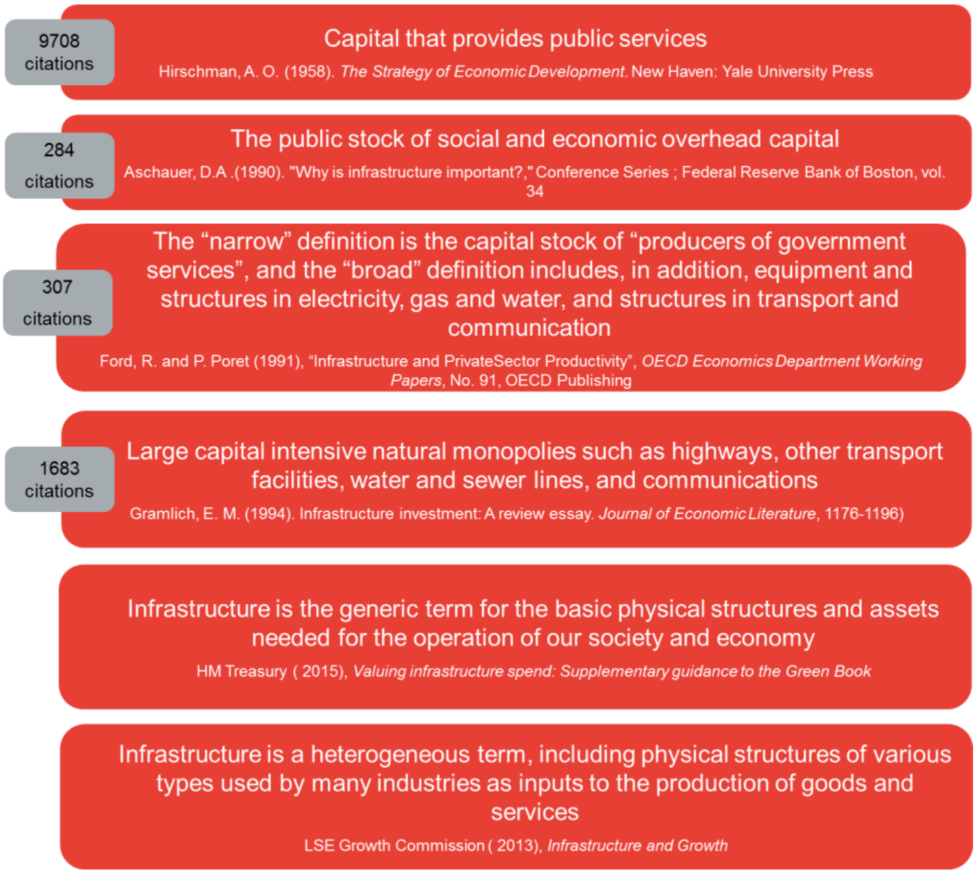
This finding is consistent with the way energy efficiency is considered by a range of international organisations, such as the European Investment Bank and the International Energy Agency (IEA). It is also consistent with the inclusion of the smart meter project in the Government's top infrastructure priorities.

2.1 Defining infrastructure

Figure 2 presents the four definitions we found in highly cited literature on infrastructure, alongside recent definitions from the LSE Growth Commission, and HM Treasury.

3 For example, HM Treasury (2015), *Fixing the Foundations*.

Figure 2. Definitions of infrastructure



Source: Frontier Economics

The definitions in Figure 2 cover two aspects of infrastructure: characteristics and functions.

- **Characteristics.** Infrastructure is generally described as capital, or as involving physical structures.

- **Functions.** The two most recent definitions (from HM Treasury and the LSE Growth Commission) describe infrastructure as an input to the production of goods and services and a requirement for the operation of the economy. The older definitions specify the function of infrastructure more narrowly, focusing on the provision of public services.

We have summarised these elements into broad and narrow definitions of infrastructure in Table 1.

Energy efficiency is infrastructure

Table 1. Broad and narrow definitions of infrastructure

	Broad definition	Narrow definition
Characteristics	Capital, physical structures	Large capital investments, with natural monopoly characteristics
Functions	Provides inputs to the production of goods and services	Provides public services

Source: Frontier Economics

We now consider how energy efficiency fits into each element of these definitions, looking first at its characteristics, and then at its functions.

2.2 Characteristics of domestic energy efficiency investments

Table 2 shows a range of common domestic energy efficiency investments, alongside information on their characteristics.

