

1. Why did the Green Deal fail? In particular, what mistakes were made in the design of the finance mechanism and the communication of the scheme?

The lack of uptake of cost effective energy efficiency measures has been characterized as the 'energy efficiency gap' [1]. The gap has been explained through a taxonomy of barriers relating to; Risk, Imperfect information, Hidden costs, Access to capital, Split incentives and Bounded rationality [2]. It can be argued that the Green Deal had an overly narrow focus on the economic issues surrounding 'Access to capital', without embedding the policy to address broader 'soft barriers'.

Recent studies have inferred some explanations as to why the Green Deal scheme has been such a failure. Dowson, Poole [3] anticipated issues of consumer appeal for the scheme; given uncertain and modest financial savings, whilst at the same time delivering limited potential returns to investors. The limitations of the golden rule also meant that more expensive measures and those covered by the subsidies schemes; Renewable Heat Incentive (RHI) and microgeneration Feed In Tariff (FIT) could not be integrated with the financing mechanism [4]. The failure of the scheme has also been attributed to the complexity of the process and a lack of marketing and information; with less than half of households surveyed having heard of the Green Deal [5]. The inherent complexity of having the homeowner source the assessment, finance, tradesmen and schedule the works, can be understood through the lens of high transaction costs. Basic techno-economic models are likely not take account of such hidden costs, although alternative models, may reduce or shift these costs to parties that are better able to manage them [6]. Perhaps the most important barrier was the high interest rates of 7-10% [3, 5]. Indeed, due to the length of the finance period and the effects of compound interest, finance costs will amount to at least 49% of the overall cost of Green Deal Plans [7]. This had the effect of deterring consumers at a time of very low interest rates for other forms of personal finance; such as mortgages [7], and also significantly limit the measures that would meet the Golden Rule. Research by Ipsos MORI [8] has suggested interest rates of 3% or under may be needed to incentivise consumer demand.

2. What aspects of the Green Deal scheme should be retained in a future policy?

Many have highlighted how the repayment 'Pay As You Save' (PAYS) mechanism, was a valuable innovation. Such mechanisms belong to a family of finance models called On-Bill Financing and On-Bill Repayment (OBF/OBR) approaches. The OBF model typically adopts utility company capital [9], whereas the OBR model relies on third party capital, and is the same basic principle behind the UK's Green Deal initiative; whereby private finance providers provided loans directly to consumers [10]. As such the credit risk associated with the Green Deal loan was considered to be equivalent to other forms of personal finance and so attached to consumer creditworthiness [9]. There is however, potential for alternate OBF/OBR models where capital is provided by utilities or public bodies, and the administration and delivery of measures could be taken upstream from the end consumer, potentially reducing systematic risk.

3. How should Green Deal-style loans for the able-to-pay sector be financed in the future? Is it necessary for the Government to provide any subsidy to the scheme?

A recent study from the UK Green Building Council has asked this very question [7]; this is also subject of my ongoing research project at CIED. Some have argued that to drive the necessary uptake in solid wall insulation, such measures may need to be subsidized [11]. However, the high interest rates incurred by the Green Deal are actually considered to be fairly competitive considering the financial framework it operated under [7]. Yet, a number of other possible mechanisms exist including using Public Works Loan Board borrowing powers shown, in in Table 1. These models may be able to reduce the cost of capital, although varying degrees of policy support may also be needed. CIED should have some outputs in the

near future regarding such mechanisms and the policy changes needed to deliver retrofit finance. In my personal view, the government is likely to need to take a more leading role in enabling public organizations with low borrowing costs, to assist in making retrofit finance affordable. As is the case in Germany, a state bank (KfW) subsidized retrofit finance scheme, the (CBRP) has been very successful; delivering near 0% interest rates for a range of measures [12].

Table 1 Business and finance models for retrofit

Revolving fund via Special Purpose Vehicle (SPV) [13]	Funds for retrofit measures are recycled through an SPV based on energy savings repayments, enabling re-deployment of retrofit finance
On-bill financing and on-bill repayment (OBF/OBR) [9] also known as Pay As You Save (PAYS)	Measures are financed by the utility (OBF) or consumer (OBR) and repaid through a charge on energy bills
The Property Assessed Clean Energy (PACE) model [9]	Measures are financed through bonds created by local authority or municipality, and repaid through property taxes
The energy savings performance contract (ESPC) implemented by an (ESCO) [14]	Measures can be financed internal or externally. Consumers enter into an ESPC for one or more energy streams, paying for downstream energy performance rather than upstream units of energy
Managed (MESA) Energy Services Agreement (ESA) [9] or 'one-stop-shop' model [15]	Energy management firm takes control over multiple elements of energy services, including financing, supply chain, installation and upstream energy procurement

4. What lessons do you anticipate from the Bonfield Review about quality assurance in the supply chain? How can these be incorporated into a Green Deal successor scheme?

