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Estimating the environmental impact of home energy visits and extent of behaviour change

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HIGHLIGHTS

- The environmental impact of the RE:NEW home energy visit programme is estimated.
- Visits do not generate significant pro-environmental behaviour change.
- Visits do not overcome the barriers to the installation loft and wall insulation.
- Small energy saving measures yield carbon savings of 145 $kgCO_2$/year.
- The average carbon abatement per household was estimated to be 146 $kgCO_2$/year.

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ABSTRACT

The objective of this study was to estimate the environmental impact of a home energy visit programme, known as RE:NEW, that was delivered in London, in the United Kingdom. These home energy visits intended to encourage reductions in household carbon emissions and water consumption through the installation of small energy saving measures (such as radiator panels, in-home energy displays and low-flow shower heads), further significant energy saving measures (loft and cavity wall insulation) and behaviour change advice.

The environmental impact of the programme was estimated in terms of carbon emissions abated and on average, for each household in the study, a visit led to an average carbon abatement of 146 $kgCO_2$. The majority of this was achieved through the installation of small energy saving measures. The impact of the visits on the installation of significant measures was negligible, as was the impact on behaviour change. Therefore, these visits did not overcome the barriers required to generate behaviour change or the barriers to the installation of more significant energy saving measures. Given this, a number of recommendations are proposed in this paper, which could increase the efficacy of these home energy visits.

1. Introduction

In the UK, the target to reduce greenhouse gas (GHG) emissions by 80% by 2050, was legislated under the Climate Change Act (DECC, 2008). In 2011, British residential energy consumption was responsible for 23% of all carbon emissions (DECC, 2013). Therefore, households clearly constitute an important target group for action, if climate change targets are to be met. Carbon modelling by the Committee on Climate Change (CCC) has demonstrated that if targets are to be met under a medium abatement scenario, then a total saving of 98 $MtCO_2$ will need to be achieved from the residential energy use sector between the years 2010 and 2030. To put this figure into perspective, of the total reduction in GHG emissions required nationally and from all sectors, this represents 34% of the total (CCC, 2012).

However, understanding the ways in which energy is used in the home and how household energy consumption can be reduced is a complex topic that has permeated the literature of a number of disciplines (Abrahamse and Steg, 2009; Abrahamse et al., 2005; Lopes et al., 2012; Steg, 2008; Steg and Vlek, 2009). As a result, different strategies are proposed to encourage energy conservation behaviours (Chatterton, 2011; Steg, 2008; Wilson and Dowlatabadi, 2007). Though generally, programmes to reduce energy consumption tend to focus on encouraging two types of household energy conservation behaviour: efficiency behaviours and curtailment behaviours (Abrahamse et al., 2005; Gardner and Stern, 1996).

Curtailment behaviours are those that are habitual and repeated, for example, taking shorter showers to use less hot water, switching

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off unnecessary lights and turning down the thermostat (Barr et al., 2005; Gardner and Stern, 1996). Efficiency behaviours can be described as one-off or occasional behaviours and include the installation of energy saving measures such as wall or loft insulation but can also relate to purchasing, for example, the purchasing of an energy efficient appliance (Barr et al., 2005; Gardner and Stern, 1996). These behaviours can be encouraged through numerous behaviour change interventions ranging from informational strategies to fiscal incentives to regulation (Parliamentary Office of Science and Technology, 2012). This paper will focus on one particular type of intervention, the home energy visit.

1.1. Abbreviations

CCC	Committee on Climate Change
CERT	Carbon Emissions Reduction Target
CFL	Compact Fluorescent Lamp
DECC	Department of Energy and Climate Change
DEFRA	Department for Environment, Food and Rural Affairs
EA	Environment Agency
EST	Energy Saving Trust
GHG	Greenhouse gas
GLA	Greater London Authority
$MtCO_2$	Mega-tonnes carbon dioxide
OFGEM	Office of Gas and Electricity Markets
RSL	Registered Social Landlord

1.2. Home energy visits

A home energy visit is described by Abrahamse et al. (2005) as a 'visit by an auditor who gives households a range of energy-saving options based on their current situation'. The visit is therefore a type of informational behaviour change strategy that revolves around the provision of specific, personalised and tailored information. This approach is contrary to more generic informational strategies, such as those delivered through mass information campaigns, which rarely result in any more than modest behavioural changes (Burgess et al., 1998; Kollmuss and Agyeman, 2002; Steg, 2008; Steg and Vlek, 2009). As a result, home energy visits may be seen as 'potentially a more effective way to encourage behavioural change' and reduce energy consumption (Abrahamse et al., 2005, 2007).

The advantage of tailored information provision over generic information campaigns is that householders should only receive tailored information that is relevant to them, rather than be bombarded with irrelevant information (Abrahamse et al., 2005). This tailored information therefore intends to address individual needs because it is personalised, but as Dowd and Hobman (2013) observe, it is difficult to provide highly individualised information cost-effectively. Examples of tailoring include providing advice on specific insulation measures available to that household for the type of building that they live in, or giving specific advice on the operation of their boiler timer and heating controls.

