

From Grants to Finance:

How to Unlock Home Retrofit  
Investment

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<b>EXECUTIVE SUMMARY</b>	<b>3</b>
<b>1. INTRODUCTION</b>	<b>6</b>
<b>2. THE CASE FOR BOOSTING INVESTMENT</b>	<b>8</b>
<b>3. PAST INVESTMENT ACTIVITY AND GOVERNMENT SUPPORT</b>	<b>13</b>
<b>4. FROM GRANTS TO FINANCE, SHALLOW TO DEEP</b>	<b>14</b>
4.1. THE THEORY	15
4.2. POLICY RESPONSE IN IRELAND	16
4.3. THE ENERGY SAVING OBLIGATION	18
4.4. THE EXPERIENCE OF THE UK PAYS MODEL	18
<b>5. INSIGHTS FOR POLICY DEVELOPMENT</b>	<b>20</b>
5.1. GOING “DEEP”	21
5.2. EXCHEQUER FUNDING AND FINANCE	22
5.3. SUPPLEMENTARY MEASURES	23
5.4. PROGRAMME EVALUATION AND ADMINISTRATIVE RESOURCES	25
<b>APPENDIX</b>	<b>26</b>

## Executive Summary

It makes sense to invest in upgrading the energy efficiency (retrofitting) of homes, both for individuals and society. For householders bills are reduced, asset values increase, and living environments become healthier and more comfortable. For society economic output is increased, thousands of new jobs are created in the dormant construction sector, exchequer finances are bolstered, fuel poverty is reduced, greenhouse gas emissions decline, and energy security is enhanced.

SEAI and independent analysis, supported by hundreds of real-life case studies, suggests that approximately 1 million houses could be brought up to a C2 level on the Building Energy Rating (BER). The average cost would €7,600 per house, resulting in average savings on energy bills of €690 - offering a simple payback period of only 11 years. This should, in theory, be an attractive proposition.

Yet efforts to convince homeowners to take action face intractable challenges, including a shortage of upfront investment finance, insufficient information, and cultural and behavioural factors. Traditional approaches to overcoming these barriers have focused on providing grant-based support, targeting low-cost (“shallow”) measures with short paybacks (such as attic and cavity wall insulation). While the number of retrofits has increased, the average spend per retrofit is only €3,000.

Since peaking in 2011, the numbers undertaking these “shallow” retrofits is now in rapid decline. This may be partly because there is a limited requirement for some measures, most notably cavity wall insulation.

But focusing on shallow retrofits is problematic in any case. Convincing a homeowner to invest once is difficult enough given the “hassle” factors and other barriers. Furthermore, a shallow retrofit makes subsequent deeper retrofits less economically and technically viable. Encouraging householders to undertake a number of retrofits over time is therefore problematic.

The key policy challenges are therefore: to treble the average retrofit spend per household by incentivising deeper retrofits; and to shift from grant-based programmes, which are dependent on exchequer support,

to sustainable market-based approaches. Ensuring a smooth transition is fraught with challenges and difficulties

Progress has been made, both in the UK and Ireland, on meeting these challenges. In Ireland a Better Energy Financing group has been established to develop a Pay As You Save (PAYS) proposal, as promised in the Programme for Government 2011. This model financing approach was launched in the UK earlier in 2013 with mixed results.

Another new scheme, which places a legal obligation on energy suppliers to deliver a certain quantity of energy savings annually, is also being introduced in Ireland (several so-called obligation schemes exist across the EU). It can be designed to work in tandem with new financing offerings to promote deeper retrofit activity.

Within the context of these on-going policy developments, we identify lessons from policy successes and failures in the UK and Ireland, which can inform future decisions. These are outlined below.

**Grants:** We have seen from the UK that if grants are withdrawn immediately, activity can collapse when transitioning to market-based PAYS approaches. Grant support therefore needs to be sustained over a transitional period. Grants might be adapted, however, so that they pave the way for deeper retrofits, not continued in their current form. Support would be more effective if it targeted incentivising packages of (three or four) measures, rather than being associated with individual measures as is currently the case. Some form of annual degression in support could be considered to reward to early adaptors.

**The Energy Savings Obligation:** Under the proposed new energy obligation scheme, suppliers might be required to deliver a proportion of savings in the residential sector. They should receive “bonus” credits if they promote deeper retrofits (combining three, four or more measures).

**PAYS financing:** The new market based PAYS financing offering might be designed to work in tandem with incentives provided by suppliers under the obligation scheme. Financing might be made available at attractive rates over longer terms to enable deeper retrofits. Within this context, government might consider subsidizing the cost of money provided for deeper retrofits and packages. The scheme should also enable debt to

be attached to the property so that whoever pays the bill repays the debt. PAYS finance must be distinguishable from personal debt.

**Supplementary Measures:** The provision of attractive financing is no silver bullet. A range of supplementary supporting measures are required to encourage the magnitude of the shift in society which is required towards retrofitting homes at scale and depth. The importance of these supplementary measures simply cannot be overstated. Specific approaches are required to promote retrofit of social housing, private rented accommodation and heavily mortgaged properties.

One particularly promising option which we explore in detail is a proposal to amend the property tax and stamp duty (in a revenue neutral manner) to take account of the energy efficiency of the home. We can see from the motor tax analogue that this type of measure can have a profound impact on consumer behaviour.

**Programme Evaluation:** If success is to be achieved, a continued and determined focus, and the willingness to trial, test, and refine policy interventions by Government is necessary. Energy efficiency investment is unlike other capital investment programmes. Investments are small and disaggregated, and have a less established track record. Investment programmes which have clearly defined and predictable outcomes, and an established and accepted methodology to evaluate their costs and benefits (such as large infrastructure projects), may therefore be unjustifiably prioritised.

New assessment methodologies are required which consider all costs and benefits of proposed programmes under an integrated framework. Further analytical work is also required to ascertain the total exchequer cash flow impact from various initiatives.

**Administrative resources:** While no doubt the public service is over-stretched, greater administrative resources are required to effectively harvest the benefits which are available to individuals, society and the exchequer from boosting investment in residential efficiency.

## 1. Introduction

It makes sense to retrofit buildings. Economic output is increased, jobs created in the dormant construction sector, and, as we show in this paper, exchequer finances are bolstered.

Investing in buildings is also unquestionably the key to unlocking Ireland's near-term decarbonization challenge. Broader benefits include superior asset values, increased productivity and competitiveness, fuel poverty alleviation, greater energy security, and reduced government health expenditure.<sup>1</sup> Investments in the residential sector are particularly labour intensive, and therefore offer a unique catalogue of benefits.<sup>2</sup>

Yet it is difficult to convince homeowners to take action. Efforts to unlock these millions of dis-aggregated investment opportunities, both in Ireland and internationally, face intractable challenges.

