# The domestic energy supply business model: why it should sell services rather than commodities

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## Keywords
domestic energy, energy efficiency financing, energy services, barriers, existing housing stock, energy-finance model

## Abstract
The prevailing energy supply business model for single unit domestic properties is the utility company model which relies on utility companies selling units of energy to domestic households. In this model household and energy supplier interests are misaligned as households do not pay directly for the services they want but instead for the commodity (i.e. units of energy) that provides those services. For example householders want a warm home but instead pay for units of energy to fuel a heating system to deliver the required warmth. This business model creates a number of barriers to investment in domestic energy efficiency measures, including asymmetrical information, high perceived risk and split incentives, which culminate in householder inertia to energy efficiency measures. Firstly this paper presents a holistic review of the techno-economic and socio-cultural barriers to domestic energy efficiency, secondly it proposes a novel business model – the Domestic Energy Service Company (DESCo) – as having the potential to mitigate some of these barriers and thirdly it summarises the results of a household energy and finance model which tests the viability of the DESCo business model. The analysis explores the relationships between risk, householder savings, contract length, rate of return, baseline energy consumption level, comfort take-back, transaction costs and energy prices. The results of the energy-finance model, which uses the UK as a test case, suggest that the DESCo business model could viably finance certain domestic energy efficiency measures, in addition to mitigating some key householder barriers and delivering adequate rates of return to investors. Using these results the paper draws conclusions on the feasibility of the DESCo business model. The paper concludes that the DESCo business model has the capacity to align the interests of consumers and suppliers and so mitigate inertia towards investment in domestic energy efficiency in the domestic energy supply market.

## Introduction
Domestic energy efficiency is a key priority of energy policymakers due to its positive effects on public health, household incomes, carbon emissions and energy security. However, despite the importance of domestic energy efficiency measures, empirical research has identified an inertia towards installing these measures; many householders are not considering, or are resistant to, installing energy efficiency measures that are suitable for their homes (e.g. E.ON, 2010; National Energy Services, 2009). One possible source of this inertia is misaligned interests in the domestic energy supply market: utility companies want to maximise unit sales, in direct conflict with the energy efficiency agenda, and householders want to maximise the quality of the provided energy services such as warmth, which are perceptually divorced from energy bills and energy efficiency measures.

Furthermore householders generally lack the information, experience and expertise to have confidence in the costs and benefits of energy efficiency measures, meaning that these investments are seen by householders as high risk. Those organisations who do have the relevant expertise, either (i) have no incentive to act on this expertise, in the case of utility companies, or (ii) have limited proficiency in managing domestic energy efficiency installations at scale, in the case of government agencies or insulation companies. This creates a market for energy efficiency measures where those who have the incentive to invest (i.e. householders) are unwilling to accept the risks and those who are in the best position to assess and manage these risks (i.e. utility companies, insulation suppliers) have limited incentive, or limited capacity, to invest.

An improved business model would therefore be one that incentivised energy suppliers to maximise the quality of energy services, rather than units of energy, that they supply to householders. In other words – selling householders what they want (warmth) rather than what they need (energy). Here the term householders refers to residents of domestic properties, either owner-occupied or rented, which have energy metering specific to the property, where the resident pays a utility company directly for the energy they consume. It therefore excludes multi-unit residential buildings, or other dwellings where occupants do not pay directly for their own individual energy consumption.

This paper outlines the rationale for this business model called the Domestic Energy Service Company (DESCo). Firstly the paper identifies and discusses the range of factors that prevent householders from investing in energy efficiency measures. Secondly it describes how the DESCo business model could address some of these factors. Thirdly it introduces an energy-finance model designed to assess the viability of the DESCo business model. Finally it presents the results of this modelling for a number of scenarios and draws conclusions about the potential for DESCos.

Previous analyses of energy service contracting in the domestic sector have predominantly assessed the potential of Energy Service Companies (ESCos) to serve multi-unit residential buildings where the client is assumed to be a business (e.g. Bleyl-Androschin and Seefeldt, 2009; Szomolanyiova and Sochor, 2012). However this study examines the potential for the energy service business model to serve single-unit domestic properties where the client would be a consumer, i.e. the householder, rather than a business.

The rationale for this is fourfold; firstly householders have very different drivers and barriers to businesses as discussed in the next section. Secondly, because of these differing barriers and drivers, the remit and returns to DESCos may differ from traditional ESCos as outlined in the following section. Thirdly single unit properties with per household energy metering, such as in the owner occupied sector, are prevalent in some countries, for example owner-occupied properties make up over 65 % of the English housing stock (Department for Communities and Local Government, 2011, Table 3), suggesting a large potential 'business to consumer' market for energy services. Finally the provision of energy services to homes is underdeveloped, compared to other sectors (Szomolanyiova and Sochor, 2012), this suggests there is large unrealised potential in this market. These points suggest that assessing the DESCo model in isolation from the 'business to business' ESCo model may be informative and for this reason the paper refers to this business model as a Domestic Energy Service Company (DESCo) and explores the drivers and viability of this model as distinct from those of a traditional ESCo.

## Barriers to household investment in energy efficiency measures

Figure 1 maps the two dominant paradigms in the debate on barriers to household investment in energy efficiency; the techno-economic and socio-cultural paradigms, as identified by Jensen (2005). Socio-cultural commentators are somewhat resistant to the term 'barriers', preferring instead 'disinclination' (Jensen, 2005) however the term is used here to maintain comprehensibility. The central area in the figure shows the techno-economic barriers to household investment in energy efficiency; hidden costs, access to capital, split incentives, asymmetrical information, risk and bounded rationality, adapted from Sorrell (2004).

Examples of hidden costs include the time or effort needed to identify, negotiate, finance and supervise energy efficiency investments, and the physical disruption entailed. Although in reality householders do not explicitly calculate the costs of the time, effort, disruption involved, perceptions of high hidden costs can turn a financially viable investment into one that is not attractive to the householder. Access to capital indicates that householders may not have sufficient finance to cover the capital cost of measures, or may not be able to access capital at a sufficiently low interest rate to make measures financially viable. Split incentives, also called the user/investor dilemma (Schleich, 2009), refers to the case where the householder cannot appropriate all of the benefits from a measure, for example if they live in a rented property, or they own their property but plan to move out before the cost of measures is repaid, in this case the incentive to invest will be split between themselves and future occupants. Asymmetrical information indicates that, because households make investment decisions on energy efficiency rarely, householders will have better information about the costs and benefits of maintaining their current level of energy consumption than about installing energy efficiency. Leading on from this, if householders are uncertain about the costs and benefits of an energy efficiency measures then they are likely to perceive these measures as high risk. Furthermore there is the risk of 'illiquid assets'; once installed, the capital invested in energy efficiency measures cannot be accessed until the savings accrue. As savings usually accrue over a number of years and measures cannot be sold on once installed these investments are illiquid and therefore higher risk than the investments such as stocks which can be sold on quickly and easily. Bounded rationality implies investors will not always act in a perfectly technically and economically rational manner, for example empirical work suggests individuals are often more sensitive to losses than to gains – loss aversion – and will often settle for an acceptable solution rather than trying to maximise their utility – satisficing behaviour (Weber and Johnson, 2009; Wilson and Dowlatabadi, 2007).