However, a review of home energy visits by Abrahamse et al. (2005) demonstrated varying levels of success in relation to energy conservation behaviours. As a result, this paper has strived to better understand the efficacy and environmental impact of a home energy visit programme known as RE:NEW. The first phase of the RE:NEW home energy visit programme (which this paper relates to) was delivered within London, the capital city of the United Kingdom, between July 2011 and April 2012. The programme was delivered by local authorities across the city's 32 administrative boroughs with the support of local contractors. During this programme 50,683 homes underwent a RE:NEW home energy visit (GLA and EST, 2013b). This paper will focus on the delivery of RE:NEW in three inner London boroughs.

1.3. The RE:NEW programme

In 2008, the Mayor of London through the Greater London Authority (GLA) committed the city to ambitious climate change targets, asserting that London would reduce its carbon emissions by 60% by 2025, based on 1990 levels (GLA, 2008). In the same year, the average London household was emitting approximately 4970 $kgCO_2$/year (GLA, 2011) which was responsible for 36% of the city's total emissions (15.9 $MtCO_2$). The RE:NEW home energy visit programme was conceived by the Office of the Mayor of London and the GLA, which controls city-wide administration, and was developed in response to this target. The main aim of this programme was to reduce domestic CO_2 emissions in London, whilst helping residents save money on their energy bills (Climate Energy, 2012; GLA and EST, 2013b).

The 'RE:NEW home energy retrofit scheme' involved 'a trained energy advisor' who visited a resident's home and gave them a 'full energy audit, simple energy and water efficiency measures and behaviour change advice' (GLA and EST, 2013b; Mayor of London, 2011d). The visit therefore intended to encourage both curtailment and efficiency behaviours. To encourage curtailment behaviours, information was provided about changes that householders could make to their behaviour 'to stop wasting energy and water' (Mayor of London, 2011d). Curtailment behaviours were also encouraged through the provision of tools such as in-home energy display meters and shower timers.

Efficiency behaviours were encouraged through the provision of a number of 'easy' measures that were provided for free. These easy measures included radiator panels, low energy light bulbs, standby switches, radiator panels, 'save a flush' cistern water savers, tap aerators, garden hose guns, letter box draught-proofers and aerating showerheads (Mayor of London, 2011c). The RE:NEW programme also aimed to convert these home energy visits into referrals and installations of what the GLA termed further measures. These were more substantial and significant structural energy saving measures, such as wall and loft insulation. If householders were interested in these options then they were offered a referral visit to explore these options further, at a later date.

This emphasis on behaviour change was further demonstrated in the RE:NEW Good Practice Manual (Mayor of London, 2011d), which was a guidance document for local authorities delivering the programme. This manual made it clear that along with being an opportunity to install easy energy and water saving measures, a RE:NEW visit was intended to be used as a platform to give 'behaviour change advice [that] will provide customers with a means to reduce their energy and water use and associated utility costs' (Mayor of London, 2011d). In addition the behaviour change element of the programme was eligible for accreditation under the national Carbon Emissions Reduction Target (CERT), a target which obliged large energy companies to support citizens in reducing their emissions. A RE:NEW home energy visit was attributed a carbon score of 0.625 t.

2. Method

This research has strived to better understand the efficacy of the RE:NEW home energy visit programme, and estimate the change in environmental impact of a household, as the result of a visit. This research relates specifically to the period of January to April 2012, when the programme and the delivery of home visits started to gain momentum. The aim of this study was to estimate

the impact of the programme in terms of carbon abated, for a number of households across three inner London boroughs (in total, 118). This research used the measure of carbon abated as a proxy for change in environmental impact, for although carbon abated is not a perfect measure, it is the most appropriate measure currently available for quantifying the impact of projects within the British context (Revell, 2013).

This research was facilitated by three inner London local authorities, herein denoted by the letters A, B and C. Within these three local authority boroughs, up to two wards were selected and targeted for the delivery of RE:NEW visits. These wards, as described by the GLA, were to be 'selected based on the maximum potential for carbon' (Mayor of London, 2011d). However, borough priorities meant that in practice, local authorities selected areas based on indicators such as demographics, tenure and fuel poverty (GLA, 2014).

2.1. Data collection

Practically, the structure of each RE:NEW visit followed the basic outline of surveying the property, providing behaviour change advice, installing easy measures and where appropriate recording referrals for further measures and then installing these further measures (GLA and EST, 2013b). Given the structure of a RE:NEW visit, data collection to inform estimation of the environmental impact of the programme was two-fold. Reductions in carbon could come from two sources, first, the easy measures installed during the visit and as a result of referrals for and installation of more significant energy saving measures and second, as a result of behavioural change.

Data collection on the number of easy measures installed in each household during each visit and referrals for more significant measures, was already built into the design of RE:NEW. This data was collected by the local authorities and utilised in this analysis. Data collection to observe behavioural change was not included in the programme design and there were no monitoring mechanisms in place to record changes in participant's energy use and water saving behaviours. Therefore, this data was collected through a separate panel survey.

