

The appeal of the green deal: Empirical evidence for the influence of energy efficiency policy on renovating homeowners



H. Pettifor^{a,*}, C. Wilson^a, G. Chryssochoidis^b

^a Tyndall Centre for Climate Change Research, University of East Anglia, Norwich NR4 7TJ, UK

^b Norwich Business School, University of East Anglia, Norwich NR4 7TJ, UK

HIGHLIGHTS

- Examines the impact of a major new energy policy, the Green Deal, on intentions towards energy efficiency.
- 502 households questioned four months prior to, and seven months after the launch.
- Renovating itself is mechanism through which households engage with the Green Deal.
- Strengthening beliefs in energy savings accelerates intentions to renovate energy efficiently.

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ABSTRACT

The Green Deal is a major new energy policy designed to support the diffusion of energy efficiency measures in UK homes. This paper provides one of the first empirical examinations of the Green Deal's success in influencing homeowners' renovation decisions. Using a repeated measures design in which households were questioned before and after the Green Deal's launch in January 2013, we assess the policy's success in raising awareness of energy efficiency. In particular, we test the effectiveness of the Green Deal's positioning to overcome barriers to renovation among homeowners already interested in or considering energy efficiency measures. Using the innovation decision process (Rogers, 2003) as a conceptual framing of the renovation decision process, we examine whether new information on energy efficiency provided by the Green Deal strengthened intentions and its antecedents. We find that (1) energy efficiency is of potential appeal to all renovators regardless of their attitudes about energy efficiency, (2) energy efficiency opportunities need to be identified in the early stages of renovation when homeowners are thinking about ways to improve their home, and (3) homeowners' intentions towards energy efficiency are weakened by uncertainty about financial benefits, helping to explain the relatively slow uptake of the Green Deal to-date.

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1. Introduction

The UK government's Energy Efficiency Strategy is structured around overcoming barriers to the adoption of cost-effective energy efficiency measures (DECC, 2012). A flagship policy, the Green Deal, has been designed to accelerate the diffusion of energy efficiency within the current building stock in England, Scotland and Wales (DECC, 2010). Underpinned by the premise that some energy efficient renovations will pay for themselves through savings in energy bills, the Green Deal creates a financing mechanism

provided by third parties to pay for the upfront costs of installing energy efficient measures in the home. These measures include those requiring larger investment such as boiler replacement, solar water or solar heating, and also measures to improve general thermal insulation of the home including loft insulation or cavity wall insulation (DECC, 2010). The relationship between improved energy efficiency and savings in energy bills is a fundamental component of the policy and has been labelled 'the Golden Rule'. Financing under the Green Deal rests with the property and not the owner, and so is repaid by whoever pays the energy bills. In accordance with the Golden Rule, this is at an annual rate no higher than the estimated annual energy savings gained from new efficiency measures installed in the home. In order to qualify for Green Deal financing, properties undergo an energy efficiency assessment estimating the potential for savings in energy costs

* Corresponding author.

E-mail addresses: h.pettifor@uea.ac.uk (H. Pettifor),
charlie.wilson@uea.ac.uk (C. Wilson),
g.chryssochoidis@uea.ac.uk (G. Chryssochoidis).



Fig. 1. The Green Deal process. An illustration of the five main stages involved in the Green Deal

(Fig. 1). The assessment report makes recommendations for proposed work. Households then have to seek quotations for costs from Green Deal accredited contractors before financing can be secured.

To support this process the Green Deal brings together an accredited network of assessors, installers, financial providers and other suppliers who provide knowledge and expertise to address information and financing barriers to efficiency renovations. The Green Deal was launched in January 2013 but take-up was slow both in terms of home assessments and financing deals. Between the period January–December 2013, 117,454 Green Deal assessments were carried out (DECC, 2013), representing a penetration of approximately 0.5% of the UK housing stock. Only a small proportion of these assessments resulted in Green Deal financing plans being pursued (approximately 1 in every 100 assessments) reflecting a conversion rate of only about 0.4% (DECC, 2013).

Although DECC has reported other outcome statistics including levels of general awareness and satisfaction of households undergoing Green Deal assessments (DECC, 2013; GfK, 2013b), the effect of the Green Deal on intentions towards energy efficiency has not been measured. This is the purpose of this study. Evaluating the Green Deal as a new policy innovation, we test the impact it has made on household intentions towards energy efficient renovations. Using an experimental design we compare three different groups of household. In each case we focus on owner-occupied households which comprise 64% of the UK market. The first group are households who, in line with the Green Deal positioning, should have found the new policy particularly salient, having expressed some interest in doing energy efficient renovations in their homes prior to the Green Deal launch. The second group of households are those considering other forms of major renovations in their home.¹ Finally, the third household type, are those who had no intentions towards renovating either before or after the Green Deal launch. By comparing these three groups we consider whether the Green Deal made any impact on changing intentions towards incorporating energy efficiency measures into homes.

2. Methods

2.1. Literature review

2.1.1. The energy efficiency gap

There are many efficiency improvements that can be made to domestic buildings, the most effective involving structural changes such as cavity wall insulation and triple-glazed windows, or upgrades to the heating and hot water systems such as high efficiency boilers (Gardner and Stern, 2008; Dietz et al., 2009). As well as energy cost savings from these efficiency measures there are other benefits to the homeowner such as reduced draughts and condensation, improved thermal comfort, and increased property value (Jakob, 2006). Despite these benefits, adoption rates of these major efficiency improvements are slow. This ‘energy efficiency gap’ between technical and economic potential on the one hand and actual adoption on the other is well documented (Jaffe and Stavins, 1994). Explanations vary, but all tend to suggest there are

¹ This includes installing new kitchens and bathrooms, building extensions, adding loft conversions or adding conservatories

many ‘barriers’ to otherwise cost-effective technology adoption decisions (Brown, 2001; DECC, 2012). These barriers include capital availability, an aversion to delayed gains and the perceived lack of credible and available information on efficiency measures. Lack of trust in contractors, access to information, lack of financing, complexity and uncertainty, and hassle and inconvenience are also repeatedly emphasised in studies and reports by policy-makers, service providers, and consumer behaviour/market researchers (DEFRA, 2009; Skelton et al., 2009; EST, 2010a; Bioregional, 2011; Cabinet Office, 2011). In their major UK review of attitudes and behaviours towards low carbon energy Whitmarsh et al. (2011) find other barriers including lack of awareness and unrealistic expectations (see also DEFRA, 2009; EST, 2010a; Roy et al., 2007) as well as hassle and disruption (see also Skelton et al., 2009).

2.1.2. The Theory of Planned Behaviour, the Innovation Decision Process, and the design of the Green Deal

The Green Deal was based on the premise that the energy efficiency gap could be closed by lowering behavioural barriers to incorporating energy-efficiency measures into the home. Current policy makers view this as both valid and fundamental to engaging households with energy efficiency (DECC, 2012). Intentional models of behaviour such as the Theory of Planned Behaviour (TPB) (Ajzen, 1991) provide some theoretical basis for these assumptions.

Applied in this context, TPB represents individuals making rational decisions to incorporate energy-efficiency measures into their homes based on the expected values or outcomes of such decisions. A central factor in TPB is an individual’s intention towards the behaviour in question: the stronger the intention, the more likely they are to perform the behaviour (Ajzen, 1991). The three factors influencing intentions in TPB are motivations (attitudes, compliance with perceived norms) subject to constraints (perceived behavioural control). Attitudes are formed from an individual’s beliefs about the behaviour (installing energy efficiency measures) as well as an evaluation of its likely outcomes (e.g., reduction in energy bills). Perceived norms are similarly formed from normative beliefs which describe an individual’s perception of what valued peers think about the behaviour as well as an evaluation of the importance of those peers. However, intentions can only be followed through if the behaviour in question is within the perceived control of the individual. In TPB this is represented by perceived behavioural control (PBC) which consists of the resources and opportunities available to the decision maker. PBC is therefore a subjective assessment of the extent to which both personal and contextual factors influence the behaviour. This is particularly relevant in decision contexts in which action is constrained or individuals do not otherwise have full control (Ajzen, 1991; Armitage and Connor, 2010).

The Green Deal was designed to address this gap between intentions and behaviour by addressing PBC. It was built on the understanding that householders face not only financial constraints to investing in energy-efficiency measures but also those barriers related to uncertainty and lack of information. The Green Deal process was designed to overcome these barriers by guiding households through a series of stages from home energy assessments to certified contractor selection.

Rogers’ conceptual model of the Innovation Decision Process (Rogers, 2003) provides an alternative perspective. It frames the

decision to engage with a new idea or innovation not as a reaction to lowered behavioural barriers and increases in PBC, but as a sequential, cumulative process through which a new idea becomes more relevant to solving a perceived problem until it is eventually adopted. This cumulative reinforcement of intentions is the result of information transmitted through peers, social networks, and also the mass media (Alcott and Mullainathan, 2010; Nolan et al., 2008). This model has been tested in various contexts including the adoption of renewable heating systems (Mahapatra and Gustavsson, 2008). In this context, the Innovation Decision Process adds an important time dimension to TPB by emphasising the context of the Green Deal launch and its association with information on energy efficiency measures and incentives that should strengthen intentions. People’s attention is drawn to what is both novel and relevant to them so homeowners with already strong intentions towards energy-efficient renovations should have found information on the Green Deal particularly salient.