The use of grant-support to drive investments in low-cost measures with short paybacks (such as attic and cavity wall insulation) prevails. Deeper more comprehensive retrofits, which in many cases constitute a sound investment proposition, remain something of a rarity – much talked about, but seldom encountered.

A central issue surrounds the shortage of upfront funding, sometimes referred to as the financial barrier. Financial constraints interact with a number of complicating behavioural, cultural, social, and informational barriers which stand in the way of investment (Text Box 1).

An emerging trend, particularly in the UK and Ireland, is a desire to shift from grant-based programmes that incentivize shallow retrofits, to market-based approaches to promote deeper retrofit activity. The ultimate goal is to establish a sustainable market for energy services with minimum exchequer support. This is a welcome development - grant programmes are characterized by several disadvantages - but ensuring a smooth transition is fraught with difficulties.

Within this context, this brief sets out valuable lessons from past policy interventions, which can guide future policy development.

It is structured as follows:

- We first review the case for undertaking greater levels of energy efficiency investment in homes;
- We then detail policy interventions from 2009 to 2013 period, and their impact;
- Within this context, we review progress on launching a Pay As You Save (PAYS) scheme in the UK and Ireland; and
- Finally, key lessons for future policy development are proposed.

#### **Text Box 1. Barriers to home energy retrofit**

The most relevant barriers to home energy efficiency investment can be categorized as follows: the principal-agent problem, lack of information, behavioural factors, financial barriers and hassle factors. These barriers are overlapping and generally mutually reinforcing.

The **principal-agent** problem describes a situation where the investment cost is borne by one market participant, while its operating savings benefit another. This typically relates to the split between the owner of a property and its renter. It can also refer to a property owner who makes an investment in energy efficiency, but sells the property and cannot therefore gain from future energy savings associated with the investment. Where deeper retrofits are concerned, with payback periods sometimes in excess of 20 years, this may be a particular issue. Underinvestment in residential efficiency is the result.

When it comes to investing in energy efficiency, householders lack relevant **information** or they cannot or are unwilling to take the time to process the information effectively (energy only accounts for a modest proportion of overall spend in the average household). Many factors obscure understanding of energy bills and the efficiency levels of competing products, and the cost-effectiveness of investment decisions and value for money calculations are difficult for many homeowners to calculate.<sup>3</sup>

Evidence suggests that even if consumers had perfect information, they may be restricted from acting in an “economically rational” manner by **psychological factors**. Behavioural economics tells us that consumers are risk averse, are attached to the status quo, and face cognitive constraints in processing information. The evidence suggests that systematic biases may exist in consumer decision making that lead to overconsumption of energy and underinvestment in energy efficiency.<sup>4</sup>

Banks and financial institutions that are reluctant to lend for energy efficiency investment for a variety of reasons. The lack of credit available for energy efficiency investment has been described as a **financial barrier** to investment.<sup>5</sup>

The transaction or **hassle** costs can also prevent action - finding a provider, checking technical and personal bona fides, and disruption to house and home routines can all be major factors in deciding against action.

## 2. The Case for Boosting Investment

The case for greater levels of energy efficiency investment in Ireland's buildings is persuasive. Assessments of the current Government programmes show that Government expenditure on retrofit was beneficial for society, delivering a ratio of benefits to costs ratio of 5:1.<sup>6</sup> This analysis only considers narrow benefits associated with the value of energy and CO<sub>2</sub> reductions. The impact of shallow retrofit works has also been assessed ex post by SEAI by monitoring energy bills after retrofit works were undertaken. These interventions were found to deliver dramatically reduced energy bills and deliver much greater levels of comfort in the home.<sup>7</sup>

Billions in investment opportunities with attractive paybacks, however, remain available. The case was made comprehensively in a NESC (2012),<sup>8</sup> which collated the empirical evidence, a summary of which is offered below.<sup>9</sup>

Of Ireland's approximately 1.65 million residential buildings, 1.1 million are estimated to have a Building Energy Rating, or BER (see Text Box 2 below) of D or lower. SEAI have estimated the costs of a standard package of energy efficiency technologies (generally comprised of roof and wall insulation, a new heating system and heating controls). These are set against the associated energy savings from improving the energy performance of these buildings to four different levels of BER rating, given in Table 1 below. The higher the level of BER aimed for, the more buildings included (for example, aiming for B3 means that all buildings in the C1, C2 and C3 categories are included).

**Table 1 Average Payback on Retrofit Investment**

Post-works BER	C3	C2	C1	B3
Number of Houses (1000s)	852	1,028	1,182	1,320
Cost of works (€)	4,388	7,600	13,600	21,500
Annual energy savings (€)	555	690	765	795
Simple Payback	7.8	11	17.7	27
Annual Energy Savings (GWh)	7,045	10,580	13,495	15,625
Annual Carbon Savings (Mt CO <sub>2</sub> )	1.7	2.6	3.3	3.8

Source: Adapted from SEAI (2012) cited in NESC (2012)

We focus here on the theoretical objective of bringing all buildings up to an average C2 level on the BER. There are approximately 1 million houses with an energy rating below C2, which could be brought up to a C2 rating at an average cost of €7,600 per house. Annual average energy savings would be €690, offering a simple payback of 11 years. Of course simple payback figures ignore the cost of finance, an issue which we return to below.

#### **Text Box 2. The BER Certificate**

The BER Certificate is an indication of the energy performance of a home. The BER is the calculated energy use for space and hot water heating, ventilation and lighting based on standard occupancy. A BER is similar to the energy label for a household electrical appliance like a fridge. The label has a scale of A-G. A-rated homes are the most energy efficient and will tend to have the lowest energy bills.

A BER is compulsory for all homes offered for sale or rent, and for all new homes. Advertisements must include BER details when a home is offered for sale or rent. BER assessments are completed by registered BER Assessors who have been trained under the National Framework of Qualifications, passed the SEAI BER Assessor exam and have registered with SEAI.

These *ex ante* findings are broadly supported by independent modelling work undertaken by UCC.<sup>10</sup> They are further supported by *ex post* research on the impact of deep retrofit work, undertaken in the North Tipperary area. In fact

the discounted<sup>11</sup> payback on works with an average cost of €8,000 was 13 years, offering an average internal rate of return on investment of 11 per cent.<sup>12</sup> This North Tipperary work is critically important, as it is the only *ex post* evidence that validates both the costs and the energy savings of deep retrofit work (Text Box 3).

