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Delivering energy efficiency in the UK through Domestic Energy Service Companies (DESCos)

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Abstract

UK government interventions such as EEC and the Green Deal attempt to close the energy efficiency gap by addressing the upfront cost and information barriers to domestic energy efficiency. This study explores whether Domestic Energy Service Companies (DESCos) have the capacity to close this gap through fixed term ‘energy service’ contracts. It employs an economic model, and an analysis of the strengths and weaknesses of DESCos, to comment on their viability. For the simple case of loft insulation the study found that DESCo contracts delivered savings on household energy bills of 7-9%, compared to 14% savings from self-financing. Plus DESCos were found to reduce the upfront cost, risk and consumer inertia barriers. The study concludes that DESCos may have the potential to deliver energy efficiency in the domestic sector but may be prevented from doing so by systemic institutional and market barriers.

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List of abbreviations/symbols

Energy Service Company	ESCo
Domestic Energy Service Company	DESCo
Energy Efficiency Commitment	EEC
Carbon dioxide	CO_2
Carbon Emissions Reduction Target	CERT
Community Energy Saving Programme	CESP
Energy Company Obligation	ECO
Feed in Tariffs	FITS
Renewable Heat Incentive	RHI
Community Domestic Energy Model	CDEM
Green Deal Impact Assessment	GDIA
Solar Photovoltaic	Solar PV
Solar Hot Water	SHW
Thermostatic radiator valves	TRVs
Cavity wall insulation	CWI
Loft insulation	LI
External wall insulation	EWI
Internal wall insulation	IWI
Demand side management	DSM
Air change rate per hour	ach
Department of Energy and Climate Change	DECC
Internal rate of return	IRR
Household savings	HS
Green Investment Bank	GIB
Integrated energy contracts	IECs

1 Introduction

Background

Domestic energy efficiency, defined here as the outcome of measures to reduce household energy use, is a priority for energy policy makers due to its positive effects on health, disposable income, carbon emissions and energy security. Domestic energy efficiency improves individual health; studies have demonstrated that exposure to cold and damp cause the majority of seasonal infection and sickness (Clinch & Healy 2001). In addition to these physical health impacts, energy efficiency can improve financial health; 18% of UK households are living in 'fuel poverty', i.e. they would need to spend more than 10 per cent of household income to achieve an 'adequate' level of warmth through the year (Hills 2011) therefore, by reducing energy costs, energy efficiency has the potential to increase these households disposable income.

Furthermore as household energy use accounts for around 30% of our total carbon emissions, domestic energy efficiency represents an important element in efforts to reach the UK's binding carbon reduction target of 80% by 2050[1] (Committee on Climate Change 2011). Finally, looking to a future where domestic heating may need to be increasingly electrified, increases in domestic energy efficiency could reduce the amount of electricity generation needed[2] and improve energy security.

The Energy Efficiency 'Gap'

Despite the importance of energy efficiency, mainstream energy literature acknowledges a 'gap' between expected and delivered levels (Sorrell 2004). This gap is apparent in the domestic sector for example, out of a random sample of UK householders who had been given recommendations of energy efficiency measures suitable for their home 44% indicated that they were either not considering, or were not sure about, taking action (National Energy Services 2009). The implication is that many energy efficiency measures, which make financial and technical sense, go unexploited.

[1] compared to 1990 levels
[2] As domestic energy use is largely accountable for daily peaks in electricity demand which in turn dictate total levels of generation capacity and reserve capacity required from our energy infrastructure (Boardman et al. 2005).

Between 2002 and 2010, government initiatives designed to close gap have focussed on reducing the upfront cost of energy efficiency measures. The Green Deal, planned for launch in 2012, represents a new type of intervention whereby the upfront cost of measures is covered by a loan. However theories used to explain the energy efficiency gap, e.g. techno-economic and socio-cultural 'barrier' models, suggest that upfront costs are only one of the barriers to energy efficiency. This calls into question whether interventions like the Green Deal have the capacity to close this energy efficiency gap and suggests the need to explore other ways of delivering domestic energy efficiency.

Energy services

One characteristic of the energy sector is that consumers pay for the amount of energy they use in the form of a *product*, e.g. units of electricity or gas, whereas what they actually consume is a *service*, e.g. a warm home, lighting, refrigeration, etc. This highlights that it is in consumer's interests to maximise the efficiency of the systems that deliver these services, in order to gain the greatest benefit from the units of energy they buy.

However, in reality, most consumers have limited knowledge of the how technologies in their home and its thermal properties affect the delivery of 'energy services', e.g. warmth, light etc. In other words they lack the expertise to optimise their energy systems. Conversely energy suppliers maximise profits by maximising unit sales therefore any increase in the efficiencies of energy systems will cause their revenues to fall. Therefore there is a conflict between the goals of the householders (maximising efficiency) and suppliers (maximising unit sales).

One mechanism which has the potential to resolve this conflict is the energy service company (ESCo). In the commercial sector, ESCos identify, finance and/or implement energy efficiency opportunities for clients and are either paid a fee (provisional on performance) or share a proportion of the energy savings (World Bank 2004). As both ESCos and clients benefit from energy efficiency, this business model aligns the interests of clients and suppliers. This study proposes that the ESCo business model may also present opportunities to deliver energy efficiency in the domestic sector.

Study aims & objectives

The aim of this study is to explore whether domestic energy service companies (DESCos) could help to overcome the barriers to domestic energy efficiency in the UK and the strengths and weakness of the DESCo business model compared to existing government interventions.

Therefore the research questions this study seeks to answer are:

- What are the barriers to domestic energy efficiency?
- Can these barriers be addressed through Domestic Energy Services Companies (DESCos)?

In order to answer these questions the study has the following objectives:

1. To review existing literature on barriers to domestic energy efficiency and Energy Service Companies (ESCos)
2. To perform a simple economic analysis of the DESCo model and explore the key influences which might affect its viability
3. To generate conclusions on whether DESCos have the capability to deliver energy efficiency in the UK domestic sector

2 Literature Review

The early parts of this chapter will discuss the barriers to cost effective domestic energy efficiency[3] and how existing government interventions address these barriers. The final parts will outline Energy Service Companies (ESCos) and Domestic Energy Services Companies (DESCos) in the context of these barriers and interventions.

2.1 Barriers to domestic energy efficiency

The most commonly stated drivers of domestic energy efficiency are financial, 'living standard' or environmental reasons (Bruel & Hoekstra 2005; Vadodaria et al. 2010). However these drivers appear to be insufficient to deliver energy efficiency in UK homes; for example 51% of homes with cavity walls remained un-insulated (Department of Energy & Climate Change 2011d)[4]. This observed discrepancy between the energy efficiency measures identified as cost effective, and those actually installed, has led to the identification of an energy efficiency gap, i.e. a 'gap' between expected and actual levels of energy efficiency investment (Sorrell 2004), and has spawned theories about the 'barriers' to energy efficiency. There are two main paradigms in the barriers debate; the techno-economic model, which uses economic theory to explain why energy efficiency opportunities may go underexploited, and the socio-cultural model, which gives weight to social and psychological and lifestyle factors in order to explain disinclination towards energy efficiency measures (Jensen 2005). These two theories are outlined below.

2.1.1 Techno-economic model

To date, the majority of literature on the barriers to energy efficiency focuses on techno-economic barriers, perhaps due to the technological nature of energy efficiency investments. Sorrell et al (2004), in their study of the economics of organisational energy efficiency, outline these barriers as:

[3] N.B. the term 'cost effective' energy efficiency is used to describe interventions whose capital and running costs are exceeded by energy savings over the interventions' lifetime. This study focuses on energy efficiency measures that might generate an 'operating profit' and so omits looking at the barriers to measures which are *predominantly* environmentally or socially motivated.

[4] despite the fact that cavity wall insulation is one of the most cost effective energy efficiency measures with a payback time of around 2 years (Energy Saving Trust 2011)

1. Risk
2. Imperfect information
3. Hidden costs
4. Access to capital
5. Split incentives
6. Bounded rationality

In reality, these barriers are not mutually exclusive and they are often linked or interact with one another. Each barrier, and potential interactions, is explored in detail below.

1. Risk

Due to complexity in the installation, operation and monitoring of measures and uncertainties associated with fuel prices or the lifetime of the investment, energy efficiency investments appear to have relatively high technical or financial risk. In the domestic context, this means if a householder is unsure about whether an installation will be done on budget, operate as expected and deliver the savings promised, they will be less likely to invest in energy efficiency or will demand higher rates of return, in terms of energy savings, than models using market interest rates might predict. The higher the perceived 'riskiness' of the measure the higher the rate of return demanded.

Discount rates are often used to illustrate this dynamic; the more risky an investment the more the consumer will 'discount' future savings as the less certain they will seem. Higher discount rates essentially reduce the value of future cost savings and this in turn extends the time it takes for a measure to pay for itself. Therefore high discount rates can turn a measure perceived to be 'cost effective' into one that does not payback within an acceptable timeframe for the householder.

However an energy service company, having expertise in energy efficiency, is likely to have greater confidence than a householder in the costs and savings of a particular measure, therefore the discount rates they would apply are likely to be lower than those applied householders[5]. This

[5] Studies have shown that consumer discount rates can be as high as 34% for energy investments (Scarpa & Willis 2010), whereas ESCos might have discount rates closer to the interest rates used in standard economic assessments, e.g. 3-20%

means a measure that is not 'cost effective' to a householder could be 'cost effective' to an energy service company.

2. Imperfect information

Good information is important for energy efficiency investments, which are made rarely and whose quality cannot be judged prior to installation. Empirical studies indicate that most householders will ask for information or advice before they take energy saving measures (Bruel & Hoekstra 2005). Conversely, the alternative to energy efficiency investments: continuing to pay for energy at the existing level, is a familiar and straightforward proposition; "energy commodities represent a simple, unchanging, easy to understand and homogenous product which is purchased from a small number of large well-established and trusted firms" (Sorrell 2004, p.60). This implies that there is an information asymmetry between energy efficiency and the alternative, i.e. consumers have access to better information on the costs and benefits of maintaining the status quo: not making energy efficiency investments, than they do about the benefits of making energy efficiency investments.

Furthermore information has some of the characteristics of a 'public good', i.e. one persons' consumption of information does not prevent another person consuming it and often information 'producers' do not have exclusive access to it[6](Sorrell 2004). These dynamics mean that the costs of producing information may, in many cases, exceed the revenue that can be gained from it. As a result the market will undersupply it because suppliers cannot appropriate the full benefits or will supply it only when it may increase other revenue streams, e.g. in the case of marketing material[7].

Imperfect information is often considered a key issue in the barriers debate (Sorrell 2004), which explains why many government energy efficiency initiatives take the form of information campaigns. Without these campaigns, consumers would be likely to encounter higher costs in finding and evaluating information on energy efficiency. For example, they may not only have to compare information on costs and benefits from a range of suppliers but also assess the reputability of this information and would incur 'search costs' associated with the time and effort

[6] as information can both be used by multiple people and can be cheaply and easily replicated
[7] Alternatively firms may try to recoup expenditure by charging for information, e.g. in the case of a home energy audit, however consumers may choose not to pay for this information as its quality and benefits will not be apparent prior to purchase

spent. A study of large organisations, where the time pent searching for information was valued using wage rates, found search costs to be 3-8% of total energy efficiency investment cost (Sorrell 2004). For smaller organisations or householders it is likely that, proportionally, search costs would be even greater due to lower initial expertise and smaller project sizes. For energy service companies, energy efficiency measures are frequent and straightforward purchases and therefore the importance of good information, and the search costs involved, are likely to be less than for householders.

3. *Hidden Costs*

'Hidden cost' is an umbrella term for any costs or disadvantages that are not taken into account by pure engineering or economic assessments. Hidden costs therefore often derive from, or are the manifestations of, other barriers to energy efficiency. Examples of hidden costs include:

- The time, effort or money needed to identify, negotiate, finance and supervise energy efficiency investments, sometimes termed the transaction cost
- The disruption or inconvenience experienced as a result of installation
- 'Making good' costs, e.g. redecoration
- Any performance-related disadvantages e.g. increased damp or noise, reduced light, less attractive appearance, increased maintenance or reduced reliability

Commonly cited examples of hidden costs include the hassle involved in loft clearance (for loft insulation) or changes to property appearance (for solid wall insulation). Perceptions of hidden costs can turn what appears a cost effective measure into one that is not attractive to the householder. NB it is the *perceived* rather than actual hidden costs of a measure which may influence whether a measure is undertaken. This means that imperfect information may increase the perception of the hidden costs from a householder's perspective[8] and illustrates how one barrier, e.g. imperfect information, may lead to a second barrier; hidden costs. This implies that the reasons for non-installation of energy efficiency by householders may be dictated by complex interactions between a number of barriers, e.g. "We haven't installed cavity wall insulation as we

[8] For example cavity wall insulation has long suffered from association with increased damp amongst certain groups of householders, whereas in fact independent studies have shown that it actually reduces the risk of damp (Energy Saving Trust 2002).

weren't sure how to go about it and it all seemed too much hassle for the savings we would make" (imperfect information leading to an increase in a hidden cost, i.e. hassle).

4. *Access to capital*

Energy efficiency measures invariably involve some sort of capital cost. The access to capital barrier suggests that householders may not have sufficient funds to cover this capital cost or cannot access funds at a sufficiently attractive interest rate. Access to capital is also a barrier due to the characteristics of energy efficiency measures themselves as these investments are illiquid, i.e. once the investment has been made it is difficult to turn it back into capital by selling it on, sometimes described as 'stranded assets'. This means that energy efficiency investments represent a greater risk to funders, due to lack of collateral, and therefore will command higher interest rates which may also prevent the uptake of otherwise 'cost effective' measures.

5. *Split incentives*

Energy efficiency may prove not to be cost effective if the investor cannot appropriate some or all of the benefits from a measure. This is termed a split incentive, as the incentives to invest in a measure may be split between two or more parties. Examples of split incentives are where a landlord owns a property, and benefits from any capital investment in the property, but a tenant pays the energy bill, and benefits from any reduction in bills. In this circumstance the savings from an investment would have to be much greater in order to make it cost effective, either for landlord or tenant, than if one party benefitted from both the capital investment and energy savings. A similar situation is experienced where a householder cannot guarantee that they will stay in the property for the lifetime of their investment and so the incentive to invest is split between the current and future owners.

In many ways the split incentives barrier is linked to imperfect information, for example if a landlord had good information that he could command a higher rent by investing in energy efficiency on behalf of his tenants this would reduce the payback time of his investment. Similarly if the householder had good information on the value that energy efficiency might add to their property they would know that they could recoup a portion of their investment. Both these examples indicate how, with good information, the split incentives barrier can be mitigated.

6. *Bounded rationality*

Bounded rationality acknowledges that investors will not always act in a perfectly technically and economically rational manner. Under orthodox economic theory, investors are assumed to act as rational 'utility maximising agents', i.e. they will take actions which present a net gain and avoid actions which present a net loss. However techno-economic models that incorporate behavioural economics acknowledge that the "the human capacity to process information is quite limited,… humans try to economise on cognitive effort by relying on shortcuts and … human cognition and judgement is subject to a wide range of biases and errors" (Foss in Sorrell 2004, p.44). Therefore rather than being utility maximising, individuals are 'satisficing', i.e. they will strive to make 'satisfactory' decisions rather than expend extra time and effort attempting to identify an optimal solution.

As a result bounded rationality theory assumes that the time, effort and mental capacity investors have to dedicate to energy efficiency decisions is limited[9]. On a more subtle level, however, it also incorporates psychological attitudes to reputational and financial risk, in particular behavioural theories that suggest that most people disproportionally prefer certain to uncertain outcomes, exhibit 'status quo bias'[10], or hold a greater preference for avoiding loss than experiencing gain[11] (Sorrell 2004).

Summary of techno-economic model

The techno-economic barrier model assumes that investors are predominantly rational utility-maximisers and uses the concepts of imperfect information, hidden costs and bounded rationality to explain why these rational, or boundedly-rational, investors might choose not to invest in energy efficiency. Empirical studies often reveal techno-economic barriers as the key reasons for the non-implementation of measures, particularly the information, capital (Jensen 2005; Vadodaria et al. 2010) and hidden cost barriers (Bruel & Hoekstra 2005; National Energy Services 2009) and UK government policy predominantly seeks to address information and capital barriers [see 2.2].

[9] In this way it is linked to the imperfect information barrier, as the time and effort involved will be influenced by the availability of information.
[10] a preference for the status quo over an alternative
[11] known as loss aversion

However we cannot discount that empirical studies may explicitly or implicitly reflect the hegemony of the techno-economic barrier model, i.e. studies may have been designed in a way that limits their ability to identify other barriers[12] or may reflect the social acceptability of techno-economic barriers as justification for non-implementation of measures. An alternative theory- the socio-cultural barrier model - suggests that social drivers may be as important in the non-implementation of energy efficiency, if not more so, as techno-economic drivers.

2.1.2 Socio-cultural model

In contrast to the techno-economic model, which assumes consumers act in a rational way in response to technical or financial barriers, the socio-cultural model implies that consumption and investment are driven by social and cultural factors. Socio-cultural theories of consumption were pioneered by Thorstein Veblen's theory of conspicuous consumption, which challenged the dominant utility-maximising theories of neoclassical economics. The theory posited that consumption preferences are determined socially and in relation to the positions of individuals in the social hierarchy (Trigg 2001). Therefore the socio-cultural model asserts that consumption is a matter of communication; explicitly of inclusion and exclusion, and is linked to the desire to maintain or enhance reputation (Jensen 2005).

In the energy efficiency realm, a measure may make technological and economic sense, with techno-economic barriers that can be overcome, however there may still be resistance to implementation deriving from lack of positive communication and/or perceived loss of reputation associated with the measure. These dynamics can be bracketed into 'lack of interest' in energy efficiency and manifest themselves in an 'inertia' towards energy efficiency (Jensen 2005). Empirical studies have found that expenditure that makes less technical or economic sense than energy efficiency measures, such as new kitchens or bathrooms, are frequently given a higher priority (Jensen 2005; Vadodaria et al. 2010) or that energy efficiency is only implemented as a by-product of other refurbishments (Vadodaria et al. 2010; Bruel & Hoekstra 2005). This indicates a degree of disinclination towards energy efficiency.

[12] By use of methodologies, e.g. closed question surveys, which may limit responses to identifying only techno-economic barriers

At the heart of the socio-cultural model is the implication is that decisions on energy efficiency measures are not taken in isolation of other consumption decisions and that the status enhancing and reputational benefits of energy efficiency will be compared to those of other consumer products. As energy efficiency measures like insulation are, at best, invisible, sometimes visually intrusive, and commonly have low levels of cachet, this puts them at a disadvantage compared to the traditional 'consumer goods'.

A further aspect of this theory is that a house is not merely a physical structure but "a dynamic entity intimately related to the living of the house owner" (Jensen 2005, p.1330) and therefore may have a strong link to individual identity. This implies that any changes to the visual and sensory experience of a property are associated with high risks to reputation and ultimately identity. If we synthesise this aspect of socio-cultural theory with techno-economic theories of risk, this implies that energy efficiency measures would require a higher rate of return, either reputationally or financially, than consumption options that present no reputational risk.

These dynamics can be illustrated by observing that renewable energy systems are considered 'desirable' as a means of conspicuous, reputation-enhancing consumption[13] despite lower levels of financial savings than home insulation,. The socio-cultural model implies that measures which combine economic and reputational benefits, or at the very least do not present a threat to reputation, have a much greater potential for implementation. One extension of this theory, as implied by Jensen (2005), is that techno-economic barriers may be used as the 'excuse' for non-installation, whereas in fact socio-cultural factors have a more decisive effect on outcomes.

2.1.2.1 Other barriers

It is worth noting that cost-effective energy efficiency measures can also be hindered by institutional barriers such as planning permission or technological 'lock-in'. 31% of UK current housing stock has solid walls and may therefore require planning permission for external wall insulation (Department of Energy & Climate Change 2011d). This represents a significant barrier which may increase 'hidden costs' in terms of time, money and effort expended. Technological lock-in is caused by vested interests and the infrastructures, technical skills and regulations of

[13] , as illustrated by references in media sources to renewable energy being "sexy" (Shere 2010; VerdeXchange 2007)

existing actors (Skea 2010). For example bias against energy efficiency measures may be exhibited in the plumbing, building and electrical trades amongst those who are less familiar with new technologies and building methods than traditional modes of operation. These biases may increase the perceived risks of energy efficiency measures, if tradespeople may fail to recommend, or actively discourage, energy efficiency measures.

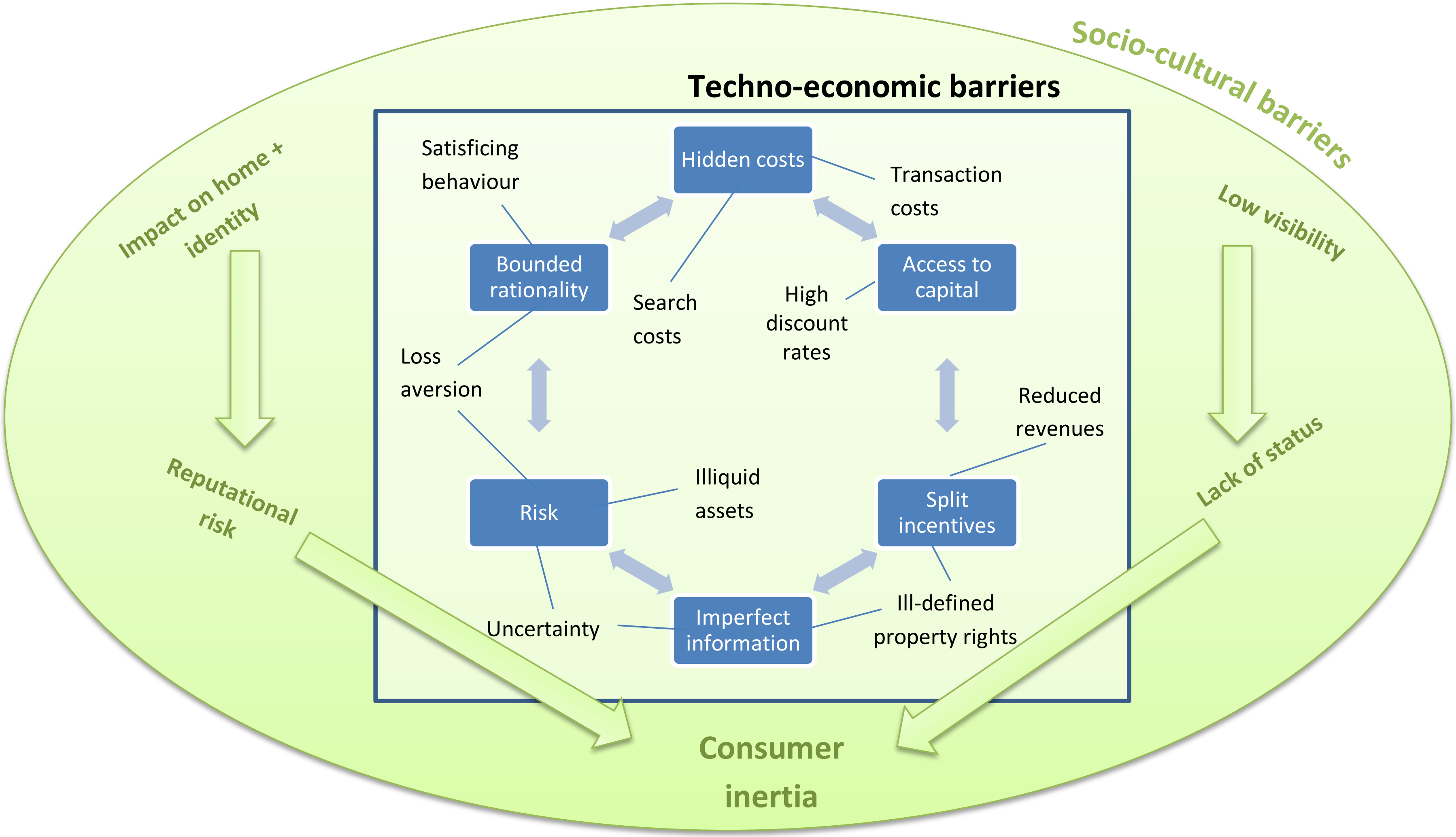
2.1.3 Summary of barrier models

Barrier models use techno-economic or socio-cultural barriers to explain the ‘energy efficiency gap’ between expected and actual installations. Techno-economic models suggest that householders predominantly act in an economically rational manner but are prevented from installing energy efficiency measures by characteristics associated with the transaction itself (e.g. risk, hidden costs, split incentives) and by limits to their own capabilities and resources (e.g. lack of capital or information or bounded rationality). These barriers are seen as ‘market failures’ and the interventions considered appropriate to address them include increasing access to capital and providing reliable information, see Section 2.1.4.