2.1.3. Energy efficiency or renovating?

The Green Deal was informed by a number of empirical studies suggesting many households already held strong positive intentions towards energy efficiency (COI, 2010; GfK, 2011; DECC, 2011a, b). Other studies, however, suggest experience of renovating with efficiency measures is more widespread and not necessarily conditional on specific intentions to purely address energy efficiency (DEFRA, 2009; Skelton et al., 2009). This extent of past experience implies renovating with efficiency measures may be a more periodic and ongoing feature of household life rather than a one-off decision. Homeowners incorporate energy efficiency into their homes alongside other types of renovations, often responding to salient events such as moving house or boiler breakdown (DECC, 2011a,b; Element_Energy, 2011; Skelton et al., 2009). This argument has been extended to home improvements more generally (EST, 2010b) suggesting decisions to invest in energy efficient technologies might also be stimulated by decisions to do other major renovations in the home.

2.2. Conceptual framework

By offering a financing mechanism and access to expert information and advice, the aim of the Green Deal was to (1) lower perceived barriers (2) strengthen intentions towards energy efficiency and (3) make it salient in more households. Whilst the rationale behind the Green Deal was that it would lead to greater adoption of energy efficiency in the home, outcome statistics suggest that a small percentage of households made this transition (DECC, 2013, GfK, 2013b).

The decision to adopt energy efficiency can also be framed as an innovation adoption more in line with Rogers (2003) in which engagement with the Green Deal involves a more sequential or

incremental process of diffusion in which new ideas on incorporating energy efficiency into the home are adopted.

Fig. 2 explains the five decision stages of Rogers’ innovation decision process: (1) a knowledge stage in which individuals become aware of an innovation and are motivated to evaluate it; (2) a persuasion stage in which individuals form a more favourable attitude towards an innovation; (3) a decision stage in which individuals engage in activities that lead to choice; (4) an implementation phase in which the innovation is put to use and; finally (5) a confirmation stage through which its use is evaluated. The advantage of this conceptual framework is that knowledge and information seeking have a central position and that it introduces a time dependency element inherent in the adoption of any innovation. In the case of energy efficiency, households with already firm intentions to incorporate energy efficiency measures into their homes by renovating are likely to find the Green Deal more salient. We apply this conceptual framework from Rogers (2003) in the form of a model of renovation decisions comprising four stages (see Fig. 3). Each stage in this model is distinctive because it requires varying levels of information and action by homeowners.

In decision stage 0 there is no intention towards renovation and overall low saliency exists towards new ideas and propositions with respect to renovations. A household in decision stage 1 is giving some thought to the possibility of renovations at some point in the near future. They are likely to be receptive to ideas and information that aid this knowledge phase. Decision stages 2 and 3 represent more detailed involvement in renovations planning and households are more actively seeking out information and advice. By decision stage 3, households are committed to going ahead or renovations are already taking place. (In decision stage 4, following renovations, households experience and evaluate the outcomes of renovating. These *ex post* experiences are not considered in depth here but are shown in Fig. 3 for completeness). As households move through the decision stages shown in Fig. 3 they are making choices and strengthening their intentions towards renovating.

2.3. Data

2.3.1. Sources of data

To examine change in intentions before and after the Green Deal launch we designed a repeated measures survey in which households were initially surveyed in September 2012, four months before the launch of the Green Deal (28th January 2013). They were repeat surveyed in August 2013, seven months after the launch and eleven months after the initial data collection. The survey was conducted by IPSOS MORI through an on-line survey of a representative sample of home owners in the United Kingdom. Only owner–occupier households (i.e. those who own their home

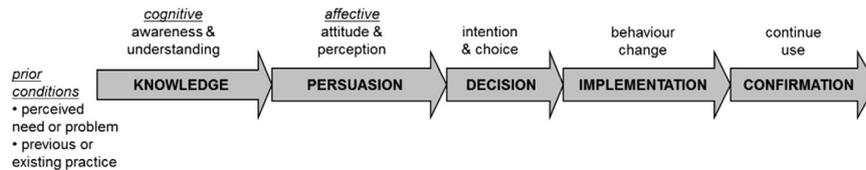


Fig. 2. Innovation Decision Process (based on Rogers, 2003). An illustration of the five main stages of Rogers Innovation Decision Process



Fig. 3. Renovation decision process. An illustration of our own model of renovation decision stages which we draw on within the paper.

Table 1

Sample comparison.

Source UK data: (ONS, 2013a, 2012), DWP (2013, 2005), (DCLG (2013a,b), DCLG (2011a).

	Original sample	Repeat sample	UK (owner occupied households)
Gender of respondents	48% male, 52% female	49% male, 51% female	n/a
Households with gross income < £25k/annum	37%	36%	43%
Mean age ^a	51 years	54 years	n/a
Age distribution across groups ^a			
18–24	5.64%	4.18%	0.6%
25–34	13.91%	9.76%	9.7%
35–44	20.14%	19.2%	18%
45–54	18%	17.53%	22%
55–64	20.23%	24.10%	19.5%
65+	22.08%	25.30%	30.2%
Single occupant households	21%	23%	25%
Households two people	44%	47%	42%
Households with four or more people	19%	15%	20%
Households with dependent children	19%	19%	26%
Educated to degree level or above ^a	20%	19%	27%
Resident in property built before 1919	17%	17%	20%
Resident in property built 1919–1944	21%	21%	19%
Resident in property built 1945–1990	44%	43%	48%
Resident in property built post 1990	18%	18%	13%
Lived in current property less than 5 years	20%	19%	n/a
Lived in current property more than 20 years	34%	34%	n/a
N	1028	502	14.7 m

^a Respondent or household representative.

outright or are paying off a mortgage) were included in the survey and within these households only individuals who were at least partly responsible for financial decisions to do with the home were invited to take part.

Our original data collection was $N=1028$. Out of this population, 502 households also took part in a repeat survey and it is this repeated sample on which this study is based. (See Appendix A for a detailed account of the sampling procedure).

2.3.2. Data description

Table 1 shows details regarding the sample breakdown of our $N=502$ households. In the UK there are approximately 23 m dwellings of which around 64% are owner occupied (DCLG, 2013b). Table 1 includes property and households characteristics of all owner-occupiers households in the UK. Our sample is slightly biased towards older properties. In terms of income we used a threshold of £25,000 gross income per year to distinguish between higher and lower income households.² Comparison to UK statistics shows our sample of owner occupied households is slightly over representative of higher income households.

Table 1 also shows a demographic breakdown of the repeat sampled households compared to the original sample. It shows the mean age of households in the repeat sample was slightly higher at 54 years compared to 51 years for the original sample of 1028. In terms of household occupancy there are slightly fewer larger households in the repeat sample (15% compared to 19%) but these differences are minor and are not expected to bias the results.

2.3.3. Measurement of constructs

In line with our conceptual approach we identify and measure three constructs, derived from Rogers (2003) model of the innovation decision process. (1) 'Awareness-knowledge (AK)', (2) 'Attitudes-beliefs (AB)', and (3) 'Intentions (I)'. Distinguishing between three types of knowledge about a new innovation, Rogers (2003:173) defines Awareness-Knowledge (AK) as information that an innovation exists. This is distinct from 'how-to knowledge'

² This is in accordance with the annual survey of hours and earnings (ONS, 2012) which reports the average income for a UK employee in 2012 was circa £25,495.

Table 2

Awareness-Knowledge Statements (AK) (9 items).

Label	Statement
Saliency	We tend to take notice of things to do with energy efficient renovations
Information availability	There is a lot of relevant and useful information available on energy efficient renovations
Information trust	This information is reliable and trustworthy
Government activity	There is a lot of government activity to promote energy efficient renovations
Effective government	This government activity is effective
Business activity	There is a lot of business activity to promote energy efficient renovations
Effective business	This business activity is effective
Financial incentives	There are a lot of financial incentives to help homeowners do energy efficient renovations
Payment information	Finding information about payment alternatives for energy efficient renovations is not a problem

and 'principles-knowledge' which involves gaining information towards a deeper understanding. In this study we conceptualise the 'AK' construct as the gaining of new knowledge about energy efficiency. This is likely to have occurred through exposure to new information on energy efficiency which the Green Deal provided in January 2013. People are more likely to become aware of innovations by actively seeking out relevant information on innovations they find more salient (Rogers, 2003). We therefore designed a series of statements concerning sources, types and reliability of information about energy efficiency which we could ask before and after the Green Deal launch (Table 2). Agreement or disagreement was captured using a 7 point Likert scale where 1 = disagree, 7 = agree.

We also asked a specific question about the Green Deal in Sept 2013 after its launch (in the repeat data collection) which measured general awareness.