The outer part of the figure illustrates that these techno-economic barriers exist within a wider socio-cultural environment. Energy efficiency measures have to compete for householder time and resources with other goods and services and, as domestic energy efficiency investments are of low visibility and status, they are likely to be a low priority for householders. For example, energy efficiency measures such as condensing boilers are not perceived as attractive an investment as kitchen renovations to householders, despite their ability to gener-

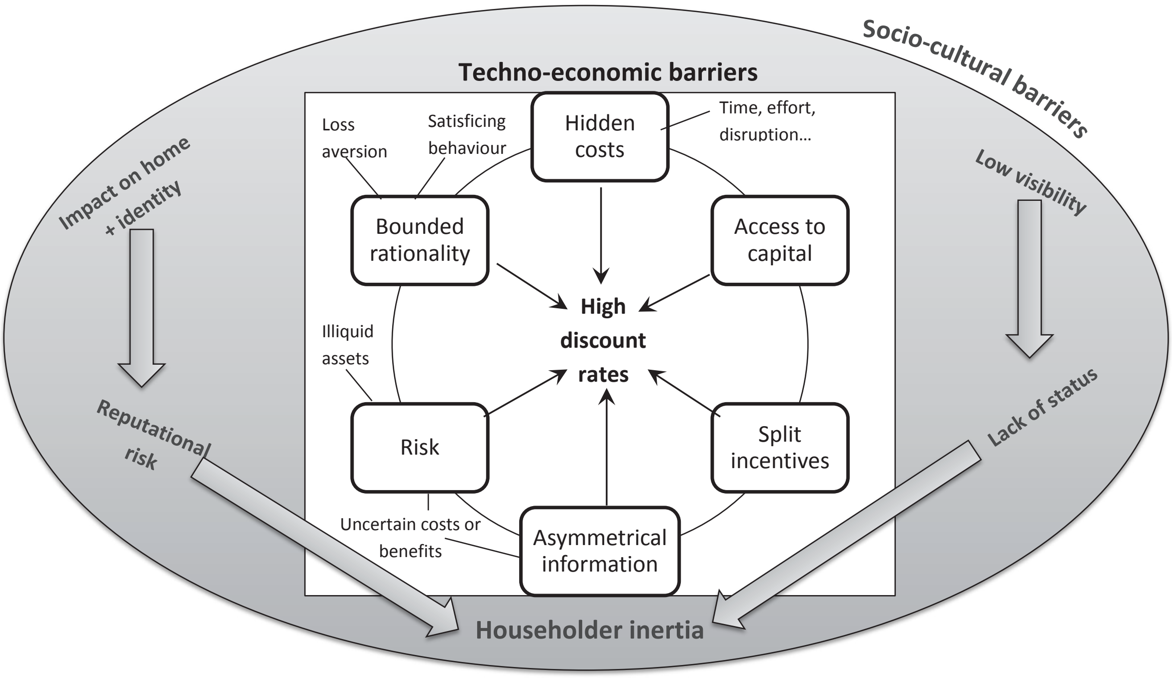


*Figure 1. A holistic representation of the barriers to householder installation of energy efficiency measures. (Source: adapted from Morris-Marsham, 2012.)*

ate savings (Vadodaria et al., 2010). Furthermore home and identity are often intimately linked (Carsten and Hugh-Jones, 1995), as some reflection on our attitudes towards our own homes might illustrate, therefore any change to the appearance or functioning of the home, including energy efficiency measures, might have an impact on identity and therefore be a reputational risk. In addition social norms – beliefs about what others are doing or approve of – are powerful driving forces of social behaviour (Nolan et al., 2008) so, unless installing these measures is considered to be the norm, the incentive to install them is likely to be reduced.

This holistic portrayal of household barriers to energy efficiency contains a number of key messages. The first message is that the existence of a number of techno-economic barriers to household investment in energy efficiency culminates in high household discount rates. Here the discount rate refers to the extent to which the householder discounts the future savings from energy efficiency measures. For example the higher the perceived risk of an investment the more the household will 'discount' future savings as the less certain they will seem. Similarly, regarding split incentives, the householder will discount to zero all savings that accrue after the end of their tenancy or occupancy. Additionally, if capital to finance energy efficiency is only available at high interest rates, or there are high hidden costs, this will reduce net savings. Finally bounded rationality may, for example, lead to householders giving greater weight to the cost of measures compared to savings, often referred to as hyperbolic discounting (Wilson and Dowlatabadi, 2007). These tendencies of householders to highly discount the savings from energy efficiency measures can turn energy efficiency investments which would be objectively attractive at market interest rates into investments which are rejected by householders (Gillingham et al., 2009).

The second key message is that the techno-economic barriers to domestic energy efficiency lie within, and cannot be divorced from, the socio-cultural sphere, i.e. even if techno-economic barriers can be overcome, there may still exist social and cultural factors that lead to householders not to install energy efficiency measures. This generates a complex and multi-layered picture of why households may choose not to install energy efficiency which can be useful in helping to explain the reported inertia of households towards energy efficiency (e.g. Department of Energy and Climate Change, 2011a; E.ON, 2010; Energy Research Partnership, 2009).

In totality this analysis suggests that the challenges of mitigating high household discount rates and household inertia within the current domestic energy supply model are significant. The rest of this paper explores an alternative model for the supply of domestic energy, one that sells services rather than units of energy – the Domestic Energy Service Company (DESCo) model. The next section explains how the DESCo model could have the potential to mitigate some of the most challenging barriers to domestic energy efficiency investments.

## Selling services not units: the Domestic Energy Service Company

A Domestic Energy Service Company (DESCo) is a company that provides energy services and/or delivers energy efficiency improvements in a domestic property and accepts some degree of risk in doing so, similar to a traditional Energy Service Company (as defined by Bertoldi et al., 2007; Bleyl-Androschin and Seefeldt, 2009). ESCos generally undertake 'energy supply contracting', where they provide efficient fuel conversion into useful energy, or 'energy performance contracting', where they provide energy saving services such as insulation in both cases distinct from the utility supplier (Bleyl-Androschin and Seefeldt, 2009). However DESCo operation would most closely resemble 'integrated energy contracting' (as defined by Bleyl-Androschin, 2009) as it could include both supplying energy and implementing system, fabric and behavioural efficiency measures.