Table 2. Characteristics of common energy efficiency investments

	Cost (incurred upfront)	Lifetime (years)	Energy saving (kWh/year, semi-detached house)	Carbon saving (kg/year, semi-detached house)
Cavity wall insulation	£500 - £1,500	42	4,550	901
Draught proofing	£80-120	10	760	151
External wall insulation	£4,000-£14,000	36	9,373	1856
Heating controls	£350 - £450	12	3,927	797
High performance doors (per door)	£500	30	371	74
Gas-fired condensing boilers	£2,200 - £3,000	12	4,595	910
Internal wall insulation	£4,000-£14,000	36	10,033	1986
Loft insulation	£100 - £350	42	1,741	345
Replacement glazing	£3,300-£6,500	20	2,529	505
Roof insulation (flat roof)	£850 - £1,500	20	2,355	466
Secondary glazing	£1,000 - £1,500	20	1,753	391
Under-floor insulation	£800 - £1,200	42	1,269	252

Source: DECC (2013) *Information for the Supply Chain on Green Deal Measures*

Based on the information in Table 2 , we argue that domestic energy efficiency measures fit with the broad definition of infrastructure characteristics, and partially fit with the narrow definition.

- **Broad definition of characteristics: Capital, physical structures.** *Domestic energy efficiency investments constitute physical capital.* Table 2 shows that domestic energy efficiency generally constitutes capital-intense physical investments into the fabric of buildings. These investments tend to involve sunk costs incurred up front, and a return gained over a long asset lifetime.

Energy efficiency is infrastructure

- **Narrow definition of characteristics: Large capital investments, with natural monopoly characteristics.** *By delivering energy savings, domestic energy efficiency investments increase available energy sector capacity just as investing in large capital natural monopoly assets would.* Though an energy efficiency programme could constitute a major investment[4], Table 2 shows that individual domestic energy efficiency investments are not large capital investments. Neither do these investments tend to have natural monopoly characteristics. **However, reductions in energy demand (delivered through an energy efficiency programme) can increase available energy sector capacity just as effectively as delivering new large capital investments (such as new generation plant, networks or gas storage)**[5]. Therefore, while domestic energy efficiency investments are not in themselves large monopoly assets, investing in them can have the equivalent impact on the economy as investing directly in large monopoly assets. This equivalence is recognised in supplementary guidance to HM Treasury's Green Book, which explicitly recognises that investment in energy efficiency reduces the need for investment in other energy system infrastructure[6]. The impacts of energy efficiency on energy sector capacity can be highly material: for example, following extensive policy intervention, domestic energy consumption per person has already fallen by 26% since 2000[7], driven to a large extent by the delivery of energy efficiency measures.

We also note the narrow definition of infrastructure characteristics is more restrictive than that used by Government. For example, the smart meter programme and the Science & Innovation Catapults already form part of HM Treasury's Top 40 infrastructure priority list[8].

A range of international organisations, such as the European Investment Bank and the IEA also use a less restrictive definition. The EIB has an infrastructure fund targeting energy efficiency and renewables, while the IEA advises infrastructure investment as one of several economic instruments that

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4 For example, the Committee on Climate Change estimate that 4m investments in cavity wall insulation, 3.3m in solid wall insulation and 3.4m in loft insulation may be required to meet the UK's fourth carbon budget. CCC (2015) *Meeting Carbon Budgets – Progress in reducing the UK's emissions*.

5 We note that while these large assets are certainly viewed as infrastructure, not all of them have natural monopoly characteristics.

6 The guidance specifies that changes in energy use delivered by energy efficiency investments should be valued by taking the long run variable cost of energy supply. This long run variable cost includes the costs of investment in new capacity (for example, 90% of transmission costs are included). *Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal*.

7 DECC (2015), *Energy Consumption in the UK*

8 HMT (2014), *National Infrastructure Plan 2014*

can be used to improve energy efficiency[9]. In addition, energy efficiency is being targeted by the European Fund for Strategic Investment, a €315 billion fund aimed at financing investment in infrastructure and innovation, and providing financing for SMEs. A French programme offering loans to support energy efficiency retrofits in residential buildings has already been announced under this fund[10].

2.3 Functions of domestic energy efficiency investments

Domestic energy efficiency investments do two things.