Attitudes and beliefs ('AB') are common to both TPB (Ajzen, 1991) and to the innovation decision process (Rogers, 2003). In TPB changes in AB are antecedent to, and a predictor of, behavioural intentions. Within the innovation decision process (Rogers, 2003) AB is a key element of the 'persuasion stage' in which a

Table 3
Attitudes-Beliefs Statements (AB) (6 items).

Label	Statement
Reducing energy	The pros of reducing the energy used in homes clearly outweigh the cons
Reducing impact	The pros of reducing the impact homes have on the environment clearly outweigh the cons
Energy worthwhile	For our household reducing energy use at home is worthwhile
Impact worthwhile	For our household reducing the impact on the environment is worthwhile
Bills too high	Our households energy bills are too high
Bills can be reduced	Our households energy bills can be reduced a lot by renovating

more favourable or unfavourable attitude towards a new innovation is formed (Fig. 2). Within this stage individuals become psychologically involved with the innovation by actively sorting through available information, deciding what messages are credible and how they should be interpreted. In this study, we conceptualise AB as the gaining of more favourable attitudes and beliefs towards energy efficiency. Although we are not formulating a causal model, an increase in AB provides additional evidence of the influence of new information about energy efficiency associated with the Green Deal. To measure the AB construct we use a series of statements designed to measure the renovations being evaluated (Table 3). Two items are specifically included to capture beliefs about the association between renovating and reductions in energy bills, a major proposition of the Green Deal. Although the single items included in the survey measured discrete effects, these are inter-related. Collectively they create a comprehensive account of attitudes towards energy efficient renovations. (See Appendix B for a critique of item measurement).

Fig. 2 describes strengthening intentions through the innovation decision process based on Rogers (2003). In this study, we conceptualise strengthening intentions using a generic model of renovation decision making (Fig. 3) which identifies four discrete stages representing the series of actions and decisions households engage in when deciding about making major structural improvements to their home.

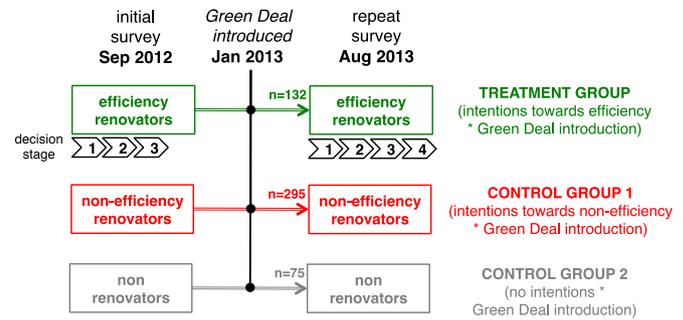
2.3.4. Identification of groups

In order to distinguish between households in terms of the status of their renovations plans, we asked them to self-identify with 5 statements related to the status of their renovations both before and after the Green Deal launch.³

In accordance with their responses we allocated households to decision stages 0, 1, 2, 3 and 4 in line with Fig. 3. To further distinguish between intentions towards efficiency renovations and non-efficiency renovations we also asked households what type of renovations they were considering and used this to identify three separate sub-samples which we use as treatment group and two controls.⁴

³ These five statements distinguished between non-renovators and those in one of four stages (1) thinking about renovations (2) planning at some point in the near future (3) in the middle of doing renovations and (4) recently completed renovations.

⁴ The final treatment group consists of households which held strong intentions towards efficiency renovations both before and after the Green Deal launch, but also includes a small number of households whose intentions towards renovations changed to efficiency following the Green Deal launch ($n=34$). Although we recognise that this is not entirely consistent with the experimental design implied, it reflects a more intuitive approach to grouping households who had potentially changed their views because of the Green Deal. Similarly households which were intending to do efficiency renovations prior to the Green Deal launch but changed their plans to non-efficiency renovations are allocated to Control Group 1.



Effect of Green Deal introduction on antecedents to renovation intentions? Ha1: changes in AK and AB for Treatment vs. Control Groups

Effect of Green Deal introduction on efficiency renovators' intentions? Ha2: comparison of AK and AB between Treatment Group renovators who progressed forwards or moved backwards in decision stages

Fig. 4. Research design and sub-samples. An illustration of the research design showing the treatment and control groups, decision stages and hypotheses tested.

Efficiency Renovators (Treatment Group): Households with intentions towards efficient renovations. Types of renovations were replacing heating/hot water systems, new windows/doors, cavity wall or loft insulation or any combination of these either independently or as part of other renovations in the home.

Non-Efficiency Renovators (Control Group 1): Households with intentions towards renovations but excluding any form of energy efficiency. Types of renovations included modernising living rooms, kitchens/bathrooms, bedrooms, building extensions or adding conservatories.

Non-Renovators (Control Group 2): Households with no plans to renovate either during the 11 month period examined or in the immediate future (these households identified with stage 0 both before and after the Green Deal launch).

2.3.5. Hypotheses

Fig. 4 represents our repeated measures experimental design, and distinguishes the sample sizes of treatment and control groups. Our basic hypothesis has two parts for testing the underlying rationale and effectiveness of the Green Deal. Ha1 tests the effect of the Green Deal introduction on the antecedents to renovation intentions according to our renovation decision model. Ha2 tests the effect of the Green Deal introduction on efficiency renovators' intentions.

Ha1 Households considering energy efficient renovations are more aware and favourable towards energy efficiency after the introduction of the Green Deal [causal influence]

Ha2 Households strengthening in intention toward efficiency renovations are more aware and favourable towards energy efficiency [salience].

2.4. Estimation

Through Ha1 we test systematically for what we refer to as 'the Green Deal effect'. By this we expect significant change in AB and AK items within the treatment group ($N=132$) which is distinctive from both control groups ($N=295$ and $N=75$) indicating the Green Deal had some causal influence on intentions to renovate but only on potential efficiency renovators. Through Ha2 we test for an association between change in AK and AB and the strengthening of intentions towards energy efficient renovations. This hypothesis is designed to capture a salience effect whereby using only the sample of households who had some intention towards energy efficiency, we use transitional matrices to create a new dummy variable which labels households according to changes in their renovation decision plans between September 2012 and August 2013 (Table 4).

Table 4
Change in renovation decision stage and intentions towards energy efficiency.

Label	Definition
Completed	Households who completed their renovations
Forwards	Households in which intentions towards energy efficiency strengthened in that they moved at least one decision stage forwards between Sept 2012 and August 2013
Same	Households in which intentions towards energy efficiency were static in that they remained in the same decision stage between Sept 2012 and August 2013
Backwards	Households in which intentions towards energy efficiency weakened in that they moved at least one decision stage backwards between Sept 2012 and August 2013

Through *Ha2* we therefore systematically test whether intentions towards energy efficiency are associated with a corresponding change in AK and AB items, and whether this association is stronger for households who moved forwards in their renovation decisions between September 2012 and August 2013.

All hypotheses are tested using repeated measures paired *t*-tests to compare change in mean difference within and between items. (See [Appendix B](#) for a critique of this choice of test).

3. Results

3.1. Green deal awareness (all samples)

Non-renovating households (Control Group 2, $N=75$) were more likely to be unaware of the Green Deal. There are no significant socio-demographic differences between non-renovating and renovating households to explain why the Green Deal was not salient ([Table 5](#)) although non-renovators are more likely to live in newer properties and so may be less interested in renovating overall. 16% of households not interested in renovations are living in properties built after 2000 compared to 7% for both other groups. This reports a positive χ^2 test ($\chi^2(10)=21.98$ $|p|=0.015$). Non-renovators are equally as likely to be earning $\pounds > 25k$ per year, have dependent children living at home or have lived in their properties for longer compared to the other groups. Non-renovators were no more likely than renovators to be facing financial constraints suggesting monetary concerns are unlikely to account for why they were not renovating.

Although similar numbers of all three groups are broadly aware of the Green Deal, there are noticeable differences between efficiency renovators and non-renovators (Control Group 2) in terms of more detailed understanding. 7% of efficiency renovators have engaged further by contacting or booking an assessment (although only a small number, $N=9$). There are only very small differences between efficiency and non-efficiency renovators (Control Group 1) suggesting engagement with the renovation process itself might be a mechanism through which households have engaged with the Green Deal. In other words having general intentions towards renovating makes the Green Deal salient. This explains why we also see a high awareness among non-efficiency renovators. Contrary to initial Green Deal positioning it appears that households

may not neatly distinguish efficiency from non-efficiency renovations (or Green Deal enabled renovations from non-Green Deal renovations).

3.2. Change in awareness-knowledge (AK) (all samples)

[Table 6](#) reports the first differences (mean differences from September 2012 to August 2013) with standard deviations for each AK item for each household group. The colour coding in [Table 6](#) shows the results of repeated measures, paired *t*-tests on these first differences. Each tests the null hypothesis that change in means is not significantly different from zero at the 95% confidence level ($|p| < =0.05$). Decreases in means are shown by red shading (darker if differences are significant); increases in means are shown by orange shading (darker if differences are significant).