Figure 2 compares the current energy supply model to DESCo operation under two different contract types; guaranteed and shared savings. Under the current domestic energy supply model, utilities charge householders for units of energy and householders pay a variable amount, depending on how many units they use. Householders can make fabric or system improvements to their property, as long as they own it or have landlords' permission, and will benefit from any energy savings. In contrast, under the DESCo business model the DESCo provides a level of 'energy service' to the householder in return for a fixed or variable payment (depending on whether the contract is of a guaranteed or shared savings type) out of which the DESCo pays the utility for the units of energy used. This business model would probably best serve owner-occupiers although it could serve private tenants if the DESCo contract was a similar length to the tenancy, or if it was possible to transfer the contract to subsequent occupants.

Under these contracts the DESCo has an incentive to part or fully finance energy efficiency measures as the householder pays for delivered 'energy services' (e.g. warmth) distinct from units of energy supplied and thereby the DESCo profits by supplying these services as efficiently as possible. Under a guaranteed savings contract the DESCo's payment is a fixed amount calculated to cover expected energy consumption, capital and transaction costs and to deliver an adequate rate of return on investment over the course of the contract. Here the term 'transaction costs' refers to the legal and other costs of administrating and monitoring the contract. Under a shared savings contract the DESCo's payment is a variable amount, based on actual energy supplied plus the DESCos' fee which, in this formulation, is either half the energy savings, or a repayment amount (set at a rate that covers the DESCos capital and transaction costs and delivers an adequate rate of return on investment over the course of the contract), whichever is greater.

In this model the DESCo takes over the purchasing and supply of energy from the utility and receives payments from households according to the terms of the DESCo contract. A key implication is that this model enables utility companies to offer householders DESCo contracts in place of current energy supply contracts. This 'utility-DESCo' configuration has number of advantages, e.g. reduced data transfer costs and the potential for significant economies of scale due to the large market share of existing utilities.

Some commentators have considered the Energy Efficiency Obligations (EEOs) operated by utility companies to be forms of DESCo-style operation (e.g. Rezessy et al., 2005; Ürge-Vorsatz et al., 2007), though this commentary would disagree due to the absence of a fixed-term commitment or any undertaking of risk by the utilities in these cases. EEOs do however provide a useful indication of the transaction costs utility-DESCo suppliers might experience: in the U.K. the transaction costs experienced by utility suppliers of domestic energy efficiency measures under the Energy Efficiency Commitment (EEC) were 18 % of project costs (Ofgem in Department of Energy and Climate Change, 2011b). This level of transaction costs was used in the initial modelling in order to explore of the financial viability of utility-DESCo contracts, the model subsequently tested the model for a range of transaction costs up to 70 %.

The benefits of this DESCo model are that it could mitigate householder barriers to energy efficiency in a number of ways. Firstly DESCos could address householder perceptions that energy efficiency investments are high risk by taking on

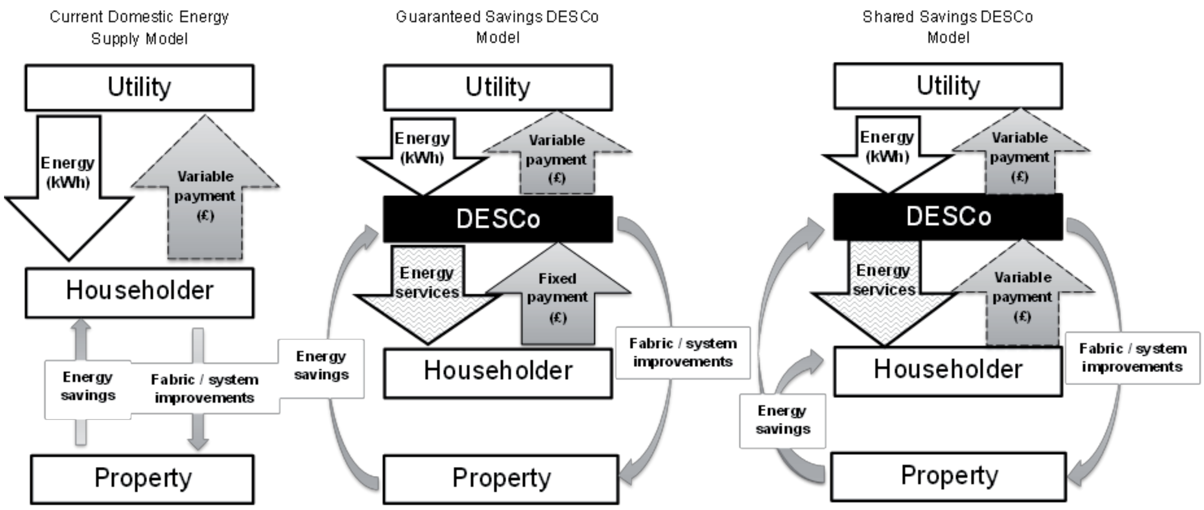


*Figure 2. Current domestic energy supply model and guaranteed and shared savings DESCo business models. (Source: Morris-Marsham, 2012.)*

specification, purchasing and monitoring of measures and, under guaranteed savings contracts, the risk of measures underperforming. Secondly due to experience and expertise in the field, the DESCo would be in a better position to accurately assess and manage the risk of investments. It might therefore apply lower discount rates and require lower rates or return, thus increasing the potential capital available for these investments. Thirdly householders could assess DESCo contracts by the same criteria as existing energy supply arrangements, mitigating the asymmetrical information barrier. Fourthly DESCo management of energy efficiency investments could reduce the associated hidden costs to householders, i.e. the time and mental resources needed to identify, negotiate, finance and supervise energy efficiency installations.

Regarding householder inertia, research suggests that householders might find fixed-price, fixed-term energy contracts, such as those offered under the DESCo model, attractive (Littlechild, 2006). Furthermore DESCo contracts could be marketed as simplifying purchasing and increasing comfort as well as reducing bills, thus these contracts could provide more tangible, psychologically salient benefits than self-financed energy efficiency installations. By providing an alternative to a form of consumption householders already engage in, buying units of energy, DESCo contracts would encourage householders to actively consider energy efficiency measures as an add-on to energy supply and so energy efficiency measures would not have to compete in householder's priorities with higher visibility or higher status consumption. Finally, while the impact on identity might still exist, the decision to invest in measures would lie with the DESCo, this then might mitigate some of the perceived reputational risk of energy efficiency measures.