- **They reduce energy use.** This reduces bills and frees up energy sector capacity to be used elsewhere in the economy, reducing the need to invest in new energy system capacity. This reduces carbon emissions (Table 2) and decreases the exposure of consumers to volatile fuel prices. In addition, these investments provide option value: because they involve multiple, small incremental investments, the scale and focus of the programme can be adjusted over time, as new information on the state of the world (including on the availabiltiy of new technologies) comes to light[11]. .
- **They result in warmer and more comfortable homes**. This increases health and wellbeing[12], and may also increase labour productivity[13].

There are trade-offs here: if consumers respond to efficiency measures by heating their homes more, the energy and carbon savings associated with these investments are reduced, but greater health and wellbeing benefits are be realised[14]. There is good evidence that a mix of both functions is delivered[15].

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9 IEA (2012), *Mobilising investment in energy efficiency*

10 Pending EFSI regulation. http://europa.eu/rapid/press-release_IP-15-5420_en.htm

11 We discuss option value further in Section 3.

12 There is both an income and a substitution effect: reduced bills mean more income is available to spend on heating, and heating the home is now relatively cheaper.

13 Mitchell, R. J., & Bates, P. (2011). Measuring Health-Related Productivity Loss. Population Health Management, 14(2), 93–98.

14 Analysis of energy efficiency measures tends to take this into account by reducing the energy savings by a 'comfort factor'. For example, recent analysis by Cambridge Econometrics for E3G uses a comfort factor of 40% for fuel poor homes. Cambridge Econometrics, *The economic and fiscal impacts of making homes energy efficient*

15 UKERC (2007), *The Rebound Effect: An Assessment of the Evidence for Economy-wide Energy Savings from Improved Energy Efficiency*

Domestic energy efficiency investments fit with both the broad and narrow definition of infrastructure functions.

- **Broad definition of functions: Inputs to the production of goods and services.** By freeing up other energy system capacity, energy efficiency delivers an input to the production of goods and services. The fact that this improvement is made via the demand side, rather than by directly increasing supply side capacity does not affect the economic outcome. In fact, HM Treasury's recent productivity plan is clear that infrastructure can make a contribution to the economy, even when it involves making improvements at a domestic level[16].

- **Narrow definition of functions: Provides public services.** Though homes are generally privately owned, investment in infrastructure measures provides public goods. Freeing up energy sector capacity provides services across the economy. Reducing carbon emissions provides a public service, given that the atmosphere is a public good[17]. Reductions in demand also contribute to energy security. In addition, by delivering warmer homes, energy efficiency provides a public service, resulting in fewer winter deaths and reduced cost to the NHS[18]. A healthier population is also likely to be a more productive one[19].

2.4 Findings

Based on this analysis, we conclude that domestic energy efficiency is a form of infrastructure (Figure 3).

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16 For example, it describes the contribution that digital infrastructure can make by removing barriers that prevent households from playing their full part in the digital economy. HM Treasury (2015), *Fixing the Foundations*.

17 While a carbon price is applied to emission from electricity generation, no price is applied on domestic gas use.

18 Hills J (2012), *Getting the measure of fuel poverty: Final Report of the Fuel Poverty Review*

19 Mitchell, R. J., & Bates, P. (2011). Measuring Health-Related Productivity Loss. Population Health Management, 14(2), 93–98.

Figure 3. Is domestic energy efficiency infrastructure?

	Broad definition of infrastructure	Narrow definition of infrastructure
Characteristics	Capital, physical structures **Fits:** Domestic energy efficiency investments constitute physical capital	Large capital investments, with natural monopoly characteristics **Partially fits:** By delivering energy savings, domestic energy efficiency investments increase available energy sector capacity just as investing in large capital natural monopoly assets would
Functions	Provides inputs to the production of goods and services **Fits:** By freeing up other energy system capacity, energy efficiency delivers an input to the production of goods and services	Provides public services **Fits:** By delivering warmer homes, energy efficiency provides a public service, resulting in fewer winter deaths and reduced cost to the NHS

Source: Frontier Economics

3 Energy efficiency provides value for money

We have shown that energy efficiency investments constitute infrastructure. However, these investments will require funding, at a time when pressure to manage budgets is very high. It is important, therefore, to ask whether energy efficiency investments deliver value for money.

In this section, we compare the estimates of the net benefits of energy efficiency schemes and with those of other schemes. We report on the standard outputs of the cost-benefit analysis of each project: the net present values (NPV) of benefits to society[20] and the benefit-cost ratios (BCRs)[21].