2.1.1. Survey design and limitations

The panel survey had two stages. Participants were householders that had received a RE:NEW home energy visit. The first stage was undertaken in March/April 2012, around the time of the home energy visit. Ideally, the survey would have been administered to residents prior to a RE:NEW home energy visit. However, this first stage of the survey was administered just after the home energy visit and this was a constraint on the study. The second stage survey was undertaken in October 2012, six months later. Both stages of the survey sought to obtain a self-reported record of participant's responses to a number of environmentally themed statements, and the frequency with which they undertook a number of energy and water saving behaviours.

Surveys collected responses from participants to five environmentally themed attitude statements (Table 1). Data was also collected on the frequency with which participants undertook five different energy and water saving behaviours. Water saving behaviours were also monitored given the energy use associated with hot water consumption and that the RE:NEW home visit intended to not only encourage energy saving behaviours but also water saving behaviours. These behaviours surveyed are detailed within Table 2. The behaviour and attitude statements were largely adapted from DEFRA's survey of public attitudes and behaviours towards the environment (DEFRA, 2009), which is a survey that has been carried out a total of six times since 1986. The survey items relate to two of DEFRA's priority behaviour groups and five headline behaviours (DEFRA, 2008). The same questions were asked at both stages of the survey.

It was not possible to survey participants prior to the home energy visit because the visits were offered on an opt-in basis. Therefore, it was not known which residents would participate in the programme until the participant had received a visit, especially as the majority of participants (68% of the sample) received a 'by chance' visit, as a result of a house-to-house door knocking exercise. The remainder of the sample obtained a visit by responding to a letter (23%) or by other means of communication (9%). It was not possible to require the contractor to survey participants immediately prior to the visit, for when this study was developed the contracts between the contractor and the local authorities had already been negotiated and agreed.

Once a visit had taken place the contact details of participants were stored with the contractor delivering the individual visits. Therefore, to survey participants the local authority had to request this information explicitly from the contractor, which added a slight delay. As a result, the survey respondents were asked to retrospectively indicate the frequency with which they undertook the pro-environmental behaviours. Specifically, they were asked to

Table 1
Environmentally-themed survey attitude statements.

Item type	Survey statement
Attitudes towards the environment	I find it difficult to change my lifestyle to become more environmentally-friendly (ATT1) I am a 'green' person (ATT2) I think that it is important that we all try to reduce our environmental impact and protect the environment (ATT3) I'm only interested in 'green' behaviour if it can save me money (ATT4) I think there is little point in changing my lifestyle to reduce my environmental impact if others don't do the same (ATT5)

Survey scale: 1=Strongly disagree, 2=Disagree, 3=Neither agree nor disagree, 4=Agree, 5=Strongly agree.

Table 2
Behavioural survey questions.

Headline behaviour (DEFRA, 2009)	Survey question
Better energy management	If I am cold I'll put a jumper on or use a blanket instead of turning up the heating (BEH1) I turn off unused appliances such as televisions and computers and do not leave them on standby (BEH2)
Better energy management and more responsible water usage	I set my washing machine to economy or low temperature cycles (BEH3) I only fill the kettle with the water that I need (BEH4)
More responsible water usage	I try to cut down on the amount of water I use at home (BEH5)

Survey scale: 1=Never, 2=Rarely, 3=Some of the time, 4=Frequently, 5=Always.

'indicate how often you did these actions, prior to the home energy visit'. Although this approach was not preferable, it was the only practical method available, through which data on behaviours at stage one could be recorded. This approach was also preferable to simply asking participants if they felt their behaviour had changed as a result of the visit.

Therefore, both stages of the survey asked participants to recall the frequency of a number of behaviours. A participant's ability to accurately recall behaviour is affected by the type of behaviour that they have been asked to recall, with more mundane and repetitive behaviours being more difficult, and the time elapsed since the event, with more recent events being recalled more accurately (Schwarz and Oyserman, 2001). It is recommended that to aid accurate recall it is best to restrict the task to a short and recent reference period, and use a recall cue; in this case the recall cue was the home energy visit and the event was recent enough that the likelihood of accurate recall is improved (Schwarz and Oyserman, 2001). Therefore, although recall of events does rely on some estimation, given the short time period between the visit and the reporting of stage one behaviours, this method is still suitable for collecting data on behaviour.

Using self-reporting to measure environmental behaviour and attitude in questionnaires is common (Barr et al., 2005; Gatersleben et al., 2002; Whitmarsh and O'Neill, 2010). However, it can be deemed controversial for it does not measure the actual reduction in energy consumption. Some studies demonstrate that self-reported data is an unreliable indicator of actual behaviour with evidence of over-reporting of the extent of conservation behaviours, and weak correlation between actual and reported behaviours (Fuj et al., 1985). However, other studies have found that in relation to energy use, self-reports do correlate with actual energy consumption (Warriner et al., 1984). Indeed, as Barr et al. (2005) mention, in their study that used a similar method of self-reporting, linking energy savings to specific behavioural changes that are habitual in nature, rather than to the structural measures that were installed at the point of the visit, would be near impossible. As a result, self-reports remain a realistic method for collecting data on habitual energy behaviours.