However traditional ESCos, i.e. those providing energy supply and energy performance contracts to the commercial sector, have only attracted only a small share of the potential market (Marino et al., 2011). Barriers to traditional ESCo operation include lack of finance, low awareness and high transaction costs and these also apply to DESCos. Transaction costs are often quoted as the major barrier to ESCos supplying smaller energy users (e.g. Szomolanyiova and Sochor, 2012), as these costs can be 7–60 % of project costs and increase proportionally as project size decreases (Bleyl-Androschin and Seefeldt, 2009). The transaction costs used in this model, and other key assumptions, are discussed in the next section.

### KEY ASSUMPTIONS

Implicit to the model is the assumption that the returns required by the DESCo are proportional to the level of risk implied by the contract. The key risks to the DESCo are the illiquidity of assets, energy price rises, excessive consumption and comfort take-back. Here illiquidity of assets encapsulates the risk that the contract may be broken before full repayment and the DESCos costs unrecoverable, sometimes referred to as stranded assets (e.g. Boait, 2009). To mitigate this risk DESCos could integrate contract transfer processes into contract terms and conditions so that if the original householder moves either the incoming householder is obliged to take over the contract, or the original householder chooses to pay off the contract, similar to the 'contract transfer' mechanism in place for the UK Green Deal programme (Department of Energy and Climate Change, 2011b). Furthermore, as the DESCo would be receiving payment via the households' energy bill, the risk of default is likely to be low as householders will wish to avoid disconnection. In the UK default rates on energy bills are around 1.5 % of revenue (Department of Energy and Climate Change, 2011b).

To manage the risk of energy price rises DESCo contracts could specify payments that tracked the wholesale energy price, include staggered price increases, or set payments at a level that took into account expected future price rises, all of which would be transparent from the outset of the contract. This would give householders confidence in future energy costs and insure the DESCo against rising prices. A key point here is that, through greater expertise, DESCos are likely be able to better manage energy purchasing, and minimise per-unit costs, than householders. Furthermore as energy prices rise, the value of potential savings will increase, increasing the future attractiveness of DESCo contracts.

Other risks to DESCos are excessive consumption and comfort take-back. Here comfort take-back refers to the proportion of the energy savings that householders take back by increasing their comfort level after an energy efficiency installation, sometimes called the rebound effect (Herring and Sorrell, 2009). The model assumes that it is in the interests of the DESCo to reduce comfort take-back and inefficient energy use, as excessive consumption by householders could jeopardise DESCo profits. Under guaranteed savings contracts there would be a particular risk of increased comfort take-back effect as under a fixed-price contract householders have the least incentive to keep consumption low.

DESCos might mitigate these risks by specifying maximum usage clauses in contracts, similar to data usage clauses used in mobile phone contracts, or incentivise behavioural reductions in energy consumption. Contracts could include novel constructs such as 'magnitude-of-use' pricing, i.e. higher tariffs on use above certain levels which could ensure that, if take-back is high, repayments will still exceed the costs of energy. DESCos could use SMS messaging or smartphone apps, like those used to monitor bank balances or smartphone data usage, to increase householder awareness of energy use. As a result the model assumes that comfort take-back would be higher under DESCo contracts than under self-financing of energy efficiency measures, but not excessively so (k in Appendix: DESCo model inputs).

This conceptualisation of DESCo operation specifies that under shared savings contracts the DESCo would share energy savings on a 50:50 split with the householder, except where savings are less than a pre-specified repayment amount. The repayment amount is designed to deliver a guaranteed minimum rate of return to the DESCo. Guaranteed savings contracts however represent a much larger risk to the DESCo as there is no guaranteed minimum rate of return. Therefore, as the risks are lower under shared savings, the model assumes that DESCos require lower rates of return than under guaranteed savings contracts, reflected by the differing interest rates used the for two contracts (r in Appendix).

Transaction costs under energy service contracts are influenced by the ease of monitoring terms and conditions and transferring assets, levels of competition in the market and government support (Sorrell, 2005). This model assumes that the DESCo business model could be operated by existing energy suppliers, or organisations of similar size, and the DESCo market might experience similar levels of competition and government support to Energy Efficiency Obligation (EEO) schemes. Therefore, in the first instance, transaction costs are assumed to be similar to those experienced under utility-operated UK EEO schemes (e in Appendix).

This model of DESCo operation assumes that energy meter data would be available to both utility and DESCo. The utility would use this data to charge the DESCo for units of energy used, if DESCO and utility are separate entities, and the DESCo would use this data to confirm baseline energy use, calculate potential, and confirm actual, savings (though technically this would be possible using the householders' energy bills). Therefore this model of DESCo operation would not be feasible for households without individual energy meters, e.g. multi-unit properties, which might be more suitable for traditional ESCo operation. Smart metering could enable the DESCo business model by facilitating online options appraisals, streamlining energy audits, facilitating contract transfers and, potentially, allowing for demand-side management as a contract option.

The model assumes householders allow DESCos to make modifications to their property, i.e. installing insulation, changing windows or heating systems. In reality DESCos sign-up processes would be likely to allow householders to choose from a list of 'packages' specifying different measures, architectural qualities and associated energy costs so that DESCos would only be managing installations that had been explicitly selected by the householder.

## Energy-Finance Model

In order to assess the viability of the DESCo business model, an energy-finance model was built using a single UK household case study. The house type specified was a 1945–64 semi-detached property, one of the most common in the UK housing stock, single-glazed with gas central heating (un-condensing boiler) and unfilled cavity walls, floor area 78 $m^2$. Standard heating patterns (weekdays: 9 hours/day, weekends: 16 hours/day) were assumed.

The energy-finance model contained three main components:

1. Inputs; including energy consumption, from the CDEM building energy model (outlined in Firth et al., 2010) , energy prices (from Department of Energy and Climate Change, 2011c) and installation cost data (from Department of Energy and Climate Change, 2011b)
2. The model; which uses equations (see Morris-Marsham, 2012) to calculate energy consumption under the baseline, guaranteed and shared savings contracts
3. Outputs; savings on household bills and the DESCos internal rate of return; a measure of an investments' worth calculated using discounted cash flow analysis.

A schematic of the model is shown in Figure 3. Table 1 shows the criteria used to determine whether contracts are viable: (1) savings on household bills must be greater or equal to zero and (2) the DESCo's internal rate of return should greater or equal the interest rate, based on the economic theory of normal profits in which firms in a competitive market will invest up to the point at which profits approach zero.