Socio-cultural models however suggest that consumption decisions are motivated by the desire to communicate identity and to maintain reputation. Therefore energy efficiency investments compete for priority with other consumer purchases. Studies suggest that, due to their low visibility, lack of status and reputational risks, energy efficiency measures often fare badly. Socio-cultural barriers are not considered a market failure but rather a consequence of social norms and hierarchies. Regarding interventions, Vadodaria et al suggest “it may be necessary to make the acquisition of carbon reducing technologies as appealing to householders as a new bathroom or kitchen” (Vadodaria et al. 2010, p.12).

Industry and academia still remain closely aligned with the techno-economic model, with the bulk of attention falling on economic barriers, however perceptions of ‘social inertia’ as a barrier are on the increase (Energy Research Partnership 2009). In reality, both models have the potential to contribute to our understanding of the gap between expected and actual energy efficiency installations. Theory and empirical studies suggest that, in any one case, energy efficiency measures may not be installed due to interacting and reinforcing dynamics linked to the characteristics of the measure, the householder and the wider social context. Figure 1 presents a holistic view of the barriers debate and attempts to illustrate the interactions between techno-economic barriers and also the influence of socio-cultural barriers. The next section explores how current government interventions address barriers to domestic energy efficiency.

Figure 1: Barriers to the installation of domestic energy efficiency measures



2.2 Government interventions in the UK domestic sector

Most of the past UK government interventions designed to mitigate the barriers to energy efficiency have focused on technical or economic barriers. The analysis below outlines current interventions and assesses their capacities to mitigate barriers to energy efficiency discussed in 2.1.

2.2.1 Energy Company Obligations

The first energy company obligation was the Energy Efficiency Commitment (EEC), 2002-2008. EEC required utility companies to spend a certain sum (later achieve a certain level of energy savings) per customer on approved energy efficiency measures. Utilities were free to arrange how money should be spent and most opted for schemes which subsidised (for able to pay groups) or fully funded (for 'priority' groups) cavity wall and loft installations. Free advice and a free site survey were included. EEC installations totalled 3.8 million, the bulk of which (3.4m) were cavity wall insulation and loft insulation (Department of Energy & Climate Change 2011e).

In 2008 EEC was replaced by the Carbon Emission Reduction Target (CERT) scheme which had similar operational boundaries, e.g. it required domestic energy suppliers to make a certain level of CO_2 savings per customer (Department of Energy and Climate Change 2011b). It had some differences to EEC; e.g. it excluded low energy light bulbs and demanded a proportion of measure are targeted at a new 'super priority group'. An additional programme, the Community Energy Saving Programme (CESP), which started in Sept 2009, ran alongside CERT and was also funded by energy companies. It took a "whole house" approach by offering a free or heavily subsidised "package of energy efficiency measures" and was only available to households in designated low income areas (Department of Energy and Climate Change 2011c). 2.4 million cavity-wall and loft installations were made under CERT between 2008 and 2009 (Department of Energy & Climate Change 2011d)

CERT is due to run until December 2012 when it will be replaced by the Energy Company Obligation (ECO) and the Green Deal. ECO is intended to target those householders and those types of property which cannot achieve financial savings without additional support (Department of Energy & Climate Change 2011c).

2.2.2 Warm Front

Warm front is a treasury-funded grant scheme, running since 2002, which funds cavity wall, loft insulation, boiler replacements and upgrades and draught proofing for qualifying households, i.e. those in receipt of income or disability related benefits. Grant funding started around £2,000 per property in 2002 and has risen to £3,500 over the course of the scheme, any costs over this sum have to be covered by the householder[14]. Like energy company obligations, participating households received free energy advice and a free home survey.

2.2.3 Feed in Tariffs & Renewable Heat Incentive

Feed in tariffs (FITs), operational since April 2010, provide a fixed payment for each kWh generated by approved small-scale renewable energy systems. Agreements last 25 years and, at initial levels, dramatically altered the cost effectiveness of some domestic renewable systems, such as solar PV[15]. The renewable heat incentive (RHI) offers a similar type of fixed payment for renewable heat generation, including biomass, solar thermal and ground and water source heat-pumps. The scheme for domestic installations will run alongside the Green Deal, from late 2012, though the RHI will apply to all approved installations dating from July 2009 (Department of Energy and Climate Change 2011e).

2.2.4 The Green Deal

The Green Deal, due to launch in 2012, is a loan to householders for a range of energy efficiency and renewable energy measures. Loans will be offered by a range of providers, mostly private companies, and repayments will be made through energy bills, administrated by utility companies. Loans are attached to the property so, if the original householder moves, repayments will be levied on subsequent occupants' energy bills. Interest will be charged on the loan, though at what rates and whether these will be fixed or variable is not currently known (Department of Energy and Climate Change 2011f).

2.2.5 Summary

Table 1 indicates how government interventions address the techno-economic and socio-cultural barriers to energy efficiency identified in 2.1. It suggests that the barriers most commonly addressed

[14] unless there is a local authority 'Warm Front top-up' scheme running in the area
[15] However tariffs were substantially reduced in December 2011 following a government review.

by government interventions are the capital and information barriers with hidden cost and bounded rationality barriers being least addressed. Progression down the table, which is in ordered by the start date of the intervention, indicates that recent policy measures address more barriers than older ones, indicating some evolution of policy. However, the planned intervention; The Green Deal, leaves three barriers entirely unaddressed; risk, hidden costs and bounded rationality, and only partially addresses consumer inertia. The challenge for policy makers is to find ways to address these lingering barriers. The rest of this report assesses the capacity for domestic energy service companies to address these barriers.

Table 1: Summary of existing government interventions and barriers addressed

	Barriers addressed						
Intervention	**Risk**	**Information**	**Capital**	**Hidden costs**	**Split incentives**	**Bounded Rationality**	**Consumer inertia**
EEC	/ (Zero for priority groups)	Free advice	/ (Part funded)	X	/ (Zero for priority groups)	X	X
Warm Front	Zero except where top-up required	Free advice	Fully funded	X	Zero as most fully funded	X	X
CERT	/ (Zero for priority groups)	Free advice	/ (Part funded)	X	/ (Zero for priority groups)	X	X
CESP	Zero	Free tailored advice	Full funding	X	Zero as fully funded	X	X
FITs	X	X	Fixed tariff	X	X	X	Includes high status measures
RHIs	X	X	Fixed tariff and one-off payment	X	X	X	Includes high status measures
ECO	/ (Zero for priority groups)	Free advice	Full funding	X	/ (Zero for priority groups)	X	X
Green Deal	X	Free tailored advice	No upfront cost	X	Loan tied to property	X	/ (Includes high status measures)

Key:
X unaddressed barrier
/ partially addressed barrier

2.3 Energy Service Companies

Energy service companies (ESCos) rose onto political agendas in the Europe in the middle of the 2000s and the bulk of literature on ESCos dates from 2002-2007[16]. This section uses the literature to define ESCos, outline their advantages and barriers.

2.3.1 Definitions

Bertoldi et al define an energy service company as “a natural or legal person that delivers energy services and/or other energy efficiency improvement measures in a user’s facility or premises, and accepts some degree of financial risk in doing so” (Bertoldi et al. 2007, p.6). The basic premise is that ESCos reduce client’s energy costs by facilitating improvements in energy or building systems. In other words, they take responsibility for improving the efficiency of client’s energy systems in return for a fee. The services commonly offered by ESCos in the commercial sector include audits, project design, management, implementation, maintenance and monitoring (Rezessy et al. 2005). A fundamental feature of the ESCo/client relationship is that it is formalised by an energy service contract[17]which, according to Sorrell, necessarily involves a “transfer of decision rights over key items of energy equipment under the terms and conditions of a long-term contract, including incentives to maintain and improve equipment performance over time” (Sorrell 2005, p.4).

Energy service contracts generally take one of two forms; shared savings or guaranteed savings. Under a shared saving contract the ESCo and client split energy bill savings over a pre-determined length of time, according to pre-determined percentages, as specified by the contract. In this case it is possible for the ESCo to share the ‘performance risk’, i.e. the risk of the project not delivering the expected savings. Conversely under a guaranteed saving contract the ESCo guarantees the client a certain level of savings, as specified in the contract, therefore takes on all the performance risk (Bertoldi et al. 2006b). In both cases, some form of monitoring may be necessary to confirm savings, though this is more critical in shared savings contracts where there are no fixed payment terms. Contracts may also specify a fixed energy price, to guard against unforeseen energy price changes

[16]interest appears to wane somewhat from 2007-2010 perhaps influenced by the increased adversity to investment risk resulting from the global financial crisis (Hannon et al. 2011; Marino et al. 2011) and also possibly by a lack of confidence in ESCos following Enron Energy Services’ bankruptcy (Hopper et al. 2007)

[17] often referred to as an energy service contract, energy performance contract, energy savings performance contract or contract energy management

(Rezessy et al. 2005). There are three options for financing ESCo projects; ESCo- financing, client-financing and third party-financing. The party who finances the project holds the 'business risk', i.e. the risk of default.

In summary the three defining features of the relationship between energy service companies and their clients are:

(i) a fixed-term[18] commitment enshrined in an energy service contract

(ii) a payment structure that relates (directly or indirectly) to efficiency savings

(iii) some degree of financial and/or technical risk undertaken by the ESCo

The literature on ESCos does not distinguish between companies that serve the domestic sector and those that serve other sectors, however surveys have found that only 11% of European ESCos were willing to work with clients whose energy bills were less than 10,000EUR (£8,400) per year. This suggests that, at present, the domestic sector in Europe is largely un-targeted by ESCos.

2.3.2 Advantages

The literature identifies a number of advantages to commercial clients of the ESCo model over the self-financing of energy efficiency projects. These include:

- **A reduction in the risk** associated with energy efficiency projects as guaranteed and shared savings contracts transfer either performance or business risk or both to the ESCo[19] (Grim 2005)
- **A reduction in upfront investment costs** via ESCo or third party financing. This mitigates the upfront cost barrier to energy efficiency (Bertoldi et al. 2007)
- **Access to the experience and technical expertise** of the ESCo thereby reducing the search costs, management time and effort (hidden costs) associated with energy efficiency installations (Bertoldi et al. 2007; Sorrell 2005)
- **Increased availability of capital** as ESCOs may accept lower returns on investment than clients, and may be able to access lower interest rates, thereby increasing the availability of capital (Hawkes et al. 2005)

[18] in the case of a 'variable term contract' the contract length may vary, depending on the rate at which savings cover agreed ESCo payments (World Bank 2004, p.13)

[19] Under guaranteed savings contracts the ESCo would hold the performance risk (the risk of the project underperforming) and under ESCo-financing it would hold the business risk (the risk of the client defaulting on the contract)

- **Reduced capital costs** due to bulk purchasing discounts available to ESCos (Sorrell 2005)
- **Guaranteed comfort / performance levels** can be specified through contract terms (Grim 2005)

In summary the main advantages of ESCos are that they make energy efficiency investments more attractive by addressing the upfront cost, risk and hidden cost barriers, they may also offer reduced capital costs, increased comfort and/or performance improvements.

2.3.3 Barriers

ESCos have operated in Europe since the late 1970s but only account for 1.5-3% of the commercial energy market (Rezessy et al. 2005). This suggests that there are barriers to ESCo expansion. Literature on the ESCo market indicates that these barriers include:

- **High perceived risk leading to lack of finance.** ESCo projects do not result in a saleable asset therefore they are considered high risk, which limits the finance available to them. Furthermore financial institutions have a limited understanding of ESCos. Some commentators conclude that financial challenges are the major stumbling block to the development of ESCos (Vine 2005)
- **Low awareness and lack of information** about ESCos and energy service contracting amongst potential clients. Some reports have identified this as a key barrier to ESCo activity (Bertoldi et al. 2007)
- **Low levels of competition, barriers to entry and a negative response by utility companies** has led to limited amounts of 'new' business being sought by existing ESCos. Barriers to entry include the cost of a supply licence and risks associated with energy price fluctuations. (Bertoldi et al. 2006a; Vine 2005; Grim 2005)
- **High transaction costs.** Transactions costs are costs to client and/or ESCo made up of the staff, consulting and legal costs of searching for suppliers/clients and the costs of negotiating, writing, monitoring and enforcing contracts (Sorrell 2005). Some studies estimate transaction costs to be 7 - 60% of project costs, with the percentage increasing as project size diminishes (Bleyl-Androschin & Seefeldt 2009). Transaction costs are positively correlated to the amount an asset is tied to a particular place or application[20] and the difficulty in monitoring outcomes[21] and

[20] known as asset specificity
[21] known as task complexity

transaction costs decrease as the industry becomes more competitive and as institutional support increases (Sorrell 2005).

- **Lack of trust**. A number of commentators suggest that there is a lack of trust in the ESCo business model amongst potential clients (Vine 2005; Grim 2005; Bertoldi et al. 2007). Commentators also suggest that consumer protection [22], which could help build trust in the industry, is inadequate (Bertoldi et al. 2006a; Bertoldi et al. 2007; Vine 2005)
- **Lack of motivation** due to low energy prices and a limited understanding of energy efficiency opportunities (Vine 2005; Bertoldi et al. 2007)
- **Aversion to long term contracts** especially where energy prices are volatile (Grim 2005; Bertoldi et al. 2006a)
- **Aversion to loss of control** over assets (Bertoldi et al. 2007; Bertoldi et al. 2006a)
- **Split incentives,** in particular between tenants and owners (Bertoldi et al. 2007; Hawkes et al. 2005)
- **A shortage of appropriate technology** for metering / monitoring contracts (Vine 2005)
- **Limited government support** for ESCos[23] (Vine 2005)

In summary, despite the many advantages to the ESCo business model, a number of barriers, predominantly lack of finance, low awareness and low levels of competition, appear to be hindering ESCo expansion.

2.4 Domestic Energy Service Companies

This study defines a Domestic Energy Service Company (DESCo) as a legal person or entity that provides energy services and/or delivers energy efficiency improvements in a domestic property and accepts some degree of financial risk in doing so. By this definition, DESCos have long been seen as the 'holy grail' in achieving energy efficiency in the UK domestic sector (Roberts 2005). Alistair Darling (then Trade and Industry Secretary) captured this mood when he stated

[22] such as accreditation schemes and protocols on monitoring and verification
[23] e.g. subsidies, fiscal incentives, codes, standards and regulations on energy efficiency and demand side management

> We must look at how [energy suppliers] can change from just selling units of electricity to providing energy services – heating and lighting homes – making it their business to increase energy efficiency and cut demand" (Darling in Watson et al. 2006, p.20).

However, to date, there is little evidence of DESCo operation in the UK. This section outlines the DESCo business model, discusses its advantages and barriers, and finally explores potential providers.

2.4.1 The DESCo business model

Figure 2 illustrates the DESCo business model using energy demand and supply curves for a single household with a baseline consumption of 24MWh/year. Following an energy efficiency installation, the household's energy demand curve would move from D_1 to D_2, as annual demand reduces from 24 to 20MWh, at price P_1[24]. Under current energy provision this would represent a net loss to the supplier of $4P_1$ [indicated by the 'lost revenue' box]. However, under a shared or guaranteed savings contract, rather than being charged per MWh the householder is charged for 'medium usage' so that, after the installation, the supplier would be charging for the equivalent of around 22MWh (under a shared savings contract) or 23 MWh (under a guaranteed savings contract[25]) while only supplying 20 MWh. This would deliver a reduction in bills to the householder of 4% under guaranteed savings or 8% under a shared savings [indicated by the 'household savings' box] and a profit to the supplier of 2 P_1 (under shared savings) or $3P_1$, (under guaranteed savings) [indicated by the 'DESCo profit' box].

[24] the current domestic energy price (£/MWh)
[25] profits required under guaranteed savings contracts would be greater as, by guaranteeing savings, the supplier takes on the entire performance risk

Figure 2: Energy supply and demand curves following an energy efficiency installation under current provision, shared savings and guaranteed savings contracts

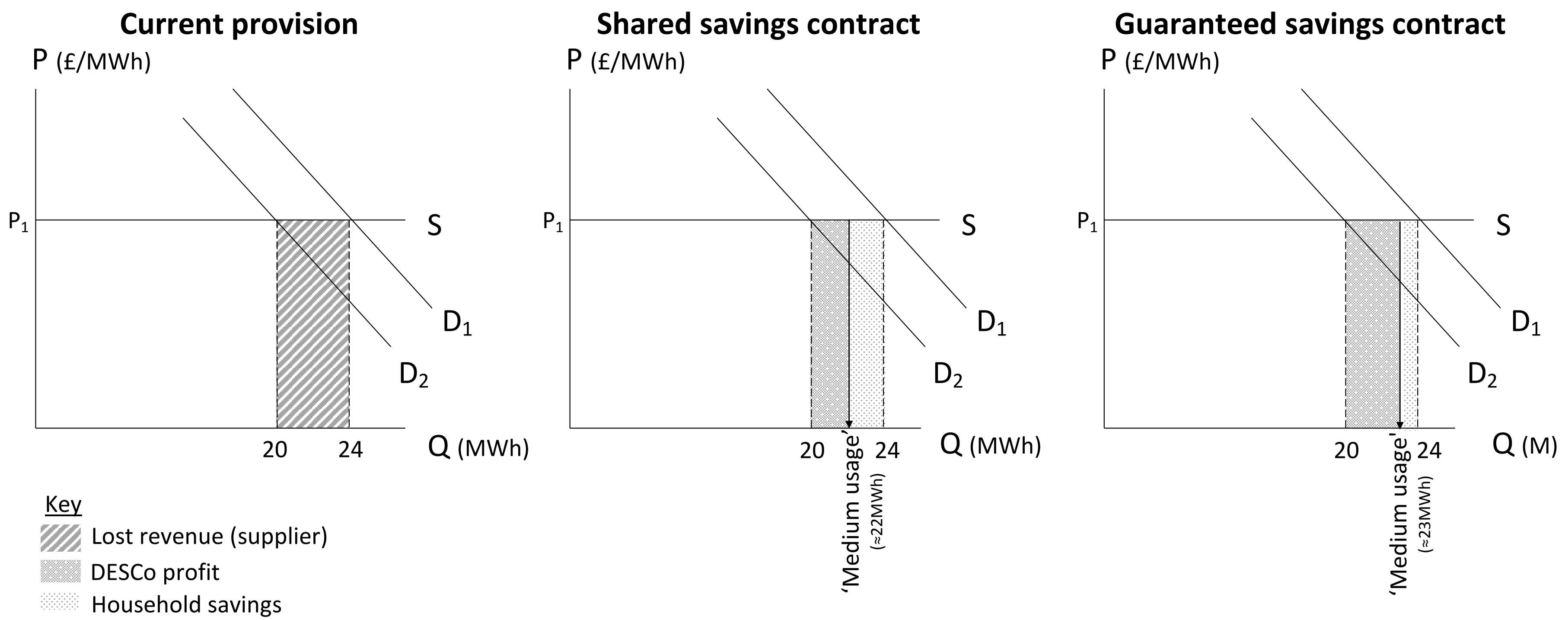


Figure 3 illustrates how DESCos could operate in practice: under the current energy supply model, utilities charge householders for units of energy and households pay a variable amount, depending on how many units they use, can make fabric or system improvements to their property and will benefit from 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 out of which it pays the utility for the units of energy used[26]. In reality this would mean, the DESCo would part or fully finance improvements and the householder would pay for 'energy services', e.g. adequate heating/lighting[27]. Under a guaranteed saving contract the DESCos payment would be a fixed amount[28] whereas under a shared savings contract it would be a variable amount, based on actual energy use plus the DESCos' fee, i.e. a share in the energy savings or a repayment amount[29] whichever is greater. The economic analysis undertaken in this study is based on these are the two types of contract[30].

[26] The model 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. The DESCo would use data to confirm baseline energy use and calculate potential, and confirm actual, savings (though technically this would be possible using householders' utility bills)

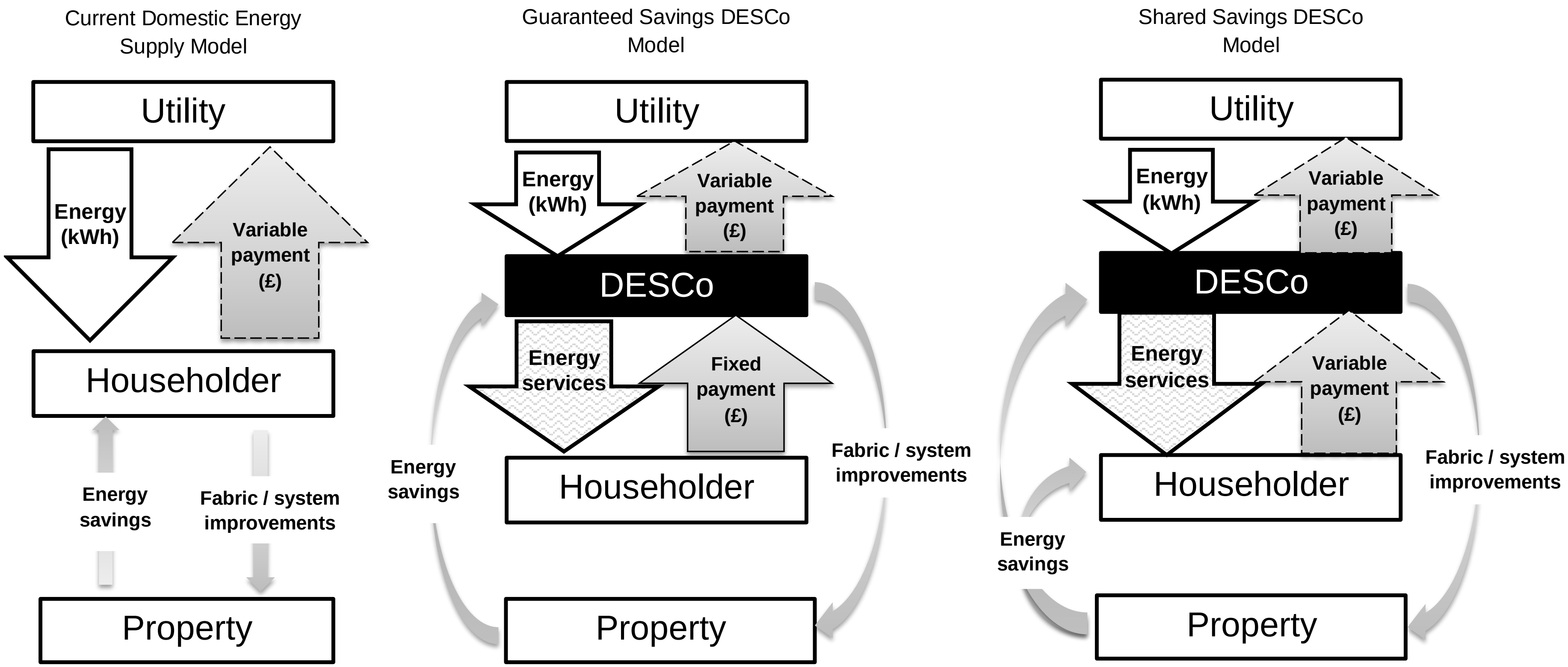
[27] The model assumes household energy use would be roughly the same under a DESCo contract as under the current supply model (except for comfort take-back; see 3.3.5: Take-back factors)

[28] set to cover the energy, capital and transaction costs and deliver an adequate rate of return on investment

[29] set to cover the DESCos capital and transaction costs and deliver an adequate rate of return on investment

[30] The type of payment arrangements used in the model mirror those identified above; the guaranteed savings model assumes the householder pays the DESCo a fixed amount. The shared savings model assumes the householder pays the DESCo energy costs plus a 50% share of the savings or a fixed amount, whichever is greater. (see Section 3.4)

Figure 3: Current Domestic Energy Supply Model and Guaranteed and Shared Savings DESCo Business Models



2.4.2 Advantages of the DESCo business model

One of the key advantages of the DESCo business model is it aligns government, consumer and supplier goals, e.g. lowering carbon emissions, reducing energy costs and generating profit (Boait 2009). For government, the opportunity to improve domestic energy efficiency using a market based tool, which might draw in external finance, has obvious attractions. Domestic energy service contracts also have the potential to encourage greater competition in the energy market and stimulate demand for energy sources with stable and predictable costs such as renewable and nuclear energy (Littlechild 2006).