### Text Box 3. The Impact of Deep Retrofit Work in North Tipperary

There has traditionally been an absence of *ex post* case study evidence on the impact of retrofit on energy bills, but the evidence base is growing. Under the SERVE project,<sup>13</sup> 357 dwellings in a defined catchment region in North Tipperary have undergone a 'deep retrofit' since 2007. Electricity and gas bills were monitored prior to retrofits and over a period of two years subsequent to installation of measures. Participant SERVE households undertook energy works that fell into two categories:

- Energy efficiency: heating controls, insulation, boiler and glazing upgrades; and
- Renewable energy: stove, biomass boiler and solar technology implementation.

On the basis of data provided by the SERVE team, the energy savings from various packages of deep retrofit measures, with an average cost of €8,000 provided a discounted payback of 13 years from energy savings alone (Maras *et al.*, 2012, see also appendix). The average internal rate of return on these investments is in the region of 11 per cent, which is far in excess of alternative investment options available to homeowners (such as the interest rate available from banks, buying government bonds etc.).

This analysis assumes that energy savings are the only benefit captured by the homeowners. Yet an increasingly comprehensive body of evidence from the UK and Ireland suggests that homeowners and renters, notwithstanding a tendency towards myopia, are coming to a more developed appreciation of the value of an energy efficient building, for which they are willing to pay a premium.<sup>14</sup> In fact, it can be extrapolated from UK research that, in many cases, the estimated increase in house value alone could cover the cost of works.<sup>15</sup> Evidence also suggests that homeowners value the increased comfort that accrues.<sup>16</sup>

Boosting investment in retrofit, even by the least cost-effective means of grant support, also boosts exchequer revenue. In the case study below we have calculated the tax revenue to government from the installation of external wall insulation. Reduced social welfare and health spending are not considered making this a low-end estimate. As we can see from the above, the grant available for external wall insulation (€2,700) is easily recouped by the exchequer.

**Table 3. Tax Take on installation of 123m<sup>2</sup> external insulation**

	Taxable Amount (€)	Tax Rate (%)	Tax Take (€)
Labour Taxes (PAYE and PRSI) paid by installers	6,064	26.6*	1,618
Labour Taxes paid by materials distributors	3,178	15**	476
Relevant Contractors' Tax (relevant to cills/pressings, transport & shipping)	1,500	35	525
VAT (on materials + labour + margin 10%)	11,816	13.5	1,595
Corporation tax on net profit	537***	12.5	67
<b>Total Tax Take</b>			<b>4,281</b>

Source: Own data and analysis based on standard industry charges

\* Combined weighted average of income tax and pay related social insurance

\*\* The distribution margin is in the region of 30 per cent, 15 per cent assumed as tax take

\*\*\* Estimated at half gross margin

**Given the broad nature of the benefits which apply to boosting retrofit activity, it is important, therefore, that this investment opportunity is not linked solely to the decarbonization agenda.**

Nevertheless, we turn briefly to the issue of decarbonization. NESC were asked by Government “to develop a set of potential policies and measures to close the distance to Ireland’s greenhouse gas emission reduction target...”.<sup>17</sup> The

focus of the NESC analysis was on the proportion (approximately 70 per cent) of Irish emissions not covered by the EU Emissions Trading Scheme (the non-ETS sector), as ETS emissions are regulated at EU level. A synthesis of the NESC analysis in Table 4 below demonstrates that the only substantive **additional** and **cost-effective** possibilities that NESC identified (beyond those already reflected in policy) for reducing emissions in the period to 2020 relate to boosting retrofit investment.

**Table 4. Three Decarbonisation Scenarios**

Scenario	EPA 1: <i>Business as Usual</i>	EPA 2: <i>Meet all targets</i>	NESC <i>Efficiency +</i>
<b>Annual gap to target (MT CO<sub>2</sub>) 2020</b>	7.8	4.1	2.36
<b>Description</b>	This scenario is the most likely outcome.	Involves meeting all efficiency and renewables policy objectives for 2020, several of which are not currently on target.	Involves even greater levels of investment to improve the efficiency of buildings beyond existing targets. The residential sector alone capable of delivering an additional annual 1.4Mt CO <sub>2</sub> savings.

Source: Own Summary of NESC (2012)

Driving much greater levels of investment in residential (and non-residential) buildings would minimize Ireland's requirement for the purchase of carbon credits. It would further allow more intractable sectors such as agriculture more room for manoeuvre in meeting decarbonization objectives.

Achieving the *Efficiency +* scenario described in Table 4, however, requires an almost doubling of the current government target for the contribution from residential buildings. The existing target is itself not being met.

The NESC analysis does not suggest, therefore, that *Efficiency +* is a likely or logistically feasible outcome, only that in a perfect world this is the most cost-effective route to compliance.

An increase in the average level of investment per house from its current norm of approximately €3,000 to a minimum of €8,000 would be required, while also increasing the number of annual retrofits gradually over time. What the ex post and ex ante evidence presented above suggests is that, for the most part, these investments offer an attractive return on investment from energy savings alone for the average householder. However, informing, enabling and otherwise convincing homeowners to act is the key challenge.

### 3. Past Investment Activity and Government Support

Ireland launched a grant-aided programme in 2009, which succeeded in breathing life into the residential retrofit industry. *Better Energy: Homes* (formerly the *Home Energy Saving* scheme), was conceived as a time-bound intervention to overcome homeowner *status quo* biases, informational barriers, and to mitigate somewhat the high up-front cost of investment.

The numbers of houses undertaking retrofit annually under Better Energy: Homes rose from 31,000 to over 88,000 from 2009 to 2011. Activity is now, however, in decline. Approximately 45,000 retrofits were supported under the programme in 2012, with numbers declining significantly again in 2013.

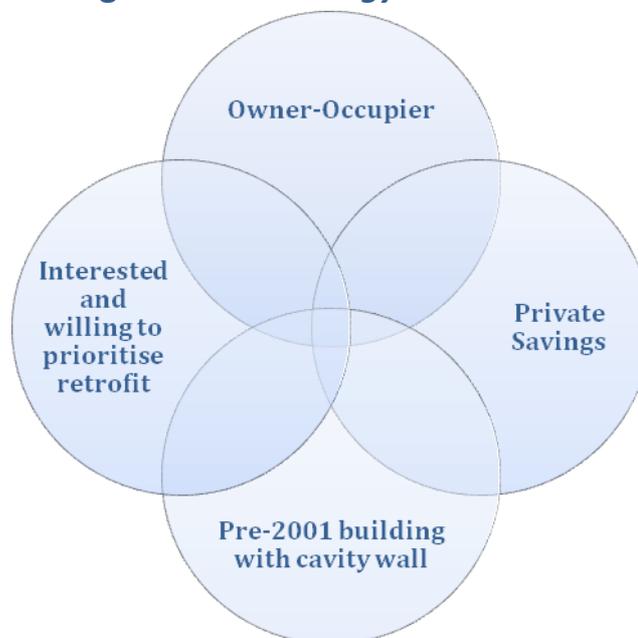
Additionally, the “depth” of interventions was significantly short of what would appear to be “cost-effective”. An average spend of approximately €3000 was recorded, which includes the grant payment of approximately €1,000. Although grants were available for “deeper” measures such as internal and external wall insulation, support was effectively targeted at shallow or cheap measures: cavity wall insulation and roof insulation predominated.