In total, 1500 households (500 households per local authority) were posted a survey. This was decided in collaboration with the facilitating local authorities who supplied the participant information. During the roll-out of RE:NEW, the three facilitating local authorities visited approximately 4400 homes in total. Therefore, the 1500 surveyed represented 34% of those receiving a visit. This sampling figure also supported estimations of a sampling error of 10% and response rate of 10%, by the end of stage two. At the end of stage one, 335 households completed and returned the survey and at the end of stage two, 157 households completed and returned the survey (47% response rate on sample of 335, 10% response rate compared to original sample of 1500). After data cleaning, the useable number of surveys returned was 118 (8% compared to original sample).

2.2. Data analysis

As discussed, the impact of the home energy visit is two-fold. Therefore, data analysis intended to first, estimate the carbon impact of the small easy measures installed during a visit and second, assess the impact of behavioural change. When the impact of the small measures and the reported behaviour change were summed together, the total carbon impact of the visit for each household could be estimated. This approach therefore evaluates the visit from an 'impact' oriented perspective (Stern, 2000). The advantage of this approach is that it observes and quantifies changes in behaviour and the installation of small measures in terms of environmental significance.

It is worth saying at this stage that this method has intended to give an indication of the environmental impact of changes in energy and water consumption for each sample household over a six month period following a home energy visit. This impact is as a result of both the installation of easy measures during a visit and any reported behavioural change. This study does not intend to give a complete and highly accurate picture of the impact of a visit, for that is not possible. Instead, the calculations here have enabled estimation of the carbon impact of each visit for each household in the sample and have been based on the most realistic and practical estimates available. This is in an effort to progress our understanding of the impact of home energy visits and their efficacy in terms of abating carbon.

2.2.1. Estimating the carbon impact of a RE:NEW visit

In practice, carbon factors were attributed to each easy measure installed in each home in the sample. This was coupled with data on the number and types of measures installed during each visit, which was supplied by the local authorities, to give an estimate of the carbon impact resulting from the installation of easy measures. The carbon values are based on a number of existing literature sources (see Table 3).

Table 3
Carbon and water savings attributed to easy measures.

Easy measure installed	Carbon and water savings		Source of information
	$kgCO_2$/year	Litres H_2O/property/yr	
CFL/lightbulb	6.74	0	Mayor of London (2011b)
Tap aerator	33.00	7,000	EA and EST (2009)
Radiator panel (solid and uninsulated cavity walls—type 1)	4.13	0	OFGEM (2008)
Radiator panel (all wall types, including insulated—type 2)	2.48	0	OFGEM (2008)
TV and PC standby switch	22.18	0	OFGEM (2013)
Real time monitor	64.40	0	OFGEM (2013)
Save a flush	3.41	4,563	Ofwat reported savings within (Mayor of London, 2011a)
Showertimer	6.91	913	Ofwat reported savings within (Mayor of London, 2011a) and (EA and EST, 2009)
Showerhead	82.93	10,950	Ofwat reported savings within (Mayor of London, 2011a) and (EA and EST, 2009)
Letterbox draught proofer	79.86	0	Mayor of London (2011b)
Garden hose gun	0.55	730	Ofwat reported savings within (Mayor of London, 2011a)

Estimating the impact of the behavioural changes was less straightforward, but using a number of existing literature sources and estimation, a total potential saving for each energy and water saving behaviour was reached. See Table 4 for information on the assumptions, information sources used and the carbon impact of each behavioural change. The carbon impact of a reported 'change in behaviour' was calculated using this information, coupled with survey data. The 'change in behaviour' refers to the difference in reported paired frequencies of behaviours between the first and second stage of the survey. Table 4 details the maximum potential carbon saving, which occurs if the frequency with which a particular behaviour was undertaken changed from 'never' to 'always'. Reported changes captured by the survey were attributed a carbon value that was calculated based on the extent of the reported behaviour change and the size of this maximum potential saving.

Finally, further analysis was undertaken to ascertain if the home energy visits had an impact on the frequency with which participants undertook the five energy and water saving behaviours. This was undertaken using the Wilcoxon signed-rank test (Wilcoxon, 1945) which can be used to ascertain whether the reported 'change in behaviour' was significant. The test is effectively a pre-post-test on the paired results of each participant. Further analysis was also undertaken to identify whether any relationships existed between the extent of reported behavioural change and attitudes towards the environment. This was done using hierarchical cluster analysis, using Ward's method. Participants were clustered according to the responses that they gave to the environmentally themed attitude statements at stage one. Non-responses on these five questions led to a reduction in the sample size ($n=112$).

3. Results and discussion

The impact of a home energy visit has been calculated as the sum of the estimated carbon saving from the installation of easy measures plus the estimated carbon saving as a result of reported behavioural changes. Carbon savings from the installation of significant measures were omitted due to the very low number of referrals. For the 118 households in the sample, the average carbon impact of a home energy visit was estimated to be 145.6 $kgCO_2$ per household per year. The breakdown of these results can be seen in Table 5.

Differences in the behavioural score between the three local authorities were observed, yet further analysis using the Kruskal–Wallis test (Field, 2009) found the difference between the mean carbon saving for each local authority to be insignificant, $H(2)=1.48$, $p>0.05$. As was the difference in the carbon abated as a result of the installation of easy measures and as a result of behavioural change. However, this is not surprising as all local authorities would have received the same guidance from the GLA.