[Table 6](#) reports the mean differences for AK items. For item 1 (saliency) in efficiency renovators (Treatment Group 1) there is a positive but not significant change in the mean score and this in contrast with non-efficiency renovators (Control Group 1) and non-renovators (Control Group 2) where there is a negative change in the mean. This indicates that the saliency of information on energy efficiency did increase in those households who already had strong intentions towards efficiency renovations, in line with our initial hypothesis.

Contrary to expectations, however, all other items for efficiency renovators show a negative but not significant change (light red shadings). The overall picture which emerges is that there was no significant change in AK for efficiency renovators. Although saliency increased slightly, perceptions of the incentives, information reliability, and perceived effectiveness of the Green Deal decreased after its launch among efficiency renovators (Treatment Group 1).

A similar picture emerges for non-efficiency renovators (Control Group 1) for whom the change in mean scores of all items is modest but negative. A further *t*-test shows that the changes in AK for efficiency renovators are not significantly different to those for non-efficiency renovators.

In non-renovators (Control Group 2) a different picture emerges where there is a large and often significant decrease in mean scores (dark red shadings). Further *t*-tests show that these changes are significantly different from both efficiency and non-efficiency renovators.

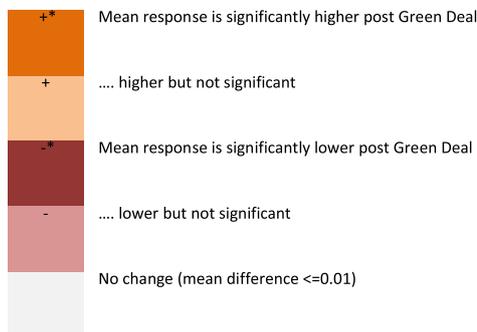
Table 5
Green Deal Awareness (all samples).

Findings post Green Deal launch	Treatment Group 1 efficiency renovators	Control Group 1 non-efficiency renovators	Control Group 2 non-renovators
We have not heard of the Green Deal	31%	30%	47%
We are aware of the Green Deal, but only in general terms	23%	26%	19%
We know a little bit about the Green Deal	23%	31%	25%
We have a good understanding of the Green Deal	17%	10%	9%
We have already been in contact with Green Deal assessors or providers/ we have booked or already had a Green Deal assessment	7%	3%	0
N	132	295	75

Table 6
Changes in Mean Household Response to AK items between 09/2012 and 08/2013. (All groups)

Awareness-Knowledge (AK)	Treatment Group 1	Control Group 1	Control Group 2
	Efficiency	Non-Efficiency	Non-renovators
Saliency	0.10 [#] [0.12]	-0.16 [0.09]	-0.21 [0.16]
Information Availability	-0.08 [#] [0.13]	-0.06 [0.08]	-0.35* [0.18]
Information Trust	-0.02 [#] [0.10]	-0.13 [0.08]	-0.36* [0.17]
Government Activity	-0.06 [#] [0.13]	0 [0.10]	-0.45** [0.13]
Effective Government	-0.15 [#] [0.14]	-0.17 [0.10]	-0.66** [0.14]
Business Activity	-0.03 [0.12]	-0.03 [0.09]	-0.11 [0.14]
Effective Business	-0.06 [0.13]	-0.15 [0.09]	-0.26 [0.16]
Financial Incentives	0 [#] [0.14]	-0.22* [0.10]	-0.50** [0.18]
Payment Information	-0.08 [0.16]	-0.08 [0.11]	-0.13 [0.19]
	N	130	244
			75

Null hypothesis = change is not significantly different from 0, *|p|<=0.05 [s.d.], **|p|<=0.01 [s.d.], #mean differences are significant between treatment group and control group 2



In summary, there are two important findings from the results shown in Table 6. The first is that AK has lowered significantly in non-renovators compared to renovators. These households found the whole Green Deal offer far less salient than renovating households. The second finding is that changes in AK were similar in households with strong intentions towards both efficiency and non-efficiency renovations. In other words, the Green Deal was salient to all renovators, regardless of their specific interest in energy efficiency.

In terms of the hypotheses, in Ha1 we hypothesise that post Green Deal launch, efficiency renovators gained more Awareness-Knowledge (AK) relative to other groups. Intuitively this is discernible by comparing the size of the negative change between groups in Table 6. It can be formally tested by comparing the size of the mean differences directly between Treatment Group 1 (efficiency renovators) and Control Group 2 (non-renovators). Although there was no increase in results there is some support for

Ha1. Change in scores on AK items dropped more for non-renovators compared to efficiency renovators and these differences are significant (denoted by # in Table 6). However, differences between efficiency and non-efficiency renovators are not significant. In this sense efficiency and non-efficiency renovators are not behaving as if they were distinctive groups.

Interestingly, however, efficiency renovators were as informed about financial incentives pre and post Green Deal launch (mean change=0) unlike non-efficiency renovators and non-renovators (mean change= -22* and -0.50* respectively, with * denoting p < 0.05). This suggests that the particular financing aspects of the Green Deal may have been more salient to these households.

3.3. Change in attitudes-beliefs (AB) (all samples)

Similar to findings for AK items there is an overall downwards trend across AB items measuring attitudes towards energy

efficiency for all groups indicative of some exogenous effect on all homeowners between 2012 and 2013 (Table 7). For the efficiency renovating group only scores on the items “energy bills are too high” and “bills can be reduced” have gone up significantly, which could imply that the Green Deal has successfully raised the saliency of energy costs and the potential for cost reduction in this group (Table 7).

Although it is conceivable that shifts in AK and AB items are indicative of a direct negative public response to the Green Deal itself which is larger in the non-renovating group (Control Group 2) we put forward three exogenous factors, summarised below, that we believe might be contributing to these effects. (See Appendix C for supplementary evidence).

- I. Risks associated with home ownership. The Green Deal was launched during a time in which the general idea of attaching additional charges to properties might not be so attractive.
- II. Economic downturn. There is a shifting of public priorities during economic downturn which is likely to have affected the overall saliency of energy efficiency and renovations.
- III. Public confidence. The Green Deal was launched at a time of low public confidence towards Government and energy companies.

3.4. Transitions in decision stages from sept 2012 to Aug 2013 (all groups)

The repeated measures design allows dynamics or transitions within the renovation decision process shown in Fig. 3 to be measured. During the 11 month period around the Green Deal launch households may have moved forwards or backwards in decision stage, or remained at the same stage (Table 4). Observed transitions are summarised in Table 8. The sample size of efficiency renovators is higher ($N=200$) because we include the group of households who completed efficiency renovations. (See full transition matrix Appendix D).

Table 8 shows that more than one in two households (54%) had strengthened their intentions towards efficiency renovations (moved forwards in decision stage or completed), a strong indication that energy efficiency had become more salient for these households. Conversely, one in eight households (12%) weakened (moved backwards) and 34% remained at the same decision stage they were in 11 months earlier. Combining these figures shows that in 88% of households questioned after the Green Deal launch, energy efficiency was as salient or was more salient than it was before the launch. Despite the low take-up of Green Deal financing, homeowners remained interested in incorporating energy efficiency measures into their homes. Comparing these to non-efficiency renovators shows there are some small differences.

Table 7
Change in Mean Household Response to AB items between Sept 2012 and Aug 2013. (All groups)

Attitude-Belief Items (AB)	Treatment Group 1	Control Group 1	Control Group 2
	Efficiency	Non-Efficiency	Non-renovators
Reducing Energy	-0.16 [0.13]	-0.25** [0.09]	-0.19 [0.17]
Reducing Impact	-0.27* [0.14]	-0.24** [0.08]	-0.22 [0.17]
Energy Worthwhile	-0.24** [0.09]	-0.20** [0.07]	-0.33* [0.14]
Impact Worthwhile	-0.28* [0.12]	-0.23** [0.07]	-0.38* [0.19]
Bills too High	+0.26* [0.11]	+0.10 [0.10]	-0.26* [0.16]
Bills can be Reduced	+0.36** [0.14]	-0.05 [0.10]	-0.15 [0.18]
	N	130	244
			75

Null hypothesis = change is not significantly different from 0, *|p|<=0.05 [s.d.], **|p|<=0.01 [s.d.], #mean differences are significant between treatment group and control group 2

+	Mean response is significantly higher post Green Deal
+	... higher but not significant
-	Mean response is significantly lower post Green Deal
-	... lower but not significant
	No change (mean difference <=0.01)

Table 8
Transitions in decision stage. (Efficiency renovators and non-renovators)

Groups	Intentions towards renovations				N
	Backwards (%)	Same (%)	Forwards (%)	Completed (%)	
Efficiency (Treatment Group)	12	34	17	37	200
Non-efficiency (Control Group 1)	14	29	27	30	295

More efficiency renovators completed their renovations (37% compared to 30%), but more efficiency renovators also weakened in their intentions towards renovating (23% compared to 14%).

Fig. 5 below shows awareness of the Green Deal after its launch in each of these transitional groups (efficiency renovators only). It provides further evidence for an association between the Green Deal and strengthening intentions towards energy efficiency. Households whose intentions towards energy efficiency strengthened or remained the same were more aware of the Green Deal than households whose intentions had weakened. Indeed, households whose intentions towards energy efficiency had weakened were actually less likely to have heard about or taken note of the Green Deal once it had been launched.