The fall off in grant applications and retrofit activity comes as no surprise. The macro environment (credit crunch, and reduced consumer spending) and perhaps tighter standards may have played some role. But these factors have not changed dramatically between 2009 (a year when real GDP growth was - 5.5 per cent, yet record numbers of grant applications were received), and 2012.

The decline in applications is perhaps explained by structural factors. The programme is attractive to only a sub-section of Ireland’s households. It targets older (pre-2001) homes (requiring a retrofit), which are owner-occupied, whose owners have access to private savings, and are willing to part with these savings for a retrofit.

Furthermore, the number of units where cavity wall insulation is feasible is limited; it cannot be applied where hollow block construction dominates, as it does along the east of the country. It was estimated in 2009 that approximately 63,000 cavity wall insulations were feasible. Between 2009 and January, 2013, over 89,000 grants for cavity wall insulation were paid (it was second only to roof insulation in popularity).

**Fig 1. Limited Coverage of Better Energy: Homes**



#### **4. From grants to finance, shallow to deep**

While the grant programme can be considered a huge success in many respects, it also illustrates the boom-bust nature of these types of programmes, which are well documented.<sup>18 19</sup>

The ultimate objective of the grants programme is to create a sustainable market for retrofit independent of Government support. Ireland is delicately poised in the transition from grants to a more market-based approach, described in the Programme for Government as a “Pay As You Save” (PAYS) scheme. In this section we explain the PAYS concept, and review on-going

policy developments in Ireland and the UK, with a view to offering recommendations for policy in the final section which follows.

#### 4.1. The Theory

Under a traditional PAYS model,<sup>20</sup> funding is provided to a homeowner by a third party to undertake works, the debt is attached as a legal charge (or lien) to the property, or can be attached to the energy meter. Attaching the debt to the energy meter means that whoever pays the energy bill automatically repays the debt – they are, after all, the ones benefitting from the investment in efficiency. **What is envisaged is not, therefore, a personal loan to the homeowner.** The money is repaid by way of a premium charged on the energy bill until the loan is repaid (by whoever is paying the energy bill associated with that premises). Although the bill-payer is subject to a premium on his/her charge per unit of energy consumed, this should in theory be cancelled out by a reduction in the number of units consumed, i.e. reduced energy demand.

The theory is that providing attractive financing upfront and a hassle free repayment mechanism to homeowners should make deeper retrofits with longer paybacks more attractive. Homeowners who may not be staying in a home for the full duration of the longer payback would not be put off. In theory, because such loans are not personal debt, if marketed correctly, it should be possible to overcome consumer resistance to “taking on more debt”.

For this type of initiative to be successful, a number of conditions must be met. A positive cash flow needs to be created (energy savings need to exceed monthly repayments so that the proposition is attractive to consumers). This generally requires:

- Pay backs (up to 20 or 25 years) – significantly longer than the average tenancy – for deeper retrofits;
- The provision of finance at attractive rates (closer to mortgage interest rates than term loan rates, 4 than 10 per cent);
- The bundling of measures with short paybacks (heating controls or attic insulation) with measures with much longer paybacks (external wall insulation) is also required, so that the package of measures considered together can generate a positive cash flow. It is important to note that programmes which “cherry-pick” loft and cavity wall insulations can therefore can work against future comprehensive retrofits, by making those interventions economically implausible at a future date.<sup>21</sup>

## 4.2. Policy Response In Ireland

Within SEAI, a Better Energy Finance (BEF)<sup>22</sup> group has been established to design an attractive PAYS offering. It is being led by private sector industry experts, with the stated objective to support the move “away from Exchequer funded grant-based incentives to what is intended to be a market-based sustainable source of accessible finance for retrofit”.

In an exemplary model of open and transparent government, progress reports are being provided at regular intervals by way of the project website, and several decisions have been made further to open consultations.

Much progress has been made by the project team, and the outline of the financing offering published by way of a discussion document in early August 2013 illustrated the comprehensive nature of the proposal. The project team envisage providing a convenient ‘one-stop shop’ for consumers, the development of a trusted brand and a quality assurance scheme, assessors that tailor recommendations to individual consumers’ requirements, offering clear statement of typical standardised costs, and savings and likely cost of repayments. These are all welcome developments.

It is also evident that the group are seeking to work with the grain of existing financing options, by offering consumers a choice of attractive and accessible loan products with convenient repayment options, not just a standard PAYS offering. A project update (July, 2013) informs us that a BEF Special Purpose Vehicle (S.P.V.) Bank and Credit Union will be established to provide “accessible finance products making finance for *small-scale* loans widely available”.

The project group also came to the conclusion that “in the current economic climate, consumers remain reluctant to borrow”. The update informs us that “evidence is clear from consumer focus groups that a ‘big bang’ investment approach will not succeed - consumers are highly reluctant to take on increased borrowings”.

While it is too early to be critical of this aspect of the proposal – which is after all the basis for another consultation - it would appear that the group has rejected, *a priori*, the core component of a PAYS proposal – to idea of attaching the debt to the energy meter (or as a charge against the property). This is seen as a key enabler of deep retrofit and longer payback periods, as it overcomes

the split incentive issue. This decision seems to have been taken on the basis of consumer sentiment, and more precisely an antipathy to personal debt.

Yet the whole idea of a PAYS proposal is that it is not a “personal loan”, but rather a charge against the energy meter, which is repaid as a fee on the energy bill. On the other hand, all of the project team’s financing offerings are personal debt-type products, and it is unclear how their offerings will overcome the antipathy to personal debt identified.

When presented with an entirely new product or service, consumers will generally tend to express reservations. PAYS is an entirely new concept, which would take time to gain acceptance in the market. While it would be foolish to ignore consumer sentiment entirely, when it comes to entirely new products and services, the Steve Jobs maxim that “a lot of times, people don’t know what they want until you show it to them” seems apposite. The short-term focus on consumer sentiment is perhaps misplaced in a scheme which seeks to put in place a financing offering, which may serve for decades to come.

The group envisages facilitating a continued consumer focus on shallow retrofit with a view to “introducing consumers to a journey of successive home improvements from shallow to medium to deeper retrofit”.

Far from enabling further deeper measures, the scheme may, however, work against them by making future interventions technically and economically unattractive.