- **This analysis finds that an energy efficiency programme can have comparable benefits to other major infrastructure investments outside the energy sector**.
- **These findings hold, even though many of the key social benefits of energy efficiency measures (for example in terms of health improvements, or option value) have not been quantified.**

This analysis is based on a review of Government Impact Assessments. We have not undertaken any new modelling work for this project.

3.1 Comparison of Green Book metrics

Figure 4 compares the net benefits and BCRs of an energy efficiency scheme with four other major schemes. This shows that an energy efficiency programme compares well to the alternative investments. An energy efficiency programme could deliver £8.7bn of benefits to the UK, compared to benefits in the range of £6.5bn-£9.9bn for smart meters, HS2 (Phase 1), Crossrail and new roads. These findings hold, even without quantifying many of the key social benefits of energy efficiency measures (for example in terms of health improvements) or the associated option value.

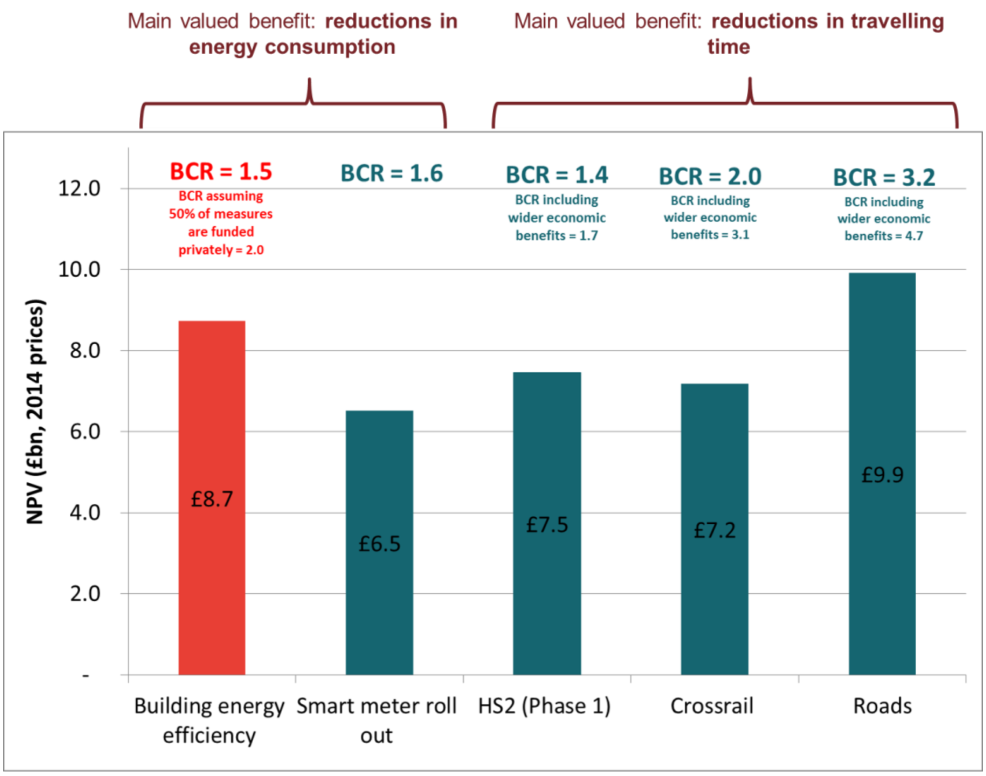
We also note the benefits of energy efficiency schemes are mainly made up of reductions in energy consumption. This is in contrast to the three transport schemes shown in Figure 4, where the core benefits are driven by reductions in travelling time. DfT acknowledges there are uncertainties around the values of time for business travellers in particular (for example, due to ongoing changes in

20 The NPV is the present value of the difference between the stream of costs and benefits of scheme.

21 In line with Webtag guidance, the BCRs represent the ratio of societal benefits to Government costs.

working and commuting patterns), and is currently seeking to collect new empirical evidence to review these values[22].

Figure 4. Summary of infrastructure scheme assessments



Source: Frontier Economics, based on sources detailed in Box 1, page 17. The NPV is the present value of the difference between the stream of costs and benefits of each scheme. The BCRs represent the ratio of societal benefits to Government costs (In line with Webtag guidance). The NPV figures do not include wider economic benefits. The base year for the present values varies between 2010 and 2013.