If existing energy suppliers were to offer DESCo contracts, they could increase their "portfolio of transactions" (Watson et al. 2006, p.21) and differentiate themselves from competitors (Biermann & Trust 2001). Furthermore, as the costs of acquiring a new customer are estimated to be 5 times that of retaining an existing one (UK Energy Research Centre 2005), offering fixed-term contracts could reduce costs by reducing account transfers.

For domestic customers the main advantages of DESCo contracts are energy savings and/or increased comfort, access to expertise and capital. Research suggests that fixed-price, fixed-term energy contracts might appeal to consumers in the same way as fixed-term mobile phone, car and house insurance contracts (Littlechild 2006) and could offer consumers price security, and simplify purchasing, in a time of confusion over supplier tariffs. This study hypothesises that the biggest driver for consumers would be savings on fuel bills and this is therefore the focus of the economic analysis [see 3.2]. In summary there are a number of policy, consumer and supplier advantages to DESCos and this suggests that DESCos could play a larger role in UK domestic energy supply.

2.4.3 Barriers to the DESCo business model

The key barriers to DESCo operation in the UK can be split into three types; consumer, financial and market-based.

Consumer barriers

Like commercial clients, domestic consumers in the UK are unfamiliar with energy service contracts and give low priority to energy efficiency[31] (Oldham et al. 2003; UK Energy Research Centre 2005). Other barriers may be suspicion of energy suppliers, fear of commitment and resistance to losing control over the implementation of energy efficiency measures (UK Energy Research Centre 2005).

Financial barriers

One financial barrier to DESCo contracts is the high risk they represent to providers (Roberts 2005; UK Energy Research Centre 2005). The main risk appears to be that of 'stranded assets' (Boait 2009), i.e. the risk that the contract will be broken before full repayment and the costs of the asset unrecoverable. One solution to the stranded asset problem is a regulatory structure that ensures that, in the case of a householder moving house or changing supplier, the incoming supplier must take over the cost of the asset, e.g. through a payment to the outgoing DESCo/financier, and would provide a quote on that basis (Boait 2009)[32]. This 'contract transfer' solution implies a smart-metering system that could provide data to potential suppliers on both energy efficiency installations present and/or the energy use patterns of the household.

The second risk is the risk of reckless behaviour by consumers under fixed-price contracts. A real example of this is that 10% of customers on E.on's 'Staywarm' contract, which offered a fixed price regardless of usage, had to be transferred to other tariffs for excessive usage (Boait 2009). Under DESCo contracts there is the risk of an increased 'take-back' effect, whereby householders take back energy efficiency savings as increased comfort levels, as, if payments are fixed (e.g. guaranteed savings contracts) or savings split (e.g. shared savings contracts), take-back could be expected to increase.

The final barrier to DESCo operation is high transaction costs as, the smaller the clients' energy bill, the larger the proportion of costs that derives from transaction costs. Some commentators state that transaction costs make energy service contracts for energy bills under a certain level uneconomic (Sorrell 2005; Bleyl-Androschin & Seefeldt 2009). However if we consider the determinants of transaction costs to be the ease of transferring assets to different uses without losing value (asset

[31] It has been suggested that this low priority is due to low UK energy prices (Biermann & Trust 2001)
[32] This is similar to the premise of the Green Deal whereby repayment charges are attached to energy bills and transfer between bill payers on a change of occupancy (Department of Energy and Climate Change 2011d)

specificity) and the ease of monitoring the terms and conditions of a contract (task complexity) plus levels of competition and government support (Sorrell 2005), through the 'contract transfer' solution, economies of scale[33], high levels of competition and/or government support, transaction costs could be substantially reduced.

Market Barriers

The 28-day rule has been cited as a key market barrier to DESCo operation:

> Ofgem's approach to market liberalisation… affects the possibility for suppliers to develop long-term customer relationships, because [it] currently insists on customers' right to switch suppliers with a 28-day notice (Biermann & Trust 2001, p.5224)

However commentators have suggested that that the 28-day rule was no more than a symbolic barrier to DESCo operation:

> There was agreement that there was little supplier interest in energy services whether or not customers are free to switch suppliers with 28 days' notice (UK Energy Research Centre 2005, p.10).

Indeed there is scant evidence of an increase in energy service provision in the UK since the abolition of the 28-day rule in 2007. An alternate view is that the key barriers which prevent existing suppliers from operating the DESCO business model are the lack of commercial incentive and reputational risk:

> There is no evidence that existing suppliers, i.e. the 'Big 6, need ESCos to secure customer loyalty and that energy services represent a reputational risk to these suppliers by necessitating reliance on third party installation agents and new models of billing (Roberts 2005).

Therefore utilities may be deterred from providing energy service contracts by a lack of incentive plus the risk to reputation that they represent. The market structure may also deter new entrants from operating DESCos as there are barriers to entering the energy supply market, including the costs of

[33] a fall in long run average costs which occurs as quantity supplied rises (Anderton 1995)

securing a supply licence[34] and risks in the wholesale markets without upstream assets (UK Energy Research Centre 2005).

It is apparent that there are a number of barriers to DESCo operation, not least the lack of obvious providers. The section below explores which types of firms might offer domestic energy service contracts.

2.4.4 Potential DESCos

The literature indicates that there are four possible types of DESCo:

1. Traditional energy suppliers (utilities)
2. Existing retailers
3. Existing energy service companies
4. New entrants e.g. 'mini-ESCos'

Traditional energy suppliers

Traditional energy suppliers are the "most likely" providers of domestic energy service contracts (UK Energy Research Centre 2005, p.2) as the domestic energy service market is arguably the hardest to break into, due to small project sizes and profit margins and utility companies have an advantage due to their existing supply relationships. Research suggests that energy inefficiency accounts for approximately 30% of the £26bn annual sales of domestic electricity and gas per year (Department of Energy & Climate Change 2010) therefore, if utilities could transfer a significant proportion of their customers onto energy service contracts while facilitating energy efficiency, they could profit from this inefficiency[35]. Furthermore utilities might face the lowest costs as, by transferring a large proportion of their customer base onto energy service companies, this would also reduce transaction costs[36] and generate economies of scale.

[34] Although licenced suppliers are supposed to offer services to exempt suppliers the extent to which they currently do so is limited (UK Energy Research Centre 2005).
[35] For example insulating all insufficiently insulated UK lofts and cavity walls would reduce domestic fuel bills by £1.1bn (Energy Saving Trust 2011b), if utilities transferred 45% of their customers onto energy service contracts, as is the case in Sweden (Littlechild 2006), the potential increase in revenue would be £0.5bn.
[36]by reducing task complexity (Sorrell 2005)

However, as a result of high debt levels, there is currently pressure on utilities to moderate or lower capital expenditure programmes and to find higher-yielding and higher-growth opportunities (Department of Energy & Climate Change 2010a). This suggests that, although utilities might be unwilling to take on debt to finance DESCos, they might be willing to fund/match fund high profit opportunities. However, as implied above, it is unlikely that utilities would offer these sorts of contracts without either a threat to their traditional business model or regulation.

Existing Retailers

Large retailers such as supermarkets, banks and telecommunication companies have extensive supply relationships with UK consumers and have higher levels of consumer trust than utilities (PR Week UK 2011). There are questions as to whether these firms would have the expertise or incentive to enter the domestic energy market, but the myriad of services now offered by supermarkets such as Marks and Spencer, e.g. banking and insurance, indicates there is appetite for product expansion. Indeed in 2011 The Co-op was trialling entry into the energy supply market (The Observer 2011) and Sainsbury's was working in partnership with British Gas "providing sustainable energy solutions to homes across the UK" (Sainsbury's Energy 2011). Retailers might be willing to debt or equity finance energy efficiency measures where rate of returns are competitive with existing business sectors. However the fact that these retailers have not already entered this market suggests that the expected rates of return have not been high enough.

Existing Energy Service Companies

Existing ESCos could provide the basis for growth in the UK domestic market due to their experience negotiating complex long term contracts (Boait 2009). Most existing ESCos are able to finance projects themselves or access third party finance however, as outlined in 2.3.3, existing UK ESCos may be too specialised and rely on contracts of too great a size to comfortably operate in the domestic sector[37]. The limited number of ESCos in the UK implies a lack of competition in the market, which may reduce the incentive to enter new markets such as the domestic sector.

New entrants ('Mini-ESCos')

[37] aside from large developments

Companies ideally placed to enter the DESCo market would be ones with existing relationships with householders in a domestic service / retrofit capacity e.g. plumbers, builders or other tradespeople. These firms would be able to market energy services at times when householders are more open to offers; termed ‘trigger points’, e.g. during other renovations / home improvements, and might benefit from being trusted local suppliers. Bertoldi et al refer to these firms as “mini-ESCos” and suggest that there is scope for the aggregation of these companies into larger organisations (Bertoldi et al. 2006a).They might also be able to work in partnership with a utility, as is the case for boiler breakdown cover whereby utility companies subcontract to local firms.

The main disadvantage of ‘mini-ESCOs’ are that transaction costs would be proportionally higher, perhaps prohibitively so, than for larger companies. Plus there is a “natural tendency of a small contractor is to continue with its successful business model” therefore information and training of contractors might be necessary to stimulate interest (Bertoldi et al. 2006a, p.11). Finally mini-ESCos might be unable or unwilling to finance measures themselves so, if householders had to finance measures themselves, this would present a capital cost barrier to households.

Summary

Table 2 outlines the advantages and disadvantages of the different providers. It suggests that utilities and retailers are well placed to offer energy services to customers as both have existing relationships with customers and would be likely to experience the lowest costs. As retail companies lack expertise in the energy efficiency sector and utilities lack consumer trust, the ideal model would be contracts provided by a retailer working in partnership with a utility. However it is likely that some form of regulation would be needed to incentivise utilities to provide energy service contracts.

Table 2: Domestic energy service contract models, by provider type

	Advantages		**Disadvantages**		**Possible government intervention**
Utility	Existing relationship	Low transaction costs	Low incentive		Regulation to encourage energy service provision
Retailer	Existing relationship	Consumer trust	Lack of expertise		Subsidies to increase rates of return
ESCo	Contract expertise		Low incentive		Mechanism to ‘pool’ projects
Mini-ESCo	Existing relationship	Present at trigger points	High transaction costs	Low incentive	Training and increased access to funds

2.5 Summary

There are multiple barriers to domestic energy efficiency, both techno-economic and cultural, many of which interact with or reinforce one another. To date, most UK government interventions have focused on the upfront cost and information barriers to domestic energy efficiency. This implies that a number of other barriers, e.g. risk, hidden costs, bounded rationality and consumer inertia, are currently unaddressed. The DESCo business model offers a means of addressing these barriers as, by offering long term energy contracts and DESCos allow consumers to access capital and expertise at no upfront cost and therefore reduce the risks of energy efficiency measures to consumers, i.e. they mitigate the capital and information barriers. The literature also suggests that fixed-price energy contracts be attractive to consumers and therefore may mitigate the consumer inertia barrier.

However there are substantial barriers to DESCo operation such as high transaction costs, lack of consumer familiarity and lack of commercial incentive by existing suppliers. Analysis of potential DESCo providers indicates that the strongest proposition is that of retailers in partnership with utilities; however it is likely that some form of government intervention would be necessary to overcome the lack of commercial incentive by incumbent suppliers. The next section explores the methods used to construct an economic tool to assess the potential of DESCos to deliver energy efficiency in the UK.

3 Methodology

This study aims to explore the conditions necessary for the operation of viable domestic energy service contracts. In order for contracts to be viable they must be attractive to both consumers and potential providers. The literature suggests that DESCo viability will depend on whether contracts can deliver positive household savings and adequate returns to the DESCo. This section outlines the approach and method chosen to explore the viability of DESCos.

3.1 Research approach

Most ESCo studies employ surveys of national or international experts, economic analysis, interviews, theoretical models or normative approaches (see Appendix F). Table 3 analyses the pros and cons of these different approaches. It illustrates that economic analysis may be the optimal approach to use to assess the viability of the DESCo business model as, in the absence of any data for UK DESCos, it can provide a conceptual framework and thus inform subsequent studies. Therefore this study will employ an economic analysis method to explore the savings on household energy bills and the internal rates of return offered by DESCos, by measure and contract type. The results should therefore provide subject matter for the debate between policy makers, industry and academia on a potential role for DESCos in delivering energy efficiency in the UK.

Table 3: Analysis of Research Approaches

	Data needed	Pros	Cons	Example Literature
Economic analysis	None	• Provides conceptual framework • Could provide subject matter for subsequent studies	• Not widely used	(Bleyl-Androschin & Seefeldt 2009) (Hawkes et al. 2005)
Surveys	20+ surveys	• Can provide statistical data	• Lack of data on residential ESCos in UK	(Vine 2005) (Bleyl-Androschin & Seefeldt 2009) (Rezessy et al. 2005) (Bertoldi, Boza-Kiss, et al. 2007)
Detailed interviews	5 or more interviews	• Provides an overview	• Prone to partiality • Not widely used	(Bertoldi, Boza-Kiss, et al. 2007)
Normative approach	None	• Critically evaluates current situation	• Lack of data on residential ESCos in UK • Not widely used	(Bertoldi, Hinnells, et al. 2006)
Theoretical model	None	• Provides conceptual framework	• Not widely used	(Sorrell 2005)

3.1.1 Basis for model

An energy service company “delivers energy services and/or other energy efficiency improvement measures in a user’s facility or premises, and accepts some degree of financial risk in doing so” (Bertoldi et al. 2007, p.6). In order to conceptualise how a *domestic* energy service company might operate we can use a worked example.

> **Worked Example**
>
> A DESCo offers cavity wall insulation to a household with un-insulated cavity walls, which would reduce the property’s £1000 annual gas bills by 20%. Under a guaranteed savings contract, the DESCo might offer the householder a five year energy service contract fixed at 5% less than their previous annual gas bill, i.e. £950. This contract would enable the DESCo to keep the difference between the actual energy bill and fixed payment, i.e. £150 (£950-800). Over 5 years, with an installation cost of £400, the DESCo would make a profit of £350[38], delivering an internal rate of return (IRR) of 25%[39] and a payback period of 2.7 years[40]. Under a shared saving agreement the contract might specify that energy savings will be evenly split between the DESCo and householder (£100 each) but there would be no savings guarantee to the householder. This contract could advertise reductions to energy bills of around 10% and would deliver an internal rate of return of 8%[41] and a payback period of 4 years[42] for the DESCo.

This example is a simplification, intended to help conceptualise how the outputs and inputs of the model interrelate and so does not include all elements incorporated into the full model, e.g. transaction costs, interest rates or take-back. It does however illustrate an important feature of the business model; under a guaranteed savings contract the DESCo keeps a larger proportion of the energy savings but takes on all the performance risk, and under shared savings contracts the DESCo keeps a smaller proportion of savings but gives up the performance risk. One final factor to consider is, take-back: in reality householders may ‘take-back’ a proportion of energy savings as increased

[38] (150*5)-400 = 350

[39] Internal rate of return is a measure of an investments’ worth based on yield. It is calculated by the equation: $PW(irr)=F_0/(1+irr)^0+F_1/(1+irr)^1+F_2/(1+irr)^2+....+F_n/(1+irr)^n=0$, where F=cash flow (Engineering ToolBox 2011). In this case: $-400/(1+0.25)^0+150/(1+0.25)^1+150/(1+0.25)^2+150/(1+0.25)^3+150/(1+0.25)^4+150/(1+0.25)^5=0$

[40] 400/150 = 2.7

[41] -400/(1+0.08)0+100/(1+0.08)1+100/(1+0.08)2+100/(1+0.08)3+100/(1+0.08)4+100/(1+0.08)5=0

[42] 400/100= 4

comfort. As guaranteed savings contracts are by nature fixed-price regardless of use, the take-back factor is likely to be higher than under shared savings contracts, as householders pay a fixed rate independent of use. This incentivises taking back more energy savings as comfort improvements than under shared savings or self-financing of measures. Therefore the key factors which are integrated into the economic model are:

- differing rates of return required under shared vs. guaranteed savings contracts to reflect the differing levels of risk associated
- differing levels of take-back under shared savings, guaranteed savings and self-financing, resulting in differing levels of energy savings

3.2 Economic model

The economic model has 3 main components, see Figure 4:

1. Inputs, including energy and cost data
2. Model, which uses equations to calculate energy consumption under the baseline, guaranteed and shared savings contracts
3. Outputs; savings on household bills and internal rate of return[43]

To perform the analysis, a spread sheet model was built using MS Excel. It was designed to be 'open source', i.e. it allows users to choose from a range of technologies, energy prices, interest rates, contract lengths, take-back factors and transaction costs, in order to test out various assumptions and explore the boundary conditions for functioning DESCos.

The output of the model is designed to indicate whether a DESCo contract is viable, i.e. attractive to consumers and suppliers. Table 4 shows the viability criteria used. The first is that savings on household bills must be greater or equal to 0%[44]. The second is that the DESCos internal rate of return should equal the interest rate based on economic theory of normal profits, i.e. a firm will operate a 'normal profit' where total revenue equals total costs in this case where the internal rate of return equals the interest rate (Anderton 1995)

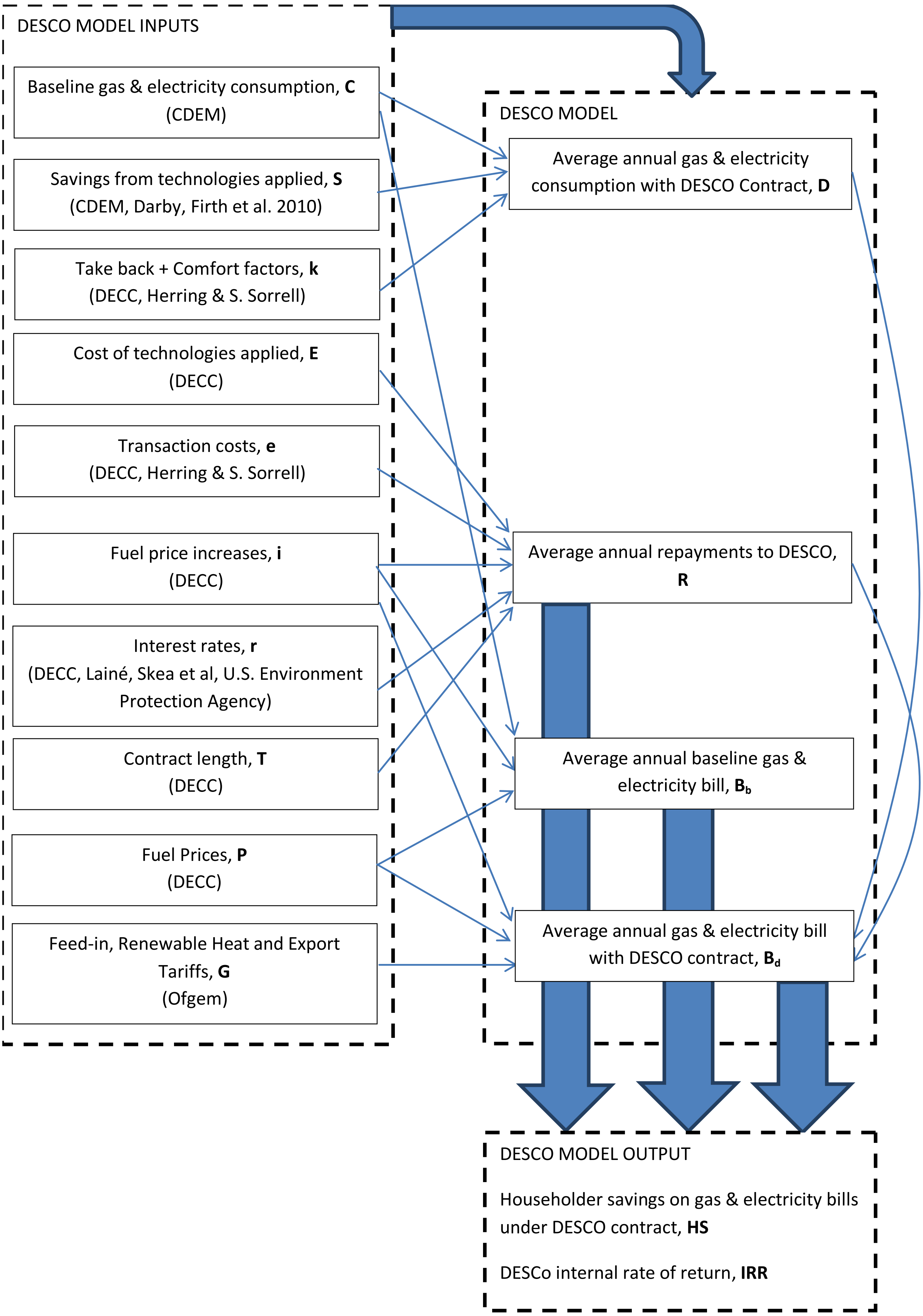
[43] a measure of an investments' worth, using discounted cash flow analysis
[44] taking into account that consumers value fixed term energy contracts (Littlechild 2006)

Table 4: 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] is greater or equal to the interest rate applied	None (the model assumes IRR=r)

[a] on baseline energy costs
[b] measures an investments' worth using discounted cash flow analysis

Figure 4: Schematic of modelling process



3.3 Inputs

3.3.1 Baseline energy consumption and savings

The Community Domestic Energy Model[45] (CDEM) was used to generate baseline energy consumption for an un-insulated 1945 to 1964 semi-detached house [see Table 6]. This house type was chosen as one of the most common house types in the English housing stock (numbering around 2.5m) and as it most closely matches the house profile used in the Green Deal Impact Assessment[46]. CDEM was then used to simulate the installation of energy efficiency measures on the baseline property [see Appendix A for details]. The results from these simulations gave the energy saved, in kWh, from each measure. For measures that could not be simulated in CDEM, e.g. solar thermal, demand side management and solar PV, the kWh savings were taken from a variety of sources [see Appendix A].These figures were converted into percentage savings of the baseline energy use; see Table 5.

3.3.2 Installation costs

The majority of the installation cost data was taken from the Green Deal Impact Assessment (Department of Energy & Climate Change 2011b) with other costs taken from a variety of sources, [see Appendix A].

3.3.3 Transaction costs

As outlined in 2.3.3, transactions costs were the costs of negotiating, writing, monitoring and enforcing contracts. The model took transaction costs for utility DESCos from the Green Deal Impact Assessment transaction cost estimate (18% of installation cost)[47]. For retailer DESCos, who have existing contract procedures and relationships with consumers, but not the same potential to benefit from economies of scale, the transactions costs were assumed to be 25%. For mini-ESCos the transaction costs are assumed to be 50% as these firms are unlikely to have processes for collecting

[45] CDEM uses a building physics model (BREDEM 8) to calculate energy consumption based on various input parameters including house type, age, U values, ventilation rate and boiler efficiency for various stock properties (for more information see Firth et al. 2010b). Thus CDEM can simulate the effects of various energy efficiency measures by implementing changes to these values.

