Splendid Isolation: How Occupants Might be Affecting Projected Energy Measure Performance

John Fawcett, Databuild Research and Solutions Ltd, Birmingham UK

Abstract

Across a number of programmes, in-home monitoring and testing are sometimes revealing a disparity between the anticipated and actual performance of household energy efficiency and micro-generation measures.

As part of our evaluation of recent government-funded retrofit schemes, occupancy evaluation was conducted to inform and explain physical monitoring data. This comprised surveying and observing occupants in homes which had been improved, to understand how they live in the property and how far this complements maximising the performance of the measures i.e. how they operate active measures and how their behaviour might affect the performance of passive measures.

Drawing upon examples from the research, this paper will explore:

- The different - and sometimes surprising - ways in which occupants behave in retrofitted homes;
- How (though not the extent to which) this behaviour could affect measure performance;
- Why such behaviour arises – in particular, the influence of householder demographics;
- How the situations and behaviours identified might best be managed / avoided.

The paper will give evaluators, programme and policy designers an important insight into the various ways in which measure performance can be affected by occupants, helping them to consider the variables that affect project impacts and therefore enable more accurate assessment of impact, and establishment of appropriate mechanisms for minimising sub-optimal behaviours.

Background to the initiatives and the evaluations

The paper draws principally upon our evaluations of two initiatives. The table below provides an outline of these programmes and our methods of evaluating them:

	Programme 1	Programme 2
Type of assistance	A pilot programme providing up front financial support and installation to home-owners for domestic energy efficiency and micro-generation measures.	A pilot programme providing financial support to social landlords for whole-house retrofit of properties, comprising domestic energy efficiency and micro-generation measures.
Timing	Pilot commenced in 2009 and completed in 2011.	Pilot commenced in 2010 and is still being delivered.
Audience	Principally owner-occupied detached or semi-detached housing in five limited pilot areas. In total, 311 households participated. The householders met the cost of the works and in all cases actively signed up. They were generally engaged with energy efficiency messages and behaviours. Most present throughout the works.	Social rented housing occupants across the UK. In total, 115 properties – a mix of detached, semi-detached and terraced - were included. The householders did not meet the cost of the works; although their approval was obtained by landlords, most did not actively seek to participate. They were not necessarily engaged with energy efficiency messages. Two thirds of properties were already occupied; of these, in almost half the occupants were decanted for the duration of the works.
Types of measures installed	• Micro-generation: solar PV panels, solar hot water systems, biomass boilers, ground-source heat pumps, air-source heat pumps. • Insulation: external and internal solid wall insulation, cavity wall insulation, draught proofing, loft insulation, window glazing (with filters) • Other: energy efficient boilers, lighting, other bathroom and kitchen appliances, heating controls and display units e.g. Smart Meters and	

	PV generation display units.	
Pilot and evaluation aim	To understand audience preferences, process challenges, and the viability of such schemes for commercial providers.	To understand the performance of innovative technology in the domestic setting, process challenges, and the challenges of such schemes to inform decisions around future similar initiatives.
Evaluation approach	Quantitative and qualitative telephone interviews with, participant householders, non-participant householders and pilot providers. Qualitative interviews enabled more detailed scenario testing with customers, beyond the standard satisfaction data obtained through the quantitative interviews. Data collection was conducted concurrent to the delivery of the pilot across three phases. In total, 182 households were covered in the evaluation (though some on multiple occasions).	Initial telephone interviews with landlords and occupants, followed by visits to participant properties and full walkthroughs. The latter were intended to provide more observable information concerning how well the technologies were working in the properties and how the occupants were interacting with them. Visits – sometimes including built environment academics - took place 3-6 months after works were completed, and were supplemented by participants completing 'diaries' of energy use. The evaluation is ongoing; currently 70 properties have been visited.
	Neither evaluation comprised collection of physical monitoring data (this is expected later in 2012) and so quantification of the effects of occupant behaviours / circumstances is not included in this paper.	

Issues identified

Occupant attitudes and behaviours that could be affecting measure performance are outlined in this section. Some are specific to particular technologies; others could affect total energy use in a much more general way. Yet each should inform the thinking of programme designers, policy makers and impact modellers in planning retrofit and eco-home programmes, and in considering the assumptions that underpin projections of programme impact.

Occupants: who and how many?

The numbers and types of occupant will affect not only the volume of energy being consumed, but also the types of appliance and use of the energy saving and renewable energy measures. Observed examples include:

- More people in the house increases solar hot water use (so the hot water runs out and people resort to the old boiler) and may require more air filtering (the house becomes too hot for the ventilation systems to cope with and doors / windows are opened).
- Younger people tended to have more energy-consuming gadgets and appliances.

However, it is sometimes very difficult to be certain about the precise numbers of occupants; key questions for evaluators are:

- How to establish and account for fluctuations in occupant numbers: examples encountered included partners who do not live in the same property, children staying with separated parents for parts of the week, friends - including those of any children - and family coming to stay. Other changes included children returning from college / university and individuals working away / abroad for long periods.
- Whether to account for pets; they can affect air-tightness through people leaving doors open for their pets to get in and out, or for air quality.