#### EXAMPLE RESULTS FROM THE MODEL: FINANCING OF VIRGIN LOFT INSULATION

The model was use to simulate the installation of virgin loft insulation on the stock property type. By integrating energy costs, installation costs, transaction costs, interest rates and take-back, before and after installation, the model was able to compare householder's final energy costs under self-financing, where the householder finances the loft insulation themselves, versus installation under DESCo guaranteed and shared savings contracts, where the DESCo finances the installation.

When the installation of virgin loft insulation was modelled in CDEM (see Firth et al., 2010) gas consumption reduced from 373 kWh/$m^2$.a to 290 kWh/$m^2$.a; a reduction of 22 %, before comfort-take-back. Comfort take back reduced these savings to 19 % under self-financing, 18 % under shared savings contracts and 17 % under guaranteed savings. This reflects the higher levels of take back assumed under guaranteed and shared savings than under self-financing (k in Appendix). Factoring in the installation cost to the householder under self-financing these savings are reduced to 14 % over 5 years. Factoring in repayment costs to the householder under guaranteed savings and shared savings, savings are reduced to 7 % and 9 % over 5 years respectively (see Table 3). Repayment costs are higher under guaranteed savings contracts than under shared savings contracts because, under guaranteed savings, the DESCos assumes more risk and therefore requires a higher rate of return on investment (r in Appendix).

Table 2 shows the costs to the householder where no insulation is installed (baseline), under self-financing, guaranteed and shared savings contracts, per year up to Year 5 and Year n, after DESCo contracts have finished. Under self-financing, the householder pays the installation costs in Year 1 and pays for energy as normal after that. Under the guaranteed and shared savings contracts there are no upfront costs to the householder, as the DESCo finances the insulation. Instead guaranteed savings contracts commit the householder to paying a fixed amount to the DESCo each year (£1,505), made up of energy costs (£944) plus repayment costs (£112). Shared savings contracts commit the householder to paying a variable amount each year, equal to energy costs (£931) plus half of the energy savings, or a repayment cost, whichever is greater. As the energy savings here are £200, half of the energy savings (£100) is greater than the repayment costs (£77) so the householder pays £1,031, i.e. £931 + £100, per year. After a DESCo contract elapses the householder reverts to paying for energy directly so, from Year 6, energy costs will be the same as under self-financing, (Year n in Table 2).

#### THE IMPACT OF LOW AND HIGH HOUSEHOLD ENERGY CONSUMPTION ON MODEL RESULTS

The model was used to simulate different households occupying the stock property (1) a low gas consumption household consuming 192 kWh/$m^2$.a (2) a low-medium gas consumption household consuming 279 kWh/$m^2$.a (3) a medium-high gas consumption household consuming 466 kWh/$m^2$.a and (4) a high gas consumption household consuming 641 kWh/$m^2$.a. The same measure, virgin loft insulation, was applied with the intention of testing the viability of DESCo contracts for a range of household types. This level of variation is based on empirical

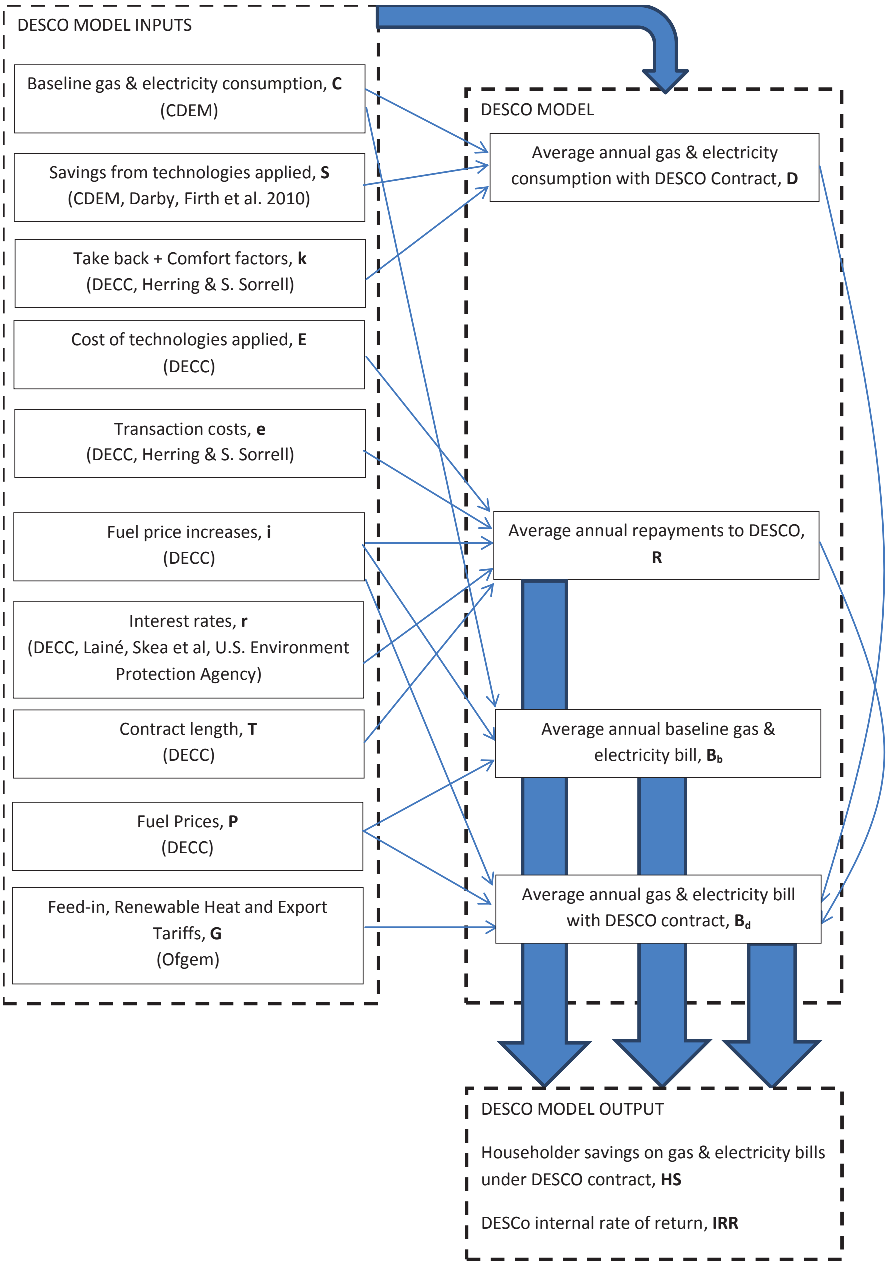


*Figure 3. Schematic of the modeling process. (Source: Morris-Marsham, 2012.)*

**Table 1. Criteria used to assess the viability of DESCos contracts.**

| Viability criteria | Description | Output variable |
|---|---|---|
| HS ≥ 0% | Household savings [a] (HS) are greater or equal to 0% | HS |
| IRR - r ≥ 0 | The DESCos internal rate of return [b] (IRR) is greater or equal to the interest rate | none (the model includes the assumption IRR=r) |