[46] The Green Deal Impact Assessment used a nominal 'stock-average' 3-bed semi; part solid wall, part insulated cavity, part un-insulated cavity (L. Clark 2011)

[47] The estimated cost of administering Energy Efficiency Commitments (Ofgem in Department of Energy & Climate Change 2011b)

ESCo style payments[48] and will not benefit from economies of scale. These transaction costs are consistent with estimated transaction costs of 4-60% implied in previous studies (Bleyl-Androschin & Seefeldt 2009) [see Appendix E].

3.3.4 Interest rates / internal rate of return

Under guaranteed savings contracts the DESCo takes on all the performance risk, therefore 'hurdle rates' were used to simulate the required internal rate of return[49]; 'Energy Star' Buildings Recommended hurdle rate (20%) and the building energy conservation hurdle rate (25%). Under shared savings contracts, the DESCo receives either a share in the energy savings or a fixed repayment amount, whichever is greater, so performance risk is low. In this case market interest rates of 3-9% were used. See Table 6 and Appendix A for details.

3.3.5 Take-back factors

The level of take-back under DESCo contracts is likely to depend on the contract specifics, e.g. the limits on energy use or penalties charged on use over certain amounts. Taking this into account, the default value for take-back is 25% under guaranteed savings and 20% under shared savings, in contrast to 15% assumed under the Green Deal. Electricity take-back is not well documented therefore the electricity take-back value is 0% in all scenarios.

3.3.6 Other inputs

Fuel price data was taken from the Department of Energy and Climate Change (DECC) Carbon Valuation Spreadsheet tool. Feed-in Tariff, Renewable Heat Incentive and export data for solar thermal and solar PV were taken from Ofgem and DECC, see Appendix A.

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[48] Therefore would experience increased task complexity and asset specificity [see 2.3.3]

[49] The hurdle rate is a term for the rate of return an investor would expect on an energy efficiency project where they are the sole carrier of risk (Skea 2010) In other words it is the interest rate adjusted for a project's risk: the higher the risk the higher the hurdle rate (U.S. Environment Protection Agency 1998).

Table 5: Percentage reduction in household energy use and installation costs by energy efficiency measure

	Baseline consumption (kWh)	Energy saved (kWh)	Savings on baseline consumption, %	Installation cost (min)	Installation cost (max)
Cavity wall insulation	29,062	5,821	20.0%	£376	£1,620
External wall insulation	31,364	7,617	24.3%	£7,600	£12,600
Internal wall insulation	31,364	7,617	24.3%	£5,000	£7,000
Double glazing	29,062	2,932	10.1%	£3,600	£3,600
0 mm to 270 mm loft insulation	29,062	6,410	22.1%	£283	£283
100 mm to 270 mm loft insulation	23,334	682	2.9%	£283	£283
150 mm to 270 mm loft insulation	23,017	365	1.6%	£283	£283
Draught proofing (to 0.5 ach)	29,062	1,423	4.9%	£100	£100
Thermostatic radiator valves	29,062	756	2.6%	£300	£300
Condensing gas boiler	29,062	3,432	11.8%	£2,520	£2,520
50mm cylinder insulation + thermostat	29,062	763	2.6%	£300	£300
Condensing gas boiler, TRVS, cylinder insulation + thermostat	29,062	4,951	17.0%	£200	£200
Solar HW (3m2)	29,062	1,387	4.8%	£1,750	£3,500
Solar HW (4m2)	29,062	1,849	6.4%	£2,000	£4,000
Monocrystalline Solar PV (1.5kWp)	2,840	570	20.1%	£5,625	£11,250
Monocrystalline Solar PV (3kWp)	2,840	1,140	40.1%	£7,500	£15,000

Table 6: DESCo model input values and sources

Category	Name	Description	Value	Units	Source
C	Baseline annual gas use (Initial value)	Semi detached house, 3 bed, 1945 to 1964, uninsulated cavity wall, no loft insulation, single glazing, uncondensing gas boiler, No TRVs, 0.86 ach infiltration rate	29,062	kWh	CDEM
C	Baseline annual gas use (Iteration 1)	Semi detached house - as above- low consumption (-25%)	21,797	kWh	Sensitivity analysis
C	Baseline annual gas use (Iteration 2)	Semi detached house - as above- high consumption (+25%)	36,328	kWh	Sensitivity analysis
C	Baseline annual electricity use	Semi detached house- as above	2,840	kWh	CDEM
P	Gas price (Initial value)	Full retail: domestic, 2011 prices (central)	3.9	p/kWh	Table 5, DECC Carbon Valuation Spreadsheet Tool
P	Gas price (Iteration 1)	Full retail: domestic, 2011 prices (low)	2.9	p/kWh	Table 5, DECC Carbon Valuation Spreadsheet Tool
P	Gas price (Iteration 2)	Full retail: domestic, 2020 prices (high)	6.2	p/kWh	Table 5, DECC Carbon Valuation Spreadsheet Tool
P	Electricity price	Full retail: domestic, 2011 prices (central)	12.0	p/kWh	Table 4, DECC Carbon Valuation Spreadsheet Tool
i	Annual gas price increase (Initial value)	Constant prices	0	%	Department of Energy & Climate Change 2011a, p23
i	Annual gas price increase (Iteration 1)	Low	1.5	%	Estimate
i	Annual gas price increase (Iteration 2)	High	4.5	%	Estimate
i	Annual electricity price increase	Constant prices	0	%	Department of Energy & Climate Change 2011a, p23
r	Guaranteed savings interest rate (Initial value)	ENERGY STAR' Buildings Recommended 'hurdle rate' (20%)	20	%	U.S. Environment Protection Agency 1998, p.3)
r	Guaranteed savings interest rate (Iteration 1)	Scenario 1, 'Access for all', Green Deal	9	%	Lainé 2011, p.24
r	Guaranteed savings interest rate (Iteration 2)	Energy 2050' Building energy conservation 'hurdle rate' (25%)	25	%	Skea 2010, p.93
r	Shared savings interest rate (Initial value)	Green Deal Impact Assessment' interest rate (5%)	5	%	Department of Energy & Climate Change 2011a, p62
r	Shared savings interest rate (Iteration 1)	Scenario 4, 'Access for all', Green Deal	3	%	Lainé 2011, p.24
r	Shared savings interest rate (Iteration 2)	Scenario 2, 'Access for all', Green Deal	7	%	Lainé 2011, p.24
T	Contract length, low cost measures	for loft, cavity wall insulation, draft proofing, demand side management	5	years	Department of Energy & Climate Change 2011a, p.63
T	Contract length, medium cost measures	for cylinder insulation, TRVs, thermostat, condensing boiler	10	years	Department of Energy & Climate Change 2011a, p.63
T	Contract length, high cost measures	for external & internal wall insulation, solar PV, solar thermal	25	years	Department of Energy & Climate Change 2011a, p.63
k	Self-financing heating takeback	Self-financing heating takeback	18	%	Green Deal Impact Assessment
k	Guaranteed savings heating takeback (Initial value)	Medium comfort factor	25	%	Estimate (based on Herring & S. Sorrell 2009, p.36)
k	Guaranteed savings heating takeback (Iteration 1)	No comfort factor	0	%	Estimate (based on Herring & S. Sorrell 2009, p.36)
k	Guaranteed savings heating takeback (Iteration 2)	High comfort factor	50	%	Estimate (based on Herring & S. Sorrell 2009, p.36)
k	Shared savings heating takeback (Initial value)	Medium comfort factor	20	%	Estimate (based on Herring & S. Sorrell 2009, p.36)
k	Shared savings heating takeback (Iteration 1)	No comfort factor	0	%	Estimate
k	Shared savings heating takeback (Iteration 2)	High comfort factor	40	%	Estimate (based on Herring & S. Sorrell 2009, p.36)
k	Guaranteed savings electricity takeback	Medium takeback	10	%	Estimate (based on Herring & S. Sorrell 2009, p.36)
k	Shared savings electricity takeback	Medium takeback	5	%	Estimate
G	Feed-in + export tariffs (1.5kWp)	1.5 kWp (FiT@21p/kWh, export tariff@3.1p/kWh, 50% exported)	287	£	Ofgem 2011b, Firth et al. 2010
G	Feed-in + export tariffs (3kWp)	3 kWp (FiT@21p/kWh, export tariff@3.1p/kWh, 50% exported)	574	£	Ofgem 2011b, Firth et al. 2010
G	Renewable Heat Incentive (3m2)	3m2 @ 8.5p/kWh	118	£	MacKay 2008, p.39 & Department of Energy & Climate Change 2011c
G	Renewable Heat Incentive (4m2)	4m2 @ 8.5p/kWh	157	£	MacKay 2008, p.39 & Department of Energy & Climate Change 2011c
e	Transaction costs (Initial value)	EEC Transaction costs (utility)	18	%	Ofgem in Department of Energy & Climate Change 2011a, p25+106
e	Transaction costs (Iteration 1)	Retailer ESCO Transaction costs	25	%	Estimate
e	Transaction costs (Iteration 2)	Mini-ESCO Transaction costs	50	%	Estimate

3.4 The model

The model uses the following equations to calculate annual energy consumption, annual repayments, average annual energy bills and household savings from the model's inputs under guaranteed savings, shared saving and self-financing.

Annual energy consumption(C)

Annual energy consumption under guaranteed (D_g), shared savings contracts (D_s) and self-financing (D_{sf}) is calculated by applying the percentage energy savings from all measures specified (S_i) to the baseline energy consumption (C) and then applying the take-back factors for guaranteed (k_g) shared savings (k_s) and self-financing (k_{sf}):

[1] $D_g = (C * \Sigma (1 - S_i))*(1+k_g)$

[2] $D_s = (C * \Sigma (1 - S_i))*(1+k_s)$

[3] $D_{sf} = (C * \Sigma (1 - S_i))*(1+k_{sf})$

($S_i = S_{CWI}, S_{EWI}, S_{IWI}, S_{LI}, S_{OI}, S_{HI}, S_{SHW}, S_{DSM,} S_{PV}$)[50]

Average annual repayments (R)

Average annual repayments are calculated under guaranteed and shared savings contracts (R_g, R_s) using a financial formula for calculating loan repayments[51], where E = cost of all measures installed, e = transaction cost (%), r_g / r_s = annual interest rates and T = the contract length:

[4] $R_g = ((E*(1+e))*r*((1+r_g)^T) / ((1+r_g)^T - 1)$

[5] $R_s = ((E*(1+e))*r_s*((1+r_s)^T) / ((1+r_s)^T - 1)$

($E = E_{CWI}+E_{EWI}+E_{IWI}+ E_{LI}+E_{OI}+E_{HI}+E_{SHW+}E_{DSM+}E_{PV}$)[52]

Average annual energy bills (B)

The average annual energy bills for the baseline (B_b), guaranteed savings contracts (B_g) and self-financing (S_{sf}) are calculated using the formulas below, where E= capital costs, T=contract length, P = fuel prices, i = fuel price rises and G = renewable energy feed in, renewable heat and export tariffs:

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50 S_{CWI}= % savings from cavity wall insulation, S_{EWI}= % savings from external wall insulation, S_{IWI}= % savings from internal wall insulation, S_{LI}= % savings from loft insulation,, S_{OI}= % savings from other insulation, S_{HI}= % savings from heating interventions, S_{SHW}= % savings from solar hot water, S_{DSM}= % savings from demand side management, S_{PV}= % savings from solar PV

51 PMT function in MS Excel

52 E_{CWI}= cost of cavity wall insulation, E_{EWI}= cost of external wall insulation, E_{IWI}= cost of internal wall insulation, E_{LI}= cost of loft insulation,, E_{OI}= cost of other insulation, E_{HI}= cost of heating interventions, E_{EHW}= cost of solar hot water, E_{DEM}= cost of demand side management, E_{PV}= cost of solar PV

[6] $B_b = C*(P*((1 + ((1+i)^T)/ 2)$

[7] $B_g = D_g*(P*((1 + ((1+i)^T)/ 2) + R_g – G$

[8] $B_{sf} = (E_{sf}/T) + D_{sf}*(P*((1 + ((1+i)^T)/ 2) + R_g - G$

Under shared savings contracts, if the share of savings is less than repayments (S/2<R) the model assumes that DESCo will recoup the repayments (R) with the remainder (S-R) going to the householder. If the share of savings is more than repayments (S/2>R) the model assumes S/2 goes to each of DESCo and the householder. Therefore household savings and annual energy bills (B_s) under shared savings are given by:

[9] $S_s = (IF(S/2)>R, S/2,S-R) – G$

[10] $B_s = B_b - S_s$

Where Bb is the baseline consumption and Ss is the householders' share of the energy savings and G is the renewable energy tariffs.

Household savings (HS)

Thus the percentage savings on consumer bills under guaranteed (HS_g), shared savings (HS_s) and self-financing (HS_{sf}) are given by:

[11] $HS_g = (B_b - B_g) / B_b$

[12] $HS_s = (B_b – B_s) / B_b$ or $HS_s = S_s / B_b$

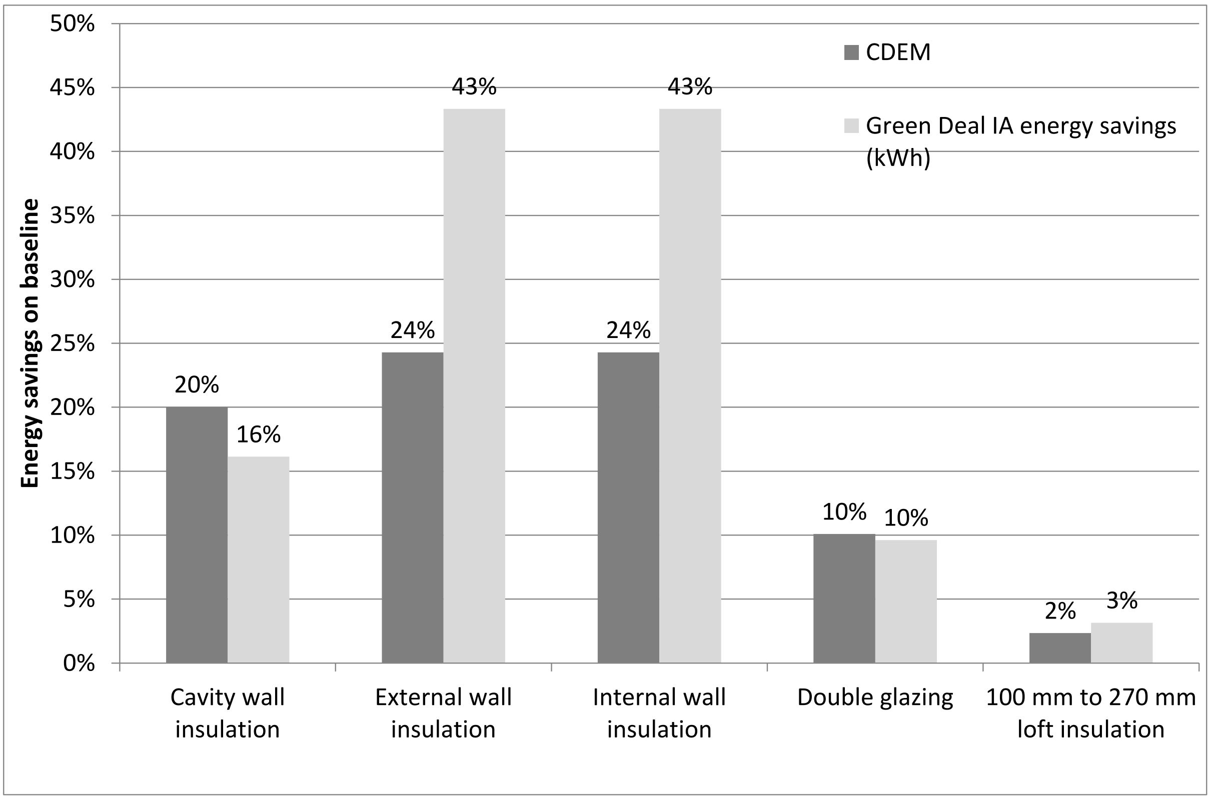
[13] $HS_{sf} = (B_b – B_{sf}) / B_b$

Where HS_g is the maximum reduction in household bills under a guaranteed savings contract and HS_s is the expected reduction in householder bills under a shared savings contract.

3.5 Validation of inputs

Figure 5 shows the energy savings from CDEM simulations compared to the savings figures used in the Green Deal Impact Assessment (GDIA). The percentage savings for cavity wall insulation, double glazing and loft top-up insulation from CDEM are within 5% of GDIA figures suggesting a good match between the two assessments. However there is a discrepancy in savings for external and internal wall insulation; with CDEM predicting 24% savings and the GDIA predicting 43%. Furthermore the baseline gas consumption under CDEM is much higher than GDIA, 29,062kWh compared to 24,341kWh. Both models use BREDEM 8 but CDEM modelled an un-insulated, semi-detached house with cavity walls (1945 to 1964) whereas the GDIA modelled a nominal 'stock-average' 3-bed semi i.e. one that was part solid wall, part insulated cavity, part un-insulated cavity (Clark 2011). Due to lack of information on the house type used in the GDIA, e.g. dimensions, U values, etc. it is not possible to identify the source of this discrepancy[53].

Figure 5: Energy savings on baseline energy use from CDEM model vs. Green Deal Impact Assessment, by energy efficiency measure



The next section presents the results from the economic model.

[53] Though 'reduction factors' may help to mitigate its effects on results, see Appendix B.

4 Results

The first section presents the results, in terms of household savings and DESCo returns, under self-financing, guaranteed savings and shared savings DESCo contracts, versus baseline energy costs[54] for a single measure (loft insulation, 0-270mm). The next section presents savings and returns after changes to key parameters. The last sections present household savings for a range of energy efficiency measures, and energy efficiency 'packages', under DESCo contracts, self-financing and under Green Deal. Finally the results are validated and critiqued.

4.1 Results for a single measure

4.1.1 Householder costs and savings

Self-financing

Under self-financing the householder funds the full cost of the loft insulation and receives all the energy savings. In this example the householder pays the installation costs[55] in Year 1 [see Table 7] and as a result energy costs are reduced to £4,593; i.e. 19% less than baseline energy costs [56] [Table 8 & Figure 6]. Including installation costs, over five years, this equates to a saving of £779[57] in total; a 14% reduction on baseline energy costs [Table 8 & Figure 6]

Guaranteed savings

Under a guaranteed savings contract, there are no upfront costs to the householder (as the DESCo finances the insulation) but the householder commits to paying a fixed amount to the DESCo each year (made up of energy costs+ repayment costs). In this example, over the 5 years, energy costs are reduced by 17%[58] to £4,718 and DESCo repayment costs are £558[59] [Figure 6] therefore household bills are reduced by£379 which equates to 7% savings on baseline energy costs [Table 8]. After the contract elapses, the householder reverts to paying for energy directly so, from Year 6, energy costs will be the same as under self-financing, i.e. 19% less than the baseline [*Year n* in Table 8][60].

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[54] where no loft insulation is installed and no contract entered into
[55] £283, see Table 5
[56]the % saving from the loft insulation [Table 5] minus the take-back factor: 0.22 * (1 – 0.15) = 0.19
[57] £5,656 -£4,593=£779
[58] the % saving from the loft insulation [Table 5] minus the take-back factor: 0.22 * (1 – 0.25) = 0.17
[59] Annual repayments are calculated using Equation [3]: $R_g = ((E*(1+e))*r_g*((1+r_g)^T) / ((1+r_g)^T - 1)$ in this case $R= ((283*(1+0.18))*0.2*((1+0.2)^5)/((1+0.2)^5-1)=111.66$ and $111.66*5=558$
[60] Assuming energy savings and take-back will now be the same as under self-financing

Shared savings

Under a shared savings contract there are no upfront costs to the householder (as the DESCo finances the insulation) instead the householder commits to paying a variable amount to the DESCo[61]. In this example the loft insulation reduces energy use by 18%[62] and, as the shared energy savings exceed the annual repayment cost, the DESCo and householder split the savings[63]. This is a saving of £500 over the 5 years, equivalent to 9% savings on the baseline energy bill [Table 8]. After 5 years the householder reverts to paying for energy use directly, therefore savings are equivalent to under self-financing; 19% savings on baseline energy bills [Table 8]

Table 7: Household costs, including repayment and installation costs, under self-financing, guaranteed savings and shared savings contracts for loft insulation, 0-270mm, 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*[e]**
Baseline [a]	£1,131	£1,131	£1,131	£1,131	£1,131	**£5,656**	£1,131
Self-financing[b]	£1,202[f]	£919[j]	£919	£919	£919	**£4,876**	£919
Guaranteed savings [c]	£1,055[g]	£1,055[g]	£1,055[g]	£1,055[g]	£1,055[g]	**£5,277**	£919[h]
Shared savings [d]	£1,031[g]	£1,031[g]	£1,031[g]	£1,031[g]	£1,031[g]	**£5,156**	£919[h]

[a] no loft insulation
[b] the householder finances the loft insulation (0-270mm)
[c] the householder takes out a 5-year guaranteed savings contract for loft insulation (0-270mm)
[d] the householder takes out a 5-year shared savings for loft insulation (0-270mm)
[e] all years after Year 5 i.e. after the DESCo contracts have elapsed
[f] energy costs plus loft installation cost: £283 from Table 5
[g] energy costs plus annual repayments [see Table 9]
[h] energy costs only, no repayments (take-back rate as under self-financing)
[j] energy costs only

Table 8: Household savings on baseline (HS) under self-financing, guaranteed savings and shared savings contracts for loft insulation, 0-270mm [Years 1-5 & *Year n* (n>5)]

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

[61] equal to energy costs plus a share of energy savings, or a repayment cost, whichever is greater
[62] the % saving from the loft insulation [Table 5] minus the take-back factor: 0.22 * (1 – 0.2) = 0.18
[63] DESCos and householders share savings whenever the share of the savings exceeds the repayment costs. Equation [4] states that repayments under a guaranteed contracts are given by: $R_s = ((E*(1+e))*r_s*((1+r_s)^T)/((1+r_s)^T - 1)$ in this case $R= ((283*(1+0.18))*0.05*((1+0.05)^5)/((1+0.05)^5-1)=77.13$. Savings equal 1,131*0.18=200, therefore 200/2>77 therefore R=100 and 100*5=500

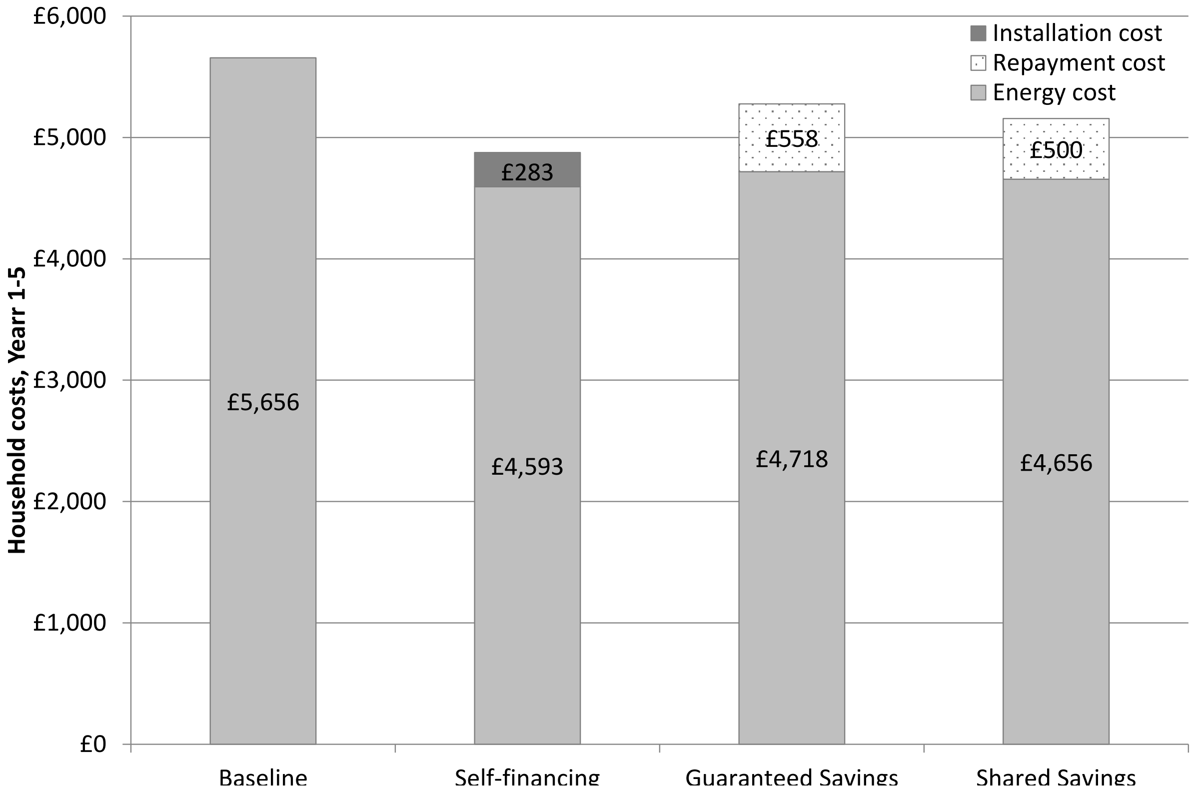
[a] no loft insulation
[b] the householder finances the loft insulation (0-270mm)
[c] the householder takes out a 5-year guaranteed savings contract for loft insulation (0-270mm)
[d] the householder takes out a 5-year shared savings for loft insulation (0-270mm)
[e] *Year n* represents all years after Year 5 i.e. after the DESCo contracts have elapsed

Figure 6 shows how the total household costs in Table 7 are broken down into energy costs, capital costs and repayment costs. It illustrates:

1. Energy costs are the highest under guaranteed savings as the householder has the greatest incentive to take-back energy savings as comfort[64]. Energy costs are second highest under shared savings as householders share the energy savings with the DESCo, and therefore have a greater incentive to take-back energy savings as comfort than under self-financing. Energy costs are the least under self-financing as householders have the least incentive to take back savings as comfort.
2. Repayment costs are greater under guaranteed savings contracts than under shared savings contracts because, under guaranteed savings, DESCos assume all the performance risk[65] and therefore require a higher rate of return on investment. Under shared savings contracts, the householder always pays the DESCo either half the energy savings, or the repayment cost (R), whichever is greater. Under this type of a contract the householder assumes the performance risk and so payments to the DESCo are lower.