Figure 4 draws on a range of published Government impact assessments. We have made some adjustments to the published figures, to ensure the outputs are comparable.

- All figures have been uplifted to 2014 prices.
- Where impact assessments do not include BCRs, we have calculated these. In line with Webtag guidance, the BCRs represent the ratio of societal benefits to Government costs[23].

22 DfT (2014), *Webtag*

23 DfT (2014), *TAG UNIT A1.1 Cost-Benefit Analysis*, page 7

Energy efficiency provides value for money

Further details on the sources of these figures are set out in Box 1.

Box 1: Sources

Energy efficiency programme

This analysis is based on the Department for Energy and Climate Change's (DECC) final impact assessment of the Green Deal and ECO[24]. This impact assessment analyses the costs and benefits of a major programme of energy efficiency measures in domestic and non-domestic properties to 2022 (the majority of the costs and benefits relate to domestic properties).

This package includes installation of cavity wall insulation (some of which is hard-to-treat) in 2.7m properties. It also includes loft insulation in 1.6m properties and solid wall insulation in 1.0m properties, as well 0.4m installations of draught-proofing, glazing or floor insulation[25][26] A small proportion of the costs reported in this impact assessment will be scheme specific costs relating to the Green Deal and ECO.

To calculate the BCR, we have assumed that 100% of the costs relating to the installation of measures are borne by Government. We have also included an estimate of the BCR that assumes 50% would be privately funded by able-to-pay consumers and businesses[27].

Other schemes

Figures for smart meter roll out were taken from DECC's final analysis of the programme, reported by the National Audit Office (NAO)[28]. The HS2 (Phase 1) analysis is based on the HS2 Company's analysis[29]. Figures for Crossrail are from the Department for Transport's analysis, reported in the NAO[30]. Figures for roads are taken from DfT's analysis of the Road Investment Strategy, focussing on the benefits of schemes that go beyond existing commitments[31].

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24 DECC (2012), *Final Stage Impact Assessment for the Green Deal and Energy Company Obligation*,

25 DECC (2012), *Final Stage Impact Assessment for the Green Deal and Energy Company Obligation*, , page 164

26 We note that the technical potential for these measures is much higher. For the example, the CCC estimate that the remaining potential to meet carbon budgets is 4.0m for cavity wall insulation, 3.3m for solid wall insulation and 3.4m for loft insulation, CCC (2015), *Meeting Carbon Budgets - Progress in reducing the UK's emissions*. Figure 2.4

27 Whether the measures are privately or publically funded does affect the NPV since this calculated by subtracting total costs (including both private and public costs) from benefits.

28 NAO (2014), *Update on preparations for Smart Metering,*

29 HS2 (2013), *The Economic Case For HS 2*. page 85.

30 NAO (2014), *Crossrail*

31 DfT (2015), *Road Investment Strategy: Economic analysis of the investment plan*

3.2 Unquantified benefits of an energy efficiency programme

Not all of the benefits associated with energy efficiency programmes have been quantified in Figure 4.

There are two main categories of direct benefits associated with energy efficiency improvements that are not valued in this assessment: option value and health benefits.

3.2.1 Option value

There is a large degree of uncertainty over future demand and supply conditions in the electricity sector to 2050. For example, global fuel prices can fluctuate significantly, and the future cost of energy generation technologies can be difficult to predict.

In the face of this uncertainty, a standard cost-benefit assessment (such as that carried out for Government Impact Assessments) may underestimate the benefits associated with schemes which can be rolled out incrementally, such as energy efficiency programmes. Because it involves multiple, small incremental investments, an energy efficiency programme has the advantage of flexibility. Unlike large, capital-intense projects (such as the construction of a nuclear plant, for example), the scale and focus of the programme can be adjusted over time, as new information on the state of the world comes to light[32].

This option value has not been quantified in the analysis set out in Figure 4. Given the scale of the uncertainty associated with supply and demand in the energy sector, it may be significant.