3.5. Changes in Awareness-Knowledge (AK) with decision intentions (efficiency renovators)

In order to test *Ha2* we compare households whose intentions strengthened between September 2012 and August 2013 (forwards group) to those who intentions weakened (backwards group). We then look at change in AK and AB items. To support *Ha2* we expect a stronger association between change in AK and AB items in households who moved forwards in decision stage.

Table 9 reports the first differences for AK items. Decreases in mean responses are shown by red shading (darker if differences are significant). Increases in mean responses after the Green Deal's launch are shown by orange shading (darker if differences are significant). Increases in most items are observed for households whose intentions towards energy efficiency strengthened (forwards and completed groups). Strengthening intentions are associated with Awareness-Knowledge of energy efficiency and the Green Deal. None of these increases are significant. However, increases are relatively large particularly for the items related to the effectiveness of government information (mean +0.26), information from businesses (+0.35) and information related to financing (+0.29). This provides support for *Ha2*.

For most AK items the change in means for households moving forwards in renovation decision stage is positive compared to households moving backwards. Although tests suffer from type II errors associated with small sample sizes, differences between forwards and backwards groups are large. As an example, for the AK item measuring effectiveness of government information, mean difference in the backwards group is -60 compared to $+26$ in the forwards group. A further *t*-test finds differences in the change in mean scores are significant for the effectiveness of government activity and provision of financial incentives (denoted by # in Table 6).

In summary there was some increase in awareness and knowledge of energy efficiency post Green Deal within households whose intentions towards energy efficiency also strengthened. This is consistent to what was referred to earlier as the Green Deal effect. What is not clear, however, is the causal direction of this association. It could be that intentions towards energy efficiency strengthened because of this increase in awareness and knowledge (forwards causal). But it could also be that households with stronger intentions towards energy efficiency found the Green

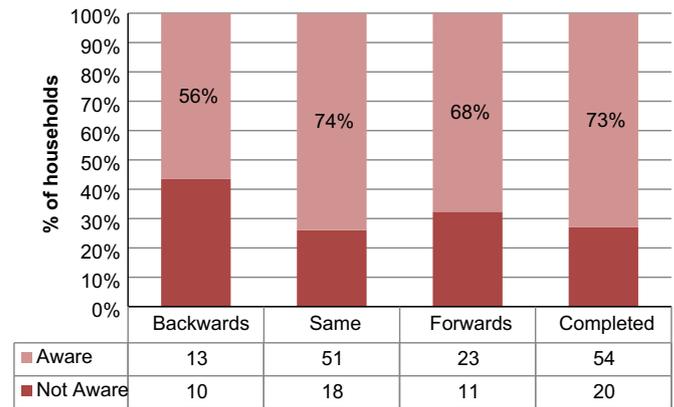


Fig. 5. Green Deal awareness in transitional groups of efficiency renovators. A bar graph showing the distribution of awareness levels across efficiency renovators according to the change in their renovation decision stages.

Deal more salient and sought out information. A cross lagged two wave regression model could test this relationship but our sample sizes are too small for this type of investigation.⁵ Instead we perform a simple test comparing the size of this association for the AK items between efficiency renovators and non-efficiency renovators. If AK is causal to efficiency renovations we would expect to see a distinction between effect sizes. Yet we find no statistically significant differences. (See Appendix E for coefficients). This suggests AK is exogenous to efficiency renovations but potentially endogenous to renovations in general. This is another important finding, and is consistent with earlier results that show the Green Deal to be equally salient amongst efficiency and non-efficiency renovators alike.

3.6. Changes in attitudes-behaviour (AB) with decision intentions (efficiency renovators)

Table 10 is illustrative again of the general decline in AB items across all household groups. However, fewer items are significantly lower in households whose intentions towards energy efficiency strengthened.

With respect to monetary incentives (the last two items in Table 10), financial savings in energy bills are strongly associated with intentions strengthening (the forwards group). This is consistent with a possible causal link. We test this by again comparing effect sizes between efficiency and non-efficiency renovators for the statement “Our energy bills can be reduced by renovating” (the last item in Table 10). The mean difference between September 2012 to August 2013 was $+0.70$ [s.d. 0.31] for efficiency renovators and $+0.10$ [s.d. 0.17] for non-efficiency renovators. The differences between these two groups is significant ($p=0.03$, see Appendix B for coefficients). In other words, beliefs about financial rewards changed more significantly in efficiency renovators than non-efficiency renovators.

⁵ See Table 9 where sample size varies between $N=23$ and $N=74$.

Table 9
Change in Mean Household Response to AK items conditional on movement in renovation decision stages from Sept 2012 to Aug 2013 (efficiency renovators only).

Awareness-Knowledge (AK)	Backwards	Same Stage	Forwards	Completed
Salience	-0.36 [0.26]	+0.12 [0.19]	0 [#] [0.23]	+0.30 [0.17]
Information Availability	-0.48 [0.38]	-0.22 [0.21]	+0.12 [0.18]	-0.12 [0.18]
Information Trust	-0.48 [0.31]	-0.17 [0.14]	+0.21 [0.21]	0 [0.15]
Information Government	-0.30 [0.45]	-0.06 [0.13]	+0.08 [0.33]	+0.07 [0.16]
...this is effective	-0.60 [0.43]	-0.28 [0.18]	+0.26 [#] [0.35]	-0.50 [0.20]
Information Business	-0.47 [0.37]	-0.11 [0.19]	+0.35 [#] [0.20]	+0.04 [0.14]
... this is effective	-0.35 [0.39]	-0.25 [0.18]	-0.08 [#] [0.29]	-0.11 [0.19]
Information Finance	-0.62 [0.48]	-0.13 [0.18]	+0.29 [0.30]	0 [0.17]
Information Payment	+0.09 [0.45]	-0.07 [0.24]	-0.15 [0.38]	-0.16 [0.19]
N	23	69	33	74

Null hypothesis = change is not significantly different from 0, *|p|<=0.05 [s.d.], **|p|<=0.01 [s.d.], #mean differences are significant between forwards and backwards group

+*	Mean response is significantly higher post Green Deal
+	... higher but not significant
-*	Mean response is significantly lower post Green Deal
-	... lower but not significant
	No change (mean difference <=0.01)

Of further interest is that households whose intentions towards efficiency weakened (backwards group) felt more strongly that their energy bills were too high but were less likely to believe that bills could be reduced by renovating. This could reflect differences within the persuasion stage in the Innovation Decision Process (Rogers, 2003) whereby innovations are adopted or rejected as the credibility of information is assessed. If this is the case, remaining or increased uncertainty with respect to the long term financial benefits of energy efficiency will present a significant barrier to the impact of the Green Deal.

4. Discussion

In this study we tested whether the Green Deal had met some of its goals in terms of providing incentives and lowering barriers to energy efficiency renovations within the UK housing stock. We

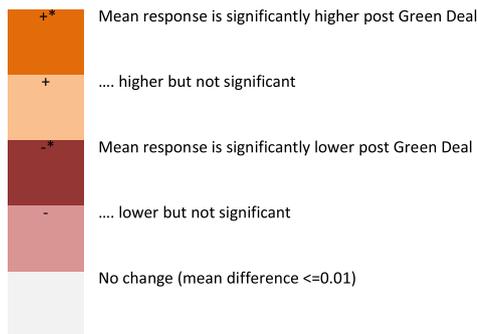
found some evidence that the Green Deal was launched during a period in which there was an overall downwards shift in the saliency of energy efficiency amongst homeowners. We do not believe effects observed here are endogenous to the Green Deal launch since we have strong evidence that some household groups found the Green Deal more salient than others. One in two households planning to do major efficiency renovations to their homes prior to the Green Deal strengthened in their intentions with some 37% completing their renovations. Although we have not been able to prove that the Green Deal was directly causal to strengthening intentions, we found significant changes in 'awareness and knowledge (AK)' and 'attitudes and beliefs (AB),' towards energy efficiency that occurred in households intending to do efficiency renovations compared to non-renovating households.

However, we found no evidence among renovating households that those planning efficiency renovations found the Green Deal

Table 10
Change in Mean Household Response to AB items conditional on movement in renovation decision stages from Sept 2012 to Aug 2013 (efficiency renovators only).