[64] As the amount they pay is fixed regardless of energy use.
[65] The risk that the project will underperform

Figure 6: Household costs under baseline [a], self-financing [b], guaranteed savings [c] and shared savings [d] contracts for loft insulation (0-270mm), T =5 [e]



[a] no loft insulation
[b] the householder finances the loft insulation (0-270mm)
[c] the householder takes out a 5-year guaranteed savings contract for loft insulation (0-270mm)
[d] the householder takes out a 5-year shared savings for loft insulation (0-270mm)
[e] T = contract length

4.1.2 DESCo costs and returns

Table 9 shows the costs and returns to the DESCo under 5 year guaranteed and shared savings contracts for loft insulation (0-270mm). In this case the contract generates an internal rate of return of 20% for guaranteed savings, 15% for shared savings[66]. As businesses will only invest when the internal rate of return is at least a few percentage points higher than the cost of borrowing (the interest rate) (Business Owner's Toolkit 2012) this contract would be attractive to DESCos as long as they could borrow for less than around 18% APR for guaranteed savings and 13% APR for shared savings contracts.

[66] Annual repayments are calculated in order to generate an internal rate of return greater or equal to the interest (or hurdle) rate, in the case of guaranteed savings, 20%, and shared savings, 5%, see formulas [3] and [4] in 3.4

Table 9: DESCo costs and returns under 5-year guaranteed and shared savings contracts (T=5) for loft insulation (0-270mm)

	Details	Guaranteed Savings	Shared Savings
Installation cost (E)	Cost of loft insulation (0-270mm)[67]	£283	£283
Transaction cost (e)	Cost of negotiating and enforcing the contract[68]	£51	£51
Total costs (E+e)	Total capital and transaction costs	£334	£334
Annual repayments (R)[a]	The repayment to the DESCo over and above the energy costs	£112	£100
Total repayments (R*T)	Total repayments (R) over contract duration (T)	£558	£500
Payback period (years)	Total costs divided by annual repayments	3.0	3.3
Internal Rate of Return (IRR)[b]	A measure of an investments' worth versus the cost of capital (interest rate)	20%	15%

[a] A function of interest rates, annual price rise, payment period, investment cost [see 3.4]
[b] A function of Total costs (E+e) and annual repayments (R) (time discounted)

In summary, this scenario indicates that 5-year DESCo contracts for loft-insulation (270mm) could save householders £400 (under guaranteed savings) - £500 (under shared savings contracts); i.e. 7% and 9%, on baseline energy costs, compared to savings of ~£800 (14%) through self-financing of measures. These contracts would provide the DESCo with rates of return of 15% (under shared savings) and 20% (under guaranteed savings), i.e. rates much higher than market interest rates for private sector loans[69]. The viability criteria for DESCo contracts is that household savings (HS) are zero or greater and the internal rate of return exceeds the interest rate [see Table 4: Criteria] therefore these results imply that guaranteed and shared savings contracts would be viable for loft insulation (270mm).

4.1.3 Impact of altering key parameters

The base case outlined above uses the default values for take-back, energy price rises, transaction costs and baseline energy use [Initial values, Table 6]. However, in reality, the values of these parameters are uncertain and so the analysis below explores the consequences of changing these values. The cases below explore in turn what would happen to the household savings (HS) and internal rates of return (IRR) from DESCo contracts for loft insulation (270mm) if the value of these parameters were varied within realistic ranges [Iterations & Sources, Table 6]. The cases explore two scenarios:

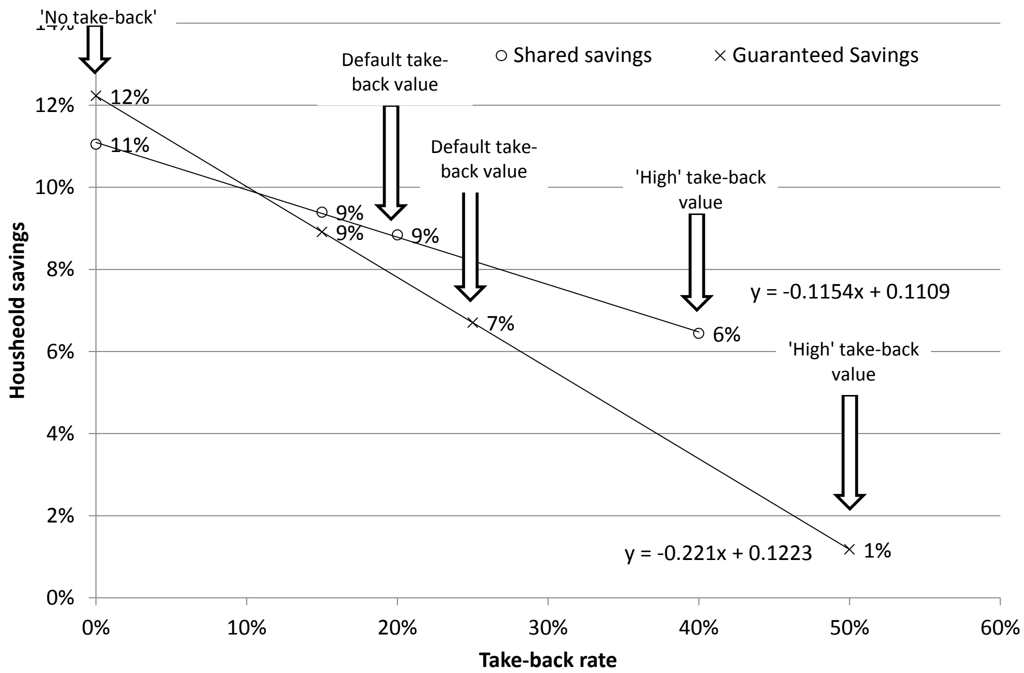
[67] See Table 5
[68] See 3.3.3
[69] 2-3% APR, private non-financial sector borrowing, March 2011 (Bank of England 2011)

1) How changes in inputs alter the level of household savings[70] (HS) assuming that the DESCos internal rate of return (IRR) is fixed.
2) How changes in inputs alter the level of internal rates of return[71] (IRR) assuming that the level of household savings (HS) is fixed.

Take-back rate[72]

Figure 7 shows that, with fixed internal rates of return, as take-back rises household savings decrease. In other words if DESCo profits remain the same then, as the householder takes-back a greater proportion of the energy savings as increased comfort, the amount they save on bills will decrease. The relative slopes of the lines indicate that guaranteed savings contracts are more sensitive to take-back than shared savings contracts[73]. The graph suggests that 'high' take-back rates [Table 6] still deliver positive household savings and therefore, with fixed internal rates of return, high take-back rates should not damage the viability of this contract.

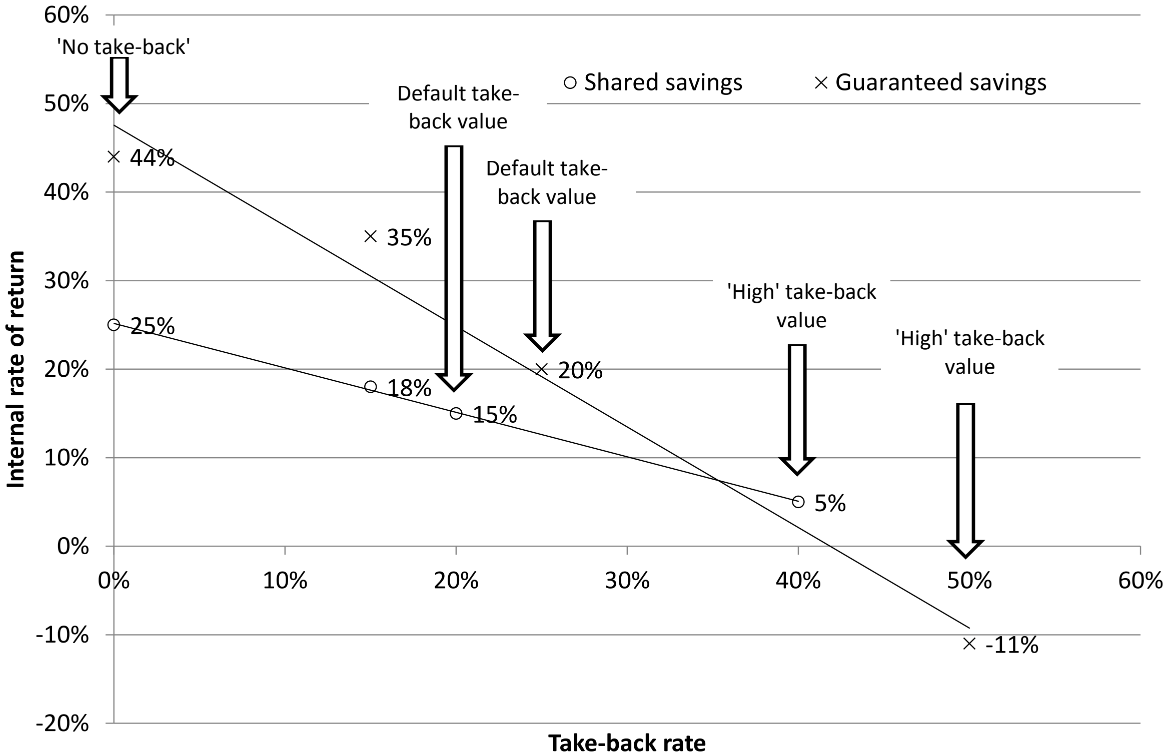
Figure 7: Household savings, as a percentage of baseline energy costs, against take-back rates under guaranteed and shared savings DESCo contracts for loft insulation (270mm), 5-year contract



[70] Savings over baseline energy costs
[71] The internal rate of return on the DESCos investment
[72] the rate at which householders take back energy efficiency savings as increased comfort; higher rates of take-back reduce total energy savings
[73] under guaranteed savings, household savings (HS) are proportional to take-back whereas, under shared savings, household savings (HS) are proportional to *half* the energy savings (S/2) and therefore proportional to *half* the take-back [equations 9 & 11]

Figure 8 shows that, as take-back increases, internal rates of return decrease. In other words, if the DESCo has promised the household a fixed level of savings, but the householder takes back more of the energy saved as increased comfort the DESCos profits will decrease. The graph shows that IRR from guaranteed savings contracts is more sensitive to take-back than shared savings contracts, this is because guaranteed savings contracts offer householders a fixed saving, leaving the DESCo to absorb the increase in take-back, whereas shared savings contracts share the effect of increased take-back between the DESCo and householder. The graph indicates that a ‘high’ take-back rate, under a guaranteed savings contract, would give a negative IRR. This implies that, with fixed household savings, ‘high’ take-back would make DESCo contracts unprofitable and therefore managing take-back is an important component of profitable DESCo contracts. Take-back rates and ways that DESCos might be able to manage them are discussed in 5.2.1.

Figure 8: DESCo internal rates for varying take-back rates, under guaranteed and shared savings DESCo contracts for loft insulation (270mm), 5-year contract



Energy Prices

Figure 9 shows that, with fixed IRR, increasing energy prices reduce household savings under guaranteed and shared savings contracts. In other words, as energy costs increase, household savings as a percentage of the *baseline costs* will reduce. The graph suggests, however, that even under 'high' price rises (4.5%pa) household savings over the baseline would be greater than zero, i.e. even high energy prices rises would not negate savings on bills.

Figure 9: Household savings, as a percentage of baseline energy costs, against energy price rises under guaranteed and shared savings DESCo contracts for loft insulation (270mm), 5-year contract

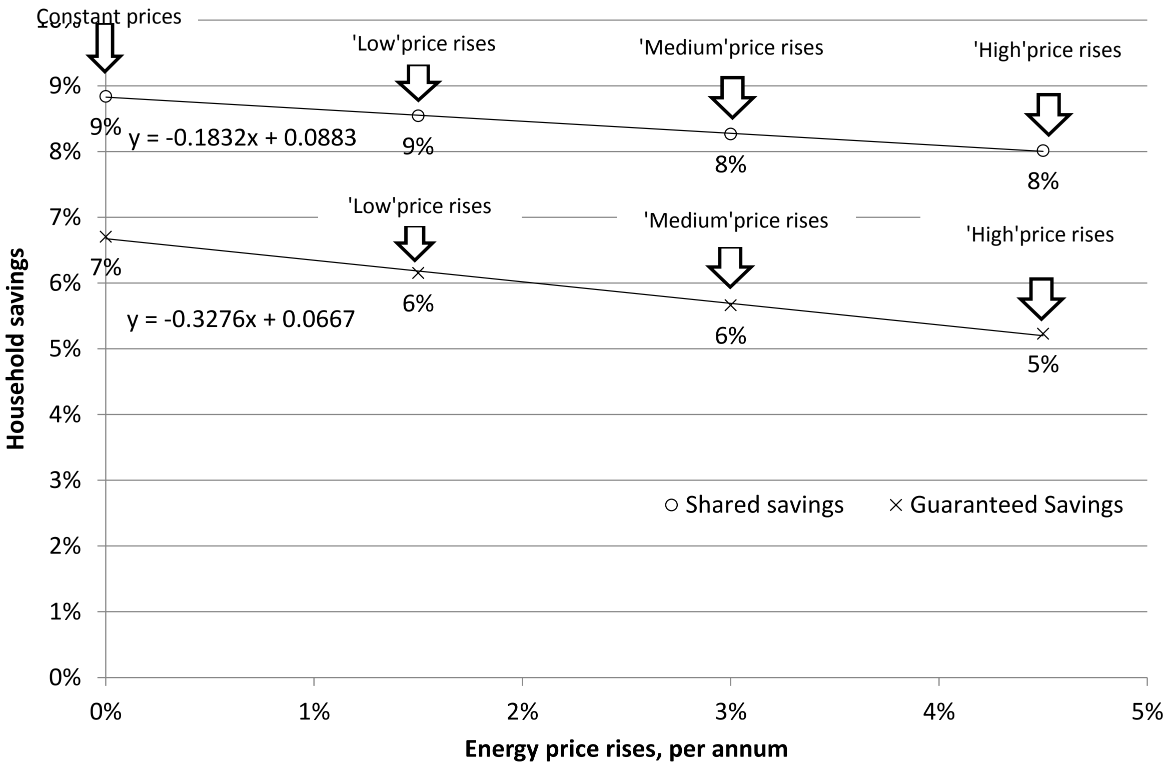
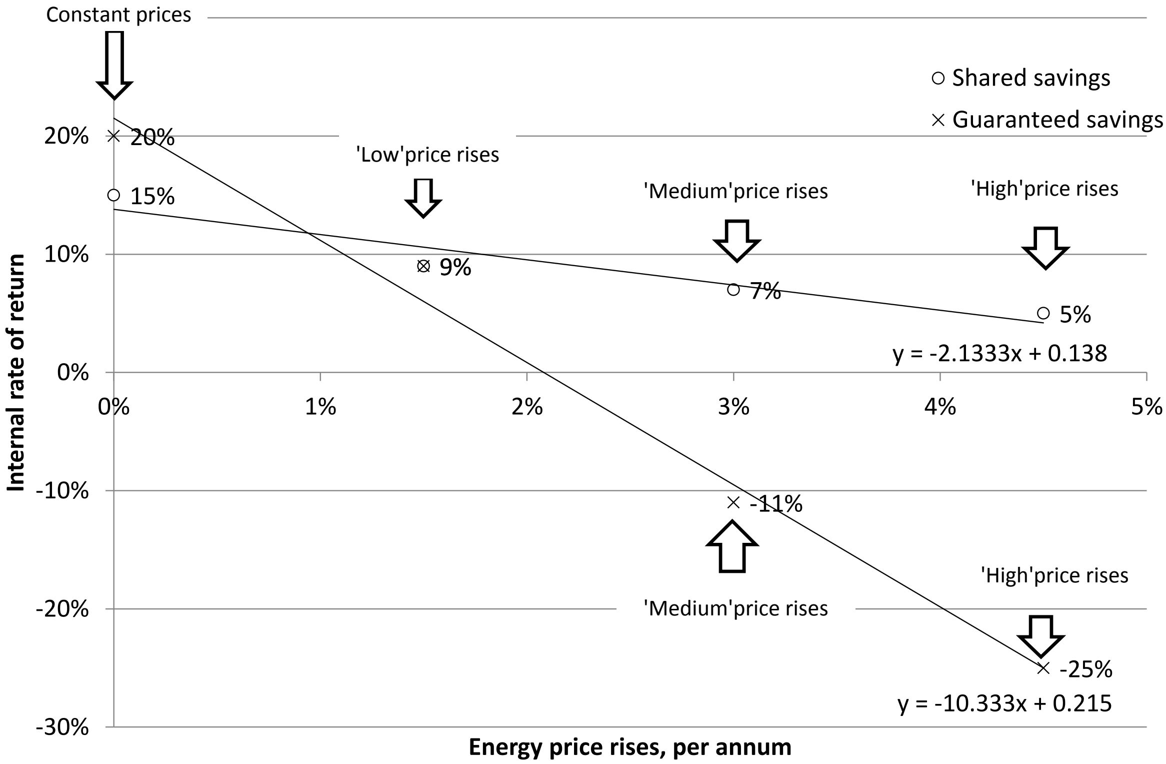


Figure 10 indicates that as energy prices increase internal rates of return decrease[74] and that guaranteed savings contracts are more sensitive to energy price rises than shared savings contracts. This is because guaranteed savings contracts offer householders a fixed saving, leaving the DESCo to absorb the price rise, whereas shared savings contracts share the effect of the price rise between the DESCo and householder[75]. The graph suggests that, for guaranteed savings contracts, energy price rises of more than 2%pa (over those anticipated) would make these contracts unprofitable. Therefore this implies that factoring anticipated energy price rises into DESCo contracts would be vital to maintaining their profitability, methods that DESCos might adopt to do this are discussed in 5.2.1

[74] As energy savings are reduced by increased prices
[75] under guaranteed savings, IRR is proportional to household savings (baseline costs – current energy costs) whereas, under shared savings, IRR is proportional to *half* household savings (baseline costs – current energy costs), i.e. S/2, and therefore proportional to *half* the energy price rise

Figure 10: DESCo internal rates for varying energy price rises, under guaranteed and shared savings DESCo contracts for loft insulation (270mm), 5-year contract



Transactions costs

Figure 11 shows that, with a fixed IRR, as transaction costs increase household savings decrease and that savings are more sensitive to transaction costs under guaranteed savings than under shared savings[76]. It indicates that, for this contract, 'high' transaction costs result in positive household savings, i.e. even when transaction costs are high DESCo contracts could still offer savings to households.