3.1. Easy measures

In relation to the easy measures installed during the visit, the most significant measures, in terms of abating carbon, were letter box draught proofers, low-flow showerheads and real time energy use monitors (see Table 3). These three easy measures were installed in 10%, 55% and 67% of homes in the sample, respectively. In addition, 66% of homes had TV or PC standby switches installed, 61% had CFL light bulbs, 31% of homes had tap aerators installed and 36% of homes installed radiator panels.

Analysis demonstrated that on average, the estimated carbon saving as result of the provision of easy measures during a visit was 144 $kgCO_2$/year. This equates to an annual average reduction in household carbon emissions of approximately 3%. This is based on the assumption that the average London household emits 4970 $kgCO_2$/year (GLA, 2011).

In terms of the method of estimation, there were limitations on the method. One of the key limitations was that the estimation of

Table 5
Average carbon abated after RE:NEW visit.

	Average water saved from easy measures (l/household/year)	Average carbon abated from		
		Easy measures	Behaviour change	Easy measures and behaviour change
		($kgCO_2$/household/year)		
Local authority A	12,059	158.8	1.2	160.0
Local authority B	9,109	144.2	−25.7	118.5
Local authority C	12,081	130.9	17.1	148.0
All	11,393	144.1	1.5	145.6

Table 4
Carbon savings attributed to behavioural change.

Behaviour description	Information and assumptions informing calculation	Potential total carbon saving if frequency of behaviour changed from 'never' to 'always'	Source of information
If I am cold I'll put a jumper on or use a blanket instead of turning up the heating (BEH1)	Turning down thermostats by 1 °C 15 m homes saves 4.1 $MtCO_2$ in the year 2022	273 $kgCO_2$ per household year	Parliamentary Office of Science and Technology (2012)
I try to cut down on the amount of water I use at home (BEH5)	Three actions including I 'wash up in a bowl instead of under a running tap', 'I turn tap off whilst brushing teeth' and 'I use the washing machine to do 3 loads a week instead of 4' can save 180 $kgCO_2$ per person per year	180 $kgCO_2$ per person per year	EA and EST (2009)
I turn off unused appliances such as televisions and computers and do not leave them on standby (BEH2)	Average standby power in the home is 1.5 kW h/day which equates to a total standby consumption of 294 $kgCO_2$/year	294 $kgCO_2$ per household year	DEFRA (2012), EST et al. (2012)
I set my washing machine to economy or low temperature cycles (BEH3)	Washing clothes at a lower temperature in 8 m homes saves 0.3 $MtCO_2$ in the year 2022	37.5 $kgCO_2$ per household year	AEA Technology Plc (2008), Parliamentary Office of Science and Technology (2012)
I only fill the kettle with the water that I need (BEH4)	A kettle is assumed to use 0.085 $kgCO_2$ per full boil. The average size of a kettle is 1.7 l. Assuming the kettle is overfilled by 1.3 l, twice daily, energy wasted equates to 47.5 $kgCO_2$/year	47.5 $kgCO_2$ per person per year	Berners-Lee (2010)

carbon abated, from the installation of easy measures, was based on pre-existing published figures (as shown in Table 3). As a result, the extent to which these figures incorporate and model realistic installation rates is uncertain. However, from the information that is available it seems sensible to conclude that the figures used are based on the assumption that all measures are installed and put to use, except in the case of shower timers which had an estimated installation rate of 50%.

However, in practice, it is unlikely that all measures provided were installed. This will be as a result of the limited length of each visit, which was on average between 40 min and 1 h, making it unlikely that advisors would have the time available to install all measures during the visit. For example, during a visit, tap aerators and shower heads may be installed, along with an energy use monitor and a demonstration of the installation of a radiator panel but it is unlikely that an advisor would have time to install each measure during the visit. In addition, some of the measures may be later removed by householders who find them inconvenient or unhelpful.

There would also be a lack of time for the advisor to explain how the home energy use monitor worked, or to speak in more detail about the specific benefits of each easy measure provided. Not being able to install all measures provided at the point of the visit is a limitation on the effectiveness of the visit. This ambiguity as to the actual extent of installation of easy measures is also a limitation on the study, for it means that only indicative estimates of the impact of the easy measures provided can be calculated, based on the assumption that all measures provided were installed. This is likely to lead to an overestimation of the impact of the installation of the easy measures.

3.2. Significant measures

Despite tailored information being provided to householders, referrals for significant measures such as loft and wall insulation, to further reduce energy consumption and associated carbon emissions, were limited. Overall, one referral was made for cavity wall insulation and five future referrals were recorded for cavity wall and loft insulation. For the scheme overall, 1 in 10 referrals leads to the installation of further measures (GLA, 2014). Potential reasons for the limited number of referrals are manifold. As a result, estimations of the carbon savings from the installation of significant measures were assumed to be negligible.