Attitude-Belief Items (AB)	Backwards	Same Stage	Forwards	Completed
Reducing Energy	-.65** [0.25]	+.06 [0.13]	0 [0.23]	-.30 [0.19]
Reducing Impact	-.39 [0.22]	-.26 [0.18]	-.21 [0.25]	-.27 [0.20]
Energy worthwhile	-.04 [0.23]	-.27* [0.11]	-.15 [0.18]	-.22 [0.14]
Impact worthwhile	-.04 [0.27]	-.40* [0.16]	-.38 [0.25]	+.01 [0.15]
Bills too high	+.39 [0.21]	-.03 [0.14]	+.63* [0.29]	+.35 [0.16]
Bills can be reduced	-.48 [0.38]	+.09 [0.19]	+.71* [0.31]	+.25 [0.21]
N	23	69	33	74

Null hypothesis = change is not significantly different from 0, *|p|<=0.05 [s.d.], **|p|<=0.01 [s.d.], #mean differences are significant between forwards and backwards group



more salient. Households intending to do other major types of renovations such as installing new kitchens and bathrooms, or adding extensions and conservatories to their properties, were equally as likely to have acquired new knowledge about energy efficiency around the time of the Green Deal. The Green Deal launch appears to have created greater saliency within renovating households more generally.

The major differences we found were between renovating and non-renovating households. Closer inspection revealed no distinctive socio-demographic characteristics which explained this but non-renovators were more likely to live in modern properties built after 2000. These properties are more energy efficient compared to the older building stock and this provides one possible explanation as to why such households did not engage with the Green Deal or seek out any information.

In looking at strengthening of intentions towards energy efficiency we examined this process as a series of decision stages reflecting the information gathering and actions in which households engage in deciding whether or not to go ahead with efficiency renovations. It is here that beliefs in the energy savings from energy efficiency emerged as strongly associated with this forwards movement in decision stages for efficiency renovators only. Our results suggest that there is a distinction between households who have accepted or rejected the information related to the financial benefits of energy efficiency which lie at the heart of the Green Deal.

5. Conclusions and policy implication

5.1. Conclusions

We used a repeated measures design to examine the impact the Green Deal has made on intentions towards energy efficiency. 502 households were questioned about their energy efficiency plans 4 months prior to the Green Deal launch and 7 months after the launch. We found that household renovation decisions are quite long and drawn out. Of those households that completed efficiency renovations in Aug 2013 the majority (49%) had taken 11 months to move from the detailed planning stage in Sept 2012 (decision stage 2 in Fig. 3). Indications that the Green Deal was launched at a time of declining saliency of energy efficiency amongst homeowners also help explain why the observed market response has been relatively small. We do find some positive outcomes of the Green Deal launch. One in two households thinking about doing major efficiency renovations to their homes before the Green Deal launch had taken actions to progress their decisions. We also found attitudes towards energy efficiency had increased in these households compared to non-renovating households. However, we found no differences in these changes between households considering energy efficiency renovations and households considering other forms of major renovations suggesting renovating itself is a mechanism through which more households will engage with the Green Deal proposition.

5.2. Policy implications

The Green Deal targets certain barriers to energy efficient renovations including high upfront costs and uncertain contractor reliability. By ensuring that energy-efficient renovation measures have a strong financial rationale, the Green Deal is designed to appeal to homeowners regardless of their renovations intentions. However our analysis shows that this central proposition of the Green Deal is not borne out. We demonstrate why by developing three broad recommendations for repositioning and further developing the Green Deal, and more generally for policy makers concerned with improving residential energy efficiency.

- (1) *Energy efficiency is of potential appeal to all households considering major renovations to their homes regardless of the type of renovation work they are initially considering.*

The Green Deal should target the inclusion of energy efficiency measures in all types of major renovation work, rather than promote efficiency-only renovations as a stand-alone decision process. Among a large, nationally-representative sample of owner-occupied households we found the Green Deal was salient to both efficiency and non-efficiency renovators alike. They were both as informed and aware of new information about energy efficiency provided through the Green Deal. This finding is consistent with in-depth studies of small numbers of households that suggest energy efficiency is not a discrete type of renovation activity (Haines and Mitchell, 2014; Judson and Maller, 2014). Rather, efficiency measures are more likely to be incorporated into other types of major home improvement. This implies that the Green Deal needs to be targeting not just would-be efficiency renovators, but all potential renovators. Green Deal assessors and installers are integral to an established supply chain for energy efficiency (e.g., insulation, windows, and heating system contractors). But other major home improvement contractors involved in revamping kitchens, remodelling bathrooms or converting loft could play a critical role in the marketing of the Green Deal to support the bundling of *additional* efficiency measures into a broad suite of renovation plans. This marketing and supply chain approach to developing the Green Deal is necessary as a regulatory approach to achieve similar objectives was rejected.⁶ Market mechanisms could therefore be used as alternative means of leveraging existing points of contact between homeowners and established service providers in the home renovations market.

- (2) *Viewing renovation decisions as a series of stages rather than a one-off event reveals not only an extended window of opportunity to engage homeowners during the often lengthy renovation-decision process, but also a mechanism by which to identify efficiency renovators much earlier as they decide whether and how to improve their homes.*

The renovation decision model used in this paper identifies five decision stages which reflect the often lengthy time dimension over which renovation decisions unfold and strengthen or weaken (Fawcett, 2014). People move from not thinking about renovations to thinking about, planning, finalising plans and completing. This is neither a deterministic nor inevitable progression and when households do finalise plans and complete renovations, this is most commonly at least 12 months after they first started thinking about renovating

(Wilson et al., 2013b). Our empirical research shows that information about the Green Deal became more salient to some households as their renovation intentions strengthened suggesting there are time points where households are particularly receptive to energy efficiency. Using decision stages to identify distinct market segments of would-be renovators would help service providers tailor information, advice and services to different types of homeowner. Homeowners close to finalising renovation plans, for example, are more likely to be preparing for major disruptions to their home and making sizeable financial decisions about their home as well as engaging with experts and installers. Homeowners just starting to think about renovations will have very different needs, particularly if this involves the inclusion of efficiency measures in other types of major home improvement. Market segmentation strategies based on decision stages allows service providers to develop more involved customer relationships and support homeowners throughout the decision process. Other research similarly suggests intentions towards energy efficiency are central to segmentation (see Haines and Mitchell, 2014).

- (3) *Some households are motivated to reduce energy bills, but this is a small proportion of the total market, and intentions towards energy efficiency were weakened by uncertainty about future financial benefits.*

Clear value propositions for energy efficient renovations should not be narrowly based on financial attributes. Our research shows a clear association between new information and strengthened intentions towards energy efficiency. However, information on energy performance and cost savings alone is insufficient to encourage homeowners to make major changes to their homes. This is consistent with market studies. For example, a consumer survey conducted in 2011 found that despite having an energy performance rating of their new home only 1 in 5 home owners acted on this information. Other studies find that homeowners undertake energy efficient renovations for a wide range of non-financial reasons including the desire to address certain imbalances in their domestic lives or improve social status (Wilson et al., 2013a, Earl and Peng, 2011). Households derive greater utility from the aesthetics and comfort of their homes (Haines and Mitchell, 2014) and energy efficiency is only likely to be considered to the extent these other considerations are not compromised. Marketing and delivery of the Green Deal should move away from its central proposition of overcoming financial barriers and saving money, and towards an emphasis on how the Green Deal information, advice, finance, and quality assurance provisions are complementary means of achieving broader home improvement objectives. Framing the Green Deal as an enabling mechanism to support diverse types of renovation could see renovation service providers developing packages of measures or 'off the shelf solutions' that bundle energy efficiency into kitchen refits, loft conversions and so on. Green Deal-financed efficiency measures thus become part and parcel of aesthetic, aspirational, identity-consistent, or esteem-enhancing home improvements.

5.3. Further research

Improving the energy efficiency of homes is one of the main objectives of UK government energy and climate policy. Understanding the mechanisms by which households make decisions to incorporate energy efficiency into their homes will make an important contribution towards the achievement of policy objectives.

First our research suggests that homeowners think about

⁶ In March 2013 'Consequential improvements' legislation was proposed alongside the Green Deal to make it mandatory for households to install efficiency measures as part of other major structural changes to their homes. But this was rejected by senior politicians, and subjected to an aggressive media campaign labelling it the 'conservatory tax' (New Statesman, 2012)

improving their homes not about improving energy efficiency. As a result, we have recommended that efficiency measures should be bundled into home improvement products and services. A market trial of this type of horizontal integration within the supply chain would provide the necessary evidence that this approach works.

Second, in our research we assumed that homeowners gained knowledge of energy efficiency independently from each other, yet there is a great deal of evidence to suggest that people talk to each other about energy efficiency in the home (Bale et al., 2013; Bolinger and Gillingham, 2012; Xiaoqi et al., 2013). This is central to the diffusion theory developed by Rogers (2003) which we use as the basis for our renovation decision model. The incorporation of energy efficiency measures into home renovation decisions is likely to be accelerated by social interactions between friends, family and neighbours (McMichael and Shipworth, 2013). Now that some homeowners have signed up to the Green Deal a micro-study measuring knock-on social influence effects would be possible. Homes are highly visible to friends, family and neighbours and we would expect to find evidence of further expanded interest in energy efficiency within these social networks. Research should identify the types of information exchanged and underlying rationales for renovating including money savings, environmental benefits, thermal comfort, home comfort, aesthetics or functionality. Of ultimate interest to future research would be the extent to which friends and family members, in close social relationships with those who have signed up to the Green Deal, change their own views about energy efficient renovations. Social network analysis would also enable research into the transmission of information about this innovation within neighbourhoods and local communities.