[76] As under guaranteed savings, household savings (HS) are baseline energy use minus repayments (which are proportional to transaction costs) whereas, under shared savings, household savings (HS) are proportional to *half* the energy savings (S/2) and therefore proportional to the baseline energy use minus *half* the costs [equations 9 & 11]

Figure 11: Household savings, as a percentage of baseline energy costs, against transaction costs under guaranteed and shared savings DESCo contracts for loft insulation (270mm), 5-year contract

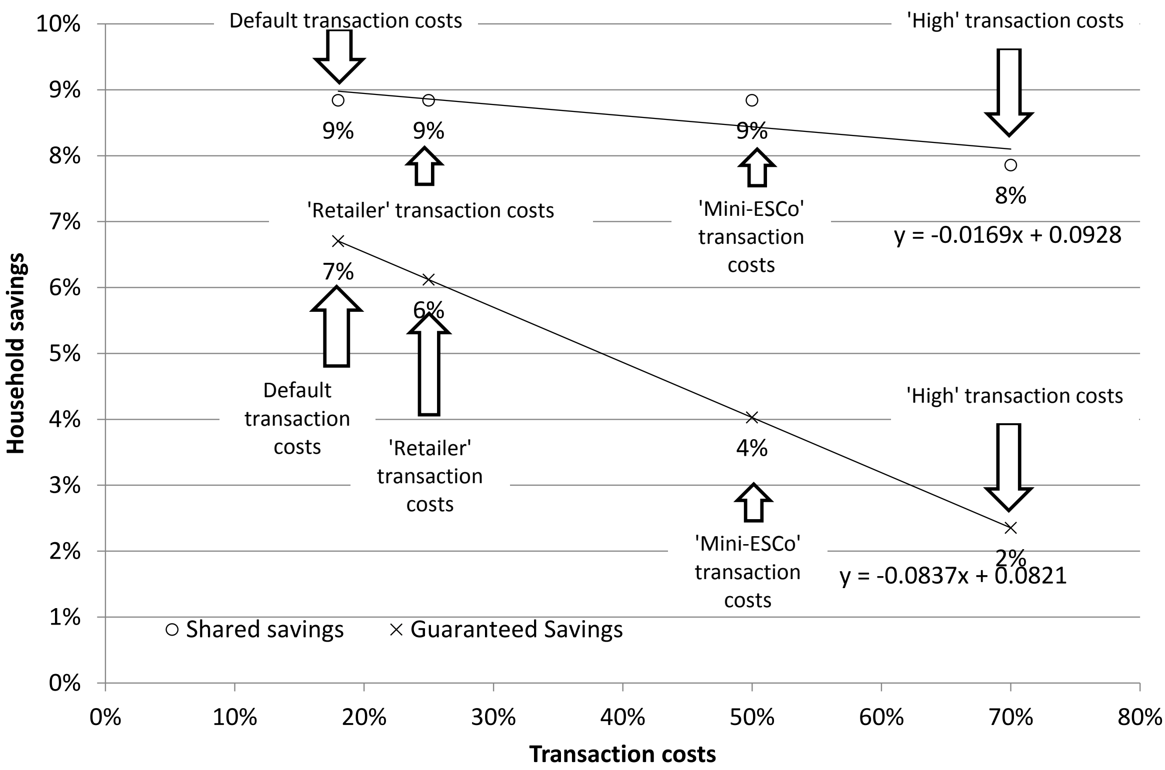
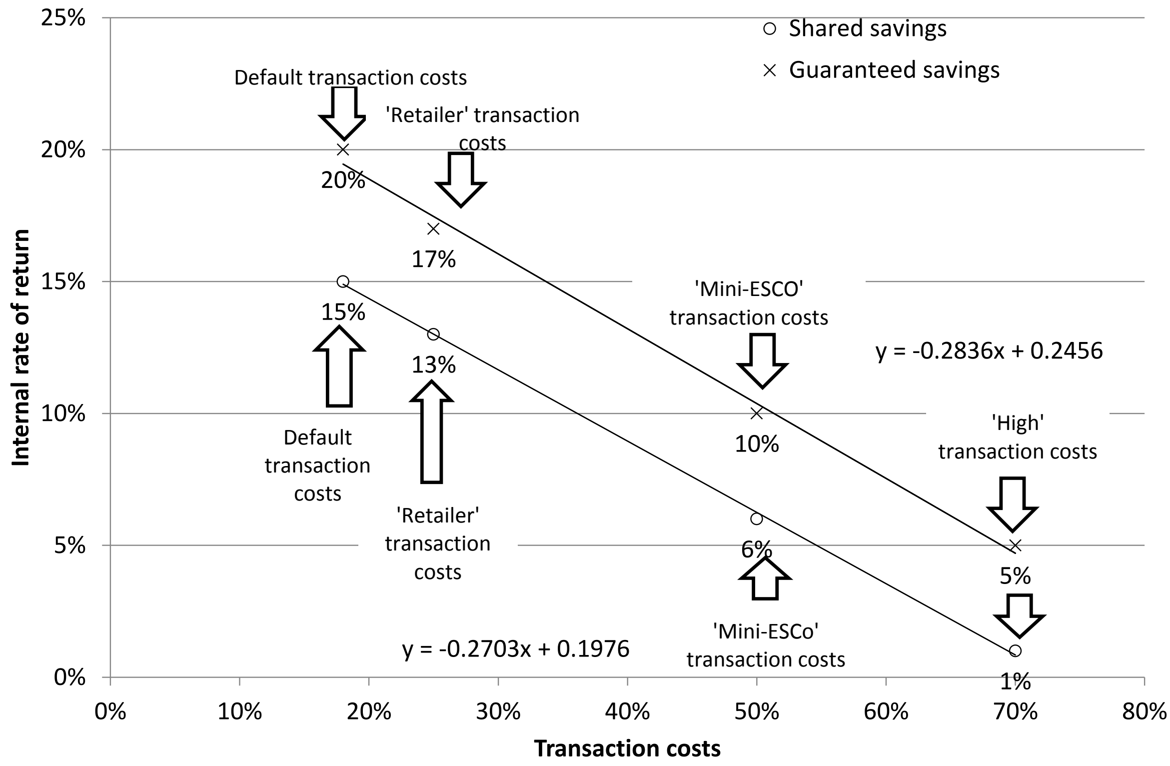


Figure 12 shows that the IRR decreases as transaction costs rise. This is because an increase in transaction costs increases the cost of the installation and therefore, as savings are fixed, this reduces the rate of return. It indicates that the IRR under ‘high’ transaction costs is positive for both guaranteed and shared savings contracts. This suggests, even at high transaction costs, this type of DESCo contract could be profitable.

Figure 12: Internal rate of return against transaction costs under guaranteed and shared savings DESCo contracts for loft insulation (270mm)



Gas consumption

Figure 13 shows that, with a fixed IRR, household savings increase as baseline gas consumption increases, i.e. the larger the baseline gas consumption the greater the savings available from installing loft insulation. The lines indicate that savings under guaranteed savings contracts are very sensitive to gas consumption; in this instance household savings increase more than double for every increase in gas use[77] because, when gas consumption increases, installation costs remain the same, therefore savings to the householder increase exponentially as usage increases. However household savings from shared savings contracts are fairly insensitive to gas use because savings are proportional to energy saved therefore actual level of gas use irrelevant[78]. For measures with higher repayments, e.g. solid wall insulation, household savings under shared savings are much more sensitive to gas use with each increase in gas use leading to a proportional increase in household savings[79]. In conclusion, for guaranteed savings contracts or shared savings contracts for high cost

[77] As illustrated by y = **2E-07x** + 0.0825
[78] This is the case with all measures that deliver a share of savings that is greater than the DESCos repayments, i.e. S/2>R
[79] See average sensitivity coefficient of household savings to baseline gas use (0.99), Appendix D

measures, high baseline gas consumption would increase the attractiveness of DESCo contracts to householders.

Figure 13: Household savings, as a percentage of baseline energy costs, against gas consumption under guaranteed and shared savings DESCo contracts for loft insulation (270mm), 5-year contract

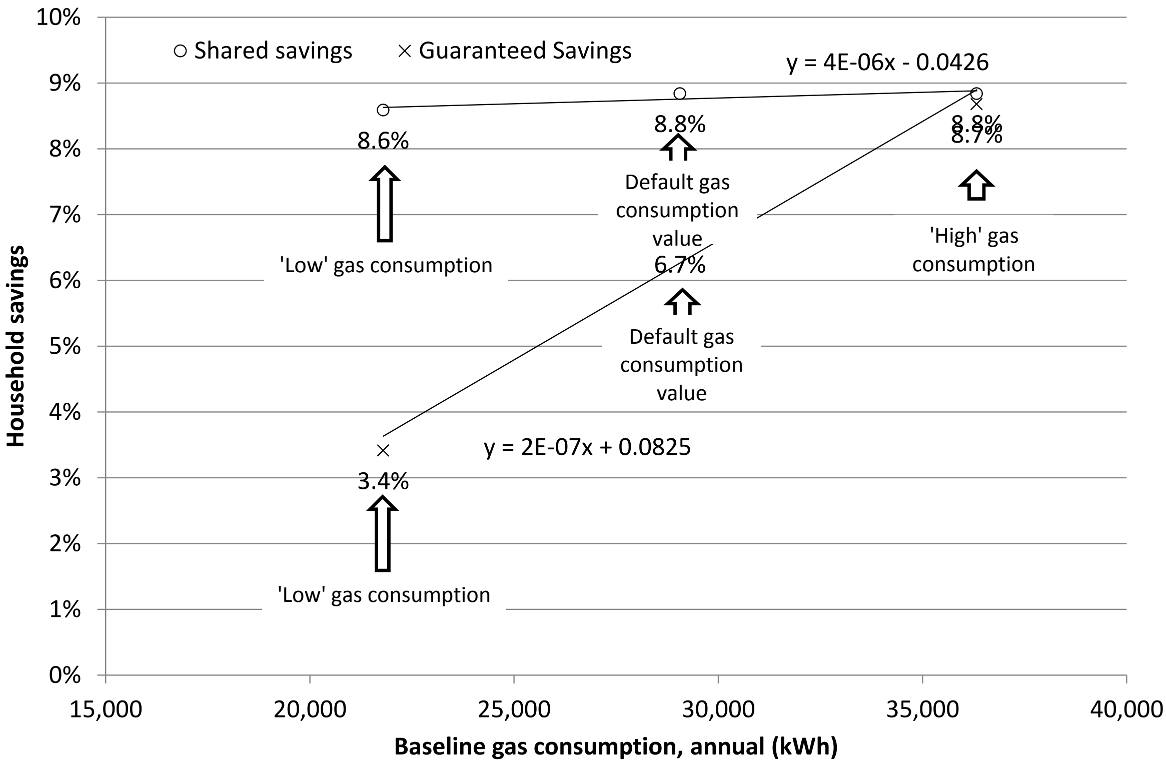
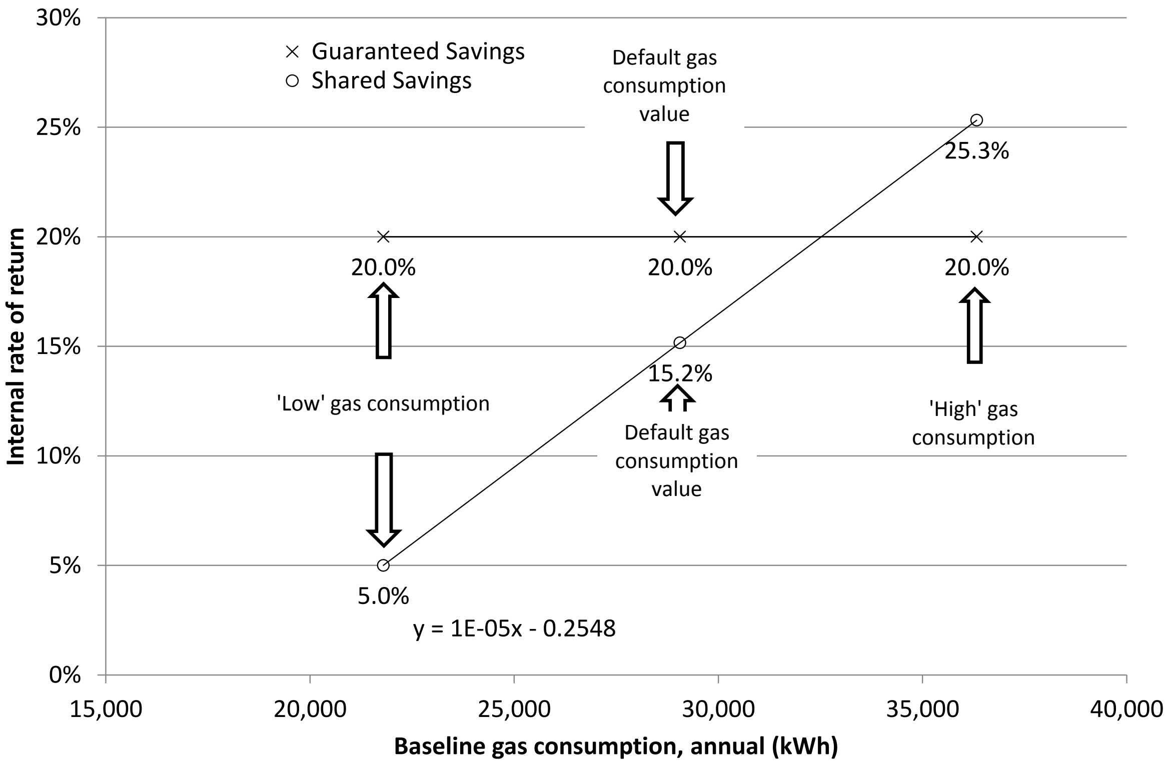


Figure 14 shows that, under shared savings, as baseline gas consumption increases the IRR also increases. This is because DESCo returns are proportional to half of total energy savings which in turn are proportional to baseline gas use[80]. However, for high cost measures under shared savings, and under guaranteed savings contracts, IRR is not affected by baseline gas consumption as repayments are proportional to *costs* rather than *savings* [see equations 9, 11 and 12].

[80] As in all situations where S/2>R

Figure 14: Internal rate of return against baseline gas consumption under guaranteed and shared savings DESCo contracts for loft insulation (270mm)



In summary, under guaranteed savings and shared savings contracts loft insulation (270mm), all the scenarios explored delivered positive household savings on baseline energy costs. This suggests that high transaction costs, high take-back, high energy price rises or low gas consumption do not materially affect the ability of this DESCo contract to deliver savings to householders. However high take-back rates and medium-high energy price rises generated negative rates of returns to DESCos. This suggests that managing take-back rates and energy price rises are critical to profitable DESCo operation. Take-back rates and energy price risk, as weaknesses of the DESCo model, are discussed in 5.2.

4.2 Results for all measures

Table 10 compares the model's outputs as percentage household savings on baseline energy costs (HS) under self-financing, guaranteed savings contracts, shared savings contracts[81].

[81] The contract lengths chosen for measures relate to the average lifetime of the measure, i.e. low cost insulation and demand side measures have lifetimes of 5+ years, heating measures have lifetimes of 10+ years and renewable energy and solid wall insulation lifetimes of 25+ years.

Table 10: Household savings (HS) on baseline energy bills (B) and internal rates of return (IRR) under self-financing, guaranteed savings and shared savings by energy efficiency measure [a], T= 5, 10, 25[b]

Measure	Household savings (HS) on baseline energy costs			Internal rate of return (IRR)	
Low cost insulation (T=5 years)	**Self-financing**	**Shared savings**	**Guaranteed savings**	**Shared savings**	**Guaranteed savings**
Loft insulation (0-270mm)	14%	9%	7%	15%	20%
Cavity wall insulation	10%	7%	2%	5%	20%
Draught proofing (0.5 ach)	2%	2%	0%	5%	20%
Loft insulation (100 to 270mm)	2%	(4%)	(8%)	5%	20%
Loft insulation (150-270mm)	(3%)	(6%)	(9%)	5%	20%
Hard to treat cavity wall insulation	(12%)	(23%)	(42%)	5%	20%
High cost insulation (T=25 years)	**Self-financing**	**Shared savings**	**Guaranteed savings**	**Shared savings**	**Guaranteed savings**
Internal wall insulation with ECO subsidy (55%)	13%	3%	(29%)	5%	20%
Internal wall insulation + 'making good' with ECO subsidy (55%)	10%	(4%)	(48%)	5%	20%
Double glazing (8 windows) with 50% client funding	(4%)	(5%)	(30%)	5%	20%
External wall insulation with ECO subsidy (55%)	9%	(6%)	(54%)	5%	20%
Internal wall insulation	3%	(18%)	(87%)	5%	20%
Double glazing (8 windows)	(4%)	(19%)	(68%)	5%	20%
External wall insulation + 'making good' with ECO subsidy (55%)	1%	(23%)	(101%)	5%	20%
Internal wall insulation + 'making good'	(4%)	(32%)	(129%)	5%	20%
External wall insulation	(6%)	(37%)	(142%)	5%	20%
External wall insulation + 'making good'	(24%)	(74%)	(247%)	5%	20%
Heating Interventions (T=10 years)	**Self-financing**	**Shared savings**	**Guaranteed savings**	**Shared savings**	**Guaranteed savings**
Cylinder insulation and thermostat, 50% client funded	0%	(1%)	1%	5%	20%
Thermostatic radiator valves, 50% client funded	(0%)	(2%)	0%	5%	20%
Cylinder insulation, thermostat and TRVs, 50% client funded	(0%)	(2%)	1%	5%	20%
Cylinder insulation and thermostat	0%	(3%)	(1%)	5%	20%
Thermostatic radiator valves	(0%)	6%	(2%)	5%	20%
Cylinder insulation, thermostat and TRVs	(0%)	(9%)	(3%)	5%	20%
Condensing gas boiler, 50% client funded	(12%)	(23%)	(8%)	5%	20%
Condensing gas boiler, TRVS, cylinder insulation, thermostat, 50% client funded	(12%)	(25%)	(7%)	5%	20%
Condensing gas boiler	(12%)	(54%)	(25%)	5%	20%
Condensing gas boiler, TRVS, cylinder insulation + thermostat	(12%)	(62%)	(27%)	5%	20%
Renewables (T=25 years)	**Self-financing**	**Shared savings**	**Guaranteed savings**	**Shared savings**	**Guaranteed savings**
Solar PV, 3 kWp (Monocrystalline), 50% client funded	15%	7%	(334%)	5%	20%
Solar thermal (4m2), 50% client funded	8%	(5%)	(75%)	5%	20%
Solar thermal (3m2), 50% client funded	5%	(8%)	(74%)	5%	20%
Solar thermal (4m2)	8%	(20%)	(117%)	5%	20%
Solar thermal (3m2)	5%	(21%)	(111%)	5%	20%
Solar PV, 1.5 kWp (Monocrystalline), 50% client funded	(37%)	(43%)	(298%)	5%	20%
Solar PV (3kWp Monocrystalline)	15%	(178%)	(860%)	5%	20%
Solar PV, 1.5 kWp (Monocrystalline)	(37%)	(181%)	(692%)	5%	20%
Demand side management (T=5 years)	**Self-financing**	**Shared savings**	**Guaranteed savings**	**Shared savings**	**Guaranteed savings**
Direct feedback via energy display + smart metering with informative billing	12%	8%	8%	5%	20%
Direct feedback via energy display	7%	4%	5%	5%	20%
Smart metering with informative billing	5%	3%	3%	5%	20%

[a] Brackets indicate negative figures, shading indicates contracts which meet the contract viability criteria e.g. HS≥0 and IRR≥ interest rate (20% for guaranteed savings, 5% for shared savings).
[b] The contract lengths (T) relate to the average lifetime of the measure, i.e. low cost insulation and demand side measures have lifetimes of 5+ years, heating measures have lifetimes of 10+ years and renewable energy and solid wall insulation lifetimes of 25+ years.

Viable contracts

Therefore the results in Table 10 suggest that viable DESCos contracts include:

- 5-year contracts for loft insulation (0-270mm), cavity wall insulation, draft-proofing, informative billing and energy displays
- 10-year contracts for cylinder insulation, central heating thermostats and thermostatic radiator valve with 50% funding from householders
- 25-year contracts for internal wall insulation with ECO subsidy and Solar PV, 3 kWp (Mono crystalline) with 50% funding from householders

4.3 Results versus the Green Deal

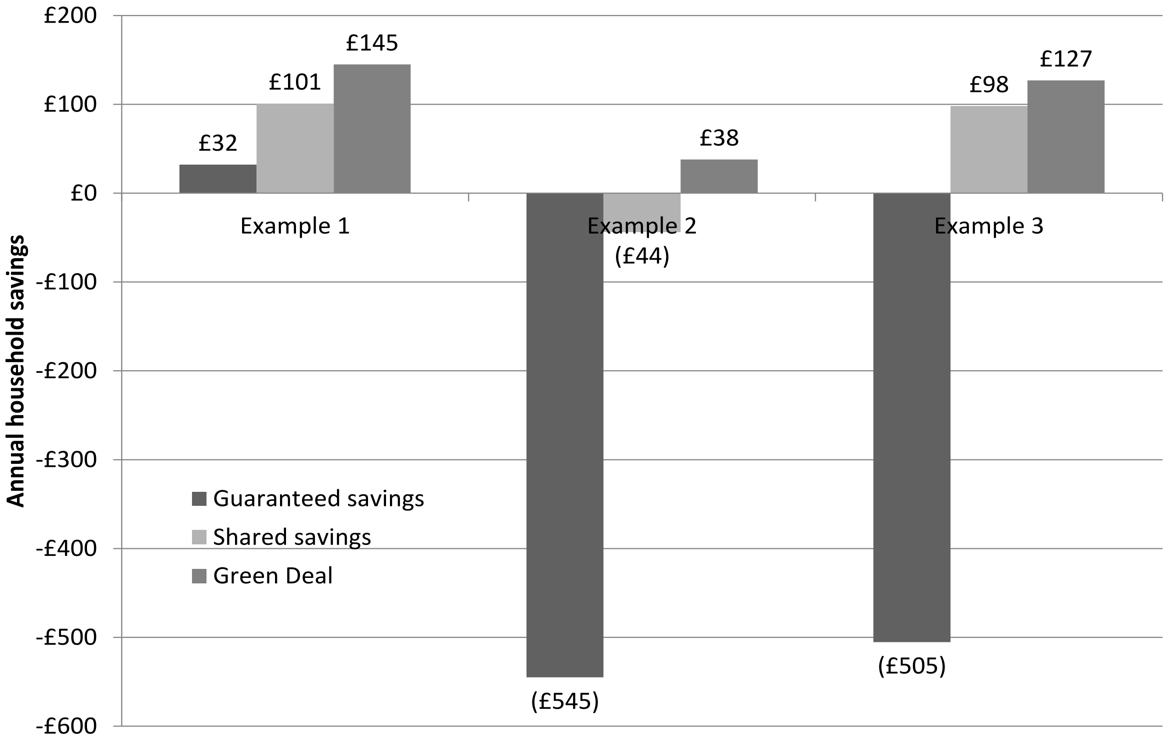
Table 11 and Figure 15 compare possible 25-year contracts packages under DESCo provision and the Green Deal. Example 1 shows that a 25 year contract to deliver cavity wall and loft insulation could generate savings of £32/year (a 3% reduction on baseline costs) under a guaranteed savings contract and £101/year (9%) under a shared savings contract [Figure 15]. By contrast the Green Deal Impact Assessment estimates household savings from a similar package would be £145/year (15%) under a Green Deal agreement[82]. Example 2 shows, for internal wall insulation + 'making good' with a 55% ECO subsidy, shared savings contract would increase bills by £44/year (4% increase) whereas a guaranteed savings contract would increase bills £545/year (48% increase). By comparison a Green Deal loan would deliver savings of £38/year for the first 25 years[83] (a 4% reduction) [Figure 15]. Example 3 indicates a contract for a 'whole-house' retrofit (with an ECO subsidy for internal wall insulation) which could deliver with savings of £98/year (9% reduction) under a shared savings contract but would increase bills by £505/year (45% increase) under guaranteed savings contract. By contrast a similar package under the Green Deal would deliver savings of £127/year[84] (a 13% reduction) [Figure 15].

[82] Annual household savings for loft insulation top up and cavity wall insulation the first 25 years of a Green Deal loan, taken from Example 1 (Department of Energy and Climate Change 2011d)
[83] Annual household savings for solid wall insulation the first 25 years of a Green Deal loan covering direct "make good" costs after an ECO subsidy, taken from Example 2 (Department of Energy and Climate Change 2011d)
[84] From "Financing the Green Deal"; £11,000 Green Deal loan taken out, subsidised by 55% upfront grant, repayment over 25 years, 50% energy savings, 6% interest rate, constant energy prices assumed (Holmes 2011, p.31)

Table 11: Cost breakdown and household savings for 25-year contract packages under guaranteed savings, shared savings and the Green Deal (T=25)

	Upfront cost to DESCo, incl. transaction cost	Upfront cost to government	Upfront cost to household	Household savings, guaranteed savings (HSg), %	Household savings, shared savings (HSs), %	Annual saving, Green Deal, %	Annual household saving, guaranteed savings (HSg), £	Annual household saving, shared savings (HSs), £	Annual saving, Green Deal, £
Example 1: Cavity wall insulation-Loft insulation top-up (100-270 mm)	£778	£0	£0	3%	9%	15%	£32	£101	£145
Example 2: Internal wall insulation + 'making good' with ECO subsidy (55%) GDIA	£334	£2,816	£0	(48%)	(4%)	4%	(£545)	(£44)	£38
Example 3: Internal wall insulation with ECO subsidy (55%) GDIA Virgin loft insulation (0 to 300mm)Draught proofing (to 0.5 ach)Cylinder insulation and thermostat	£3,343	£1,238	£0	(45%)	9%	13%	(£505)	£98	£127

Figure 15: Annual household savings from Example packages, compared to baseline energy costs, under 25-year contracts under guaranteed, savings shared savings and the Green Deal [a]



[a] Example 1: Cavity wall insulation-Loft insulation top-up (100-270 mm). Example 2: Internal wall insulation + 'making good' with ECO subsidy (55%) GDIA. Example 3: Internal wall insulation with ECO subsidy (55%) GDIA Virgin loft insulation (0 to 300mm)Draught proofing (to 0.5 ach)Cylinder insulation and thermostat

4.4 Validation of the model

Table 12 compares viable DESCo contracts to fixed-term contracts offered by UK utilities and ESCos. It shows that, though DESCo contracts are generally longer than current offerings, they offer greater household savings or install more expensive measures than existing contracts. It therefore suggests that the model has validity.