Advisors also offered advice to encourage householders to adopt efficiency behaviours and make structural changes to their homes. The provision of this advice was recorded and 10% of households were given advice on DIY insulation with 17% of households being given advice on solid wall insulation. 17% of households were given advice on secondary glazing and only 9% of households were given advice on renewables. Therefore, the extent of advice given on more structural measures was rather limited. One reason for this may be that the advisor had asked the householder about the tenure of their property, and if they ascertained that it was rented, then they may have assumed that the householder had limited control over structural changes, and therefore felt it was not worthwhile to discuss such significant measures. For, on average, 61% of the residents in the sample live in rented accommodation (privately, council or RSL), which is higher than the London average of 49% but slightly less than the borough average of 65%.

Given this, many of these tenants would have limited control over the fabric of their homes and may not have the ability to make significant structural changes to the property, such as installing insulation. In addition, they may be disincentivised from investing financially in such measures as they do not own their homes. Second, the majority of participants in the study lived in flats or maisonettes, 66% and 13% respectively. As a result, many of these homes would not even have lofts, as they could be located between other flats. In addition, insulation of walls may require negotiation between neighbours. Finally, high rise flats with 6 stories or more are seen as particularly difficult to insulate, and are deemed as hard-to-treat (Dowson et al., 2012).

A further barrier to insulation is that London has the highest proportion of hard-to-treat properties in England, with 58% of properties being solid-walled (Centre for Sustainable Energy, 2011). Within this study, 64% of homes were solid-walled and 32% had cavity walls. This means that the cost of insulating these buildings will be significant. In addition, given that 48% of the buildings in the sample date from pre-1900, a number of these homes are likely to be listed with National Heritage or situated within conservation areas, which means that solid wall insulation will only be possible on the interior of the building, rather than the exterior.

Finally, it was observed by council officers that much work had already been done in these boroughs to insulate cavity walls and lofts, where possible. Therefore, prior to the project, it was mentioned by officers that they thought it was unlikely that many visits would lead to the installation of these measures. When coupled together these factors may have led to a low conversion rate from home energy visit to referral and to the installation of significant measures.

3.3. Behaviour change

Despite the provision of behaviour change advice and tailored information being part of the RE:NEW home energy visits, on average, the visits did not have an impact on the frequency with which programme participants undertook a number of curtailment energy saving behaviours. Analysis using the Wilcoxon signed-rank test found that the frequency with which the sample group undertook the different energy and water saving behaviours, before the visit, and again at a period of six months later, was not significant (see Table 6).

These results, coupled with the results of the individual household behavioural analysis, which demonstrated that estimated average carbon saved as result of behavioural change was negligible at 1.5 $kgCO_2$/year, suggest that it is reasonable to conclude that the home energy visits did not have a significant impact on participant's energy and water behaviours. Potential reasons to explain this observed lack of behaviour change are many.

First, the information to encourage curtailment behaviours may have been too generic due to a lack of training and expertise of the advisors. Second, the provision of information may have been too limited and not targeted. It was recorded that on average less than half of householders (46%) were given advice on using their heating controls and less than a quarter (19%) was given advice on understanding their bills. Third, it is relatively well established within the academic literature that the provision of generic

Table 6
Result of analysis on reported frequency of behaviour change, at stage 1 and stage two, using the Wilcoxon signed-rank test.

	Mean		Median		Sum of ranks (T)	Significance (p)	Effect size (r)
	Stage 1	Stage 2	Stage 1	Stage 2			
BEH1	3.93	4.00	3.96	4.00	676.00	0.532	−0.041
BEH2	4.54	5.00	4.44	5.00	163.00	0.234	−0.081
BEH3	4.23	5.00	4.30	5.00	285.00	0.627	−0.035
BEH4	4.50	5.00	4.54	5.00	223.50	0.626	−0.033
BEH5	4.29	5.00	4.20	4.00	419.00	0.253	−0.078

information to increase knowledge and awareness, does not necessarily lead to pro-environmental behaviour (Burgess et al., 1998; Kollmuss and Agyeman, 2002; Peattie, 2010).

3.4. Cluster analysis

As mentioned, cluster analysis was used to group the sample based on their attitudes towards the environment at survey stage one. This analysis generated three clusters. The first cluster was characterised by respondents who identified themselves as being 'green', and with an ability to change their lifestyles to become more environmentally-friendly. They also strongly believe that it is important that the population all try and reduce their environmental impact. The second cluster was similar to the first and was characterised by respondents who generally identified themselves as being 'green', though this was to a lesser extent than in cluster one. In addition, this group did not necessarily feel that they had the ability to change their lifestyle to become more environmentally-friendly, with more than half of respondents identifying that they find it difficult. This cluster did believe that it is important that the population all try and reduce their environmental impact but more than 20% identified that they are only interested in pro-environmental behaviours if they can save them money.

The third and final cluster was characterised by respondents who did not identify with being 'green' and over 60% described themselves this way. This cluster did feel that they have the ability to change their lifestyles to become more environmentally-friendly, though whether this ability is exercised is unknown. All respondents identified that they believe that it is not important that the population tries to reduce its environmental impact and most identified that they felt strongly about this.