It is also worth recalling that applications for shallow measures have declined significantly in 2012 and 2013, even with the availability of a grant. This may reflect structural limits in the market, as well as the broader economic environment. It is unlikely that withdrawing grants and offering personal loans in their stead can reverse this trend.

Nonetheless, it must be acknowledged that the project team are seeking to work with the grain by allowing shallow retrofits to be financed. The balance in emphasis between shallow and deep has yet to be worked out in practice. It could be, for example, that the group envisages offering finance for shallow retrofits at market rates, while subsidizing deeper retrofit activity (see section 5.)

### 4.3. The Energy Saving Obligation

A national obligation was introduced on the state's 18 largest energy suppliers (including Electric Ireland, Airtricity and Bord Gáis) to deliver energy savings among customers. Energy suppliers receive credits for every investment in efficiency made by customers under one of their programmes.

Under the current design, there is legal uncertainty<sup>23</sup> around whether energy saving targets are binding, nor are there guidelines on how targets can be achieved, or in which sectors. For example, there are no requirements to meet targets by promoting residential retrofit, and energy companies are largely meeting targets in the industrial processing sector at minimal cost. It is highly questionable if the schemes add anything as currently designed, as these investments in industrial processing would probably have been delivered without the scheme, and are covered in any case by an existing programme: SEAI's Large Industry Energy Network (LIEN).

This scheme will be significantly amended by the transposition of the EU Directive on Energy Efficiency (EED), agreed in 2012, and scheduled for transposition in Ireland by mid-2014. Under this Directive obligated parties must deliver much more onerous targets (550GWh annual savings has been proposed, of which it is proposed that 30 per cent will be delivered in the residential sector).<sup>24</sup> The legal nature of these targets will be made more clear, and there will be automatic penalties for non-compliance.

There is potential for the obligation scheme to work in tandem with the PAYS programme to drive a more market orientated approach to retrofit from 2014, reducing the requirement for direct government intervention. *If* energy utilities are required to meet part of their energy saving targets required under the EU Energy Efficiency Directive in the residential sector, there may be additional support available to homeowners to retrofit homes *via* consumers' energy companies. In this scenario, energy companies would recoup any costs arising through an increase in the charge per unit of energy delivered, but there would be a level playing field for all energy companies.

### 4.4. The experience of the UK PAYS model

Valuable lessons can be garnered in Ireland by attempts to implement a viable financing model in the UK, to replace a grant-based scheme. The proposal is running approximately two years ahead of progress in Ireland.

The UK Green Deal attempts to address the financing barrier by providing up-front funding to interested homeowners who want to invest in efficiency. Homeowners repay the loan as they save money on energy bills over the years.

The bill payer repays the investment, so that if a home is sold, the new owner takes on responsibility for the repayment stream (optionally, the loan can be repaid at this point). This is a key enabler of deeper retrofit activity.

Since the programme went live earlier this year, the number of homes installing cavity wall insulation and other measures declined significantly. Households had become used to receiving heavy subsidies for measures, and are understandably reluctant to take out what may be perceived as a personal loan.

The lack of emphasis on publicity has been an ongoing criticism. Throughout 2012 Government repeatedly rebuffed calls for a high-profile advertising and communications campaign to drive awareness of the scheme. The reason for this was a Government moratorium on marketing expenditure. However, in November 2012 the UK Government made a partial U-turn and announced a national communications campaign to promote the Green Deal. However, some sources voiced concerns about the relatively small scale of the communications budget.<sup>25</sup>

The launch of the programme has also been widely criticized. The Green Deal was first beleaguered by a several delays, followed by a number of “soft launches”. Major retailers such as supermarkets and DIY stores are viewed as essential to the success of the scheme. Yet they were not ready to join these launches adding to a general sense of confusion.<sup>26</sup>

The withdrawal of the existing framework has also come in for criticism. It may have been prudent to delay phasing out the old policy framework for residential energy until after the Green Deal had managed to get off the ground. Perhaps in response to this criticism, and in order to reward first movers, the Department of Energy and Climate Change (DECC) brought forward a Green Deal “cash back” scheme to part-subsidise works under the Green Deal.

While short-term teething problems should not be a cause of concern, critics say that the programme suffers from more fundamental flaws.

They argue that money is too expensive, with interest rates in the region of 7 per cent the norm. This compares unfavorably to mortgage products, which are becoming increasingly common in the market place. For example, Ecology Building Society charge 3.9 – 4.9 per cent for mortgages for energy saving home improvements.

DECC survey data<sup>27</sup> shows that homeowners who have had a Green Deal assessment still cite finance as the biggest barrier – the one that this programme was supposed to overcome.

The principle of the debt attaching to the energy meter has also come in for criticism, with many arguing that it could act as a disincentive when it comes to selling the property. If works are undertaken, however, this means a more valuable property, more comfortable living conditions and lower bills. Buyers and sellers of homes are increasingly coming to understand the value of an efficient home, and this is perhaps a more important enabling condition for market acceptance. It is too early to tell if this design characteristic will achieve market acceptance, and it is perhaps dependent on marketing and communication.

Even if loans with competitive interest rates were available, critics in the UK have argued that this would not be sufficient to drive widespread retrofit. Because of the fundamental newness of the offering, and the cultural shift required, the UK Green Building Council have argued that “long term structural incentives would still be needed to ensure sufficient uptake”.

A final issue faced in the UK echoes our concerns, outlined above, that focusing on shallow retrofits makes subsequent deeper retrofit less likely. Sara Vaughan, E.ON’s director of energy policy identifies this as a key problem in the UK, stating “the low-hanging fruit has been picked so it is more difficult to get the remaining consumers to sign up for insulation”.

## **5. Insights for Policy Development**

The analysis presented herein first establishes the evidence for boosting investment in deep retrofit. The argument runs as follows:

- Retrofits costing nearly treble the current average spend are cost-effective to consumers, even when only energy savings are considered;

- There are a range of ancillary benefits to homeowners in terms of improved asset values, comfort and health benefits, and fuel poverty alleviation;
- For Ireland, the benefits include job creation, energy security, and boosted exchequer returns.

Yet retrofit activity is exclusively focused on promoting shallow retrofits, with measures such as cavity and roof insulation, lagging jackets, draft proofing, CFL replacements, and to a lesser extent more efficient heating systems and controls predominating.

Even this shallow retrofit activity is in sharp decline, and this is at least in part because much of the low hanging fruit has been picked. In particular few cavity walls remain to be insulated. For this reason alone, the focus in policy needs to change to promoting deeper retrofit activity.

But there are other reasons. Cherry-picking loft and cavity wall insulations (and other cheap measures) can work against comprehensive retrofits by making further interventions technically and economically unfeasible. Bundling of “deep” and “shallow” measures is required for packages to have reasonable payback periods. It will also not be possible to convince a homeowner to invest in further measures due to hassle factors and other inconveniences. In this sense ‘introducing consumers to a journey’ may not a strong argument.