Table 12: Comparison of contract length and savings of viable DESCo contracts versus existing fixed term energy contracts [a]

Name	Measures offered	Contract length (years)	Household savings	Details / Example measures	Source
EdF Energy: capped product	None	2	0%	Capped product with no price rises	Littlechild, 2006, p16
Utilita PriceTracker Promise	Free energy survey + credits towards energy saving equipment	3	0%	Price of services to track a reference price related to incumbent suppliers.	Littlechild, 2006, p5 + 16
Npower fixed-price package	Free energy efficiency home audit + finance package	3	0%	Spreads discounted cost of measures over the term of the contract	Littlechild, 2006, p5
Scottish power capped-price product	None	3	0%	Including premium refunded at the end of the contract period as a "loyalty bonus".	Littlechild, 2006, p14
British Gas: fixed-price gas + electricity	None	1 - 3	0 to 3.5%	A premium on standard prices of 2.25% (electricity) and 3.5% (gas)	Littlechild, 2006, p15
5 year guaranteed or shared savings	Low cost measures	5	0-12%	Loft insulation (0-300mm), cavity wall insulation, energy displays and demand-side measures	DESCo model
10 year guaranteed savings	Low cost heating interventions (50% client funded)	10	0-1%	Cylinder insulation, thermostats and TRVs	DESCo model
EcoCentroGen Ltd	Energy and broadband supply	15 - 30	10%	Funding, design, construction and operation of embedded energy generation	Oldham et al 2003, p20
25 years shared savings	Renewable energy (50% funded by householder)	25	7%	Solar PV, 3 kWp (Monocrystalline)	DESCo model
25 years shared savings	High cost insulation, 50% funded by government or householder	25	3%	Internal wall insulation	DESCo model

[a] Ordered by contract length, low-high. Shading indicates DESCo contracts

4.5 Critique of the model

The model has a number of potential weaknesses:

1. It only explores one house type; a pre-1980 un-insulated cavity-wall semi, therefore the energy savings, and arguably the results, cannot be extrapolated to other house types due to differences in size and thermal properties
2. The interest rates used are 3- 25%, indicating the level of uncertainty about what interest rates DESCo investments would be subject to
3. The take-back factors used are 0 - 50%, highlighting the level of uncertainty that currently exists around the level of comfort take-back that would result from any particular energy efficiency intervention under an energy service contract
4. The transaction costs used are 18-70% thus illustrating the level of uncertainty as to what level of transaction costs DESCos would experience

5. The viability criteria is open to debate as there is currently no data on what level of household savings would make an energy service contract attractive to consumers and therefore no way to confirm the validity of the level chosen (≥0%)
6. The repayment formulas used represent only one of a range of possible options for DESCo repayment structuring
7. One of the assumptions of the model is that the DESCo makes ‘normal’ profits, e.g. their rate of return equals the interest rate. If DESCos made profits over and above normal levels this would reduce household savings.
8. Energy savings are based on a building energy model[85] however empirical studies have shown that, in reality, installations generally deliver energy savings smaller than energy modelling suggests.

All these weaknesses mean that confidence in the final results should be extremely cautious and that the results should predominantly be seen as a focus for discussions on the viability of domestic energy service company business model rather than accurate financial predictions.

4.6 Summary

For a single measure (virgin loft insulation) 5-year DESCo contracts could save householders £400-£500 (7-9%) on baseline energy bills, compared to £800 (14%) under self-financing and delivered an internal rate of return of 15-20% to DESCos. High take-back, high energy price rises, high transaction costs and low baseline energy use still delivered positive household savings but high take-back rates and medium energy price rises led to negative returns on investment for DESCos, suggesting managing take-back and price rises are key to the profitability of this DESCo contract.

The results for all measures suggest that DESCos could viably finance virgin loft insulation; cavity wall insulation; draft-proofing and demand-side measures at no upfront cost to householder, and cylinder insulation; central heating thermostats; TRVS, and solar PV (3kWp) with 50% funding from the householder, and internal wall insulation with a 55% ECO subsidy. 25-year contract packages for these measures could deliver savings comparable with those of the Green Deal. These results and salient influences, particularly energy prices, transaction costs and take-back factors, are discussed in detail in the next section.

[85] CDEM, for more details see Firth et al, 2010b

5 Discussion

The results from the previous section indicate that DESCo contracts could viably finance certain energy efficiency measures. The following section discusses the strengths, weaknesses, opportunities and barriers of the DESCo business model in order to explore its prospects for delivering energy efficiency in the UK.

5.1 Strengths of the DESCo business model

The strengths of the DESCo business model can be categorised into economic or socio-cultural benefits.

5.1.1 Economic benefits

- **Incentive alignment:** DESCos are advantageous compared to the existing energy supply model as they align the economic interests of consumer and supplier. By selling consumers energy services DESCos can profit from reductions in primary energy use, therefore, by installing energy efficiency measures, DESCos can generate profits as well as offer consumers lower cost energy. Unlike existing government interventions which rely on some level of coercion of suppliers or consumers, energy service contracts represent a persuasive business case and therefore might reduce the expense and inefficiency of government intervention.
- **No upfront costs:** If DESCos install measures at no upfront cost this would help to mitigate the access to capital barrier to energy efficiency installations.
- **Reduced performance risk**: As DESCos offer either a guarantee or a share of energy savings they reduce the risk to the householder that installations will underperform.
- **Reduced search costs**: DESCos would have access to more reliable information on the costs and benefits of energy efficiency measures than householders and this would reduce the 'search costs' of investments.
- **Increased access to capital**: DESCos could be expected not to 'discount' future energy savings to the same extent that householder's do as, due to experience and expertise, they have greater confidence in outcomes. Therefore, at any given interest rate, DESCos should have a greater propensity to invest in energy efficiency measures than householders, thus they increase access

to capital. Plus DESCos might also be able to borrow at lower interest rates than householders. Plus DESCo contracts could replace existing utility supply contracts, which traditionally have low default rates and this would reduce the cost of capital.

- **Lower capital costs**: DESCos might be able to bulk purchase equipment and materials which would lower capital costs.
- **Mitigating split incentives:** DESCos could mitigate the split incentive barrier by ensuring that, if a householder leaves the property, the cost of energy efficiency measures can be transferred to the next occupant through a 'contract transfer' process.

5.1.2 Socio-cultural benefits

- **Reduces consumer inertia:** Evidence has also shown that consumers find fixed price contracts attractive (Littlechild 2006) and consumer research for the Green Deal indicated a strong preference for guarantees:

> A lack of a guarantee for the savings reduced interest in the Green Deal with 62% of participants saying it would make them less likely to take it out, of which over a fifth (22%) said it would make them much less likely. (Department of Energy & Climate Change 2011f, p.8)

Guaranteed savings contracts therefore could be an attractive proposition to householders. Shared savings contracts, though not fixed price, could provide some form of reassurance to the householder as they may confer some of the performance risk to the DESCo as logic dictates that contracts where the supplier takes on some of the performance risk will appear more attractive to consumers than one where there is no risk to the supplier. Therefore although shared savings contracts might not mitigate consumer inertia in the same way as guaranteed savings contracts, they might give householders more confidence in the business case to install measures.

- **Encouraging behaviour change.** As it is in the interests of the DESCo to reduce inefficient energy use and comfort take-back they might specify maximum usage in contracts or incentivise energy conservation and so encourage behaviour change. Contracts could include usage limit or fair use clauses similar to those used in mobile phone contracts[86] which might actually increase householder awareness of energy use, for example text messaging or smart phone apps are now routinely used by consumers to monitor bank balances and 3G data usage. Contracts could also include higher tariffs on use above certain levels which could ensure, that even if take-back is high, payments will always exceed the costs of energy[87].

DESCos could also use advice and information to encourage energy reduction. The RELISH project suggests that substantial energy savings can be achieved, particularly by high energy users, through suitably framed advice recommending specific behavioural actions (RELISH 2011). As an added incentive, contracts could reward usage *under* certain levels. A reward scheme is already operated by Southern Electric's betterplan tariff: householders are given a £15 reward, and discounts on energy efficient appliances, for cutting energy use by 10% (Southern Electric 2011).

5.2 Weaknesses of the DESCo business model

The weaknesses of the DESCo business model can be categorised into economic and socio-cultural drawbacks.

5.2.1 Economic drawbacks

- **High risk.** The risks to DESCos include:
    a) **Performance risk:** DESCos take on some, or all, of the performance risk of energy efficiency measures. Under guaranteed savings contracts especially, the DESCo is liable for any underperformance of measures (performance risk), whereas EEC/Green Deal finance where providers do not assume any of the performance risk.
    b) **Stranded assets:** Energy efficiency installations are illiquid meaning that they are not easily converted back into capital. This means DESCos are subject to 'stranded asset' risks, i.e. it is difficult to recoup their investment should a contract be broken.
    c) **Take-back:** The DESCo is liable for the energy bills of the property but their revenue is dependent on the actions of the householder who may choose to take back energy savings

[86] under which providers reserve the right to impose limits, charge reasonable additional charges or suspend or terminate services if use is not consistent with normal, fair and reasonable use (Vodafone 2011)
[87] This in turn could reduce inherent risks to the DESCo and could further lower interest rates.

as increased comfort. This exposes the DESCo to the risk of underperformance due to high take-back.

The risk of stranded assets may be mitigated by administrating contracts through energy bills, which have traditionally low default rates, and having a 'contract transfer' procedure in place in the event of an occupant change. The risks of high take-back may be mitigated by contract clauses that discourage or counteract take-back [see **Encouraging behaviour change** above]

The risk of underperformance, however, is systemic to energy efficiency investments. DESCo contracts transfer this risk from the householder to the DESCo, which may arguably be in a better position to manage these risks.

- **Transaction costs:** DESCos require capital to be spent on setting up, monitoring and enforcing contracts. Whether these transaction costs would be prohibitive in reality is open to debate but arguably, if contracts were delivered by utility companies, then transaction costs might be no greater than those of EEC and the Green Deal and the modelling suggests that even high levels of transaction costs may not prohibitive.
- **Energy price risk:** If household repayments are set as a percentage of the past usage[88] any increase in energy costs will reduce the DESCos profit [as illustrated in 4.1.3]. One way of mitigating this risk would be for payments to track the wholesale energy price, though this would mitigate the fixed price selling point. Another method would be to include staggered price increases in the contract which would be transparent at the outset. This would serve to give consumers confidence in future prices and insure the DESCo against rising prices. Volatile energy prices are a systemic risk of the current energy system and arguably DESCos would be in a better position to anticipate and hedge price risks than the householder. Furthermore, as high energy price increase contract viability (by increasing the value of savings), if prices continue to rise DESCo contracts would become increasingly attractive.

5.2.2 Socio-cultural drawbacks

- **Disinclination towards unfamiliar measures:** Consumer preferences, surveyed for the Green Deal and ECO Impact Assessment, suggest that the greatest influence on choice of packages was

[88] e.g. 93% of previous bills

the attractiveness of the energy efficiency measure and that preferences were driven by the perceived *need* for measures (Department of Energy & Climate Change 2011f). In this context boiler replacements fared much better than unfamiliar measures such as solid wall insulation, this implies that householders might be disinclined to sign up to contracts that specify unfamiliar measures. This taps into another issue with energy service contracts; householders may not be willing to relinquish control over which measures are installed. In reality DESCos energy audit process could allow householders to choose from a list of 'packages' with different measures and savings rates.

- **Disinclination towards long term contracts:** The modelling suggests that DESCos would require householders to sign up to contracts of 5+ years and, although consumers are becoming increasingly familiar with long term contracts for other utilities (e.g. mobile phones), 3+ year contracts are still fairly uncommon[89]. Indeed consumer research performed for the Green Deal indicated that long payback periods were considered one of the main disadvantages of the Green Deal (Department of Energy & Climate Change 2011a). However, as under a DESCo contract, in most cases the householders would not pay any upfront cost, arguably, 'payback'[90] would not be relevant. To use the analogy of a mobile phone contract, consumers would enter into a DESCo contract for the benefits it would confer[91] rather than for the expected 'payback' time.
- **Physical disruption/hassle:** These 'hidden costs' are a substantial barrier to the installation of energy efficiency measures; 15% of householders surveyed stated that hassle or disruption were one of the things that prevented them from making their home more energy efficient (Department of Energy & Climate Change 2011a). One way of mitigating physical disruption under DESCo contracts would be to include 'making good' costs in the cost of measures. Arguably, DESCos might also reduce 'hassle' to householders by managing installers. However, hidden costs such as physical disruption are seemingly inevitable with some forms of energy efficiency measure, e.g.

[89] and in some cases unlawful (Global Telecoms Business 2011)
[90] Defined as the time required for the cash revenues from a capital investment project to equal the cost (Bloomsbury Information Ltd 2009)
[91] e.g. upgraded building fabric, improved comfort and/or reduced costs

solid wall insulation[92], therefore it is arguably beyond the scope of a financial solution to remove these costs and instead efforts must be made to monetise and offset them[93].

5.3 Opportunities for DESCo operation

The UK energy landscape changes yearly as new initiatives come into force, others reach maturity or technology offers new opportunities. Below are the opportunities the energy landscape currently presents for the DESCo business model:

- **The Green Deal.** The Green Deal establishes a finance arrangement compatible with DESCos; allowing households to take out long term commitments to pay for energy efficiency and tying the costs of measures to the property rather than the occupant. Indeed ESCos have been proposed as a way of delivering the Green Deal in the non-domestic sector (Department of Energy and Climate Change 2011f; Hannon et al. 2011).Being integrated into the Green Deal would give DESCos an institutional framework within which to work, and access to government subsidies[94].
- **Green Investment Bank (GIB).** The GIB could be a source upfront capital for the Green Deal (Holmes 2011) and so, by offering capital at low interest rates, the GIB could increase the viability of DESCos[95].
- **Smart metering and smart appliances.** Smart meters and smart appliances could increase the viability of DESCos by facilitating demand-side management, streamlining the energy audit process that would precede most energy service offers[96] and facilitating contract transfers.
- **Micro-generation**. As an asset-based investment, funders may be more inclined to invest in micro-generation than elements that are embedded in building structures. Furthermore feed in tariffs could be attractive to energy service providers, as exemplified by 'rent-a-roof' schemes (YouGen 2010; E.ON 2011). Plus some micro-generation technologies, such as solar PV, require on-going support and maintenance, which could be integrated into energy service contracts.

[92] Which either changes property appearance, in the case of external wall insulation, or reduces usable floor area, in the case of internal wall insulation

[93] the loss of internal living space, hassle and disruption costs from solid wall insulation are estimated to increase installation costs by 28 - 55% (Department of Energy and Climate Change 2011f)

[94] e.g. ECO funding for solid wall insulation

[95] by increasing savings, reducing the subsidies required and/or increasing DESCo returns

[96] e.g. by enabling customers to input their own surveys and do online options appraisals (UK Energy Research Centre 2005).

- **Integrated energy contracts (IECs).** IECs could add value to DESCo contracts by bundling all energy sources, management and billing into one contract. This could appeal to UK consumers as surveys suggest that 80% find current energy tariffs confusing (PowerSwitch 2011).
- **Increasing energy prices.** The media attention surrounding price rises of 10- 15% quickly generated an interest in fixed price contracts (This is money 2011; The Telegraph 2011), suggesting that if prices continued to increase, interest in DESCo contracts might increase.
- **Commercial energy rates.** DESCos could generate extra profit by negotiating commercial rates for energy which are up to 25% cheaper than consumer rates[97].

5.4 Barriers to DESCo operation

- **Requires a strong co-operative relationship.** The DESCo business model relies on the alignment of supplier and consumer interests and, as such, requires a strong degree of co-operation in order to maximise financial savings from energy efficiency investments (Hannon et al. 2011). This relationship does not exist in traditional models of energy supply and therefore building and maintaining it might be a risky and time-consuming process for DESCos.
- **Institutional lock-in.** Though the Green Deal and Green Investment Bank may be able to provide some institutional support for the DESCo model, the energy supply system is largely geared towards the traditional model of supply. This creates a level of institutional 'lock-in' and inertia towards new models of supply. This suggests a change in the socio-technological regime surrounding energy supply might be necessary for new models of energy provision to prosper (Hannon et al. 2011).
- **Lack of commercial incentive by incumbent suppliers.** As indicated in 2.4.2, incumbent utility companies face little incentive to alter their business model. The analysis suggests that, as these firms are in the best position to profit from DESCos, this could be a major barrier to DESCo operation.

[97] **The model uses domestic energy prices for both DESCo and household energy costs [Table 6]Table 6: DESCo model input values and sources**

- **Lack of track record.** DESCo finance is subject to the same issues as Green Deal loans: it can be perceived as "unsecured consumer finance [with] no track record…competing with better understood infrastructure investment opportunities" (Holmes 2011, p.19)
- **Lack of familiarity by consumers.** As hinted in previous sections, consumers are averse to unfamiliar propositions and will exhibit biases towards the status quo. This suggests that lack of familiarity would be a barrier to DESCo operation.

Table 13 summarises the strengths, weaknesses, opportunities of and barriers to the DESCo business model.

Table 13: DESCo business model: Strengths, weaknesses, opportunities and barriers

Strengths	Weaknesses	Opportunities	Barriers
Aligns supplier and consumer incentives	Stranded assets	The Green Deal	Requires a strong co-operative relationship
No upfront cost to householder	Possibility of high take-back rates	Green Investment Bank	Lack of commercial incentive by incumbent suppliers
Mitigates performance risk to householder	Transaction costs	Smart-metering	Institutional lock-in
Mitigates financial risk to householder	Hidden costs	Micro-generation	Lack of track record
Reduces search costs	Status quo bias	Integrated energy contracts	Lack of familiarity by consumers
Increases access to capital	Impact on identity	Increasing energy prices	
Lowers capital costs	Energy price risk (guaranteed contracts)	Commercial energy rates	
Mitigates split incentives	Disinclination towards unfamiliar measures	Carbon trading	
Mitigates consumer inertia	Disinclination towards long term contracts		
Could promote behaviour change	Physical disruption/hassle		

5.5 Advantages over the Green Deal

Table 14 shows the advantages and disadvantages of the DESCo business model over the Green Deal. The main advantages are that DESCos align supplier and consumer incentives, mitigate performance risk to the householder, increase access to capital and, via guarantees, reduce consumer inertia. The weaknesses are the possibilities of high take-back rates and energy price rises.

Table 14: DESCo business model: Advantages and disadvantages over the Green Deal

Advantages	Disadvantages
Aligns supplier and consumer incentives	Stranded assets
No upfront cost to householder	Possibility of high take-back rates
Mitigates performance risk to householder	Transaction costs
Mitigates financial risk to householder	Hidden costs
Reduces search costs	Status quo bias
Increases access to capital	Impact on identity
Lowers cost of capital	Energy price risk (under guaranteed contracts)
Lowers capital costs	Disinclination towards unfamiliar measures
Mitigates split incentives	Disinclination towards long term contracts
Reduces consumer inertia	Physical disruption/hassle
Could promote behaviour change	

In summary, the DESCo business model can mitigate the risk, information, access to capital and consumer inertia barriers to energy efficiency but does not fully address hidden costs or bounded rationality[98] [Table 15].

Table 15: Summary how DESCos address the barriers to energy efficiency

Risk	Information	Capital	Hidden costs	Split incentives	Bounded rationality	Consumer inertia
Reduces performance and/or financial risk to householder	Free tailored advice	No upfront cost	/ DESCo management can reduce hassle	Contract tied to property	X	Offers fixed price contracts or guarantees

Key:
X unaddressed barrier
/ partially addressed barrier

5.6 Summary

The DESCo business model has a number of advantages over current government initiatives designed to deliver domestic energy efficiency in the UK; the key ones are the alignment of supplier and consumer incentives, increased access to capital and the reduction in householder risk and inertia. The weaknesses of the model are the risks of high take-back and energy price rises. However the discussion above concludes that contract terms that include behavioural incentives and staggered price rises could be used to manage these risks. The analysis therefore suggests that the DESCo

98 i.e. status quo bias

business model may be hindered by institutional / market-based barriers rather than economic, or socio-cultural, drawbacks. The Green Deal, Green Investment Bank and smart-metering currently present new opportunities for the DESCO business model however, without explicit government intervention, barriers such as the lack of commercial incentive by incumbent suppliers and institutional inertia may continue to impede DESCo operation.

6 Conclusion

This study suggests that, for the simple case of virgin loft insulation[99], Domestic Energy Service Company (DESCo) contracts[100] could deliver savings on baseline energy bills of 9%, under shared savings, and 7%, under guaranteed savings, compared to 14% savings under self-financing of insulation. Returns to the DESCo in this case would be 15%, under shared savings, and 20%, under guaranteed savings. These household savings levels and rates of return suggest that a DESCo contract for loft insulation is viable and given that, under this contract, the householder would not have to pay any upfront cost, and would be exposed to less risk, householders might find this contract attractive. In addition, guaranteed savings contracts fix energy costs which, under current market conditions[101], might appeal to consumers.

However the modelling found that the contracts' viability was influenced by comfort take-back rates and changes in energy prices. In the simple case of loft insulation (0-270mm) a 'high' take-back rate[102] reduced internal rates of return from 20% to -11%, under guaranteed savings, and from 15% to 5%, under shared savings. However, high take-back had a much lesser impact on household savings; reducing household savings from 7% to 1%, under guaranteed savings, and from 9% to 6%, under shared savings. Similarly, although energy price rises of 3.5% per annum reduced DESCo rates of return from 20% to -11%, (guaranteed savings) and from 15% to 7% (shared savings), household savings were only reduced from 7% to 6% (guaranteed savings) and from 9% to 8% (shared savings). The implication is that DESCos would have to anticipate and mange comfort take-back and energy price rises to preserve profitability.

The other measures which were found to be viable under DESCo contracts were cavity wall insulation (7% and 2% household savings from shared and guaranteed savings contracts respectively), draft-proofing (2% and 0% household savings from shared and guaranteed savings contracts respectively), internal wall insulation with ECO subsidy[103] (3% household savings from shared contracts) and 3kWp

[99] loft insulation (0-270mm)
[100] Fixed-term contracts of 5 years
[101] E.g. volatile energy prices and complex tariffs structures
[102] i.e. 50% or 40% of energy savings taken-back as comfort under guaranteed and shared savings contracts respectively
[103] ECO subsidy= 55% installation costs

solar PV[104] with 50% client-funding (7% household savings from shared savings contracts). The analysis indicated that packages of measures under DESCo contracts could deliver household savings comparable to those under the Green Deal. This suggests that DESCo contracts could be viable for low cost insulation, at no upfront cost the householder, and high cost measures, with part-funding by government or householder.

This study found that DESCos present a number of advantages over existing government initiatives such as reducing performance risk to the householder, increasing access to capital and reducing consumer inertia. The literature suggests that upfront cost, risk and consumer inertia are key barriers to energy efficiency and this implies that DESCo contracts could help to close the 'energy efficiency gap', i.e. the gap between expected and actual levels of installations.

Looking forward, initiatives such as the Green Deal, Green Investment Bank and smart-metering may provide new opportunities for DESCo operation. However, even though the economic and social case for DESCos appears encouraging, without intervention persistent barriers such as institutional inertia, and lack of commercial incentive by those best placed to offer DESCo contracts, may continue to impede the DESCo business model. To further understand the potential for DESCo operation in the UK research is needed in order to evaluate these barriers; explore how consumers would respond to guaranteed and/or shared savings contracts and examine how the persistent barriers to energy efficiency, e.g. hidden costs and bounded rationality, might affect the viability of DESCo contracts.