Analysis was undertaken on these three clusters to identify whether one group opted for the installation for more small energy saving measures than another, or whether one group changed their behaviour to a greater extent, compared to the others. The results of this analysis are detailed within Table 7. There was limited difference between the clusters, in terms of the carbon and water saved as a result of the installation of easy measures. However, of interest is the difference between clusters in terms of the carbon saved as a result of behaviour change, which suggests that there may be a link between people's attitudes towards the environment before a visit and the efficacy of a home energy visit, in relation to behaviour change.

When looking at the cluster agglomerations, the amount of carbon saved as a result of behaviour change, for cluster one and two, is slightly negative and could be considered negligible. However, the average carbon saving as a result of behaviour change for cluster three is very large at 106.6 $kgCO_2$, this represents over 40% of the total carbon saved in this cluster. However, despite this apparent difference, further analysis between clusters, using the Kruskal–Wallis test, found the difference between groups, in terms of the carbon abated as a result of behavioural change, to be statistically insignificant, $H(2)=3.24$, $p>0.05$. This is because the third cluster was very small and comprised of only 8 people.

These results are therefore interesting but they are inconclusive and there is a need to be cautious about these results, given the small size of this cluster (8 in 112). However, these findings indicate that this could be a potential area for future research and if proven to be accurate then this finding could be used to improve project performance and impact by targeting less environmentally-inclined citizens during pro-environmental behaviour change programmes.

4. Policy recommendations to improve visits

The RE:NEW programme and the specification of the visit were conceived at City Hall and were based on a policy intent of reducing carbon emissions, rather than as the result of demands or expressed desire from residents. As a result, the appetite for the programme, from householders, was questionable. A number of local authorities found it difficult to obtain the desired penetration rates and in fact one of the local authorities in the sample did not manage to meet their target number of visits.

To overcome this potential lack of appetite, incentives were used. The visit was free and householders were given free energy saving measures that were likely to generate modest savings for residents, on their fuel bills. However, despite these efforts, the findings of this research demonstrate that the effectiveness of visits could be improved. As a result, this study has led to the identification of improvements that may increase the effectiveness of the home energy visit. The summary evaluation report of RE:NEW, and the final evaluation report published in February 2014, also identify a number of recommendations and these are discussed here (GLA, 2013b; 2014).

4.1. Time constraints on visits

First, one of the limitations of the home energy visit was the time constraint on visits. Visits generally lasted about an hour and this was due to a number of reasons. Most of the advisors were employed as contract workers and were paid a fixed price for each visit delivered. The intention of this was to incentivise advisors to complete more visits, because as the RE:NEW post-evaluation report notes the 'delivery of RE:NEW emphasised achieving the home visit target and achieving a high penetration rate of home visits' (GLA and EST, 2013b). However, in reality this meant that there was a focus on the number of visits delivered, rather than the length or quality of the visit. As a result, visits were short in length and this was compounded by the fact that advisors had to pay for local car parking. A car was necessary due to the easy measures they had to carry with them. This constrained the visit and meant that advisors could not run over the allocated time or they would receive a parking fine.

In addition, the short visit length meant that advisors did not have adequate time to install all of the easy measures provided during the visit. Therefore, to improve the likelihood that measures provided remain installed after the visit, and will continue to deliver their assumed carbon savings, it is recommended that all measures be installed at the point of the visit by the advisor. In addition, it is recommended that the advisor be specific about the benefits of each measure, to encourage householders to keep

Table 7
Average carbon abated per household reported by cluster.

	Cluster 1	Cluster 2	Cluster 3	All participants
Average water saved from easy measures (l/year)	12,254.5	9518.7	12,199.7	11,393.0
Average carbon saved from easy measures ($kgCO_2$/year)	147.3	139.6	145.7	144.1
Average carbon saved from behaviour change ($kgCO_2$/year)	−6.6	−9.0	106.6	1.5
Average total carbon saved ($kgCO_2$/year)	140.7	130.6	252.3	145.6

using them. These recommendations are in agreement with those of the GLA who recommend that future visits should set targets based on carbon targets, rather than the number of visits delivered (GLA, 2014).

This is likely to lead to visits lasting longer and therefore it is also recommended that visits be allocated more time or be delivered by more than one advisor. In addition, to improve the estimation of the carbon impact of the easy measures provided, it is suggested that follow up monitoring be undertaken at reasonable intervals after the visit, to observe and record the extent to which measures remain in place. This information could then be used to improve the evaluation and give a more accurate estimation of the carbon impact of the easy measures. In addition, monitoring of electricity and gas consumption prior to the visit and after the visit would allow further investigation into energy use consumption patterns. However, it would still be challenging to link any changes in consumption patterns to specific behavioural changes or to the installation of specific easy energy saving measures without enhanced monitoring (beyond household metering).

4.2. Expertise and training of energy advisers

The effectiveness of visits, specifically in relation to encouraging the adoption of curtailment behaviours, was limited by the expertise of the 'energy advisors' who had inadequate training prior to delivering visits. As mentioned, energy advisors tended to be temporary contract workers and as a result, the investment in their training was limited. It was concluded in the RE:NEW post-evaluation report that future programmes should 'consider a more effective, focused programme of training for Home Energy Advisors to ensure accuracy of in home assessments and opportunities for installations' (GLA and EST, 2013b).