It can seem simplistic to make assumptions around how particular types of people will behave, use energy and interact with particular measures. However, the research has indicated that modelling stereotypes around demographics is not without some credence; here are a few examples:

- Older people also tend to be less confident with active / controllable measures / display units.
- Older people do seem to like their homes warmer (and will tend to override the preferences of younger occupants). Similarly, households with babies / infants seemed to prefer their properties to be consistently warm, even beyond their own comfort level.

- Older people also seemed more likely to be engaged with a culture of frugality with regards to energy use. However, their perceptions of their good behaviour and their actual behaviour did not always align, and there is a general shift towards not wasting energy.
- Properties with children and teenagers tended to have considerably more appliances person. One family of two adults and five children had multiple gadgets in separate rooms, including PCs, laptops, and games consoles etc. As well as high energy use, this also increased the temperature of the rooms where those gadgets were used; the teenagers complained that their bedrooms were too warm.
- Ethnicity does affect sensitivity to temperatures and so the temperatures and timings adopted for the heating the property.
- Where occupants have long term health issues, this invariably affects what they consider as 'comfortable' and their ability to operate / control measures. Disabled or less mobile occupants felt the cold more and required the heating on more regularly and for longer periods of time.
- Households with smokers generally had doors and windows open - even in Winter - for the sake of convenience, even where window filters were retrofitted.

Unintended outcomes of the actual measures

Some installed measures themselves have led to sub-optimal behaviour and energy consumption; examples of this are outlined below:

- Sometimes, a measure designed to improve one aspect of comfort can then impinge upon another aspect of comfort, leading the occupant to do something to address this which then increases consumption. For example, the temptation in the UK is to develop packages of measures which maximise air-tightness and avoid occupants being too cold. However, several properties over-heated during the summer because of the insulation and the air tightness measures; occupants had to keep all windows and doors open for most of the day. A different example is of radiators being taken out (in place of another heating source such as ground source heat pump or underfloor heating) and families therefore struggling to get washing dry, so using a tumble dryer more frequently.
- Where equipment – e.g. thermostats - comes with active controls, these can be problematic in two ways:
    1. Occupants are not confident in adjusting them, even when existing settings might be making the property uncomfortable.
    2. Occupants end up changing settings in a way that inadvertently increases energy consumption.

- Measures can be installed in a way that means they cannot be used and managed e.g. where Mechanical Ventilation & Heat Recovery (MVHR) filters are used, these filters eventually need to be replaced. But for some occupants, filters were placed in lofts / attics and were very difficult to get to, even for checking up on the need for replacement. They may then not bother and the measure will become less effective. In addition, some householders did not know how to change the filters.
- One household had so much monitoring, control and display equipment in their property that they were convinced their electricity bill had actually increased. There were also two examples where properties with air source heat pumps had very high electricity bills – although it isn't clear that there is a definite link.
- Where display units are not working or are difficult to comprehend, occupants can lose confidence that the measures are working, and resort to old habits e.g. in one property, occupants had reverted back to switching the boiler on because they were not confident that the solar hot water was working / meeting their needs. One set of occupants kept trying to control heating within the property but the controls kept reverting to default settings. In a handful of cases occupants said it took so long for the heating system to be effective e.g. warm up or cool down, that they had to anticipate what the weather / temperature was going to be like 1-2 days in advance.

Installer and occupant understanding

For some installations, lack of understanding as to how the different technologies work and interact has led to situations where energy performance could be affected.

Issues with the quality of guidance given to occupants were widespread, with many occupants being given a brief tour of a number of technologies – sometimes on the day they moved back in - of the installed measures and then being given very technical installer manuals to answer outstanding questions.

Where unreliable advice (or no advice) is received, occupants had a tendency to do nothing (and occasionally ended up addressing issues in an energy intensive way). Alternatively, some asked individuals who they trusted for advice – e.g. friends or relatives – even though these individuals were not necessarily qualified to do so.

Lack of proper briefing for occupants also led to comfort issues - several believed that they should not open windows when using MVHR, therefore resulting in the property being intolerably hot.

On rare occasions, where multiple contractors were working on the same property, installers could compromise each other's work e.g. in one property, the contractors who were restoring external features such as back gates ended up drilling through the wall insulation.