Focusing on gaining market acceptance for the concept of a deeper retrofit is the only approach capable of delivering a sustainable market. Programmes must focus therefore on raising the average expenditure on retrofit from €3,000 to a minimum of €8,000. There needs to be a clear emphasis in government policy in favor of deeper measures.

With these points in mind we offer options for into how policy might be progressed below.

### **5.1. Going “Deep”**

Currently grant support is associated with the installation of individual measures.<sup>28</sup> As long as grant support persists, it should be targeted at incentivising packages (of three or four) measures to households, rather than individual measures.

Under the new market based approach, the energy obligation scheme proposed for suppliers can also be used to support the new financing offering. Suppliers must first of all be required to meet a proportion of their energy saving target in the residential sector. Suppliers could be offered bonuses if they succeed in driving “deeper” retrofits among consumer. For example, when a homeowner installs a package of four or more measures measures (say attic, external wall insulation, draft proofing and heating system with controls) the supplier should be granted a bonus in the number of credits they receive.

Furthermore, the PAYS offering which is under development should enable debt to be attached to the meter (or as a lien against the property) in order to incentivise packages of measures with longer paybacks.

## **5.2. Exchequer funding and finance**

Experience in the UK reminds us that 7 per cent interest rates are unattractive to consumers. If financing cannot be provided at more attractive rates, and over 20 to 25 year terms, programmes aimed at promoting deep (or even shallow) retrofit will fail. It may not, however, be possible to attract risk-adjusted capital at these rates into the retrofit market until the concept is proven. Withdrawing grants and expecting a fully market-based approach to take off is also unrealistic.

We illustrated above how supporting retrofit is good value for the exchequer. Some limited form of exchequer support is therefore justified, at least in the period of transition from a grants programme. Government support should be entirely focused on promoting take up of deeper retrofit measures and packages.

Within this context options for Government support could include:

- Persistence with grants focused on deeper measures and bundles of measures, perhaps with some form of annual degression in support to incentivize early adaptors; or
- Subsidizing the cost of money provided through the Special Purpose Vehicle (S.P.V.) Bank and Credit Unions for deeper retrofits and packages, structured in a manner which rewards early adaptors.

### 5.3. Supplementary measures

A range of supplementary supporting measures are required to encourage the magnitude of the shift in society which is required towards retrofitting homes at scale and depth. The options for policy interventions have set out and assessed in a comprehensive analysis undertaken by for the International Energy Agency (Ryan, L, 2013).<sup>1</sup>

Heterogeneous measures are required to target various market segments. Measures to incentivise retrofit of social housing, private rented accommodation or heavily mortgaged properties, are different, as are measures for apartments, houses, listed buildings etc.

With this in mind a recent BEF project document<sup>29</sup> acknowledges that high level policy interventions might be brought to bear in support of the BEF scheme, to overcome various market barriers identified.

We focus on one key issue here, again drawing on NESC (2012). We know from empirical evidence that consumers are somewhat myopic when it comes to future energy costs associated with purchasing an electrical appliance, a vehicle or a house (Text Box 4). This is why the EU Eco-Design Directive, for example, sets minimum efficiency standards for appliances, and the EU Eco-Labeling Directive requires labelling for efficiency. It is further why almost all EU countries have moved to reflect incentives in car purchase tax (VRT) and annual car tax to encourage the purchase of more efficient vehicles.

The profound shift in consumer behaviour which has resulted demonstrates how effective these instruments can be in changing behaviour. Taxes on fuel, for example, are just not as salient or impactful for the reasons explained in Text Box 4.

Similarly, consumers are shortsighted in relation to the future energy use implicit with the purchase of a house. One option would be to amend the property tax to take account of the energy efficiency of the home in a revenue neutral manner.

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<sup>1</sup> Hilke, A. and L. Ryan (2012) "Mobilising Investment in Energy Efficiency: Economic instruments for low energy buildings", IEA Insights Paper, OECD/IEA, Paris.

There is a direct parallel between VRT and stamp duty on the one hand, and annual car tax and the annual property tax on the other. Using these instruments would be likely to have as profound an impact as amending the car tax, by galvanizing interest in retrofit to avoid taxes.<sup>30</sup> Furthermore, this is a measure which can be introduced on a bonus-malus basis, and can therefore be designed in a revenue neutral manner.

#### Text Box 4: Consumer Myopia

In standard economic theory, on-going energy taxes are often preferred because they act on both the extensive margin (encourage the purchase of more efficient houses), and on the intensive margin (encouraging lowering thermostats and less use of heating system, etc.). By contrast, it is argued that one-off purchase taxes act only once – at the time of purchase.

This logic only holds true if consumers value equally future costs and benefits relative to the upfront purchase price. This is not the case. For example, evidence suggests that:

- Consumers trade off the upfront costs of appliances with the energy costs of using them in a manner that suggests that they discount them highly;<sup>31</sup>
- Mutual fund investors are less attentive to management fees than upfront payments;<sup>32</sup>
- Shoppers in general are less responsive to sales taxes than to prices;<sup>33</sup>
- Shoppers on E-bay are less elastic to shipping and handling charges than to the listed purchase price;<sup>34</sup> and perhaps most relevant
- Based on a dataset of 86 million car transactions at auto dealerships consumers significantly discounted future gas purchases, so that €1 of gas purchases was equivalent to only 76 cents in vehicle purchase price.<sup>35</sup>

These behaviours may be influenced by price schedules and costs that are complicated and/or opaque,<sup>36</sup> of the lack of information on future fuel prices or efficiency, computational limitations, of lack of upfront investment capital.

If consumers undervalue future energy purchases, upfront taxes may be preferable so that individuals do not make purchases that lead them to consume energy in excess of their private optimum. These decisions could be further still from a socially optimal level (which would include externalities related to energy security and climate change), leading to a substantial welfare loss for both individuals and society.

#### 5.4. Programme evaluation and administrative resources

If success is to be achieved, a continued and determined focus, and the willingness to trial, test, and refine policy interventions is a necessary condition. Policymakers may consider this to be relatively new field. Investing scarce resources to what can be considered a somewhat uncertain area, particularly in the current climate of fiscal retrenchment, is highly challenging.

This may be partly because the impacts and outcomes of investing in residential efficiency are considered somewhat uncertain. By contrast, the Department of Public Expenditure and Reform may prioritise more established areas of capital expenditure, such as roads programmes. These programmes have clearly defined and predictable outcomes, and an established and accepted methodology exists where these outcomes can be established *ex ante*. By contrast programmes supporting energy efficiency are only partly understood by conventional economic appraisals.