Third, although our study suggested information was important in the diffusion of a new policy innovation such as the Green Deal our small sample sizes prevented any causal modelling. Larger samples would enable more robust longitudinal analysis and we recommend that UK tracker studies such as the UK Social Attitudes Survey, Understanding Society or the UK Green Deal tracker survey incorporate some measure of intentions towards energy efficiency. This should include all households not only those who have expressed some prior interest in energy efficiency.

Fourth, in our research we assumed that households contain single decision makers yet most of our households were multi-occupant. Segmentation studies suggest that households hold various different orientations towards renovations such as home as a project, as a haven or as a social space (Aune, 2007; Haines and Mitchell, 2014). This type of variation might be associated with household composition, lifestyle or life-stage. Renovation decisions are likely to involve multiple decision makers and it would be useful to understand whether even within homes there are multiple or conflicting incentives. New information on energy efficient household renovations or bundled products could be positioned and communicated more accurately if the target market is understood, appealing with the right messages and framed within appropriate settings in the home.

Acknowledgements

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Appendix A. Sampling procedure

In order to identify households planning major capital investments in their homes (for whom the Green Deal might be

attractive), we conceptualised renovations as major changes to the physical properties of the home, changes that would usually require contractors or builders to do the work. This excluded do-it-yourself projects, redecorating and changing appliances.

To ensure a representative sample of homeowners were included in the survey, exploratory research was conducted which concluded 60% of UK individuals aged 18+ would be eligible to take part (they were both homeowners and partly responsible for financial decisions). During the data collection process strict quotas were set based on the four stages of the renovations decision process (0, 1, 2, 3) and these were monitored daily with fresh invitations sent out during the fieldwork to achieve the quotas. Initially 31,466 invitations were sent with 15,719 follow up reminders. The median length of time it took respondents to complete the survey was 26 min and checks were made on the data to exclude respondents who had completed the survey in an unrealistically short amount of time. Although this was an on-line survey the final sample of 502 households were drawn from of a wide range of age groups. The mean age of respondents was 54 years with a standard deviation of 14.6 years. The youngest person taking part was age 18 and the oldest 85 years. 50% of respondents were in the age range 41 to 65 years. Direct comparison between the age distribution of our sample compared to UK homeowners (Table 1) shows our sample is modestly over-representative and under-representative at the tail ends of the distribution (4.2% age group 18–24 compared to 0.6% of UK homeowners and 25.3% age group 65+ compared to 30.2% UK homeowners). However, these are modest differences and not sufficient to conclude that the on-line data collection process has significantly biased the sample. Internet use in the UK show large numbers of all age groups have on-line access, 65% of people age 16–24, 77% of 35–44 year olds, 69% of 55–64 year olds and 41% of those aged 65+ regularly using the internet (ONS, 2013b).

Appendix B. Critique of item measurement and analysis methods (paired *t*-test)

In this study we use single items to measure constructs. These offer the flexibility to test a theory without making the survey difficult to administer, unduly long or monotonous to complete, thus reducing response bias. In terms of the measurement of 'AB', items were designed to measure the salience of information from a variety of sources including government and business as well as specific information on finance and attitudes towards energy bills. The disadvantage of taking this approach is that some of the items are likely to be strongly correlated, which in a regression framework would be problematic. Although multi-item scales can represent a single construct more completely than a single item, the novel approach taken in this research combined with a lack of established empirical research made single item measurements the most appropriate. All measurement items were developed based on existing literature and subjected to three rounds of testing for clarity, comprehensibility and consistency during the period June–August 2012 (between 20 and 40 homeowners per round).

The choice of parametric test (paired *t*-test) is based on the assumption that the mean is the most appropriate point estimate for all items (measured on a 7 point Likert scale). Examination of the distribution of each set of repeated item responses for all samples shows mild skew in most cases (skewness statistic of < 0.22), confirmed by a Shapiro Wilks 'W' test for normality. To ensure that the repeated measures paired *t*-test produces robust estimates for all items, we use a further permutation test in the form of bootstrapping. This approach does not rely on the *t*-test fulfilling assumptions of normality, instead calculates mean

differences, standard deviations and confidence intervals from a sampling distribution obtained by repeat sampling from item distributions (1000 iterations in this case). Significance testing for change within items is based on comparing the null hypothesis that change is not significantly different from zero for $|p| < = 0.05$. Significant change between items is measured by comparing treatment group to control group(s). Where χ^2 tests are used, cell sizes are higher than 5 and therefore meet the requirements for approximations to be valid.

Appendix C. Exogenous factors affecting the saliency of the Green Deal: supplementary evidence

I. Risks associated with home ownership: Although the house price index between Oct 2012 and 2013 showed an overall small increase in property prices of 0.2% (Land Registry, 2013), planning applications to local authorities decreased by 6% during the period Jan to Mar 2013. Periods of recession are known to relate to public uncertainty about the benefits and risks of home ownership (Vaitilingam, 2009). Since 1986 there has been a steady increase in perceptions of risks associated

with home ownership. In 1986 25% of people agreed that owning your home was a 'risky investment' but by 2008 this figure stood at 40% (DCLG, 2011b).

II. Economic downturn: In their study Scruggs and Benegal (2012) examined 40 years of public opinion data on environmental policy finding a clear rebound effect existed with respect to beliefs and concerns about climate change and short-term economic activity. Although during the Sept 2012-Aug 2013 period we examined, consumer confidence grew slightly, from -29 to -12 (GfK, 2013a), overall confidence was still negative.

III. Public confidence: Opinion polls in 2013 showed low satisfaction with the way the government was running the country and although this did not change significantly between Sept 2012 and Aug 2013 (IPSOS Mori, 2013), the government is one of many institutions that have fallen in the public's estimation, alongside banks and the media, and only 1 in 5 trust government to put the nation's needs above those of the political party (Park et al., 2013). There is also low confidence in energy companies and energy pricing. According to a Which magazine poll in November 2013 'energy' is the least trusted of all consumer industries with 59% of consumers saying that they distrust energy companies.

Table D1

Transition matrix for efficiency renovators ($N=200$) (treatment group). (Reporting conventions are explained in the note).

		Decision stage post Green Deal				
Decision stage before Green Deal		Households that have not recently completed renovations			Households that have recently completed renovations	
Deal		Stage 1	Stage 2	Stage 3	Stage 4	Total
Stage 0		10	1	0	13	24
	%	42	4	0	54	100
Stage 1		22	3	7	16	48
	%	46	6	14	33	100
Stage 2		7	22	13	9	51
	%	14	43	25	18	100
Stage 3		7	9	25	36	77
	%	9	12	32	47	100
Total		46	35	45	74	200
Have not moved stage		N = 69 (34%)				
Have moved on at least one stage		N = 34 (17%)				
Have moved back at least one stage		N = 23 (12%)				
Have completed renovations		N = 74 (37%)				

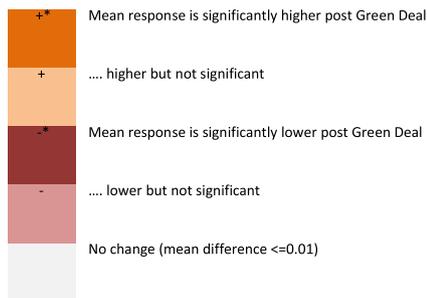
Table E1

Change in Mean Household Response to AK and AB items for households whose intentions towards renovations strengthened (efficiency renovators compared to non-efficiency renovators).

Awareness-Knowledge (AK)	Efficiency Renovators	Non-Efficiency Renovators
	(Forwards)	(Forwards)
Saliency	0 [0.23]	-.11 [0.18]
Information Availability	+.12 [0.18]	+.19 [0.15]
Information Trust	+.21 [0.21]	+.20 [0.21]
Information Government	+.08 [0.33]	0 [0.19]
...this is effective	+.26 [0.35]	-.12 [0.19]
Information Business	+.35 [0.20]	-.02 [0.18]
... this is effective	-.08 [0.29]	+.02 [0.17]
Information Finance	+.29 [0.30]	+.04 [0.17]
Information Payment	-.15 [0.38]	+.04 [0.21]
N	33	78

Attitude-Belief Items (AB)		
Reducing Energy	0 [0.23]	-.28* [0.14]
Reducing Impact	-.21 [0.25]	-.15 [0.13]
Energy worthwhile	-.15 [0.18]	-.04 [0.11]
Impact worthwhile	-.38 [0.25]	-.06 [0.11]
Bills too high	+.63* [0.29]	+.20 [0.15]
Bills can be reduced	+.71*# [0.31]	+.10 [0.17]
N	33	74

Null hypothesis = change is not significantly different from 0 *|p|<=0.05, #mean differences are significant between efficiency and non-efficiency forwards renovators



Appendix D

See Table D1.