[a] *on baseline energy costs*

[b] *measures an investments' worth using discounted cash flow analysis*

**Table 2. Household costs, including repayment and installation costs, under self-financing, guaranteed savings and shared savings contracts for loft insulation, 0–270 mm, Years 1–5 & Year n (n>5).**

| | Household costs | | | | | | |
|---|---|---|---|---|---|---|---|
| | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Total, Years 1–5 | *Year n* |
| **Baseline** [a] | £1,131 | £1,131 | £1,131 | £1,131 | £1,131 | **£5,656** | £1,131 |
| **Self-financing** [b] | £1,202[e] | £919[f] | £919 | £919 | £919 | **£4,876** | £919[i] |
| **Guaranteed savings** [c] | £1,055[g] | £1,055 | £1,055 | £1,055 | £1,055 | **£5,277** | £919[i] |
| **Shared savings** [d] | £1,031[h] | £1,031 | £1,031 | £1,031 | £1,031 | **£5,156** | £919[i] |

[a] *no loft insulation*

[b] *the householder finances the loft insulation*

[c] *the householder takes out a 5-year guaranteed savings contract for loft insulation*

[d] *the householder takes out a 5-year shared savings for loft insulation*

[e] *energy costs, including comfort take-back: £919, plus loft installation cost: £283*

[f] *energy costs, including comfort take-back: £919, only*

[g] *energy costs, including comfort take-back, £944, plus annual repayments, £112*

[h] *energy costs, including comfort take-back, £931, plus annual repayments, £77, or half energy savings, £100, whichever is greater*

[i] *energy costs including comfort take-back, £919*

**Table 3. Household savings on baseline (HS) under self-financing, guaranteed savings and shared savings contracts for loft insulation, 0–270 mm, Years 1–5 & Year n (n>5).**

| | Years 1–5, Household savings over baseline (HS) | | *Year n*, Household savings over baseline (HS) | |
|---|---|---|---|---|
| **Baseline** [a] | £0 | 0% | £0 | 0% |
| **Self-financing** [b] | £779 | 14% | £212 | 19% |
| **Guaranteed savings** [c] | £379 | 7% | £212 | 19% |
| **Shared savings** [d] | £500 | 9% | £212 | 19% |

[a] *no loft insulation*

[b] *the householder finances the loft insulation*

[c] *the householder takes out a 5-year guaranteed savings contract for loft insulation*

[d] *the householder takes out a 5-year shared savings for loft insulation*

evidence that the heating consumption of households occupying identical homes can vary by a factor of 3 (Gram-Hanssen, 2012).

Figure 4 indicates how household savings vary with baseline gas consumption under guaranteed and shared savings contracts. It shows that households with higher baseline gas consumption will benefit from greater savings rates under DESCo contracts. This is logically valid as insulation will deliver greater net savings, i.e. including installation costs, where baseline consumption levels are high. The trend-lines suggest that guaranteed savings contracts might not be attractive for households with baseline consumption levels below around 220 kWh/m$^2$.a as they would deliver negative savings (increases in energy bills). The slope of the trend-lines indicates that guaranteed savings contracts are more sensitive to energy consumption; this is because the DESCo repayments are fixed regardless of the consumption level. Shared savings contracts are less sensitive to consumption level as repayments are linked to a share of the savings and so increase as energy savings increase. This implies guaranteed savings contracts could be particularly attractive for households with high energy consumption, here households consuming over 500 kWh/m$^2$.a.

Figure 5 indicates how the DESCos internal rate of return (IRR) varies with energy consumption under guaranteed and shared savings contracts. It shows that for guaranteed savings contracts IRR is independent of consumption level, as repayments are a fixed repayment amount based on installation cost. In contrast under shared savings contracts the returns to the DESCo increase as baseline consumption increases. This is because the DESCo gets a share of the energy savings and the value of these savings increases as baseline consumption increases.

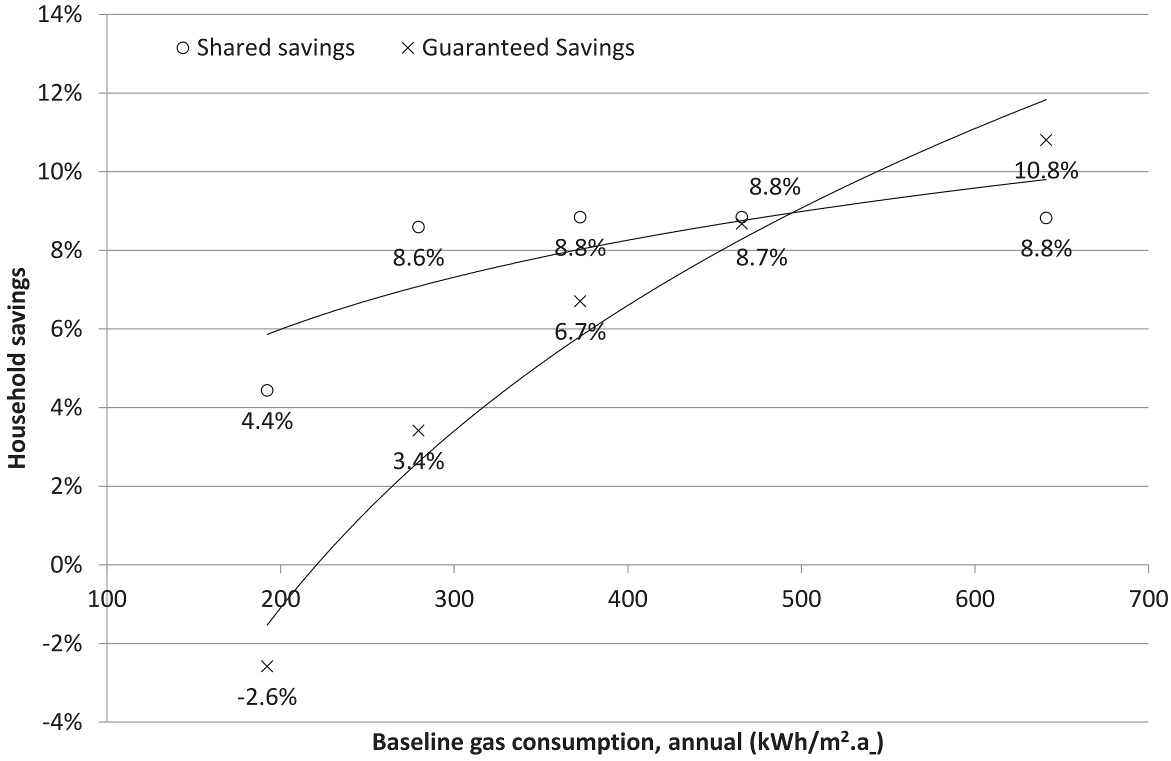


*Figure 4. Household savings, as a percentage of baseline energy costs, against baseline gas consumption under guaranteed and shared savings DESCo contracts for loft insulation (270 mm), 5-year contract.*