3.2.2 Health benefits

In their analysis of the energy efficiency programme set out in Figure 4, DECC assume a level of 'comfort take'[33]. That is, they assume that consumers use some of the financial savings they have gained from energy efficiency, to purchase more heating. There are likely to be significant health benefits associated with this as living in cold conditions can be linked to a number of negative physical and mental health impacts. For example, the Hills Fuel Poverty Review found

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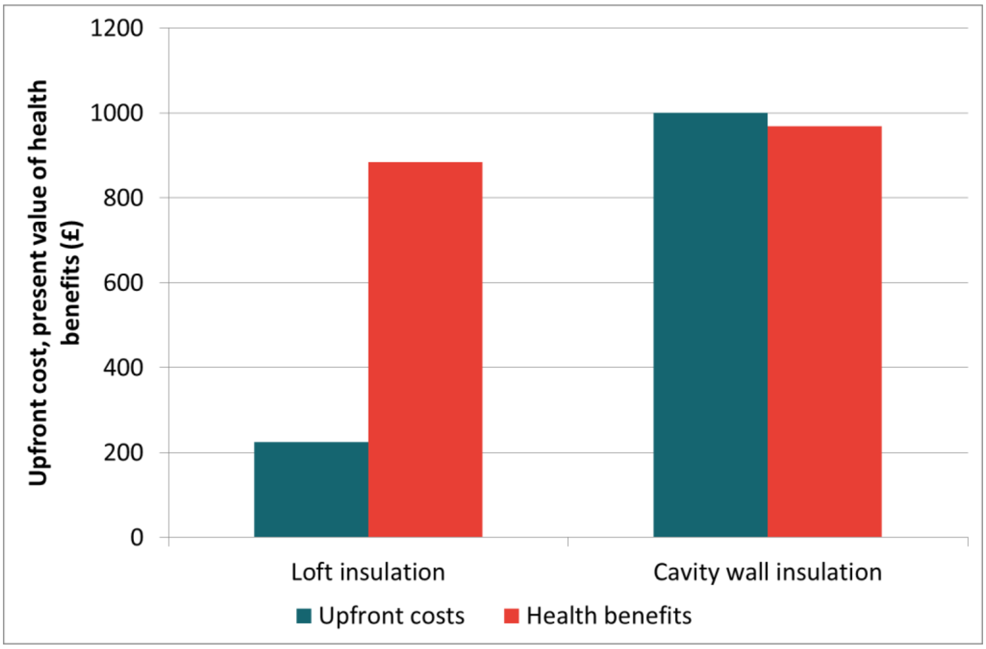
32 We note that it is important for the supply chain that these changes are well-planned and made with adequate notice.

33 A given percentage level of comfort take means that the energy savings resulting from the installation of efficiency measures will be that percentage lower than they would have been in the absence of the comfort taking.

that low-temperatures in homes can create conditions which increase the likelihood of cardiovascular events, some of which may result in death, exacerbate the risk of respiratory disease and cause physical discomfort, which can contribute to mental health issues[34].

DECC has undertaken modelling to value the health benefits associated with some energy efficiency investments[35]. Figure 5 shows that these can be significant. In fact, for loft insulation, these benefits alone outweigh the costs of installing the measures, even before energy savings are taken into account.

Figure 50. Estimated health benefits of loft and cavity wall insulation, compared to upfront costs



Source: DECC (2013), *Fuel Poverty: a Framework for Future Action – Analytical Annex;* DECC (2013) *Information for the Supply Chain on Green Deal Measures.*

These health benefits have not been valued in the assessment set out above. Again, this is likely to have led to an underestimate of benefits.

34 Hills (2011), *Fuel poverty: The problem and its measurement.*

35 DECC (2013), *Fuel Poverty: a Framework for Future Action – Analytical Annex*

3.3 Comparison according to Government's Top 40 criteria

The strategic benefits of energy efficiency investments may also be important.

Each year, the Government publishes a National Infrastructure Plan. This includes a list of the top 40 priority projects. Published analysis suggests that an energy efficiency programme performs well against the three criteria used in the selection of these projects[36].

- **Potential contribution to economic growth**. Macroeconomic modelling by Cambridge Econometrics and Verco for E3G suggests that an energy efficiency programme could have a significant positive impact on growth[37].

- **Nationally significant investment that delivers substantial new or replacement infrastructure with enhanced quality, sustainability and capacity**. An energy efficiency programme could be judged to meet this criterion just as well as other schemes which are included in the top 40, for example, the smart meter roll out programme, road investments or the Science & Innovation Catapults.

- **Projects that attract or unlock significant private investment.** An energy efficiency investment scheme has the potential to deliver private investment, where able-to-pay households fund at least some of the cost measures in their homes. Some but not all of the infrastructure schemes in the Top 40 attract private investment**.** For example, HS2 and most roads are publically funded.