Circumstantial Changes

Follow up of participants in one of the evaluations showed that a wide range of circumstances will alter within a year since installations are completed, many of which will have a profound effect upon actual energy consumption compared to that originally projected / modelled:

- 40% changed their energy supplier or tariff. Of these, 10 had changed only their tariff and 6 had switched energy supplier entirely.
- 40% had installed energy efficiency or renewable measures additional to those funded by the programme. Improvements ranged from simple energy saving measures (such as draft proofing) to complete refurbishments.
- 33% had been away from the property for a total of two weeks or more during the year of data collection.13% mentioned that the working patterns of some members of the household had changed over the course of the year; in four cases this led to the house being occupied more than previously, and in one case the house was occupied less as a result.
- Two respondents mentioned that the number of occupants had changed or fluctuated at some point in the year:

Implications for programme managers / designers

There are two sets of implications arising from the issues highlighted above:

- What do policy makers and energy performance modellers / forecasters need to be thinking about in assessing the potential impact of programmes?
- What can be done to address some of the sub-optimal outcomes being identified in the evaluations?

Predicting programme / retrofit impact

Occupancy evaluation experiences have shown that any modelling or forecasting of energy performance of measures in a property needs to take account of a wide variety of variables, in particular around the demographics and energy use needs of the occupants and property users.

This raises questions for those conducting physical monitoring: from what assumptions are savings factors for retrofit projects being derived, and how far are the data listed here being collected and used to inform and refine savings factors? The latter is particularly important in light of important circumstances changing with high levels of frequency.

Ongoing surveying and data collection – especially wider monitoring as more and more properties are retrofitted - could enable an 'average' or 'typical' performance factor for each measure, but these could also have formulae allowing variances depending upon circumstances relating to the variables outlined above.

Further data collection and modelling of variances would not only help to more accurately / realistically assess the potential impact of retrofit and eco-home programmes, but could lead to assessment of how programmes are designed and implemented i.e. capturing likely impact before doing anything.

Minimising sub-optimal outcomes

Issues regarding occupant handover and understanding provide a number of things for programme designers and managers to consider:

- Ensuring good advice and handover for occupants:
  - It should cover how measures work, what occupants can and shouldn't do, how what they do affects measure performance and who to go to for further information.
  - Occupants should not be left to chase information and shouldn't just be given the installer manual. Occupants expressed a preference for being talked through the measures and most said that they struggled to understand the technical literature.

    - Thought needs to be given as to who provides the advice; is it realistic to expect contractors to be experts on each measure? Most occupants wanted a consistent project manager to answer queries throughout the process.
    - Thought needs to be given as to when advice is provided i.e. the day on which the occupant returns to the property (if they have been decanted) is not ideal.
- Ensuring that disruption from the installation process is minimal and that works quality is good: it is important to avoid occupants becoming immediately disengaged by ruining their house and making them dislike or distrust the measures (e.g. ripping up the garden, losing hot water etc). This can be further exacerbated by the need for workers to come back to repair poor work. A full check of works post-installation is a way to ensure that measures have been properly installed.
- Similarly, installer expertise should be ensured in advance of recruiting them for installations. There are a number of accreditation schemes developing which are intended to ensure installer reputability.
- The range of issues arising from a large number of measures affecting each other's performance (and proving complicated for the occupant(s)) raises the question of whether or not there is an argument for doing less and doing it better?

Evaluation experiences

For one post-installation evaluation in particular, the approach taken – property visits and walkthroughs followed by energy use diaries - was very intensive and unusual; it produced a number of interesting observations on occupancy evaluation:

- A visit is preferable if it's affordable or practical; what people do and what they say they do can be very different (e.g. respondents would talk about how careful they were with energy use whilst leaving the TV on during the interview). You can observe the occupant and see the unusual in what they think is typical. You are also reminded that there is no typical householder.
- If you can, wait for physical monitoring data before interviewing occupants. The lack of monitoring data was a significant challenge in tailoring occupancy evaluation interviews to important issues. Monitoring data helps to provide the conversation with some structure i.e. focusing upon spikes in energy use.
- Try to be impartial and consider how occupants might be influenced. As evaluators, we generally want to observe rather than influence, yet some questions are fraught with potential to affect the way in which they perceive, use and interact with measures.
- Incentives are important; we are asking to come into someone's home and disrupt their day. Participants will put up with a lot if they are expecting some incentives. Though these should be attached to conditions, especially where you might need further feedback or information.
- Try not to plan the conversation too closely; there are things people will want to talk about immediately, and these may very well not be the things we want to talk about. Similarly, have a Plan B for getting information. For example, we wanted to engage all occupants in a walkthrough of the property; this was occasionally not possible for a variety of reasons including access to lofts / attics, household members still being asleep in rooms, and even aggressive pets being kept upstairs during the visit
- Manage occupant expectations around confidentiality, particularly with a small sample of properties and client expectation that a wide number of stakeholders should be able to access and use the data.
- Don't make any assumptions; we quickly realised when developing the methodology that questions had to be carefully phrased to obtain a sensible answer. For example, it wasn't enough to ask whether or not the property was comfortable, we had to ascertain what 'comfortable' meant to different people. Even a small sample of interviews reveals acceptable in-home temperatures to be anything from 16˚C to 28˚C. There were also challenges in establishing benchmarks and counterfactuals e.g. what is a 'typical week' in any household?