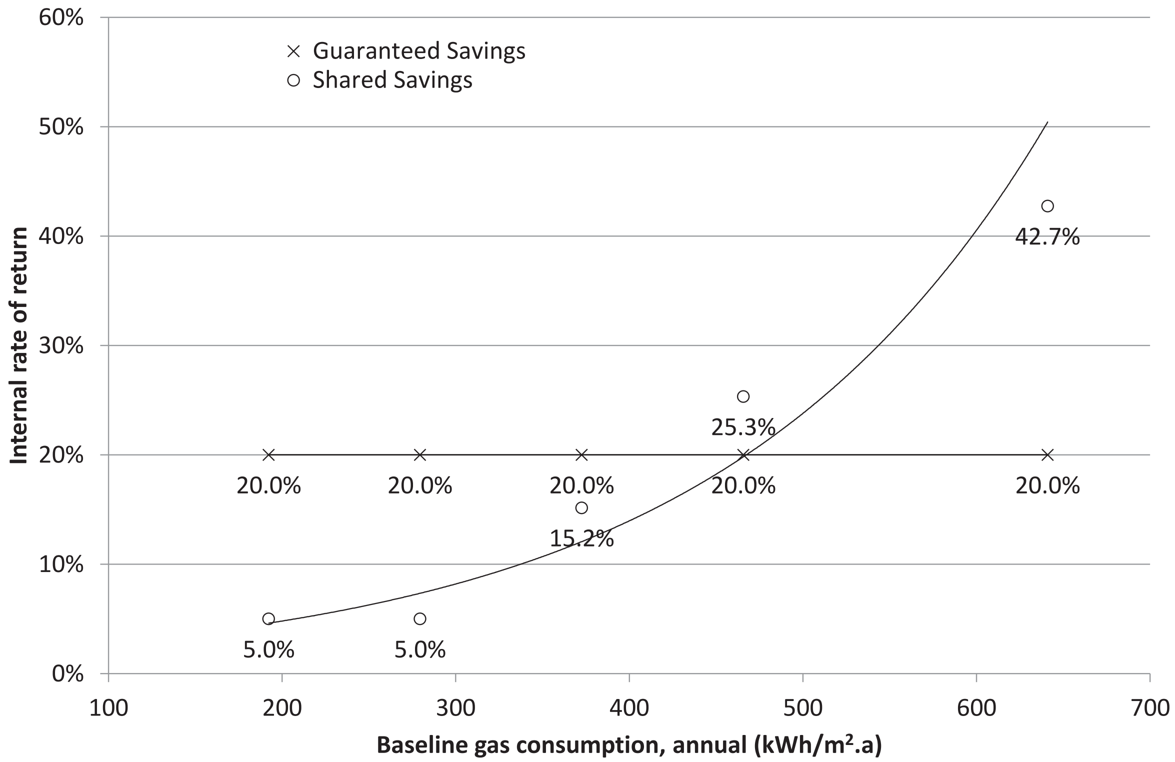


*Figure 5. Internal rate of return against baseline gas consumption under guaranteed and shared savings DESCo contracts for loft insulation (270 mm).*

Therefore at consumption levels over around 460 kWh/m$^2$.a DESCos would receive greater returns from a shared savings than guaranteed savings contracts. For shared savings contracts the minimum internal rate of return is 5 % as the DESCo charges for energy consumed plus either a share of the energy savings or a fixed repayment amount whichever is greater. This guarantees the DESCo a minimum IRR under shared savings of 5 %.

The results shown in Figures 4 and 5 imply that (1) DESCo contracts would result in energy bill increases for households with a low level of baseline consumptions, e.g. less than 220 kWh/m$^2$.a and (2) contracts would deliver the most benefits, to DESCos and households, when baseline consumption is high, e.g. over 460–500 kWh/m$^2$.a. These findings have implications for viability of DESCo contracts for different socio-economic household types as low income households are likely to have lower baseline consumption and also higher rates of comfort take-back (Herring and Sorrell, 2009), making them the most risky and least profitable for DESCos. This suggests that low consumption or low income households might be excluded from entering into DESCo contracts.

#### OTHER SCENARIOS EXPLORED

The energy-finance model was used to explore a number of other scenarios including high transaction costs, high comfort take-back and high energy price rises (Morris-Marsham, 2012). In these analyses all scenarios delivered positive savings to householders at the standard gas consumption level 373 kWh/m$^2$.a. However contracts generated negative rates of returns to DESCos when comfort take-back was high, i.e. in excess of 40 % of total energy savings, and unanticipated by the DESCo. DESCo returns were also negative if energy price rises were high, i.e. in excess of 2 % p.a., and unanticipated. Low rates of return (1–5 %) were generated when transaction costs reached 70 % of project costs. This suggests that correctly anticipating comfort take-back and energy prices and managing transaction costs would be critical to profitable DESCo operation.

The model also investigated the viability of contracts offering other energy efficiency measures, at the standard baseline consumption level (Morris-Marsham, 2012). The results suggested that 5 year contracts for cavity wall insulation, draught proofing and demand side management measures (energy displays and informative billing) would be viable, according to the viability criteria in Table 1, as would 25-year contracts for part-subsidised internal wall insulation (55 % subsidy in line with UK government ECO funding) and part-subsidised 3 kWp solar PV (50 % funded by householder). However 25 year contracts for external wall insulation, solar hot water, double-glazing, replacement boilers, unsubsidised internal wall insulation and unsubsidised solar PV were found not to be viable. This implies, under current economics and assumptions (1) short-term DESCo contracts might be limited to lower cost, lower impact measures (2) higher impact measures would require longer contracts and/or part-subsidisation and (3) DESCo contracts might not be viable for high cost measures.