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36 HMT (2014), *National Infrastructure Plan 2014*

37 This modelling found that an energy efficiency programme could increase annual GDP in 2030 by around £14bn Cambridge Econometrics and Verco (2014), *Building the Future: The economic and fiscal impacts of making homes energy efficient*

4 Energy efficiency can be delivered as infrastructure

We have shown that energy efficiency investments are a type of infrastructure, and that they provide value for money. We now consider what this means for the delivery of these investments.

This analysis finds that the characteristics of energy efficiency as infrastructure mean that Government intervention is required to deliver the socially optimal[38] level of investment for the UK.

It also finds that there are benefits to an approach that is directly funded by Government. It may be easier to deliver a coordinated area-based scheme under this approach and to target the customers who would benefit the most. It is also less regressive to fund an increase in energy efficiency investment through general taxation, rather than through bills.

4.1 Why does Government need to be involved?

HM Treasury has identified eight characteristics of infrastructure that should be taken into account in appraisals of new policy decisions to support infrastructure[39]. These are set out in Figure 6, along with an explanation of why they apply to energy efficiency decisions, and what this implies for Government intervention.

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38 The socially optimal level of investment refers to the level that maximises net social benefits for the UK.

39 HM Treasury (2015), *Valuing infrastructure spend: Supplementary guidance to the Green Book*

Figure 6. Why is Government intervention required?

	Does this apply to energy efficiency?	What does this mean for delivery?
Long-term	Investments have long asset lives	**In the absence of Government intervention, there will be underinvestment**. Consumers and businesses tend to have a higher discount rate than society as a whole. This means that where costs are incurred upfront, and benefits accrue over long lifetimes, consumers and the private sector will tend to invest less than the optimal amount.
Location specific	Investments are tied to buildings in specific locations	**In the absence of Government intervention, there will be underinvestment.** The level of sunk costs associated with energy efficiency measures is important. It makes it difficult for businesses to offer credit to customers to install these measures, as to do so is akin to providing an unsecured loan (i.e. businesses cannot reclaim the insulation if the consumer defaults).
Interdependent	There is interdependency between energy efficiency infrastructure and the rest of the energy system	**Government intervention can help ensure benefits are maximised**. Energy efficiency investments may deliver the greatest system benefits when focussed on particular locations (e.g. where distribution networks are congested) or focussed on reducing energy consumption at a particular time of day (to reduce peak demand). Energy prices for domestic consumers do not currently deliver granular signals on location, and the majority do not deliver timing signals.
Scale effects	Supply chain impacts mean that the scale of energy efficiency programmes is important	**Government intervention can help to ensure coordinated delivery.** DECC's 2012 Energy Efficiency Strategy identified embryonic markets as one of the four main barriers to the roll out of energy efficiency measures, pointing out that a lack of expertise in a relatively immature market can increase costs and therefore slow roll out. A coordinated approach to roll out (for example, based on local areas) could help markets deliver.
Non marginal impacts	Supports and enables economic output by freeing up energy capacity for other uses	**In the absence of Government intervention, there will be underinvestment**. Analysis by Cambridge Econometrics suggests that an energy efficiency programme could help stimulate economic growth. Private individuals and business will not take the impact on the overall economy into account when making their decisions, and therefore may invest less than the optimal amount for society.
Shapes preferences	Can change how consumers heat their homes	**Government intervention can help secure health benefits.** If energy efficiency investments are targeted at the fuel poor, they may result in health benefits, and reductions in costs for the NHS.
Public good aspects	The atmosphere is a public good.	**In the absence of Government intervention, there will be underinvestment.** Investors in energy efficiency will not take their impact on emissions into account when making their investment decisions. This means that without Government intervention, consumers and the private sector will invest less than the optimal amount.
Market power	Not applicable	

Source: Frontier Economics.

Energy efficiency can be delivered as infrastructure

The analysis in Figure 6 shows that seven of the eight characteristics of infrastructure are relevant in the case of an energy efficiency programme. It also shows that these characteristics have implications for Government intervention.

- **In the absence of Government intervention, there will be under-delivery of energy efficiency investments**. This is the case both because of the infrastructure characteristics highlighted in Figure 6, and because of the well-known behavioural barriers associated with energy efficiency investments (for example those associated with lack of interest, low awareness, risk aversion and lack of trust)[40].