[104] mono crystalline

7 References

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8 Appendices

A. Energy Savings and installation costs

The energy savings for the following measures were simulated in CDEM:

- Cavity wall insulation
- External/internal wall insulation
- Double glazing
- 0 mm to 270 mm loft insulation
- 100 mm to 270 mm loft insulation
- 150 mm to 270 mm loft insulation
- Draft proofing to 0.5 ach
- Thermostatic radiator valves (TRVs)
- Condensing gas boiler
- Hot water interventions (50mm cylinder insulation + thermostat)
- Condensing gas boiler, TRVS, cylinder insulation + thermostat

For measures not included in CDEM, the energy savings by technology were taken from:

- Solar hot water (MacKay 2008, p.39)
- Demand side management (Darby 2006, pp.11–13)
- Solar photovoltaics (Firth et al. 2010, Table 4)

The majority of the installation cost data was taken from the Green Deal Impact Assessment (Department of Energy & Climate Change 2011b) including costs for:

- Cavity wall insulation
- Hard to treat cavity wall insulation
- External wall insulation
- External wall insulation + 'make good'[105]
- Internal wall insulation
- Internal wall insulation + 'make good'[106]
- Virgin loft insulation (0 to 270mm)
- Loft top-up loft insulation (100 to 270mm)
- Loft top-up loft insulation (150 to 270mm)
- Double glazing (8 windows)
- Condensing gas boiler
- Condensing gas boiler, TRVS, cylinder insulation + thermostat

Other costs were taken from a variety of sources:

- Solar HW (Department of Energy & Climate Change & Energy Saving Trust 2009b)
- Demand side management (Darby 2006, p.11)
- Solar PV (Department of Energy & Climate Change & Energy Saving Trust 2009a)
- Thermostatic radiator valves (estimate)
- 50mm cylinder insulation + thermostat (estimate)

[105] Not including householder time cost, disruption or loss of floor space
[106] Not including householder time cost, disruption or loss of floor space

PV Assumptions

Results are presented from a monitoring study of the performance of a sample of UK domestic PV systems. Five-minute average climatic and performance data was recorded for 27 PV systems at two sites for up to 2 years of operation. Average kWh/kWp/year (1.5kWh, monocrystalline): 760kWh (Firth, Lomas & Rees 2010). Generation tariff: @ 21p/kWh, 50% exported, export tariff @3.1p/kWh: (Ofgem 2011b). Typical cost: £5,000-£7500 per kWp (Department of Energy & Climate Change & Energy Saving Trust 2009a; Energy Saving Trust 2010; Department of Energy and Climate Change 2011a)

SHW Assumptions

Solar HW: 3-4m², southeast - southwest facing roof receiving direct sunlight for the main part of the day (Department of Energy & Climate Change & Energy Saving Trust 2009b). The typical installation cost for a domestic system is £3,000 - £5,000.(Department of Energy & Climate Change & Energy Saving Trust 2009b) Generation tariff: RHI @ 8.5p/kWh (Department of Energy & Climate Change 2011g)

Demand side management assumptions

Costs of smart metering with informative billing = £0; covered by smart meter roll out.

Loft insulation assumptions

Loft insulation: "Of all dwellings with a loft space, only 4% now have no insulation at all. Almost a quarter have loft insulation of depths less than 100 mm, whilst 21% have loft insulation to a thickness of 200 mm or more." (BRE 2009, p.3)

Interest rate assumptions

Interest rates were taken from a number of sources.

- For guaranteed saving contracts: 'Energy Star' Buildings Recommended hurdle rate= 20% (U.S. Environment Protection Agency 1998, p.3), building energy conservation hurdle rate= 25% (Skea 2010, p.93)
- For shared saving contracts: Green Deal Impact Assessment =5% (Department of Energy & Climate Change 2011b, p.62) and Consumer Focus 'Access for All' report= 3%, 5%,7% and 9% (Lainé 2011, p.24)

B. Reduction Factor Assumption in Green Deal Impact Assessment

"The energy savings in the Green Deal IA were calculated by BRE using the BREDEM model. For cavity wall insulation and loft insulation, we know that there is a practical underperformance issue, so the BREDEM savings are decreased by 50% (due to a combination of technical underperformance and comfort taking: see Glasgow Caledonian University report, which summarises the findings of many years work on different studies http://www.decc.gov.uk/en/content/cms/what_we_do/consumers/saving_energy/analysis/analysis.aspx).

DECC has little practical evidence for the 'real life' effectiveness of solid wall insulation in saving energy, so has applied a preliminary 15% technical underperformance factor while we wait for evidence. Annex 4 of the published IA (p. 107) gives the kWh savings for a range of measures, together with explanatory notes. (Clark 2011)

Evidence suggests that cavity wall and loft insulations have not in general achieved the level of savings in reality as suggested by physics models. Consequently an underperformance reduction of

35% has been applied. ["Review of Differences between Measured and Theoretical Energy Savings for Insulation Measures", Glasgow Caledonian University, 2006]. Following discussions within DECC it was decided to apply a level of underperformance for solid wall insulation, especially as it is still a relatively new technology, with few field trials in place.

Scientists within DECC suggested an underperformance level (prior to comfort taking) of 15%, to reflect defects in the application of insulation and problems with representing the technology in BREDEM (Building Research Establishment Domestic Energy Model), such as accounting for thermal bridges that exist even after 'correct' application of the insulation. This change for SWI was made because the assumptions underpinning the GD IA are for both GDF and the ECO, consequently some assumptions have had to be developed to ensure consistency for both policies. The 15% underperformance for SWI is applied as it is expected that (as was found with loft and cavity wall insulation) there is likely to be a lower level of saving from SWI in real life situations than calculated by physics models. (Glasgow Caledonian University in Department of Energy & Climate Change 2011a, p.107)

"These figures suggest that the best estimates for the reduction factor and comfort factor to come from the surveys reviewed are: Reduction factor: 50% Comfort factor: 15%." (Sanders & Phillipson 2006, p.22)

C. Internal Rate of Return Tables

Table 16: Internal rate of return, loft insulation (0-270mm)

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	IRR
Baseline	0	£0	£0	£0	£0	£0	-
Self-financing	-£283	£212	£212	£212	£212	£212	70%
Guaranteed savings	-£334	£112	£112	£112	£112	£112	20%
Shared savings	-£334	£100	£100	£100	£100	£100	15%

Table 17: Internal rate of return, loft insulation (0-270mm) at varying take-back rates

default take-back	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	IRR
Baseline	0	£0	£0	£0	£0	£0	
Self-financing	-£283	£212	£212	£212	£212	£212	70%
Guaranteed savings	-£334	£112	£112	£112	£112	£112	20%
Shared savings	-£334	£100	£100	£100	£100	£100	15%
No take-back	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	IRR
Baseline	0	£0	£0	£0	£0	£0	
Self-financing	-£283	£175	£175	£175	£175	£175	55%
Guaranteed savings	-£334	£175	£175	£175	£175	£175	44%
Shared savings	-£334	£77	£77	£77	£77	£77	5%
GDIA take-back (15%)	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	IRR
Baseline	0	£0	£0	£0	£0	£0	
Self-financing	-£283	£175	£175	£175	£175	£175	55%
Guaranteed savings	-£334	£150	£150	£150	£150	£150	35%
Shared savings	-£334	£77	£77	£77	£77	£77	5%
High take-back	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	IRR
Baseline	0	£0	£0	£0	£0	£0	
Self-financing	-£283	£175	£175	£175	£175	£175	55%
Guaranteed savings	-£334	£46	£46	£46	£46	£46	-11%
Shared savings	-£334	£77	£77	£77	£77	£77	5%

Table 18: Internal rate of return, loft insulation (0-270mm), at varying energy price rises

constant prices	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Average	IRR
Baseline	0	£0	£0	£0	£0	£0		
Self-financing	-£283	£212	£212	£212	£212	£212	£212	70%
Guaranteed savings	-£334	£112	£112	£112	£112	£112	£112	20%
Shared savings	-£334	£100	£100	£100	£100	£100	£100	15%
low p rises	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Average	IRR
Baseline	0	£0	£0	£0	£0	£0		
Self-financing	-£283	£212	£212	£212	£212	£212	£212	70%
Guaranteed savings	-£334	£112	£98	£84	£69	£54	£83	9%
Shared savings	-£334	£101	£87	£77	£77	£77	£84	9%
medium p rises	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Average	IRR
Baseline	0	£0	£0	£0	£0	£0		
Self-financing	-£283	£212	£212	£212	£212	£212	£212	70%
Guaranteed savings	-£334	£112	£84	£55	£25	-£6	£54	-11%
Shared savings	-£334	£101	£77	£77	£77	£77	£82	7%
high p rises	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Average	IRR
Baseline	0	£0	£0	£0	£0	£0		
Self-financing	-£283	£212	£212	£212	£212	£212	£212	70%
Guaranteed savings	-£334	£112	£70	£25	-£21	-£69	£23	-25%
Shared savings	-£334	£101	£77	£77	£77	£77	£82	7%

Table 19: Internal rate of return, loft insulation (0-270mm), at varying transaction costs

EEC	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	IRR
Baseline	0	£0	£0	£0	£0	£0	
Self-financing	-£283	£212	£212	£212	£212	£212	70%
Guaranteed savings	-£334	£112	£112	£112	£112	£112	20%
Shared savings	-£334	£100	£100	£100	£100	£100	15%
retailer	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	IRR
Baseline	0	£0	£0	£0	£0	£0	
Self-financing	-£283	£212	£212	£212	£212	£212	70%
Guaranteed savings	-£354	£112	£112	£112	£112	£112	17%
Shared savings	-£354	£100	£100	£100	£100	£100	13%
mini-esco	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	IRR
Baseline	0	£0	£0	£0	£0	£0	
Self-financing	-£283	£212	£212	£212	£212	£212	70%
Guaranteed savings	-£425	£112	£112	£112	£112	£112	10%
Shared savings	-£425	£100	£100	£100	£100	£100	6%

D. SENSITIVITY ANALYSIS FOR A PACKAGE OF MEASURES

Table 20: Sensitivity analysis for household savings under a shared saving contract for a package of measures (Example 2)

Category	Input parameter	Initial value for input parameter (Vi)	Iteration 1 (V1)	Iteration 2 (V2)	Iteration 1 (∆Vi)	Iteration 2 (∆Vi)	Initial savings on energy bills (HSi)	Savings on energy bills, iteration 1 (HS1)	Savings on energy bills, iteration 2 (HS2)	Overall change in savings, iteration 1 (∆HSi)	Overall change in savings, iteration 2 (∆HSi)	Sensivity Indicator 1	Sensivity Indicator 2	Average Sensitivity
C	Baseline annual gas use (kWh)	29,062	21,797	36,328	-25%	25%	14%	9%	16%	-37%	12%	1.50	0.47	0.99
C	Baseline annual electricity use (kWh)	2,840	2,130	3,550	-25%	25%	14%	14%	14%	1%	-1%	-0.04	-0.04	-0.04
P	Gas price (p/kWh)	3.89	2.88	6.20	-26%	59%	14%	9%	16%	-39%	15%	1.51	0.25	0.88
P	Electricity price (p/kWh)	11.99	9.49	16.94	-21%	41%	14%	14%	14%	1%	-1%	-0.04	-0.03	-0.04
ṗ	Annual gas price increase	0.0%	1.5%	4.5%	100%	300%	14%	15%	16%	4%	11%	0.04	0.04	0.04
ṗ	Annual electricity price increase	0.0%	1.5%	4.5%	100%	300%	14%	14%	12%	-2%	-12%	-0.02	-0.04	-0.03
r	Shared savings interest rate	5%	3%	7%	-40%	40%	14%	14%	11%	3%	-24%	-0.07	-0.60	-0.33
k	Shared savings heating takeback	20%	0%	40%	-100%	100%	14%	18%	11%	25%	-24%	-0.25	-0.24	-0.25
k	Shared savings electricity takeback	5%	0%	10%	-100%	100%	14%	15%	13%	7%	-10%	-0.07	-0.10	-0.09
e	Transaction costs	18%	25%	50%	39%	178%	14%	13%	10%	-8%	-30%	-0.20	-0.17	-0.19

Table 21: Sensitivity analysis for household savings under a guaranteed saving contract for a package of measures (Example 2)

Category	Input parameter	Initial value for input parameter (Vi)	Iteration 1 (V1)	Iteration 2 (V2)	Iteration 1 (ΔVi)	Iteration 2 (ΔVi)	Initial savings on energy bills (HSi)	Savings on energy bills, iteration 1 (HS1)	Savings on energy bills, iteration 2 (HS2)	Overall change in savings, iteration 1 (ΔHSi)	Overall change in savings, iteration 2 (ΔHSi)	Sensivity Indicator 1	Sensivity Indicator 2	Average Sensitivity
C	Baseline annual gas use (kWh)	29,062	21,797	36,328	-25%	25%	-19%	-32%	-11%	-66%	45%	2.64	1.79	**2.22**
C	Baseline annual electricity use (kWh)	2,840	2,130	3,550	-25%	25%	-19%	-21%	-18%	-9%	8%	0.34	0.31	**0.32**
P	Gas price (p/kWh)	3.89	2.88	**6.20**	-26%	59%	-19%	-32%	**-3%**	-69%	87%	2.66	1.47	**2.06**
P	Electricity price (p/kWh)	11.99	9.49	16.94	-21%	41%	-19%	-21%	-17%	-7%	12%	0.34	0.29	**0.32**
ṗ	Annual gas price increase	0.0%	1.5%	**4.5%**	100%	300%	-19%	-15%	**-2%**	24%	87%	0.24	0.29	**0.27**
ṗ	Annual electricity price increase	0.0%	1.5%	4.5%	100%	300%	-19%	-18%	-14%	7%	27%	0.07	0.09	**0.08**
r	Guaranteed savings interest rate	20%	**9%**	25%	-55%	25%	-19%	**4%**	-31%	122%	-59%	-2.22	-2.37	**-2.30**
k	Guaranteed savings heating takeback	25%	0%	50%	-100%	100%	-19%	-10%	-28%	45%	-45%	-0.45	-0.45	**-0.45**
k	Guaranteed savings electricity takeback	10%	0%	20%	-100%	100%	-19%	-17%	-21%	10%	-10%	-0.10	-0.10	**-0.10**
e	Transaction costs	18%	25%	50%	25%	50%	-19%	-22%	-32%	-15%	-67%	-0.58	-1.33	**-0.96**

E. TRANSACTION COSTS

The literature suggests that levels of transaction costs are inversely proportional to project size which in turn is linked to annual heating consumption (Bleyl-Androschin & Seefeldt 2009, pp.986–9). The transaction costs gathered by Bleyl-Androschin and Seefeldt from survey data are between 7% (2,040 MWh annual heat consumption or equivalent of 70 households) and 59% (61 MWh annual heat consumption or equivalent of 2 households). Based on the assumption that a mini DESCo may enter into 3 or more contracts, a retail DESCo may enter into 100 or more contracts and a utility DESCo 1000 or more, Table 22 indicates that the transaction costs used are comparable to those suggested by Bleyl-Androschin and Seefeldt's surveys.

Table 22: Transaction cost comparison

Source	**DESCO model (mini ESCO)**	**DESCO model (retailer)**	**DESCO model (utility)**	Bleyl-Androschin & Seefeldt (61,000 kWh/yr)	Bleyl-Androschin & Seefeldt (102,000 kWh/yr)	Bleyl-Androschin & Seefeldt (204,000 kWh/yr)	Bleyl-Androschin & Seefeldt (1,020,000 kWh/yr)	Bleyl-Androschin & Seefeldt (2,040,000 kWh/yr)
Equivalent no. households	**3**	**100**	**1000**	2	4	7	35	70
Transaction cost, t	**50%**	**25%**	**18%**	59%	45%	22%	9%	7%

F. Previous ESCo Studies

Study	Focus	Methods	Data input	Outputs	Useful features
(Bleyl-Androschin & Seefeldt 2009)	Energy contracting in the residential sector in Germany + transaction costs	1. Conceptual analysis of Energy Supply Contracting. 2. Economic analysis of transaction +life cycle cost 3. Survey of market participants	1. Previous studies 2. Energy and service Ps, interest + discount rates, annual P increase, required ROIs, est. transaction cost (experience and survey) 3. ~125 responses (70% non-response), 100 queries	1. Definition, concept, efficiency potentials, 2. Total discounted costs energy contracting vs. in house (Sum of capital, operation and consumption costs over project term) 3. Quantitative data on companies, products/services, efficiencies, barriers	Economic analysis could serve as a model. Survey could be replicated in UK by including CERT providers though not ESCo specific
(Sorrell 2005)	The economics of energy service contracts	Theoretical model of energy service contracting.	Assumptions surrounding production costs, transaction costs and payments to contractors	Models: a. Determinants of production cost savings b. Necessary conditions for successful contracts (technical potential, size, specificity, competeveness) c. Determinants of transaction costs (specificity, complexity, competitiveness, support) d. Determinants of contract viability (savings, costs + above) ➢ Hypotheses on viability of ESCs (by size, specificity, context)	A theoretical model could be used as the basis for economic modelling.
(Vine 2005)	The current level of ESCo activity internationally	Survey/questionnaire of key ESCo contacts	38 responses (5% non-response) – one from each country, plus literature review + discussions with experts	Number of ESCos, key sectors, most important barriers, total value and future for each country, actions for promoting ESCos	Survey of experts approach could be used as justification for qualitative interviews.

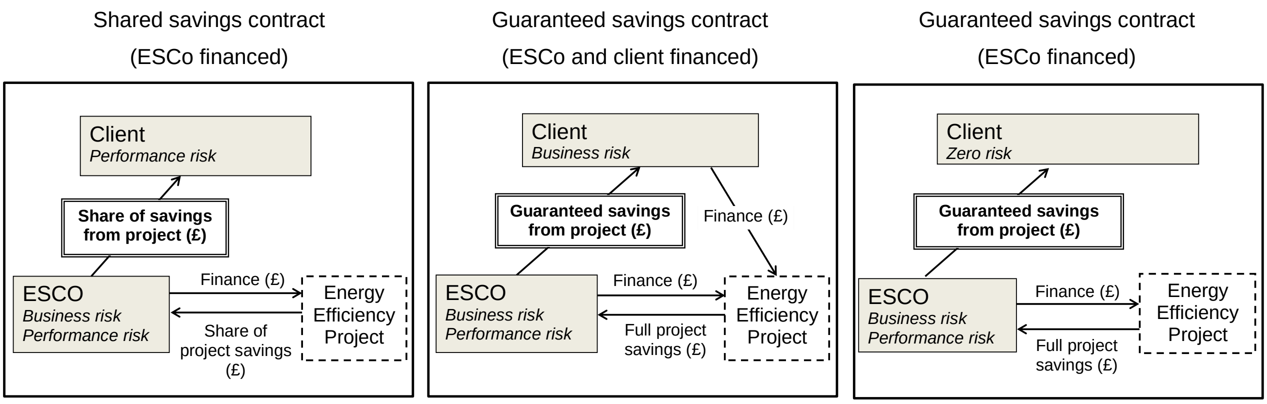
(Grim 2005)	The development & current state of the ESCo industry in Europe	1. Survey/questionnaires of ESCo businesses, experts and national authorities 2. Informal semi-structured interviews based on the questionnaire	1. Data from 3 questionnaires a. General open-ended (3*25) b. 106 Characterisation Forms c. 22 Project Forms	1. Character of ESCos, Targeted sectors, Support, Financing 2. As above in depth	General open ended questionnaires and interviews could serve as model for gathering data on potential for ESCos in UK residential sector
(Bertoldi et al. 2007)	Current ESCo developments	1. Survey/questionnaires of experts, ESCos, academics, and financial institutions (by e-mail) 2. Interviews with stakeholders (phone/in person)	100 surveys/interviews (1-5 expert opinions per country)	ESCo industry summaries, by country, including changes from 2000, barriers and success factors.	Interviews of stakeholders could be used as model
(Hawkes et al. 2005)	Economic and environmental impacts of a hypothetical ESCo	Model of hypothetical ESCo product	Time of use tariff, annual electricity + heat demand (3 bed, 4 occupants) grid average emissions rate	Equivalent Annual Cost + CO2 emissions: load shifting vs. baseline	Could be used as a model for assessing the compatibility of technologies and ESCo products
(Grim 2005)	The current situation in the Austrian EPC market	Structured assessment of market	Experience from talks, interviews and campaigns	Barriers to owners, ESCos and financial institutions and EPC models	-
(Bertoldi et al. 2006a)	Facilities management, community and domestic sector ESCo models	Case study: UK	Literature review and UKERC seminar	Models, opportunities, barriers and policy recommendations for each sector	Could utilise the normative approach, e.g. how ESCos could be made to work in domestic sector
(Biermann & Trust 2001)	Energy services in UK domestic markets	Case study: UK domestic sector	Literature review and experience from two unpublished EST studies (Impetus, 2000 & OXERA, 2001)	Experiences with ESCos, barriers, mechanisms to overcome barriers	-

G. EXAMPLE ESCO CONTRACT STRUCTURES

According to a survey of 22 European ESCo projects almost all had a third party financing element, i.e. they were financed through a mixture of ESCo financing (equity or leasing) and debt financing, and equal numbers of projects specified shared and guaranteed savings (Rezessy et al. 2005). This limited survey suggests that, in real examples of energy service contract, performance and business risks are most commonly shared between ESCo and client. These two common forms of energy service contract are illustrated in detail in Figure 16.

Figure 2 illustrates different ESCo contract structures. The shared saving structure dictates that the client shares the performance risk but does not usually finance the project, the guaranteed savings structure dictates that the ESCo takes on the performance risk by guaranteeing a level of savings to the client and, depending on the contract, will share the business risk with the client (1) or take on the whole business risk (2). These contract structures are used to inform the calculations of household savings (HS) in the economic assessment (see 3.4)

Figure 16: Energy service contract structures



(Adapted from fig.1: Bertoldi et al. 2006b)

H. ESCOS IN THE UK

Most of the data on the UK ESCo market comes from questionnaire and survey data from ESCo businesses, national authorities, academics, and financial institutions, generated by three studies; “Energy service companies in Europe: assembling the puzzle” (Rezessy et al. 2005), “An international survey of the energy service company (ESCo) industry” (Vine 2005) and “Latest Development of Energy Service Companies across Europe” (Bertoldi et al. 2007). Bertoldi et al suggest indicate that there were 20-24 ESCos operating in the UK in 2007, predominantly in the industrial, commercial and public sectors, with operation in the domestic sector mainly limited to district heating schemes. Marino et al reference issues of access to finance as a result of the economic down as responsible for decreasing growth in the UK ESCo market during 2007 -2010 (Marino et al. 2011)

The study also suggests there has been stagnation in the UK ESCo market since 2002 due to a decline in combined heat and power (CHP) projects and also new electricity trading arrangements, implemented in 2002, which resulted in falling electricity prices (Bertoldi et al. 2006a; Bertoldi et al. 2007).

UK ESCos are estimated to have captured around 5% of the market potential (Sorrell in Bertoldi et al. 2007) and some commentators see the U.K. as a one of the “largest and most advanced” ESCo markets in Europe (Bertoldi et al. 2007, p.8). However a number of studies (Ürge-Vorsatz et al. 2007; Rezessy et al. 2005) quote UK energy supplier obligations, such as EEC, as examples of energy service offerings; “A specific attribute of the UK energy service market is its focus on the residential sector; this is a result of more than a decade of conventional energy suppliers having been required to assist their residential customers in improving energy efficiency” (Rezessy et al. 2005, p.842).This paper argues that these energy supplier obligations do *not* constitute ESCo activity as they fail the three determining characteristics of energy service contracts outlined in 2.3.1; a fixed term commitment, a payment structure that relates to efficiency savings and providers undertaking some of the financial or technical risk of the projects.

There is some debate about the major barriers to UK ESCos; Vine’s study concludes that in the U.K. low energy prices, lack of government support and the requirement of short payback periods by financiers are the most important barriers to ESCo operation. Rezessy et al state that small project sizes and lack of support are barriers, with the major players, such as oil/utility-company owned ESCos which can command the greatest finance, only dealing with customers whose annual energy bills exceed 75,000 Euro. They found no support mechanisms for ESCos in the UK apart from the opportunity to claim capital tax allowances investments and pass this on to the customer (Rezessy et al. 2005). Bertoldi et al’s study did not find any major regulatory or legal barriers to ESCos or barriers to financing of projects with pay-back times below 3 years. Their study also concluded that UK government climate changes policies, such as Energy Performance Certificates, have benefitted UK ESCos (Bertoldi et al. 2007)