#### LIMITATIONS OF THE RESULTS

These results have a number of limitations:

1. They only assess DESCo contracts for one house type; a 1945–64 un-insulated cavity-wall semi-detached property.
2. The default interest rate/internal rate of return, used to dictate repayments to the DESCo, was 5 % for shared savings contracts and 20 % for guaranteed savings but there is considerable uncertainty about what interest rates/internal rates of return would be appropriate in practice.
3. The default take-back factors used were 15 % for self-financing, 20 % for shared savings and 25 % for guaranteed savings, based on research findings (Department of Energy and Climate Change, 2011b; Herring and Sorrell, 2009), but high levels of uncertainty exist around the levels of comfort take-back that would be exhibited in practice by householders under DESCo contracts.
4. The default transaction costs used were based on those experienced by suppliers in EEO schemes (Department of Energy and Climate Change, 2011b) but the level of transaction costs DESCos would experience in reality is likely to depend on a number of factors including levels of competition in the market, level of government support and the ease of monitoring terms and conditions.
5. The repayment formulas used represent only one of a range of possible options for DESCo repayment structuring.
6. Energy savings are based on a building energy model (CDEM, Firth et al., 2010) however empirical studies have shown that, in reality, installations often deliver savings rates very different than those suggested by building energy modelling.
7. There is currently no data on what level of household savings would make an energy service contract attractive to householders, nor data to confirm what rate of returns DESCos would require, therefore the viability criteria chosen remain unproven.

Limitations 1 to 6 have been addressed to some extent by the facility to alter these variables within the energy-finance model. However the final limitation can only be addressed by actual operation of DESCos in real markets. Overall these limitations mean that confidence in the results should be extremely cautious and that they should be seen as a focus for discussions on the viability of domestic energy service company business model rather than accurate financial predictions.

## Conclusion

Despite the multiple benefits of domestic energy efficiency there remains a level of householder inertia towards installing energy efficiency measures. The holistic representation of householder barriers to energy efficiency measures presented here shows that households are likely to heavily discount the savings from these measures and that they may be disinclined to install measures due to competing consumption priorities and potential reputational risk. The Domestic Energy Service Company (DESCo) business model presented would offer householders energy efficiency measures in addition to energy supply, under repayment structures which would reflect the varying degree of risk assumed by the DESCo. For householders these contracts would offer some price stability and/or savings guarantees, would devolve some of the reputational risk to the DESCo and would be an alternative to an existing form of consumption; energy purchasing, rather than competing with other priorities.

The assumption of this model is that DESCos would have a better understanding of the profits and risks presented by domestic energy efficiency, would apply lower discount rates and be willing to accept lower levels of return than householders. Therefore, providing DESCos had credit rating similar to householders, this would increase the levels of capital available to finance domestic energy efficiency. DESCos could thus align the economic interests of householder and energy supplier; by selling householders energy services DESCos could profit from reductions in energy use and householders can benefit from lower energy bills. Therefore, unlike policy measures which rely on some level of coercion of suppliers or householders, domestic energy service contracts represent a persuasive business case and therefore might reduce the expense of government intervention in the energy efficiency market.

The results presented suggest that DESCos could viably deliver a number of low cost, or part-subsidised, energy efficiency measures to households with average consumption levels. However DESCos would be exposed to a number of risks; excessive consumption by householders, unanticipated energy price rises and high transaction costs, which would have to be anticipated and managed to ensure profitability. The modelling also suggests that low income or low consumption householders might not offer profitable opportunities to DESCos and therefore might be excluded from participating in these types of contract. A key barrier to the business model could be potential householder disinclination towards long term energy contracts and/or unfamiliar models of supply although empirical evidence from Sweden suggests some consumers value fixed-price, fixed-term energy contracts (Littlechild, 2006). However, in the absence of any operating DESCos, it is not possible to comment either way on the potential householder response.

In summary a business model which sells services rather than units of energy, as outlined here, has the capacity to align the interests of householders and suppliers and mitigate some key householder barriers to installing energy efficiency; risk (reputational and financial), asymmetrical information, access to capital and competing consumption priorities. In this way it might hold the potential to lessen inertia towards investment in energy efficiency in the domestic energy supply market. The energy-finance modelling performed suggests that this model of energy supply could viably finance certain energy efficiency measures, at no upfront cost and little risk to householders, and generate reasonable rates of return to suppliers. In conclusion, the analysis presented here supports the view that the DESCo business model may be impeded by institutional and market barriers and a lack of regulatory support (Hannon et al., 2011) and that these currently prevail over the potential benefits and financial viability of DESCo contracts.

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## Acknowledgements

This research was made possible by EPSRC support for the London-Loughborough Centre for Doctoral Research in Energy Demand (EP/H009612/1).

## Appendix: DESCo model inputs

| Ref. | Name | Description | Value | Units | Source |
|---|---|---|---|---|---|
| C | Baseline annual gas use (default) | Semi-detached house, 3 bed, 1945 to 1964, un-insulated cavity wall, no loft insulation, single glazing, regular gas boiler, no TRVs, 0.86 ach infiltration rate | 373 | kWh/m$^2$.a | CDEM (Firth et al., 2010) |
| C | Baseline annual gas use (low) | Semi-detached house – as above- low consumption | 192 | kWh/m$^2$.a | – |
| C | Baseline annual gas use (low-medium) | Semi-detached house – as above- low-medium consumption (25%< standard) | 279 | kWh/m$^2$.a | – |
| C | Baseline annual gas use (medium-high) | Semi-detached house – as above- medium- high consumption (25%>standard) | 466 | kWh/m$^2$.a | – |
| C | Baseline annual gas use (high) | Semi-detached house – as above- high consumption | 641 | kWh/m$^2$.a | – |
| P | Gas price | Full retail: domestic, 2011 prices (central) | 3.9 | p / kWh | (Department of Energy and Climate Change, 2011c, Table 5) |
| i | Annual gas price increase | Constant prices | 0 | % | – |
| i | Annual electricity price increase | Constant prices | 0 | % | – |
| r | Guaranteed savings interest rate | ENERGY STAR' Buildings Recommended 'hurdle rate' | 20 | % | (U.S. Environment Protection Agency, 1998, p. 3) |
| r | Shared savings interest rate | Green Deal Impact Assessment interest rate | 5 | % | (Department of Energy and Climate Change, 2011a, p. 62) |
| T | Contract length | for loft insulation | 5 | years | – |
| k | Self-financing comfort take back | Comfort take back factor | 15 | % | (Department of Energy and Climate Change, 2011a, p. 62) |
| k | Guaranteed savings comfort take back | Comfort take back factor | 25 | % | Estimate (based on Herring and Sorrell, 2009, p. 36) |
| k | Shared savings comfort take back | Comfort take back factor | 20 | % | Estimate (based on Herring and Sorrell, 2009, p. 36) |
| e | Transaction costs | EEC Transaction costs (energy supplier) | 18 | % | (Ofgem in Department of Energy and Climate Change, 2011a, p. 25) |