The programmes of government expenditure to improve energy efficiency need more sophisticated assessment methodologies which take full account of all costs and benefits. SEAI's cost-benefit assessments of their investment programmes, and their excellent *ex post* billing analysis are a very useful contribution in this respect. Yet even in these cases, benefits were restricted to consideration of energy and carbon savings alone. Wider benefits to society may be challenging to model within an integrated framework, but this does not mean that they should be disregarded in programme evaluations.

Nor has there been an assessment of the impact for exchequer cash flow of support programmes, though the case study presented here suggests an attractive proposition.

Finally, as argued in NESC 2012 “a key issue surrounds how to gather sufficient analytical and administrative capacity to drive this agenda forward. The current level of administrative resources targeted on these issues is insufficient to put in place the required policy infrastructure”. While no doubt the public service is over-stretched, greater administrative resources need to be directed to this policy priority.

**Appendix**

**Table SERVE Provisional Results on Return on Energy Saving Investment**

<b>Measures</b>	<b>Number of applicants</b>	<b>Average Investment per retrofit (€)</b>	<b>Energy savings (%)</b>	<b>Discounted Payback (years)<sup>37</sup></b>	<b>Internal rate of return (%)</b>
Insulation, heating investments	83	6294	42	12	12
Insulation, heating investments, biomass stove/boiler	54	8564	35	19	7
Insulation, heating investments, lighting	42	4890	36	10	14
Insulation, heating investments, lighting	18	4929	33	10	14
Insulation, windows, heating investments	14	14902	54	15	10
Insulation, windows, heating investments, biomass boiler/stove	11	13667	48	16	9
Insulation, heating investments, lighting, solar	9	8597	34	9	16
Heating investments	9	5754	36	21	6
Insulation, heating investments, biomass boiler/stove, solar	8	12325	46	16	9
Insulation, heating investments, solar	8	11333	58	9	16
Insulation, room in roof-insulation, heating investments	5	10821	36	30	4
Insulation, windows, heating investments, biomass boiler/stove, solar	4	22900	54	11	13
Insulation, novel insulation, heating investments, lighting	3	3918	32	20	7

Insulation, heating investments, lighting, biomass boiler/stove, solar	3	11634	39	11	13
Insulation, room in roof, heating investments, biomass boiler/stove	2	11495	36	18	8
Insulation, novel insulation, heating investments	2	6653	28	22	6
Insulation, windows, biomass boiler/stove	1	13850	24	66	-2
	<b>Number of applicants</b>	<b>Average Investment per retrofit (€)</b>	<b>Energy savings (%)</b>	<b>Discounted Payback (years)<sup>38</sup></b>	<b>Internal rate of return (%)</b>
Insulation, windows, heating investments, lighting	1	8955	29	18	8
Insulation, windows, heating investments, lighting, biomass boiler/stove	1	18483	33	51	-0.17
Insulation, novel insulation, heating investments, lighting, biomass boiler/stove	1	5224	28	15	9
Windows, heating investments, biomass boiler/stove	1	11085	65	14	11
Heating investments, biomass boiler/stove, solar	1	9774	30	18	8
<b>Total</b>	<b>281</b>	<b>8016</b>		<b>13</b>	<b>11</b>