This research concludes that it may be more beneficial for the council to employ advisors directly, to ensure that the quality of training is adequate. Local authorities could provide training that is sensitive to local residents needs and directed at the prevalent housing types within the borough. This would lead to more informed recommendations of appropriate measures that could reduce emissions and fuel bills.

In addition, as long-term staff develop their skills and knowledge they will be able to provide better, more area specific, tailored information. Also, if advisors are long-term employees of the local authority then they may have a greater vested interest in learning and developing their skills to be effective advisors, if they have the possibility of developing their careers further within the local authority. However, although the GLA observe that a 'higher level of staff training would be beneficial' they do not go as far as these recommendations, instead they identify that it would be helpful to 'link the day-to-day delivery of RE:NEW with other council activity' (GLA, 2014).

Finally, training in the giving of behaviour change advice i.e., how to tailor information, induce commitment and frame the recommendations, would improve the likelihood that householders will act on advisor's advice and install more significant measures (Gonzales et al., 1988). For it is clear from these results, that presently, the provision of information under the current programme has no effect on behaviour. Therefore, if adequate training is not provided, it is unlikely that behavioural change will be observed in home visits that operate similarly.

4.3. Targeting of visits

In relation to penetrating different sectors of the society, the RE:NEW participants were not necessarily representative of the ward. Study participants were more likely to be females and in households of multiple occupancy and with children. Council and RSL owned properties were also overrepresented. This is most likely as a result of the times of the visit. Visits were generally undertaken during regular working hours and given the focus on achieving the home visits target, and that the most prevalent method of recruitment was door-knocking, the advisors tended to target areas where they thought people would be at home. This is likely to have led to an overrepresentation of these groups. To counter this, out-of-hours door knocking could reach more groups.

This finding was also observed in the RE:NEW post-evaluation report, which noticed that 'in some cases delivery agents focused delivery of visits to social housing properties because this met the council's fuel poverty objectives and they were more likely to respond during daylight hours' (GLA and EST, 2013b). However, these visits were not necessarily co-ordinated with the landlords and this meant that in over 70% of the visits to the sample groups in local authorities B and C, the householder receiving the visit was living in rented (privately, council or RSL) housing and did not have control over the potential to install further measures.

4.4. Agreement and alignment of aims

Finally, the GLA and the local authorities were focused on achieving different outcomes from the RE:NEW visits. For the GLA, the focus of the visits was on reducing carbon emissions, whereas for the local authorities, the focus was on reducing fuel poverty, but these differing aims are not necessarily complementary (GLA and EST, 2013b). The evaluation report of RE:NEW observed that a balance needs to be struck 'between achieving carbon saving and alleviating fuel poverty' (GLA and EST, 2013b), yet these aims are contradictory. Both reducing carbon emissions and reducing fuel poverty are important political aims but this paper suggests that they should not be sought in the same project, for what is most effective at delivering reductions in environmental impact, is unlikely to be most effective at reducing fuel poverty.

If an impact-oriented approach is taken to reducing carbon emissions then the focus of home energy visits may better placed be on high energy consumers, who are likely to be from more wealthy neighbourhoods (Druckman and Jackson, 2008) and home-owners who will have the control over their properties to make structural changes. Though using tax-payers money to fund such work is unlikely to be politically acceptable, therefore an alternative would be to work with social landlords directly to deliver structural changes and reduce energy consumption. This is an improvement that has been taken forward by the GLA, who now assert that they intend to 'move away slightly from the individual property door-knocking exercises' and towards 'much more strategic engagement with the major landlords' in on-going RE:NEW work (GLA, 2013a). They have also identified that they need to bring both the priorities of the GLA and the local authorities into greater alignment (GLA, 2014).

5. Conclusion

This evaluation of the carbon impact of the RE:NEW home energy visit programme, for 118 households, from three inner London boroughs, identified that the greatest carbon savings achieved during these home energy visits occurred as result of the installation of easy energy saving measures. Negligible savings were achieved as a result of the installation of significant measures. The impact of the visit on energy and water saving behaviours were also negligible. Overall, for these households, the impact of a visit led to an estimated average reduction in annual household emissions of 3%.

In the final evaluation report of this roll-out phase of RE:NEW by the GLA, it was identified that 'residents will be making savings

based on the behaviour change advice provided during visits' and that these savings had not been incorporated into their results (GLA, 2014). However, this study demonstrates that on average, the RE:NEW home energy visit did not cause the frequency with which participants undertook different energy and water related pro-environmental behaviours to change to any significant extent. Therefore, these visits do not overcome the barriers to behaviour change. In addition, RE:NEW visits do not overcome the barriers to the installation of more significant measures, such as loft and wall insulation.

Given this, a number of potential improvements to the scheme were identified. These include providing longer and more tailored visits that are delivered by better trained staff that are specifically trained in giving behaviour change advice. It is also recommended that all easy measures are installed at the point of the visit, and their benefits explained to householders. In addition, it is likely to be beneficial to work with social landlords to increase the uptake of significant measures. Finally, the GLA should work with local authorities to identify the most suitable locations for delivering visits, to achieve the largest environmental impact from the programme.

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