What we can immediately determine from the table is that in line with earlier expectations, the renovation decision making process itself is not instantaneous but instead long and drawn out. Of those households that completed efficiency renovations in August 2013 (stage 4) the majority (49%) had taken 11 months to move from the detailed planning (stage 3) in September 2012. In previous analysis when we examined our larger sample of households gathered in September 2012 ($N=1028$) we found 41% of all households had first started thinking about renovating over a year before and this percentage increased to 61% for households feeling financial difficulties (Wilson et al. 2013b). This provides some rationale for the relatively slow uptake of Green Deal since its launch. Table also shows that 1 in 8 households who said they were considering efficiency renovations in August 2013 had no intentions towards this prior to Green Deal launch.

Appendix E

See Table E1.

References

- Alcott, H., Mullainathan, S., 2010. Behavior and energy policy. *Science* 327 (5970) 1204e1205.
- Armitage, C.J., Connor, M., 2010. Efficacy of the theory of planned behaviour: a meta-analytic review. *British Journal of Sociology* 40, 471–499.
- Aune, M., 2007. “Energy comes home.”. *Energy Policy* 35 (11), 5457–5465.
- Ajzen, I., 1991. The theory of planned behaviour. *Organ. Behav. Hum. Decis. Process.* 50, 179–211.
- Bale, S.E., McCullen, N.J., Foxon, T.J., Rucklidge, A.M., Gale, W.F., 2013. Harnessing social networks for promoting adoption of energy technologies in the domestic sector. *Energy Policy* 63, 833–844.
- Bioregional, 2011. Helping to inform the Green Deal: green shoots from pay as you save. Wallington, Surrey, Bioregional, with B&Q and the London Borough of Sutton.
- Bollinger, B., Gillingham, K., 2012. Peer effects in the diffusion of solar PV panels. *Mark. Sci.* 31, 900–912.
- Brown, M.A., 2001. “Market failures and barriers as a basis for clean energy policies.”. *Energy Policy* 29, 1197–1207.
- Cabinet Office, 2011. Behaviour Change and Energy Use. Cabinet Office: Behavioural Insights Team, London, UK.
- COI, 2010. Insight and Strategy for Motivating Take-Up of Home Insulation Measures: Final Report. Central Office of Information (COI) and Department for Environment, Food, and Rural Affairs (DEFRA), London, UK.
- DCLG, 2013a. Planning Applications Jan to March. Department for Communities and Local Government (DCLG), England.
- DCLG, 2013b. Dwelling stock estimates: 2013, England, Housing Statistical Release.. Department for Communities and Local Government, London, UK.
- DCLG, 2011a. English Housing Survey. Department for Communities and Local Government (DCLG), London, UK.
- DCLG, 2011b. Public attitudes to housing in Britain: Report based on the results from British Social Attitudes Survey. Department for Communities and Local Government (DCLG), London, UK.
- DECC, 2013. Statistical Release. Experimental Statistics. Department of Energy and Climate Change (DECC), London, UK.
- DECC, 2012. The Energy Efficiency Strategy: the Energy Efficiency Opportunity in the UK. Department of Energy and Climate Change (DECC), London, UK.
- DECC, 2011a. Understanding Potential Consumer Response to the Green Deal. Department of Energy and Climate Change (DECC), London, UK.
- DECC, 2011b. Consumer needs and wants for the Green Deal: researching the consumer response to the Green Deal proposition amongst homeowners and small businesses. Department of Energy and Climate Change (DECC), London, UK.
- DECC, 2010. The Green Deal, A Summary of the Government’s Proposals. Department of Energy and Climate Change (DECC), London, UK.
- DEFRA, 2009. Attitudes & Behaviours Towards the Environment. Department for Environment, Food and Rural Affairs, London, UK.
- DWP, 2005. Low-Income Homeowners in Britain: Descriptive Analysis. Department for Work and Pensions (DWP), London, UK.
- Dietz, T., Gardner, G.T., Gilligan, J., Stern, P.C., Vandenbergh, M.P., 2009. “Household actions can provide a behavioral wedge to rapidly reduce US carbon emissions.”. *Proc. Natl. Acad. Sci.* 106 (44), 18452–18456.
- DWP, 2013. Households Below Average Income. Department for Work and Pensions, London, UK.
- Earl, P.E., Peng, T., 2011. Home improvements. In: Cameron, S. (Ed.), *Handbook on the economics of leisure*. Edward Elgar Publishing Limited, Cheltenham, UK, pp. 197–220.
- EST, 2010a. At Home With Energy: A Selection of Insights Into Domestic Energy Use Across the UK. Energy Saving Trust, London, UK.
- EST, 2010b. Trigger Points: A Convenient Truth-Promoting Energy Efficiency in the Home.. Energy Saving Trust, London, UK.
- Element_Energy, 2011. Green Deal Household Model Assumptions. Element Energy, Cambridge, UK.
- Fawcett, T., 2014. Exploring the time dimension of low carbon retrofit: owner-occupied housing. *Build. Res. Inf.* 42 (4), 477–488.
- Gardner, G.T., Stern, P.C., 2008. “The short list: the most effective actions US households can take to curb climate change.”. *Environment* 50 (5), 12–24.
- GfK, 2013a. United Kingdom Consumer Confidence. Trading Economics, UK.
- GfK, 2013b. Green Deal Assessment Survey. GfK NOP., London, UK.
- GfK, 2011. Survey of Potential Consumer Demand for the Green Deal. GfK NOP., London, UK.
- Haines, V., Mitchell, V., 2014. A persona-based approach to domestic energy retrofit. *Build. Res. Inf.* 42 (4), 462–476.
- I.P.S.O.S. Mori, 2013. Political trends. Opinion Poll Research.
- Jaffe, A.B., Stavins, R.N., 1994. “The energy efficiency gap: what does it mean?”. *Energy Policy* 22 (10), 804–810.
- Jakob, M., 2006. “Marginal costs and co-benefits of energy efficiency Investments: the case of the Swiss residential sector.”. *Energy Policy* 34, 172–187.
- Judson, E.P., Maller, C., 2014. “Housing renovations and energy efficiency: insights from homeowners’ practices.”. *Build. Res. Inf.* 42 (4), 501–511.
- Land Registry, 2013. House price index available at (<http://www.landregistry.gov.uk/public/house-prices-and-sales>) (accessed 1.01.14).
- ONS, 2013a. Statistical bulletin: families and households. Office of National Statistics.
- ONS, 2013b. Internet access – households and individuals. Office of National Statistics.
- ONS, 2012. Annual survey of hours and earnings, provisional results. Office of National Statistics.
- Mahapatra, K., Gustavsson, L., 2008. An adopter-centric approach to analyse the diffusion patterns of innovative residential heating systems in Sweden. *Energy Policy* 36, 577–590.
- McMichael, M., Shipworth, D., 2013. The Value of social networks in the diffusion of energy-efficiency innovations in UK households. *Energy Policy* 53, 159–168.
- New Statesman Online, 2012. Available at (<http://www.newstatesman.com/blogs/uk-politics/2012/04/giving-conservatory-tax-leaves-green-deal-tatters>) (accessed 16.06.14).
- Nolan, J.M., Schultz, W., Cialdini, R.B., Goldstein, N.J., Griskevicius, V., 2008. Normative social influence is underdetected. *Personal. Soc. Psychol. Bull.* 34, 913.
- Park, A., Bryson, C., Clery, E., Curtice, J., Phillips, M., 2013. *British Social Attitudes*, 30. Natcen, London.
- Rogers, E.M., 2003. *Diffusion of Innovations*. Free Press, New York.
- Roy, R., Caird, S., Potter, S., 2007. People centred eco-design: consumer adoption of low and zero carbon products and systems. *Governing Technology for Sustainability*. In: Murphy, J. (Ed.), 2007. Earthscan, London, UK, pp. 41–62.
- Scruggs, L., Benegal, S., 2012. Declining public concern about climate change: can we blame the great recession? *Glob. Environ. Ch.* 22, 505–515.
- Skelton, Fernandez, D., Fitzgibbons, A., 2009. Energy Saving Trust Green Finance Uptake. Final debrief. Quadrangle & Energy Savings Trust (EST), London, UK.
- Whitmarsh, L., Upham, P., Poortinga, W., McLacian, C., Darnton, A., Devine-Wright, P., Sherry-Brennan, G., 2011. Public Attitudes, Understanding, and Engagement in Relation to Low-Carbon Energy: A Selective Review of Academic and Non-Academic Literatures. Research Councils UK (RCUK), London, UK.
- Wilson, C., Crane, L., Chryssochoidis, G., 2013a. The conditions of Normal Domestic Life Help Explain Homeowners’ Decisions to Renovate. ECEEE Summer Study (European Council for an Energy Efficient Economy), Toulon, France.
- Wilson, C., Pettifor, H., Chryssochoidis, G., 2013b. Understanding Homeowners’ Renovation Decisions: Findings of the VERD Project. University of East Anglia, Norwich, UK.
- Vaitilingam, R., 2009. Recession Britain. Findings from Economic and Social Research. ESRC, London, UK.
- Xiaoqi, X., Taylor, J.E., Pisello, A.L., 2013. Network synergy effect: establishing a synergy between building network and peer network energy conservation effects. *Energy Build.* 68, 312–320.