**Source:** Maras *et al.* (2012)

- <sup>1</sup> The multiple benefits of energy efficiency policy for Ireland are discussed in more depth in Curtin, Joseph and Maguire, Josephine, *Thinking Deeper: Financing Options for Home Retrofit*, Institute of International and European Affairs, Dublin, Ireland, September 2011. For more general discussion see: IEA (2012) *Spreading the Net: the Multiple Benefits of Energy Efficiency Policy*, IEA: Paris.
- <sup>2</sup> This is not to suggest that there is not an enormous opportunity associated with investing in commercial and public building sector efficiency. In fact this sector offers advantages to the residential sector in that projects are of a larger size, decision-making tends to be somewhat more economically rational, and in some cases paybacks are more attractive.
- <sup>3</sup> Curtin, J (2011) *Thinking Deeper: Financing Options for Home Retrofit*. IIEA: Dublin.
- <sup>4</sup> Curtin, J (2011) *Thinking Deeper: Financing Options for Home Retrofit*. IIEA: Dublin.
- <sup>5</sup> Curtin, J (2011) *Thinking Deeper: Financing Options for Home Retrofit*. IIEA: Dublin.
- <sup>6</sup> See:  
[http://www.seai.ie/Publications/Statistics\\_Publications/Energy\\_Forecasts\\_for\\_Ireland/Economic\\_Analysis\\_of\\_Residential\\_and\\_Small-Business\\_Energy\\_Efficiency\\_Improvements.pdf](http://www.seai.ie/Publications/Statistics_Publications/Energy_Forecasts_for_Ireland/Economic_Analysis_of_Residential_and_Small-Business_Energy_Efficiency_Improvements.pdf)
- <sup>7</sup> See:  
[http://www.seai.ie/Publications/Energy\\_Modelling\\_Group\\_/Energy\\_Modelling\\_Group\\_Publications/Better\\_Energy\\_Homes\\_Impact\\_Report\\_Billing\\_Analysis.pdf](http://www.seai.ie/Publications/Energy_Modelling_Group_/Energy_Modelling_Group_Publications/Better_Energy_Homes_Impact_Report_Billing_Analysis.pdf)
- <sup>8</sup> NESCC (2012) *Towards a New National Climate Change Policy: Interim Report of the NESCC secretariat*. NESCC: Dublin. Note: I worked on this project as a consultant.
- <sup>9</sup> Modeling work of SEAI, UCC, as well as *ex post* data gathering from the STRIVE investment projects, where energy savings have been recorded for two years.
- <sup>10</sup> See: Dineen, D., Rogan, F., Cronin, W. & Ó Gallachóir, B. (2012), *Modelling Residential Energy Savings Due to Ireland's National Retrofit Programme Using DEAP and LEAP*, Working Paper, Cork: University College Cork.
- <sup>11</sup> A discount rate of 6.7% was used, as recommended by the National Development Finance Agency.
- <sup>12</sup> Maras, H., Segon, V., Domac, J. & Ryan, P. (2012), *Deliverable Report D6.7*, Work Package No. 5, Concerto Initiative. Available: [http://www.servecommunity.ie/wp-content/uploads/2010/08/SERVE\\_D6-7-Socio-Economic-Analysis-2010.pdf](http://www.servecommunity.ie/wp-content/uploads/2010/08/SERVE_D6-7-Socio-Economic-Analysis-2010.pdf).
- <sup>13</sup> Funded through the EU Concerto Programme, the SEAI and North Tipperary County Council.
- <sup>14</sup> Hylanda, M, Lyons, R and Lyons, S (2012) The value of domestic building energy efficiency – evidence from Ireland. University of Oxford: Oxford. Available: <http://www.economics.ox.ac.uk/materials/papers/12042/paper614.pdf>
- <sup>15</sup> Fuerst, F, Nanda, A and Wyatt, P (2013) "An Investigation of the Effect of EPC Ratings on House Prices" Department of Energy and Climate Change: London. Available:  
[https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/207196/20130613\\_-\\_Hedonic\\_Pricing\\_study\\_-\\_DECC\\_template\\_2\\_.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/207196/20130613_-_Hedonic_Pricing_study_-_DECC_template_2_.pdf)
- <sup>16</sup> Motherway, B. & Halpin, T. (2009), *Bringing Retrofit Home: Understanding How People Think About Energy in their Home*, Dublin: Sustainable Energy Authority of Ireland.
- <sup>17</sup> NESCC Terms of Reference, available:  
[http://www.nescc.ie/assets/files/downloads/project\\_climate%20change/Terms%20of%20Reference\\_Climate%20Policy.pdf](http://www.nescc.ie/assets/files/downloads/project_climate%20change/Terms%20of%20Reference_Climate%20Policy.pdf)
- <sup>18</sup> See for example, Curtin, J (2009) Greenprint for a national energy efficiency retrofit programme. IIEA: Dublin, p 41  
or:  
[http://www.brookings.edu/~media/research/files/papers/2012/4/18%20clean%20investments%20muro/0418\\_clean\\_investments\\_final%20paper.pdf](http://www.brookings.edu/~media/research/files/papers/2012/4/18%20clean%20investments%20muro/0418_clean_investments_final%20paper.pdf)
- <sup>19</sup> IEA (2007) *Financing Energy Efficient Homes: Existing policy responses to Financial Barriers*. IEA: Paris.
- <sup>20</sup> Variations on the central model are described in more detail in: Curtin, Joseph and Maguire, Josephine, *Thinking Deeper: Financing Options for Home Retrofit*, Institute of International and European Affairs, Dublin, Ireland, September 2011.
- <sup>21</sup> See Curtin, J (2011) *Thinking Deeper: Financing Options for Home Retrofit*. IIEA: Dublin for further details. The can also be technically unfeasible for a number of reasons.
- <sup>22</sup> See: <http://www.betterenergyfinancing.ie/>
- <sup>23</sup> The Energy Miscellaneous Provisions Act (No. 3 of 2012) allows for binding obligations to be placed on suppliers if 'reasonable endeavours' are not made to meet voluntary targets. Suppliers, however, may argue that 'reasonable endeavours' do not include provision of incentives that may be necessary to overcome barriers and galvanize investment in energy efficiency.
- <sup>24</sup> The target of achieving a 1.5 per cent saving in the EED would be equivalent to approximately three times the current target, although various derogations and could reduce this significantly.
- <sup>25</sup> ECEEE SUMMER STUDY PROCEEDINGS (2013) Somewhere between a 'Comedy of errors' and 'As you like it'? A brief history of Britain's 'Green Deal' so far, available: [http://www.ukace.org/wp-content/uploads/2013/06/1-306-13\\_Guertler.pdf](http://www.ukace.org/wp-content/uploads/2013/06/1-306-13_Guertler.pdf)
- <sup>26</sup> ECEEE SUMMER STUDY PROCEEDINGS (2013) Somewhere between a 'Comedy of errors' and 'As you like it'? A brief history of Britain's 'Green Deal' so far, available: [http://www.ukace.org/wp-content/uploads/2013/06/1-306-13\\_Guertler.pdf](http://www.ukace.org/wp-content/uploads/2013/06/1-306-13_Guertler.pdf)
- <sup>27</sup> See: <https://www.gov.uk/government/publications/green-deal-household-tracker-survey-waves-1-and-2-report>
- <sup>28</sup> See:  
[http://www.seai.ie/Grants/Better\\_energy\\_homes/homeowner/Step\\_1\\_Decide\\_on\\_work\\_to\\_be\\_done/Decide\\_on\\_work\\_to\\_be\\_done\\_and\\_grant\\_to\\_be\\_applied\\_for.html](http://www.seai.ie/Grants/Better_energy_homes/homeowner/Step_1_Decide_on_work_to_be_done/Decide_on_work_to_be_done_and_grant_to_be_applied_for.html)
- <sup>29</sup> See:  
[http://www.betterenergyfinancing.ie/Better\\_Energy\\_Financing/Project\\_Documents/Better\\_Energy\\_Financing\\_Supporting\\_Policies\\_Measures.pdf](http://www.betterenergyfinancing.ie/Better_Energy_Financing/Project_Documents/Better_Energy_Financing_Supporting_Policies_Measures.pdf)
- <sup>30</sup> See: Ryan, L, Ferreira and Convery, F (2009). [The impact of fiscal and other measures on new passenger car sales and CO<sub>2</sub> emissions intensity: Evidence from Europe](http://www.betterenergyfinancing.ie/Better_Energy_Financing/Project_Documents/Better_Energy_Financing_Supporting_Policies_Measures.pdf) *Energy Economics* 31 (3), 365-374, 2009
- <sup>31</sup> Hausman, J. A. (1979), 'Individual Discount Rates and the Purchase and Utilization of Energy-Using Durables', *The Bell Journal of Economics*, 10(1): 33- 54.
- <sup>32</sup> Barber, B., Odean, T. & Zheng, L. (2005), 'Out of Sight, Out of Mind: The Effects of Expenses on Mutual Fund Flows', *Journal of Business*, 78(6): 2095-2120.
- <sup>33</sup> Chetty, R., Looney, A. & Kroft, K. (2009), 'Salience and Taxation: Theory and Evidence', *American Economic Review*, 99(4): 1145-77.
- <sup>34</sup> Hossain, T. & Morgan, J. (2006), '.... Plus Shipping and Handling: Revenue (Non) Equivalence in Field Experiments on eBay', *Advances in Economic Analysis and Policy*, 6(2): Article 3.

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<sup>35</sup> Ilcott, H and Wozney, N (2012) Gasoline Prices, Fuel Economy, and the Energy Paradox, NBER working paper series no:18583. NBER: Cambridge.

<sup>36</sup> Larrick, R.P. & Soll, J.B. (2008), 'The MPG Illusion', *Science*, 320(5883): 1593-94.

<sup>37</sup> A discount rate of 6.7 per cent is used as recommended by the National Development Finance Agency (NDFA) for Design, Build and Operate projects of between 5 and 20 years.

<sup>38</sup> A discount rate of 6.7 per cent is used as recommended by the National Development Finance Agency (NDFA) for Design, Build and Operate projects of between 5 and 20 years.