- A **targeted** approach can help maximise the benefits of an energy efficiency programme by focussing on:
  - the consumers that can gain the most from these investments (e.g. the fuel poor); and
  - interventions that tackle consumption at certain times of day (efficiency improvements that reduce peak demand).

- A **coordinated area-based approach** can also help maximise the benefits of an energy efficiency programme, by focussing on:
  - coordinating area-wide approaches that allow local markets to mature;
  - coordinated targeting of areas where the benefits to the energy system are greater (e.g. areas with network congestion).

  An area-based approach can also help overcome behavioural barriers, for example by creating new social norms around efficiency measures.

4.2 What does this mean for direct funding?

At the moment, policy-driven energy efficiency measures are largely financed through ECO and delivered by suppliers. This supplier-led approach can tackle many of the issues identified in Figure 6.

But would a supplier-led approach be the most efficient way of delivering a further increase in energy efficiency investments? There are three reasons why an infrastructure investment programme, directly funded by Government may add value.

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40 See for example, the discussion in DECC (2012), *The Energy Efficiency Strategy: The Energy Efficiency Opportunity in the UK*

- **A direct Government approach could be more effective in delivering a coordinated, area-based approach**. This type of approach may be difficult to deliver through suppliers, given the number of suppliers that compete in the energy market, their uneven distribution across different localities, and the transaction costs associated with specifying very narrowly who suppliers should target[41].

- **A scheme targeting those customers that will benefit the most in terms of health and wellbeing may be easier to deliver directly through an infrastructure programme, led by cities**. While suppliers can be incentivised to focus on vulnerable customers and the fuel poor, the design of such a scheme can become complex and again can lead to inefficiently high transaction costs. Some of these transaction costs could be avoided by drawing on the knowledge that Government, and in particular Local Government, already has on housing stock and vulnerability of occupants.

- **Bill-payers may be reluctant accept a further increase in the costs of a supplier obligation.** Funding through energy bills (with ECO) is consistent with the polluter pays principle and provides an added incentive for efficiency. However, it will generally be less regressive to fund schemes through general taxation (as is common in Europe)[42].

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41 We note that internationally, many obligation schemes are delivered through distribution network operators, and these issues do not apply. The UK is the only EU country to use a supplier obligation to tackle fuel poverty.

42 CEER (2015), *Status Review of Renewable and Energy Efficiency Support Schemes*

5 Conclusions

There is a strong case for Government to make energy efficiency investments an infrastructure priority, and to introduce a further programme of energy efficiency investments.

- **Energy efficiency investments constitute infrastructure.** Domestic energy efficiency investments can free up energy sector capacity just as effectively as delivering new generation plant, networks or storage would. Energy efficiency investments provide public services, by reducing carbon emissions and improving health and wellbeing. They also provide option value in the face of uncertainty over future energy sector conditions (e.g. fuel prices)[43]. An energy efficiency programme would meet the criteria HM Treasury apply for determining their top 40 infrastructure requirements. It would also fit with the eight characteristics of infrastructure identified in HM Treasury's valuation guidance. In addition, classifying energy efficiency as infrastructure is consistent with the way energy efficiency is considered by a range of international organisations, such as the European Investment Bank and the International Energy Agency (IEA).

- **Energy efficiency investments provide value for money.** Our analysis of Government Impact Assessments shows that an energy efficiency programme can have comparable benefits to other major infrastructure investments. In fact, a programme to make British buildings more energy efficient would generate £8.7 billion of net benefits. This finding holds, even without quantifying many of the key social benefits of energy efficiency measures (for example health improvements and option value).

- **There is a case for Government intervention, in the form of a publicly funded investment programme and there are benefits to an approach that is directly funded by Government.** It may be easier to deliver a coordinated area-based scheme under this approach and to target the customers who would benefit the most. It is also less regressive to fund an increase in energy efficiency investment through general taxation, rather than through bills.

43 The incremental nature of energy efficiencies investments means that strategies can be changed as new information comes to light. This flexibility is not possible with more lumpy capital investments (for example nuclear power plants).

FRONTIER ECONOMICS EUROPE
BRUSSELS | COLOGNE | LONDON | MADRID
Frontier Economics Ltd 71 High Holborn London WC1V 6DA
Tel. +44 (0)20 7031 7000 Fax. +44 (0)20 7031 7001 www.frontier-economics.com