To be honest I haven't been following this process closely, although it is widely acknowledged that there is a skills and performance gap when it comes to energy efficiency in buildings in the UK. The government needs to help embed the transition to energy efficient housing more comprehensively within the wider construction industry. This means not focusing solely on economic instruments and subsidies, but by building capacity in terms of training and networks that integrate and develop new skills in the sector, fostering learning and innovation in a more holistic fashion. Several projects such as the Innovate UK funded Retrofit for the future project [16], showed a promising test bed for exploring how retrofit innovations can be demonstrated. However, this project was over 5 years ago and there hasn't been a successor that has built on the lessons of these demonstration scale projects, to carry lessons into mainstream application. This will likely need guidance for government and local authorities, to develop strong public-private sector partnerships, in delivering a several orders of magnitude increase in comprehensive domestic retrofit. In my view the emergence of the new municipal/local authority (LA) energy sector in places such as Bristol, Nottingham and Cheshire East [17] could be a major catalyst for this.

5. How can a Green Deal successor scheme be successfully communicated to consumers?

Again communications and marketing isn't a strongpoint, although as previously mentioned, various surveys have shown that overall public visibility of the Green deal was relatively poor [5]. Various people I have spoken to in the industry have described how there was often consumer confusion; as the majority of promotional material came from central government, but the initiative itself was delivered by the private sector. This meant that consumers were unclear as to who they should contact if they

indeed were interested in the scheme. Again I feel the role of local government here could be crucial. Public trust is considered to be very high with councils, so LAs could work with arms-length intermediary organizations to be a central point of contact, providing a one stop shop to advise, organize, finance and deliver measures. This has already been well developed by organizations such as the Nottingham Energy Partnership <http://www.nottenergy.com/>, providing a highly successful intermediary service for energy efficiency policies and works; this should be promoted nationally.

6. What are the best options for decarbonising the domestic heat sector?

Increasing low carbon heat is particularly challenging. Unlike electricity it is characterized by a large amount of sunk and complex heat infrastructure investment, which presents significant compatibility issues with low carbon heat sources. The major viable sources of low carbon heat are that of combined heat and power (CHP) systems, heat pumps, and biogas; each presenting their own challenges. CHP and district heat network systems have been incentivized through requirements in new planning applications. Having worked in consultancy in this area, it is my view that these measures are too weak or easily overridden by developers to be seriously effective. If CHP is to make a big impact, the infrastructure may need to be provided in advance of the consumer demand, as was the case with the first electricity networks. It is hard to see how this can be done without significant public funding. Heat pumps have been far less successful in achieving diffusion through the RHI compared to the FIT for PV. The reasons for this are related to the added disruption and complexity of replacing gas central heating. Heat pumps produce much lower flow temperatures so often require upgrading of heat emitters, or even the full replacement of central heating systems. This added hassle factor as compared to PV panels can go a long way to explaining the much more modest success of the RHI for heat pumps [18]. This highlights the importance of ensuring heat pumps are installed at crucial touch points; such as when boilers may be replaced, or major renovations are undertaken. Again where issues of 'split incentives' can be an important barrier. Biogas has the benefit of enabling integration with much of the existing infrastructure, also providing an additional waste management service. Whilst anaerobic digestion is demonstrating growth in the UK, more could be done to integrate feedstock supply chains to coordinate farming, municipal and industrial waste streams; perhaps with stronger taxes on landfill as a further incentive. In short I believe all three solutions will need to be pursued in concert, and none will likely be sufficient on their own.

7. How can the Government incentivise the take-up of renewable heat technologies within a Green Deal successor scheme?

As previously mentioned, a first start would be to relax the restrictions on enabling retrofit finance for measures that don't strictly meet the Golden Rule; discussed further by [12]. Many of the solutions in the previous section could contribute to this goal, however the policy U-turns on the Green Deal and the Zero Carbon Homes target have significantly damaged confidence in the industry. In my view, heat pumps and passive design for new build are likely to be the big solutions, long term. There is strong potential to integrate heat pump operation with smart grids and variable pricing to capitalize on intermittent renewables through the use of thermal storage to ameliorate daily demand spikes. Successful past schemes were often based on strong regulatory signals such as the boiler efficiency requirements. The same could be done to require heat pumps in new builds, this could deliver increased confidence in the technology and drive down costs for the larger retrofit market. Again economic incentives need to be balanced with wider network and capacity building if low carbon heat is to be successful.

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